



**PRELIMINARY FOUNDATION INVESTIGATION  
AND DESIGN REPORT  
for  
CPR OVERHEAD REPLACEMENT CULVERT  
HIGHWAY 11, STATION 22+290  
SITE NO. 30-080  
TOWNSHIP OF SEVERN  
SIMCOE COUNTY, ONTARIO  
CENTRAL REGION, G.W.P. 2177-10-00**

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PML Ref.: 12KF069A-C2  
Index No.: 072FIR/119FDR  
GEOCRES No.: 31D-558  
May 1, 2013/March 10, 2014



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for  
CPR OVERHEAD REPLACEMENT CULVERT  
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 Geocres No. 31D-254, January 1978

**PRELIMINARY FOUNDATION INVESTIGATION REPORT**

for  
CPR Overhead Replacement Culvert  
Highway 11, Station 22+290  
Site No. 30-080  
Township of Severn  
Simcoe County, Ontario  
Central Region, GWP 2177-10-00

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**1. INTRODUCTION**

This report summarizes the results of the foundation investigation carried out at the site of the existing CPR overhead on Highway 11 at approximate Station 22+290 in the Township of Severn. The investigation was carried out by Peto MacCallum Ltd. (PML) for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The existing overhead will be removed and the opening partially filled by a pedestrian culvert, as shown in the General Arrangement Drawing 'HWY 11 CPR REPLACEMENT C. I. P. BOX CULVERT' prepared by AECOM dated January 13, 2013.

The purpose of this report was to summarize the subsurface stratigraphy and groundwater conditions encountered in the foundation investigation. The results of two boreholes that were drilled in 1977 based on Geocres Report No. 31D254 are included in this report.

**2. SITE DESCRIPTION AND GEOLOGY**

The contemplated culvert will be located at about 60 m south of the existing Highway 11 Southbound Lanes (SBL) / Hampshire Mills Line at-grade intersection. The site is about 1.0 km north of the City of Orillia in the Geographic Township of Severn, Simcoe County.

Land use in the vicinity of the site includes commercial activities to the west and isolated residential houses to the east. Locally, the existing Highway 11 is a four lane highway. The local topography of the site is generally flat. The existing Highway 11 embankment is about 9.0 m high at the overhead location. The abandoned CPR tracks pass through the existing overhead in an



approximate southeast to northwest direction. The ground cover includes grasses, bushes and trees.

The soil cover at the project site is derived from glaciolacustrine plain deposits (clayey silts and sands) which overlie Paleozoic (Middle Ordovician) age Simcoe Group, Bobcaygeon Formation (limestone) bedrock. The bedrock is estimated at 20 to 30 m depth at the proposed culvert location based on Aggregate Resources Inventory Paper 80, Simcoe County from the Ontario Geological Survey, Ministry of Northern Development and Mines, 1994.

### **3. INVESTIGATION PROCEDURES**

The subsurface investigation was carried out on January 9, 2013. A total of two boreholes (CPR-101 and CPR-102) were drilled to 10.8 and 6.4 m depths at the locations shown on Drawing CPR-1, appended. Although the results of the investigation are considered representative, allowances should be made for local variations in subsurface stratigraphy.

The locations of the boreholes were selected by PML allowing for drill rig accessibility and buried utilities. The ground surface elevations at the borehole locations were surveyed by exp Geomatics in March 2013. All elevations in this report are expressed in metres.

The boreholes were advanced using continuous flight solid stem augers through the soil cover with a track-mounted CME-55 drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a PML field supervisor.

Soil samples were recovered from the boreholes at regular 0.75 and 1.5 m intervals of depth using the standard penetration test method. Standard penetration tests were conducted to assess the strength characteristics of the substrata. Soils were identified in accordance with the MTO soil classification manual procedures.



The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, where encountered, by measuring the groundwater level in the open holes.

The boreholes were backfilled with a bentonite/cement mixture where required in accordance with the MTO guideline and MOE Reg. 903 for borehole abandonment.

The recovered soil samples were returned to the PML laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program included the following tests:

- Natural moisture content determinations (19)
- Atterberg Limits (3)
- Grain size distribution analyses (7)

The laboratory grain size distribution charts are presented in Figures CPR-GS-1 and CPR-GS-2. The Atterberg Limits results are presented in Figures CPR-PC-1 and CPR-PC-2. All of the test results are summarized on the Record of Borehole sheets.

#### **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, standard penetration test results and groundwater observations. The results of laboratory grain size distributions, Atterberg Limits and moisture content determinations are also shown on the Record of Borehole sheets.

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



Two previous boreholes were drilled in 1977 based on the Geocres Report No. 31D254 and the results of the two boreholes are included in Appendix A. The two boreholes were drilled from the top of the approach embankments through 6.8 and 7.8 m thick fills comprising clayey silt with sand and gravel. The fill is underlain by silt to clayey silt deposits. The deposit extended beyond 14.0 and 19.3 m, the termination depths of the boreholes.

The subsurface stratigraphy revealed in the current boreholes is variable although generally consistent with the Geocres Report No. 31D254 in Appendix A and generally included layers of fill and clayey silt till underlain by a silty sand to sand till deposit.

#### **4.1 Fill**

A 0.9 and 1.4 m thick layer of gravelly sand and sand fill was encountered surficially in both boreholes CPR-101 and CPR-102, respectively. The fill extended to 1.4 m (elevation 225.0) in borehole CPR-101 and to 0.9 m (elevation 226.4) in borehole CPR-102. N values varied from 9 to 10 indicating loose compactness. The moisture content determinations ranged from 6 to 30%.

#### **4.2 Clayey Silt Till**

A clayey silt till deposit was encountered below the fill at 1.4 m (elevation 225.0) in borehole CPR 101. The layer was 1.6 m thick extending to the silty sand to sand till at 3.0 m (elevation 223.4) in borehole CPR-101. N values ranged from 41 to 51 indicating a stratum with hard consistency.

The results of grain size distribution analysis for the clayey silt till sample are included in Figure CPR-GS-1. The Atterberg plasticity chart is presented in Figure CPR-PC-1. The liquid limit of the clayey silt till sample was 42, and the plastic limit was 22 with the corresponding plasticity index value of 20. The Atterberg limits of a sample of the same soil tested in the previous borehole 1 indicated a liquid limit of 35, plastic limit of 17 and a computed plasticity index of 18. The moisture content determinations were 6 and 8%.



#### **4.3 Silty Sand to Sand Till**

A silty sand to sand till deposit was encountered below the clayey silt till at 3.0 m (elevation 223.4) in borehole CPR-101 and below the fill at 0.9 m (elevation 226.4) in borehole CPR-102. The boreholes were terminated in the silty sand to sand till at 10.8 and 6.4 m (elevations 215.6 and 220.9). N values ranged from 16 to 100 for 18 cm indicating compact to very dense compactness.

The results of grain size distribution analyses for the silty sand to sand till samples are included in Figure CPR-GS-2. The Atterberg plasticity charts are presented in Figure CPR-PC-2. The liquid limits of the silty sand to sand till samples were 13 and 14, and the plastic limits were both 11, respectively with the corresponding plasticity index values of 2 and 3, essentially non-plastic material. The moisture content determinations ranged from 7 to 12%.

#### **4.4 Groundwater**

Groundwater was encountered in both boreholes. During drilling, groundwater was observed at 1.1 m and ground surface (elevations 225.3 and 227.3) in boreholes CPR-101 and CPR-102, respectively. Upon completion of drilling, groundwater was measured at 6.1 m and 0.6 m (elevations 220.3 and 226.7) in boreholes CPR-101 and CPR-102, respectively.

The groundwater level is subject to seasonal fluctuations and rainfall patterns. Perched groundwater may likely have accumulated within fill units. In the wet or spring thaw seasons, the perched groundwater level may be high and rise close to the ground surface.





## 5. CLOSURE

Mr. F. Portela carried out the field investigation for this study under the supervision of Mr. B. Rao, P. Eng., and Mr. C. M. P. Nascimento, P. Eng., Project Manager. Walker Drilling Ltd. supplied the drill rig for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This Foundation Investigation Report was prepared by Mr. B. Rao, P. Eng., and reviewed by Mr. B. R. Gray, MEng, P. Eng., MTO Designated Principal Contact. Mr. C. M. P. Nascimento, P. Eng., Project Manager conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



