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LOCATION ROYAL WINDSOR ⓦ UNDERPASS

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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FOUNDATION INVESTIGATION AND DESIGN
ROYAL WINDSOR DRIVE UNDERPASS
QUEEN ELIZABETH WAY
HIGHWAY 403 W.P. 67-98-00
DISTRICT 4/6, TORONTO

Submitted to:

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TABLE OF CONTENTS

PART A – FIELD INVESTIGATION

ROYAL WINDSOR DRIVE UNDERPASS
QUEEN ELIZABETH WAY
HIGHWAY 403 W.P. 67-98-00
DISTRICT 4/6, TORONTO

1.0 INTRODUCTION

Golder Associates Ltd. has been retained by McCormick Rankin Corporation (McCormick Rankin) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a geotechnical investigation at the site of the proposed underpass structure at Royal Windsor Drive in the Town of Oakville, Ontario. The underpass structure is part of the project which consists of an extension of a 2 km long westbound auxiliary lane on Queen Elizabeth Way (QEW) between Highway 403 (Oakville Link) and Trafalgar Road in MTO District 4/6. Incorporated into the project are highway widening, pavement rehabilitation and modifications to affected interchanges. This report addresses the proposed bridge structure over QEW and its approaches within 20 m of the structure.

The purpose of the geotechnical investigation is to determine the subsurface conditions at the site of the proposed bridge structure by drilling boreholes, and carrying out in situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the geotechnical aspects of design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect design of the proposed bridge and approach embankments.

The configuration of the proposed underpass structure at Royal Windsor Drive was shown on the drawing provided to us which was a 1:1000 preliminary plan. Bennett Young Limited, professional land surveyors staked the locations of the bridge abutments in the field.

The terms of reference for the scope of work are outlined in our proposal letter P81-1021, dated January 13, 1998. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, dated March 10, 1998. During the course of the field work, the number of boreholes was increased to accommodate the site conditions as encountered.

2.0 SITE DESCRIPTION

The site is located approximately 150 m to the south of the existing Royal Windsor Drive in the Town of Oakville, Ontario, within MTO District 4/6.

The topography of the site is relatively flat. The ground surface generally slopes down to the east towards Lake Ontario. The ground surface to the west of QEW generally varies between Elevations 105.2 m and 105.6 m; there is a drainage ditch approximately 2 m in depth along the west side of QEW. The ground surface to the east of QEW varies between Elevation 103.6 m and Elevation 103.9 m. The grade of the existing QEW in the area of the proposed bridge site is at about Elevation 105.5 m. Vegetation cover on both sides of the existing highway consists of grass and shrubs.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on August 10 and 11, 1998. At this time twelve boreholes were put down at the site. Five boreholes, numbered 2, 3 and PH1 to PH3, were put down at the proposed east bridge abutment and five boreholes numbered 1, 4 and PH5 to PH7, were drilled at the location of the proposed west abutment. In addition, Boreholes PH4 and PH8 were put down within the east and west approach embankments, respectively. It is understood that during discussion with MTO, it was agreed that it would be acceptable to delete the drilling of the two boreholes in the median of the QEW and still comply with the MTO guidelines for foundation design.

The investigation was carried out using a bombardier mounted CME 55 drill rig supplied and operated by Master Soil Investigation of North York. In the boreholes, samples of the overburden and bedrock were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. Three of the boreholes, namely Boreholes 2 to 4, were extended by coring into the bedrock and were terminated between 4.9 m and 5.2 m depth. NQ size rock core samples were obtained from these boreholes. The remaining boreholes were terminated between 1.5 m and 2.0 m depth below existing ground surface. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers were installed in two boreholes to permit monitoring of the groundwater levels at the site.

The field work was supervised on a full-time basis by a member of our technical staff who located the boreholes in the field, directed the drilling, sampling and in situ testing operations, and logged the boreholes. The soil and rock samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and on Figure 1.

The boreholes located at each limit of the proposed abutments were staked in the field by Bennett Young Limited prior to our mobilization to site. We understand that the borehole elevations are referenced to Geodetic Datum. The ground surface elevations and locations of the remaining boreholes were established in the field by our personnel with reference to the staked out locations surveyed by Bennett Young Limited. The northing and easting co-ordinates of the borehole locations are indicated on the Record of Borehole sheets; the locations of the boreholes and probeholes are shown on a Drawing N1122001, "QEW Underpass at Royal Windsor Drive, Borehole Locations and Soil Strata", attached.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

From published geologic information, the site is located in the physiographic region known as the Peel Plain. The Peel Plain is generally composed of clayey soils covering the central portions of York, Peel and Halton Regions (Chapman and Putnam, "The Physiography of Southern Ontario", 3rd Edition, 1984). The surface topography of the Peel Plain slopes gradually and fairly uniformly towards Lake Ontario. The local physiography is characterized by shallow overburden consisting mainly of silty clay till with frequent shale fragments. The overburden is underlain by shale bedrock of the Georgian Bay Formation. The depth to bedrock at this site is shallow, varying typically between 1.5 m and 2 m below existing ground surface.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets, following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

Relevant information on subsurface conditions was obtained from Boreholes 1 to 4 and PH1 to PH8. The subsurface information obtained from the current investigation was supplemented by the borehole information obtained for geotechnical / pavement component of the project (new auxiliary lane and ramp at Royal Windsor Drive) and provided to us by John Emery Geotechnical Engineering Limited.

In summary, the subsoils at the site consist of surficial topsoil and / or fill overlying a stratum of silty clay till. The overburden is underlain by grey shale bedrock that contains limestone interlayers. A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil and Fill Materials

Topsoil was encountered in all of the boreholes put down on site; the topsoil thickness varied between 150 mm and 180 mm. Underlying the topsoil is fill material extending to depths between 0.3 m to 0.9 m. The fill material typically consists of silty clay with trace sand, gravel and trace organic matter (rootlets and topsoil lenses). This fill is likely native silty clay till reworked during QEW construction.

The silty clay fill is stiff to very stiff. Standard Penetration Test (SPT) 'N' values ranging from 8 blows for 0.3 m of penetration to 21 blows per 0.3 m penetration were measured in the fill material.

4.2.2 Silty Clay Till

The fill is underlain by a till deposit consisting of brown and grey, mottled, silty clay with trace sand, trace gravel and shale fragments. The silty clay till is very stiff to hard and extends to depths between 1.1 m and 1.5 m.

