



FOUNDATION INVESTIGATION AND DESIGN 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:

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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	Two boreholes (southwest and northeast retaining walls)

Culvert No.	Station	Existing Culvert		Boreholes Drilled	Proposed Work	Foundation Investigation Requirement
		Type	Dimension			
					concrete wingwall at 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 together with design discussion and recommendations for the rehabilitation of Culvert No. 17 at Station 13+835.

The factual results of the soil conditions encountered in the boreholes and laboratory tests (without design discussion and recommendations) for the rehabilitation of existing Culvert No. 17 at Station 13+835 are presented in a separate report titled "Foundation Investigation 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
(Cl原因ey 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. - 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.

6.0 DISCUSSION AND RECOMMENDATIONS

In preparation of this report, the following documents were considered:

- I. Highway 21 Culvert Recommendations Table, dated 18 January 2012;
- II. Hwy 21 Culvert Summary Table, dated 13 December 2011; and
- III. AMEC Preliminary Drawing No. S1 (Sheet No. S9) dated April 2012 for Culvert No. 17 at Station 13+830.

The existing culvert is a rigid concrete, box type structure, 1.2 m wide x 1.2 m high x 27.05 m long. Highway 21, at this culvert location, is a two lane asphalt concrete paved road about 7 m wide, which runs on top of an embankment built up above the surrounding grade with an approximate fill cover above the culvert of about 1.4 m. The inverts of the culvert are at elevation of about 195.7 m and about 195.2 m, at inlet and outlet, respectively.

The project comprises the following components:

- Replacement of the southwest concrete retaining wall;
- Installation of northeast retaining wall (new), as per Culvert Recommendation Table; and
- Installation of northwest and southeast retaining wall (new), as per Drawing No. S1 (Sheet No. S9).

Southwest Retaining Wall

Currently, a concrete retaining wall is located at the southwest corner of the culvert (Drawings 2 and 3). The base of the existing retaining wall (approximately 8.0 m long x 2.5 m high) is at elevation of about 194.6 m. The retaining wall is recommended for replacement.

Northeast Retaining Wall (at Inlet)

Based on the drawing, the new retaining wall would be approximately 3.5 m long and 2.0 m high. As per the profile drawing, the base of the proposed retaining wall would likely be at elevation of 195.1 m. The drawing also shows that the culvert invert elevation is 195.7 m.

Northwest (Outlet) and Southeast (Inlet) Retaining Wall

Based on the drawing, the new retaining walls would be approximately 2.0 m long and 2.0 m high. As per the profile drawing, the base of the proposed retaining wall would likely be at elevation of about 195.0 m.

Details of the proposed retaining walls were not available at the time of writing this report. The new retaining walls comprise gravity type or cast-in-place concrete type or Retained Soil System (RSS) retaining wall.

The following sections discuss the geotechnical aspects of the proposed replacement CIP retaining wall and gabion wingwall. The recommendations should be reviewed when the detail design is available.

6.1 Retaining Wall Options

The proposed retaining walls could be gravity type or cast-in-place concrete retaining wall.

A comparison of the feasible retaining wall structures is provided in Table 6.1.

Table 6.1 - Comparison of Retaining Wall Structure Options

Option	Description	Advantages	Disadvantages	Risks / Consequences	Cost Comparison
Cast-in-place concrete retaining wall	Typically, cantilevered, reinforced-concrete, retaining wall.	Durable and low maintenance. Not susceptible to erosion by water flow and ice forces. No specialized contractor is needed.	Rigid structure which may show minor cracks. Labour intensive for placing reinforcing bars and formwork. Possible need more time for construction to allow for curing concrete.	Temporary slope excavated into the existing road embankment may have to stand up longer before backfilling.	Medium to high
Gravity Type Retaining Wall - Gabion	Gabions are rectangular steel baskets filled with stone and stacked on one another.	Construction is relatively simple. Flexible type of structure Drain freely.	Gabions are labour-intensive in order to properly place stones inside the gabion baskets. Steel baskets may not be stable in long term. Gabion may be subject to erosion by creek water flow and ice forces.	Maintenance or replacement may be frequent.	Medium to low

Option	Description	Advantages	Disadvantages	Risks / Consequences	Cost Comparison
Gravity Type Retaining Wall - Armourstone	Armourstones are large-sized stones, typically up to 1 m wide by 1 m high by 1.5 m long.	Construction is relatively simple. Flexible type of structure. Drain freely. Good resistance to water flow and ice forces. Possibly less installation time.	Source and transportation to site may be high		Medium to low
Retained Soil System (RSS)	Stone/concrete facade in front of soil mass reinforced with metal strips or geogrids.	Flexible type of structure	RSS requires specialised contractor according to MTO's DSM. Facade material has to be properly selected to prevent erosion by water flow and ice forces. Labour intensive for construction. Reinforcing strips may not be durable.	May require some maintenance	Medium

Considering that the length and height of retaining walls at this site, gravity-type retaining walls (e.g. gabion wall, armourstone, etc) would be a good option for all walls, from the geotechnical viewpoint, because of relatively simple construction and flexible structure. However, at the southwest corner, due to flow path of the creek, this wall would be exposed to flowing water. As such, a cast-in-place retaining wall may be preferred for the southwest location. Also, the existing retaining wall at the location is a cast-in-place retaining wall.

6.2 Foundations

Based on the cross-section drawing, the base of the existing culvert lies at elevations of about 195.5 m and 195.0 m at the inlet and outlet, respectively. Based on the cross-section drawing, the founding elevation of existing concrete retaining wall at the southwest corner is 194.0 m. The new retaining wall at this location is anticipated to be installed at the same elevation.

The investigation indicates that stiff to very stiff clayey silt / silty clay is likely to be encountered at the proposed retaining wall founding elevations. Sub-excavation may be required to remove any topsoil, loose / soft soils, and / or otherwise deleterious materials, if any. If sub-excavation is required, the grade could be restored by placing lean concrete or compacted 20 mm crusher-run limestone (or approved similar) up to the proposed founding elevation.