Bin Rao, P.Eng.  
Project Engineer

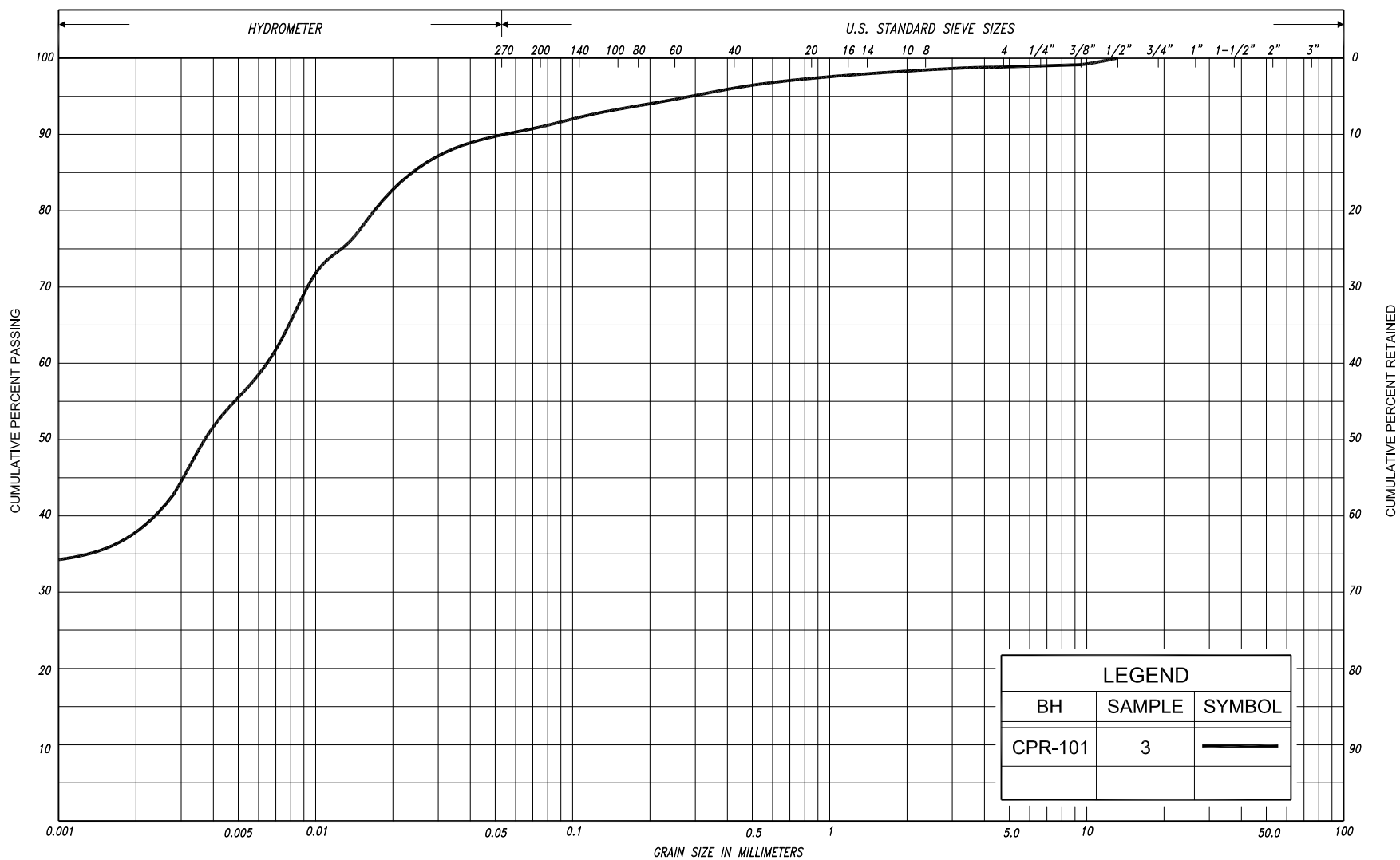


Carlos M.P. Nascimento, P.Eng.  
Project Manager



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

BR/CN/BRG:br-mi-sq



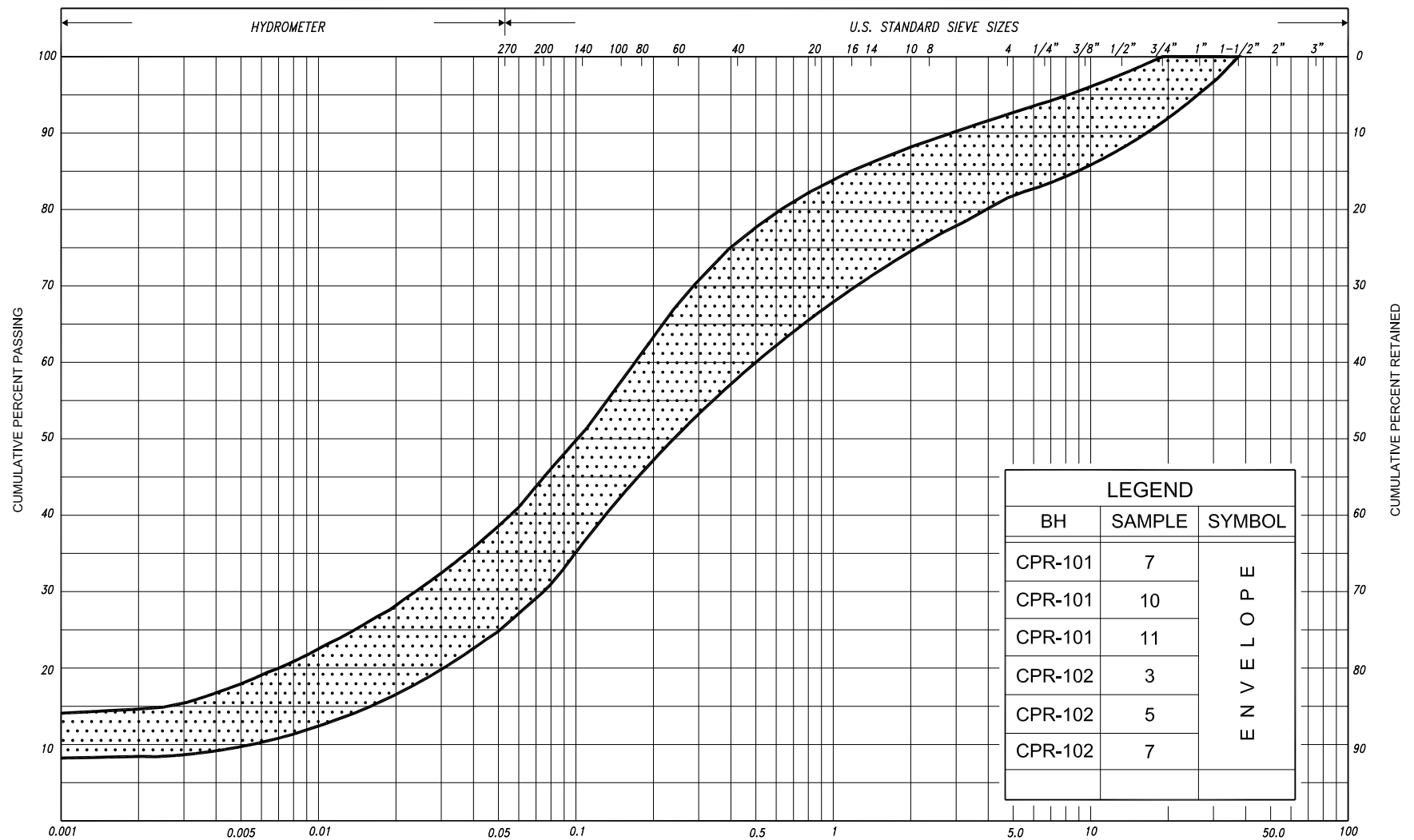
LEGEND		
BH	SAMPLE	SYMBOL
CPR-101	3	—

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



# **GRAIN SIZE DISTRIBUTION** CLAYEY SILT, trace sand, trace gravel (TILL)

FIG No.	CPR-GS-1
HWY:	11
W.P. No.	2177-10-00



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

## GRAIN SIZE DISTRIBUTION

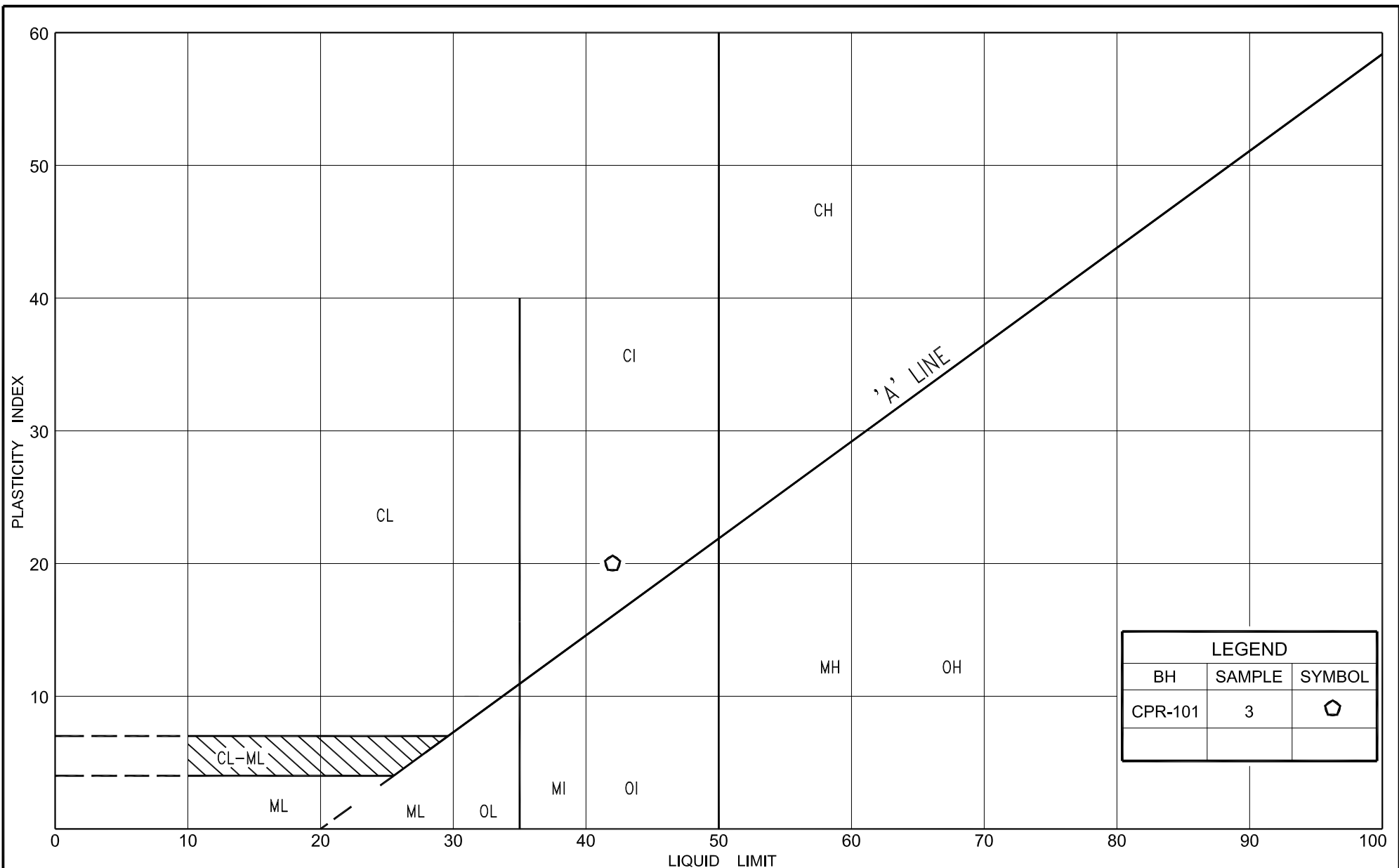
SILTY SAND to SAND with silt, trace to some gravel, trace to some clay  
(TILL)

