

# Foundation Investigation Report

## Culvert #48 Highway 101

Station 20+326 Township of Foleyet

GWP 5383-11-00

Geocres No.: 42B-10

### SUBMITTED TO:

Hatch Mott MacDonald  
200 South Syndicate  
Thunder Bay, Ontario  
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### SUBMITTED BY:

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### SUBMISSION DATE:

Mach 13, 2015



**TBT ENGINEERING**  
CONSULTING GROUP

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Appendix A, Borehole Logs  
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Appendix C, Borehole Locations, and Soil Strata Drawing

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## **Part A - FOUNDATION INVESTIGATION REPORT**

### **1 Introduction**

TBT Engineering Limited (TBTE) has been retained by Hatch Mott MacDonald (HMM) to provide foundation investigation and design services for the proposed culvert replacements on Highway 101 at four separate locations. These sites are a part of the Highway 101 Resurfacing, from 0.3 km west of Young Street in Foleyet, easterly for 20.9 km, to 0.7 km east of Horwood Lake Road. The foundation investigations were conducted to provide subsurface data for the proposed culvert replacements.

This report addresses the conditions for Culvert #48 located at Sta. 20+326 in the Township of Muskego. The remaining foundation sites (Culvert 17, Culvert 21 and Culvert 34) are addressed under separate covers.

This investigation consisted of two midpoint boreholes drilled adjacent to the existing culvert, two boreholes drilled for roadway protection, two boreholes drilled at the culvert openings, laboratory testing and geotechnical analysis of the data. This report (Part A) describes the subsurface conditions encountered during the investigation. The boreholes are labeled from 100 to 105.

The foundation section has assigned GEOCRES No. 42B-10 to this site.

## 2 Site Description

The foundation investigations were carried out to investigate subsurface conditions for Culvert #48 located at Sta. 20+326 along Hwy 101 in the Township of Muskego, in the county of New Liskeard Area. The culvert located at this site is an 800 mm centreline CSP which is in poor condition. The culvert services an unnamed water course.

The culvert site is located in a rural area of moderate terrain relief. The area is generally tree covered and bedrock outcrops are common.

The road embankment at this location is approximately 3.5 m high with side slopes of approximately 2 horizontal to 1 vertical on both the right and left side. To the left side of Hwy 101 at the culvert location there is a low lying swamp area draining through the culvert to the right side of the highway. There is a bedrock outcrop westerly on the right side of the highway. The water level in the water course at the culvert inlet was measured approximately 150 mm above the invert, (approx. elevation of 335.0) on July 16, 2013.



Site Photo 1 . Looking Westerly from Culvert

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## **2.1 Surficial Geology**

Available surficial geology mapping (OGS NOEGTS Map 5102 . Foleyet) indicates the site is located in a terrain unit comprised of bedrock knob with a subordinate landform of sand and boulder till ground moraine. The surrounding terrain is of moderate local relief which is rolling to undulating.

## **3 Investigation Procedures**

A geotechnical site investigation was undertaken from August 9 to the 21, 2013. The borehole locations are illustrated on the Borehole Location and Soil Strata Drawings found in Appendix D.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using an all terrain mounted drill rig equipped with hollow stem augers and a cat head used to carry out Standard Penetration Testing (SPT). Where auger drilling methods proved unsatisfactory, casing was advanced using wash boring techniques. Soil samples were obtained from the auger flights and using a split spoon sampler as a part of the Standard Penetration Testing . Refusal material was sampled using diamond coring techniques.

Surveys were completed by HMM and were based on North American Datum 1983, MTM CSRS Zone 12. HMM has indicated control was established from existing published Horizontal Control Monuments and a Geodetic Benchmark using the Canadian Geodetic Vertical Datum 1928. The following horizontal control points and vertical control points were utilized throughout this project (as provided by HMM):

- HCM #00820020065, #00820020066, #00820020067, #00820020068, #00820020071, #00820020072 and #00820020073
- VCM (GBM) #00819728231 Elev. 329.411, #00819728232 Elev. 328.108, #00819728233 Elev. 343.051, #00819728235 Elev. 345.516, #00819728236 Elev. 349.557 and #00819728239 Elev. 336.635

All boreholes were backfilled with a bentonite mixture following drilling. Temporary standpipes have been removed and decommissioned.

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## **4 Laboratory Testing**

Samples which were obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content, Atterberg limits and grain size analysis (where appropriate). The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

## **5 Sub-Surface Conditions**

Details of the subsurface conditions are provided on the borehole and core logs (Appendix A) and on the Soil Strata Drawing (Appendix D).

The subsurface soils at this site typically consist of fills through the embankment which overlie sand over bedrock. Clay was encountered within one borehole. Numerous cobbles and boulders were present within the fill materials, and occasional cobbles and boulders within the sand. All boreholes extended to practical refusal (100+ blows/0.3 m) and refusal material was drilled and/or sampled using diamond casing/coring techniques.

### **5.1 Asphalt**

Asphalt was encountered at the embankment surface at Boreholes 100, 101, 102, and 103. The asphalt's thickness ranges from 45 to 55 mm.

### **5.2 Organic Matter**

Organic matter was encountered at the ground surface of Borehole 104. The material has a thickness of 0.3 m. Based on a single sample the natural moisture content of this material is 107 %.

### **5.3 Fill - Sand**

Sand fill was encountered beneath the asphalt at Boreholes 100, 101, 102, and 103. The sand fill was encountered at elevation 337.8 to 338.8 and varied in thicknesses from 0.6 to 1.4 m. Four samples were selected for grain size distribution testing. The fill ranges from silty sand with trace gravel to gravelly sand with some silt. The test results indicate a grain size distribution of 7 to 26 % gravel, 60 to 76 % sand, and 10 to 22 % silt/clay sized particles. The sand is compact to dense as indicated by  $N_{60}$  values ranging from 11 to 40 blows/0.3 m.



#### **5.4 Fill – Sand and Gravel with Cobbles and Occasional Boulders**

Inferred sand and gravel with numerous cobbles and occasional boulders was encountered beneath the sand fill at Boreholes 100, 101, 102, and 103. Boulders were identified in Borehole 103. Auger refusal was met at the interface between the two fill materials and the boreholes were advanced using wash boring techniques. Recovery of sample material from SPT testing proved difficult due to the presence of numerous cobbles and boulders and the matrix material was determined through observations of the wash water. The coarse fill was encountered at elevation 336.4 to 337.5 and varied in thicknesses from 1.9 to 2.6 m. The material is very dense as indicated by  $N_{60}$  values of 100+ blows/0.3 m, which were mainly noted to be on cobbles/boulders. At Boreholes 100 and 103 at depths of 1.7 and 1.3 m respectively,  $N_{60}$  values of 5 and 4 blows/0.3 m respectively, were recorded, indicating the sand and gravel matrix material is loose.

#### **5.5 Sand**

Gravelly sand with trace silt to silty sand was encountered beneath the fill at Boreholes 100, 101, 102, 103, beneath the organic matter at Borehole 104 and at ground surface at Borehole 105. The sand was encountered at elevation 333.8 to 336.0 and varied in thicknesses from 1.0 to 4.2 m. Five samples were selected for grain size distribution testing. The test results indicate a grain size distribution of 0 to 29 % gravel, 58 to 80 % sand, and 9 to 32 % silt/clay sized particles. Occasional cobbles were noted within this stratum. The sand is typically very loose to compact as indicated by  $N_{60}$  values ranging from 1 to 12 blows/0.3 m. At Borehole 101 at a depth of 4.0 m, an  $N_{60}$  value of 43 blows/0.3 m was recorded.

#### **5.6 Clay**

Silty clay with sand was encountered beneath the sand at Borehole 100. The silty clay was encountered at an elevation of 333.1 with a thickness of 1.0 m. Based on a single Atterberg Limit test, the silty clay has a natural moisture content approaching the plastic limit. The clay is stiff as indicated by an  $N_{60}$  value of 12 blows/0.3 m.

