



FOUNDATION INVESTIGATION AND DESIGN REPORT

**HIGHWAY 48 AND HERALD ROAD WIDENING
(HIGHWAY 48 FROM STA 15 + 050 TO STA 15 + 340)
TOWN OF EAST GWILLIMBURY, ONTARIO**

**MINISTRY OF TRANSPORTATION ONTARIO
CENTRAL REGION**

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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 - Central Region (“MTO”) to provide Detail Foundation Investigation and Design Services for the Highway 48 and Herald Road signalization project located in the Town of East Gwillimbury, Ontario. The services included detail foundation investigation and detail design of high fills/cuts and culvert to accommodate the roadway platform widening. The site location plan is shown in Drawing No. 1.

Based on the Foundations Engineering Terms of Reference (TOR), the project comprises the components shown in Table 1.1.

Table 1.1 - Project Components

Location	Approximate Station	Component
West side of Highway 48	Sta. 15+075 to Sta. 15+110	Road and embankment widening
East side of Highway 48	Sta. 15+200 to Sta. 15+300	
East side of Highway 48	Unnamed tributary of Mount Albert Creek culvert at approximate Sta. 15+267	Culvert extension or No culvert extension with headwall / wingwall combination at inlet

To provide the required geotechnical information for the Detail Design Services for the proposed Highway 48 widening, AMEC conducted a foundation investigation along the existing embankment crest and toe areas of Highway 48 within the project limits. The investigation comprised advancing a total of seven (7) boreholes (BH 1 to BH 6 and BH 1A) as shown in the borehole location plan on Drawing No. 1. As per the TOR, five (5) boreholes (BH 1 to BH 5) were specified, including two (2) at the culvert location (BH 2 and BH 3). AMEC advanced two (2) additional boreholes (BH 1A and BH 6) at the toe areas of the existing high fills to obtain additional subsurface information.

The purpose of the foundation investigation was to obtain information on the subsurface conditions along the embankment crest and toe areas of the project road, by means of boreholes, in-situ tests and laboratory tests on selected samples.

This report includes the factual results (i.e. “Foundation Investigation Report” submitted separately) and design discussions and recommendations for the proposed widening of Highway 48 from Sta. 15+050 to Sta. 15+340.

2.0 SITE DESCRIPTION

The project road is Highway 48 - just north of Herald Road in the Town of East Gwillimbury, Ontario (Drawing No. 1). It is about 290 m long and stretches northerly from about Sta. 15+050 to Sta. 15+340. A tributary of Mount Albert Creek crosses the project road at approximate Sta. 15+267, where an existing culvert is located. The surrounding area is primarily rural in nature. The embankment slopes were covered with tall grasses and other low vegetation at the time of the fieldwork.

The project road 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. Based on the cross-sections provided, the heights of the existing embankment range from about 2 m to 8 m, while the side slope inclinations range from 2H:1V to 2.5H:1V.

The existing culvert at the creek crossing is a 1500 x 1600 RFO culvert (inverted 'U' shape) at Sta. 15+267. The direction of flow through the culvert is from east to west direction. The maximum fill cover height over the culvert is approximately 7.0 m.

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) Glaciolacustrine deposits consisting of sand, gravelly sand and gravel; nearshore and beach deposits; and (ii) Glaciofluvial ice-contact deposits consisting of gravel and sand, minor till, end moraine, ice marginal delta and subaqueous fan deposits.

4.0 INVESTIGATION PROCEDURES

4.1 Field Investigation

A total of seven (7) boreholes (BH 1, BH 1A, BH 2 to BH 6) were advanced along the project road. Boreholes BH 1, BH 2 and BH 4 were drilled at the east shoulder (between Sta. 15+200 to 15+300), and Borehole BH 5 was drilled at the west shoulder (between Sta. 15+075 to Sta. 15+110). Similarly, Boreholes BH 1A and BH 3 were drilled at the east toe of embankment, and Borehole BH 6 was drilled at the west toe of embankment. The borehole locations are presented on Drawing No. 1.

The fieldwork was performed on 12 October and 13 October 2011 after acquiring all necessary permits for road occupancy and clearing underground utilities. AMEC personnel surveyed the existing ground surface elevation at the borehole locations using the centre line of Highway 48 at Borehole BH 5 location as temporary benchmark (TBM). The approximate TBM elevation of 269.9 m (geodetic) was taken from the profile drawing (GWP No. 2140-10-00). The elevations for the TBM and the borehole surfaces should not be used for any accurate measurements /

calculations.

The boreholes were advanced using hollow-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 1.5m 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) outside diameter 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.

Dynamic Cone Penetration Tests (DCPT) were carried out below the sampling / auger refusal depths in three (3) boreholes (BH 1, BH 2 and BH 4) and consisted of freely dropping a 63.5 kg (140 lb) hammer for a vertical distance of 0.76 m (30 inches) to drive a 51 mm (2 inches) diameter cone into the ground. The number of blows of the hammer required to drive the cone assembly into the relatively undisturbed ground by a vertical distance of 0.30 m (12 inches) was recorded as the DCPT value in blows/0.3 m. The results of the DCPT are shown in the Record of Boreholes.

The groundwater conditions were observed in the boreholes during sampling and upon completion of drilling, if encountered. Groundwater depths were measured and the results are presented on the Record of Boreholes.

The boreholes were backfilled with bentonite in accordance with the general requirements of Ministry of the Environment Regulation 903.

Upon completion of drilling, 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 grain size analysis, Liquid and Plastic Limits, and in-situ water content determination on selected samples. A soil corrosivity analysis was carried out on one (1) selected soil sample at the culvert location. The corrosivity tests were carried out by Maxxam Analytics, an accredited CAEL laboratory in Mississauga, Ontario.

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

AMEC will retain the soil samples for a period of one year after completion of the Project (i.e., until the end of April 2013), 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 (60);
- Grain size distribution analysis (15);
- Soil corrosivity (1).

The results of laboratory tests are included on the Record of Boreholes in Appendix A. The grain size distribution curves are shown in Appendix B.

5.0 SUB-SURFACE CONDITIONS

Based on the investigation results, the soil profile consisted predominantly of ground surface cover, i.e., topsoil in boreholes drilled at the toe areas (Boreholes BH 1A, BH 3 and BH 6), and sand and gravel and/or gravelly sand fill in boreholes drilled at the shoulder areas (Boreholes BH 1, BH 2, BH 4 and BH 5). The ground surface cover was underlain by fill soils (silty sand / silt and sand) overlying various native deposits (sandy gravel / gravelly sand, sand, silty sand, silt and sand, and silt) which extended to the sampling depths of Boreholes BH 1, BH 2 and BH 4, and termination depths of Boreholes BH 1A, BH 3, BH 5 and BH 6.

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). Stratigraphical cross sections showing the existing subsurface soil and groundwater conditions are provided in Drawing Nos. 1 and 2.

Soil and groundwater conditions may vary between and beyond the borehole locations.

5.1 Topsoil

Topsoil was encountered at the existing grade in Boreholes BH 1A, BH 3 and BH 6 drilled at toe areas of the Highway 48 road embankment. The measured thickness of topsoil ranged from about 300 mm to 600 mm. The topsoil consisted primarily of organic matter with some rootlets and soils, and extended to about Elevation 258.9 m in Borehole BH 1A, about Elevation 258.7 m in Borehole BH 3, and about Elevation 265.2 m in Borehole BH 6.

The thickness of topsoil could vary between and beyond the borehole locations.

5.2 Fill Soils

Sand and Gravel / Gravelly Sand Fill

Boreholes BH 1, BH 2, BH 4 and BH 5 drilled through the shoulder areas of Highway 48 encountered sand and gravel fill at the existing grade. In Boreholes BH 1, BH 4 and BH 5, gravelly sand was encountered below the sand and gravel fill. The measured thickness of gravelly sand and / or sand and gravel fill ranged from about 0.6 m to 1.4 m. The gravelly sand and / or sand and gravel fill extended to about Elevation 265.2 m in Borehole BH 1, about Elevation 265.7 m in Borehole BH 2, about Elevation 266.7 m in Borehole BH 4, about Elevation 268.5 m in Borehole BH 5.

The SPT N-values measured within the sand and gravel / gravelly sand fill ranged from 19 to 31 blows per 0.3 m. Two (2) water contents determined within the sand and gravel / gravelly sand fill were 3 % and 6 %.

Silty Sand / Silt and Sand / Sandy Silt Fill

Silty sand / silt and sand / sandy silt fill was encountered underneath the sand and gravel and / or gravelly sand fill in Boreholes BH 1, BH 2, BH 4 and BH 5. The silty sand /silt and sand / sandy silt fill extended to depths ranging from about 7.0 m to 10.0 m below the existing grade (Elevations 256.3 m to 262.8 m). Silty sand / sandy silt fill was also encountered underlying the surficial topsoil in Boreholes BH 1A, BH 3 and BH 6, to depths ranging from about 0.7 m to 2.1 m below existing grade (Elevations of about 257.1 m to 264.3 m).

The silty sand /silt and sand / sandy silt fill was brown in colour and contained trace to some clay and gravel, and trace cobbles / boulders.

The SPT N-values measured within the silty sand /silt and sand / sandy silt fill ranged from 3 to greater than 50 blows per 0.3 m. The water contents determined for the silty sand /silt and sand / sandy silt fill ranged from about 4 % to 22 %.

Grain size analyses were performed on five (5) samples of the silty sand / silt and sand / sandy silt fill, and the results are presented in Table 5.1.

**Table 5.1 - Results of Grain Size Analyses
(Silty sand / silt and sand / sandy silt fill)**

Borehole No.	Sample No.	Depth (Elevation) (m)	Percent Distribution (%)			
			Gravel	Sand	Fines	
					Silt	Clay
BH 1	SS 4	2.0 - 2.6 (263.8 - 263.2)	13	40	37	10
BH 2	SS 4	2.3 - 2.7 (256.9 - 256.5)	4	31	55	10
BH 4	SS 5	3.1 - 3.4 (264.3 - 264.0)	10	30	52	8
BH 5	SS 3	1.5 - 2.0 (268.3 - 267.8)	11	49	40	
BH 5	SS 7	6.1 - 6.6 (259.6 - 259.1)	0	55	41	4

The grain size distribution curves are presented in Figure No. B 1 in Appendix B.

5.3 Sandy Gravel / Gravelly Sand

Native sandy gravel / gravelly sand deposit was encountered below the silty sand / silt and sand / sandy silt fill in Boreholes BH 1 and BH 3; and below the native silty sand (Section 5.4) in Borehole BH 1A. The sandy gravel / gravelly sand extended to about 9.2 m depth (Elevation about 250 m) in Borehole BH 1A; about 10 m depth (Elevation about 249.3 m) in Borehole BH 3 and at least 14 m depth (Elevation 251.8 m) in Borehole BH 1.

DCPT test was performed below the sampling depths of about 14.0 m (Elevation 251.8 m) in Borehole BH 1 and about 15.4 m (Elevation about 250.9 m) in Borehole BH 2; and auger refusal depth of about 15.0 m (Elevation of 252.4 m in Borehole BH 4. The DCPT tests were terminated due to penetration refusal (more than 100 blows / 0.3 m) at depths of about 17.5 m (Elevation about 248.5 m) in Borehole BH 1; about 17.4 m (Elevation about 248.9 m) in Borehole BH 2; and about 16.4 m (Elevation about 251.0 m) in Borehole BH 4.

The sandy gravel / gravelly sand was grey in color, and contained trace clay and some silt. The SPT 'N' values of the sandy gravel / gravelly sand ranged from 31 to greater than 50 blows per 0.3 m, indicating a dense to very dense condition. The measured moisture contents in the sandy gravel / gravelly sand ranged from 3 % to 11 %.

Grain size analyses were performed on two (2) samples of the sandy gravel / gravelly sand, and the results are presented in Table 5.2.

Table 5.2 - Results of Grain Size Analyses

(Sandy gravel / gravelly sand)

Borehole No.	Sample No.	Depth (Elevation) (m)	Percent Distribution (%)		
			Gravel	Sand	Fines (Silt & Clay)
BH 1	SS 10	10.6 - 11.0 (255.2 - 254.8)	73	23	4
BH 3	SS 4	2.3 - 2.7 (257.0 - 256.6)	33	59	8
BH 3	SS 6	4.6 - 5.1 (254.7 - 254.2)	66	31	3

The grain size distribution curves are presented in Figure No. B 2 in Appendix B.

5.4 Silty Sand / Silt and Sand / Sandy Silt

Silty sand / silt and sand / sandy silt was encountered below the sandy gravel / gravelly sand in Boreholes BH 1A and BH 3; and below the silty sand / sandy silt fill in Boreholes BH 2 and BH 4. The silty sand / silt and sand / sandy silt extended to the sampling / termination depths of about 10.8 m to 15.0 m below the existing grade (Elevations of about 248.3 m to 252.4 m). Native silty sand was also encountered below the silty sand / sandy silt fill in Borehole BH 1A to a depth of about 4.3 m (Elevation about 255.0 m) overlying the sandy gravel / gravelly sand.

