Geocres No:
30M12-321

Terraprobe

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

FOUNDATION INVESTIGATION & DESIGN REPORT
HEART LAKE ROAD WATERMAIN INSTALLATION
HIGHWAY 410 EXTENSION – PHASE III
FROM 300 m EAST OF HEART LAKE ROAD TO HIGHWAY 10
W.P. 105-00-01

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

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

File No. 1-06-1346 (HLR)
April 04, 2007

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

Distribution:

3 Copies	-	MTO Central Region
1 Copy	-	Region of Peel
2 Copies	-	Giffels Associates Limited
1 Copy	-	Terraprobe Limited, Brampton

TABLE OF CONTENTS

Part 1

Part 2

Appendices

FOUNDATION INVESTIGATION AND DESIGN REPORT
HEART LAKE ROAD WATERMAIN INSTALLATION
HIGHWAY 410 EXTENSION – PHASE III
ONTARIO
W.P. 105-00-01

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of the proposed watermain installation east of the Heart Lake Road underpass structure and crossing under the proposed four-lanes of Highway 410 in the Town of Caledon, Ontario. Previous, foundation investigations were carried out by Terraprobe Limited for the Heart Lake Road underpass structure and the applicable factual data from this investigation was used to supplement the current field investigations.

The purpose of this investigation was to explore the subsurface conditions at the site and based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a description of the subsurface conditions. A model of the subsurface conditions was developed using existing data and information obtained from this investigation.

Terraprobe conducted the investigation as a sub-consultant to Giffels Associates Ltd. (Giffels), for the Region of Peel.

The following documents are referenced in the preparation of this report:

- Terraprobe Limited, "Foundation Investigation & Design Report, Heart Lake Road Underpass Structure, Highway 410 Extension – Phase III, From 300 m East of Heart Lake Road to Highway 10", Agreement No. 2005-A-000230, W.P. 105-00-00, dated March 27, 2006.

2 SITE DESCRIPTION

The site is located on Heart Lake Road about 420± m north of the Heart Lake Road/Mayfield Road intersection in the Town of Caledon. Heart Lake Road is a two lane asphalt paved road with granular shoulders and ditches on both sides. At the site the topography is flat and vegetation is light consisting mainly of grass and occasional large trees. North of the Mayfield Road intersection the profile grade of Heart Lake Road rises gradually by about 6.5 ± m over a horizontal distance of 420 m becoming relatively level further north of the bridge site.

The site is located in the physiographic region of Southern Ontario referred to as the Peel Plain whose topography slopes gradually and gently towards Lake Ontario. Etobicoke Creek and other rivers have cut deep valleys across the Peel Plain.

The Peel Plain is known to consist of generally clayey and silty soils that cover the central portion of the regions of York, Peel and Halton[1]. There are exceptions to be noted in these major soil groups. Trains of sandy alluvium can be found at various places in the stream valleys. These overburden soils are underlain by the Queenston Formation.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out on November 13, 2006 and consisted of drilling and sampling two boreholes to depths of 12.4 m below ground surface. The boreholes were numbered BH1 and BH2 and their approximate locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations, coordinates and geodetic elevations were established in the field by surveyors from Shiu Geomatics Limited based on drawings provided by Giffels. Utility clearances were obtained by Terraprobe prior to drilling.

The drilling, sampling and in-situ testing operations were conducted with a track mounted drill rig owned and operated by Drill Tech Drilling of Newmarket, Ontario. Solid stem auger drilling techniques were used to advance the boreholes and 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. A standpipe piezometer consisting of 19 mm PVC pipe with a slotted screen enclosed in sand was installed in each borehole to permit longer term groundwater level monitoring. The locations and completion details of the piezometers are shown in Table 3.1.

Table 3.1 – Piezometer Installation Details

Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
BH1	12.2/256.3	Piezometer with 3.0 m slotted screen installed with filter sand to 8.5 m, bentonite seal from 8.5 m to 7.3 m, drill cuttings from 7.3 m to 0.9 m and bentonite seal from 0.9 m to ground surface.
BH2	12.2/255.7	Piezometer with 3.0 m slotted screen installed with filter sand to 9.1 m, bentonite seal from 9.1 m to 7.6 m, drill cuttings from 7.6 m to 0.9 m and bentonite seal from 0.9 m to ground surface.

[1] Chapman and Putnam, "The Physiography of South Ontario", 3rd Edition, 1984.

A member of Terraprobe's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor 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. 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 from previous investigations are illustrated in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A and the applicable Record of Borehole sheets from the previous Terraprobe investigations included in Appendix B. Details of the encountered soil stratigraphy are presented in these appendices and on the "Borehole Locations and Soil Strata" drawing in Appendix D. 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, fill and overburden deposits consisting of very stiff to hard clayey silt till and very dense sand.

5.1 Topsoil

A layer of topsoil ranging from 300 mm to 350 mm in thickness was encountered in Boreholes 1 and 2. Topsoil thickness may vary between and beyond the boreholes.

5.2 Silty Sand Fill

Silty sand fill was encountered in some of the boreholes at the site. This fill is approximately 0.6 m to 0.7 m thick and extends to elevations ranging from 268 m to 267.9 m.

A Standard Penetration test in this fill material yielded an 'N' value of 50 blows for less than 0.3 m penetration. Since the previous boreholes were drilled in relatively cold weather (March) it is our opinion that this relatively high 'N' value may signify frozen ground conditions.

The moisture content of samples of this fill ranged from 10% to 11% by weight.

5.3 Clayey Silt Fill

Clayey silt fill was encountered at depths ranging from 0.7 m to 1.4 m below ground surface or to elevations ranging from Elev. 267.8 m to Elev. 267.1 m.

Refer to Figure C1 for the grain size distribution curve of a sample of this fill material. The results show a grain size distribution consisting of 0% gravel, 29% sand, 48% silt and 23% clay size particles.

