

**FOUNDATION INVESTIGATION AND DESIGN REPORT
NAISCOOT LAKE BRIDGE – NBL STRUCTURE
HIGHWAY 69 FOUR-LANING
FROM THE SOUTH JUNCTION OF HIGHWAY 529,
NORTHERLY 15 KM**

G.W.P. 5076-06-00, W.P. 5197-06-01, Site 44-449/1

Geocres Number: 41 H-92

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the location of the proposed bridge carrying Highway 69 northbound lanes (NBL) over Naiscoot Lake. The proposed bridge is part of the four-laning of Highway 69 from the south junction of Highway 69 and Highway 529, northerly for 15 km.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM), under the Ministry of Transportation Ontario (MTO) Agreement Number 5006-E-0030.

2 SITE DESCRIPTION

The site of the proposed structure is located approximately 3.9 km north of the intersection of Highway 529 and Highway 69. The proposed structure lies approximately 80 m east of the existing structure that carries Highway 69 over Naiscoot Lake. The new structure will carry Highway 69 NBL over Naiscoot Lake as well as over Flicker Trail (located on the south shore) and Teal Trail (located on the north shore).

At the location of the proposed Naiscoot Lake NBL structure the lake is approximately 125 m wide. The water level in the lake was measured at Elevation 182.07 in August 2010.

The south lake shore slope is approximately 11 m high and the north lake shore slope is approximately 16 m high. The lake shore slopes are generally well treed, with grass and shrubs along the river banks and in the open areas. In places, bedrock is exposed at surface at the lake shore. Site Photos are included in Appendix F.

The lands surrounding the site are generally undeveloped forested land with open swamps. Bedrock outcroppings, ridges and small creeks/water bodies are visible along the existing Highway 69 corridor.

The site lies within the physiographic region known as the Georgian Bay Fringe, which covers Parry Sound and Muskoka. The region is characterized by very shallow overburden and bare rock knobs and ridges. Bedrock is exposed in many areas and intermittent swamps were filled in when glacial lake Algonquin inundated the area. The overburden materials consist of sand, silt and clay. Recent organic deposits of peat and muck occur in abundance in the bedrock hollows and valleys.

The area is underlain by strongly foliated and highly to moderately deformed rocks of Precambrian age of the following types:

- Gneisses of metasedimentary origin.
- Migmatitic rocks and gneisses.
- Felsic igneous rocks (tonalite, granodiorite, monzonite, granite, syenite, derived gneisses).
- Tectonite unit (tectonites, various gneisses).

3 SITE INVESTIGATION AND FIELD TESTING

Site investigation and field testing for this project was based on sampled boreholes carried out in two phases. The first phase was carried out from January 13 to 28, 2010 and the second phase was carried out from August 10 to 18, 2010.

Phase 1 of the sampling program consisted of drilling and sampling a total of 24 boreholes located at the proposed foundation elements of the Naiscoot Lake NBL structure that are located on land (South Abutment, Pier 1, Pier 3, and North Abutment). These boreholes are identified as BH10-07 to 12, BH10-19 to 24, BH10-31 to 36, and BH10-43 to 48.

Phase 2 of the sampling program consisted of drilling and sampling 12 boreholes located at the approximate location of Pier 2 of the Naiscoot Lake NBL structure. These boreholes are identified as NL10-13 to NL10-24.

Borehole advancement within the overburden on land generally ranged from 0 m to 0.8 m where the drill rig encountered refusal, while borehole advancement within the lake bed deposits generally ranged from 1.8 m to 4.2 m (below the top of the lake bed) prior to refusal. Bedrock

outcrops and very shallow bedrock (0.1 m depth or less) were noted at the locations of Boreholes BH10-09, BH10-10, BH10-23, BH10-24, BH10-31 to BH10-36, BH10-44, BH10-45, BH10-46, and BH10-48. Twelve boreholes from Phase 1 and 6 boreholes from Phase 2 were advanced 2.8 to 3.9 m into bedrock by NQ and NQ2” size diamond coring.

The approximate borehole locations are shown on the drawing entitled “Borehole Locations and Soil Strata Drawing” included in Appendix E.

Prior to drilling, the borehole locations were marked in the field and all necessary utility clearances were obtained. At this site, utility location included the use of a dive team to locate the submerged Bell cable crossing the site and to attach buoys to it for future reference.

Access to the borehole locations on land proved to be difficult due to the terrain and, as a result, a light tripod drill rig powered by a Hilti electric drill was mobilized. This equipment was adequate in view of the shallow overburden existing at this site. Similarly, accessing the borehole locations in Naiscoot Lake was difficult since travel from the local marina was obstructed by the existing highway bridge and loading from the lake shore would have involved unacceptable impacts on the lake shore. Accordingly, a small barge was mobilized and fitted with a light tripod drill powered by a Hilti DD-250. Soil samples were obtained using a split spoon sampler and bedrock coring was carried out in selected boreholes.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber’s technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber’s laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Four standpipe piezometers consisting of 25 mm PVC pipe with slotted screens were installed and enclosed in filter sand to permit longer term groundwater level monitoring. One piezometer was installed at the proposed location of each foundation element located on land. The locations and completion details of the piezometers are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

NBL Foundation Element	Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
South Abutment	BH10-07	3.1 / 186.0	Sand from 3.1 m to 1.2 m, bentonite from 1.2 m to surface.
	BH10-08	None installed	Borehole backfilled with cuttings to surface.
	BH10-09	None installed	Borehole backfilled with cuttings to surface.
	BH10-10	None installed	Borehole backfilled with cuttings to surface.
	BH10-11	None installed	Borehole backfilled with bentonite to surface.
	BH10-12	None installed	Borehole backfilled with bentonite to surface.
Pier #1	BH10-19	None installed	Borehole backfilled with cuttings to surface.
	BH10-20	None installed	Borehole backfilled with bentonite to surface.
	BH10-21	3.1 / 179.9	Sand from 3.1 m to 1.2 m, bentonite from 1.2 m to surface.
	BH10-22	None installed	Borehole backfilled with bentonite to surface.
	BH10-23	None installed	Borehole backfilled with cuttings to surface.
	BH10-24	None installed	Bedrock at surface.
Pier #2	NL10-13	None installed	Borehole backfilled with bentonite to 6.4 m. Slough to lake bed surface.
	NL10-14	None installed	Slough to lake bed surface.
	NL10-15	None installed	Slough to lake bed surface.
	NL10-16	None installed	Borehole backfilled with bentonite to 6.4 m. Slough to lake bed surface.
	NL10-17	None installed	Slough to lake bed surface.
	NL10-18	None installed	Borehole backfilled with bentonite to 6.4 m. Slough to lake bed surface.
	NL10-19	None installed	Borehole backfilled with bentonite to 7.0 m. Slough to lake bed surface.
	NL10-20	None installed	Slough to lake bed surface.
	NL10-21	None installed	Borehole backfilled with bentonite to 6.7 m. Slough to lake bed surface.
	NL10-22	None installed	Slough to lake bed surface.
	NL10-23	None installed	Slough to lake bed surface.
	NL10-24	None installed	Borehole backfilled with bentonite to 6.7 m. Slough to lake bed surface.
Pier #3	BH10-31	3.2 / 181.5	Sand from 3.2 m to 1.3 m, bentonite from 1.3 m to surface.
	BH10-32	None installed	Borehole backfilled with bentonite to surface.
	BH10-33	None installed	Bedrock at surface.
	BH10-34	None installed	Borehole backfilled with cuttings to surface.
	BH10-35	None installed	Bedrock at surface.
	BH10-36	None installed	Borehole backfilled with bentonite to surface.
North Abutment	BH10-43	3.7 / 191.1	Sand from 3.7 m to 1.9 m, bentonite from 1.9 m to surface.
	BH10-44	None installed	Borehole backfilled with cuttings to surface.

NBL Foundation Element	Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
	BH10-45	None installed	Borehole backfilled with cuttings to surface.
	BH10-46	None installed	Borehole backfilled with cuttings to surface.
	BH10-47	None installed	Borehole backfilled with bentonite to surface.
	BH10-48	None installed	Borehole backfilled with bentonite to surface.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and rock samples to geological logging. Moisture content determinations were carried out on all soil samples. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and on the figures presented in Appendix B.

Point load tests were carried out in the laboratory on selected samples of intact bedrock to assist in evaluation of the compressive strength of the bedrock. The results of the point load tests performed on the rock core samples are summarized on the Record of Borehole sheets in Appendix A. The estimated UCS value recorded on the Record of Borehole sheets is the average value per core run.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general terms, the overburden encountered in the boreholes drilled on land at this site consists of peat overlying thin layers of native sand overlying bedrock. At a few borehole locations a thin layer of cobbles and/or boulders was encountered below the sand. As well, in some locations bedrock was exposed at the surface. In the boreholes drilled in Naiscoot Lake, the lake bed deposits generally consist of silty clay to clayey silt overlying a layer of sandy silt to silty sand overlying bedrock.

5.1 Overburden (Boreholes Drilled on Land)

5.1.1 Peat

Peat was encountered at surface in 15 of the 24 boreholes that were drilled on land. Where peat was not encountered, either bedrock (6 boreholes) or sand (3 boreholes) was encountered surficially.

The natural moisture content of the peat was typically greater than 100%. Lower moisture contents were measured for some peat samples and can likely be attributed to lower organic content.

The thickness of the peat varied from less than 100 mm to 230 mm. It should be noted that the peat thickness may vary between and beyond the borehole locations and this data is not intended for the purpose of estimating quantities.

5.1.2 Sand

Of the 24 boreholes drilled on land, sand was encountered at surface in 3 boreholes and below a thin layer of peat in 4 boreholes. The sand was generally brown containing trace silt, occasional rootlets, and trace gravel in some boreholes. Occasional cobbles and/boulders were also encountered within the sand layer.

The thickness of the sand layer ranged from 0.2 to 0.6 m. The elevation of the bottom of the sand layer varied from Elevation 183.0 m to Elevation 196.0 m.

SPT N-values recorded in the sand layer generally ranged from 8 to 12 blows per 0.3 m penetration, indicating a loose to compact relative density. Several SPT N-values of 50 blows for less than 0.3 m penetration were also recorded in the sand layer, however these values were typically recorded just above bedrock and may not be representative of the relative density of the sand.

The measured moisture contents of samples collected from the sand layer generally ranged from 20% to 49%. The higher moisture contents are attributed to the presence of organics in the upper portion of the sand layer.

5.1.3 Cobbles and Boulders

A thin layer of cobbles and/or boulders was encountered in 2 boreholes (BH10-43 and BH10-47) drilled on land for the NBL structure. The thin layer of cobbles and/or boulders was encountered below the sand layer and overlying bedrock. The layer of cobbles and boulders was 0.2 m thick in these boreholes, with an underside elevation of 194.3 m to 195.9 m.

5.2 Lake Bed Deposits (Boreholes Drilled in Naiscoot Lake)

5.2.1 Silty Clay to Clayey Silt

A layer of silty clay to clayey silt was encountered from the surface of the lake bed in all 12 boreholes drilled at the approximate location of Pier 2. This layer ranged from 1.4 to 2.6 m thick, with the elevation of the bottom of this layer ranging from 175.4 m to 177.0 m.

Very few SPT N-values were recorded in this layer as the split spoon sampler typically sank to the bottom of this layer. An SPT N-value of 3 blows for 0.3 m penetration was recorded in this layer, indicating a soft consistency. A few SPT N-values of 50 blows for less than 0.3 m penetration were also recorded in this layer, however these high N-values were noted just above refusal or probable bedrock. The natural moisture content of the very soft layer ranged from 30% to over 100%.

Selected samples of the silty clay underwent gradation and Atterberg Limits testing. The results of these tests are presented on the Record of Borehole sheets included in Appendix A and are summarized below.

Soil Particles	Percentage (%)
Gravel	0
Sand	0 to 3
Silt	37 to 59
Clay	38 to 63

The grain size distribution curves corresponding to these results are presented in Figure B1 in Appendix B.

Index Property	Percentage (%)
Liquid Limit	30 to 52
Plastic Limit	17 to 23
Plasticity Index	14 to 29

The results of these Atterberg Limits tests indicate that the silty clay varies from a low plastic clay to a high plastic clay.

5.2.2 Sandy Silt to Silty Sand

A layer of sandy silt to silty sand was encountered below the silty clay to clayey silt in 9 of the 12 boreholes drilled at the approximate location of Pier 2. The thickness of this layer ranges from 0.6 to 2.1 m, with the elevation of the bottom of this layer ranging from 173.7 m to 175.7 m.

SPT N-values recorded in this layer ranged from 4 to 32 blows per 0.3 m penetration, indicating a loose to dense relative density. A few SPT N-values of greater than 50 blows for less than 0.3 m penetration were also recorded in this layer, however these values were typically noted above refusal on probable bedrock bedrock.

The moisture content of the sandy silt to silty sand typically ranged from 15 to 25 %.

Selected samples of the sandy silt to silty sand were subjected to laboratory gradation testing. The results of these tests are presented on the Record of Borehole sheets in Appendix A and are summarized below. The grain size distribution curves for these samples are presented in Figure B2 in Appendix B.

Soil Particle	Percentage (%)
Gravel	4 to 13
Sand	33 to 45
Silt	38 to 59
Clay	3 to 4

5.3 Bedrock

The overburden soils described above are underlain by granitic gneiss bedrock. The bedrock is generally fresh and occasionally slightly weathered. The bedrock was generally grey with black, pink and white bands visible throughout most cores. Occasional mechanical breaks, sub-horizontal and sub-vertical fractures, and highly broken zones were observed in the rock cores.

Bedrock was encountered below a thin layer of topsoil in 11 of the 24 boreholes drilled on land and was exposed at surface at the following six borehole locations; BH10-24, BH10-31, BH10-33, BH10-35, BH10-36, and BH10-48. In Naiscoot Lake, bedrock was encountered below 1.8 to 4.2 m of lake bed deposits.

Bedrock was proved by coring in 50% of the boreholes drilled at each proposed foundation element. Table 5.3 summarizes depths and elevations to the top of bedrock in the boreholes. Where coring was not carried out, bedrock was inferred from auger or spoon refusal.

Table 5.3 – Depths and Elevations of Top of Bedrock

NBL Foundation Element	Borehole	Bedrock Depth Below Ground Surface (m)	Bedrock Elevation (m)
South Abutment	BH10-07	0.2	188.9*
	BH10-08	0.2	188.3
	BH10-09	0.1	188.1
	BH10-10	0.1	188.7
	BH10-11	0.8	186.9*
	BH10-12	0.6	186.6*

NBL Foundation Element	Borehole	Bedrock Depth Below Ground Surface (m)	Bedrock Elevation (m)
Pier 1	BH10-19	0.6	183.4
	BH10-20	0.6	183.0*
	BH10-21	0.2	182.9*
	BH10-22	0.3	183.1*
	BH10-23	0.1	183.1
	BH10-24	0.0	182.4
Pier 2	NL10-13	2.8**	175.7*
	NL10-14	2.1**	176.2
	NL10-15	2.6**	175.4
	NL10-16	2.2**	175.7*
	NL10-17	1.8**	176.8
	NL10-18	2.8**	175.6*
	NL10-19	3.5**	174.9*
	NL10-20	2.6**	175.4
	NL10-21	2.9**	175.4*
	NL10-22	3.7**	174.5
	NL10-23	4.2**	173.7
	NL10-24	2.5**	175.1*
Pier 3	BH10-31	0.0	184.7*
	BH10-32	0.1	184.0*
	BH10-33	0.0	183.3
	BH10-34	0.1	185.7
	BH10-35	0.0	187.2
	BH10-36	0.0	187.3*
North Abutment	BH10-43	0.5	194.4*
	BH10-44	0.1	194.7
	BH10-45	0.1	195.4
	BH10-46	0.1	196.3
	BH10-47	0.3	195.9*
	BH10-48	0.0	196.8*

* Bedrock proved by coring techniques.

