



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
for**

**VINCENT CREEK CULVERT REPLACEMENT
HIGHWAY 129
TOWNSHIP OF REANEY, ALGOMA DISTRICT, ONTARIO
ASSIGNMENT NO. 5013-E-0040
G.W.P. 5222-05-00
SITE NO. 46-004/C
WP NO. 5291-13-01**

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PML Ref.: 14TF038
Index No.: 083FIR and 084 FDR
GEOCRES No.: 410-16
October 5, 2016



PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

VINCENT CREEK CULVERT REPLACEMENT

HIGHWAY 129

TOWNSHIP OF REANEY, ALGOMA DISTRICT, ONTARIO

ASSIGNMENT NO. 5013-E-0040

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PART A
PRELIMINARY FOUNDATION INVESTIGATION REPORT

for
Replacement of Vincent Creek Culvert
Highway 129 (Site No.46-004/C)
Township of Reaney, Algoma District, Ontario
GWP 5222-05-00, WP No. 5291-13-01

1. INTRODUCTION

This report summarizes the results of the preliminary foundation investigation carried out for the proposed replacement of culvert located at the crossing of Vincent Creek and Highway 129 (Sta. 10+000) in the Township of Reaney, Algoma District, approximately 80.2km north of the intersection of Highway 129 and Highway 556.

The field work was carried out from December 13 and 14, 2016 to January 9,11 and 14, 2015. The purpose of the investigation was to explore the subsurface conditions expected to influence of the preliminary design of the Vincent Creek culvert replacement and to aid the designer in selecting the suitable type of replacement structure.

AECOM Canada Ltd (AECOM) has retained Peto MacCallum Ltd. (PML) on behalf of the Ministry of Transportation Ontario (MTO) to provide preliminary foundation engineering services for the replacement of seven culverts on Highway 129. The scope of this project involves providing subsurface information for the preliminary design of the proposed Vincent Creek culvert replacement.

2. SITE DESCRIPTION

Refer to Photographs V1 to V4 provided in Appendix A for the general view of the site. The proposed replacement culvert is located approximately 80.2 km north of the intersection of Highway 129 and Highway 556. Vincent Creek is about 5 m wide at the culvert location and flows through a relatively flat terrain from west to east side of highway. The topography of the project area is generally flat, except for the highway embankments. Generally, the site surrounding the culvert, with the exception of creek flood plain is heavily wooded. The existing grade of Highway 129 at the crossing of culvert is at about El. 445.5 and the road is approximately 4.0 m higher than the surrounding area.



The existing culvert is a 3.3 m diameter and 35 m long Corrugated Steel Pipe structure with a fill height of 600 mm above the crown. This culvert was constructed in 1982 and the road accommodates two lanes of vehicular traffic. The inlet and outlet of the culvert were snow covered during the fieldwork and the conditions of the embankment or culvert could not be assessed.

3. FIELD INVESTIGATION PROCEDURES

The staff of PML visited the site on December 11, 2014 and January 14, 2015 to mark out the borehole locations. The underground services at the borehole locations were cleared by the respective utility companies. Public and private utility authorities were informed and all the utility clearance documents were obtained before the commencement of drilling work.

The location of boreholes in the field were established by portable GPS device. Subsequently, exp Geomatics under contract to AECOM carried out the survey of the borehole locations and elevations, and provided the co-ordinates for locations in MTM NAD 83 northing and easting. PML used the survey data provided by AECOM for preparing this report. All elevations reported in this report are referred to Geodetic and expressed in meters.

The equipment used for drilling was owned and operated by Landcore Drilling of Chelmsford, Ontario. Landcore Drilling is a specialist drilling contractor was working under the full time supervision of a PML field supervisor. The investigation included advancing four (4) boreholes numbered VC-1, VC-2, VC-3 and VC-4 to a maximum depth of 13.0 m (El. 432.4). Boreholes VC-2 and VC-3 were located on the paved area of the road and these boreholes and VC-1 were advanced using hollow stem augers aided by a truck-mounted CME-55 drill rig. Boreholes VC-1 and VC-4 were located at the inlet and outlet of the culvert, respectively and VC-4 was advanced using portable tripod drill rig employing 75 mm diameter casings and wash boring method. The drill rig was equipped with 63.5 kg (140 lb) automatic hammer calibrated to fall freely through 760 mm (30 in.). Borehole VC-3 was sampled to a maximum depth of 13.0 m (El.432.4). However, Borehole VC-2 was sampled to a maximum depth of 11.3 m and below this depth, the borehole was advanced by conducting Dynamic Cone Penetration Test (DCPT) to a depth of 13.0 m where refusal to DCPT was encountered. Standard penetration and dynamic cone penetration (DCP) tests were conducted to assess the strength characteristics of the substrata. Location of boreholes is shown on the attached Drawing No. VC-1. Representative soil samples were recovered from the boreholes at 0.75m intervals using a conventional 51 mm O.D split spoon



sampler in accordance with the Standard Penetration Test (SPT) procedures. Standard penetration and dynamic cone penetration tests were conducted to assess the strength characteristics of the substrata. Vane Shear Tests using an MTO 'N' size vane (150 mm x 75 mm) were also conducted in Boreholes VC-3 and VC-4, to measure the in-situ undrained shear strength of the clayey strata intercepted.

The groundwater conditions at the borehole locations were observed during drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in open boreholes. Upon completion of drilling, the boreholes were backfilled with bentonite/cement grout in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures.

The recovered soil samples were returned to our laboratory for detailed visual examination, and index tests.

4. LABORATORY TEST PROCEDURES

Laboratory tests on representative SPT samples recovered during the field work were carried out by the laboratory owned by PML, located in Toronto. The laboratory testing program included the following:

- Natural moisture content determinations (31)
- Grain size distribution analyses (9)
- Atterberg Limits Tests (3)

The laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow American Society for Testing Materials (ASTM) test procedures, with the exception of hydrometer test (LS-702). The results of the grain size distribution analyses tests are presented in Figures VC-GS-1 to VC-GS-3. Results of the Atterberg limits tests are provided in Figure VC-PC-1. All of the test results are summarized on the attached Record of Borehole sheets.



5. SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

The project site lies in a deep valley located within Pre-Cambrian rock formations, which in this area consist mainly of granite and other intrusive rocks such as tonalite to granodiorite foliated to gneissic with minor supracrustal inclusions. During the last ice age, continental glaciers eroded much of the bedrock and laid down a shallow mantle of glacial debris that covered the area. Based on the Quaternary Geology map published by Ontario Ministry of Northern Development and Mines, the surface conditions in the vicinity of the project area consist of Glaciofluvial outwash deposits, which includes gravel and sand.

5.2 Subsurface Conditions

The existing CSP culvert is located within approximately 1.8 to 1.9 m high embankment consisting of rock fill placed over the native soils. In summary, the subsurface stratigraphy consists of 200 mm to 700 mm pavement structure followed by 1.8 m to 1.9 m rock fill under the paved area. The boreholes located at the inlet and outlet revealed presence of 100 mm to 300 mm thick peat layer. The rock fill and peat layer are underlain by 3.2 m to 3.8 m thick sand to silty sand deposit, which is followed by 1.4 m to 2.1 m thick clayey silt to silt layer. The clayey silt to silt layer is underlain by silty sand to sandy silt deposit, which extends to the maximum borehole depth of 13.0 m (EL. 432.4) below the existing grade of highway. For classification purposes, the soils encountered at this site can be divided into six distinct zones.

- a) Pavement Structure
- b) Peat
- c) Rock Fill
- d) Sand to Silty Sand, Trace Clay
- e) Clayey Silt to Silt, Trace Sand
- f) Silty Sand to Sandy Silt, Trace Clay

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations and stratigraphic profile sections are shown on Drawings VC-1. The boundaries between soil strata have been established at the borehole locations only. Between



and beyond the borehole locations, the boundaries are assumed and may vary from location to location. Description of the soil strata encountered are summarised below.

5.1.1 Pavement Structure

Approximately 180 mm thick asphalt layer over 20 mm to 520 mm granular base was encountered in Boreholes VC-2 and VC-3 located on the paved area. Granular base consists of varying proportions of sand and gravel and extends to about elevation El. 444.7.

5.1.2 Peat

A thin layer of peat was encountered only in Boreholes VC-1 and VC-4 located near the inlet and outlet of the culvert. It was intercepted immediately below 200 mm thick ice in VC-1 and in VC-4, it was encountered immediately below the surface. The thickness of this deposit varies from 100 mm at the inlet to 300 mm at the outlet.

5.1.3 Rock Fill

The pavement structure is immediately followed by rock fill in Boreholes VC-2 and VC-3 located on the highway shoulders. This rock fill layer ranges in thickness from 1.8 m to 1.9 m and extends to a depth ranging from 2.0 m to 2.6 m (El. 443.5 to El. 442.8) below the asphalt surface. The rock fill consists of gravelly size particles to cobbles ranging in particle size from 100 mm to 150 mm.

However, boulders ranging in diameter from 200 mm to as high as 1.5 m were encountered in borehole VC-3 below about El. 443.8. Coring was carried out below El. 444.0 to advance the borehole through the rock fill. Presence of 1.5 m size boulder in the rock fill was confirmed by coring.

5.1.4 Sand to Silty Sand, Trace Clay

The peat deposit at the inlet and outlet, and the rock fill below the pavement are underlain by sand to silty sand deposit at depths ranging from 300 mm in Borehole VC-1 (El. 443.7) to 2.6 m in Borehole VC-3 (El. 442.8). This sandy deposit extends to a maximum depth of 6.4 m (439.0) below the asphalt surface. In Boreholes VC-1, VC-3 and VC-4, seams of fine fibrous to amorphous peat was encountered at various depths.



The N-values in this deposit ranged from none to 14 blows/300 mm, indicating very loose to compact state of compaction.

The moisture contents of this deposit was determined from nine samples. The moisture contents of the samples that contained predominantly sand to silty sand varied from 20% to 30%. However, moisture contents of samples with organics (peat) varied from 50% to as high as 223%.

The results of the grain size distribution test performed on a selected sand sample is presented in Figure VC-GS-1. The test sample consisted of 2% clay, 35% silt, 63% sand and 0% gravel sized particles.

5.1.5 Clayey Silt to Silt, Trace Sand

The sand to silty sand layer is underlain by clayey silt to silt deposit. The clayey silt to silt deposit was intercepted at a depth of 3.8 m near the inlet (El. 439.8) and at 6.4 m (El. 439.0) below the paved surface, and extended to depths ranging from 5.3 m to 7.8 m (El. 438.2 to El. 437.6). The thickness of this deposit varies from 1.4 m to 2.1 m.

