

FOUNDATION INVESTIGATION REPORT

PROPOSED REPLACEMENT/EXTENSION OF
STRUCTURAL CULVERT 12-410-C
REHABILITATION OF
HIGHWAY 21 FROM ST. JOSEPH TO BAYFIELD

G.W.P. 406-94-00
Agreement # 3006-E-0095



I.E.
Group

FOUNDATION INVESTIGATION
AND DESIGN REPORT

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STRUCTURAL CULVERT 12-410-C
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HIGHWAY 21 FROM ST. JOSEPH TO BAYFIELD

G.W.P. 406-94-00
Agreement # 3006-E-0095

Prepared for:

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September 21, 2009
08-1-IEG2-12-410-C

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Geocres No.: 40P5-14

TABLE OF CONTENTS

PART A – FOUNDATION INVESTIGATION	1
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	1
2.1 Site Location.....	1
2.2 Physiography and Topography	2
3.0 INVESTIGATION PROCEDURES	2
3.1 Field Investigation	2
3.2 Laboratory Analysis	3
4.0 SUBSURFACE CONDITIONS	3
4.1 General Subsurface Conditions	3
4.1.1 Fill	4
4.1.2 Silty Clay Till.....	4
4.1.3 Silt	5
4.2 Groundwater Conditions.....	6
5.0 STATEMENT OF LIMITATION	7

Drawings & Appendices

Drawing 1	Borehole Locations and Soil Strata	
Appendix “A”	Explanation of Terms Used in Report	
	Record of Borehole Sheets	Boreholes 12-410-C1 to 12-410-C3
Appendix “B”	Laboratory Test Results	
	Grain Size Distribution	Figures 1, 3, 5 and 6
	Plasticity Chart	Figures 2, 4 and 7
Appendix “C”	Limitations of Report	
Appendix “D”	Site Photographs	

PART A – FOUNDATION INVESTIGATION

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out on May 20, 2008 by Infrastructure Engineering Group Inc. (IEG) on behalf of Stantec Consulting Ltd. (Stantec).

This assignment involves the rehabilitation Highway 21 from 0.20 km south of Huron County Road 84 (Zurich/Hensall Road, St. Joseph) northerly to 0.28 km south of Huron County Road 3 (Mill Street, Bayfield), including the rehabilitation of the Bayfield River Bridge; Length = 15.92 km.

It includes the replacement/rehabilitation/extension of thirteen (13) existing structural culverts and the Bayfield River Bridge. The project also includes resurfacing, pavement widening, intersection realignments, intersection improvements, minor horizontal and vertical alignment improvements and electrical work.

Foundation investigation and recommendations are required for the design and construction of the replacement/rehabilitation/extension of thirteen (13) existing structural culverts as part of the improvement of Highway 21. This report covers the site of Structure 12-410-C.

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. Partial or full replacement of the culvert may be required pending on the results of the culvert inspection specified under Section 6.3.1 of the RFP document.

Authorization to complete this assignment was given by Mr. Dan Green, P. Eng., of Stantec Consulting Ltd., the TPM Consultant who is completing this assignment for MTO under Agreement # 3006-E-0095.

2.0 SITE DESCRIPTION

2.1 Site Location

Structure 12-410-C is located on Highway 21, approximately 5.5 km north of the south limit of the project (Station 19+060), located at Station 11+175. The transition in chainage is located between the boundaries of Townships of Hay and Stanley (23+380.613=10+000). Photographs of this culvert site are presented in Appendix “D”. The existing structure is a reinforced concrete, rigid frame box culvert with a span of 3.66 m, a height of 1.52 m and a length of 26.20 m, with an overfill height of approximately 1.7 m. The culvert opening dimensions were provided in the RFP documents.

The culvert site is located within a drainage valley in which the stream flows westerly. The road embankments were built on both the south and north sides of the culvert, with a maximum height of approximately 3.9 m. The embankment slopes are typically 2.5H:1V to 3H:1V and are grass covered. Minor toe erosion was observed on both the upstream and downstream sides of the embankment and along the creek banks at the time of this foundation investigation.

A brown silty clay till deposit was noted at the streambed during our field investigation. There was less than 0.3 m of water running in the creek during our fieldwork on May 20, 2008.

2.2 Physiography and Topography

The thirteen (13) culvert sites investigated for this project are located within the physiographic region referred to as the Huron Slope (Chapman and Putnam, 1984), which runs along the east side of Lake Huron between Sarnia and Tobermory and is situated between the Algonquin shorecliff and the Wyoming Moraine. The area is characterized by a relatively flat topography, heavy textured soil and poor drainage. The surficial deposits consist of brown, calcareous clayey tills which contain very few cobbles and boulders. The tills are known to be underlain by grey stratified clays of lacustrine origin.

The asphalt pavement surface over the existing culvert is near elevation 199.2 m, while the ground surface at the base of the embankment and adjacent to the stream is between elevation 195.28 m (west side) and 195.65 m (east side).

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

On May 20, 2008, a bombardier-mounted Murooka drill rig was supplied by London Soil Test Ltd. and used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Three (3) boreholes were drilled and sampled to obtain data for foundation design of the proposed rehabilitation work and potential culvert replacement/extension. The locations of the boreholes are shown on Drawing 1.

The boreholes were numbered 12-410-C1 to 12-410-C3 for the subject culvert and the depths of sampling were as follows:

Borehole No.	Depth of Sampling (m)
12-410-C1	8.08
12-410-C2	10.21
12-410-C3	8.08

The boreholes were drilled using continuous flight solid 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. It is noted that the measured shear strength value would be slightly lower than the actual value due to sampling disturbance.

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

The stations, offsets and ground surface elevations at the as drilled borehole locations were surveyed by Stantec Consulting Ltd. 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, Atterberg Limit tests and unit weight tests were performed on selected samples.

The results of the laboratory testing are presented on the Record of Borehole sheets (Appendix "A"), and Laboratory Test Results (Figures 1 to 7, 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.

In general, the subsurface deposits at the site consist of topsoil and loose to compact embankment fill placed on a major stratum of very stiff to hard, brown to grey silty clay till which is further underlain by a very dense silt deposit.

4.1.1 Fill

Borehole 12-410-C2, located at the east shoulder of Highway 21, encountered 460 mm shoulder gravel and a 1.67 m thick layer of sand fill with some gravel and silt, underlain by mixed fill consisting of sand and gravel, silt, clay and topsoil which extended to 2.9 m depth. The bottom of the fill layer at this location is located at Elevation 196.12 m.

Borehole 12-410-C1, put down west of the existing culvert, encountered a 150 mm thick layer of topsoil underlain by a 1.07 m thick layer of fill consisting of a mixture of sand, silt and clay, with a trace of gravel (bottom Elevation 195.53 m).

Borehole 12-410-C3, put down east of the existing culvert, encountered a 1.22 m thick layer of topsoil fill mixed with sand and silt (bottom Elevation 196.19 m).

