

# Terraprobe

**Consulting Geotechnical & Environmental Engineering  
Construction Materials Engineering, Inspection & Testing**

GEOCROS No:  
30M5-265

**FOUNDATION INVESTIGATION & DESIGN REPORT  
HIGH FILL RAMP EMBANKMENTS (APPLEBY LINE INTERCHANGE)  
QUEEN ELIZABETH HIGHWAY  
FROM BRANT STREET TO BURLOAK DRIVE  
AGREEMENT No. 2006-E-0026, W.P. 2831-02-01  
MINISTRY OF TRANSPORTATION, ONTARIO  
CENTRAL REGION**

**PREPARED FOR:** Giffels Associates Ltd.  
30 International Blvd.  
Toronto, Ontario

**Attention:** Mr. Stephen Chiu, P.Eng.  
Manager, Transportation Engineering

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**Terraprobe Limited.**  
10 Bram Court  
Brampton, Ontario  
L6W 3R6  
Phone: (905) 796 2650  
Fax: (905) 796 2250

**Distribution:**

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**Terraprobe Limited**

10 Bram Court  
Brampton, Ontario L6W 3R6  
(905) 796-2650 Fax 796-2250

220 Bayview Drive, Unit 25  
Barrie, Ontario L4N 4Y8  
(705) 739-8355 Fax 739-8369

1012 Kelly Lake Road, Unit 1  
Sudbury, Ontario P3E 5P4  
(705) 670-0460 Fax 670-0558  
[www.terraprobe.ca](http://www.terraprobe.ca)

903 Barton Street, Unit 22  
Stoney Creek, Ontario L8E 5P5  
(905) 643-7560 Fax 643-7559

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the Queen Elizabeth Highway (QEW)/Appleby Line interchange where high fill ramp embankments are proposed. This project is the Ministry of Transportation of Ontario undertaking to rehabilitate and widen the QEW from Brant Street to Burloak Drive.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide borehole location plans, records of boreholes, laboratory test results and a description of the subsurface conditions.

Terraprobe conducted the investigation as a sub-consultant to Giffels Associates Limited, under The Ministry of Transportation of Ontario Agreement No. 2006-E-0026, W.P. 2831-02-01.

**2 SITE DESCRIPTION**

This project is located in the Regional Municipality of Halton, City of Burlington, Ontario, and extends a distance of approximately 8.2 km from Sta.11+700 to Sta.10+330. Within the project limits, this divided highway comprises of six lanes, and fully paved shoulders. There is an existing storm sewer located close to the median centreline of the highway. There are four QEW interchanges within the project limits: Guelph Line, Walkers Line, Appleby Line and Burloak Drive.

The highway crosses over several major facilities. These include a bridge over the CN Rail tracks (Stn. 12+350), and the following creek culvert crossings: Tuck Creek (Stn. 15+370), Shoreacres Creek (Stn. 16+765), West Appleby Creek (Stn. 17+870), Appleby Creek (18+275), and Sheldon Creek (18+725). There are several other smaller culvert and utility crossings beneath the highway.

The site is located in the physiographic region of Southern Ontario referred to as the Iroquois Plain<sup>1</sup>. This strip of land is approximately 3 km wide and is located between the shoreline of the

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<sup>1</sup> Chapman and Putnam, "The Physiography of South Ontario", 3<sup>rd</sup> Edition, 1984.



former glacial lake, Lake Iroquois and Lake Ontario. The topography is flat to moderately rolling and the terrain slopes gently towards Lake Ontario.

The soils generally consist of fine grained silts and clays, underlain by silty clay glacial till. The overburden soils are further underlain by bedrock of the Queenston Formation which is predominantly shale, and is known to exist at relatively shallow depths within the project limits. Very often the basal portion of this till is distinctly red in colour from large amounts of incorporated Queenston shale.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing for this project were carried out during the period January 28, 2008 to March 31, 2008 and consisted of drilling and sampling a total of 4 boreholes to depths ranging from 2.8 m to 5.5 m below ground surface. The approximate borehole locations are shown on the attached Borehole Locations Drawings in Appendix C.

Based on drawings provided by Giffels Associates Limited the borehole locations were established in the field by Terraprobe, and the locations were surveyed by JD Barnes, who provided Terraprobe with their coordinates and geodetic elevations. Utility locates were obtained by Terraprobe prior to drilling.

The drilling, sampling and in-situ testing operations were conducted using track-mounted drill rigs owned and operated by D.B.W. Drilling Limited of Ajax, and Drill Tech Drilling of Newmarket, Ontario. Solid stem auger drilling techniques were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils. Groundwater conditions in the open boreholes were observed throughout the drilling operations and upon completion of the boreholes.

A member of Terraprobe's engineering staff observed the drilling and supervised the sampling and in-situ testing operations on a full time basis. The supervisors logged the boreholes and processed the recovered soil samples for transport to Terraprobe's Brampton laboratory for further examination and testing.

### **4 LABORATORY TESTING**

The recovered soil samples were subjected to Visual Identification (VI) and natural moisture content determination. Gradation analysis and Atterberg Limits tests were also conducted on selected samples retrieved from the cohesive deposits. The results of this testing program are shown on the Record of Borehole sheets in Appendix A. The grain size distribution curves and plasticity charts are illustrated in Appendix B.



## 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, the site is underlain by topsoil, very stiff to hard silty clay fill material and a native deposit of hard silty clay glacial till. These overburden soils are further underlain by shale bedrock of the Queenston Formation.

### 5.1 Topsoil

Topsoil approximately 50 mm to 130 mm thick was encountered across the site. Topsoil thickness may vary between and beyond the boreholes.

### 5.2 Silty Clay Fill

Silty clay fill was encountered across the site. The fill extends to depths ranging from 0.3 m to 5.2 m (Elev. 115.7 m to Elev. 117.1 m).

Grain size distribution curves of samples of this fill material are presented in Figure B1. These results show grain size distributions consisting of 3 to 29% gravel, 24% sand, 34 to 49% silt and 13 to 24% clay size particles.

Samples of the silty clay fill were also subjected to Atterberg Limits tests and the results are illustrated in Figure B3. The summarized index values from these tests are presented herein.

Liquid Limit:	30%
Plastic Limit:	18%
Plasticity Index:	12%
Natural Moisture Content:	13 to 14%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in the silty clay fill yielded 'N' values ranging from 11 to 100 blows for less than 0.3 m penetration. Based on these results the fill is considered to have a stiff to hard consistency.

The moisture content of samples of this fill ranged from 6% to 21% by weight.

### 5.3 Silty Sand

A 500 mm thick layer of silty sand was encountered below the silty clay fill in Borehole AHF3. The silty sand extends to a depth of 1.7 m (Elev. 116.0 m).



The silty sand is inferred to have very dense relative density. The moisture content of a sample of the silty sand was 36% by weight.

#### 5.4 Silty Clay Till

Silty clay glacial till was encountered across the site extending to depths ranging from 1.5 m to 2.7 m below ground surface or to elevations ranging from Elev. 114.5 m to Elev. 115.7 m. In Borehole AHF4, the till extends to a borehole termination depth of 5.5 m (Elev. 115.9 m).

