

FOUNDATION INVESTIGATION REPORT  
PROPOSED NEW STRUCTURAL CULVERT  
AT PEEL STREET NORTH, THORNBURY  
TOWNSHIP OF COLLINGWOOD  
HIGHWAY 26 FROM MEAFORD TO THORNBURY

G.W.P. 57-00-00  
Agreement # 3006-E-0002



I.E.  
Group

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**Prepared for:**

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## **PART A – FOUNDATION INVESTIGATION**

### **1.0 INTRODUCTION**

This report presents the results of a foundation investigation carried out on July 9, 2009 by Infrastructure Engineering Group Inc. (IEG) on behalf of Stantec Consulting Ltd. (Stantec).

This assignment involves the rehabilitation of the pavement structure on Highway 26 from 0.2 km east of the Thornbury west limit (Peel Street) westerly 10.06 km to the Town of Meaford east limit.

It includes the rehabilitation and extension of two existing structural culverts, as well as many non-structural culvert extensions and replacements. The project also includes intersection realignments, intersection improvements, construction of two new 1.5 km long passing lanes, minor horizontal and vertical alignment improvements and electrical work. The original assignment included the re-alignment of the Blue Mountains/Meaford Town Line which has been deleted from the assignment.

Foundation investigation and recommendations are required for the design and construction of culvert replacements and extension as part of the improvement of Highway 26. Two (2) structural culverts, twenty-four (24) non-structural culverts, two shale bin replacements, and a high cut area are to be investigated. There is a change in the scope of work to include two additional culvert extensions which were not part of the original scope of work for foundation investigations, and re-allocation of the foundations investigation work for three (3) CSP culverts to the geotechnical investigation portion of this assignment. A new structural culvert located at Peel Street North in Thornbury is also added to the scope of work.

This report covers the site of the new structural culvert at Peel Street North in Thornbury, in the Collingwood Township.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes and, based on the findings, to provide geotechnical recommendations for the foundation elements. Armour Stone or gabion wing walls may be required at the inlet and outlet of the new structure.

Authorization to complete this assignment was given by Mr. Adam Barg, P. Eng., of Stantec Consulting Ltd., the TPM Consultant who is completing this assignment for MTO under Agreement # 3006-E-0002.

## **2.0 SITE DESCRIPTION**

### **2.1 Site Location**

It is proposed to construct a new structural culvert in conjunction with the Peel Street North realignment north of Highway 26. Based on information supplied by Stantec, the new culvert will consist of a 4 m span by 1.3 m high by 29 m in length. The location of the proposed culvert is approximately 16 m north of the centerline of Highway 26, between STA 14+035.5 and 14+064.5. Photographs of this culvert site are presented in Appendix "D".

The culvert site is located within a drainage ditch in which the ditch flows easterly. The approach embankments will be constructed on both the north and south sides of the culvert, with a maximum height of approximately 2.0 m. The embankment slopes will be typically 2.5H to 1V.

The proposed new culvert is located within a swampy area between STA 13+900 and 14+200 and spanning from the north-west towards the south-east at the Highway 26 and the Peel Street North intersection. The ground surface at the location of the proposed culvert was covered with bulrushes and reasonably dry, but partly inundated at the existing ditch located north of the proposed culvert with water level of less than 0.5 m above the ground surface at the time of field work.

Details of the proposed culvert are not known at the time of preparing this draft report. It is understood that the proposed culvert will consist of a precast concrete box culvert.

### **2.2 Physiography and Topography**

The Town of Meaford is situated at the mouth of the Bighead River where the river enters Nottawasaga Bay, part of the Georgian Bay of Lake Huron. The subsurface of the Town of Meaford is comprised of predominately silty clay, and smooth to gently sloping topography. Pockets of sand and gravelly sands exist which also exhibit smooth to gently sloping topography. The Town is located on the coastal plain left by glacial Lake Algonquin. East of Meaford, the Algonquin shore cliff coincides with the base of the Niagara Escarpment. The coastal plain in this area consists of sand and gravel beach terraces overlying the bedrock. Overburden thickness is generally less than 5 m.

Bedrock consists of the shale and limestones of the Georgian Bay Formation. Grey, impure carbonate beds (limestone and dolomite) alternate with grey and blue/grey shale.

West of Meaford, the coastal plain consists of the same beach deposits as found in the east. To the west away from the Lake, overburden becomes a glacio-lacustrine derived silt to clayey till. Numerous drumlins of calcareous till with red shale inclusions are found in the Meaford area.

Progressing west on Highway 26 toward Owen Sound and the Niagara Escarpment, the bedrock types progress from Queenston shales, the Clinton and Cataract shales and dolomites to the cap

rock of the Amabel dolomites and limestones. Overburden thickness can be as much as 15 m, but is generally less than 5 m.

The existing ground surface Elevations range from 193.3 m to 193.9 m, with a proposed finish road grade of Elevation 195.25 m. The proposed invert of the culvert will be placed at Elevation 193.0±m.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Field Investigation**

Three (3) boreholes were drilled and sampled to obtain data for foundation design of the proposed new structural culvert. The locations of the boreholes are shown on Drawing 1.

A Diedrich D-50 Bombardier-mounted drill rig was supplied by Walker Drilling Ltd. on July 9, 2009, for drilling and Standard Penetration Testing (SPT), following the procedures of ASTM D 1586). The boreholes were drilled using continuous flight solid and hollow stem augers. Soil samples were retrieved at selected intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of depth of 0.75 m to the maximum depth of exploration.

Field pocket penetrometer was used on the retrieved SPT samples, where applicable, to determine the undrained shear strength of the cohesive soil deposits. These undrained shear strengths are used to supplement the properties of the cohesive soils. It is noted that the measured shear strength value would be slightly lower than the actual value due to sampling disturbance.

The soil samples obtained were placed in labeled containers and transported to IEG's London laboratory for further examination and laboratory testing.

The locations of the boreholes are shown on Drawing 1 and the depths of sampling were as follows:

<b>Borehole No.</b>	<b>Depth of Sampling (m)</b>
31A-1	5.72
31A-2	5.77
31A-3	3.35

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. All boreholes were grouted with a bentonite/cement mix at completion of sampling in accordance with Ontario Regulation 903.

Our field engineer, Mr. Joseph Law, P. Eng., supervised the fieldwork and worked under the direction of the project engineer, Mr. Eric Chung, P. Eng. Our field staff cleared the location of buried utilities and logged the boreholes.

The stations, offsets and ground surface elevations at the as drilled borehole locations were surveyed by Stantec and provided to IEG for the purpose of this report.

The results of the drilling, sampling, in-situ testing and groundwater observations are summarized on the Record of Borehole sheets and enclosed in Appendix "A".

### **3.2 Laboratory Analysis**

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses and Atterberg Limit tests were performed on selected soil samples.

The results of the laboratory testing are presented on the Record of Borehole sheets (Appendix "A"), and Laboratory Test Results (Figures 1 to 6, Appendix "B").