FIG No. CPR-GS-2

HWY: 11

W.P. No. 2177-10-00





LEGEND		
BH	SAMPLE	SYMBOL
CPR-101	3	⬠

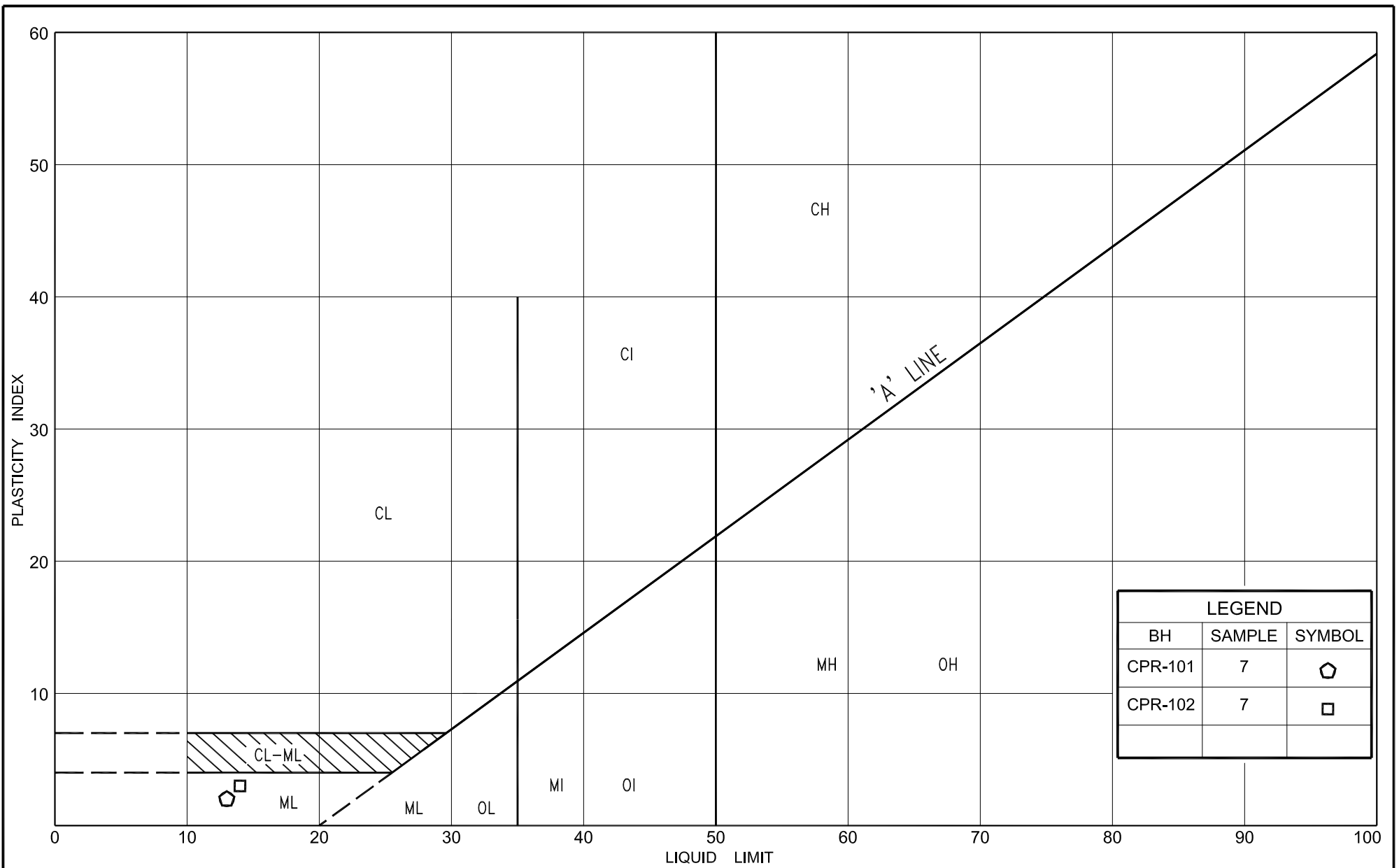


# PLASTICITY CHART CLAYEY SILT, trace sand, trace gravel (TILL)

FIG No. CPR-PC-1

HWY: 11

W.P. No. 2177-10-00



## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

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

**RECORD OF BOREHOLE No CPR-101**

1 of 1

**METRIC**

**G.W.P.** 2177-10-00      **LOCATION** Coords: 4 945 953.7 N; 311 401.1 E      **ORIGINATED BY** F.P.  
**DIST** Central      **HWY** 11      **BOREHOLE TYPE** Continuous Flight Solid Stem Augers      **COMPILED BY** B.R.  
**DATUM** Geodetic      **DATE** January 09, 2013      **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa									
							20 40 60 80 100									
226.4	Ground Surface															
0.0	Gravelly sand, trace silt		1	SS	10	▽*	226									2 7 53 38
	Compact Dark brown Moist															
	Sand, trace silt		2	SS	9											
225.0	Loose Brown (FILL) Moist							225								
1.4	Clayey silt trace sand, trace gravel		3	SS	41											
	Hard Grey Moist (TILL)		4	SS	51			224								
223.4																
3.0	Silty sand to Sand with silt trace to some clay trace to some gravel		5	SS	34			223								
	Dense to Brown Moist very dense to wet (TILL)		6	SS	104/20cm			222								
			7	SS	52			221								
	with gravel, trace clay		8	SS	81			220								
			9	SS	61			219								
			10	SS	101		218									
			11	SS	123		217									
215.6	End of borehole		12	SS	100/18cm		216									
10.8																

**RECORD OF BOREHOLE No CPR-102**

1 of 1

**METRIC**

**G.W.P.** 2177-10-00      **LOCATION** Coords: 4 945 989.1 N; 311 360.6 E      **ORIGINATED BY** F.P.  
**DIST** Central      **HWY** 11      **BOREHOLE TYPE** Continuous Flight Solid Stem Augers      **COMPILED BY** B.R.  
**DATUM** Geodetic      **DATE** January 09, 2013      **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
227.3	Ground Surface						20	40	60	80	100									
0.0	Gravelly sand, trace silt		1	SS	10								○							
	Compact Dark brown Moist to wet																			
226.4	(FILL)		2	SS	16								○							
0.9	Silty sand to Sand with silt some clay trace to some gravel		3	SS	74								○			13 41 33 13				
	Compact to Brown Moist very dense to wet																			
	(TILL)		4	SS	117/23cm															
			5	SS	110/23cm								○			18 38 32 12				
			6	SS	101								○							
			7	SS	122								○H			8 55 22 15				
222																				
			8	SS	119								○							
220.9	End of borehole																			
6.4																				
										</										

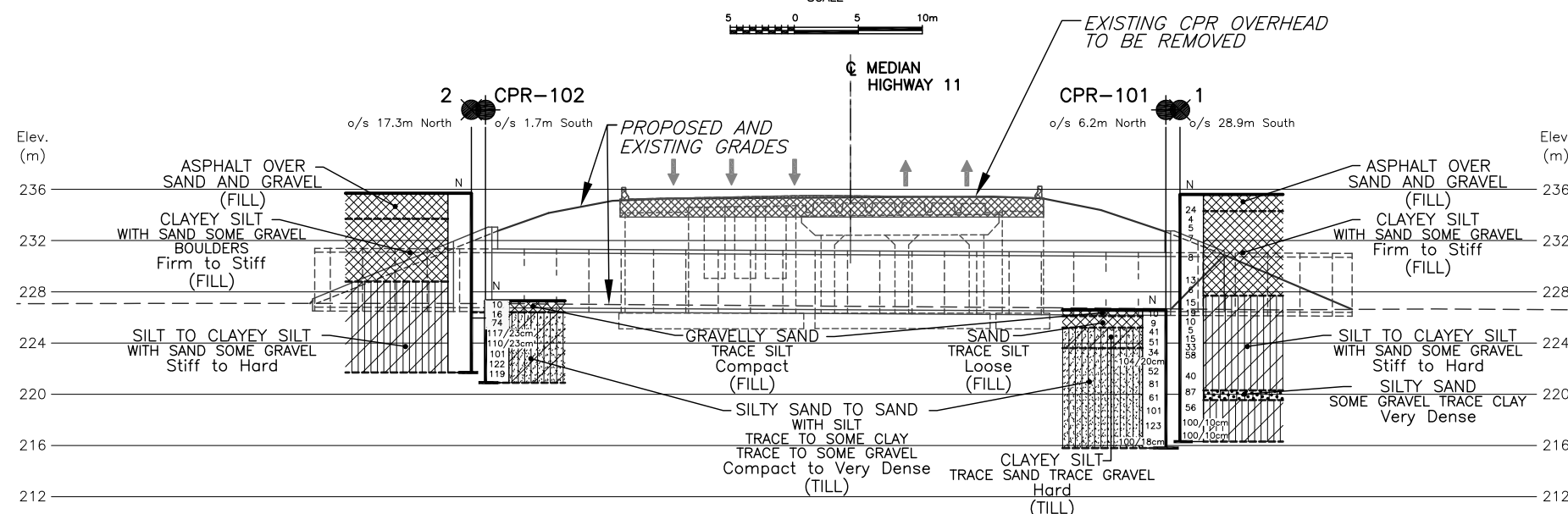
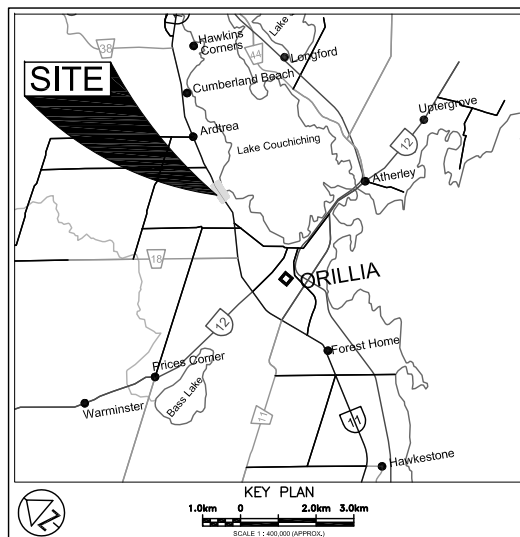
\* 2013 01 09

▽ Water level observed during drilling

▼ Water level measured after drilling

Borehole open upon completion of drilling.












SCALE

5 0 5 10m

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

LEGEND			
	Borehole		
	Previous Borehole from Geocres Report		
N	Blows/0.3m (Std. Pen Test, 475 J/blow)		
CONE	Blows/0.3m (60 Cone, 475 J/blow)		
	WL at time of investigation Jan. 2013		
*	Water level not established		
	HEAD		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		

BH No	ELEVATION	NORTHINGS	EASTINGS
CPR-101	226.4	4 945 953.7	311 401.1
CPR-102	227.3	4 945 989.1	311 360.6

GEOCRES REPORT BOREHOLES			
1	235.6	4 945 930.3	311 375.0
2	235.7	4 946 002.2	311 374.4

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

HWY No	11			DIST	North Bay
SUBM'D	NA	CHECKED	BR	DATE	MAY 01, 2013
DRAWN	NA	CHECKED	BRG	APPROVED	CN
				DWG	CPR-1



Reference AECOM Drawings:  
60282808-ST-CULVERT\_30-080\_GA\_Precast-Alt3&4.dwg dated Jan. 2013  
and B-189-11-120933.dwg



## **APPENDIX A**

### **GEOCRES REPORT**

Foundation Investigation Report for CPR Overhead Widening,  
Geocres No. 31D-254, January 1978

**G.I.-30 SEPT. 1976**

REMARKS: \_\_\_\_\_

ENGINEERING MATERIALS OFFICE  
SOIL MECHANICS SECTION

WP 162-75-04

DIST 5

HWY 11

STR SITE 30-80

C.P.R. Overhead Widening  
0.8 Miles North of  
North Junction Hwy. 11B and Hwy. 11

DISTRIBUTION

A.P. Watt (2)  
J.R. Roy  
A. Wittenberg  
J.H. Blevins (2)

A.E. McKim  
G.A. Wrong  
B.J. Giroux  
R.S. Pillar

R. Hore

A. Crowley  
J. Anderson  
G. Sloan

Files ✓

SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	78-01-06	WJG
TUBES	—	—
ROCK COCKES	—	—

## FOUNDATION INVESTIGATION REPORT

For  
C.P.R. Overhead Widening  
.0.8 Miles North of  
North Junction Hwy.11B and Hwy.11  
Hwy.11, District 5, Owen Sound  
W.P. 162-75-04, Site #30-80

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### INTRODUCTION

This report contains the results of a foundation investigation carried out at the above location. Fieldwork was completed on September 21 and 22, 1977. A muskeg vehicle mounted power auger equipped with 3¼ inch I.D. hollow stem augers was used to advance two boreholes. Additional shallow borings were put down by hand auger adjacent to the existing bridge footings.