Grain size distribution curves of tested samples of this silty clay till are shown in Figure B2. The results generally show a grain size distribution consisting of 0 to 1% gravel, 5 to 6% sand, 63 to 68% silt and 26 to 31% clay size particles. Random cobble and boulder inclusions can also be expected to occur in till soils.

Samples of the silty clay till were also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart in Figure B4. The index values from these tests are summarized below:

Liquid Limit:	28 to 31%
Plastic Limit:	17 to 19%
Plasticity Index:	11 to 12%
Natural Moisture Content:	7 to 13%

These values are characteristic of clayey soils of generally low plasticity.

Standard Penetration tests in the silty clay till gave 'N' values ranging from 67 to more than 100 blows for 0.3 m penetration. Based on these results the silty clay till is considered to have a hard consistency.

The moisture content of samples from this deposit ranged from 7% to 13% by weight.

#### 5.5 Bedrock

The bedrock beneath the site is of the Queenston Formation, a deposit predominantly comprised of thickly bedded to massive brick red shale of Ordovician age. The rock contains within the shale matrix occasional layers of limestone, sandstone and siltstone, and occasionally green calcareous shale layers. There is typically a horizontal zone of weathering at the contact between the weak rock of the Queenston Formation and the glacial soil overburden. In the Ontario Ministry of Transportation and Communications document RR229, *Evaluation of Shales for Construction Projects*, there is reproduced from Skempton, Davis and Chandler, *a typical weathering profile of a low durability shale*, that characterizes the shale surface into three grades of weathering and four zones described as follows:



	Zone	Description	Notes
<b>Fully Weathered</b>	IVb	soil like matrix only	indistinguishable from glacial drift deposits, slightly clayey, may be fissured
<b>Partially Weathered</b>	IVa	soil like matrix with occasional pellets of shale less than 3 mm diameter	little or no trace of rock structure, although matrix may contain relic fissures
	III	soil like matrix with frequent angular shale particles up to 25 mm diameter	moisture content of matrix greater than the shale particles
	II	angular blocks of unweathered shale with virtually no matrix separated by weaker chemically weathered but intact shale	spheroidal chemical weathering of shale pieces emanating from relic joints and fissures, and bedding planes
<b>Unweathered (sound)</b>	I	shale	regular fissuring

At the base of the Glacial Till deposit there is sometimes found a zone of silty clay and fragmented shale that can be interpreted as the lowest portion of the till or as partially weathered rock of Zone III. The distinction is subjective and depends on the investigator. The surface of the bedrock as indicated on the Borehole Logs from this investigation is to be consistently interpreted as the surface of Zone II in the profile.

Shale bedrock was encountered within the depth of investigation in all boreholes except Borehole AHF4. In each borehole, the bedrock was penetrated by solid stem augering, and samples were obtained by split spoon sampling.

Tabulated below are the bedrock depth and elevation at the borehole locations.

BH No.	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
AHF1	2.1	115.7
AHF2	1.5	114.5
AHF3	2.7	115.0

## 5.6 Water Levels

Two boreholes (AHF 1 and AHF 3) were dry and open upon completion of drilling. During drilling water infiltration was observed in Boreholes AHF 2 and AHF 4 and an unstabilized water level 3.7 m below ground surface was measured in both boreholes after drilling was complete.

Perched water can also be expected to occur especially in the fill where more permeable soil layers are underlain by relatively impermeable layers of silty clay soils.

All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.



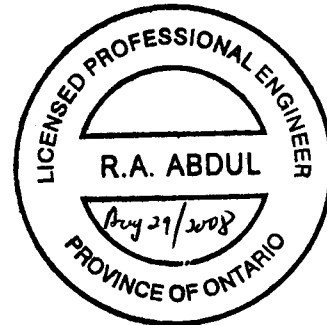
## Terraprobe Limited



Report Prepared by:  
Minkyung Kwak, M.A.Sc., P.Eng.,  
Geotechnical Engineer



Report Reviewed by:  
R. Abdul, P.Eng.,  
Senior Geotechnical Engineer



Michael Tanos, P.Eng.,  
Principal, Designated MTO Contact





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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**6 GENERAL**

This report provides geotechnical recommendations for the design of the high fill embankment ramps W-N/S and N-E at the Appleby Line interchange of the QEW, City of Burlington, Ontario.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of the investigations.

**7 SUMMARIZED SUBSURFACE CONDITIONS**

In general, the site is underlain by topsoil, very stiff to hard silty clay fill material and a native deposit of hard silty clay glacial till. These overburden soils are further underlain by shale bedrock of the Queenston Formation.

The groundwater is estimated to generally follow the ground surface topography falling towards the creeks located within the project limits. There is also a downward gradient from north to south and perched water can also be expected to occur especially in the fill where more permeable soil layers are underlain by relatively impermeable layers of silty clay soils. The groundwater will also fluctuate seasonally and after severe weather events.

**8 DESIGN CONSIDERATIONS**

At this site, the geometry of the Appleby Line N-E and W-N/S ramps will be adjusted as part of the QEW widening.

Due to the increased turning radius of the Appleby Line N-E ramp a new embankment will be constructed to tie in to the existing ramp between Sta. 10+025 and Sta. 10+200 approximately. The profile and cross section drawings indicate the design grade of the N-E ramp will range from about Elev. 124.2± m at Sta. 10+000 to about Elev. 119.0± m at Sta. 10+200. The maximum embankment height measured from the centre line profile of the N-E ramp to the founding elevation of the embankment is estimated to be about 2.0± m at Sta. 10+140.



Due to the outward shift of the N-E ramp the Appleby Line W-N/S ramp will require realignment from about Sta. 10+150 to Sta. 10+300. The design grade of the W-N/S ramp will range from about Elev. 119.2± m at Sta. 10+000 to about Elev. 121± m at Sta. 10+300. The maximum embankment height measured from the centre line profile of the W-N/S ramp to the founding elevation of the embankment is estimated to be about 4.5± m at Sta. 10+275 decreasing in height towards Sta. 10+000.

## **8.1 Embankment Settlement**

### **8.1.1 N-E Ramp**

The maximum height of fill is expected to be about 2.0± m. The estimated settlement under the weight of the proposed embankment will be about ±10 mm.

Settlement of non-cohesive fill used for the new embankment will also occur. This settlement is expected to be about 20 mm for a 2.0± m high embankment. The settlement within the non-cohesive fill should be immediate in nature and essentially be complete shortly after construction has been completed.

### **8.1.2 W-N/S Ramp**

The maximum height of fill is estimated to about 4.5± m at Sta. 10+275. The estimated settlement under the weight of the proposed embankment will be about ±10 mm.

Settlement of non-cohesive fill used for the new embankment will also occur. This settlement is expected to be about 45 mm for a 4.5± m high embankment. The settlement within the non-cohesive fill should be immediate in nature and essentially be complete shortly after construction has been completed.

