FOUNDATION INVESTIGATION REPORT

REHABILITATION OF HIGHWAY 21
FROM BAYFIELD TO GODERICH, ONTARIO

CULVERT NO. 17 AT STATION 13+835

MINISTRY OF TRANSPORTATION ONTARIO - WEST REGION
PURCHASE ORDER NUMBER 3009-E-0022
GWP 834-93-00

MTO GEOCRES NO. 40P12-20

Submitted to:

Ministry of Transportation Ontario - West Region
3rd Floor, 659 Exeter Road
London, Ontario, N6E 1L3
Canada

Submitted by:

AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited
104 Crockford Boulevard
Scarborough, Ontario, M1R 3C3
Canada

Tel: (416) 751-6565
Fax: (416) 751-7592

January 2013

TP110076

TABLE OF CONTENTS

DRAWINGS

APPENDICES

1.0 INTRODUCTION

AMEC Environment & Infrastructure, a Division of AMEC Americas Limited ("AMEC"), was retained by the Ministry of Transportation Ontario - West Region ("MTO") to provide Detail Design Services for the Rehabilitation of Highway 21, Ontario. The project highway is about 20 km long stretching northerly from about 1.85 km south of Bayfield River Bridge (Bayfield) to about 0.17 km north of Huckins Street (Goderich), Ontario, as shown in Drawing No. 1.

In May 2011, AMEC conducted a foundation investigation comprising 21 boreholes (BH G1 to BH G21) at the locations of eight existing culverts identified for rehabilitation / replacement. The design reports for these culverts have been submitted to MTO separately.

In March 2012, AMEC conducted additional foundation investigations at the locations of 11 additional existing culverts, as shown on Drawing No. 1. The number of boreholes and locations of the boreholes were based on the Highway 21 Culvert Recommendations Table (dated 18 January 2012). The details of the additional culverts investigated, and the boreholes advanced at each location, are summarized in Table 1.1.

Table 1.1 - Culvert Details for Additional Foundation Investigations (March 2012)*

Culvert No.	Station	Existing Culvert		Boreholes Drilled	Proposed Work	Foundation Investigation Requirement
		Type	Dimension			
2	10+267	Concrete Rigid Frame - Open Footing	0.9 x 0.9 x 38.5 m	BH G22 and BH G23	Extend culvert and clean out	Two boreholes for extension
8	11+691	Concrete Rigid Frame Box	3.75 x 2.30 x 68.4 m	BH G24 and BH G25	Rehabilitate and install RSS to stabilize steep roadway embankment	Foundations for RSS / slopes and protection system to stage the construction
10	12+138	Concrete Box	1.2 x 1.2 x 24.2 m	BH G26 and BH G27	Rehabilitate inlet, remove outlet precast block wing walls, place gabion wingwalls at east end. Construct CIP wingwalls at west outlet, including scour protection.	Two boreholes at outlet end for retaining wall foundations
17	13+835	Concrete Box	1.2 x 1.2 x 27.05 m	BH G28 & BH G28A and BH G29	Replace southwest concrete retaining wall with CIP concrete retaining walls. Construct CIP concrete wingwall at	Two boreholes (southwest and northeast retaining walls)

Culvert No.	Station	Existing Culvert		Boreholes Drilled	Proposed Work	Foundation Investigation Requirement
		Type	Dimension			
					northeast.	
20	15+205	Concrete Arch - Open Footing	7.16 x 3.66 x 29.6 m	BH G30	Rehabilitate and install RSS to stabilize steep roadway embankment. Replace southwest wingwall.	Foundations for RSS / slopes (both sides of the roadway) and protection system for construction. Protection will be installed. One borehole for southwest wingwall.
30	18+380	Rigid Frame Box	3.66 x 1.52 x 21.4 m	BH G31, BH G32, BH G32A, BH G33 and BH G34	Rehabilitate concrete at both ends and soffit and add wingwalls or extend culvert	Boreholes required for a retaining wall between culverts 12-422, and 12-424 on Highway 21 and 12-423 on Cut Line Road , southeast of Intersection. Or lengthening of the culvert. (min. 4 BH for these 3 culverts total)
31	18+393		3.05 x 0.91 x 15.3 m		Rehabilitate and construct wing walls between this culvert and 12-422/C	
32	18+409		3.66 x 1.52 x 21.4 m		Rehabilitate and construct wing walls between this culvert and 12-423/C	
34	18+843	Concrete Frame - Open Footing	1.5 x 1.1 x 24.7 m	BH G35 and BH G36	Rehabilitate ends and replace wingwalls with CIP concrete. Repair culvert interior. Extend inlet end.	Two boreholes (one at each end)
56	25+232	Concrete Frame - Open Footing	2.9 x 0. 9 x 20.8 m	BH G37	Replace sandbag wingwalls with gabions at west end and CIP concrete retaining wall at east end. Repair outlet concrete. Place scour protection.	One Foundation borehole (east end)
61	26+521	Concrete Frame - Open Footing	1.8 x 1.2 x 23.5 m	BH G38 and BH G39	Rehabilitate ends and replace sand bag retaining walls with CIP concrete retaining walls	Two Foundation boreholes (one at each end)

* Based on Hwy 21 Culvert Summary Table (dated 13 December 2011), and Hwy 21 Culvert Recommendations Table (dated 18 January 2012).

The purpose of the additional foundation investigation was to obtain information on the subsurface conditions at the additional culvert sites (Table 1.1) by means of boreholes, in-situ tests and laboratory tests on selected soil samples. Based on AMEC's interpretation of the data obtained in the investigation, recommendations are provided on the geotechnical aspects of replacement / rehabilitation / extension of the culverts.

As per the Terms of Reference (TOR) in the Request for Proposal (Purchase Order Number: 3009-E-0022, dated March 2010), separate reports have been prepared - one for each culvert site, except at the intersection of Highway 21 and Cut Line Road, where one report has been prepared for the three culverts located at the intersection.

This report presents the results of foundation investigation for the rehabilitation of Culvert No. 17 at Station 13+835.

The design discussion and recommendations for Culvert at Station 13+835, including factual results of the soil conditions encountered in the boreholes and laboratory tests, are presented in a separate report titled "Foundation Investigation and Design Report".

2.0 SITE AND PROJECT DESCRIPTION

The investigated culvert site (at Station 13+835) is located at Cuttlefish Creek crossing Highway 21, about 1.63 km north of Bayfield Road, near Bayfield, Ontario (Drawing No. 1).

At this location, Highway 21 is a two-lane asphaltic concrete paved road with gravel shoulders on both sides, and runs on top of an embankment built up above the surrounding grade. The surrounding area is primarily rural in nature, with active agricultural operations and/or farm houses / vacant lands / wood lots.

As noted in Table 1.1 (Section 1.0), the existing culvert at this location is a concrete box structure that is 1.2 m wide, 1.2 m high and 27.05 m long. The inverts of the existing culvert are at elevations of 195.71 m and 195.16 m at the inlet and outlet, respectively. Preliminary Drawing No. S1 (Sheet S9), dated April 2012, indicates that the height of the existing embankment at the culvert location is about 2.0 to 3.0 m above the surrounding grade. The existing concrete retaining wall at the southwest corner of the culvert is about 2.0 m high. An existing Bell utility crosses underneath the retaining wall.

As per the design recommendation, the existing concrete retaining wall located at the southwest corner of the culvert would be replaced. Additionally, new retaining walls are also proposed at the northwest, northeast and southeast corners of the existing culvert. Details of the proposed retaining walls were not available at the time of preparation of this report.

At the time of field work, the inlet and outlet ends of the existing culvert were covered with vegetation. Site photographs showing the culvert are presented in Appendix C (Photographs 1 and 2).

3.0 GEOLOGY

Based on Map 2556 (Southern Sheet): 'Quaternary Geology of Ontario' prepared by Ministry of Northern Development and Mines of Ontario (1991), the site is located in an area of transition where the overburden comprises (i) St. Joseph Till (Huron - Georgian Bay lobe) consisting of silt to silty clay matrix, clay content increases southward, clast poor, and (ii) Glaciolacustrine deposits consisting of sand, gravelly sand and gravel; nearshore and beach deposits; and (iii) Glaciolacustrine deposits consisting of silt and clay, minor sand, basin and quiet water deposits.