### SITE DESCRIPTION

The site is located 1.0 mile north of the north junction of Hwy. 11B and Hwy. 11 in the Township of Orillia. Hwy. 11 passes over the C.P.R. tracks on a multiple span structure with 22 to 25 feet of fill present behind the abutments.

Both deciduous and coniferous trees make up the vegetation of this gently rolling area, which lies in the physiographic region of the Sand Plains of the Simcoe Lowlands.

### SUBSURFACE CONDITIONS

#### General

The subsoil within the investigated area was found to consist of fill material (asphalt, sand, gravel and clayey silt) followed by silt to clayey silt with sand and with gravel within the depth of borings.

The extent of the various deposits are shown on the Record of Borehole Sheets in the Appendix. An estimated stratigraphic profile has been prepared on Drawing No. 1627504-A.

Soil types encountered in the boreholes can be described as follows:

#### Fill Material

Two different types of material were observed within the existing approaches. The upper 4-7 feet consists of asphalt, sand and gravel, while the lower portion is cohesive in nature.

This cohesive zone, made up of clayey silt, with sand, some gravel, extends to the limits of the fill, approximately 22 to 25 feet below pavement. A bouldery zone is present from 7 to 18 feet in B.H. 2 and a layer of organic material around 15 feet in B.H. 1. Generally this layer is firm to stiff in consistency with moisture contents varying from 4% to 16%.

#### Silt to Clayey Silt, With Sand and Gravel

Silt to clayey silt, with sand and gravel extends from the fill material to the limits of the boreholes. Standard Penetration 'N' values range from 10 blows per foot to 100 blows for 2 inches of penetration giving this material a stiff to hard consistency. Virtual refusal to augering was reached at elevation 711 in B.H. 1 and elevation 727 in B.H. 2.

In B.H. 1, approximately the first 8 feet of the deposit is lacking in sand and gravel and a very dense layer of silty sand, some gravel, trace of clay, is present around elevation 723. The moisture content of this soil varies from 5% to 10%.

#### Groundwater

Observations showed groundwater at elevation 744 in B.H. 1. The source of this water is a silty sand seam around elevation 723. No groundwater was measured in the remaining borings.

## APPENDIX



## RECORD OF BOREHOLE No 1

W P 162-75-04

LOCATION Co-ords N 16,226,079; E 1,021,542

ORIGINATED BY JM

DIST 5 HWY 11

BOREHOLE TYPE Continuous Flight Auger (MVM)

COMPILED BY JM

DATUM Geodetic

DATE September 21, 1977

CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
773.0	Ground Level																
0.0	Asphalt, Sand, Gravel (Fill Material)		1	SS	24		770										58 38 (4)
768.8	Fill Material		2	SS	4												
4.2	Clayey Silt with Sand		3	SS	5												
	Some Gravel		4	SS	7												11 43 36 10
	Black Organic		5	SS	8		760										
	Firm to Stiff		6	SS	13												
			7	SS	6		750										14 38 33 15
747.0			8	SS	15												
26.0			9	SS	19												
	Silt to Clayey Silt with Sand, Gravel		10	SS	10												
			11	SS	5		740										
			12	SS	15												
			13	SS	33												27 38 26 9
			14	SS	58		730										
			15	SS	40												
	Silty Sand		16	SS	87		720										
	Some Gravel, Trace of Clay		17	SS	56												
	Stiff to Hard		18	SS	100/4"												
709.7			19	SS	100/4"		710										8 45 32 15
63.3	End of Borehole																
	<p><u>PML Note:</u> Fill symbol added from 4.2 to 26.0 ft. depth</p>																

\*<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity

20  
15  $\pm$  5 (%) STRAIN AT FAILURE  
10



## RECORD OF BOREHOLE No 2

W P 162-75-04 LOCATION Co-ords N 16,226,315; E 1,021,540 ORIGINATED BY JM  
 DIST 5 HWY 11 BOREHOLE TYPE Continuous Flight Auger (MVA) COMPILED BY JM  
 DATUM Geodetic DATE September 22, 1977 CHECKED BY /-5

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										WATER CONTENT (%)		
								SHEAR STRENGTH										W <sub>p</sub> W W <sub>L</sub>		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE													
773.2	Ground Level																GR SA SI CL			
0.0																				
766.7	Asphalt, Sand, Gravel (Fill Material)		1	SS	44		770										39 53 ( 8 )			
6.5	Fill Material		2	SS	13															
	Clayey Silt With Sand, Some Gravel		3	SS	19												2 93 ( 5 )			
	Boulders		4	SS	5															
			5	SS	102/ 11"		760													
			6	SS	7															
750.7	Firm to Stiff		7	SS	11		750										15 41 32 12			
22.5			8	SS	13															
	Silt to Clayey Silt With Sand, Gravel		9	SS	18															
			10	SS	24												30 41 22 7			
			11	SS	34		740													
	Stiff to Hard		12	SS	16															
			13	SS	100/ 2"															
727.2			14	SS	100/ 3"		730										37 33 21 9			
46.0	End of Borehole																23 49 18 10			
	Note: Water Level Not Observed																			

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

## EXPLANATION OF TERMS USED IN REPORT

**'N' VALUE:** AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS  $N_c$ .

**DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3):** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 1/2" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

**SOIL QUALITY:** SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

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

$S_u$ (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSITY:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 15	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

**ROCK QUALITY:** 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 DRILLED IN THAT CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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:**

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

### ABBREVIATIONS & SYMBOLS

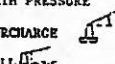

#### LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EC.  $\bar{C}IU$  = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

#### FIELD SAMPLING

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

#### EARTH PRESSURE TERMS

$\mu$  COEFFICIENT OF FRICTION  
 $\delta$  ANGLE OF WALL FRICTION  
 $k_o$  COEFFICIENT OF EARTH PRESSURE AT REST  
 $k_a$  COEFFICIENT OF ACTIVE EARTH PRESSURE  
 $k_p$  COEFFICIENT OF PASSIVE EARTH PRESSURE  
 $i$  ANGLE OF INCLINATION OF SURCHARGE  
 $w$  SLOPE ANGLE-BACKFACE OF WALL   
 $\beta$  ANGLE OF SLOPE   
 $N_q, N_c$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
 $B, L$  FOOTING DIMENSIONS

#### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{w_L - w_p}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w_p}{w_L - w_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p}{w_L - w_p}$  Fraction  
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u(undisturbed)}{S_u(remoulded)}$

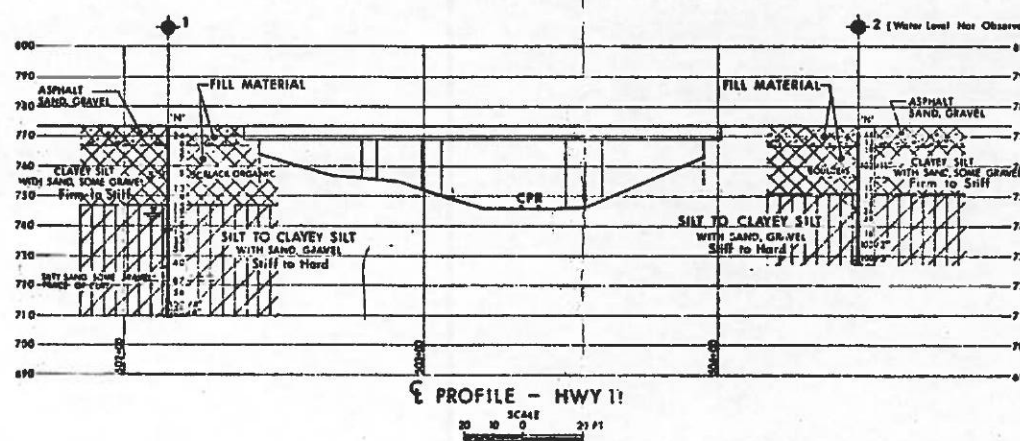
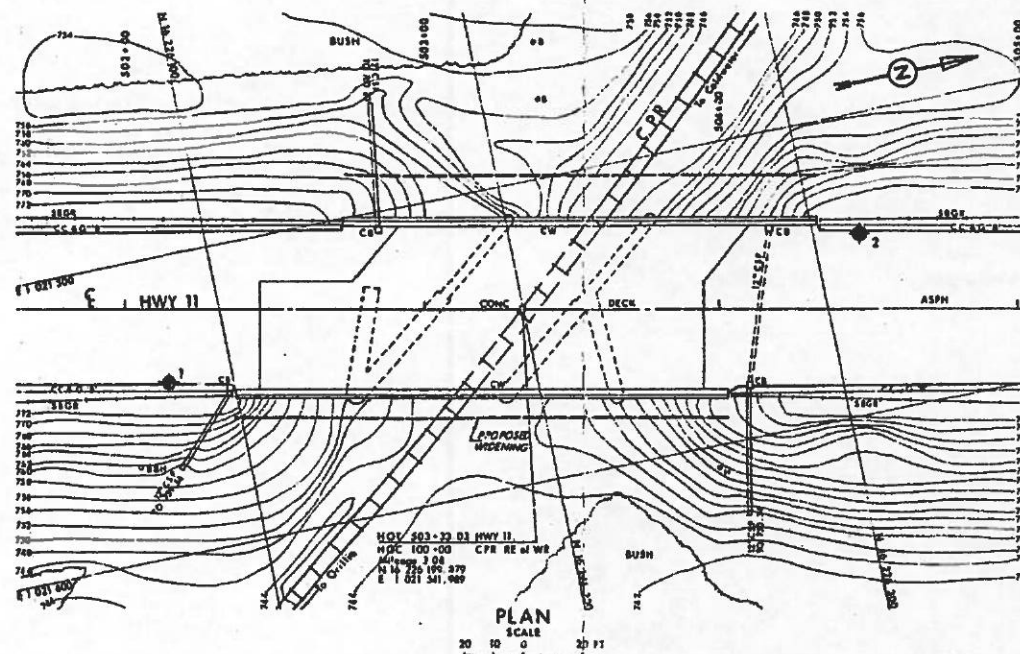
#### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS

**NOTE:** EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHES ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

#### HYDRAULIC TERMS

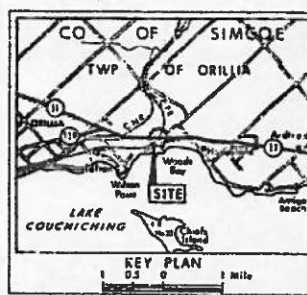
$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
 $v$  VELOCITY OF FLOW  
 $i$  HYDRAULIC GRADIENT  
 $j$  SEEPAGE FORCE PER UNIT VOLUME  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $\alpha_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_c$  OVERCONSOLIDATION RATIO (OCR)