## **4.0 SUBSURFACE CONDITIONS**

### **4.1 General Subsurface Conditions**

Reference is made to the Record of Borehole sheets (Appendix "A") and Laboratory Test Results (Appendix "B") for detailed subsurface soil and groundwater conditions encountered in the boreholes. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, consequently, represent transitions between soil types rather than exact planes of geological change. The soil profiles depicting the subsurface conditions on Drawing 1 will vary between and beyond the borehole locations.

The subsurface deposits at the site consist of a 0.15 m to 0.53 m thick layer of topsoil and/or organic deposits, underlain by a 0.76 m to 2.14 m thick layer of very soft to stiff silty clay. The silty clay layer generally becomes stiff at depths of between 0.5 m and 1.5 m below the existing ground surface (between Elevations 192.2 and 193.0 m). The silty clay is in-turn underlain by a 0.6 m and 0.9 m thick layer of very stiff layered silt and silty clay. The layered silt and silty clay is subsequently underlain by a sand and silt till which extends beyond the vertical extents of the boreholes at depth of between 3.35 m and 5.77 m (Elevations 190.53 m and 187.91 m).

Drilling advance was difficult at the locations of Borehole 31A-1 and 31A-3 and encountered cobbles and/or boulders within the sand and silt till which caused auger and sampler refusal. Borehole 31A-3 was terminated after 3 unsuccessful attempts to drill below a depth of 3.35 m.

#### 4.1.1 Topsoil, Organic Silt and Fill

All three boreholes encountered topsoil of between 150 mm and 300 mm thick. The topsoil in Borehole 31A-1 is underlain by a 0.23 m thick layer of organic silt. The topsoil in Borehole 31A-3 is underlain by a 0.61 m thick layer of mixed fill consisting of silty clay and organics.

Standard penetration tests yielded “N”-values generally ranging from 1 to 2 blows per 0.3 m.

The fill is dark brown to brown in color, and the organic silt is greenish grey in color. Moisture content of the fill and organic materials measured natural moisture contents ranging from 25 to 94%. Based on the above field and laboratory test results, together and tactile examination, the organic soils and fill materials exhibited very loose compactness condition.

Unit weight of the fill was not determined due to poor sample recovery and excessively disturbed samples.

#### 4.1.2 Silty Clay

A stratum of brown with grey mottling silty clay, with a trace to some sand is present below the fill and organic materials at all three borehole locations. The silty clay is generally interbedded with frequent silt pockets, seams and layers.

Standard penetration tests yielded “N”-values ranging from 1 to 14 blows per 0.3 m. “N”-values of less than 8 blows per 0.3 m were generally encountered to depths of between 0.6 m and 1.5 m below the existing ground surface (between Elevations 192.2 m and 193.0 m).

Four (4) grain size distribution analyses were performed on the silty clay deposit and the results are presented on Figure 1 of Appendix “B”.

Four (4) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 2 of Appendix “B” and summarized below:

<b>Atterberg Limits</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>
<b>Liquid Limit (W<sub>L</sub>), %</b>	26	38	31.3
<b>Plastic Limit (W<sub>P</sub>), %</b>	17	22	19.0
<b>Plasticity Index (I<sub>p</sub>), %</b>	9	16	12.3

The natural moisture contents of the samples were between 17 and 37%. These results are characteristic of clayey soils of low to medium plasticity (CL-CI). The measured natural moisture contents are generally between the plastic and liquid limits and indicate that the deposit is slightly pre-consolidated.

Pocket penetrometer readings taken on the SPT samples yielded correlated unconfined shear strength of between 20 and 250 kPa.

Based on the above field and laboratory test results, together with visual and tactile examination, the silty clay deposit exhibited generally firm to stiff consistency, with near surface soft to very soft zones, and hard zones at depth.

Unit weight of the silty clay was determined on three (3) samples to be between 23.8 and 25.6 kN/m<sup>3</sup>.

#### 4.1.3 Layered Silt and Silty Clay

A stratum of grey and reddish brown layered silt and silty clay, with a trace to some sand, and occasional fine gravel is present below the silty clay layer at all of the borehole locations.

Standard penetration tests yielded “N”-values ranging from 16 to 19 blows per 0.3 m.

Three (3) grain size distribution analyses were performed on the layered silt and silty clay deposit and the results are presented on Figure 3 of Appendix “B”.

Three (3) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 4 of Appendix “B” and summarized below:

<b>Atterberg Limits</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>
<b>Liquid Limit (W<sub>L</sub>), %</b>	22	25	23.3
<b>Plastic Limit (W<sub>P</sub>), %</b>	16	18	16.7
<b>Plasticity Index (I<sub>p</sub>), %</b>	6	7	6.7

The natural moisture contents of the samples were between 14 and 18%. These results are characteristic of a clay soil of low plasticity (CM-CL). The measured natural moisture contents are generally at or less than the plastic limit and indicate that the deposit is pre-consolidated.

Pocket penetrometer readings taken on the SPT samples yielded unconfined shear strength of between 120 and 175 kPa.

Based on the above field and laboratory test results, together with visual and tactile examination, the layered silt and silty clay deposit exhibited generally very stiff consistency.

A single unit weight of the layered silt and silty clay was determined to be 22.7 kN/m<sup>3</sup>.

#### 4.1.4 Sand and Silt Till

The layered silt and silty clay layer is in-turn underlain by a grey sand and silt till. Cobbles and boulders are present within the sand and silt till, with localized pockets of saturated sand and gravel. Slight plasticity was observed with samples taken from Boreholes 31A-1 and 31A-2.

Standard penetration tests yielded “N”-values ranging from 49 to over 100 blows per 0.3 m.

Three (3) grain size distribution analyses were performed on the silty clay deposit and the results are presented on Figure 5 of Appendix “B”.

Three (3) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 6 of Appendix “B” and summarized below:

<b>Atterberg Limits</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>
<b>Liquid Limit (W<sub>L</sub>), %</b>	14	20	17.0
<b>Plastic Limit (W<sub>P</sub>), %</b>	12	12	12.0
<b>Plasticity Index (I<sub>p</sub>), %</b>	2	8	5.0

The natural moisture contents of the samples were between 6 and 22%. These results are characteristic of sand and silt till (ML-SM).

Based on the above field and laboratory test results, together with visual and tactile examination, the sand and silt till has a dense to very dense compactness condition.

A single unit weight of the varved clay was determined to be 25.0 kN/m<sup>3</sup>.

#### 4.2 Groundwater Conditions

The groundwater condition was monitored during and upon completion of sampling. There was less than 0.5 m of water ponding on the existing ditch at the time of our field work on July 9, 2009, and assumed to be of low to moderate flow condition due to rainfall events just prior to our field work.

On completion of drilling, free groundwater was observed in the boreholes and the respective depth and elevation are summarized below:

<b>Borehole</b>	<b>Water Level in Borehole, m (Elevation, m)</b>	<b>Remarks</b>
31A-1	5.03 (188.66)	
31A-2	1.98 (191.70)	
31A-3	1.20 m (192.68)	Dry on second and third attempt for the short duration the boreholes were kept open.