N values measured during the Standard Penetration testing carried out within the till deposit range from 19 to in excess of 100 blows per 0.3 m of penetration, indicating a very stiff to hard consistency. Grain size distribution test results for samples of the silty clay till are shown on Figure 1. Atterberg Limit tests indicate liquid limit ranging from 45 per cent to 51 per cent and plasticity index ranging from 23 per cent to 26 per cent.

4.2.3 Bedrock

Bedrock of the Georgian Bay Formation consisting of grey shale with interbeds of limestone was encountered in all of the boreholes. The bedrock surface was inferred from penetration resistance during drilling and visual examination of samples retrieved. The surface of the bedrock varies from about Elevation 103.7 m to about Elevation 104.1 m in the boreholes located on the west side of QEW (west abutment) and from Elevation 102.3 m to Elevation 102.7 m in the boreholes located on the east side of QEW (east abutment). The bedrock surface steps down to the east; there is approximately 1.5 m difference in the bedrock surface elevation as encountered in the boreholes put

down on the west and east side of the highway. The bedrock surface appears to be relatively flat in the north to south direction on both sides of QEW.

The bedrock surface depths and elevations at the borehole locations put down during the investigation are summarized below:

Borehole		*Ground Surface Elevation (m)*	*Bedrock Surface*	
Number	*Location*		*Depth (m)*	*Elevation (m)*
3	East Abutment	103.90	1.52	102.38
PH1		103.87	1.52	102.35
PH2		103.86	1.52	102.34
PH3		103.89	1.22	102.67
2		103.88	1.52	102.36
PH4	East Approach	103.63	1.07	102.56
4	West Abutment	105.24	1.50	103.74
PH5		105.26	1.52	103.74
PH6		105.27	1.52	103.75
PH7		105.25	1.20	104.05
1		105.18	1.22	103.96
PH8	West Approach	105.57	1.52	104.05

Bedrock coring was carried out in Boreholes 2 to 4 for a length of about 3.0 m in each borehole. The bedrock samples obtained consist of grey, fine grained, thinly bedded shale with interlayers of fresh crystalline and fossilferous limestone. Limestone bands comprise between 24 per cent and 30 per cent of the total core length.

In the two boreholes at the east abutment, measured Rock Quality Designation (RQD) values of 7 per cent and 22 per cent were obtained in the upper portion of the core samples (above about Elevation 101.2 m). Below Elevation 101.2 m, RQD values of greater than 45 per cent were measured on the core samples. Based on inspection of the rock core samples, there are numerous limestone layers below Elevation 101.5 m in Borehole 2 and below Elevation 101.2 m in Borehole 3 and the rock is generally in a moderately weathered state. In Borehole 4 located in the area of the west abutment, an RQD value measured on the upper portion of core sample (above Elevation 102.0 m) was 0 per cent and below Elevation 102.0 m, the measured RQD value was 56 per cent.

Point load tests were carried out on the core samples retrieved from the boreholes. The diametral Point Load Indices $Is_{(50)}$ measured on the shale samples ranged from about 0.27 MPa to 0.69 MPa; values ranging from about 1.54 MPa to 5.07 MPa were obtained for samples of the fresh limestone. The results of point load tests carried out on the core samples obtained are summarized below:

SUMMARY OF POINT LOAD TESTING

Borehole Number	*Sample Depth (m)*	*Point Load Index $Is_{(50)}$*	*Rock Type*
2	3.0	2.485	Limestone
	3.2	2.219	Limestone
	3.4	4.753	Limestone
	4.3	1.535	Limestone
	4.6	0.519	Shale
3	3.5	4.374	Limestone
	3.7	4.508	Limestone
	3.9	3.078	Limestone
	4.3	4.578	Limestone
	4.4	2.720	Limestone
4	3.0	0.682	Shale
	3.5	3.391	Limestone
	4.0	0.685	Shale
	4.2	5.070	Limestone
	4.4	0.270	Shale

Based on an empirical relationship between point load index and uniaxial compressive strength, these results correspond to an average unconfined compressive strength of 12 MPa for the moderately weathered to fresh shale and 28 MPa for the fresh limestone.

4.3 Groundwater Conditions

On completion of drilling, all of the boreholes, except Boreholes 2 to 4, were dry. Boreholes 2 to 4, where rock coring was carried out, were dry during drilling in the overburden, however, on completion of drilling the water level in open boreholes was influenced by water used during rock coring.

Piezometers were installed in Boreholes 2 and 4 to monitor the groundwater conditions. Details of the piezometer installations and water level measurements are shown on the attached Record of Borehole sheets. The water levels measured in the piezometers were at Elevation 101.3 m in Borehole 2 located on the east side of QEW and at Elevation 102.1 m in Borehole 4 located on the west side of QEW. The measurements indicate that the groundwater level slopes downward toward the east. Groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

PART B – FOUNDATION DESIGN

ROYAL WINDSOR DRIVE UNDERPASS
QUEEN ELIZABETH WAY
HIGHWAY 403 W.P. 67-98-00
DISTRICT 4/6, TORONTO

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of the underpass structure at Royal Windsor Drive based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

The works described in this report are associated with the proposed bridge and its approaches within 20 m of the structure. It is understood that the proposed underpass structure to carry the realigned Royal Windsor Drive over the QEW will be a two span structure about 64 m in length. The final road grade at the structure will be at about Elevation 114.3 m and will require approximately 9 m to 10.5 m high embankments.

The proposed horizontal and vertical alignment for the underpass structure was shown on the preliminary drawings provided to us as part of the preliminary design report and on the General Arrangement Plan.

5.2 Bridge Foundations

The surface of the bedrock varies from about Elevation 103.7 m to about Elevation 104.1 m at the location of the west abutment and from about Elevation 102.3 m to Elevation 102.7 m at the location of the east abutment, some 1.2 m to 1.5 m below the existing ground surface. At the location of the proposed pier, the bedrock surface was interpolated to be at about Elevation 103.0 m based on the borehole information at the west and east abutments. The upper 1.0 m to 1.7 m of the bedrock is typically highly fractured. The water levels in the piezometers installed within the bedrock were at Elevation 102.1 m in the area of the west abutment and at Elevation 101.3 m in the area of the east abutment, or about 3.1 m and 2.5 m depths below existing ground surface, respectively.