Standard Penetration tests in this fill material yielded 'N' values of 2 blows to 18 blows for 0.3 m penetration. Based on these 'N' values the clayey silt fill is considered to have a soft to very stiff consistency.

The moisture content of samples of this fill material ranged from 19% to 23% by weight.

5.4 Clayey Silt Till

Across the site a major deposit of clayey silt till was encountered. This deposit extends to depths ranging from 5.4 m (Elev. 263.1 m) to 8.4 m (Elev. 260.1 m) below ground surface.

The grain size distribution curves of tested samples of this clayey silt till are presented in Figure C2. These results show a grain size distribution consisting of 0-6% gravel, 32-38% sand, 39-54% silt and 14-17% clay size particles. Till soils are also known to contain cobbles and boulders due to their mode of deposition.

One sample was also subjected to an Atterberg Limits test and the results are presented in Figure C3. The index values from this test are summarized below:

Liquid Limit:	21%
Plastic Limit:	6%
Plasticity Index:	15%
Natural Moisture Content:	11%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in this clayey silt till layer yielded 'N' values ranging from 24 blows to more than 100 blows for 0.3 m penetration indicating a very stiff to hard consistency.

The moisture content of samples from this deposit ranged from 6% to 19% by weight and the bulk unit weight of samples ranged between 21 kN/m^3 and 23.1 kN/m^3.

5.5 Sand (Possible Till)

Across the site the boreholes encountered a layer of sand with trace to some silt, trace gravel and trace clay. This layer extends to a depth of 11.5 m (Elev. 257 m) below ground surface in Borehole 1. In Borehole 2, HLR 2 and HLR 6 this deposit extends to borehole termination depths ranging from 10.8 m to 12.4 m below ground surface or to elevations ranging from 257.9 m to 255.5 m.

The results of a grain size distribution test conducted on a sample from this stratum are illustrated in Figure C4. The results show a grain size distribution consisting of 1% gravel,

81% sand, 13% silt and 5% clay size particles. Cobbles and boulders can also be expected in till soils.

Standard Penetration tests in this stratum gave 'N' values of more than 100 blows for 0.3 m penetration indicating a very dense relative density.

The moisture content of samples from this stratum ranged from 2% to 11% by weight.

5.6 Silty Sand

In Borehole 1 a layer of silty sand was encountered at a depth of 11.5 m (Elev. 257 m) and extends to the borehole termination depth of 12.4 m (Elev. 256.1 m) and possibly beyond.

A Standard Penetration test in this stratum gave an 'N' value of more than 100 blows for 0.3 m penetration indicating a very dense relative density.

The moisture content of a sample from this stratum was 21% by weight.

5.7 Water Levels

A standpipe piezometer was installed in both boreholes. The water level readings were measured on a separate visit made after the completion of drilling. The water level measurements of the present and previous readings at this site are presented in Table 5.1 below.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
BH1	Nov. 20, 2006	Dry	-
BH2	Nov. 20, 2006	11.6	256.3
HLR2	April 18, 2005	Dry	-
	Sept. 09, 2005	Dry	-
HLR6	April 18, 2005	Dry	-
	Sept. 09, 2005	10.8*	257.9

* Wet at Base (no free water in standpipe)

These observations suggest that the local groundwater level at the site is likely to exist at elevations ranging from 257.9 m to 256.3 m. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.

Prepared by:
R. Abdul, P.Eng.,
Senior Geotechnical Engineer

Report Reviewed by:
Michael Tanos, P.Eng.,
Review Principal

FOUNDATION INVESTIGATION AND DESIGN REPORT
HEART LAKE ROAD WATERMAIN INSTALLATION
HIGHWAY 410 EXTENSION – PHASE III
ONTARIO
W.P. 105-00-01

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical design recommendations for the proposed watermain installation.

An approximately 116.5 m long, 400 mm diameter concrete pressure pipe (CPP) watermain will be installed approximately 22 m east of the existing centre line of Heart Lake Road. This watermain will cross under the proposed four-lanes of Highway 410 at about Sta. 22+383 and will be aligned 9.5 m± east of the proposed Heart Lake Road underpass structure.

At the south limit of the alignment the watermain invert will be about Elev. 265.4 m falling to Elev. 258.7 m over a horizontal distance of 3.9 m. The watermain will then cross under the proposed Highway 410 at Elev. 258.7 m over a horizontal distance of 84 m then rising upwards to an invert elevation of Elev. 266.2 m over a horizontal distance of 7.5 m at the north limit.

Below Highway 410 the watermain will be installed in a 64 m long, 1100 mm diameter steel liner with invert and obvert elevations of Elev. 258.3 m and Elev. 259.4 m respectively.

It is understood that the proposed construction sequence will be to install the liner and watermain during highway construction and before the underpass structure is constructed.

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 WATERMAIN

7.1 General

Under the proposed Highway 410 the 400 mm diameter CPP watermain will be installed in a steel liner 1100 mm in diameter and approximately 64 m in length. Since the watermain installation will precede highway construction it is likely that the following construction sequence will be adopted.

- Excavate overburden soils at this site to design elevations.
- Excavate to invert elevation of watermain bedding by trenching. This will require excavations below subgrade of Highway 410 and along the face of cut slopes.
- Prepare trench bottom and install watermain.
- Place and compact select backfill material in open trench.
- Proceed with construction of other elements such as Heart Lake Road underpass structure.

Based on the foregoing construction sequence and considering that the watermain will be installed before Highway 410 is constructed, other installation methods such as Jack and Bore, Directional Drilling and Pipe ramming have been eliminated. These methods only become economically viable when tunnelling under existing structures.

7.2 Open Cut Trenching

It is recommended that the watermain be installed by open cut trenching. Other methods such as Jack and bore, Directional drilling and Pipe ramming provide no advantages nor are they more economical.