#### **5.7 Bedrock**

Bedrock was encountered at all borehole locations. The following table indicates the recorded bedrock elevation and depth at each borehole. Bedrock was encountered underlying the silty clay at Borehole 100 and beneath the sand at all remaining boreholes. Bedrock was sampled using diamond coring techniques. The bedrock is

medium grained biotite granite. Detailed core logs and photos of the rock cores are provided in Appendix A.

**Table 5.1: Bedrock**

Borehole Number	Bedrock Depth (m)	Bedrock Elevation
100	6.2	332.1
101	5.0	332.8
102	4.6	333.5
103	5.4	333.4
104	4.5	330.9
105	3.5	332.5

The rock quality designation (RQD) is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths (greater than 100 mm) to the total length cored. The RQD index is used to provide a classification for the rock quality according to the following limits.

**Table 5.2: RQD/ Rock Quality Correlation**

RQD %	ROCK QUALITY
0 . 25	Very Poor
25 . 50	Poor
50 . 75	Fair
75 . 90	Good
90 . 100	Excellent

The RQD as presented on the borehole and core logs varies from 47 to 100 %. The majority of RQDs were measured to be 71 to 100 % and can be described as fair to excellent, with one sample with an RQD of 47 % indicating poor quality at Borehole 104.

In order to classify the bedrock with respect to strength, point load tests were conducted on selected core samples. The test results are tabulated below.



**Table 5.3: Estimated Uniaxial Compressive Strength**

Borehole Number	Depth (m)	Elevation	*Estimated Uniaxial Compressive Strength (MPa)
100	6.50	331.8	591
	8.30	330.0	271
	9.10	329.2	411
101	5.70	332.1	214
	7.00	330.8	240
	7.40	330.4	192
102	5.30	332.8	209
	6.50	331.6	220
	7.70	330.4	286
103	5.80	333.0	240
	7.30	331.5	251
	9.70	329.1	207
104	4.50	330.9	276
	5.60	329.8	269
	7.30	328.1	296
105	3.50	332.5	207
	5.70	330.3	251
	6.60	329.4	253

\* Estimated based on published correlations.

Based on the range in estimated uniaxial compressive strength, the intact bedrock is classified as very strong to extremely strong.

## 5.8 Ground Water

The ground water levels were observed upon completion of drilling from August 9 to 21, 2013 at and are provided below. Ground water levels will vary from season to season and from the effects of heavy precipitation events. The water level in the culvert was at elevation 335.0 on July 16, 2013.

**Table 5.4: Ground Water Level**

Borehole	Depth below Ground Surface (m)	Elevation
100	3.0	335.3
101	2.8	335.0
103	3.0	335.8
105	0.6	334.9

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## **6 Miscellaneous**

Laboratory testing was carried out at the TBT Engineering Limited laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering. The field operations were supervised by Alan Finke and Peter Pilgrim. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by Steven Seller, P.Eng, and reviewed by W. Hurley, P.Eng (TBTE designated principal contact identified for MTO Foundation Engineering projects).

## **7 Limitations**

Conclusions and recommendations presented in this report are based on the information determined at the borehole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

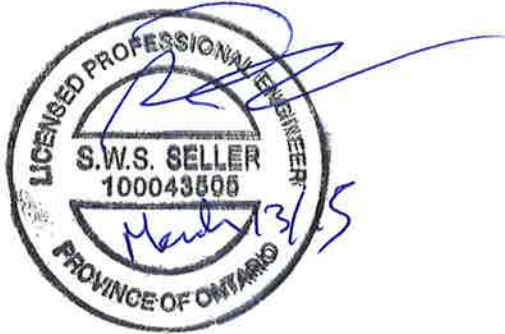
The information contained within this report in no way reflects any environmental aspect of the site or soil.

## 8 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,

For TBT ENGINEERING



Steven Seller, P.Eng  
Project Engineer



Wayne Hurley, P.Eng.  
Senior Engineer  
Principal Contact for MTO Foundations

## **APPENDIX A**

### **Borehole Logs**

## 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 (RQD), FOR MODIFIED RECOVERY, IS:

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

**JOINTING AND BEDDING:**

	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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

TBT Engineering Consulting Group			RECORD OF Borehole No 100			1 OF 1			METRIC											
W.P. <b>5383-11-00</b>			PROJECT <b>Culvert Investigation</b>			SITE NO. <b>Culvert #48</b>			ORIGINATED BY <b>A.F.</b>											
TWP <b>Muskego</b> HWY <b>101</b>			LOCATION <b>MTM 12 N5341962.109, E208910.306</b>			TBTE JOB# <b>13-121</b>			COMPILED BY <b>T.B.</b>											
DATE <b>2013 August 9</b>			BOREHOLE TYPE <b>Hollow Stem Auger/B Casing</b>			DATUM <b>Geodetic</b>			CHECKED BY <b>S.S.</b>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ			GR SA SI CL			
338.7	ASPHALT - 45 mm		1	AS			338	○ UNCONFINED    ✕ FIELD VANE			W <sub>p</sub> W    W <sub>L</sub>			kN/m <sup>3</sup>			7 76 (16)			
337.7	FILL - SAND - some silt, trace gravel, brown		2	SS	100+		337	■ SPT (N)    ★ LAB VANE			20 40 60 80 100						Auger Refusal @ 0.9 m. Advanced with B Casing.			
335.7	FILL - SAND & GRAVEL - numerous cobbles, loose to very dense (inferred)		3	SS	5		336													
333.5	SAND - some silt, brown, very loose to loose		4	SS	3		335										Water level @ 3.0 m on completion.			
332.5			5	SS	4		334										0 80 (20)			
333.5	CLAY - Silty, some sand, trace gravel, stiff		6	SS	9		333										1 16 57 27			
332.5			7	SS	12		332										RC # 1 REC = 100% RQD = 87%			
329.3	BEDROCK - Biotite Granite: Medium grained, weakly foliated/lineated, white		8	SS	100+		331										RC # 2 REC = 90% RQD = 71%			
329.3			1	RC			330										RC # 3 REC = 93% RQD = 93%			
329.3			2	RC																
329.3	End of Borehole @ 9.4 m.		3	RC																

ONL\_MOT\_BH\_MTM 13-121 CULVERT 48.GPJ ONL\_MOT\_GDT 15/3/13

✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity  
NP Non Plastic  
○ 3% STRAIN AT FAILURE



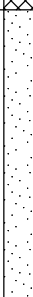



<b>TBT Engineering Consulting Group</b>		<b>RECORD OF Borehole No 101</b>		1 OF 1	<b>METRIC</b>
W.P. <b>5383-11-00</b>	PROJECT <b>Culvert Investigation</b>	SITE NO. <b>Culvert #48</b>	ORIGINATED BY <b>A.F.</b>		
TWP <b>Muskego</b> HWY <b>101</b>	LOCATION <b>MTM 12 N5341945.036, E208928.283</b>	TBTE JOB# <b>13-121</b>	COMPILED BY <b>T.B.</b>		
DATE <b>2013 August 9</b>	BOREHOLE TYPE <b>Hollow Stem Auger/B Casing</b>	DATUM <b>Geodetic</b>	CHECKED BY <b>S.S.</b>		

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
337.8 338.4	ASPHALT - 55 mm FILL - SAND - some silt, trace gravel, brown, dense		1	AS										GR SA SI CL
			2	SS	40									6 74 (20)
336.4 1.4	FILL - SAND & GRAVEL - numerous cobbles, very dense (inferred)		3	SS	100+									Auger Refusal @ 1.3 m. Advance with B Casing.
			4	SS	100+									On cobbles.
333.8 4.0	SAND - Gravelly, trace silt, grey, dense		5	SS	43								29 63 (9)	
332.8 5.0	BEDROCK - Biotite Granite: Medium grained, weakly foliated/lineated, white		6	SS	100+									RC # 1 REC = 96% RQD = 96%
			1	RC									RC # 2 REC = 93% RQD = 93%	
			2	RC										
			3	RC										RC # 3 REC = 100% RQD = 100%
329.5 8.3	End of Borehole @ 8.3 m.													