## **8.2 Embankment Stability**

Embankment construction using non-cohesive earth fill is feasible provided the embankment is constructed on the underlying stiff to hard silty clay fill and hard silty clay till.

For the purpose of stability analyses, the commercially available slope stability program Slide developed by Rocscience Inc. was used to analyse the proposed sections using the Bishop's simplified method of stability analysis. The global, internal and surficial stability of the embankment fill will depend on the slope geometry and also to a large degree on the material used to construct the embankment. Embankments constructed using granular material, select subgrade material or non-cohesive earth will have stable side slopes at inclinations of up to 2H:1V.



## 9 CONSTRUCTION CONSIDERATIONS

It is recommended that the topsoil, any deleterious material and soft/loose and other unsuitable soils be removed within an envelope given by an imaginary slope not steeper than 1H:1V from the toe of the proposed embankment. Based on the borehole data, the thickness of unsuitable soils to be stripped is variable but an average value of 0.5 m is recommended for estimating purposes.

After stripping, the exposed subgrade should be inspected, approved and properly compacted from the surface, using a suitably sized compactor. Materials used for constructing the embankment can consist of approved earth fill or SSM. Earth fill should be placed in lifts not exceeding 300 mm before compaction and each lift should be uniformly compacted to at least 95 % of the material's Standard Proctor Maximum Dry Density (SPMDD). Embankment construction should be in accordance with OPSS 501 and OPSS 206, as amended by Special Provision "Amendment to OPSS 206, December 1993", dated November 2002.

Sections of the proposed embankment will tie into the existing embankments. Benching of the existing embankment side slopes should be carried out in accordance with OPSD 208.010 to key in the new fill.

Proper erosion control measures should be implemented both during construction and permanently. Temporary erosion and sediment control must be provided in accordance with OPSS 577. Earth fill embankment slopes must be provided with permanent erosion protection in accordance with OPSS 571 and/or OPSS 572.



## Terraprobe Limited



Engineering Analysis and Report Preparation by:  
Minkyung Kwak, M.A.Sc., P.Eng.,  
Geotechnical Engineer



Report Reviewed by:  
R. Abdul, P.Eng.,  
Senior Geotechnical Engineer

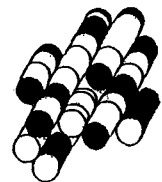


Michael Tanos, P.Eng.,  
Principal, Designated MTO Contact



# APPENDICES

**Terraprobe Limited**



## LIMITATIONS AND RISK

### Procedures

The soil conditions were confirmed at the borehole locations only and conditions may vary between and beyond the boreholes. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of stratigraphic change.

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities.

### Changes In Site And Scope

It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

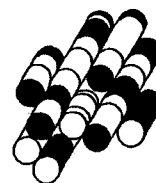
The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional information relevant to the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructibility issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report

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# **APPENDIX A**

## **Record of Borehole Sheets**

**Terraprobe Limited**



## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg. FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$C_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_r$	1	SENSITIVITY = $c_u / \tau_r$

## PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1%	VOID RATIO	$e_{min}$	1%	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1%	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1%	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>2</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	1	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $(w - w_p) / I_p$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_c$	1	CONSISTENCY INDEX = $(w_L - w) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1%	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						



RECORD OF BOREHOLE No AHF1

1 OF 1

METRIC

W.P. 2831-02-01 LOCATION Coords: N:4804430.7 E:282778.1 ORIGINATED BY JS  
DIST HWY QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY DB  
DATUM Geodetic DATE 31.03.08 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
117.8	Ground Surface							20	40	60	80	100					
0.0	130mm TOPSOIL																
0.1	FILL - Silty Clay, trace to some sand, trace gravel, very stiff, reddish brown, moist		1	SS	27												
117.1																	
0.7	SILTY CLAY trace sand, trace gravel, hard, reddish brown, damp to moist  (GLACIAL TILL)		2	SS	67												1 6 62 31
			3	SS	82												
115.7																	
2.1	SHALE BEDROCK reddish brown (Queenston Formation)		4	SS	50/ 5cm												
115.0			5	SS	60/ 1cm												
2.8	End of Borehole  Auger Refusal at 2.8m  Borehole was open and dry upon completion of drilling.																

# RECORD OF BOREHOLE No AHF2

1 OF 1

METRIC

W.P. 2831-02-01 LOCATION Coords: N:4804451.9 E:282867.3 ORIGINATED BY JS  
DIST HWY QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY DB  
DATUM Geodetic DATE 28.01.08 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
116.0	Ground Surface							20 40 60 80 100						
0.0	50mm TOPSOIL													
115.7	FILL - Silty Clay, trace to some sand, trace gravel, hard, brown, damp to moist		1	SS	35									
0.3	SILTY CLAY trace sand, trace gravel, occasional shale inclusions, hard, reddish brown, damp (GLACIAL TILL)		2	SS	95		115							0 5 66 29
114.5	SHALE BEDROCK reddish brown  (Queenston Formation)		3	SS	100/ 5cm		114							
1.5			4	SS	100/ 2.5cm		113							
			5	SS	100/ 8cm		112							
			6	SS	100/ 5cm									
111.4	End of Borehole		7	SS	100/ 5cm									
4.6	Water level at 3.7m (unstabilized) and hole open to 4.3m upon completion of drilling.													

# RECORD OF BOREHOLE No AHF3

1 OF 1

METRIC

W.P. 2831-02-01 LOCATION Coords: N:4804453.7 E:282745.1 ORIGINATED BY JS  
 DIST HWY QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY DB  
 DATUM Geodetic DATE 28.01.08 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
117.7	Ground Surface																	
0.0	80mm TOPSOIL		1	SS	11													
	FILL - Silty Clay, trace sand, trace gravel, trace organics, stiff to hard, reddish brown, damp to moist		2	SS	100/ 23cm													
116.5																		
1.2	SILTY SAND trace clay, trace gravel, inferred very dense, brown, wet		3	SS	100/ 27cm													
116.0																		
1.7	SILTY CLAY trace sand, trace gravel, with shale inclusions, hard, reddish brown, damp (GLACIAL TILL)		4	SS	100/ 15cm													
115.0																		
2.7	SHALE BEDROCK reddish brown  (Queenston Formation)		5	SS	100/ 5cm													
			6	SS	100/ 13cm													
113.1																		
4.6	End of Borehole		7	SS	100/ 2.5cm													
	Borehole was open and dry upon completion of drilling.																	

