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REPORT ON

FOUNDATION INVESTIGATION AND DESIGN REPORT NOISE WALL BARRIER WEST OF MONTREAL STREET KINGSTON, ONTARIO G.W.P. 78-99-00

Submitted to:

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GEOCRES No. 31C-204

Report Number: 08-1111-0044-3

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REPORT



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Table of Contents

PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
3.0 INVESTIGATION PROCEDURES	3
4.0 SITE GEOLOGY AND STRATIGRAPHY	5
4.1 Regional Geological Conditions.....	5
4.2 Site Stratigraphy	5
4.2.1 Topsoil	5
4.2.2 Fill	5
4.2.3 Silty Clay to Clayey Silt	5
4.2.4 Sandy Silt Till	6
4.2.5 Auger Refusal and Bedrock	6
4.3 Groundwater Conditions	7
5.0 CLOSURE.....	8

PART B - FOUNDATION DESIGN REPORT

6.0 ENGINEERING RECOMMENDATIONS.....	9
6.1 General.....	9
6.2 Noise Wall Barrier and Retaining Wall Foundation Options.....	9
6.2.1 Strip/Spread Footings	10
6.2.1.1 Geotechnical Resistance	10
6.2.1.2 Resistance to Lateral Forces	10
6.2.1.3 Construction Considerations.....	11
6.2.2 Drilled Caissons	11
6.2.2.1 Geotechnical Resistance	12
6.2.2.2 Resistance to Lateral Forces	12
6.2.2.3 Construction Considerations.....	13
6.2.3 Lateral Earth Pressures	13
6.2.4 Excavation and Temporary Cut Slopes.....	14
7.0 CLOSURE.....	16



LIST OF TABLES

Table 1	-	Design Parameters for Noise Wall Barrier
Table 2	-	Evaluation of Noise Wall Barrier Foundations/Construction Alternatives

LIST OF DRAWINGS

Drawing 1	-	Noise Wall Barrier Borehole Locations and Soil Strata
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LIST OF FIGURES

Figure 1	-	Plasticity Chart – Silty Clay/Clayey Silt
Figure 2	-	Core Photographs
Figures 3-4	-	Rock Cut Photographs
Figure 5	-	Unconfined Compressive Strength Test Results – Limestone

LIST OF APPENDICES

APPENDIX A

List of Abbreviations and Symbols
Rock Description Terminology
Record of Borehole Sheets

APPENDIX B

Non-Standard Special Provisions



PART A

**FOUNDATION INVESTIGATION REPORT
NOISE WALL BARRIER WEST OF MONTREAL STREET
KINGSTON, ONTARIO
G.W.P. 78-99-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation associated with the Highway 401 expansion in Kingston, Ontario. The section of Highway 401 included in this assignment (G.W.P. 78-99-00) extends from west of Montreal Street to about 1.8 kilometres east of the Canadian National Railway (CNR) structure.

Foundation investigation services are required for the following components:

- CNR Bridge Rehabilitation/Widening;
- Highway 401 Embankment Widening – Cataraqui wetlands;
- Montreal Street Underpass Replacement;
- Overhead Signs (total of 2); and,
- Noise Barrier Wall.

This report addresses the noise wall barrier component, Geocres Number 31C-203.

The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated April 2008. The work was carried out in accordance with Golder's Quality Control Plan dated November 2008.



2.0 SITE DESCRIPTION

The noise wall barrier site is located west of the existing Montreal Street underpass and south of Highway 401 between Stations 26+080 and 26+280, near Kingston, Ontario. Based on information provided by MRC, the roughly 245 m long noise wall will be constructed to separate the rear property line of eight residential properties at 1504 through 1530 Montreal Street from Highway 401 and the N/S-E ramp to the northwest. No specific information was provided on the proposed height or configuration of the noise wall.

The residential properties are situated on the tablelands some 15 to 20 m back from the crest of the near-vertical exposed rock side walls at Highway 401. Within the MTO right-of-way between the rear of the residential properties and the crest of the rock cut, vegetation cover generally consists of grass, bushes, and a few mature trees. Some fill has been placed at the rear of the residential properties, creating a slope between the noise wall and the crest of the rock cuts. The existing ground surface elevation along the noise wall barrier increases from 101.7 m at the west end, to a peak of 105.2 m in the middle, to 103 m at the east end. Highway 401 at this location is currently a four-lane divided highway with a rural cross section which runs northeast-southwest in a rock cut up to about 7 m high. Based on available information, the approximate existing grade of Highway 401 adjacent to the noise wall barrier is about elevation 100 m.



3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out at the proposed location of the noise wall barrier between February 16 and 18, 2010 and on March 11, 2010, at which time four boreholes and three augerholes (numbered NW1 to NW4 and NW5 to NW7, respectively) were advanced at the locations shown on Drawing 1. The testholes were put down at accessible locations along the proposed wall alignment at roughly 50 m spacing. The boreholes and augerholes were located within 5 m of the proposed noise wall foundation locations, with the exception of NW6 and NW7 which were located 9 and 12 m from the noise wall, respectfully, due to accessibility constraints.

Boreholes NW1 through NW4 were advanced using 108 mm inside diameter (I.D.) continuous-flight hollow stem augers on a track-mounted drill rig supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths ranging from 4.1 to 6.5 m below the existing ground surface. Augerholes NW5 through NW7 were advanced to auger refusal at 2.2 to 2.7 m below the existing ground surface using 200 mm diameter (O.D.) continuous flight solid stem augers on a truck-mounted drill rig supplied and operated by Sunrae Construction Ltd. of Kingston, Ontario.

Soil samples were obtained nearly continuously during the borehole drilling at intervals of 0.75 m depth using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) ASTM D1586 procedures. Bedrock was cored in NQ size at each borehole. The boreholes were backfilled with bentonite pellets, mixed with native soils, and the site conditions restored following completion of the work. Groundwater conditions in the open boreholes were observed throughout the drilling operation and upon completion of drilling. Soils were visually logged but no samples were obtained at augerholes NW5 to NW7.

The field work was supervised throughout by a member of our technical staff, who located the testholes, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil and rock samples. The soil samples were identified in the field, placed in appropriate containers, labelled, and transported to our Ottawa geotechnical laboratories where the samples underwent further detailed visual examination and laboratory testing, including grain size distribution, water content. Continuous samples of bedrock core were stored in boxes and laboratory unconfined compressive strength testing was carried out on selected core samples at Golder's Mississauga geotechnical laboratory. Laboratory tests were carried out to MTO and/or ASTM Standards as appropriate.

