Terraprobe

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

FOUNDATION INVESTIGATION REPORT

VALLEYWOOD BOULEVARD 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. 108-00-01, SITE #: 24-745

PREPARED FOR: Giffels Associates Ltd.
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File No. 1-00-0350
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ONTARIO
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of the Valleywood Boulevard underpass structure on the proposed four-lane of Highway 410 in the Town of Caledon, Ontario. Previous, preliminary investigations were carried out by Golder Associates Ltd. (Golder) and the Ministry of Transportation (MTO), and the factual data from these investigations have been used as general reference for the preparation of this report.

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 and cross-sections, laboratory test results and a description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained.

Terraprobe conducted the investigation as a sub-consultant to Giffels Associates Ltd., under the Ministry of Transportation Ontario (MTO) Agreement Number 2005-A-000230.

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

- Golder Associates Ltd., "Supplementary Foundation Feasibility Investigation, Proposed Highway 410 Extension, Bovaird Drive to Highway 10", W.P. 22-79-00, MTO District 6, Toronto, GEOCRES No. 30M12-208, dated April 1999.
- Ministry of Transportation, "Highway 410 Route Planning Study, Bovaird Drive Northerly to Highway 10", W.P. 22-79-00, MTO District 6, GEOCRES 30M12-208, dated January 24, 1989.

2 SITE DESCRIPTION

The site is located about 50 m east of Valleywood Boulevard and 175 m northeast of Highway 10 in the Town of Caledon. There are residential subdivisions to the north and east of the site. The topography across the site is flat with light vegetation consisting of grass and small shrubs.

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 during the period February 15 to 28, 2005 and consisted of drilling and sampling six boreholes to depths ranging from 12.4 m to 26.4 m. The boreholes were numbered VB1, VB2, VB3, VB4, VB5 and VB6 and their approximate locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C.

The borehole locations were established in the field by surveyors from Shiu Geomatics Limited who also provided Terraprobe with their coordinates and geodetic elevations. Terraprobe obtained utility clearances prior to drilling.

The drilling, sampling and in-situ testing operations were conducted with a track mounted CME 75 drill rig owned and operated by Groundworks Drilling Limited of Toronto, Ontario. Solid and hollow-stem auger drilling techniques were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipes piezometers consisting of 19 mm PVC pipe with a slotted screen (enclosed either in sand or geotextile fabric) were installed in selected boreholes 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

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
VB1	12.4/245.9	Piezometer with 1.5 m slotted screen installed with filter sand to 10.8 m, bentonite seal from 10.8 m to 9.1 m, drill cuttings from 9.1 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
VB2	24.3/234.9	Piezometer with 1.5 m slotted screen wrapped in filter cloth, drill cuttings from 24.3 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.

Table 3.1 – Piezometer Installation Details (Cont'd)

VB3	26.2/233.0	Piezometer with 1.5 m slotted screen wrapped in filter cloth, drill cuttings from 26.2 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
VB5	25.9/232.2	Piezometer with 1.5 m slotted screen wrapped in filter cloth, drill cuttings from 25.9 m to 1.2 m and bentonite seal from 1.2 m to ground surface.
VB6	13.7/244.1	Piezometer with 1.5 m slotted screen installed with filter sand to 12.2 m, bentonite seal from 12.2 m to 11.8 m, drill cuttings from 11.8 m to 0.9 m and bentonite seal from 0.9 m to ground surface.

Members of Terraprobe's technical staff supervised the drilling and sampling operations on a full time basis. The supervisors logged the boreholes and processed the recovered soil samples for transport to Terraprobe's Brampton laboratory for further examination and testing.

4 LABORATORY TESTING

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

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the "Borehole Locations and Soil Strata" drawing in Appendix C. 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 and overburden deposits of clayey silt till, sand and silt till, silty sand, clayey silt and silt till.

5.1 Topsoil

Topsoil approximately 100 mm to 500 mm thick was encountered across the site. Topsoil thickness may vary between and beyond the boreholes.

5.2 Clayey Silt Till

Across the site a clayey silt till deposit was encountered below the topsoil layer. This clayey silt till layer extends to depths ranging from 10.1 m (Elev. 248.2 m) to 13.2 m (Elev. 245.6 m) below ground surface.

The grain size distribution curves of tested samples of this clayey silt till are presented in Figure B1. These results show a grain size distribution consisting of 4-9% gravel, 18-33% sand, 40-46% silt and 16-38% clay size particles. Till soils are also known to contain cobbles and boulders due to their mode of deposition.

Two samples were also subjected to Atterberg Limits tests and the results are presented in Figure B2. The index values from these tests are summarized below:

Liquid Limit:	23-28%
Plastic Limit:	14-15%
Plasticity Index:	9-13%
Natural Moisture Content:	9-16%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in this clayey silt till layer yielded 'N' values ranging from 7 to 52 blows for 0.3 m penetration indicating a firm to hard consistency. The moisture content of samples from this deposit ranged from 7% to 21% by weight.

5.3 Sand and Silt Till

The site is underlain by layers of sand and silt till. These layers were fully penetrated in the deeper boreholes (Boreholes VB2, VB3, VB4 and VB5) at depths of 20.8 m to 23.9 m below ground surface or to elevations ranging from 238 m to 234.3 m. At some of the boreholes (Boreholes VB2, VB3 and VB5) the sand and silt till is divided by a layer of silty sand.

The results of grain size distribution tests conducted on samples obtained from these deposits are illustrated in Figure B3. These results show grain size distributions consisting of 1-35% gravel, 28-59% sand, 29-49% silt and 2-9% clay size particles. Cobbles and boulders can also be expected in till soils.

Standard Penetration tests in the sand and silt till gave 'N' values that ranged from 14 to more than 100 blows for 0.3 m penetration. Based on these results the sand and silt till is considered to have a generally compact to very dense relative density. The moisture content of samples from this stratum ranged from 4% to 16% by weight.

5.4 Silty Sand

In some of the deep boreholes a layer of silty sand was encountered. This deposit was not encountered at Borehole VB4. This silty sand layer extends to depths ranging from 15.4 m to 20.2 m below ground surface or to elevations ranging from 242.7 m to 239 m.

The grain size distribution curve of a sample from this deposit is illustrated in Figure B4.

The silty sand deposit is considered to have a very dense relative density based on SPT 'N' values that ranged from 51 to 57 blows for 0.3 m penetration. The moisture content of samples from the deposit ranges from 17% to 22% by weight.