Based on the natural moisture content of the soils samples, the groundwater encountered likely reflects water perched within the upper fill and organic materials and the near surface silty clay.

It should be noted that the groundwater level will fluctuate seasonally and in response to weather events. Under adverse conditions, water could be ponding on the ground surface under high flow conditions. It is reasonable to assume that groundwater could be similar to the water level in the swampy area west of the existing Peel Street North during high flow conditions.

## 5.0 STATEMENT OF LIMITATION

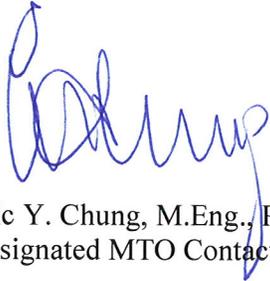
We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as Quoted in Appendix "C", is an integral part of this report.

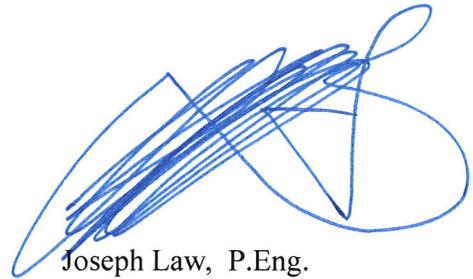
We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

Yours truly,

**Infrastructure Engineering Group Inc.**



Eric Y. Chung, M.Eng., P.Eng.  
Designated MTO Contact



Joseph Law, P.Eng.  
Project Manager



Tom O'Dwyer, P. Eng.  
Quality Review Engineer



Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
Rehabilitation of Highway 26 from Meaford to Thornbury  
Agreement # 3006-E-0002

08-1-IEG1-PEEL  
Final Report  
Drawing 1  
November 25, 2009

Drawing 1  
Borehole Locations  
And  
Soil Strata

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

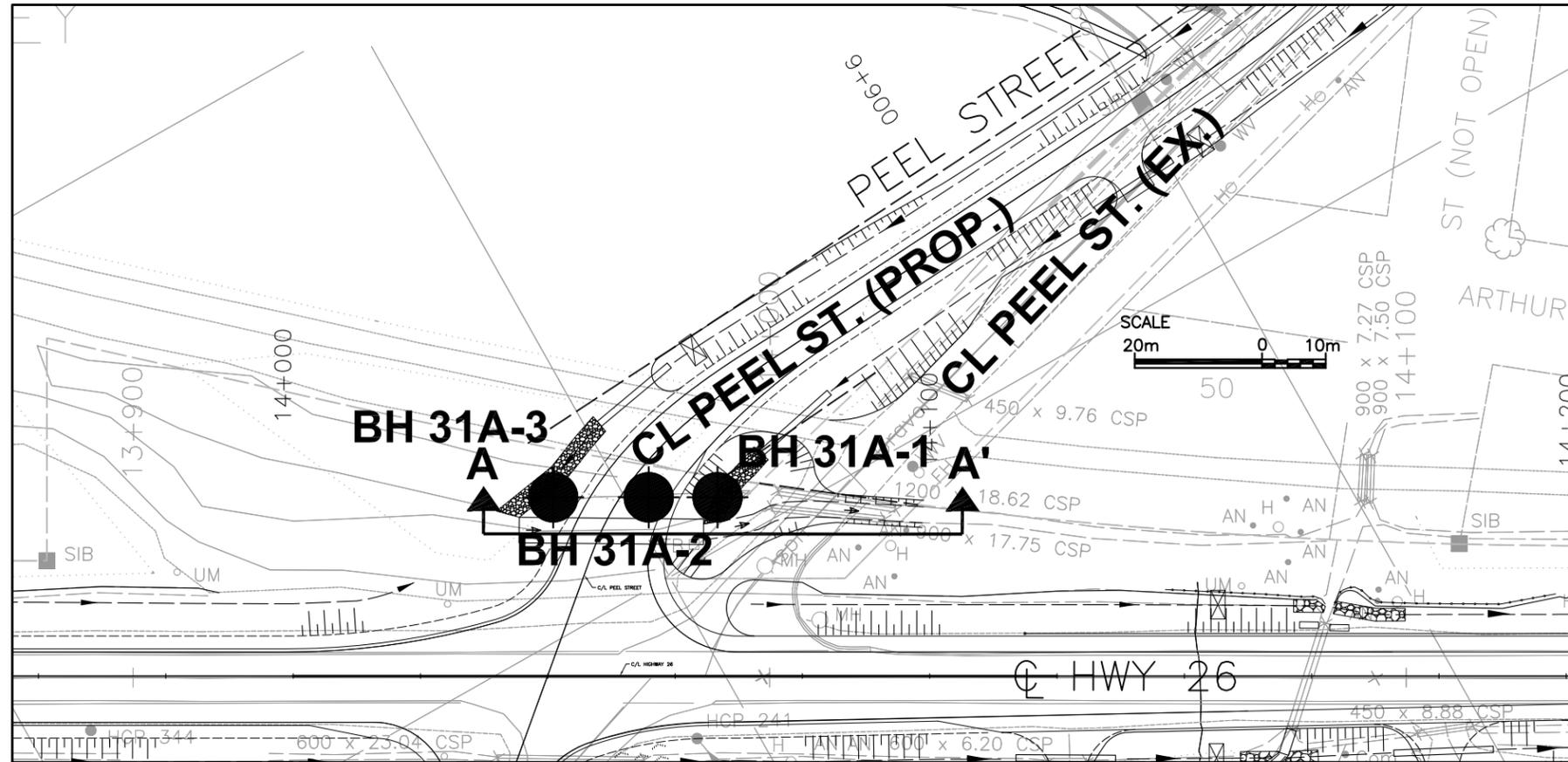
CONT No xxxx-xxxx  
WP No GWP 57-00-00



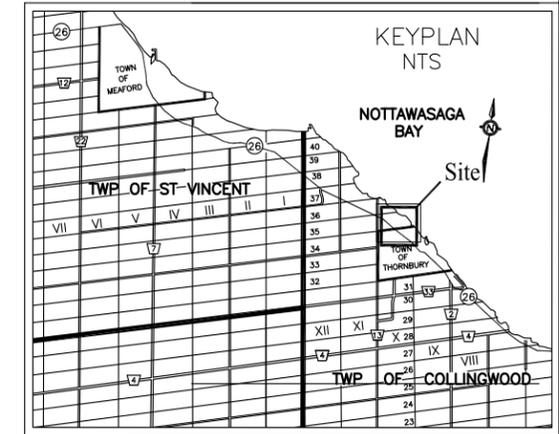
PEEL STREET NORTH NEW CULVERT  
Highway 26  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET  
1

