



FOUNDATION INVESTIGATION AND DESIGN REPORT

for

**SECORD ROAD UNDERPASS
HIGHWAY 69, SITE 46-491
WP 5042-00-01
TOWNSHIP OF BURWASH
DISTRICT 54, SUDBURY**

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PML Ref.: 03TF012A
Index No.: 113FIR and 114FDR
Geocres No.: 41I-176
September 30, 2004



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Peto MacCallum Ltd.

C O N S U L T I N G E N G I N E E R S

FOUNDATION INVESTIGATION REPORT

for

Secord Road Underpass

Highway 69, Site 46-491

WP 5042-00-01

Township of Burwash

District 54, Sudbury

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed construction of an underpass to be located at Secord Road and Highway 69 some 15 km south of Sudbury, Ontario. The investigation was conducted for Totten Sims Hubicki Associates (TSH) on behalf of the Ontario Ministry of Transportation.

Secord Road passes over Highway 69 at approximate Station 15+020, Highway 69 chainage, in the Township of Burwash (ref. Drawing 1 'Hwy 69 – Secord Road Underpass. Preliminary General Arrangement' prepared by TSH in December 2003).

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

2. SITE DESCRIPTION AND GEOLOGY

The site is situated at the crossing of Highway 69 about 15 km south of Sudbury. The structure to be erected will carry Secord Road traffic over Highway 69.

Highway 69 is designated as a south-north road. Therefore, the alignment of the underpass is considered to extend west-east.

The site is situated in the area of the Precambrian Laurentian peneplane. The topography is irregular in detail and dotted with areas of wet ground separated by steep rock ridges. Pleistocene lacustrine/fluviial deposits and recent swamp sediments have been laid down in depressions and are probably associated with the Nipissing post-glacial stage of the Great Lakes. The native soils are typically represented by sand/silt and/or clay deposits.



Metasedimentary rocks of the Huronian Supergroup and gneisses of the Grenville Province underlay the alignment. The area has undergone considerable folding, intrusive activity, regional metamorphism and faulting. The bedrock is at various depths ranging from surface to over 35 m, with the overburden/bedrock interface exhibiting sharp elevation differences along the alignment of Highway 69.

3. INVESTIGATION PROCEDURES

The field work for this study was carried out during the period of April 17 to 19, 2004 and comprised 29 boreholes drilled to depths of 0.0 to 4.6 m at the locations shown on Drawing 1, appended. Further details are summarized in the following table:

LOCATION	BOREHOLE No.	DEPTH (m)		
		AUGER	ROCK CORE ⁽¹⁾	TOTAL
West Approach	491-1	0.5	–	0.5
West Abutment	491-2	0.6	3.1	3.7
	491-3	0.3	–	0.3
	491-4	0.1	–	0.1
	491-5	0.2	–	0.2
	491-6	0.2	2.9	3.1
	491-7	0.3	–	0.3
	491-8	0.0	–	0.0
	491-9	0.1	–	0.1
	491-10	0.1	3.0	3.1
Central Pier	491-11	0.7	3.9	4.6
	491-12	0.1	–	0.1
	491-13	0.0	–	0.0
	491-14	0.3	–	0.3
	491-15	0.6	3.6	4.2
	491-16	0.3	–	0.3
	491-17	0.2	–	0.2
	491-18	0.3	–	0.3
	491-19	0.4	4.2	4.6



LOCATION	BOREHOLE No.	DEPTH (m)		
		AUGER	ROCK CORE ⁽¹⁾	TOTAL
East Abutment	491-20	0.5	3.3	3.8
	491-21	0.8	–	0.8
	491-22	0.3	–	0.3
	491-23	0.0	–	0.0
	491-24	1.1	3.2	4.3
	491-25	0.4	–	0.4
	491-26	0.0	–	0.0
	491-27	0.7	–	0.7
	491-28	0.8	3.1	3.9
East Approach	491-29	0.3	–	0.3

⁽¹⁾ NQ diamond rock coring equipment

The alignment of Secord Road at the structure location was staked in the field by Totten Sims Hubicki Associates. The positions of the boreholes along the staked alignment were selected by Peto MacCallum Ltd. The locations of and ground surface elevations at the boreholes were also determined by Peto MacCallum Ltd. The following temporary benchmark (TBM) was used for vertical reference:

TBM: Control survey point CSP-008
 850012 MTC

Elevation: 255.283 (geodetic, metric)

The boreholes were advanced manually or using continuous flight solid stem augers, powered by a track-mounted CME-55 Bombardier drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff. Three boreholes at each foundation element (the centre pier and both abutments) were extended 2.9 to 4.2 m into bedrock using NQ diamond rock coring equipment supplemented by NW casing and wash boring techniques.



Neither sampling nor testing of the soil was conducted at the site due to shallow bedrock. The groundwater conditions at the borehole locations were assessed during drilling by visual examination of soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open boreholes. All the boreholes were backfilled with a suitable bentonite/cement mixture in accordance with the MTO guidelines for borehole abandonment procedures.

4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations and groundwater observations.

The borehole locations and stratigraphic cross-sections prepared from the borehole data are presented on the appended Drawings 1 and 2.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised a surficial fill or peat deposit mantling shallow bedrock. Bedrock was exposed at four borehole locations and contacted/inferred in the remaining boreholes at depths of 0.1 to 1.1 m (elevation 253.2 to 256.1). The strata encountered are summarized below.

4.1 Fill

A surficial layer of fill was identified in boreholes 491-1, 491-24, 491-25, 491-27 and 491-28. The fill comprised sand and gravel and was overlain by asphalt in boreholes 491-24 and 491-27. This layer was 0.4 to 1.0 m thick and penetrated at elevation 253.2 to 254.7.

4.2 Peat

A deposit of peat was present surficially in boreholes 491-2 to 491-7, 491-9, 491-10, 491-12, 491-14 to 491-20 and 491-22. The peat had a thickness of 100 to 600 mm and was penetrated at elevation 253.7 to 256.1.



4.3 Sand

A cohesionless deposit of sand of various granulometric composition was encountered surficially in boreholes 491-11, 491-21, 491-29 or directly beneath the peat or fill at elevation 253.7 to 255.6 in boreholes 491-15, 491-19, 491-27. This unit was 200 to 800 mm thick and penetrated at depths of 0.3 to 0.8 m (elevation 253.5 to 255.4).

It is noteworthy that cobbles and boulders were encountered within the sand and gravel stratum in boreholes 491-11 and 491-15.

4.4 Bedrock

Bedrock was exposed at elevation 254.0 to 255.9 in boreholes 491-8, 491-13, 491-23 and 491-26. In the remaining boreholes, the bedrock surface was confirmed by rock coring or inferred by refusal at depths of 0.1 to 1.1 m (elevation 253.2 to 256.1). The bedrock comprises a grey to black amphibolite, with the exception of borehole 491-28 where a pink granitic gneiss was identified. A detailed description of the rock cores retrieved from boreholes 491-2, 491-6, 491-10, 491-11, 491-15, 49-19, 491-20, 491-24 and 491-28 is provided in Table 1, appended.

The measured core recovery varied between 87 and 100%, decreasing to 31 and 71% in the upper 0.4 and 1.1 m in boreholes 491-15 and 491-19 respectively. The RQD determined from the rock cores was in a typical range of 66 to 100%, indicating a fair to excellent quality rock. The upper rock cores in boreholes 491-15, 491-19 and 491-20 exhibited an RQD of 25 to 46% (poor quality rock).