DCPT test was performed below the sampling depth of about 15.4 m (Elevation 250.9 m) in Borehole BH 2 to the refusal depth of about 17.7 m (Elevation 248.1 m).

The silty sand / silt and sand / sandy silt was grey in color, and contained trace gravel and cobbles / boulders. The SPT 'N' values of the silty sand / silt and sand / sandy silt ranged from 14 to greater than 50 blows per 0.3 m, indicating a compact to very dense condition. The measured moisture contents in the silty sand / silt and sand / sandy silt ranged from 8 % to 18 %.

Grain size analyses were completed on four (4) samples of the silty sand / silt and sand / sandy silt, and the results are presented in Table 5.3.

**Table 5.3 - Results of Grain Size Analyses
(Silty sand / silt and sand / sandy silt)**

Borehole No.	Sample No.	Depth (Elevation) (m)	Percent Distribution (%)			
			Gravel	Sand	Fines	
					Silt	Clay
BH 2	SS 11	12.1 - 12.5 (247.1 - 246.7)	10	69	21	
BH 3	SS 10	10.7 - 10.8 (248.6 - 248.5)	19	45	36	
BH 4	SS 8	7.6 - 7.9 (259.8 - 259.5)	0	50	48 (non-plastic)	2
BH 4	SS 11	12.2 - 12.4 (255.2 - 255.0)	0	73	27	

The grain size distribution curves are presented in Figure No. B 3 in Appendix B.

5.5 Sand

Sand was encountered below the silty sand / sandy silt fill in Borehole BH 5 and below silt (Section 5.6) in Borehole BH 6. The sand extended to the termination depths of about 10.8 m (Elevation 259.0 m) in Borehole BH 5 and about 4.9 m (Elevation 260.8 m) in Borehole BH 6.

The sand was brown in color and contained trace silt and clay. The SPT 'N' values of the sand were all greater than 50 blows per 0.3 m, indicating a very dense condition. Measured moisture contents in the sand ranged from about 1 % to 17 %.

Grain size analyses were completed on two (2) samples of the sand, and the results are presented in Table 5.4.

**Table 5.4 - Results of Grain Size Analyses
(Sand)**

Borehole No.	Sample No.	Depth (Elevation) (m)	Percent Distribution (%)		
			Gravel	Sand	Fines (Silt and Clay)
BH 5	SS 10	10.7 - 10.8 (259.1 - 259.0)	0	89	11
BH 6	SS 6	4.6 - 4.9 (261.1 - 260.8)	0	87	13

The grain size distribution curves are presented in Figure No. B 4 in Appendix B.

5.6 Silt

Silt was encountered below the silty sand fill in Borehole BH 6. The silt extended to about 3.1 m below the existing grade (Elevation 262.6 m).

The silt was brown in color and contained trace sand and clay. Two (2) SPT 'N' values of the silt were 15 and 34 blows per 0.3 m, indicating a compact to dense condition. Two (2) measured moisture contents within the silt were both about 19 %.

A grain size analysis was completed on one (1) sample of the silt, and the result is presented in Table 5.5. The silt was non-plastic.

**Table 5.5 - Result of Grain Size Analysis
(Silt)**

Borehole No.	Sample No.	Depth (Elevation) (m)	Percent Distribution (%)			
			Gravel	Sand	Silt	Clay
BH 6	SS 4	2.3 - 2.7 (263.4 - 263.0)	0	9	87	4

The grain size distribution curve is presented in Figure No. B 5 in Appendix B.

5.7 Groundwater Conditions

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

The results of groundwater measurements are shown on the Record of Boreholes and summarized in Table 5.6.

Table 5.6 - Results of Groundwater Measurements

Borehole No.	Measured Groundwater Level	
	Depth (m)	Approximate Geodetic Elevation (m)
BH 1	7.2 m	258.6 m
BH 1A	1.7 m	257.7 m
BH 2	10.5 m	255.8 m
BH 3	1.3 m	257.9 m
BH 4	9.3 m	258.1m
BH 5	dry	-
BH 6	dry	-

It should be noted 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.

5.8 Soil Corrosivity

One (1) soil sample (BH 3 - SS 3) was analysed by Maxxam Analytics Laboratory in Mississauga to determine the soil corrosivity potential with respect to concrete and steel. The results are presented in Table 5.7, and the Certificates of Analyses are provided in Appendix C.

Table 5.7 - Results of Corrosivity Testing

Soil Sample No.	pH	Electrical Conductivity (µmho/cm)	Resistivity (ohm-cm)	Chloride (µg/g)	Sulphate (µg/g)
BH 3 - SS 3	7.4	453	2200	180	< 20

6.0 DISCUSSIONS AND RECOMMENDATIONS

In preparation of this report, the following drawings were available for information:

- i. Sheet 8 (GWP No. 2140-10-00) New Construction Highway 48 Sta. 15+000 to Sta. 15+340.
- ii. Highway 48 Embankment Cross-section Drawings (undated and un-numbered) at Sta. 15+075.000, Sta. 15+100.000, Sta. 15+200.000, Sta. 15+225.000, Sta. 15+250.000, Sta. 15+267.000 and Sta. 15+267.010.

The project comprises the following components:

- West side of Highway 48 : Road and embankment widening at
Approximately Sta. 15+075 to Sta. 15+110
- East side of Highway 48: Road and embankment widening at
Approximately Sta. 15+200 to Sta. 15+300
- East side of Highway 48: Culvert extension
or
No culvert extension with headwall / wingwall
combination at existing inlet (at Sta. 15+267)

The following sections discuss the geotechnical aspects of the proposed Highway 48 road and embankment widening and culvert extension options.

6.1 West Side of Highway 48

On the west side of Highway 48, the existing road and embankment will be widened from approximately Sta. 15+075 to Sta. 15+110. Two (2) cross-section drawings within the road section to be widened show that the existing Highway 48 roadway is approximately 19 m wide, and runs on top of an embankment built up approximately 4.0 to 4.5 m above the surrounding grades. The side slope of the existing embankment is about 1.8H:1V or flatter. The cross-section drawings also show that the roadway will be widened by approximately 4 m to the west. The widening would require placement of approximately 2.0 to 3.0 m thick new fill over the existing slope surface and toe area.

A global slope stability analysis was carried out for the proposed widened embankment section at Sta. 15+075 (Section A-A on Drawing Nos. 1 and 2) using GeoStudio 2007 Slope/W software (Version 7.17) employing the Bishop's simplified method.

Table 6.1 summarizes the soil parameters used for the global stability analysis. These soil parameters were assumed based on the soil conditions encountered in Boreholes BH 5 and BH 6. No freestanding groundwater was encountered in Boreholes BH 5 and BH 6. For the slope stability analyses, groundwater was considered at the elevation of 259.5 m, which is approximately 1 m higher than the groundwater elevations measured within the project limits (Table 5.6) to account for annual fluctuation. New compacted granular fill (refer to Table 6.1) was considered for the proposed road embankment widening, and also for replacement of about 1.5 m thick weak / loose fill at the toe area encountered in Borehole BH 6 (Section 6.4). The side slope for the widened embankment was considered to be 2H:1V. Because of the existing non-cohesive soils at the site, the effective stress analysis was used. For traffic loads, a surcharge of 15 kPa was applied on the pavement areas.

Table 6.1 - Summary of Soil Parameters

Soil Type	Unit Weight (kN/m ³)	Cohesion c' (kPa)	Angle of Internal Friction, ϕ' (Degree)
New fill (granular)	21	0	33
Existing fill	21	0	33
Dense silty sand / silt and sand (subgrade)	22	0	33

The results of global slope stability analysis are presented in Figure No. 1. Based on the results, the calculated minimum factor of safety is 1.7, which is sufficient to provide a stable slope.

6.2 East Side of Highway 48

On the east side of Highway 48, the existing road and embankment will be widened from approximately Sta. 15+200 to Sta. 15+300. Five (5) cross-section drawings within the road sections to be widened show that the existing roadway is approximately 18 to 19 m wide, and runs on top of an embankment about 6.5 to 7.0 m above the surrounding grades. The side slope of the existing embankment is about 2H:1V or flatter. The cross-section drawings also show that the road will be widened by approximately 3 to 4 m. The widening will require placement of approximately 1.5 to 2.0 m thick new fill over the existing slope surface and toe area.

A global slope stability analysis was carried for the proposed widened embankment at Sta. 15+225 (Section B-B on Drawing Nos. 1 and 2) using GeoStudio 2007 Slope/W software (Version 7.17) employing the Bishop's simplified method. This section was chosen for analysis as it was the most critical section (i.e., highest embankment) within the proposed road widening section.

Table 6.1 (Section 6.1) summarizes the soil parameters used for the global stability analysis. These soil parameters were assumed based on the soil conditions encountered in Boreholes BH 4 and BH 3. Groundwater was encountered in the boreholes at elevation of about 258.0 m. For the slope stability analysis, groundwater was considered at elevation of 259.5 m. New compacted fill (granular) was considered for the proposed widening and also for replacement of about 2 m weak / loose fill at the toe area encountered in Borehole BH 3. The side slope of the widened embankment was considered to 2H:1V. Because of the existing non-cohesive soils at the site, the effective stress analysis was used. For traffic loads, a surcharge of 15 kPa was applied on the pavement areas.

The results of global slope stability analysis are presented in Figure No. 2. Based on the results, the calculated minimum factor of safety is 1.6, which is sufficient to provide a stable slope.

6.3 Culvert at Sta. 15+267

An existing 1500 x 1600 RFO culvert is located at the unnamed tributary of Mount Albert Creek crossing at Sta. 15+267. The existing roadway at this location is approximately 18 m wide, and runs on top of an embankment approximately 7.0 m above the surrounding grades. The side slope of the existing embankment is approximately 2H:1V. The road and embankment cross-section drawing at Sta. 15+267 shows that the road will be widened by about 2.5 to 3.0 m. The widening will require placement of approximately 1.5 m thick new fill (granular) over the existing slope surface. The height of fill above the invert of the existing culvert would be approximately 2.0 m. Currently, no headwall or wingwall is in place adjacent to the culvert inlet (east end).

6.3.1 Comparison of Culvert Extension and No Culvert Extension Options

Based on the TOR, two (2) alternative options are being considered, namely; (i) culvert extension; and (ii) no culvert extension coupled with a headwall / wingwall combination to retain the proposed roadway embankment widening. The headwall / wingwall may comprise a combination of cast-in-place headwall and Retained Soil System (RSS) wingwalls, or RSS wingwalls and headwall. A comparison of these options is provided in Table 6.2.

Table 6.2 - Comparison of Culvert Extension and No Culvert Extension Options

Option	Description	Advantages	Disadvantages	Risks / Consequences	Cost Comparison
Culvert extension	Existing 1500 x 1600 RFO culvert will be extended to accommodate the widened embankment without the use of a head wall.	Minimum excavation of the existing slope at the culvert inlet area. New embankment at the extended culvert can be constructed in the similar way from the toe to the top of the new embankment.	Will require dewatering and/or water flow diversion during construction. Excavation adjacent to and below the existing culvert foundation will be required to install the new culvert section.	Differential settlement could result in poor hydraulic flow (low spots) and ponding within the culvert. May require special permits from the related conservation authority due to disruption of water flow in the creek.	high
No culvert extension	Headwall / wingwall will be constructed at toe areas above and on either side of existing RFO culvert to support the widened embankment. (cast-in-place headwall and RSS wingwalls, or RSS wingwalls and headwall, or similar gravity-type walls)	Construction is relatively simple. RSS walls are flexible type of structure. Can accommodate minor relative settlement. Does not significantly interfere with creek water flow.	Excavation around the existing culvert inlet slope will be required. RSS Wall requires specialised contractor according to MTO's DSM.	Reduces stability of the existing embankment by excavating its toe. Temporary shoring may be required for the installation of walls.	low to medium

Based on the information in Table 6.2, 'no culvert extension' would be the better option, because of relatively simple construction, flexible structure and possibly lower construction cost. The type of wall will be based on constructability, cost, etc.

6.3.2 Culvert Extension

If the culvert extension option is chosen, the following recommendations should be considered.

The invert of the existing culvert lies below the elevation of about 257.5 m, and the new foundations are anticipated to be at or below the same grade. Dense to very dense sandy gravel / gravelly sand is likely to be encountered at the founding elevation, although Borehole BH 3 indicates that minor sub-excavation to remove incompetent soils could be required. Sub-excavation may also be required to remove any incompetent fill, loose, and/or otherwise deleterious materials, if any. If sub-excavation is required, the grade can be restored by placing lean concrete (or approved similar) up to the proposed founding elevation.

The geotechnical Ultimate Limit State (ULS)/Serviceability Limit State (SLS) values provided in Table 6.3 should be used for the design of the culvert extension.