ONTARIO MOT 1-07-2145 HIGH FILLS.GPJ ONTARIO MOT.GDT 15/05/08

# RECORD OF BOREHOLE No AHF4

1 OF 1

METRIC

W.P. 2831-02-01 LOCATION Coords: N:4804488.7 E:282824.1 ORIGINATED BY JS  
 DIST HWY QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY DB  
 DATUM Geodetic DATE 28.01.08 CHECKED BY RA

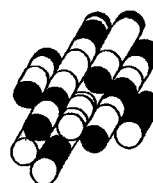
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20   40   60   80   100	20   40   60   80   100	w <sub>p</sub>	w	w <sub>L</sub>		
121.4	Ground Surface													
0.0	80mm TOPSOIL													
0.1	FILL - Silty Clay, some sand to sandy, trace gravel, trace rootlets, stiff to very stiff, brown / reddish brown, moist		1	SS	15		121					○		
			2	SS	19							○	┌───┐	3   24   49   24
			3	SS	23		120					○		
			4	SS	14		119					○		
	gravelly		5	SS	19		118					○	┌───┐	29   24   34   13
			6	SS	24		117					○		
			7	SS	28							○		
116.2	SILTY CLAY - trace sand, trace gravel, occasional shale inclusions, hard, reddish brown, damp (GLACIAL TILL)		8	SS	100/ 20cm		116					○	┌───┐	0   6   68   26
5.2	End of Borehole													
115.9	Water level at 3.7m (unstabilized) and hole open to 4.6m upon completion of drilling.													
5.5														

ONTARIO MOT 1-07-2145 HIGH FILLS.GPJ ONTARIO MOT.GDT 15/05/08

# **APPENDIX B**

## **Laboratory Test Results**

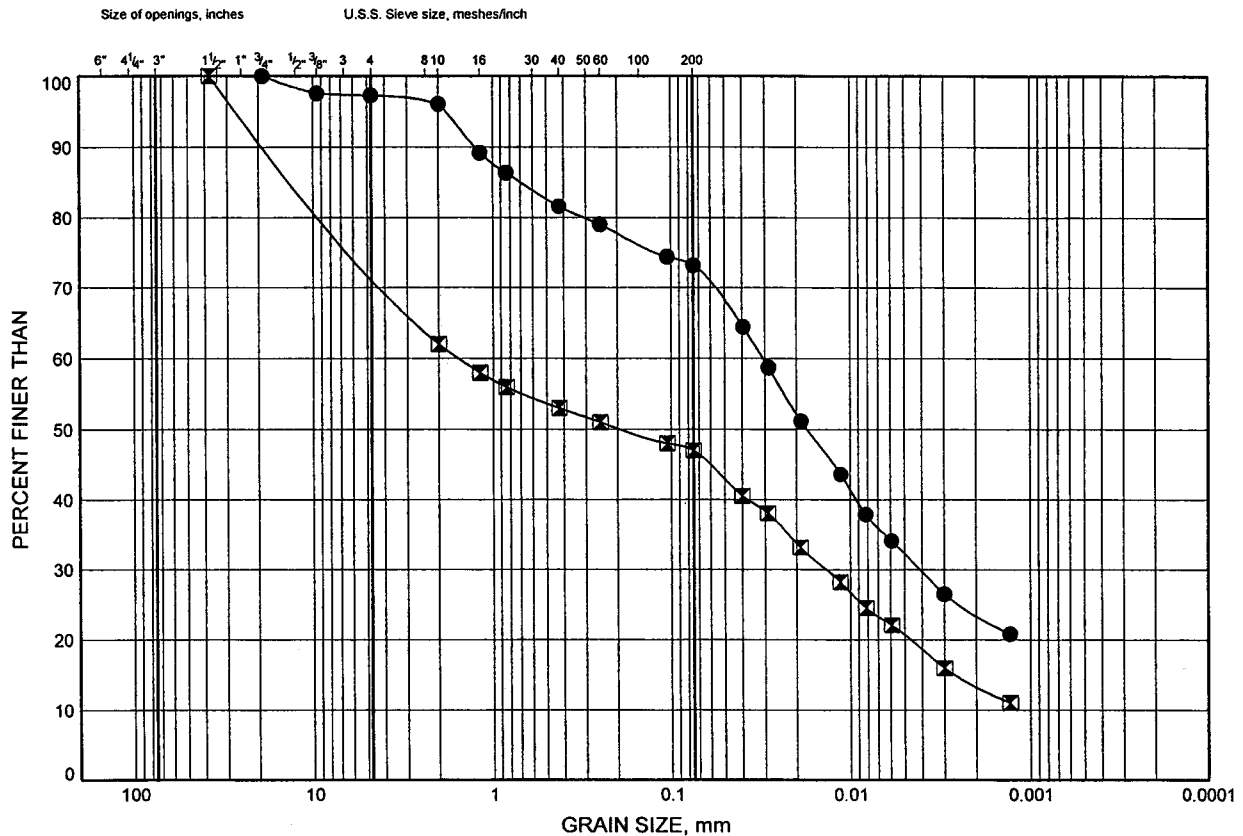
**Terraprobe Limited**



# GRAIN SIZE DISTRIBUTION

FIGURE B1

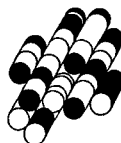
## Silty Clay Fill



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	AHF4	1.0	120.4
☒	AHF4	3.2	118.2

