



Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

FOUNDATION INVESTIGATION REPORT
DEEP CUT Sta. 13+900 TO Sta. 14+100
HIGHWAY 406 TWINNING
PORT ROBINSON ROAD TO EAST MAIN STREET
AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE:
GEOCRES No. 30M3-251

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FOUNDATION INVESTIGATION REPORT
HIGHWAY 406 CUT SECTION (Sta. 13+900 to 14+100)
HIGHWAY 406 TWINNING
ONTARIO
AGREEMENT No. 2008-E-0016, W.P. 280-99-00
GEOCRES No. 30M3-251
PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report summarizes the subsurface data obtained from investigations conducted at the cut section (Sta. 13+900 to Sta. 14+100) along the proposed Highway 406 NBL alignment in the City of Thorold, Ontario.

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 written 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 20085-E-0016.

2 SITE DESCRIPTION & PHYSIOGRAPHY

The site is located about 900 m south of the Merritt Road interchange and north of the Old Welland Canal in the City of Thorold, Regional Municipality of Niagara. The centre line of the proposed alignment is approximately 30 m east of the centre line of the present Highway 406 that currently carries both north and south bound traffic.

The topography is generally flat to undulating with scattered man-made high ground areas. Vegetation at this site consists primarily of deciduous trees and wild bush.

The site is located between the Niagara Escarpment and Lake Erie in the physiographic region of Southern Ontario referred to as the Haldimand Clay Plain. The Haldimand Clay Plain is best described as falling into a series of parallel belts with the highest ground adjacent to the Escarpment. Generally this region is flat and poorly drained although it includes several distinctive landforms such as dunes, cobble, clay and sand beaches, limestone pavements and back-shore wetland basins¹.

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



The Niagara Region is underlain by a sequence of very gently south-dipping dolostones, limestones, shales and sandstones overlying Precambrian basement rock. The key elements in the bedrock geology of the region are the multiple layers of softer sedimentary limestones, shale, sandstone and dolostone.

The bedrock unit at this site is the Salina Formation of Upper Silurian Age². This unit consists essentially of easily weathered, grey, very finely crystalline, laminated argillaceous dolostone with grey, calcareous shale partings and gypsum veins and lenses of varying thicknesses.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between November 09 and December 15, 2009 and consisted of drilling and sampling five boreholes and eight test pits. The boreholes were extended to depths ranging from 18.8 m to 24.0 m and the test pits were excavated to depths ranging from 3.9 m to 6.6 m below ground surface.

Test pit photographs depicting the excavated soils are provided in Appendix C. The approximate locations of the boreholes and test pits are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix D.

The borehole locations were marked in the field by surveyors from Callon Dietz Inc. who also provided Terraprobe with their coordinates and geodetic elevations. Test pit locations were established by referring to existing boreholes and the staked centre line of Hwy. 406 NBL. Utility clearances and permits were obtained by Terraprobe prior to drilling.

Samples of the overburden soils were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT), as specified in ASTM Method D1586. In the cohesive (clayey) deposits the undrained shear strength of the soil was measured in-situ by means of field vane tests using an MTO type field vane. Relatively undisturbed soil samples were also collected with thin-walled Shelby Tube samplers.

Groundwater conditions in the open boreholes were observed throughout the drilling operations and standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen enclosed in sand were installed in selected boreholes to permit longer term groundwater level monitoring. The standpipe installations were constructed and are currently being maintained in accordance with MOE Regulation 903. These piezometers will be abandoned in the future in accordance with MOE Regulation 903.

² Ontario Division of Mines, "Quaternary Geology Of The Welland Area", Preliminary Map P.796, 1972.



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
NBL 13+950Lt	18.2/168.4	Piezometer with 1.5 m slotted screen installed with filter sand to 16.1 m, bentonite seal from 16.1 m to 15.5 m, silty clay from 15.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
NBL 13+950Rt	18.2/168.2	Piezometer with 1.5 m slotted screen installed with filter sand to 16.1 m, bentonite seal from 16.1 m to 15.5 m, silty clay from 15.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
NBL 14+020CL	22.8/162.9	Piezometer with 3.0 m slotted screen installed with filter sand to 19.2 m, bentonite seal from 19.2 m to 18.6 m, silty clay from 18.6 m to 0.3 m and bentonite seal from 0.3 m to ground surface.
NBL 14+075Lt	18.2/163.0	Piezometer with 3.0 m slotted screen installed with filter sand to 14.6 m, silty clay from 14.6 m to 0.3 m and bentonite seal from 0.3 m to ground surface.
NBL 14+075Rt	14.3/169.9	Piezometer with 3.0 m slotted screen installed with filter sand to 10.7 m, bentonite seal from 10.7 m to 10.1 m, silty clay from 10.1 m to 0.3 m and bentonite seal from 0.3 m to ground surface.

The drilling, sampling and test pit operations were observed on a full time basis by members of Terraprobe's technical staff who logged the boreholes and test pits 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. Select samples were also subjected to a laboratory testing programme consisting of gradation analysis and Atterberg Limits tests. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and the figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole and Test Pit sheets in Appendix A. Details of the encountered soil stratigraphy are presented in these appendices and on the "Borehole Locations and Soil Strata" drawings 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 and Test Pit Sheets governs any interpretation of the site conditions.

In general, the site is underlain by topsoil and overburden soils consisting of fill material (silty clay, sandy silt, cobbles and gravel) and native deposits of silty clay, silt and silty clay till.



5.1 Topsoil

Topsoil ranging from 25 mm to 90 mm thick was encountered across the site. Topsoil thickness may vary between and beyond the boreholes.

5.2 Fill – Silty Clay

Silty clay fill material was encountered along this alignment extending to depths ranging from 5.1 m to 9.2 m below ground surface or to elevations ranging from 174.8 m to 179.1 m.

Samples of the silty clay fill were subjected to grain size distribution tests and the results show a grain size distribution consisting of 0-8 % gravel, 6-13 % sand, 45-73 % silt and 17-46 % clay size particles. Refer to Figure B1 for the grain size distribution curves.

Four samples of the silty clay fill material were also subjected to Atterberg Limits tests and the results indicate clayey soils of low to intermediate plasticity (Figure B2). The index values from these tests are summarized below:

Liquid Limit:	27-38%
Plastic Limit:	16-23%
Plasticity Index:	7-18%
Natural Moisture Content:	16-38%

SPT 'N' values in the silty clay fill ranged from 1 to 50 blows for 0.3 m penetration but generally most of the recorded 'N' values ranged from 3 to 23 blows for 0.3 m penetration. Based on these values the silty clay fill generally has a soft to very stiff consistency with occasional very soft and hard zones. The moisture content of samples of the silty clay fill generally varies from 11% to 29% by weight and a moisture content of 38% was recorded in an organic rich zone in Borehole 13+950Rt.

5.3 Fill – Sandy Silt

A layer of sandy silt fill divides the silty clay fill material in Boreholes 13+950Lt., 13+950Rt., and 14+020CL. This fill material was also encountered in Test Pits 1A, 1B, 1C and 1D. The sandy silt fill was fully explored to depths ranging from 2.8 m to 5.6 m below ground surface or to elevations ranging from 178.9 m to 181.8 m. Test Pit 1D was terminated in this material at a depth of 5.7 m (Elev. 180.5 m)

A sample of the sandy silt fill was subjected to a grain size distribution test (Figure B3) and the results show a grain size distribution consisting of 5 % gravel, 30 % sand, 55 % silt and 10 % clay size particles.

The sandy silt fill has a very loose relative density based on SPT 'N' values of 1 blow for 0.3 m penetration. The moisture content of samples of the sandy silt fill varies from 23% to 29% by weight.



5.4 Fill – Cobbles and Gravel

Fill consisting of cobbles, sand and gravel was encountered in Boreholes 14+075Lt. and 14+075Rt. at depths of 2.9 m (Elev. ± 178.3 m) and 5.1 m (Elev. ± 179.1 m) respectively. The test pit excavations (Test Pit 1A, 1F and 1H) also revealed occasional to frequent boulder inclusions. The thickness of this fill ranges from 0.7 m to 3.5 m and extends to depths of 1.2 m (Elev. ± 184.3 m) to 8.6 m (Elev. ± 175.6 m) below ground surface.

SPT 'N' values in this fill material (cobbles, sand and gravel) ranged from 5 to 17 blows for 0.3 m penetration indicating a loose to compact relative density. The moisture content of samples of this fill material ranged from 9% to 10% by weight.

5.5 Silty Clay

A major silty clay deposit was encountered at this site in all of the boreholes. This silty clay deposit was fully penetrated in Boreholes 14+020CL and 14+075Lt. at depths of 23.1 m (Elev. 162.6 m) and 19.5 m (Elev. 161.7 m) respectively. In the remaining boreholes the silty clay deposit was explored to borehole termination depths ranging from 18.8 m of (Elev. 167.8 m) to 21.8 m (Elev. 162.4 m).

Samples of the silty clay deposit were subjected to grain size distribution tests (Figures B4 to B6) and the results show a grain size distribution consisting of 0-1 % gravel, 0-4 % sand, 51-82 % silt and 18-48 % clay size particles.

Samples of the silty clay deposit were also subjected to Atterberg Limits tests (Figures B7 to B9) and the results indicate a cohesive soil of low to intermediate plasticity with occasional clayey silt zones. The index values from these tests are summarized below:

Liquid Limit:	23-44%
Plastic Limit:	15-20%
Plasticity Index:	6-23%
Natural Moisture Content:	19-31%

Standard Penetration tests in this deposit yielded 'N' values ranging from 0 to 28 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 22 kPa to in excess of 100 kPa. These values indicate that the consistency of the silty clay is generally soft to very stiff. The moisture content (by weight) of samples of the silty clay ranged from 14% to 35%.

The undrained shear strength of the silty clay deposit varies along the alignment. At Sta. 13+950 where the overlying fill is relatively thick the silty clay deposit is stiff to very stiff within the investigated depths. At Sta. 14+020 CL the upper silty clay deposit that extends to a depth of 11.7 m (Elev. 174 m) is stiff to very stiff and the lower silty clay deposit that extends from 13.2 m depth (Elev. 172.5 m) to 23.1 m depth (Elev. 162.6 m) is firm to stiff. Further north at Sta. 14+075 the silty clay deposit is generally firm to stiff



and in Borehole 14+075 Lt. a soft zone exists between 6.4 m depth (Elev. 174.8 m) and about 7.2 m depth (Elev. 174 m).

5.6 Silt

A 1.5 m thick layer of silt divides the silty clay deposit in Boreholes 13+950Rt. and 14+020CL. The silt deposit extends to depths of 13.2 m or to elevations ranging from 173.2 m to 172.5 m.

A sample of the silt deposit was subjected to a grain size distribution test (Figure B10) and the results show a grain size distribution consisting of 0 % gravel, 0 % sand, 91 % silt and 9 % clay size particles.

SPT 'N' values in the silt deposit ranged from 20 to 46 blows for 0.3 m penetration indicating a compact to dense relative density. The moisture content of samples of the silt ranged from 18% to 21% by weight.

5.7 Silty Clay Till

A silty clay till deposit was encountered in Boreholes 14+020CL and 14+075Lt extending to borehole termination depths of 24 m (Elev. 161.7 m) and 20.3 m (Elev. 160.9 m) respectively.

Samples of the silty clay till were subjected to grain size distribution tests (Figure B11) and the results show a grain size distribution consisting of 3 % gravel, 6-9 % sand, 67-68 % silt and 21-23 % clay size particles. Till soils can also be expected to contain random cobble and boulder inclusions.

Samples of the silty clay till were also subjected to Atterberg Limits tests (Figure B12) and the results generally indicate a cohesive deposit of low plasticity. The index values from these tests are summarized below:

Liquid Limit:	25-26%
Plastic Limit:	15%
Plasticity Index:	10-11%
Natural Moisture Content:	12-21%

Standard Penetration tests conducted in this deposit gave 'N' values ranging from 48 to 62 blows for 0.3 m penetration indicating a hard consistency. The moisture content (by weight) of samples of the silty clay till ranged from 12% to 21%.