Table 6.3 - SLS and ULS Values for Shallow Footings

Borehole No.	Founding Stratum	Depth below existing grade (m)	Approximate Elevation (m)	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS ⁽¹⁾ , (kPa)
BH 3	Fill soils	1.0 - 2.1 m (±)	257.0 m and above	Not recommended	Not recommended
	Dense to very dense sandy gravel / gravelly sand	2.1 m (±) & below	257.1 m and below	200	300

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

The soil parameters in Table 6.4 may be used for design.

Table 6.4 - Summary of Geotechnical Parameters

Soil Stratum	Bulk Unit Weight of Soil, γ (kN/m ³)	Earth Pressure Coefficient		
		At-rest, K_o	Active, K_a	Passive, K_p^*
Existing fill	21	0.42	0.32	2.0
New fill (granular)	21	0.40	0.30	2.0
Granular B	21	0.40	0.30	2.0

* The K_p (passive condition) values are reduced in order to limit the lateral soil movement that is required to mobilize the passive resistance.

A frost penetration depth of 1.2 m should be used at this site. 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.

For construction of culvert foundations, OPSS 902 (Nov/10) - Construction Specifications for excavating and Backfilling - Structures should be followed. Backfill, backfill transition and cover for the concrete culvert should conform to OPSD 803.010. The excavation and groundwater control are discussed in Section 6.5.

Any organic soils and other deleterious materials encountered must be excavated from beneath the foundation limits. As per the specification (OPSS 902), the excavation should be inspected by the Contract Administrator. Lean concrete mud mat (or approved material) should be placed at the exposed subgrade for foundation construction.

6.3.3 Head Wall / Wingwall (No Culvert Extension)

If the no culvert extension is selected, a RSS headwall / wingwall or cast-in-place headwall and RSS wingwall, or similar gravity-type retaining walls, will be required at the end of the culvert (inlet) to support the widened embankment. Based on the available road and embankment cross-section drawing at Sta. 15+267, the base of the headwall / wingwall would be at an approximate elevation of 257.5 m, with an approximately 2 m high wall.

- **Slope Stability Analysis**

A global slope stability analysis was carried for the slope at the culvert location (Sta. 15+267), with headwall / wingwall, using GeoStudio 2007 Slope/W software (Version 7.17) employing the Bishop's simplified method. For the analysis, the height of gravity-type headwall / wingwall was assumed as 2.0 m.

Table 6.5 summarizes the soil parameters used for the global stability analysis. These soil parameters were assumed based on the soil conditions encountered in the Boreholes BH 2 and BH 3. Groundwater was encountered in Borehole BH 3 at an elevation of about 258.0 m. For the slope stability analyses, as noted in Section 6.1, groundwater was considered at the elevation of 259.5 m. New compacted fill (granular) was considered for the proposed widening. The side slope of the widened embankment was considered to be 2H:1V. Because of the generally sandy soils existing at the site, effective stress parameters were used in the slope analysis. For traffic loads, a surcharge of 15 kPa was applied on the pavement areas.

Table 6.5 - Summary of Soil Parameters

Soil Type	Unit Weight (kN/m ³)	Cohesion, c' (kPa)	Angle of Internal Friction, ϕ' (Degree)
Headwall / wingwall*	24	1000	35
New fill (granular)	21	0	33
Existing fill	21	0	33
Dense silty sand (subgrade)	22	0	33
Granular B (or similar for wall backfill)	21	0	33

* Soil parameters for the gravity-type headwall / wingwall are used only for slope stability modelling purpose to disregard slip surface through the wall.

The results of global slope stability analysis are presented in Figure No. 3. Based on the results, the calculated minimum factor of safety is 1.5. The slope at the culvert with the headwall / wingwall should be stable.

• Design and Construction

The subgrade for the headwall / wingwall wall will likely consist of fill soils (Borehole BH 3), which are not considered suitable to support the wall. To prepare the subgrade, all topsoil and soil mixed with topsoil / organic matter and loose/soft soil, if any, should be removed down to about 2.0 m (Elevation of about 257.0 m as mentioned in Section 6.4). The exposed subgrade should be proof-rolled (or similar) and any loose, soft or unstable areas sub-excavated. The final subgrade should be inspected by Contract Administrator. After the bearing surface is approved, lean mix concrete or 20 mm crusher-run limestone (or equivalent) should be placed to restore the grade to the base of the walls.

The geotechnical ULS/SLS values provided in Table 6.3 may be used for the design of the wall footing. If the footing is placed on properly compacted soil, as noted above, a geotechnical reaction / resistance of 150 kPa (SLS) and 225 kPa (factored ULS) may be used for design purposes, provided the subgrade is prepared as described in the preceding section. The soil parameters in Table 6.4 may be used for design.

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

For sliding resistance, the unfactored coefficient of friction at the base of head wall / wingwall should be considered as follows:

- Granular fill and non-cohesive subgrade – 0.40
- Concrete and non-cohesive subgrade – 0.35

A resistance factor of 0.8 should be considered.

The headwall / wingwall wall should be backfilled with granular soil (OPSS granular 'A' or granular 'B') and placed in 125 mm thick loose lifts that can be compacted with light equipment without damaging the walls to at least 98% of Standard Proctor Maximum Dry Density (SPMDD).

The headwall / wingwall wall should be provided with a positive drainage system to prevent the build up of hydrostatic pressure. It is recommended that a suitable nonwoven geotextile (Terrafix 270R or equivalent) be installed between the free draining granular backfill and earth fill / native soils, or immediately behind and underneath the wall, 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.

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 6.5.

Excavations to replace fill / incompetent soils with lean concrete or compacted granular fill below the proposed wall should be carried out carefully to ensure that the existing foundation of the adjacent culvert is 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.

6.4 Embankment Widening Construction

The embankment widening should be constructed with compacted engineered fill at 2H:1V (or flatter) side slopes. The construction should be in accordance with OPSS 501 (Construction Specification for Compacting) and OPSS 206 (Construction Specification for Grading). Bonding between the existing embankment fill and new fill should be achieved as per OPSD - 208.010 (Benching of Earth Slopes). The selection, placement and compaction of the fill should be carried out under a geotechnical control program.

All topsoil, organic matters, soft / loose and unsuitable soils should be removed from the footprint of the proposed widening areas, as per Ministry of Transportation of Ontario's current practice, with an envelope given by a gradient not steeper than 1H:1V away from the toe of the embankment. Topsoil should be stripped from existing slope prior to placement of new embankment fill. The investigation indicated that there was very loose silty sand fill along the existing toes at the locations of Boreholes BH 3 and BH 6. For the west side of the existing embankment, the subgrade preparation will require stripping of about 1.5 m surficial fill soils (Elevation 264.3 m) under the footprint area of the embankment widening and replace with compacted engineered fill. The minimum lateral extent of excavation at the toe of the widened embankment should be the sum of the width of the footprint of the widened embankment plus the depth of excavation. At the east side of the embankment, it is possible that the surficial soils below the footprint of the embankment widening would have to be stripped to about 2.0 m depth (Elevation 257.0 m) at the vicinity of Borehole BH 3. If deeper excavation is required during construction, a temporary shoring system (e.g, trench box) may be required. The stripping / removal of the very loose soil at the embankment toe should not cause any instability to the existing road embankment.

After stripping, the exposed subgrade should be inspected by the Contract Administrator. Backfill over the excavated surface should be properly compacted to a minimum of 98 % Standard Proctor Maximum Dry Density (SPMDD), under the supervision of qualified geotechnical personnel. Any soft spots identified during stripping and/or re-compacting should be sub-excavated and replaced with compacted engineered fill. Care should be exercised to minimize disturbance to the subgrade during preparation and the construction of embankment.

The fill soils used for the proposed embankment widening should consist of approved, clean granular fill (e.g. Select Subgrade Materials - OPSS 1010). The existing silty sand / sandy silt fill soils are acceptable, provided their water contents are within $\pm 2\%$ of the optimum water contents and no organic matter is present. Each loose lift should not exceed 200 mm before compaction and should be uniformly compacted to at least 98% of SPMDD of the materials.

Provided that the widened embankment is founded on dense to very dense soils at its toe and the new fill is properly compacted on the existing embankment side slope, its long-term settlement should not be significant. The subgrade settlement under the new embankment load should be immediate in nature and should be completed during or shortly after construction.

6.5 Other Construction Considerations

- **Construction Detour**

The construction of the road embankment widening will likely require the closure of one traffic lane, unless a construction detour can be provided. Proper traffic control is necessary, if one traffic lane is closed.

- **Erosion Control**

Proper erosion control measures of the existing and new embankment surfaces should be implemented, both during construction and on a permanent basis. This can be achieved by immediate seeding or sodding (OPSS 572) or equivalent.

- **Excavation and Groundwater Control**

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 sand / sandy silt fill	Type 3
Compact to dense sandy gravel / gravelly sand / silty sand	Type 2 (above water)
	Type 3 (below water)

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. Temporary shoring may be required, if a 1H:1V slope cannot be established during the construction of culvert extension or head wall/wingwall, and should be in accordance with OPSS 539 (Construction Specification for Temporary Protection Systems).

In order to prevent slope instability of the existing road embankment, excavation along the toe of the existing embankment should follow OPSS 209 (Construction Specification for Embankment over Swamps and Compressible Soils), particularly Section 209.07.03. However, the statement in Section 209.07.03 that "Excavation shall be to the full width and full depth in one operation to backfilling" should be used only when the excavation will not compromise the stability of the existing road embankment. For soft/loose soils located immediately along the toe of the existing road embankment, the requirement of OPSS 209.07.03 that "The operations of excavating and backfilling shall be carried out simultaneously" should be followed. Any excavation beyond the toe of the existing embankment should limit the maximum length along the existing highway alignment, which depends on the actual soil conditions encountered, so that the slope stability of the road embankment will not be compromised at any time. Such an excavation should be backfilled without delay at least to the same original level prior to extending the excavation length. The existing road embankment cannot be undermined at any time without the approval of the Contract Administrator.

Groundwater may be encountered during excavation due to the presence of sandy soils near the existing ground surface and the existing creek. Other water sources could be perched groundwater and/or surface runoff. Dewatering in the excavation within the footprint of the road

embankment widening could be carried out by gravity drainage and/or pumping from a properly filtered sump. The base of the excavation should be graded towards a sump in order to drain any surface water inflow into the excavation and avoid excessive softening of the road embankment subgrade.

No major excavation difficulties are foreseen, but allowance should be made for boulders/ cobbles and / or rip-raps, or similar, which could be present in fill soils and native soil deposits. Dewatering within the widened embankment toe area may be required for a dry working area. Dewatering, if required, should proceed ahead of the excavation operation.

6.6 Construction Specifications

Construction specifications, which should be included in the Contract Documents, where applicable, are provided in Table 6.6.

Table 6.6 - List of Construction Specifications and Drawings

Specification / Drawing	Title
Specifications	
OPSS 180 (Nov/05)	General Specification for the Management and Disposal of Excess Materials
OPSS 206 (Nov/09)	Construction Specification for Grading (Re-issued 2010-11)
OPSS 902 (Nov/10)	Construction Specifications for excavating and Backfilling
OPSS 501 (Nov/10)	Construction Specification for Compacting
OPSS 539 (Nov/09)	Construction Specification for Temporary Protection Systems
OPSS 1010(Apr/04)	Material Specifications for Aggregates – Base, subbase, select subgrade, and backfill material
Drawings	
OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill, backfill transition and cover for the concrete culvert

6.7 Special Provisions

The following Special Provisions should be included in the contract documents regarding the groundwater conditions.

- Special Provision No. SP 199S48 (December 2005) - Quality Verification Engineering Services
- Special Provision No. SP 539S01 - Design of Protection System for Retained Soil Systems (RSS) - if RSS is selected;
- Special Provision No. SP 599S22 (March 2001) - Design, Supply and Construction of Retained Soil Systems (RSS) - if RSS is selected;
- Special Provision No. SP 599S23 (March 2001) – Requirements for material, quality control and quality assurance testing and acceptance criteria for Retained Soil Systems (RSS) - if RSS is selected;

6.8 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. The foundation subgrade and excavations should be inspected by the Contract Administrator. Quality Verification Engineer (QVE), as per MTO protocol, may be required in some cases as expressed in the relevant specifications.

7.0 CLOSURE

The sub-soil information contained in this report should be used solely for the purpose of proposed widening of Highway 48 and Herald Road, East Gwillimbury, Ontario.

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

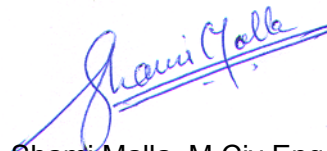
This report was prepared by Mohammad Mollah, M.Eng., P.Eng. and Shami Malla, M. Civ. P.Eng., and was reviewed by Prapote Boonsinsuk, Ph.D., P.Eng.

Sincerely,

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



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



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**AMEC Environment & Infrastructure,
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REPORT LIMITATIONS

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.

