



FOUNDATION INVESTIGATION AND DESIGN REPORT  
CULVERT REPLACEMENT  
WALLIS MUNICIPAL DRAIN  
HIGHWAY 23

AGREEMENT # 3010-E-0033  
MTO WEST REGION  
SITE # 19-613-C

**MTO GEOCRES No. 40P6-23**

Submitted to:

**Ministry of Transportation**  
West Region  
Geotechnical Section  
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## 1.0 INTRODUCTION

AMEC Earth & Environmental, a division of AMEC Americas Limited ("AMEC"), Consulting Geotechnical, Construction Quality Control and Environmental Engineers, was retained by the Ministry of Transportation (West Region) to conduct a foundation investigation for the replacement of a structural culvert. The existing culvert is located where Wallis Municipal Drain crosses Hwy 23 (Mitchell Line) in the Township of Blanshard, Perth County, Ontario. The overall site location is shown on Drawing 1.

Available subsurface information from previous projects was reviewed prior to carrying out the fieldwork for this project. The following information was reviewed at the MTO Foundation Library (GEOCRES), in Downsview, and used in preparing this report, wherever applicable:

- ***"Foundation Investigation, Fish Creek (North) Bridge Replacement, Highway 23, Site 25-224, GWP 313-94-00, Agreement Number 3005-A-000078"***, Prepared by Golder Associates Ltd, Dated September 2001. (GEOCRES NO. 40P6-18).
- ***"Foundation Investigation, Fish Creek (Centre) Bridge Replacement, Highway 23, Site 25-225, GWP 313-94-00, Agreement Number 3005-A-000078"***, Prepared by Golder Associates Ltd, Dated September 2001. (GEOCRES NO. 40P6-19).
- ***"Foundation Investigation, Fish Creek (South) Bridge Replacement, Highway 23, Site 25-226, GWP 313-94-00, Agreement Number 3005-A-000078"***, Prepared by Golder Associates Ltd, Dated September 2001. (GEOCRES NO. 40P6-20).

Based on a review of these documents, the soils generally consist of variable thicknesses of topsoil and fill materials underlain by silt, silty clay and, sand and gravel. These soils were underlain by sandy silt till and/or clayey silt till.

This investigation was carried out by means of a limited number of boreholes, in-situ tests and laboratory tests on selected samples. The factual results of the soil conditions encountered in the boreholes and laboratory tests are presented in this report, together with design considerations.

## 2.0 SITE DESCRIPTION

Culvert 19-613-C is located north of intersection between Hwy 23 (Mitchell Line) and Whalen Line at the border of two townships, TWP of Biddulph (Station 20+396.1) and TWP of Blanshard (Station 10+000). Wallis Municipal Drain runs parallel to Whalen Line and crosses Hwy 23 via culvert 19-613-C (Drawing 2).

Table 1 lists the designation, stationing, dimensions and the type of culvert.

**Table 1 – Details of Culvert 19-613-C**

NAME	SITE #	STATION	DIMENSIONS WxHxL (m)	TYPE
Wallis Municipal Drain	19-613-C	±20+396	3.05 x 1.52 x 44.3	Concrete Open

Hwy 23 at the culvert location is a two lane paved road. North of the culvert, Hwy 23 runs on top of an embankment built up above the surrounding grade with an approximate fill height above the culvert of 1.1 m. The top of the culvert lies at elevation 292.670 m and 292.725 m, at the inlet and outlet, respectively.

The road embankment at the culvert location is approximately 1.4 m to 2.1 m above the surrounding grades. The embankment slopes were covered with low vegetation, granular aggregates and tall grasses at the time of the fieldwork. Based on field measurements, the embankment slopes adjacent to the culvert have a maximum slope of 1H:1V from the edge of the shoulder to the toe of the embankment. The culvert inlet and outlet have sand bags and/or stone rip-rap walls to prevent soil erosion.

At the time of the fieldwork, the water flow in the drain was low. The flow runs from east to west. Photographs taken at an earlier date (April 19, 2011) indicate significantly more water flowing through the culvert.

Typical site photographs of the culvert locations can be found in Appendix C.

### **3.0 GEOLOGY**

Ontario Road Network, National Topographic Database (Canvec) basemap shapefiles, Tile 30M12, indicates that the native soils at the culvert locations consist of Silty Clay Rannoch Till. Map 2254, Paleozoic Geology of Southern Ontario indicates the region is underlain by limestone of the Dundee formation. The rock surface is typically found at depths of about 12 to 27 m below the ground surface.

### **4.0 INVESTIGATION PROCEDURES**

#### **4.1 Field Investigation**

In accordance with the Terms of Reference for this investigation, three (3) borehole locations were staked and cleared for underground utility services. Borehole 1 was drilled to a depth of 11.1 m below ground surface at mid shoulder of Hwy 23, north of the culvert. Borehole 2 and 3 were drilled close to culvert inlet and outlet, respectively. Borehole 2 and 3 were drilled to a depth of 9.6 m below ground surface.

Borehole locations were adjusted based on the proximity of underground and overhead utilities, as well as limited drill rig access due to steep slopes. The borehole locations are presented in Drawing 2.

The fieldwork was performed on May 12<sup>th</sup>, 2011 under the full-time supervision of experienced geotechnical personnel from AMEC. Prior to drilling, utility locates were carried out. Drilling operations were performed using a track-mounted drilling rig, outfitted with hollow stem augers.

Ground surface elevations at the borehole locations were surveyed by AMEC personnel. The elevations at the project site were related to the geodetic benchmark (BM) listed on Engineering Transportation References (ETR's) for Site # 19-613-C. The benchmark is located on top of the culvert inlet with geodetic elevation of 292.670 m.

Soil samples were taken at 0.75m intervals for the top 3 m and subsequently at 1.5 m intervals during the performance of Standard Penetration Test (SPT) in accordance with ASTM D1586. This consisted of freely dropping a 63.5 kg hammer for a vertical distance of 0.76 m to drive a 51 mm 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 300 mm was recorded as SPT 'N' value of the soil, which indicated the consistency of cohesive soils or the compactness of non-cohesive soils.

Combustible soil headspace vapour readings were measured for each soil sample recovered from the boreholes, using a portable vapour meter (GasTector<sup>TM</sup> 1238ME).

The groundwater levels were monitored during, and upon completion of the drilling operations. Upon completion of drilling, Borehole 1 and 3 were backfilled with bentonite in accordance with the general requirements of Ont. Regulation 903. In accordance with the Terms of Reference, a standpipe piezometer was installed in Borehole 2 to monitor groundwater level. The standpipe was decommissioned at the end of the day.

The results of the in-situ and laboratory tests are presented in the corresponding Records 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 the Ministry.

## **4.2 Laboratory Tests**

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

- In-situ water content determination (29);
- Grain size distribution analysis (3);
- Atterberg Limits (2);
- Soil Corrosivity (1).

The results of the laboratory tests are included in the Record of Boreholes in Appendix A. The grain size distribution curves, Plasticity Chart and results of soil corrosivity testing are shown in Appendix B.

### **4.3 Miscellaneous**

The boreholes were drilled by Determination Drilling and Soil Investigations, who are licensed well drillers. The drilling operations were supervised by Shailendrasinh Jadeja, P.Eng. of AMEC.

Upon completion of drilling, the soil samples were transported to AMEC's Laboratory in Hamilton for further examination and laboratory testing. Testing to determine the corrosivity of the soils was subcontracted to Maxxam Analytics, an accredited CAEL laboratory. The laboratory test results are included in Appendix B.

## **5.0 SUB-SURFACE CONDITIONS**

The general soil profile through the road embankment consisted of granular fill over silty clay fill and buried topsoil. The native soil encountered below fill was mainly silty clay till and/or clayey silt till deposits with a discrete seam / layer of sand or sand & gravel.

The stratigraphic units and groundwater conditions at the borehole locations are discussed in the following sections. Detailed information is provided in the Record of Boreholes (Appendix A), and the interpolated soil stratigraphical sections are shown on Drawing 2. However, soil and groundwater conditions may vary between the borehole locations.

### **5.1 Stratigraphy**

#### Topsoil

Topsoil was encountered at all three (3) borehole locations; at surface in Borehole 2 and 3, and buried in Borehole 1. The thickness of surface topsoil varied from 150 mm to 200 mm. Buried topsoil was encountered at approximate elevation of 291.3 m (at a depth of 2.1m) and was approximately 500 mm thick.

#### Fill

Through the shoulder embankment, a gravelly sand fill of 0.5 m thickness was encountered in Borehole 1 overlying silty sand and gravel fill mixed with traces of silty clay. The silty sand and gravel fill extended to a depth of 1.2 m. Beneath the silty sand and gravel fill, a 0.9 m thick deposit of silty clay fill (trace of sand and gravel) was encountered overlying a 0.5 m thick deposit of buried topsoil. The fill and buried topsoil at Borehole 1 extended to a geodetic elevation of 290.8 m. The gravelly sand fill was compact, with SPT 'N' value of 14 blows per 300 mm. The silty sand and gravel fill was loose with 'N' value of 8 blows for 300 mm. The silty

clay fill had a firm consistency with a single SPT 'N' value of 4 blows per 300 mm. Moisture content within the gravelly sand and silty sand and gravel fill was recorded at 15% and 9%, respectively. A sample from the cohesive fill indicated moisture content of 21 %.

At Boreholes 2 and 3, silty clay fill with a trace of sand and gravel was encountered, below the topsoil. The silty clay fill extended to 1.4 m (Elev. 291.0 m) and 2.1 m (Elev. 289.6 m) below grade in Boreholes 2 and 3, respectively. The fill was stiff at Borehole 2 with 'N' values of 8 and 10 blows per 300 mm. The consistency of the silty clay fill at Borehole 3 changed downward from firm to soft, with 'N' values of 7, 6 and 3 blows per 300 mm. The moisture contents varied from 20 % to 28 %.

The results of laboratory testing carried out on a sample are summarized in Table 2.

**Table 2 – Summary of Index Testing – Gravelly Sand Fill**

	%			Atterberg Limits	Soil Classification	Moisture Content, %
	Gravel	Sand	Fines			
BH1-SS1	33.1	56	10.9	-	Gravelly sand, trace silt	15

#### Clayey Silt Till / Silty Clay Till

Native clayey silt till or silty clay till deposits was encountered at geodetic elevations 290.8 m, 291.0 m and 289.6 m in Boreholes 1, 2 and 3, respectively. The native cohesive deposit extended to at least the maximum depths investigated. The deposit also contained trace to some amount of sand and gravel. The color of deposit varied from brown to grey.

Standard Penetration testing indicated the clayey silt till / silty clay till was firm to hard, with 'N' values ranging from 7 to 35 blows per 300 mm.

The results of laboratory testing carried out on selected samples are summarized in Table 3.

**Table 3 – Summary of Index Testing – Native (Till)**

	%				Atterberg Limits	Soil Classification	Moisture Content, %
	Gravel	Sand	Silt	Clay			
BH1-SS6	1	10.5	49.5	39.0	LL=24, PL=14, PI=10	Clayey silt, trace sand, trace gravel	14
BH3-SS6	11.8	6.8	45.4	36.0	LL=25, PL=15, PI=10	Clayey silt, some gravel, trace sand	14

One sample was submitted for analytical testing to determine the soil aggressiveness towards corrosion. The laboratory test certificates can be found in Appendix B. The test results are summarized below in Table 4.