5.8 Water Levels

A standpipe piezometer was installed in selected boreholes. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
NBL 13+950Lt	November 30, 2009	8.9	177.7
	December 08, 2009	8.6	178.0
	January 04, 2010	8.3	178.3
	January 14, 2010	8.3	178.3
NBL 13+950Rt	November 19, 2009	8.8	177.6
	November 30, 2009	8.6	177.8
	December 08, 2009	8.3	178.1
	January 04, 2010	8.1	178.3
	January 14, 2010	8.0	178.4
NBL 14+020CL	November 19, 2009	4.1	181.6
	November 30, 2009	9.5	176.2
	December 08, 2009	9.2	176.5
	January 04, 2010	9.2	176.5
	January 14, 2010	9.2	176.5
NBL 14+075Lt	November 20, 2009	4.3	176.9
	November 30, 2009	8.5	172.7
	December 08, 2009	5.4	175.8
	January 04, 2010	5.3	175.9
	January 14, 2010	5.3	175.9
NBL 14+075Rt	November 19, 2009	7.3	176.9
	November 30, 2009	8.2	176.0
	December 08, 2009	8.1	176.1
	January 04, 2010	8.1	176.1
	January 14, 2010	8.1	176.1

Test Pit 1A was dug at Sta. 13+900 approximately and groundwater seepage was observed at a depth of 4.2 m (Elev. ± 177.5 m) after excavations were complete. The remaining test pits were dry.

The water level measurements and observations made during test pit excavations suggest that the local groundwater level at the site generally follows the ground surface topography. At Sta. 13+950 the groundwater level exists at elevations ranging between ± 178.3 m and ± 178.4 m falling to the south where the groundwater level is estimated to exist at Elev. ± 177.5 at Sta. 13+900 approximately. North of Sta. 13+950 the groundwater elevation falls to about Elev. ± 176.5 m at Sta. 14+020 decreasing further north to elevations ranging from ± 175.9 m to ± 176.1 m at Sta. 14+075.

Perched water can also be expected to occur in the fill material where relatively permeable sandy silt and cobble and gravel soils are underlain by more impermeable silty clay soils. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.



5.9 Miscellaneous

The borehole drilling, sampling and in-situ testing operations were conducted with track and truck mounted drill rigs owned and operated by DBW Drilling Ltd. of Toronto, Ontario and Determination Drilling & Soil Investigations of Hamilton, Ontario. Hollow-stem auger drilling techniques were used to advance the boreholes. The test pits were excavated with a 9010 Case Excavator owned and operated by R & D Construction of Thorold, Ontario.

Messrs. Bob Racher, C.E.T, Lucas Yu, E.I.T and Marc Paoliello, E.I.T carried out the field supervision and the laboratory testing was performed at Terraprobe's Brampton laboratory. The report was written by Rehman Abdul, P.Eng. and reviewed by Michael Tanos, P.Eng.



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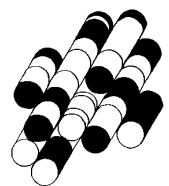


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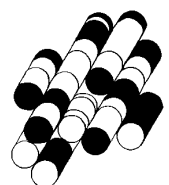
APPENDICES

TERRAPROBE INC.



APPENDIX A

TERRAPROBE INC.



LIMITATIONS AND RISK

Procedures

The soil conditions were confirmed at the borehole and test pit 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

This report was prepared for the express use of the Ministry of Transportation, its retained design consultants and Giffels Associates Ltd./IBI Group. It is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe Inc. The Ministry of Transportation, its retained design consultants and Giffels Associates Ltd./IBI Group, are authorized users.

EXPLANATION OF TERMS USED IN REPORT

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

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 476J 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
VS	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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

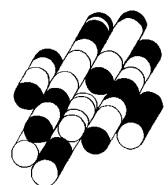
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_{α}	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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_r	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	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_b	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_p)/I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(w_L - w)/I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

BOREHOLE SHEETS

TERRAPROBE INC.



RECORD OF BOREHOLE No NBL 13+950Lt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765400.5 E:327107.5 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Track-Mounted / Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.16.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
186.6 0.0	Ground Surface							20 40 60 80 100						
	trace gravel		1	SS	18		186							
	----		2	SS	17		185							
	FILL - Silty Clay, trace sand, trace gravel, stiff to very stiff, brown, damp to moist		3	SS	22		184							3 6 45 46
			4	SS	23		183							
			5	SS	14		182							
182.6 4.0	FILL - Sandy Silt, trace clay, trace gravel, very loose, grey / brown, wet		6	SS	1		181							5 30 55 10
181.0 5.6	FILL - Silty Clay, trace sand to 7.0m, trace to some gravel to 7.0m, firm, brown, moist		7	SS	5		180							
			8	SS	6		179							
							178							
177.4 9.2	topsoil stained		9	SS	13		177							
	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		10	SS	28		176							0 1 55 44
							175							
			11	SS	17		174							
							173							
			12	TW	PH		172							

ONTARIO MOT 1-09-4135 HWY 406 NBL GPU ONTARIO MOT, GDT 01/21/10

Continued Next Page

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

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

RECORD OF BOREHOLE No NBL 13+950Rt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765407.3 E:327124.1 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Track-Mounted / Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.16.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L			WATER CONTENT (%)	
186.4	Ground Surface							20 40 60 80 100						GR SA SI CL		
0.0	FILL - Silty Clay, trace sand, trace gravel, stiff to hard, brown, damp ----- occasional sand seams		1	SS	13		186									
			2	SS	20											3 10 47 40
			3	SS	50											
			4	SS	18											
			5	SS	15		183									
182.4	FILL - Sandy Silt, trace to some clay, very loose, brown, wet		6	SS	1		182									
180.8	FILL - Silty Clay, trace to some organics to 7.0m, trace to some sand, very soft to soft, dark brown to 7.0m, brown below, damp to moist		7	SS	2		180									
5.6																0 10 73 17
			8	SS	1											
							178									
177.8	SILTY CLAY trace sand, stiff to very stiff, brown, damp		9	SS	18		177								0 1 51 48	
8.6																
			10	SS	22											
174.7	SILT trace clay, dense, brown, wet		11	SS	46		174									
11.7																
173.2	SILTY CLAY trace sand, stiff, brown, moist		12	SS	14		173									
13.2																0 1 63 36
							172									
		</														

Continued Next Page

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

ONTARIO MOT 1-09-4135 HWY 406 NBL GPU ONTARIO MOT, GDT 01/21/10

2 OF 2

METRIC

DATUM	Geodetic	DATE	11.16.09	CHECKED BY	RA
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+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No NBL 14+020CL

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765463.9 E:327083.3 ORIGINATED BY MP
 DIST HWY 406 BOREHOLE TYPE Track-Mounted / Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 11.10.09 - 11.11.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
185.7	Ground Surface							20 40 60 80 100						
185.7 0.1	50mm TOPSOIL		1	SS	10			○ UNCONFINED + FIELD VANE						
	FILL - Silty Clay, trace sand, trace gravel, stiff to very stiff, brown, damp		2	SS	12			● QUICK TRIAXIAL × LAB VANE						
			3	SS	17									
			4	SS	12									
			5	SS	8									
181.7 4.0	FILL - Sandy Silt, trace clay, very loose, brown, wet		6	SS	1									
180.1 5.6	FILL - Silty Clay, trace sand, firm to stiff, brown, damp		7	SS	8									
177.8 7.9	weathered		8	SS	8									
	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		9	SS	24									0 1 62 37
			10	SS	13									Nov.10
174.0 11.7	SILT trace clay, compact, brown, wet		11	SS	20									Nov.11
172.5 13.2	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist		12	SS	7									0 0 91 9
														1 4 72 23
				</										

Continued Next Page

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

ONTARIO MOT 1-09-4135 HWY 406 NBL GPJ ONTARIO MOT GDT 03/24/10

METRIC

W.P.	280-99-00	LOCATION	Coords: N:4765463.9 E:327083.3	ORIGINATED BY	MP
DIST	HWY 406	BOREHOLE TYPE	Track-Mounted / Hollow Stem Augers	COMPILED BY	DB
DATUM	Geodetic	DATE	11.10.09 - 11.11.09	CHECKED BY	RA

[illegible]

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

RECORD OF BOREHOLE No NBL 14+075Lt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765507.4 E:327041.7 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Track-Mounted / Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.10.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
181.2 0.0	Ground Surface 25mm TOPSOIL		1	SS	9		181	○ UNCONFINED	+ FIELD VANE					
	FILL - Silty Clay, trace to some sand, trace gravel, firm to stiff, brown, damp		2	SS	11		180	● QUICK TRIAXIAL	× LAB VANE					
			3	SS	6		179							
			4	SS	8		178							7 13 47 33
178.3 2.9	FILL - Cobbles, Sand and Gravel, loose to compact, brown, damp		5	SS	5		177							
			6	SS	13		176							
176.0 5.2	FILL - Silty Clay, trace sand, trace gravel, soft to firm, brown, damp to moist		7	SS	3		175							
174.8 6.4	soft		8	SS	4		174							
	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist		9	SS	10		173							0 1 74 25
			10	SS	7		172							
			11	SS	7		171							1 3 75 21
			12	SS	8		170							
							169							
							168							
							167							0 2 76 22

Continued Next Page

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

ONTARIO MOT 1-09-4135 HWY 406 NBL GPJ ONTARIO MOT GDT 01/21/10

RECORD OF BOREHOLE No NBL 14+075Lt

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765507.4 E:327041.7 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Track-Mounted / Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.10.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE		w _p w w _L						
								● QUICK TRIAXIAL × LAB VANE								
						20 40 60 80 100		10 20 30			GR SA SI CL					
	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist <i>(continued)</i>		13	SS	8		166							0 0 71 29		
			14	SS	4		165									
			15	SS	0	164										
161.7							163									
19.5	SILTY CLAY trace sand, trace gravel, hard, brown, damp (GLACIAL TILL)															
160.9																
20.3	End of Borehole						162									
	Water level at 9.4m (not stabilized) on completion.						161									
	Resistance to augering at 2.9-5.2m.															
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen.															
	Water Level Readings: Date Depth(m) Elevation(m) Nov.20.09 4.3 176.9 Nov.30.09 8.5 172.7 Dec.08.09 5.4 175.8 Jan.04.10 5.3 175.9 Jan.14.10 5.3 175.9															

RECORD OF BOREHOLE No NBL 14+075Rt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765514.4 E:327054.9 ORIGINATED BY MP
 DIST HWY 406 BOREHOLE TYPE Track-Mounted / Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 11.09.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
184.2	Ground Surface							20 40 60 80 100							
184.1	90mm TOPSOIL							20 40 60 80 100							
0.1			1	SS	4		184				○				
	FILL - Silty Clay, trace sand, trace gravel, firm, brown, damp to moist		2	SS	8		183				○				
	----		3	SS	8		182				○				
	frequent silt pockets		4	SS	5		181				○				
	----		5	SS	4		180				○				
			6	SS	5		179				○				
179.1							178								
5.1	FILL - Cobbles and Gravel, trace to some sand, trace clay, loose to compact, brown, damp		7	SS	17		177								
			8	SS	5		176				○				
							175								
175.6			9	SS	3		174								
8.6	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp		10	SS	3		173								
			11	SS	3		172								
			12	TW	PH		171								
							170								

Continued Next Page

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

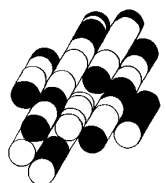
2 OF 2

METRIC[illegible]

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

TEST PIT SHEETS

TERRAPROBE INC.