4.5 Groundwater

Groundwater was not observed in any of the boreholes during or upon completion of drilling. However, minor seepage should be anticipated locally at the soil/bedrock interface within depressions in the bedrock surface.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

5. CLOSURE

The field work was carried out under the supervision of Mr. F. Portela, C.E.T., and direction of Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer. The equipment was supplied by Marathon Drilling Co. Ltd.

The report was prepared by Mr. Grigory O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. Dennis W. Kerr, MEng, P.Eng., Chief Foundation Engineer. Mr. Brian R. Gray, MEng, P.Eng., MTO Designated Contact, carried out an independent review of the report.

Yours very truly

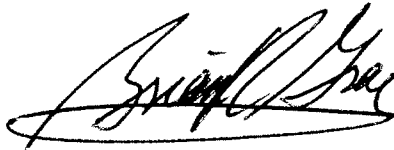
Peto MacCallum Ltd.



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



Dennis W. Kerr, MEng, P.Eng.
Chief Foundation Engineer



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



GD/DWK:gd-mm-mi



TABLE 1
 ROCK CORE DESCRIPTION
 SECORD ROAD UNDERPASS

CORE RECOVERY					CORE DESCRIPTION	
HOLE No.	CORE No.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
491-2	1	0.60 – 2.15	97	84	0.60 – 3.70	Amphibolite: Black, fine crystalline, medium to high strength, unweathered, close to moderate spaced flat partings, rough planar, dark green sandy filling, becoming oxidized to tight, good to excellent quality
	2	2.15 – 3.70	100	98		
491-6	1	0.20 – 1.55	87	75	0.20 – 3.10	Amphibolite: Grey to black, fine crystalline, high strength, unweathered, close to moderate spaced flat to dipping partings, rough planar, oxidized to tight, good to excellent quality
	2	1.55 – 3.10	97	95		
491-10	1	0.10 – 1.60	95	66	0.10 – 3.10	Amphibolite: Grey to black, fine crystalline, with layer of pink, coarse crystalline pegmatite, high strength, unweathered, close spaced flat to dipping partings, rough planar, oxidized, fair quality
	2	1.60 – 3.10	100	70		
491-11	1	0.70 – 1.55	88	74	0.70 – 4.60	Amphibolite: Grey to black, fine crystalline, high strength, slightly weathered to unweathered, vertical parting in upper 100 mm, close to moderate spaced flat partings, rough planar, oxidized, fair to excellent quality
	2	1.55 – 3.05	93	88		
	3	3.05 – 4.60	100	100		
491-15	1	0.60 – 1.00	31	25	0.60 – 4.20	Amphibolite: Grey to black, fine crystalline, high strength, unweathered, very close to moderate spaced flat to dipping partings, silty filling to oxidized, becoming tight, poor quality, becoming good
	2	1.00 – 2.60	100	46		
	3	2.60 – 4.20	100	86		

Originated: JW
 Compiled: GD
 Checked: DK



TABLE 1
 ROCK CORE DESCRIPTION
 SECORD ROAD UNDERPASS

CORE RECOVERY					CORE DESCRIPTION	
HOLE No.	CORE No.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
491-19	1	0.40 – 1.50	71	38	0.40 – 4.60	Amphibolite: Grey to black, fine crystalline, with 450 mm layer of pink, granitic gneiss, high strength, slightly weathered to unweathered, very close to moderate spaced flat to dipping partings, rough planar, sandy filling to oxidized, vertical parting below 4.37 m depth, poor to excellent quality
	2	1.50 – 3.00	93	93		
	3	3.00 – 4.60	100	82		
491-20	1	0.50 – 2.00	100	38	0.50 – 3.80	Amphibolite: Grey to 1.65 m depth, becoming dark grey to black, fine crystalline, medium to high strength, slightly weathered to 0.8 m depth, becoming unweathered, very close to moderate spaced flat to dipping partings, rough planar, oxidized to slightly altered, becoming tight, occ. Vertical parting with black silt filling, poor to fair quality
	2	2.00 – 3.80	100	72		
491-24	1	1.10 – 2.70	95	95	1.10– 4.30	Amphibolite: Grey, becoming dark grey to black, fine crystalline, with 660 mm thick layer of pink granitic gneiss, high strength, unweathered, close to moderate spaced flat partings, rough planar, tight, good to excellent quality
	2	2.70 – 4.30	100	82		
491-28	1	0.80 – 2.35	91	80	0.80 – 3.90	GRANITIC GNEISS: Pink, medium crystalline, high strength, unweathered, close to wide spaced flat partings, rough planar, tight, good to excellent quality
	2	2.35 – 3.90	100	93		

Originated: JW
 Compiled: GD
 Checked: DK

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
C_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 491-1

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 804 N; 319 210 E
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GP

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					
255.2																	
0.0	Sand and gravel with topsoil inclusions	X	1	AS			255										
254.7	(FILL)	X															
0.5	End of borehole Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 491-2

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 814 N; 319 230 E
DIST 54 HWY 69 BOREHOLE TYPE NW Casing & Wash Boring
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY

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							WATER CONTENT (%)			
								○ UNCONFINED								+ FIELD VANE		● QUICK TRIAXIAL
254.9	Ground Surface							20	40	60	80	100						
0.0	Peat, fine fibrous																	
254.3	Dark brown																	
0.6	Bedrock																	
	Amphibolite																	
	Medium to high strength		1	RC NQ	REC 97		254											RQD 84
	Good to excellent quality						253											
			2	RC NQ	REC 100		252											RQD 98
251.2	End of borehole																	
3.7																		
	* Borehole dry on completion of drilling																	

RECORD OF BOREHOLE No 491-3

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 802 N; 319 228 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel SECOND ROAD STA. 9+958, o/s 3m Lt. Secord Twp.
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GD

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									
255.2	Ground Surface																
0.0	Peat, fine fibrous Dark brown	~ ~ ~					255										
0.3	End of borehole Refusal on probable bedrock																
	 <																

RECORD OF BOREHOLE No 491-4

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 789 N; 319 226 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GT

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20	40	60	80	100	W _p	W	W _L			
256.1	Ground Surface															
0.0	Peat, fine fibrous															
0.1	Dark brown															
	End of borehole															
	Refusal on probable bedrock															
	* Borehole dry															

RECORD OF BOREHOLE No 491-5

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 809 N; 319 231 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY SD

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								
255.1	Ground Surface															
0.0	Peat, fine fibrous															
0.2	Dark brown															
	End of borehole															
	Refusal on probable bedrock															
	* Borehole dry															

RECORD OF BOREHOLE No 491-6

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 801 N; 319 230 E
DIST 54 HWY 69 BOREHOLE TYPE NW Casing & Wash Boring
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GP



SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L		
255.2	Ground Surface															GR SA SI CL
0.0	Peat, fine fibrous					255										
0.2	Dark brown Bedrock															
	Amphibolite		1	RC NQ		254										RQD 75
	High strength															
	Good to excellent quality		2	RC NQ		253										RQD 95
252.1	End of borehole															
3.1																
	* Borehole dry on completion of drilling															

RECORD OF BOREHOLE No 491-7

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 794 N; 319 229 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel ORIGINATED BY FP
DATUM Geodetic DATE April 19, 2004 COMPILED BY FP
CHECKED BY GJ

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 (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						x LAB VANE		
255.7	Ground Surface						20	40	60	80	100	20	40	60						
0.0	Peat, fine fibrous																			
0.3	Dark brown End of borehole Refusal on probable bedrock																			
	* Borehole dry																			

RECORD OF BOREHOLE No 491-8

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 813 N; 319 235 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GD

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								
255.1	Ground Surface															
0.0	Bedrock at surface															
	* Borehole dry															

RECORD OF BOREHOLE No 491-9

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 801 N; 319 233 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GP

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								
255.3	Ground Surface						20	40	60	80	100					
0.0	Peat, fine fibrous						○ UNCONFINED			+	FIELD VANE					
0.1	Dark brown						● QUICK TRIAXIAL			x	LAB VANE					
	End of borehole															
	Refusal on probable bedrock															
			</													

RECORD OF BOREHOLE No 491-10

1 of 1

METRIC

W.P. 5042-00-01

LOCATION

Co-ords. 5 130 788 N; 319 231 E

Second Road Sta.9+963, o/s 10m Rt. Second Twp.