**Table 4 – Summary of Analytical Testing**

Soil Characteristic	Units	BH2-SS6
Resistivity	ohm-cm	4100
Soluble (20:1) Chloride (Cl)	ug/g	<20
Conductivity	umho/cm	244
Available (CaCl2) pH	pH	7.76
Soluble (20:1) Sulphate (SO4)	ug/g	70

### Sand/Sand & Gravel

A 0.6 m thick layer of wet, coarse sand was found embedded between silty clay till deposits at elevation 286.1 m in Borehole 1. A seam of sand was encountered in Borehole 3 at elevation 283.8 m. In Borehole 2, a 1.3 m thick wet sand and gravel layer was observed within the silty clay till deposits at elevation 285.2 m. The sand layer was compact (N=18) and the sand and gravel layer was very dense to compact (N=57 to 24).

## **5.2 Groundwater**

Upon completion of drilling, groundwater depths were recorded at 4.6 m, 4.2 m and 4.0 m below ground surface in Boreholes 1, 2 and 3, respectively.

A standpipe piezometer was installed in Borehole 2 to a depth of 8.2 m, and the water level was measured at the end of the day following the installation. The groundwater level was recorded at 3.9 m below ground surface. The piezometer was decommissioned at the end of the day as per Ministry of Environmental Regulation 903.

The noted groundwater levels are not considered to represent long-term stabilized groundwater conditions and the groundwater levels are expected to fluctuate due to climatic and seasonal fluctuations.

## **5.3 Organic Vapour Measurements**

Combustible soil headspace vapour readings were measured using a portable vapour meter GasTechtor™ 1238E. Combustible soil vapour headspace measurements for all of the soil samples recovered from Boreholes 1, 2 and 3 ranged from non-detectable to 30 parts per million (ppm).

## **6.0 DISCUSSION & RECOMMENDATIONS**

Culvert 19-613-C is an open concrete culvert with dimensions for width, height and length of 3.05 x 1.52 x 44.3 m. Hwy 23 at the culvert location is a two lane paved road. North of the culvert, Hwy 23 runs on top of an embankment built up above the surrounding grade with an approximate fill height above the culvert of 1.1 m. The areas to the southeast of the culvert appear to be at grade with the road. The top of the culvert lies at elevation 292.67 m and



292.73 m, at the inlet and outlet, respectively. The road embankment at the culvert location is approximately 1.4 m to 2.1 m above the surrounding grades. MTO plans to replace the deteriorated culvert at this site.

## 6.1 Comparison of Alternative Foundation Types

Based on the conditions encountered in the boreholes drilled for this investigation, the preferred foundation type is a shallow system. A comparison of the possible foundation options are shown in Table 5.

**Table 5 - Comparison of Foundation Types for Culvert Replacement**

Foundation	Description	Advantages	Disadvantages	Risks / Consequences	Cost Comparison
Shallow Foundation (Strip Footings)	Strip foundations supported on clayey silt/silty clay till subgrade (e.g. rigid frame open bottom).	Use of standard excavation and construction equipment.  No specialist contractor is required.  Will require short construction period and minimal disruption to traffic if precast culvert panels are used.	Will require isolated areas, over-excavation of fill below footings and placement of structural fill up to proposed founding elevation. Non-cohesive (granular) structural/engineered fill is preferred over cohesive structural/engineered fill.  Will require formwork and reinforcing steel installation for footing construction.	Improper installation could result in poor hydraulic flow (low spots) and ponding within the culvert.  Unless fills are removed from beneath the complete limits of the structure, differential settlement could result.	Medium
Shallow Foundation (i.e., mat foundation on lean concrete on grade)	Rigid Frame box culvert on lean concrete.	Use of standard excavation and construction equipment.  No specialist contractor is required.  Will require short construction period and minimal disruption to traffic if precast boxes are used.  Requires low design bearing capacity.	Will require over-excavation of fill from beneath the complete limits of the culvert, and placement of lean concrete or structural fill to up to proposed founding elevation. Non-cohesive (granular) structural/engineered fill is preferred over cohesive structural/engineered fill.  Erosion at inlet or outlet could affect structure.	Improper installation could result in poor hydraulic flow (low spots) and ponding within the culvert.  Unless fills are removed from beneath the complete limits of the structure, differential settlement could result.	Low to medium

Foundation	Description	Advantages	Disadvantages	Risks / Consequences	Cost Comparison
Deep Foundation	Driven or drilled piles or similar bearing on very stiff silty clay till, supporting strip foundations (e.g. precast open bottom box or arch culvert).	<p>No over-excavation of fill below proposed founding elevation.</p> <p>Little to no settlement.</p> <p>Erosion at inlet or outlet would have little effect on the structure if piles are monolithically tied to the culvert structure.</p>	<p>Requires specialist contractor (Contractor specializing in pile installation).</p> <p>Requires staging area for piling equipment - larger area of disturbance.</p> <p>Will require longest construction period and disruption to traffic.</p> <p>Will require formwork and reinforcing steel placement for footing construction</p>	<p>Will result in a 'hard' or unyielding spot in the road, possibly resulting in significant differential settlement.</p> <p>Risk of encountering cobbles/boulders, which may complicate pile installation.</p>	High

Based on this comparison of the foundation alternatives, it is recommended that a shallow foundation system be constructed, consisting of either an open frame culvert with strip footings or a a box culvert with mat foundation.

## 6.2 Foundation Design

The invert of the culvert lies approximately at elevation 291.21 m, and the new shallow foundations are anticipated to extend to at least elevation 290.0 m. Very stiff to hard silty clay till/clayey silt till is anticipated at the founding elevation at Borehole 1 and 2 locations. However, Borehole 3 indicates soft fill and/or firm clayey silt till at founding level and some sub-excavation will be required along the footing alignment (open culvert). Fills and incompetent native soils will need to be removed from the complete limits of foundation footprints to expose the native, very stiff clayey silt till/silty clay till. The grade can then be restored by placing engineered fill and/or lean concrete up to the proposed founding elevation. Non-cohesive (granular) structural/engineered fill is preferred over cohesive structural/engineered fill. Specifications for engineered fill are enclosed in Appendix D. The following design parameters may be used:

**Table 6 – Bearing Pressures (ULS / SLS)**

Location	Elevation of suitable subgrade for shallow foundations (m)	Consistency of Clayey Silt Till/Silty Clay Till (foundation subgrade)	Factored Ultimate Bearing Resistance at ULS	Serviceability Bearing Reaction at SLS
Borehole 1 & 2	290.0	Very Stiff to hard	225 kPa	150 kPa
Borehole 3	288.6	Stiff	150 kPa	100 kPa
	287.1	Very stiff	225 kPa	150 kPa

The recommended SLS bearing reaction value is based on an anticipated total settlement less than 25 mm. Detailed foundation analysis will be necessary if accurate values of settlement are required.

Should higher bearing value be required for the foundation design, the culvert may be supported by deep foundations bearing on the very stiff silty clay till. If discussion on deep foundation alternatives is required, AMEC should be contacted.

### **6.3 Earthquake Consideration**

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

### **6.4 Traffic Protection and Temporary Detours**

For the replacement of the culvert at Site # 19-613-C, the following scenarios can be considered for construction:

- Scenario 1 - reduction of traffic to one-lane using staged open-cut construction, with construction of widened limits on the east/west side of Hwy 23, as required to provide a temporary detour and maintain north-south traffic. Given the proximity of the culvert to Whalen Line, open cut excavation will also require widened limits on the south side of Whalen Line to maintain east-west traffic; or
- Scenario 2 - reduce traffic to one-lane using traffic protection (sheet piling) with no temporary detour required. Again, some method of shoring would be required to maintain east-west traffic on Whalen Line. Temporary protection systems should be provided according to OPSS 539;
- Scenario 3 - close the road entirely to traffic and provide an alternate route.

The road embankment at the culvert location is approximately 1.4 to 2.1 m above the surrounding grade, with approximately 1.1 m thick fill between the top of the culvert and the road surface.

### **6.5 Dewatering and Drain Diversion during Construction**

No plans are available for the new culvert, although excavations to expose suitable subgrade soils for founding upon are expected to extend to between elevations 290.0 and 287.1 m. Groundwater levels ranging in elevation from 288.8 to 287.8 m were recorded in the boreholes. Due to the short period of time over which the groundwater level was observed, it is unlikely that the measured groundwater level reflects the long term level, which could be higher.

It is expected that groundwater inflows can be controlled using properly filtered sumps and pumps. However, there could also be significant groundwater contained in the gravelly sand fill

and sandy fill encountered in the boreholes. An allowance should be made for a more aggressive dewatering system, should this occur.

At the time the fieldwork (May 12, 2011) was carried out, some amount of water flow was observed in the drain. Photographs taken approximately 3 weeks prior to field work in early spring showed even more flow through the culvert. Provision must be made to divert water flows from one side of the road to the other during construction.

For phased construction, the drain flow could be collected from the upstream side and pumped to the downstream side. The hoses could be run through the portion of the culvert still in place (upstream half), then routed around to the north or south limit of the construction excavation for the downstream portion (or reversed if the upstream portion is replaced first). If the road were closed entirely to traffic, the drain flows could be pumped/diverted around the excavation.

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 to reduce the groundwater inflow into the excavation.

Dewatering plans must also consider any flows from the road side ditches that enter into the drain at the culvert locations.

## **6.6 Excavation and Backfill**

Reference should be made to OPSS 902 for earth excavation. Backfill, backfill transition and cover for the concrete culvert should conform to OPSD 803.010.

Any organic soils and other deleterious materials, if encountered, must be excavated from beneath the foundation limits. It is recommended that the foundation subgrade be inspected by a geotechnical engineer prior to placing concrete. To prevent creating a pathway for water below a box culvert and/or foundation subgrade, it is recommended that lean concrete be placed as bedding below the culvert.

Foundation backfill should consist of lean concrete, which will prevent water from entering and flowing through the backfill below the culvert. If fill other than lean concrete is used, or if the existing fill (Borehole 3) remains in place below the culvert, a permanent cutoff wall should be constructed at the inlet and the outlet.

A frost penetration depth of 1.4 m should be used for design at this site.

## **6.7 Construction Comments / Concerns**

Any excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects.

All fills, as well as firm to stiff native undisturbed soils, are considered to be Type 3 soils. Very stiff clayey silt/silty clay till is considered as Type 2 soil.

The work should be protected from freezing. No structures or bedding material should be placed on frozen native soils or fill.

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

## **6.8 Soil Corrosion Potential**

One soil sample was submitted for testing to determine the corrosivity of the soil. The laboratory test certificates can be found in Appendix B, and are summarized in Table 4 of Section 5.1.

According to the American Waterworks Association, the degree of corrosion associated with a chloride concentration in the order of 10-25 µg/g is considered "slightly corrosive" and a chloride concentration in the order of 25-100 µg/g is considered "moderately corrosive". The chloride concentrations within the soil was <20 µg/g.

CSA A23.1-04 describes the degree of sulphate exposure for concrete as being moderate for soils having sulphate values of between 0.10 and 0.20%, severe for values between 0.20 and 2.0%, and very severe for values over 2.0%. Test results showed soluble sulphate value less than 0.10%. The use of special sulphate resistant cements is not considered necessary based on these results.

The test results for resistivity, pH, redox potential, sulphides and moisture are used to evaluate the soil corrosivity to ductile iron piping as per ANSI/AWWA C105/A21.5-05. For each test carried out on the soils (resistivity, pH, redox potential, sulphides and moisture), the results are categorized according to their contribution to corrosivity. If the sum of the assigned points is equal to 10 or more, the soil is corrosive to ductile iron pipe, and protection against exterior corrosion should be provided.

Table 7 summarizes the point values assigned to the test results for resistivity, pH and the assigned moisture category. No testing was carried out for sulphides and redox potential. However, the possible range for sulphides test results range from 0 to 3.5 and for redox potential test results ranges from 0 to 5 points. This system of evaluation is limited to soil corrosion and does not include consideration of stray direct current.