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

DRAWINGS

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PURCHASE ORDER NUMBER:

2009-E-0041

W.P. NO. 2140-10-00

GEORES NO. 31D-532

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 48 AND HERALD ROAD WIDENING
FROM STA. 15+050 TO STA. 15+340
TOWN OF EAST GWILLIMBURY, ONTARIO

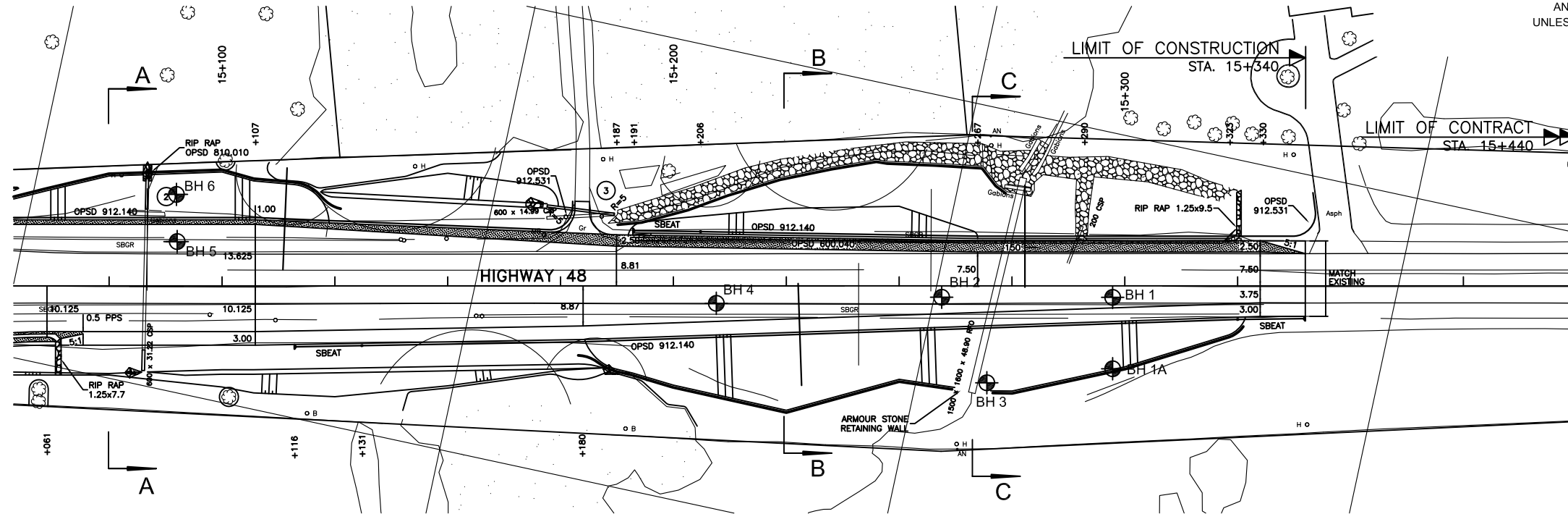
BOREHOLE LOCATION PLAN & SOIL STRATA

ameco

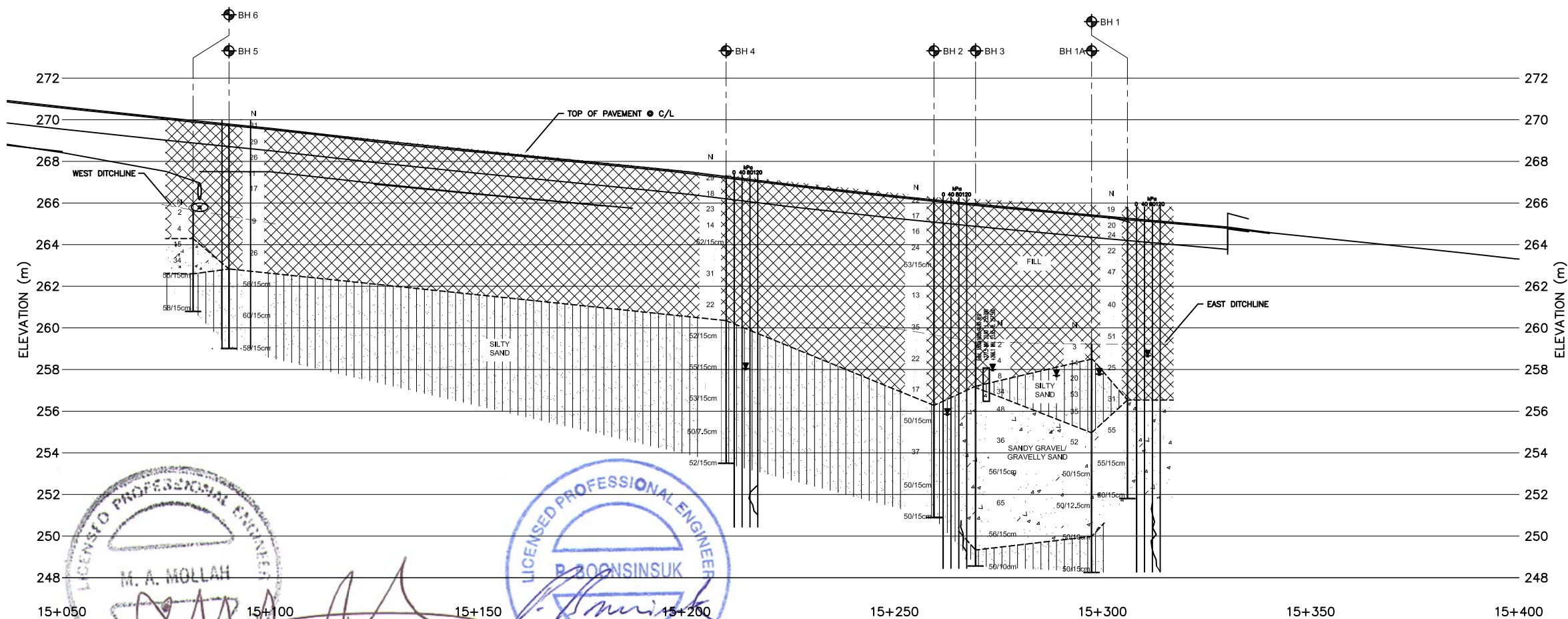
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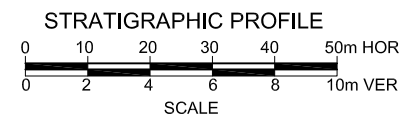
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PLAN



PROFILE



KEY PLAN

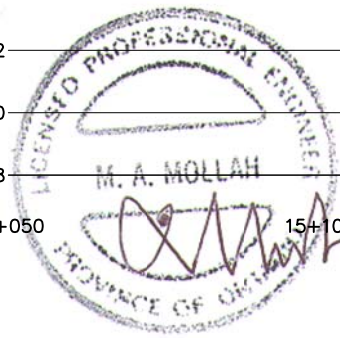
Approximate Scale

LEGEND

- BOREHOLE
- 'N' BLOWS / FT
- GROUNDWATER LEVEL AT TIME OF INVESTIGATION

BOREHOLE	MTM COORDINATES		ELEVATION (m)
	NORTHING	EASTING	
BH 1	4885925	634768	265.8
BH 1A	4885930	634760	259.2
BH 2	4885901	634472	266.3
BH 3	4885907	634792	259.3
BH 4	4885857	634782	267.4
BH 5	4885721	634800	269.8
BH 6	4885721	634793	265.7

DESIGN PB	CHK PB	DATE MAR. 2012
DRAWN KW	CHK MM	DWG 1



METRIC
DIMENSIONS ARE IN METRES
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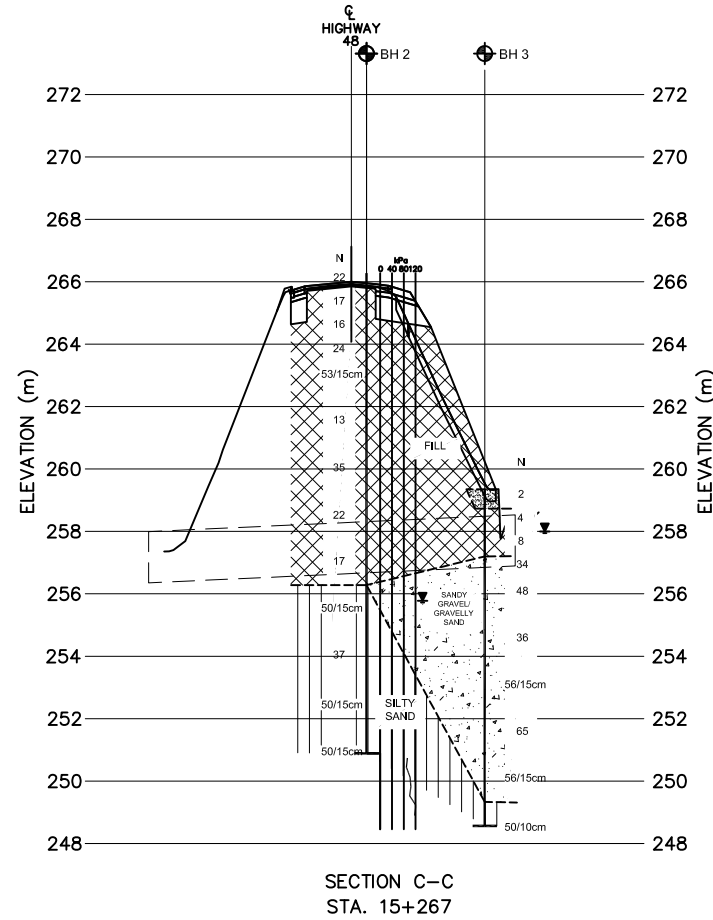
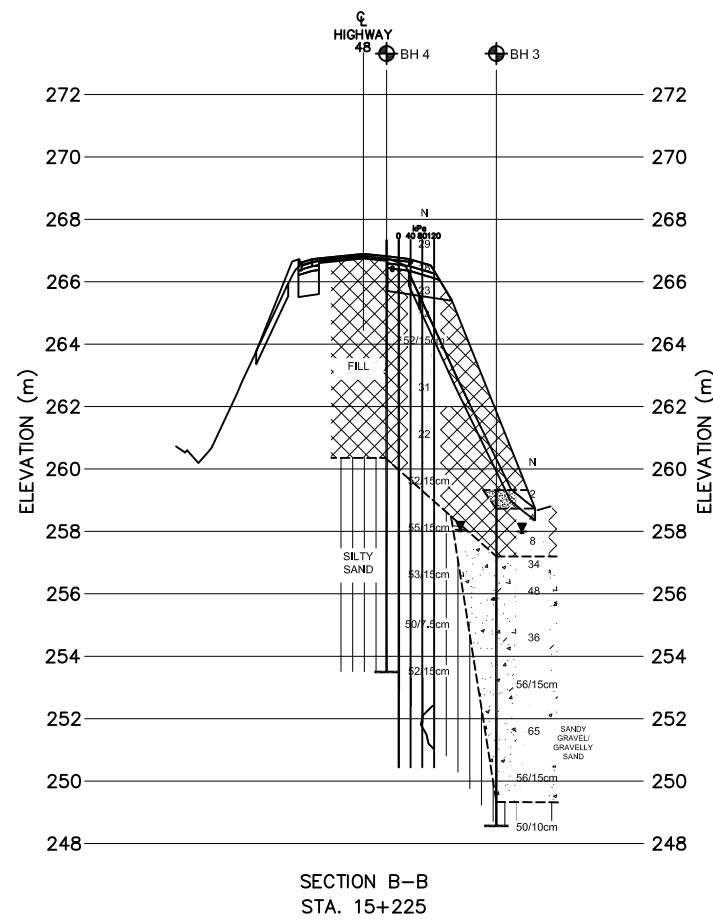
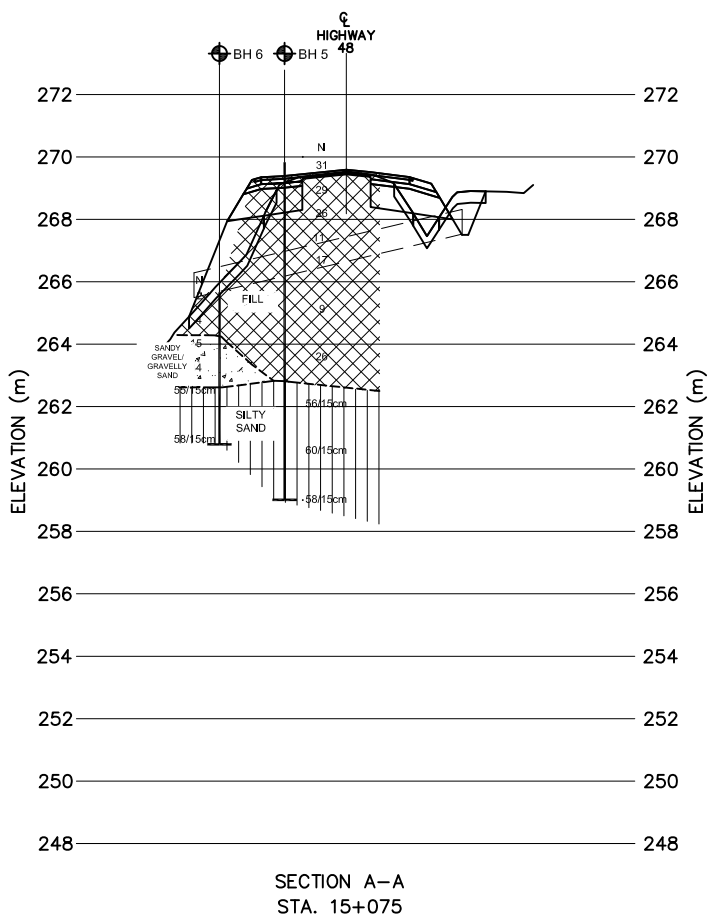
PURCHASE ORDER NUMBER:	2009-E-0041
W.P. NO.	2140-10-00
GEORES NO.	31D-532