Considering the shallow depth of the bedrock, it is recommended that the bridge structure be supported by spread footings founded on bedrock. A founding level at the surface of the shale bedrock (on the fractured portion) or extended deeper to the less fractured bedrock may be assumed for design of the abutment and pier footings, as indicated below.

5.2.1 Factored Geotechnical Resistance

Spread footings for the abutments placed on properly prepared shale bedrock at the surface of the shale bedrock may be designed for a factored geotechnical resistance at Ultimate Limit States (FCULS) of 850 kPa. Spread footings taken deeper to found on the less fractured shale interbedded with crystalline and fossilferous limestone at Elevation 102.0 m at the location of the west abutment and at Elevation 101.2 m at the location of the east abutment and at Elevation 101.5 m at the pier may be designed for a FCULS of 2,000 kPa. These values are for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as appropriate. Serviceability Limit States (SLS) conditions do not apply to footings placed on bedrock.

The following table summarizes the highest recommended design founding elevations and the factored geotechnical resistances at Ultimate Limit States (FCULS):

Abutment Location	*Reference Boreholes*	*Higher Design Founding Elevation (m)*	*FCULS (kPa)*	*Alternate Design Founding Elevation (m)*	*FCULS (kPa)*
West Abutment	1, 4 and PH5 to PH7	103.7	850	102.0	2,000
Central Pier	Subsurface conditions interpolated from the borehole information put down at the west and east abutments	103.0		101.5	
East Abutment	2, 3 and PH1 to PH3	102.3		101.2	

All footing excavations should be inspected prior to placing concrete to ensure that the base has been adequately cleaned and that the bedrock conditions as exposed at the founding level are consistent with the design assumptions. All loose or shattered rock within the footprint of the footings and at the founding level should be removed and replaced with concrete. To prevent

deterioration of the shale, a mud mat of lean concrete should be placed immediately after excavation.

If space restrictions within the median do not allow the use of spread footings for the pier, consideration could be given to supporting the pier on caissons socketted into the lower portion of the shale. For typical caisson diameters of 0.9 m to 1.5 m, the caissons should be designed based on shaft friction developed on the portion of the caisson formed within the bedrock. For initial sizing of the caissons, the following design values may be assumed:

Within the upper 1.5 m of weathered, fractured bedrock, a geotechnical resistance at Ultimate Limit States of 550 kPa may be assumed for unit shaft friction for loading in compression. Below Elevation 101.5 m, a FCULS value of 850 kPa may be assumed.

5.2.2 Horizontal Resistance

Resistance to lateral forces / sliding resistance between the concrete spread footings and bedrock should be calculated in accordance with Section 6-8.4.3 of the OHBDC. For the spread footings placed on the moderately weathered shale at the lower founding level, horizontal shear resistance can be supplemented by passive resistance from the weathered / fractured rock in front of the footing. For design, an unfactored effective angle of friction of 30 degrees (Kp = 3.0) and effective cohesion, c′, of 80 kPa can be assumed for design. A unit weight of 23 kN/m^3 can be used in design.

If necessary, sliding resistance can be supplemented by doweling into bedrock. The dowels will be formed within the relatively unfractured, unweathered bedrock below Elevation 101.5 m. For loading in tension, a unit bond stress of 450 kPa at Ultimate Limit States may be assumed for the grout-to-rock interface for the dowels. The dowels should be a minimum of 1.0 m long within the rock and the structural strength of the dowel and the compressive strength of the grout should not be exceeded.

5.2.3 Frost Protection

All footings should be provided with a minimum of 1.2 m of earth cover for frost protection purposes.

5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments and the retaining walls in accordance with OHBDC:

- Select free-draining granular fill meeting the specifications of OPSS Granular A or Granular B but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. All granular fill should be compacted in lifts of loose thickness not greater than 200 mm to 95 per cent of the material's Standard Proctor maximum dry density.

- Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.

- The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the stem (Case I) or within the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the footing (Case II).

- If the wall support allows lateral yielding of the stem (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (restrained structure), at-rest pressures should be assumed for geotechnical design.

- A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with OHBDC Figure 6-7.4.3.

- For Case I, the pressures are based on the embankment fill materials and the following parameters (unfactored) may be assumed:

  Soil unit weight 21 kN/m^3
  (assuming clean earth fill)

  Coefficients of lateral earth pressure:
  'active' 0.31
  'at rest' 0.47

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	Granular A	**Granular B**
Soil Unit Weight	22 kN/m^3	21 kN/m^3
Coefficients of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

	Granular A	Granular B
Soil Unit Weight	22 kN/m³	21 kN/m³
Coefficients of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00.

5.4 Excavations

At the abutments, the excavations for footing construction at the higher level will be about 1.5 m deep below existing ground surface and will extend through the fill and silty clay till deposit into the highly weathered bedrock consisting of shale with limestone interbeds. As shown on the Preliminary Design Study drawings, the existing road grade of QEW is at about Elevation 105.5 m at the location of the pier and the excavation for footing construction at the pier will extend through as much as 2.5 m of the existing road fill.

Conventional excavation equipment would be suitable for excavating the overburden. Temporary cuts in the overburden may be made with side slopes not steeper than 1 horizontal to 1 vertical (1H:1V). For the footing placed at the lower elevation within the less fractured bedrock, excavation into the shale bedrock may be carried out with conventional hydraulic equipment equipped with rock teeth. Rock splitting equipment (hoe ram) may be required to break up fresh limestone layers encountered within the bedrock. Temporary shallow excavations into the shale may be made in vertical cut. Some ravelling of the fractured bedrock present in the upper 1.0 m to 1.7 m zone should be expected. Where space is restricted, such as likely will be the case at the pier, consideration should be given to the use of solider pile and lagging for temporary support to the sides.

The water levels measured in the piezometers were at Elevation 102.1 m at the west abutment and at Elevation 101.3 m at the east abutment (about 3.1 m and 2.5 m depths below existing ground surface). The base of the footing excavations will likely be at or below the groundwater level; some water inflow into the excavations should be expected. This inflow can be handled by

5.5 Approach Embankments

The proposed underpass structure will require 9 m to 10.5 m in height embankments. Topsoil and fill materials should be stripped from below the footprint area of the fill embankment and all subgrade soils should be proof-rolled prior to fill placement. The subgrade consists of silty clay till.