There was no resistance to SPT Test at several depths in this deposit and the weight of the hammer alone was sufficient to drive the split spoon through 300 mm of clayey silt to silt. The N-values in this deposit range from none to 13 blows/300 mm, indicating very soft to stiff consistency. However, the shear strength values from two in-situ vane shear test range from 14 kPa to 45 kPa, indicating soft to firm consistency.

The moisture content of six samples tested varied from 19% to 42%. The results of the sieve analysis test performed on four (4) representative samples from this deposit are provided on Figure VC-GS-2. The test results indicate that this deposit consists of 0% gravel, 2% to 27% sand, 64% to 75% silt and 2% to 34% clay. Atterberg limit test was performed on three samples and the results are provided on Figure VC-PC-1. Based on the Atterberg limit values, the soil may be classified as silts of low plasticity (CL-ML) in the Unified Soil Classification System (USCS).



5.1.6 Silty Sand to Sandy Silt, Trace Clay

The clayey silt to silt deposit is immediately followed by silty sand to sandy silt layer, which extends to the maximum depth of investigation of 13.0 m (El. 432.4) below the grade of highway. The N-values in this layer vary from 2 blows/300 mm to 11 blows/300 mm, indicating very loose to compact state of compaction.

The moisture content of eight (8) samples tested varied from 20% to 23%. The results of the sieve analysis test performed on four (4) representative samples from this deposit are provided on Figure VC-GS-3. The test results indicate that this deposit consists of 0% gravel, 7% to 76% sand, 23% to 90% silt, and 1% to 7% clay.

Borehole VC-2 was advanced below the sampling depth of 11.3 m by conducting Dynamic Cone penetration test (DCPT). Refusal to DCPT was encountered at a depth of 13.0 m (El. 432.5) on probable bedrock.

6. GROUNDWATER

Vincent Creek flows from west to east side of highway and the water level in the creek was observed at about El. 441.99 at the time of the investigation.

The groundwater was observed during and upon completion of drilling. The groundwater level was measured at a depth of 5.1 m (El. 440.3) below the existing grade of the road. However, it was observed at a depth of 800 mm (El. 443.5) below the ground surface of the inlet.

The groundwater level may fluctuate due to the influence of precipitation and seasonal changes.



7. CLOSURE

Mr. F. Portela carried out the field investigation for this study under the supervision of Ms. M. Kamranzadeh, MSc, E.I.T., and Mr. C. M. P. Nascimento, P. Eng., Project Manager. LandCore 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.

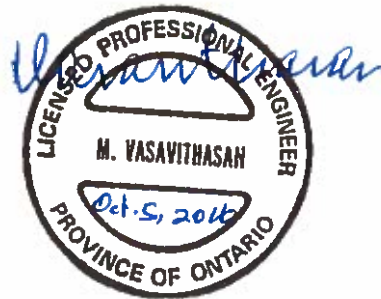
This report was prepared by Mr. Mansoor Khorsand, BSc., EIT. Project Supervisor and reviewed by Mark Vasavithasan, M.Sc. Eng., P.Eng. Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, appearing to read "Mansoor", is written over a circular stamp.

Mansoor Khorsand, BSc., EIT.
Project Supervisor, Geotechnical Services



Mark Vasavithasan, M.Sc. Eng., P.Eng
Senior Engineer, Geotechnical Services



Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MK/MV/CN:nk



APPENDIX A

Sites Photographs



Photograph V1: Looking west from the centre of Highway 129 WBL at the location of the Borehole VC-1. (January, 2015)



Photograph V2: Looking south from the north side of the Vincent Creek at the location of the Borehole VC-2. (December, 2014)



Photograph V3: Looking north from center of Highway 129. Borehole VC-3 advanced using a truck mounted drill rig at this location. (December, 2014)



Photograph V4: Looking north to Vincent Creek outlet. The slope was covered with ice and snow at the time of the investigation. The borehole VC-4 was advanced using a manual method (tripod). (January, 2015)



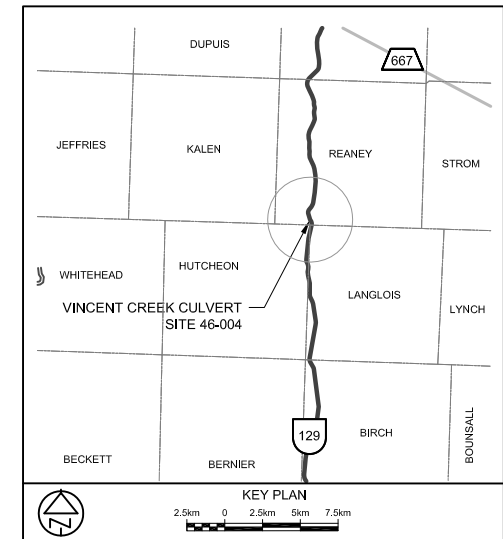
APPENDIX B

Borehole Locations Plan and Soil Strata

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Laboratory Analyses



LEGEND			
	Borehole		
	Cone		
	Borehole and Cone		
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. 2015		
	Head		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		
BH No	ELEVATION	NORTHINGS	EASTINGS
VC-1	444.0	5 263 599.2	364 112.7
VC-2	445.5	5 263 586.3	364 114.4
VC-3	445.4	5 263 590.8	364 123.7
VC-4	443.6	5 263 579.5	364 124.9

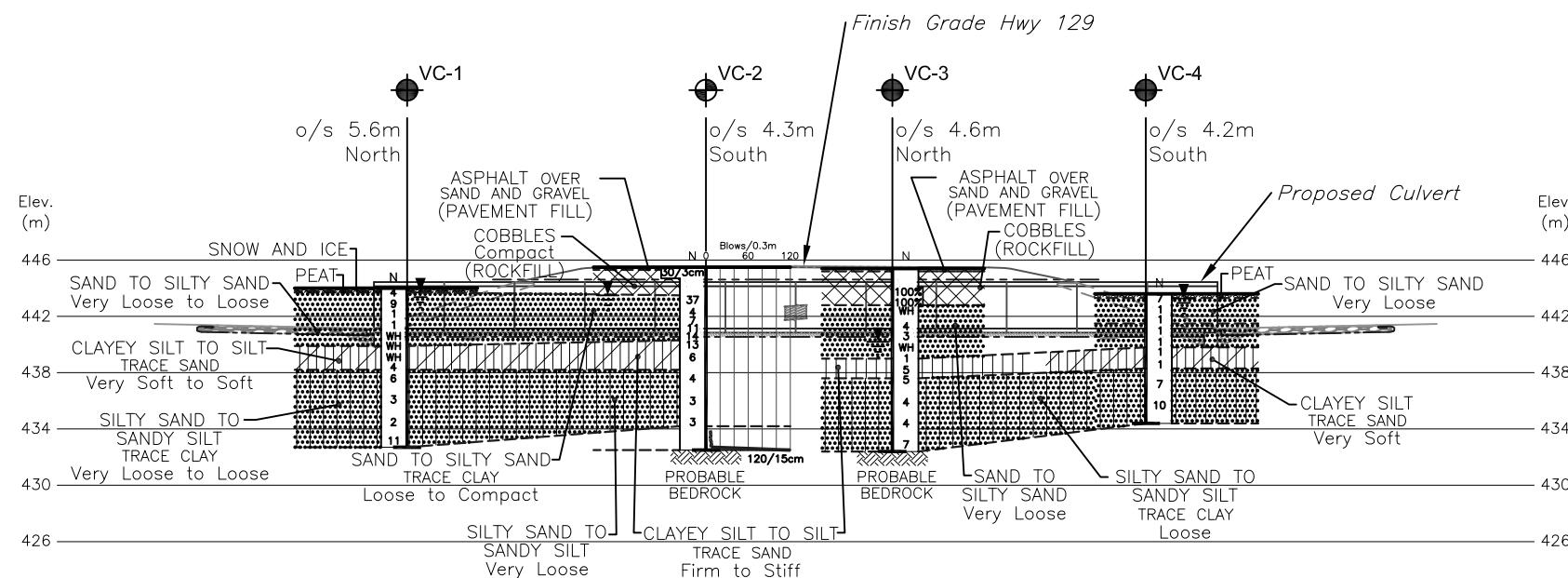
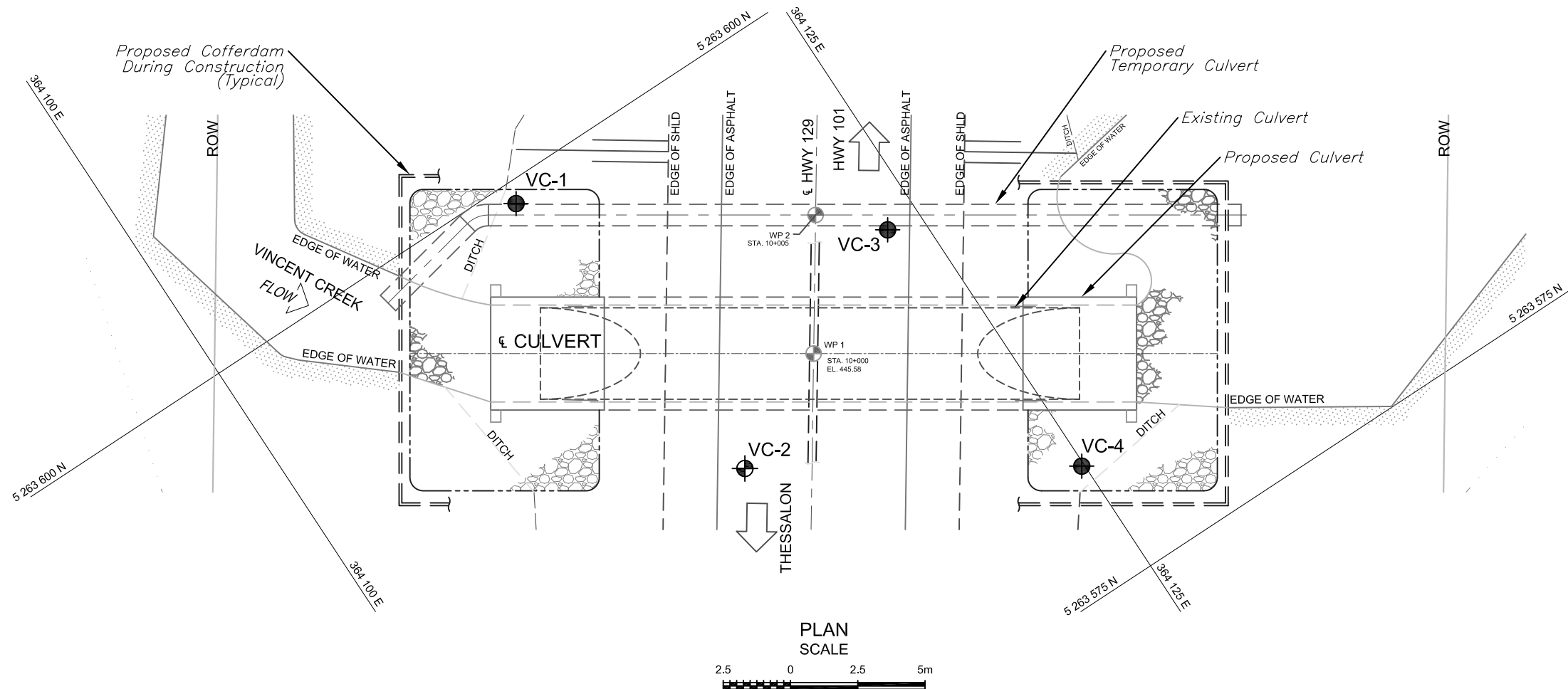
NOTE -
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

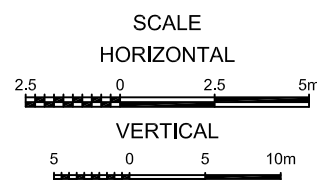
Geocres No. 410-16			
HWY No	129	DATE	OCT. 04, 2016
SUBM'D	NA	CHECKED	MKh
DRAWN	NA	CHECKED	MV
APPROVED	CN	DATE	OCT. 04, 2016
DWG	VC-1	SITE	46-004/C



REF AECOM Drawing: 60333079-P60.dwg dated June 2015



PROFILE ALONG CENTRELINE VINCENT CREEK CULVERT



NOTES:

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

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No VC-1

1 of 1

METRIC

G.W.P. 5222-05-00

LOCATION

Vincent Creek

Coords: 5 263 599.2 N: 364 112.7 E

ORIGINATED BY F.P.