CONT No  
WP No 162-75-04

CPR Q'HEAD - STR. WIDENING  
( U.S. 241 PM at Hwy 113 )  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



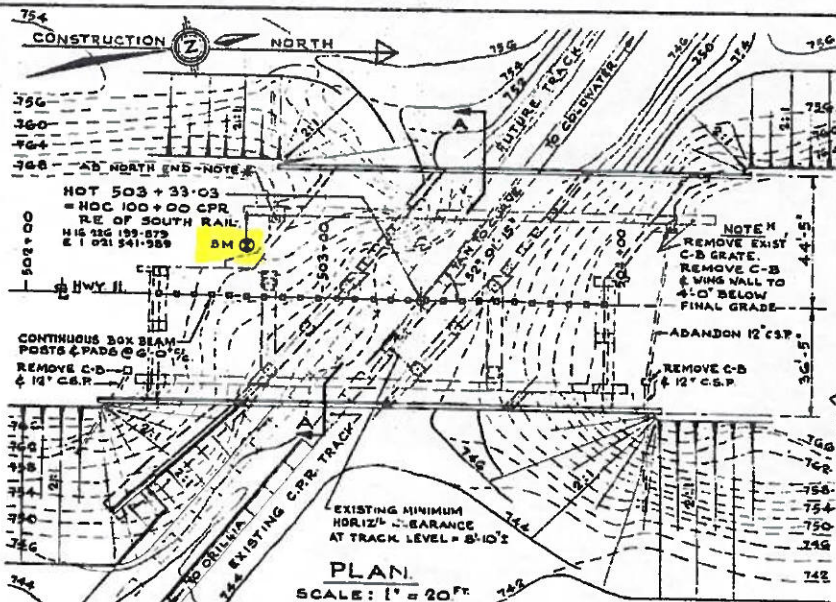
- LEGEND
- Bore Hole
  - ⊕ Dynamic Cone Penetration Test (Cone)
  - ◆ Bore Hole & Cone
  - W Blows/ft (Std Pen Test 350 ft Re range)
  - CONC Blows/ft (60° Cone, 350 ft Re range)
  - W1 at time of investigation SEPT, 1977

No	ELEVATION	CO - NORTH	ORDINATES EAST
1	773.0	16 226 079	1 021 562
2	773.2	16 226 315	1 021 540

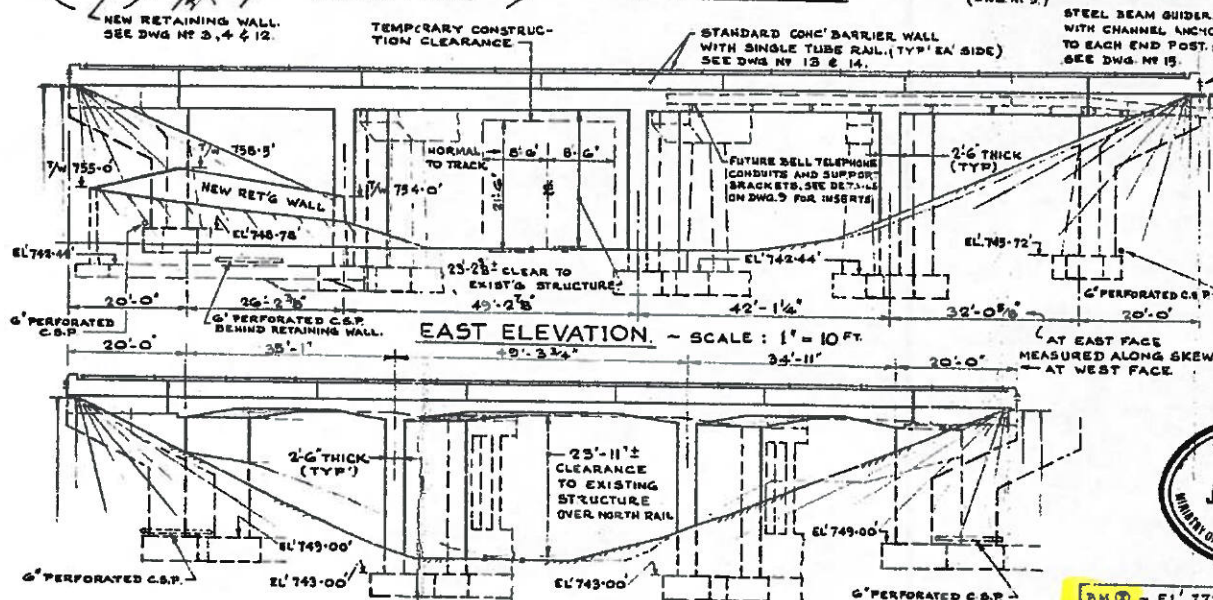
**-NOTE-**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

DATE	DESCRIPTION

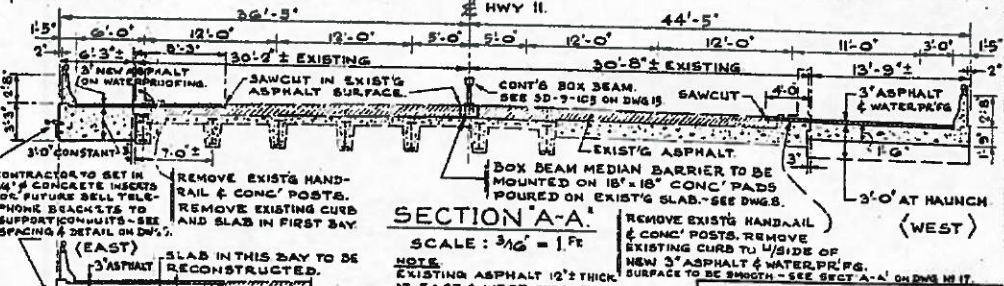
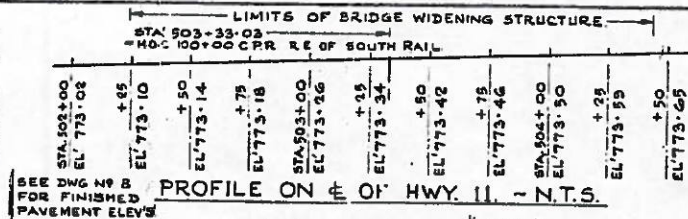




PLAN  
SCALE: 1" = 20'



WEST ELEVATION ~ SCALE: 1" = 10'



SECTION A-A'  
SCALE: 3/16" = 1'

NOTE:  
EXISTING ASPHALT 12" THICK AT EAST & WEST CURB FACE. FOR REMEDIAL WORK TO UNDERSIDE OF EXISTING CONC. ENCASED STEEL BEAMS SEE DRAWING NO 18 FOR TRAFFIC DIVERSION, ROADWAY PROTECTION AND TRACK PROTECTION DURING CONSTRUCTION - SEE DWG 17 & 18.

#### LIST OF DRAWINGS

- 1 - GENERAL LAYOUT.
- 2 - BOREHOLE LOCATIONS & SOIL STRATA.
- 3 - FOOTINGS - LAYOUT
- 4 - FOOTINGS - REINF.
- 5 - BRIDGE FRAME (WEST WIDENING) - LAYOUT.
- 6 - BRIDGE FRAME (WEST WIDENING) - REINF.
- 7 - NORTHWEST & SOUTHWEST WINGWALLS.
- 8 - FINISHED PAVEMENT ELEVATIONS.
- 9 - BRIDGE FRAME (EAST WIDENING) - LAYOUT.
- 10 - BRIDGE FRAME (EAST WIDENING) - REINF.
- 11 - N.E. AND S.E. ABUTMENTS & WINGWALLS.
- 12 - RETAINING WALL.
- 13 - BARRIER WALL.
- 14 - STEEL RAILING (SINGLE TUBE)
- 15 - STANDARD DETAILS (I)
- 16 - STANDARD DETAILS (II)
- 17 - TRAFFIC DIVERSION DURING CONSTRUCTION.
- 18 - TEMPORARY SHORING DURING CONSTRUCTION.
- 19 - TEMPORARY WORK TO EXISTING BEAMS.



DIST No 5		SHEET
CONT No		
WP No 162-75-04		
HIGHWAY 11 WIDENING OVER C.P.R. 0.8 MILES NORTH OF NORTH JUNCTION OF HIGHWAY 11 AND HIGHWAY 11 GENERAL LAYOUT		
MAKSYMIEC & ASSOCIATES LIMITED TORONTO SUDBURY CANADA		

**NOTES**

**CLASS OF CONCRETE:**  
BRIDGE FRAMES (INCLUDING DECK), ABUTMENTS AND WINGWALLS. 16. CONC. IN BRIDGE - 4000 PSI. BARRIER WALLS - 4000 PSI. RETAINING WALLS - 4000 PSI. FOOTINGS - 3000 PSI. MEDIAN PADS FOR B/BEAM - 3000 PSI. MASS CONCRETE - 2000 PSI.

**CLEAR COVER TO REINF. STEEL:**  
TOP OF DECK SLAB - 2"  
BOTTOM OF DECK SLAB - 1 1/2"  
RETAINING WALLS (BACK & FRONT) - 3"  
FOOTINGS AND ABUTMENTS - 3" (OR AS NOTED ON THE DRAWING)

**REINFORCING STEEL:**  
REINF. BARS WITH THE DESIGNATION 'C' AT THE END OF BAR MARKS SHALL BE COATED BARS. GRADE 400 REINFORCING STEEL.

**CONSTRUCTION NOTES:**  
BACKFILL TO ABUTMENTS TO BE GRANULAR 3" PLACED AND COMPACTED SIMULTANEOUSLY FROM BOTH SIDES. DIMENSIONS OF EXISTING STRUCTURE ARE TO BE CHECKED IN THE FIELD.