7.2.1 Vertical Alignment

The invert elevation at the south limit is 265.4 m falling to Elev. 258.7 m. Towards the north limit the watermain invert will rise upwards to Elev. 266.2 m. The liner invert is Elev. 258.3 m. Based on the subsurface stratigraphy encountered at this site the trench bottom will lie in clayey silt till and possible till consisting of sand with trace to some silt and trace gravel. The groundwater table is anticipated to be below the depth of excavation.

At the proposed invert level the clayey silt till is very stiff to hard and the sand (possible till) is very dense. These soils will provide excellent support to the pipe.

7.2.2 Excavation

The soils described at this site are considered to be suitable for excavation using trenching and excavating equipment, such as backhoes normally used by contractors for watermain installation. Excavations should be undertaken in accordance with OPSS 514.

Till soils inherently contain cobbles and boulders and the contract documents must identify this fact to bidders. The frequency of boulders is unlikely to be high enough to prevent the use of suitable trenching and excavating equipment. However, the contract documents should include a NSSP alerting bidders to the fact that cobbles and boulders may be encountered in the soil. Suggested wording for this NSSP is included in Appendix E.

7.2.3 OHSA Soil Classification

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils at this site may be classified as Type 2 soils. Excavations above the water table may be sloped at 1.5H:1V

7.2.4 Groundwater Control

Since the groundwater level is estimated to be below the depth of excavation i.e. below Elev. 258 m ± it is unlikely that excavations will encounter groundwater at this site. However, provision should be made for controlling any surface water run-off into excavations as well as minor subsurface seepage from any wet sand seams within the overburden.

The design of the unwatering system should be the responsibility of the Contractor. A suitable system that might be employed can include gravity drainage and pumping from strategically placed filtered sumps.

Any accumulation of water at the base of the excavation should be removed prior to placing and compacting the pipe bedding. Placement of the pipe bedding must be done in the dry.

7.2.5 Bedding

The bedding for the watermain and its liner must conform to the requirements of OPSD 802.030 (rigid pipe in earth excavation).

It is recommended that the bedding material consist of OPSS Granular "A".

Additional bedding requirements that may be imposed by the supplier must also be followed.

7.2.6 Backfill

At the Highway 410 crossing, it is recommended that the trench backfill consist of Granular "B" Type I. The backfill should be compacted to a minimum of 98% of the Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within ±2% of the optimum value.

Elsewhere the backfill may consist of the excavated soil compacted to 95% SPMDD at a moisture content within ±2% of the optimum value.

8 EARTH PRESSURE

The excavation walls will have to be supported using either a system of close shoring or a suitably designed trench box.

Earth pressures acting on the shoring system may be assumed to be triangular and to be governed by the characteristics of the soil being retained. Earth pressure computations must also take into

account the groundwater level. Above the groundwater level, earth pressure is computed using the bulk unit weight of the retained soil. Below the groundwater level, the earth pressures are computed using the submerged unit weight of the soil. A hydrostatic pressure is also applied if the retained soil is not fully drained.

Earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC. The appropriate pressures can be computed from the expression:

$P_h = K[\gamma (h - h_w) + (\gamma' h_w) + q] + h_w \gamma_w$

P_h = horizontal pressure on the wall (kPa)

K = earth pressure coefficient (see table 8.1)

γ = bulk unit weight of retained soil (see table 8.1)

γ' = submerged unit weight of soil ($\gamma - \gamma_w$)

γ_w = unit weight of water (9.81 kN/m^3)

h = depth below surface (m)

h_w = depth below the groundwater level (m)

q = value of any surcharge (kPa)

If the shoring is internally braced at more than one level, then it is recommended that the design of the system be undertaken based on an earth pressure distribution consisting of a uniformly distributed pressure defined by the expression:

$P = 0.65\ K[\gamma h + q] + h_w \gamma_w$

K = earth pressure coefficient (see table 8.1)

γ = bulk unit weight of retained soil (see table 8.1)

γ_w = unit weight of water

h = depth below surface (m)

h_w = depth below the groundwater level (m)

q = value of any surcharge (kPa)

The appropriate values of the parameters for use in the design of structures subject to unbalanced earth pressures are given in Table 8.1 below.

Table 8.1 – Earth Pressure Coefficients

Stratum	ϕ	γ	K_a	K_o	K_p
Clayey Silt Glacial Till	28	20	0.36	0.53	2.80
Sand (Possible Till)	30	20	0.33	0.50	3.00

The factors in the table above are "ultimate" values and require certain movements for the active and passive conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC, 2000.

9 ALIGNMENT CONSIDERATIONS

It is noted that excavations for the watermain installation will be undertaken along an alignment approximately 9.5 m± east of the footprint of the proposed underpass structure. If excavations are undertaken within close shoring or trench boxes the founding soils below the foundation elements of the proposed underpass will be sufficiently removed from the excavation so as to be unaffected by the excavation activity.

10 CONSTRUCTION CONCERNS

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to foundation construction.

Potential construction concerns include, but are not necessarily limited to:

- the possibility of boulders being encountered during excavation.
- the potential for groundwater levels to be higher at the time of construction than those recorded in this report.

Engineering Analysis and Report Preparation by:
R. Abdul, P.Eng.,
Senior Geotechnical Engineer

Report Reviewed by:
Michael Tanos, P.Eng.,
Review Principal

APPENDIX A

Record of Borehole Sheets

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

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 $\hat{N}$.