Construction of the embankment above the prepared subgrade may be carried out using clean earth fill (in accordance with OPSS 212) or Select Subgrade Material (in accordance with OPSS 1010), depending on material available. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 per cent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 per cent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical. Vegetation cover should be established on all slopes to protect embankment fill against surficial erosion.

GOLDER ASSOCIATES LTD.

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LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):
An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_S)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:
1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π = 3.1416
ln x, natural logarithm of x
$\log_{10}$ x or log x, logarithm of x to base 10
g acceleration due to gravity
t time
F factor of safety
V volume
W weight

II. STRESS AND STRAIN

γ shear strain
Δ change in, e.g. in stress: $\Delta\sigma$
ε linear strain
ε_v volumetric strain
η coefficient of viscosity
ν Poisson's ratio
σ total stress
σ' effective stress ($\sigma' = \sigma - u$)
σ'_{vo} initial effective overburden stress
$\sigma_1,\sigma_2,\sigma_3$ principal stresses (major, intermediate, minor)
σ_{oct} mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ shear stress
u porewater pressure
E modulus of deformation
G shear modulus of deformation
K bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$ bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$ dry density (dry unit weight)
$\rho_w(\gamma_w)$ density (unit weight) of water
$\rho_s(\gamma_s)$ density (unit weight) of solid particles
γ' unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R relative density (specific gravity)of solid particles ($D_R = \rho_s/\rho_w$) (formerly G_s)
e void ratio
n porosity
S degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w water content
w_l liquid limit
w_p plastic limit
I_P plasticity Index = $(w_l - w_p)$
w_S shrinkage limit
I_L liquidity index = $(w - w_p)/I_p$
I_C consistency index = $(w_l - w)/I_p$
e_{max} void ratio in loosest state
e_{min} void ratio in densest state
I_D density index = $(e_{max} - e)/(e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h hydraulic head or potential
q rate of flow
v velocity of flow
i hydraulic gradient
k hydraulic conductivity (coefficient of permeability)
j seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c compression index (normally consolidated range)
C_r recompression index (overconsolidated range)
C_S swelling index
C_α coefficient of secondary consolidation
m_v coefficient of volume change
c_v coefficient of consolidation
T_v time factor (vertical direction)
U degree of consolidation
σ'_p pre-consolidation pressure
OCR Overconsolidation ratio $= \sigma'_p/\sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r peak and residual shear strength
ϕ' effective angle of internal friction
δ angle of interface friction
μ coefficient of friction = tan δ
c' effective cohesion
c_u, S_u undrained shear strength ($\phi = 0$ analysis)
p mean total stress $(\sigma_1 + \sigma_3)/2$
p' mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q $(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u compressive strength $(\sigma_1 - \sigma_3)$
S_t sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$
2. Shear strength = (Compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains >60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
∥ - Parallel To	
⊾ - Perpendicular To	

FORM...G.A.R.T-3

W.P. 67-98-00

DIST. QEW / ROYAL WINDSOR DRIVE

LOCATION: 4814606.408N; 290680.528E

RECORD OF BOREHOLE 1

BORING DATE: AUG.11/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		105.18				SHEAR STRENGTH Cu, kPa — nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp — W — Wl (10 20 30 40)		
		Topsoil		0.00							
		Silty Clay, trace sand, trace gravel, trace organics Very stiff Brown (FILL)		0.15	1	50 DO	16				
				0.30	2	50 DO	60/ .10				
1		Silty Clay, trace sand, trace gravel, trace shale fragments Very stiff to hard Grey and brown, mottled (TILL)		103.96							
				1.22							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		103.66 1.52							
2		END OF BOREHOLE									Note: Open borehole dry on completion of drilling.
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122001.BHS

DATA INPUT: PS AUG.26/98

SOIL M6

W.P. 67-98-00

DIST. QEW / ROYAL WINDSOR DRIVE

LOCATION: 4814635.240N; 290756.997E

RECORD OF BOREHOLE 2

BORING DATE: AUG.10/98

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		103.88				SHEAR STRENGTH Cu, kPa: nat V - +, rem V - ⊕	WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)		
		Topsoil		0.00				Q - ●, U - ○			
		Silty Clay, some sand, trace gravel, occ. topsoil lenses Very stiff Dark brown and grey (FILL)		0.15	1	50 DO	21				
				103.03							
1		Silty Clay, trace sand, trace gravel, trace shale fragments Very stiff Grey and brown, mottled (TILL)		0.85	2	50 DO	19		MH		BENTONITE SEAL
				102.36							
2		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.52							SAND FILTER
				101.75							
		BOREHOLE CONTINUED FOR BEDROCK CORING DETAILS, REFER TO SHEET 2.		2.13							Note. Open borehole dry during drilling in overburden.
3											
4											
5											
6											
7											
8											
9											
10		CONTINUED ON NEXT PAGE									

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122002.BHS

DATA INPUT: PS AUG.26/98

SOILM6

W.P. 67-98-00

DIST. QEW / ROYAL WINDSOR DRIVE

LOCATION: 4814635.240N 290756.997E

RECORD OF BOREHOLE: 2

DRILLING DATE: AUG.10/98

DRILL RIG: CME 55 BOMBARDIER

DRILLING CONTRACTOR: MASTER SOILS

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 981-1122

FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN | F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED | SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR | FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED | BC-BROKEN CORE MB-MECH. BREAK B-BEDDING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / % RETURN / COLOUR	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
0		CONTINUED FROM PREVIOUS PAGE														
1																
2		CONTINUED FROM SHEET 1.		101.75												
3	NQ CORING AUG.10/98	Highly weathered becoming moderately weathered below 2.4m depth, grey, fine grained, thinly bedded Shale (70%) and fresh crystalline and fossiliferous Limestone (30%) typically in 25mm to 100mm thick layers. (Georgian Bay Formation)		2.13	1	0.25	100						300mm BC 50mm BC 20mm BC 10mm Clay Seam 50mm BC 20mm BC 10mm Clay Seam			SAND FILTER
4					2	0.42	100						50mm BC 10mm BC ST,R,UE ST,R,UE 75mm BC			
5		END OF BOREHOLE Note: Limestone layers greater than 100mm in thickness were encountered at the following depths: 3.22m - 140mm 3.41m - 180mm 4.33m - 270mm 4.90m - 110mm		98.70 5.18												Note: Water level in piezometer at 101.4m depth on Aug.19, 1998 and at Elev. 101.3m on Oct.3, 1998.
6																
7																
8																
9																
10																