DIST Algoma HWY 129

BOREHOLE

TYPE Continuous Flight Hollow Stem Augers

COMPILED BY M.Kh.

DATUM Geodetic

DATE _____

January 9 and 11, 2015

CHECKED BY M.V.

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS
		NUMBER	TYPE	"N" VALUES	
444.0	Ground Surface				
443.8	Snow and ice				
443.7	Peat, coarse fibrous Dark brown		1	SS	4
0.3	Sand, layers of peat fine fibrous to amorphous Very loose Dark Wet to loose brown		2	SS	9
			3	SS	1
			4	SS	1
			5	SS	WH**
439.9	Clayey silt, trace sand		6	SS	WH
4.1	Very soft Grey Wet to soft		7	SS	WH
438.2	Silty sand to sandy silt trace clay		8	SS	4
5.8	Very loose Grey Wet to compact		9	SS	6
			10	SS	3
			11	SS	2
			12	SS	11
432.7	End of borehole				
11.3					
<div>* 2015 01 09 & 11</div> <div> Water level observed during drilling</div> <div> Water level measured on completion</div> <div>WH** denotes penetration due to weight of hammer and rods</div> <div>NOTE Borehole caved in at 0.9m</div>					

RECORD OF BOREHOLE No VC-2

1 of 2

METRIC

G.W.P. 5222-05-00

LOCATION

Vincent Creek

Coords: 5 263 586.3 N; 364 114.4 E

ORIGINATED BY F.P.

DIST Algoma

HWY 129

BOREHOLE

TYPE C.F.H.S.A. + Casing and Dynamic Cone Penetration Test

COMPILED BY M.Kh.

DATUM Geodetic

DATE

December 13, 2014

CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	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									
445.5	Ground Surface																
445.3 0.2	180mm Asphalt over sand and gravel (PAVEMENT FILL) --- cobble and boulders compact (ROCKFILL)		1	AS	30/3cm		445							Top 0.3m is frozen			
443.5 2.0	Sand to silty sand trace clay, trace gravel Loose to Grey Wet dense		2	SS	37		444										
							443										
			3	SS	4		442										
			4	SS	7		441										
			5	SS	11		440										
			6	SS	14		439										
440.3 5.2	Clayey silt to silt with sand Firm to Grey Wet stiff		7	SS	13		438										
			8	SS	6		437										
438.2 7.3	Silty sand to sandy silt Very loose Grey Wet		9	SS	4**		436										
			10	SS	3**		435										
			11	SS	3**		434										
434.2 11.3	End of borehole Switch to dynamic cone penetration at 11.3m Probable sandy silt Very loose						433										
432.5 13.0	End of dynamic cone penetration test Probable bedrock Sample 1: Sampler bouncing																

Cont'd

RECORD OF BOREHOLE No VC-2

2 of 2

METRIC

G.W.P.	5222-05-00	LOCATION	Vincent Creek Coords: 5 263 586.3 N; 364 114.4 E	ORIGINATED BY	F.P.
DIST	Algoma	HWY	129	BOREHOLE TYPE	C.F.H.S.A. + Casing and Dynamic Cone Penetration Test
DATUM	Geodetic	DATE	December 13, 2014	CHECKED BY	M.V.

[illegible]

RECORD OF BOREHOLE No VC-3

1 of 2

METRIC

G.W.P. 5222-05-00 LOCATION Vincent Creek Coords: 5 263 590.8 N; 364 123.7 E ORIGINATED BY F.P.
DIST Algoma HWY 129 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and casing COMPILED BY M.Kh.
DATUM Geodetic DATE December 14, 2014 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
								20 40 60 80 100									
								20 40 60 80 100									
445.4	Ground Surface																
0.0	180mm Asphalt over sand and gravel						445										
444.7	(PAVEMENT FILL)																
0.7	cobbles and boulders																
	(ROCKFILL)																
	1.5m boulder penetrated		1	RC	REC 100%		444										
			2	RC	REC 100%		443										
442.8	Sand to silty sand layers of peat, fine fibrous		3	SS	WH**		442										
2.6	Very loose Moist		4	SS	4		441										
	organics		5	SS	3		440							151			
	Brown Moist		6	SS	WH		439										
	clay seams wet		7	SS	1		438										
439.0	Silt to clayey silt trace sand		8	SS	5		437										
6.4	Firm Grey Moist		9	SS	5		436										
437.6	Silty sand to sandy silt trace clay		10	SS	4		435										
7.8	Loose Grey Wet		11	SS	4		434										
	silt seams		12	SS	7		433										
432.4	End of borehole																
13.0	Probable bedrock																

RECORD OF BOREHOLE No VC-3

2 of 2

METRIC

G.W.P.	5222-05-00	LOCATION	Vincent Creek Coords: 5 263 590.8 N; 364 123.7 E	ORIGINATED BY	F.P.
DIST	Algoma	HWY	129	BOREHOLE TYPE	Continuous Flight Hollow Stem Augers and casing
DATUM	Geodetic	DATE	December 14, 2014	CHECKED BY	M.V.
COMPILED BY M.Kh.					

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	N"	"N" VALUES
430.4					
* 2014 12 14					
Water level observed during drilling					
Water level measured on completion					
WH** denotes penetration due to weight of hammer and rods					

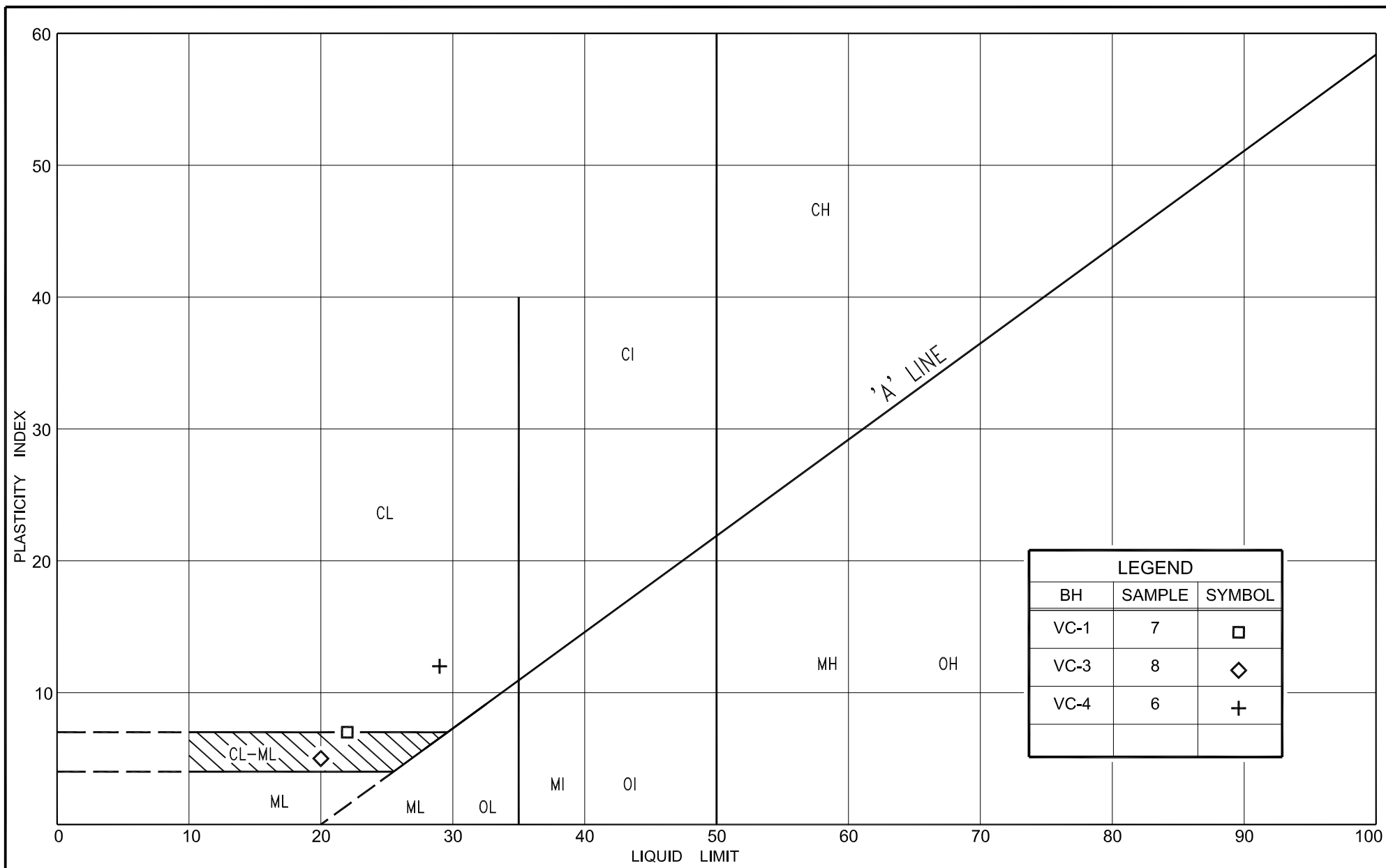
RECORD OF BOREHOLE No VC-4

1 of 1

METRIC

G.W.P. 5222-05-00 LOCATION Vincent Creek Coords: 5 263 579.5 N; 364 124.9 E ORIGINATED BY F.P.
DIST Algoma HWY 129 BOREHOLE TYPE Tripod + Casing COMPILED BY M.Kh.
DATUM Geodetic DATE January 14, 2015 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	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		
443.6	Ground Surface						20	40	60	80	100									
0.0 443.3 0.3	Peat, fine fibrous Dark brown		1	SS	7	▽*									852					
	Sand to silty sand organics layers of fine fibrous peat Very loose Brown Wet					▽	443													
			2	SS	1															
			3	SS	1															
	amorphous peat layers		4	SS	1		441								223					
			5	SS	1		440													
439.8 3.8	Clayey silt, trace sand Very soft Grey Wet		6	SS	1											0 2 64 34				
	some clay			FV			439	+	3											
			7	SS	1															
438.3 5.3	Silty sand to sandy silt trace clay Loose Brown Wet to compact						438									0 42 51 7				
			8	SS	7		437													
			9	SS	10		436													
435.4 8.2	End of borehole																			
	* 2015 01 14 ▽ Water level observed during drilling ▽ Water level measured on completion NOTE: Borehole caved in at 1.5m																			