Three (3) grain size distribution analyses of the fill are shown in Figure 1 of Appendix "B". A single sample of the fill material was tested and exhibited the following Atterberg Limits. These results are shown in Figure 2 of Appendix "B" and summarized below:

Liquid Limit (W_L)	26%
Plastic Limit (W_P)	12%
Plasticity Index (I_p)	14%

Standard penetration tests yielded "N"-values of between 2 and 13 blows per 0.3 m.

The fill is brown to dark brown in colour and the measured natural moisture contents range from 5 to 24%. Based on the above field and laboratory test results, together and tactile examination, the fill materials exhibited very loose to compact compactness condition.

Unit weight was not determined due to disturbed samples of irregular shapes and sizes.

4.1.2 Silty Clay Till

A major stratum of brown to grey silty clay till was contacted below the fill materials at all three boreholes and extended to depths of 5.33 m, 7.62 m and 5.18 m in Boreholes 12-410-C1, C2 and C3, corresponding to Elevations 191.42 m, 191.40 m and 192.23 m respectively. Occasional silt partings and seams are present within the silty clay till stratum.

Eight (8) grain size analyses were performed on the silty clay till deposit and the results are presented on Figure 3 of Appendix “B”.

Eight (8) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 4 of Appendix “B” and summarized below:

Liquid Limit (W_L)	23 to 31%, average at 28.0%
Plastic Limit (W_P)	11 to 14%, average at 12.8%
Plasticity Index (I_p)	12 to 18%, average at 15.3%

Standard penetration tests yielded “N”-values from 15 to over 100 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer on retrieved SPT samples ranged from 150 kPa to over 300 kPa.

The natural moisture contents were in the range of 11 to 15%. These results are characteristic of clayey soils of low plasticity (CL). The measured natural moisture contents are near or below the measured plastic limits and indicate that the deposit is pre-consolidated.

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

The unit weight of the silty clay till was determined on five (5) samples, and yielded a range of 23.1 kN/m³ to 26.1 kN/m³ and an average of 24.7 kN/m³.

4.1.3 Silt

The silty clay till stratum is further underlain by a silt deposit which extended beyond the vertical limit of the investigation at a maximum depth of 10.21 m below the ground surface of Borehole 12-410-C2 (Elevation 188.81 m), with the lowest Elevation 188.67 m investigated in Borehole 12-410-C1. Pockets, partings, seams and layers of silty clay are present within the silt deposit.

Six (6) grain size analyses were performed on the silt deposit and the results are presented on Figure 5 of Appendix “B”. Two (2) grain size analyses were performed on the silty clay seams and layers within the silt deposit and the results are presented on Figure 6 of Appendix “B”.

Two (2) samples of the silty clay seams and layers within the silt deposit were tested and exhibited the following Atterberg Limits. These results are shown in Figure 7 of Appendix “B” and summarized below:

Liquid Limit (W_L)	20 and 21%
Plastic Limit (W_P)	13 and 12%

Plasticity Index (I_p) 7 and 9%

Standard penetration tests taken within the silt deposit yielded “N”-values from 54 to over 100 blows per 0.3 m. Two standard penetration tests taken on the silty clay seams and layers within the silt deposit yielded N-values of 83 and 95 blows per 0.3 m.

The natural moisture contents of the silt deposit were in the range of 9 to 17%. Moisture content determinations taken on the silty clay seams and layers within the silt deposit yielded results in the order of 10%.

The above data indicate that the silt deposit is generally very dense and considered moist to wet.

4.2 Groundwater Conditions

The groundwater condition was monitored during and upon completion of sampling. All of the three (3) boreholes were dry and open at the completion of drilling.

The water level in the creek was estimated to be less than 0.3 m above the creek bottom at the time of the investigation, and reflected a low flow condition.

It should be noted that the groundwater level will fluctuate seasonally and in response to weather events. Under adverse conditions, water could be perched within the embankment fill and on top of the silty clay till. It is reasonable to assume that groundwater could be similar to the water level in the creek during high flow conditions.

Ministry of Transportation/Stantec Consulting Ltd.
G.W.P. 406-94-00
Rehabilitation of Highway 21 from St. Joseph to Bayfield
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Geocres No.: 40P5-14

08-1-IEG2-12-410-C
Final Report
Page 7
September 21, 2009

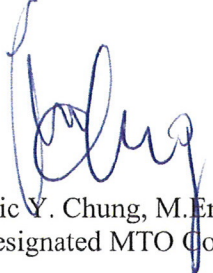
5.0 Limitations of Report

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

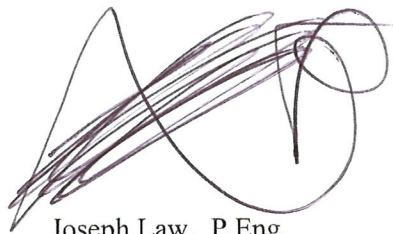
The Limitations of Report, as Quoted in Appendix "C", is an integral part of this report.