RECORD OF TEST PIT No 1A

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Sta: 13+900 NBL CL / Coords: N:4765357.6 E:327139.9 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa					WATER CONTENT (%)				
						20	40	60	80	100	W _p	W	W _L			
181.7 0.0	Ground Surface															
	FILL - Silty Clay, trace to some gravel, trace sand, brown, moist		1	CS												
179.8 1.9	FILL - Cobbly Sandy Silt, some gravel, grey / brown, damp		2	CS												
178.9 2.8	FILL - Cobbles and Boulders															
176.7 4.2	FILL - Silty Clay, trace sand, trace gravel, trace organics, dark brown / black, moist End of Test Pit		3	CS												
	Ground water seepage at 4.2m below ground surface. Caving in cobbles and boulders layer.															

RECORD OF TEST PIT No 1B

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Sta: 13+925 NBL, 25m Rt. of CL / Coords: N:4765391.7 E:327151.1 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
							○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
184.7 0.0	Ground Surface																					
	FILL - Sandy Silt, some gravel, some cobbles, frequent silty clay inclusions, brown, very moist		1	CS																		
182.8 1.9	FILL - Silty Sand to Sandy Silt, some gravel, brown, damp		2	CS																		
181.8 2.9	FILL - Silty Clay, trace gravel, trace organics, brown, moist		3	CS																		
178.6 6.1	SILTY CLAY brown, moist		4	CS																		
178.1 6.6	End of Test Pit																					
	Test Pit was dry and open to full depth after excavation.																					

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

RECORD OF TEST PIT No 1C

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Sta: 13+950 NBL CL / Coords: N:4765402.1 E:327116.3 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa					WATER CONTENT (%)				
						20	40	60	80	100	W _p	W	W _L			
185.8 0.0	Ground Surface															
	FILL - Silty Clay, trace sand, trace gravel, trace rootlets, tree stump at 1.9m below ground surface, brown, moist		1	CS												
183.4 2.4			2	CS												
	FILL - Sandy Silt, some gravel, brown, damp															
181.2 4.6			3	CS												
	FILL - Silty Clay, trace to some sand, brown / grey, moist															
179.7 6.1	End of Test Pit		4	CS												
	Test Pit was dry and open to full depth after excavation.															



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

RECORD OF TEST PIT No 1D

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Sta: 14+000 NBL CL / Coords: N:4765447.1 E:327091.8 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L				
186.2 0.0	Ground Surface		1	CS		186												
						185												
						184												
183.1 3.1	FILL - Silty Clay, some gravel, brown, moist to wet		2	CS		183												
	grey					182												
						181												
180.5 5.7	End of Test Pit		3	CS														
	Test Pit was dry after excavation. Moderate caving at 3.1m below ground surface.																	

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

RECORD OF TEST PIT No 1E

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Sta: 14+035 NBL, 25m Rt. of CL / Coords: N:4765490.1 E:327093.9 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
185.5	Ground Surface																		
0.0	FILL - Silty Clay, some cobbles, brown, moist																		
185.0																			
0.5	FILL - Cobbles and Boulders																		
184.3																			
1.2	FILL - Silty Clay, trace to some sand, trace gravel, brown, moist		1	CS															
	trace organics, grey																		
			2	CS															
					</														

1 OF 1

METRIC

[illegible]

MTO TP 1-09-4135 TP.GPJ ONTARIO MOT.GDT 03/26/10

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

RECORD OF TEST PIT No 1G

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Sta: 14+075 NBL, 25m Rt. of CL / Coords: N:4765525.2 E:327069.6 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa					WATER CONTENT (%)				
						20	40	60	80	100	W _p	W	W _L			
183.5 0.0	Ground Surface															
	FILL - Silty Clay, trace sand, brown, moist		1	CS												
			2	CS												
177.9 5.6	End of Test Pit															
	Test Pit was dry and open to full depth after excavation.															

RECORD OF TEST PIT No 1H

1 OF 1

METRIC

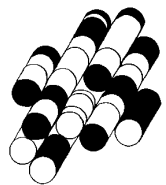
W.P. 280-99-00 LOCATION Sta: 14+100 NBL CL / Coords: N:4765530.7 E:327034.1 ORIGINATED BY BR
 DIST HWY 406 EQUIPMENT 9010 CASE Excavator COMPILED BY DB
 DATUM Geodetic DATE 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa								
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
179.1	Ground Surface					20	40	60	80	100					
0.0	FILL - Silty Clay, trace sand, trace rootlets, brown, damp		1	CS											
177.4															
1.7	FILL - Cobbles and Boulders														
176.3															
2.8	FILL - Silty Clay, trace sand, trace gravel, trace organics, brown, moist		2	CS											
175.8															
3.3	SILTY CLAY trace organics, dark brown, moist														

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

APPENDIX B

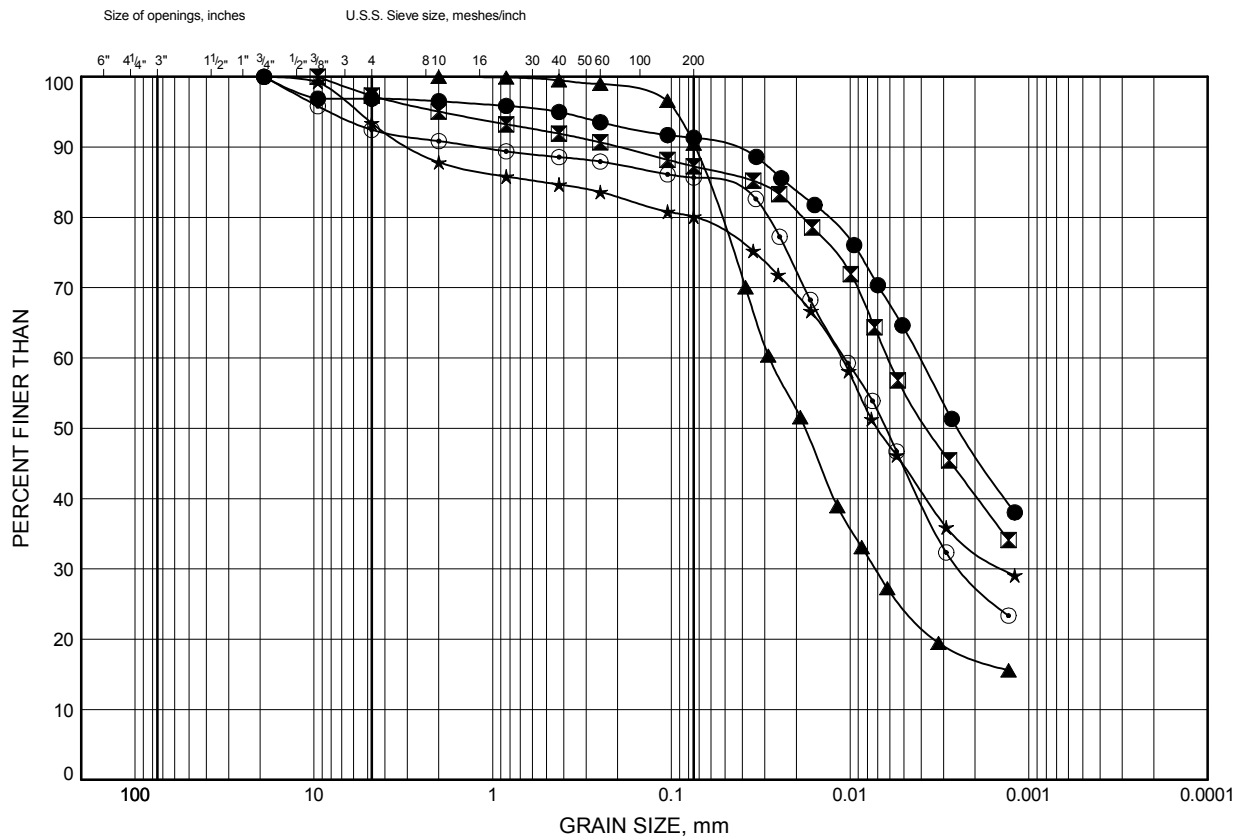
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL - Silty Clay



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

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	NBL 13+950Lt	1.7	184.9
⊠	NBL 13+950Rt	1.0	185.4
▲	NBL 13+950Rt	6.3	180.1
★	NBL 14+075Lt	2.5	178.7
⊙	NBL 14+075Rt	4.7	179.5

Date March 2010

Project 1-09-4135



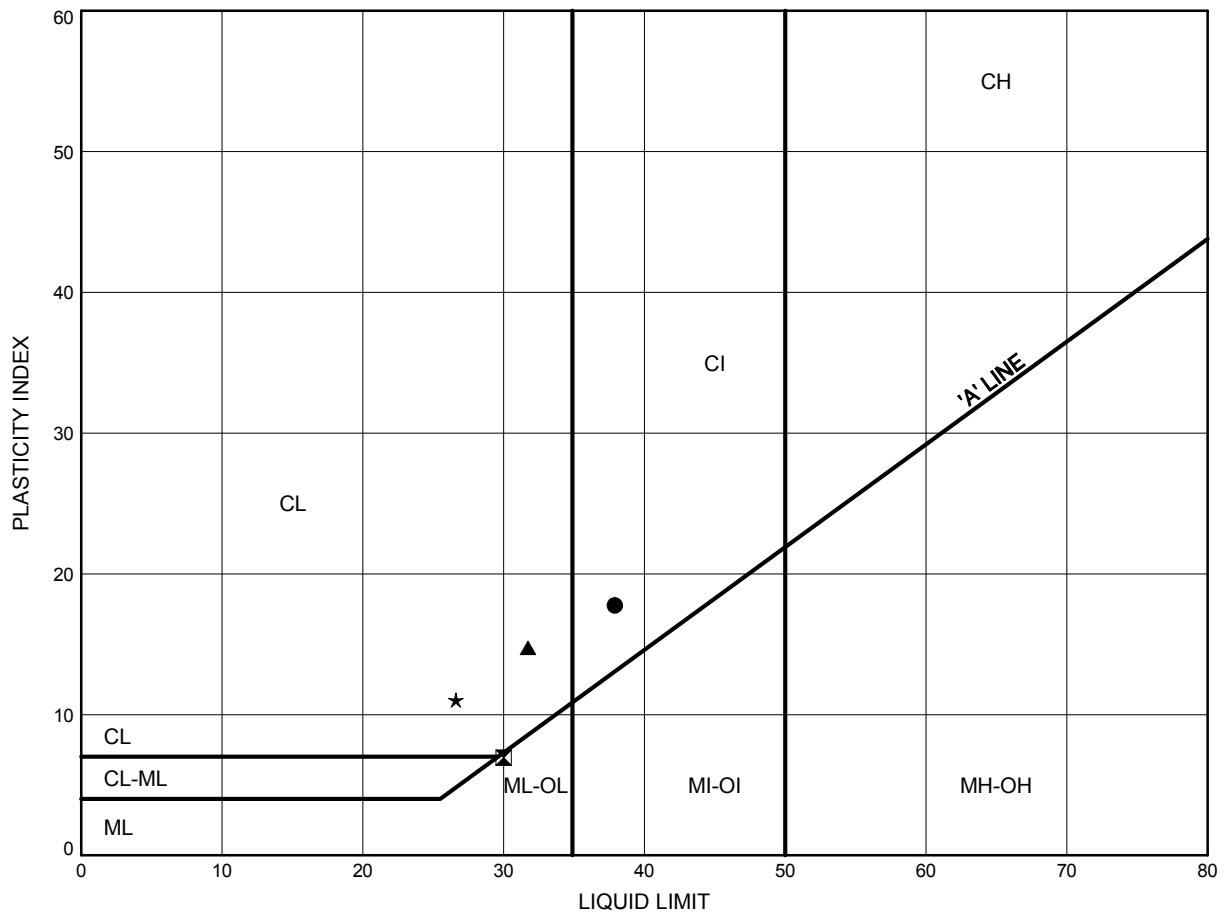
Prep'd DB

Chkd. RA

ATTERBERG LIMITS TEST RESULTS

FIGURE B2

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 13+950Rt	1.0	185.4
⊠	NBL 13+950Rt	6.3	180.1
▲	NBL 14+075Lt	2.5	178.7
★	NBL 14+075Rt	4.7	179.5