PLASTICITY CHART

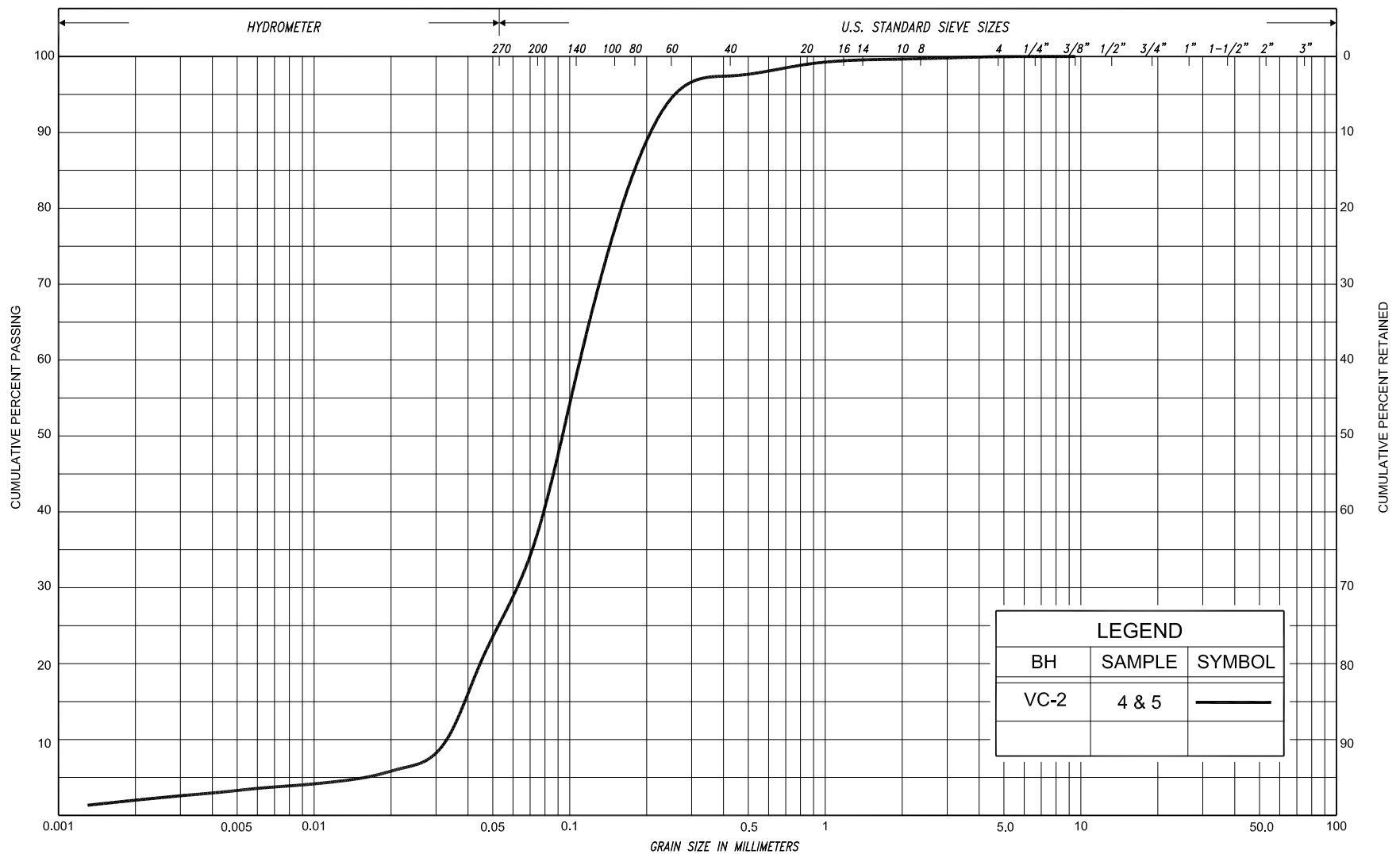
SILT TO CLAYEY SILT, trace to with sand (CL-ML to CL)