**CONCRETE QUANTITIES.**  
CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS.

	CU YD.
CONCRETE IN BRIDGE	593 (4000 PSI) 3 (3000 PSI) 5 (4000 PSI)
CONCRETE IN BARRIER WALLS	29
CONCRETE IN RETAINING WALL	46

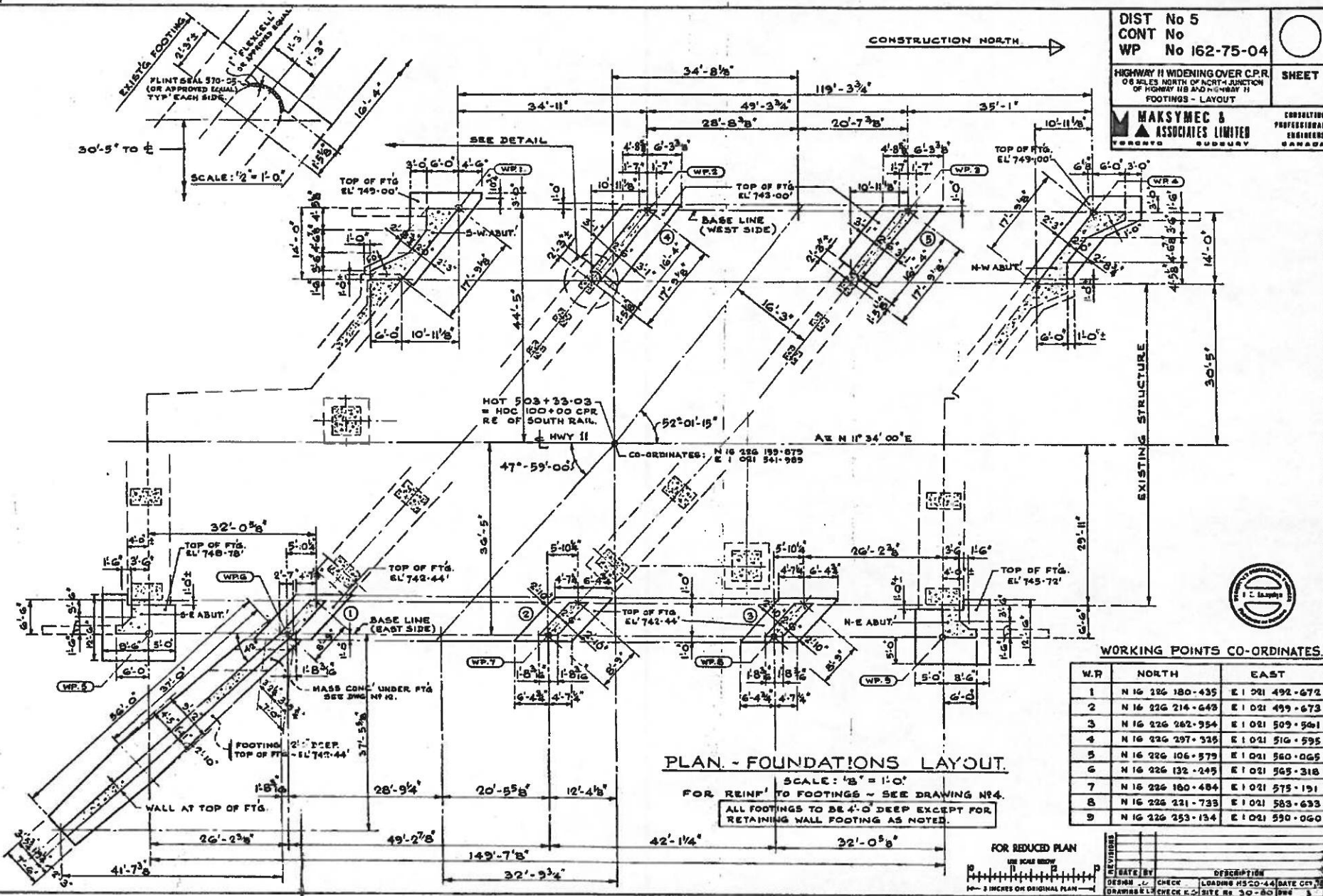
BM 10 - EL 772.78  
CC ON S-W CORNER OF CW AT 6-END OF EXIST' BRIDGE 28' LEFT AT STA 502+75

FOR REDUCED PLAN



DATE	CHECK	DESCRIPTION
DESIGN	10	LEADING: 20-44
DRAWING	10	CHECK: SITE No 30-80





DIST No 5	SHEET
CONT No	
WP No 162-75-04	
HIGHWAY 11 WIDENING OVER C.P.R. 0.6 MILES NORTH OF NORT-H JUNCTION OF HIGHWAY 118 AND N-HIGHWAY 11 FOOTINGS - LAYOUT	
<b>MAKSYMIEC &amp; ASSOCIATES LIMITED</b> CONSULTING PROFESSIONAL ENGINEERS TORONTO SUDBURY CANADA	

WORKING POINTS CO-ORDINATES.

W.P.	NORTH	EAST
1	N 16 226 180-435	E 1 021 492-672
2	N 16 226 214-643	E 1 021 499-673
3	N 16 226 262-954	E 1 021 509-541
4	N 16 226 297-325	E 1 021 516-595
5	N 16 226 106-579	E 1 021 560-065
6	N 16 226 132-245	E 1 021 565-318
7	N 16 226 180-484	E 1 021 575-191
8	N 16 226 221-733	E 1 021 583-633
9	N 16 226 253-134	E 1 021 590-060

FOR REDUCED PLAN

DESIGN	CHECK	DATE	BY

SCALE: 1/2" = 1'-0"

FOR REINF. TO FOOTINGS - SEE DRAWING NO. 4

ALL FOOTINGS TO BE 4'-0" DEEP EXCEPT FOR RETAINING WALL FOOTING AS NOTED.



**PRELIMINARY FOUNDATION DESIGN REPORT  
CPR OVERHEAD REPLACEMENT CULVERT  
HIGHWAY 11, STATION 22+290  
SITE NO. 30-080  
TOWNSHIP OF SEVERN  
SIMCOE COUNTY, ONTARIO  
CENTRAL REGION, G.W.P. 2177-10-00**

PETO MacCALLUM LTD.  
165 CARTWRIGHT AVENUE  
TORONTO, ONTARIO  
M6A 1V5  
Phone: (416) 785-5110  
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PML Ref.: 12KF069A-C2  
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GEOCRES No.: 31D-558  
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**PRELIMINARY FOUNDATION DESIGN REPORT**

for  
CPR Overhead Replacement Culvert  
Highway 11, Station 22+290  
Site No. 30-080  
Township of Severn  
Simcoe County, Ontario  
Central Region, GWP 2177-10-00

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**1. INTRODUCTION**

The installation of a new culvert to replace the existing CPR overhead is planned as part of the rehabilitation of a section of Highway 11 in the Township of Severn. This report was prepared for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

This preliminary foundation design report provides foundation engineering comments and recommendations for the proposed culvert design and construction and temporary roadway protection which will be required for the staged construction.

According to the preliminary GA drawing dated January 13, 2013, the proposed culvert will replace the existing CPR overhead at Sta. 22+290 in the Township of Severn, Simcoe County. The proposed culvert will be a 4.0x4.0 m cast-in-place concrete box culvert with a total length of 53.0 m. This culvert is proposed at a skew angle of 38°41' towards southeast at the Highway 11 centreline. The temporary roadway protection will be located along the centre line of Highway 11.

All elevations in this report are expressed in metres.

In summary, the subsurface stratigraphy revealed in the boreholes generally comprised a 1.4 to 0.9 m thick fill layer underlain by a discontinuous deposit of clayey silt till over a silty sand to sand till. The groundwater levels were measured at 6.1 m and 0.6 m (elevations 220.3 and 226.7) during the current field investigation. The measured groundwater level of 0.6 m in borehole CPR-102 may be due to perched water in the fill. Therefore, the groundwater level may be considered at 6.1 m (elevation 220.3).

It is understood that the initial design called for a cast-in-place concrete box culvert to be installed at the existing CPR overhead location. As requested by AECOM email dated February 26, 2013,





in addition to the box culvert alternative, the attached Table 1 outlines the feasibility of open footing and barrel arch culvert alternatives and the corresponding geotechnical design parameters.

It is considered that a cast-in-place culvert can typically tolerate a maximum of 25 mm of differential settlement, after which, cracking may appear within the culvert. Since the expected differential settlements for this culvert between the centreline and the two ends are in the 15 to 20 mm range as outlined in Section 2 of this report, from a foundation perspective, the construction of the proposed cast-in-place culvert is feasible at the proposed location, subject to the following comments.

During staged construction, the Contractor should use appropriate materials and equipment on the compaction of the backfill of the culvert and the installation of the temporary roadway protection system. The backfilling material should satisfy the specifications within MTO SP 110S13. The compaction and equipment should be in conformance to OPSS 501.

The design and installation of the temporary roadway protection system should be in accordance with OPSS 539.

The construction of the culvert may need to consider conventional groundwater control due to potential perched water in the fill, seasonal fluctuations and rainfall patterns despite the low groundwater levels measured at the site at the time of investigation.

The foundation frost penetration depth at the site is 1.7 m according to OPSD 3090.101.

The "red flag" issues outlined in the preceding paragraphs and the recommended methods of overcoming these issues noted in the following sections of the report are intended to alert and aid the Designer and the Contractor. It is noted that no responsibility or liability is assumed by the Consultants or the MTO for alerting the Contractor to all critical issues. The requirement to deliver acceptable construction quality remains the responsibility of the Contractor.

A list of the standard specifications referenced in this report is compiled in Table 2.



## **2. CPR OVERHEAD REPLACEMENT CULVERT**

### **2.1 Foundations**

The road grade at the proposed culvert location will be elevation 235.5, corresponding to an embankment height of about 9.0 m.

Referring to GA Drawing 1, the invert levels of the proposed culvert are set at elevation 226.5 at the east end and elevation 226.8 at the west end. The subgrade level for the concrete box culvert is interpreted to be about 0.6 m below the proposed invert levels at elevations 225.9 and 226.2 allowing for the thickness of concrete base of the culvert and for the bedding and levelling course.

The subgrade soils revealed in borehole CPR-101 below the anticipated culvert subgrade level (elevation 225.9) at the east end comprised of 0.9 m fill underlain by hard clayey silt till. The fill at the east end should be excavated to elevation 225.0 and replaced with compacted granular material as outlined in Section 2.2 of this report. At the west end (borehole CPR-102), the subgrade at elevation 226.2 comprised of compact to very dense silty sand to sand till. At the west end, 0.5 m of compact silty sand to sand till should be excavated to elevation 225.9 and replaced with compacted granular material as outlined in Section 2.2 of this report. Along the proposed culvert alignment, the compacted fill material should be expected.

Groundwater was contacted at elevation 220.3 in borehole CPR-101 during the field investigation. The groundwater level at the time of the field investigation in January 2013 was assumed to be also at about 6.1 m (elevation 220.3) below the inferred subgrade level. It should be noted that the groundwater level is subject to seasonal fluctuations and rainfall patterns, and that perched water may be encountered in the fill.

It is estimated that about 1.4 m of fill excavation at the east end (borehole CPR-101) and 0.9 m of fill and 0.5 m compact silty sand to sand till excavation at the west end (borehole CPR-102) will be required to achieve the anticipated culvert subgrade level, respectively. The level of the excavation for fill and silty sand to sand till removal may vary under the Highway 11 embankment.



The culvert bedding should be 300 mm thick and comprise Granular A or Granular B Type II with a maximum particle size of 37.5 mm.

The Granular A / Granular B Type II bedding materials and the underlying hard clayey silt till or very dense silty sand to sand till that are in the zone of influence below the design subgrade level are considered capable of adequately supporting the stress imposed by the concrete box culvert and overlying embankment fill.

The estimated total settlement of the culvert is some 5 mm at the two ends and 20 to 25 mm at the centreline. It is estimated that the resulting differential settlement between the east end and centreline of the culvert and between the centreline and the west end of the culvert will be 15 to 20 mm.