Date March 2010

Project 1-09-4135



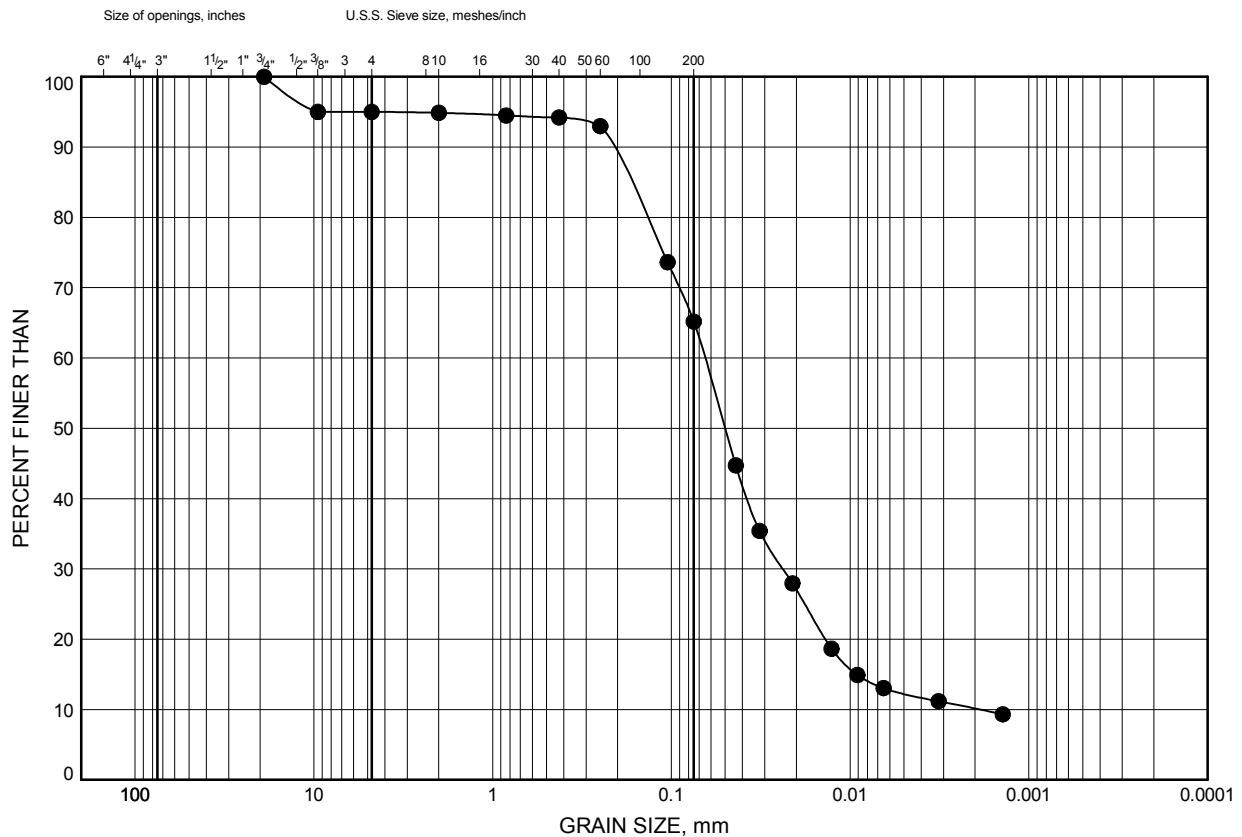
Prep'd DB

Chkd. RA

GRAIN SIZE DISTRIBUTION

FIGURE B3

FILL - Sandy Silt



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 13+950Lt	4.7	181.9

Date March 2010

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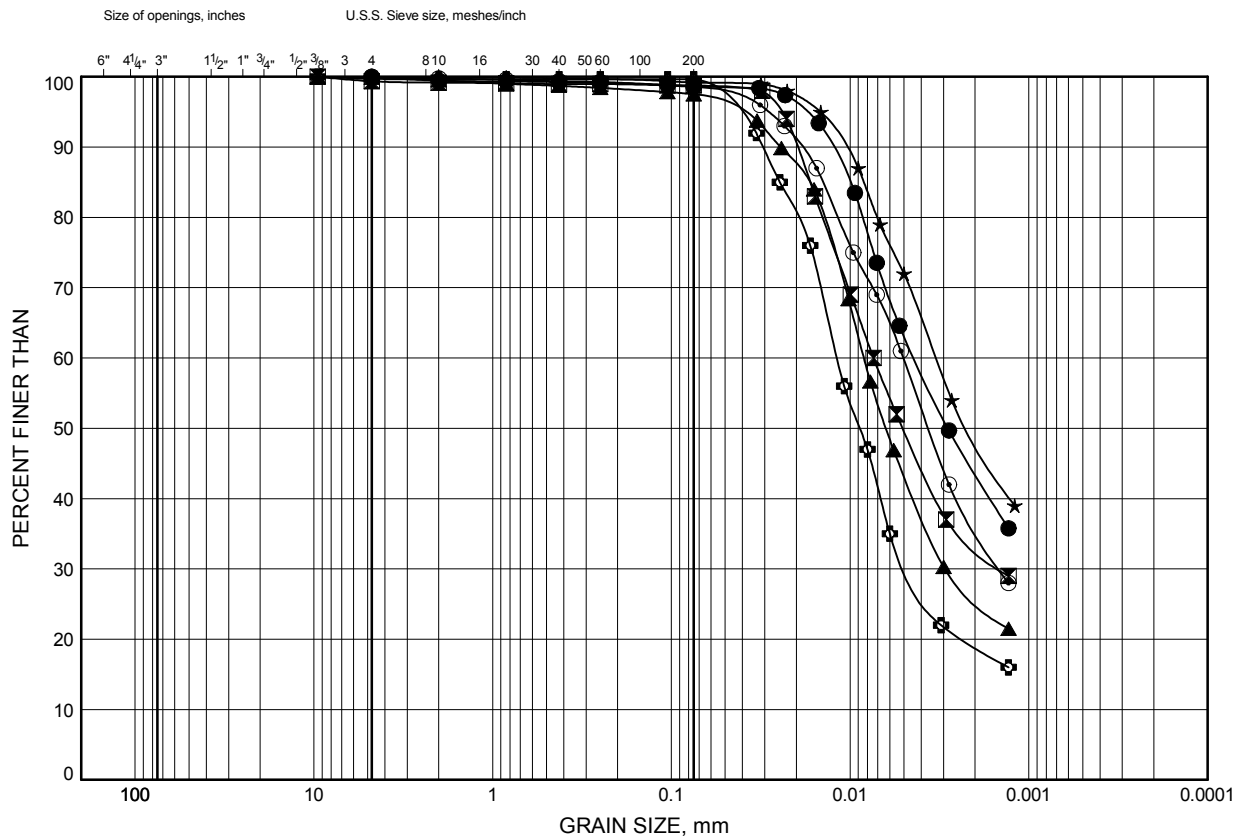
Prep'd DB

Chkd. RA

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 13+950Lt	10.9	175.7
⊠	NBL 13+950Lt	15.4	171.2
▲	NBL 13+950Lt	18.5	168.1
★	NBL 13+950Rt	9.3	177.1
⊙	NBL 13+950Rt	13.9	172.5
⊕	NBL 13+950Rt	17.0	169.4

Date March 2010

Project 1-09-4135



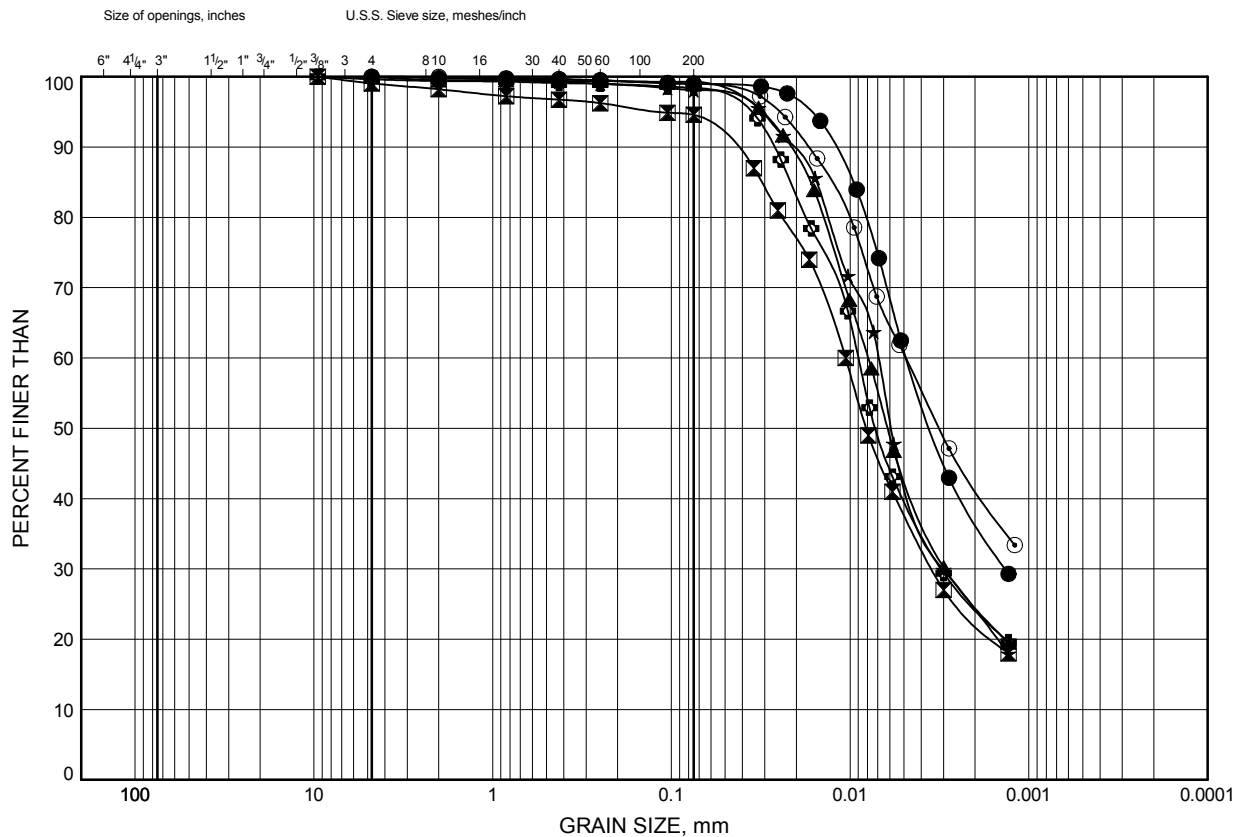
Prep'd DB

Chkd. RA

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY

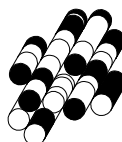


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 14+020CL	9.3	176.4
⊠	NBL 14+020CL	13.9	171.8
▲	NBL 14+020CL	17.0	168.7
★	NBL 14+020CL	20.0	165.7
⊙	NBL 14+020CL	21.5	164.2
⊛	NBL 14+075Lt	9.3	171.9