**I.E. Group** Infrastructure Engineering Group Inc.  
Pavement & Construction Materials Consulting Engineers  
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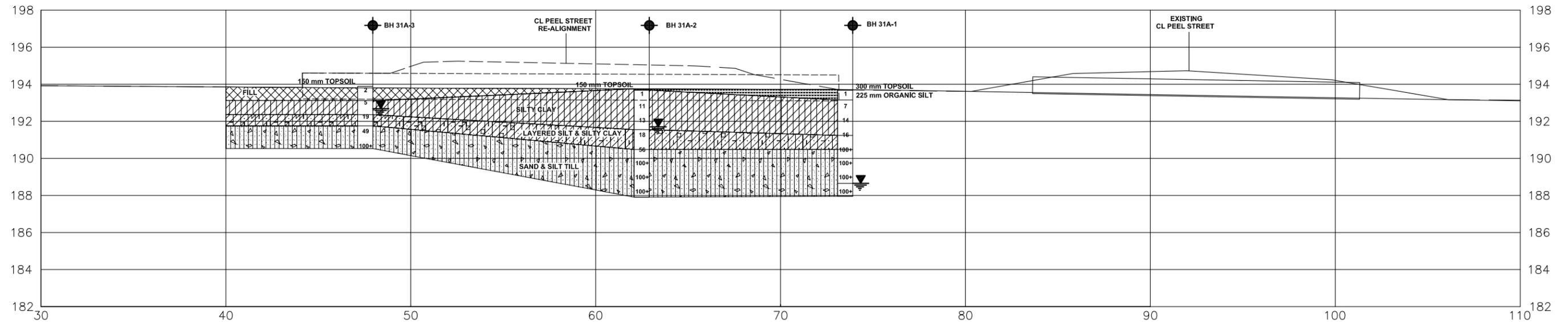


**BOREHOLE LOCATION PLAN**

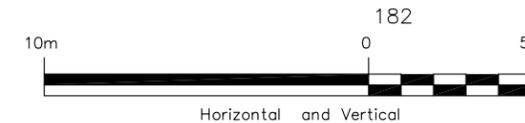


**LEGEND**

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe



**SECTION A-A'  
CENTERLIND OF CULVERT**



**NOTES**

1. THE COMPLETE FOUNDATION INVESTIGATION AND DESIGN REPORT FOR THIS PROJECT AND OTHER RELATED DOCUMENTS MAY BE EXAMINED AT THE ENGINEERING MATERIALS OFFICE, DOWNSVIEW. INFORMATION CONTAINED IN THIS REPORT AND RELATED DOCUMENTS ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 OF OPS GEN. COND.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES AND BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES	
		NORTH	EAST
31A-1	193.69	4936907	228113
31A-2	193.68	4936913	228103
31A-3	193.88	4936920	228090

REVISIONS	DATE	BY	DISCRIPTION
	25/11/09	J.L.	Final
	27/07/09	J.L.	Draft

Geocres : 41A-209

HWY No.	HWY 26	DIST	Owen Sound
SUBM'D	J.L. CHECKED E.C.	DATE 27/07/09	SITE Peel Street North New Culvert
DRAWN	J.L. CHECKED J.L.	APPROVED E.C.	DWG 1

Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
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08-1-IEG1-PEEL  
Final Report  
Appendix A  
November 25, 2009

## Appendix A

Explanation of Terms Used in Report

Record of Borehole Sheet

Boreholes C31A-1 to C31A-3

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_r$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_c$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_c}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	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

### PHYSICAL PROPERTIES OF SOIL

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

**RECORD OF BOREHOLE No 31A-1**

1 OF 1

**METRIC**

W.P. GWP 57-00-00 LOCATION HWY 26, Thornbury to Meaford Northing - 4936907, Easting - 228113 ORIGINATED BY JL  
 DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia., H/S Augering, 110 mm diam. ID COMPILED BY JL  
 DATUM Geodetic DATE 9.7.09 - 9.7.09 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE		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			STANDARD ●	DYN. CONE						
193.69 0.00	Ground														
193.39 0.30	300 mm Organic TOPSOIL.		1	SPT	1		30								
193.16 0.53	225 mm Organic SILT.														
	Silty CLAY, CL Brown and grey mottled, moist to wet, firm to stiff, interbedded with frequent silt pockets, seams and layers, some sand.		2	SPT	7		40					23.8	0 15 61 24 (85)		
			3	SPT	14					250					
191.25 2.44			Layered Silt and Silty CLAY, CL-ML Grey and reddish brown layers, moist, very stiff, 2 to 5 mm cyclic layers, trace sand.	4	SPT	16					120			22.7	0 2 77 21 (98)
190.49 3.20	SAND & SILT TILL, ML-SM Grey, moist, very dense, with embedded gravel, frequent cobbles and possibly boulders, and silty clay seams.		5	SPT	100+					135					
			6	SPT	100+									11 39 39 11 (50)	
			7	SPT	100+										
187.97 5.72			End of borehole.	8	SPT	100+									Water level measured @ 5.0 m @ completion.
														spoon and H/S auger refusal @ 3.28 m. Moved 1.5 m west, switched to S/S auger and continued drilling, spoon and auger refusal @ 3.96m. Moved 1.5 m south and continued sampling.	

JOE.MTO 07-6-IEG1.GPJ ONTARIO.MOT.GDT 30/11/09

+ 3, X 3: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

**RECORD OF BOREHOLE No 31A-2**

1 OF 1

**METRIC**

W.P. GWP 57-00-00 LOCATION HWY 26, Thornbury to Meaford Northing - 4936913, Easting - 228103 ORIGINATED BY JL  
 DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY JL  
 DATUM Geodetic DATE 9.7.09 - 9.7.09 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			STANDARD	DYN. CONE					
193.68 0.00	Ground 150 mm Organic TOPSOIL.		1	SPT	1		20							
191.39 2.29	Silty CLAY, CI to CL Brown and grey mottled, moist to wet, very soft to stiff, interbedded with frequent silt pockets, seams and layers, trace sand.		2	SPT	11		130					24.4	0 2 56 42 (98)	
190.48 3.20	Layered Silt and Silty CLAY, CL-ML Grey and reddish brown layers, moist, very stiff, 2 to 5 mm cyclic layers, some sand, trace gravel.		3	SPT	13		200						0 1 71 28 Water level(99) measured @ 2.0 m @ completion.	
187.91 5.77	SAND & SILT TILL, ML-SM Grey, moist, very dense, with embedded gravel, frequent cobbles and possibly boulders, occasional saturated sand and gravel pockets, and silty clay seams.		4	SPT	18		175						5 21 55 20 (74)	
			5	SPT	56									
			6	SPT	100+								12 39 36 13 (49)	
			7	SPT	100+									
			8	SPT	100+							25.0		
187.91 5.77	End of borehole.												Borehole terminated after third sample with sampler refusal.	