The borehole locations and ground surface elevations were determined by Golder personnel at the site using a Trimble R8 GPS unit. The augerhole locations and ground surface elevations were estimated relative to existing site features. The testhole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized in the following table and are shown on Drawing 1.

Testhole No.	Borehole/Augerhole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Approximate Noise Wall Chainage (m)	Ground Surface Elevation(m)
NW1	NW of 1504 Montreal St. rear fence	4904023.6	306711.4	62	103.5
NW2	NW of 1522 Montreal St. rear fence	4904064.1	306734.0	109	104.4



FOUNDATION INVESTIGATION - G.W.P. 78-99-00

Testhole No.	Borehole/Augerhole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Approximate Noise Wall Chainage (m)	Ground Surface Elevation(m)
NW3	NW of 1528 Montreal St. rear fence	4904113.0	306771.0	171	103.8
NW4	North of 1530 Montreal St. side fence	4904120.2	306813.6	213	103.2
NW5	SW of 1504 Montreal St. (btwn ramp and property)	4903982.5	306757.8	3	101.8
NW6	SW of 1504 Montreal St. (btwn ramp and property)	4903996.4	306739.2	26	102.3
NW7	SW of 1504 Montreal St. (btwn ramp and property)	4904011.4	306722.5	47	102.9



4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The site is located in the physiographic region of southern Ontario known as the Napanee Plain (The Physiographic of Southern Ontario, Chapman and Putnam, 3rd Edition, 1984). The overburden is typically shallow. The Napanee plain, which is generally flat to undulating, has been stripped of most of its overburden during the late Wisconsinian glaciation period some 11,000 years ago.

Geologic mapping (Map 2544, Ministry of Northern Development and Mines, 1991) indicates the bedrock at the site consists of Paleozoic rock of the middle Ordovician age. The predominant bedrock type in the area is limestone of the Gull River Formation. The local bedrock is generally located at or near the ground surface. Within the area of the Montreal Street Underpass and adjacent noise wall barrier, the existing Highway 401 has been constructed in cut, exposing the limestone bedrock on both sides of the highway.

4.2 Site Stratigraphy

The detailed subsurface soil, bedrock, and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil and bedrock core samples, are given on the attached Record of Borehole and Augerhole sheets and on Figures 1 to 4. The testhole locations and ground surface elevations, together with a stratigraphic profile along the noise wall barrier, are shown on Drawing 1.

The stratigraphic boundaries shown on the Record of Borehole sheets and stratigraphic section are inferred from non-continuous sampling and in-situ testing and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the testhole locations.

In summary, the subsurface conditions encountered consist of up to about 0.8 to 3.1 m of fill or native silty clay to clayey silt soil overlying limestone bedrock at an elevation of between 99.5 and 103 m. Along the western portion of the wall at testholes NW5, NW6, NW7, NW1 and NW2, the limestone bedrock is overlain by about 2.3 m of silty clay to clayey silt. At NW2 the silty clay is, in turn, underlain by a thin veneer or till. Along the eastern portion of the wall at NW3 and NW4, the limestone bedrock is overlain by 0.8 to 0.9 m of fill.

A more detailed description of the subsurface conditions encountered in the boreholes put down at the site of the proposed noise wall barrier is provided in the following sections of the report.

4.2.1 Topsoil

A 50 to 180 mm thick surficial layer of topsoil was encountered in boreholes NW1, NW2, and NW4 and at augerhole NW5.

4.2.2 Fill

At ground surface at borehole NW3 and beneath 50 mm of topsoil at borehole NW4, roughly 0.8 m of fill comprising predominantly silt, with clay, gravel, sand, roots and organics was encountered.

4.2.3 Silty Clay to Clayey Silt

At boreholes NW1 and NW2 and augerholes NW5 to NW7, the topsoil is underlain by a deposit of native silty clay to clayey silt, containing a trace of sand. The deposit was fully penetrated at these testhole locations and varies in thickness from about 2.1 to 2.5 m.



Standard Penetration Tests carried out within the silty clay to clayey silt deposit gave 'N' values ranging from 14 to 24 blows per 0.3 m of penetration, indicating a very stiff consistency. The results of Atterberg limit testing carried out on two samples of the silty clay and clayey silt are shown on Figure 1. As the results plotted at or below the A-line, the two tests were repeated as a check and gave the same results. Results indicate plasticity index values of 18 and 24 percent and liquid limit values of 46 to 52 percent, reflecting intermediate to high plasticity silty clay to clayey silt. The measured water content of the silty clay to clayey silt ranges from approximately 28 to 33 percent, which is generally close to the measured plastic limit.

4.2.4 Sandy Silt Till

At borehole NW2, the silty clay and clayey silt are underlain by glacial till at a depth of 2.6 m below ground surface. The till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt with some clay. The till was fully penetrated at borehole NW2 and was 0.8 m thick. The recorded Standard Penetration Test 'N' value for this material was 27 blows per 0.3 m of penetration indicating a compact state of packing.

4.2.5 Auger Refusal and Bedrock

Bedrock was encountered beneath the fill, silty clay and glacial till, and cored for about 3 m depth, at boreholes NW1 through NW4. At augerholes NW5 through NW6, the top of bedrock was inferred from auger refusal

The following table summarizes the bedrock surface depths and elevations as encountered at the four borehole and three augerhole locations.

Borehole/ Augerhole Number	Existing Ground Surface Elevation (m)	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Approximate Noise Wall Chainage (m)
NW1	103.5	2.3	101.2	62
NW2	104.4	3.4	101.0	109
NW3	103.8	0.8	103.0	171
NW4	103.2	0.9	102.3	213
NW5	101.8	2.2	99.6	3
NW6	102.3	2.7	99.6	26
NW7	102.9	2.5	100.4	47

The bedrock encountered in boreholes NW1 to NW4 consists of fresh to slightly weathered grey limestone. The bedrock is generally strong and thinly to medium bedded. At boreholes NW2 and NW3 (from 4.6 to 4.9 m depth and 2.7 to 3.0 m depth, respectively), the rock core was highly fractured (disking) and friable. The Rock Quality Designation (RQD) values measured on recovered limestone core samples were quite variable and ranged from 0 to 67 percent, indicating a very poor to fair quality rock. The discontinuities observed in the rock core are typically horizontal, associated with the bedding planes. Some bedding joints were infilled with soil at boreholes NW-1 and NW-4. Borehole core photographs are presented in Figure 2. Photographs of the rock cut along Highway 401 adjacent to the proposed noise wall barrier are provided in Figures 3 and 4.