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

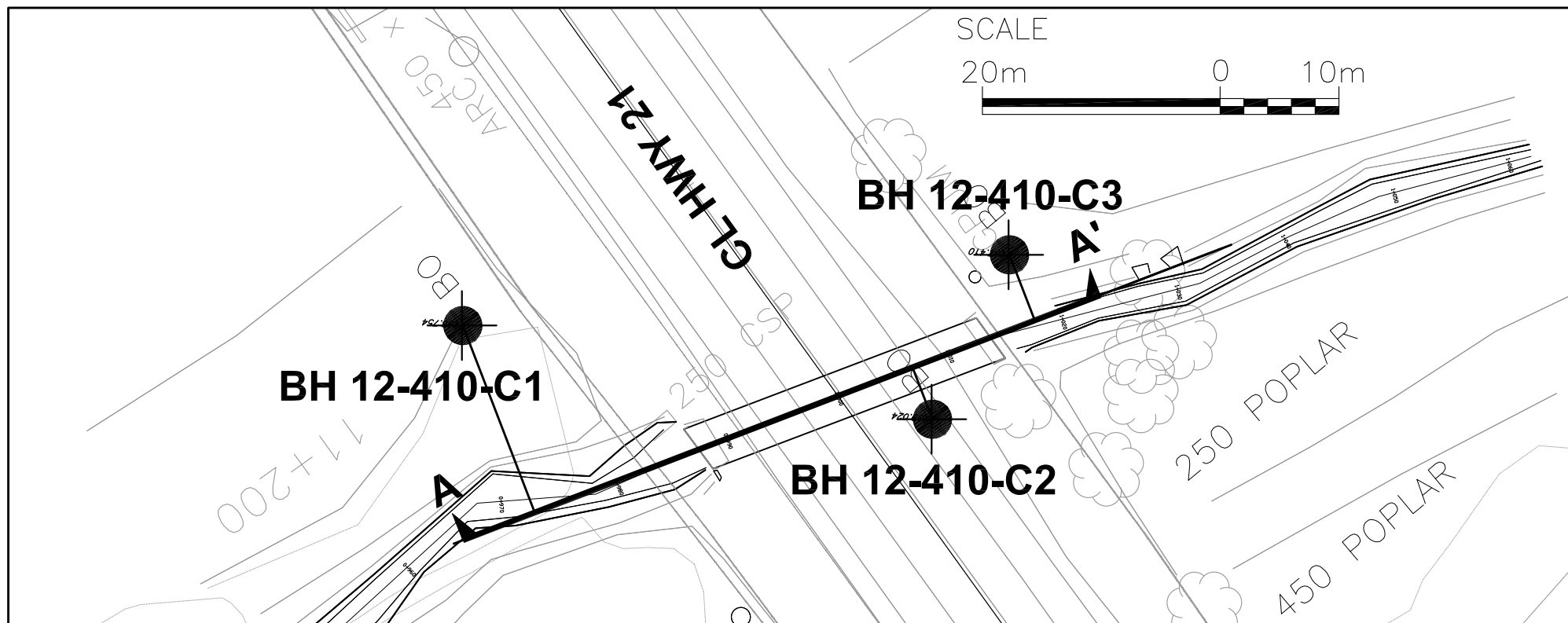


Infrastructure Engineering Group Inc.

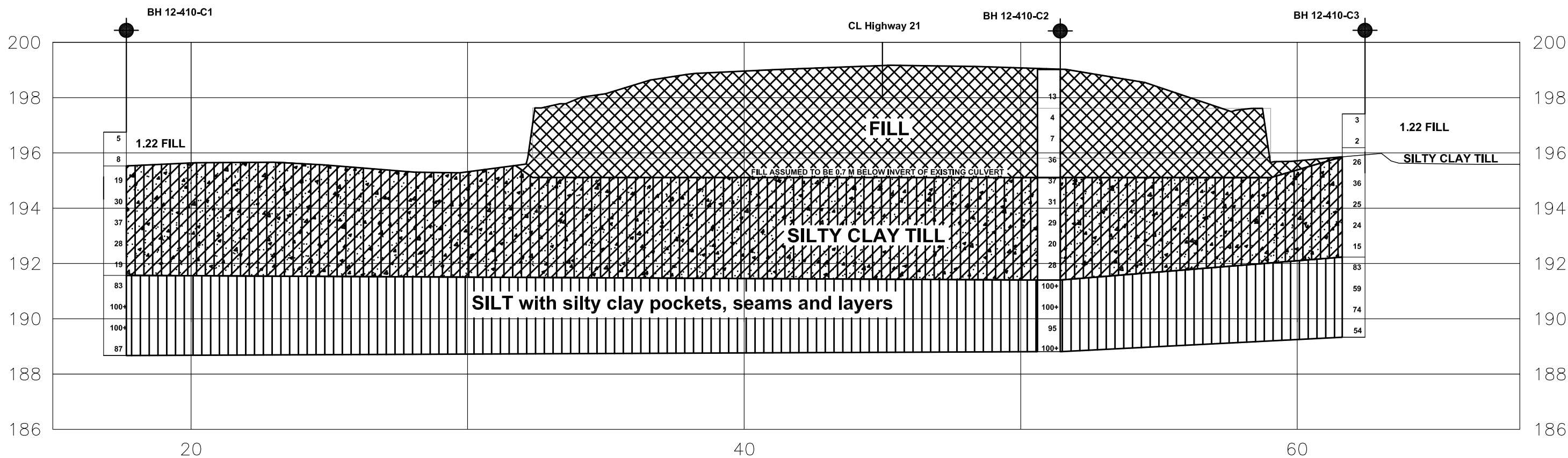
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G.W.P. 406-94-00
Rehabilitation of Highway 21 from St. Joseph to Bayfield
Agreement # 3006-E-0095

08-1-IEG2-12-410-C
Final Report
Drawing 1
September 21, 2009

Drawing 1
Borehole Locations
And
Soil Strata



BOREHOLE LOCATION PLAN

SECTION A-A'
CENTERLINE OF CULVERT

SCALE

5m 0 2m

Horizontal and Vertical

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.

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No xxxx-xxxx
WP No GWP 406-94-00

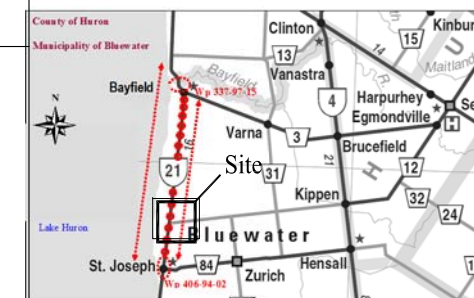
Culvert # 12-410-C
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA

I.E. Group Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor



SHEET
1

KEYPLAN NTS



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

REVISIONS	DATE	BY	DISCRIPTION
19/05/09	J.L.	Draft	

Geocres : XXX-XXX

BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES	HWY No.	HWY 21	DIST	Owen Sound
12-410-C1	196.75	4813761	4813761	369497		
12-410-C2	199.02	4813735	4813735	369526		
12-410-C3	197.41	4813735	4813735	369531		

HWY No.	HWY 21	DIST	Owen Sound
SUBM'D	J.L.	CHECKED E.C.	DATE 25/03/09
DRAWN	J.L.	CHECKED J.L.	APPROVED E.C.
			DWG 1

Ministry of Transportation/Stantec Consulting Ltd.
G.W.P. 406-94-00
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Agreement # 3006-E-0095

08-1-IEG2-12-410-C
Final Report
Appendix A
September 21, 2009

Appendix A

Explanation of Terms Used in Report

Record of Borehole Sheet

Boreholes 12-410-C1 to 12-410-C3

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 1" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

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'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_r	kPa	RESIDUAL SHEAR STRENGTH
τ_c	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_c}$