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 48 AND HERALD ROAD WIDENING
FROM STA. 15+050 TO STA. 15+340
TOWN OF EAST GWILLIMBURY, ONTARIO
SOIL STRATIGRAPHY



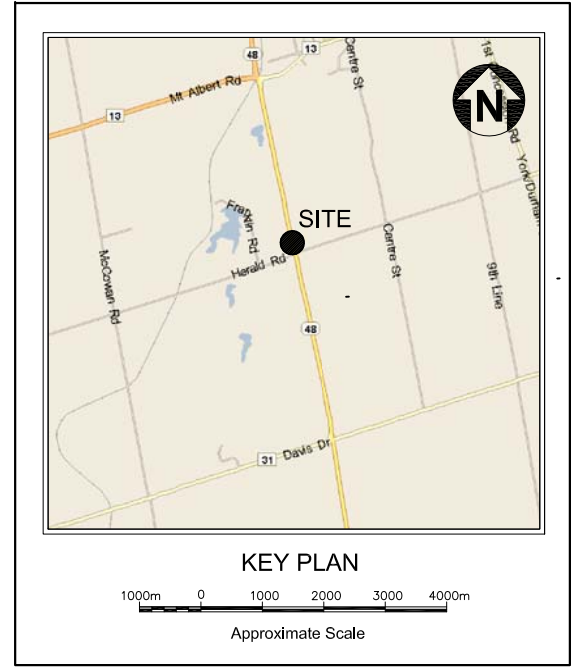
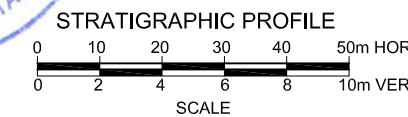
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SHEET
1 OF 1



LICENSED PROFESSIONAL ENGINEER
M. A. MOLLAH
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
B. BOONSINSUK
PROVINCE OF ONTARIO



LEGEND			
	BOREHOLE		
	'N' BLOWS / FT		
	GROUNDWATER LEVEL AT TIME OF INVESTIGATION		
BOREHOLE	MTM COORDINATES		ELEVATION (m)
	NORTHING	EASTING	
BH 1	4885925	634768	265.8
BH 1A	4885930	634760	259.2
BH 2	4885901	634472	266.3
BH 3	4885907	634792	259.3
BH 4	4885857	634782	267.4
BH 5	4885721	634800	269.8
BH 6	4885721	634793	265.7

DESIGN PB	CHK PB	DATE MAR. 2012
DRAWN KW	CHK MM	DWG 2

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FIGURES

Ref: TP110092.007

Highway 48 and Herald Road Widening

Section A-A at Sta. 15+075 (Based on Boreholes BH 5 and BH 6)

Effective Stress Analysis with Groundwater Assumed at 259.5 m

Soil Properties

Soil Layer No.	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (Deg.)	
1	21	0	33	(New Fill - granular)
2	21	0	33	(Existing Fill - silty sand / silt and sand)
3	22	0	33	(Dense silty sand / silt and sand)

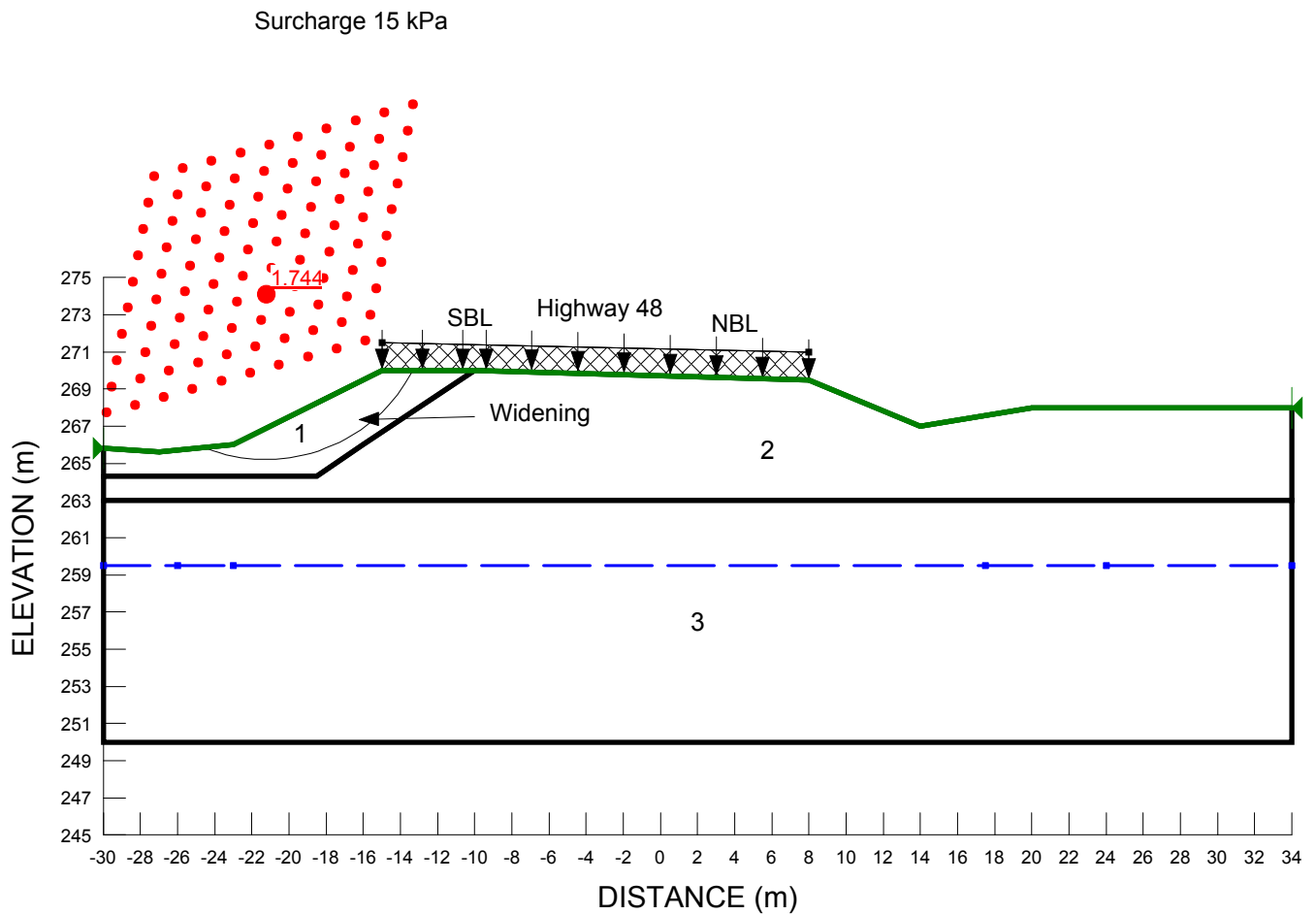


Figure No. 1 Slope Stability Analysis for Section A - A (Sta. 15 + 075)

Ref: TP110092.007

Highway 48 and Herald Road Widening

Section B-B at Sta. 15+225 (based on Boreholes BH 4 and BH 3)

Effective Stress Analysis with Groundwater Assumed at 259.5 m

Soil Properties

Soil Layer No.	Unit Wt. (kN/m ³)	Cohesion (kPa)	Friction Angle (Deg.)	
1	21	0	33	(New Fill - granular)
2	21	0	33	(Existing Fill - silty sand / silt and sand)
3	22	0	33	(very dense Silty sand / silt and sand)

Surcharge 15 kPa

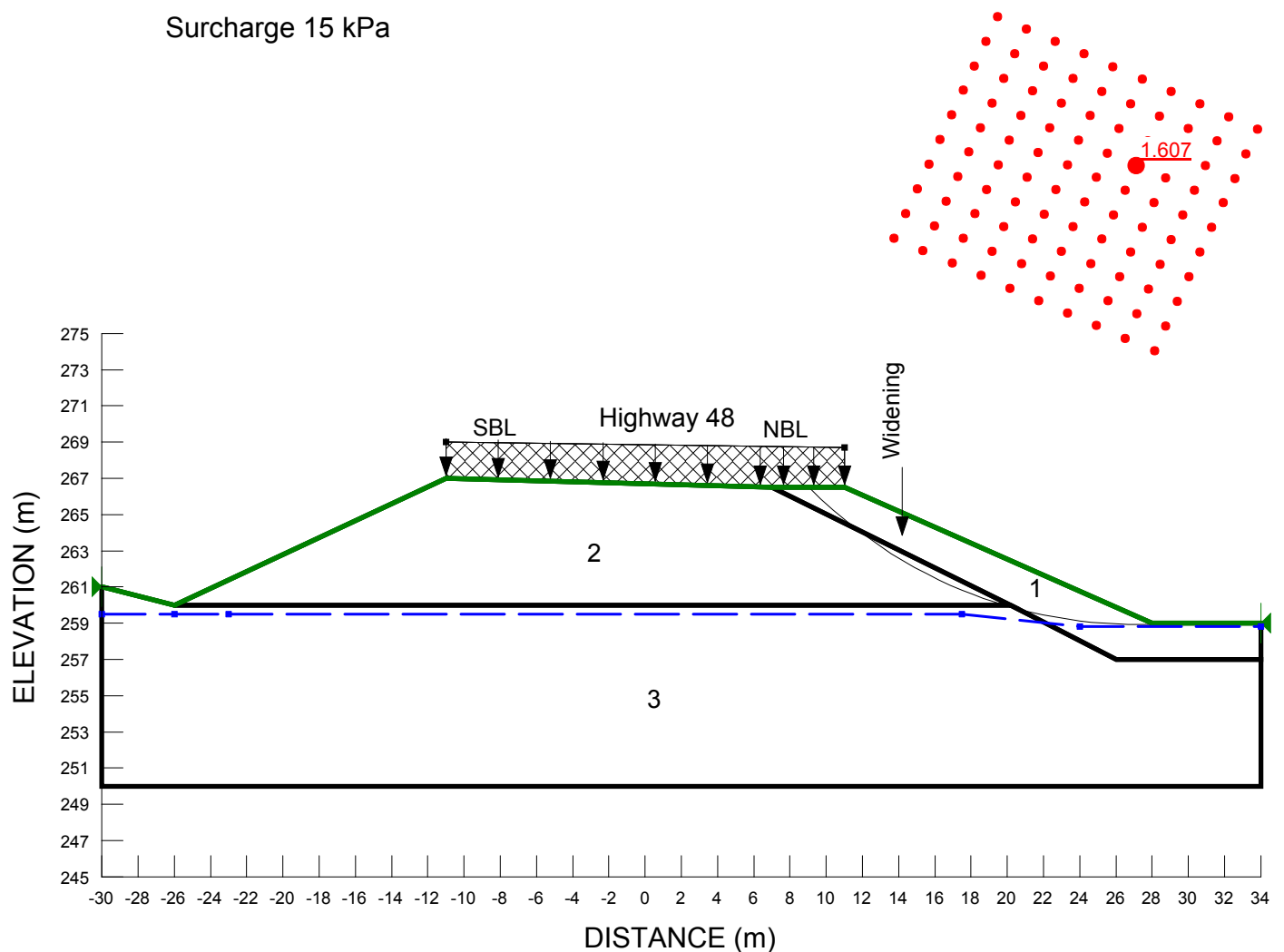


Figure No. 2 Slope Stability Analysis for Section B - B (Sta. 15 + 225)

Ref: TP110092.007

Highway 48 and Herald Road Widening

Cast-in-place or RSS Headwall at Sta. 15+267 (Based on Boreholes BH 2 and BH 3)

Effective Stress Analysis with Groundwater Assumed at 259.5 m

Soil Properties

Soil Layer No.	Bulk Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (Deg.)	
1	24	1000	35	(Wall)
2	21	0	33	(New Fill - granular)
3	21	0	33	(Existing Fill - silty sand / silt and sand)
4	22	0	33	(Dense Silty sand)
5	21	0	33	(Granular B)