Laboratory unconfined compressive strength testing carried out on two intact samples of limestone core resulted in unconfined compressive strength (UCS) values of 76 and 110 MPa, indicating that the strength of the intact rock is strong to very strong. The results are summarized on Figure 5.

4.3 Groundwater Conditions

Groundwater was not encountered within the depth of our drilling investigation and no seepage or ice build-up was noted along the rock cut just north of the noise wall location. It should be noted that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events and perched water conditions may form at the fill/rock or till/rock interface.



5.0 CLOSURE

This report was prepared by Ms. Erin O'Neill, P. Eng., under the direction of the Project Manager, Mr. Michael Snow, P. Eng.. Mr. Fintan Heffernan, P. Eng., Golder's Designated MTO Contact for this project, conducted a technical and independent quality control review of the report.

Yours truly,

GOLDER ASSOCIATES LTD.

Erin O'Neill, P.Eng.
Geotechnical Engineer

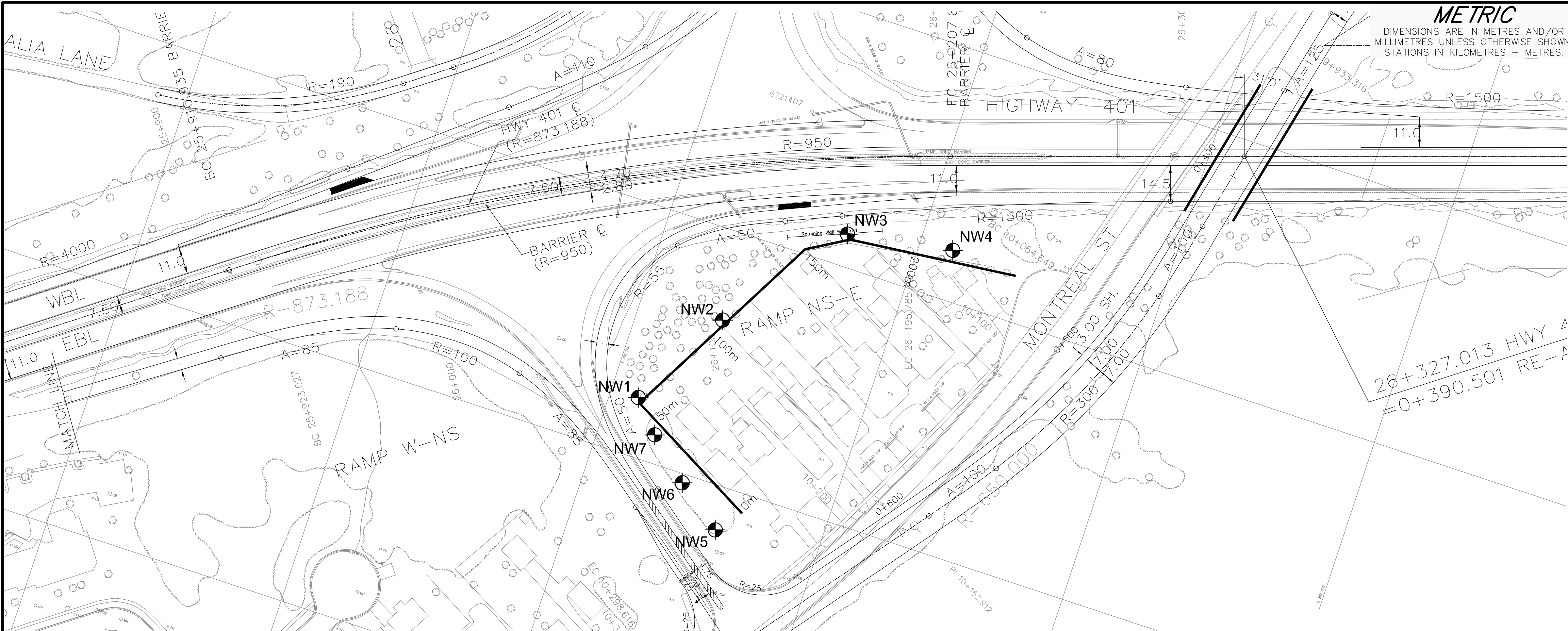
Michael Snow, P.Eng.
Principal

Fintan Heffernan, P.Eng.
Designated MTO Contact

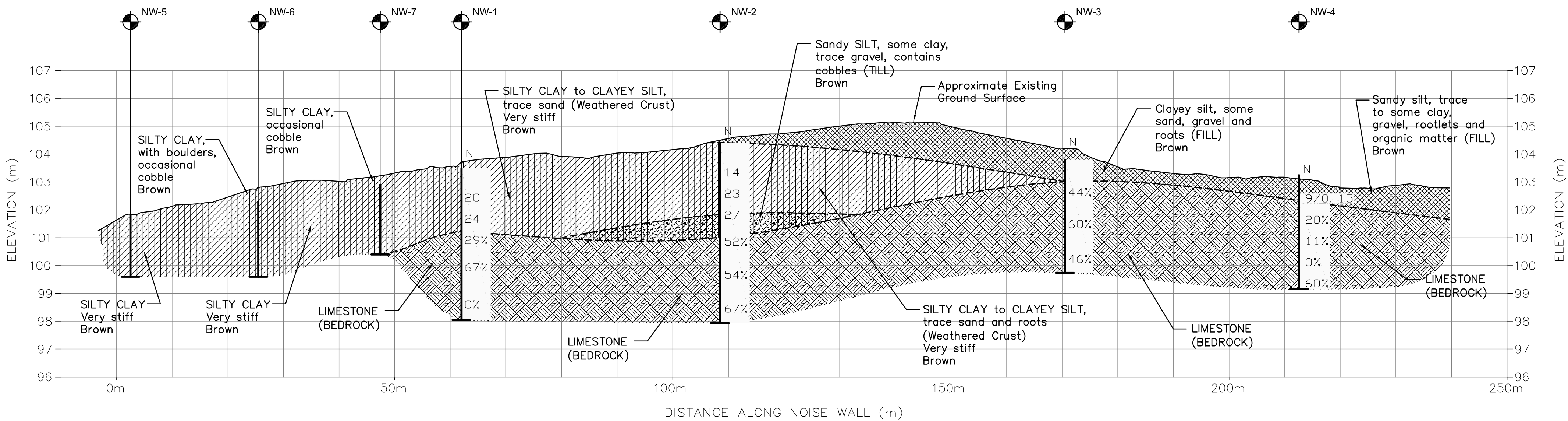


ESO/MSS/FJH/tm

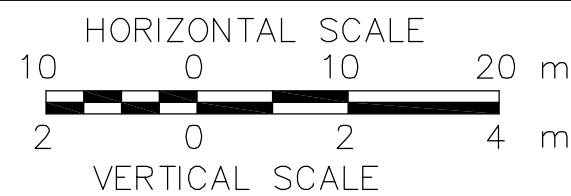
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PLAN