5.5 Clayey Silt

A layer of grey clayey silt was encountered in some boreholes. In Borehole VB5 this layer is 1.6m thick and extends to a depth of 25.4 m (Elev.232.7 m) below ground surface. In Boreholes VB3 and VB4 the clayey silt layer extends to borehole termination depths of 26.2 m below ground surface.

Two samples from this clayey silt deposit were subjected to grain size distribution tests and the results are illustrated in Figure B5. These results show a grain size distribution consisting of 0 % gravel, 1-7 % sand, 65-71 % silt and 22-34 % clay size particles.

A sample of the clayey silt was also subjected to an Atterberg Limits test and the results are presented in Figure B6. The index values from this test are summarized below:

Liquid Limit:	24%
Plastic Limit:	19%
Plasticity Index:	5%
Natural Moisture Content:	20%

These values are characteristic of clayey soils of low plasticity

SPT 'N' values ranged from 100 to more than 100 blows for 0.3 m penetration in the deposit indicating a hard consistency. The moisture content by weight of samples from this deposit varies from 11% to 20%.

5.6 Silt Till

Discontinuous layers of silt till were encountered across the site. This deposit was encountered in Boreholes VB2 and VB5 where it extends to the termination depths of the boreholes and possibly beyond.

The grain size distribution curve of a sample from this deposit is illustrated in Figure B7. These results show a grain size distribution consisting of 0 % gravel, 4 % sand, 90 % silt and 6 % clay size particles.

SPT 'N' values more than 100 blows for 0.3 m penetration were obtained in this deposit indicating a very dense relative density. The moisture content of samples from this stratum ranged from 16% to 19% by weight.

5.7 Water Levels

A standpipe piezometer was installed in Boreholes VB1, VB2, VB3, VB5 and VB6. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.1.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
VB1	April 18, 2005	7.5	250.8
	Sept. 09, 2005	8.2	250.1
VB2	April 18, 2005	8.7	250.5
	Sept. 09, 2005	8.8	250.4
VB3	April 18, 2005	8.5	250.7
	Sept. 09, 2005	9.2	250.0
VB5	April 18, 2005	8.2	249.9
	Sept. 09, 2005	9.0	249.1
VB6	April 18, 2005	7.0	250.8
	Sept. 09, 2005	*	*

* Damaged piezometer

These observations suggest that the local groundwater level at the site varies from about 249± m to 251± m. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.

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APPENDICES

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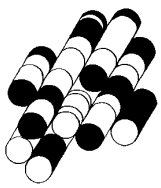

APPENDIX A

Record of Borehole Sheets

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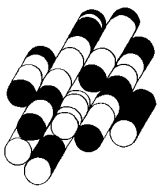


LIMITATIONS AND RISK

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 ú.

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

r_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 = $\frac{e_{max} - e}{e_{max} - e_{min}}$
r_w	kg/m^3	DENSITY OF WATER						
γ_w	kN/m^3	UNIT WEIGHT OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
r	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
r_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
r_{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
r'	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 VB1

1 OF 1

METRIC

W.P. 108-00-01 LOCATION N4844600.9;E278073.8 ORIGINATED BY MS

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 15.02.05 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) (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
258.3											
0.0 / 258.0	**300mm TOPSOIL**, dark brown		1	SS	8		258				
0.3	weathered, trace rootlets										
	CLAYEY SILT - Sandy, trace gravel, damp to moist, firm to 0.7m, very stiff to hard below		2	SS	34		257				
	(GLACIAL TILL)		3	SS	26						5 29 46 20
			4	SS	45		256			22.5	
			5	SS	38		255				
							254				
			6	SS	38						
							253				
			7	SS	21		252			23.2	
	brown / grey										
			8	SS	29		251				
							250				
			9	SS	36		249				
248.2 / 10.1	**SAND AND SILT** trace to some gravel, trace clay, damp to moist, very dense, grey						248				
	(GLACIAL TILL)		10	SS	100						
							247				
245.9 / 12.4	End of Borehole		11	SS	100/25cm		246				

Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.

WATER LEVEL READINGS

Date	Depth(m)	Elevation(m)
Ap.18.05	7.5	250.8
Sept.09.05	8.2	250.1

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

ONTARIO MOT 1-00-0350 HWY 410 VALLEYWOOD BLVD.GPJ ONTARIO MOT.GDT 20/09/05

RECORD OF BOREHOLE No VB2

1 OF 2

METRIC

W.P. 108-00-01 LOCATION N4844620.9;E278074.5 ORIGINATED BY MS

DIST HWY 410 Phase III BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 25.02.05 - 28.02.05 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 / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.2								20 40 60 80 100	10 20 30		
0.1	**100mm TOPSOIL**, dark brown, weathered, trace rootlets		1	SS	7		259				
	CLAYEY SILT - Sandy, trace gravel, damp to moist, firm to 0.7m, very stiff to hard below		2	SS	22		258				
	(GLACIAL TILL)		3	SS	29		257				
			4	SS	34		256				
			5	SS	22		255			22.5	
	brown / grey		6	SS	32						
			7	SS	27		254				8 31 42 19
			8	SS	16		253			21.2	
			9	SS	25		252				
			10	SS	37		251				
			11	SS	29		250				Feb. 25, 2005 / Feb. 28, 2005
			12	SS	28		249				
247.5							248				
11.7	**SAND AND SILT** some gravel, trace clay, moist, grey		13	SS	14		247				15 40 39 6
	(GLACIAL TILL)						246				
	compact / very dense		14	SS	100/13cm		245				

Continued Next Page

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

RECORD OF BOREHOLE No VB2 2 OF 2 METRIC

W.P. 108-00-01 LOCATION N4844620.9;E278074.5 ORIGINATED BY MS

DIST _____ HWY 410 Phase III BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 25.02.05 - 28.02.05 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) (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
	SAND AND SILT some gravel, trace clay, moist, very dense, grey (GLACIAL TILL) *(continued)*		15	SS	100/ 15cm		244		○		
							243				
			16	SS	100/ 10cm				○		
241.5							242				
17.7	**SILTY FINE SAND** wet, very dense, grey						241				
			17	SS	57				○		0 82 (18)
239.9							240				
19.3	**SAND AND SILT** trace to some gravel, trace clay, damp to moist, very dense, grey (GLACIAL TILL)		18	SS	100/ 13cm				○		
							239				
			19	SS	100/ 13cm		238		○		
							237				
			20	SS	102/ 25cm		236		○		
235.3											
23.9	**SILT** trace sand, trace clay, damp, very dense, grey (GLACIAL TILL)						235				
234.5			21	SS	103				○		
24.7	End of Borehole										

Wet cave at 20.1m on completion.

Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen wrapped in filter cloth.

WATER LEVEL READINGS

Date	Depth(m)	Elevation(m)
Ap.18.05	8.7	250.5
Sept.09.05	8.8	250.4

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

RECORD OF BOREHOLE No VB3

1 OF 2

METRIC

W.P. 108-00-01 LOCATION N4844645.2;E278064.4 ORIGINATED BY MS

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 18.02.05 - 22.02.05 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
259.2							259				
0.0 / 258.7	**500mm TOPSOIL** moist, compact, dark brown		1	SS	12						
0.5	weathered, trace rootlets		2	SS	12		258				
	stiff		3	SS	17					21.3	
	very stiff to hard		4	SS	18		257				9 33 42 16
			5	SS	31		256			21.6	
	brown / grey						255				
	CLAYEY SILT - Sandy, trace gravel, damp to moist (GLACIAL TILL)		6	SS	16		254				
			7	SS	37		253				
			8	SS	26		252				
			9	SS	20	▼	251				4 18 40 38
							250				Feb. 17, 2005
			10	SS	16		249				Feb. 18, 2005
	stiff						248				
			11	SS	14		247				
246.0 / 13.2	**SAND AND SILT** trace to some gravel, trace clay, moist to wet, very dense, grey (GLACIAL TILL)		12	SS	65		246				
							245				

Continued Next Page

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

RECORD OF BOREHOLE No VB3

2 OF 2

METRIC

W.P. 108-00-01 LOCATION N4844645.2;E278064.4 ORIGINATED BY MS

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 18.02.05 - 22.02.05 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 / 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
	SAND AND SILT trace to some gravel, trace clay, moist to wet, dense to very dense, grey (GLACIAL TILL) *(continued)*		13	SS	80		244		○		
							243				
			14	SS	118		242		○		
							241				
			15	SS	34				○		3 39 49 9
239.9							240				
19.3	**SILTY FINE SAND** wet, dense, grey										
239.0			16	SS	51		239		○ ○		
20.2	**SAND AND SILT** trace to some gravel, trace clay, moist, very dense inferred, grey (Possible Till)						238				
237.7			17	SS	119				○ ○		
21.5	**CLAYEY SILT** trace sand, occasional silty fine sand seams and partings, moist, hard, grey						237				
			18	SS	100		236		○		Feb. 18, 2005
							235				Feb. 21, 2005 0 1 65 34
			19	SS	103		234				Feb. 21, 2005 Feb. 22, 2005
233.0			20	SS	100/14cm		233		○		
26.2	End of Borehole Wet cave at 10.7m on completion. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen wrapped with filter cloth. WATER LEVEL READINGS Date Depth(m) Elevation(m) Ap.18.05 8.5 250.7 Sept.09.05 9.2 250.0										

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

RECORD OF BOREHOLE No VB4 1 OF 2 METRIC

W.P. 108-00-01 LOCATION N4844646.5;E278081.6 ORIGINATED BY MS

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 17.02.05 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 / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.8								20 40 60 80 100	10 20 30		
0.0 / 258.3	**500mm TOPSOIL** moist, very loose, dark brown		1	SS	3						
0.5	weathered, trace rootlets		2	SS	14		258				
			3	SS	24		257			22.2	
			4	SS	20		256				
	brown		5	SS	12						
	grey						255				
			6	SS	15		254				5 31 46 18
	stiff to very stiff						253				
	hard		7	SS	34		252				
	stiff to very stiff										
	CLAYEY SILT - Sandy, trace gravel, damp to moist (GLACIAL TILL)		8	SS	13		251				
			9	SS	13		250			21.0	
			10	SS	13		249				
			11	SS	16		248				
245.6							247				
13.2	**SAND AND SILT** - Gravelly, trace clay, damp to moist, very dense, grey (GLACIAL TILL)		12	SS	100/ 18cm		246				
							245				35 28 29 8
							244				

Continued Next Page

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

RECORD OF BOREHOLE No VB4 2 OF 2 METRIC

W.P. 108-00-01 LOCATION N4844646.5;E278081.6 ORIGINATED BY MS

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 17.02.05 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
	SAND AND SILT - Gravelly, trace clay, damp to moist, grey (GLACIAL TILL) *(continued)*		13	SS	95		243		○		
	very dense		14	SS	90		242		○		
	compact		15	SS	25		241		○		
	very dense		16	SS	61		240		○		
238.0							239				
20.8	**CLAYEY SILT** trace sand, occasional silty fine sand seams and partings, damp, hard, grey		17	SS	123		238		○		
			18	SS	118		237		○		0 7 70 23
			19	SS	126		236		○		
232.6			20	SS	100/15cm		235		○		
26.2	End of Borehole Water level at 10.7m (not stabilized) and hole open to 18.9 on completion. Attempted piezometer installation. Pipe dropped into hole during backfilling.						234				
							233				

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

RECORD OF BOREHOLE No VB5

1 OF 2

METRIC

W.P. 108-00-01 LOCATION N4844673.3;E278067.9 ORIGINATED BY MS

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 23.02.05 - 24.02.05 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
258.1											
0.1	**100mm TOPSOIL**, dark brown weathered, trace rootlets, firm		1	SS	7		258				
	CLAYEY SILT - Sandy, trace gravel, damp to moist (GLACIAL TILL)		2	SS	52		257				
			3	SS	23						
			4	SS	25		256				
			5	SS	43		255				
			6	SS	25		254				
	brown		7	SS	33					21.7	
	grey		8	SS	34		253				
			9	SS	32		252				
			10	SS	23		251				
	very stiff to hard						250				
	stiff		11	SS	13		249				
			12	SS	14		248				
245.7			13	SS	28		247			20.8	
12.4	**SAND AND SILT** trace to some gravel, trace clay, damp to moist, very dense, grey (GLACIAL TILL)						246				
			14	SS	83		245				
243.4							244				
14.7	**SILTY SAND** - trace gravel										