FIG No. VC-PC-1

HWY: 129

G.W.P. No. 5222-05-00





LEGEND		
BH	SAMPLE	SYMBOL
VC-2	4 & 5	—

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



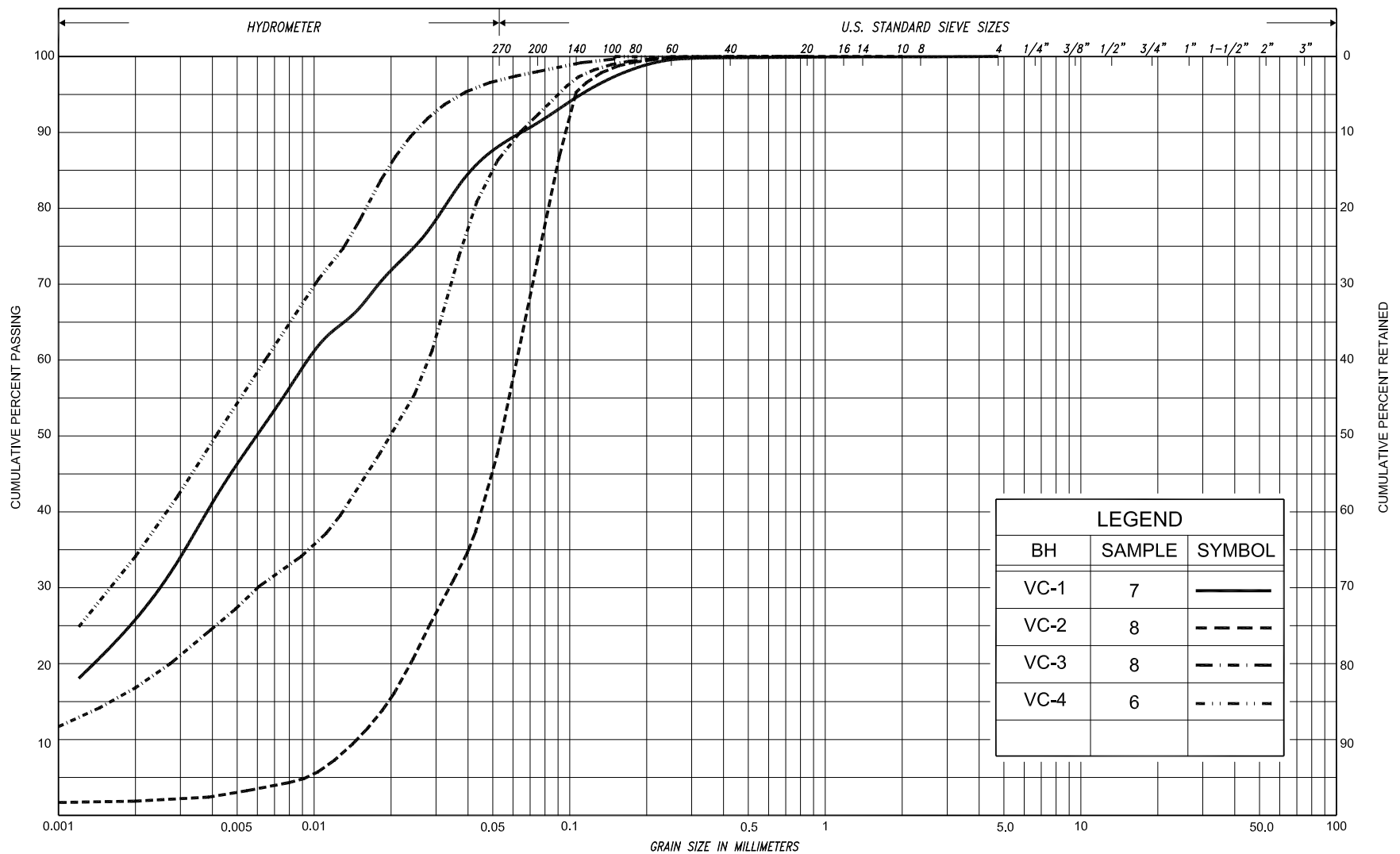
GRAIN SIZE DISTRIBUTION

SAND TO SILTY SAND, trace clay

FIG No. VC-GS-1

HWY: 129

G.W.P. No. 5222-05-00



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



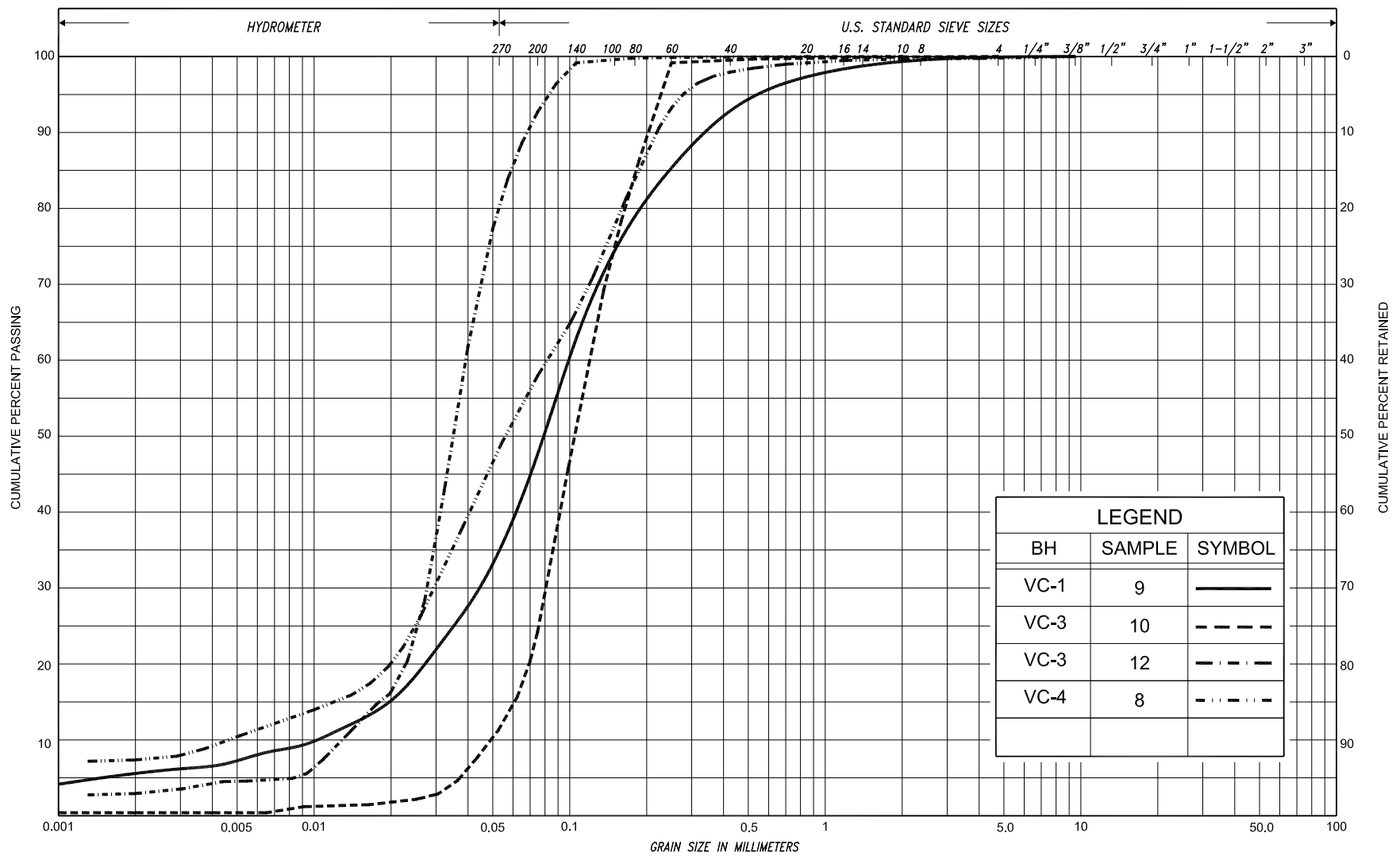
GRAIN SIZE DISTRIBUTION

SILT TO CLAYEY SILT, trace to with sand (CL-ML)

FIG No. VC-GS-2

HWY: 129

G.W.P. No. 5222-05-00



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



GRAIN SIZE DISTRIBUTION

SILTY SAND TO SANDY SILT, trace clay

FIG No. VC-GS-3

HWY: 129

G.W.P. No. 5222-05-00



PART B - PRELIMINARY FOUNDATION DESIGN REPORT

for

VINCENT CREEK CULVERT REPLACEMENT

HIGHWAY 129

TOWNSHIP OF REANEY, ALGOMA DISTRICT, ONTARIO

ASSIGNMENT NO. 5013-E-0040

G.W.P. 5222-05-00

SITE NO. 46-004/C

WP NO. 5291-13-01

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Non-Standard Specific Provision (NSSP)

PART B
PRELIMINARY FOUNDATION DESIGN REPORT
for
Replacement of Vincent Creek Culvert
Highway 129 (Site No.46-004/C)
Township of Reaney, Algoma District, Ontario
GWP 5222-05-00, WP No. 5291-13-01

8. INTRODUCTION

This preliminary foundation investigation and design report with the interpretation and recommendations are intended for the use of AECOM Canada Ltd on behalf of the ministry of transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The design-build contractor must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided only to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual information provided in Part A of the report, as it may affect equipment selection, proposed construction methods and scheduling.

9. PROJECT DESCRIPTION

9.1 General

This report provides preliminary foundation design recommendations based on interpretation of the geotechnical data presented in the factual report (Part A) to assist the design team in the selection of a suitable type of foundation for the culvert replacement at the crossing of Highway 129 and Vincent Creek in the Township of Reaney, District of Algoma. Based on the General Arrangement drawings (GA) provided by AECOM, it is proposed to replace the existing corrugated steel pipe culvert (CSP) with a 3.6 m wide and 3.0 m high precast concrete box culvert. Details of the proposed culvert are shown on the GA provided in Appendix D.

The discussions and recommendations presented in this report are based on the GA received by PML and the factual data obtained during the preliminary geotechnical investigation carried out by PML. The designers must review the geotechnical data presented to determine the adequacy of the information for the detail design of the proposed structure. Additional geotechnical investigation must be carried out if the geotechnical data presented is inadequate.



9.2 Existing Culvert

The proposed culvert to be replaced is located at the crossing of Vincent Creek and Highway 129 (Sta. 10+000), approximately 33 km south of the intersection of Highway 129 and Highway 101. The existing culvert consists of 3.3 m diameter and 35 m long corrugated steel pipe structure with a fill height of 600 mm above the crown. Based on the GA drawing provided by AECOM, the invert of the existing culvert at the centerline of Highway 129 (Sta. 10+00) is located at approximate elevation of El. 441.7 and the embankment above the creek bed is approximately 5.3 m high. There is no riprap on either side of the creek, i.e., inlet or outlet, to protect against scour or erosion. A review of the Google Earth Map indicates that the toe of the embankment on both sides of the culvert is eroded and undermined. The inlet side of the culvert has been eroded severely.

This culvert was constructed in 1982 and the road accommodates two lanes of vehicular traffic. The RFP reveals that the condition of the existing culvert is fair. However, it exhibits localised moderate corrosion and deterioration of the structural steel coating, which require replacement of the existing culvert.

9.3 Proposed Culvert

The RFP specifies that the viability of the following three options required to be evaluated for replacing the existing culvert along the same vertical and horizontal alignments:

- Replacement with a precast concrete box culvert,
- Replacement with a cast-in-place concrete box culvert, and
- Replacement with a three-sided open footing concrete culvert.

Further, it requires that the length of new culvert shall be sufficient to accommodate the width of the roadway and the side slopes. Headwalls and wing walls may have to be designed to contain the roadway embankment fill and to minimise the length of the culvert.

However, the GA provided by AECOM indicate that the proposed replacement structure will be a 24.0 m long precast concrete box culvert with an opening size of 3.6 m in span, 3.0 m in rise and a wall thicknesses of 300 mm. The proposed replacement culvert is 11.0 m shorter than the existing and does not include headwalls or wing walls on the GA provided to PML. The proposed



invert of the box culvert slopes from about El. 441.14 at the inlet to an elevation of El. 440.99 at the outlet. The founding level of the subgrade at the inlet and outlet is proposed to be at El. 440.24 and El. 440.09, respectively. It is proposed to construct the replacement culvert along the same vertical and horizontal alignment. Grade of the road at the culvert location will be maintained at the existing elevation of El. 445.58, which will result in a fill height, including the pavement structure, of 1.1 m above the box culvert, compared to 600 mm high fill above the existing CSP culvert.

There is no local detour available to divert the traffic and the construction of the replacement culvert will be carried out in two stages by allowing the traffic to use one side of the highway. A properly designed temporary roadway protection along the centerline of the road will be required.

9.4 Structure Foundation

In summary, the subsurface stratigraphy at the proposed culvert generally consists of 1.8 m to 1.9 m rock fill with cobbles and boulders, followed by 3.2 m to 3.8 m thick sand to silty sand deposit with seams of peat. It is underlain by 1.4 m to 2.1 m thick, soft to firm clayey silt to silt layer. The clayey silt to silt layer is underlain by very loose to compact silty sand to sandy silt deposit, which extends to the maximum depth of investigation of 13.0 m (El. 432.4) below the existing grade of highway shoulder.

The groundwater level was observed between El. 443.5 and El. 440.3 during the fieldwork. However, the GA drawing indicate an approximate creek water level of El. 441.99 in September 2014, which is about 1.5 m lower than the highest groundwater level observed during the investigation.

Considering the subsoil conditions, the recommendations for the replacement culvert are provided below in the order of preference. A comparison of the technical advantages and disadvantages for the replacement culvert are presented in Appendix D. The discussions with AECOM suggests that option of using pipe culvert (CSP) need not be considered. Therefore, this report does not include any discussion on the option of using CSP culvert.



9.4.1 Option 1: Precast Concrete Box Culvert

Based on the GA drawing, it is assumed that the precast box culvert will be placed at about elevation El. 440.2±. The bedding for the proposed culvert is expected to be placed on soft to firm clayey silt to silt layer, which is capable of providing adequate geotechnical resistance to support the proposed box culvert. The option of a precast box culvert will require at least 75 mm of levelling course meeting the requirement of OPSS 422.07.08 and bedding material as specified in OPSS 422.05.13. The bedding for the replacement culvert should be placed in accordance with Section 422.07.07 of OPSS 422.

As required by Clauses 1.9.5.6 and 1.9.11.6.5 of Canadian Highway Bridge Design (CHBDC, 2014), cut-off walls at both ends of the culvert shall be provided. Cut-off walls shall be in accordance with OPSD 812.010 or made of precast concrete with similar dimensions to prevent washout of granular bedding with provision to protect the clayey silt to silt subgrade material below invert. For the design of the 4.2 m wide precast box culvert, a geotechnical resistance of 100 kPa at U.L.S and 60 kPa at S.L.S shall be utilized. The design should meet the requirements of Clauses 1.9.5.6 and 1.9.11.6.5 of CHBDC, 2014.

There will be no grade raise of the road to impose additional load on the culvert to cause settlement. Considering the soft to firm clayey material below the invert, the settlement induced by the bearing resistance at SLS recommended will be about 40 mm to 50 mm and associated differential settlement will be about 25 mm. Continuing settlements and associated differential settlements are expected to be within the tolerable limit for the proposed box culvert.

9.4.2 Option 2: Cast-In-Place Reinforced Concrete Box Culvert

The soft to firm clayey silt to silt layer and the loose sandy material encountered below the proposed founding level is not favorable or capable of providing adequate geotechnical resistance to support cast-in place reinforced concrete culvert at the proposed invert level. Considering the subsoil conditions below the invert, it is not cost effective or practical to excavate about 6.0 m of material and replace with lean concrete to support the culvert. In addition, construction under 3.3 m of ground water will impose greater difficulties for construction in dry conditions. In view of the subsoil conditions, deep foundation such as piles will be required if option of using cast-in-place reinforced concrete box culvert is considered. For these reasons, this option is not preferred.



9.4.3 Option 3: Three-Sided Open Precast Concrete Culvert on Strip Footing

The clayey silt to silt material encountered below the proposed founding level of the replacement culvert is susceptible for scour. Section C1.9.11.1 of the Canadian Highway Bridge Design Code commentary (CHBDC, 2014) suggests avoiding placing open footing on material that is susceptible to scour. Same as in Option 2, use of deep foundation will be required for supporting strip footing.

If Options 2 and 3 are considered, additional investigation will be required to establish the bedrock elevation.