For the culvert, cut-off wall, should be should be installed to prevent flow below the culvert that could erode base materials.

The geotechnical Ultimate Limit State (ULS) / Serviceability Limit State (SLS) values provided in Table 6.2 should be used for the design of the proposed retaining walls. The recommended SLS bearing value is based on a total settlement of up to 25 mm. Detailed foundation analysis will be necessary if accurate values of settlement are required.

Table 6.2 - SLS and ULS Values for Retaining Wall

Structure	Borehole No.	Founding Stratum	Depth below Existing Grade (m)	Approximate Elevation (m)	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS ⁽¹⁾ , (kPa)
Southwest Retaining Wall	BH G28	Very stiff to hard clayey silt / silt	0.8 m (±) & below	195.8 m (±) and below	200 ⁽²⁾	300 ⁽²⁾
Northeast Retaining wall	BH G29	Hard clayey silt / silty clay	2.4 m (±) & below	195.7 m (±) and below	200 ⁽²⁾	300 ⁽²⁾

Note: ⁽¹⁾ A resistance factor of $\Phi = 0.5$ has been applied to the values provided.

⁽²⁾ Higher values could be provided if required, subject to detailed analysis.

The soil parameters in Table 6.3 may be used for design.

Table 6.3 - Summary of Geotechnical Parameters

Soil Stratum	Bulk Unit Weight of Soil, γ (kN/m ³)	Angle of Internal Friction (degree)	Earth Pressure Coefficient ⁽¹⁾		
			At-rest, K_o	Active, K_a	Passive, K_p
Existing silty clay fill	17	25	0.58	0.40	2.0
Existing silty sand fill	18	30	0.50	0.33	2.0
Existing granular fill	21	32	0.47	0.30	2.0
Clayey Silt / Silt / Silty Clay	20	28	0.53	0.35	2.0

Soil Stratum	Bulk Unit Weight of Soil, γ (kN/m ³)	Angle of Internal Friction (degree)	Earth Pressure Coefficient ⁽¹⁾		
			At-rest, K_o	Active, K_a	Passive, K_p
Granular A	22	32	0.47	0.30	2.0
Granular B	21	35	0.43	0.27	2.0

⁽¹⁾ Values based on semi-empirical relationships. The K_p (passive condition) values are reduced in order to limit the lateral soil movement that is required to mobilize the passive resistance.

The design frost penetration depth of 1.2 m should be considered in the design of the retaining wall.

For sliding resistance, the unfactored coefficient of friction 0.35 with a resistance factor of 0.8 should be considered at the base of retaining wall.

The new retaining walls should be backfilled with granular soil (OPSS Granular 'A' or Granular 'B' complying OPSS 1010), and compacted as per OPSS 501. Materials for gabion wall, if used, must comply with OPSS 1430 (*Material Specification for Gabion Baskets and Mats*).

The retaining wall should be provided with a positive drainage system to prevent the built up of hydrostatic pressure. It is recommended that a suitable nonwoven Class II geotextile (with a FOS of 75 - 150 μ m according to OPSS 860) be installed between the free draining granular backfill and earth fill / native soils, or immediately behind (and underneath the wall if gabion is used), to prevent migration of fines.

If the retained soil system (RSS) wall is selected, the design of the RSS wall should be carried out as per the manufacturer's specifications based on the type of wall selected.

Ministry of Transportation's (MTO) RSS Design Guidelines, including the Non Standard Special Provision for RSS (January 2008) included therein, and/or Standard Special Provision to OPSS - SSP 599S23, should be used for the design, supply and construction of the RSS, in addition to any contract requirements and RSS manufacturer's standards.

The existing retaining wall should be demolished and completely removed. All excavations should be carried out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. The excavation and dewatering are discussed in details in Section 6.4 and Section 6.5.

Excavations for constructing the new retaining walls should be carried out carefully to ensure that the existing foundation of the adjacent culvert and the existing road embankment are not compromised.

A small cofferdam (earth dyke) may be required to keep water flows from entering the work area. Dewatering plans must also consider any flows from the road side ditches that enter into the culvert.

Excavation for retaining wall foundations should comply with OPSS 902 (Nov/10) (*Construction Specifications for Excavating and Backfilling - Structures*) should be followed. Backfill should be placed according to OPSS 206 (*Construction Specification for Grading*), and compacted according to OPSS 501 (*Construction Specification for Compacting*). Backfill for the retaining wall should conform to OPSS 3121.150 (*Minimum Granular Backfill Requirement - Walls Retaining*).

All topsoil and soil mixed with topsoil / organic matter and loose/soft soil, if any, should be removed. Any organic soils and other deleterious materials encountered must be removed from the footprint of the foundations. Excavation to replace soft / loose soils should be carried out carefully to ensure that the foundation of existing culvert is not compromised. The exposed subgrade should be verified by proof-rolling (or other acceptable method), and any loose, soft or unstable areas sub-excavated and replaced with competent material.

6.3 Temporary Shoring

Temporary shoring may be required during the demolition of the existing retaining wall and excavation work of the new retaining wall. The temporary shoring should conform to OPSS 539: "Construction Specification for Temporary Protection Systems".

The temporary shoring system should be designed to resist the lateral earth, surcharge and hydrostatic pressure which could occur during construction. The design of temporary shoring should be carried out in accordance with Canadian Highway Bridge Design Code CAN/CSA-S6-06. Soil parameters given in Table 6.3 may be used for design considerations.

6.4 Excavation

All excavations should be carried out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. The soils to be excavated can be classified as follows:

Silty clay / silty sand fill	Type 3
Very stiff to hard clayey silt/ silt / silty clay	Type 2

Accordingly, a bank slope of 1H:1V is required for excavations in Type 2 and Type 3 soils in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. For Type 2 soil, a 1.2 m high vertical cut at the bottom of excavation may generally be constructed. A flatter slope may be required depending on the site and groundwater conditions.

If open cut excavation cannot be carried out due to space restriction, temporary shoring will be required. The temporary shoring is discussed in Section 6.3.

Excavated materials should be stock piled at least 3 m from the edge of the excavation to avoid the slope instability.