4.0 INVESTIGATION PROCEDURES

4.1 Field Investigation

In accordance with the highway 21 Culvert Recommendations Table, two (2) boreholes (BH G28 and BH G29) were advanced with SPT sampling. One borehole (BH G28A) was advanced by augering without sampling for installation of a monitoring well for a hydrogeological study purpose. The findings of the hydrogeological study are presented in a separate report. Borehole BH G28 was drilled near the culvert outlet to an approximate depth of 6.6 m below the existing grade; and Borehole BH G29 was advanced to an approximate depth of 9.6 m below the existing grade at the mid-shoulder area of the northbound lane. Borehole BH G28A was drilled adjacent to BH G28 to an approximate depth of 3 m below the existing grade and a monitoring well was installed. The as-drilled borehole locations are presented on Drawing No. 2.

The fieldwork was performed on 7 March 2012 after acquiring all necessary permits for road occupancy, and obtaining clearance for underground utilities. The ground surfaces at the borehole locations were surveyed with reference to the nearest geodetic benchmark (BM HCP # 102, Sta. 10+449.955, El 197.134).

The boreholes were advanced using solid-stem augers, with a track-mount power-auger drilling rig under the full-time supervision of experienced geotechnical personnel from AMEC. The drilling, sampling and in-situ testing operations were conducted by using a track-mount drill rig owned and operated by Drilltech Drilling Inc., Newmarket, Ontario.

Soil samples were generally taken at 0.76 m intervals for the initial 3 m of the borehole, and 1.5 m thereafter, while performing the Standard Penetration Test (SPT) in accordance with ASTM D1586. This consisted of freely dropping a 63.5 kg (140 lbs.) hammer for a vertical distance of 0.76 m (30 inches) to drive a 51 mm (2 inches) diameter O.D. split-barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the

sampler into the relatively undisturbed ground by a vertical distance of 0.30 m (12 inches) was recorded as SPT 'N' value of the soil which indicated the consistency of cohesive soils or the compactness of non-cohesive soils.

The groundwater conditions were observed in the boreholes during sampling and upon completion of drilling. The groundwater depth measurements, wherever encountered, are presented on the Record of Boreholes.

Upon completion of drilling, the boreholes were backfilled in accordance with the general requirements of Ministry of the Environment Regulation 903.

Upon recovery, all soil samples were screened using a hand-held hydrocarbon surveyor (RKI Eagle), the results of which are presented on the Record of Boreholes.

One selected sample was tested for soils corrosivity potential with respect to concrete and steel, the results of which are discussed in Section 6.6.

The soil samples were transported to AMEC's Advanced Soil Laboratory in Scarborough (Toronto) for further examination and laboratory soil testing. The program of laboratory testing included, where applicable, the grain size analysis, Liquid and Plastic Limit, in-situ water content determination, and soil corrosivity analysis, which was subcontracted to Maxxam Analytics, an accredited CAEL laboratory located in Mississauga, Ontario.

The results of the in-situ and laboratory tests are presented in the corresponding Record of Boreholes (Appendix A) and Laboratory Test Results (Appendix B).

AMEC will retain the soil samples for a period of one year after completion of the project, unless otherwise advised in writing by MTO.

4.2 Laboratory Tests

In accordance with the Terms of Reference for this investigation, the following tests were conducted in the laboratory:

- In-situ water content determination (16);
- Grain size distribution analysis (4);
- Atterberg Limit tests (4); and
- Soil corrosivity (1).

The results of in-situ and laboratory tests are presented in the Record of Boreholes in Appendix A. The grain size distribution curves and plasticity chart, and the results of soil corrosivity tests are presented in Appendix B.

5.0 SUB-SURFACE CONDITIONS

Based on the investigation results, the soil profile at the borehole locations consisted predominantly of ground surface cover (topsoil / sand and gravel fill) underlain by fill soils (silty clay / silty sand) overlying native deposit comprising of clayey silt / silt / silty clay, which extended to the termination depths of the boreholes at elevations of about 190.1 m in BH G28 and about 188.6 m in BH G29.

The stratigraphic units and groundwater conditions at the borehole location is discussed in the following sections. Detailed information is provided in the Record of Borehole in Appendix A. Interpolated stratigraphical cross sections through the existing culvert are provided in Drawing No. 3.

It should be noted that the soil and groundwater conditions may vary between and beyond the borehole locations.

5.1 Ground Surface Cover

Topsoil was encountered at the existing grade in BH G28 located close to the culvert outlet. The measured thickness of the topsoil was about 480 mm.

Sand and gravel fill was encountered at the existing surface in Borehole BH G29, drilled through the existing shoulder. The measured thickness of sand and gravel fill was about 400 mm.

A single SPT N-value measured in the sand and gravel fill was 17 blows per 0.3 m. The corresponding moisture content measured in the sand and gravel fill was about 7 %.

5.2 Fill Soils

Silty clay / silty sand fill were encountered below the topsoil in Borehole BH G28 and below the sand and gravel fill in Borehole BH G29. The fill soils extended to about 0.7 m below the existing grade (Elevation 195.9 m) in Borehole BH G28, and about 2.4 m below the existing grade (Elevation 195.7 m) in Borehole BH G29.

The silty clay / silty sand fill was brown / grey in color, and contained trace organic matter and rootlets.

Two SPT N-values measured in the silty sand fill were 17 and 11 blows per 0.3 m and the measured moisture contents were 18 % and 11 %.

5.3 Clayey Silt / Silt / Silty Clay

Native clayey silt / silt / silty clay was encountered below the silty clay / silty sand fill in both boreholes. The clayey silt / silt / silty clay extended to the termination depths of the boreholes at elevations of about 190.1 m in BH G28 and about 188.6 m in BH G29.

The clayey silt / silt / silty clay was brown / grey in color, and contained trace to some sand, and trace gravel and cobbles / boulders. The SPT 'N' values of the clayey silt / silt / silty clay ranged from 18 to 50 blows per 0.3 m, indicating a very stiff to hard consistency. The measured moisture contents in the clayey silt / silt / silty clay ranged from 10 % to 20 %.

Grain size analyses and Atterberg Limit tests were completed on 4 samples of the clayey silt / silt / silty clay, and the results are presented in Table 5.1.

Table 5.1 - Laboratory Test Results
(Clayey Silt / Silt / Silty Clay)

Borehole No.	Sample No.	Depth (Elevation) (m)	Grain Size Distribution				Atterberg Limits			USCS Modified Group Symbol
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index	
BH G28	SS 2	0.8 - 1.2 (195.8 - 195.4)	0	2	82	16	23	17	6	CL-ML
BH G28	SS 3	1.5 - 2.0 (195.1 - 194.6)	0	1	79	20	23	16	7	CL
BH G29	SS 5	3.1 - 3.5 (195.0 - 194.6	3	14	53	30	25	14	11	CL
BH G29	SS 9	9.1 - 9.5 (189.0 - 188.6)	3	12	49	36	26	13	13	CL

The grain size distribution curves are presented in Figure No. B 1, and the plasticity chart is presented in Figure No. B 2, in Appendix B.

5.4 Groundwater Conditions

Groundwater conditions in the open boreholes were observed during and on completion of drilling. All boreholes were dry on completion.

The groundwater levels were also measured in the monitoring well installed in Boreholes BH G28 and BH G28A. The groundwater measurements are shown on the Record of Boreholes and summarized in Table 5.2.

Table 5.2 - Results of Groundwater Measurements

Borehole	Measured Groundwater Level			Remarks
	Date	Depth (m)	Elevation (m)	
BH G28	7 March 2012	Dry	-	Completion of drilling
	7 May 2012	0.9 m ±	195.7 m ±	In monitoring well
BH G28A	7 March 2012	Dry	-	Completion of drilling
	7 May 2012	1.0 m ±	195.6 m ±	In monitoring well
BH G29	7 March 2012	Dry	-	Completion of drilling

It should be pointed out that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to major weather events and water level in the Cuttlefish Creek.

5.5 Limited Environmental Investigation

In accordance with the Terms of Reference and AMEC proposal, soil samples obtained during the geotechnical field drilling program were field screened for evidence of environmental impact. The field screening activities included measuring the combustible organic vapours (COV) in the headspace of samples with a portable hydrocarbon surveyor instrument (RKI Eagle).