**Table 7 – Summary of Soils Corrosion Testing (ANSI/AWWA C105/A21.5-05)**

	<b>Resistivity, ohm-cm</b>	<b>pH</b>	<b>Sulphides</b>	<b>Redox Potential</b>	<b>Moisture</b>	<b>Total Point Value</b>
<b>BH2-SS6</b>	4100	7.76	-	-	Poor	<b>Min = 2 Max = 10.5</b>
Points assigned to test result based on ANSI/AWWA C105/A21.5-05	0	0	Min = 0 Max = 3.5	Min = 0 Max = 5	2	

Based on these results, provision of protection against exterior corrosion due to soil may not be needed. The corrosivity potential should be assessed by an expert if necessary.

## 6.9 Construction Inspection

It is recommended that a quality control program of inspection and testing be carried out during the construction phase of the project to confirm that the conditions encountered are consistent with design assumptions; and to confirm that the various project specifications and material requirements and handling are followed.

## 7.0 CLOSURE

The Limitations of Report, as quoted on the following page, is an integral part of this report.

The sub-soil information contained in this report should be used solely for the purpose of foundation assessment of this site.

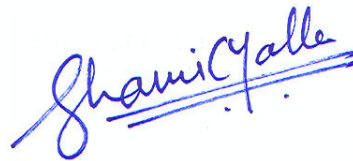
The information presented in this report is complete within AMEC's terms of reference. If there are any further questions concerning this report, please do not hesitate to contact the undersigned.

Sincerely,

AMEC Earth & Environmental,  
A division of AMEC Americas Limited



Shailendrasinh Jadeja, M.A.Sc., P.Eng.  
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Designated Principal Contact

## **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. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the testholes.

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

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. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.



The benchmark and elevations mentioned in this report were obtained strictly for use by this office in the geotechnical design of the project. They should not be used by any other party for any other purpose.

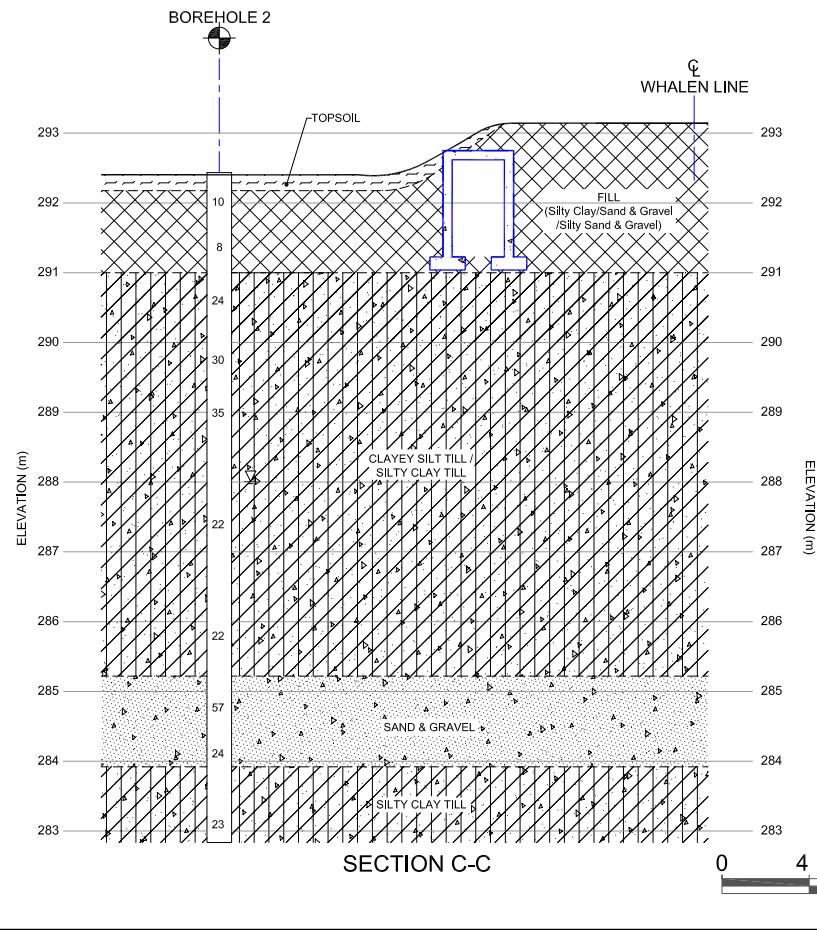
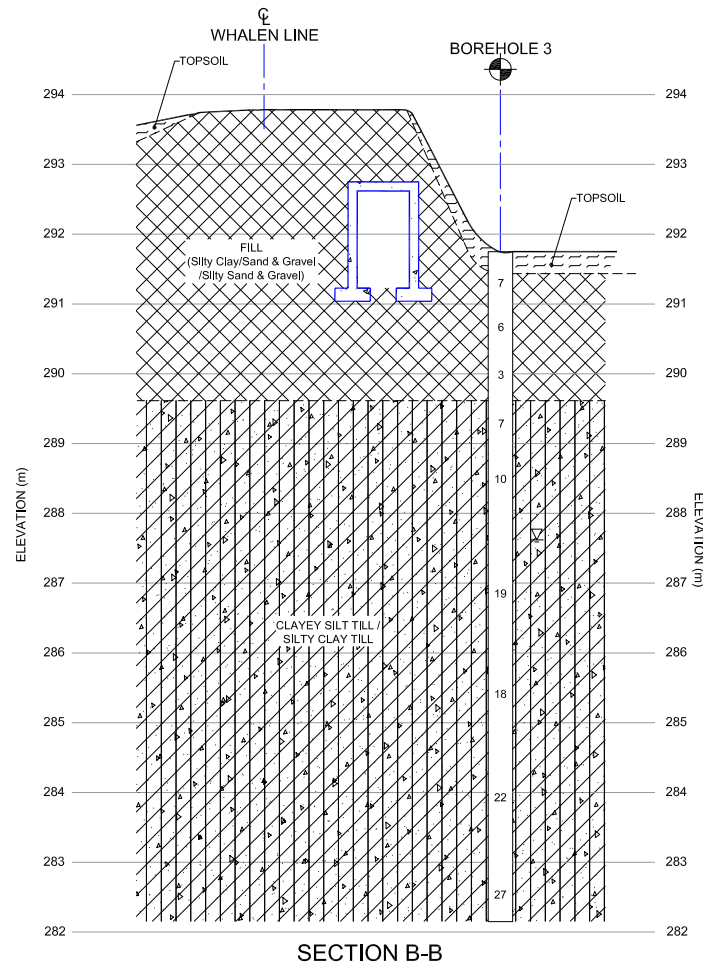
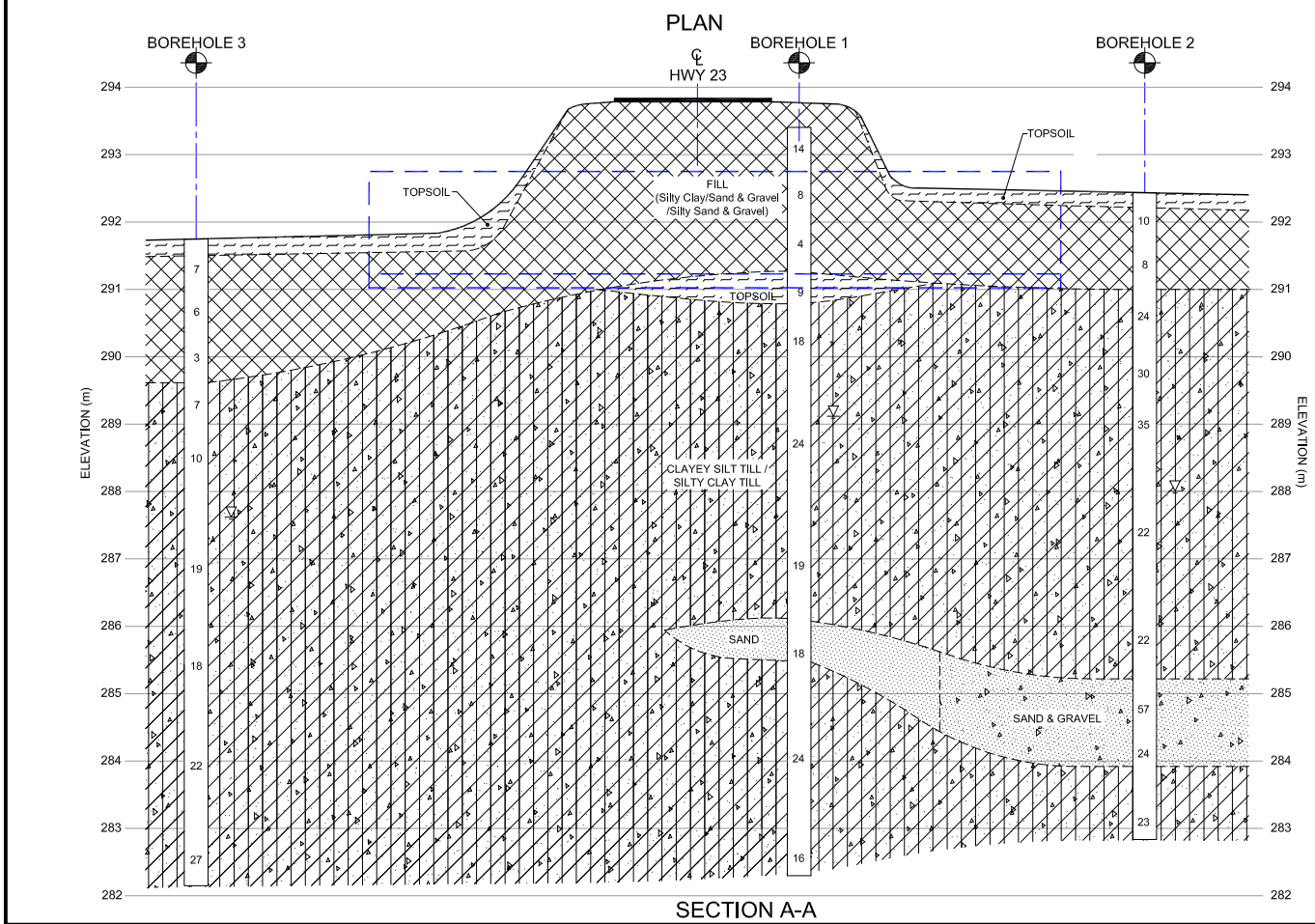
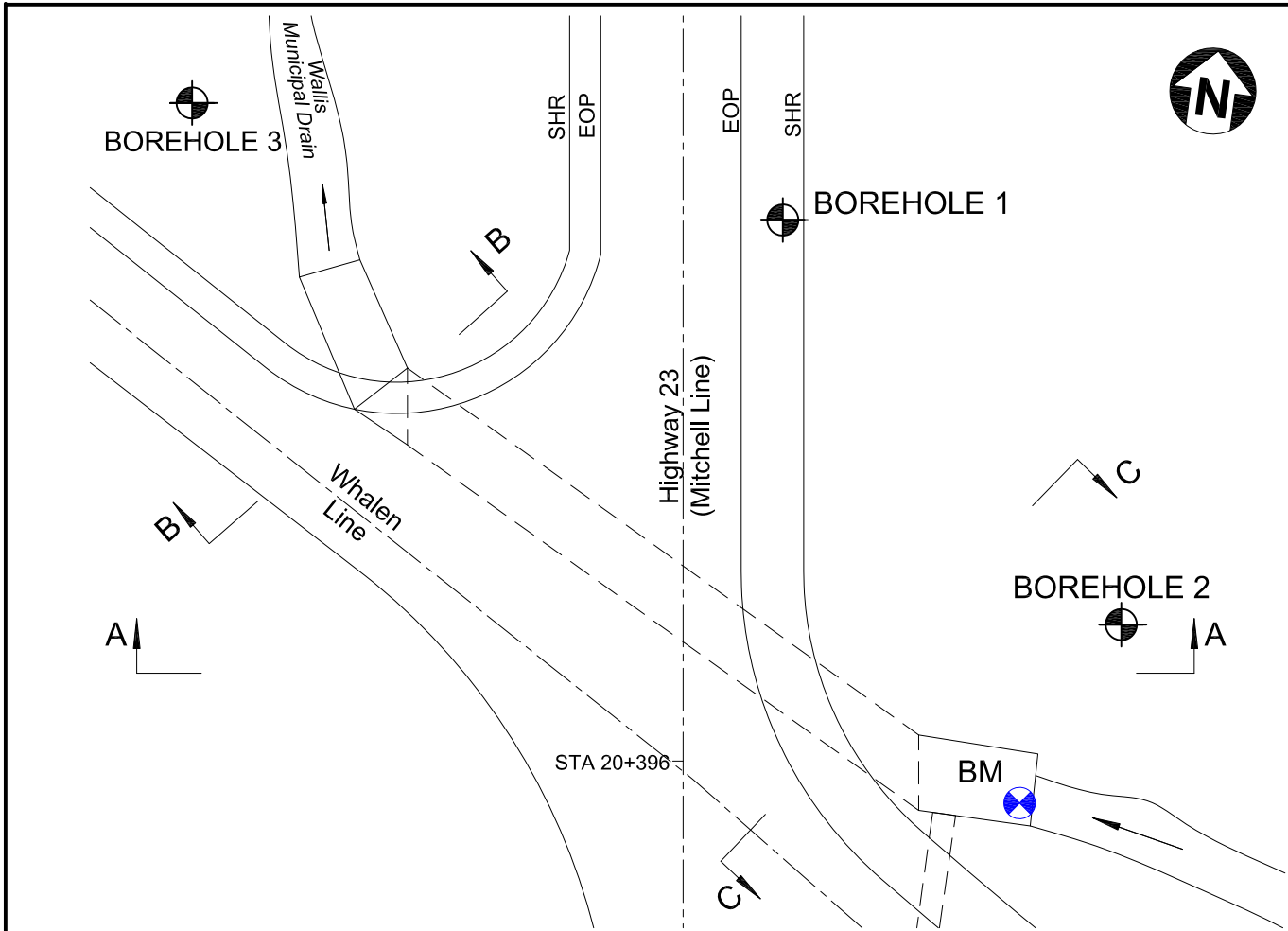