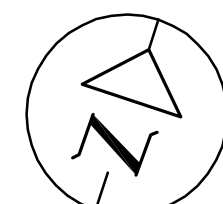
PROFILE ALONG NOISE WALL



METRIC

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

CONT No.
WP No. 78-99-00

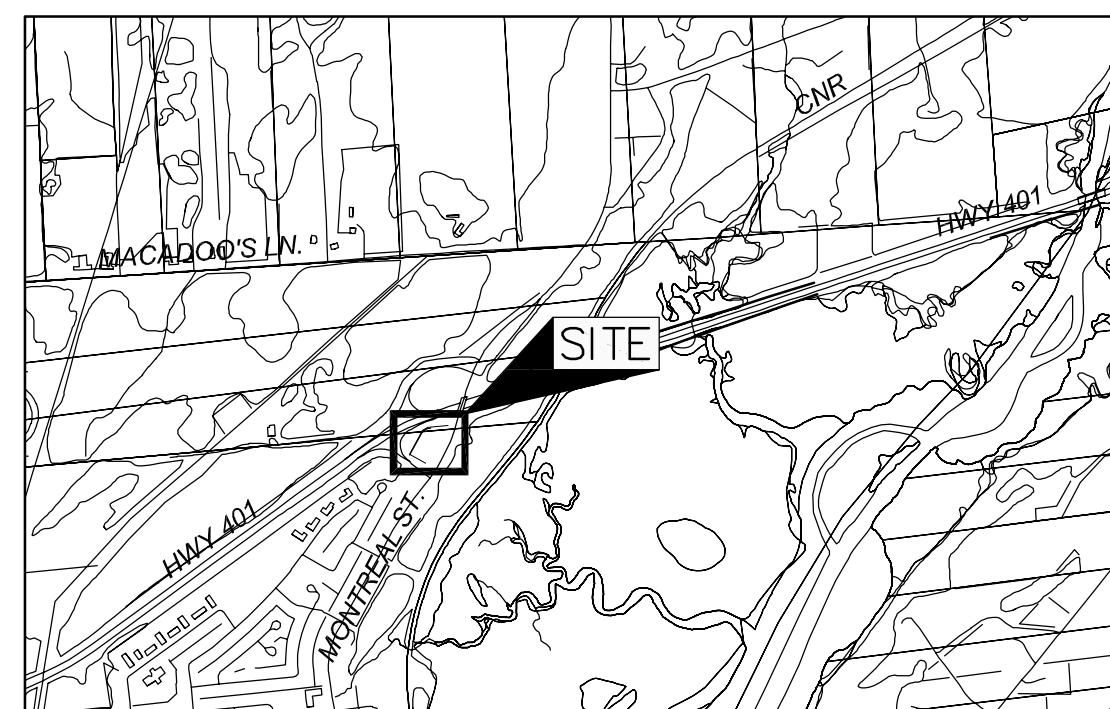


HIGHWAY 401
NOISE WALL BARRIER
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Golder Associates Ltd.
OTTAWA, ONTARIO, CANADA



KEY PLAN



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock quality designation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
NW-1	103.5	4904023.6	306711.4
NW-2	104.4	4904064.1	306734.0
NW-3	103.8	4904113.0	306771.0
NW-4	103.2	4904120.2	306813.6
NW-5	101.8	4903982.5	306757.8
NW-6	102.3	4903996.4	306739.2
NW-7	102.9	4904011.4	306722.5

NOTES

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

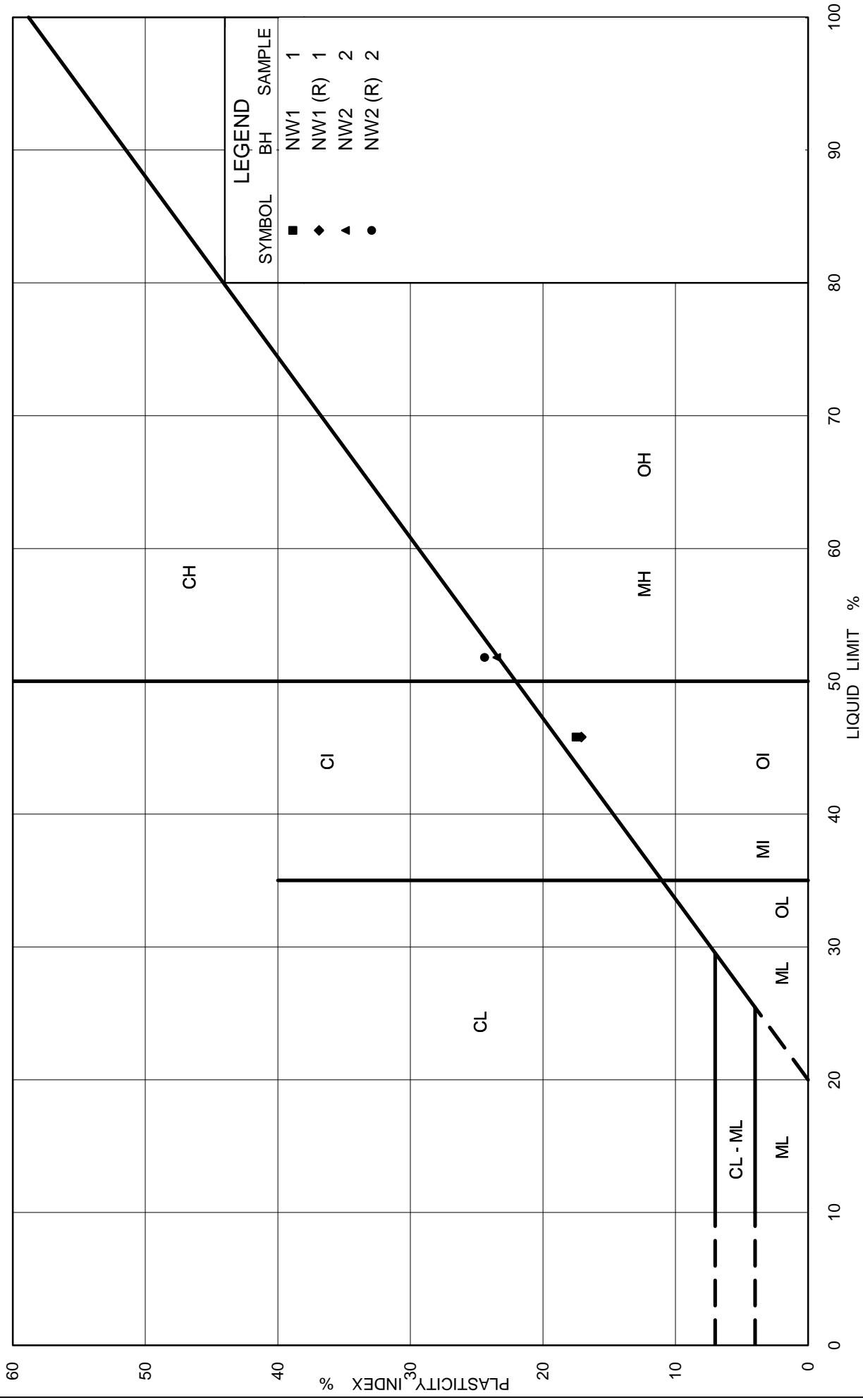
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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