No visual or olfactory evidence of environmental impact was observed in the fill and native soil samples recovered from the boreholes. The measured COV concentrations in all soil samples were relatively low, ranging from non-detect to 15 ppm as shown in the Record of Boreholes. The COV results are semi-quantitative at best and are generally used only for relative sample comparison purposes when selecting samples for laboratory analysis. Based on the field screening results, evidence of environmental impact is not suspected.

5.6 Soil Corrosivity

To determine the soil corrosivity potential with respect to concrete and steel, one soil sample (BH G28 - SS 2) was submitted to Maxxam Analytics Laboratory in Mississauga, and tested for pH, soluble chloride, sulphate, electrical conductivity and resistivity. The test results are presented in Table 5.2. The Certificate of Analysis is included in Appendix B.

Table 5.2 - Results of Corrosivity Test

Soil Sample No.	pH	Electrical Conductivity µmho/cm	Resistivity (ohm-cm)	Chloride (µg/g)	Sulphate (µg/g)
BH G28 - SS 2	7.71	532	1030	550	<20

The test results have shown that the sulphate content of the soil is <20 ppm (µg/g). As per Table 3 "Additional Requirements for concrete subjected to sulphate attack", Clause 4.1.1.6 of CSA Standards Specification A23.1-09, any soil which has sulphate content below 0.1% (i.e., 1,000 ppm or µg/g) is not considered aggressive with respect to concrete. As such, in accordance with Table 6 of CSA A23.1-09, Type GU (general use) cement can be used for concrete.

6.0 CLOSURE

The sub-soil information contained in this report should be used solely for the purpose of foundation assessment of the culvert site at Station 13+835 on Highway 21, near Bayfield, Ontario.

The Limitations of Report is an integral part of this report.

This report was prepared by Mohammad Mollah, M.Eng., P.Eng. and Shami Malla, M. Civ. Eng., P. Eng,, and was reviewed by Prapote Boonsinsuk, Ph.D., P.Eng.

Sincerely,

AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited

Mohammad Mollah, M.Eng., P.Eng.
Senior Geotechnical Engineer

Shami Malla, M.Civ.Eng. P. Eng.
Project Manager

Prapote Boonsinsuk, Ph.D., P.Eng.
Principal Designated Contact

AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited

LIMITATIONS OF REPORT

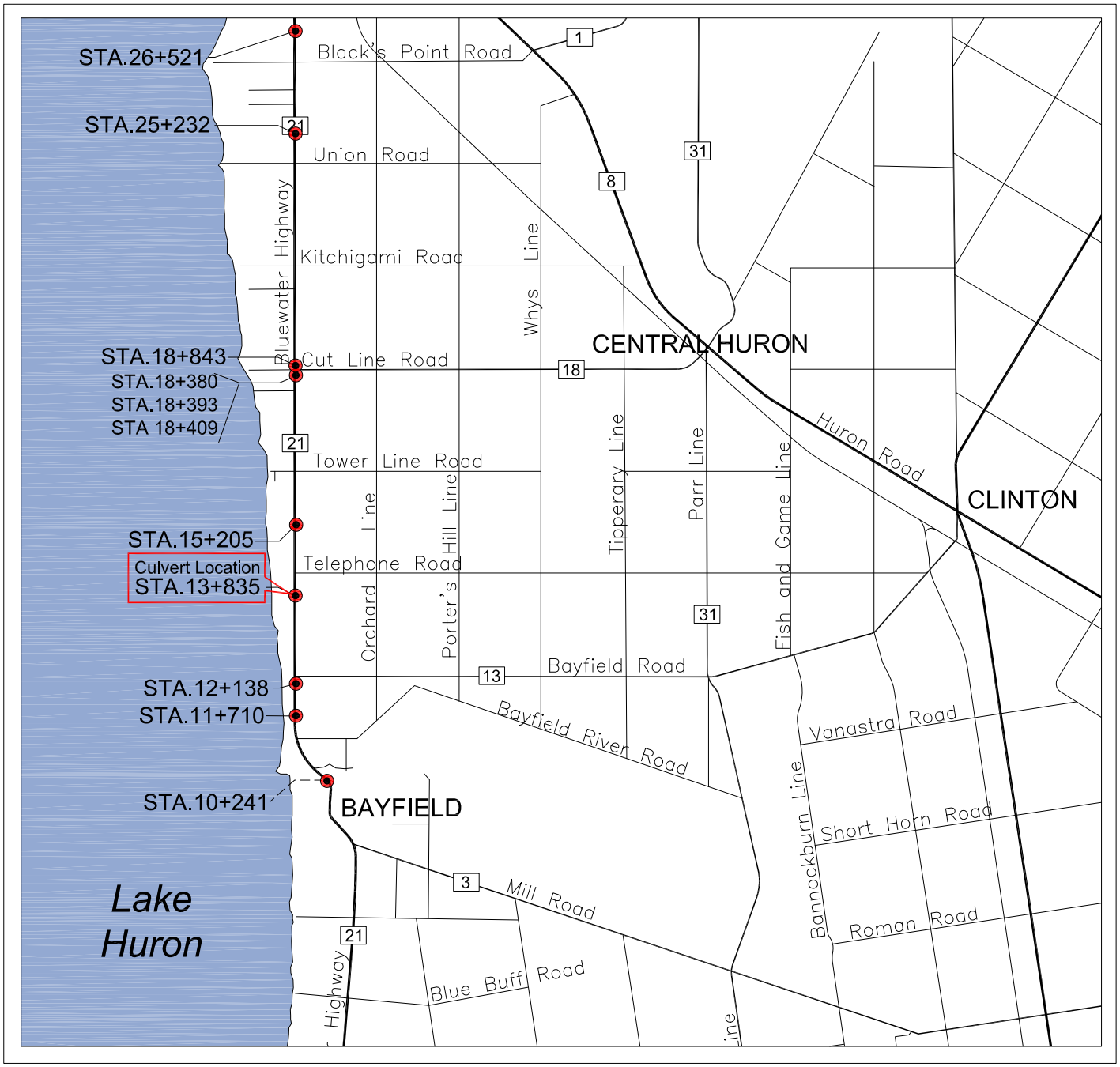
The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation.

The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. 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 conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

This report was prepared specifically for the culvert at Station 13+835 in Highway 21 near Bayfield, Ontario, as described in the report. 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. AMEC Environment & Infrastructure, a Division of AMEC Americas Limited, accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

DRAWINGS

DRAWING NO. 1	**CULVERT LOCATION PLAN**
DRAWING NO. 2	**BOREHOLE LOCATION PLAN**
DRAWING NO. 3	**STRATIGRAPHIC CROSS SECTIONS**