** Depth to bedrock measured from the surface of the lake bed.

Solid core recovery in the bedrock ranged from 73% to 100%, though typically core recovery ranged from 85% to 100%. The RQD values typically ranged from 75% to 100% indicating good to excellent rock quality. For 4 core runs the RQD value was less than 75%, ranging from 54% to 73% which indicates a fair rock quality.

The Fracture Index (FI) of the rock core, expressed as fractures per 0.3 m of core, generally ranged from 0 to 5 in most cores. Occasionally the FI was greater than 5, though the FI was never greater than 10.

The estimated uniaxial compressive strength (UCS) of the rock cores generally ranges from 60 MPa to 246 MPa, indicating a strong to very strong rock. Typically the UCS was greater than 100 MPa, which corresponds to very strong rock. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the average Point Load Test Results per core run are presented on the Record of Borehole Sheets in Appendix A.

5.4 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. One standpipe piezometer was installed at each foundation element during Phase 1 of the investigation to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.4.

Table 5.4 – Water Level Measurements

Location	Foundation Element	Borehole	Date	Water Level (m)	
				Depth	Elev.
NBL	South Abutment	BH10-07	28-Jan-10	0.8	188.3
	Pier #1	BH10-21	28-Jan-10	0.8	182.3
	Pier #3	BH10-31	28-Jan-10	1.1	183.6
	North Abutment	BH10-43	28-Jan-10	0.9	193.9

The piezometric readings taken at the locations of the foundation elements for the NBL structure indicate that the groundwater levels range from Elevations 182.3 m to 193.9 m. The groundwater levels were generally higher in the boreholes located at the top of the lake shore slope.

The water level in Naiscoot Lake was measured at Elevation 182.07 m in August 2010, during Phase 2 of the field investigation.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Borehole locations were selected by Thurber Engineering Ltd. Surveyors from MMM Group Limited staked these locations in the field, confirmed the co-ordinates and recorded the corresponding ground surface elevations.

Thurber obtained utility clearances for the borehole locations prior to drilling.

OGS Drilling Inc. of Almonte, Ontario supplied and operated the portable coring equipment used to drill and core all of the boreholes at this site.

Phase 1 field work was supervised on a full time basis by Mr. George Azzopardi and Phase 2 field work was supervised by Mr. Stephane Loranger, C.E.T., both of Thurber. Overall planning and supervision of the field program was conducted by Mr. Tony Harte, M.Sc. Interpretation of the data and preparation of the report was carried out by Mrs. L. Blaine, E.I.T. and Mr. Alastair E. Gorman, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system and approach embankments for the proposed Highway 69 Naiscoot Lake Bridge NBL structure.

Based on the preliminary General Arrangement (GA) drawing provided by MMM Group Limited, a four-span structure supported on two abutments and three piers is proposed. The total length of the structure will be 207.5 m, with 33.5 m between the south abutment and Pier 1, 60 m between Pier 1 and Pier 2, 79 m between Pier 2 and Pier 3, and 35 m between Pier 3 and the north abutment. The proposed structure will be approximately 14 m wide. The proposed finished grade at the structure will vary from Elevations 196.9 at the south abutment to 198.4 at the north abutment.

At the south abutment, the finished grade will be at Elevation 196.9 and the existing ground is at approximately Elevation 193. The approach embankment will be up to 4 m high relative to the existing ground. Below the approach embankment, the forward slope down to the river level will be formed by placing fill on the existing river valley slope.

At the north abutment, the finished grade will be at Elevation 198.4 and the existing ground is at approximately Elevation 197. The approach embankment will be up to 1.5 m high relative to the existing ground.

The discussion and recommendations presented in this report are based on the information provided by MMM Group Ltd. and on the factual data obtained in the course of the investigations.

8 STRUCTURE FOUNDATIONS

In general terms, the overburden encountered at this site consists of peat and/or thin layers of sand. In Naiscoot Lake the lake bed deposits consist of layers of silty clay to clayey silt and sandy silt to silty sandy. Granitic gneiss bedrock was encountered below the overburden, generally at depths ranging from 0 to 0.8 m. Granitic gneiss bedrock was also encountered below the lake bed deposits, generally at depths of 1.8 to 4.2 m, relative to the top of the lake bed.

The piezometric readings measured at the foundation elements for the NBL structure indicate that the groundwater levels range from Elevations 182.3 m to 193.9 m.

The water level measured at Naiscoot Lake was at Elevation 182.07 in August 2010.

Initial consideration was given to the following foundation types:

- Spread footings on native soils
- Spread footings on bedrock
- Socketted H-piles
- Drilled shafts
- Driven steel H-piles

A comparison of the foundation alternatives based on advantages and disadvantages of each one is included in Appendix C.

8.1 Spread Footings on Native Soils

Spread footings founded on native soils are not a feasible foundation option at this site due to the presence of bedrock at very shallow depth, generally 0 to 0.8 m below ground surface at the foundation elements located on land (south abutment, Pier 1, Pier 3, and north abutment). Founding on native soil in the lake bed is not considered to be a viable option due to the soft soil conditions and issues related to underwater construction.

8.2 Spread Footings on Bedrock

Based on the subsurface stratigraphy encountered at this site, spread footings founded on bedrock are feasible for the support of the proposed structure.

Spread footings bearing on undisturbed bedrock at or below elevations presented in Table 8.1 may be designed as follows:

- Factored geotechnical resistance of 2,000 kPa at Ultimate Limit States (ULS)
- The SLS condition will not govern design of footings founded on bedrock.

The ULS resistance has been selected taking account of the sloping nature of the bedrock.

This resistance value is for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

Prior to constructing the footing, if the slope of the bedrock surface exceeds 5%, the rock must be excavated to the minimum extent necessary to prepare a bearing surface with a slope no greater than 5%. It is recommended that this be determined during design and be shown on the Contract Drawings in order to be biddable.

If, during construction, it is found that the prepared bedrock surface lies below the specified founding elevation, then the area must be brought up to founding elevation using concrete fill.

Comments related to the construction of spread footings at specific foundations elements are presented below.

8.2.1 South Abutment

At the south abutment, the elevation of the top of bedrock varies from 186.6 to 188.9, with a mean value of 187.9.

Two possible approaches to preparation of the bearing surface are:

1. Prepare a level surface in the bedrock at Elevation 186.5
2. Adopt a founding elevation around Elevation 188.9 and stipulate that the low areas must be made up using concrete fill. Low areas must be levelled to within a 5% slope prior to placing concrete.

The lower of these founding elevations is 4.5 m above the recorded lake level and thus there are not any anticipated problems related to constructing this foundation in the dry.

8.2.2 Pier 1

At Pier 1, the elevation of the top of bedrock varies from 182.4 to 183.4, with a mean value of 183.1.

Two possible approaches to preparation of the bearing surface are:

1. Prepare a level surface in the bedrock at Elevation 182.3
2. Adopt a founding elevation around Elevation 183.4 and stipulate that the low areas must be made up using mass concrete. Low areas must be levelled to within a 5% slope prior to placing concrete.

The lower of these founding elevations is less than 0.3 m above the recorded lake level. Therefore, depending on the lake level at the time of construction, it is possible that a base at the lower elevation will be under water. The presence of water will not cause

deterioration of the bedrock at this site, but provisions must be made for unwatering prior to placing concrete.

Adopting a higher founding elevation, e.g. 183.4, would reduce the risk of the actual footing base being inundated. However, the concrete fill required in this case must also be placed in the dry, necessitating provision for unwatering.

8.2.3 Pier 2

Pier 2 will be constructed in Naiscoot Lake. Construction in this location will require the use of a cofferdam and will require the excavation of the overburden from within the cofferdam to expose the underlying bedrock. The construction methodology must allow for complete removal of all overburden from within the cofferdam and for the placement of concrete on bare bedrock. This may require a combination of excavation methods, such as clam shell followed by air-lift for the final cleaning.

The bedrock elevation across the area investigated for Pier 2 varies from 173.7 to 176.8, with a mean value of 175.4. The elevation of the top of the overburden (lake bottom) ranges from 177.6 to 178.6, with a mean value of 178.2.

Apart from a veneer of cohesionless soil on top of the bedrock, the overburden soils are identified as very soft to soft clay.

When considering possible cofferdam schemes, it can be assumed that steel sheet piles can be driven through the overburden readily but that they will not penetrate into the bedrock. Two possible consequences include:

1. Toe support cannot be obtained by driving the sheet piles into bedrock. Thus, toe support must be provided by some other means, such as multiple levels of walers and bracing or by pinning the tips of the sheet piles to the bedrock.
2. It will not be possible to achieve a tight seal between lower edge of a steel cofferdam and the bedrock. One consequence of this lack of seal will be a need to maintain a positive head of water inside the cofferdam at all times in order to reduce the risk of water flowing in below the bottom edge of the cofferdam and carrying soil in with it.

8.2.4 Pier 3

At Pier 3, the elevation of the top of bedrock varies from 183.3 to 187.3, with a mean value of 185.4.

Two possible approaches to preparation of the bearing surface are:

1. Prepare a level surface in the bedrock at Elevation 183.2

2. Adopt a founding elevation around Elevation 187.3 and stipulate that the low areas must be made up using mass concrete. Low areas must be levelled to within a 5% slope prior to placing concrete.

The lower of these founding elevations is approximately 1 m above the recorded lake level. Therefore, depending on the lake level at the time of construction, it is possible that a base at the lower elevation will be under water. The presence of water will not cause deterioration of the bedrock at this site, but provisions must be made for unwatering prior to placing concrete.

Adopting a higher founding elevation, e.g. 187.3, would reduce the risk of the actual footing base being inundated. However, the mass concrete required in this case must also be placed in the dry, necessitating provision for unwatering.

8.2.5 North Abutment

At the north abutment, the elevation of the top of bedrock varies from 194.4 to 196.8, with a mean value of 195.6.

Two possible approaches to preparation of the bearing surface are:

1. Prepare a level surface in the bedrock at Elevation 194.3.
2. Adopt a founding elevation around Elevation 196.8 and stipulate that the low areas must be made up using mass concrete. Low areas must be levelled to within a 5% slope prior to placing concrete.

However, the GA indicates that bedrock must be removed in order to develop sufficient length of abutment stem. Accordingly, the founding elevation may be specified on the basis of the required elevation from a structural perspective.

Assuming a founding elevation in the vicinity of Elevation 192, the footing base will be approximately 10 m above the recorded lake level and thus there are not any anticipated problems related to constructing this foundation in the dry.

The forward edge of this footing must be at least 3.0 m behind the crest of the excavation formed for the Teal Trail.

Table 8.1 – Highest Permitted Founding Elevations

Foundation Unit	Borehole	Top of Bedrock	
		Depth below ground surface (m)	Founding Elevation
South Abutment	BH10-07	0.2	188.9
	BH10-08	0.2	188.3
	BH10-09	0.1	188.1
	BH10-10	0.1	188.7
	BH10-11	0.8	186.9
	BH10-12	0.6	186.6
Pier 1	BH10-19	0.6	183.4
	BH10-20	0.6	183.0
	BH10-21	0.2	182.9
	BH10-22	0.3	183.1
	BH10-23	0.1	183.1
	BH10-24	0	182.4
Pier 2	NL10-13	2.8*	175.7
	NI10-14	2.1*	176.2
	NI10-15	2.6*	175.4
	NI10-16	2.2*	175.7
	NI10-17	1.8*	176.8
	NI10-18	2.8*	175.6
	NI10-19	3.5*	174.9
	NL10-20	2.6*	175.4
	NL10-21	2.9*	175.4
	NL10-22	3.7*	174.5
	NL10-23	4.2*	173.7
	NL10-24	2.5*	175.1
Pier 3	BH10-31	0	184.7
	BH10-32	0.1	184.0
	BH10-33	0	183.3
	BH10-34	0.1	185.7
	BH10-35	0	187.2
	BH10-36	0	187.3
North Abutment	BH10-43	0.5	194.4
	BH10-44	0.1	194.7
	BH10-45	0.1	195.4
	BH10-46	0.1	196.3
	BH10-47	0.3	195.9
	BH10-48	0	196.8

* Depth to bedrock measured from the surface of the lake bed.

8.2.6 Lateral Resistance on Bedrock

Initial calculations of the horizontal resistance may be carried out using a value of 0.7 for the ultimate friction factor of concrete poured on rock.

If the frictional component is insufficient, the horizontal resistance may be increased by dowelling the footing into the rock mass. Dowels are considered to be comparatively short steel bars that may be assumed to provide only shear resistance. If vertical resistance in tension is required, rock anchors must be included in the design.

The dowel will fail geotechnically when the ultimate lateral resistance of the rock or grout is exceeded. Using lower bound values for the strength of the rock, an ultimate horizontal resistance of 2.6 MN may be assumed for a 50 mm steel dowel embedded 2,500 mm into the rock. The depth of embedment is measured below the bedrock surface.

The shearing resistance of the selected dowel must be checked structurally.

8.2.7 Uplift of Footings on Bedrock

Uplift forces on footings founded on bedrock may be resisted by steel dowels grouted in to the bedrock.

The dowels may be designed on the basis of a bond strength of 1,500 kPa between the grout and the bedrock, assuming that the minimum compressive strength of the grout is 30 Mpa. This is the ultimate resistance and a load factor of 0.4 must be applied, giving a factored ULS resistance of 600 kPa.

The installation of the dowels must be carried out in accordance with the special provision for Dowels into Rock. The text of the SP is included in Appendix D and includes blank fields that must be completed by the designer before it is included in the Contract Package.

8.3 Socketed H-Piles

H-piles grouted into sockets drilled into the bedrock are considered to be technically feasible for Pier 2 of the NB Naiscoot Lake bridge. This system is not considered to be applicable to the other foundation elements due to the presence of bedrock essentially at the ground surface.

If an HP 310 X 110 pile is used, design can be carried out on the basis of a factored ULS resistance of 2,000 kN per pile. The SLS condition will not govern for a pile grouted into bedrock.

A possible construction sequence is:

- i. Drill a cased hole of suitable size, e.g.900 mm, to bedrock and advance far enough into bedrock to achieve a seal

- ii. Advance a 750 mm diameter hole, but not the casing, a further 1 m into bedrock or the depth dictated by structural considerations.
- iii. Flush the hole clean
- iv. Place the pile in contact with bedrock at the bottom of the hole and brace it in position
- v. Grout at least the lower 1.0 m of the pile in bedrock with 30 MPa grout
- vi. From a geotechnical perspective, it is only necessary to ensure that the piles are grouted into the bedrock. However, since installation will take place through the water column and through very soft soil, consideration should be given to leaving the outer casing in place permanently.

One possible method of installation would be to use a duplex drilling system that advances a steel casing as the hole is being drilled. The method of advance can be left to the Contractor, provided the resulting cased holes meets the requirements. However, systems that could be considered include rotary drilling with roller bits or a down the hole hammer (DTH) system with simultaneous casing advance.

This foundation system will require a pile cap and that, in turn, will require that the piles be installed inside a cofferdam. After pile installation, a plug of tremie concrete should be placed inside the cofferdam to permit unwatering of the cofferdam and construction of the pile cap in the dry. Prior to pile driving, any soil above the level of the underside of the tremie plug should be excavated, though this does not appear to be necessary at this location.

The soil that will lie in the base of the cofferdam is very soft and may fail under the weight of the wet concrete if it is allowed to build up under the tremie discharge. To mitigate this problem, it is recommended that the contract specify construction of a two stage tremie plug. In the first stage, the concrete thickness should be limited to 0.5 m and the Contractor must be instructed to keep the tremie discharge pipe moving across the area of the cofferdam so that the wet concrete does not build up in one area. This initial layer must be allowed to harden, following which the second layer of the plug may be placed.

An alternative approach at this site would be to construct a floating cofferdam with sleeves through which the piles would be installed.

8.4 Drilled Shafts

Support of Pier 2 on drilled shafts is considered to be technically feasible at this site. An advantage of this system is that it could eliminate the need for a cofferdam, if the shafts can be continued up to the pier cap with no pile cap.