Date May 2008  
Project 2831-02-01

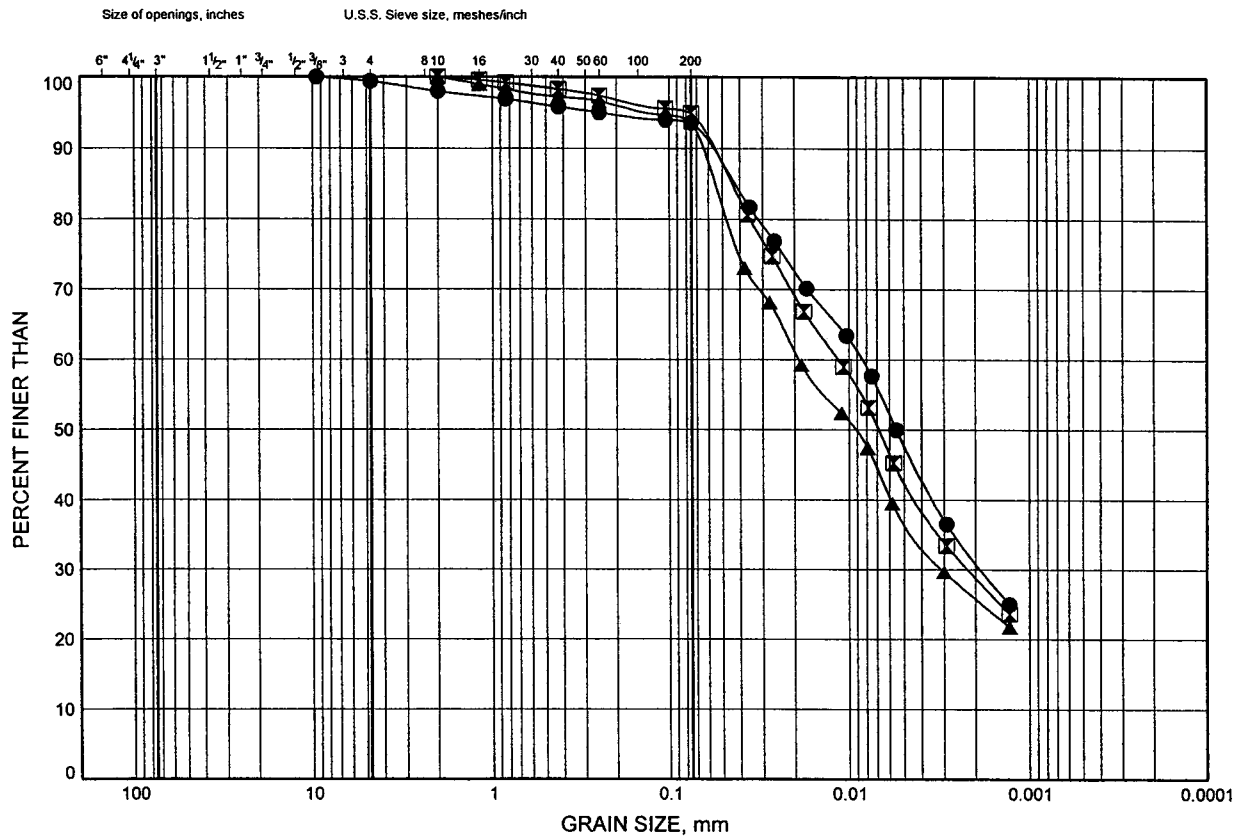


Prep'd DB  
Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B2

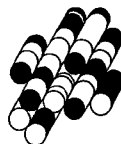
## Silty Clay Till



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	AHF1	1.0	116.8
☒	AHF2	1.0	115.0
▲	AHF4	5.4	116.0

Date May 2008  
Project 2831-02-01

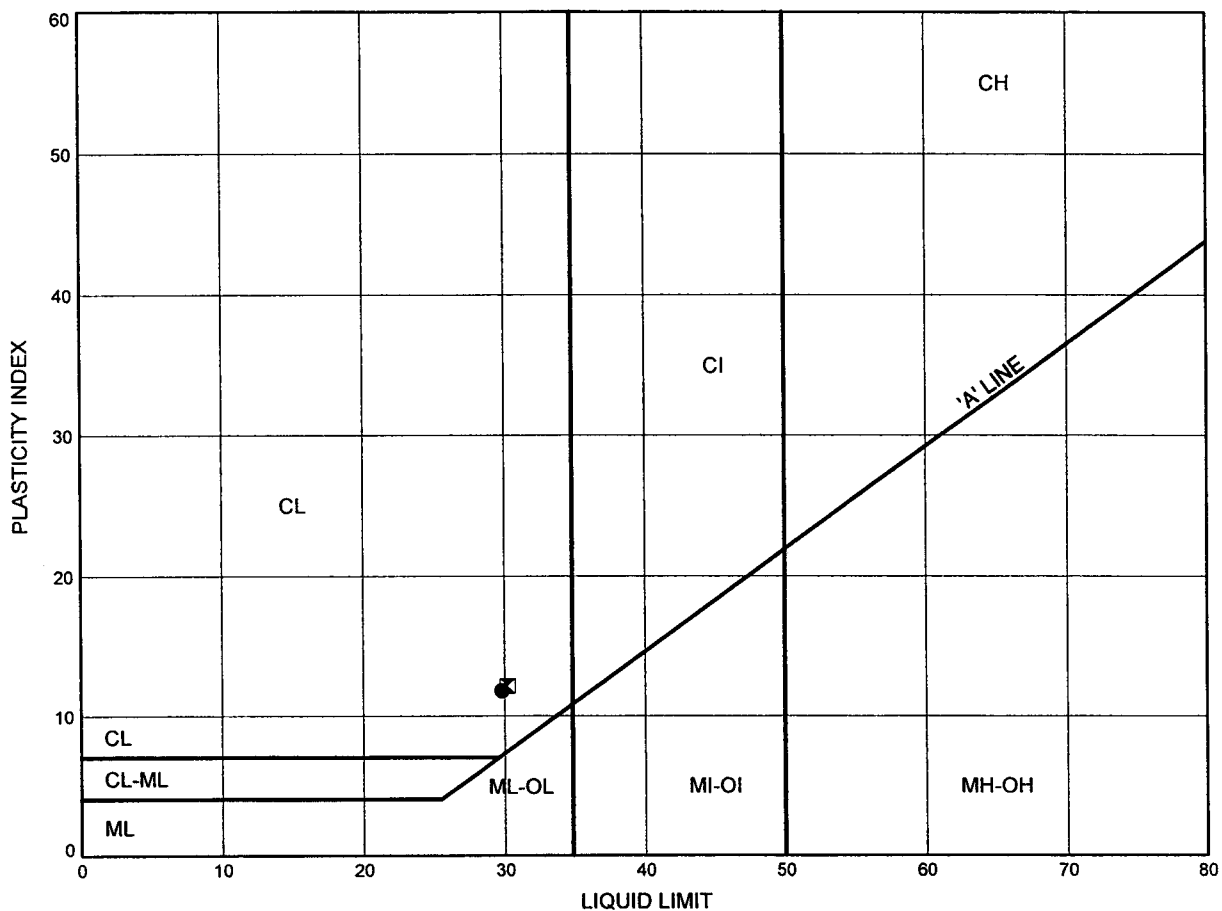


Prep'd DB  
Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

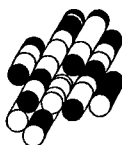
FIGURE B3

## Silty Clay Fill



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	AHF4	1.0	120.4
☒	AHF4	3.2	118.2