ORIGINATED BY FP

DIST 54

HWY 69

BOREHOLE TYPE

NW Casing & Wash Boring

COMPILED BY FP

DATUM Geodetic

DATE _____

April 18, 2004

CHECKED BY *GT*

[illegible]

RECORD OF BOREHOLE No 491-11

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 809 N; 319 270 E
DIST 54 HWY 69 BOREHOLE TYPE NW Casing & Wash Boring
DATUM Geodetic DATE April 18, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GD

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
255.9	Ground Surface															
0.0	Sand and gravel with cobbles and boulders															
255.2																
0.7	Bedrock															
	Amphibolite		1	RC NQ	REC 88	255										RQD 74
	High strength		2	RC NQ	REC 93	254										RQD 88
	Fair to excellent quality		3	RC NQ	REC 100	253										
						252										RQD 100
251.3	End of borehole															
4.6																
	* Borehole dry on completion of drilling															

RECORD OF BOREHOLE No 491-12

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 796 N; 319 268 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY

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					
255.6	Ground Surface													
0.0	Peat, fine fibrous													
0.1	Dark brown End of borehole													
	Refusal on probable bedrock													
	* Borehole dry													

RECORD OF BOREHOLE No 491-13

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 784 N; 319 266 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GP

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					
255.9	Ground Surface												
0.0	Bedrock at surface												
	* Borehole dry												

RECORD OF BOREHOLE No 491-14

1 of 1


METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 803 N; 319 271 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GP

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									
								20 40 60 80 100									
255.7	Ground Surface																
0.0	Peat, fine fibrous																
0.3	Dark brown																
	End of borehole																
	Refusal on probable bedrock																

RECORD OF BOREHOLE No 491-15

1 of 1

METRIC

W.P. 5042-00-01

LOCATION

Co-ords. 5 130 796 N; 319 270 E

Second Road Sta.10+000, CL Second Twp.

ORIGINATED BY FP

DIST 54

69

BOREHOLE TYPE

NW Casing & Wash Boring

COMPILED BY FP

DATUM Geodetic

DATE _____

April 18, 2004

CHECKED BY *GT*

[illegible]

RECORD OF BOREHOLE No 491-16

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 789 N; 319 269 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GD


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 (%)			
						20	40	60	80	100	W _p	W	W _L			
255.5	Ground Surface															
0.0	Peat, fine fibrous															
0.3	Dark brown End of borehole Refusal on probable bedrock															
	* Borehole dry															

RECORD OF BOREHOLE No 491-17

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 808 N; 319 274 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GJ

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									
255.4	Ground Surface																
0.0	Peat, fine fibrous																
0.2	Dark brown End of borehole																
	Refusal on probable bedrock																
	 <																

RECORD OF BOREHOLE No 491-18

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 796 N; 319 273 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GD

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										WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
255.3	Ground Surface							20	40	60	80	100						
0.0	Peat, fine fibrous	~																
0.3	Dark brown End of borehole Refusal on probable bedrock																	
	* Borehole dry																	

RECORD OF BOREHOLE No 491-19

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Second Road Sta.10+003, o/s 13m Rt. Second Twp. ORIGINATED BY FP
 DIST 54 HWY 69 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY FP
 DATUM Geodetic DATE April 18, 2004 CHECKED BY GP

[illegible]

1 of 1

METRIC

[illegible]

RECORD OF BOREHOLE No 491-21

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 792 N; 319 307 E
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GD

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	80	100					
254.5	Asphalt																
0.0	Silty sand		1	AS													
253.7	(FILL)						254										
0.8	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 491-22

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 778 N; 319 305 E
Second Road Sta.10+037, o/s 15.5m Rt. Secord Twp. ORIGINATED BY EP
DIST 54 HWY 69 BOREHOLE TYPE Shovel COMPILED BY EP
DATUM Geodetic DATE April 19, 2004 CHECKED BY GP

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 X LAB VANE									
254.2								20	40	60	80	100					
0.0	Peat, fine fibrous	~~~~~					254										
0.3	Dark brown End of borehole Refusal on probable bedrock	~~~~~															
	* Borehole dry																

RECORD OF BOREHOLE No 491-23

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 798 N; 319 310 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel Second Road Sta.10+040, o/s 4.5m Lt. Secord Twp.
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GD

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	80	100					
254.0																	
0.0	Bedrock at surface																
	* Borehole dry																

RECORD OF BOREHOLE No 491-24

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 791 N; 319 309 E
DIST 54 HWY 69 BOREHOLE TYPE NW Casing & Wash Boring
DATUM Geodetic DATE April 17, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY GD

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 x LAB VANE									
								WATER CONTENT (%)									
254.4 0.0 0.1	Asphalt Sand and gravel (FILL)						254										
253.3 1.1	Bedrock Amphibolite High strength Good to excellent quality		1	RC NQ	REC 95		253										RQD 95
							252										
			2	RC NQ	REC 100		251										RQD 82
250.1 4.3	End of borehole																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 491-25

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 783 N; 319 308 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GP

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	80	100					
254.2																	
0.0	Sand and gravel		1	AS													
253.8	with topsoil inclusions																
0.4	(FILL)																
	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry																

RECORD OF BOREHOLE No 491-26

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 803 N; 319 313 E
DIST 54 HWY 69 BOREHOLE TYPE Shovel
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE 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					WATER CONTENT (%)			
						20 40 60 80 100 O UNCONFINED + FIELD VANE • QUICK TRIAXIAL X LAB VANE					20 40 60 w _p w w _L					
254.2 0.0	Bedrock at surface															
	* Borehole dry															

RECORD OF BOREHOLE No 491-27

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 790 N; 319 311 E
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers
DATUM Geodetic DATE April 19, 2004

ORIGINATED BY FP

COMPILED BY FP

CHECKED BY

SOIL PROFILE

SAMPLES

DYNAMIC CONE PENETRATION
RESISTANCE PLOT

PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT

SHEAR STRENGTH kPa

○ UNCONFINED + FIELD VANE

● QUICK TRIAXIAL x LAB VANE

W_p W W_L

WATER CONTENT (%)

UNIT WEIGHT

γ

KN/m³

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	20	40	60	20	40	60	GR	SA	SI	CL
254.2	Asphalt																					
0.1	Sand and gravel																					
253.7	(FILL)		1	AS			254															
0.5	Silty sand																					
253.5	End of borehole																					
0.7	Refusal on probable bedrock																					
	* Borehole dry on completion of drilling																					