Surcharge 15 kPa

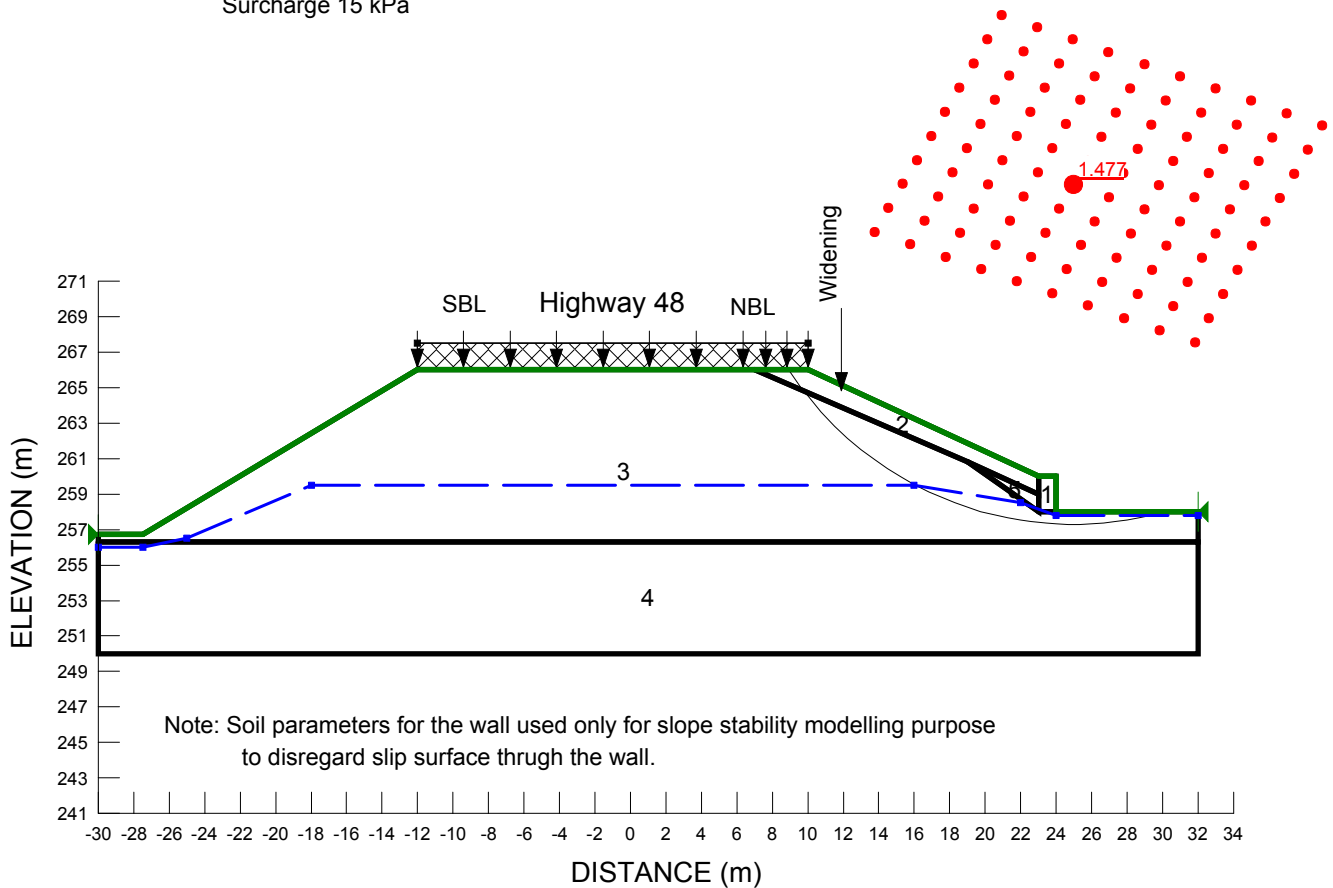


Figure No. 3 Slope Stability Analysis at Culvert Inlet (Sta. 15 + 267)

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.

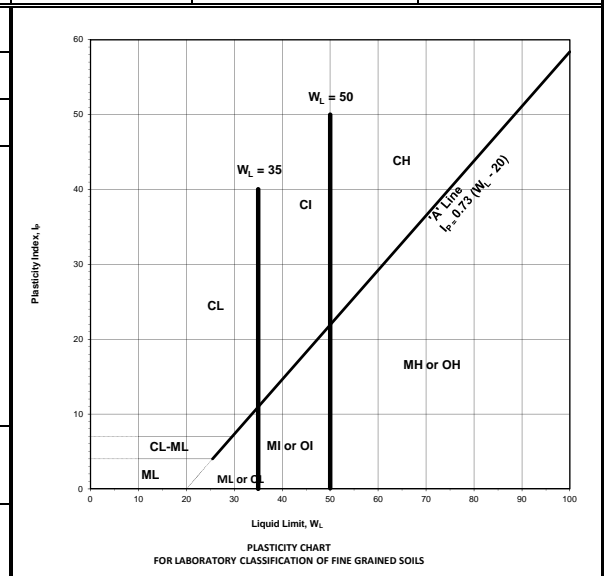
MTC SOIL CLASSIFICATION

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 PARTICULAR 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.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3				
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH STONE INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES						
		GRAVEL WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND- SILT MIXTURES						
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES						
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNT OF ALL INTERMEDIATE PARTICLE SIZES	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES			FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION & DRAINAGE CHARACTERISTICS	NOT MEETING ALL GRADATION REQUIREMENTS FOR GW		
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES						
SANDS WITH FINES (APPLICABLE AMOUNT OF FINES)		NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES							
		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.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3			
	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.	NOT MEETING ALL GRADATION FOR SW	
		NONE	QUICK	NONE	ML						INORGANIC SILTS & SANDY SILTS OR SLIGHTLY PLASTICITY, ROCK FLOUR
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL						SILTY CLAYS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS
		SLIGHT TO MEDIUM	SLOW	SLIGHT	OL						ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS
	LIQUID LIMIT BETWEEN 35 AND 50	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI						INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS
		HIGH	NONE	MEDIUM TO HIGH	CI						SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY
		SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI						ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY
		SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH						INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMEACACOUS FINE SANDY SILTS, ELASTIC SILTS
	LIQUID LIMIT GREATER THAN 50	HIGH TO VERY HIGH	NONE	HIGH	CH						CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS
		MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH						ORGANIC CLAYS OF HIGH PLASTICITY
		HIGH ORGANIC SOILS			READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE						Pt

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 Environment & Infrastructure,
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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

1 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532		LOCATION	Stn. 15+290 : N4885925 E634768	1 OF 2	ORIGINATED BY	JF
DIST E. Gwillimbury HWY 48		BOREHOLE TYPE	200 mm diameter borehole (Hollow Stem)		COMPILED BY	SAL
DATUM Geodetic		DATE	13 October 2011 - 13 October 2011		CHECKED BY	SM
PROJECT Highway 48 and Herald Road Widening					JOB NO.	TP110092.007

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

G.W.P. 2140-10-00; Geocres No. 31D-532	LOCATION Stn. 15+290 : N4885925 E634768	2 OF 2	ORIGINATED BY JF
DIST E. Gwillimbury HWY 48	BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem)		COMPILED BY SAL
DATUM Geodetic	DATE 13 October 2011 - 13 October 2011		CHECKED BY SM
PROJECT Highway 48 and Herald Road Widening			JOB NO. TP110092.007

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

RECORD OF BOREHOLE No BH 1A

1 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532 LOCATION Stn. 15+290 ; N4885930 E634760 ORIGINATED BY JF
 DIST E. Gwillimbury HWY 48 BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem) COMPILED BY SAL
 DATUM Geodetic DATE 13 October 2011 - 13 October 2011 CHECKED BY SM
 PROJECT Highway 48 and Herald Road Widening JOB NO. TP110092.007

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				
259.2 0.0	about 300 mm TOPSOIL																	
258.9 0.3	brown Silty Sand / Sandy Silt FILL trace clay moist		1	SS	3		259											
258.5 0.7	brown SILTY SAND trace gravel and clay compact to very dense moist to wet		2	SS	14		1											
							258											
							257											
	trace cobbles / boulders in SS 4		3	SS	20		2											
							256											
							255											
255.0 4.3	brown SANDY GRAVEL / GRAVELLY SAND some silt trace cobbles / boulders very dense wet		4				5											
			5				6											
			6				7											
			7	SS	50/15cm		8											
			8	SS	50/12.5cm		251											


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

RECORD OF BOREHOLE No BH 2

1 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532 LOCATION Stn. 15+260 : N4885901 E634472 ORIGINATED BY JF
 DIST E. Gwillimbury HWY 48 BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem) COMPILED BY SAL
 DATUM Geodetic DATE 13 October 2011 - 13 October 2011 CHECKED BY SM
 PROJECT Highway 48 and Herald Road Widening JOB NO. TP110092.007

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
									○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	20					40	60	80				
266.3									20	40	60	80	100				kN/m ³							
0.0	brown Sand and Gravel FILL some silt moist		1	SS	22		266								○									
265.7																								
0.6	brown Silty Sand / Silt & Sand / Sandy Silt FILL trace gravel, trace to some clay moist		2	SS	17		1									○								
								265																
				3	SS	16											○							
								264									○							
				4	SS	24																		
								3																
	--- trace cobbles / boulders			5	SS	53/15cm		263								○								
								4																
							262																	
	trace organic matter in SS 6		6	SS	13		5									○								
							261																	
							6																	
			7	SS	35		260								○									
							7																	
							259																	
	--- grey		8	SS	22		8								○									
							258																	
	pocket of grey silty clay fill																							

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2 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532	LOCATION Stn. 15+260 : N4885901 E634472	2 OF 2	ORIGINATED BY JF
DIST E. Gwillimbury HWY 48	BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem)		COMPILED BY SAL
DATUM Geodetic	DATE 13 October 2011 - 13 October 2011		CHECKED BY SM
PROJECT Highway 48 and Herald Road Widening			JOB NO. TP110092.007





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

RECORD OF BOREHOLE No BH 3

1 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532 LOCATION Stn. 15+270 ; N4885907 E634792 ORIGINATED BY JF
 DIST E. Gwillimbury HWY 48 BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem) COMPILED BY SAL
 DATUM Geodetic DATE 12 October 2011 - 12 October 2011 CHECKED BY SM
 PROJECT Highway 48 and Herald Road Widening JOB NO. TP110092.007

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	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	20						40	60	80
259.3 0.0	about 600 mm of TOPSOIL		1	SS	2		259														
258.7 0.6	dark brown to brown Silty Sand FILL trace to some clay trace rootlets moist		2	SS	4		1														
			3	SS	8		2														
257.1 2.1	brown SANDY GRAVEL / GRAVELLY SAND some silt dense to very dense wet		4	SS	34		257									33 59	(8)				
	trace cobbles / boulders		5	SS	48		256														
			6	SS	36		255										66 31	(3)			
			7	SS	56/15cm		253														
			8	SS	65		251														

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

G.W.P. 2140-10-00; Geocres No. 31D-532	LOCATION Stn. 15+270 : N4885907 E634792	2 OF 2	ORIGINATED BY JF
DIST E. Gwillimbury HWY 48	BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem)		COMPILED BY SAL
DATUM Geodetic	DATE 12 October 2011 - 12 October 2011		CHECKED BY SM
PROJECT Highway 48 and Herald Road Widening			JOB NO. TP110092.007



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

RECORD OF BOREHOLE No BH 4

1 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532 LOCATION Stn. 15+210 ; N4885857 E634782 ORIGINATED BY JF
 DIST E. Gwillimbury HWY 48 BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem) COMPILED BY SAL
 DATUM Geodetic DATE 12 October 2011 - 12 October 2011 CHECKED BY SM
 PROJECT Highway 48 and Herald Road Widening JOB NO. TP110092.007

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa							PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L			
									○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
									WATER CONTENT (%)												
267.4									20	40	60	80	100	10	20	30	GR	SA	SI	CL	
0.0	brown Sand and Gravel FILL some silt moist		1	SS	29		267							○			10	30	52	8	
266.9																					
0.5	brown													○							
266.7	Gravelly Sand FILL some silt moist		2	SS	18		1														
0.7	brown to dark brown Silty Sand / Sandy Silt FILL some clay moist trace organic matter in SS 3																				
				3	SS	23		266							○						
								2													
			4	SS	14		265								○						
							3														
			5	SS	52/15cm		264								○						
							4														
							263														
			6	SS	31		5								○						
							262														
							6														
			7	SS	22		261								○						
							7														
260.4	brown SILTY SAND / SILT & SAND trace clay very dense moist to wet						260										0	50	48	2	
7.0			8	SS	52/15cm		8								○						
							259														

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

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

1 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532		LOCATION	Stn. 15+090; N4885721 E634800	1 OF 2	ORIGINATED BY	JF
DIST E. Gwillimbury HWY 48		BOREHOLE TYPE	200 mm diameter borehole (Hollow Stem)		COMPILED BY	SAL
DATUM Geodetic		DATE	12 October 2011 - 12 October 2011		CHECKED BY	SM
PROJECT Highway 48 and Herald Road Widening					JOB NO.	TP110092.007

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT			NATURAL MOISTURE CONTENT			LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)									
									○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE	LAB VANE	W _p	W	W _L						
269.8						20	40	60	80	100	10	20	30										
0.0	brown Sand and Gravel FILL some silt moist		1	SS	31																		
269.2	brown / grey Gravelly Sand FILL some silt trace cobbles / boulders moist		2	SS	29																		
268.5	brown Silty Sand / Silt & Sand / Sandy Silt FILL trace to some gravel trace clay wet		3	SS	26																		
1.4	trace organic matter in SS 5		4	SS	11																		
			5	SS	17																		
			6	SS	9																		
			7	SS	26																		
			8	SS	56/15cm																		
262.8	brown to grey SAND trace clay very dense moist																						
7.0																							

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

RECORD OF BOREHOLE No BH 5

2 OF 2

G.W.P. 2140-10-00; Geocres No. 31D-532 LOCATION Stn. 15+090; N4885721 E634800 ORIGINATED BY JF
 DIST E. Gwillimbury HWY 48 BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem) COMPILED BY SAL
 DATUM Geodetic DATE 12 October 2011 - 12 October 2011 CHECKED BY SM
 PROJECT Highway 48 and Herald Road Widening JOB NO. TP110092.007

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
						20 40 60 80 100 20 40 60 80 100												
259.0	brown to grey SAND trace clay very dense moist		9	SS	60/15cm													
10.8			10	SS	58/15cm													
	End of Borehole Note: The borehole was dry on completion of drilling.																	