ONL\_MOT\_BH\_MTM 13-121 CULVERT 48.GPJ ONL\_MOT\_GDT 15/3/13

<b>TBT Engineering Consulting Group</b>		<b>RECORD OF Borehole No 102</b>		1 OF 1	<b>METRIC</b>
W.P. <b>5383-11-00</b>	PROJECT <b>Culvert Investigation</b>	SITE NO. <b>Culvert #48</b>	ORIGINATED BY <b>A.F.</b>		
TWP <b>Muskego</b> HWY <b>101</b>	LOCATION <b>MTM 12 N5341951.001, E208912.543</b>	TBTE JOB# <b>13-121</b>	COMPILED BY <b>T.B.</b>		
DATE <b>2013 August 9</b>	BOREHOLE TYPE <b>Hollow Stem Auger/B Casing</b>	DATUM <b>Geodetic</b>	CHECKED BY <b>S.S.</b>		

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
338.3	ASPHALT - 50 mm														
338.4	FILL - SAND - trace gravel, trace silt, brown		1	AS											
337.7	FILL - SAND & GRAVEL - numerous cobbles (inferred)														
0.6															
335.8	SAND - Silty, trace gravel, brown, loose to compact														
2.5			2	SS	7										
			3	SS	12										
333.7	BEDROCK - Biotite Granite: Medium grained, weakly foliated/lineated, white														
4.6			1	RC											
			2	RC											
330.5	End of Borehole @ 7.8 m.														
7.8															

ONL\_MOT\_BH\_MTM 13-121 CULVERT 48.GPJ ONL\_MOT\_GDT 15/3/13

TBT Engineering Consulting Group			RECORD OF Borehole No 103			1 OF 1			METRIC														
W.P. <b>5383-11-00</b>			PROJECT <b>Culvert Investigation</b>			SITE NO. <b>Culvert #48</b>			ORIGINATED BY <b>P.P.</b>														
TWP <b>Muskego</b> HWY <b>101</b>			LOCATION <b>MTM 12 N5341967.979, E208894.559</b>			TBTE JOB# <b>13-121</b>			COMPILED BY <b>T.B.</b>														
DATE <b>2013 August 20</b>			BOREHOLE TYPE <b>Hollow Stem Auger/B Casing</b>			DATUM <b>Geodetic</b>			CHECKED BY <b>S.S.</b>														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	γ	GR SA SI CL								
339.4	ASPHALT - 45 mm		1	AS					339														
338.9	FILL - SAND - Gravelly, trace silt, brown, compact		2	SS	11				338						26 64 (10)								
338.1	FILL - SAND & GRAVEL - numerous cobbles & boulders, loose to very dense (inferred)		3	SS	4				338						18 60 (22)								
1.3			4	SS	100+				337						Auger Refusal @ 1.2 m. Advanced B Casing.								
	- boulder		5	SS	100+				336														
335.6	SAND - some gravel, some silt, occasional cobbles, brown, loose		6	SS	7				335														
334.0	BEDROCK - Biotite Granite: Medium grained, spaced/weak biotite foliation, light to dark in colour		1	RC					334						RC # 1 REC = 100% RQD = 86%								
5.4	- light to dark in colour with zones of pink/red		2	RC					333						RC # 2 REC = 100% RQD = 100%								
	- light to dark in colour with zones of pink/red that intensify closer to a coarse grained (pegmatitic) zone		3	RC					332						RC # 3 REC = 71% RQD = 71%								
329.2	End of Borehole @ 10.2 m.								330														

ONL\_MOT\_BH\_MTM 13-121 CULVERT 48.GPJ ONL\_MOT\_GDT 15/3/13

x<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity  
 NP Non Plastic  
 ○ 3% STRAIN AT FAILURE

TBT Engineering Consulting Group		<b>RECORD OF Borehole No 104</b>		1 OF 1		<b>METRIC</b>	
W.P. <b>5383-11-00</b>		PROJECT <b>Culvert Investigation</b>		SITE NO. <b>Culvert #48</b>		ORIGINATED BY <b>P.P.</b>	
TWP <b>Muskego</b> HWY <b>101</b>		LOCATION <b>MTM 12 N5341944.958, E208905.722</b>		TBTE JOB# <b>13-121</b>		COMPILED BY <b>T.B.</b>	
DATE <b>2013 August 14</b>		BOREHOLE TYPE <b>Hollow Stem Auger/B Casing</b>		DATUM <b>Geodetic</b>		CHECKED BY <b>S.S.</b>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
								○ UNCONFINED ■ SPT (N)	✕ FIELD VANE ★ LAB VANE		W <sub>p</sub>	W	W <sub>L</sub>		
335.4 0.0	ORGANIC MATTER - 300 mm		1	AS									106.9	Advanced with B casing @ 0.6 m.	
335.1 0.3	SAND & GRAVEL - numerous cobbles & boulders		2	SS	100+			>>■							
	----- - cobbles														
	----- - boulders														
330.9 4.5	BEDROCK - Biotite Granite: Medium grained, weakly foliated/lineated, white		1	RC										RC # 1 REC = 100% RQD = 92%	
			2	RC											RC # 2 REC = 100% RQD = 46.8%
327.8 7.6	End of Borehole @ 7.6 m.														

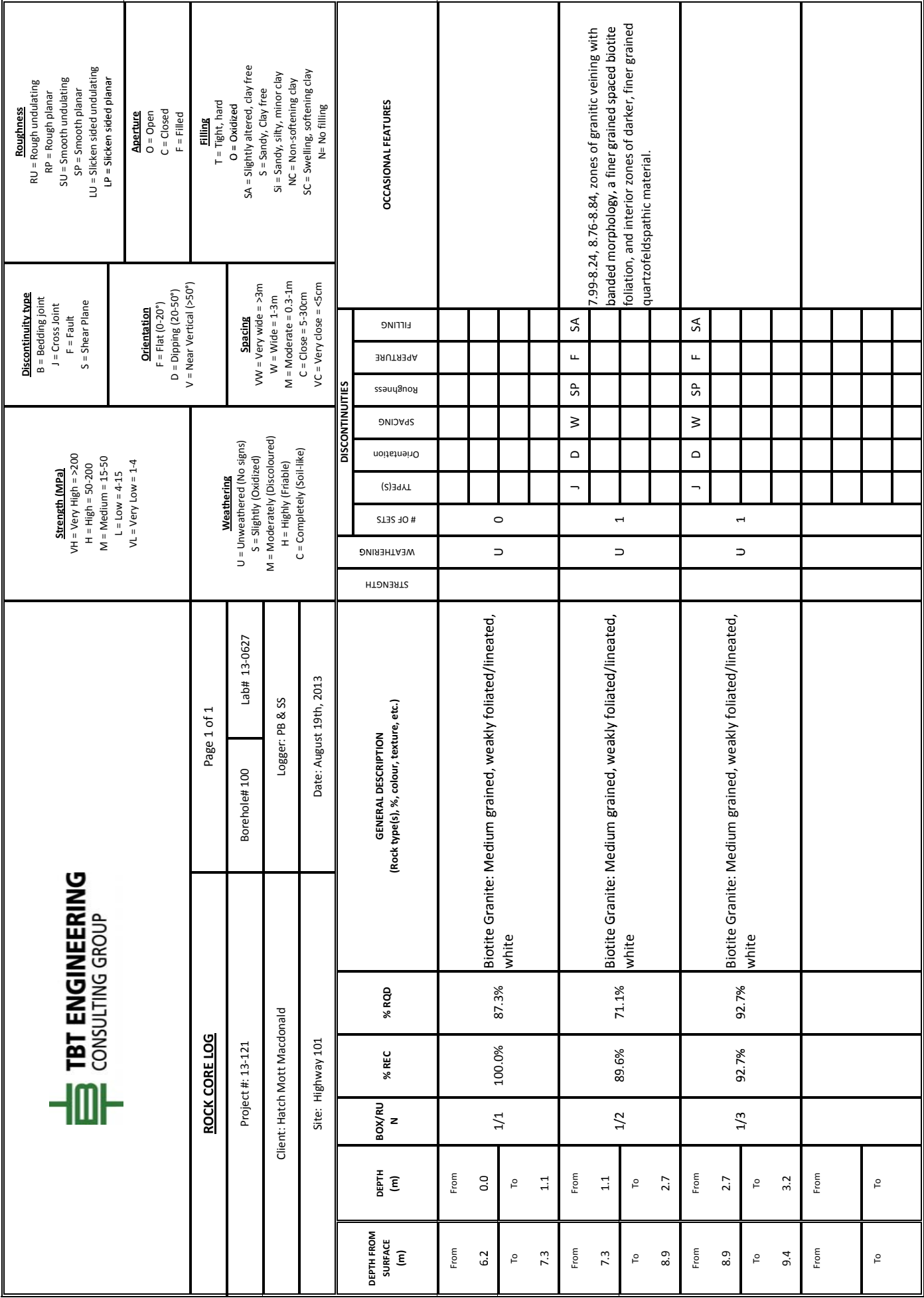
ONL\_MOT\_BH\_MTM 13-121 CULVERT 48.GPJ ONL\_MOT\_GDT 15/3/13