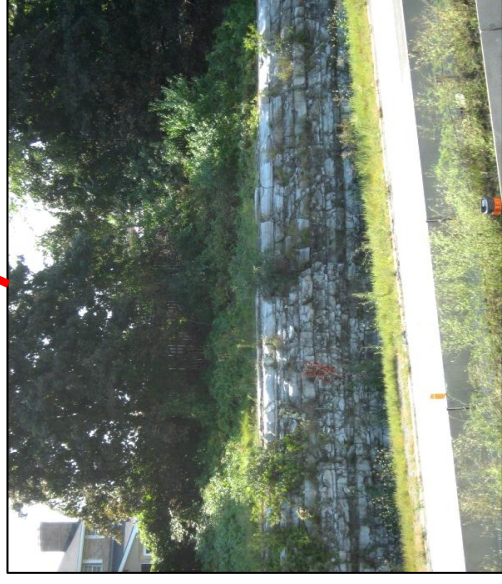
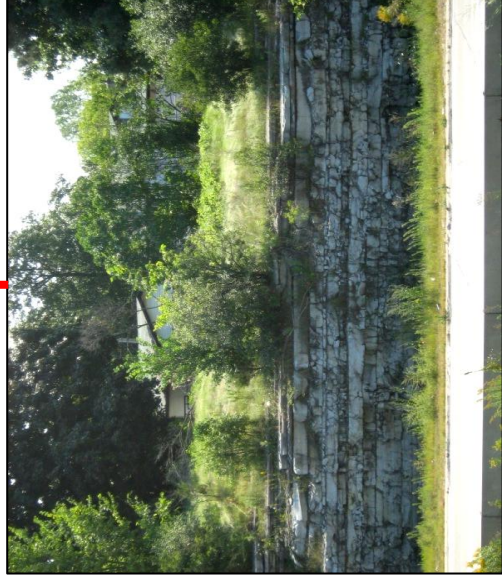
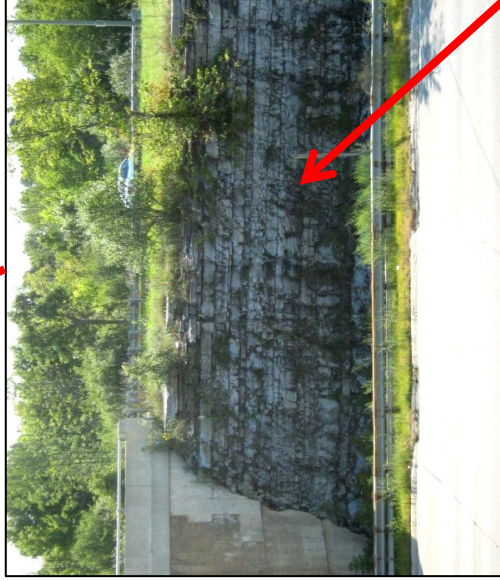
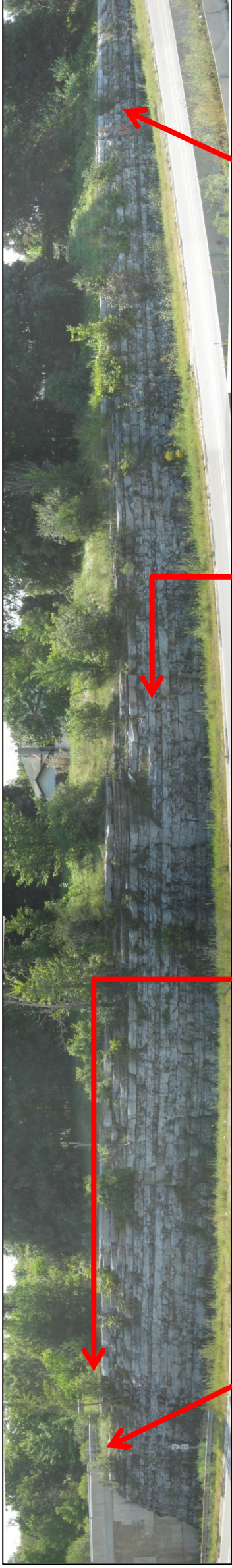
REFERENCE

Base plans provided in digital format by MRC (Drawing File No. "Plan-Base (BA).dwg", received Jan. 16, 2009 and "NS-E Property Plan and Profile.dwg", received on Mar. 8, 2010).

NO.	DATE	BY	REVISION
Geocres No. 31C-204			
HWY. 401	PROJECT NO. 08-1111-0044		DIST.
SUBM'D. E.O.	CHKD. MSS	DATE: 1/18/2011	SITE:
DRAWN: JM	CHKD. MSS	APPD. FJH	DWG. 1







Example of blocky
structure and
ravelling due to
ongoing freeze-thaw
processes

Dampness due to
seepage lower down
on face

View looking west from the south side of
the Hwy 401-Montreal Street Underpass.