Cobbles and boulders should be expected within the soils. **The construction contract should include a Nonstandard Special Provision (NSSP) to warn the contractor of the possible presence of cobbles / boulders.**

There may be underground utilities (gas, water, sewer and telephone) within the road embankment which may be exposed during the excavation. All utilities, if present, should be adequately supported or relocated prior to excavation work. Approval should be sought from relevant authorities and utilities companies regarding excavation works around such services.

6.5 Dewatering and Drain / Ditch Diversion

No groundwater was encountered on completion of the drilling work. Excavation to replace the existing retaining wall with CIP retaining wall and construction of new retaining wall / wingwall may encounter seepage due to perched water. Groundwater seepage is expected to be slow through the clayey silt / silt / silty clay soils, and could be dewatered using a system of sumps and pumps. High rates of seepage may occur from surface water, and dewatering effort could require an increased number of sumps and pumps.

Given the variations in drain flow, and depending on the extent of the work area, a cofferdam (earth dyke) or sheet-piling could be required to prevent drain flows from entering the work area and/or reducing the groundwater inflow into the excavation.

Dewatering plans must consider any flows from the highway side drains / ditches that enter into the drain / ditch at the culvert location.

Dewatering and drain / ditch diversion activities should proceed ahead of the excavation operation.

6.6 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 6.4. The Certificate of Analysis is included in Appendix B.

Table 6.4 - Results of Corrosivity Test

Soil Sample No.	pH	Electrical Conductivity $\mu\text{mho/cm}$	Resistivity (ohm-cm)	Chloride ($\mu\text{g/g}$)	Sulphate ($\mu\text{g/g}$)
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 ($\mu\text{g/g}$). 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 $\mu\text{g/g}$) 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.

Based on the results of soil resistivity of analyzed soil sample (1030 ohm-cm), the degree of corrosivity should be considered as "severe" for exposed metallic structures. This is based on a comparison of the test results to literature reference (J.D. Palmer, Soil Resistivity Measurement and Analysis, Materials Performance, Volume 13, 1974).

A corrosion specialist should be retained, if necessary, to review the test results and provide recommendation for the most effective protection solutions.

6.7 Earthquake Considerations

In conformance with the criteria in Clause 4.4.6.2 in Section 4: Seismic Design of the Canadian Highway Bridge Design Code CAN/CSA-S6-06 (May 2010), the site seismic soil profile is Type I.

7.0 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, north of 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.

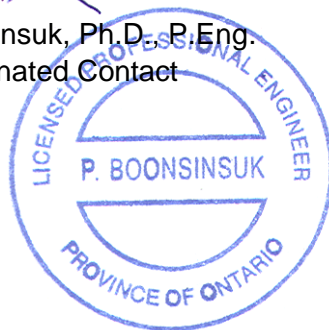
Sincerely,

**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 conclusions and recommendations given in this report are based on information determined at the testhole locations. 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 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.

The comments made in this report relating to potential construction problems and possible methods of construction 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. 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.

List of Construction Specifications and Drawings

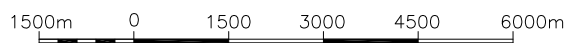
Specification / Drawing	Title
Specifications	
OPSS 180 (Nov/11)	General Specification for the Management and Disposal of Excess Materials
OPSS 206 (Nov/09)	Construction Specification for Grading (Re-issued 2010-11)
OPSS 501 (Nov/10)	Construction Specification for Compacting
OPSS 511 (Apr/11)	Construction Specification for rip-rap, rock protection, and granular sheeting
OPSS 539 (Nov/09)	Construction Specification for temporary protection systems
OPSS 572 (Nov/03)	Construction Specification for Seed and Cover
OPSS 802 (Nov/10)	Construction Specification for Topsoil
OPSS 803 (Nov/10)	Construction Specification for Sodding
OPSS 804 (Nov/10)	Construction Specification for Seed and Cover
OPSS 902 (Nov/10)	Construction Specifications for excavating and Backfilling of structures
OPSS 1004 (Nov/06)	Material Specifications for Aggregates - Miscellaneous
OPSS 1010(Apr/04)	Material Specifications for Aggregates – Base, subbase, select subgrade, and backfill material
OPSS 1860 (Apr/12)	Material Specification for Geotextiles
OPSS 1430 (Nov/12)	Material Specification for Gabion Baskets and Mats
SSP 599S23 (Mar/06)	Special Provision for Materials, Quality Control and Quality Assurance Testing and Acceptance Criteria for Precast Concrete Facing Elements including Panels
Drawings	
OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill, backfill transition and cover for the concrete culvert
OPSD 810.010	Rip-rap treatment for sewer and culvert outlets
OPSD 3121.150	Minimum granular backfill requirements - walls retaining