9.4.4 Recommended Option for Culvert Replacement

From a geotechnical perspective and based on the subsurface conditions, precast concrete box culvert placed at about EI 440.2± is the preferred option for the replacement of the existing culvert.

Option 2 and 3 are technically feasible but not cost effective or practical. Considering the construction difficulties and cost of deep foundation, these two options are not recommended.

9.4.5 Lateral Earth Pressure

Earth pressure for the concrete structure should be computed as per the Clause 6.12.2 (b) of Canadian Highway Bridge Design Code (CHBDC, 2014). Sufficient movement of the structure wall may not be permitted for all three options and “at rest” conditions may be assumed for the calculation of earth pressure. The earth pressure calculation should include maximum water level expected in the creek. The lateral earth and water pressure, p (kPa), may be computed using the equivalent fluid pressures presented in Section 6.12 of the CHBDC, 2014 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

γ = unit weight of backfill material above design water level (kN/m³)

γ' = unit weight of submerged backfill ($\gamma - \gamma_w$) material below design water level (kN/m³)

γ_w = unit weight of water (9.8 kN/m³)

h₁ = depth below final grade (m), above design water level

h₂ = depth below design water level (m)

q = Surcharge load (kPa)

C_p = compaction pressure (refer to Clause 6.12.3 of CHBDC, 2014)

C_s = earth pressure induced by seismic events, kPa (refer to clause 4.6.5 of CHBDC, 2014)

Where,

Ø = angle of internal friction of retained soil (35° for Granular A or B Type II)

δ = angle of friction between soil and wall (24° for Granular A or B Type II)

The seismic site coefficient for the conditions at this site is provided in Section 11.0 of this report. Granular 'A' or 'B' should be utilized as backfill material and should be carried out in accordance with the requirements specified in the OPSS 902. The following parameters are recommended for the granular backfill:

Table 8.4.5: Recommended Geotechnical Parameters

Geotechnical Parameter	Granular 'A'	Granular B Type II
Angle of Internal Friction, degrees	35°	30°
Unit Weight, kN/m ³	22.5± 0.3	21.5 ± 0.3
Coefficient of Active Earth Pressure (K _a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K _o)	0.43	0.5
Coefficient of Passive Earth Pressure (K _p)	3.69	3

Backfill shall be placed simultaneously behind both sides of the culvert, maintaining the height of backfill approximately the same. At no time should the difference in backfill elevation from one side to the other be greater than 500 mm.



9.5 Approach Embankment

The height of the existing approach fill is approximately 5.3 m above the creek bed. PML understands that there will be no increase in the profile grade of the road and it will be maintained at El. 445.58. No major instability problems are anticipated for the embankment constructed with 2H: 1V side slope. Considering the high water level, the fill should consist of well compacted granular material, preferably Granular B Type II. Any spongy or soft area observed within the base of the embankment should be removed before placing the fill. Rip-rap should be provided on both the upstream and downstream sides of the creek to protect the toe of the embankments and to prevent erosion of creek bed in the proximity of the culvert. Rip-rap shall be in accordance with OPSD 810.010 and provided to a minimum height of 1.0 m above the high flood level expected in the creek.

10. FOUNDATION FROST DEPTH

In accordance with OPSD 3090.101, a minimum of 2.3 m earth cover is required to protect against the frost penetration in the area where the site is located.

Frost tapers within the granular backfill should be constructed in accordance with OPSD 3101.150. The frost penetration depth, f , is measured from the top of the grade to the bottom of the footing.

11. SEISMIC CONSIDERATIONS

The reference Peak Ground Acceleration (PGA) for the project site is 0.036 based on the Town of Chapleau, Ontario (National Building Code of Canada, 2015). The soil at this site for seismic design purposes is classified as Type E in accordance with Clause 4.4.3.2, CHBDC, 2014.

12. CONSTRUCTION CONSIDERATIONS

12.1 Cover and Backfill

Backfill materials shall meet the requirements of Group I, or Group II specified in OPSS 422.05.14, Table 1 and placed according to the procedures described in Section 422.07.11. It shall be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501. Backfill on each side of the box culvert shall be completed



simultaneously and at no time, the levels on each side of the culvert exceeds more than 400 mm. Restrictions on compaction near the culvert shall be as specified in OPSS 902.07.06.02.

The clayey silt to silt layer that will be exposed at the founding subgrade level of the box culvert, especially under water will be susceptible to degradation. In order to limit this degradation, it is recommended that bedding material shall be placed on the subgrade within four hours after preparation, inspection and approval of the subgrade.

Cover material shall meet the requirements of OPSS 422.05.14 and placed in accordance with OPSS 422.07.12.

12.2 Excavation

Staged construction with a roadway protection system will be required to remove the existing culvert and to install the new culvert while maintaining traffic on Highway 129. Surface water should be diverted away from open excavations and all excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO Regulations for Construction Projects. The protection system for excavations should be in accordance with OPSS 539, Construction Specification for Temporary Protection Systems, and OPSS 902, Construction Specifications for Excavating and Backfilling – Structures. Excavated material shall not be stockpiled on top of the excavation.

Based on the record of boreholes, the excavations for the construction of replacement culvert will be advanced through existing rock fill material underlain by sandy deposit with seams of peat. For OHSA classification purposes, the fill materials and loose sandy deposit should be classified as Type 3 soils. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation.

Considering the soft to firm clayey silt to silt at the base, open excavation with a side slope of 2H:1V may not be stable. A side slope of at least 3H:1V or a 2.0 m wide berm will be required to stabilise an open excavation. In view of this, sheet pile walls around the excavation with horizontal struts to support the wall will be required to install the proposed culvert. The sheet piles should be driven to an adequate depth, i.e., below El. 437.0, to protect against any blow out of the base of excavation.



12.3 Staged Construction

The construction of culvert replacement is expected to be carried out in two stages. The subsoil conditions encountered at this site, with the exception of rock fill with occasional boulders, is favourable for driving sheet piles to design and construct a shoring system to maintain traffic on Highway 129. The cobbles and boulders within the rock fill will have to be removed to prevent obstructions for driving the sheet piles. A shoring system consisting of sheet pile wall with strutted excavation may be feasible. Alternatively, shoring system consisting of soldier piles and timber laggings supported by rock anchors may be considered. This type of shoring system will be very costly for the type of proposed structure and additional investigation will be required to establish the bedrock elevation and quality of the rock.

Temporary roadway protection shall be designed to meet a Performance Level of 2 and constructed in accordance with OPSS 539 (Temporary Protection Systems). Additional foundation investigation may be required to determine the type and method of installation of temporary roadway protection system.

13. GROUNDWATER CONTROL

The groundwater level was encountered between El. 443.5 and El. 440.3 and the excavation to the founding level will have to be carried out under 3.3 m high water level. The groundwater level should be lowered to a minimum of 0.5 m below the proposed founding levels to allow for construction in the dry and to place bedding materials.

The creek may have to be temporarily diverted and a cofferdam will be required due to the relatively pervious nature of the subsoil. A cofferdam consisting of sheet pile walls may be utilised for excavation and dewatering. Alternatively, a cofferdam consisting of sand bags and clay puddle may be constructed by damming the upstream and downstream of the culvert. Dewatering may be carried out from the sumps located along the periphery of the cofferdam. If any environmental restrictions are imposed on placing clay puddle in the creek, the culvert replacement may have to be constructed under the prevailing water level. If the construction is carried out under water, the backfill material shall consist of Granular B Type II containing particle sizes not finer than 75 µm.



The contractor shall be responsible for the selection, performance and detailed design of the dewatering system including the cofferdam. The dewatering system should be designed to conform to the requirement of OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation) and OPSS 518 (Construction Specification for Control of Water from Dewatering Operations) in addition to the NSSP provided in Appendix E.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

14. SCOPE OF ADDITIONAL INVESTIGATION AND DESIGN SERVICES

The recommendations in this report are preliminary. Detailed foundation engineering services will be required during the Detail Design phase of the project.

The extent of further investigations at this site should include a minimum of 2 boreholes on the Highway 129 for recommendations on roadway protection. The boreholes should extend to sufficient depth to provide information for shoring and dewatering. It is recommended that the boreholes extend at least 3.0 m into bedrock if it is encountered.



15. CLOSURE

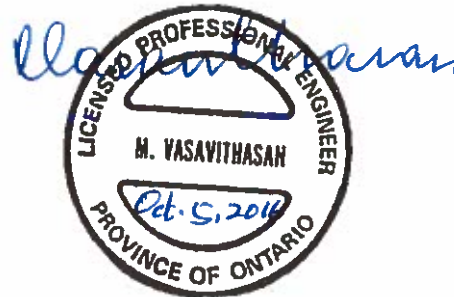
The Foundation Design portion of this report was prepared by Mr. Mansoor Khorsand, BSc., EIT. Project Supervisor, and reviewed by Mr. Mark Vasavithasan, P.Eng, Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, appearing to read 'Mansoor', is positioned above the name of the Project Supervisor.

Mansoor Khorsand, BSc., EIT.
Project Supervisor, Geotechnical Services



Mark Vasavithasan, M.Sc. Eng., P.Eng
Senior Engineer, Geotechnical Services



Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MK/MV/CN:nk



APPENDIX C

Slope Stability Analyses Figures



Figure 1 – Slope Stability (2H:1V)