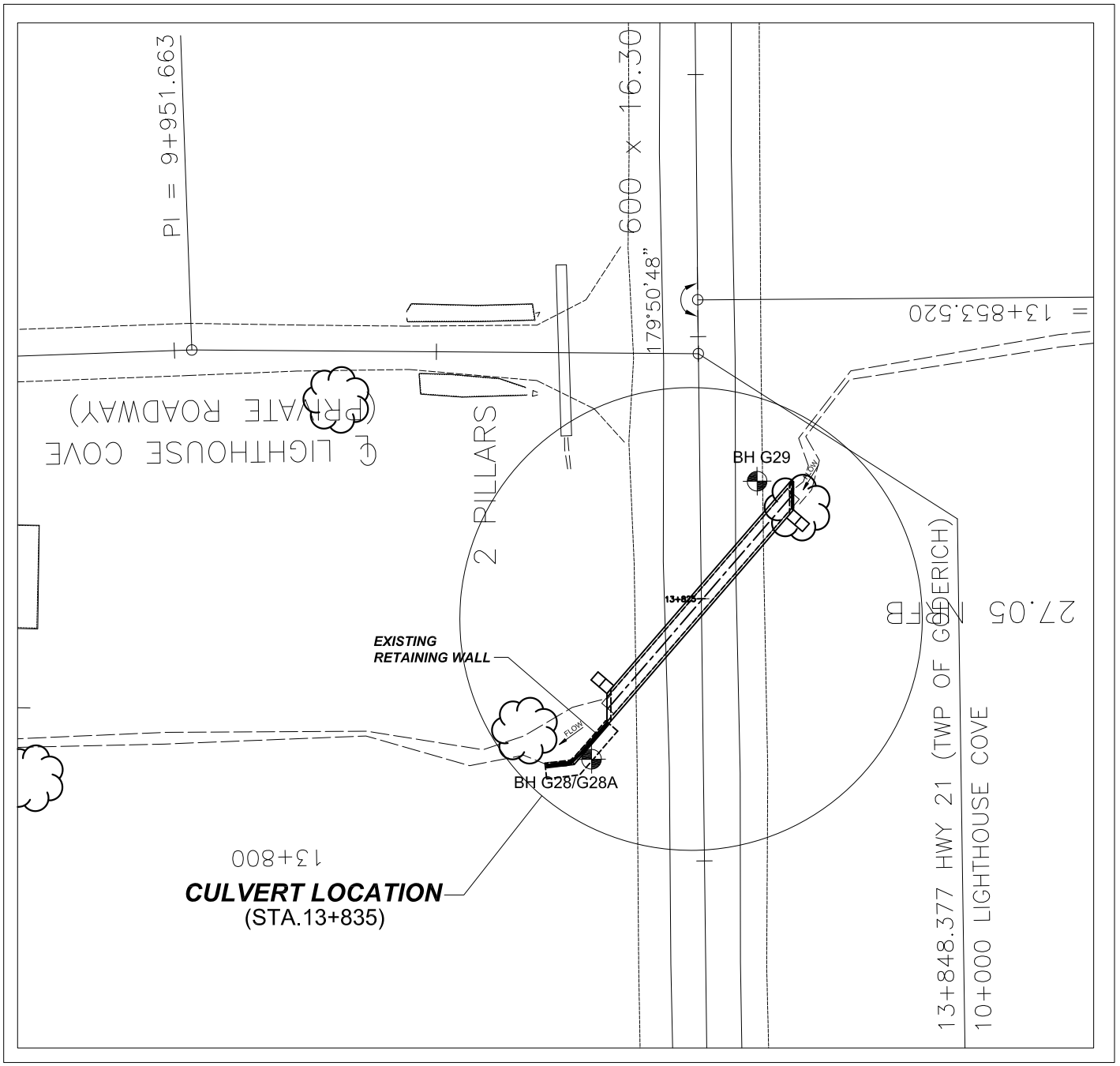
SCALE

1500m 0 1500 3000 4500 6000m

LEGEND

CULVERT LOCATION

AMEC Environment & Infrastructure, a Division of AMEC Americas Limited		CLIENT LOGO: Ontario	CLIENT: MINISTRY OF TRANSPORTATION ONTARIO WEST REGION	
TITLE: CULVERT LOCATION PLAN		DWN BY: KW	DATUM: -	DATE: JANUARY 2013
PROJECT: REHABILITATION OF HIGHWAY 21 - FROM BAYFIELD TO GODERICH, ONTARIO PURCHASE ORDER NUMBER: 3009-E-0022, WP 834-93-00, GEOCRES No.: 40P12-20		CHK'D BY: PB	REV. NO.: A	PROJECT NO: TP110076
		PROJECTION: -	SCALE: AS SHOWN	DRAWING No. 1



SCALE

5m 0 5 10 15 20m

AMEC Environment & Infrastructure, a Division of AMEC Americas Limited	amec	CLIENT LOGO Ontario	CLIENT MINISTRY OF TRANSPORTATION ONTARIO WEST REGION	
TITLE BOREHOLE LOCATION PLAN		DWN BY: KW	DATUM: -	DATE: JANUARY 2013
PROJECT REHABILITATION OF HIGHWAY 21 - FROM BAYFIELD TO GODERICH PURCHASE ORDER NUMBER: 3009-E-0022, WP 834-93-00, GEOCRES No.: 40P12-20		CHK'D BY: PB	REV. NO.: A	PROJECT NO: TP110076
		PROJECTION: -	SCALE: AS SHOWN	DRAWING No. 2