RECORD OF BOREHOLE No 491-28

1 of 1

METRIC

W.P. 5042-00-01 LOCATION Co-ords. 5 130 778 N; 319 310 E
DIST 54 HWY 69 BOREHOLE TYPE NW Casing & Wash Boring
DATUM Geodetic DATE April 17, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE 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					W _p W W _L				
254.0 0.0	Sand and gravel							20 40 60 80 100					20 40 60				
253.2 0.8	Brown (FILL)							20 40 60 80 100					20 40 60				
	Bedrock		1	RC NQ	REC 91		253									RQD 80	
	Granitic Gneiss High strength Good to excellent quality		2	RC NQ	REC 100		252									RQD 93	
250.1 3.9	End of borehole						251										
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 491-29

1 of 1

METRIC


W.P. 5042-00-01 LOCATION Co-ords. 5 130 788 N; 319 319 E
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers
DATUM Geodetic DATE April 19, 2004
ORIGINATED BY FP
COMPILED BY FP
CHECKED BY GD

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 (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
253.9								20 40 60 80 100							
0.0	Silty sand with topsoil inclusions														
0.3	End of borehole														
	Refusal on probable bedrock														
	* Borehole dry on completion of drilling														

ON MOT LINES OVER BDRY 03TF012A 491 SECORD ROAD GR/L ON MOT CRT 3004000000

PLAN SCALE

10 5 0 10 20m

<p>CONT No</p> <p>WP No 5042-00-01</p>	
<p><u>HIGHWAY 69</u></p> <p>SECOND ROAD UNDERPASS</p> <p>BOREHOLE LOCATIONS & SOIL STRATA</p>	<p>SHEET</p>

A key plan map showing the location of the site. The map includes the following features:

- Locations:** Sudbury (top left), Estoire (bottom right), and a "SITE" marked with a black rectangle near the bottom center.
- Roads:**
 - WAKAMEN RD (top center, running diagonally down-right)
 - SECOND RD (left side, running diagonally down-right)
 - WAKAMETI RIVER (left side, flowing down)
 - CH R (center, running diagonally down-right)
 - HWY 69 (center, running diagonally down-right)
 - HWY 69 (EXIST) (center, running diagonally down-right)
 - HWY 69 (NEW) (center, running diagonally down-right)
 - ELBOW LAKE RD (right side, running diagonally down-right)
 - NEE-WA-MASS LAKE RD (right side, running diagonally down-right)
- Towns:**
 - DILL TWP (top right)
 - BURWASH TWP (middle right)
 - SECORD TWP (left side)
 - BURWASH STATION (bottom right)
- Other Features:**
 - A north arrow pointing upwards, located in the bottom left corner.
 - A "KEY PLAN SCALE" bar at the bottom, marked with 0, 1, and 2 km.

NOTE:
REFER TO DRAWING 2 FOR SECTIONS B-B, C-C AND D-D.

REF No E-SECORD-GA.dwg; June 2004
1_bpl06.dwg; October 2002
Hwy69-S-orden.dwg; February 2003

BH No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
491-1	255.2	5 130 804	319 210
491-2	254.9	5 130 814	319 230
491-3	255.2	5 130 802	319 228
491-4	256.1	5 130 789	319 228
491-5	255.1	5 130 809	319 231
491-6	255.2	5 130 801	319 230
491-7	255.7	5 130 794	319 229
491-8	255.1	5 130 813	319 235
491-9	255.3	5 130 801	319 233

(Legend Continued)

<p>- NOTE -</p> <p>The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.</p>
--

REVISIONS					
DATE	BY	DESCRIPTION			

Geocross No.

ENTRY No	09					DIST	54
SUBENT'D	GD	CHECKED	GD	DATE	JULY 19, 2004	SITE	48-491
DRAWN	MM	CHECKED	DWK	APPROVED	DWK	DWG	1

REF No E-SECOND-GA.dwg; June 2004
1_bpl06.dwg; October 2002
Hwy69-S-des.dwg; February 2004

METRIC

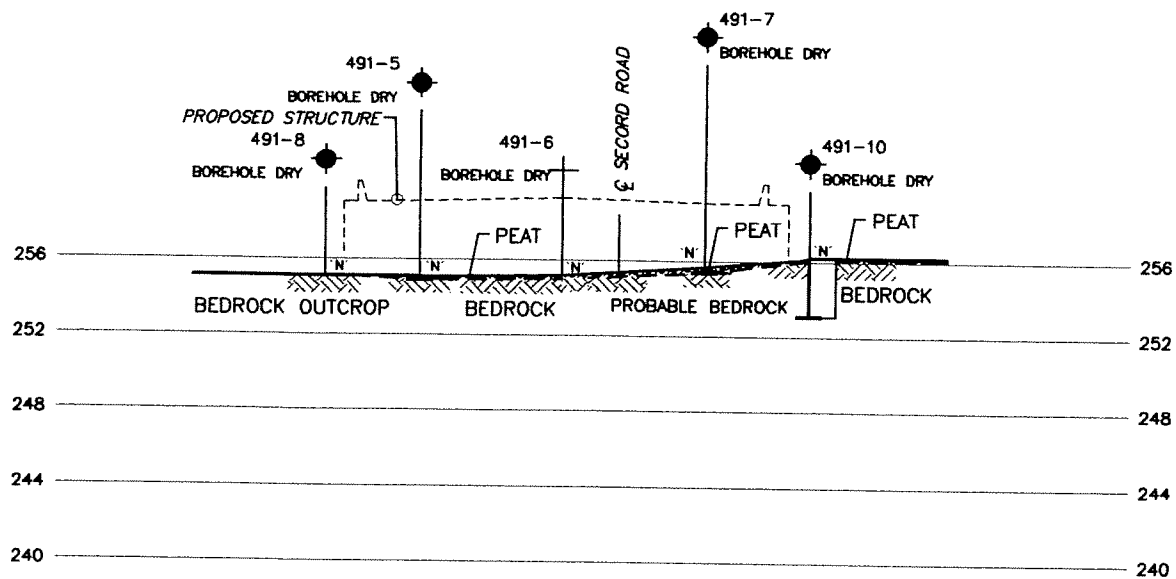
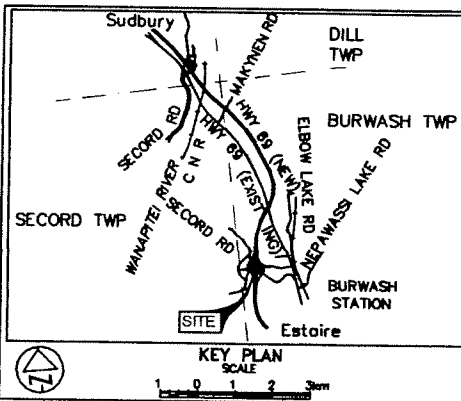
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