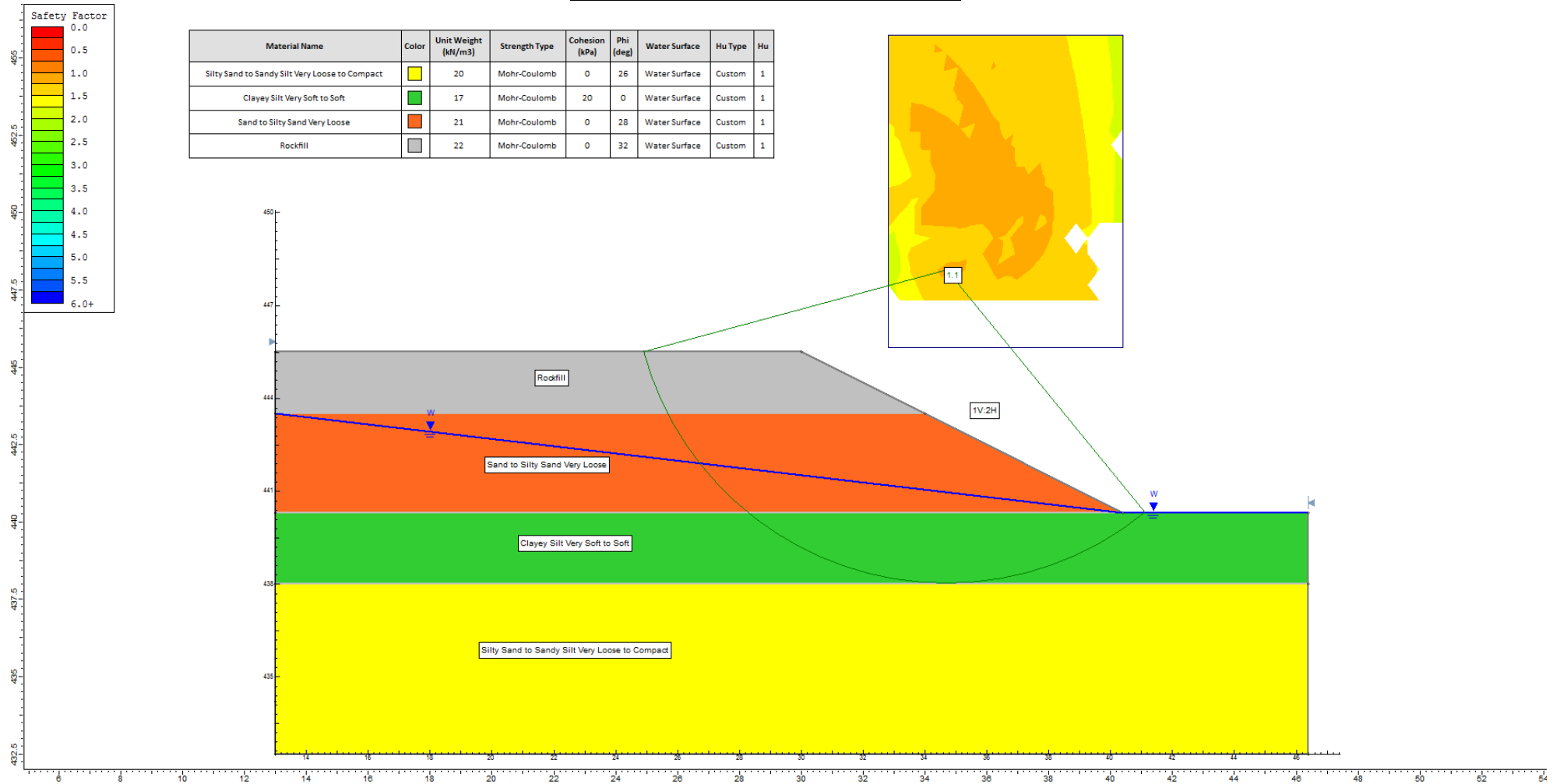




Figure 2 – Slope Stability (2H:1V with 3.0 m Bench)

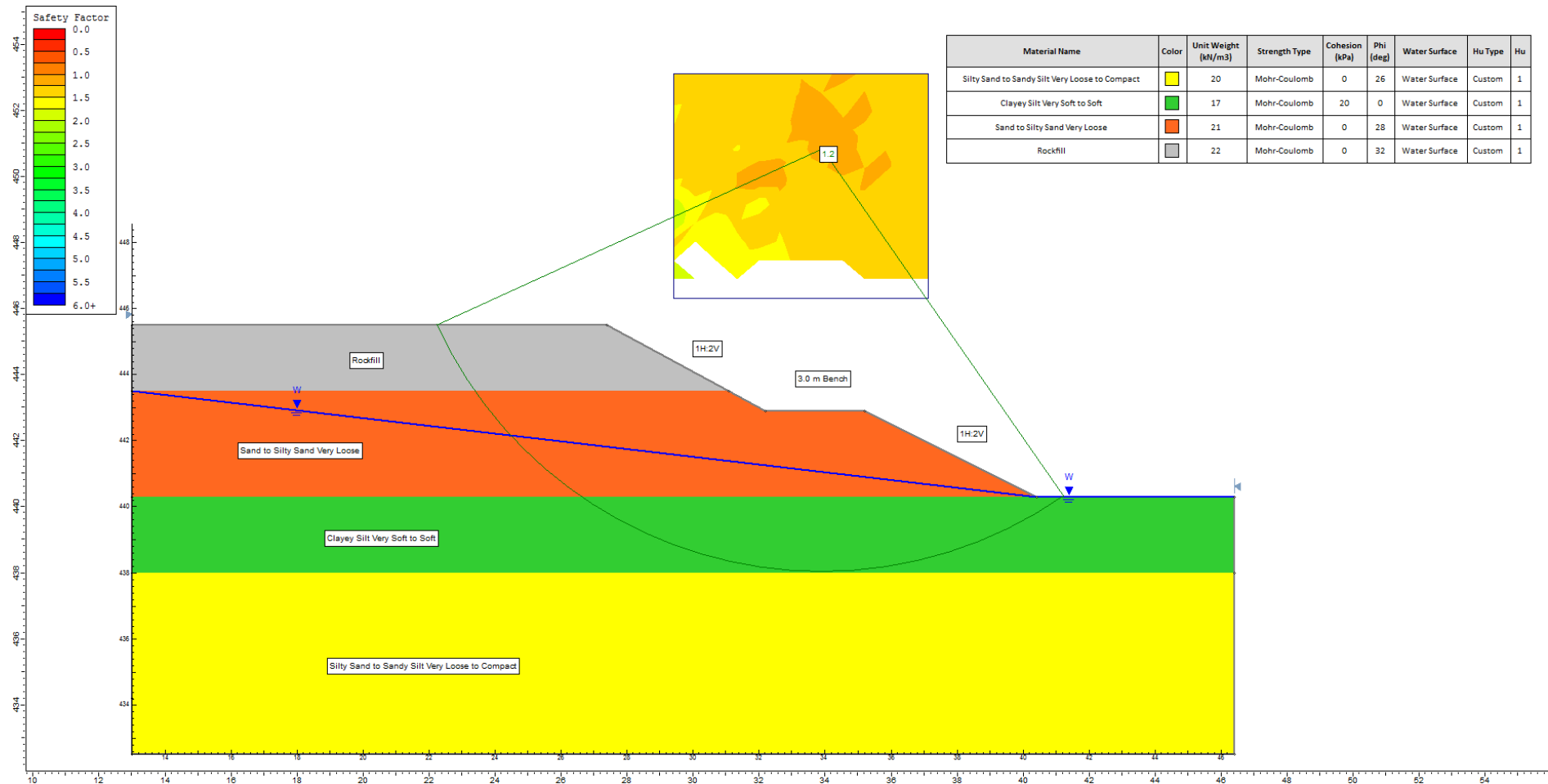
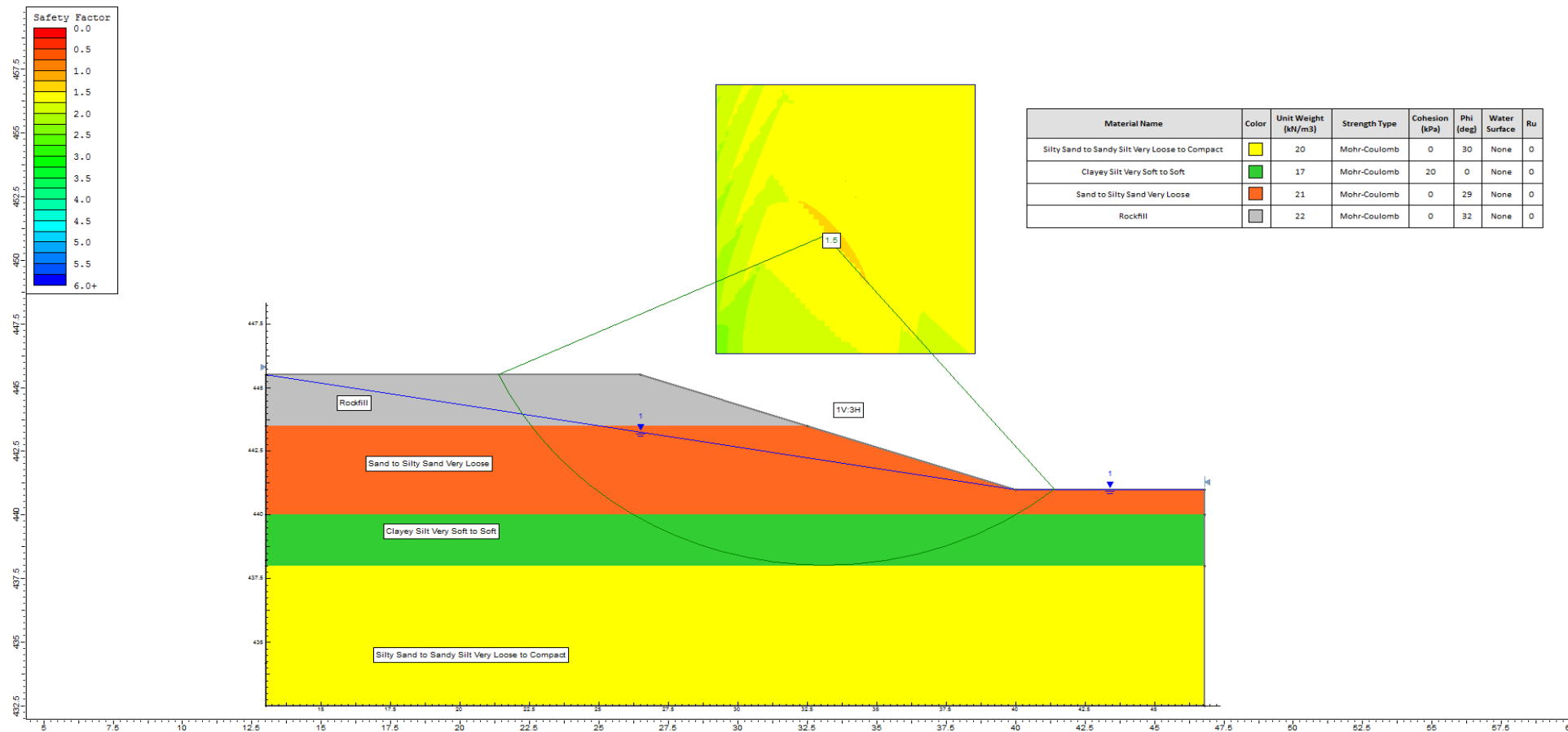




Figure 3 – Slope Stability (3H:1V)