PHYSICAL PROPERTIES OF SOIL

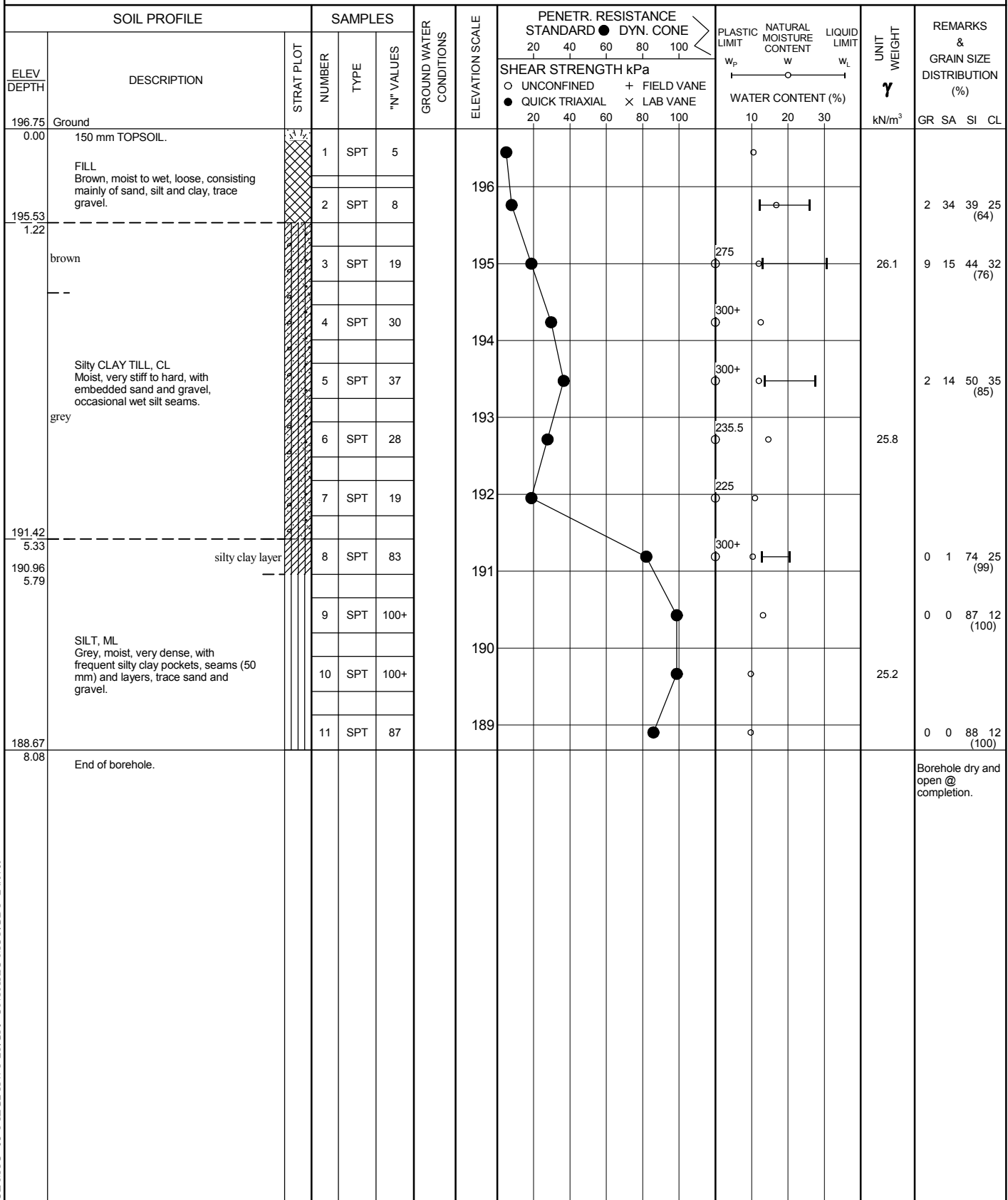
ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1. %	VOID RATIO	e_{min}	1. %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1. %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1. %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT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

RECORD OF BOREHOLE No 12-410-C1

1 OF 1

METRIC

W.P. GWP 406-94-00 LOCATION St. Joseph to Bayfield Northing - 4813761, Easting - 369497 ORIGINATED BY RB
 DIST Owen Sound HWY 21 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY NN
 DATUM Geodetic DATE 20.5.08 - 20.5.08 CHECKED BY JL



JOE MTO 08-1-IEG2 HWY 21.GPJ ONTARIO MOT.GDT 24/9/09

+ 3, X 3: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 12-410-C2

1 OF 1

METRIC

W.P. GWP 406-94-00 LOCATION St. Joseph to Bayfield Northing - 4813735, Easting - 369526 ORIGINATED BY RB
 DIST Owen Sound HWY 21 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY NN
 DATUM Geodetic DATE 20.5.08 - 20.5.08 CHECKED BY JL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
199.02 0.00	Ground														
198.56 0.46	460 mm Granular FILL														
196.89 2.13	FILL Brown, moist to wet, loose to compact, consisting mainly of sand, some gravel and silt.		2	SPT	13		198			○				22 65 (12)	
			3	SPT	4		197			○					
196.12 2.90	FILL Brown to dark brown, moist, loose, consisting of silty clay mixed with sand and gravel, trace topsoil.		4	SPT	7		197			○					
			5	SPT	36		196	○	300+	○	φ	—	2 15 48 35 (83)		
	brown		6	SPT	37		195	○	300+	○	○				
			7	SPT	31		194	○	300+	○	φ	—	3 15 48 35 (83)		
	Silty CLAY TILL, CL Moist, very stiff to hard, with embedded sand and gravel, occasional silt seams.		8	SPT	29		194	○	300+	○	○				
			9	SPT	20		193	○	225	○	○		24.3		
	grey		10	SPT	28		192	○	150	○	φ	—	3 16 53 28 (81)		
			11	SPT	100+		191	○		○			0 1 85 14 (99)		
189.88 9.14	SILT, ML Grey, moist, very dense, with frequent silty clay pockets, seams (50 mm) and layers, trace sand and gravel.		12	SPT	100+		191	○		○			0 0 89 11 (100)		
			13	SPT	95		190	○		○	φ	—	1 3 70 26 (96)		
188.81 10.21	End of borehole.		14	SPT	100+		189	○					Borehole dry and open @ completion.		

JOE MTO 08-1-IEG2 HWY 21.GPJ ONTARIO MOT.GDT 24/9/09

+ 3, × 3: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

1 OF 1

METRIC

W.P.	GWP 406-94-00	LOCATION	St. Joseph to Bayfield Northing - 4813735, Easting - 369531	ORIGINATED BY	RB
DIST	Owen Sound HWY 21	BOREHOLE TYPE	S/S Augering, 110 mm dia.	COMPILED BY	NN
DATUM	Geodetic	DATE	20.5.08 - 20.5.08	CHECKED BY	JL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	PENETR. RESISTANCE STANDARD DYN. CONE				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								
							○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE					
197.41 0.00	Ground														
196.19 1.22	FILL Brown, moist to wet, very loose, consisting mainly of topsoil, sand and silt.		1	SPT	3										
			2	SPT	2										
	brown		3	SPT	26						225+			24.2	1 44 41 14 (56)
			4	SPT	36						300+				2 16 46 36 (82)
			5	SPT	25						300+				3 14 47 35 (83)
			6	SPT	24						300+			23.1	
	grey		7	SPT	15						150				6 15 46 32 (78)
			8	SPT	83										
192.23 5.18	SILT, ML Grey, moist to wet, very dense, with frequent silty clay pockets, seams (50 mm) and layers, trace sand and gravel.		9	SPT	59									23.8	0 1 93 6 (99)
			10	SPT	74										0 0 93 7 (100)
189.33 8.08	End of borehole.		11	SPT	54										Borehole dry and open @ completion.