CONT No
WP No 5042-00-01

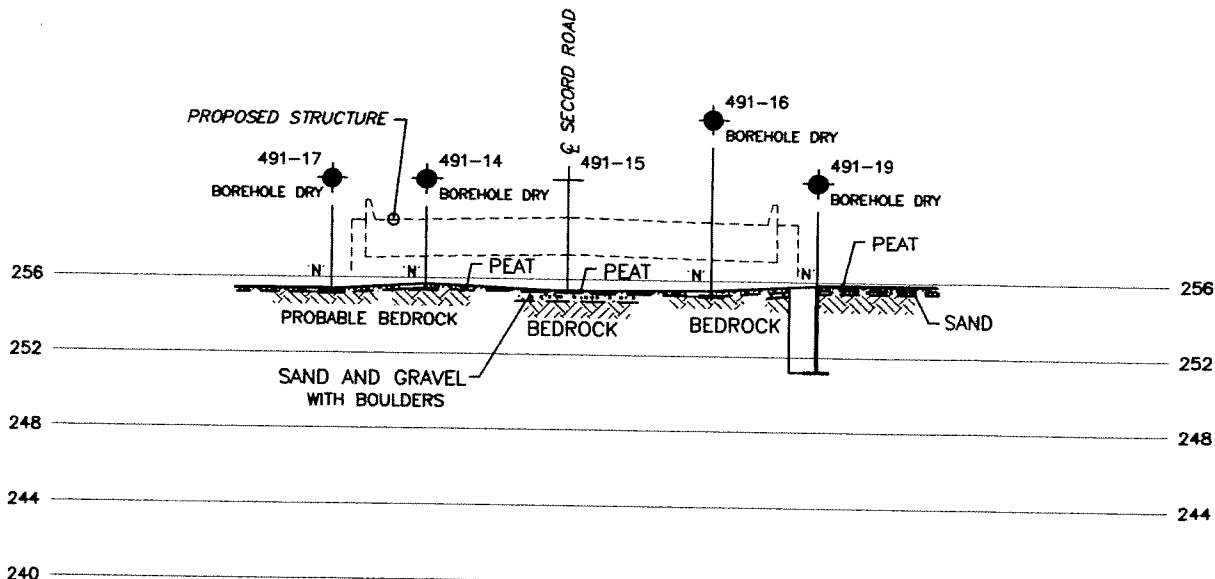
HIGHWAY 69
SECOND ROAD UNDERPASS
SOIL STRATA

SHEET

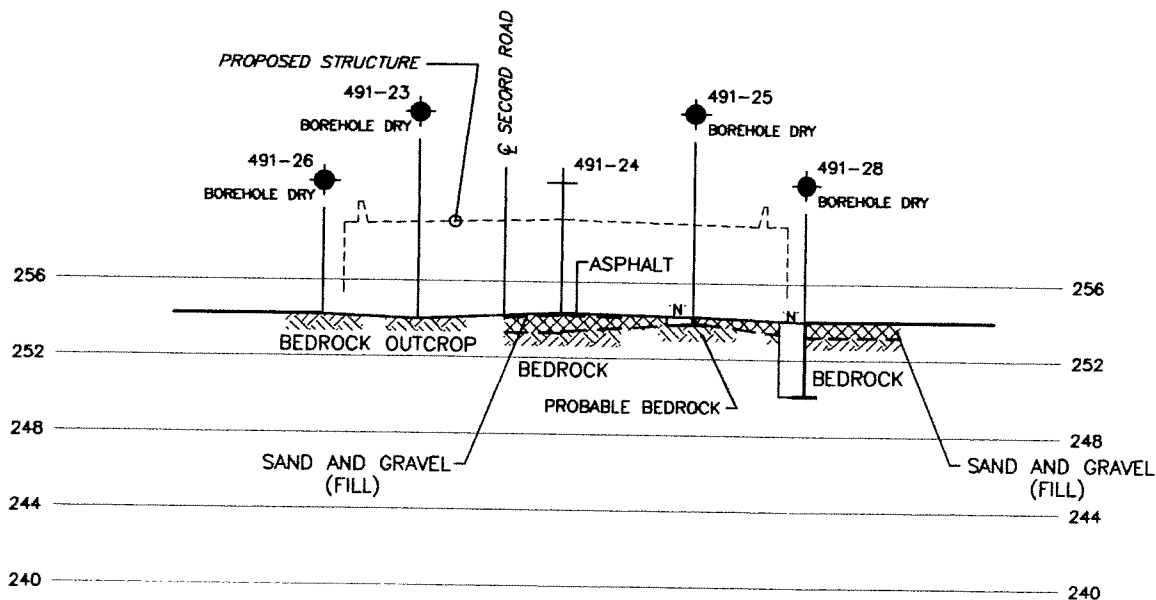
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CONSULTING ENGINEERS



B-B



C-C



D-D

SECTIONS
SCALE



NOTE:
REFER TO DRAWING 1 FOR PLAN AND SECTION A-A.

LEGEND

	Borehole
	Dynamic Cone Penetration Test (Cone)
	Borehole & Cone
N	Blows/0.3m (Std. Pen Test, 475 J / blow)
CONE	Blows/0.3m (60° Cone, 475 J / blow)
	W.L. at time of investigation Apr 2004
	Head
	ARTESIAN WATER
	Encountered
	PIEZOMETER

BH No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
(Refer to drawing 1 for co-ordinates)			

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No.			
HWY No	69	DIST	54
SUBMIT	GD	CHECKED	GD
DATE	JULY 19, 2004	SITE	46-491
DRAWN	MM	CHECKED	MM
DATE		DWG	2

REF No E-SECORD-GA.dwg; June 2004
1_bp106.dwg; October 2002
Hwy69-S-des.dwg; February 2004



FOUNDATION DESIGN REPORT

for

**SECORD ROAD UNDERPASS
HIGHWAY 69, SITE 46-491
WP 5042-00-01
TOWNSHIP OF BURWASH
DISTRICT 54, SUDBURY**

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PML Ref.: 03TF012A
Index No.: 114FDR 2004-09-30
Geocres No.: 41I-176
September 30, 2004



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Figure 1 - Abutment on Compacted Fill Showing Granular 'A' Core

Figure 2 - Rock Fill Drainage in Slope Flattened Areas

Peto MacCallum Ltd.

C O N S U L T I N G E N G I N E E R S

FOUNDATION DESIGN REPORT

for

Secord Road Underpass

Highway 69, Site 46-491

WP 5042-00-01

Township of Burwash

District 54, Sudbury

1. INTRODUCTION

This report provides foundation engineering comments and recommendations regarding design and construction of foundations, abutments and approaches for the proposed underpass to be located at Secord Road and Highway 69 some 15 km south of Sudbury, Ontario. The investigation was conducted for Totten Sims Hubicki Associates (TSH) on behalf of the Ontario Ministry of Transportation (MTO).

Secord Road will pass over Highway 69 at approximate Station 15+020, centreline of Highway 69 chainage, and Station 10+000, centreline of Secord Road. The proposed underpass will be a two span CPCI 1900 precast concrete girder and deck structure with a span length of 39.5 m and width of about 21.4 m (ref. Drawing 1 'Hwy 69 – Secord Road Underpass. Preliminary General Arrangement' prepared by TSH in December 2003).

The road grade on Highway 69 at the underpass location is planned to be at elevation 251.1 and therefore will be cut 3 to 5 m into bedrock. The Secord Road grade will be near elevation 259.3 at the west abutment and 258.4 at the east abutment. The approach embankments to the structure are envisaged to be some 4 m high (interpolated from ground surface elevations at borehole locations and the road grade shown on the TSH drawing referred to above).

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised a surficial fill or peat deposit mantling shallow bedrock. Bedrock was exposed at four borehole locations, confirmed by rock coring in 9 boreholes and inferred in the remaining boreholes at depths of 0.1 to 1.1 m (elevation 253.2 to 256.1).