Approximate Scale



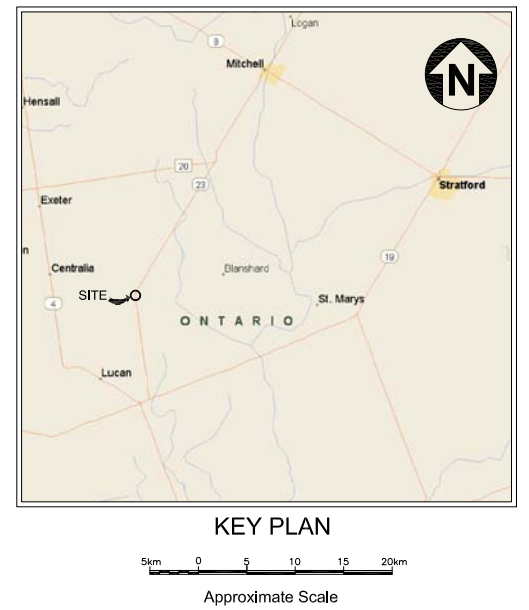
<b>AMEC Earth &amp; Environmental, a Division of AMEC Americas Limited</b>			CLIENT LOGO 	CLIENT <b>MINISTRY OF TRANSPORTATION ONTARIO</b>	
TITLE <b>SITE MAP</b>			DWN BY: KW	DATUM: -	DATE: AUGUST 2011
PROJECT <b>CULVERT REPLACEMENT HIGHWAY 23 AT WHALEN LINE - WALLIS MUNICIPAL DRAIN</b> <small>AGREEMENT NUMBER 3010-E-0033, Site 19-613C - STATION 20+396</small>			CHK'D BY: PB	REV. NO.: A	PROJECT NO: TB112041
			PROJECTION: -	SCALE: AS SHOWN	DRAWING No. <b>1</b>



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



AGREEMENT No. <b>3010-E-0033</b>	
G.W.P. No. -	
CULVERT REPLACEMENT HIGHWAY 23 AT WHALEN LINE WALLIS MUNICIPAL DRAIN <b>SITE 19-613C - STA 20+396</b>	<b>SHEET 1 OF 1</b>
 AMEC Earth & Environmental, a Division of AMEC Americas Limited	



LEGEND		
	BOREHOLE LOCATION	
	GROUND WATER LEVEL AT TIME OF INVESTIGATION	
	GEODETIC BENCHMARK	
EOP	EDGE OF PAVEMENT	
SHR	SHOULDER ROUND	
BOREHOLE	STATION / OFFSET	ELEVATION (m)
1	STA. 10+017 / 7.23m RT	293.40
2	STA. 10+006 / 21m RT	292.38
3	STA. 10+023 / 23.6m LT	291.73

- 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. Foundation elevation not confirmed.
  3. This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**SOIL STRATIGRAPHY**

	Silty Clay / Sand & Gravel/ Silty Sand & Gravel FILL		Sand
	Topsoil		Sand & Gravel
	Clayey Silt Till / Silty Clay Till		



REVISIONS				
DESIGN PB	CHK PB	CODE CHBDC-06	CL 625-ONT	DATE AUG. 2011
DRAWN KW	CHK HS	SITE 19-613C	DWG 2	

**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.

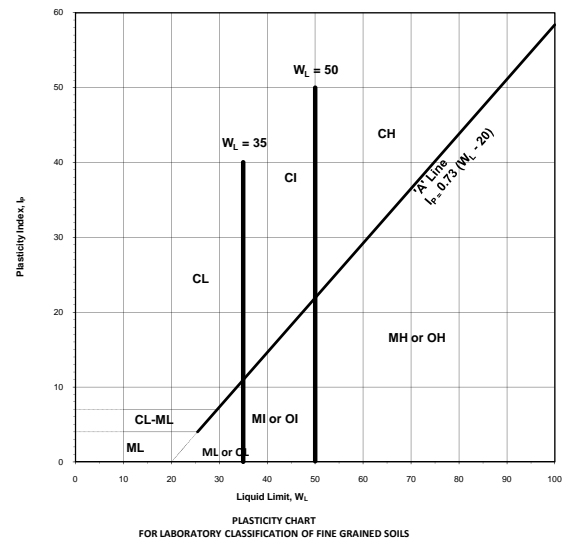
**MTC SOIL CLASSIFICATION**  
Based on MTC Soil Classification Manual



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 PARTICLE SIZES	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, & HARDNESS OF THE COARSE GRAINS, LOCAL OR GEOLOGICAL NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION, & SYMBOL IN PARENTHESIS.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4;	
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3	
	SANDS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	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		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW	
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES			
		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	ATTENBERG LIMITS BELOW A-LINE OR $I_p$ LESS THAN 4	
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES			
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILT AND CLAYS	LIQUID LIMIT LESS THAN 35 AND 50	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE AND CHARACTER OF PLASTICITY, AMOUNT AND MAXIMUM SIZE OF COARSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & SYMBOL IN PARENTHESIS.	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	
			NONE	QUICK	NONE			
			MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM			
			SLIGHT TO MEDIUM	SLOW	SLIGHT			
		LIQUID LIMIT BETWEEN 35 AND 50	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT		NOT MEETING ALL GRADATION FOR SW	
			HIGH	NONE	MEDIUM TO HIGH			
			SLIGHT TO MEDIUM	VERY SLOW	SLIGHT			
			SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM		ATTENBERG LIMITS BELOW A- LINE OR $I_p$ LESS THAN 4	
			HIGH TO VERY HIGH	NONE	HIGH			
			MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM			
							ATTENBERG LIMITS ABOVE A- LINE WITH $I_p$ GREATER THAN 7	
	LIQUID LIMIT GREATER THAN 50	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

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
	FINE	26.5 mm	4.75 mm		
SAND	COARSE	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



AMEC Earth & Environmental,  
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[www.amec.com](http://www.amec.com)

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

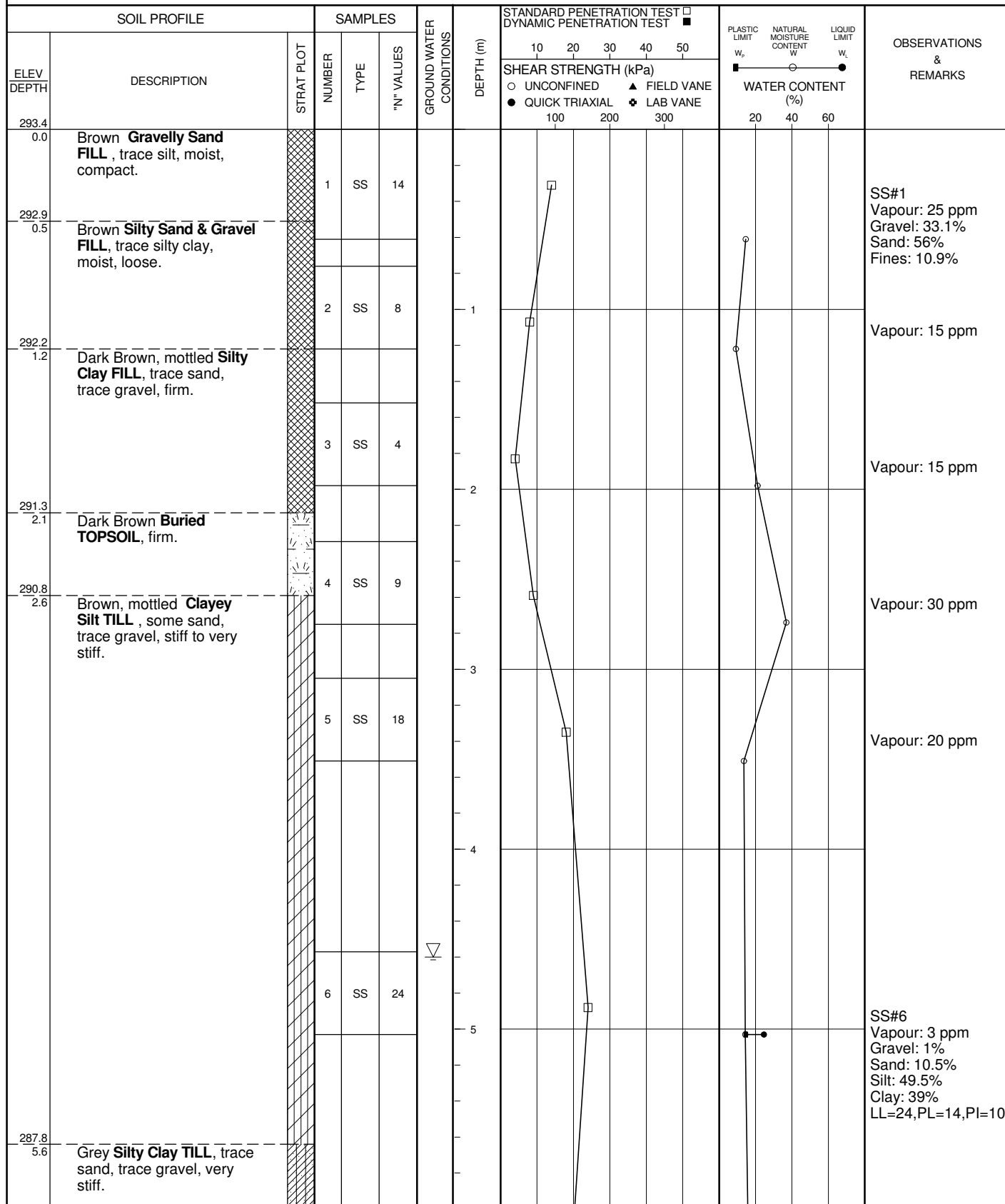


TYPICAL NAMES OF SOIL GROUPS	GROUP SYMBOLS	PERMEABILITY WHEN COMPACTED	STRENGTH WHEN COMPACTED	COMPRESSIBILITY WHEN COMPACTED	WORKABILITY AS A CONSTRUCTION MATERIAL	SCOUR RESISTANCE	SUSCEPTIBILITY TO SURFICIAL EROSION	SUSCEPTIBILITY TO FROST ACTION	DRAINAGE CHARACTERISTICS
WELL-GRADED GRAVELS, GRAVEL-SAND 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 1