DEPTH SCALE:

1 to 50

Golder Associates

LOGGED: SB

DATE:

CHECKED: AMP

N1122002.BHR

DATA INPUT: PS AUG.26/98

ROCKMV5

W.P. 67-98-00
DIST. QEW / ROYAL WINDSOR DRIVE
LOCATION: 4814612.253N; 290747.229E

RECORD OF BOREHOLE 3

BORING DATE: AUG.10/98

SHEET 1 OF 2
DATUM: GEODETIC
PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		103.90				SHEAR STRENGTH Cu, kPa nat V - + Q - ● rem V - ⊕ u - O	WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)		
0	CME 55 BOMBARDIER SOLID STEM AUGERS	Topsoil		0.00							
		Silty Clay, some sand, trace gravel, trace shale fragments, occ. topsoil lenses Very stiff Dark brown and grey (FILL)		0.18	1	50 DO	20				
				103.14							
1		Silty Clay, trace sand, trace gravel, trace shale fragments Very stiff Grey and brown, mottled (TILL)		0.76	2	50 DO	27		O——	MH	
				102.38							
		Shale Bedrock Weathered Grey		1.52	3	50 DO	60/ .15				
2				102.07							
				1.83							
		BOREHOLE CONTINUED FOR BEDROCK CORING DETAILS, REFER TO SHEET 2.									
3											
4											
5											
6											
7											
8											
9											
10		CONTINUED ON NEXT PAGE									

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SB
CHECKED: AMP

N1122003.BHS
DATA INPUT: PS AUG.26/98
SOILM6

W.P. 67-98-00

DIST. QEW / ROYAL WINDSOR DRIVE

LOCATION: 4814612.253N;290747.229E

RECORD OF BOREHOLE: 3

DRILLING DATE: AUG.10/98

DRILL RIG: CME 55 BOMBARDIER

DRILLING CONTRACTOR: MASTER SOILS

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 981-1122

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R -ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W -WAVY B -BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C -CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	FLUSH / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
0		CONTINUED FROM PREVIOUS PAGE														
1		CONTINUED FROM SHEET 1.		102.07												
2	NQ CORING AUG.20/98	Highly weathered becoming moderately weathered below 2.7m depth, grey, fine grained, thinly bedded Shale (72%) and fresh crystalline and fossiliferous Limestone interlayers (28%). (Georgian Bay Formation)		1.83	1	0.55	100						50mm Clay Seam 80mm BC 70mm BC 50mm BC 90mm BC 10mm Clay Seam 150mm BC			
3																
4					2	0.2	100						70mm BC 50mm BC 20mm Clay Seam 110mm BC 30mm BC 50mm BC			
5		END OF BOREHOLE Note: Limestone layers greater than 100mm in thickness were encountered at the following depths: 2.69m - 100mm 3.49m - 140mm 3.67m - 127mm 3.91m - 178mm 4.20m - 292mm		99.02 4.88												
6																
7																
8																
9																
10																

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SB
DATE:
CHECKED: AMP

DATA INPUT: PS AUG.26/98

ROCKMV5

N1122003.BHR

W.P. 67-98-00

DIST. QEW / ROYAL WINDSOR DRIVE

LOCATION: 4814586.730N; 290672.187E

RECORD OF BOREHOLE 4

BORING DATE: AUG.11/98

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		105.24							
		Topsoil		105.09							
		Silty Clay, some sand, trace gravel, trace organics Very stiff Brown (FILL)		0.15 104.48	1	50 DO	16				BENTONITE SEAL
1		Silty Clay, trace sand, trace gravel, occ. shale fragments Hard Brown and grey, mottled (TILL)		0.76 103.74	2	50 DO	60/.15				
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.50 1.67	3	50 DO	75/.12				
2		BOREHOLE CONTINUED FOR BEDROCK CORING DETAILS, REFER TO SHEET 2.									Note: Open borehole dry during drilling in overburden.
3											
4											
5											
6											
7											
8											
9											
10		CONTINUED ON NEXT PAGE									

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122004.BHS

DATA INPUT: PS AUG.25/98

SOILM6

W.P. 67-98-00

DIST. QEW / ROYAL WINDSOR DRIVE

LOCATION: 4814586.730N;290672.187E

RECORD OF BOREHOLE: 4

DRILLING DATE: AUG.11/98

DRILL RIG: CME 55 BOMBARDIER

DRILLING CONTRACTOR: MASTER SOILS

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 981-1122

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
0		CONTINUED FROM PREVIOUS PAGE														
1		CONTINUED FROM SHEET 1.		103.57												
2	NQ CORING AUG.20/98	Highly weathered becoming moderately weathered below 3.2m depth, grey, fine grained, thinly bedded Shale (76%) and fresh crystalline and fossiliferous Limestone (24%) typically in 25mm to 100mm thick layers. (Georgian Bay Formation)		1.67	1	0.125	100									BENTONITE SEAL
3																
4					2	0.32	100						25mm BC 10mm clay seam 20mm BC			SAND
5		END OF BOREHOLE		100.52 4.72												Note: Water level in piezometer at Elev. 102.14m on Aug.19, 1998 and on Oct.3, 1998.
6		Note: Limestone layers graeter than 100mm in thickness encountered at the follow depth: 3.51m - 140mm 4.23m - 140mm														
7																
8																
9																
10																

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SB

DATE:

CHECKED: AMP

N1122004.BHR

DATA INPUT: PS AUG 26/98

ROCKMV5

W.P. 67-98-00
DIST. QEW/ROYAL WIN.
LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH1

BORING DATE: AUG.10/98

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		103.87							
		Topsoil		0.00							
		Silty Clay, some sand, trace gravel, trace organics Stiff Brown (FILL)		0.15	1	50 DO	11		○		
				103.11							
1		Silty Clay, trace sand, trace gravel, trace shale fragments Very stiff Grey and brown, mottled (TILL)		0.76	2	50 DO	26		○		
				102.35							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.52	3	50 DO	60/ .15				
2				101.89							
		END OF BOREHOLE		1.98							Note: Open hole dry on completion of drilling.
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SB
CHECKED: AMP

N1122PH1.BHS
DATA INPUT: PS NOV.19/98
SOILM6

W.P. 67-98-00

DIST. QEW/ROYAL WIN.

LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH2

BORING DATE: AUG.10/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		103.86							
		Topsoil		0.00							
		Silty Clay, some sand, trace gravel, trace shale fragments Very stiff Brown and grey, mottled (FILL)		0.15	1	50 DO	17		W ○		
				103.36 0.50							
1		Silty Clay, trace sand, trace gravel, occ. shale fragments Very stiff Brown and grey, mottled (TILL)			2	50 DO	19		W ○		
				102.34							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.52		50 DO	50/ .03				
2				102.03 1.83							Note: Open hole dry on completion of drilling.
		END OF BOREHOLE									
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122PH2.BHS

DATA INPUT: PS AUG 26/98

SOILM6

W.P. 67-98-00

DIST. QEW/ROYAL WIN.

LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH3

BORING DATE: AUG.10/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		103.89				SHEAR STRENGTH Cu, kPa: nat V - +, rem V - ⊕; Q - ●, U - ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		
		Topsoil		0.00							
		Silty Clay, some sand, trace gravel, trace organics Stiff Brown and grey (FILL)		0.15	1	50 DO	13				
				103.29							
				0.60							
1		Silty Clay, trace sand, trace gravel, trace shale fragments Hard Brown and grey, mottled (TILL)		102.67	2	50 DO	60/.15				
				1.22							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		102.37							
				1.52							
2		END OF BOREHOLE									
3											
4											
5											
6											
7											
8											
9											
10											

Note:
Open hole dry on completion of drilling.

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122PH3.BHS

DATA INPUT: PS NOV 19/98

SOILM6

W.P. 67-98-00

DIST. QEW/ROYAL WIN.

LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH4

BORING DATE: AUG.10/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat V - + Q - ● rem V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp W Wl, 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		103.63							
		Topsoil		0.00							
		Silty Clay, some sand, trace gravel, trace shale fragments, occ. topsoil lenses Stiff Brown and grey (FILL)		0.15	1	50 DO	8				
				102.73							
1		Silty Clay, trace sand, trace gravel, trace shale fragments Hard Grey and brown, mottled (TILL)		0.90	2	50 DO	60/ .15		O		
				1.07							
				102.11							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.52							
2		END OF BOREHOLE									Note: Open borehole dry on completion of drilling.
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122PH4 BHS

DATA INPUT: PS NOV 19/98

SOIL#6

W.P. 67-98-00
DIST. QEW/ROYAL WIN.
LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH5

BORING DATE: AUG.11/98

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - O)	WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		105.26									
		Topsoil		0.00									
		Silty Clay, some sand, trace organics (FILL)		0.17	1	50 DO	29				O		
				0.30									
1		Silty Clay, trace sand, trace gravel, trace shale fragments, occ. cobble, occ. silt partings Very stiff to hard Brown and grey, mottled (TILL)			2	50 DO	35				O		
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		103.74 1.52	3	50 DO	60/ .15						
2				1.68									
		END OF BOREHOLE											
3													
4													
5													
6													
7													
8													
9													
10													

Note:
Open hole dry on completion of drilling.

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SB
CHECKED: AMP

N1122PH5.BHS
DATA INPUT: PS NOV.19/98
SOILM6

W.P. 67-98-00

DIST. QEW/ROYAL WIN.

LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH6

BORING DATE: AUG.11/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		105.27				SHEAR STRENGTH Cu, kPa: nat V - + Q - ● rem V - ⊕ U - O	WATER CONTENT, PERCENT: Wp — W — Wl (10 20 30 40)		
		Topsoil		0.00							
		Silty Sand, trace gravel, occ. silty clay lenses Compact Brown (FILL)		0.15	1	50 DO	18				
				104.66							
				0.61							
1		Silty Clay, trace sand, trace gravel, occ. shale fragments Hard (TILL)			2	50 DO	64		O		
				103.75							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.52	3	50 DO	75/.15				Note: Open hole dry on completion of drilling.
2				1.68							
		END OF BOREHOLE REFUSAL TO AUGER PENETRATION PROBABLY ON LIMESTONE LAYER.									
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122PH6 BHS

DATA INPUT: PS NOV 19/98

SOIL M6

W.P. 67-98-00

DIST. QEW/ROYAL WIN.

LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH7

BORING DATE: AUG.11/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		105.25				SHEAR STRENGTH Cu, kPa: nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)		
		Topsoil		0.00							
		Silty Clay, some sand, trace gravel, occ. topsoil lenses Stiff Brown (FILL)		0.15	1	50 DO	14				
				104.64							
				0.61							
1		Silty Clay, trace sand, trace gravel, occ. shale fragments Hard Brown and grey, mottled (TILL)		104.18	2	50 DO	50/.08				
				1.07							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		103.73							
2				1.52							
		END OF BOREHOLE									
3											
4											
5											
6											
7											
8											
9											
10											

Note:
Open hole dry on completion of drilling.

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SB

CHECKED: AMP

N1122PH7.BHS

DATA INPUT: PS AUG.26/98

SOILM6

N1122PH8.BHS

W.P. 67-98-00

DIST. QEW/ROYAL WIN.

LOCATION: N 4814606.408; E 290680.528

RECORD OF BOREHOLE PH8

BORING DATE: AUG.11/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 BOMBARDIER SOLID STEM AUGERS	GROUND SURFACE		105.57				SHEAR STRENGTH Cu, kPa: nat V - +, rem V - ⊕; Q - ●, U - ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		
		Topsoil		0.00							
		Silty Clay, some sand, trace gravel, trace shale fragments Stiff Brown (FILL)		0.15	1	50 DO	15				
				104.97							
				0.60							
1		Silty Clay, trace sand, trace gravel, trace shale fragments Hard Grey and brown, mottled (TILL)			2	50 DO	59		○		
				104.05							
		Shale Bedrock Weathered Grey (Georgian Bay Formation)		1.52	3	50 DO	58/.15				
				1.68							
2		END OF BOREHOLE									Note: Open hole dry on completion of drilling.
3											
4											
5											
6											
7											
8											
9											
10											