Date March 2010

Project 1-09-4135



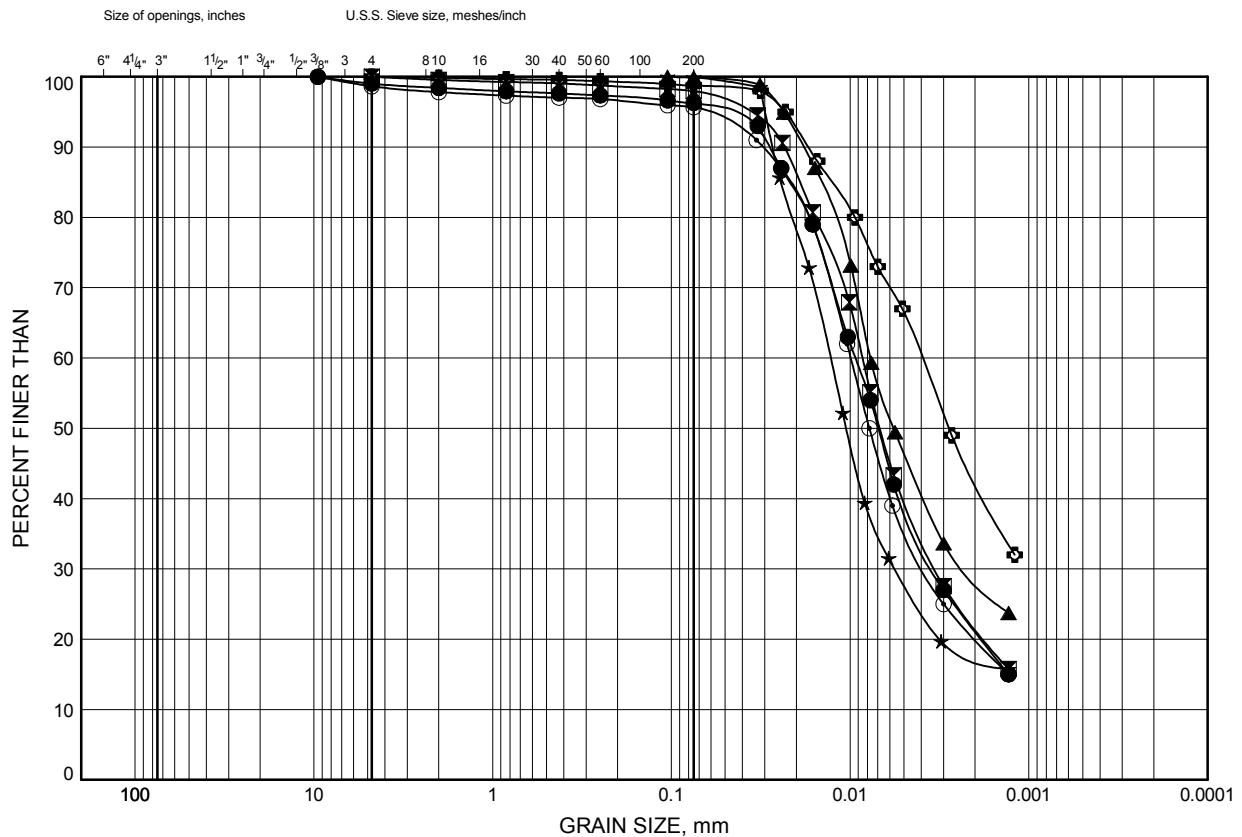
Prep'd DB

Chkd. RA

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY CLAY



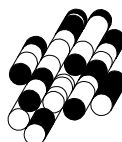
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	NBL 14+075Lt	10.9	170.3
⊠	NBL 14+075Lt	13.9	167.3
▲	NBL 14+075Lt	17.0	164.2
★	NBL 14+075Rt	10.9	173.3
⊙	NBL 14+075Rt	17.0	167.2
⊛	NBL 14+075Rt	21.5	162.7

Date March 2010

Project 1-09-4135

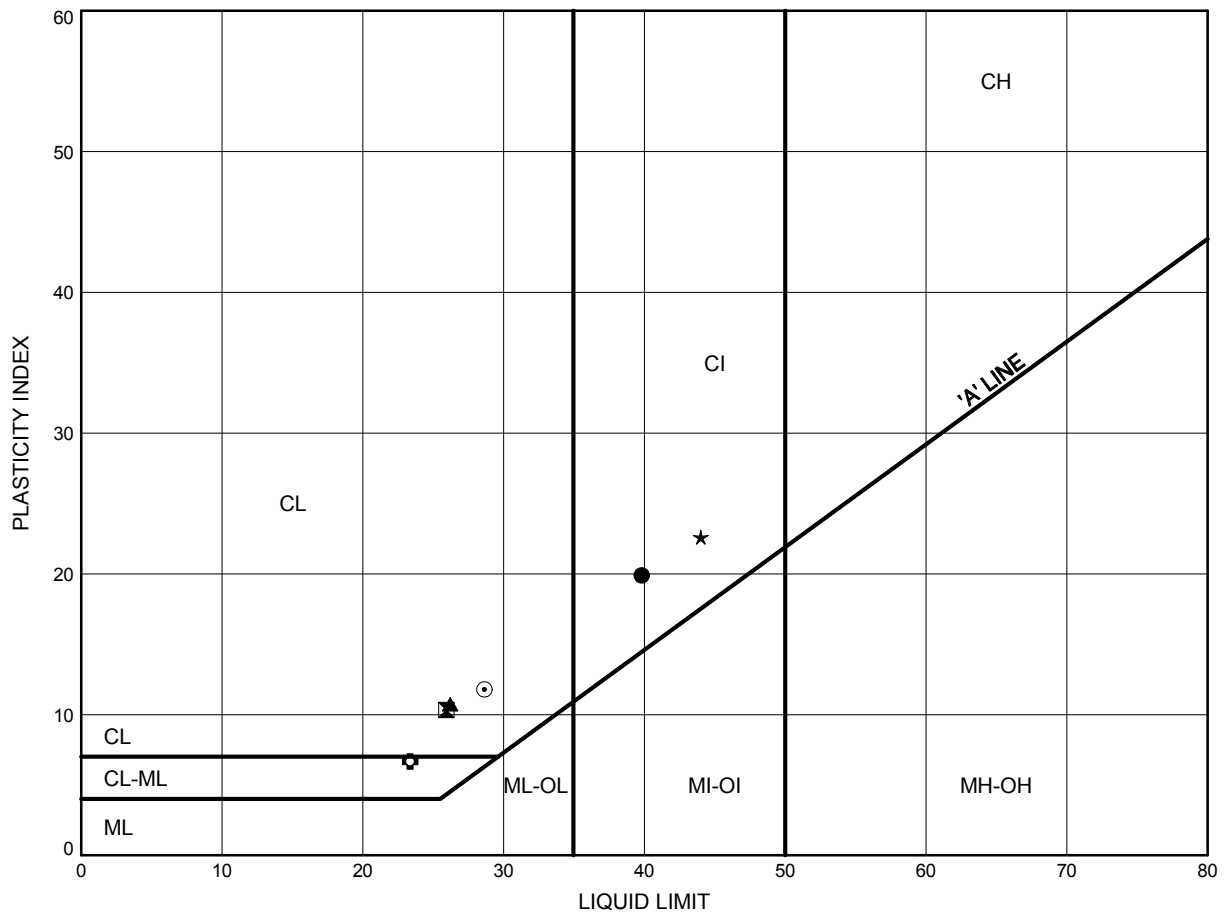


Prep'd DB

Chkd. HA

FIGURE B7

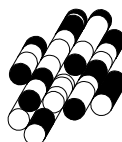
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 13+950Lt	10.9	175.7
⊠	NBL 13+950Lt	15.4	171.2
▲	NBL 13+950Lt	18.5	168.1
★	NBL 13+950Rt	9.3	177.1
⊙	NBL 13+950Rt	13.9	172.5
⊕	NBL 13+950Rt	17.0	169.4

Date March 2010

Project 1-09-4135



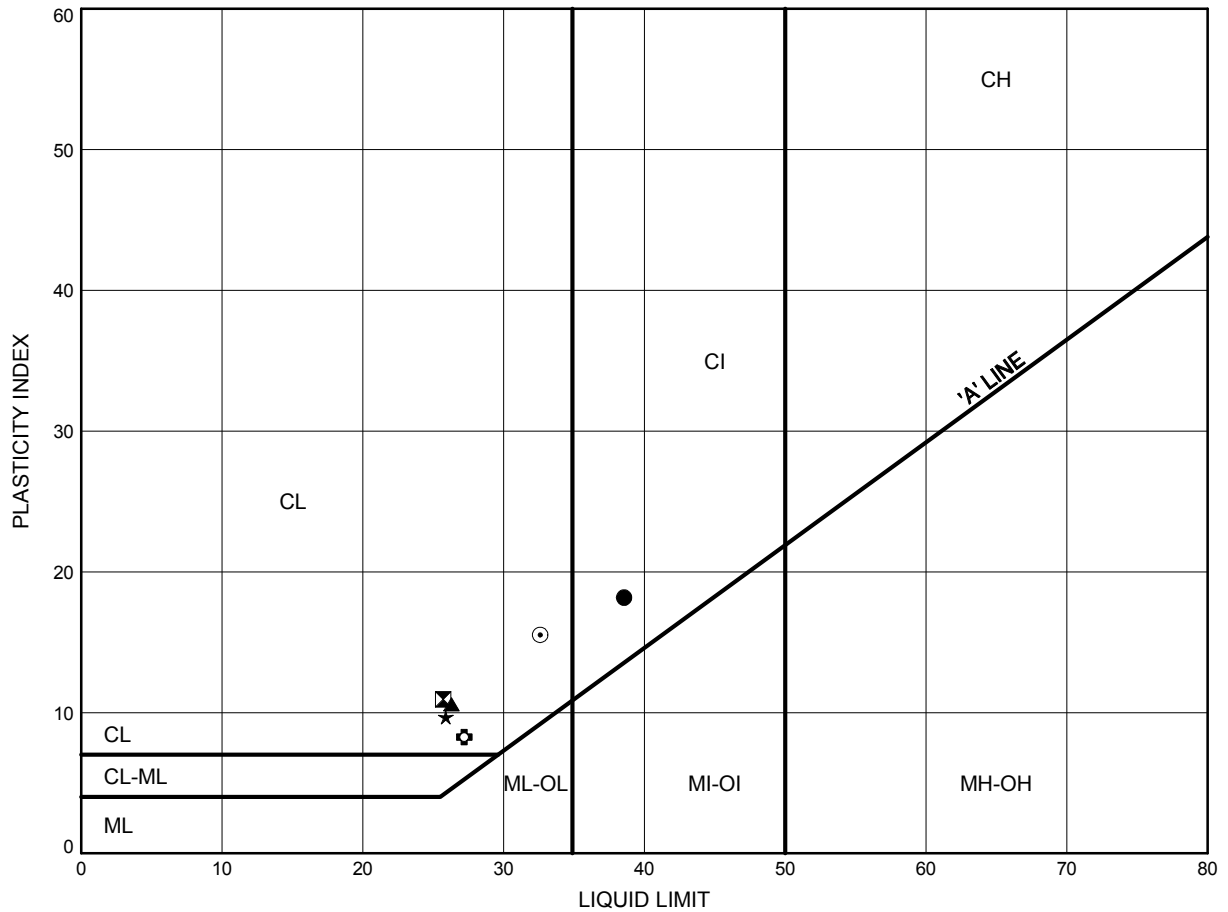
Prep'd DB

Chkd. RA

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

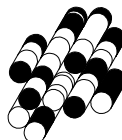
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 14+020CL	9.3	176.4
⊠	NBL 14+020CL	13.9	171.8
▲	NBL 14+020CL	17.0	168.7
★	NBL 14+020CL	20.0	165.7
⊙	NBL 14+020CL	21.5	164.2
⊗	NBL 14+075Lt	9.3	171.9