The preliminary recommended factored geotechnical bearing resistances at Ultimate Limit States (ULS) and the geotechnical reaction at Serviceability Limit States (SLS) for the 4.0 m wide concrete box culvert constructed on the native clayey silt and sand soil below the granular bedding layer are as follows:

CULVERT SECTION	SUBGRADE SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL REACTION AT SLS (kPa)
Entire Length	Granular A or Granular B Type II over Hard Clayey Silt Till or Very Dense Silty Sand to Sand Till	380	250

The geotechnical reaction at SLS normally allows for a 25 mm compression of the founding medium. A foundation embedment depth of 1.4 m and groundwater at about 4.7 to 5.6 m below the excavation level were assumed for computation of the geotechnical resistance.

The advantages and restrictions of the different foundation types are shown in Table 1, appended. The corresponding soil parameters for the different foundation types are also listed in this table. A cast-in-place box culvert is recommended as the preferred foundation type from the geotechnical perspective.



## **2.2 General Comments**

### **2.2.1 Subgrade Preparation**

Preparation of the subgrade for construction of the culvert should be performed and monitored in accordance with OPSS 902. All the cobbles and boulders should be removed from the subgrade level and replaced by granular fill material compacted to 95% of the ASTM D-698 (Standard Proctor) maximum dry density in conformance to OPSS 501 (Method A). A site review should be conducted by qualified geotechnical personnel during preparation of the subgrade and compaction of the granular fill.

For the box culvert, it is recommended to provide a 300 mm thick granular bedding below the culvert. The bedding material should comprise Granular A or Granular B Type II, satisfying the specifications within MTO SP 110S13, compacted to 95% of the ASTM D-698 (Standard Proctor) maximum dry density in conformance to OPSS 501 (Method A).

The geometry of the subgrade preparation, cover backfill and frost taper treatment for the box culvert should be carried out in accordance with OPSS 422 and MTO SP 109S31.

Topsoil/organic silt/fill and any other deleterious soils revealed during the subgrade preparation should be excavated prior to placement of the granular base below the box culvert and the materials replaced with compacted Granular A or Granular B Type II. Granular B Type II should be preferred for construction under wet conditions.

Clayey silt till or silty sand to sand till is anticipated at the subgrade final excavation level (elevation 225.0 to 225.9). Site conditions will be favourable due to the low water level below the final excavation level. However, conventional groundwater control measures should be carried out during the construction of the culvert to handle heavy rainfall and surface water runoff.



### 2.2.2 Modulus of Subgrade Reaction

The estimated values of the modulus of subgrade reaction for a box culvert constructed on various undisturbed subgrade native soils or compacted materials are as follows.

SOIL TYPE	MODULUS OF SUBGRADE REACTION, MN/m <sup>3</sup>
Granular A or Granular B Type II	45
Clayey Silt Till	15
Silty Sand to Sand Till	20

### 2.2.3 Sliding Resistance

The following parameters should be used to compute the sliding resistance of cast-in-place headwall and wingwall foundations.

SOIL TYPE	FOUNDATION FRICTION ANGLE, DEGREES	COHESION, kPa	UNIT WEIGHT, kN/m <sup>3</sup>
Granular A or Granular B Type II	35	0	22.8
Clayey Silt Till	28	20	21.0
Silty Sand to Sand Till	32	0	21.0

### 2.2.4 Seismic Site Coefficient

The seismic site coefficient for the conditions at the subject site is 1.0 –Type I soil profile as per clause 4.4.6 of the CHBDC.

## 3. CULVERT BACKFILL

Backfill adjacent to the culverts should be placed in accordance with OPSD 3121.150, OPSS 422 and MTO SP 422S01.

Backfill should be brought up simultaneously on each side of the culvert and operation of heavy equipment within 0.5 times the height of the culvert (each side) should be restricted to minimize



the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to MTO OPSS 501 and 902 for additional comments.

The proposed culvert must be designed to support the stress imposed by the overlying fill as well as to resist the unbalanced lateral earth pressure and compaction pressure exerted by the backfill adjacent to the culvert walls.

The lateral earth and water pressure,  $p$  (kPa), should be computed using the equivalent fluid pressures presented in Section 6.9 of the Canadian Highway Bridge Design Code (CHBDC) or employing the following equation assuming a triangular pressure distribution.

$$p = K (\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

where  $p$  = lateral earth pressure (kPa)  
 $K$  = lateral earth pressure coefficient  
 $\gamma$  = unit weight of backfill material above design water level (kN/m<sup>3</sup>)  
 $\gamma'$  = unit weight of submerged backfill material below design water level (kN/m<sup>3</sup>)  
 $\quad = \gamma - \gamma_w$   
 $\gamma_w$  = unit weight of water  
 $\quad = 9.8 \text{ kN/m}^3$   
 $h_1$  = depth below final grade (m), above design water level  
 $h_2$  = depth below design water level (m)  
 $q$  = any surcharge load (kPa)  
 $C_p$  = compaction pressure (refer to clause 6.9.3 of CHBDC)  
 $C_s$  = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)  
 where  $\phi$  = angle of internal friction of retained soil (35° for Granular A or B Type II)  
 $\delta$  = angle of friction between soil and wall (23.5° for Granular A or B Type II)

The seismic site coefficient for the conditions at this site was provided in Section 2.2.4.

The following parameters are recommended for design:

PARAMETER	GRANULAR A OR GRANULAR B TYPE II
Angle of Internal Friction, degrees	35
Unit Weight, kN/m <sup>3</sup>	22.8
Coefficient of Active Earth Pressure ( $K_a$ )	0.27
Coefficient of Earth Pressure At Rest ( $K_o$ )	0.43
Coefficient of Passive Earth Pressure ( $K_p$ )	3.69

The coefficient of earth pressure at rest should be employed to design rigid and unyielding walls.



#### **4. HEADWALLS AND WINGWALLS**

The previous recommendations and geotechnical parameters for culvert foundations and backfill should be utilized for the design of the foundations for headwalls and wingwalls. The wall founding levels should match those of the respective culverts where the walls are designed integral with the culvert structure. For walls designed separately from the culvert structure, the founding levels should be established with 1.7 m of earth cover for adequate frost protection.

The design of the walls should be checked for sliding resistance using the geotechnical parameters provided previously in Section 2 for cast-in-place concrete foundations. It is understood, based on AECOM email dated February 26, 2013 that a number of wall types including gabion or other gravity types are possible alternatives in addition to the concrete retaining walls. The retaining wall types are listed in the appended Table 3 together with the potential advantages and construction constraints of the different types of retaining walls.

It is anticipated that the wingwalls of the existing CPR overhead would be preserved during construction. Based on the specific site condition, all of types of retaining walls including reinforced retaining soil system (RSS), reinforced concrete cantilever retaining wall and gabion gravity retaining wall are feasible at this site.

A weeping tile system and/or weep holes should be installed to minimize the build-up of hydrostatic pressure behind the headwalls and wingwalls. The weeping tiles should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75-150  $\mu$ m according to OPSS 1860) placed to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade.

#### **5. CONSTRUCTION CONSIDERATIONS**

##### **5.1 Staged Construction**

Staged construction will be required to remove the existing overhead and to install the new CPR culvert while maintaining traffic on the Highway 11. AECOM provided the 30% Detail Design



staged construction Drawing attached in Appendix FDR-1 for reference. Six foundation construction stages are identified and are as follows.

- Stage 1: Installation of the new pedestrian culvert
- Stage 2: Backfill to the culvert to an appropriate height restricted by the clear height under the overhead
- Stage 3: Move NBL traffic to SBL and removal of NBL lanes of Highway 11 of the existing overhead
- Stage 4: Backfill of NBL over the new culvert, reinstate the Highway 11 pavement and move all traffic to the new NBL
- Stage 5: Removal of SBL lanes of Highway 11 of the existing overhead
- Stage 6: Backfill of SBL lanes over the new culvert, reinstate the Highway 11 pavement and restore original traffic patterns

It is anticipated that a suitable roadway protection scheme following OPSS 539 will be necessary to support the existing overhead abutment backfill and adjacent traffic lanes during staged construction as discussed in the following section of this report.

## **5.2 Roadway Protection**

To maintain traffic adjacent to the construction area, roadway protection will be required during the new culvert backfill and the existing CNR overhead abutment removals. To reduce the extent of the roadway protection system, it is envisaged that the abutments may be left in place while the new culvert is partially backfilled under the existing structure and only the upper 1.7 m of the abutments be removed in Stages 3 and 5 noted in the previous section.

The minimum 1.7 m depth of abutment removal is recommended to minimize the effect of frost action that could otherwise distort the pavement over buried unyielding obstructions. The depth of the abutment wall removals could be further reduced by incorporating rigid expanded polystyrene insulation over the remaining abutment portions, subject to the minimum cover for adequate pavement design considerations.

A roadway protection system designed for a minimum performance level 2 according to OPSS 539 is recommended to prevent excessive lateral and/or vertical movement of the existing embankment





during construction. The Contractor is responsible for the selection, performance and detailed design of the roadway protection scheme. To meet the performance Level 2, the maximum lateral displacement is limited to 25 mm with a maximum allowable angular distortion of 1:200.

Alternative roadway protection schemes such as sheet piling or soldier piles and lagging were considered. Typically, sheet piling can be used to reduce loss of native soils below the water table. Soldier piles and lagging systems are generally considered suitable for applications above groundwater table. For possible shallow excavations where the excavated side slopes can be cut at 1H:1V, the roadway protection system may be eliminated where space limitations allow.

The following table presents an overview assessment of the advantages and disadvantages, including relative costs and risk/consequences of the roadway protection system alternatives from the foundation perspectives at the culvert site.

ALTERNATIVES	ADVANTAGES	DISADVANTAGES
Sheet piles	<ul style="list-style-type: none"><li>• Sheet piles will be interlocked therefore loss of native soils will be negligible</li><li>• Suitable for high water table</li><li>• Suitable to drive for varying bedrock profile, if required</li><li>• Low risk of soil loss</li></ul>	<ul style="list-style-type: none"><li>• Higher cost</li><li>• May require soil anchors/rakers for lateral support</li><li>• Larger construction equipment is required than for soldier piles</li></ul>
Soldier piles and lagging	<ul style="list-style-type: none"><li>• Lower cost</li><li>• Smaller construction equipment is required than for sheet piles</li></ul>	<ul style="list-style-type: none"><li>• Excessive settlement may occur due to loss of cohesionless soils</li><li>• Higher risk of soil loss</li></ul>

The contractor should select the type of shoring alternative to be employed, if required. Based on the above table, it is noted that sheet piles are considered to be preferable due to the likely presence of cohesionless soils in the embankment fill near the abutments. Soldier piles and lagging systems of road protection are least favorable in this regard.



### **5.3 Excavation**

Excavation to the anticipated founding level of the new culvert is expected to extend through the fill into the native deposit of clayey silt and sand till. Subject to adequate groundwater control, excavation of the existing soils should be feasible using conventional equipment. All excavations should be conducted in accordance with OPSS 902.