DATA INPUT: PS NOV 19/98

SOILM6

DEPTH SCALE

1 to 50

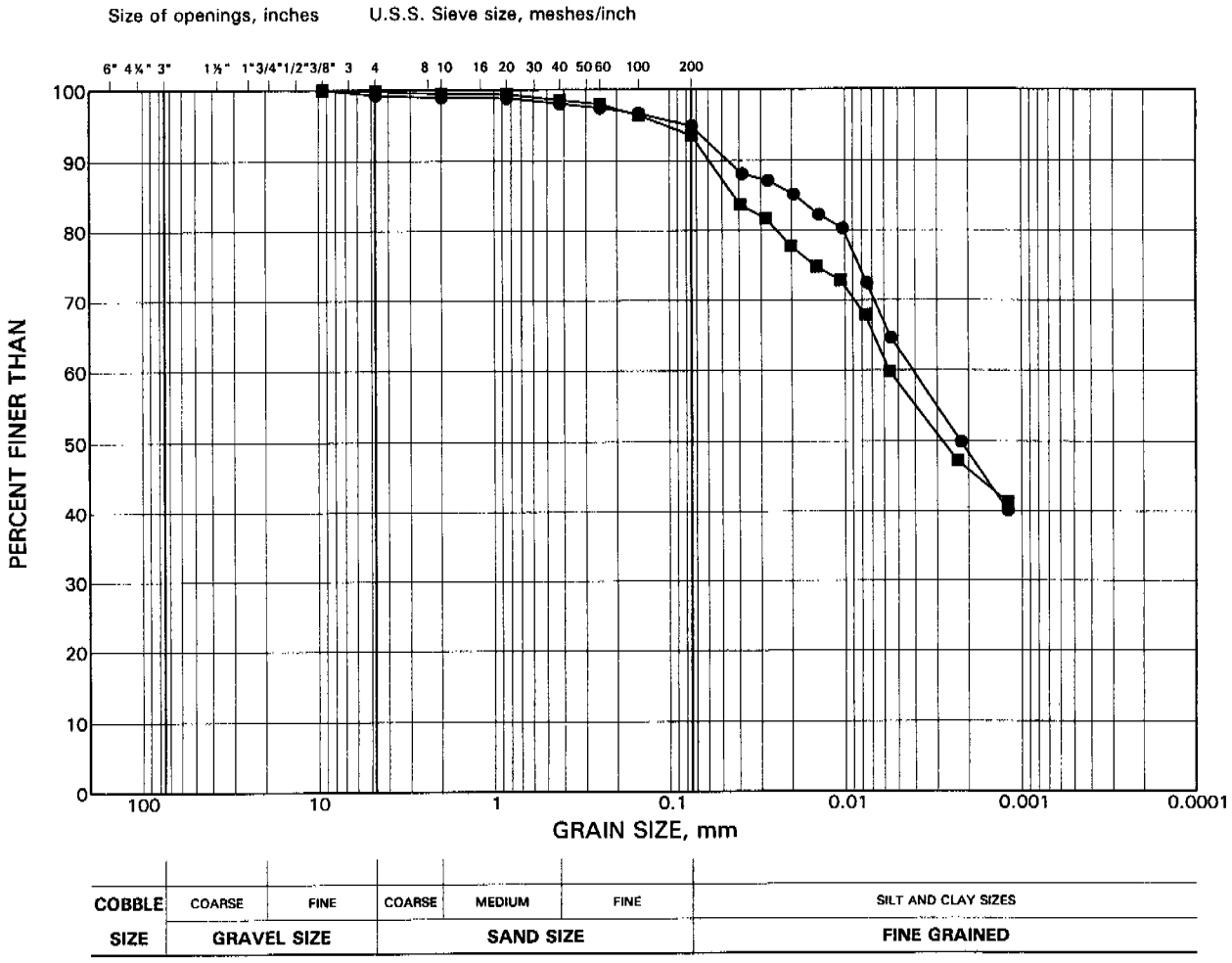
Golder Associates

LOGGED: SB

CHECKED: AMP

GRAIN SIZE DISTRIBUTION

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	2	2	102.6
■	3	2	102.8

Project 981-1122

Golder Associates

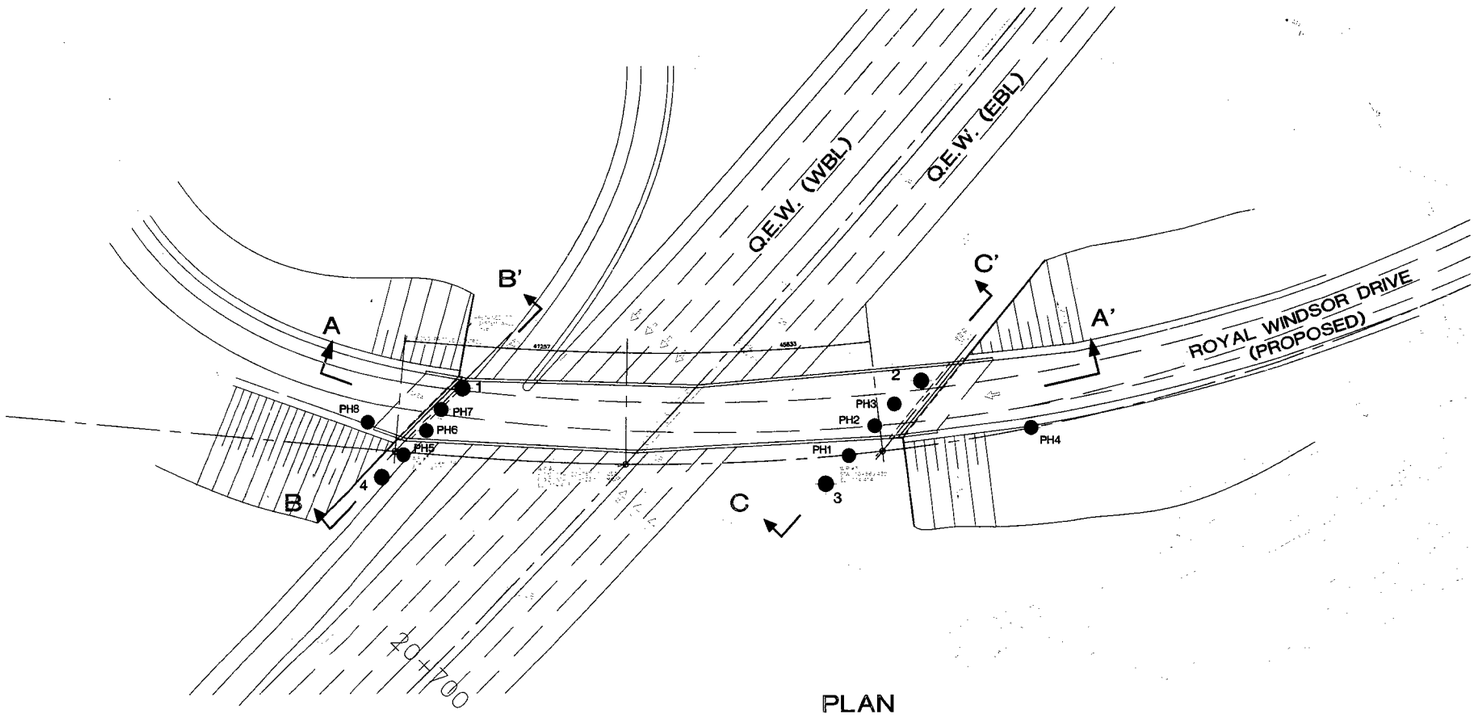
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT. No.
WP No. 67-98-00