1 OF 2

PROJECT Agreement # 3010-E-0033 Hwy 23 LOCATION Wallis Municipal Drain - Site # 19-613-C ORIGINATED BY SJ  
 CLIENT MTO West Region Hwy 23, Sta(20+396) COMPILED BY SJ  
 JOB NO. TB112041 DATE 12 May 2011 Mid Shoulder, NBL, 7.23 m Rt of CL. CHECKED BY WK



Continued Next Page

# RECORD OF BOREHOLE No 1

2 OF 2

PROJECT Agreement # 3010-E-0033 Hwy 23 LOCATION Wallis Municipal Drain - Site # 19-613-C ORIGINATED BY SJ  
 CLIENT MTO West Region Hwy 23, Sta(20+396) COMPILED BY SJ  
 JOB NO. TB112041 DATE 12 May 2011 Mid Shoulder, NBL, 7.23 m Rt of CL. CHECKED BY WK

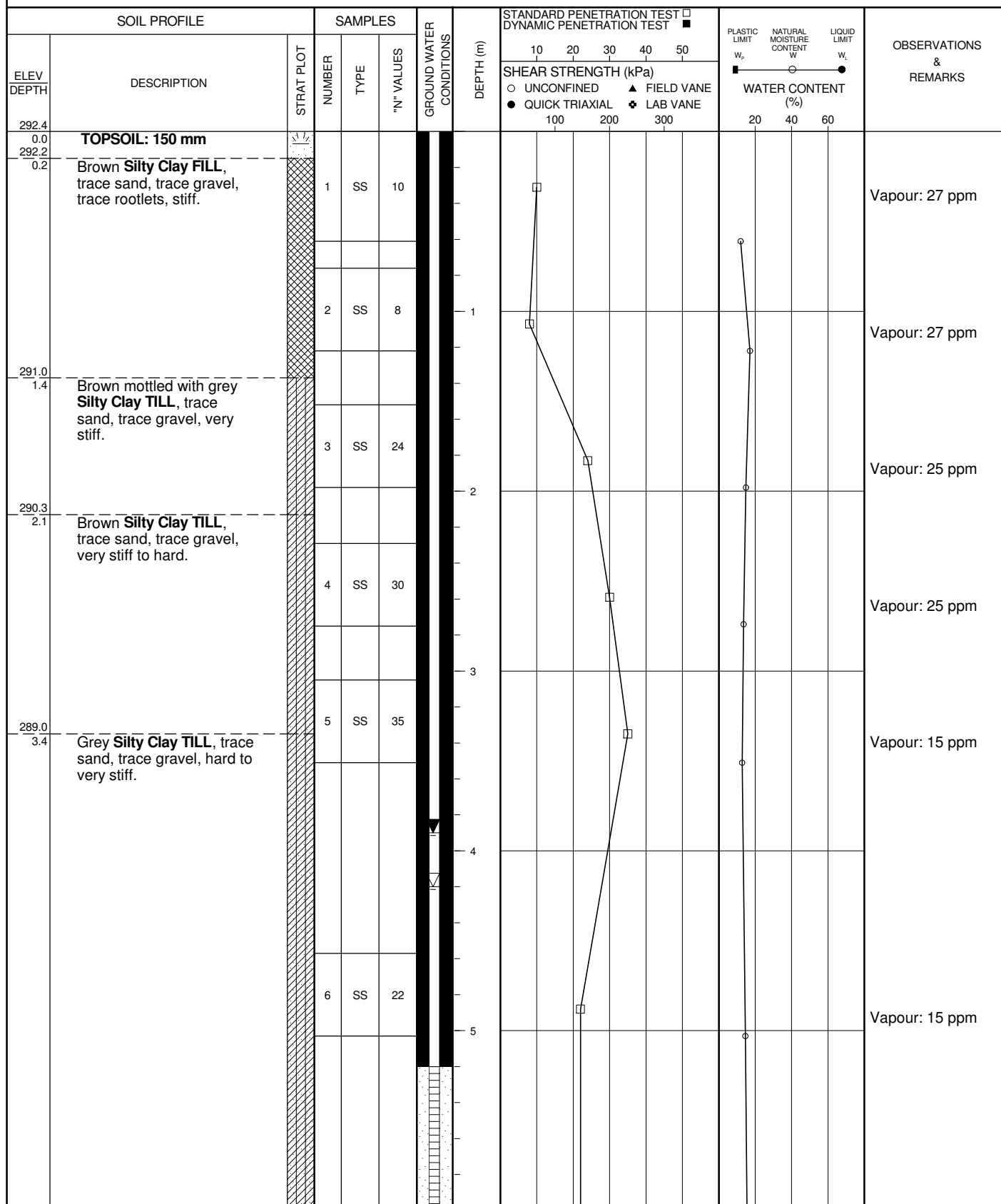
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST DYNAMIC PENETRATION TEST		WATER CONTENT (%)	OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)			
								○ UNCONFINED ● QUICK TRIAXIAL	▲ FIELD VANE ✱ LAB VANE		
							10 20 30 40 50 100 200 300		PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub>		
			7	SS	19						Vapour: N/D
286.1 7.3	Brown, coarse <b>SAND</b> , trace gravel, saturated, compact.		8	SS	18						Vapour: 3 ppm
285.5 7.9	Greyish brown <b>Silty Clay TILL</b> , trace sand, trace gravel, very stiff.		9	SS	24						Vapour: 15 ppm
			10	SS	16						Vapour: 10 ppm
282.3 11.1	<b>End of Borehole</b>										Upon Completion: Borehole open to 7.32 m & GWL at 4.6 m.



# RECORD OF BOREHOLE No 2

1 OF 2

PROJECT Agreement # 3010-E-0033 Hwy 23 LOCATION Wallis Municipal Drain - Site # 19-613-C ORIGINATED BY SJ  
 CLIENT MTO West Region Hwy 23, Sta(20+396) COMPILED BY SJ  
 JOB NO. TB112041 DATE 12 May 2011 7.9 m N-E of Culvert Inlet, East of Hwy 23. CHECKED BY WK