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	- °	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	- °	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER						
γ_w	kN/m^3	UNIT WEIGHT OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	w_S	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_P	%	PLASTICITY INDEX = $(w_L - w_P)$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_P)/I_P$	i	1	HYDRAULIC GRADIENT
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	I_C	1	CONSISTENCY INDEX = $(w_L - w)/I_P$	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL	e_{max}	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. _____ LOCATION Coords: N:4846257.7 E:280066.5 ORIGINATED BY AZ

DIST _____ HWY Heart Lake Road BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 13.11.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
268.5	Ground Surface						
0.0 / 268.2	350mm TOPSOIL		1	SS	2		268
0.4 / 267.8	FILL-Clayey Silt,trace to some sand, trace gravel,soft,brown,damp to moist						
0.7	CLAYEY SILT sandy, trace gravel, hard, brown, damp (GLACIAL TILL)		2	SS	35		267
			3	SS	48		
			4	SS	78		266
			5	SS	95		265
			6	SS	50/ 8cm		264
263.1							
5.4	SAND trace to some silt, trace clay, trace gravel, very dense, brown, dry to damp (POSIBLE TILL)		7	SS	75/ 13cm		263
			8	SS	80/ 13cm		262
			9	SS	100/ 13cm		261
			10	SS	70/ 15cm		260
257.0							259
11.5 / 256.1	SILTY SAND very dense, brown, moist to wet		11	SS	100/ 15cm		258
12.4	End of Borehole						257

Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with a 3.0m slotted screen.

Water Level Readings:

Date	Depth(m)	Elevation(m)
20/11/06	Dry	-

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 1-06-1346 HLR SEWERS.GPJ ONTARIO MOT.GDT 22/11/06

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. _____ LOCATION Coords: N:4846196.2 E:280126.7 ORIGINATED BY AZ

DIST _____ HWY Heart Lake Road BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 13.11.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
267.9	Ground Surface										
0.0 / 267.6	300mm TOPSOIL										
0.3 / 267.2	FILL - Clayey Silt, sandy, trace gravel, very stiff, brown, moist		1	SS	18						No Sample Recovery.
0.7	CLAYEY SILT some sand, trace gravel, very stiff to hard, brown, damp (GLACIAL TILL)		2	SS	24		267				
			3	SS	49		266				
			4	SS	56/ 15cm		265				
			5	SS	76/ 18cm		264				
	---- grey		6	SS	50/ 8cm		263				No Sample Recovery.
			7	SS	50/ 8cm		262				
260.9							261				
7.0	SAND some sill, trace clay, trace gravel, very dense, brown, damp to moist (POSIBLE TILL)		8	SS	56/ 8cm		260				
			9	SS	50/ 5cm		259				
			10	SS	60/ 8cm		258				
							257				
255.5			11	SS	70/ 5cm		256				
12.4	End of Borehole										

Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with a 3.0m slotted screen.

Water Level Readings:

Date	Depth(m)	Elevation(m)
20/11/06	11.6	256.3

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 1-06-1346 HLR SEWERS.GPJ ONTARIO MOT.GDT 22/11/06

APPENDIX B

Record of Borehole Sheets
(Previous Investigations)

Terraprobe Limited

RECORD OF BOREHOLE No HLR2

1 OF 1

METRIC

W.P. _____ LOCATION Coords: N:4846192.7 E:280121.5 (Heart Lake Road) ORIGINATED BY MS

DIST _____ HWY Heart Lake Road BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 07.03.05 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
268.5	Ground Surface										
0.0 / 267.9	**FILL** - Silty **Sand**, some gravel, trace clay, brown, frozen		1	SS	50/ 15cm		268		○		
0.6 / 267.1	**FILL** - Clayey Silt, Sandy, damp, stiff, brown		2	SS	11				○		0 29 48 23
1.4	**CLAYEY SILT** - Sandy, trace gravel, occasional sandy silt partings, damp, hard, brown (GLACIAL TILL)		3	SS	34		267		○		
			4	SS	42		266		○		6 38 39 17
			5	SS	79		265		○	21.0	
			6	SS	82/ 28cm		264		○		
			7	SS	100/ 8cm		263				
			8	SS	100/ 0cm		262		○		0 32 54 14
260.1							261				
8.4	**SAND** some silt, trace gravel, trace clay, dry, very dense, brown (POSSIBLE TILL)		9	SS	100/ 15cm		260		○		
257.7							259				1 81 13 5
10.8	End of Borehole Piezometer installation consists of 19mm dia. Schedule 40 PVC pipe with a 1.5m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) 18/04/05 Dry - 09/09/05 Dry -		10	SS	100/ 10cm		258		○		

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

RECORD OF BOREHOLE No HLR6 1 OF 1 METRIC

W.P. _____ LOCATION Coords: N:4846221.9 E:280092.8 (Heart Lake Road) ORIGINATED BY MS

DIST _____ HWY Heart Lake Road BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 08.03.05 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
268.7	Ground Surface										
0.0 / 268.0	**FILL** - Silty Sand, some gravel, moist, brown		1	AS							
0.7	**CLAYEY SILT** some sand, trace gravel, occasional silty sand seams and partings, damp, hard, brown (GLACIAL TILL)		2	SS	32		268				
			3	SS	32		267				
			4	SS	72		266			22.0	
			5	SS	50/ 10cm		265				
			6	SS	100/ 8cm		264				
			7	SS	100/ 8cm		263			23.1	
			8	SS	100/ 13cm		262				
261.4			9	SS	100/ 15cm						
7.3	**SAND** some silt, trace gravel, trace clay, damp, very dense, brown (POSSIBLE TILL)		10	SS	100/ 8cm		261				
			11	SS	100/ 10cm		260				
			12	SS	100/ 13cm		259				
257.9			13	SS	100/ 8cm		258				
10.8	End of Borehole										

Piezometer installation consists of 19mm dia. Schedule 40 PVC pipe with a 1.5m slotted screen.