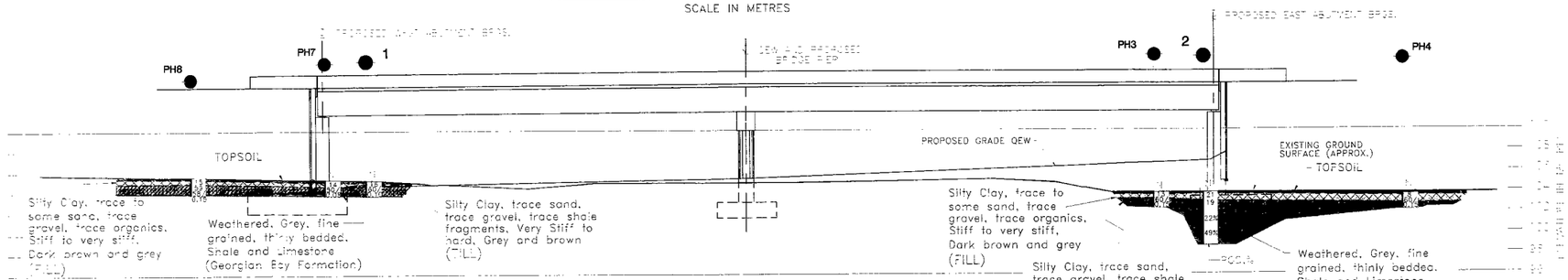
Q.E.W. UNDERPASS AT ROYAL WINDSOR DRIVE
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

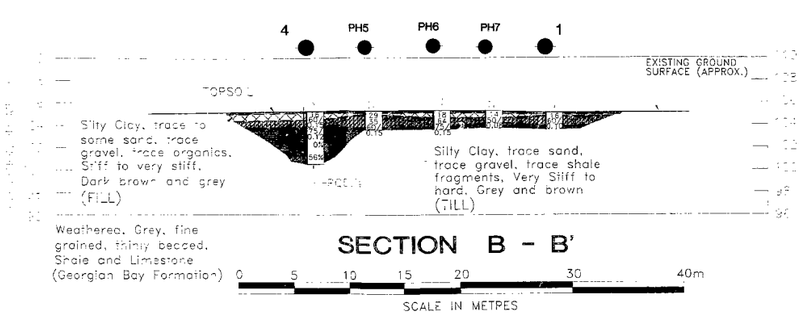
Golder Associates
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



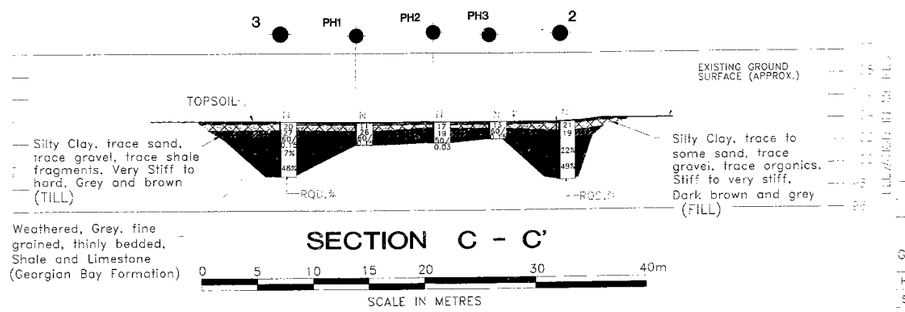
PLAN
0 10 20 30 40 60 80m
SCALE IN METRES



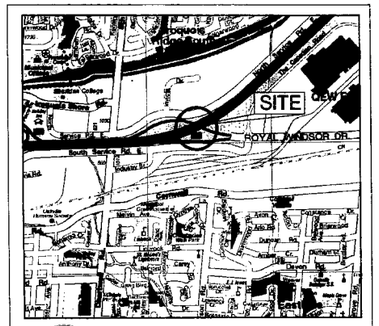
SECTION A - A'
0 5 10 15 20 30 40m
SCALE IN METRES



SECTION B - B'
0 5 10 15 20 30 40m
SCALE IN METRES



SECTION C - C'
0 5 10 15 20 30 40m
SCALE IN METRES



KEY PLAN
0.5 0 0.5 1.0 km
SCALE: km

LEGEND
- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Core
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Core — Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation

No.	ELEVATION	LOCATION NORTHING	EASTING
1	105.18	4,814,606.408	290,650.528
2	103.88	4,814,635.240	290,756.997
3	103.90	4,814,612.253	290,747.229
4	105.24	4,814,586.730	290,672.187
PH1	103.87	4,814,606.408	290,650.528
PH2	103.86	4,814,606.408	290,650.528
PH3	103.89	4,814,606.408	290,650.528
PH4	103.63	4,814,606.408	290,650.528
PH5	105.26	4,814,606.408	290,650.528
PH6	105.27	4,814,606.408	290,650.528
PH7	105.25	4,814,606.408	290,650.528
PH8	105.57	4,814,606.408	290,650.528

NO. DATE BY REVISION

Geocres No.

HWY. No. QEW PROJECT NO.: 981-1122 DIST. 4/6
SUBM'D. AMP CHKD: AMP DATE: 1998 11 06 SITE 10-162
DRAWN: MHW CHKD. AMP APPD. DWG. N1122001