Continued Next Page

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

RECORD OF BOREHOLE No VB5 2 OF 2 METRIC

W.P. 108-00-01 LOCATION N4844673.3;E278067.9 ORIGINATED BY MS

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 23.02.05 - 24.02.05 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
242.7	**SILTY SAND** - trace gravel, wet, grey *(continued)*						243				
15.4	**SAND AND SILT** trace to some gravel, trace clay, moist, dense to very dense, grey (GLACIAL TILL)		15	SS	54		242		○		
			16	SS	107		241		○		Feb. 23, 2005
			17	SS	34		240		○		Feb. 24, 2005
			18	SS	45		239		○		
			19	SS	100/13cm		238		○		
			20	SS	100/13cm		237		○		
234.3							236		○		
23.8	**CLAYEY SILT** trace sand, trace gravel, damp, hard, grey		21	SS	159		235		○		
232.7							234		○		
25.4	**SILT** trace sand, trace clay, damp, very dense, grey (GLACIAL TILL)		22	SS	110		233		○		0 4 90 6
231.7							232		○		
26.4	End of Borehole Water level at 9.1m (not stabilized) and hole open to 18.3m on completion. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen wrapped in filter cloth. WATER LEVEL READINGS Date Depth(m) Elevation(m) Ap.18.05 8.2 249.9 Sept.09.05 9.0 249.1										

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

RECORD OF BOREHOLE No VB6

1 OF 2

METRIC

W.P. 108-00-01 LOCATION N4844693.5;E278068.7 ORIGINATED BY MS

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 15.02.05 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 / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.8								20 40 60 80 100	10 20 30		
0.0 / 257.4	**400mm TOPSOIL** moist, loose, dark brown		1	SS	7				○		
0.4	weathered, trace rootlets										
	CLAYEY SILT - Sandy, trace gravel, damp to moist, firm to stiff to 1.4m, very stiff to hard below (GLACIAL TILL)		2	SS	11		257		○		
			3	SS	20		256		○		
			4	SS	42		255		○		
			5	SS	45		254		○		
	brown / grey		6	SS	45		253		○	21.7	
			7	SS	22		252		○		
			8	SS	17		251		○		
			9	SS	15		250		○		
			10	SS	16		249		○		
246.1 / 11.7	**SAND AND SILT** trace gravel, trace clay, damp to moist, very dense, grey (GLACIAL TILL)		11	SS	100/23cm		248		○		
			12	SS	73		247		○		1 59 38 2
243.6							246				
14.2	End of Borehole Wet cave at 13.7m on completion.						245				
							244				

Continued Next Page

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

APPENDIX B

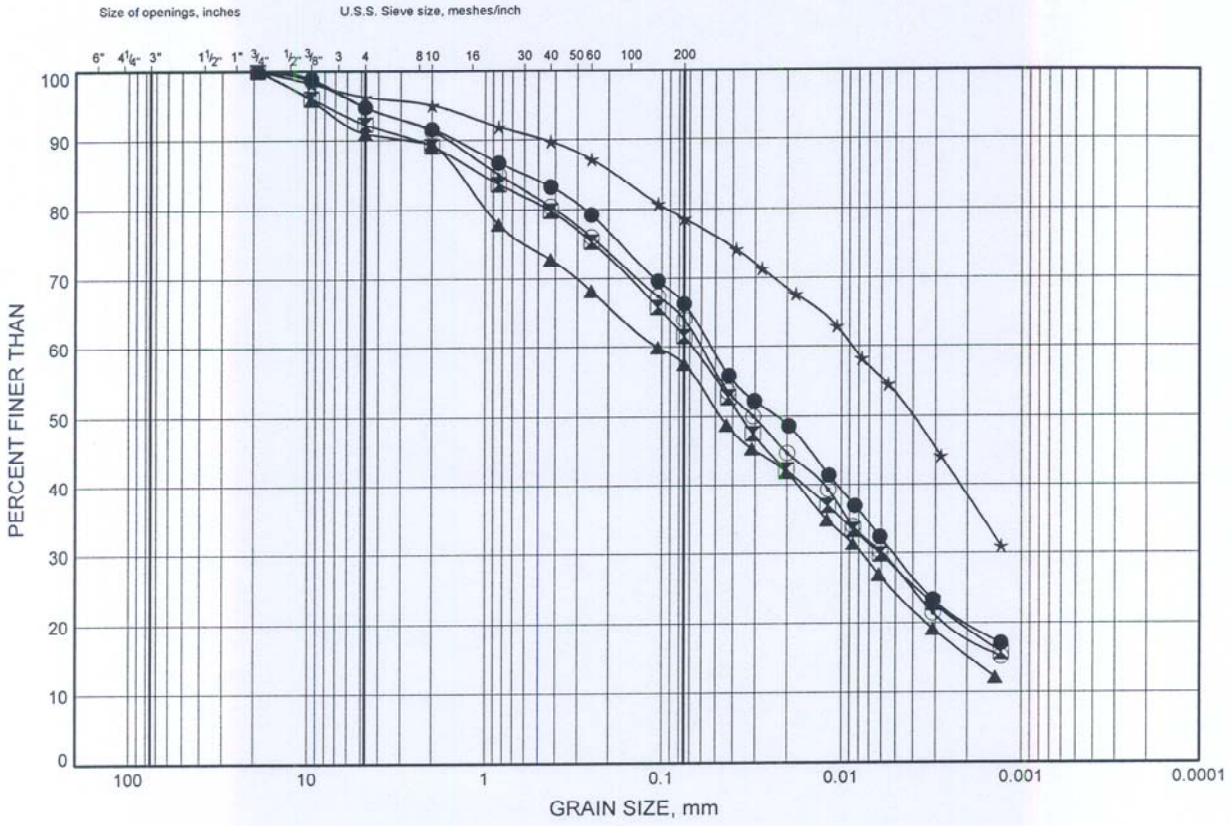
Laboratory Test Results

TERRAPROBE LIMITED

GRAIN SIZE DISTRIBUTION

FIGURE B1

Clayey Silt Till



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	VB1	1.7	256.6
⧓	VB2	4.7	254.5
▲	VB3	2.5	256.7
★	VB3	9.3	249.9
⊙	VB4	4.7	254.1