DRAWINGS

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



SCALE



LEGEND

 CULVERT LOCATION

**AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited**



CLIENT LOGO



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, GEOCRETS No.: 40P12-20

CHKD BY:
PB

REV. NO.:
A

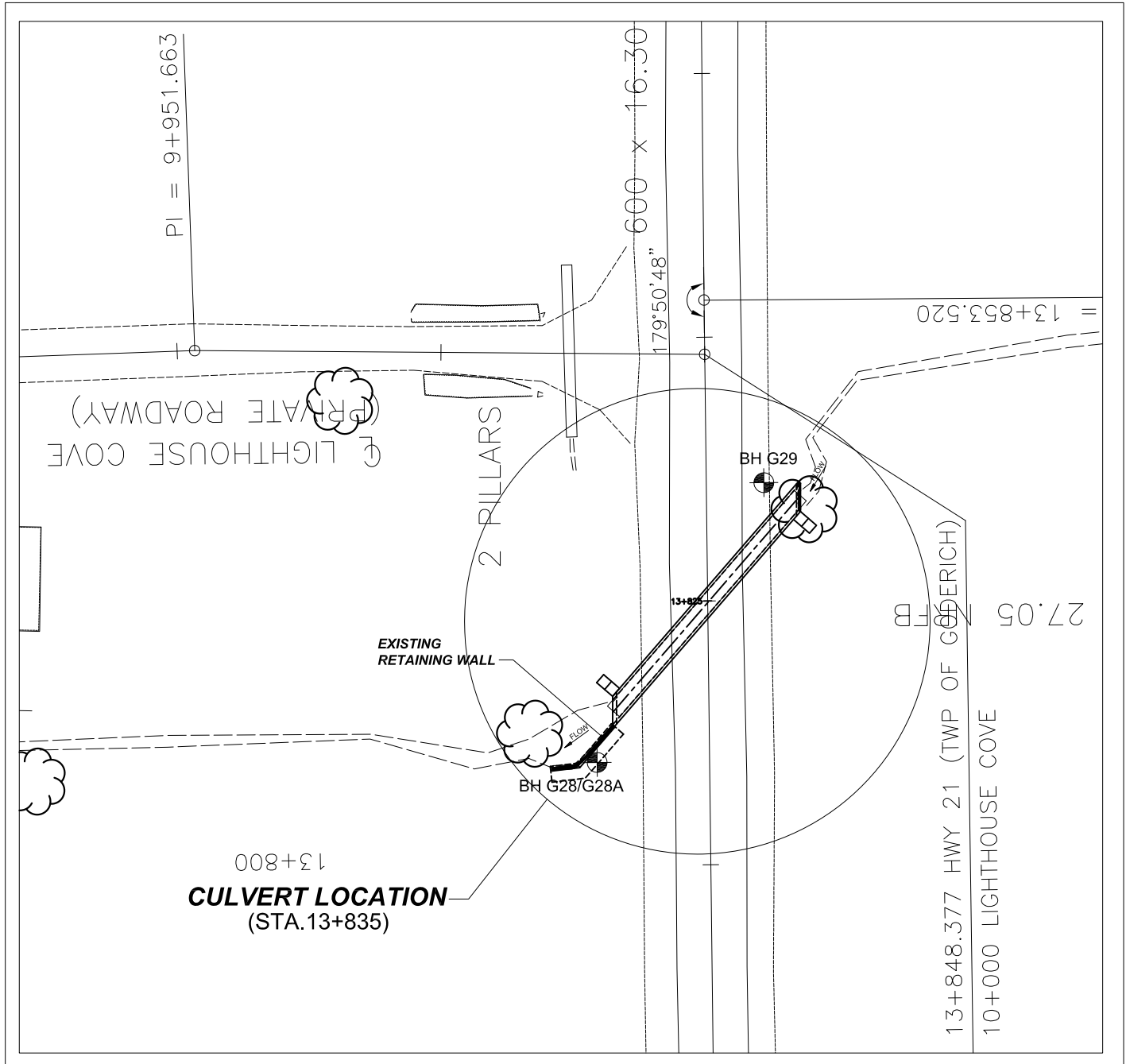
PROJECT NO:
TP110076

PROJECTION:
-

SCALE:
AS SHOWN



DRAWING No.