JOE.MTO 07-6-IEG1.GPJ ONTARIO.MOT.GDT 9/8/09

+ 3, X 3: Numbers refer to Sensitivity      ○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

**RECORD OF BOREHOLE No 31A-3**

1 OF 1

**METRIC**

W.P. GWP 57-00-00 LOCATION HWY 26, Thornbury to Meaford Northing - 4936920, Easting - 228090 ORIGINATED BY JL  
 DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY JL  
 DATUM Geodetic DATE 9.7.09 - 9.7.09 CHECKED BY EC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		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	SHEAR STRENGTH kPa					
						○ UNCONFINED	+ FIELD VANE						
						● QUICK TRIAXIAL	× LAB VANE						
								20	40	60	80	100	
								10	20	30			
193.88 0.00	Ground 150 mm Organic TOPSOIL. FILL Dark brown to brown, moist to wet, very loose, consisting mainly of silty clay and organics, trace to some sand and gravel.		1	SPT	2			40				94	
193.12 0.76	Silty CLAY, CL Brown and grey mottled, moist to wet, firm, interbedded with frequent silt pockets, seams and layers, some sand, trace gravel.		2	SPT	5			55				25.6	1 21 49 30 (79) Water level measured @ 1.2 m @ completion.
192.36 1.52	Layered Silt and Silty CLAY, CL-ML Grey and reddish brown layers, moist, very stiff, thick silt layers, trace sand.		3	SPT	19					170			0 1 80 19 (99)
191.75 2.13	SAND & SILT TILL, ML-SM Grey, moist, very dense, with embedded gravel, frequent cobbles and possibly boulders, occasional saturated sand and gravel pockets.		4	SPT	49								
190.53 3.35	End of borehole.		5	SPT	100+								5 41 46 8 (54) sampler and auger refusal @ 3.35 m. Moved 1.5 m west, and continued drilling. Auger refusal @ 3.35m. Moved 1.5 m south-east and continued drilling. Auger refusal @ 3.35 m. Borehole terminated @ 3.35 m after third attempt with auger and sampler refusal.

JOE.MTO 07-6-IEG1.GPJ ONTARIO.MOT.GDT 9/8/09

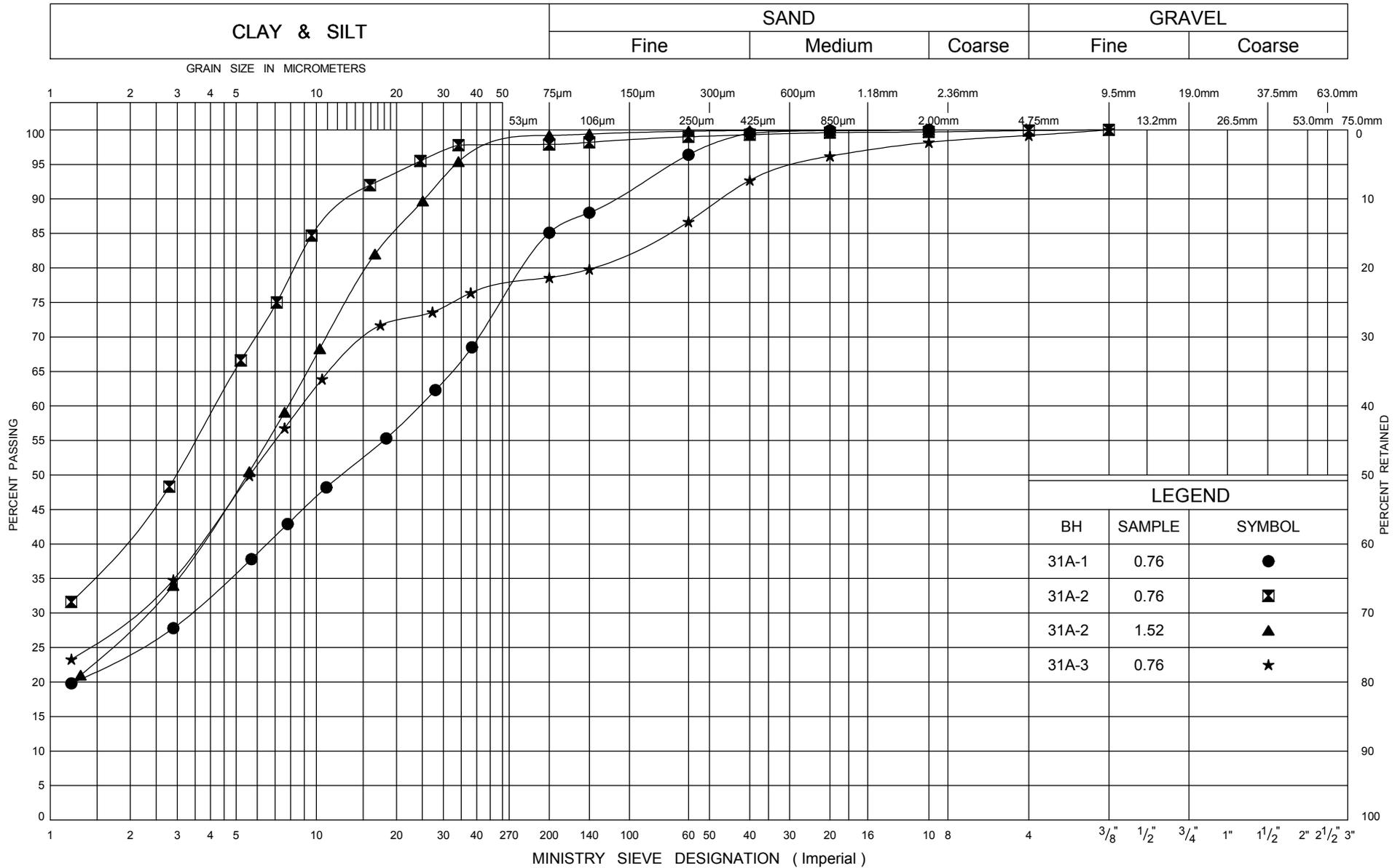
+ 3, X 3: Numbers refer to Sensitivity      ○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## Appendix B

### Laboratory Test Results

Grain Size Distribution	Figures 1, 3 and 5
Plasticity Chart	Figures 2, 4 and 6

### UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO MOT GRAIN SIZE LARGE CULVERTS 07-6-IEG1.GPJ ONTARIO.MOT.GDT 30/7/09