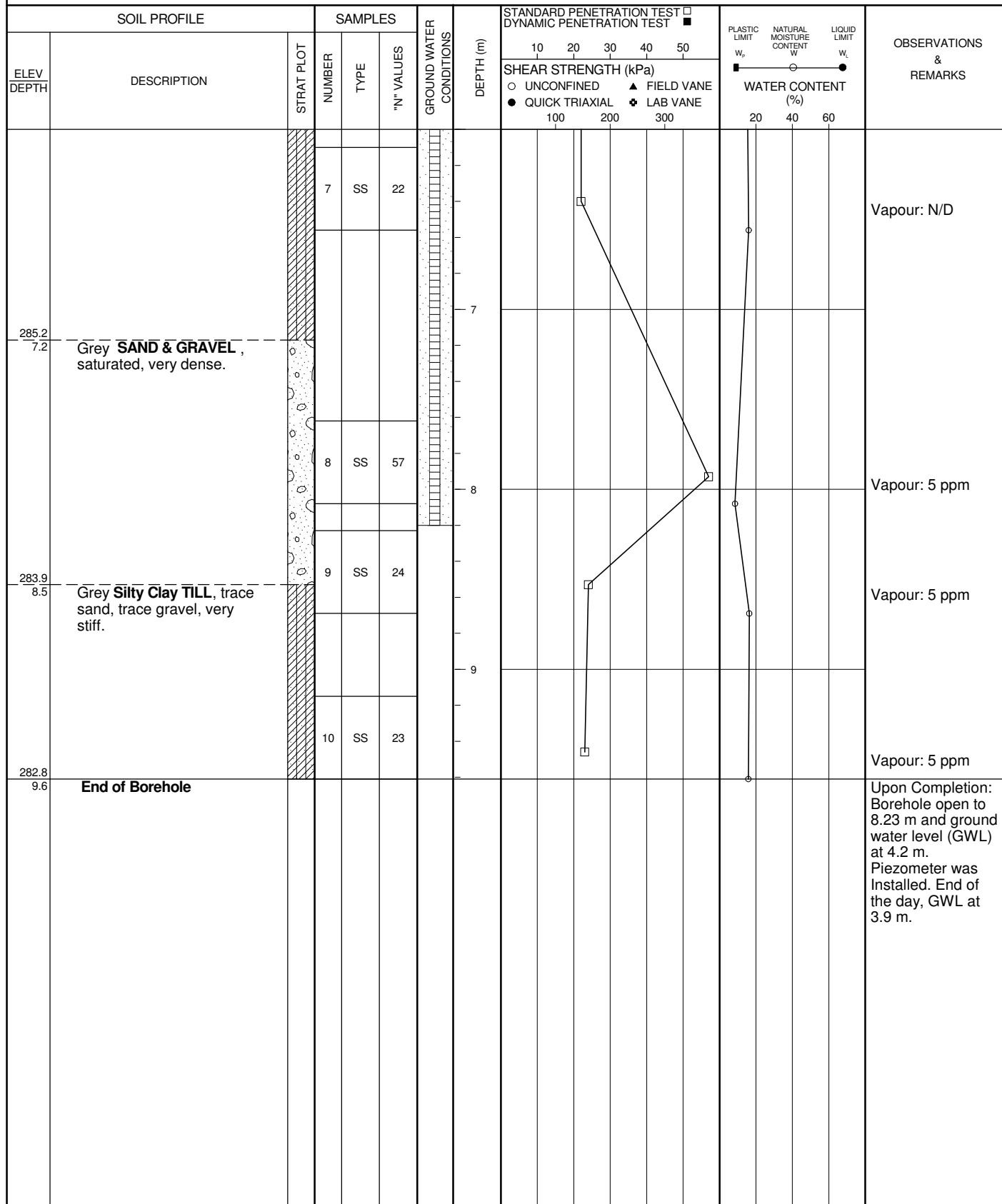


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# RECORD OF BOREHOLE No 2

2 OF 2

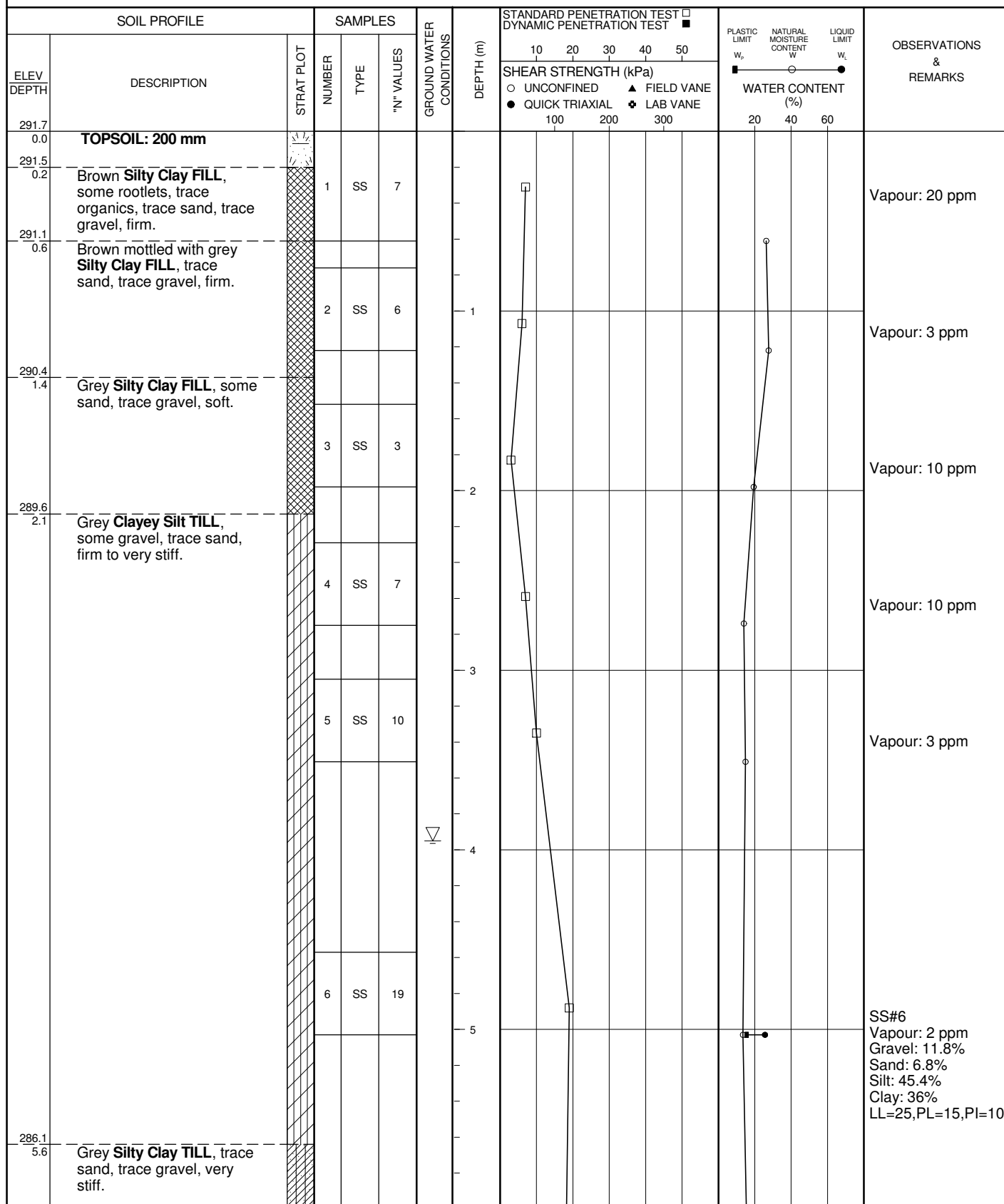
PROJECT Agreement # 3010-E-0033 Hwy 23 LOCATION Wallis Municipal Drain - Site # 19-613-C ORIGINATED BY SJ  
 CLIENT MTO West Region Hwy 23, Sta(20+396) COMPILED BY SJ  
 JOB NO. TB112041 DATE 12 May 2011 7.9 m N-E of Culvert Inlet, East of Hwy 23. CHECKED BY WK



# RECORD OF BOREHOLE No 3

1 OF 2

PROJECT Agreement # 3010-E-0033 Hwy 23 LOCATION Wallis Municipal Drain - Site # 19-613-C ORIGINATED BY SJ  
 CLIENT MTO West Region Hwy 23, Sta(20+396) COMPILED BY SJ  
 JOB NO. TB112041 DATE 12 May 2011 N-W of Culvert Outlet, West of Hwy 23. CHECKED BY WK



Continued Next Page

# RECORD OF BOREHOLE No 3

2 OF 2

PROJECT Agreement # 3010-E-0033 Hwy 23 LOCATION Wallis Municipal Drain - Site # 19-613-C ORIGINATED BY SJ  
 CLIENT MTO West Region Hwy 23, Sta(20+396) COMPILED BY SJ  
 JOB NO. TB112041 DATE 12 May 2011 N-W of Culvert Outlet, West of Hwy 23. CHECKED BY WK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST DYNAMIC PENETRATION TEST		WATER CONTENT (%)	OBSERVATIONS & REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)				
								10 20 30 40 50	100 200 300			
							○ UNCONFINED	▲ FIELD VANE				
							● QUICK TRIAXIAL	✱ LAB VANE				
									PLASTIC LIMIT W <sub>p</sub>		NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>
283.8 7.9	Seam of Sand		7	SS	18		7				Vapour: 5 ppm	
			8	SS	22		8				Vapour: 5 ppm	
			9	SS	27		9				Vapour: 5 ppm	
282.1 9.6	End of Borehole										Upon Completion: Borehole open to 8.23 m and GWL at 3.95 m.	

**APPENDIX B**

**LABORTORY TEST RESULTS**

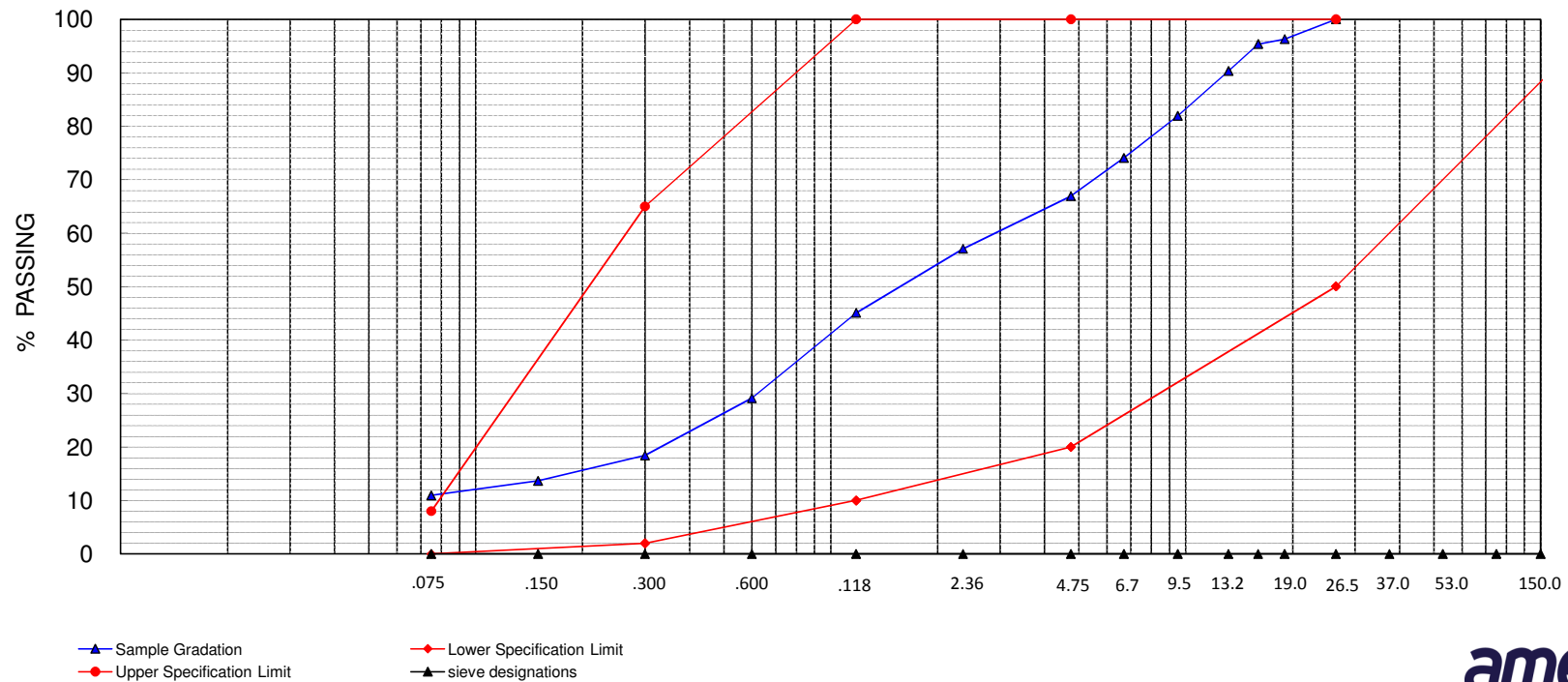
# MATERIAL FINER THAN 75 $\mu$ m BY WASHING AND SIEVE ANALYSIS OF AGGREGATES MTO LS-601 & LS-602

Enclosure: 1  
Date: 31 May 2011  
Project: TB112041

**Client:** MTO West Region  
**MTO Assignment #** 3010-E-0033  
**Sample Source:** BH1 - SS1  
**Culvert Name:** Wallis Drain (19-613-C)  
**Sample Type:** Bore Hole  
**Specification:** Granular B, Type I

**Lab No:** S315-11  
**Date Sampled:** May 2011  
**Sampled by:** AMEC  
**Date Received:** 20 May 2011  
**Date Tested:** 30 May 2011

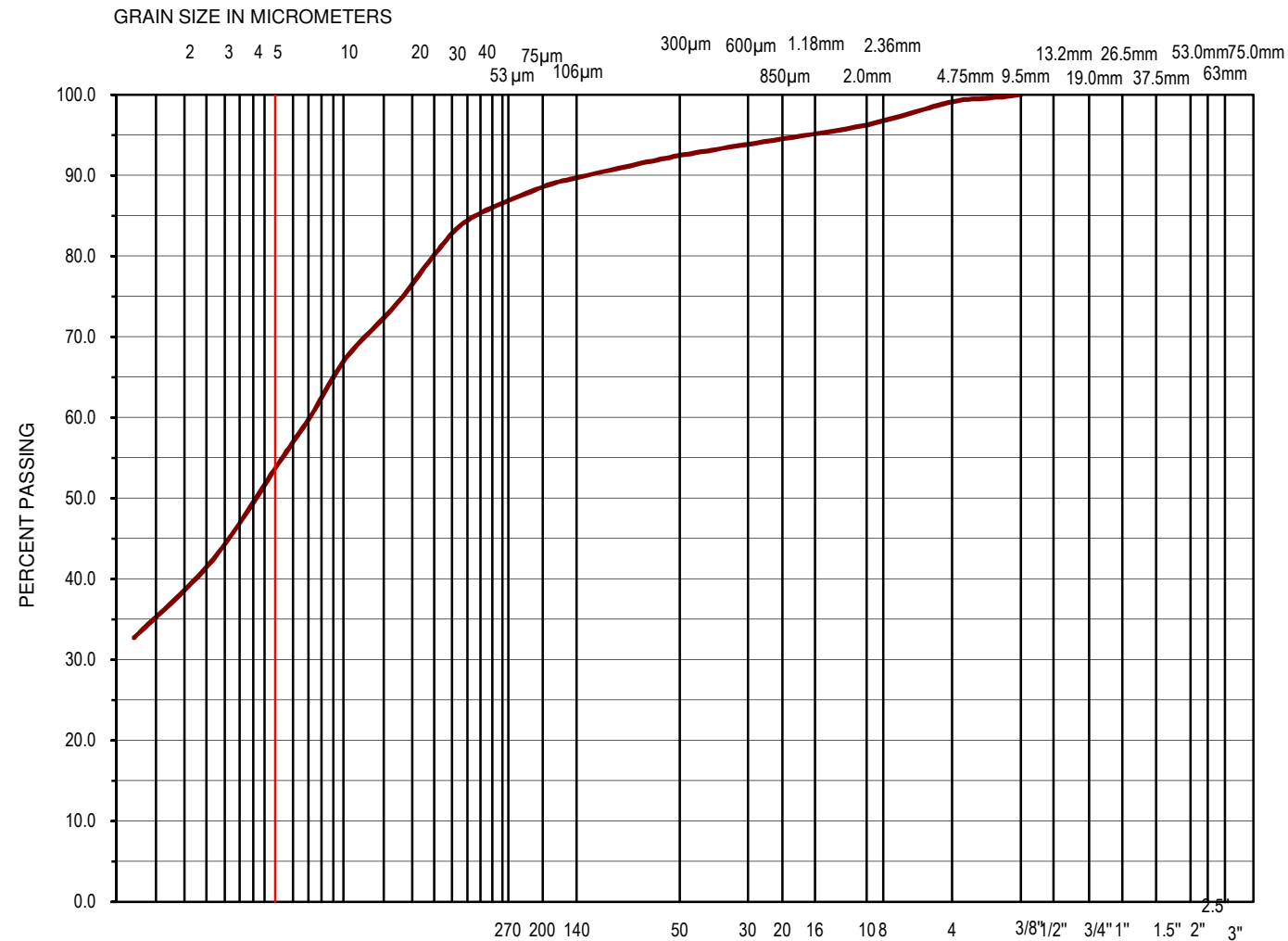
SIEVE SIZES (mm)	150	75.0	53.0	37.5	26.5	19.0	16.0	13.2	9.5	6.7	4.75	2.36	1.18	0.600	0.300	0.150	0.075
SPECIFICATIONS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% PASSING	-	-	-	-	100.0	96.3	95.4	90.3	81.9	74.0	66.9	57.1	45.1	29.1	18.4	13.7	10.9