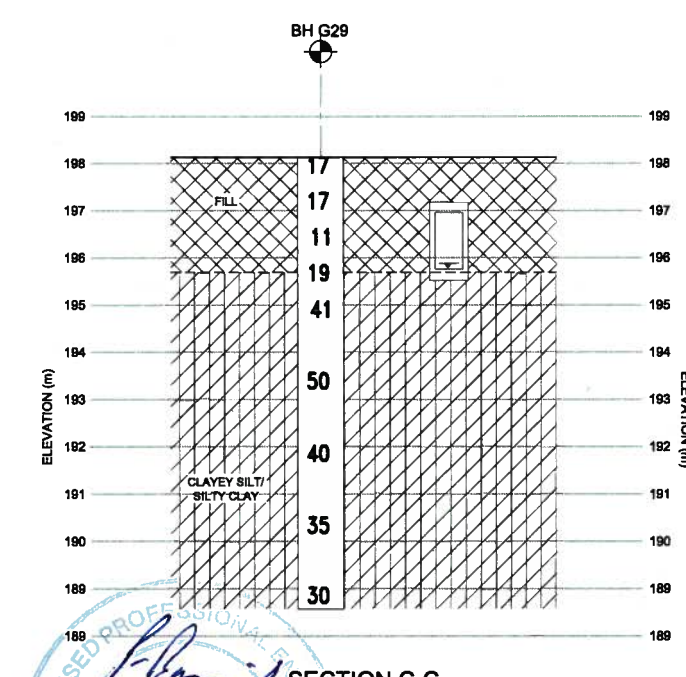
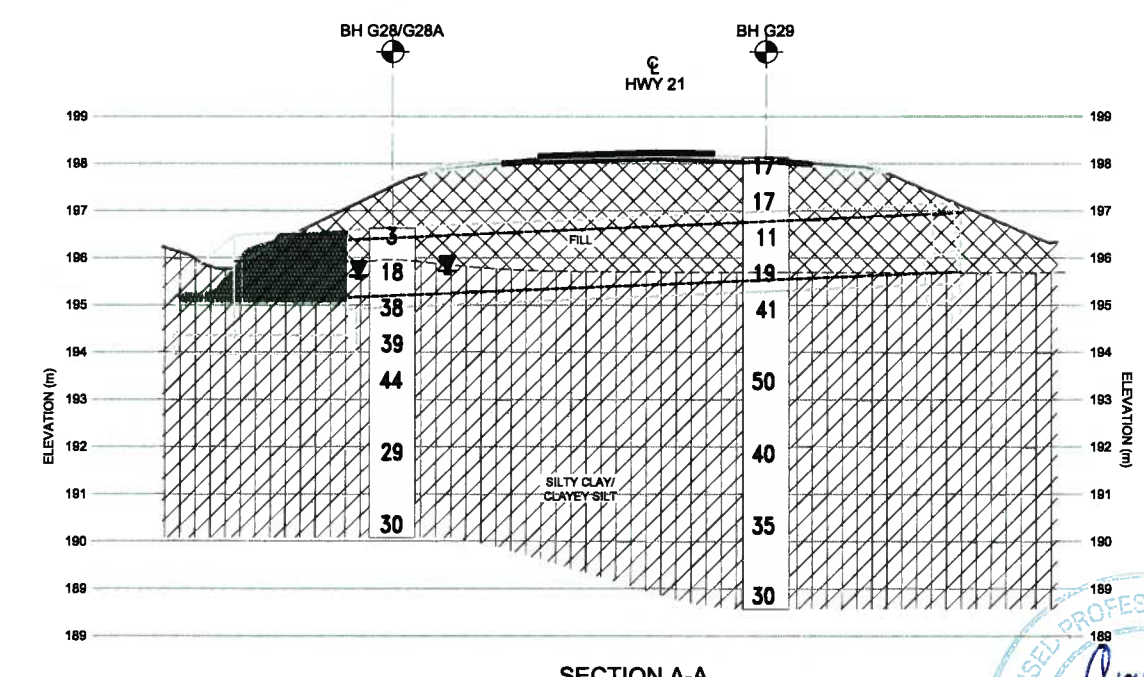
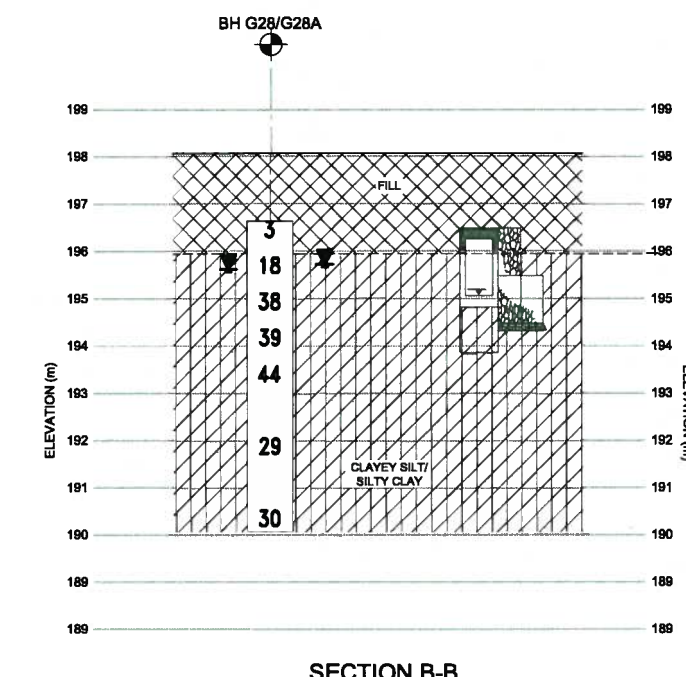
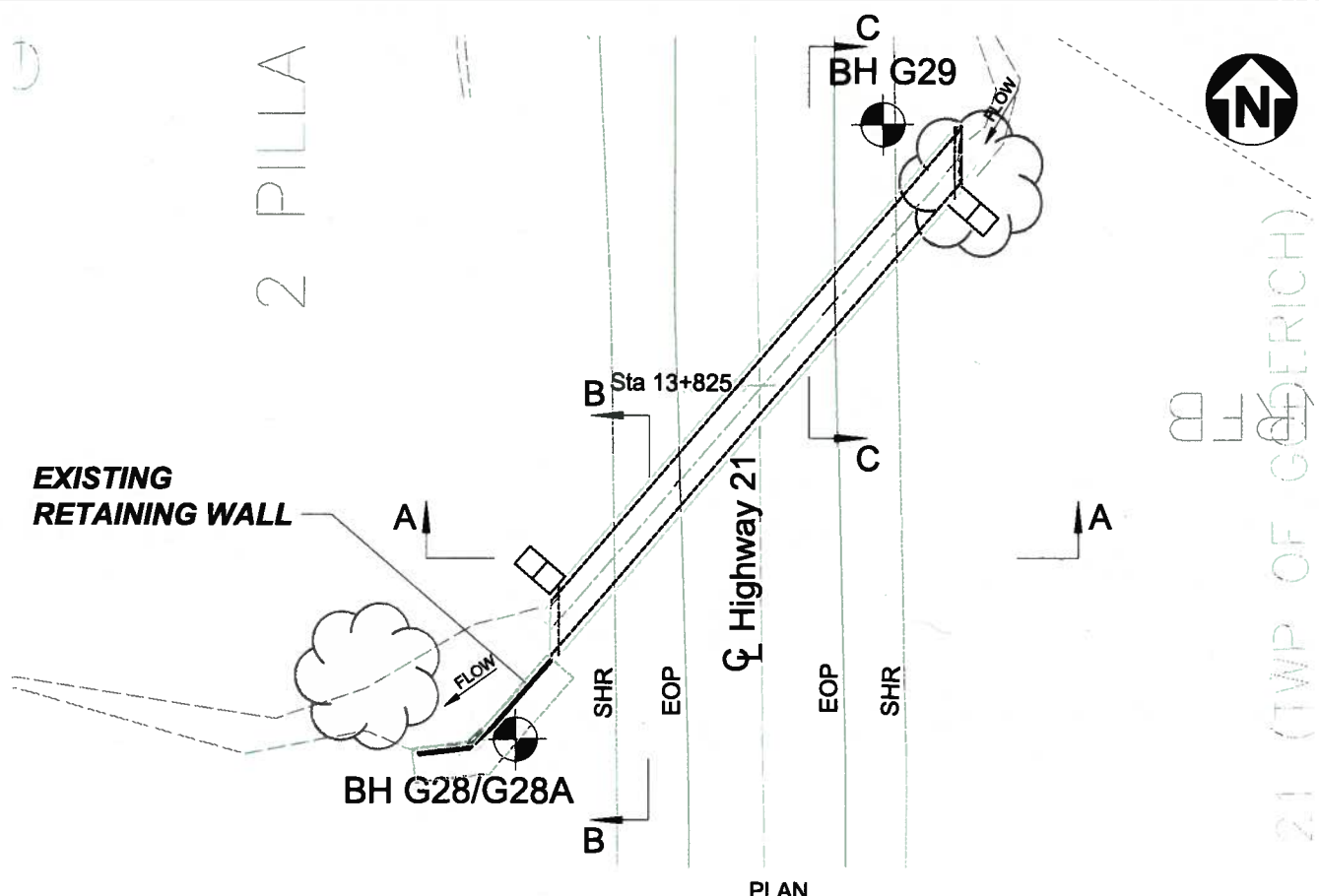
1