RECORD OF BOREHOLE No BH 6

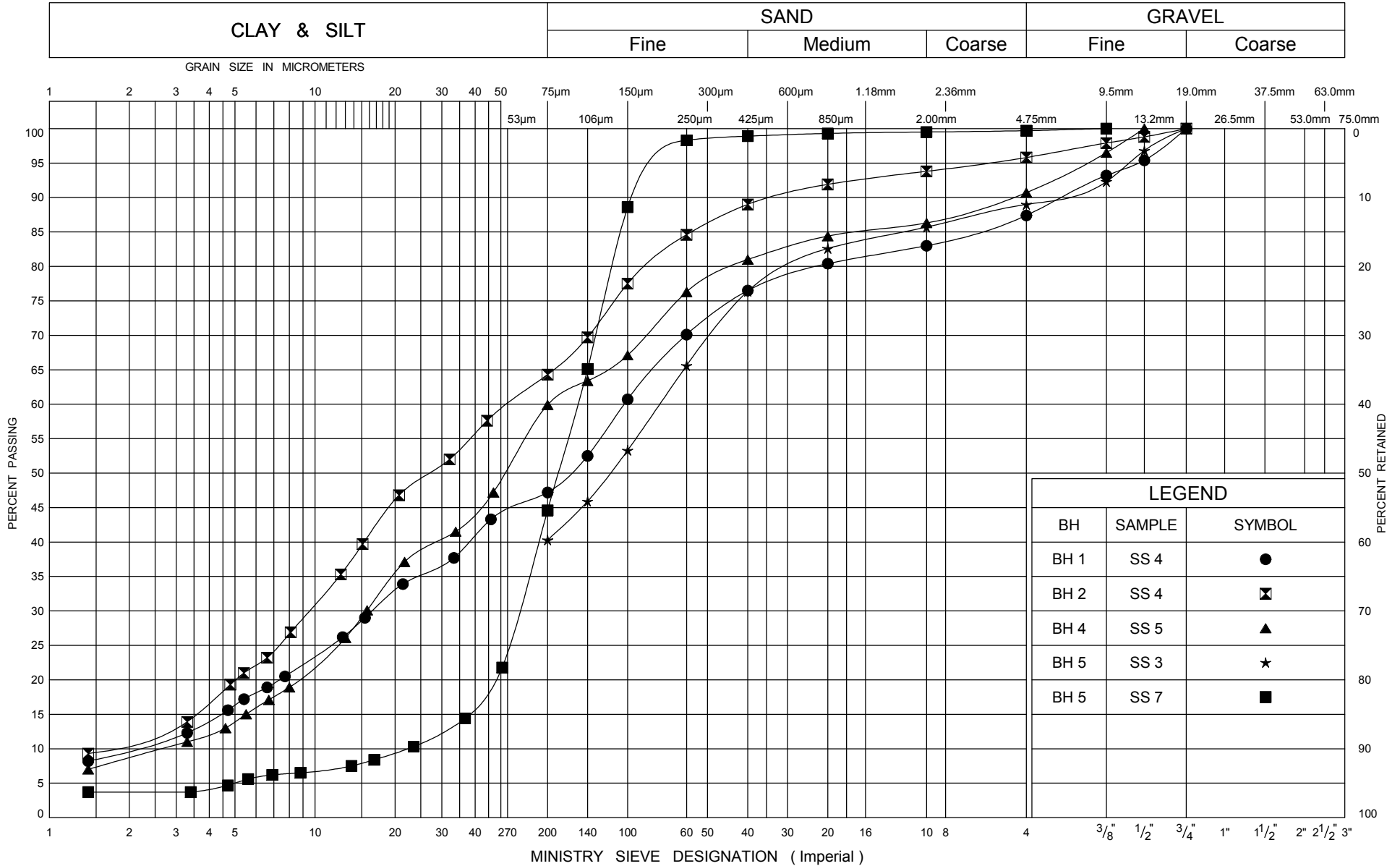
1 OF 1

G.W.P. 2140-10-00; Geocres No. 31D-532 LOCATION Stn. 15+090 ; N4885721 E634793 ORIGINATED BY JF
 DIST E. Gwillimbury HWY 48 BOREHOLE TYPE 200 mm diameter borehole (Hollow Stem) COMPILED BY SAL
 DATUM Geodetic DATE 12 October 2011 - 12 October 2011 CHECKED BY SM
 PROJECT Highway 48 and Herald Road Widening JOB NO. TP110092.007

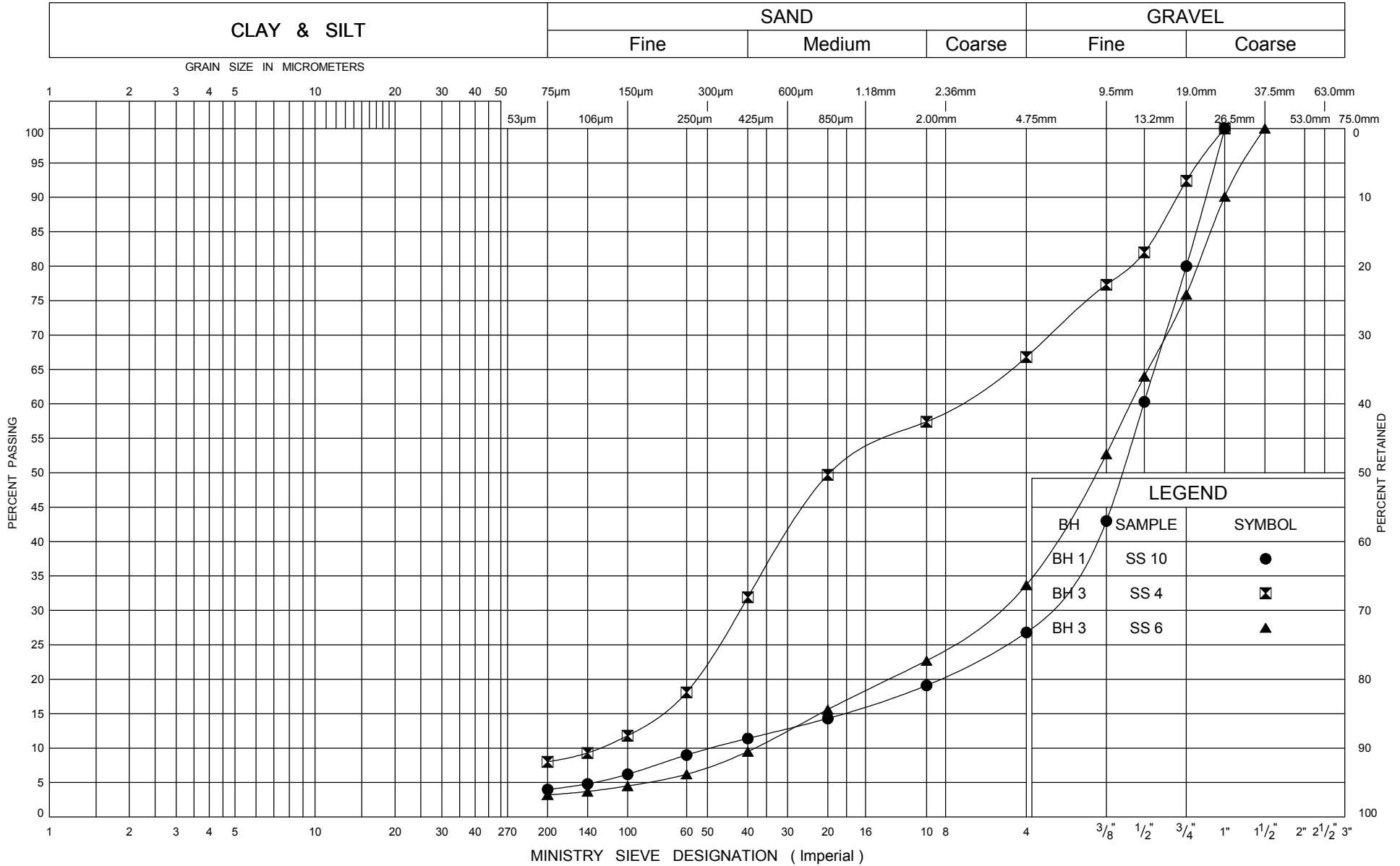
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa										WATER CONTENT (%)		
									○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
265.7									20	40	60	80	100								
0.0	about 500 mm TOPSOIL		1	SS	2																
265.2	dark brown Silty Sand FILL trace clay trace organic matter and rootlets moist		2	SS	4			265													
0.5							1														
264.3	brown SILT trace clay and sand compact to dense wet		3	SS	15			264													
1.4							2														
			4	SS	34			263													
262.6	brown SAND some silt, trace clay very dense wet		5	SS	55/15cm		3														
3.1								262													
							4														
260.8			6	SS	58/15cm			261													
4.9																					
	End of Borehole																				
	Note: The borehole was dry on completion of drilling.																				
									</												