It is anticipated that the lower zones of the abutments, headwalls and wingwalls of the existing CPR overhead will be preserved during construction. No obvious unsupported temporary cuts will be carried out during construction. However, for any possible cut, the construction work should be carried out in accordance with Ontario Health and Safety Act (OHSA).

### **5.4 Groundwater Control**

The groundwater level was 4.7 to 5.6 m (at elevation 220.3) below the proposed excavation level during foundation investigation. It is considered that conventional sump pumping should be applicable to control localized seepage that may occur from precipitation, surface water runoff and any perched water in the fill during excavation to the anticipated founding levels. The flow of surface water should be diverted away from the excavations.

It should be noted that the groundwater level is subject to seasonal fluctuations and rainfall patterns.

The design and construction of dewatering and groundwater control system, if required, should comply with OPSS 517 and 518 provisions.

## **6. EROSION CONTROL**

Any newly constructed embankment slopes and retained soils behind the headwalls and wingwalls should be covered with topsoil or suitable earth fill and seeded in accordance with OPSS 802 and 804, as soon after grading as possible to prevent erosion. Where slopes are inclined at 2.5H:1V or steeper, the permanent slopes should be protected with erosion control blankets. Also, sod (as per OPSS 803) shall be placed if applicable. Additional appropriate erosion control measures for the project should be assessed during the detail design.



## 7. ADDITIONAL STUDIES

For the detail foundation design, a minimum of three boreholes are recommended to be drilled at the centreline of the Highway 11 (under the structure) and the two outside ends of the retaining walls. It is also recommended that the quality and composition of the fill to the abutment be investigated for the purpose of the design of the roadway protection system.

## 8. CLOSURE

This Foundation Design Report was prepared by Mr. B. Rao, P. Eng., and reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C. M. P. Nascimento, P. Eng., Project Manager conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



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



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

BR/CN/BRG:nb-mi-nk



**TABLE 1**  
**CULVERT FOUNDATION TYPES AND PRELIMINARY SOIL PARAMETERS**

CULVERT TYPE	ADVANTAGES	DISADVANTAGES	FOUNDING ELEVATION (m)	GEOTECHNICAL RESISTANCE (kPa)		FOUNDATION FRICTION ANGLE (Degree)
				Factored ULS	SLS	
Closed Box (Cast-in-Place or Precast Concrete)	<ul style="list-style-type: none"> <li>- High flexibility for variable soil conditions</li> <li>- Induces relatively small geotechnical reaction</li> <li>- Relatively smaller settlement than open footing culverts</li> <li>- Relatively larger contact area with subgrade than open footing culverts offers higher geotechnical resistance against sliding</li> </ul>	<ul style="list-style-type: none"> <li>- Concrete bottom slab may require deeper installation to accommodate earth bottom</li> <li>- Easier construction due to shallower excavations required</li> </ul>	225.0 to 225.9	380	250	Compacted Fill: 35 Clayey silt till: 28 Silty sand to sand till: 32
Open Footing Box (Cast-in-Place or Precast Concrete)	<ul style="list-style-type: none"> <li>- Natural earth bottom</li> </ul>	<ul style="list-style-type: none"> <li>- More difficult construction due to required deeper excavations than for closed box culverts</li> <li>- Induces relatively larger geotechnical reaction than closed box culverts</li> <li>- Relatively larger settlements than closed box culverts</li> <li>- Smaller footing contact area with subgrade than closed box culverts offers lower geotechnical resistance against sliding</li> </ul>	224.7 to 225.6	380	250	Compacted Fill: 35 Clayey silt till: 28 Silty sand to sand till: 32



**TABLE 1**  
**CULVERT FOUNDATION TYPES AND PRELIMINARY SOIL PARAMETERS**

CULVERT TYPE	ADVANTAGES	DISADVANTAGES	FOUNDING ELEVATION (m)	GEOTECHNICAL RESISTANCE (kPa)		FOUNDATION FRICTION ANGLE (Degree)
				Factored ULS	SLS	
Arch (Open Footing)	<ul style="list-style-type: none"> <li>- Thin top arch</li> <li>- Larger span possible than with box culverts</li> <li>- Natural earth bottom</li> </ul>	<ul style="list-style-type: none"> <li>- Induces relatively larger geotechnical reaction than closed box culverts</li> <li>- Relatively larger settlements than closed box culverts</li> <li>- Smaller footing contact area with subgrade than closed box culverts offers lower geotechnical resistance against sliding</li> <li>- Arch induces horizontal thrust force to walls</li> <li>- Difficult construction under overhead</li> <li>- Potential height and width restrictions due to existing piers</li> </ul>	224.7 to 225.6	380	250	Compacted Fill: 35 Clayey silt till: 28 Silty sand to sand till: 32

Note: Advantages and disadvantages taken from the Foundation Engineering standpoint at the subject site.



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

<b>DOCUMENT</b>	<b>TITLE</b>
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 518	Construction Specification for Control of Water From Dewatering Operations
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 803	Construction Specification for Sodding
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1860	Material Specification for Geotextiles
SP 109S31	Substitution of Precast Concrete Box Culverts for Cast-In-Place Concrete Box Culverts
SP 110S13	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material
SP 422S01	Construction Specification for Precast Concrete Box Culvert
OPSD 3090.101	Foundation Frost Depth for Southern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements - Walls Retaining



**TABLE 3**  
**COMPARISON OF RETAINING WALL TYPES**

RETAINING WALL TYPE	ADVANTAGES	DISADVANTAGES
Reinforced Concrete Cantilever	<ul style="list-style-type: none"> <li>- Narrower base width requirement than RSS walls</li> </ul>	<ul style="list-style-type: none"> <li>- More difficult construction than other retaining wall types</li> <li>- Full frost protection required</li> </ul>
Extended Box Culvert	<ul style="list-style-type: none"> <li>- Low lateral space requirement</li> </ul>	<ul style="list-style-type: none"> <li>- More difficult construction than other retaining wall types</li> <li>- Not cost effective</li> </ul>
Gravity (Gabion)	<ul style="list-style-type: none"> <li>- Easier construction than other retaining wall types</li> </ul>	<ul style="list-style-type: none"> <li>- Requires protection against erosion of backfill material</li> <li>- Low appearance level</li> <li>- Higher bearing capacity requirement</li> <li>- Requires ongoing maintenance</li> </ul>
Reinforced Retaining Soil System (RSS)	<ul style="list-style-type: none"> <li>- Only shallow (typically 0.6 m) excavation for frost protection</li> <li>- Cost effective</li> <li>- Feasible at this site</li> <li>- High appearance level, if required</li> </ul>	<ul style="list-style-type: none"> <li>- Longer base width requirement than other wall types</li> </ul>

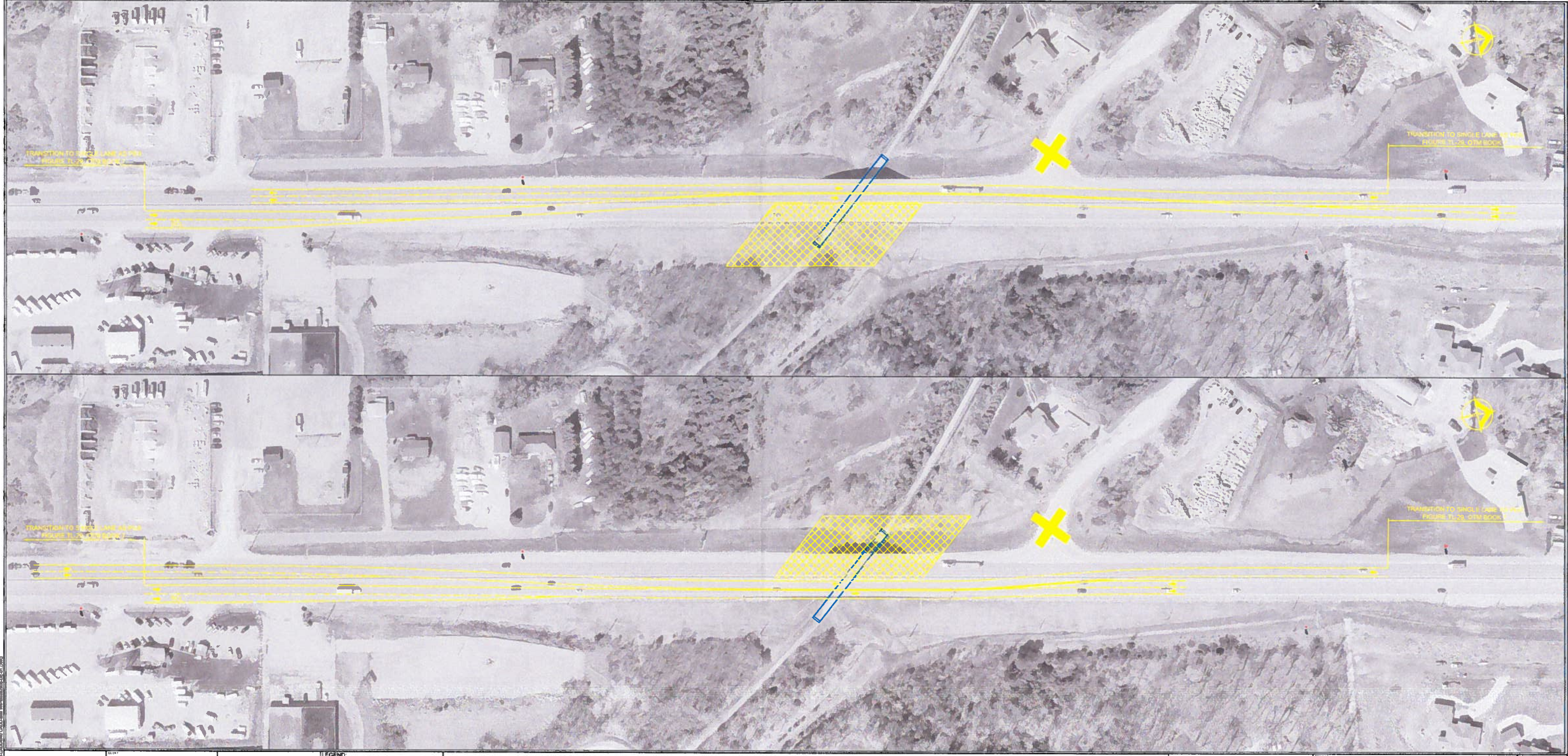
Note: Advantages and disadvantages taken from the Foundation Engineering standpoint at the subject site.



## **APPENDIX FDR-1**

Construction Staging Drawing





Project Management: 677mm x 1025mm  
Designer: 21  
Checked: 21  
Approved: 21

Last revised by: 6/24/2013 10:00 AM  
Last revised by: 6/24/2013 10:00 AM  
Last revised by: 6/24/2013 10:00 AM

Legend



LEGEND



30% DETAIL DESIGN OF HIGHWAY 11 STRUCTURES  
FOR REPLACEMENT OR REHABILITATION  
G.W.P.2177-10-00  
SITE 30-080 1/2 - CPR OVERHEAD AT ORILLIA  
30% DESIGN PLAN - CONSTRUCTION STAGING

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