SCALE



AMEC Environment & Infrastructure, a Division of AMEC Americas Limited			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 <small>PURCHASE ORDER NUMBER: 3009-E-0022, WP 834-93-00, GEOCREs No.: 40P12-20</small>			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

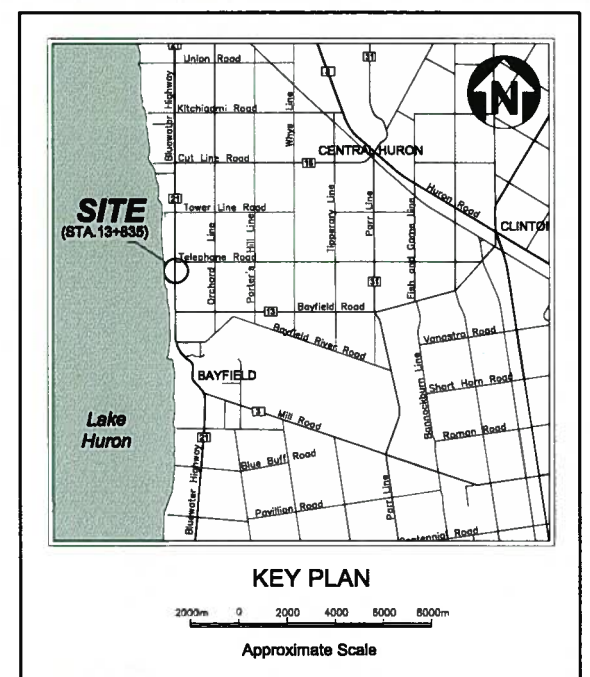
PURCHASE ORDER NUMBER:
3009-E-0022

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

amec
AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited

SHEET
1 OF 1



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)
BH G28/G28A	NORTHING	EASTING	
BH G29	4827871	443053	198.1
	4827845	443037	196.6

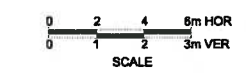
- NOTES:**
- The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.
 - This drawing is for subsurface information only. Surface details and features are for conceptual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

SOIL STRATIGRAPHY

TOPSOIL FILL SILTY CLAY/ CLAYEY SILT

LICENSED PROFESSIONAL ENGINEER
S. MALLA
100025629
11 Mar '13
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. BOONSINSUK
10 Mar '13
PROVINCE OF ONTARIO



AMEC Reference: TP110076

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

P:\GEOProjects\2011\TP-Burlington\TP-110076-HWY 21\05-Foundations\Drawings\1TB112041 - 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 strata, 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	
<u>Cohesionless Soils</u>	<u>SPT N-Value*</u>
Very loose	0 to 5
Loose	5 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of	
<u>Cohesive Soils</u>	<u>Undrained Shear Strength</u>
	<u>kPa</u>
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

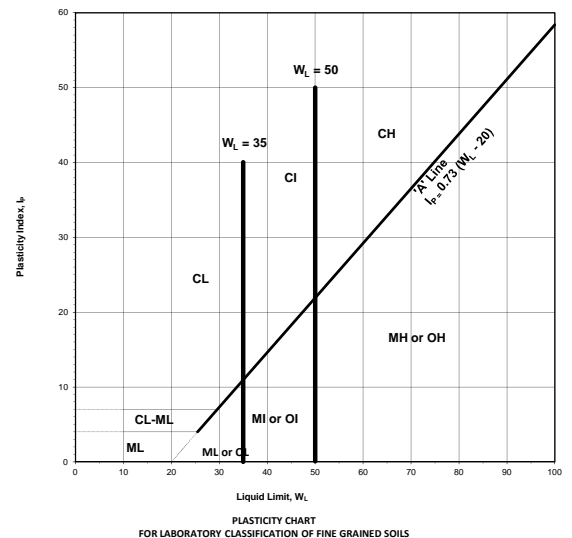
Based on MTC Soil Classification Manual



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 PARTICUL 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 DESCRIPTIVE INFORMATION, & SYMBOL IN PARENTHESIS.	$C_u = \frac{D_{60}}{D_{10}}$ ----- D_{10} $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ ----- $D_{10} \times D_{60}$ GREATER THAN 4; 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
			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				
		PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES				
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	IDENTIFICATION PROCEDURE ON FRACTION SMALLER THAN 425µm					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. FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED AND REMOLDED STATES, MOISTURE & DRAINAGE CONDITION.	$C_u = \frac{D_{60}}{D_{10}}$ ----- D_{10} $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ ----- $D_{10} \times D_{60}$ GREATER THAN 6; BETWEEN 1 AND 3 NOT MEETING ALL GRADATION FOR SW ATTENBERG LIMITS BELOW A- LINE OR I_p LESS THAN 4 ATTENBERG LIMITS ABOVE A- LINE WITH I_p GREATER THAN 7 ATTENBERG LIMITS BELOW A- LINE OR I_p LESS THAN 4 ATTENBERG LIMITS ABOVE A- LINE WITH I_p GREATER THAN 7	ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS	
	SILT AND CLAYS	LIQUID LIMIT LESS THAN 35 AND 50	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)				
			NONE	QUICK	NONE				ML
			MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM				CL
			SLIGHT TO MEDIUM	SLOW	SLIGHT				OL
	LIQUID LIMIT BETWEEN 35 AND 50	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI				INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS
									CI
		SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI				ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY
									MH
	LIQUID LIMIT GREATER THAN 50	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	CH				CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS
									OH
		HIGH ORGANIC SOILS	READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE						Pt