At the foundation level, this shaft might typically be in the order of 1.5 m in diameter and must be advanced into the bedrock to develop the required geotechnical resistance.

It is recommended that the geotechnical resistance be based on adhesion between the concrete shaft and the bedrock. At this site, the recommended value of adhesion for SLS design is 5% of the compressive strength of the concrete used in the shaft. Thus, if 30 MPa concrete is used, the value for shaft adhesion is 1,500 kPa. Higher values of adhesion can be used if higher strength concrete is specified for the foundation. For the ULS condition, an adhesion 20% higher than the SLS value can be used, i.e. 1,800 kPa in this example.

Using the 1,500 kPa adhesion and a 1.5 diameter shaft, the geotechnical resistance developed per metre length of shaft is 7,000 kN.

The top 1 m of penetration into the bedrock must be ignored in resistance calculations to allow for the variations in the bedrock surface and possible, localized, surface fracturing.

8.5 Driven Piles

Driven piles are not considered to be a feasible foundation system for this bridge. Except at Pier 2, the bedrock is too shallow to permit the use of piles. At pier 2, the overburden is too weak to provide lateral restraint of piles driven to end bearing on the bedrock.

8.6 Abutment Design Considerations

The ground conditions at this site are considered suitable for conventional or semi-integral abutment design.

8.7 Recommended Foundation

From a geotechnical perspective, based on the subsurface conditions and taking account of the relative costs, the recommended foundation type for this site is spread footings bearing on bedrock.

8.8 Frost Cover

The design depth of frost penetration at this site is 1.8 m.

However, frost penetration is not an issue for footings bearing on bedrock or concrete fill placed on bedrock.

9 EXCAVATION

Minor excavation of overburden soils (native sand) and peat removal will be required at this site. Peat is generally 100 to 230 mm thick and the layers of sand with occasional cobbles and/or boulders range from 0.2 to 0.6 m in thickness. Rock excavation will be required for the NBL

structure foundation elements as well as for the new Teal Trail that passes under the structure along the north shore.

9.1 Earth Excavation

The thickness of overburden at the NB structure site is a maximum of 800 mm.

If earth excavation is required, it must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils within the probable depth of excavation at this site may be classed as Type 3 soils above water level and Type 4 below water level.

The excavation and backfilling for foundations must be carried out in accordance with SP 902S01.

9.2 Rock Excavation

Minor rock excavation may be required at the foundation locations in order to prepare the founding surface. Rock excavation will also be required at the north shore to achieve the proposed grade of the new Teal Trail, which passes under the bridge.

At the Teal Trail, blasting may be employed to create the necessary bench in the bedrock.

At the footing locations, where only a shallow depth of excavation is required, it is strongly recommended that blasting be avoided and that excavation be carried out using pneumatic breakers, or other methods that will avoid disturbing the bedrock below the founding elevation.

The Special Provision governing the use of explosives must be included in the contract. The text of the SP is included in Appendix D.

The design of the blast and removal procedures should be the responsibility of the Contractor. However, it is important that his procedures incorporate methods of reducing damage to the founding surfaces or to any adjacent structures. Such methods may include, though not necessarily be limited to, line drilling, pre-splitting and cushion blasting.

10 UNWATERING

Groundwater may enter foundation excavations at this site in the form of seepage from the bedrock and from the shallow overburden. The volume of water is expected to be low and the bedrock bearing surface will not be degraded by the presence of water.

At the abutments, unwatering requirements are expected to consist of provision to drain the seepage water away from the bearing surface to allow concrete to be placed in dry conditions.

The unwatering requirements at Pier 1 and Pier 3 include the drainage requirement set out above. At these two locations, there is the added risk of inundation if the lake level is above the founding level at the time of construction. The Contractor must be advised of this risk and it is recommended that the Contract contain a requirement for him to provide protection against lake levels up to a specified elevation. The appropriate water elevation for design of protection must be assessed by a hydrologist.

The design of the unwatering system and protection against inundation from the lake must remain the responsibility of the Contractor.

11 COFFERDAM

Where a cofferdam is required, e.g. for the construction of Pier 2, the design of the cofferdam must be carried out by the Contractor. However, when assessing the feasibility and constructability of the cofferdam, the following points must be kept in mind:

1. It will not be possible to drive the sheet piles into the bedrock.
2. The overburden soils are very soft to soft and may not be relied on to provide toe support for the cofferdam.
3. Alternate methods of providing toe support must be considered. These could include drilling a dowel into the bedrock at each sheeting pan in order to pin the sheet in place, or else constructing multiple levels of walers and advancing the lower walers down the sheeting as the excavation proceeds.

It will not be possible to construct a watertight cofferdam using sheet piles. Accordingly, if a spread footing bearing on bedrock is designed, steps must be taken to guard against soil being carried into the cofferdam enclosure by water flow around the tips of the sheet piles. One way of achieving this is to maintain a positive head of water inside the cofferdam at all stages of excavation and cleaning. The positive head must be maintained until the bedrock surface has been cleaned and a plug of tremie concrete has been placed and allowed to set.

12 APPROACH EMBANKMENTS

The immediate approach embankments will be in order of 1.0 to 4.0 m high. The foundation for the embankments will be bedrock or shallow overburden, maximum thickness 0.8 m based on the borehole data, overlying bedrock.

No settlement or stability issues exist for the planned approach embankments.

Earth fill embankments may be constructed with side slopes no steeper than 2H:1V.

Rock fill embankments may be constructed with side slopes no steeper than 1.25H:1V. The width of the rock fill platform must satisfy the requirements of the most recent Northeastern Region Policy on rock fill.

Earth fill embankment slopes must be provided with erosion protection in accordance with OPSS 572.

13 BACKFILL TO ABUTMENTS

Backfill to the abutment should be granular material.

In the case of a conventional abutment, granular backfill is recommended but rock backfill can be permitted. A NSSP is required to specify grading limits for the rock fill.

In all cases where the approach embankment consists of rock fill and granular backfill to the abutment wall is used, the granular backfill must consist of OPSS Granular “B” Type II.

The backfill to the abutment walls must be in accordance with OPSS 902 as amended by Special Provision 902S01. Granular backfill must be placed to the extents shown in OPSD 3101.150, and rock backfill must be placed to the extents shown in OPSD 3101.200. All granular material should meet the requirements of SP 110F13 Amendment to OPSS 1010, March 1993.

Compaction equipment to be used adjacent to the abutment walls must be restricted in accordance with SP 105S10.

The design of the abutment must incorporate a subdrain as shown in OPSD 3101.150 or OPSD 3101.200, as applicable.

14 EARTH PRESSURE

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K(\gamma h + q)$$

Where:

P_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see table below)

γ = unit weight of retained soil (see table below)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 14.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

Table 14.1 – Earth Pressure Coefficient (K)

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$		Rock Fill (Limited to 300 mm size) $\phi = 42^\circ, \gamma = 19 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H: 1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.48*	0.2	0.28*
At rest (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	5.0	-

* For wing walls.

15 SEISMIC CONSIDERATIONS

15.1 Seismic Design Parameters

The site is treated as lying in Seismic Zone 1. The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 1
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Horizontal Acceleration 0.08

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

15.2 Liquefaction Potential

The founding stratum will be bedrock and there is no risk of liquefaction under a seismic event.

15.3 Retaining Wall Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading.

For the design of retaining walls, the coefficients of horizontal earth pressure in Table 15.1 may be used:

Table 15.1 – Earth Pressure Coefficient for Earthquake Loading

Earth Pressure Coefficient (K) for Earthquake Loading						
Wall Condition	Granular A or Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$		Rock Fill $\phi = 42^\circ$; $\gamma = 19.0 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.3	0.47	0.34	0.58	0.22	0.31
Passive (K_{PE})	3.6	-	3.2	-	4.9	-
At Rest (K_{OE})**	0.53	-	0.57	-	0.43	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

16 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

16.1 Variations in the elevation of the bedrock surface

The surface of the bedrock has been shown in the investigation to be variable. Since the elevation of the bedrock surface was only established at discrete points, it is possible that higher or lower elevations will be encountered during construction. Also, the slope of the bedrock is expected to be locally steeper than that depicted by joining the elevations established at the boreholes.

The bedrock elevation variability may lead to difficulty sealing out groundwater at the toe of a sheet pile enclosure

16.2 Control of groundwater and surface water

If the lake level is abnormally high, the excavations for Piers 1 and 3 may require cofferdams and unwatering.

17 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Alastair E. Gorman, P.Eng., M.Sc.
Senior Foundations Engineer



Report reviewed by:
P.K. Chatterji, P.Eng., Ph.D.
Review Principal



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


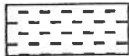
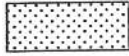


 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			Field Estimation of Hardness*
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No BH10-07

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 462.0 E 234 782.3 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.15 - 2010.01.16 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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189.1	GROUND SURFACE						20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			</

+³, ×³: Numbers refer to Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10-08

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 463.1 E 234 787.1 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilli COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.15 - 2010.01.15 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20	40	60	80	100	20	40	60			
188.5	GROUND SURFACE															
0.0	PEAT		1	SS	50/											
0.2	END OF BOREHOLE AT 0.2 m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN AND DRY TO 0.2 m.				.150											

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10-09

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 464.3 E 234 792.2 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.15 - 2010.01.15 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W _P	W		
188.2	GROUND SURFACE												
0.0	PEAT		1	SS	50/								
0.1	END OF BOREHOLE AT 0.1 m ON PROBABLE BEDROCK. BOREHOLE OPEN AND DRY TO 0.1 m.				100								

ONTMT4S 6121(NAISCOOT LAKE)GPJ 5/3/12

RECORD OF BOREHOLE No BH10-10

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 466.8 E 234 781.1 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.15 - 2010.01.15 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
188.8	GROUND SURFACE												
0.0	PEAT		1	SS	50/								
0.1	END OF BOREHOLE AT 0.1 m ON PROBABLE BEDROCK. BOREHOLE OPEN AND DRY TO 0.1 m.				100								

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

+ 3, × 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10-11

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 468.0 E 234 786.0 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.16 - 2010.01.16 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
187.7	GROUND SURFACE							20	40	60	80	100		
0.0	PEAT (150mm)							20	40	60	80	100		
0.2	SAND, trace silt, occasional rootlets, occasional iron oxide staining Compact Brown Damp		1	SS	10									
186.9			2	SS	50 / 0.05		187							
0.8	BEDROCK, granitic gneiss, fresh, coarse grained, strong to very strong, black/pink		1	RUN										
	Sub-horizontal joint at 1.91m. Occasional mechanical breaks.		2	RUN			186							
			3	RUN			185							
183.8							184							
3.9	END OF BOREHOLE AT 3.9 m. BOREHOLE OPEN TO 3.9 m AND WATER LEVEL AT 1.8 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

RECORD OF BOREHOLE No BH10-12

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 469.2 E 234 791.3 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.16 - 2010.01.16 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
187.2	GROUND SURFACE													
0.0	PEAT (230mm)													
0.2	SAND, trace silt, occasional rootlets		1	SS	10									
186.6	Compact		2	SS	50 / 0.04									
0.6	Brown Damp to Wet													
	BEDROCK, granitic gneiss, fresh, coarse grained, very strong, grey/black/pink(red)/white Occasional mechanical breaks. Highly broken zone at 0.63 to 0.74m. Horizontal joint at 1.45 and 1.60m.		1	RUN										
			2	RUN										
			3	RUN										
183.5														
3.7	END OF BOREHOLE AT 3.7 m BOREHOLE OPEN TO 3.7 m AND WATER LEVEL AT 1.1 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

RECORD OF BOREHOLE No BH10-19

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 494.5 E 234 774.5 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.17 - 2010.01.17 CHECKED BY LRB

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		WATER CONTENT (%)				
184.0	GROUND SURFACE							20 40 60 80 100						
0.0	PEAT (100mm)						184	20 40 60 80 100						
0.1	SAND, trace silt Loose Brown Damp		1	SS	8									
183.4														
0.6	END OF BOREHOLE AT 0.6 m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN AND DRY TO 0.6 m. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.													




ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-20

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 495.7 E 234 779.4 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.17 - 2010.01.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
183.6	GROUND SURFACE															
0.0	PEAT (230mm)															
0.2	SAND, trace silt Compact Brown Wet		1	SS	12	▽										
183.0	BEDROCK , granitic gneiss, fresh, medium to coarse grained, very strong, grey/black/occasional red Occasional mechanical breaks. Quartz seam at 1.88 to 2.03m.		1	RUN												
0.6																
			2	RUN												
			3	RUN												
180.0																
3.7	END OF BOREHOLE AT 3.7 m. BOREHOLE OPEN TO 3.7 m AND WATER LEVEL AT 0.4 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.															

+ 3, x 3 : Numbers refer to 20
Sensitivity 15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10-21

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 496.9 E 234 784.5 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.17 - 2010.01.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)					
								20	40	60				80	100	20	40	60	
183.1	GROUND SURFACE															GR	SA	SI	CL
0.0	PEAT		1	SS	50/														
0.2	BEDROCK, granitic gneiss, fresh, coarse grained, strong to very strong, dark grey/black/occasional red Occasional mechanical breaks. Horizontal joints at 0.53, 0.76 and 0.97m. Sub-horizontal joints at 1.70 and 1.91m. Iron oxide staining at 1.70 and 1.93m. Horizontal joint at 2.03m.				150														
			1	RUN															
				2	RUN														
				3	RUN														
179.9																			
3.1	END OF BOREHOLE AT 3.1 m. BOREHOLE OPEN TO 3.1 m AND WATER LEVEL AT 0.4 m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2010.01.28 0.8 182.3																		

RECORD OF BOREHOLE No BH10-22

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 499.4 E 234 773.4 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.17 - 2010.01.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
183.4	GROUND SURFACE													
0.0	SAND, occasional rootlets		1	SS	50/	▽								
183.1	Loose				150									
0.3	Dark Brown to Brown Damp						183							
	BEDROCK, granitic gneiss, fresh, medium to coarse grained, very strong, dark grey/black/white/red Occasional mechanical breaks. Sub-horizontal joint at 0.46m.		1	RUN										
			2	RUN			182							
			3	RUN			181							
180.0														
3.4	END OF BOREHOLE AT 3.4 m. BOREHOLE OPEN TO 3.4 m AND WATER LEVEL AT 0.2 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-23

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 500.6 E 234 778.2 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.17 - 2010.01.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
183.2	GROUND SURFACE													
0.0	PEAT		1	SS	50/									
0.1	END OF BOREHOLE AT 0.1 m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN AND DRY TO 0.1 m.				125									

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-24

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 501.8 E 234 783.3 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.17 - 2010.01.17 CHECKED BY LRB

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W P W W L	20 40 60			
182.4	GROUND SURFACE													
0.0	BEDROCK AT SURFACE													



ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-31

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 627.9 E 234 737.0 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.27 - 2010.01.27 CHECKED BY LRB


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			WATER CONTENT (%) w _p w w _L							
184.7	GROUND SURFACE							20	40	60	80	100						
0.0	BEDROCK , granitic gneiss, fresh, coarse grained, strong to very strong, black/white/salmon Occasional mechanical breaks. Horizontal joint at 0.08m. Horizontal joint at 0.99m.		1	RUN			184											
			2	RUN			183											
			3	RUN			182											
181.5																		
3.2	END OF BOREHOLE AT 3.2 m. BOREHOLE OPEN TO 3.2 m AND WATER LEVEL AT 0.4 m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2010.01.28 1.1 183.6																	

RECORD OF BOREHOLE No BH10-32

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 629.5 E 234 741.8 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.27 - 2010.01.28 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								WATER CONTENT (%)	
184.1	GROUND SURFACE		1	SS	50/		184							FI	RUN #1		
0.0	PEAT BEDROCK , granitic gneiss, slightly weathered to fresh, coarse grained, very strong, white/black/salmon Occasional mechanical breaks. Horizontal joint at 0.13m. Highly broken zone at 1.19 to 1.50m.		1	RUN	.075									1	TCR=100% SCR=100% RQD=95% UCS=136MPa		
0.1															0		
					2	RUN			183							0	RUN #2 TCR=100% SCR=73% RQD=73% UCS=121MPa
					3	RUN			182							0	RUN #3 TCR=100% SCR=100% RQD=100% UCS=113MPa
180.7							181							0			
3.4	END OF BOREHOLE AT 3.4 m. BOREHOLE OPEN TO 3.4 m AND WATER LEVEL AT 0.9 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													0			