Date September 2005

Project 108-00-01

Prep'd DB

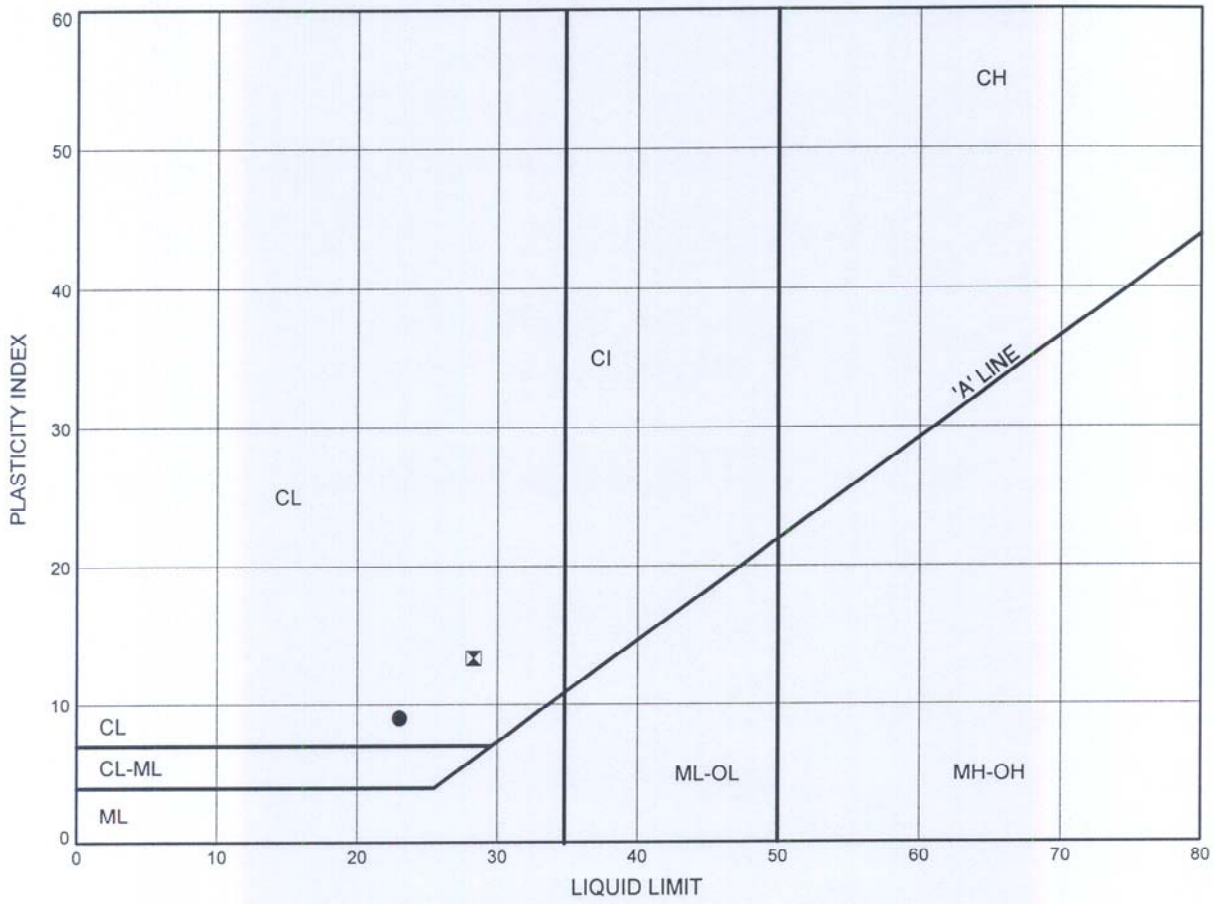
Chkd. RA

GSD 1-00-0350 HWY 410 VALLEYWOOD BLVD.GPJ 20/09/05

ATTERBERG LIMITS TEST RESULTS

FIGURE B2

Clayey Silt Till



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	VB2	4.7	254.5
⊠	VB3	9.3	249.9

Date September 2005

Project 108-00-01

Prep'd DB

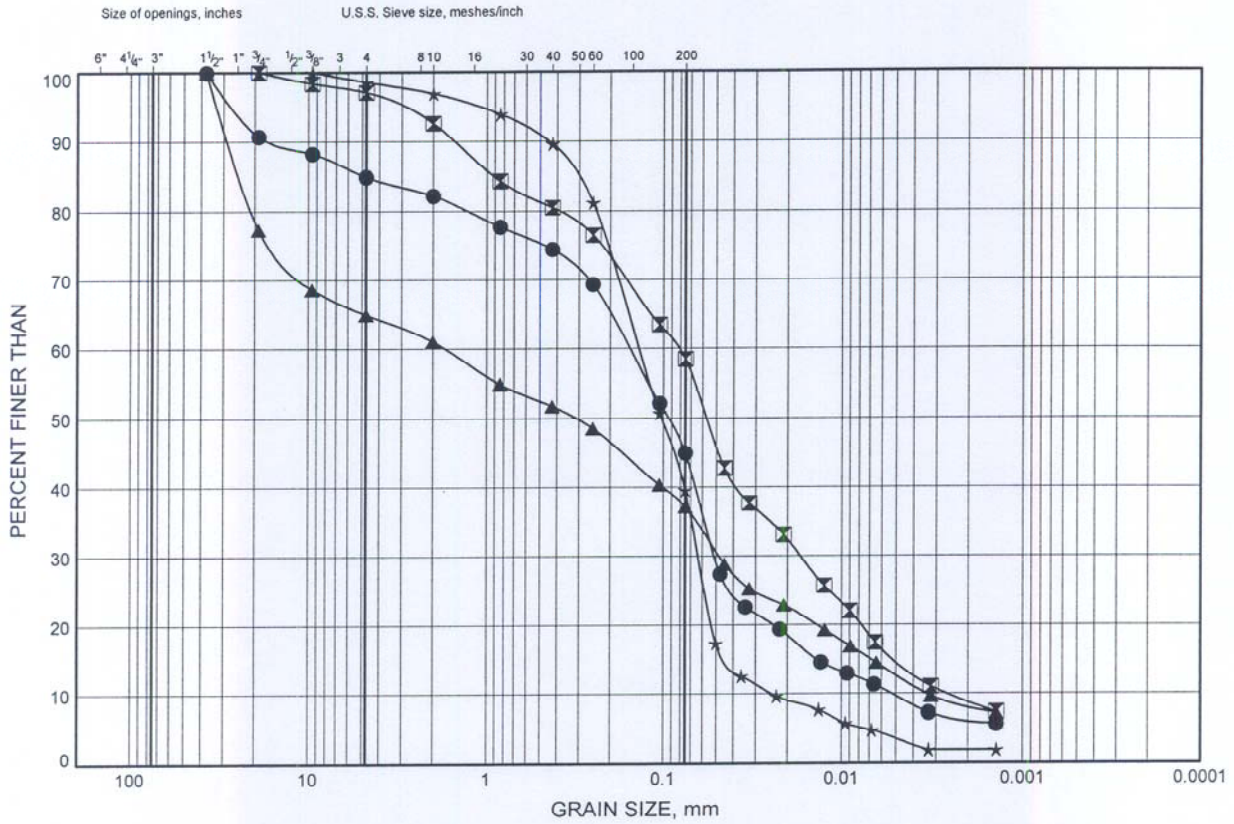
Chkd. RA

ALTR 1-06-0350 HWY 410 VALLEYWOOD BLVD.GPJ 20/09/05

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sand and Silt Till



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	VB2	12.3	246.9
⊠	VB3	18.5	240.7
▲	VB4	13.9	245.0
★	VB6	13.9	243.9