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

LOCATION	BOREHOLE No.	DEPTH TO ROCK (m)	BEDROCK ELEVATION
West Approach	491-1	0.5	254.7
West Abutment	491-2	0.6*	254.3
	491-3	0.3	254.9
	491-4	0.1	256.0
	491-5	0.2	254.9
	491-6	0.2*	255.0
	491-7	0.3	255.4
	491-8	0.0	255.1
	491-9	0.1	255.2
	491-10	0.1*	256.1
Central Pier	491-11	0.7*	255.2
	491-12	0.1	255.5
	491-13	0.0	255.9
	491-14	0.3	255.4
	491-15	0.6*	254.8
	491-16	0.3	255.2
	491-17	0.2	255.2
	491-18	0.3	255.0
	491-19	0.4*	255.4
East Abutment	491-20	0.5*	253.7
	491-21	0.8	253.7
	491-22	0.3	253.9
	491-23	0.0	254.0
	491-24	1.1*	253.3
	491-25	0.4	253.8
	491-26	0.0	254.2
	491-27	0.7	253.5
	491-28	0.8*	253.2
East Approach	491-29	0.3	253.6

* Confirmed by rock core



2. FOUNDATIONS

2.1 General

The seismic coefficient for the conditions at this site is 1.0 (soil profile Type I, CHBDC clause 4.4.6).

Since bedrock was exposed at the bridge site and the soil cover at the borehole locations is less than 1 m, it is considered that liquefaction of the soil and rock is unlikely to occur (refer to clause 4.6.2 of the Canadian Highway Bridge Design Code (CHBDC), CAN/CSA-S6-00).

2.2 Piles

The bedrock surface is within 3 to 5 m of the proposed road grade and the soil cover on the bedrock is typically 0 to 500 mm. Consequently, use of steel H-piles to support the foundation loads does not appear to be practical. Similarly, construction of integral abutments supported by steel H-piles is not feasible at this site unless a trench is excavated in the bedrock to provide the length of piles required for integral abutments (ideally 6 m). Further comments in this regard can be provided if required.

2.3 Spread Footings

2.3.1 General

Supporting the underpass structure on conventional spread footings founded on either bedrock or structural fill placed directly on bedrock is considered to be feasible.

All footings subject to frost action should be provided with the normal 1.7 m of earth cover or equivalent thermal insulation. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover. Footings bearing directly on bedrock do not require protection from frost.



Construction of the footings should be performed and monitored in accordance with SP 902S01 (December 2001) to verify the competency of the founding surface. In addition, a rock engineering specialist should be retained to examine the integrity and/or impact on bedrock below the footings should blasting be required near the structure foundations.

2.3.2 Footings Constructed on Bedrock

Footings bearing on the sound bedrock should be designed using a factored bearing resistance at ULS of 10,000 kPa. Considering the bedrock to be non-yielding, the design will not be governed by settlement criteria since the loading required to produce 25 mm deformation is much larger than the factored capacity at ULS. The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC.

The anticipated depths/elevations to bedrock at this site are indicated in the table provided in the previous section. The bedrock surface elevation ranges from 254.3 to 256.1 at the west abutment, 254.8 to 255.9 at the centre pier and 253.2 to 254.2 at the east abutment. Mass concrete could be placed to provide a level founding surface for the footings. Alternatively, the rock surface could be "stepped" to follow variations in the bedrock surface elevation thereby creating a level subgrade by a combination of rock excavation and placement of mass concrete.

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

Subject to these comments, the bearing resistance provided for footings bearing on bedrock is considered to be appropriate for mass concrete with an unconfined compressive strength of at least 35 MPa.

Comments concerning excavation of bedrock to enable construction of the footings are provided in subsequent sections of the report.



The horizontal force imposed on the foundations will be resisted in part by the friction force developed between the underside of the footing and the bedrock. If the footings are poured directly on the surface of the bedrock (bedrock surface not roughened by excavation/construction activities), an unfactored friction factor of 0.6 should be employed since this bedrock surface is relatively smooth, presumably as a result of weathering and/or glaciation. If excavation of the bedrock is required, an unfactored friction factor of 0.7 could be used.

The lateral resistance of footings founded on bedrock could be increased by means of a shear key and/or by installing dowels/anchors into the bedrock (SP 999S26, December 2002). The increased lateral resistance will be provided by the shear strength of steel dowels if used, the horizontal resistance of the bedrock, the horizontal component of tensile forces developed in any inclined anchors and/or a greater frictional resistance between the footing and rock if the anchors are prestressed to increase the vertical pressure. The factored horizontal resistance at ULS of the bedrock is considered to be 5000 kPa.

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

If anchors are installed, a factored bond stress at the rock/grout interface of 1.4 MPa at ULS (a resistance factor of 0.4 is applied for a minimum 35 MPa grout) is recommended for design. The anchors should extend a minimum 30 bar diameters into sound bedrock and be spaced at a distance of at least four times the diameter of the anchor hole. The total capacity of a group of closely spaced anchors may be less than the summed capacities of the individual anchors; the impact of anchor interaction should be assessed if the spacing is less than one-fifth of the anchor length. Design, installation and testing of the anchors subjected to tensile stresses should be conducted in accordance with SP 999S26 dated December 2002 and clause 6.10.4 of the CHBDC.

2.3.3 Footings Constructed on Structural Fill

Footings constructed on structural fill placed in the approach embankments could also be employed to support the foundation loads. The structural fill should comprise OPSS Granular A material placed in maximum 200 mm thick lifts, compacted to 100% standard Proctor maximum dry density and extended laterally to a line inclined downwards at 45° to the horizontal originating at least 1 m from the top of the footing. This scheme is illustrated in Figure 1, appended.

Footings should not be constructed on rock fill. However, rock fill may be placed adjacent to the Granular 'A' core noted in Figure 1.

The recommended bearing resistance for 2.5 m wide footings constructed on structural fill (bearing resistance independent of fill thickness due to shallow bedrock at this site) is as follows:

$$\begin{aligned}\text{Factored Bearing Resistance at ULS} &= 900 \text{ kPa} \\ \text{Bearing Resistance at SLS} &= 350 \text{ kPa}\end{aligned}$$

The resistance at SLS normally allows for 25 mm of compression of the founding medium. Differential settlement is expected to be less than 75% of this value. A footing embedment depth of 1.7 m was assumed for computation of the ULS resistance.

The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC.

The horizontal force imposed on the foundations will be resisted in part by the friction force developed between the underside of the footing and the structural fill. An unfactored friction factor of 0.7 is recommended for footings on granular fill.



3. ABUTMENT WALLS

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

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

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

The seismic coefficient for the conditions at this site was provided in Section 2.1.

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

<u>PARAMETERS</u>	<u>GRANULAR A</u>	<u>GRANULAR B TYPE II</u>	<u>ROCK FILL</u>
Angle of Internal Friction, degrees	35	35	42
Unit weight, kN/m^3	22.8	22.8	18.0
Coefficient of Active Earth Pressure K_a	0.27	0.27	0.20
Coefficient of Earth Pressure At Rest K_o	0.43	0.43	0.33
Coefficient of Passive Earth Pressure K_p	3.69	3.69	5.04

The coefficient of earth pressure at-rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

A weeping tile system and/or weep holes should be installed to minimise the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly



designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

Backfilling adjacent to retaining structures should be carried out in conformance with Ontario Provincial Standards specifications for granular or rock backfill at abutments (OPSD 3501 and 3505).

Operation of compaction equipment adjacent to retaining structures should be restricted to limit the compaction pressure noted in clause 6.9.3 of the CHBDC. Refer to SP 105S10 dated March 2004 for additional information in this regard.

A retained soil system (RSS) could also be employed. A high performance, high appearance rated RSS wall should be employed.