OE MTO 08-1-IEG2 HWY 21.GPJ ONTARIO MOT.GDT 24/9/09

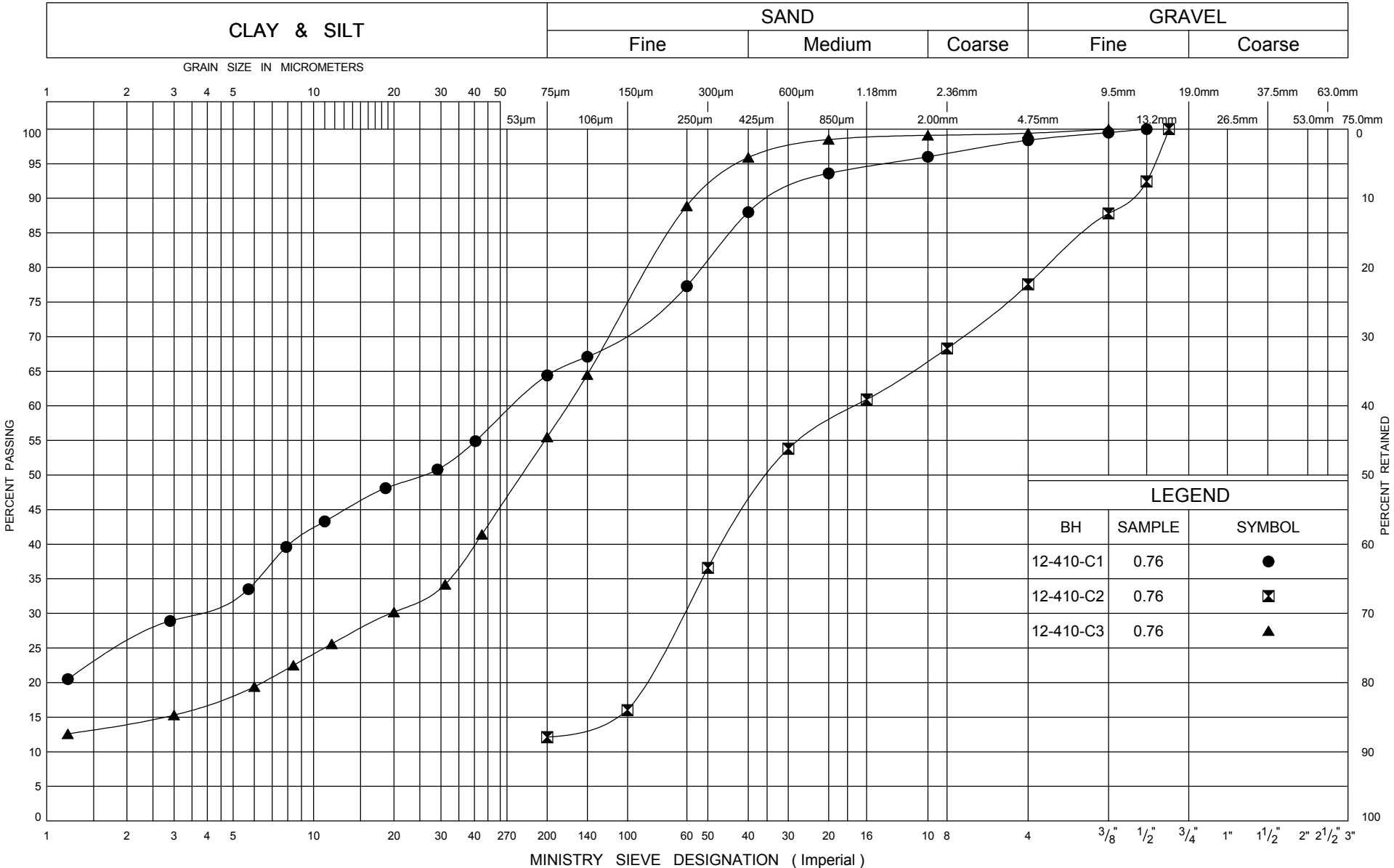
○ ¹⁵⁰ UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

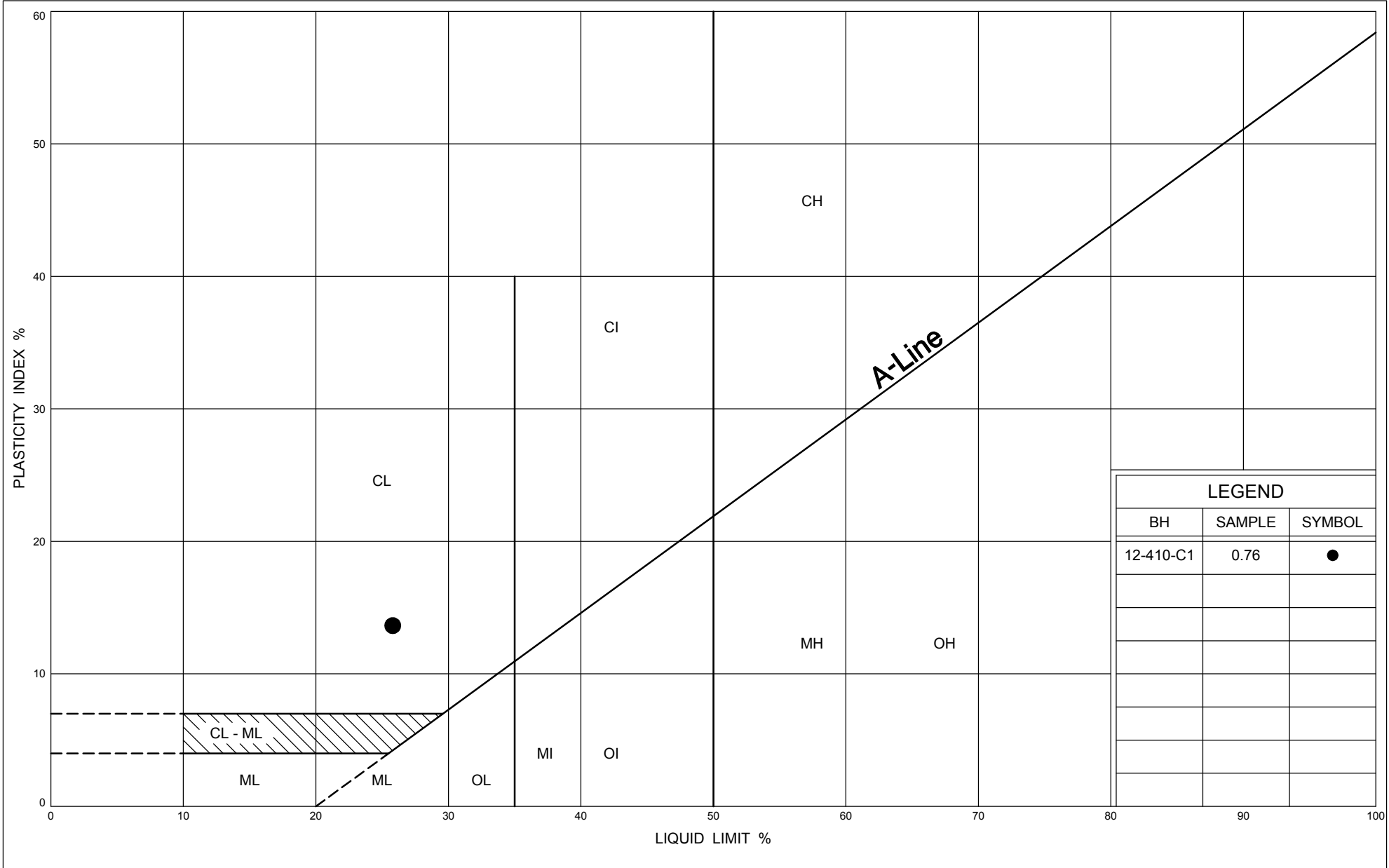
Appendix B

Laboratory Test Results

Grain Size Distribution	Figures 1, 3, 5 and 6
Plasticity Chart	Figures 2, 4 and 7