Date March 2010

Project 1-09-4135



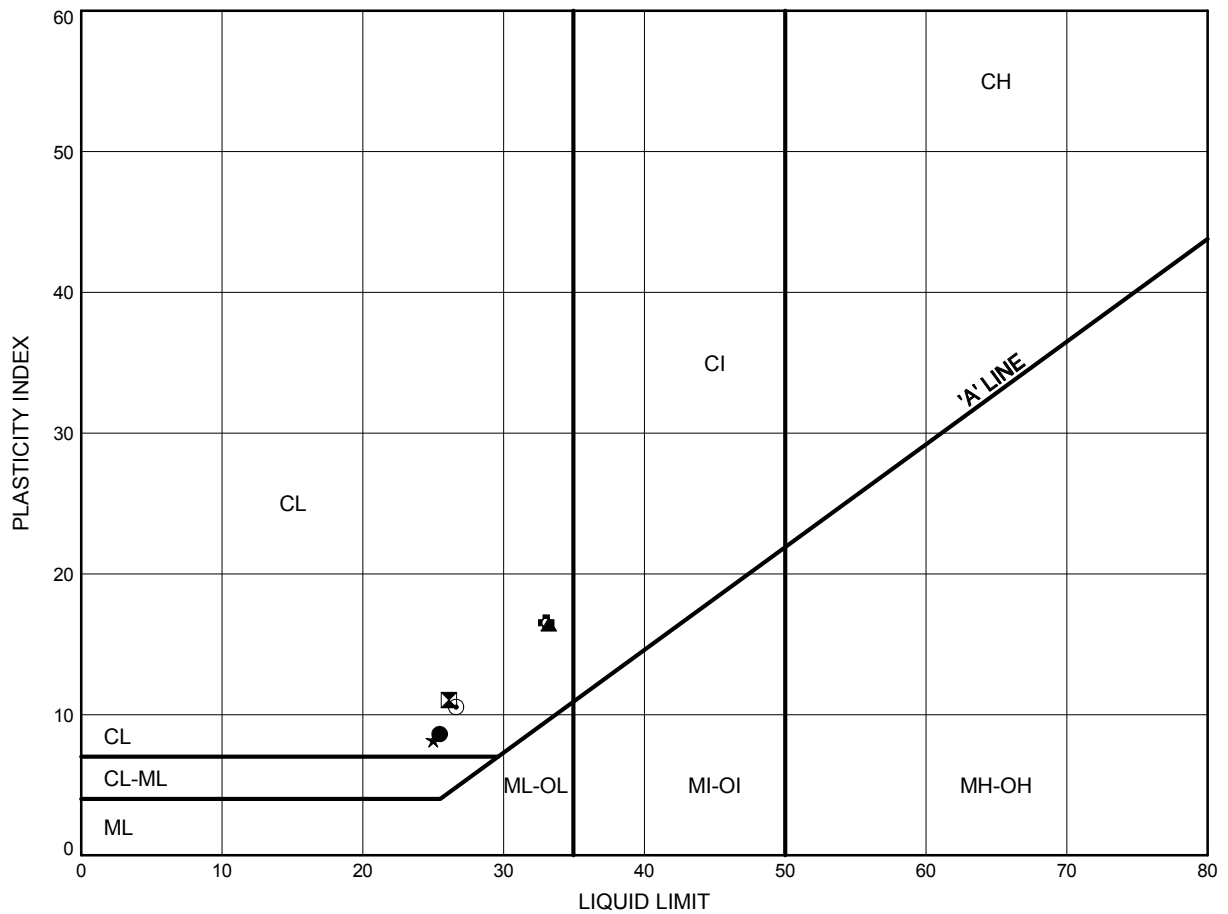
Prep'd DB

Chkd. RA

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 14+075Lt	10.9	170.3
⊠	NBL 14+075Lt	13.9	167.3
▲	NBL 14+075Lt	17.0	164.2
★	NBL 14+075Rt	10.9	173.3
⊙	NBL 14+075Rt	17.0	167.2
⊛	NBL 14+075Rt	21.5	162.7

Date March 2010

Project 1-09-4135



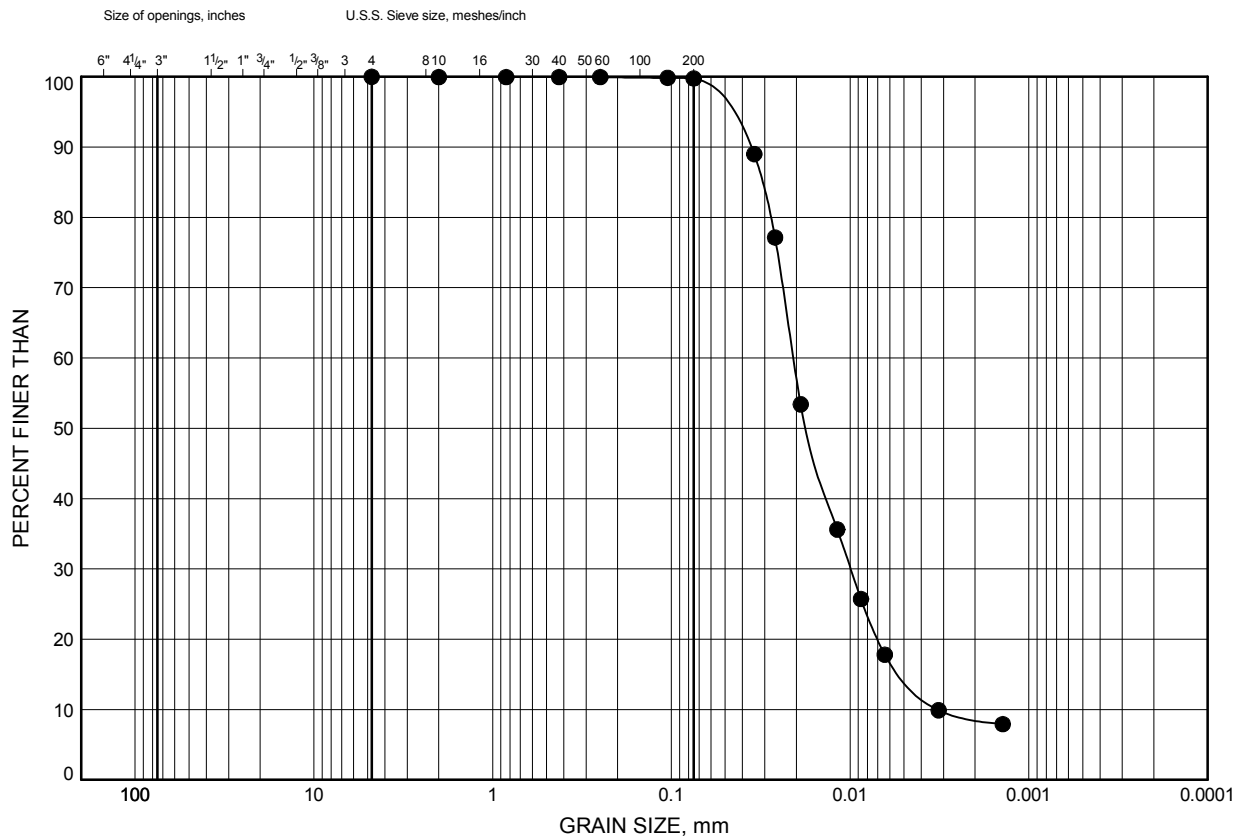
Prep'd DB

Chkd. RA

GRAIN SIZE DISTRIBUTION

FIGURE B10

SILT

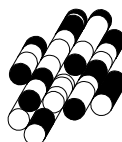


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 14+020CL	12.4	173.3

Date March 2010

Project 1-09-4135



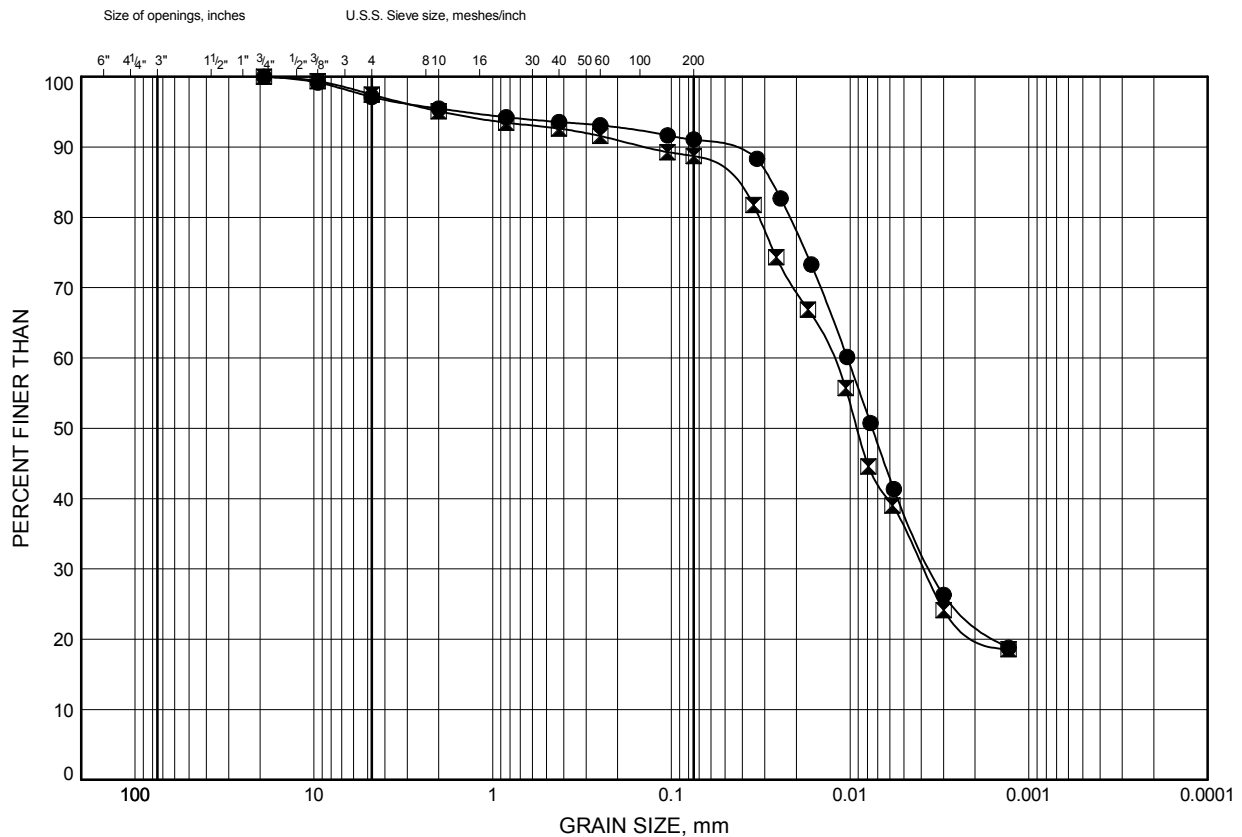
Prep'd DB

Chkd. RA

GRAIN SIZE DISTRIBUTION

FIGURE B11

SILTY CLAY TILL



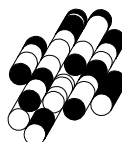
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