+³ ×³: Numbers refer to Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10-33

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 631.0 E 234 746.7 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.27 - 2010.01.27 CHECKED BY LRB

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20 40 60 80 100			20 40 60 80 100	W P W W L	20 40 60							
183.3	GROUND SURFACE																	
0.0	BEDROCK AT SURFACE																	

ONTMT4S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No BH10-34

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 632.7 E 234 735.5 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilli COMPILED BY MFA
DATUM Geodetic DATE 2010.01.28 - 2010.01.28 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
185.8	GROUND SURFACE													
0.0	PEAT		1	SS	50/									
0.1	END OF BOREHOLE AT 0.1 m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE OPEN AND DRY TO 0.1 m. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.				100									

ONTMT4S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No BH10-35

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 634.2 E 234 740.2 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilt COMPILED BY MFA
DATUM Geodetic DATE 2010.01.27 - 2010.01.27 CHECKED BY LRB

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20 40 60 80 100			20 40 60 80 100	W P W W L	20 40 60				
187.2	GROUND SURFACE														
0.0	BEDROCK AT SURFACE														



ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-36

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 635.9 E 234 745.2 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.28 - 2010.01.28 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
187.3	GROUND SURFACE							20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
0.0	BEDROCK , granitic gneiss, fresh, coarse grained, strong to very strong, black/white/salmon Occasional mechanical breaks.		1	RUN			187																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		</

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-43

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 661.0 E 234 725.9 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hill COMPILED BY MFA
DATUM Geodetic DATE 2010.01.26 - 2010.01.26 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
194.8	GROUND SURFACE														
0.0	SAND , trace silt, trace gravel, occasional rootlets, organic odour Loose Brown Damp BOULDER BEDROCK , granitic gneiss, fresh, coarse grained, very strong, grey/black/white/salmon Occasional mechanical breaks. Horizontal joints at 0.51, 0.56, 0.61, and 0.66m. Horizontal joint at 1.65m. Quartz seam from 2.13 to 2.62m. Sub-vertical joint at 2.62m.		1	SS	50/										
194.5															
194.4						125									
0.5															
			1	RUN			194							FI	RUN #1 TCR=100% SCR=100% RQD=82% UCS=163MPa RUN #2 TCR=100% SCR=100% RQD=100% UCS=153MPa RUN #3 TCR=100% SCR=100% RQD=100% UCS=246MPa
													4		
													0		
													0		
													0		
			2	RUN			193						1		
													0		
													0		
													0		
			3	RUN			192						1		
													0		
191.1													0		
3.7	END OF BOREHOLE AT 3.7 m. BOREHOLE OPEN TO 3.7 m AND WATER LEVEL AT 1.3 m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2010.01.28 0.9 193.9													0	

+ 3, × 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10-44

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 662.7 E 234 730.6 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.26 - 2010.01.26 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
194.8	GROUND SURFACE													
0.0	PEAT		1	SS	50/									
0.1	END OF BOREHOLE AT 0.1 m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER BOREHOLE OPEN AND DRY TO 0.1 m.				.125									

ONTMT4S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No BH10-45

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 664.4 E 234 735.6 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.26 - 2010.01.26 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
195.5	GROUND SURFACE													
0.0	PEAT		1	SS	507									
0.1	END OF BOREHOLE AT 0.1 m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE OPEN AND DRY TO 0.1 m.				075									

ONTMT4S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No BH10-46

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 665.7 E 234 724.2 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilti COMPILED BY MFA
DATUM Geodetic DATE 2010.01.26 - 2010.01.26 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
196.4	GROUND SURFACE												
0.0 0.1	PEAT	AAA	1	SS	50/								
	END OF BOREHOLE AT 0.1 m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE OPEN AND DRY TO 0.1 m.				.075								

RECORD OF BOREHOLE No BH10-47

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 667.3 E 234 728.9 ORIGINATED BY GA
 HWY 69 BOREHOLE TYPE Tripod/Hilli COMPILED BY MFA
 DATUM Geodetic DATE 2010.01.26 - 2010.01.26 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			WATER CONTENT (%) w _p w w _L				
196.2	GROUND SURFACE						20	40	60	80	100				
0.0	SAND, trace silt, occasional rootlets, organic odour		1	SS	50/										
196.9	Loose Brown Damp				150										
0.3	COBBLES and BOULDERS		1	RUN											
	BEDROCK, granitic gneiss, fresh, medium to coarse grained, very strong, black/white/salmon Occasional mechanical breaks. Sub-vertical joint at 0.71 to 0.81m. Vertical joint at 0.94m.														
	Sub-vertical joint at 2.64 to 2.90m.		2	RUN											
			3	RUN											
192.8															
3.4	END OF BOREHOLE AT 3.4 m. BOREHOLE OPEN TO 3.4 m AND WATER LEVEL AT 0.7 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.														

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No BH10-48

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 669.1 E 234 733.9 ORIGINATED BY GA
HWY 69 BOREHOLE TYPE Tripod/Hilli COMPILED BY MFA
DATUM Geodetic DATE 2010.01.27 - 2010.01.27 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			w _p	w	w _L			GR	SA
196.8	GROUND SURFACE							20	40	60	80	100					
0.0	BEDROCK , granitic gneiss, fresh, coarse grained, very strong, black/white/salmon Occasional mechanical breaks.		1	RUN			196										RUN #1 TCR=100% SCR=100% RQD=100% UCS=136MPa
			2	RUN			195										RUN #2 TCR=100% SCR=100% RQD=100% UCS=171MPa
			3	RUN			194										RUN #3 TCR=100% SCR=100% RQD=100% UCS=202MPa
193.4	END OF BOREHOLE AT 3.5 m. BOREHOLE OPEN TO 3.5 m AND WATER LEVEL AT 0.4 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																
3.5																	

RECORD OF BOREHOLE No NL10-13

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 553.2 E 234 760.2 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.14 - 2010.08.14 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
182.1	LAKE SURFACE							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
0.0	WATER						182	20 40 60 80 100				
							181					
							180					
							179					
178.5							178					
3.6	Silty CLAY Very soft Grey (Cl)											
			1	GS								
177.0							177					0 0 38 62
5.1	Sandy SILT, trace gravel Loose Grey Moist to wet		2	SS	4							
							176					
175.7							175					
6.4	BEDROCK, granitic gneiss, very strong Vertical joint at 6.40 to 6.55 m		1	RUN								
							174					
	Sub-vertical joints at 7.72 to 7.92 m		2	RUN								
							173					
	Rubble zone from 8.56 to 8.59 m		3	RUN								
172.3	Sub-vertical joints at 9.65 to 9.75 m											
9.8	END OF BOREHOLE AT 9.8 m											

ONTM14S 6121(NAISCOOT LAKE).GPJ 5/3/12

+³, ×³: Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NL10-14

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 557.3 E 234 759.9 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.18 - 2010.08.18 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
182.0	LAKE SURFACE						182							
0.0	WATER													
178.3							181							
3.7	Silty CLAY Very soft Grey						180							
176.5							179							
5.5							178							
176.2			1	GS			177							
5.8	Silty CLAY Very soft Grey													
5.5	SILT , some clay Soft		2	SS	100 / 0.									
5.8	END OF BOREHOLE AT 5.8 m UPON REFUSAL ON PROBABLE BEDROCK.													

RECORD OF BOREHOLE No NL10-15

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 560.2 E 234 759.0 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.18 - 2010.08.18 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
182.1	LAKE SURFACE						20 40 60 80 100	20 40 60						
0.0	WATER						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
178.0														
4.1	Silly CLAY Very soft to soft Grey		1	GS								○		
176.2														
5.9	SILT , some sand to sandy, trace gravel Compact Grey Moist to wet		2	SS	16							○		
175.5														
175.6	Gravelly SAND Very dense Grey Wet		3	SS	100 / 0									
6.7	END OF BOREHOLE AT 6.7 m UPON REFUSAL ON PROBABLE BEDROCK.													

ONTM14S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No NL10-16

1 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 562.2 E 234 758.6 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.14 - 2010.08.15 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE							
182.1	LAKE SURFACE							20	40	60	80	100	20	40	60	
0.0	WATER															

Continued Next Page

+³ ×³ : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NL10-16

2 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 562.2 E 234 758.6 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010 08 14 - 2010 08 15 CHECKED BY AEG

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							
	Continued From Previous Page							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE	20 40 60	W _P W W _L		1	GR SA SI CL
171.7						172									
10.3	END OF BOREHOLE AT 10.3 m.														

RECORD OF BOREHOLE No NL10-17

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 554.0 E 234 764.8 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.18 - 2010.08.18 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
182.0	LAKE SURFACE						20 40 60 80 100	○ UNCONFINED + FIELD VANE	20 40 60	W _P W W _L				
0.0	WATER						20 40 60 80 100	● QUICK TRIAXIAL × LAB VANE						
178.6														
3.4	Silty CLAY , trace sand Very soft Grey (CL)													
			1	GS										
177.0														
176.8	Clayey SILT Soft Grey		2	SS										
5.2	END OF BOREHOLE AT 5.2 m UPON REFUSAL ON PROBABLE BEDROCK.													

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _p W W _L		
182.1	LAKE SURFACE						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100				GR SA SI C

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No NL10-18

2 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 558.3 E 234 763.3 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.17 - 2010.08.17 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
171.9	Continued From Previous Page						172							
10.2	END OF BOREHOLE AT 10.2 m.													

ONTM74S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No NL10-19

1 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 560.1 E 234 763.1 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.16 - 2010.08.17 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
182.1	LAKE SURFACE						20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
0.0	WATER						20 40 60 80 100	20 40 60 80 100	W _P	W	W _L	
										</		

Continued Next Page

+³, X³; Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

ONTMT4S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No NL10-19

2 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 560.1 E 234 763.1 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.16 - 2010.08.17 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
171.9	Continued From Previous Page						172						1	
10.2	END OF BOREHOLE AT 10.2 m.													

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No NL10-20

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 563.5 E 234 762.2 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.18 - 2010.08.18 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100	PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w		
182.0	LAKE SURFACE											
0.0	WATER											

ONTMT4S 6121(NAISCOOT LAKE) GPJ 5/3/12

RECORD OF BOREHOLE No NL10-21

1 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 556.4 E 234 769.0 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.16 - 2010.08.16 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)							
182.1	LAKE SURFACE						20	40	60	80	100	W _P	W	W _L	GR	SA	SI	CL
0.0	WATER						20	40	60	80	100							
178.3							182											
							181											
							180											
							179											
178.3							178											
3.8	Silty CLAY Very soft Grey		1	GS			177											
							176											
176.2			2	SS	3		175											
5.9	SAND, some silt to silty, trace gravel Loose Grey Moist to wet Occasional cobbles (100 mm)						174											
175.4							173											
6.7	BEDROCK, granitic gneiss, fresh, very strong		1	RUN														
			2	RUN														
			3	RUN														

Continued Next Page

+³ . X³ : Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NL10-21

2 OF 2

METRIC

W.P. 5076-06-00 LOCATION N 5 056 556.4 E 234 769.0 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.16 - 2010.08.16 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
171.9	Continued From Previous Page						172							
10.2	END OF BOREHOLE AT 10.2 m.													

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No NL10-22

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 558.6 E 234 767.6 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.17 - 2010.08.17 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
182.0 0.0	LAKE SURFACE WATER						182					
178.2 3.8	Silty CLAY Soft Grey		1	GS			181					
175.9 6.1	Sandy SILT , with 200 mm sand seam Compact to dense Grey Moist		2	SS	17		179					
174.5 7.5	END OF BOREHOLE AT 7.5 m UPON REFUSAL ON PROBABLE BEDROCK.		3	SS	100 / 0.25		178					
							177					
							176					
							175					

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No NL10-23

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 561.7 E 234 766.6 ORIGINATED BY SLL
HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
DATUM Geodetic DATE 2010.08.17 - 2010.08.18 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
182.1	LAKE SURFACE							20 40 60 80 100					
0.0	WATER							20 40 60 80 100					

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

RECORD OF BOREHOLE No NL10-24

1 OF 1

METRIC

W.P. 5076-06-00 LOCATION N 5 056 564.3 E 234 765.3 ORIGINATED BY SLL
 HWY 69 BOREHOLE TYPE BW Casing - Split Spoon/AQ Core COMPILED BY LRB
 DATUM Geodetic DATE 2010.08.15 - 2010.08.15 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
182.1	LAKE SURFACE							20 40 60 80 100				
0.0	WATER							20 40 60 80 100				
	</											

ONTMT4S 6121(NAISCOOT LAKE).GPJ 5/3/12

+³ . X³ : Numbers refer to
Sensitivity

20
15
10

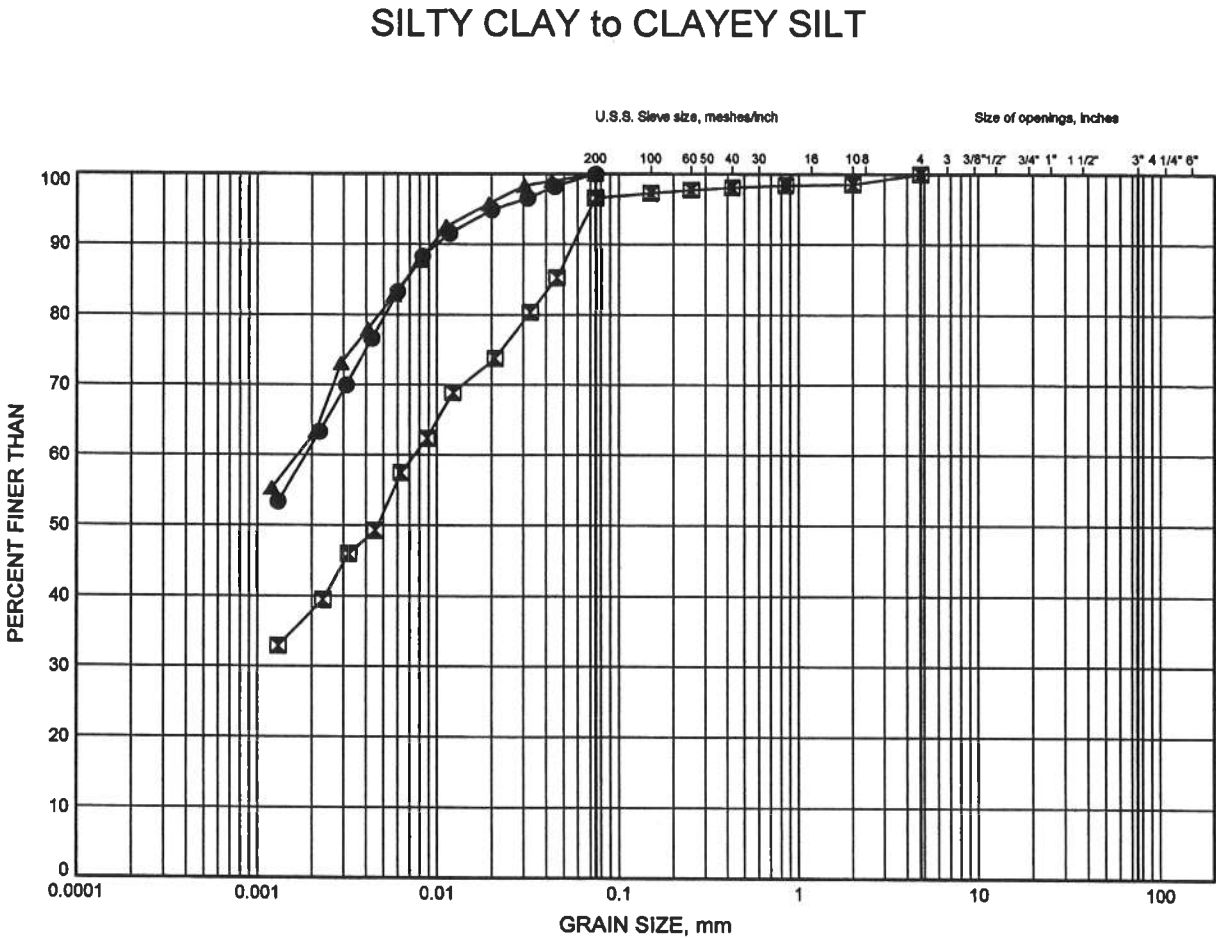
(%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