Date September 2005

Project 108-00-01

Prep'd DB

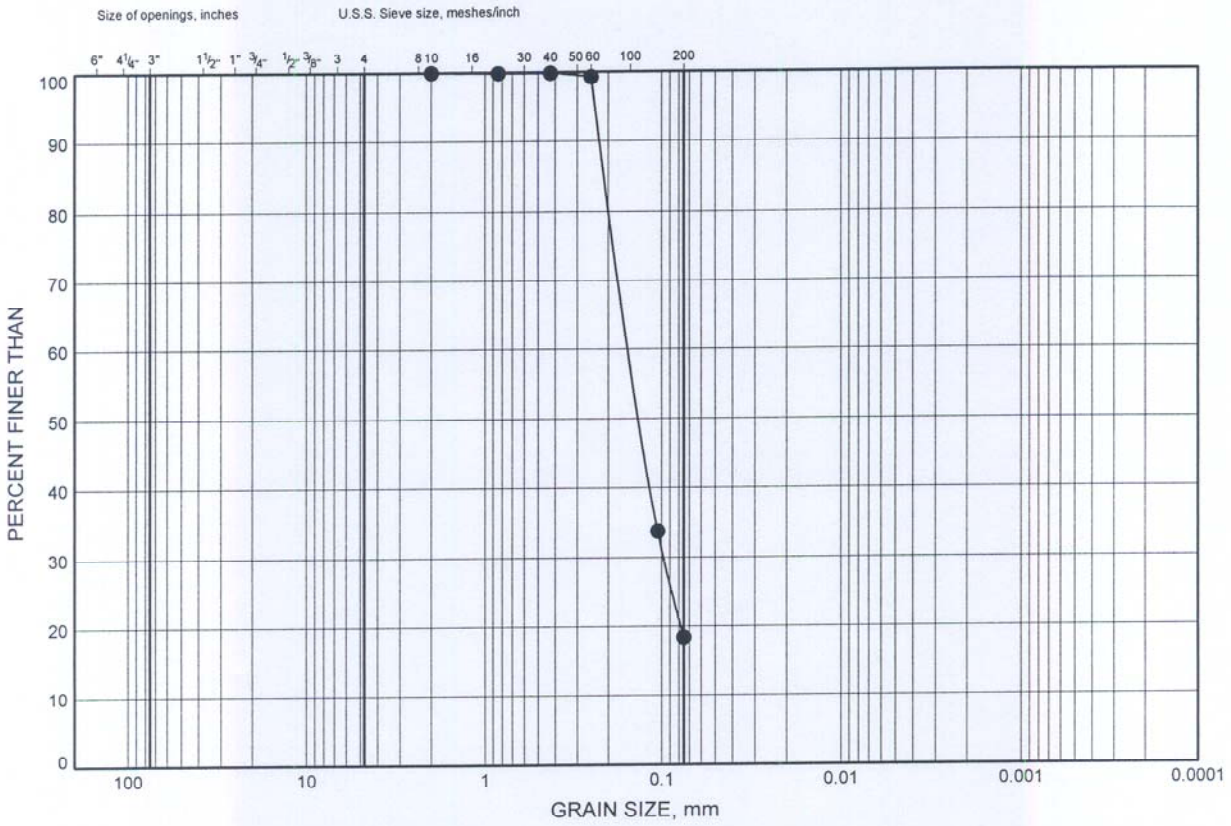
Chkd. RA

GSD 1-00-0350 HWY 410 VALLEYWOOD BLVD.GPJ 20/09/05

GRAIN SIZE DISTRIBUTION

FIGURE B4

Silty Fine Sand



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	VB2	18.5	240.7

Date September 2005

Project 108-00-01

Prep'd DB

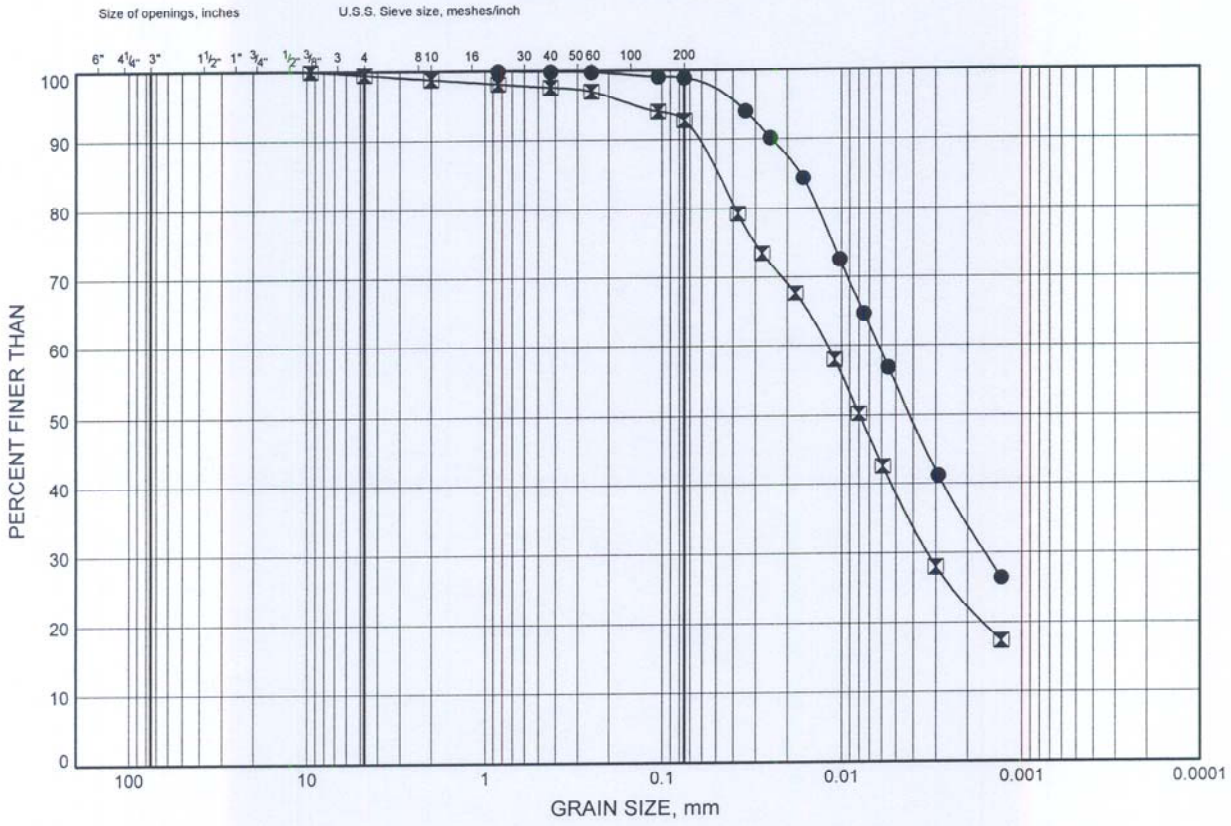
Chkd. RA

GSD 1-00-0350 HWY 410 VALLEYWOOD BLVD.GPJ 20/09/05

GRAIN SIZE DISTRIBUTION

FIGURE B5

Clayey Silt



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	VB3	24.6	234.6
⊠	VB4	23.1	235.7