<b>TBT Engineering Consulting Group</b>		<b>RECORD OF Borehole No 105</b>		1 OF 1	<b>METRIC</b>
W.P. <b>5383-11-00</b>	PROJECT <b>Culvert Investigation</b>	SITE NO. <b>Culvert #48</b>	ORIGINATED BY <b>P.P.</b>		
TWP <b>Muskego</b> HWY <b>101</b>	LOCATION <b>MTM 12 N5341967.148, E208923.154</b>	TBTE JOB# <b>13-121</b>	COMPILED BY <b>T.B.</b>		
DATE <b>2013 August 21</b>	BOREHOLE TYPE <b>Hollow Stem Auger/B Casing</b>	DATUM <b>Geodetic</b>	CHECKED BY <b>S.S.</b>		

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED ■ SPT (N)	✕ FIELD VANE ★ LAB VANE		W <sub>p</sub>	W	W <sub>L</sub>			
335.5 0.0	SAND - trace silt to Silty, some gravel, occasional cobbles, compact, brown  ----- - grey  ----- - trace organics, brown		1	AS										18 74 (9)  Water level @ 0.6 m on completion.  11 58 (32)     Temporary Standpipe installed to 3.0 m.  RC # 1 REC = 100% RQD = 100% Advanced with B Casing.  RC # 2 REC = 100% RQD = 97%		
332.0 3.5	BEDROCK - Biotite Granite: Medium grained, spaced/weak biotite foliation, light to dark in colour with pink/red zones		1	RC												
			2	RC												
328.8 6.7	End of Borehole @ 6.7 m.															

✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity  
NP Non Plastic      ○ 3% STRAIN AT FAILURE

ONL\_MOT\_BH\_MTM 13-121 CULVERT 48.GPJ ONL\_MOT\_GDT 15/3/13





**ROCK CORE LOG**

Project #: 13-121

Client: Hatch Mott Macdonald

Site: Highway 101

Page 1 of 1

Borehole# 101

Lab# 13-0628

Logger: Patrick Belshaw

Date: August 19th, 2013

**Strength (MPa)**

VH = Very High = >200  
H = High = 50-200  
M = Medium = 15-50  
L = Low = 4-15  
VL = Very Low = 1-4

**Weathering**

U = Unweathered (No signs)  
S = Slightly (Oxidized)  
M = Moderately (Discoloured)  
H = Highly (Friable)  
C = Completely (Soil-like)

**Discontinuity type**

B = Bedding Joint  
J = Cross Joint  
F = Fault  
S = Shear Plane

**Orientation**

F = Flat (0-20°)  
D = Dipping (20-50°)  
V = Near Vertical (>50°)

**Spacing**

VW = Very wide = >3m  
W = Wide = 1-3m  
M = Moderate = 0.3-1m  
C = Close = <5cm  
VC = Very close = <5cm

**Roughness**

RU = Rough undulating  
RP = Rough planar  
SU = Smooth undulating  
SP = Smooth planar  
LU = Slickened undulating  
LP = Slickened planar

**Aperture**

O = Open  
C = Closed  
F = Filled

**Filling**

T = Tight, hard  
O = Oxidized  
SA = Slightly altered, clay free  
S = Sandy, Clay free  
SI = Sandy, silty, minor clay  
NC = Non-softening clay  
SC = Swelling, softening clay  
N = No filling

**OCCASIONAL FEATURES**

**DISCONTINUITIES**

**# OF SETS**

**WEATHERING**

**STRENGTH**

**TYPE(S)**

**Orientation**

**SPACING**

**Roughness**

**APERTURE**

**FILLING**

Biotite Granite: Medium grained, weakly foliated/lineated, white

95.9%

95.9%

1/1

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

Biotite Granite: Medium grained, weakly foliated/lineated, white

93.1%

93.1%

1/2

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

Biotite Granite: Medium grained, weakly foliated/lineated, white

100.0%

100.0%

1/3

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

From  
5.0  
To  
5.7

**ROCK CORE LOG**

Project #: 13-121

Client: Hatch Mott Macdonald

Site: Highway 101

Page 1 of 1

Borehole# 102

Lab# 13-0629

Logger: Patrick Belshaw

Date: August 19th, 2013

**Strength (MPa)**

VH = Very High = >200  
H = High = 50-200  
M = Medium = 15-50  
L = Low = 4-15  
VL = Very Low = 1-4

**Weathering**

U = Unweathered (No signs)  
S = Slightly (Oxidized)  
M = Moderately (Discoloured)  
H = Highly (Friable)  
C = Completely (Soil-like)

**Discontinuity type**

B = Bedding Joint  
J = Cross Joint  
F = Fault  
S = Shear Plane

**Orientation**

F = Flat (0-20°)  
D = Dipping (20-50°)  
V = Near Vertical (>50°)

**Spacing**

VW = Very wide = >3m  
W = Wide = 1-3m  
M = Moderate = 0.3-1m  
C = Close = 5-30cm  
VC = Very close = <5cm

**Roughness**

RU = Rough undulating  
RP = Rough planar  
SU = Smooth undulating  
SP = Smooth planar  
LU = Slickensided undulating  
LP = Slickensided planar

**Aperture**

O = Open  
C = Closed  
F = Filled

**Filling**

T = Tight, hard  
O = Oxidized  
SA = Slightly altered, clay free  
S = Sandy, Clay free  
SI = Sandy, silty, minor clay  
NC = Non-softening clay  
SC = Swelling, softening clay  
N = No filling

**OCCASIONAL FEATURES**

**DISCONTINUITIES**

# OF SETS

TYPE(S)

Orientation

SPACING

Roughness

APERTURE

FILLING

WEATHERING

STRENGTH

**GENERAL DESCRIPTION**  
(Rock type(s), %, colour, texture, etc.)

% RQD

% REC

BOX/RUN

DEPTH FROM SURFACE (m)