Hwy 69 Four-Laning North of Hwy 529
GRAIN SIZE DISTRIBUTION

FIGURE B1



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NL10-13	4.88	177.21
⊠	NL10-17	4.72	177.30
▲	NL10-23	4.72	177.33

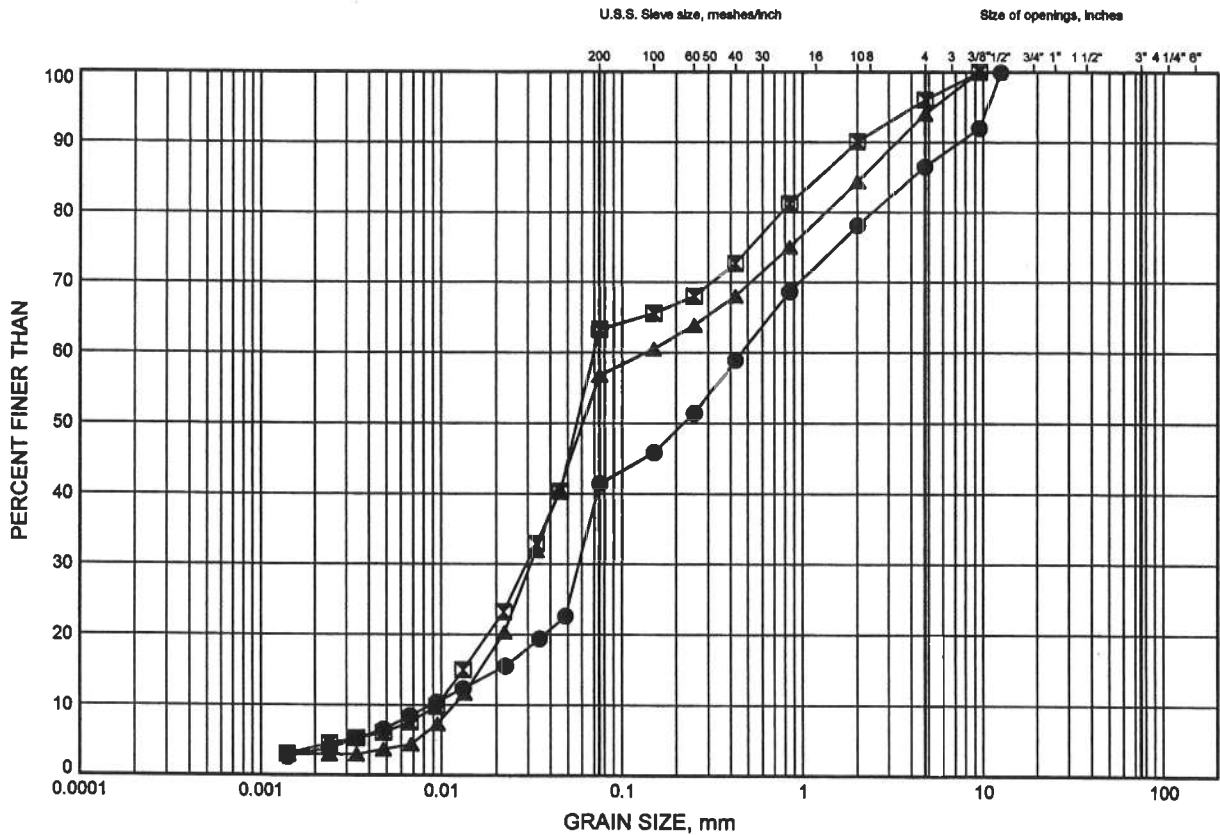


W.P.# 5076-06-00
Prepared By AN
Checked By TJH

Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE B2

SANDY SILT to SILTY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NL10-16	5.92	176.14
■	NL10-19	6.30	175.76
▲	NL10-24	6.80	175.26

GRAIN SIZE DISTRIBUTION - THURBER 6121(NAISCOOT LAKE).GPJ 12/10/10

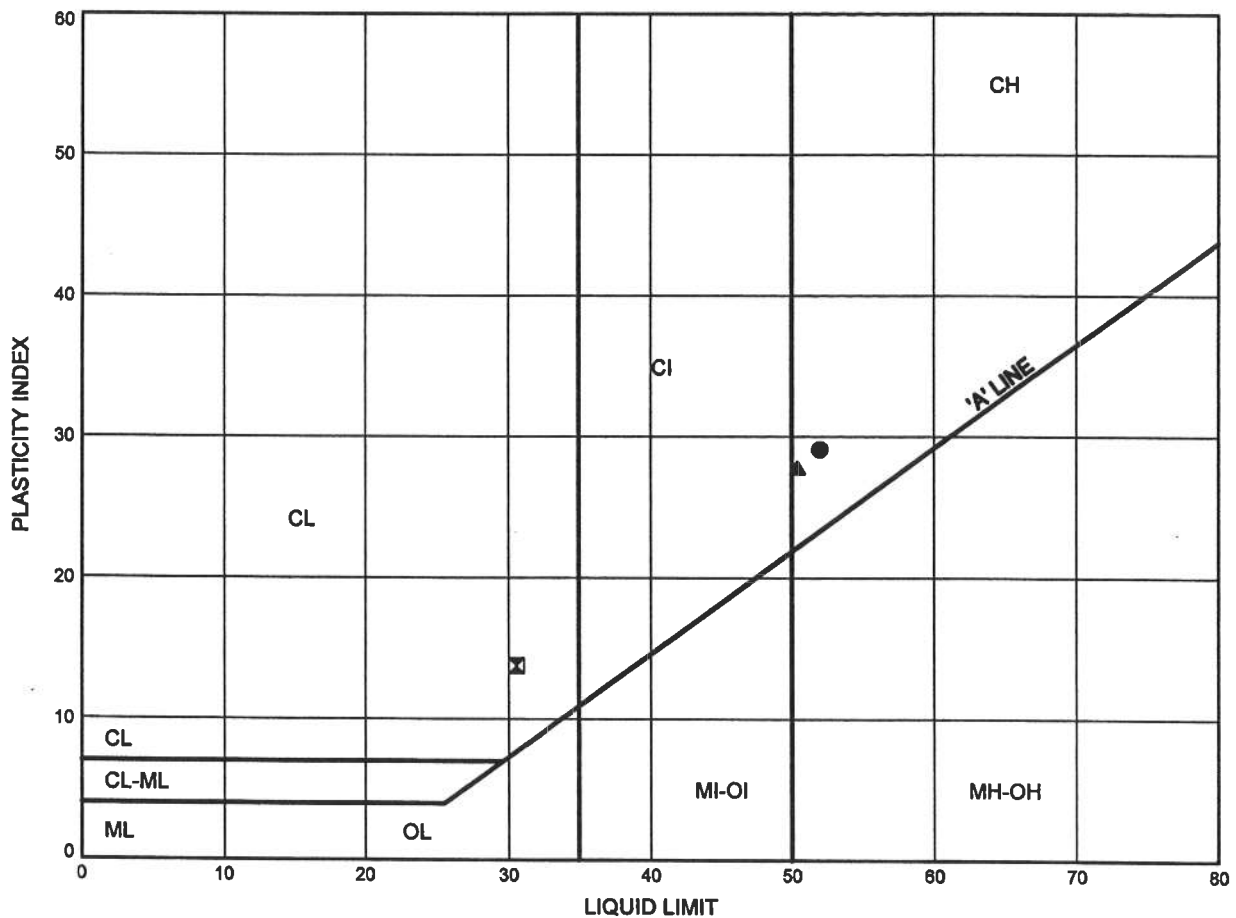
W.P.# .5076-06-00
Prepared By .AN.
Checked By .TJH.



Hwy 69 Four-Laning North of Hwy 529
ATTERBERG LIMITS TEST RESULTS

FIGURE B3

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NL10-13	4.88	177.21
⊠	NL10-17	4.72	177.30
▲	NL10-23	4.72	177.33

Date December 2010

Project 5076-06-00



Prep'd AN

Chkd. TJH

FROM THE SOUTH JUNCTION OF HIGHWAY 69 AND HIGHWAY 529, NORTHERLY 15 KM

[illegible][illegible][illegible][illegible]

FROM THE SOUTH JUNCTION OF HIGHWAY 69 AND HIGHWAY 529, NORTHERLY 15 KM

[illegible][illegible][illegible][illegible]

[illegible]

[illegible]

[illegible]

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Footings on Bedrock	Drilled Piles	Drilled Shafts
<p>Advantages:</p> <ul style="list-style-type: none"> i. High values of geotechnical resistance are available on the bedrock. ii. Conventional construction iii. Lower cost than deep foundations <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Stepped footing may be required ii. High cost of excavation of bedrock. iii. In the case of Pier 2, there will be the high cost of cofferdam and construction below the lake level. iv. Mass concrete fill required to create a level founding surface. v. Some groundwater drainage may be required. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance available for units founded on bedrock. i. (Considered only for Pier 2). <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Possibly higher unit cost compared to other foundation options such as footings ii. Difficulties in obtaining seal below the liner to pour concrete in dry conditions <p>FEASIBLE BUT NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> ii. High geotechnical resistance available for units founded on bedrock. iii. May be used to eliminate the need for a cofferdam <p>Disadvantages:</p> <ul style="list-style-type: none"> iii. Higher unit cost compared to other foundation options such as footings or driven piles. iv. Difficulties in obtaining seal below the liner to pour concrete in dry conditions v. Potential difficulty in unwatering, cleaning and inspecting bases.
<p>Advantages:</p> <ul style="list-style-type: none"> i. Economical to install. ii. Ease of construction <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Soil conditions encountered at this site are considered unsuitable. ii. Not suitable for integral abutment design. 		
NOT RECOMMENDED/NOT VIABLE	FEASIBLE AT ABUTMENTS	NOT RECOMMENDED

Appendix D

List of SPs and OPSS, and Suggested Text for Selected NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 902 as modified by SP 902S01 (June 2006).
- OPSS 572
- OPSD 3101.150,
- OPSD 3101.200.
- SP 110F13 Amendment to OPSS 1010, March 1993.
- SP 105S10.

2. Suggested text for a NSSP on Dewatering

Excavations at the abutments will penetrate below the groundwater level.

The soils overlying the bedrock at this site are predominantly cohesionless and will be readily disturbed by unbalanced water heads or by flow of water.

The Contractor shall design, install and operate systems that shall:

1. Unwater the excavations
2. Control the flow of groundwater and surface water into the excavations
3. Prevent the disturbance of the base of the excavation
4. Prevent the sloughing of soil into the excavations.

The selection and design of suitable unwatering and shoring systems shall remain the responsibility of the Contractor.

3. Suggested text for pile driving

Steel H-piles driven at this site must be founded on bedrock. All driven piles shall be fitted with cast steel, H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent. Piles placed in rock sockets shall not be fitted with rock points.

NSP 98 Northeastern

REQUIREMENTS FOR BLASTING

1. GENERAL

- 1.1 The Contractor shall comply with OPSS 120 unless otherwise noted in the Contract.
- 1.2 For the purpose of work related to blasting, a Blasting Consultant is defined as: A Professional Engineer licensed to practice in the Province of Ontario with a minimum of five years (5) experience

Highway 69 Four Laning: South junction of Hwy 529, northerly 15 Km
Naiscoot Lake Bridge – NBL Structure

related to blasting.

The Blasting Consultant shall be retained by the Contractor and shall be independent of the Contractor and any subcontractor doing blasting work. The Blasting Consultant shall be required to complete the specified monitoring of vibration levels and provide a report detailing the vibration levels and copies of the recorded ground vibration documents to the Contractor and the Contract Administrator immediately following each blast and prior to the next blast.

- 1.3 All blasting shall be designed and carried out in a manner, such that no damage occurs to the buildings or equipment.
- 1.4 Under no circumstances will the Contractor blast within the vicinity of any TransCanada Pipelines, Union Gas Pipelines, Ontario Hydro lines and Bell Fibre optics lines without a representative from TransCanada Pipelines, Ontario Hydro or Bell Canada on site.

The Contractor shall notify the following appropriate representative 72 hours in advance of blasting.

* Fill - in as appropriate for the project

Hydro One Networks Inc.
45 Sarjeant Drive
Box 6700
Barrie, ON
L4M 5N5

Attn: Arthur Conlon
Telephone : (888) 238-2398
Fax: (705) 746-7293

Bell Canada
9 High Street
Huntsville, ON
P1H 1P2

Attn: Timothy Beachy
Telephone: (705) 789-9638
Fax: (705) 789-6223

The Contractor shall notify the following appropriate representative 10 days in advance of blasting.

* Fill - in as appropriate for the project

TransCanada Pipelines Ltd.
801 Seventh Avenue S.W.
P.O. Box 2535, Station M
Calgary, Alberta

Attn: Elio Ramos
Telephone: (403) 261-8256
and Ron Marsh
(705) 840-7454

T2P 2N6

Union Gas Limited
P.O. Box 3040
36 Charles Street East
North Bay, ON
P1B 8K7

Attn: Jeff Peroff
Telephone: (705) 475-7923
Fax: (866) 252-2012

2.0 DESIGN AND SUBMISSION REQUIREMENTS



2.1 Section 120.04.02 b) iii is deleted and replaced with:

A letter signed by the Contractor certifying that a pre-blast survey has been carried out in accordance with the Pre-Blast Survey subsection. A copy of the pre-blast survey shall be provided to the Contract Administrator.

3.0 **EQUIPMENT**

3.1 Section 120.06.02 is amended by the addition of the following:

The transducer used to measure ground vibration levels shall be coupled to the ground by either pinning or burying.

4.0 **CONSTRUCTION**

4.1 The last bullet (c) of Section 120.07.03 is deleted and replaced with the following:

- (c) Clear quality 35 mm photographs and/or DVD videos, and written report necessary for proper recording of areas of concern and condition of the property. Photographs and DVDs shall be clearly labeled as to location.

4.2 Section 120.07.03 is amended by the addition of the following:

The contractor will be supplied with a "Permission to Enter For Pre-Blast and Post-Blast Inspection" form that the contractor shall use to record the permission to carry out an inspection.

4.3 Section 120.07.05.02 is amended by the addition of the following:

TransCanada Pipelines has requirements in addition to Table 1. When providing vibration monitoring within 100m of the TransCanada pipeline, the Contractor shall ensure that the following vibration limits in the vicinity of the pipeline are measured and are met:

- ☐ Vibrations are to be controlled to a maximum peak particle velocity of 50mm/s above the pipeline.
- ☐ Should any two consecutive seismographic readings fall between 50 and 80mm/s the pipeline is to be exposed and monitored to ensure that a third reading taken on the pipe falls below 50mm/s.
- ☐ should any seismographic reading taken below the pipe fall above 80mm/s or taken on the pipe fall above 50mm/s the loading pattern should be adjusted to fall below these limits.
- ☐ Delays shall be designed to prevent double readings.

When blasting is within 100m of the TransCanada pipeline, a TransCanada representative and /or blasting consultant may be present to monitor vibrations and any other effects on the pipeline.

5.0 **RESPONSIBILITY**

This special provision in no way intends to remove any of the responsibility for a safe blast from



Highway 69 Four Laning: South junction of Hwy 529, northerly 15 Km
Naiscoot Lake Bridge – NBL Structure

the Blasting Contractor.