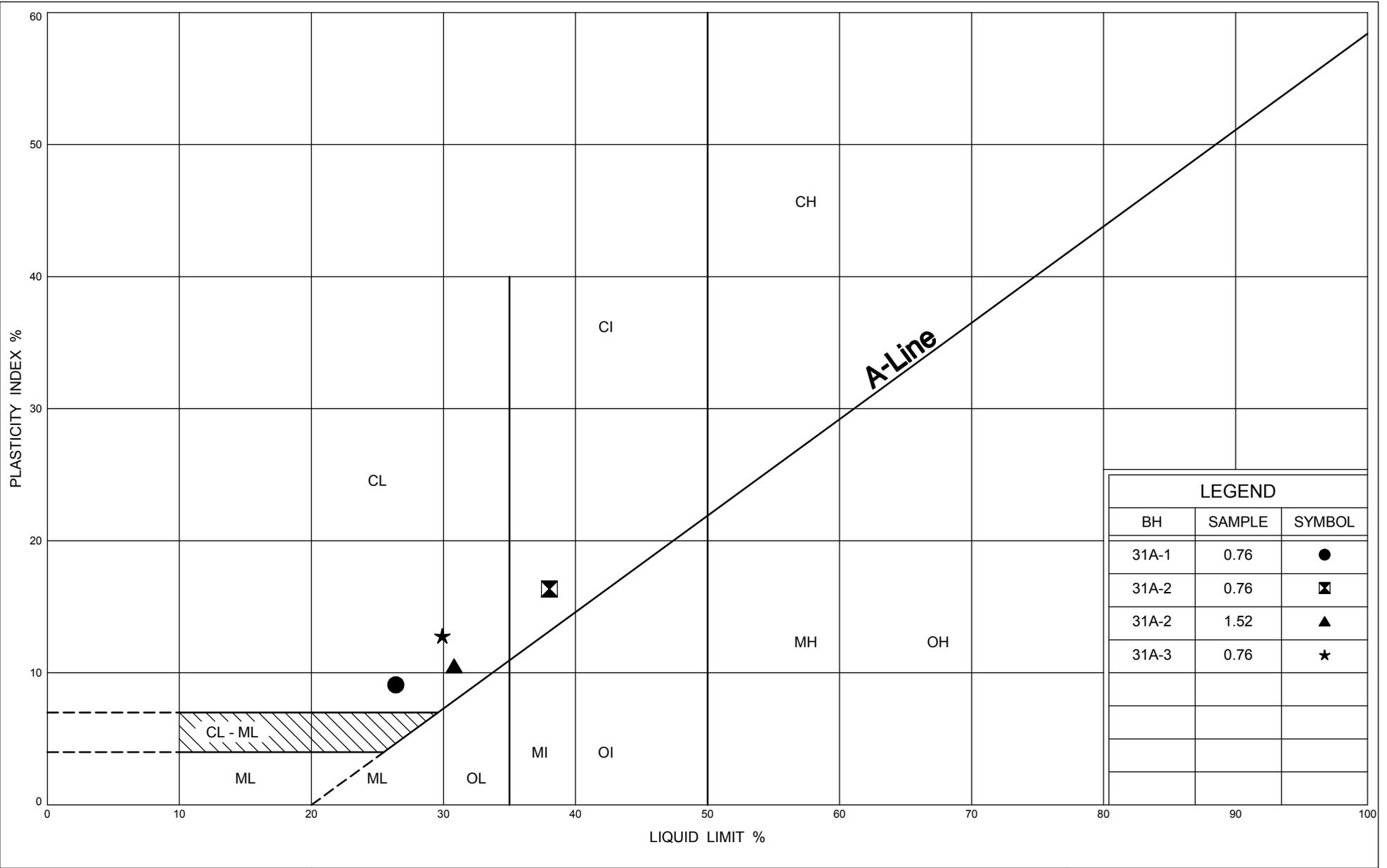


## GRAIN SIZE DISTRIBUTION SILTY CLAY, CL TO CI

FIG No 1

GWP 57-00-00

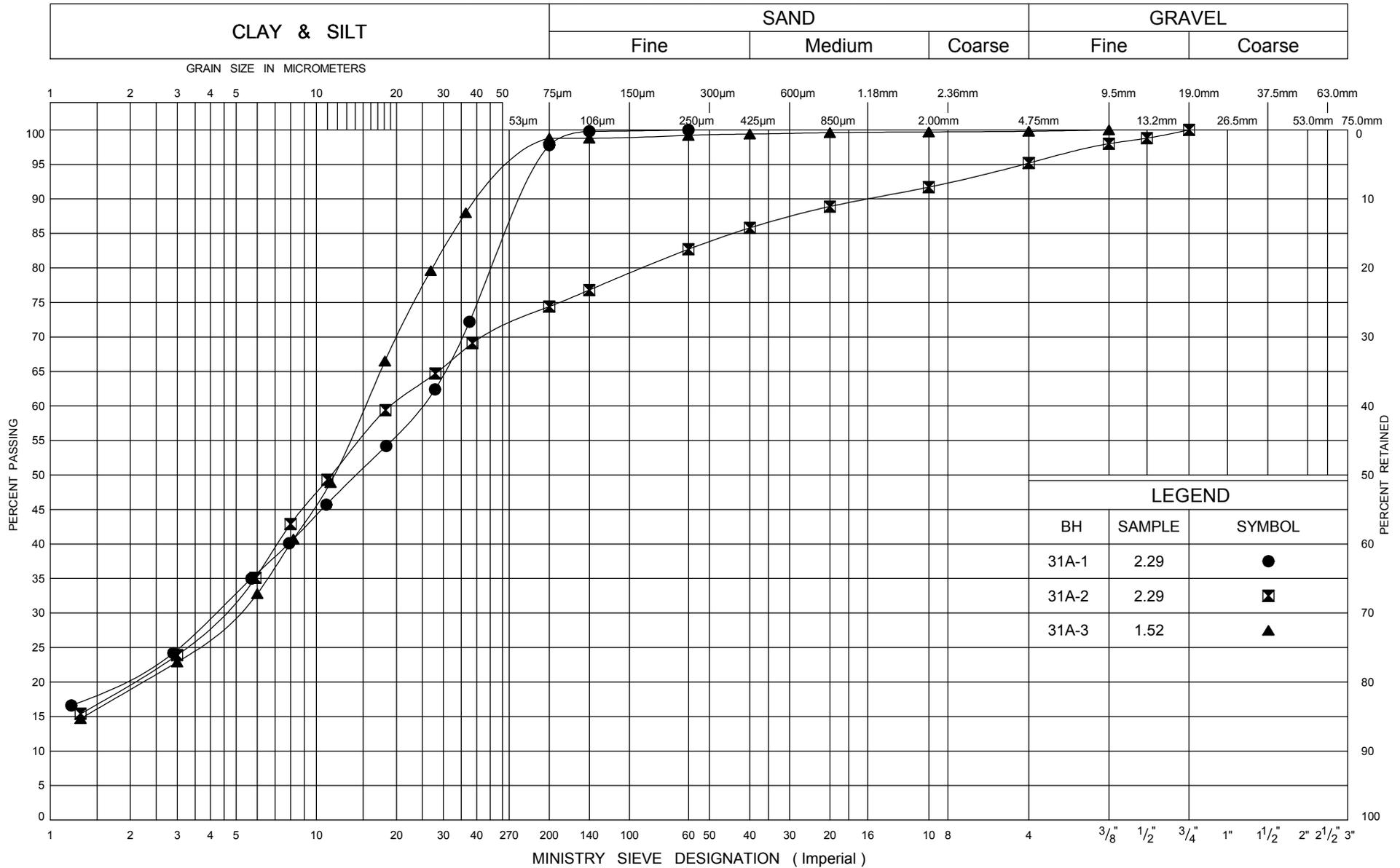
HWY 26, Thornbury to Meaford



**PLASTICITY CHART**  
**SILTY CLAY, CL TO CI**

**FIG No 2**  
**GWP 57-00-00**  
HWY 26, Thornbury to Meaford

UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO MOT GRAIN SIZE LARGE CULVERTS 07-6-IEG1.GPJ ONTARIO.MOT.GDT 30/7/09