Looking east along rock cut (east of NW3)



Looking east along rock cut (west of NW3)

3-4 m crest
height



Looking east along rock cut (west of NW3)

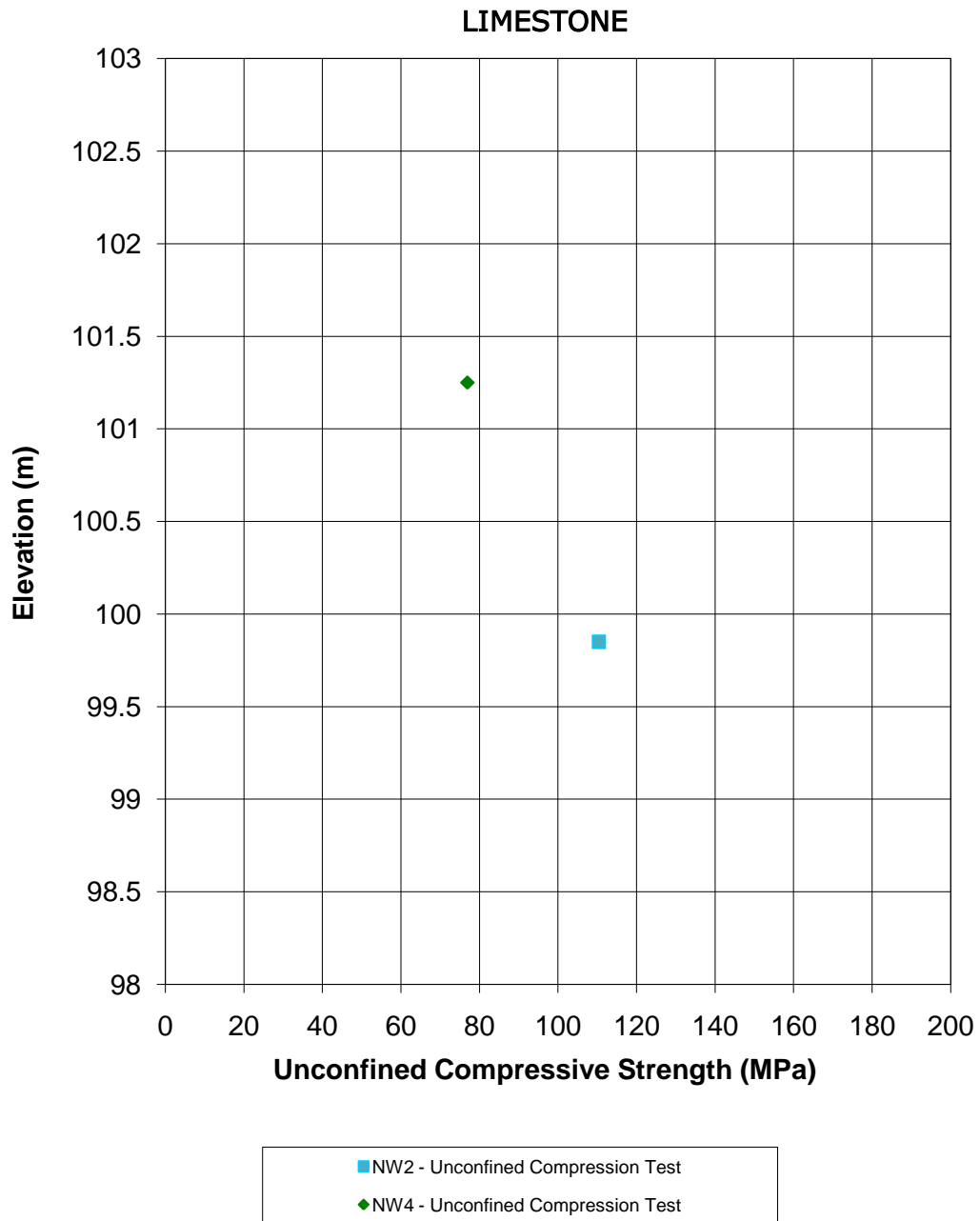
Minimal seepage
indicated by lack
of ice build-up
along rock cut

Example of blocky
structure

Overburden slope
between top of rock
and noise wall barrier

**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH
MEASUREMENTS**

FIGURE 5





APPENDIX A

List of Abbreviations and Symbols
Rock Description Terminology
Record of Borehole Sheets

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE		III. SOIL DESCRIPTION	
AS	Auger sample	(a)	Cohesionless Soils
BS	Block sample		
CS	Chunk sample	Density Index	N
DO	Drive open	(Relative Density)	Blows/300 mm
DS	Denison type sample		Or Blows/ft.
FS	Foil sample	Very loose	0 to 4
RC	Rock core	Loose	4 to 10
SC	Soil core	Compact	10 to 30
ST	Slotted tube	Dense	30 to 50
TO	Thin-walled, open	Very dense	over 50
TP	Thin-walled, piston		
WS	Wash sample	(b)	Cohesive Soils
DT	Dual Tube sample	Consistency	C _n or S _u
II. PENETRATION RESISTANCE			
Standard Penetration Resistance (SPT), N:			
The number of blows by a 63.5 kg. (140 lb.)			
hammer dropped 760 mm (30 in.) required			
to drive a 50 mm (2 in.) drive open			
Sampler for a distance of 300 mm (12 in.)			
DD- Diamond Drilling			
Dynamic Penetration Resistance; N_d:			
The number of blows by a 63.5 kg (140 lb.)			
hammer dropped 760 mm (30 in.) to drive			
Uncased a 50 mm (2 in.) diameter, 60° cone			
attached to "A" size drill rods for a distance			
of 300 mm (12 in.).			
PH:	Sampler advanced by hydraulic pressure		
PM:	Sampler advanced by manual pressure		
WH:	Sampler advanced by static weight of hammer		
WR:	Sampler advanced by weight of sampler and rod		
Peizo-Cone Penetration Test (CPT):			
An electronic cone penetrometer with			
a 60° conical tip and a projected end area			
of 10 cm ² pushed through ground			
at a penetration rate of 2 cm/s. Measurements			
of tip resistance (Q _t), porewater pressure			
(PWP) and friction along a sleeve are recorded			
Electronically at 25 mm penetration intervals.			
		IV. SOIL TESTS	
		w	water content
		w _p	plastic limited
		w _l	liquid limit
		C	consolidaiton (oedometer) test
		CHEM	chemical analysis (refer to text)
		CID	consolidated isotropically drained triaxial test ¹
		CIU	consolidated isotropically undrained triaxial test ¹
			with porewater pressure measurement ¹
		D _R	relative density (specific gravity, G _s)
		DS	direct shear test
		M	sieve analysis for particle size
		MH	combined sieve and hydrometer (H) analysis
		MPC	modified Proctor compaction test
		SPC	standard Proctor compaction test
		OC	organic content test
		SO ₄	concentration of water-soluble sulphates
		UC	unconfined compression test
		UU	unconsolidated undrained triaxial test
		V	field vane test (LV-laboratory vane test)
		γ	unit weight