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY	SILT	SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse

MINISTRY SIEVE DESIGNATION (Metric)



Particle Size	Percent Passing
75	100.0
63	100.0
37.5	100.0
26.5	100.0
19	100.0
16	100.0
13.2	100.0
9.5	100.0
6.7	99.6
4.75	99.1
2	96.3
0.85	94.54
0.425	93.19
0.25	92.04
0.106	89.73
0.075	88.57
0.0363	84.72
0.0262	80.87
0.0172	74.13
0.0102	67.39
0.0073	60.65
0.0053	54.87
0.0026	42.36
0.0012	32.73



GRAIN SIZE DISTRIBUTION  
Clayey Silt, Some Sand, Trace Gravel

BH1 - SS6

Lab No. S315-11

TB112041

Date Sampled: May 2011

Date Received: 20 May 2011

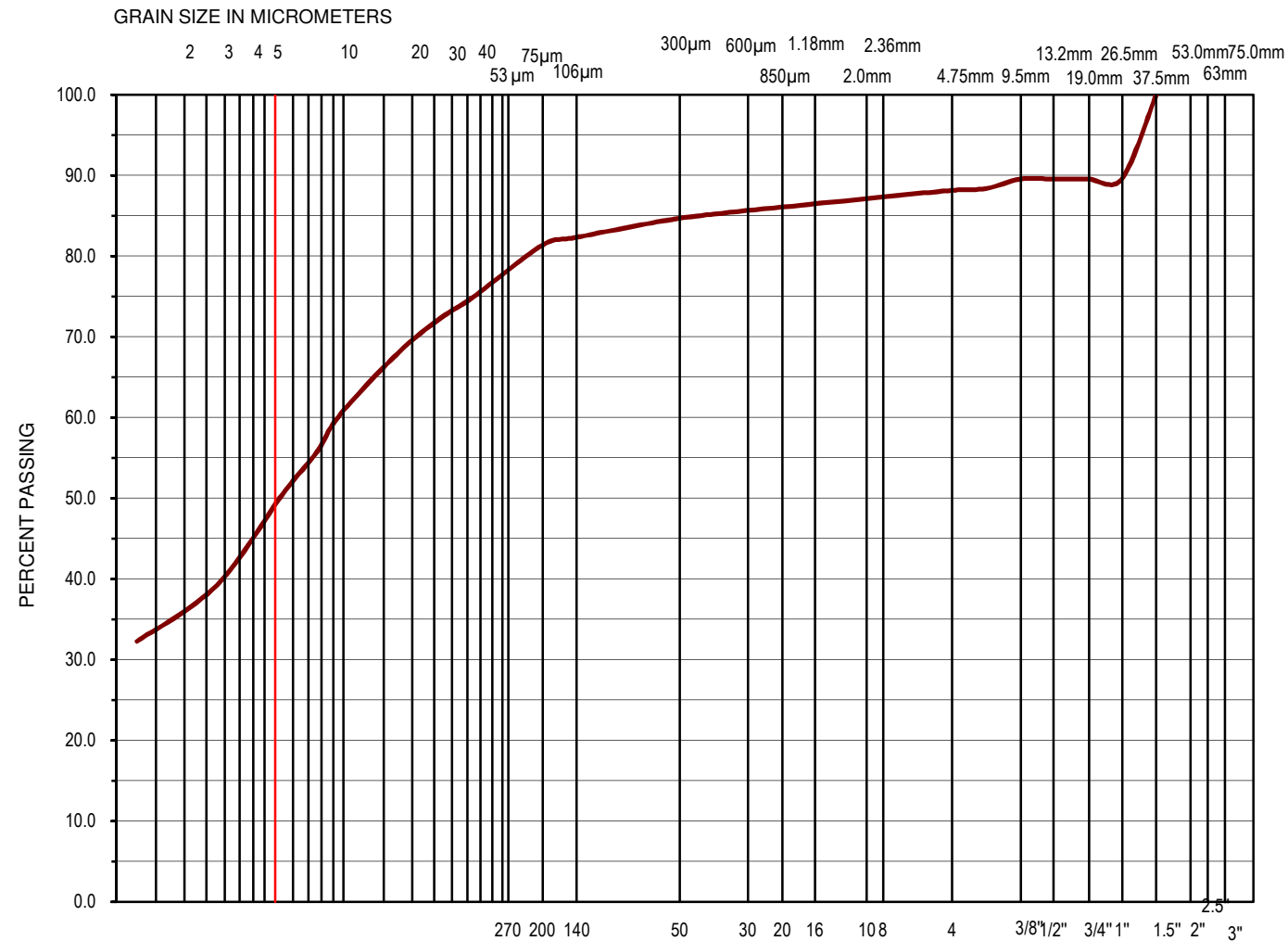
June 2, 2011

Enclosure: 1

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY	SILT	SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse

MINISTRY SIEVE DESIGNATION (Metric)



Particle Size	Percent Passing
75	100.0
63	100.0
37.5	100.0
26.5	89.6
19	89.6
16	89.6
13.2	89.6
9.5	89.6
6.7	88.4
4.75	88.2
2	87.1
0.85	86.08
0.425	85.21
0.25	84.32
0.106	82.32
0.075	81.36
0.0371	74.91
0.0266	72.30
0.0173	67.94
0.0095	60.10
0.0076	55.75
0.0054	50.52
0.0028	39.20
0.0012	32.23

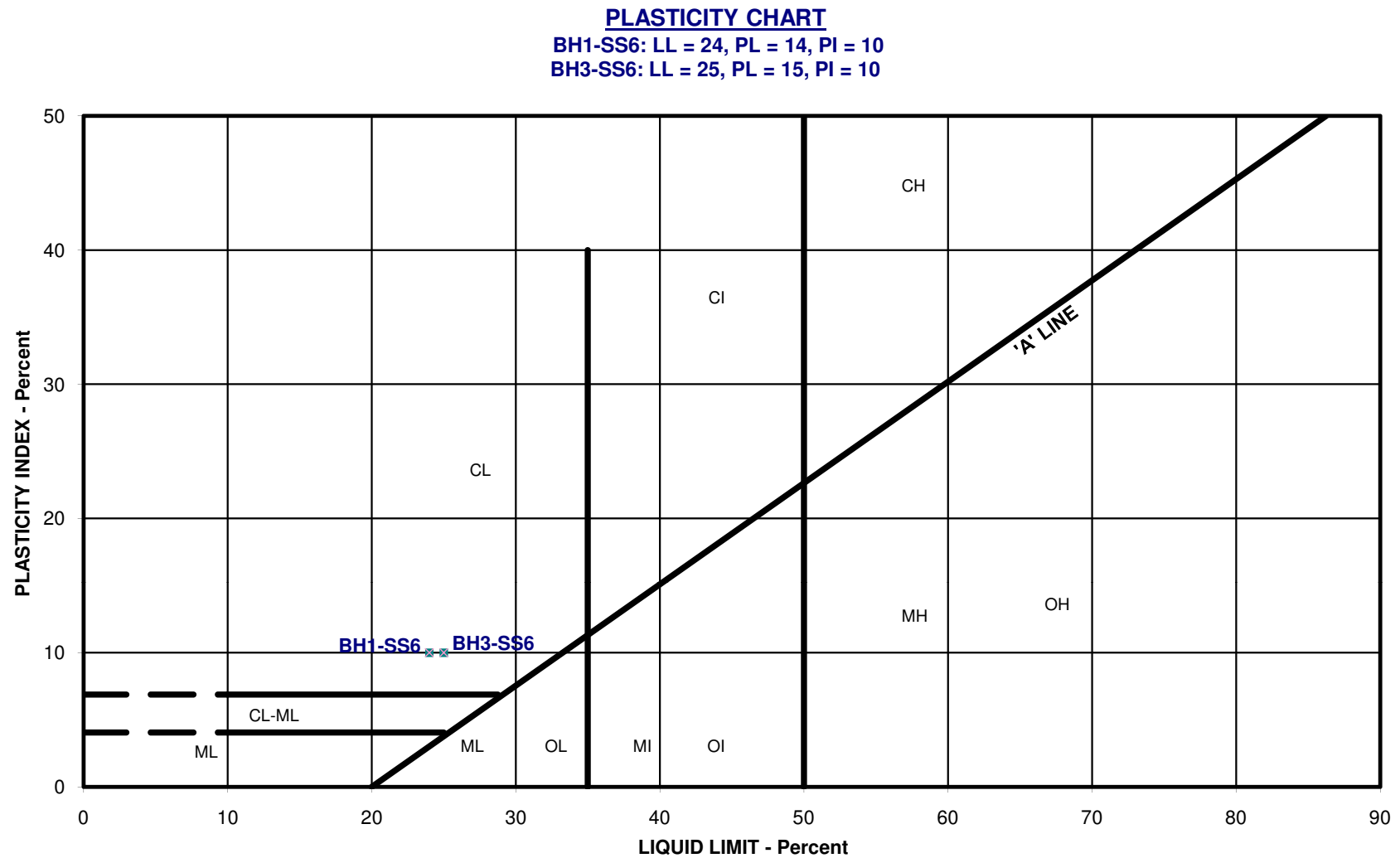


GRAIN SIZE DISTRIBUTION  
Clayey Silt, Some Gravel, Trace Sand  
BH3 - SS6

Lab No. S315-11 TB112041  
Date Sampled: May 2011  
Date Received: 20 May 2011

May 31, 2011  
Enclosure: 1





Your Project #: TB112041  
 Site: HWY 23 AGREEMENT#3010-E-0033  
 Your C.O.C. #: 19912