● NBL 14+020CL 23.7 162.0
 ⊠ NBL 14+075Lt 20.0 161.2

Date March 2010

Project 1-09-4135



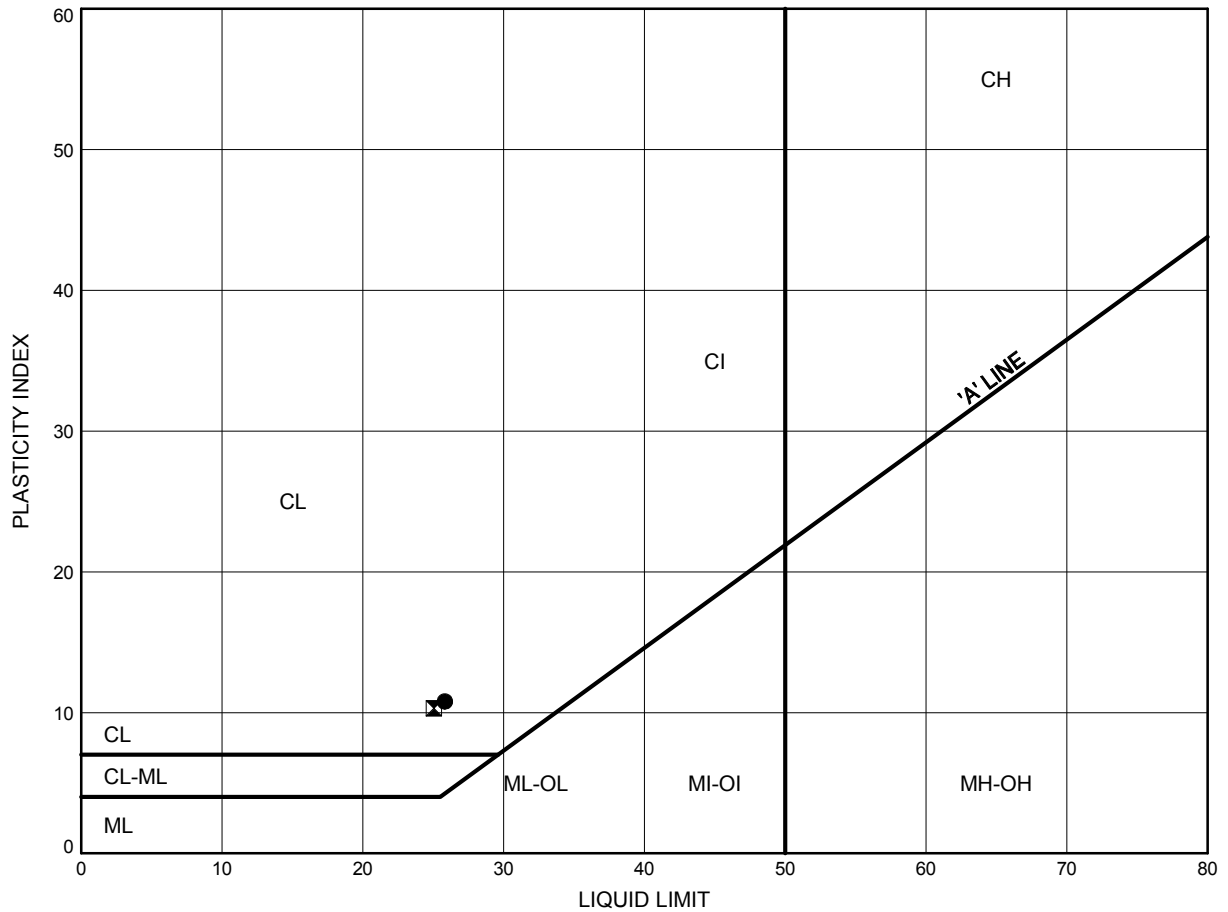
Prep'd DB

Chkd. RA

ATTERBERG LIMITS TEST RESULTS

FIGURE B12

SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 14+020CL	23.7	162.0
⊠	NBL 14+075Lt	20.0	161.2

Date March 2010

Project 1-09-4135

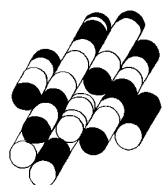


Prep'd DB

Chkd. RA

APPENDIX C

TERRAPROBE INC.



Test Pit 1A (Sta. 13+900 NBL CL)



Test Pit 1A (Sta. 13+900 NBL CL)



Test Pit 1A (Sta. 13+900 NBL CL)



Test Pit 1B (Sta. 13+925 NBL, 25 m Rt. of CL)



Test Pit 1B (Sta. 13+925 NBL, 25 m Rt. of CL)



Test Pit 1B (Sta. 13+925 NBL, 25 m Rt. of CL)



Test Pit 1C (Sta. 13+950 NBL CL)



Test Pit 1C (Sta. 13+950 NBL CL)



Test Pit 1C (Sta. 13+950 NBL CL)



Test Pit 1D (Sta. 14+000 NBL CL)



Test Pit 1D (Sta. 14+000 NBL CL)



Test Pit 1D (Sta. 14+000 NBL CL)



Test Pit 1E (Sta. 14+035 NBL, 25 m Rt. of CL)



Test Pit 1E (Sta. 14+035 NBL, 25 m Rt. of CL)



Test Pit 1E (Sta. 14+035 NBL, 25 m Rt. of CL)



Test Pit 1F (Sta. 14+050 NBL CL)



Test Pit 1F (Sta. 14+050 NBL CL)



Test Pit 1F (Sta. 14+050 NBL CL)



Test Pit 1G (Sta. 14+075 NBL, 25 m Rt. of CL)



Test Pit 1G (Sta. 14+075 NBL, 25 m Rt. of CL)



Test Pit 1G (Sta. 14+075 NBL, 25 m Rt. of CL)



Test Pit 1H (Sta. 14+100 NBL CL)



Test Pit 1H (Sta. 14+100 NBL CL)

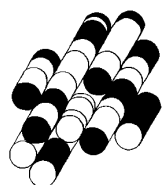


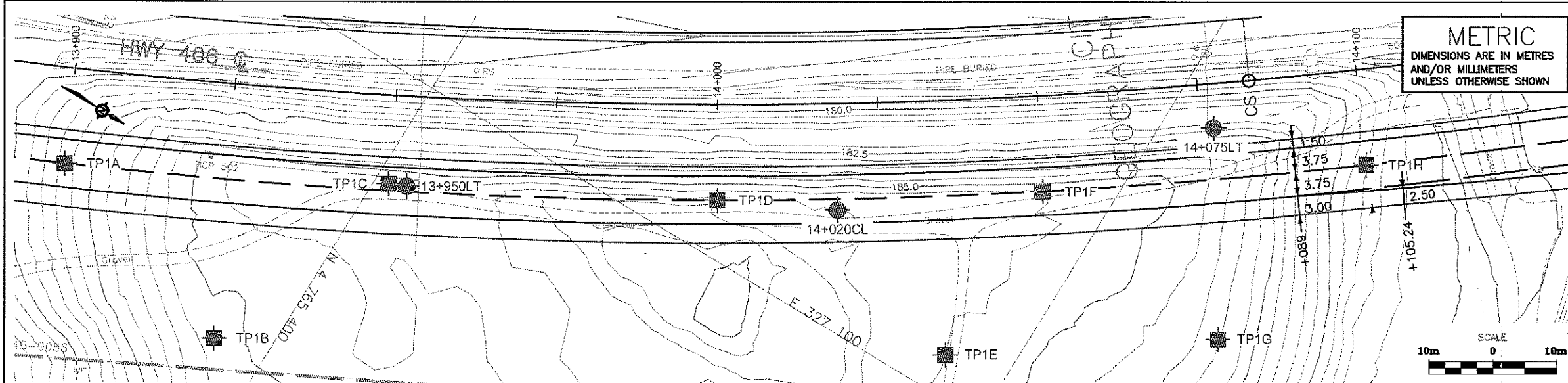
Test Pit 1H (Sta. 14+100 NBL CL)



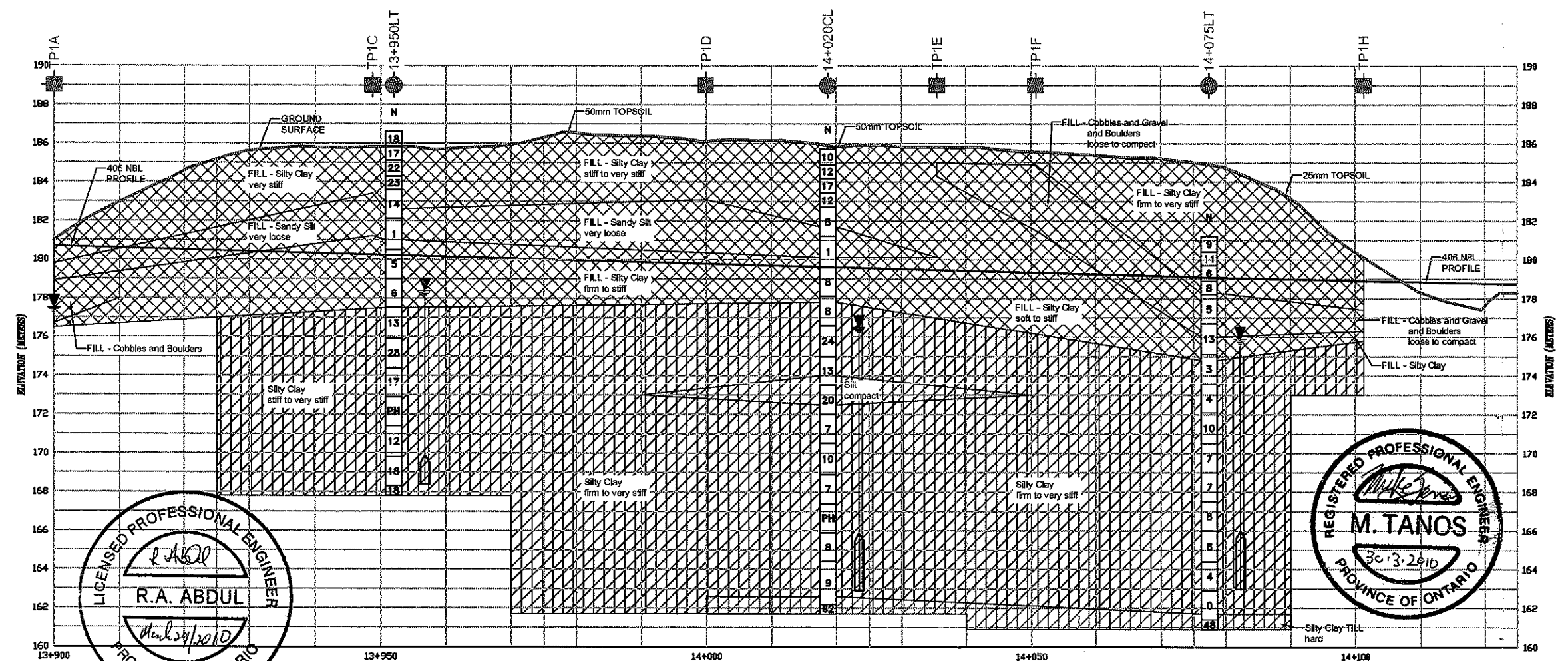
APPENDIX D

TERRAPROBE INC.





406 NBL PLAN - LEFT OF CENTRE LINE



406 NBL PROFILE - LEFT OF CENTRE LINE

CONT No
WP No 280-99-00

HIGHWAY 406
CUT SECTION
STA. 13+900 TO STA. 14+100

SHEET
1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company

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

KEY PLAN

LEGEND

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

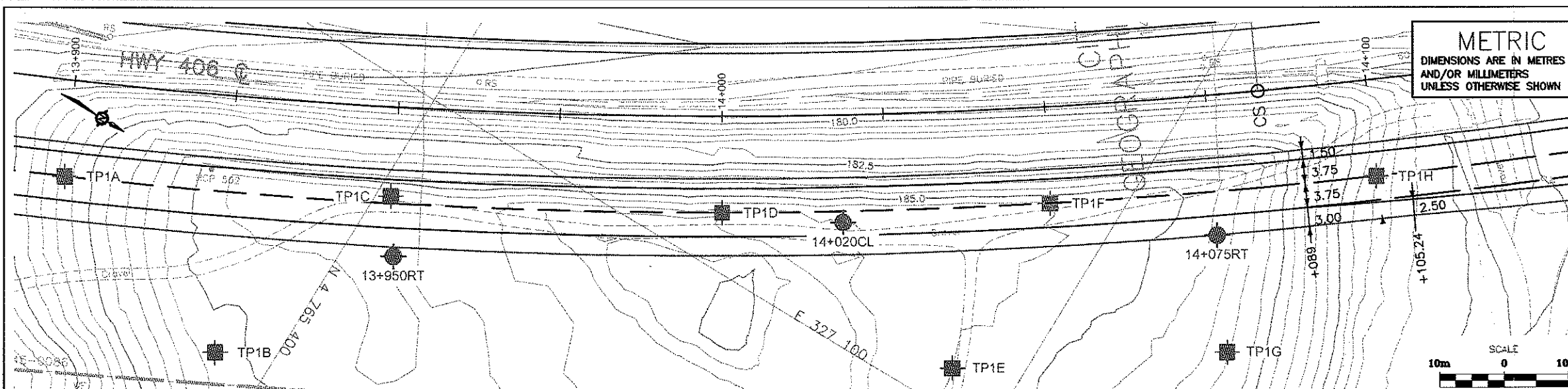
No	ELEV.	COORDINATES	
		NORTHING	EASTING
NBL 13+950LT	186.6	4765404.7	327115.2
NBL 14+020CL	185.7	4765463.9	327083.3
NBL 14+075LT	181.2	4765507.4	327041.7
TP1A	181.7	4765357.6	327139.9
TP1B	184.7	4765391.7	327151.1
TP1C	185.8	4765402.1	327116.3
TP1D	186.2	4765447.1	327091.8
TP1E	185.5	4765490.1	327093.9
TP1F	185.4	4765489.7	327064.1
TP1G	183.5	4765525.2	327069.6
TP1H	179.1	4765530.7	327034.1