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

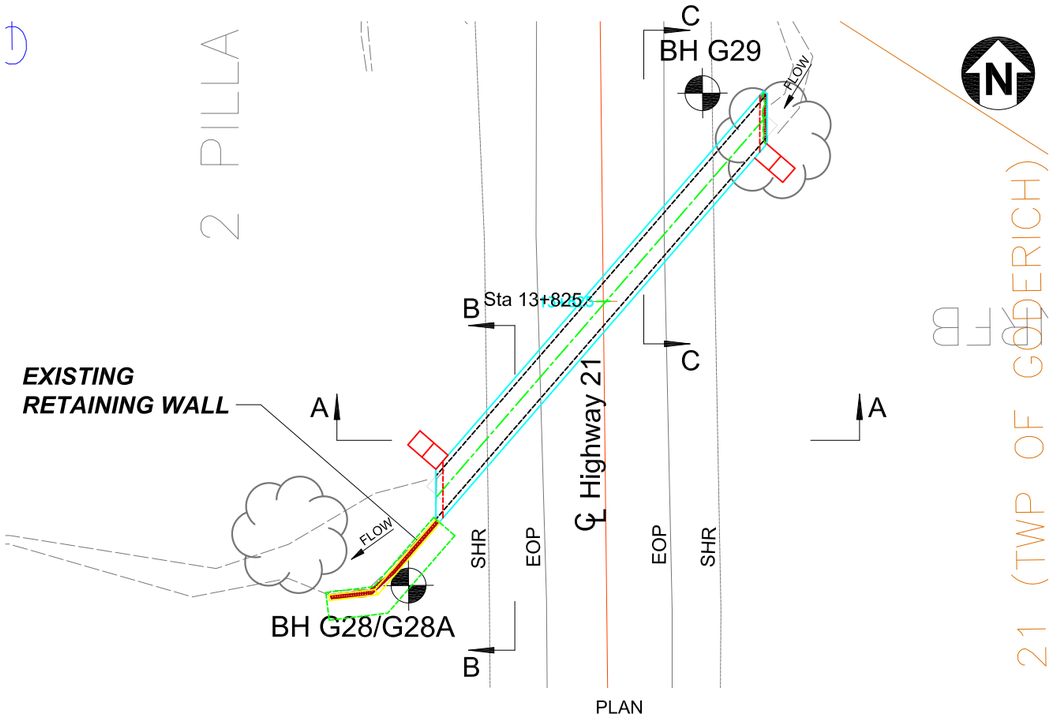
PURCHASE ORDER NUMBER: 3009-E-0022

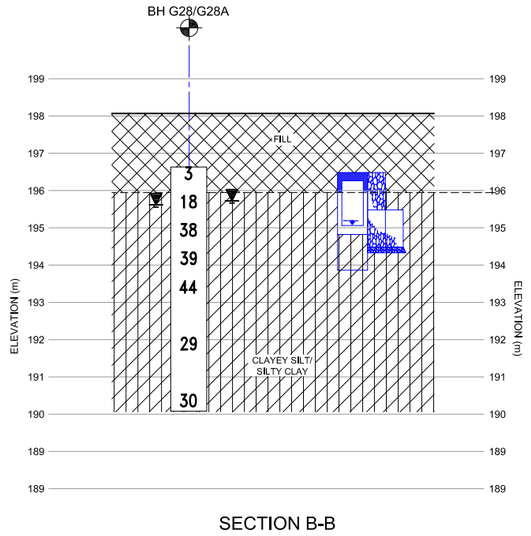
G.W.P. No. 834-93-00

REHABILITATION OF HWY 21 FROM BAYFIELD TO GODERICH
GEOCRES No.40P12-20
CULVERT AT STA 13+835
STRATIGRAPHIC CROSS SECTION

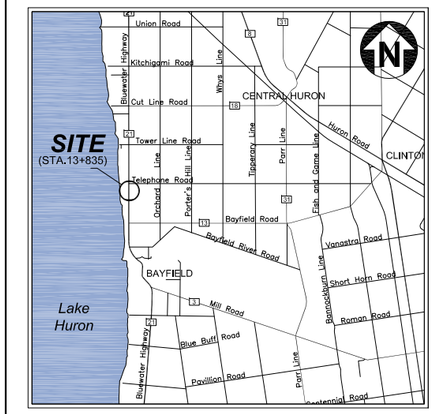
SHEET 1 OF 1

AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited





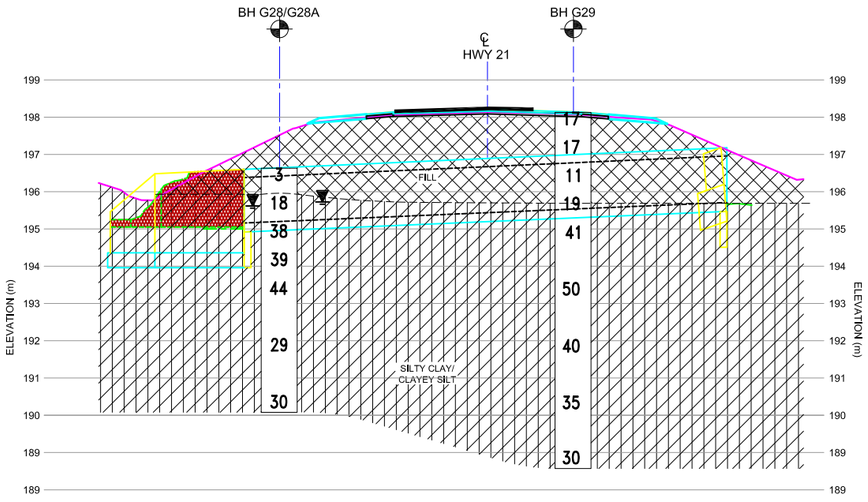
SECTION B-B



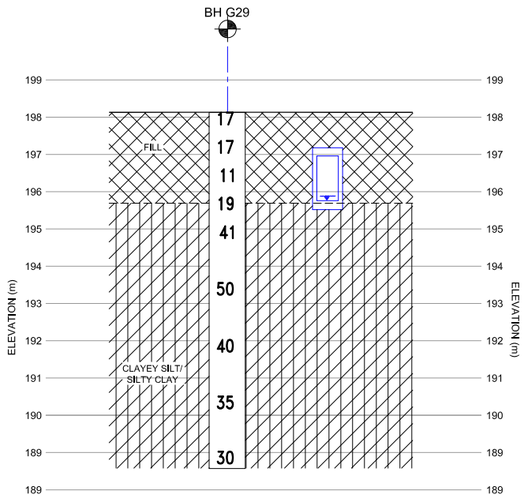
KEY PLAN

2000m 0 2000 4000 6000 8000m

Approximate Scale



SECTION A-A



SECTION C-C

LEGEND

⊕	BOREHOLE LOCATION
▽	GROUND WATER LEVEL AT TIME OF INVESTIGATION
▼	GROUND WATER LEVEL IN MONITORING WELL (HIGHEST)
EOP	EDGE OF PAVEMENT
SHR	SHOULDER ROUND

DESCRIPTION	UTM COORDINATES		ELEVATION (m)
	NORTHING	EASTING	
BH G28/G28A	4827871	443053	198.1
BH G29	4827845	443037	196.6

NOTES:
1. The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.
2. This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3. Borehole without ▽ ▼ was dry.

SOIL STRATIGRAPHY

TOPSOIL FILL SILTY CLAY/ CLAYEY SILT

LICENSED PROFESSIONAL ENGINEER
S. MALLA
100025829
JAN. 23, 2013
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
G. S.W. CHOW
JAN. 23, 2013
PROVINCE OF ONTARIO

0 2 4 6m HOR
0 1 2 3m VER
SCALE

AMEC Reference: TP110076

REVISIONS					
DESIGN PB	CHK PB	CODE CHBDC-06	CL 625-ONT	DATE JAN. 2013	
DRAWN KW	CHK HS	SITE 13+835		DWG 3	

P:\GEOProjects\2011\TP-Burlington\TP110076-HWY 21\05-Foundation\Drawings...\TB112041 - Washburn Drain.DWG

APPENDIX A

RECORD OF BOREHOLES

EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

SOIL LITHOLOGY

Elevation and Depth

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

Lithology Plot

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

Description

This column gives a description of the soil stratums, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *MTC Soil Classification Manual*.

The compactness condition of cohesionless soils (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows *(Ref. MTC Soil Classification Manual)*:

Compactness of Cohesionless Soils	SPT N-Value*
Very loose	0 to 5
Loose	5 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Undrained Shear Strength kPa
Very soft	0 to 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	Over 200

* For penetration of less than 0.3 m, N-values are indicated as the number of blows for the penetration achieved (e.g. 50/25: 50 blows for 25 centimeter penetration).

Soil Sampling

Sample types are abbreviated as follows:

SS Split Spoon	TW Thin Wall Open (Pushed)	RC Rock Core	GS Grab Sample
AS Auger Sample	TP Thin Wall Piston (Pushed)	WS Washed Sample	AR Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery and numerical testing results.

Field and Laboratory Testing

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

Instrumentation Installation

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section. Water levels, if measured during fieldwork, are also plotted. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors.

Comments

This column is used to describe non-standard situations or notes of interest.

MTC SOIL CLASSIFICATION
Based on MTC Soil Classification Manual

Ontario

MAJOR DIVISION					GROUP SYMBOL	TYPICAL DESCRIPTION	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICAL SIZE		GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROX % OF SAND & GRAVEL ; MAX SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESSOF THE COARSE GRAINS, LOCAL OR GEOLOGICAL NAME & OTHER PERTINENT DESCRICTIVE INFORMATION, & SYMBOL IN PARENTHESIS.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH STONE INTERMEDIATE SIZES MISSING		GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		
		GRAVEL WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND- SILT MIXTURES		
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES		
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNT OF ALL INTERMEDIATE PARTICLE SIZES		SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION & DRAINAGE CHARACTERISTICS	NOT MEETING ALL GRADATION REQUIREMENTS FOR GW
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING		SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		
		SANDS WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW A-LINE OR Ip LESS THAN 4 — ABOVE A-LINE WITH Ip BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE A- LINE WITH Ip GREATER THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	IDENTIFICATION PROCEDURE ON FRACTION SMALLER THAN 425µm							
	SILT AND CLAYS	LIQUID LIMIT LESS THAN 35	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)			
			NONE	QUICK	NONE	ML	INORGANIC SILTS & SANDY SILTS OR SLIGHTLY PLASTICITY, ROCK FLOUR	GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE AND CHARACTER OF PLASTICITY, AMOUNT AND MAXIMUM SIZE OF COURSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRICTIVE INFORMATION & SYMBOL IN PARENTHESIS. FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTANCY IN UNDISTURBED AND REMOLDED STATES, MOISTURE & DRAINAGE CONDITION.
			MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL	SILTY CLAYS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS	
			SLIGHT TO MEDIUM	SLOW	SLIGHT	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS	
		LIQUID LIMIT BETWEEN 35 AND 50	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICIT, CLAYEY SILTS	
			HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY	
			SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY	
		LIQUID LIMIT GREATER THAN 50	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMECACOUS FINE SANDY SILTS, ELASTIC SILTS	
			HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS	
			MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGH ORGANIC SOILS	READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE				Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS		

USE GRAIN SIZE CURVE IN IDENTIFYING THE FACTORS AS GIVEN UNDER FIELD IDENTIFICATION

DETERMINE PERCENTAGE OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 µm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:

LESS THAN 5%	GW, GP, SW, SP
MORE THAN 12%	GM, GC, SM, SC
5% TO 12%	BORDER LINE CASES REQUIRE USE OF DUAL SYMBOL.

$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 6;

$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3

NOT MEETING ALL GRADATION FOR SW

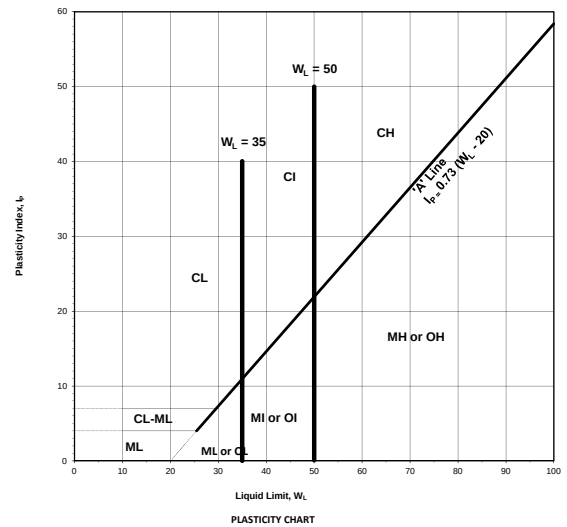
ATTERBERG LIMITS BELOW A- LINE OR Ip LESS THAN 4 — ABOVE A-LINE WITH Ip BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