APPENDIX B
LABORATORY TEST RESULTS

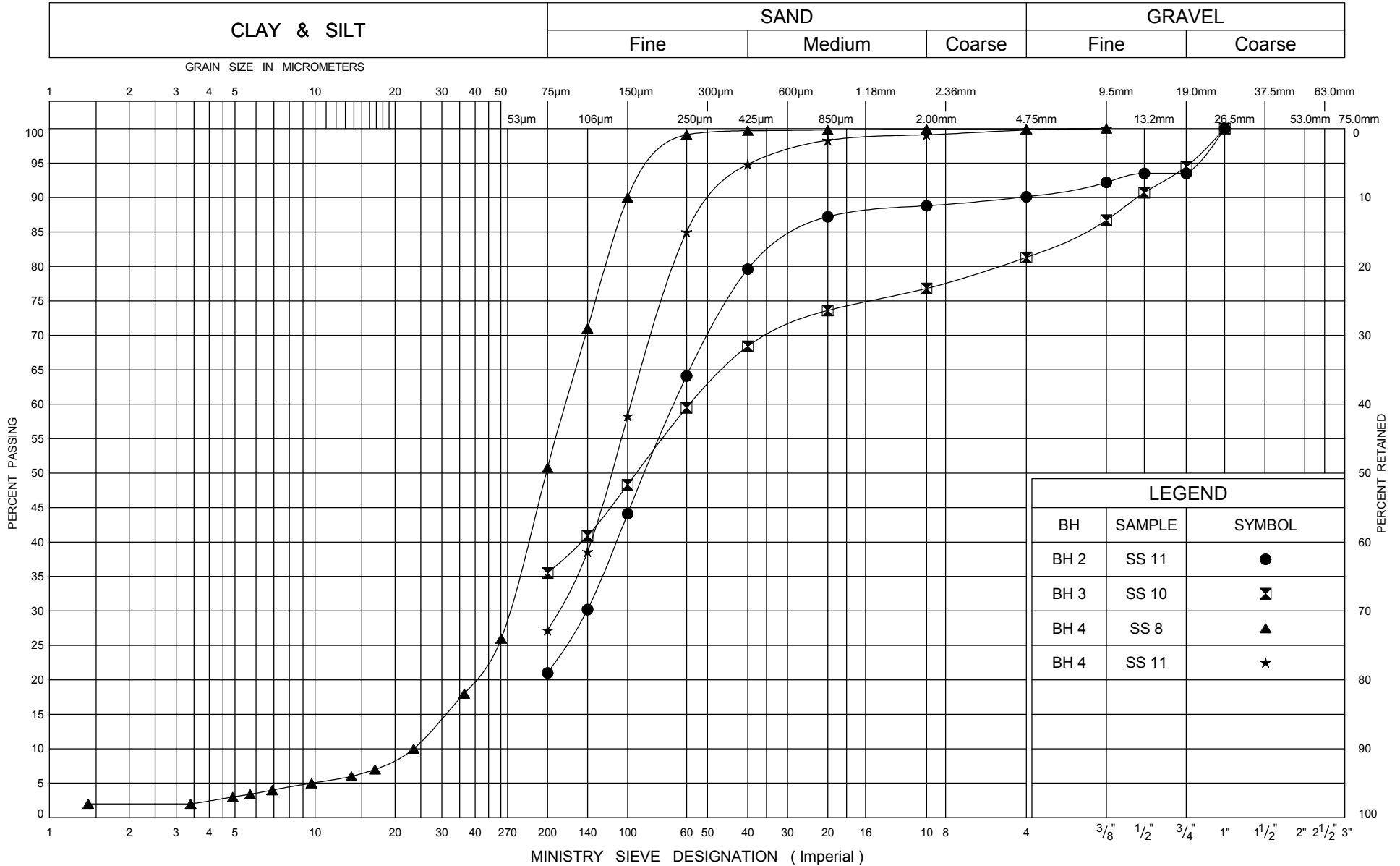
UNIFIED SOIL CLASSIFICATION SYSTEM



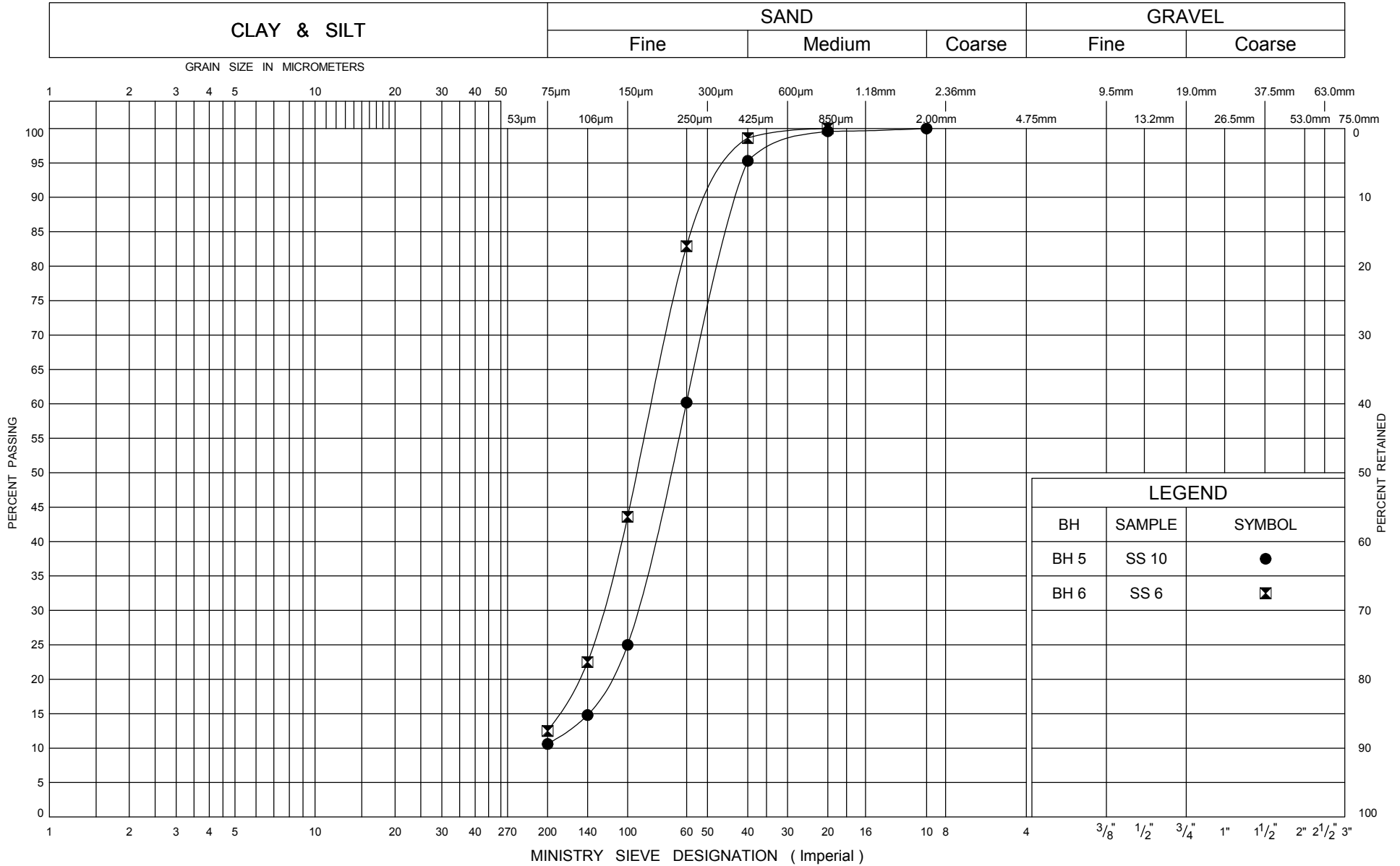
UNIFIED SOIL CLASSIFICATION SYSTEM



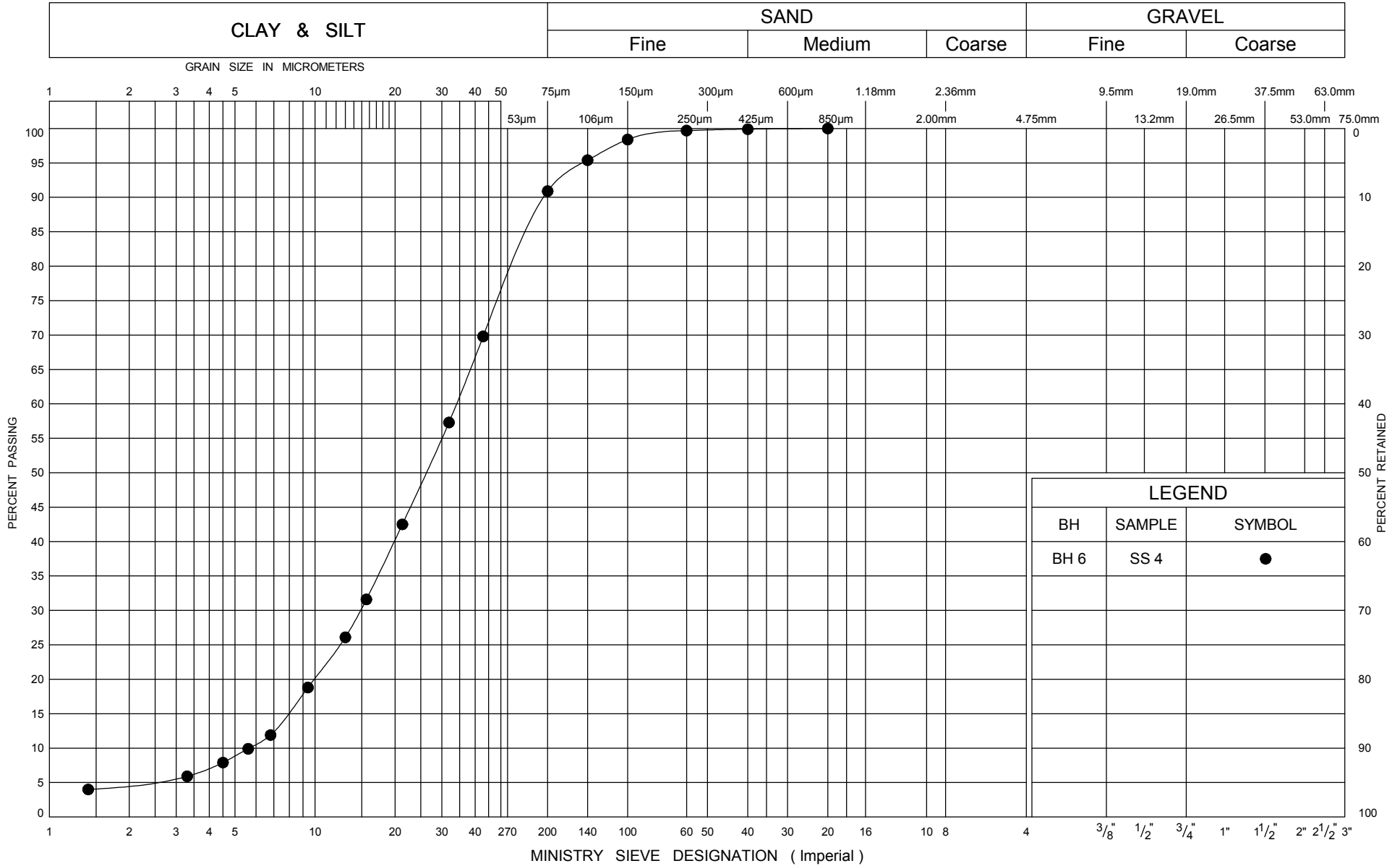
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



APPENDIX C

CERTIFICATES OF ANALYSES

Your Project #: TP110092.007
Your C.O.C. #: 47612

Attention: Shami Malla
AMEC Earth & Environmental Ltd
Scarborough
104 Crockford Blvd
Sacroborough, ON
CANADA M1R3C3

Report Date: 2011/10/24

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1G1386

Received: 2011/10/17, 16:03

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Chloride (20:1 extract)	1	N/A	2011/10/21	CAM SOP-00463	
Conductivity	1	N/A	2011/10/24	CAM SOP-00414	APHA 2510
pH CaCl2 EXTRACT	1	2011/10/21	2011/10/21	CAM SOP-00413	SM 4500 H
Resistivity of Soil	1	2011/10/17	2011/10/24	CAM SOP-00414	APHA 2510
Sulphate (20:1 Extract)	1	N/A	2011/10/21	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.

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.

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 Job #: B1G1386
Report Date: 2011/10/24

AMEC Earth & Environmental Ltd
Client Project #: TP110092.007

-2-

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 #: B1G1386
Report Date: 2011/10/24

AMEC Earth & Environmental Ltd
Client Project #: TP110092.007

RESULTS OF ANALYSES OF SOIL

Maxxam ID		LG8728		
Sampling Date		2011/10/12		
	Units	BH3 SS3	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	2200		2649892
Inorganics				
Soluble (20:1) Chloride (Cl)	ug/g	180	20	2655342
Conductivity	umho/cm	453	2	2657220
Available (CaCl2) pH	pH	7.42		2655116
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	2655343

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1G1386
Report Date: 2011/10/24

AMEC Earth & Environmental Ltd
Client Project #: TP110092.007

Test Summary

Maxxam ID LG8728
Sample ID BH3 SS3
Matrix Soil

Collected 2011/10/12
Shipped
Received 2011/10/17

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2655342	N/A	2011/10/21	DEONARINE RAMNARINE
Conductivity	COND	2657220	N/A	2011/10/24	NEIL DASSANAYAKE
pH CaCl2 EXTRACT		2655116	2011/10/21	2011/10/21	XUANHONG QIU
Resistivity of Soil		2649892	2011/10/24	2011/10/24	AUTOMATED STATCHK
Sulphate (20:1 Extract)	AC/EC	2655343	N/A	2011/10/21	DEONARINE RAMNARINE

Maxxam ID LG8728 Dup
Sample ID BH3 SS3

Collected 2011/10/12
Shipped

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride (20:1 extract)	AC/EC	2655342	N/A	2011/10/21	DEONARINE RAMNARINE
Conductivity	COND	2657220	N/A	2011/10/24	NEIL DASSANAYAKE

Maxxam Job #: B1G1386
Report Date: 2011/10/24

AMEC Earth & Environmental Ltd
Client Project #: TP110092.007

Package 1	7.0°C
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Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Maxxam Job #: B1G1386
Report Date: 2011/10/24

AMEC Earth & Environmental Ltd
Client Project #: TP110092.007

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
2655342	Soluble (20:1) Chloride (Cl)	2011/10/21	93	75 - 125	102	75 - 125	<20	ug/g	10.7	35		
2655343	Soluble (20:1) Sulphate (SO4)	2011/10/21	101	75 - 125	103	85 - 115	<20	ug/g	NC	35		
2657220	Conductivity	2011/10/24					<2	umho/cm	0.2	35	102	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 #: B1G1386

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 "Cristina Carriere", is written over a horizontal line.

CRISTINA CARRIERE, Scientific Services

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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.