Water Level Readings:

Date	Depth(m)	Elevation(m)
18/04/05	Dry	-
09/05/05	wet at base	257.9

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 1-06-1346 HLR SEWERS.GPJ ONTARIO MOT.GDT 22/11/06

APPENDIX C

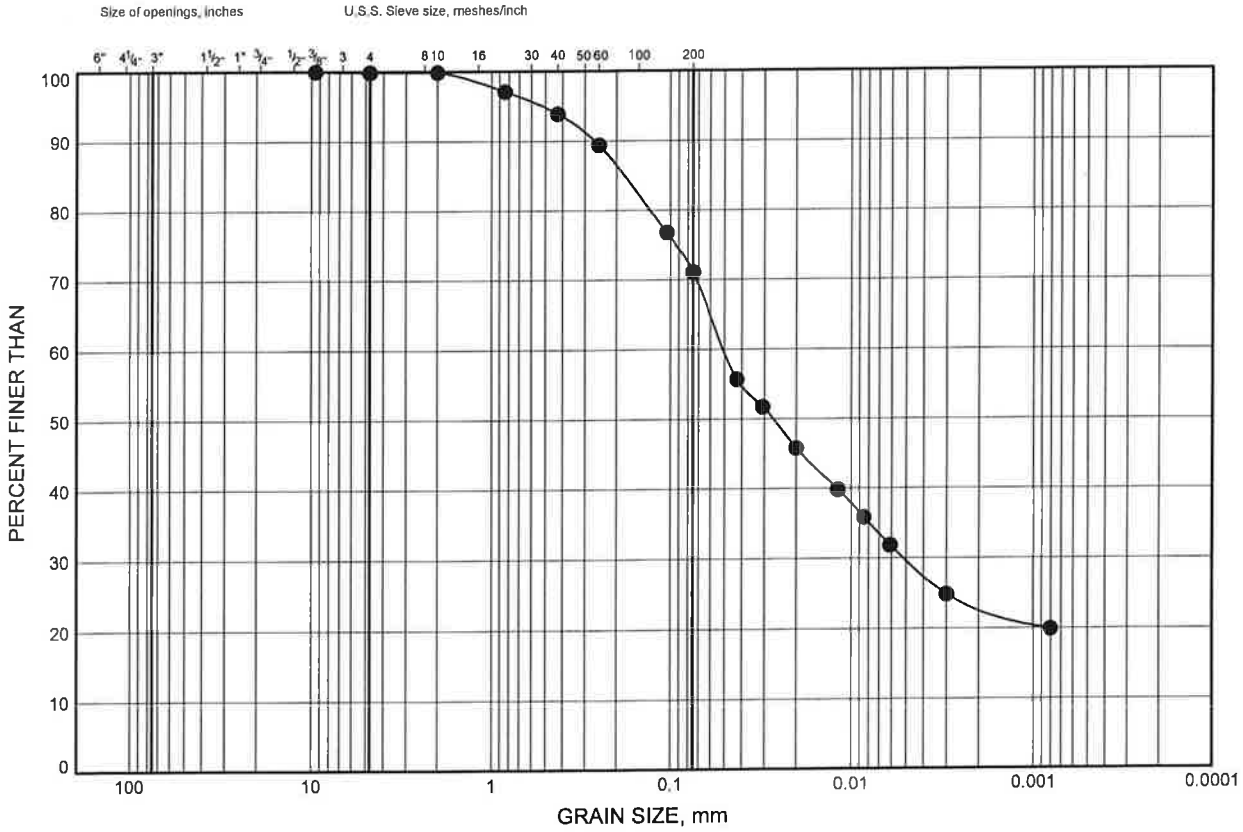
Laboratory Test Results (Previous Investigations)

Terraprobe Limited

GRAIN SIZE DISTRIBUTION

FIGURE C1

Clayey Silt (Fill)



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	HLR2	1.0	267.5

Date November 2006

Project 1-06-1346 (HLR)