Date May 2008  
Project 2831-02-01



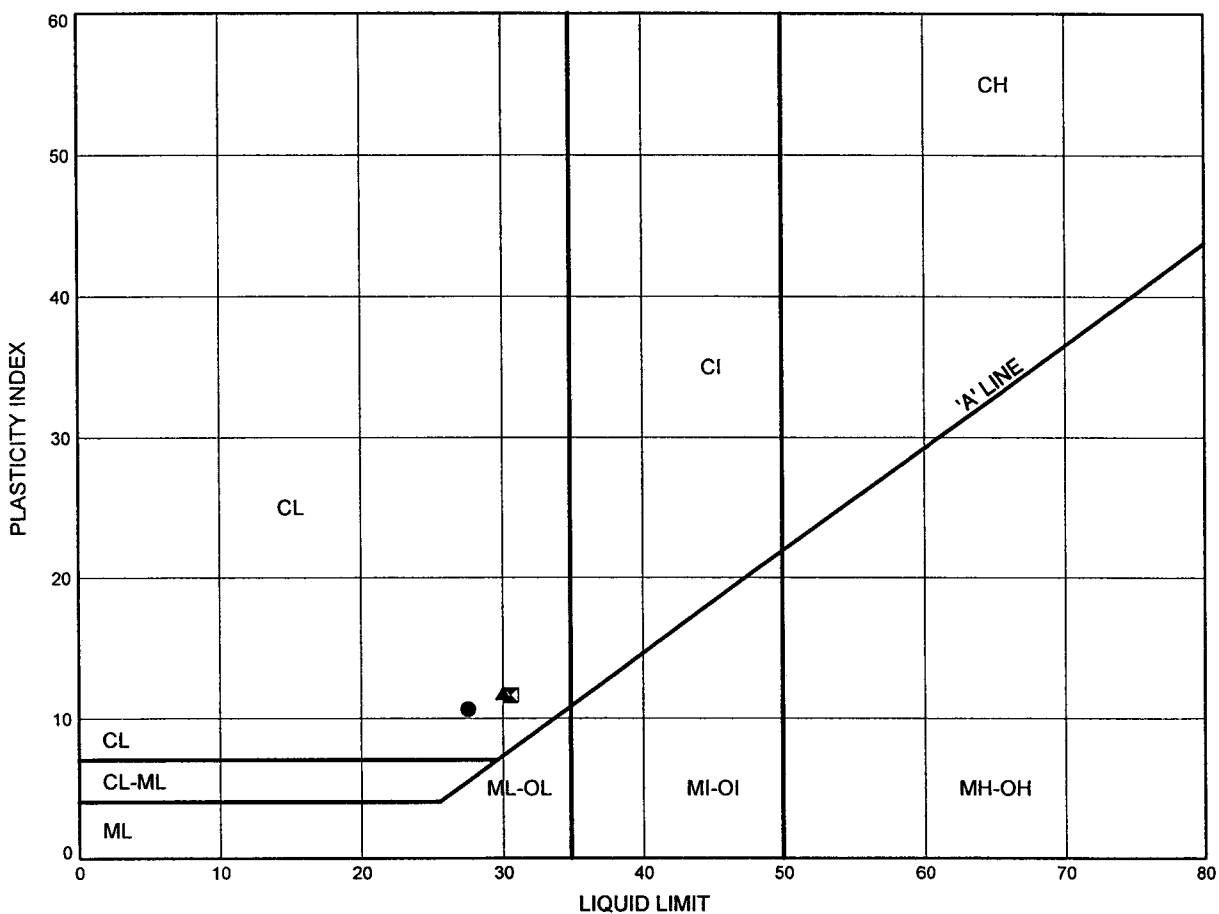
Prep'd DB  
Chkd. RA



# ATTERBERG LIMITS TEST RESULTS

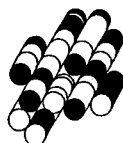
FIGURE B4

## Silty Clay Till



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	AHF1	1.0	116.8
⊠	AHF2	1.0	115.0
▲	AHF4	5.4	116.0

Date May 2008  
 Project 2831-02-01

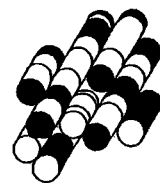


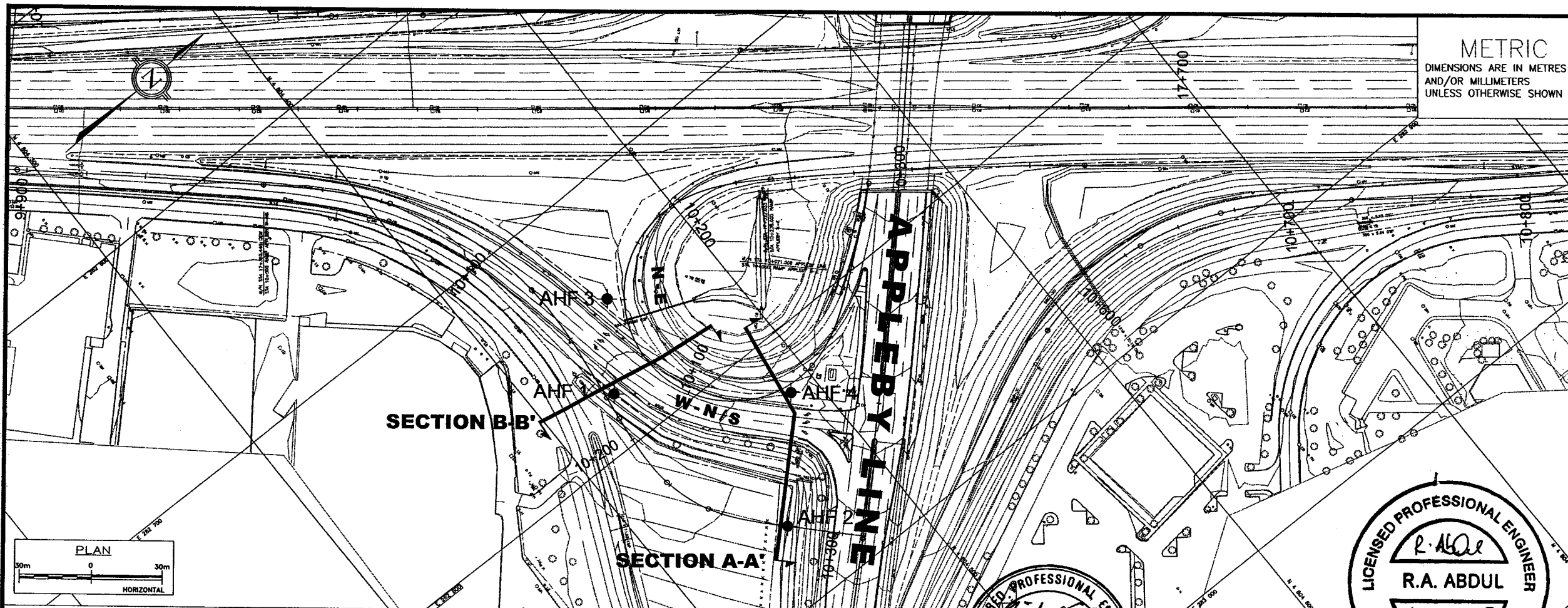
Prep'd DB  
 Chkd. RA

# **APPENDIX C**

**Drawing titled  
“Borehole Locations”**

**Terraprobe Limited**





METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETERS  
UNLESS OTHERWISE SHOWN

CONT No  
WP No2831-02-01

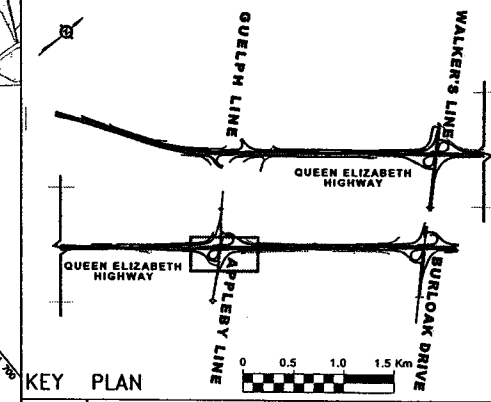
QUEEN ELIZABETH HIGHWAY  
BRANT STREET TO BURLOAK DRIVE  
HIGH FILL  
BOREHOLE LOCATIONS



SHEET  
1 OF 2

**Giffels**  
An Ingenium Group Company

**Terraprobe**  
Consulting Geotechnical & Environmental Engineering  
Construction Materials Engineering, Inspection & Testing