From

To

From

To

From

To

From

To

From

To

From

To

From

To

From

To

From

To

From

To

From

To

From

To

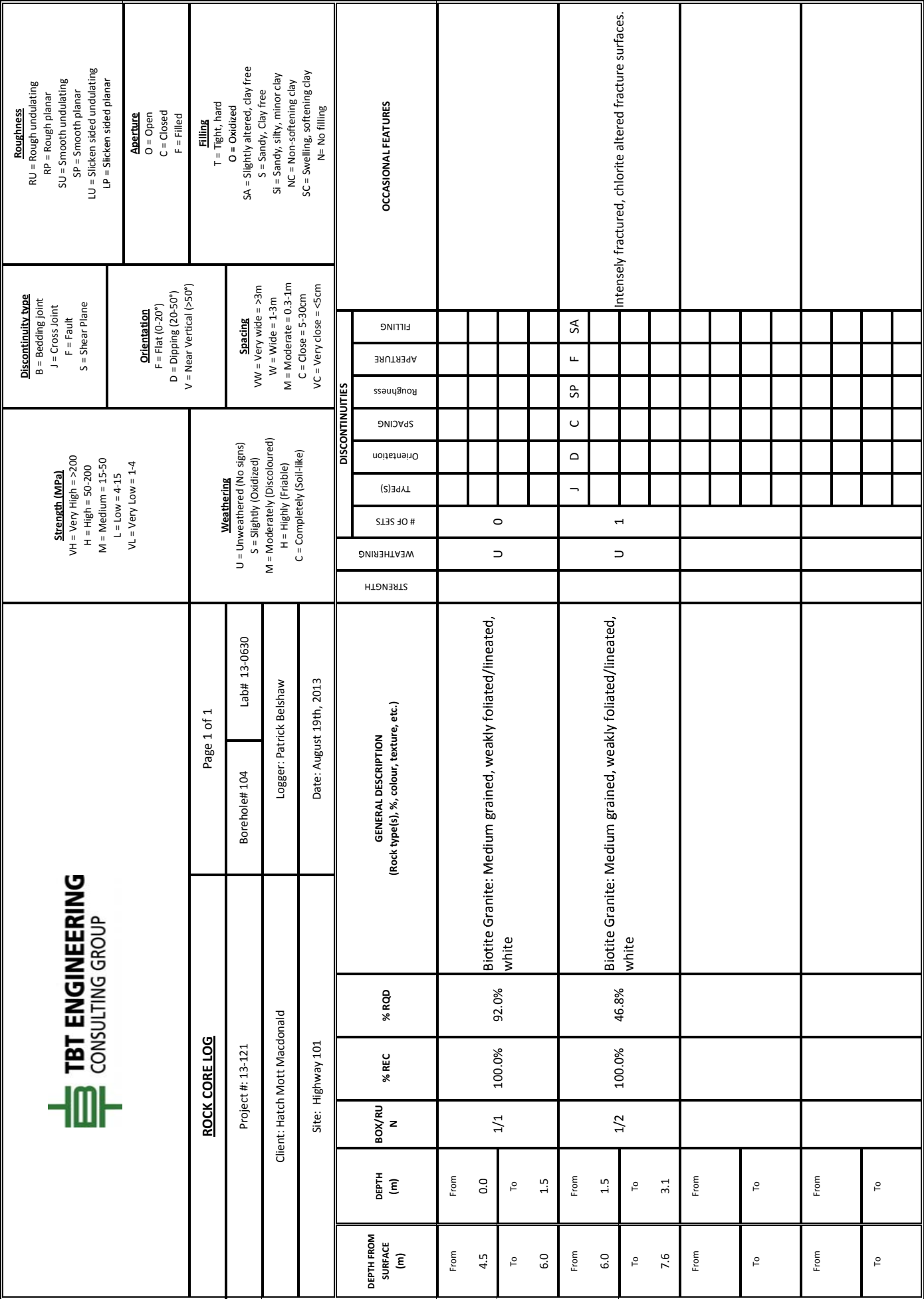
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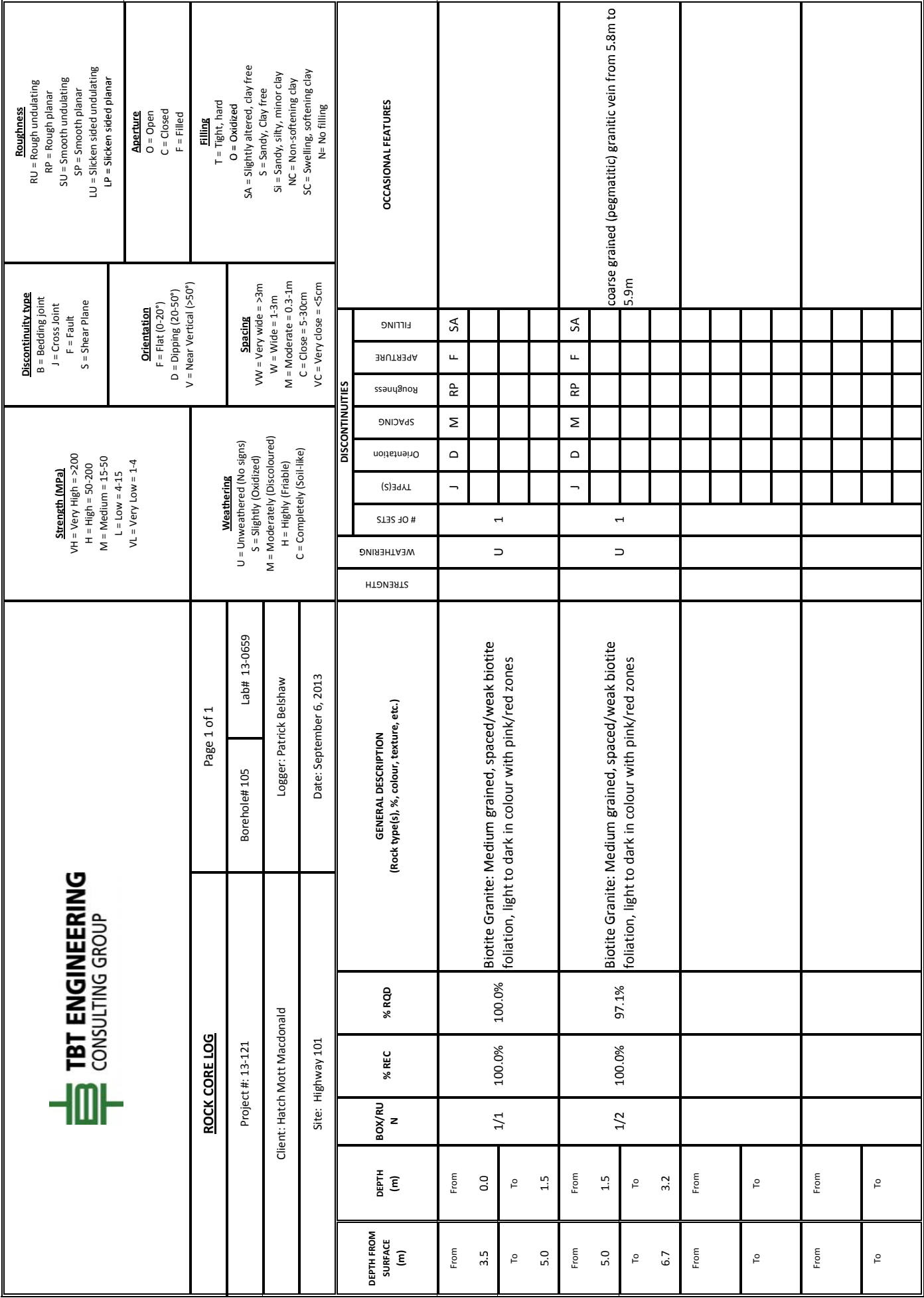
To