ATTERBERG LIMITS ABOVE A- LINE WITH Ip GREATER THAN 7

FRACTION	U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS		
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	75 mm	26.5 mm	40-50	AND
	FINE	26.5 mm	4.75 mm	30-40	Y/EY
SAND	COARSE	4.75 mm	2.00 mm	20-30	WITH
	MEDIUM	2.00 mm	425 µm	10-20	SOME
	FINE	425 µm	75 µm	1-10	TRACE
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			

OVERSIZED MATERIAL

ROUNDED OR SUBROUNDED: COBBLES 75 mm TO 200 mm BOULDERS > 200 mm	NOT ROUNDED: ROCK FRAGMENTS > 75 mm ROCKS > 0.76 CUBIC METRE IN VOLUME



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

BOUNDARY CLASSIFICATION: BOUNDARY CLASSIFICATION: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS FOE EXAMPLE GW-GC
WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

amec

AMEC Environment & Infrastructure,
a Division of AMEC American

www.amec.com

ENGINEERING PROPERTIES OF SOIL

Ontario

TYPICAL NAMES OF SOIL GROUPS	GROUP SYMBOLS	PERMEABILITY WHEN COMPACTED	STRENGTH WHEN COMPACTED	COMPRESSIBILITY WHEN COMPACTED	WORKABILITY AS A CONSTRUCTION MATERIAL	SCOUR RESISTANCE	SUSCEPTIBI LIIY TO SURFICIAL EROSION	SUSCEPTIBILI TY TO FROST ACTION	DRAINAGE CHARACTERISTICS
WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GW	PERVIOUS	EXCELLENT	NEGLIGIBLE	EXCELLENT	MEDIUM	NEGLIGIBLE	NEGLIGIBLE	EXCELLENT
POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GP	VERY PERVI0US	GOOD	NEGLIGIBLE	GOOD	MEDIUM	NEGLIGIBLE	NEGLIGIBLE	EXCELLENT
SILTY GRAVELS, POORLY GRADED GRAVEL- SAND-SILT MIXTURES	GM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	NEGLIGIBLE	GOOD	LOW TO MEDIUM	SLIGHT	SLIGHT	FAIR TO SEMI IMPERVIOUS
CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES	GC	IMPERVIOUS	GOOD TO FAIR	VERY LOW	GOOD	MEDIUM	SLIGHT	NEGLIGIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SW	PERVIOUS	EXCELLENT	NEGLIGIBLE	EXCELLENT	LOW TO MEDIUM	SLIGHT	NEGLIGIBLE	EXCELLENT
POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SP	PERVIOUS	GOOD	VERY LOW	FAIR TO GOOD	LOW TO MEDIUM	MODERATE	NEGLIGIBLE TO SLIGHT	EXCELLENT
SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES	SM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	LOW	FAIR	LOW	MODERATE	SLIGHT TO MODERATE	FAIR TO SEMI IMPERVIOUS IMPERVIOUS
CLAYEY SANDS, POORLY GRADED SAND WITH SOME CLAY MIXTURES	SC	IMPERVIOUS	GOOD TO FAIR	LOW	GOOD	VERY LOW TO LOW	MODERATE TO SLIGHT	NEGLIGIBLE	PRACTICALLY IMPERVIOUS
INORGANIC SILTS AND SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR	ML	SEMI-PERVIOUS TO IMPERVIOUS	FAIR	MEDIUM	FAIR	VERY LOW	SEVERE	SEVERE	FAIR TO POOR
INORGANIC CLAYEY SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS	CL	IMPERVIOUS	FAIR	MEDIUM	GOOD TO FAIR	LOW TO MEDIUM	SLIGHT TO MODERATE	MODERATE TO SEVERE	PRACTICALLY IMPERVIOUS
ORGANIC SILTS OF LOW PLASTICITY	OL	SEMI-PERVIOUS TO IMPERVIOUS	POOR	MEDIUM	FAIR TO POOR	VERY LOW TO LOW	SEVERE	SEVERE	POOR
INORGANIC COMPRESSIBLE SILTS OF MEDIUM PLASTICITY	MI	SEMI-PERVIOUS TO IMPERVIOUS	FAIR	MEDIUM TO HIGH	FAIR TO POOR	LOW	MODERATE	MODERATE TO SEVERE	FAIR TO POOR
INORGANIC SILTY CLAYS OF MEDIUM PLASTICITY	CI	IMPERVIOUS	FAIR TO POOR	HIGH	FAIR	LOW TO MEDIUM	SLIGHT	MODERATE TO SEVERE	SEMI IMPERVIOUS TO PRACTICALL Y
ORGANIC SILTY CLAY OF MEDIUM PLASTICITY	OI	SEMI-PERVI0US TO IMPERVIOUS	POOR	HIGH	POOR	VERY LOW TO LOW	SEVERE	MODERATE TO SEVERE	POOR TO PRACTICALLY IMPERVIOUS
INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	MH	SEMI-PERVIOUS TO IMPERVIOUS	FAIR TO POOR	HIGH	POOR	VERY LOW	MEDIUM	SEVERE	POOR
INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	CH	IMPERVIOUS	POOR	HIGH	FAIR TO POOR	LOW TO MEDIUM	SLIGHT TO NEGLIGIBLE	NEGLIGIBLE	PRACT I.CALL Y IMPERVIOUS
ORGANIC CLAYS OF HIGH PLASTICITY	OH	IMPERVIOUS	POOR	HIGH	POOR	LOW	MODERATE	NEGLIGIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
PEAT AND OTHER HIGHLY ORGANIC SOILS	Pt	-	-	-	-	LOW	SEVERE	-	FAIR TO GOOD

Ontario

RECORD OF BOREHOLE No. BH G28

1 OF 1

G.W.P. 834-93-00 | LOCATION Sta.13+835, 10.6m E of Rd C/L, 4.0m S of Culv C/L, E443053 N4827871 | ORIGINATED BY JF

DIST Goderich HWY 21 | BOREHOLE TYPE 150 mm diameter borehole (Solid Stem) | COMPILED BY DA

DATUM Geodetic | DATE March 7, 2012 - March 7, 2012 | CHECKED BY SM

PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario | JOB NO. TP110076

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	DEPTH (m)	ELEVATION SCALE (m)	SOIL VAPOUR READING (PPM)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.6								
0.0	**about 480 mm of TOPSOIL**	1	SS	3			5	
196.2						196		
0.5	dark brown							
195.9	**Silty Clay FILL**							
0.7	trace rootlets pocket of sandy silt	2	SS	18	1		0	- 2 82 16
	brown **CLAYEY SILT / SILT** trace sand very stiff to hard	3	SS	38		195	0	- 1 79 20
					2			
		4	SS	39		194	0	
					3			
		5	SS	44		193	0	
	--- grey				4			
		6	SS	29		192	0	
					5			
						191		
					6			
		7	SS	30			0	
190.1								
6.6	**End of Borehole**							

Monitoring well details:

- 50 mm diameter PVC pipe:
- concrete: 0.0 - 0.3 m
- hole plug: 0.3 - 4.5 m
- sand pack 4.5 - 4.6 m
- slotted pipe: 4.6 - 6.1 m
- sand pack: 6.1 - 6.5 m
- protective casing: 0.9 m above ground.