Date September 2005

Project 108-00-01

Prep'd DB

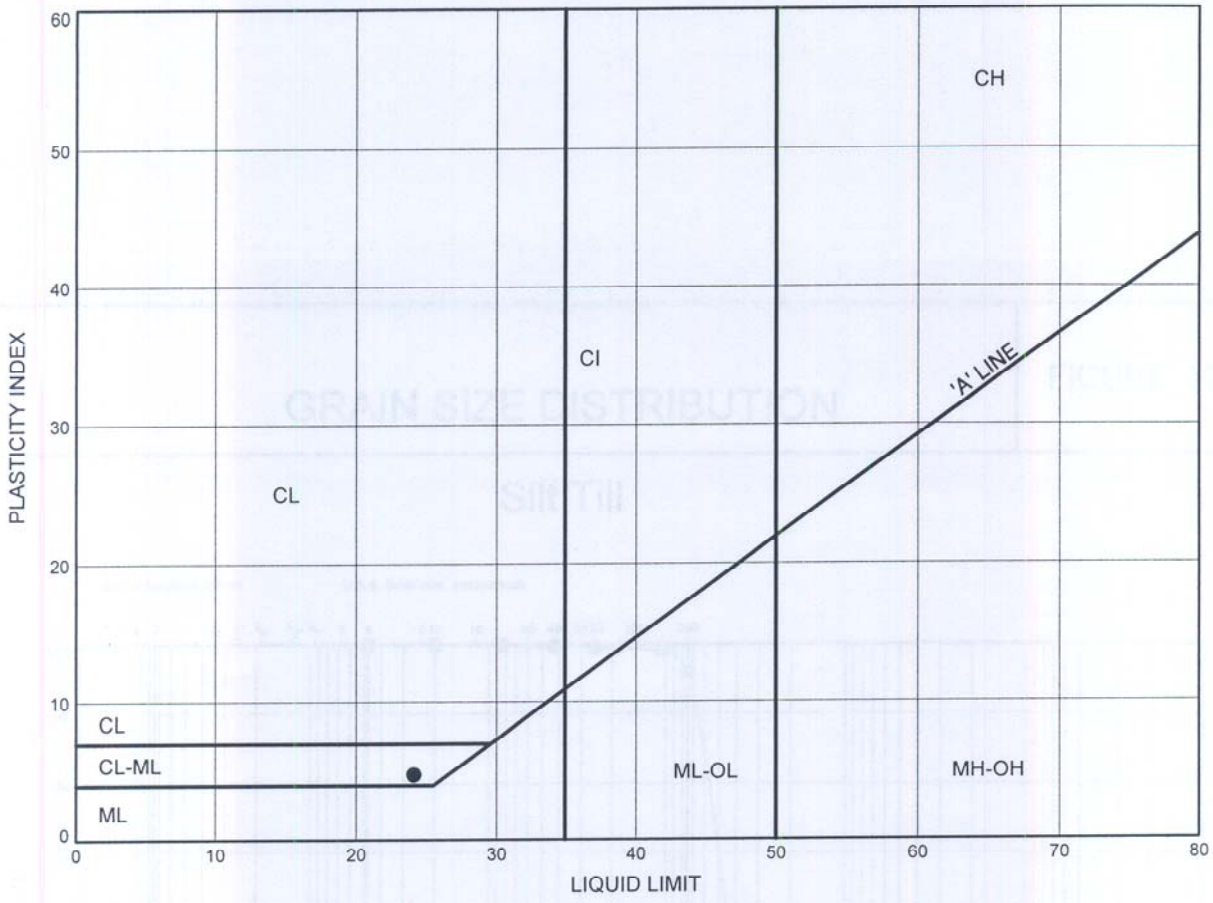
Chkd. RA

GSD 1-00-0350 HWY 410 VALLEYWOOD BLVD.GPJ 23/01/07

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Clayey Silt



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	VB3	24.6	234.6

Date September 2005

Project 108-00-01

Prep'd DB

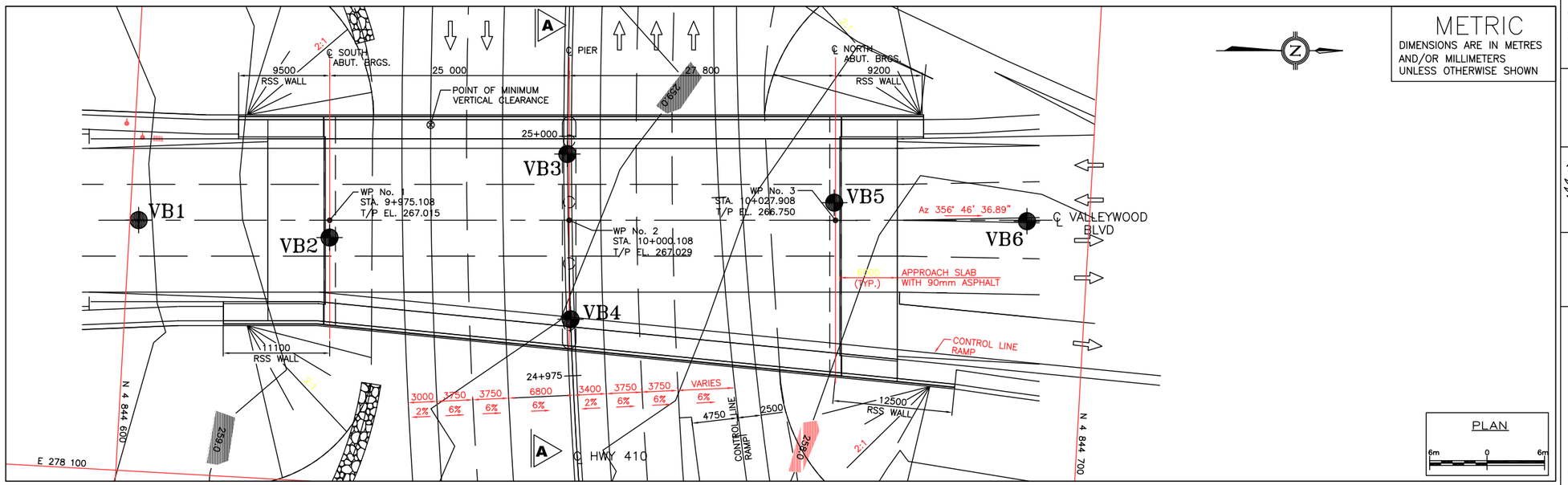
Chkd. RA

ALTR 1-00-0350 HWY 410 VALLEYWOOD BLVD.GPJ 20/09/05

APPENDIX C

Drawing Titled “Borehole Locations and Soil Strata”

TERRAPROBE LIMITED



PLAN

6m 0 6m

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETERS UNLESS OTHERWISE SHOWN

CONT.

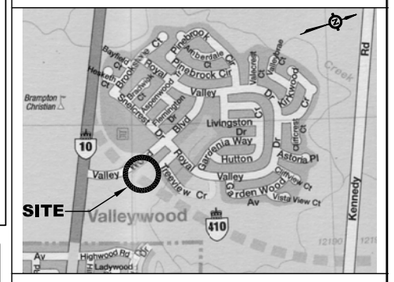
W.P. 108-00-01

HIGHWAY 410 – PHASE III
VALLEYWOOD BOULEVARD – UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