From

To



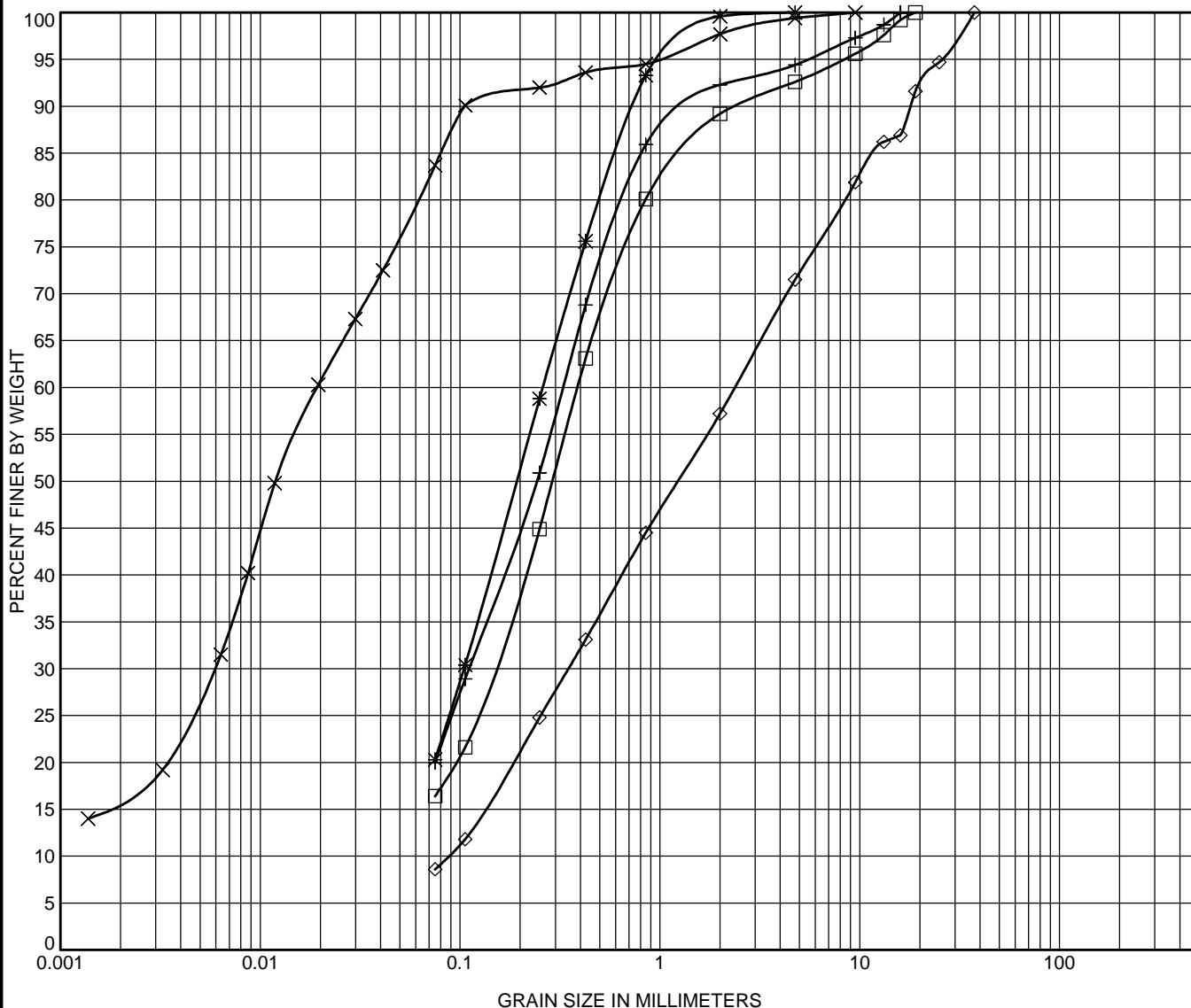




## **APPENDIX B**

### **Laboratory Test Data**





SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:  
SILT & SAND & GRAVEL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 100	0.40	19	0.388	0.144		7.4	76.2	16.4	
* 100	3.80	4.75	0.26	0.105		0.0	79.7	20.3	
× 100	5.30	9.5	0.019	0.006		0.6	15.7	83.7	
+ 101	0.75	16	0.327	0.111		5.6	74.4	20.0	
◇ 101	4.00	37.5	2.369	0.349	0.087	28.5	62.9	8.6	



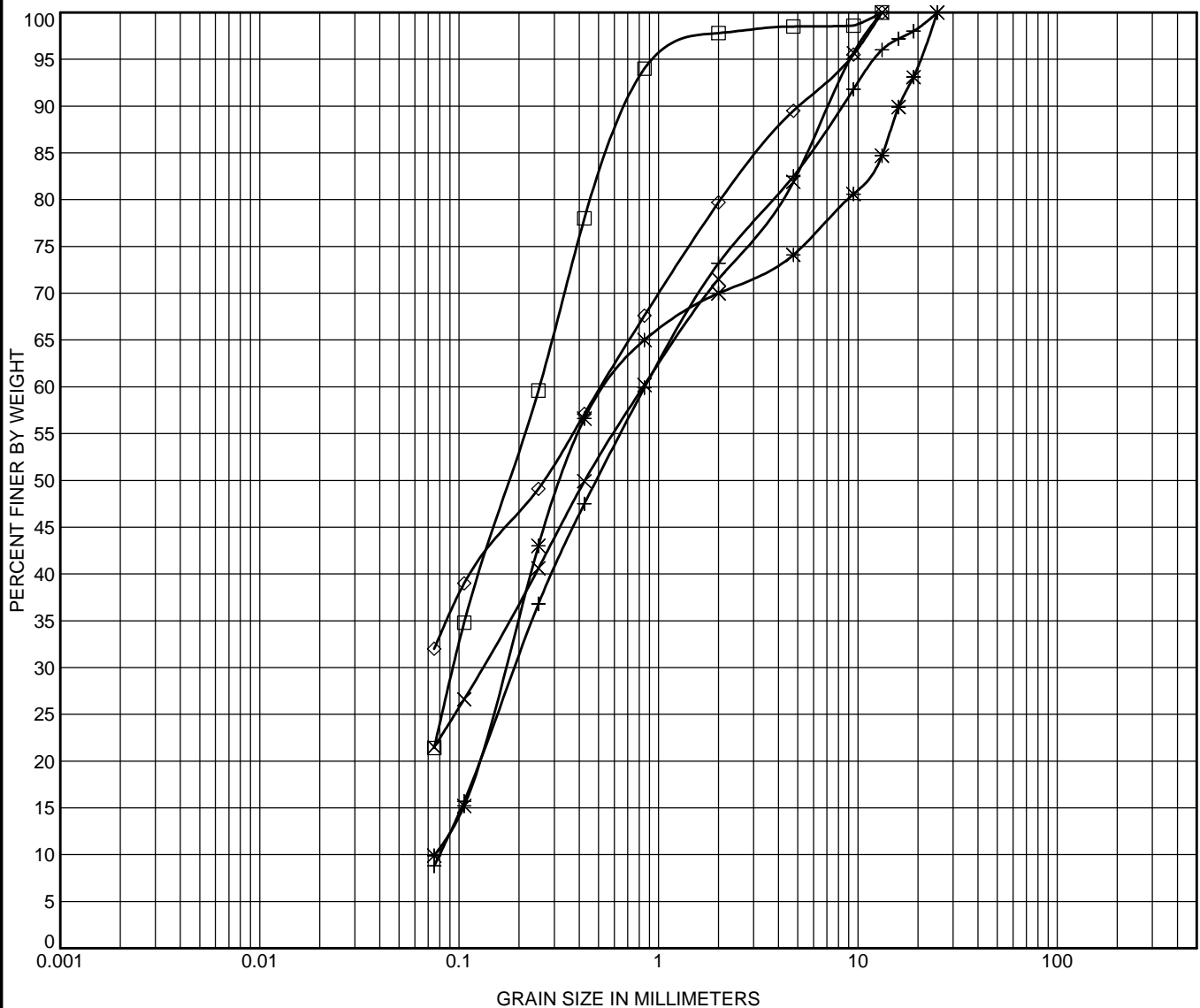
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

## GRAIN SIZE DISTRIBUTION

Project: Culvert Investigation

W P: 5383-11-00

DIST: Muskego HWY: 101



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:  
SILT & SAND & GRAVEL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 102	3.00	13.2	0.253	0.094		1.5	77.1	21.4	
* 103	0.75	25	0.563	0.167	0.075	25.9	64.2	9.9	
x 103	1.30	13.2	0.839	0.131		18.1	60.4	21.5	
+ 105	0.30	25	0.855	0.19	0.08	17.5	73.7	8.8	
◇ 105	1.50	13.2	0.515			10.5	57.5	32.0	