UNIFIED SOIL CLASSIFICATION SYSTEM



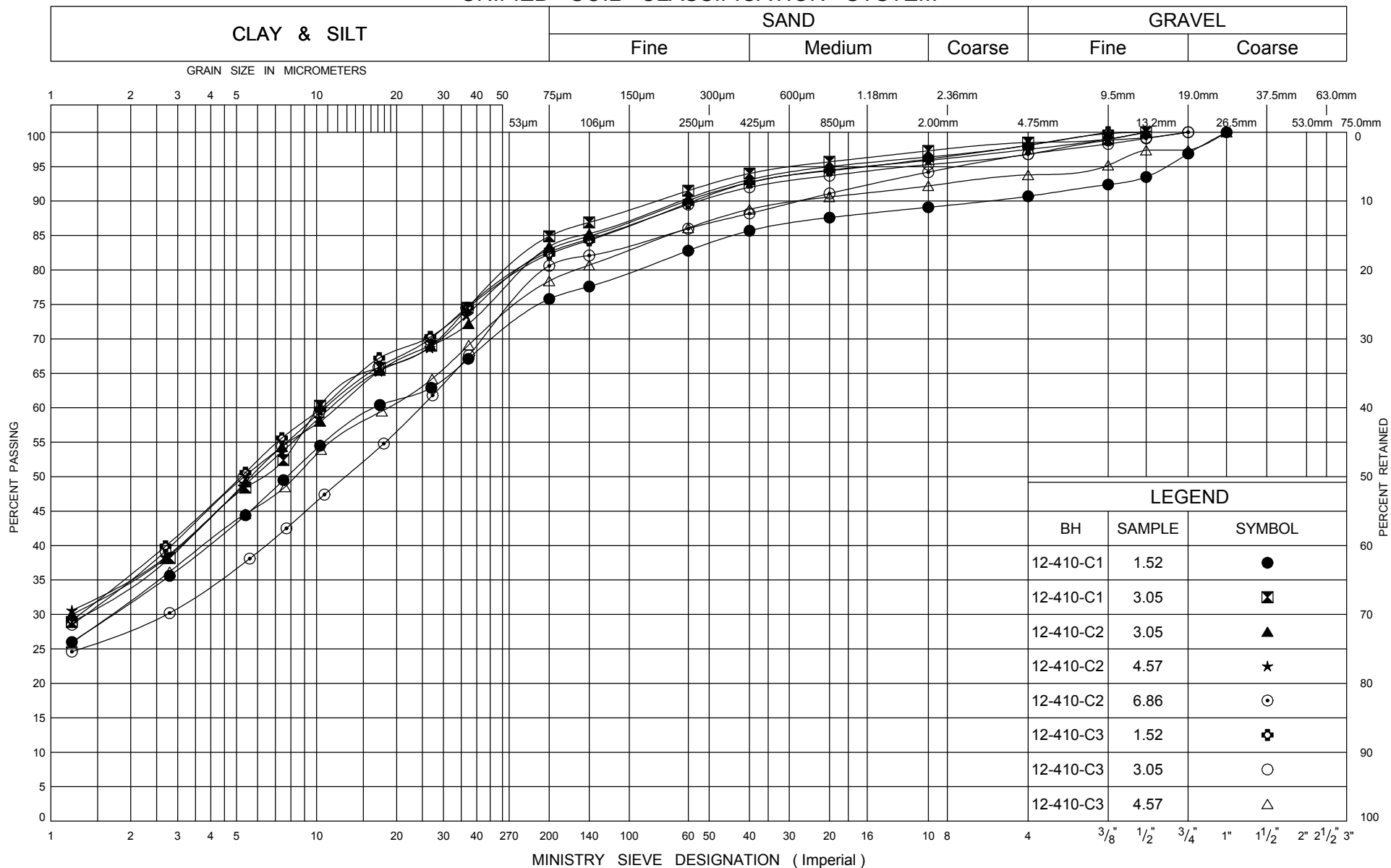


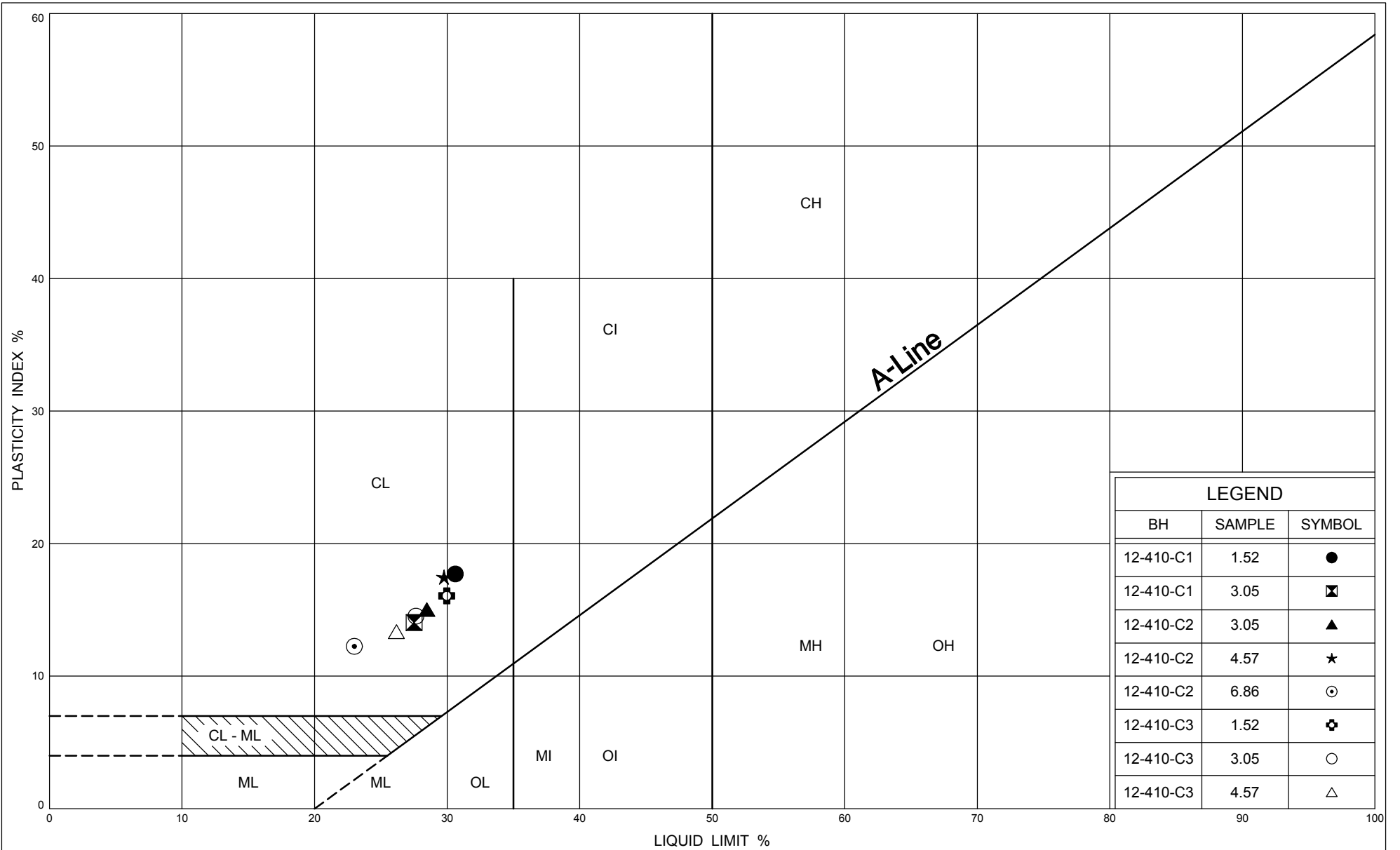
Ministry of
Transportation

PLASTICITY CHART FILL

FIG No 2
GWP 406-94-00
St. Joseph to Bayfield

UNIFIED SOIL CLASSIFICATION SYSTEM





Ministry of
Transportation

PLASTICITY CHART

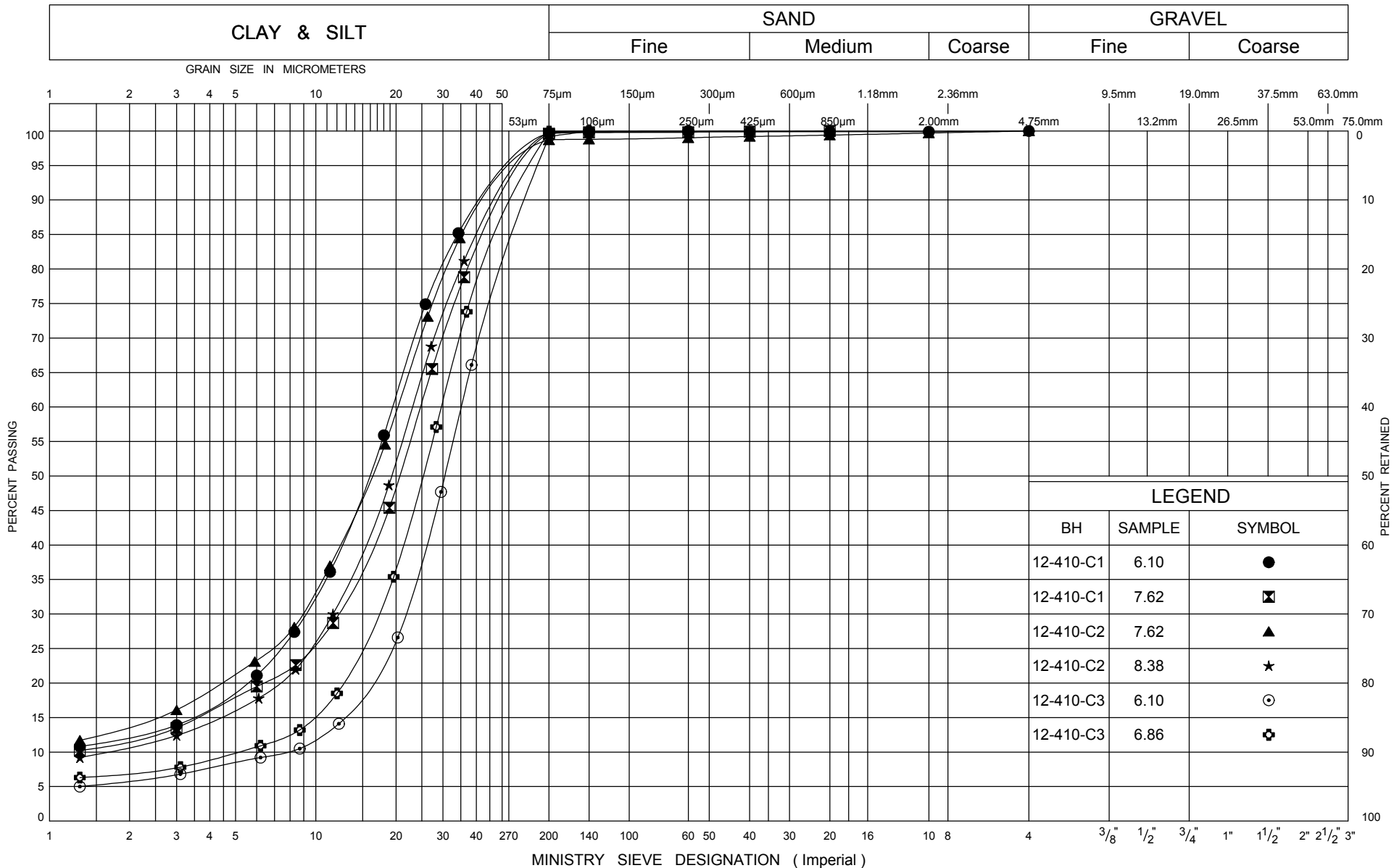
Silty CLAY TILL, CL

FIG No 4

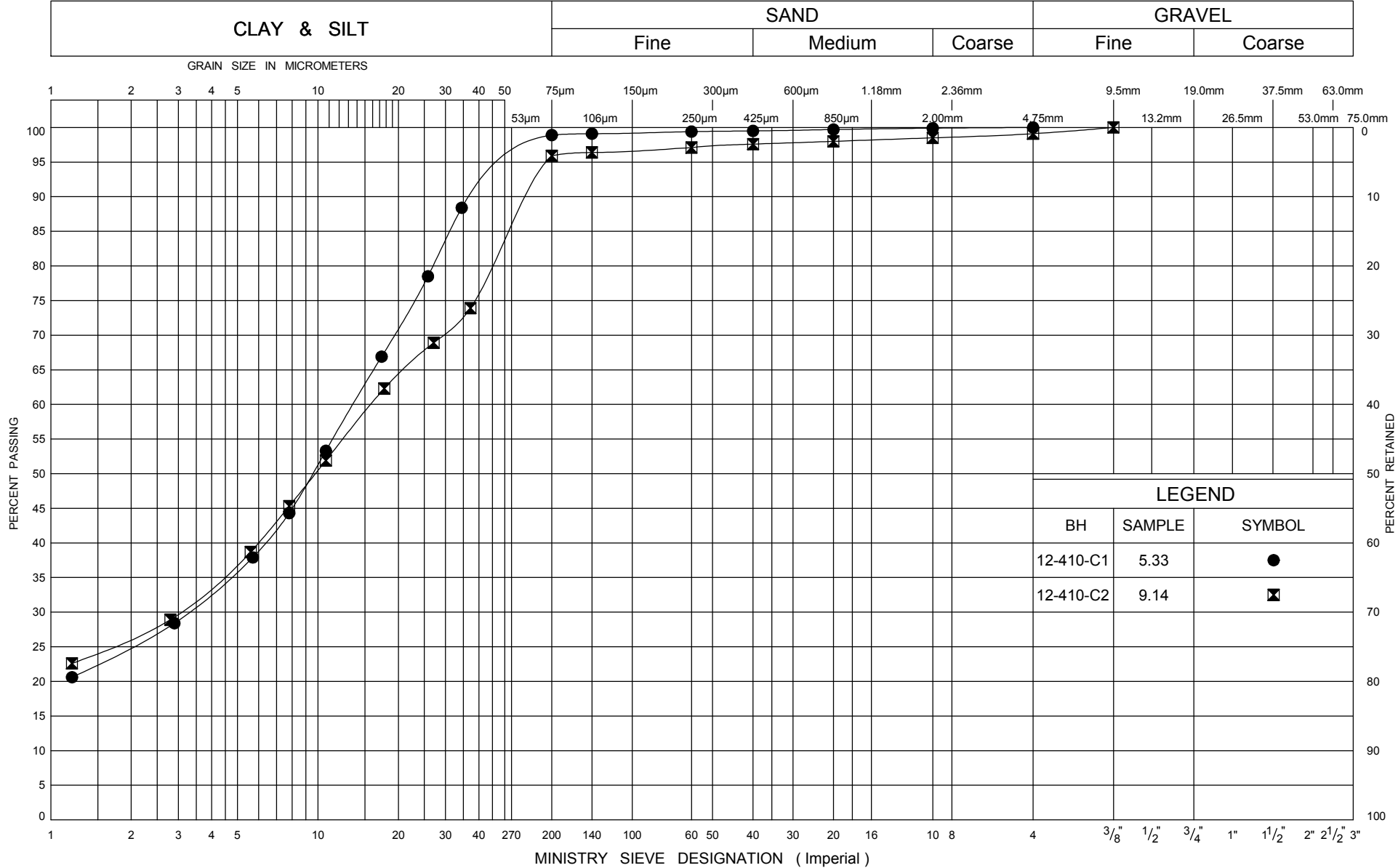