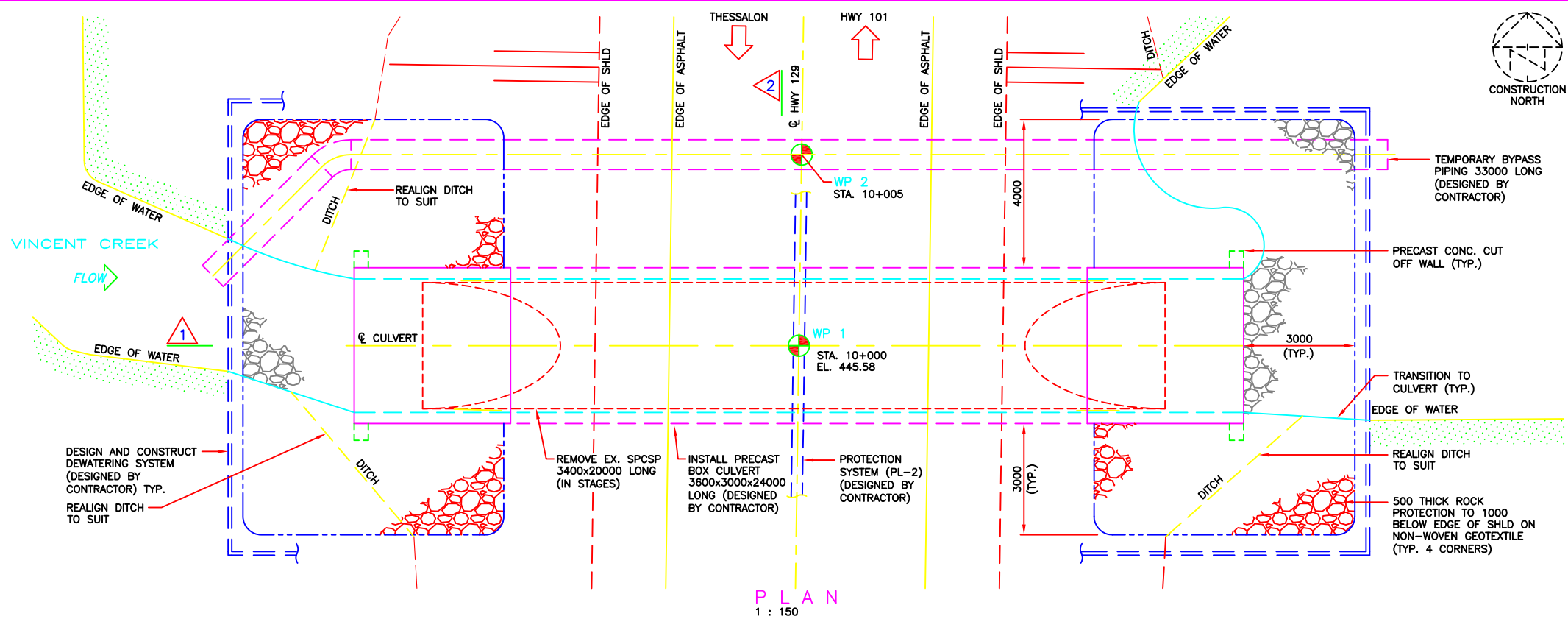




APPENDIX D

General Arrangement Drawing

DRAWING FILE: C:\Users\User\Documents\2016 DWGS\2014 JOBS\1470309\Aug. 14, 2015 CAD QA\60333079-P60
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METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



HWY 129
CONT No
WP No 5291-13-01



VINCENT CREEK CULVERT
STA. 10+000, REANEY TWP.
GENERAL ARRANGEMENT

SHEET

AECOM

GENERAL NOTES :

1. CLASS OF CONCRETE : PRECAST 40 MPa
2. CLEAR COVER TO REINFORCING STEEL : PRECAST 50 ± 10
3. REINFORCING STEEL :
 1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
 2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL SHALL BE CLASS B.
 3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.
4. GEOTEXTILE :
 1. NON-WOVEN, CLASS II, FOS 50 TO 100µm.

CONSTRUCTION NOTES :

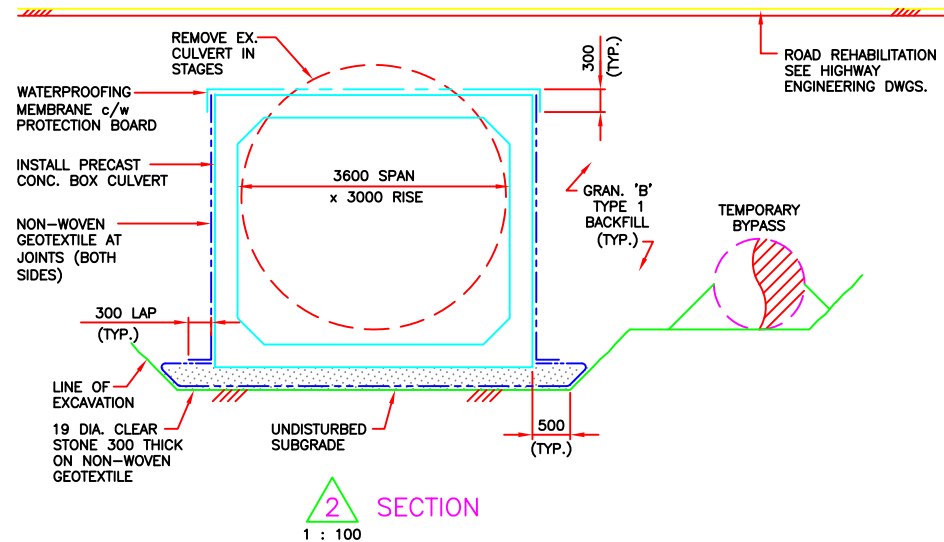
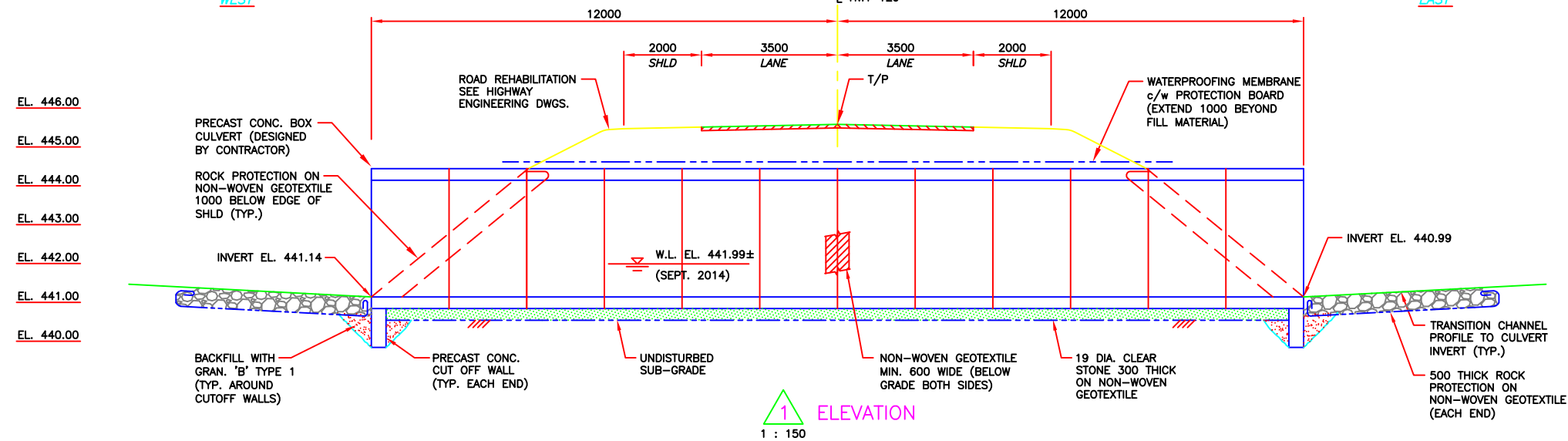
1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS OF THE EXISTING WORK AND ALL DETAILS ON SITE AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE PROCEEDING WITH THE WORK.
2. THE CONTRACTOR SHALL CARRY OUT SITE SURVEYS TO DETERMINE THE EXISTING ELEVATIONS OF ASPHALT PRIOR TO REMOVALS.
3. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS, KEEPING THE HEIGHT OF BACKFILL APPROXIMATELY THE SAME, AT NO TIME SHALL THE DIFFERENCE IN BACKFILL HEIGHTS BE GREATER THEN 200mm.
4. ALL SITE ACCESS TO COMPLETE THE WORK IS THE RESPONSIBILITY OF THE CONTRACTOR.

APPLICABLE STANDARD DRAWINGS :

OPSD 3941.200 FIGURES IN CONCRETE, SITE NUMBER, AND DATE, LAYOUT

LIST OF ABBREVIATIONS :

CL	CENTRELINE	SHLD	SHOULDER
CONC.	CONCRETE	SPCSP	STRUCTURAL PLATE
c/w	COMPLETE WITH		CORRUGATED STEEL
DIA.	DIAMETER		PIPE
DWG.	DRAWING	STA	STATION
EL.	ELEVATION (METRES)	TYP.	TYPICAL
EX.	EXISTING	T/P	TOP OF PAVEMENT
MIN.	MINIMUM	W.L.	WATER LEVEL
ROW	RIGHT OF WAY		
SBGR	STEEL BEAM GUIDE RAIL		



DRAWING NOT TO BE SCALED
50 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	J.P.	CHK G.M.	CODE CHBDC 2006 LOAD CL.-625-ONT
DRAWN	T.G.	CHK J.P.	SITE 46-004/C STRUCT SCHEME DWG P1



APPENDIX E

List of Ontario Provincial Standard Documents Relevant to Report
Non-Standard Specific Provision (NSSP)



LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts And Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 804	Construction Specification for Seed and Cover
OPSS 902 903	Excavation and Backfilling of Structures
OPSS 1205	Material Specification for Clay Seal
OPSS 1860	Material Specification for Geotextiles
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV.804	Construction Specification for Seed and Cover
OPSS.PROV.1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates - Base, Subbase, Select Subgrade, And Backfill Material
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
SP 206S03	Construction Specification for Grading
SP 422S01	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers
SP 902S01	Excavation and Backfilling of Structures
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Depth for Northern Ontario



NON-STANDARD SPECIAL PROVISIONS (NSSP)

NSSP – Surface Water Control and Dewatering (Addition to OPSS 902)

The Contractor shall take measures for necessary surface water diversions and drainage. For construction in-the-dry, the Contractor shall implement dewatering to lower the prevailing groundwater level a minimum of 0.5 m below the base of excavations.

NSSP – Excavations and Slope Stability (Addition to OPSS 902 and OPSS 539)

The Contractor is advised that the weak subsoils at the site require careful design of excavation and fill slope geometries and shoring schemes including slope and excavation protection for the removal of one barrel of the existing CSP culvert to maintain the stability of the CSP culvert that will be left in place for water diversion. The Contractor is also advised to restrict the stockpiling of material and the placement of heavy equipment near slope crests in order to prevent slope instabilities. The analyses and discussions in the Foundation Design Report are provided for conceptual illustration of the issue. The Contractor is responsible for carrying out slope stability analyses and design of excavation and slope geometries and temporary roadway protection schemes and shoring schemes required for their operations.

NSSP – Settlement Management (Addition to OPSS 902)

The Contractor is advised that their design and construction should minimize additional loading on foundation soil over existing levels as increases in loading over existing levels will cause related settlements that may be excessive.