Prep'd DB

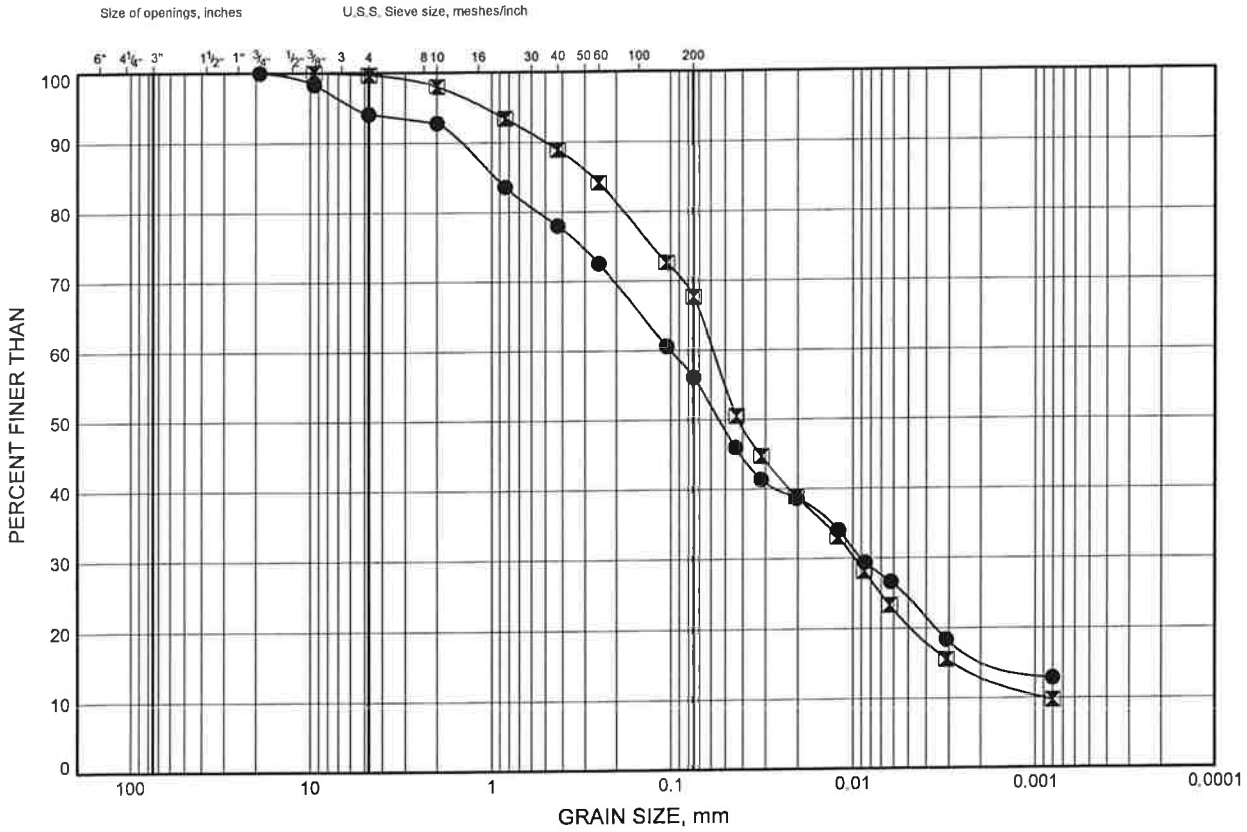
Chkd. RA

GSD 1-06-1346 HLR SEWERS.GPJ 22/11/06

GRAIN SIZE DISTRIBUTION

FIGURE C2

Clayey Silt Till



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	HLR2	2.5	266.0
⊠	HLR2	6.3	262.2

Date November 2006

Project 1-06-1346 (HLR)

Prep'd DB

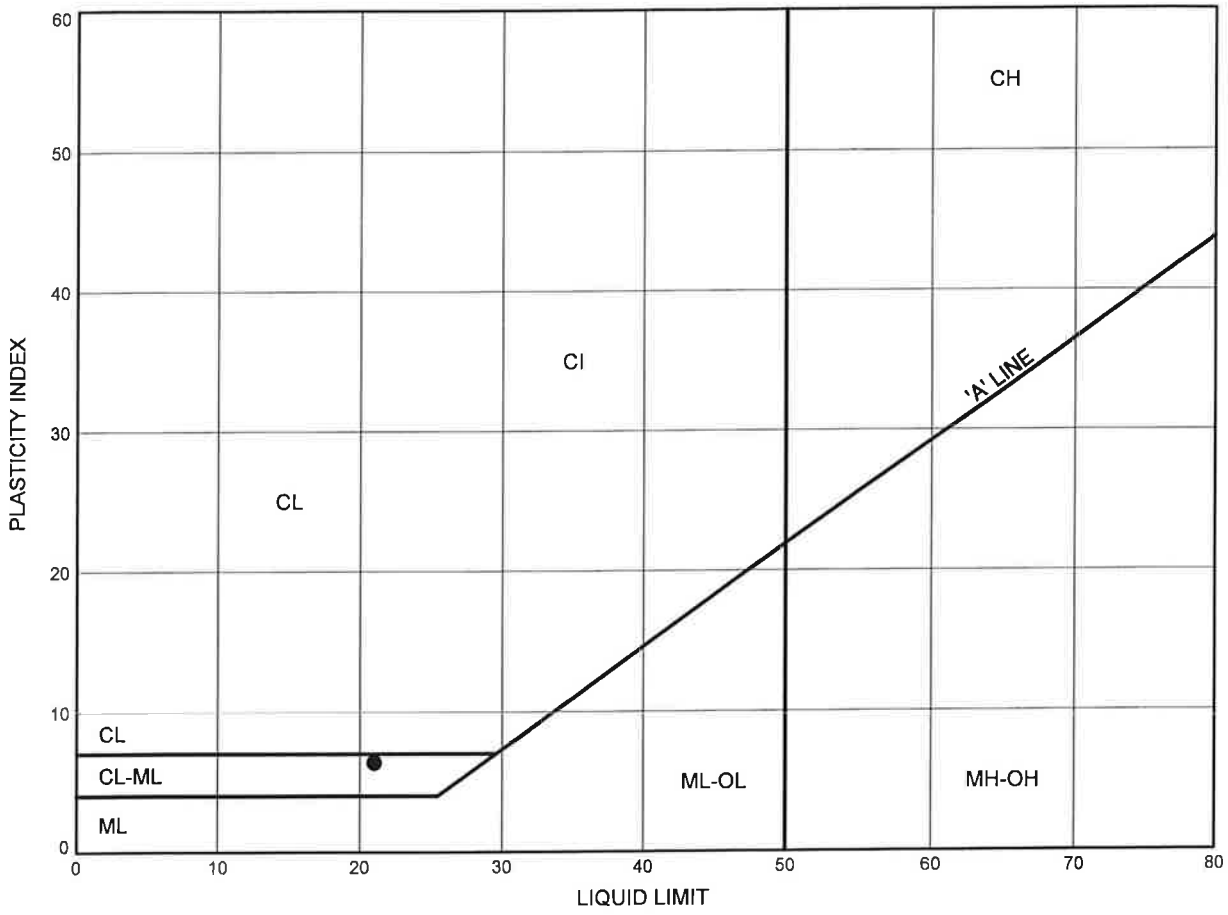
Chkd. RA

GSD 1-06-1346 HLR SEWERS.GPJ 22/11/06

ATTERBERG LIMITS TEST RESULTS

FIGURE C3

Clayey Silt Till



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	HLR2	2.5	266.0

Date November 2006

Project 1-06-1346 (HLR)