6.0 BASIS OF PAYMENT

Compensation for the Contractor to provide blast monitoring and schedule his operations in accordance with these requirements, including all equipment, labour and materials, shall be deemed to be included in the contract bid price for the various tender items.

Note to designer:

Confirm with the Contracts Office whether the minimum distance for the Pre-Blast Survey should be increased.

18 DOWELS INTO ROCK – Item No.

Special Provision

**CONSTRUCTION SPECIFICATION FOR THE SUPPLY, INSTALLATION AND TESTING
OF DOWELS INTO ROCK FOR PIER FOOTINGS**

1.0 SCOPE

The work for the above noted tender item shall be in accordance with OPSS 904, including all Special Provisions, except as extended herein. This document specifies additional requirements for the supply, installation and testing of Dowels into Rock for the pier footing.

2.0 REFERENCES

This Special Provision refers to the following standards, specifications, or publications:

ASTM International

D1143M Standard Test Methods for Deep Foundations Under Static Axial Compressive Load

3.0 DEFINITIONS

For the purpose of this Special Provision, the following definitions apply:

Dowels into Rock: reinforcing steel bar and non-shrink grout.

Design Engineer: An Engineer who has a minimum of five (5) years experience in all aspects associated with the installation of Dowels into Rock, including drilling, grouting and doweling work. The Design Engineer shall be retained by the Contractor to design various components for the installation and testing for the Dowels into Rock.

Quality Verification Engineer: An Engineer who has a minimum of five (5) years experience in all aspects associated with the installation of Dowels into Rock, including drilling, grouting and doweling work. The Quality Verification Engineer shall be retained by the Contractor to ensure conformance with the contract documents and issue certificate(s) of conformance.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Working Drawings

Working Drawings shall consist of drawings, testing and installation records, procedures and reports, and work plans.

The Contractor shall submit Working Drawings to the Contract Administrator as follows:



Highway 69 Four Laning: South junction of Hwy 529, northerly 15 Km
Naiscoot Lake Bridge – NBL Structure

- a) All Working Drawings that include drawing, testing and installation procedures and reports, and work plans shall be sealed and signed by the Design Engineer.
- b) All Working Drawings that include testing and installation results and reports shall be signed and sealed by the Quality Verification Engineer.

Upon completion of testing or installation and testing for each component, the Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by a Quality Verification Engineer. The Certificate shall state that the work has been carried out in conformance with the Working Drawings and in general conformance with the contract documents.

Working Drawings consisting of testing an installation records and reports shall be submitted four days after completion of testing and installation. All other Working Drawings shall be submitted two weeks prior to construction.

Working Drawings to be submitted include the following with further details outlined in the remainder of this specification:

- a) Design calculations, specifications and shop drawings covering all aspects of fabrication, installation and acceptance testing of Dowels into Rock.
- b) Test results verifying the 28 day strength of non-shrink grout.
- c) The method for constructing of the holes, maintaining the holes, and placing reinforcing steel bars, grout and other materials in the holes, including casing sizes, bit sizes and tremie grouting methods.
- d) The procedures to verify hole length. Records of measurements that verify the hole length.
- e) Records of all drilling procedures, rock conditions encountered, and installation times.
- f) Test procedures for Dowels into Rock.
- g) Drawings and design calculations for a suitable reaction system for the applied test loads.
- h) Records of vertical and horizontal movements of the reaction system, and elongation of the reinforcing steel bar.
- i) Drawings and details for reference system arrangement.
- j) Current calibration curves shall be provided for all gauges.
- k) Complete test records for all tests including plots of dowel movement versus dowel load, dowel load versus time, and dowel movement versus time.
- l) Remedial measures for unacceptable stressing results.

5.0

MATERIALS



5.01 Non-Shrink Grout

The non-shrink grout shall be an approved product from the MTO's Pre-Qualified Products List.

5.02 Anti-Washout Agent

The anti-washout agent shall be used with the non-shrink grout for the Dowels into Rock. The anti-washout agent shall be one of the following proprietary products:

- 1) Sikament 100 SC Anti-Washout Admixture
Sika Canada Inc.
6915 Davand Drive
Mississauga, ON, L5T 1L5
Toll Free Phone: 800-933-7452
- 2) Rheomac UW 450 Anti-Washout Admixture
BASF Construction Chemicals Canada Ltd (Master Builders)
1800 Clark Blvd
Brampton, ON, L6T 4M7
Toll Free Phone: 416-520-1392

5.03 Manufacturer Information

The Contractor shall provide the following information from the manufacturer for non-shrink grout and anti-washout agent:

- a) Data sheets for the non-shrink grout and anti-washout agent,
- b) Technical information that proves that the non-shrink grout and anti-washout agent are compatible, and
- c) installation procedures

6.0 EQUIPMENT

All equipment for the installation of the Dowels into Rock shall be suitable for the intended purposes and capable of working on the site under the prevailing access and clearance conditions.

The equipment shall not cause damage to the reinforcing steel bars.

7.0 CONSTRUCTION

7.01 Instructions to Contractor

These instructions are to be read in conjunction with the Contract Drawings.

A total of 2 test Dowels into Rock are required for the Dowels into Rock at the pier.

Dowels into rock at the pier shall be installed into sound bedrock to the specified embedment depth.

7.02 Responsibilities of the Contractor

The Contractor shall prove the allowable bond stress by tests of the Dowels into Rock on non-production Dowels into Rock.

The Contractor shall supply equipment, materials and skilled personnel to install production Dowels into Rock and conduct the specified acceptance tests. It shall be the responsibility of the Contractor to constantly monitor the acceptance tests, maintain specified test loads and record test measurements as specified by the Contract Administrator.

The Contractor is responsible for materials and workmanship. Any remedial measures, required because of defects in materials or workmanship, shall be completed by the Contractor at no cost to the Owner.

The Contractor shall submit 4 copies of all Working Drawings to the Contract Administrator as outlined in Section 4.0.

7.03 Subsurface Conditions

Rock and groundwater conditions are described in the Foundation Investigation Report for this Contract.

7.04 Construction of Holes

The sides and end of the hole shall not be disturbed. The Contractor shall submit Working Drawings to the Contract Administrator that include the method for constructing of the holes, maintaining the holes, and placing reinforcing steel bar, grout and other materials in the holes. All excavated material shall be removed from the site.

The hole diameters and hole length for this project are as specified on the Contract Drawings. Prior to commencing drilling operations, the Contractor shall submit Working Drawings to the Contract Administrator outlining devised procedures to verify hole length. The Contractor shall submit Working Drawings that include drilling operations records to the Contract Administrator that include the above noted records.

At all times, the Contractor shall keep a record of all drilling procedures, rock conditions encountered, and installation times. The Contractor shall submit Working Drawings to the Contract Administrator that include the above noted records.

7.05 Installation of Reinforcing Steel Bar

Reinforcing steel bar shall be installed in strict accordance with the Contract Drawings and installation procedures.

Centering devices shall be provided to ensure that the reinforcing steel bar is located centrally in the hole.

Dowels into Rock at the pier shall be installed into sound bedrock.

Reinforcing steel bar shall be installed after the dowel hole has been filled with non-shrink grout.

7.06 Grout and Anti-Washout Agent

The non-shrink grout shall entirely fill the annular space between the reinforcing steel bar and side for the dowel hole.

The placement of grout for the test Dowels into Rock shall be identical to the production Dowels into Rock.

Anti-washout agent shall be used in accordance with the specifications of the manufacturer.

Non-shrink grout shall be placed into the dowel hole using tremie placement methods.

8.0 QUALITY ASSURANCE

All work for the installation of Dowels into Rock shall be inspected by the Quality Verification Engineer.

8.01 Qualifications

8.01.01 Qualifications of Staff from Contractor or Sub-Contractor Completing Work for the Dowels into Rock

All work shall be performed under the direction of personnel experienced with all aspects associated with the installation of Dowels into Rock. Such experience shall have been obtained within the preceding five (5) years on projects of similar nature and scope to the work required for this project.

8.01.02 Qualifications of the Quality Verification Engineer

A resume of the work experience of the Quality Verification Engineer shall be submitted to the Contract Administrator for record purposes. The Quality Verification Engineer shall be a Professional Engineer licensed in the Province of Ontario having a minimum of five years of experience on projects of similar nature and scope to the work required for this project.

8.01.03 Qualifications of the Design Engineer

A resume of the work experience of the Design Engineer shall be submitted to the Contract Administrator for record purposes. The Design Engineer shall be a Professional Engineer licensed in the Province of Ontario having a minimum of five years of experience of projects of similar nature and scope to the work required for this project.

8.02 Testing Requirements

All work for the testing of Dowels into Rock shall be inspected by the Quality Verification Engineer.

8.02.01 General Testing Requirements

Refer to the attached Instructions to Contractor and the Contract Drawings for specific test details.

The Contractor shall install the number of Dowels into Rock specified in the contract documents for testing purposes. The purpose of the testing the Dowels into Rock is to prove the adequacy of the proposed anchor configuration and installation procedures under the site conditions, and to provide design parameters.

The equipment, labour and materials for test dowels shall be identical to Dowels into Rock at the pier. The Dowels into Rock for testing shall be M dowels grouted into mm diameter holes filled with an approved non-shrink grout with a minimum mm embedment into sound bedrock.

The Contractor shall submit Working Drawings that include proposed procedures for testing of the Dowels into Rock to the Contract Administrator. Such testing shall be executed in strict accordance with the proposed procedures of the Contractor.

The Quality Verification Engineer shall supervise the testing of the Dowels into Rock. The Contractor will notify the Contract Administrator of the testing schedule at least 10 days prior to commencement of the testing program. Testing for Dowels into Rock shall be conducted concurrently, as scheduled by the Contract Administrator. The tests shall normally be conducted between 8:00 hrs and 20:00 hrs from Monday to Friday, unless otherwise directed by the Contract Administrator.

The Contractor shall supply materials and skilled personnel to conduct the tests for the Dowels into Rock. The equipment and materials shall be capable of stressing the Dowels into Rock to the specified loads. It shall be the responsibility of the Contractor to constantly monitor the test, maintain specified test loads and to record test measurements as specified by the Quality Verification Engineer.

The test site shall be restored to its pre-test condition. Reinforcing steel bars used in tests shall be cut down 25 mm below the top of the sound bedrock.

8.02.02 Testing Location

The Contractor shall remove all loose rock down to sound bedrock at the test location.

The test Dowels into Rock shall be constructed at locations specified by the Contract Administrator.

If site conditions dictate, changes to the test locations will be considered. The Contractor shall provide the Contract Administrator at least 2 days notice in writing of this operation.

8.02.03 Testing Equipment

The dowels into rock will be carried out generally in accordance with the prevailing requirements of ASTM International D1143M superseded where applicable by the procedures specified in this document.

The Contractor shall submit Working Drawings for a suitable reaction system for the applied test loads to the Contract Administrator. Jacks must be secured with chains to provide adequate protection for the personnel in the event of breakage of the reinforcing steel bar or stressing system.

The Contractor shall submit Working Drawings for the reference system arrangement to the Contract Administrator. All reference beams shall be as follows:

The beams shall be independently supported with the support firmly embedded in the ground.

The testing device shall not apply compression to the bedrock surrounding the test for the Dowels into Rock, within a circle concentric with the dowel hole and a diameter equal to 4.0 m.

Reference beams shall be sufficiently rigid to support instrumentation such that variations in readings do not occur.

The Contractor shall construct suitable enclosures to provide complete protection for equipment and instruments from variations in the weather conditions and disturbances during the test program. These provisions must meet the approval of the Quality Verification Engineer and will include that the test enclosures must be weather-proof and provide a consistent temperature in order to eliminate temperature variations that could affect instrumentation.

8.02.04 Testing for Dowels Into Rock, and Report

At all times, the Contractor shall keep records of vertical and horizontal movements of the reaction system, elongation of reinforcing steel bar, and the record of test enclosure temperature. The movements shall be recorded with respect to an independent fixed reference point. The Contractor shall submit Working Drawings that include the above noted records to the Contract Administrator.

Dial gauges shall have at least a 76.2 mm (3.0 in.) travel. Longer gauge stems or sufficient gauge blocks shall be provided to allow for greater travel if required. Gauges shall have precision of at least 0.025 mm (0.0001 in.). The dial gauges shall be placed on smooth bearing surfaces mounted perpendicular to the direction of movement. All gauges, scales or reference points attached to the test anchor shall be mounted so as to prevent movement relative to the test anchor during the test. The Contractor shall submit Working Drawings that include details for current calibration and curves for all gauges to the Contract Administrator.

Jacks used for reinforcing steel bars shall have a minimum ram dimension of 152.6 mm (6.0 in.). The Contractor shall submit Working Drawings that include details for current calibration and curves for all gauges to the Contract Administrator.

Requirements for Clauses 5.4.1 to 5.4.4 shall be repeated as required at different testing locations.

8.02.05 Testing Loading

The testing procedures shall safely load test the Dowels into Rock in tension at a rate of approximately 100kN per minute to the test load of kN. The load shall be increased by an additional 50 kN beyond this level as directed by the Quality Verification Engineer.

Each load shall be maintained for a minimum time of 15 minutes and until the rate of displacement is not greater than 0.25 mm (0.01 inches) per hour.

8.03 Acceptance Criteria

The following acceptance criteria apply:

- a) The testing of dowels shall be carried out in advance of the instalment of Dowels into Rock at the pier footing.
- b) Tests for Dowels into Rock shall have a capacity of at least kN. The Quality Verification Engineer shall report on the acceptance of the tests for Dowels into Rock. The Quality Verification Engineer shall report on the testing of the Dowels into Rock including recommendations for increasing embedment depth, if necessary.

9.0 MEASUREMENT FOR PAYMENT

For measurement purposes, a count shall be made of the number of dowels installed.

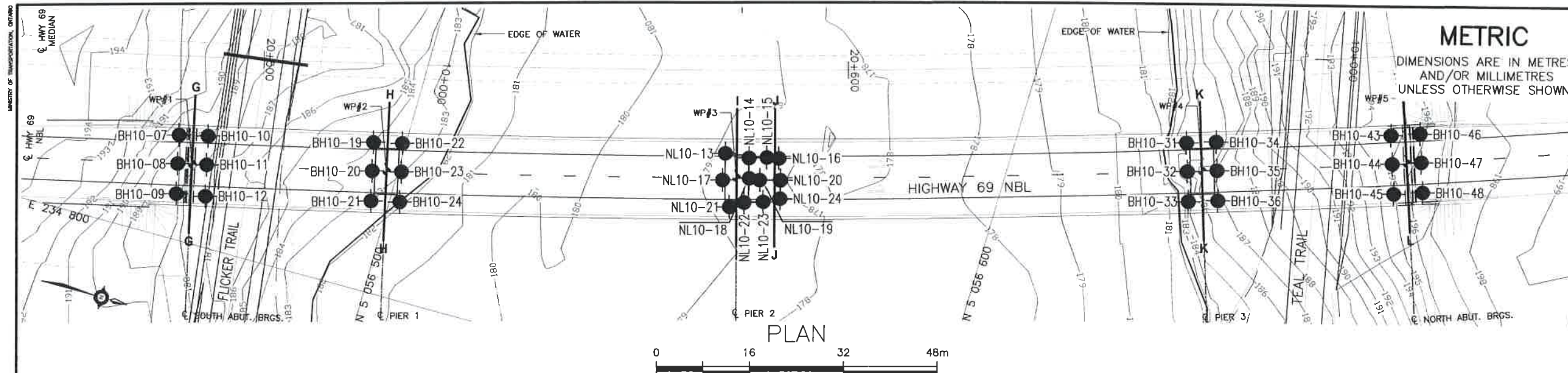
10.0 BASIS OF PAYMENT

Payment at the contract unit price for the above tender item shall include full compensation for all labour, equipment, and materials to do the work. No additional payment will be made for tests for Dowels into Rock which are deemed as included as part of the work for the above noted item.