GWP 406-94-00

St. Joseph to Bayfield

UNIFIED SOIL CLASSIFICATION SYSTEM



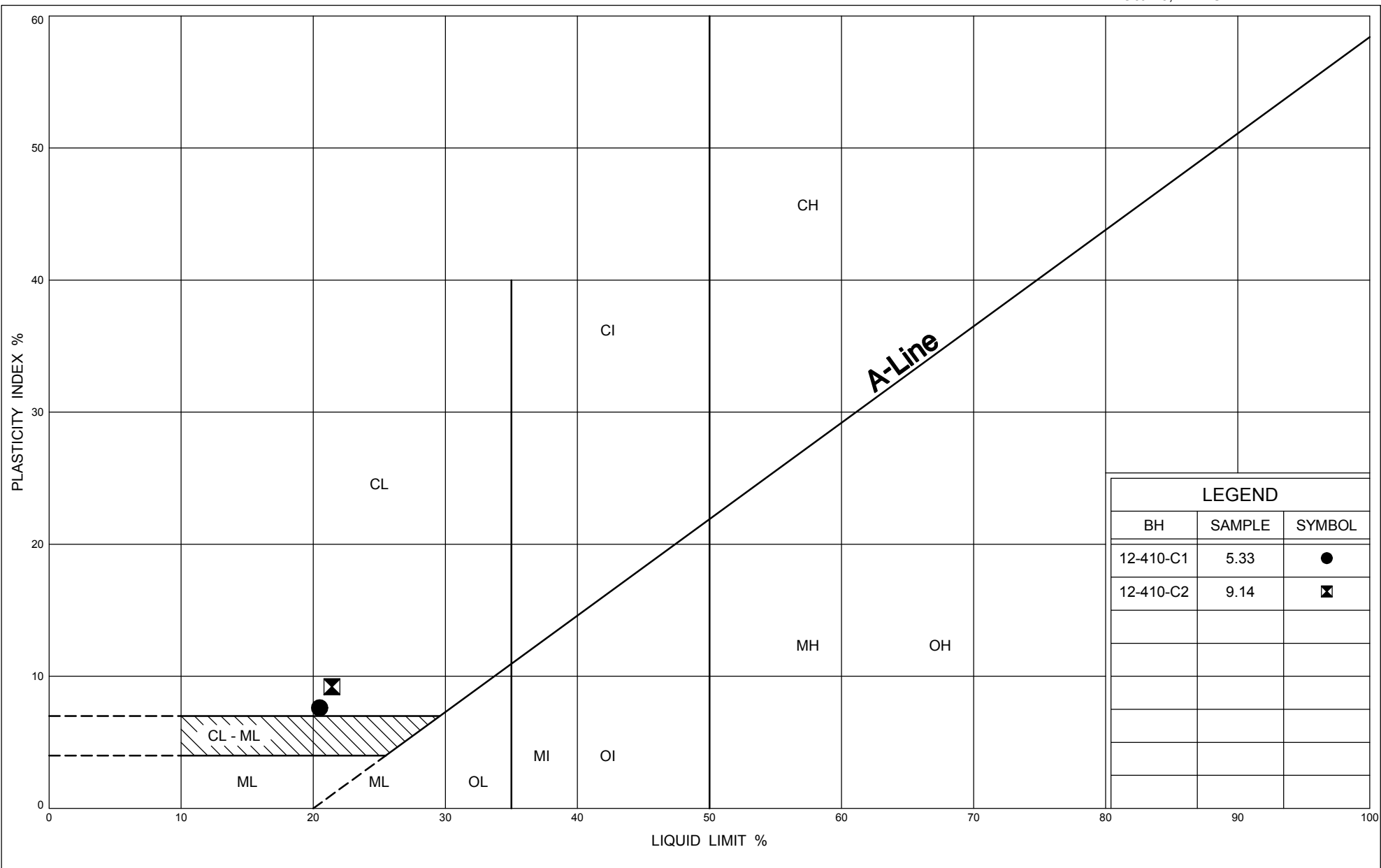
UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
SILTY CLAY SEAMS AND LAYERS

FIG No 6
GWP 406-94-00
St. Joseph to Bayfield





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G.W.P. 406-94-00
Rehabilitation of Highway 21 from St. Joseph to Bayfield
Agreement # 3006-E-0095

08-1-IEG2-12-410-C
Final Report
Appendix C
September 21, 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. 406-94-00
Rehabilitation of Highway 21 from St. Joseph to Bayfield
Agreement # 3006-E-0095

08-1-IEG2-12-410-C
Final Report
Appendix D
September 21, 2009

Appendix D

Site Photographs



Culvert 12-410-C Looking East



Culvert 12-410-C Outlet



Culvert 12-410-C, Inlet



Culvert 12-410-C, Outlet