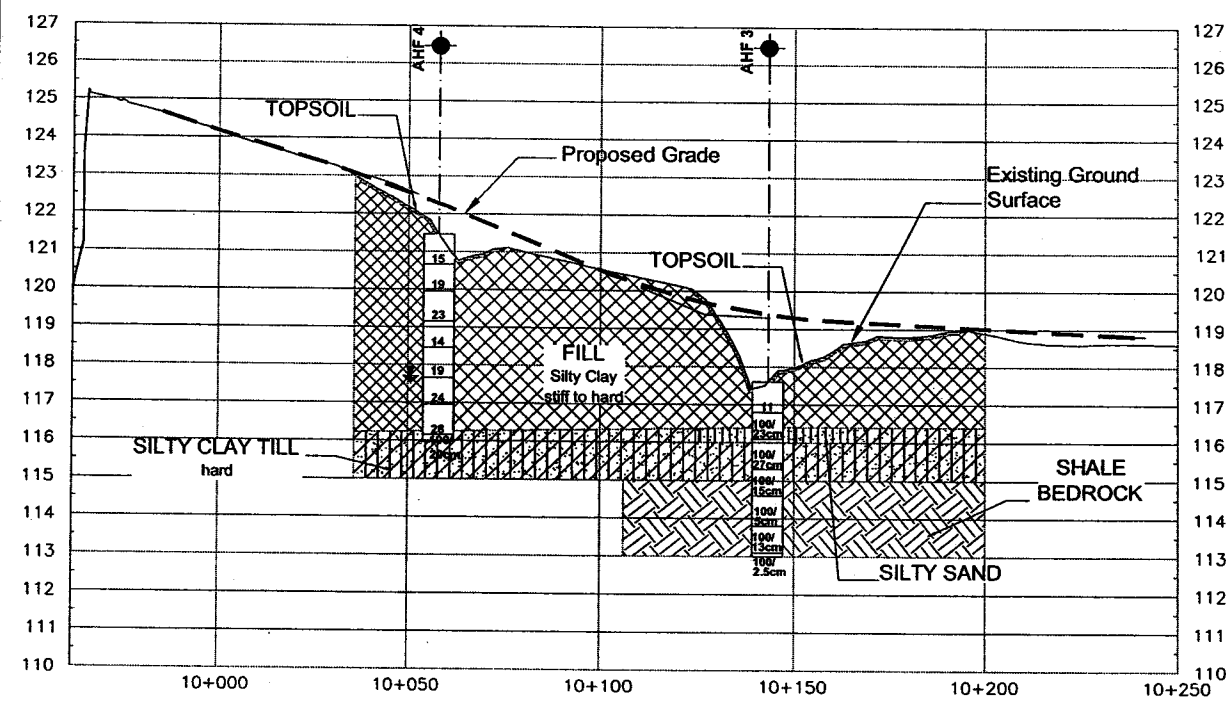
KEY PLAN

- LEGEND**
- Bore Hole
  - ⊕ Dynamic Cone Penetration Test (Cone)
  - ⊕ Bore Hole & Cone
  - 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
  - CONE Blows/0.3m (60° Cone, 475 J/blow)
  - WL at Time of Investigation
  - WL in Piezometer
  - Piezometer
  - 90% Rock Quality Designation
  - A/R Auger Refusal

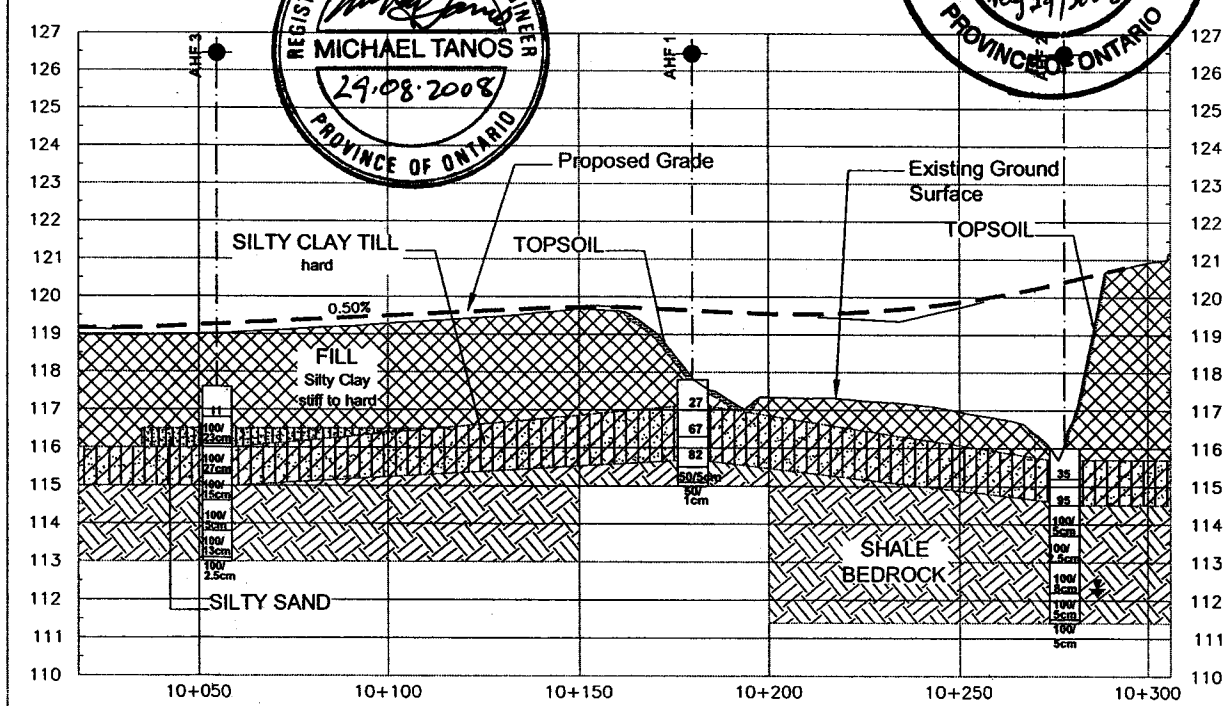
No	ELEVATION	COORDINATES	
		NORTHING	EASTING
AHF 1	117.8	4 804 430.7	282 778.1
AHF 2	116.0	4 804 451.9	282 867.3
AHF 3	117.7	4 804 453.7	282 745.1
AHF 4	121.4	4 804 488.7	282 824.1

**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION
DESIGN J.C. CODE	CHBDC2006	LOAD	DATE MAY 2008
DRAWN S.F. CHK R.A.			STRUCT