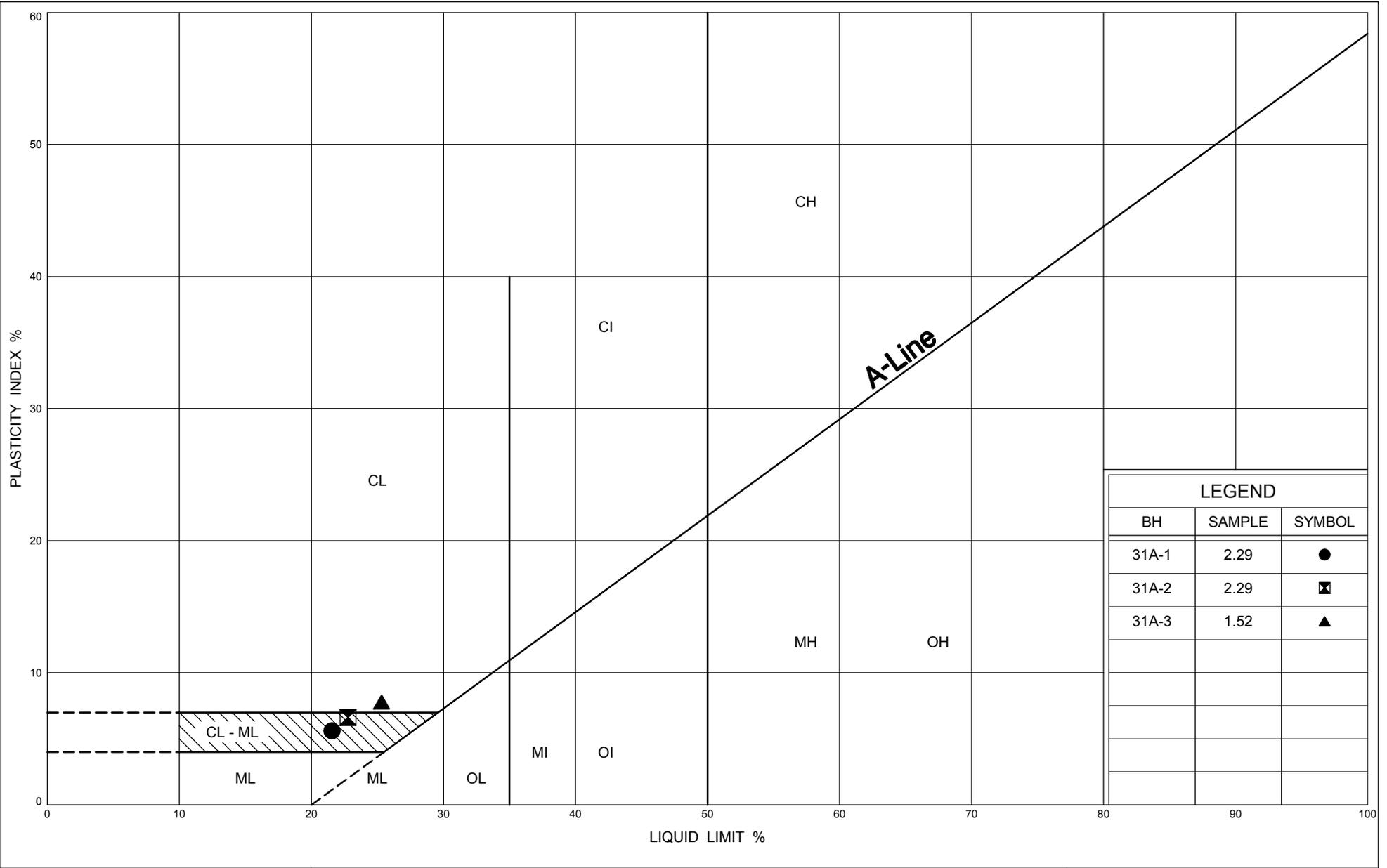


GRAIN SIZE DISTRIBUTION  
LAYERED SILT AND CLAY, CL-ML

FIG No 3

GWP 57-00-00

HWY 26, Thornbury to Meaford



LEGEND		
BH	SAMPLE	SYMBOL
31A-1	2.29	●
31A-2	2.29	■
31A-3	1.52	▲

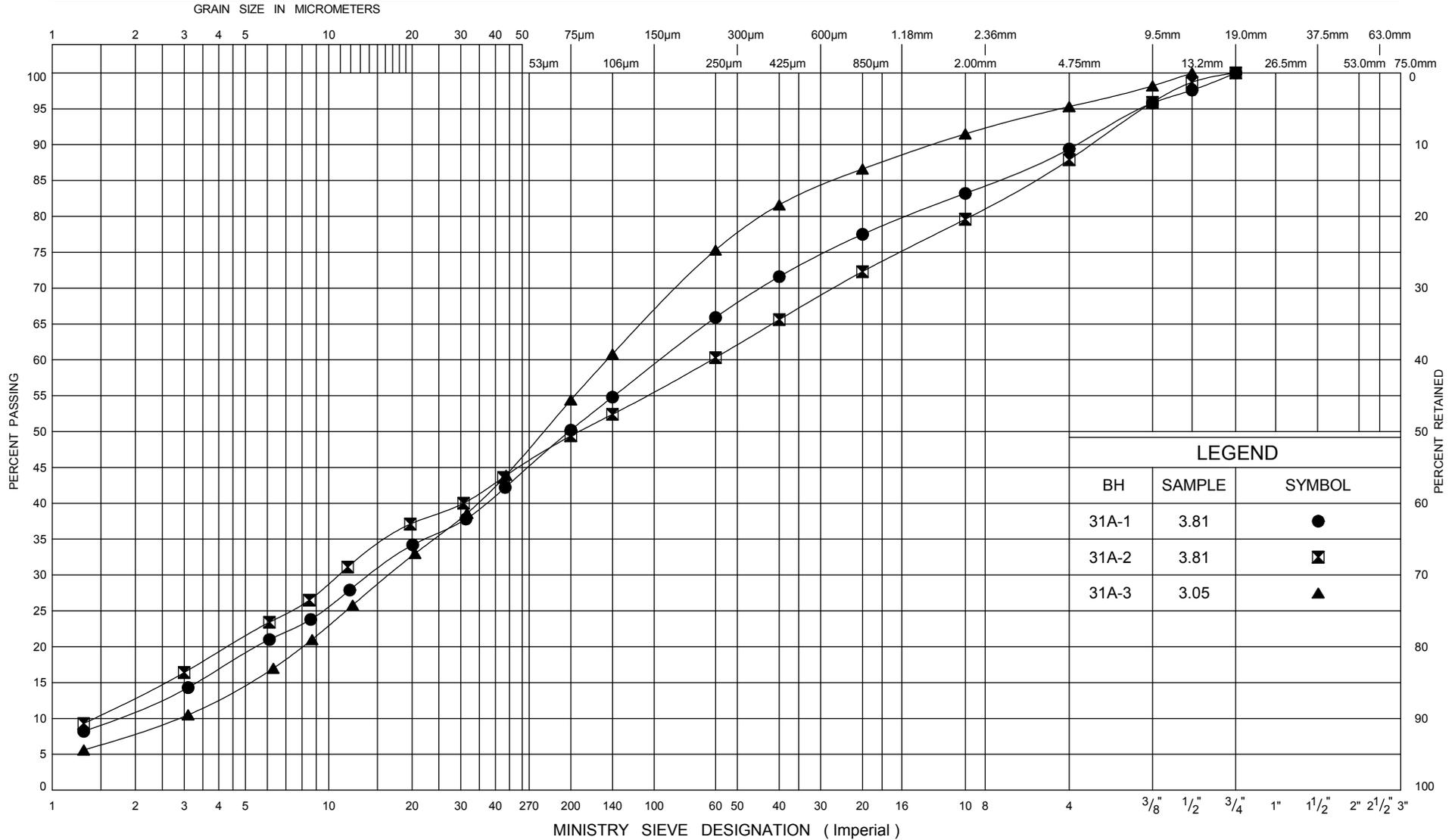


**PLASTICITY CHART**  
**LAYERED SILT AND CLAY, CL-ML**

**FIG No 4**  
**GWP 57-00-00**  
HWY 26, Thornbury to Meaford

### UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



ONTARIO MOT GRAIN SIZE LARGE CULVERTS 07-6-IEG1.GPJ ONTARIO.MOT.GDT 30/7/09



## GRAIN SIZE DISTRIBUTION

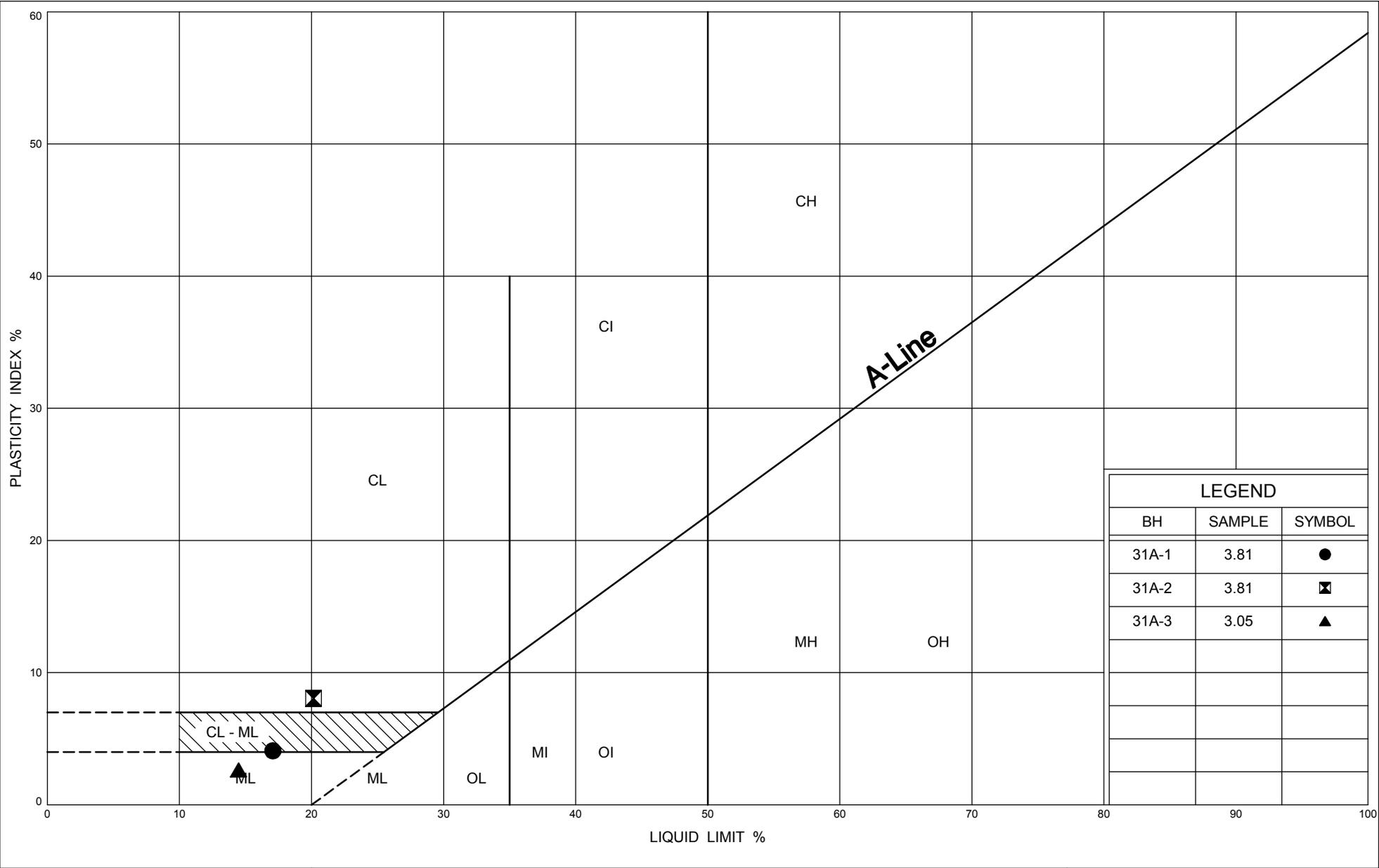
### SAND & SILT TILL WITH SILTY CLAY SEAMS, ML-SM

FIG No 5

GWP 57-00-00

HWY 26, Thornbury to Meaford

ONTARIO MOT PLASTICITY CHART LARGE CULVE 07-6-IEGI.GPI ONTARIO MOT.GDT 30/7/09



LEGEND		
BH	SAMPLE	SYMBOL
31A-1	3.81	●
31A-2	3.81	⊠
31A-3	3.05	▲



**PLASTICITY CHART**  
**SAND & SILT TILL WITH SILTY CLAY SEAMS, ML-SM**

**FIG No 6**  
**GWP 57-00-00**  
 HWY 26, Thornbury to Meaford

Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
Rehabilitation of Highway 26 from Meaford to Thornbury  
Agreement # 3006-E-0002

08-1-IEG1-PEEL  
Final Report  
Appendix C  
November 25, 2009

## Appendix C

### Limitations of Report

## **APPENDIX C**

### **LIMITATIONS OF REPORT**

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Infrastructure Engineering Group Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, IEG recommends that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
Rehabilitation of Highway 26 from Meaford to Thornbury  
Agreement # 3006-E-0002

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Appendix D  
November 25, 2009

Appendix D  
Site Photographs



Existing Peel Street looking west towards realignment



Existing Peel Street looking north-west at proposed culvert site



Proposed Peel Street North Structural Culvert Site looking south



Existing Peel Street North non-structural twin culverts inlet