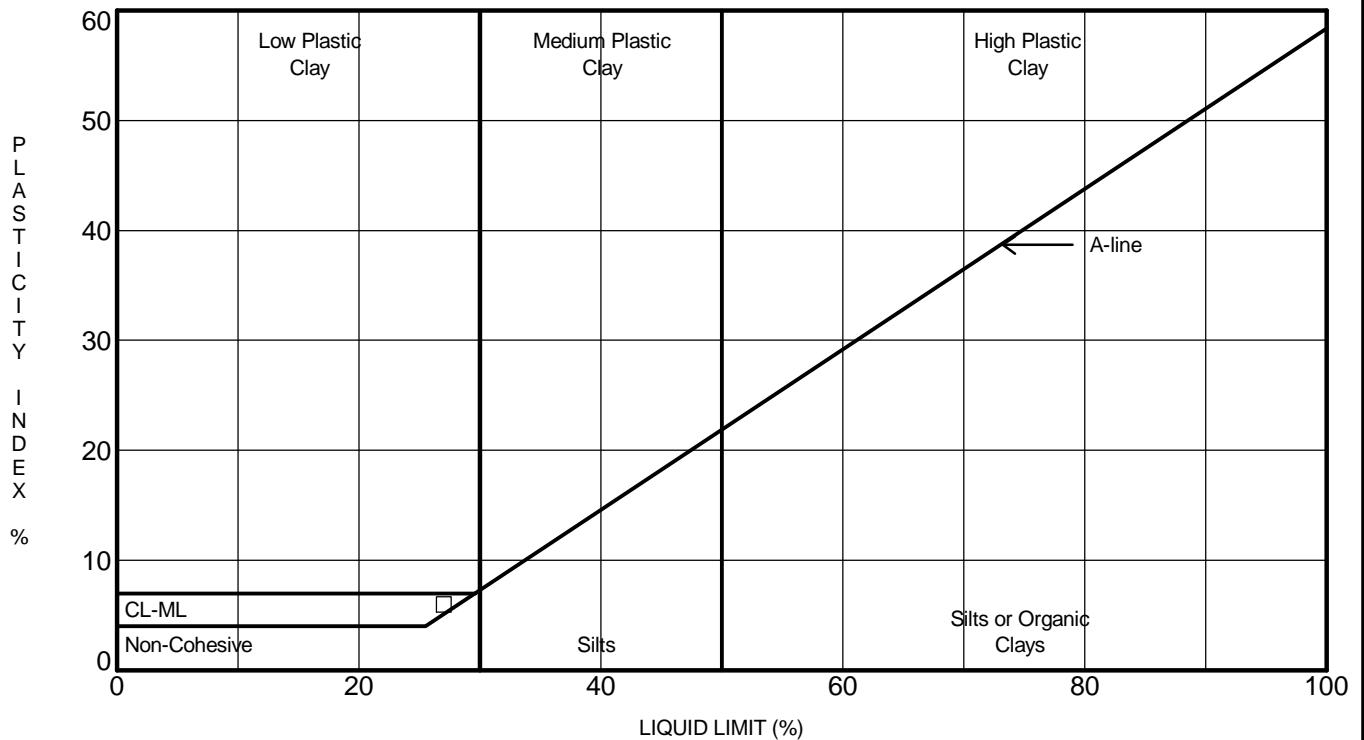
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

## GRAIN SIZE DISTRIBUTION

Project: Culvert Investigation

W P: 5383-11-00

DIST: Muskego HWY: 101



Remarks:  
NON-PLASTIC - SAND & SILT

Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
<input type="checkbox"/> 100		5.30	27	21	6	22



**TBT Engineering Ltd.**  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
Telephone: 807-624-5160  
Fax: 807-624-5161

## ATTERBERG LIMIT RESULTS

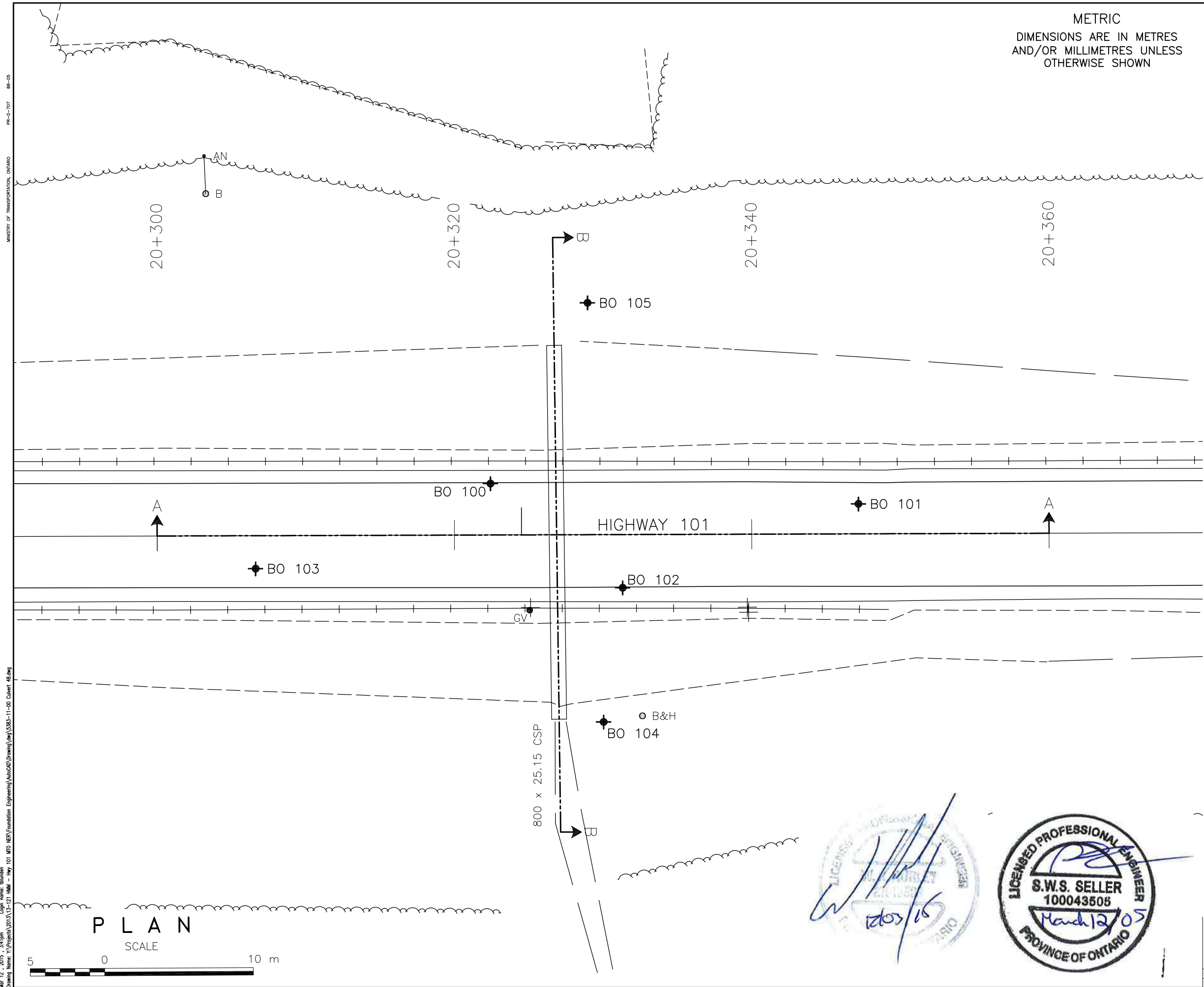
W P: 5383-11-00

District: Muskego

Highway: 101

## **APPENDIX C**

### **Borehole Locations and Soil Strata Drawing**




METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN


GEOCRES No. 42B-10

CONT No. .


GWP No. 5383-11-00



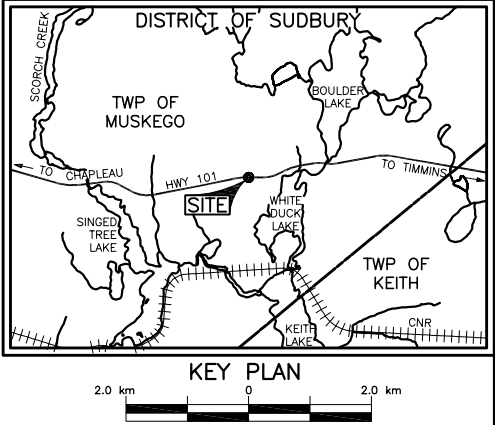
SHEET



Ontario



TBT ENGINEERING  
CONSULTING GROUP



LEGEND				
◆	Borehole			
'N'	Std Pen Test (Blows/0.3m)			
▼	Water Level			
EOH	End of Hole			
AR	Auger Refusal			