The founding material is expected to comprise bedrock or granular engineered fill. The geotechnical parameters employed to design the RSS will be dependent upon the type of backfill required for internal stability of the proprietary system as well as the soil contiguous to the RSS system that will govern global stability, overturning and/or sliding of the base. The following parameters should be employed:

	<u>GRANULAR A</u>	<u>GRANULAR B</u>	<u>SILTY SAND/ SAND AND GRAVEL</u>
Friction Angle, degrees	35	35	32
Cohesion, kPa	0	0	0
Unit Weight, kN/m ³	22.8	22.8	19.5

The earth pressure coefficients provided previously are considered to be appropriate for the RSS wall. The bearing resistance recommended previously for footings founded on bedrock or structural fill is considered to be suitable for the RSS.



The horizontal force at the base of the RSS will be resisted in part by the friction force developed through the granular backfill or along the interface between the granular backfill and the founding soil, subject to site specific design details. An unfactored friction factor of 0.7 is considered to be appropriate for both situations at this site. The global stability should be assessed using the geotechnical parameters noted above. A design groundwater level of 500 mm above the weeping tile outlet should be used.

The RSS supplier should be responsible for specifying the type of backfill material employed, taking into consideration the engineering properties of the proprietary product, the design life of the structure, the pullout resistance required, drainage requirements and the predicted settlements noted in the section titled "Approach Embankments".

The supplier of the RSS should also be responsible for design of the structure (backfill, reinforcement, internal and external stability) and provide drawings to show pertinent information such as location, length, height, elevations, performance level, appearance etc.

4. APPROACH EMBANKMENTS

It is anticipated that the approach embankments will be constructed with earth borrow/granular materials or rock fill. Both the east and west approach fill embankments will be about 4 m high. Construction of the fill on the sand and/or bedrock that underlies a surficial deposit of peat is considered to be feasible.

The peat identified in boreholes 491-2 to 491-7, 491-9 and 491-10 to depths of 0.1 to 0.6 m (elevation 254.3 to 256.1) at the west abutment and in boreholes 491-20 and 491-22 to depths of 0.3 to 0.5 m (elevation 253.7 to 253.9) at the east abutment should be stripped prior to placement of the embankment fill.

The embankments should be constructed in accordance with OPSD 201.010, 201.020, 202.010 and OPSS 206 dated December 1993, amended by Special Provision (Draft dated June 20, 2001). The side slopes of the approach embankments should be inclined no steeper than 2 horizontal to 1 vertical for earth fill and 1.25 horizontal to 1 vertical for rock fill. The 2 m



wide mid-height berm called for in the Northeastern Region Pavement Design Practices and Guidelines for erosion control and slope maintenance purposes should not be necessary since the anticipated slope height is less than 6 m.

Where slope flattening is proposed, a drainage gap should be provided in accordance with OPSD 202.020. Where slopes are flattened to eliminate the need for a guide rail, a granular infilled drainage gap should be provided in accordance with Northeastern Region Pavement Design Practices and Guidelines as shown in Figure 2, appended. OPSS Granular B Type II should be used for the drainage gaps.

It is considered that the approach embankments constructed in accordance with these recommendations will be stable. Settlement of the embankment fill due to consolidation of the underlying native soil is computed to be less than 10 mm and completed within one month following placement of the fill.

Some settlement of the embankment fill surface, both during and following completion of construction, due to "consolidation" of the rockfill is likely to occur. The magnitude of total settlement is estimated to be 0.5% of the rockfill height (20 mm), 5 to 10 mm during construction (based on a 12 month construction period) and 5 to 15 mm during the ten year period following completion of construction.

Some settlement of the road surface adjacent to the abutments should also be expected due to "consolidation" of the backfill.

The backfill placed adjacent to the abutments will be about 4 m thick. The magnitude of "consolidation" of this fill will be dependent on the workmanship employed by the contractor and, if placed in 200 to 300 mm thick lifts compacted to 98% of standard Proctor maximum dry density in accordance with the requirements of SP902S01 amended December 2001 and OPSS 501 (Method A) dated February 1996, should be less than 10 mm.

Consequently, total settlement of the approach fill surface near the abutments should be less than 10 mm and be essentially complete within 2 to 4 months after placement of the fill.



The embankment platform width should be widened by 1 m if founded on bedrock and 2 m if founded on the native inorganic soil in accordance with the Northeastern Region Engineering Directive (NRE 98-200) dated October 28, 1998.

Earth fill slopes where employed should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 571 or 572 for time constraints and the type of seed and mulch required.

5. EXCAVATION AND GROUNDWATER CONTROL

Excavation for construction of the structure foundations if supported on spread footings founded on bedrock will extend through sandy soils to depths of up to 1.1 m. Excavation of the fill and native soils is expected to be relatively straightforward.

The soil at the site is classified as Type 3 soil according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Therefore, temporary cut slopes over the full depth of the excavation should be inclined at 45° to the horizontal. The need to excavate flatter sideslopes if excessively soft/wet materials or concentrated seepage zones are encountered locally should not be overlooked.

Excavation of bedrock will be more difficult and necessitate conventional rock excavation techniques such as blasting (OPSS 120, General Specification for the Use of Explosives, August 1994) and jack-hammering. The actual equipment required and method of excavation within the bedrock will be dependent upon the geometry of cut and relative depth of excavation into the bedrock. The need for preshearing and presplitting to overbreak should not be overlooked.

It is important that blasting/excavation of the rock is controlled to prevent fracturing and/or disturbance of the bedrock surface on which footings will be founded. In this regard, reduced charges to minimise overbreak should be considered. Any overblasting/overexcavation should be made the sole responsibility of the contractor and all loosened rock resulting from blasting operations is to be removed by mechanical means. A large excavator equipped with a tiger-



toothed bucket in conjunction with a jack-hammer or hoe ram is the preferred method of excavation to shallow depths in rock at foundation locations.

Mechanical means should be employed to excavate the loosened rock at the footing. Mass concrete could be employed to level minor variations in the bedrock surface.

Near vertical sidewalls may be utilised for excavations in bedrock. Examination of the sidewalls and removal of any loosened rock fragments should be carried out continually for the safety of workmen.

Groundwater was not observed in any of the boreholes during or upon completion of drilling. However, minor seepage should be anticipated locally at the soil/bedrock interface within depressions in the bedrock surface. It is anticipated that conventional sump pumping techniques will be sufficient to control seepage of groundwater into the excavations. Groundwater levels are subject to seasonal fluctuations and rainfall patterns.

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

6. CLOSURE

The report was prepared by Mr. Grigory O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. Dennis W. Kerr, MEng, P.Eng., Chief Foundation Engineer. Mr. Brian R. Gray, MEng, P.Eng., MTO Designated Contact, carried out an independent review of the report.

Yours very truly

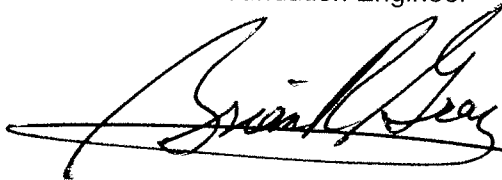
Peto MacCallum Ltd.