Groundwater level on
7 March 2012: dry
17 May 2012: 0.9 (El 195.7 m)

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (20 40 60)

GROUND WATER CONDITIONS

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Ontario

RECORD OF BOREHOLE No. BH G28A

1 OF 1

G.W.P. 834-93-00 | LOCATION Sta.13+835, 10.6m E of Rd C/L, 4.0m S of Culvert C/L, E443053 N4827871 | ORIGINATED BY JF

DIST Goderich HWY 21 | BOREHOLE TYPE 150 mm diameter borehole (Solid Stem) | COMPILED BY MM

DATUM Geodetic | DATE March 7, 2012 - March 7, 2012 | CHECKED BY MM

PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario | JOB NO. TP110076

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)	ELEVATION SCALE (m)	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	SOIL VAPOUR READING (PPM)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.6									20 40 60 80 100	20 40 60		
0.0	**Augered down to 3.0 m to install monitoring well** Refer to BH G28 for soil information.						1	196				
							2	195				
193.6							3	194				
3.0	**End of Borehole** **Monitoring well details:** - 50 mm diameter PVC pipe: - concrete: 0.0 - 0.3 m - hole plug: 0.3 - 1.5 m - slotted pipe: 1.5 - 3.0 m - protective casing: 0.9 m above ground. Groundwater level on 7 March 2012: dry 17 May 2012: 1.0 (El 195.6 m)											

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ontario

RECORD OF BOREHOLE No BH G29

1 OF 1

G.W.P. 834-93-00 | LOCATION Sta.13+835, NBL, 5.3m E of Rd C/L, 3.0m N of Culv C/L, E443037 N4827845 | ORIGINATED BY JF

DIST Goderich HWY 21 | BOREHOLE TYPE 150 mm diameter borehole (Solid Stem) | COMPILED BY DA

DATUM Geodetic | DATE 7 March 2012 - 7 March 2012 | CHECKED BY SM

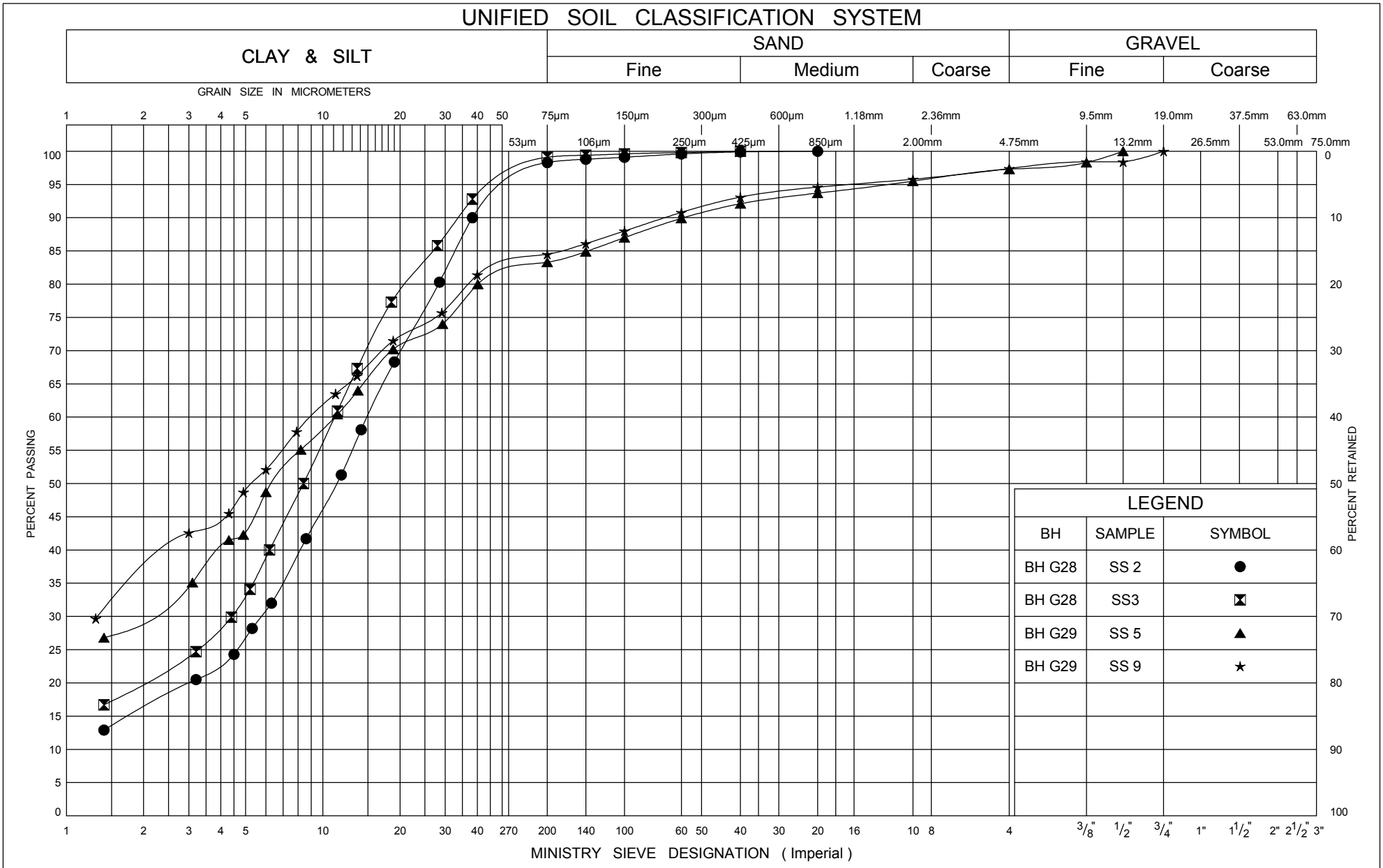
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario | JOB NO. TP110076

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)	ELEVATION SCALE (m)	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	SOIL VAPOUR READING (PPM)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.1												
0.0	brown **Sand and Gravel FILL** some silt moist		1	SS	17		0	198		7	0	
197.7 / 0.4	brown and grey **Silty Sand FILL** some clay and organic matter moist trace rootlets in SS2		2	SS	17		1	197		18	0	
			3	SS	11		2	196		11	15	
195.7 / 2.4	brown / grey **CLAYEY SILT / SILTY CLAY** some sand trace gravel very stiff to hard		4	SS	19		3	195		20	5	
			5	SS	41		4	194		13	0	3 14 53 30
	trace cobbles / boulders		6	SS	50		5	193		13	0	
			7	SS	40		6	192		15	0	
			8	SS	35		7	191		16	0	
			9	SS	30		8	190		15	0	3 12 49 36
188.6 / 9.6	**End of Borehole** Groundwater Level on 7 March 2012: dry						9	189				

$+^{3}$, $\times^{3}$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

APPENDIX B

LABORATORY TEST RESULTS



ONTARIO MOT GRAIN SIZE TP1100076-5-3 MTO.GPJ ONTARIO MOT.GDT 01/06/12

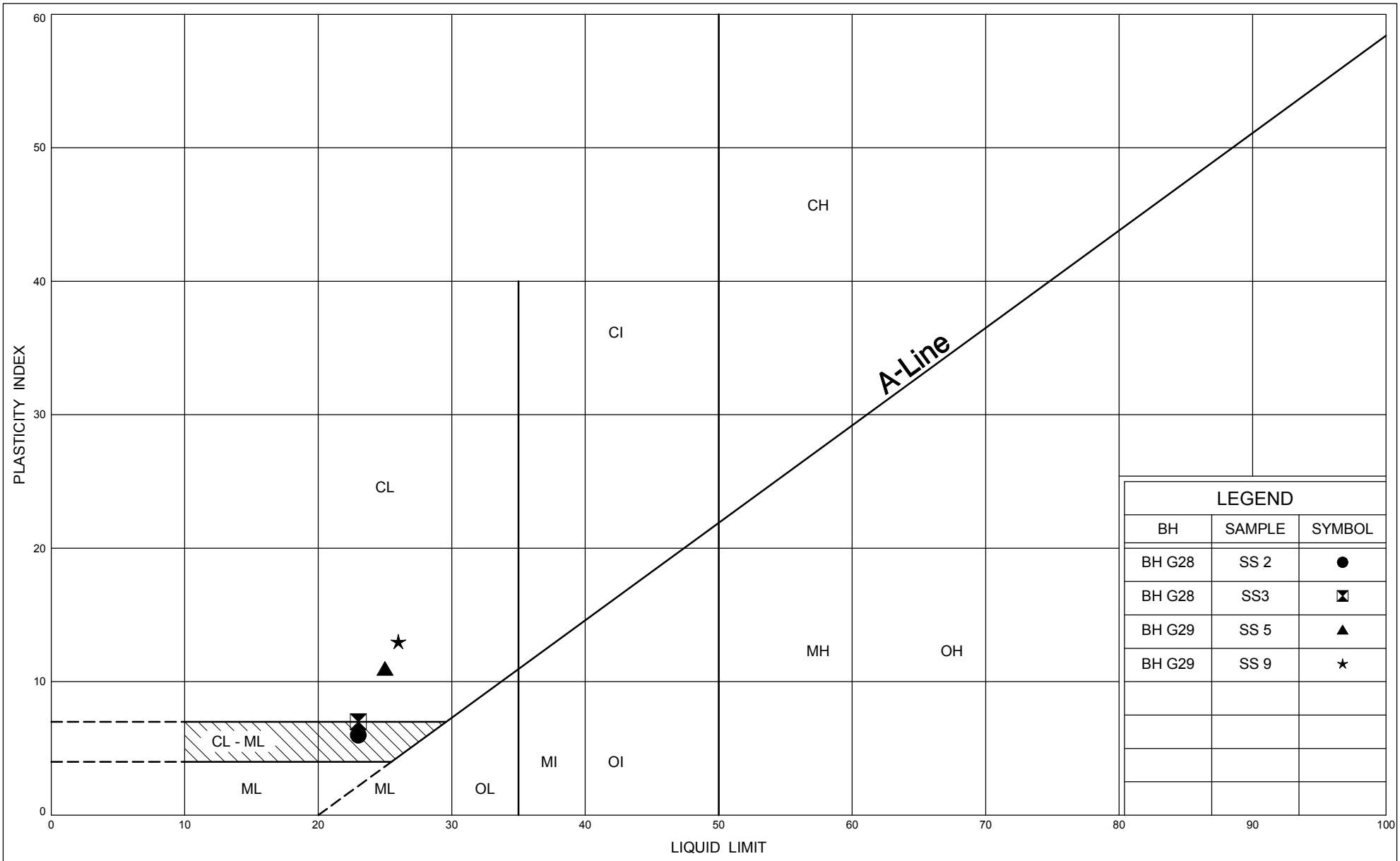
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT / SILTY CLAY