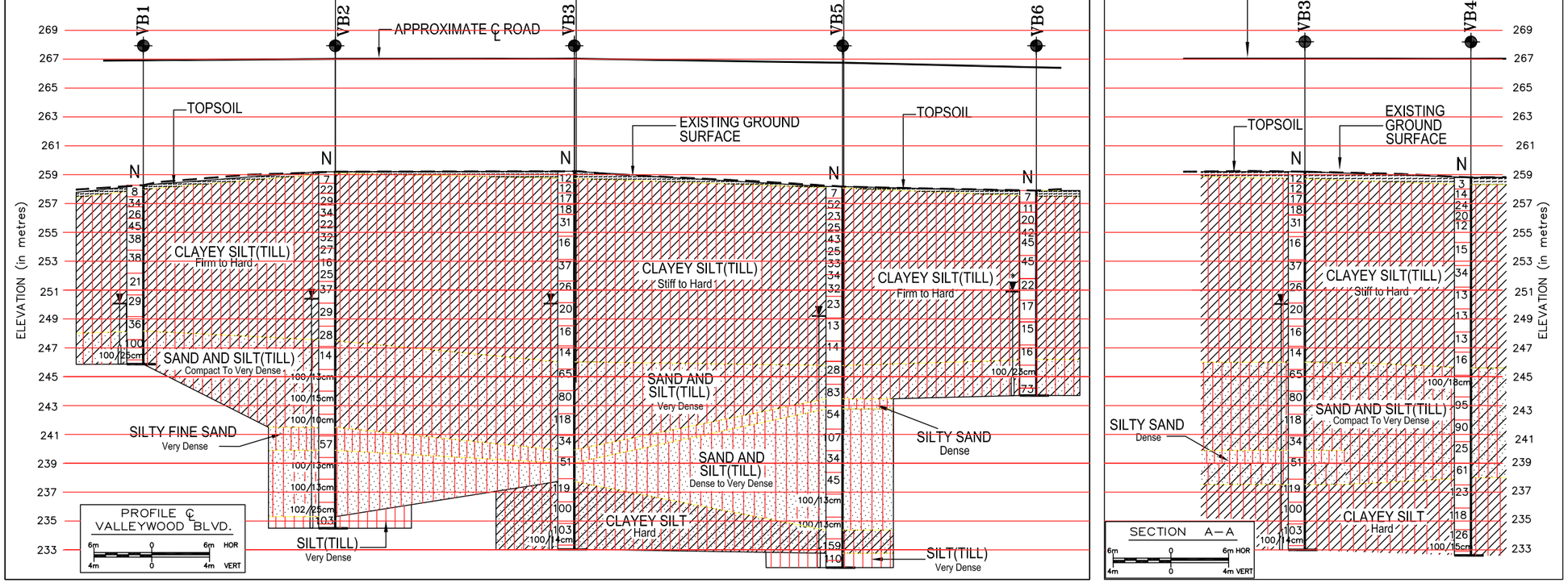
SHEET 364

Giffels
An Ingenium Group Company

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



KEY PLAN



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

LEGEND

⊕	Bore Hole
⊕	Dynamic Cone Penetration Test
⊕	Bore Hole And 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 2005-09 * 2005-04
	Piezometer
90%	Rock Quality Designation
A/R	Auger Refusal

No	ELEVATION	COORDINATES NORTHING	COORDINATES EASTING
VB1	258.3	4844600.9	278073.8
VB2	259.2	4844620.9	278074.5
VB3	259.2	4844645.2	278064.4
VB4	258.8	4844646.5	278081.6
VB5	258.1	4844673.3	278067.9
VB6	257.8	4844693.5	278068.7

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	CHBDC2000	LOAD		DATE	SEPT.2005
DRAWN	P.S	CHK	R.A	SITE:	24-745	STRUCT	DWG 2