Appendix E

Drawings

Borehole Locations and Soil Strata

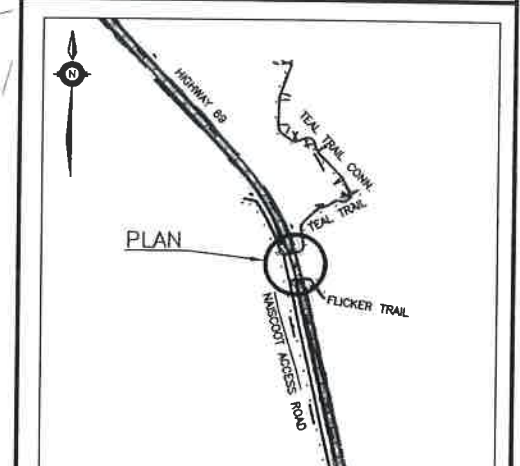


CONT No
WP No 5076-06-00

HIGHWAY 69 FOUR-LANING
NAISCOOT LAKE BRIDGE
NORTHBOUND LANES
BOREHOLE LOCATIONS AND SOIL STRATA

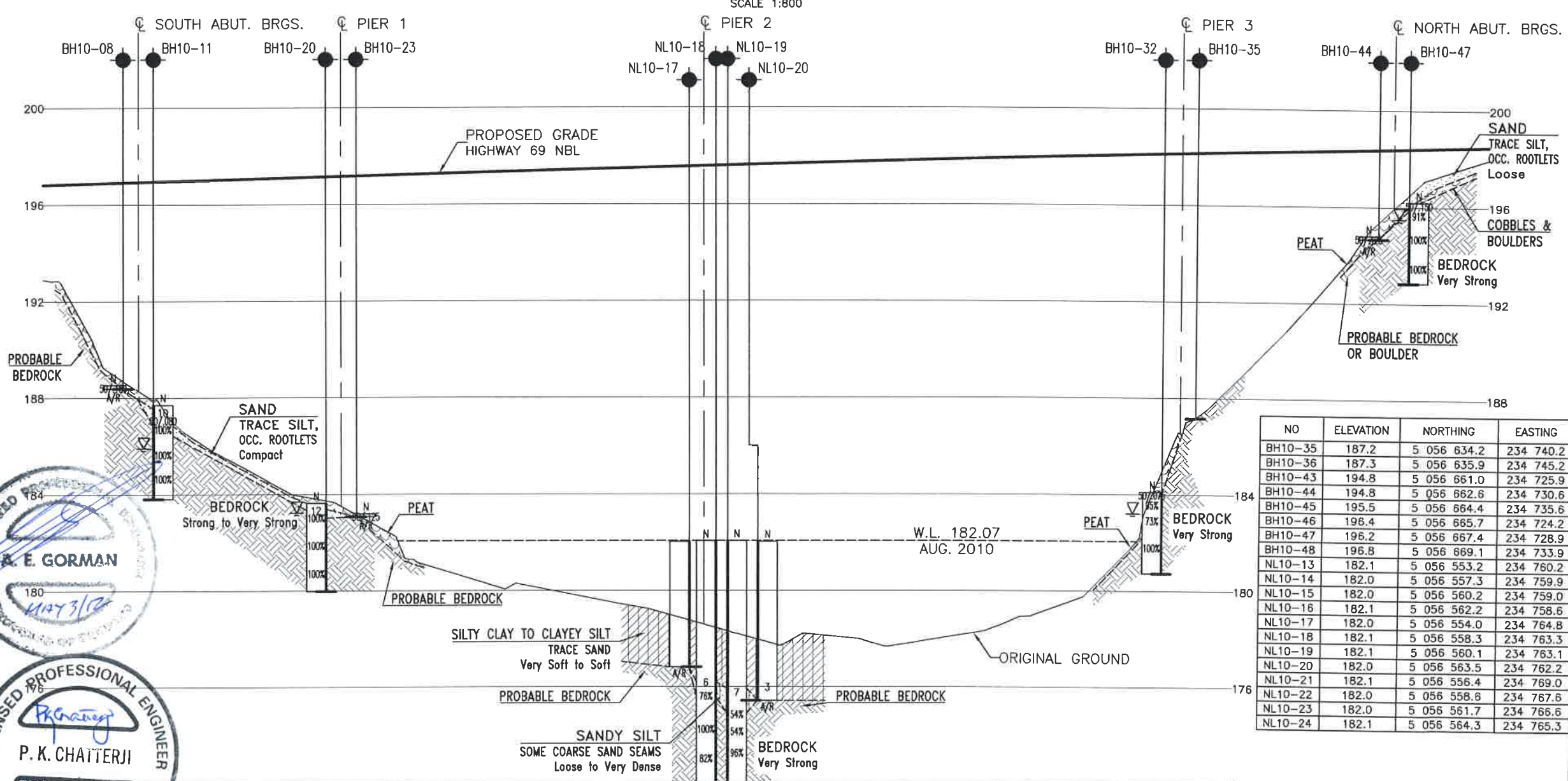
MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN LEGEND

- Borehole
- Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal



E. E. GORMAN
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO
May 3/12

P. K. CHATTERJI
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO
May 3/12

NO	ELEVATION	NORTHING	EASTING	NO	ELEVATION	NORTHING	EASTING
BH10-35	187.2	5 056 634.2	234 740.2	BH10-07	189.1	5 056 462.0	234 782.3
BH10-36	187.3	5 056 635.9	234 745.2	BH10-08	188.5	5 056 463.1	234 787.1
BH10-43	194.8	5 056 661.0	234 725.9	BH10-09	188.2	5 056 464.3	234 792.2
BH10-44	194.8	5 056 662.6	234 730.6	BH10-10	188.8	5 056 466.8	234 781.1
BH10-45	195.5	5 056 664.4	234 735.6	BH10-11	187.7	5 056 468.0	234 786.0
BH10-46	196.4	5 056 665.7	234 724.2	BH10-12	187.2	5 056 469.2	234 791.3
BH10-47	196.2	5 056 667.4	234 728.9	BH10-19	184.0	5 056 494.5	234 774.5
BH10-48	196.8	5 056 669.1	234 733.9	BH10-20	183.6	5 056 495.7	234 779.4
NL10-13	182.1	5 056 553.2	234 760.2	BH10-21	183.1	5 056 496.9	234 784.5
NL10-14	182.0	5 056 557.3	234 759.9	BH10-22	183.4	5 056 499.4	234 773.4
NL10-15	182.0	5 056 560.2	234 759.0	BH10-23	183.2	5 056 500.6	234 778.2
NL10-16	182.1	5 056 562.2	234 758.6	BH10-24	182.4	5 056 501.8	234 783.3
NL10-17	182.0	5 056 554.0	234 764.8	BH10-31	184.7	5 056 627.9	234 737.0
NL10-18	182.1	5 056 558.3	234 763.3	BH10-32	184.1	5 056 629.5	234 741.8
NL10-19	182.1	5 056 560.1	234 763.1	BH10-33	183.3	5 056 631.1	234 746.8
NL10-20	182.0	5 056 563.5	234 762.2	BH10-34	185.8	5 056 632.7	234 735.5
NL10-21	182.1	5 056 556.4	234 769.0				
NL10-22	182.0	5 056 558.8	234 767.6				
NL10-23	182.0	5 056 561.7	234 766.6				
NL10-24	182.1	5 056 564.3	234 765.3				

- NOTES-**
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
 - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41H-92

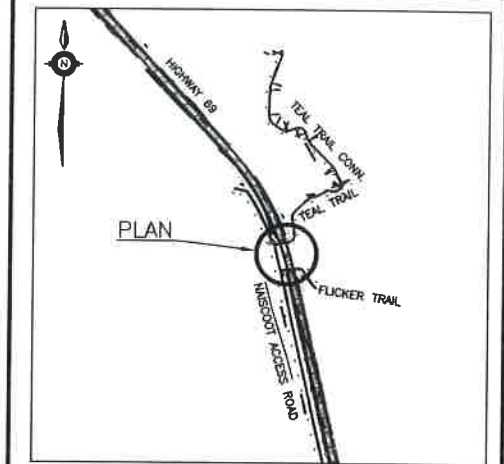
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DATE	BY	DESCRIPTION
DESIGN	LRB	CHK AEG
DRAWN	MFA	CHK PKC

LOAD DATE MAY 2012
STRUCT DWG 4

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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWNCONT No
WP No 5076-06-00HIGHWAY 69 FOUR-LANING
NAISCOOT LAKE BRIDGE
NORTHBOUND LANES
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

**KEYPLAN****LEGEND**

	Borehole
	Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

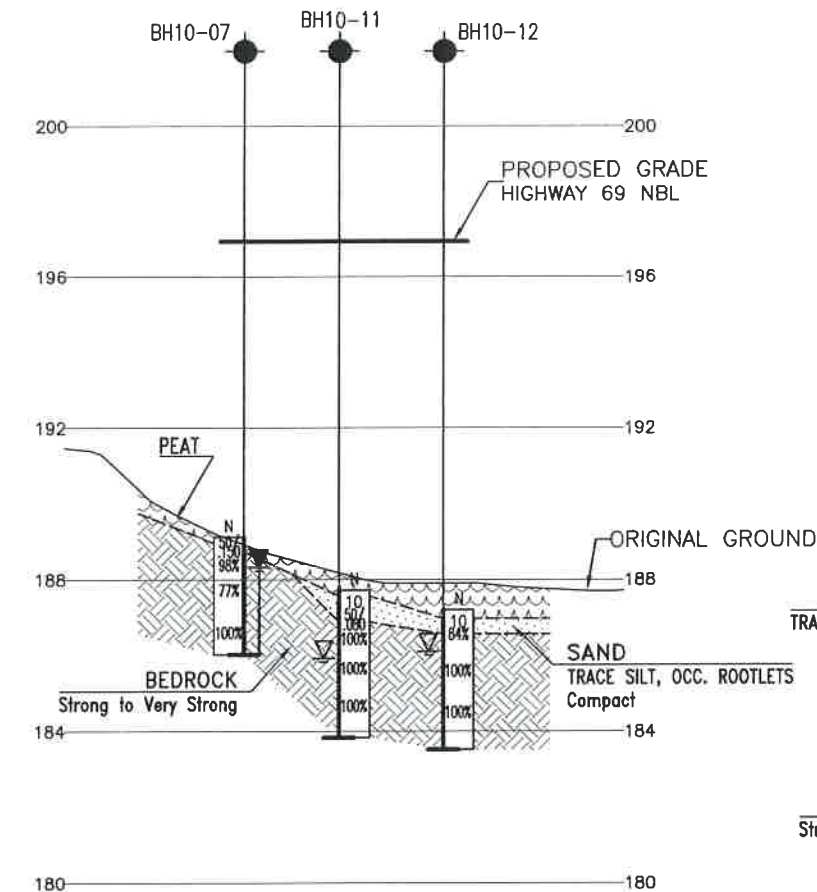
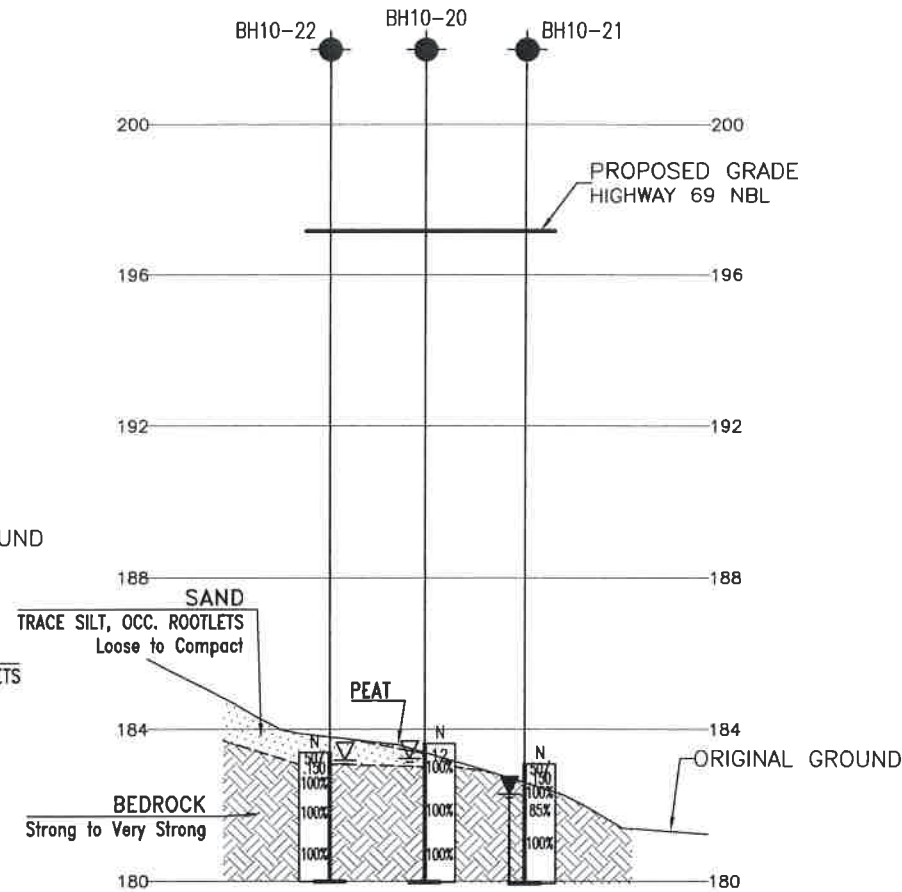
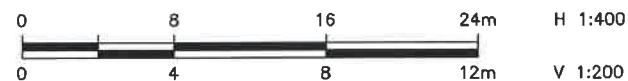
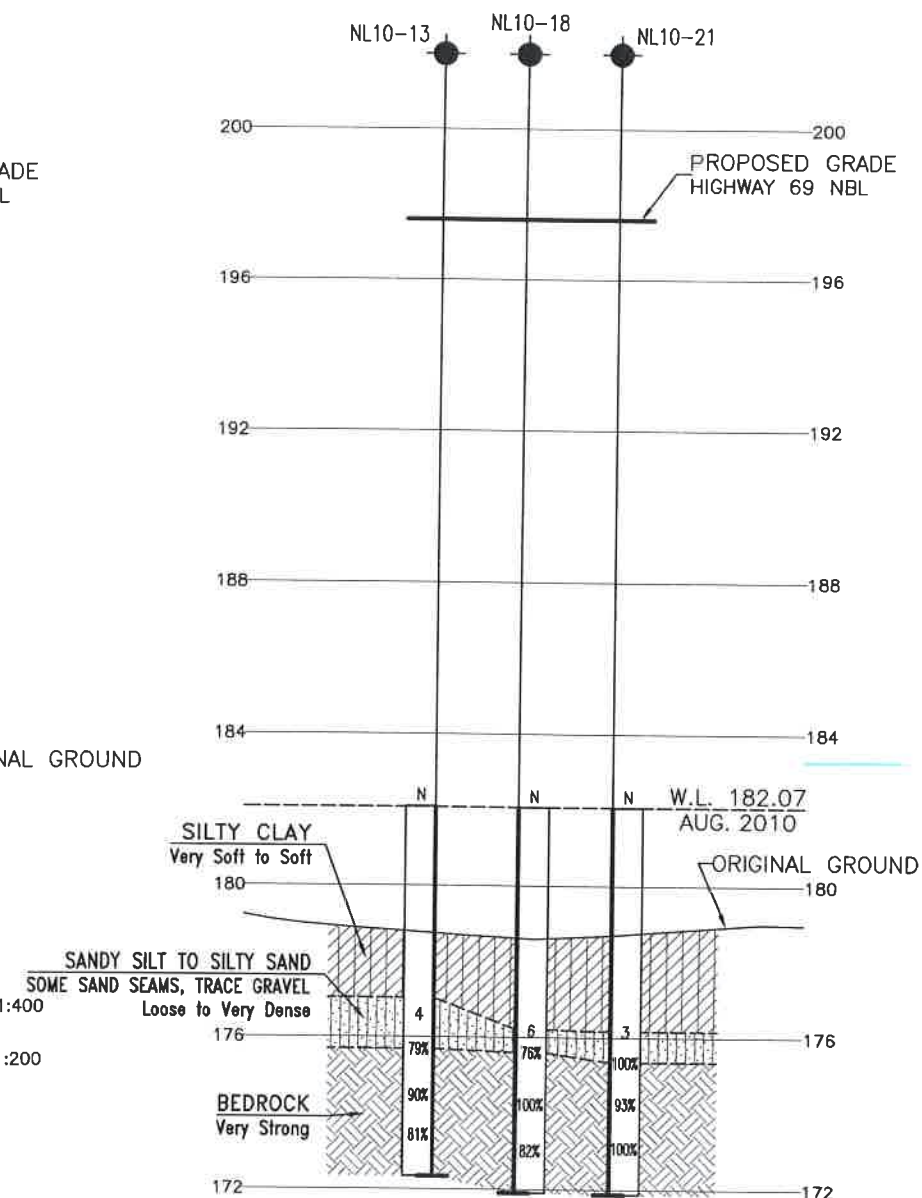
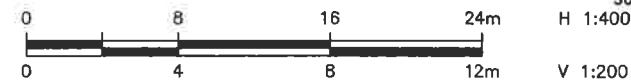
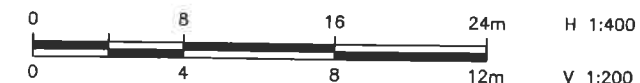
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BH10-08	188.5	5 056 463.1	234 787.1
BH10-09	188.2	5 056 464.3	234 792.2
BH10-10	188.8	5 056 466.8	234 781.1
BH10-11	187.7	5 056 468.0	234 786.0
BH10-12	187.2	5 056 469.2	234 791.3
BH10-19	184.0	5 056 494.5	234 774.5
BH10-20	183.6	5 056 495.7	234 779.4
BH10-21	183.1	5 056 496.9	234 784.5
BH10-22	183.4	5 056 499.4	234 773.4
BH10-23	183.2	5 056 500.6	234 778.2
BH10-24	182.4	5 056 501.8	234 783.3
BH10-31	184.7	5 056 627.9	234 737.0
BH10-32	184.1	5 056 629.5	234 741.8
BH10-33	183.3	5 056 631.1	234 746.8
BH10-34	185.8	5 056 632.7	234 735.5