Prep'd DB

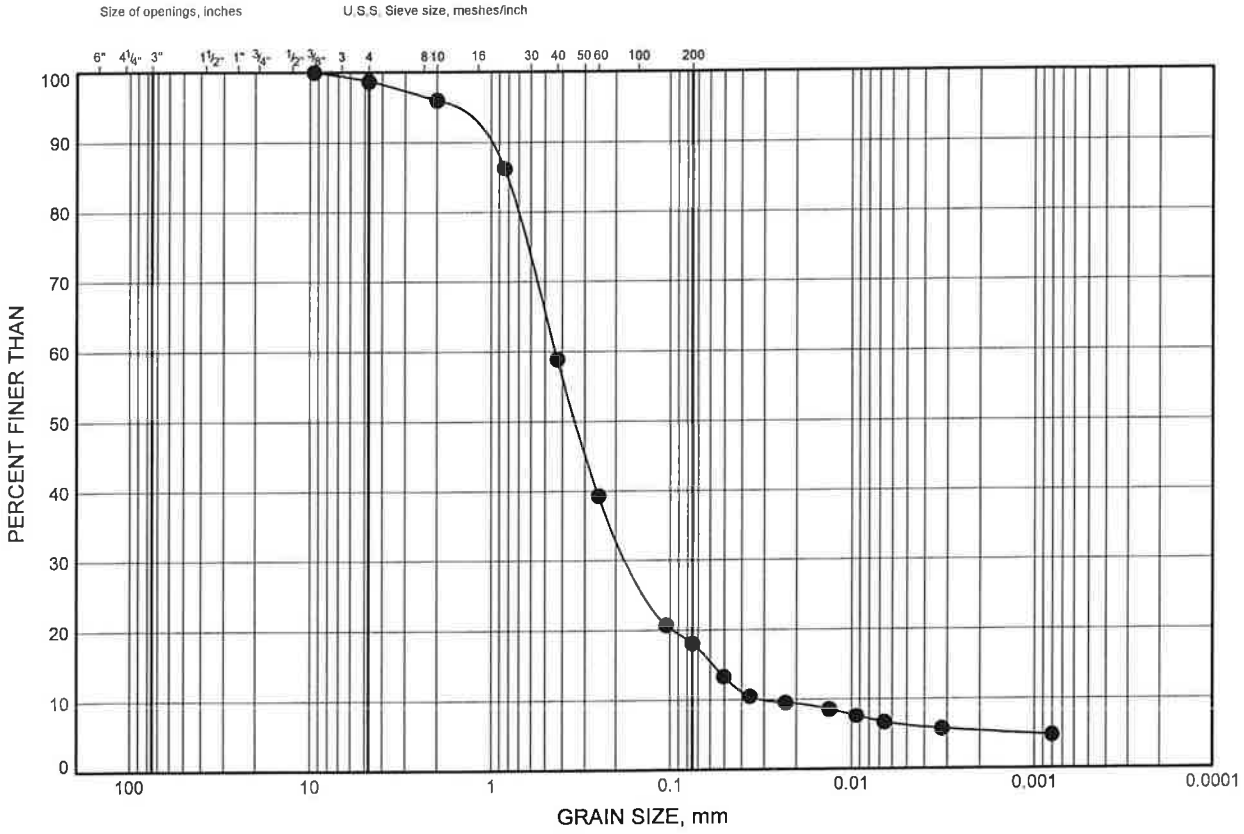
Chkd. RA

ALTR 1-06-1346 HLR SEWERS.GPJ 22/11/06

GRAIN SIZE DISTRIBUTION

FIGURE C4

Sand (Possible Till)



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	HLR2	9.2	259.3

Date November 2006

Project 1-06-1346 (HLR)