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



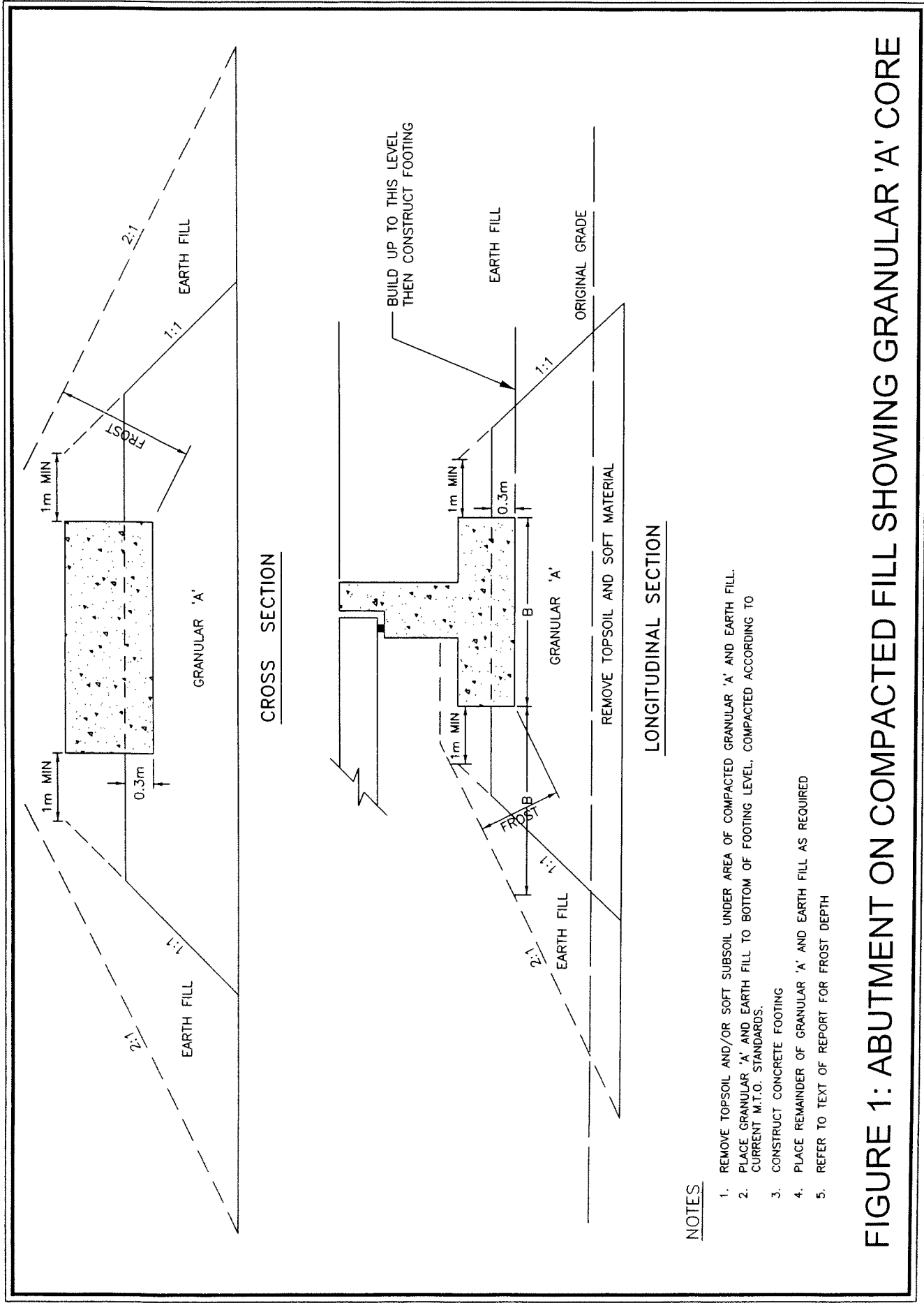
Dennis W. Kerr, MEng, P.Eng.
Chief Foundation Engineer

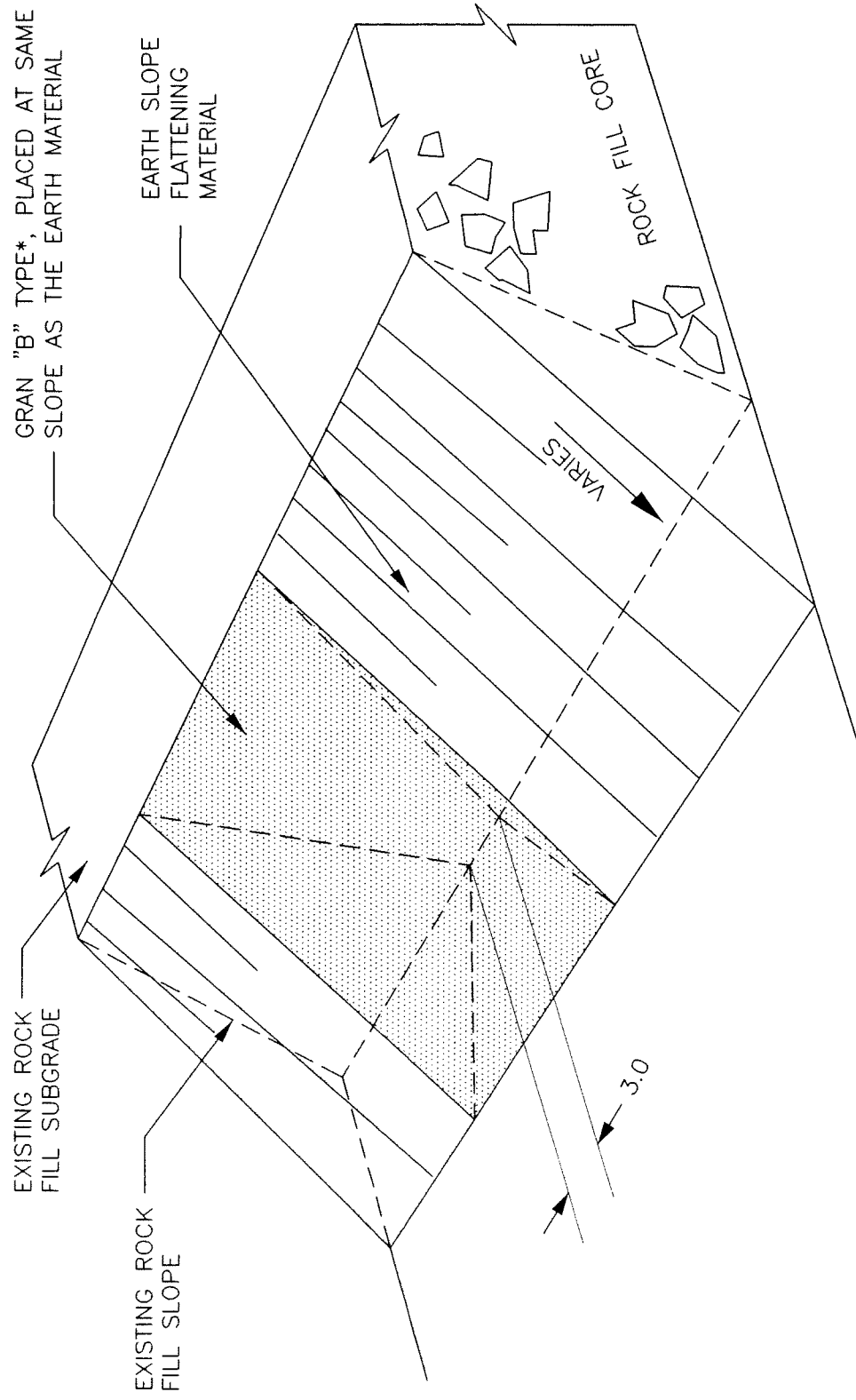


Brian R. Gray, MEng, P.Eng.
MTO Designated Contact



GD/DWK:gd-mm-mi





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

FIGURE 2: ROCK FILL DRAINAGE IN SLOPE FLATTENED AREAS

NOT TO SCALE