Figure No. B 1

G.W. P: 834-93-00

Culvert at Sta. 13+835, Hwy 21, Bayfield to Goderich



AMEC MOT PLASTICITY CHART TP1100076-5-3 MTO.GPJ ONTARIO MOT.GDT 01/06/12

Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT / SILTY CLAY

Figure No. B 2

G.W.P. 834-93-00

Culvert at Sta. 13+835, Hwy 21, Bayfield to Goderich

Your Project #: TP110076.05
Your C.O.C. #: 27188503, 271885-03-01

Attention: Shami Mala
AMEC Environment & Infrastructure
Scarborough
104 Crockford Blvd
Sacroborough, ON
CANADA M1R3C3

Report Date: 2012/03/23

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B238403
Received: 2012/03/19, 12:10

Sample Matrix: Soil
Samples Received: 9

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Chloride (20:1 extract)	9	N/A	2012/03/23	CAM SOP-00463	EPA 325.2
Conductivity	9	N/A	2012/03/23	CAM SOP-00414	APHA 2510
pH CaCl2 EXTRACT	8	2012/03/22	2012/03/22	CAM SOP-00413	SM 4500H+ B
pH CaCl2 EXTRACT	1	2012/03/22	2012/03/23	CAM SOP-00413	SM 4500H+ B
Resistivity of Soil	9	2012/03/19	2012/03/23	CAM SOP-00414	APHA 2510
Sulphate (20:1 Extract)	9	N/A	2012/03/23	CAM SOP-00464	EPA 375.4

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. Reporting results to two significant figures at the RDL is to permit statistical evaluation and is not intended to be an indication of analytical precision.

The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following the 'Alberta Environment Draft Addenda to the CWS-PHC, Appendix 6, Validation of Alternate Methods'. Documentation is available upon request. Maxxam has made the following improvements to the CWS-PHC reference benchmark method: (i) Headspace for F1; and, (ii) Mechanical extraction for F2-F4. Note: F4G cannot be added to the C6 to C50 hydrocarbons. The extraction date for samples field preserved with methanol for F1 and Volatile Organic Compounds is considered to be the date sampled.

Maxxam Analytics is accredited by SCC (Lab ID 97) for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

../2

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

GINA BAYBAYAN,
Email: GBAYBAYAN@maxxam.ca
Phone# (905) 817-5766

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 2

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

RESULTS OF ANALYSES OF SOIL

Maxxam ID		MV6494	MV6495	MV6496	MV6497	MV6498		
Sampling Date		2012/03/13 10:00	2012/03/13 10:00	2012/03/13 10:10	2012/03/13 10:10	2012/03/13 09:50		
	Units	**G22-SS6**	**G26-SS4**	**G28-SS2**	**G31-SS2**	**G35-SS1B**	**RDL**	**QC Batch**
Calculated Parameters								
Resistivity	ohm-cm	3400	1400	970	1700	3400		2793995
Inorganics								
Soluble (20:1) Chloride (Cl)	ug/g	90	350	550	290	90	20	2799578
Conductivity	umho/cm	292	734	1030	598	290	2	2799683
Available (CaCl2) pH	pH	7.64	7.41	7.71	7.72	7.71		2798076
Soluble (20:1) Sulphate (SO4)	ug/g	25	54	<20	<20	20	20	2799579

Maxxam ID		MV6499	MV6500		MV6501		MV6502		
Sampling Date		2012/03/16 14:30	2012/03/16 14:40		2012/03/16 15:50		2012/03/16 14:50		
	Units	**G24-SS4**	**G30-SS2**	**QC Batch**	**G37-SS2**	**QC Batch**	**G38-SS2**	**RDL**	**QC Batch**
Calculated Parameters									
Resistivity	ohm-cm	1300	800	2793995	1300	2793995	1100		2793995
Inorganics									
Soluble (20:1) Chloride (Cl)	ug/g	380	640	2799578	350	2799578	450	20	2799578
Conductivity	umho/cm	771	1250	2799683	785	2799683	949	2	2799683
Available (CaCl2) pH	pH	7.47	7.82	2798076	8.05	2799276	7.35		2798048
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	2799579	<20	2799579	<20	20	2799579

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Test Summary

Maxxam ID MV6494
Sample ID G22-SS6
Matrix Soil

Collected 2012/03/13
Shipped
Received 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam ID MV6495
Sample ID G26-SS4
Matrix Soil

Collected 2012/03/13
Shipped
Received 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam ID MV6496
Sample ID G28-SS2
Matrix Soil

Collected 2012/03/13
Shipped
Received 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Test Summary

Maxxam ID MV6497 **Collected** 2012/03/13
Sample ID G31-SS2 **Shipped**
Matrix Soil **Received** 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam ID MV6498 **Collected** 2012/03/13
Sample ID G35-SS1B **Shipped**
Matrix Soil **Received** 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam ID MV6499 **Collected** 2012/03/16
Sample ID G24-SS4 **Shipped**
Matrix Soil **Received** 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Test Summary

Maxxam ID MV6500 **Collected** 2012/03/16
Sample ID G30-SS2 **Shipped**
Matrix Soil **Received** 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798076	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam ID MV6501 **Collected** 2012/03/16
Sample ID G37-SS2 **Shipped**
Matrix Soil **Received** 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2799276	2012/03/22	2012/03/23	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam ID MV6502 **Collected** 2012/03/16
Sample ID G38-SS2 **Shipped**
Matrix Soil **Received** 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2799578	N/A	2012/03/23	DEONARINE RAMNARINE
Conductivity	COND	2799683	N/A	2012/03/23	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2798048	2012/03/22	2012/03/22	XUANHONG QIU
Resistivity of Soil		2793995	2012/03/23	2012/03/23	CRISTINA CARRIERE
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Test Summary

Maxxam ID MV6502 Dup
Sample ID G38-SS2
Matrix Soil

Collected 2012/03/16
Shipped
Received 2012/03/19

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Sulphate (20:1 Extract)	AC/EC	2799579	N/A	2012/03/23	DEONARINE RAMNARINE

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Package 1	10.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Maxxam Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2799578	Soluble (20:1) Chloride (Cl)	2012/03/23	107	75 - 125	106	75 - 125	<20	ug/g	NC	35		
2799579	Soluble (20:1) Sulphate (SO4)	2012/03/23	114(1)	75 - 125	104	85 - 115	<20	ug/g	NC(2)	35		
2799683	Conductivity	2012/03/23					<2	umho/cm	0.1	35	99	75 - 125

N/A = Not Applicable
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Matrix Spike Parent ID [MV6502-01]
(2) - Duplicate Parent ID [MV6502-01]

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Validation Signature Page

Maxxam Job #: B238403

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

CRISTINA CARRIERE, Scientific Services

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

APPENDIX C

SITE PHOTOGRAPHS

HIGHWAY 21, GODERICH, ONTARIO
(CULVERT AT Sta. 13 + 835)

PHOTOGRAPH NO. 1

Looking towards the existing culvert inlet area.

Note eroded banks.

PHOTOGRAPH NO. 2

Looking towards the existing culvert outlet area.

Note damage to retaining wall/wingwall