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
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GEOCRES No. 41H-92

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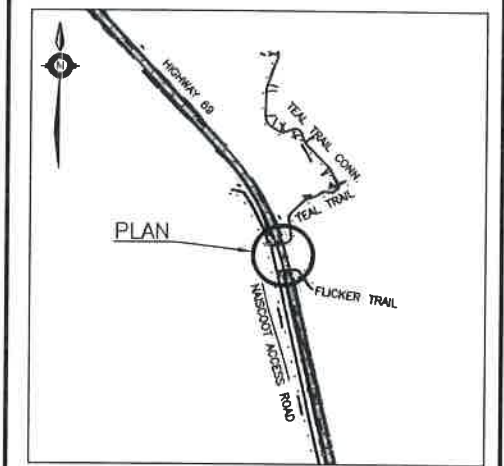
SECTION G-G
S. ABUT. HWY 69 NBL AT NAISCOOT LAKESECTION H-H
PIER 1 HWY 69 NBL AT NAISCOOT LAKESECTION I-I
PIER 2 HWY 69 NBL AT NAISCOOT LAKE

NO	ELEVATION	NORTHING	EASTING
BH10-35	187.2	5 056 634.2	234 740.2
BH10-36	187.3	5 056 635.9	234 745.2
BH10-43	194.8	5 056 661.0	234 725.9
BH10-44	194.8	5 056 662.6	234 730.6
BH10-45	195.5	5 056 664.4	234 735.6
BH10-46	196.4	5 056 665.7	234 724.2
BH10-47	196.2	5 056 667.4	234 728.9
BH10-48	196.8	5 056 669.1	234 733.9
NL10-13	182.1	5 056 553.2	234 760.2
NL10-14	182.0	5 056 557.3	234 759.9
NL10-15	182.0	5 056 560.2	234 759.0
NL10-16	182.1	5 056 562.2	234 758.6
NL10-17	182.0	5 056 554.0	234 764.8
NL10-18	182.1	5 056 558.3	234 763.3
NL10-19	182.1	5 056 560.1	234 763.1
NL10-20	182.0	5 056 563.5	234 762.2
NL10-21	182.1	5 056 556.4	234 769.0
NL10-22	182.0	5 056 558.6	234 767.6
NL10-23	182.0	5 056 561.7	234 766.6
NL10-24	182.1	5 056 564.3	234 765.3

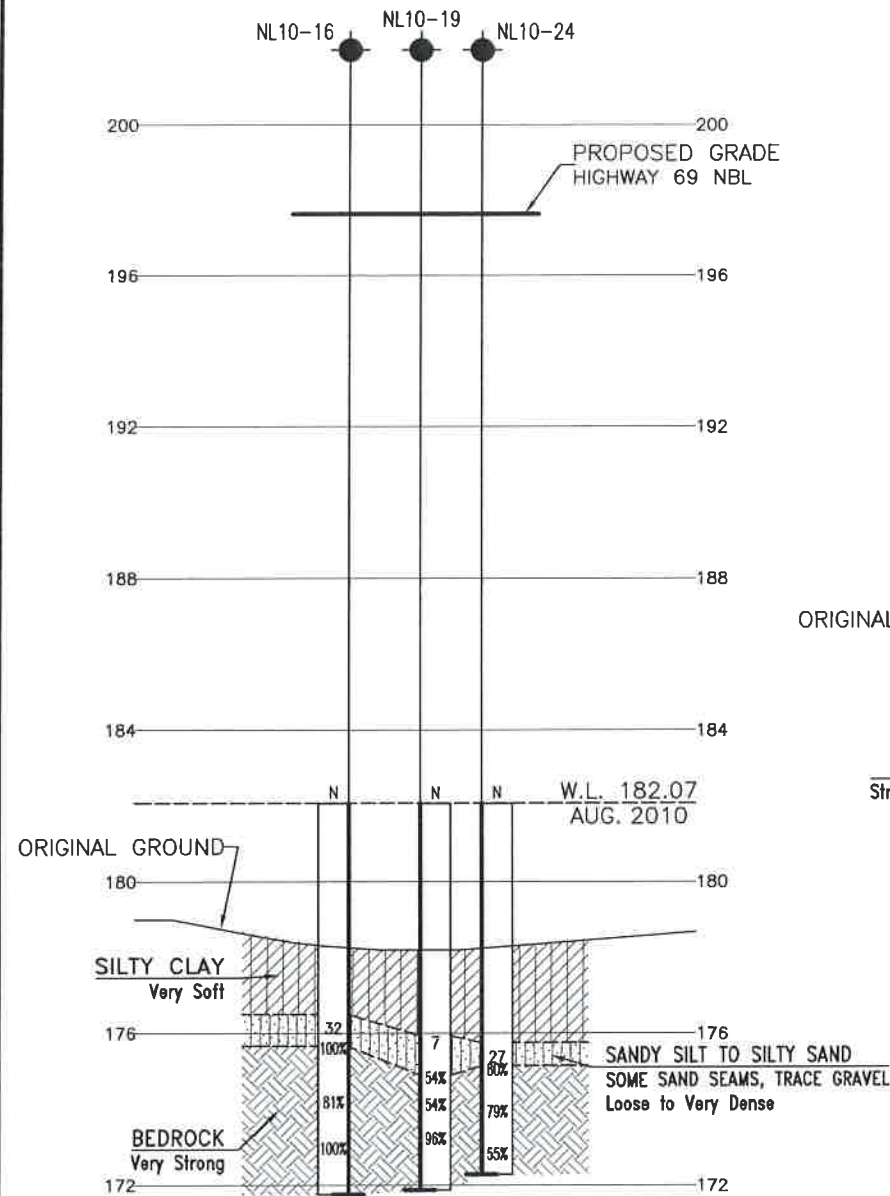


METRICDIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWNCONT No
WP No 5076-06-00HIGHWAY 69 FOUR-LANING
NAISCOOT LAKE BRIDGE
NORTHBOUND LANES
BOREHOLE LOCATIONS AND SOIL STRATA

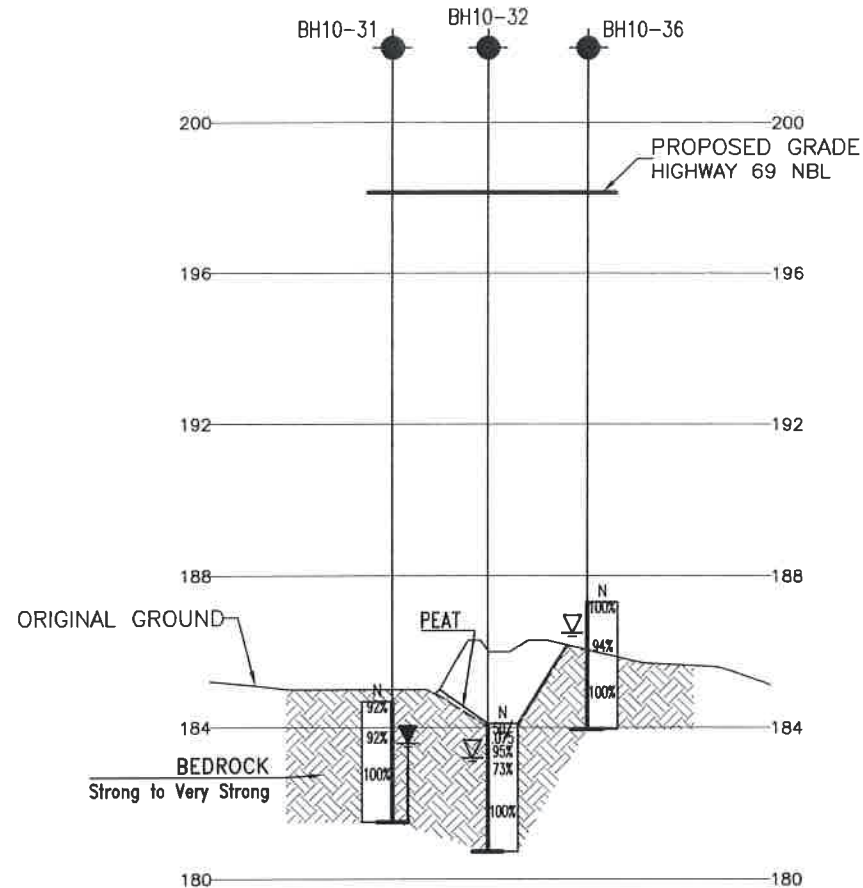
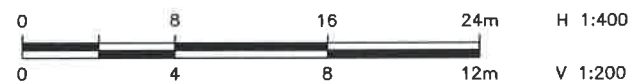
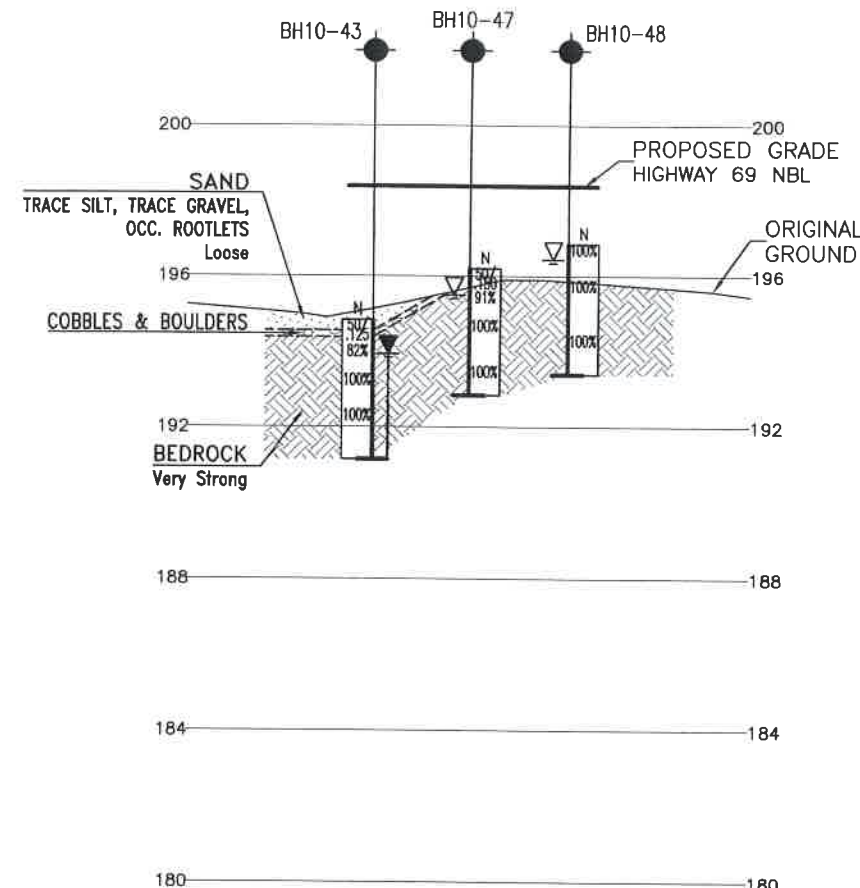
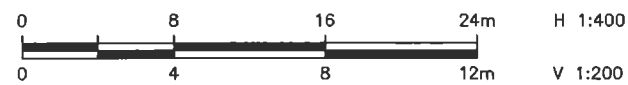
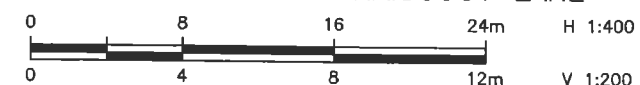
SHEET

**KEYPLAN****LEGEND**

	Borehole
	Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

**SECTION J-J**

PIER 2 HWY 69 NBL AT NAISCOOT LAKE

**SECTION K-K**
PIER 3 HWY 69 NBL AT NAISCOOT LAKE**SECTION L-L**
N. ABUT. HWY 69 NBL AT NAISCOOT LAKE

NO	ELEVATION	NORTHING	EASTING	NO	ELEVATION	NORTHING	EASTING
BH10-35	187.2	5 056 634.2	234 740.2	BH10-07	189.1	5 056 462.0	234 782.3
BH10-36	187.3	5 056 635.9	234 745.2	BH10-08	188.5	5 056 463.1	234 787.1
BH10-43	194.8	5 056 661.0	234 725.9	BH10-09	188.2	5 056 464.3	234 792.2
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BH10-46	196.4	5 056 665.7	234 724.2	BH10-12	187.2	5 056 469.2	234 791.3
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NL10-14	182.0	5 056 557.3	234 759.9	BH10-22	183.4	5 056 499.4	234 773.4
NL10-15	182.0	5 056 560.2	234 759.0	BH10-23	183.2	5 056 500.6	234 778.2
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NL10-17	182.0	5 056 554.0	234 764.8	BH10-31	184.7	5 056 627.9	234 737.0
NL10-18	182.1	5 056 558.3	234 763.3	BH10-32	184.1	5 056 629.5	234 741.8
NL10-19	182.1	5 056 560.1	234 763.1	BH10-33	183.3	5 056 631.1	234 746.8
NL10-20	182.0	5 056 563.5	234 762.2	BH10-34	185.8	5 056 632.7	234 735.5
NL10-21	182.1	5 056 556.4	234 769.0				
NL10-22	182.0	5 056 558.6	234 767.6				
NL10-23	182.0	5 056 561.7	234 766.6				
NL10-24	182.1	5 056 564.3	234 765.3				

-NOTES-

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GEOCRES No. 41H-92

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK AEG	CODE
DRAWN	MFA	CHK PKC	SITE
			LOAD
			STRUCT
			DATE MAY 2012
			DWG 6

Appendix F

Site Photographs

Highway 69 Four Laning: South junction of Hwy 529, northerly 15 Km
Naiscoot Lake Bridge – NBL Structure



Photo 1. Naiscoot Lake north shore from existing Highway 69



Photo 2. Looking Naiscoot Lake south shore from existing Highway