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

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



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



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**MTC SOIL CLASSIFICATION MANUAL
ENGINEERING PROPERTIES OF SOIL**



TYPICAL NAMES OF SOIL GROUPS	GROUP SYMBOLS	PERMEABILITY WHEN COMPACTED	STRENGTH WHEN COMPACTED	COMPRESSIBILITY WHEN COMPACTED	WORKABILITY AS A CONSTRUCTION MATERIAL	SCOUR RESISTANCE	SUSCEPTIBILITY TO SURFICIAL EROSION	SUSCEPTIBILITY TO FROST ACTION	DRAINAGE CHARACTERISTICS
WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GW	PERVIOUS	EXCELLENT	NEGLECTIBLE	EXCELLENT	MEDIUM	NEGLECTIBLE	NEGLECTIBLE	EXCELLENT
POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GP	VERY PERVIOUS	GOOD	NEGLECTIBLE	GOOD	MEDIUM	NEGLECTIBLE	NEGLECTIBLE	EXCELLENT
SILTY GRAVELS, POORLY GRADED GRAVEL- SAND-SILT MIXTURES	GM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	NEGLECTIBLE	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	NEGLECTIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SW	PERVIOUS	EXCELLENT	NEGLECTIBLE	EXCELLENT	LOW TO MEDIUM	SLIGHT	NEGLECTIBLE	EXCELLENT
POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SP	PERVIOUS	GOOD	VERY LOW	FAIR TO GOOD	LOW TO MEDIUM	MODERATE	NEGLECTIBLE 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	NEGLECTIBLE	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 PRACTICALLY
ORGANIC SILTY CLAY OF MEDIUM PLASTICITY	OI	SEMI-PERVIOUS 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 NEGLECTIBLE	NEGLECTIBLE	PRACTICALLY IMPERVIOUS
ORGANIC CLAYS OF HIGH PLASTICITY	OH	IMPERVIOUS	POOR	HIGH	POOR	LOW	MODERATE	NEGLECTIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
PEAT AND OTHER HIGHLY ORGANIC SOILS	Pt	-	-	-	-	LOW	SEVERE	-	FAIR TO GOOD

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

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				
									○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _p W W _L				
						20 40 60 80 100				20 40 60	PPM	GR SA SI CL						
196.6 0.0	about 480 mm of TOPSOIL		1	SS	3								17 _○	5				
196.2 0.5	dark brown Silty Clay FILL trace rootlets		2	SS	18		1	196					16 _○ H	0	- 2 82 16			
195.9 0.7	pocket of sandy silt brown CLAYEY SILT / SILT trace sand very stiff to hard		3	SS	38		2	195					16 _○ H	0	- 1 79 20			
			4	SS	39		3	194					15 _○	0				
			5	SS	44		4	193					14 _○	0				
	grey		6	SS	29		5	192					10 _○	0				
			7	SS	30		6	191					15 _○	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)																		

RECORD OF BOREHOLE No. BH G28A

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	1 OF 1	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

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)							
196.6									20	40	60	80	100	W _p	W	W _L	PPM	GR	SA	SI	CL
0.0	Augered down to 3.0 m to install monitoring well Refer to BH G28 for soil information.																				
193.6	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 (EI 195.6 m)																				
3.0																					

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

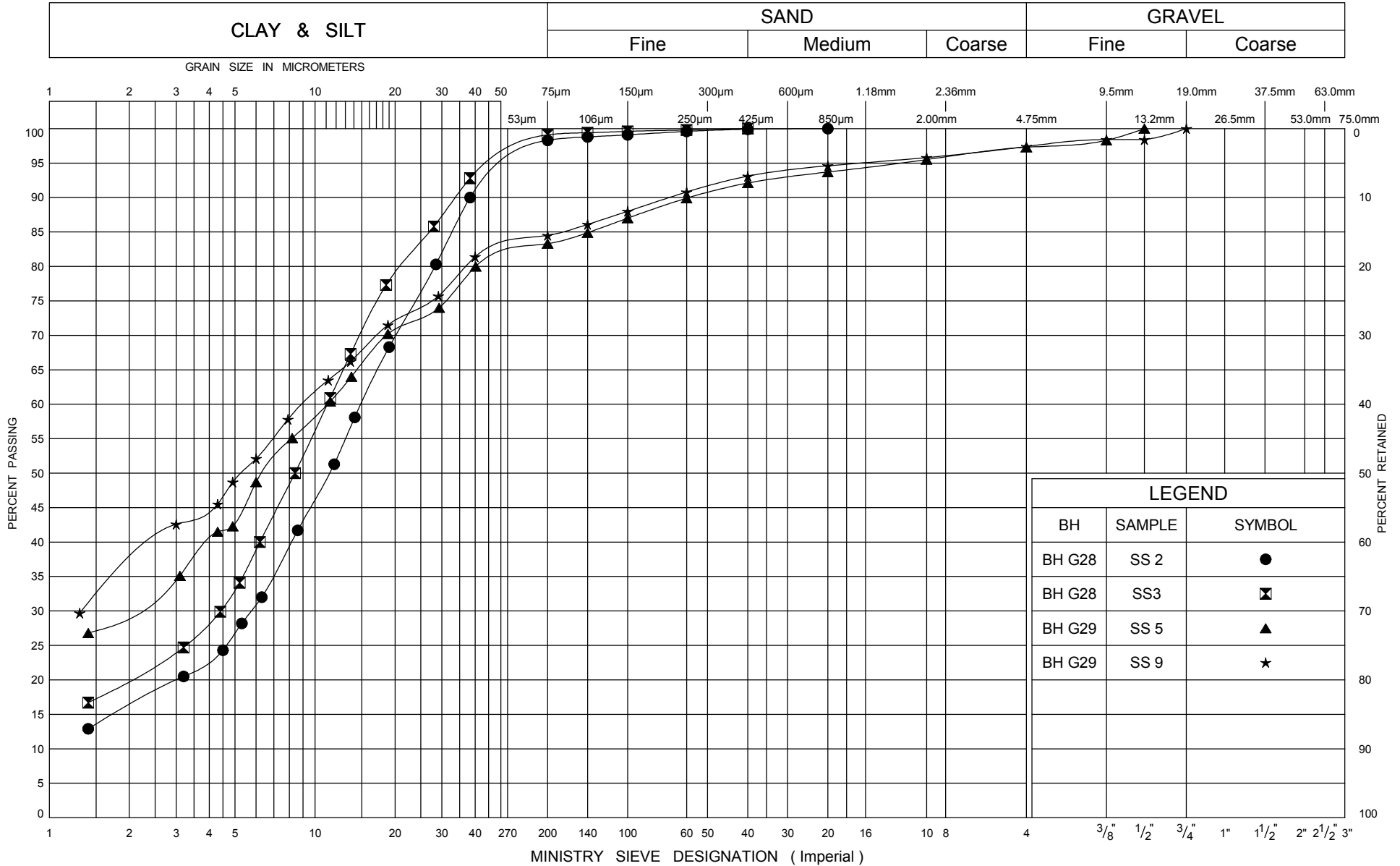
[illegible]