**Attention: Shail Jadeja**  
 AMEC Earth & Environmental Ltd  
 Hamilton - Standing Offer  
 505 Woodward Ave  
 Unit 1  
 Hamilton, ON  
 L8H 6N6

**Report Date: 2011/05/27**

## CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B172126**  
**Received: 2011/05/20, 14:20**

Sample Matrix: Soil  
 # Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Chloride (20:1 extract)	2	N/A	2011/05/27	CAM SOP-00463	
Conductivity	2	N/A	2011/05/27	CAM SOP-00414	APHA 2510
pH CaCl2 EXTRACT	2	2011/05/26	2011/05/26	CAM SOP-00413	SM 4500 H
Resistivity of Soil	2	2011/05/21	2011/05/27	CAM SOP-00414	APHA 2510
Sulphate (20:1 Extract)	2	N/A	2011/05/27	CAM SOP-00464	EPA 375.4

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

Encryption Key

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

MARIJANE CRUZ, Project Manager  
 Email: MCruz@maxxam.ca  
 Phone# (905) 817-5756

=====

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: 1

Maxxam Job #: B172126  
Report Date: 2011/05/27

AMEC Earth & Environmental Ltd  
Client Project #: TB112041  
Project name: HWY 23 AGREEMENT#3010-E-0033

### RESULTS OF ANALYSES OF SOIL

Maxxam ID		JO7086	JO7087		
Sampling Date		2011/05/12 13:00	2011/05/13 13:00		
	<b>Units</b>	<b>BH2-SS6 WALLIS DRAIN</b>	<b>BH2-SS6 WASHBURN</b>	<b>RDL</b>	<b>QC Batch</b>
<b>Calculated Parameters</b>					
Resistivity	ohm-cm	4100	4700		2495498
<b>Inorganics</b>					
Soluble (20:1) Chloride (Cl)	ug/g	<20	<20	20	2500532
Conductivity	umho/cm	244	213	2	2500541
Available (CaCl2) pH	pH	7.76	7.84		2499078
Soluble (20:1) Sulphate (SO4)	ug/g	70	52	20	2500535

RDL = Reportable Detection Limit  
QC Batch = Quality Control Batch

Maxxam Job #: B172126  
Report Date: 2011/05/27

AMEC Earth & Environmental Ltd  
Client Project #: TB112041  
Project name: HWY 23 AGREEMENT#3010-E-0033

Package 1	23.7°C
-----------	--------

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

**GENERAL COMMENTS**

Maxxam Job #: B172126  
Report Date: 2011/05/27

AMEC Earth & Environmental Ltd  
Client Project #: TB112041  
Project name: HWY 23 AGREEMENT#3010-E-0033

### 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
2500532	Soluble (20:1) Chloride (Cl)	2011/05/27	108	75 - 125	102	85 - 115	<20	ug/g	NC	35		
2500535	Soluble (20:1) Sulphate (SO4)	2011/05/27	101	75 - 125	103	85 - 115	<20	ug/g	NC	35		
2500541	Conductivity	2011/05/27					<2	umho/cm	1.9	35	103	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.

## Validation Signature Page

**Maxxam Job #: B172126**

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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, appearing to read "BRAD NEWMAN", is written over a horizontal line.

BRAD NEWMAN, Scientific Specialist

=====

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

6740 Campobello Road, Mississauga, ON L5N 2L8  
Phone: 905-817-5700 Fax: 905-817-5778 Toll Free: (800) 561-1111

20-May-11 14:20

MARIJANE CRUZ



B172126

MHO

ENV-034

## CHAIN OF CUSTODY RECORD

19912

Page 1 of 1

<b>INVOICE INFORMATION</b> Company Name: AMEC Earth & Environmental Contact Name: Shail Jadeja Address: 505 Woodward Avenue, Unit 1 Hamilton L8H 6N6 Phone: 905-312-0700 Fax: 905-312-0777 Email: Shail.jadeja@amec.com		<b>REPORT INFORMATION</b> Company Name: Contact Name: Address: Phone: Fax: Email:		<b>PROJECT INFORMATION</b> Project #: TB112041 Project Name: Agreement # 3010-E-0033 Location: Hwy 23 Sampled By: Shail Jadeja		<b>MAXXAM JOB NUMBER</b>  <b>CHAIN OF CUSTODY #</b> 00
---	--	---	--	--	--	---

REGULATORY CRITERIA				ANALYSIS REQUESTED (Please be specific)				TURNAROUND TIME (TAT) REQUIRED	
Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form. <input type="checkbox"/> MISA Reg. 153 <input type="checkbox"/> Sewer Use <input type="checkbox"/> PWQO <input type="checkbox"/> Table 1 Residential / Parkland <input type="checkbox"/> Sanitary <input type="checkbox"/> Reg. 558 <input type="checkbox"/> Table 2 Industrial / Commercial <input type="checkbox"/> Storm <input type="checkbox"/> Table 3 Medium / Fine Municipality: <input type="checkbox"/> Table 6 Coarse Other (specify): Report Criteria on C of A? <input type="checkbox"/>				Regulated Drinking Water? (Y / N) Metals Field Filtered? (Y / N) Chloride Sulphate pH Resistivity				<b>PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS.</b> Regular (Standard) TAT: <input type="checkbox"/> 5 to 7 Working Days Rush TAT: Rush Confirmation #: (call Lab for #) <input type="checkbox"/> 1 day <input type="checkbox"/> 2 days <input type="checkbox"/> 3 days DATE Required: TIME Required:	
<b>SAMPLES MUST BE KEPT COOL (&lt;10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM.</b>									
Sample Identification	Date Sampled	Time Sampled	Matrix (GW, SW, Soil, etc.)	Regulated Drinking Water? (Y / N)	Metals Field Filtered? (Y / N)	Chloride	Sulphate	pH	Resistivity
1 BH2 - SS6 Wallis Drain	May 12	1:00pm	Soil	N	N	✓	✓	✓	✓
2 BH2 - SS6 Washburn	May 13	1:00pm	Soil	N	N	✓	✓	✓	✓
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

RELINQUISHED BY (Signature/Print)	RECEIVED BY (Signature/Print)	Date	Time	# JARS USED AND NOT SUBMITTED	Laboratory Use Only
Shail Jadeja	[Signature]	May 20	11:00 AM		Temperature (°C) on Receipt
	[Signature]	20110520	14:20		24/24/23

\*MANDATORY SECTIONS IN GREY MUST BE FILLED OUT. AN INCOMPLETE CHAIN OF CUSTODY WILL RESULT IN ANALYTICAL TAT DELAYS.

**APPENDIX C**

**SITE PHOTOGRAPHS**



## APPENDIX C - PHOTOGRAPHIC RECORD

**PROJECT NO.** TB112041

**PROJECT** MTO West Region - Agreement # 3010-E-0033

**LOCATION** Wallis Municipal Drain, Highway 23

**ENCLOSURE** 1

	<table border="1"> <tr> <td><b>PHOTOGRAPH</b></td> <td><b>1</b></td> </tr> </table>	<b>PHOTOGRAPH</b>	<b>1</b>
<b>PHOTOGRAPH</b>	<b>1</b>		
<table border="1"> <tr> <td><b>Description</b></td> </tr> <tr> <td> <p><a href="#">Culvert # 19-613-C</a></p> <p>Inlet</p> </td> </tr> </table>		<b>Description</b>	<p><a href="#">Culvert # 19-613-C</a></p> <p>Inlet</p>
<b>Description</b>			
<p><a href="#">Culvert # 19-613-C</a></p> <p>Inlet</p>			

	<table border="1"> <tr> <td><b>PHOTOGRAPH</b></td> <td><b>2</b></td> </tr> </table>	<b>PHOTOGRAPH</b>	<b>2</b>
<b>PHOTOGRAPH</b>	<b>2</b>		
<table border="1"> <tr> <td><b>Description</b></td> </tr> <tr> <td> <p><a href="#">Culvert # 19-613-C</a></p> <p>Upstream - Wallis Municipal Drain</p> </td> </tr> </table>		<b>Description</b>	<p><a href="#">Culvert # 19-613-C</a></p> <p>Upstream - Wallis Municipal Drain</p>
<b>Description</b>			
<p><a href="#">Culvert # 19-613-C</a></p> <p>Upstream - Wallis Municipal Drain</p>			

## APPENDIX C - PHOTOGRAPHIC RECORD

**PROJECT NO.** TB112041

**PROJECT** MTO West Region - Agreement # 3010-E-0033

**LOCATION** Wallis Municipal Drain, Highway 23

**ENCLOSURE** 2

	<b>PHOTOGRAPH</b>	<b>3</b>
	<b>Description</b>	
<p><a href="#">Culvert # 19-613-C</a></p> <p>Outlet</p>		

	<b>PHOTOGRAPH</b>	<b>4</b>
	<b>Description</b>	
<p><a href="#">Culvert # 19-613-C</a></p> <p>Downstream - Wallis Municipal Drain</p>		

**APPENDIX D**

**SPECIFICATIONS FOR ENGINEERED  
FILL**



## **Specifications for Engineered Fill**

The following placement procedure is recommended.

- (i) The aerial extent of engineered fill should be controlled by proper surveying techniques to ensure that the top of the engineered fill extends a minimum of 0.5 metres beyond the inside and outside edge of the proposed footing. The base of the engineered fill must extend beyond the edge of footing (inside and outside edge), a distance equal to the depth of the engineered fill plus 0.5 metres.
- (ii) The area to receive the engineered fill should be stripped of all fills, organic matter, and other compressible, weak and deleterious materials. After stripping, the entire area should be inspected and approved by the geotechnical engineer. Spongy, wet or soft/loose spots should be sub-excavated to expose stable subgrade and replaced with compactable approved soil, compatible with subgrade conditions, as directed by the geotechnical engineer.
- (iii) The engineered fill material must be a uniform, homogeneous material, and should be placed in thin layers not exceeding approximately 200 mm when loose. Oversize particles (cobbles and boulders) larger than 120 mm should be discarded. The material for backfilling the excavation and raising the grades should consist of OPSS Granular B, OPSS Select Sub-grade, or approved equivalent. Fine grained cohesive soils with close to optimum moisture contents can be used as engineered fill in mass fill placement subject to some restrictions in the thickness and time of construction. Non-cohesive (granular) structural/engineered fill is preferred over cohesive structural/engineered fill. For engineered fill below foundations, each fill layer should be uniformly compacted with heavy compactors, suitable for the type of fill used, to at least 100% of its Standard Proctor Maximum Dry Density. Above the foundation level and below floor slabs, the degree of compaction can be lowered to 98%.
- (iv) Full-time geotechnical inspection and quality control (by means of frequent field density and laboratory testing) are necessary for the construction of a certifiable engineered fill. The compaction procedure and efficiency should be controlled by the geotechnical engineer.
- (v) The engineered fill should not be frozen and should be placed at water contents within 2 % of the optimum value for compaction. The engineered fill should not be placed during winter months when freezing ambient temperatures occur persistently or intermittently.

An allowable soil bearing pressure of 150 kPa can be used for design, for footings supported on engineered fill overlying competent native soils and constructed in accordance with the above recommendations. AMEC also recommends that the footing subgrade be evaluated by the geotechnical engineer prior to placing the formwork.

It is good engineering practice to increase the rigidity of foundations of structures erected over engineered fill, and this is generally achieved by making the footings at least 0.5 m wide, and adding nominal reinforcing (e.g. two 15M bars), to the footings. This measure helps bridge over variations or weak spots in the fill.

For footings designed and constructed in accordance with the above criteria, total and differential settlements should be less than 25 mm and 20 mm respectively. These values are usually within tolerable limits. The total and differential settlements quoted above also apply to footings founded partly on native soil and partly on engineered fill.