Note:

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

LIST OF SYMBOLS

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

I. GENERAL

π	= 3.1416
$\ln x$	natural logarithm of x
$\log_{10} x$ or $\log x$	logarithm of x to base 10
g	Acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = p_s/p_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is p . Unit weight symbol is γ where $\gamma = pg$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (cont'd.)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio = σ'_p/σ'_{vo}

(d) Shear Strength

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

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = $(\text{Compressive strength})/2$

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	>2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	<6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	>3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	<50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	>60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns - 2mm
Fine Grained	2 – 60 microns
Very Fine Grained	<2 microns

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

O:\ Templates\Rock Description Terminology

CORE CONDITION

Total Core Recovery

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including naturally occurring fractures but not including mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

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

Description and Notes

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

Abbreviations

B -	Bedding	Ca -	Calcite
FO -	Foliation/Schistosity	P -	Polished
CL -	Cleavage	S -	Slickensided
SH -	Shear Plane/Zone	SM -	Smooth
VN -	Vein	R -	Ridged/Rough
F -	Fault	ST -	Stepped
CO -	Contact	PL -	Planar
J -	Joint	FL -	Flexured
FR -	Fracture	UE -	Uneven
MF -	Mechanical	W -	Wavy
A -	Angular	C -	Curved
BP -	Bedding Plane	H -	Hackly
BL -	Blast Induced	SL -	Sludge Coated
-	Parallel To	TCA -	To Core Axis
⊥ -	Perpendicular To	STR -	Stress Induced

PROJECT 08-1111-0044		RECORD OF BOREHOLE No NW-1		1 OF 1 METRIC	
G.W.P. 78-99-01		LOCATION N 4904023.6 ; E 306711.4		ORIGINATED BY DWM	
DIST HWY 401		BOREHOLE TYPE CME 55, Power Auger, 200mm Diam. Hollow Stem		COMPILED BY JM	
DATUM Geodetic		DATE February 16, 2010		CHECKED BY EO	

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 60 80 100	20 40 60 80 100					
103.5	GROUND SURFACE													
0.0	TOPSOIL													
0.1	SILTY CLAY to CLAYEY SILT, trace sand (Weathered Crust) Very stiff Brown Damp		1	SS	20									
			2	SS	24									
101.2	LIMESTONE (BEDROCK) Fresh Thinly to medium bedded Strong Grey		C1	NQ RC	DD									
2.3	- Soil-filled seam from 4.0 m to 4.1 m depth		C2	NQ RC	DD									
99.2	LIMESTONE (BEDROCK) Fresh to slightly weathered Strong Grey		C3	NQ RC	DD									
4.3	- Soil-filled joint at 5.3 m depth													
98.0	Note: Bedrock cored between 2.3 m and 5.5 m depth. For bedrock coring details refer to Record of Drillhole NW-1.													
5.5	End of Borehole													
	Note: Open borehole dry upon completion of drilling													

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 1/18/11 DD

PROJECT 08-1111-0044				RECORD OF BOREHOLE No NW-2				1 OF 1 METRIC							
G.W.P. 78-99-01				LOCATION N 4904064.1 ; E 306734.0				ORIGINATED BY DWM							
DIST HWY 401				BOREHOLE TYPE CME 55, Power Auger, 200mm Diam, Hollow Stem				COMPILED BY JM							
DATUM Geodetic				DATE February 16, 2010				CHECKED BY EO							
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			20	40	60					
104.4	GROUND SURFACE														
0.0	TOPSOIL														
0.2	SILTY CLAY to CLAYEY SILT, trace sand and roots (Weathered Crust) Very stiff Brown Damp - Contains roots in upper 1.5 m		1	SS	14										
			2	SS	23										
101.8			3	SS	27										
2.6	Sandy SILT, some clay, trace gravel, contains cobbles (TILL) Brown Damp														
101.0															
3.4	LIMESTONE (BEDROCK) Fresh to slightly weathered Thinly to medium bedded Strong Grey - Core diskings and friable from 4.6 m to 4.9 m depth Note: Bedrock cored between 3.4 m and 6.5 m depth. For bedrock coring details refer to Record of Drillhole NW-2.		C1	NQ RC	DD										
			C2	NQ RC	DD										
			C3	NQ RC	DD										
97.9															
6.5	End of Borehole Note: Open borehole dry upon completion of drilling														

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 1/18/11 DD

PROJECT: 08-1111-0044

RECORD OF DRILLHOLE: NW-2

SHEET 1 OF 1

LOCATION: N 4904064.1 ; E 306734.0

DRILLING DATE: February 16, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG:

DRILLING CONTRACTOR:

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	COLOUR (m/min)	FR/FX-FRACTURE F-FAULT			SM-SMOOTH			FL-FLEXURED			BC-BROKEN CORE			DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION			
									CL-CLEAVAGE			J-JOINT			R-ROUGH			UE-UNEVEN					MB-MECH. BREAK		
									SH-SHEAR			P-POLISHED			ST-STEPPED			W-WAVY					B-BEDDING		
		GROUND SURFACE		101.00																					
4		LIMESTONE (BEDROCK) Fresh to slightly weathered Thinly to medium bedded Strong Grey - Core diskings and friable from 4.6 m to 4.9 m depth		3.40	1																				
5					2																				
6					3																				
		End of Borehole		97.90 6.50																					
7		Note: Open borehole dry upon completion of drilling																							
8																									
9																									
10																									
11																									
12																									
13																									
14																									
15																									
16																									
17																									
18																									

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED: EO

MIS-RCK 001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 1/18/11 DD

PROJECT 08-1111-0044		RECORD OF BOREHOLE No NW-3				1 OF 1 METRIC							
G.W.P. 78-99-01		LOCATION N 4904113.0 ; E 306771.0				ORIGINATED BY DWM							
DIST HWY 401		BOREHOLE TYPE CME 55, Power Auger, 200mm Diam. Hollow Stem				COMPILED BY JM							
DATUM Geodetic		DATE February 18, 2010				CHECKED BY EO							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	25 50 75	γ	GR SA SI CL	
103.8 0.0	GROUND SURFACE Clayey silt, some sand, gravel and roots (FILL) Brown												
103.0 0.8	LIMESTONE (BEDROCK) Fresh to slightly weathered Medium to thinly bedded Strong Grey - Core diskings and friable from 2.7 m to 3.0 m depth Note: Bedrock cored between 0.8 m and 4.1 m depth. For bedrock coring details refer to Record of Drillhole NW-3.		C1	NQ RC	DD		103						
			C2	NQ RC	DD		102						
			C3	NQ RC	DD		101						
99.7 4.1	End of Borehole Note: Open borehole dry upon completion of drilling						100						

PROJECT: 08-1111-0044

RECORD OF DRILLHOLE: NW-3

SHEET 1 OF 1

LOCATION: N 4904113.0 ; E 306771.0

DRILLING DATE: February 18, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR:

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	RECOVERY	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE		103.00										
1		LIMESTONE (BEDROCK) Fresh to slightly weathered Medium to thinly bedded Strong Grey		0.80	1									
2		- Core diskings and friable from 2.7 m to 3.0 m depth			2									
3					3									
4		End of Borehole		99.70 4.10										
5		Note: Open borehole dry upon completion of drilling												
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED: EO

MIS-RCK-001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 1/18/11 DD

PROJECT 08-1111-0044			RECORD OF BOREHOLE No NW-4			1 OF 1 METRIC																	
G.W.P. 78-99-01			LOCATION N 4904120.2 ; E 306813.6			ORIGINATED BY DWM																	
DIST HWY 401			BOREHOLE TYPE CME 55, Power Auger, 200mm Diam. Hollow Stem			COMPILED BY JM																	
DATUM Geodetic			DATE February 17, 2010			CHECKED BY EO																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p W W _L	25 50 75	γ	GR SA SI CL	GR SA SI CL									
103.2	GROUND SURFACE																						
8.9	TOPSOIL																						
102.3	Sandy silt, trace to some clay, gravel, rootlets and organic matter (FILL) Brown		1	SS	9/0.15		103																
0.9	LIMESTONE (BEDROCK) Fresh to slightly weathered Thinly to medium bedded Strong Grey		C1	NQ RC	DD		102																
	- Soil-infilled seams from 1.4 m to 1.5 m, 2.1 m to 2.2, 2.6 m to 2.7 m, and at 4.0m depths		C2	NQ RC	DD		101																
	Note: Bedrock cored between 0.9 m and 4.1 m depth. For bedrock coring details refer to Record of Drillhole NW-4.		C3	NQ RC	DD		100																
			C4	NQ RC	DD																		
99.2	End of Borehole																						
4.1	Note: Open borehole dry upon completion of drilling																						

PROJECT: 08-1111-0044

RECORD OF DRILLHOLE: NW-4

SHEET 1 OF 1

LOCATION: N 4904120.2 ; E 306813.6

DRILLING DATE: February 17, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR:

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOR & RETURN	FR/FX-FRACTURE F-FAULT				SM-SMOOTH				FL-FLEXURED				BC-BROKEN CORE				DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
									CL-CLEAVAGE				J-JOINT				UE-UNEVEN				MB-MECH. BREAK					
									SH-SHEAR				P-POLISHED				ST-STEPPED				W-WAVY					
									VN-VEIN				S-SLICKENSIDED				PL-PLANAR				C-CURVED					
								RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.3		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY										
								TOTAL CORE %		SOLID CORE %				DIP w.r.t CORE AXIS		TYPE AND SURFACE DESCRIPTION		10 ⁻⁵ K _s cm/sec		10 ⁻² K _s cm/sec						
								0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100		0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100		0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100		0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100		0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100		0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100		0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100						
1		GROUND SURFACE		102.30																						
1		LIMESTONE (BEDROCK) Fresh to slightly weathered Thinly to medium bedded Strong Grey		0.90	1																					
2		- Soil-infilled seams from 1.4 m to 1.5 m, 2.1 m to 2.2, 2.6 m to 2.7 m, and at 4.0m depths			2																					
3					3																					
4					4																					
4		End of Borehole		99.10																						
		Note: Open borehole dry upon completion of drilling		4.10																						
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										
13																										
14																										
15																										

UCS = 76.9 MPa

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED: EO

MIS-RCK 001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 1/18/11 DD

PROJECT 08-1111-0044		RECORD OF BOREHOLE No NW-5		1 OF 1 METRIC	
G.W.P. 78-99-01	LOCATION N 4903982.5 ; E 306757.8	ORIGINATED BY RS			
DIST HWY 401	BOREHOLE TYPE Power Auger, 200mm Diam, Solid Stern	COMPILED BY JM			
DATUM Geodetic	DATE March 11, 2010	CHECKED BY EQ			

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						
101.8	GROUND SURFACE													
0.0	Clay (TOPSOIL) Brown													
0.1	SILTY CLAY Very stiff Brown Moist													
101														
100														
99.6														
2.2	End of Augerhole Auger Refusal Inferred top of bedrock													

MIS-MTO 001 08-1111-0044.GPJ GAL-MISS GDT 1/16/11 DD

PROJECT <u>08-1111-0044</u>		RECORD OF BOREHOLE No NW-6				1 OF 1 METRIC						
G.W.P. <u>78-99-01</u>		LOCATION <u>N 4903996.4 ; E 306739.2</u>				ORIGINATED BY <u>RS</u>						
DIST <u>HWY 401</u>		BOREHOLE TYPE <u>Power Auger, 200mm Diam. Solid Stem</u>				COMPILED BY <u>JM</u>						
DATUM <u>Geodetic</u>		DATE <u>March 11, 2010</u>				CHECKED BY <u>EO</u>						
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED				WATER CONTENT (%) W _p — W — W _L
102.3	GROUND SURFACE							20 40 60 80 100				
0.0	SILTY CLAY, with boulders, occasional cobble						102	20 40 60 80 100				
0.2	Brown						101	20 40 60 80 100				
	SILTY CLAY Very stiff Brown Moist						100	20 40 60 80 100				
99.6	End of Augerhole											
2.7	Auger Refusal Inferred top of bedrock											

PROJECT 08-1111-0044		RECORD OF BOREHOLE No NW-7				1 OF 1 METRIC						
G.W.P. 78-99-01		LOCATION N 4904011.4 ; E 306722.5				ORIGINATED BY RS						
DIST HWY 401		BOREHOLE TYPE Power Auger, 200mm Diam. Solid Stem				COMPILED BY JM						
DATUM Geodetic		DATE March 11, 2010				CHECKED BY EO						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L			
102.9	GROUND SURFACE											
0.0	SILTY CLAY, occasional cobble											
0.2	Brown											
	SILTY CLAY											
	Very stiff											
	Brown											
	Moist											
100.4												
2.5	End of Augerhole											
	Auger Refusal											
	Inferred top of bedrock											