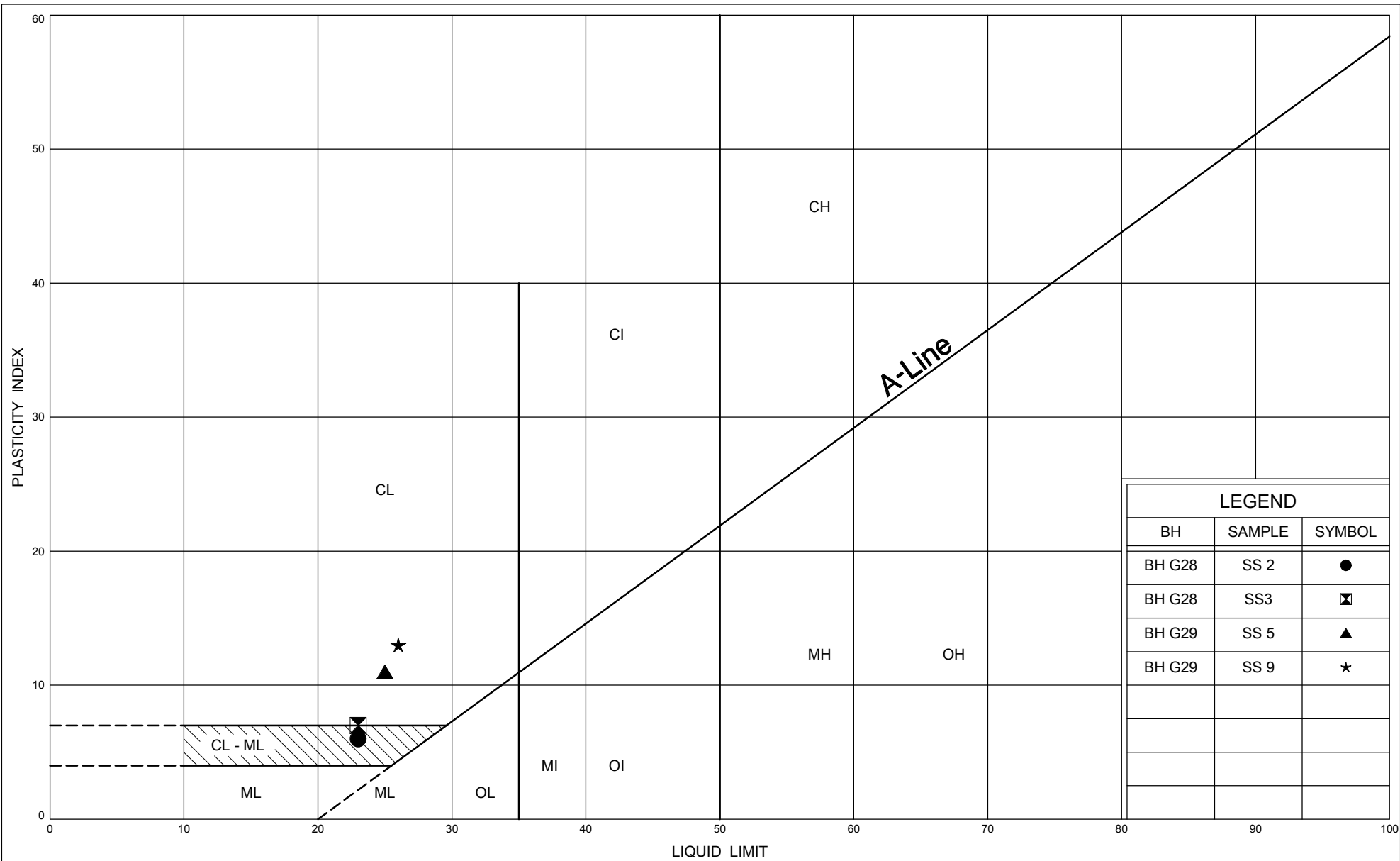
+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

APPENDIX B

LABORATORY TEST RESULTS

UNIFIED SOIL CLASSIFICATION SYSTEM





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

Attention: Shami Mala
AMEC Environment & Infrastructure
Scarborough
104 Crockford Blvd
Scarborough, 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 CaCl ₂ EXTRACT	8	2012/03/22	2012/03/22	CAM SOP-00413	SM 4500H+ B
pH CaCl ₂ 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

-2-

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
Sample ID G31-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 ID MV6498
Sample ID G35-SS1B
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 MV6499
Sample ID G24-SS4
Matrix Soil

Collected 2012/03/16
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 MV6500
Sample ID G30-SS2
Matrix Soil

Collected 2012/03/16
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 MV6501
Sample ID G37-SS2
Matrix Soil

Collected 2012/03/16
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		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
Sample ID G38-SS2
Matrix Soil

Collected 2012/03/16
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		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 Job #: B238403
Report Date: 2012/03/23

AMEC Environment & Infrastructure
Client Project #: TP110076.05

Package 1	10.7°C
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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

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
			% 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 (SO ₄)	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]

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).

A handwritten signature in black ink, reading "Cristina Carriere". The signature is written in a cursive, flowing style.

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.

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