Prep'd DB

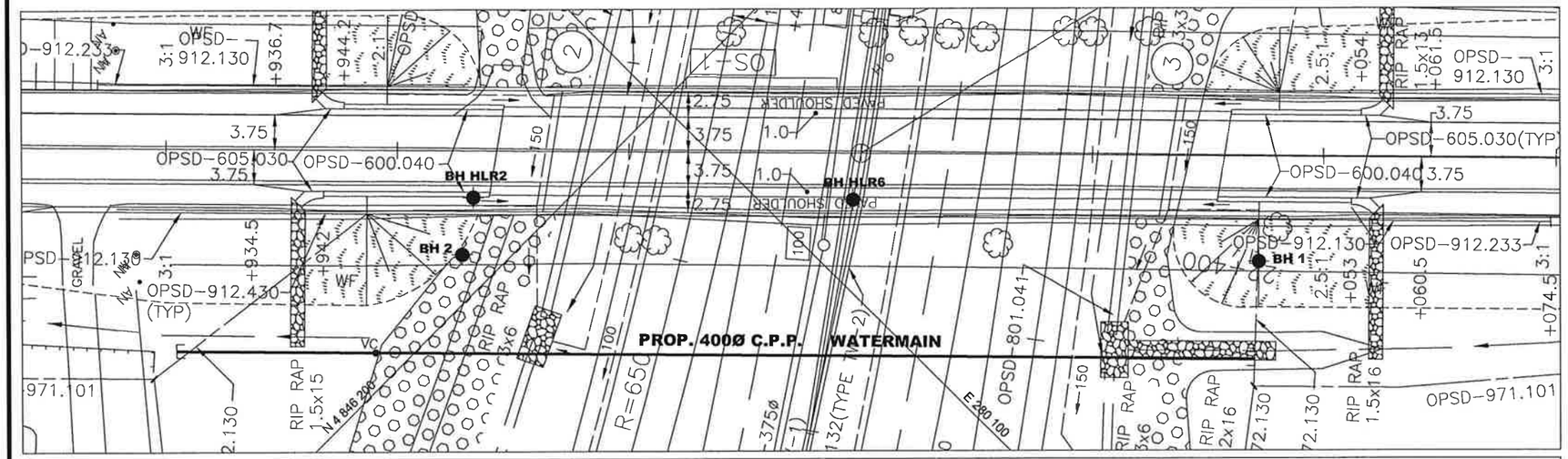
Chkd. RA

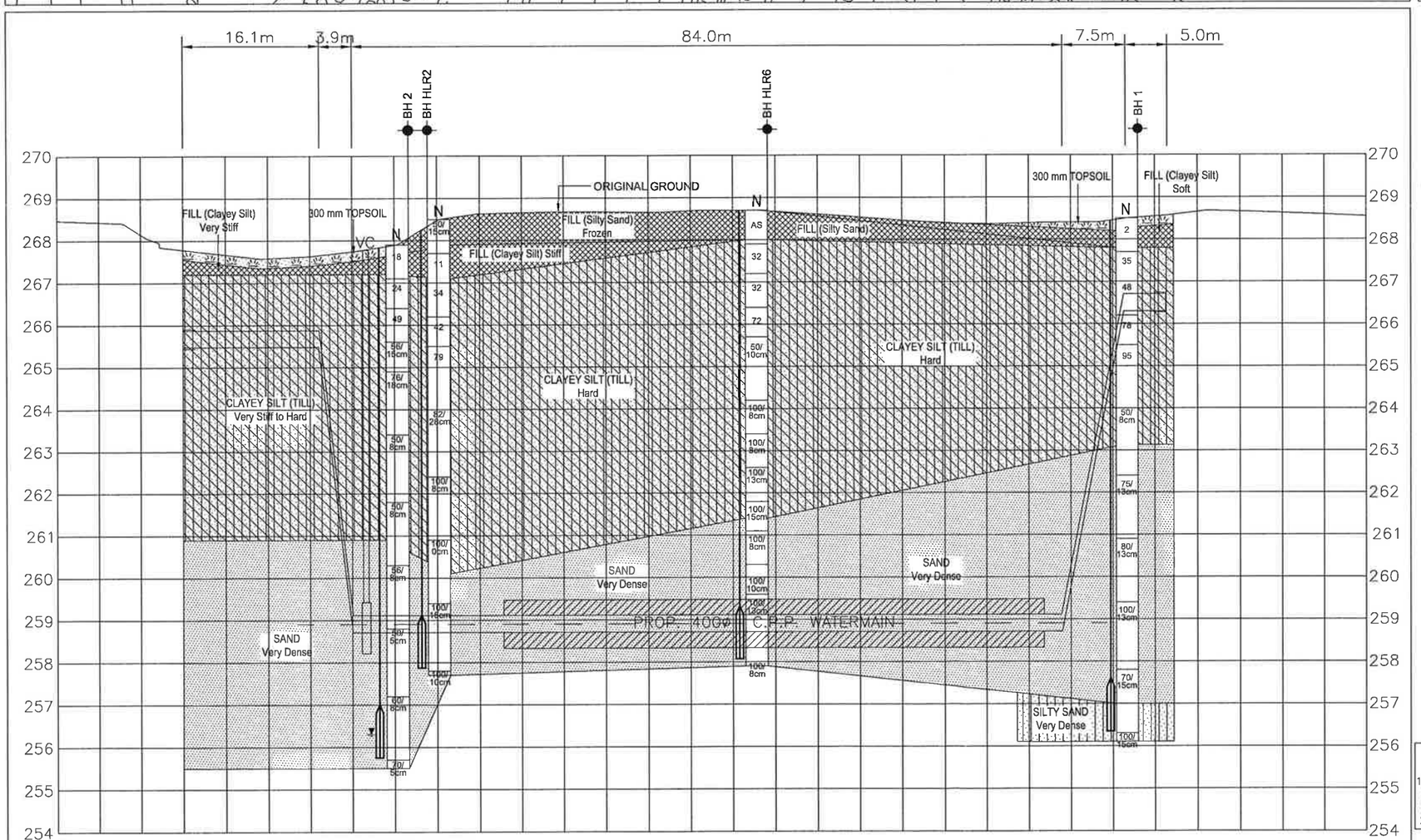
GSD 1-06-1346 HLR SEWERS.GPJ 22/11/06

APPENDIX D

Drawing titled
"Borehole Locations and Soil Strata"

Terraprobe Limited





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

PLAN
10m 0 10m

Profile ℄ Watermain
10m 0 10m HORIZ
2m 0 2m VERT

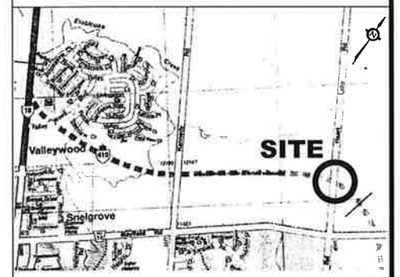
CONT No
WP No 105-00-01

SHEET

HIGHWAY 410-PHASE III
HEARTLAKE ROAD WATERMAIN
BOREHOLE LOCATIONS AND SOIL STRATA

Giffels
An Ingenium Group Company

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



KEY PLAN 1000m

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 2006, 11
	Piezometer
90%	Rock Quality Designation
A/R	Auger Refusal

No	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH1	268.5	4846257.7	280066.5
BH2	267.9	4846196.2	280126.7
HLR2	268.5	4846192.7	280121.5
HLR6	268.7	4846221.9	280092.8

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	R.A	CODE	–	LOAD	DATE NOV.2006
DRAWN	JDM	CHK	R.A	SITE:	STRUCT DWG

APPENDIX E

Suggested NSSP Wording

TERRAPROBE LIMITED

In this report reference is made to the following Provincial Standard

- OPSS 514, November 2005.

The contract documents should contain a NSSP containing the following wording:

Cobbles and Boulders

"The Contractor is informed that the soils at this site may contain cobbles and boulders that may impede the progress of trenching. The soil conditions are described in the Foundation Investigation Report prepared for this site. Reference should be made to this report for a description of the soil conditions"