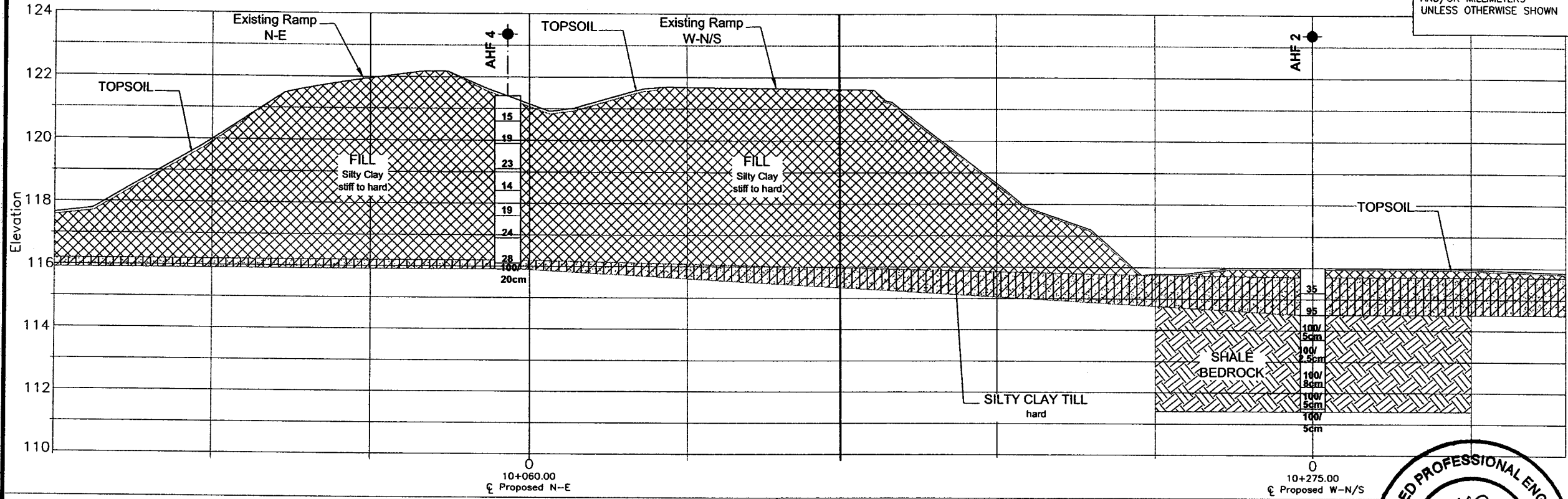
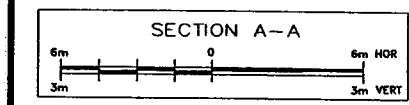


PROFILE Q RAMP NE  
30m 0 30m HOR  
3m 0 3m VERT



PROFILE Q RAMP W-N/S  
30m 0 30m HOR  
3m 0 3m VERT

DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING



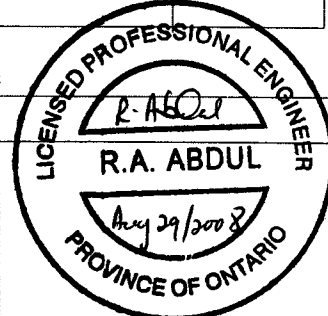
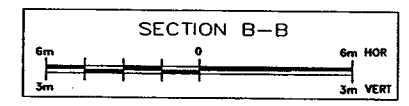
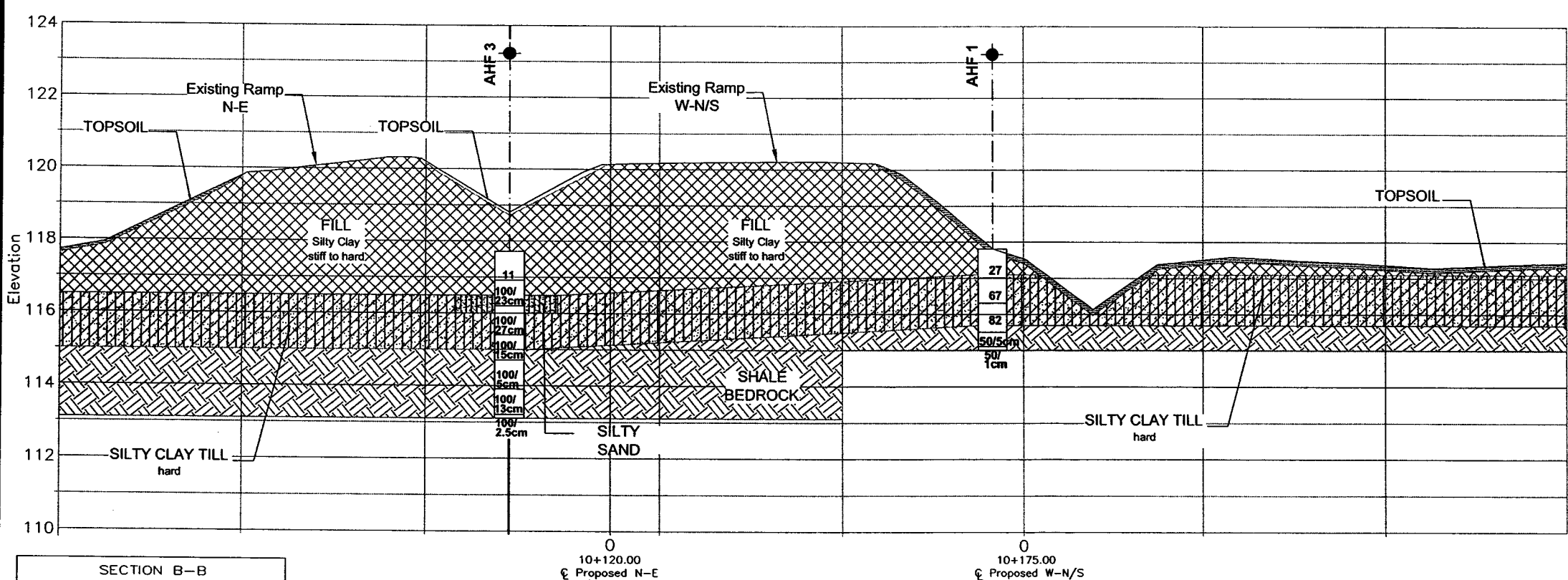
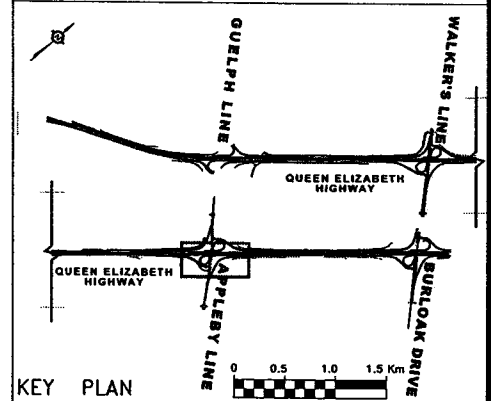
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETERS  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 2831-02-01

QUEEN ELIZABETH HIGHWAY  
BRANT STREET TO BURLOAK DRIVE  
HIGH FILL  
BOREHOLE LOCATIONS



SHEET  
2 OF 2



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60° Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer
- Piezometer
- Rock Quality Designation
- Auger Refusal

No	ELEVATION	COORDINATES	
		NORTHING	EASTING
AHF 1	117.8	4 804 430.7	282 778.1
AHF 2	116.0	4 804 451.9	282 867.3
AHF 3	117.6	4 804 453.7	282 745.1
AHF 4	121.4	4 804 488.7	282 824.1

NOTE  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION
DESIGN J.C.	CODE	CHBDC2006	LOAD
DRAWN S.F.	CHK	R.A.	STRUCT
DATE	MAY 2008		

DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING