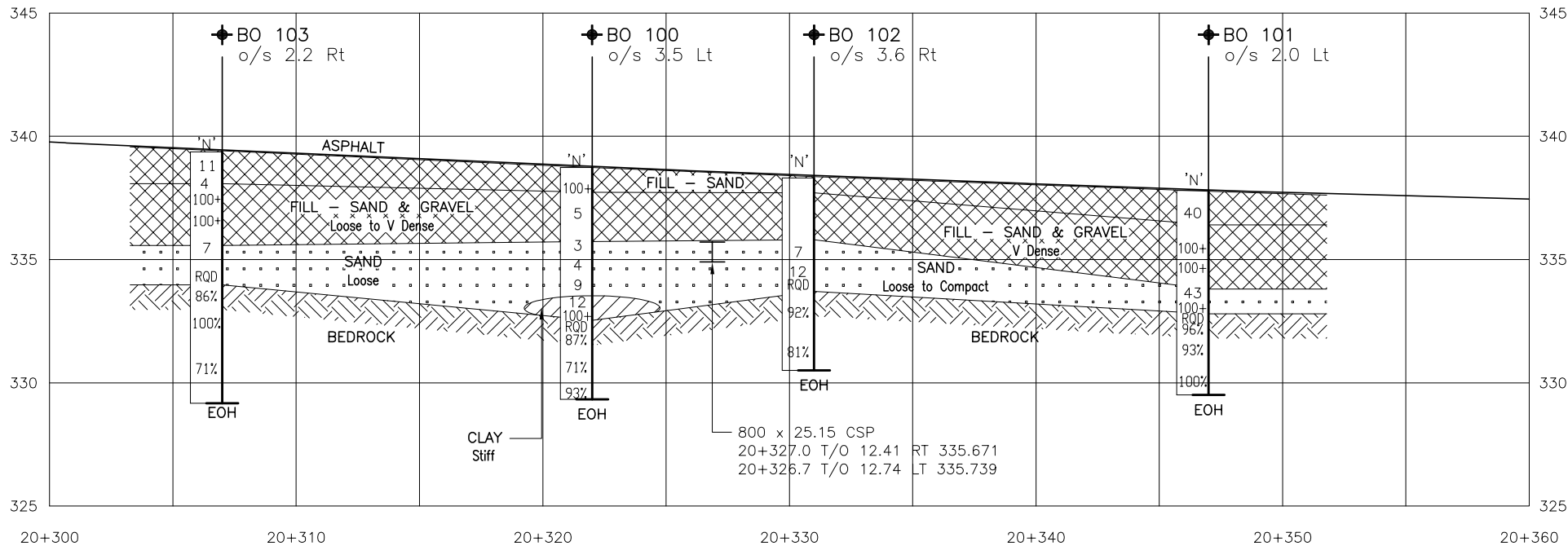
No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
100	338.7	12 5 341 962	208 910
101	337.8	12 5 341 945	208 928
102	338.3	12 5 341 951	208 913
103	339.4	12 5 341 968	208 895
104	335.4	12 5 341 945	208 906
105	335.5	12 5 341 967	208 923

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



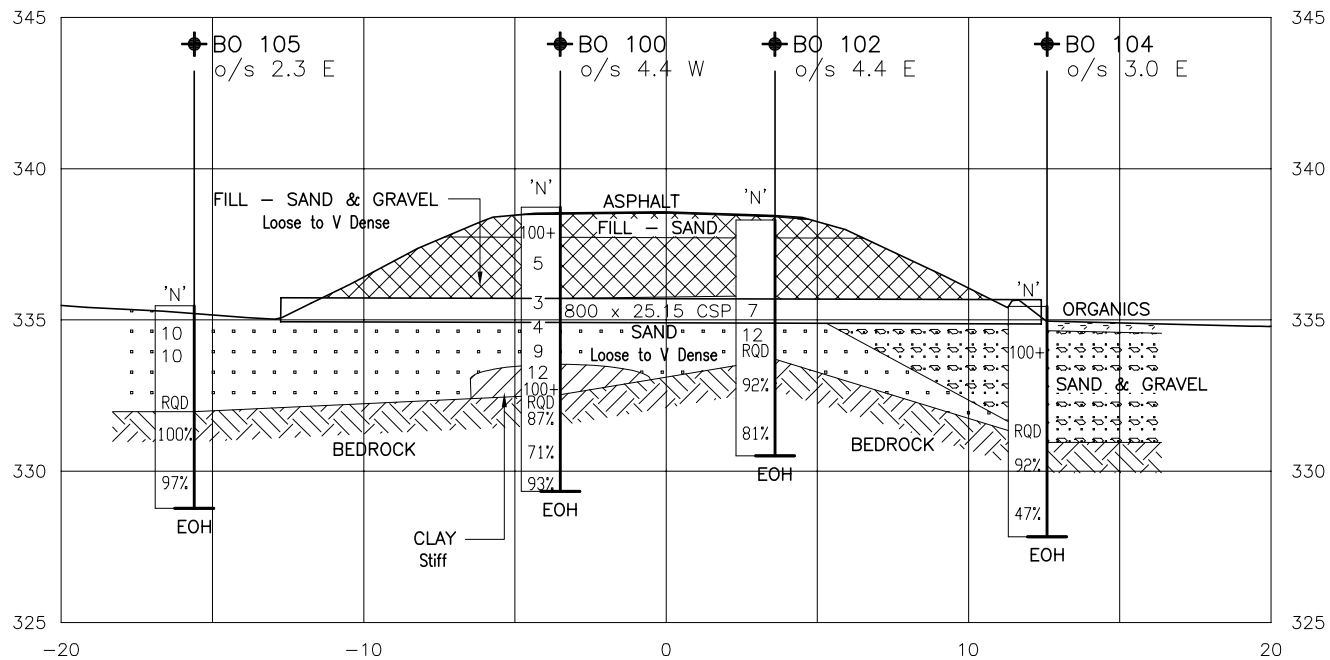
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PR-D-707 88-05  
MINISTRY OF TRANSPORTATION, ONTARIO  
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SECTION A - A

SCALE

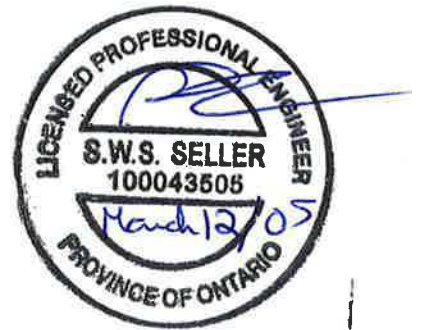


SECTION B - B

SCALE



METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN

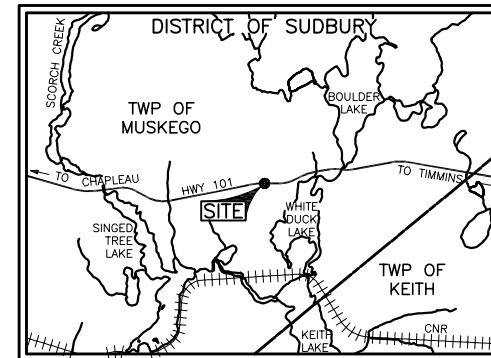


GEOCREs No. 42B-10  
CONT No. .  
GWP No. 5383-11-00



CULVERT 48  
AT HWY 101  
CULVERT INVESTIGATION  
SOIL STRATA

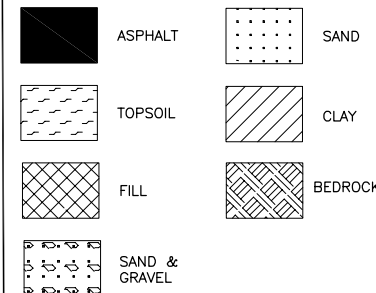
SHEET



KEY PLAN



SOIL STRATA SYMBOLS



LEGEND

- ◆ Borehole
- 'N' Std Pen Test (Blows/0.3m)
- 100% Rock Quality Designation (RQD)
- ▽ Water Level
- EOH End of Hole
- AR Auger Refusal

No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
100	338.3	12 5 341 962	208 910
101	337.8	12 5 341 945	208 928
102	338.1	12 5 341 951	208 913
103	338.8	12 5 341 968	208 895
104	335.4	12 5 341 945	208 906
105	336.0	12 5 341 967	208 923

-NOTE-

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

REVISIONS	13/12/10		WH		ISSUED IN DRAFT		DESCRIPTION
	DESIGN	SS	CHK	WH	CODE	LOAD.	
	DRAWN	TB	CHK	WH	SITE		DATE 2013/12/23 DWG 2