NOTE

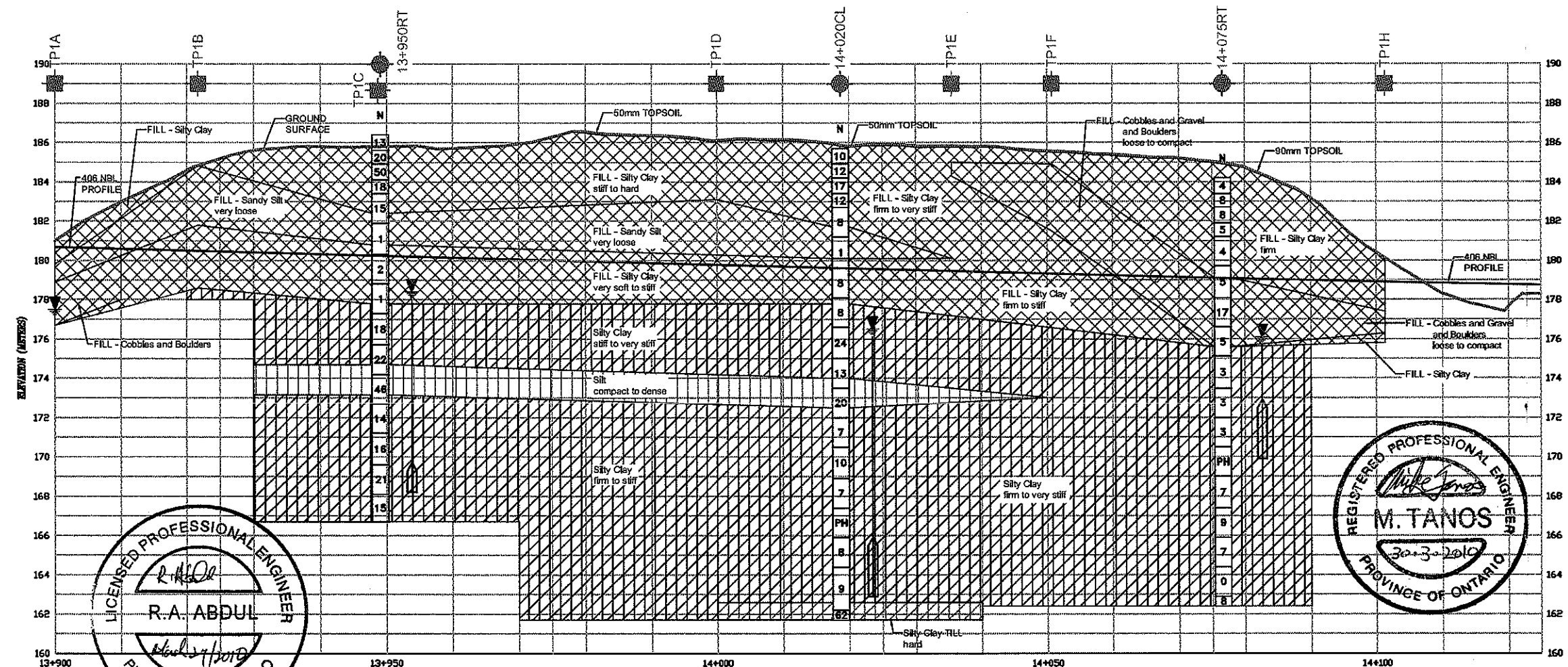
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

REVISIONS

DATE	BY	DESCRIPTION
DESIGN R.A.	CODE CHBDC2008	LOAD
DRAWN B.S.	CHK R.A.	STRUCT



406 NBL PLAN - RIGHT OF CENTRE LINE



406 NBL PROFILE - RIGHT OF CENTRE LINE

CONT No
WP No 280-99-00



HIGHWAY 406
CUT SECTION
STA. 13+900 TO STA. 14+100

SHEET
1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company



KEY PLAN

LEGEND

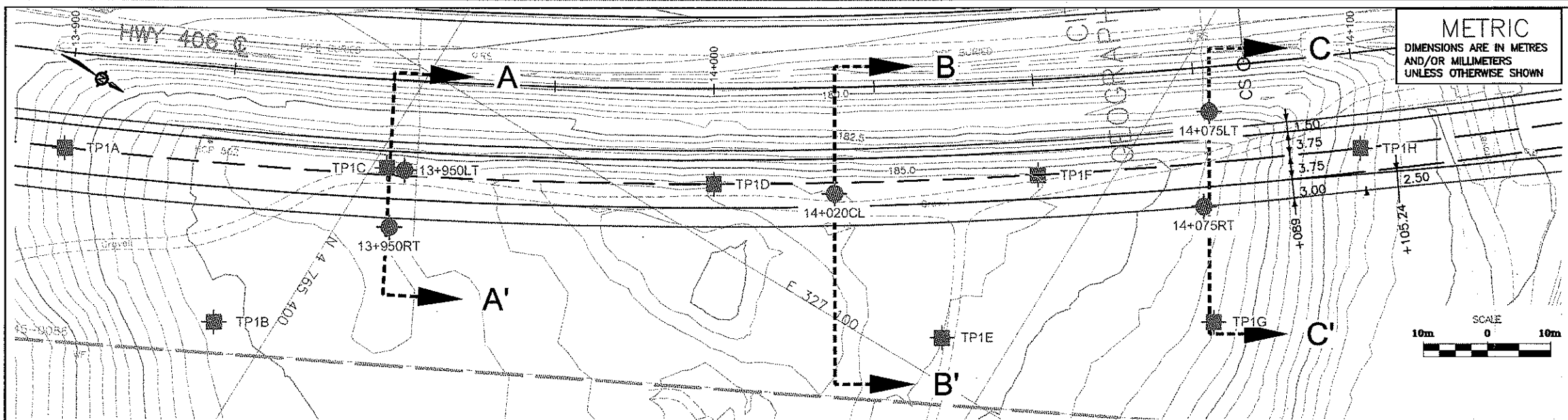
- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Test Pit
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60' Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer
- Piezometer
- Rock Quality Designation
- Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
NBL 13+950RT	186.4	4765407.3	327124.1
NBL 14+020CL	185.7	4765463.9	327083.3
NBL 14+075RT	184.2	4765514.4	327054.9
TP1A	181.7	4765357.6	327139.9
TP1B	184.7	4765391.7	327151.1
TP1C	185.8	4765402.1	327116.3
TP1D	186.2	4765447.1	327081.8
TP1E	185.5	4765490.1	327093.9
TP1F	185.4	4765489.7	327064.1
TP1G	183.5	4765525.2	327069.6
TP1H	179.1	4765530.7	327034.1

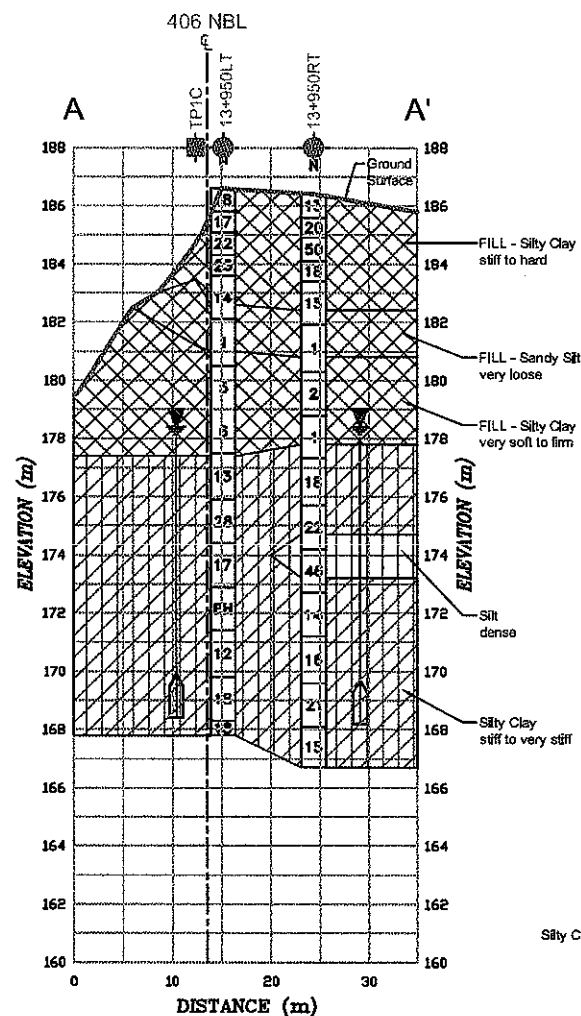
NOTE

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

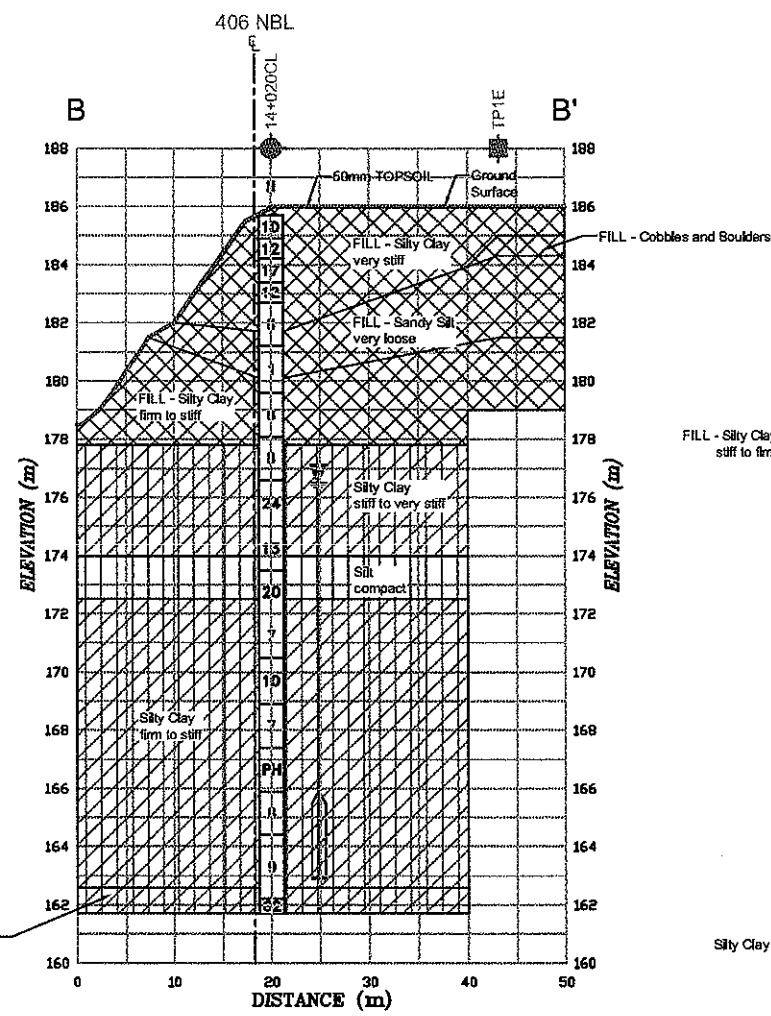
REVISIONS	DATE	BY	DESCRIPTION
DESIGN R.A.	CODE CHBDC2006	LOAD	DATE MAR, 2010
DRAWN B.S.	CHK R.A.	STRUCT	



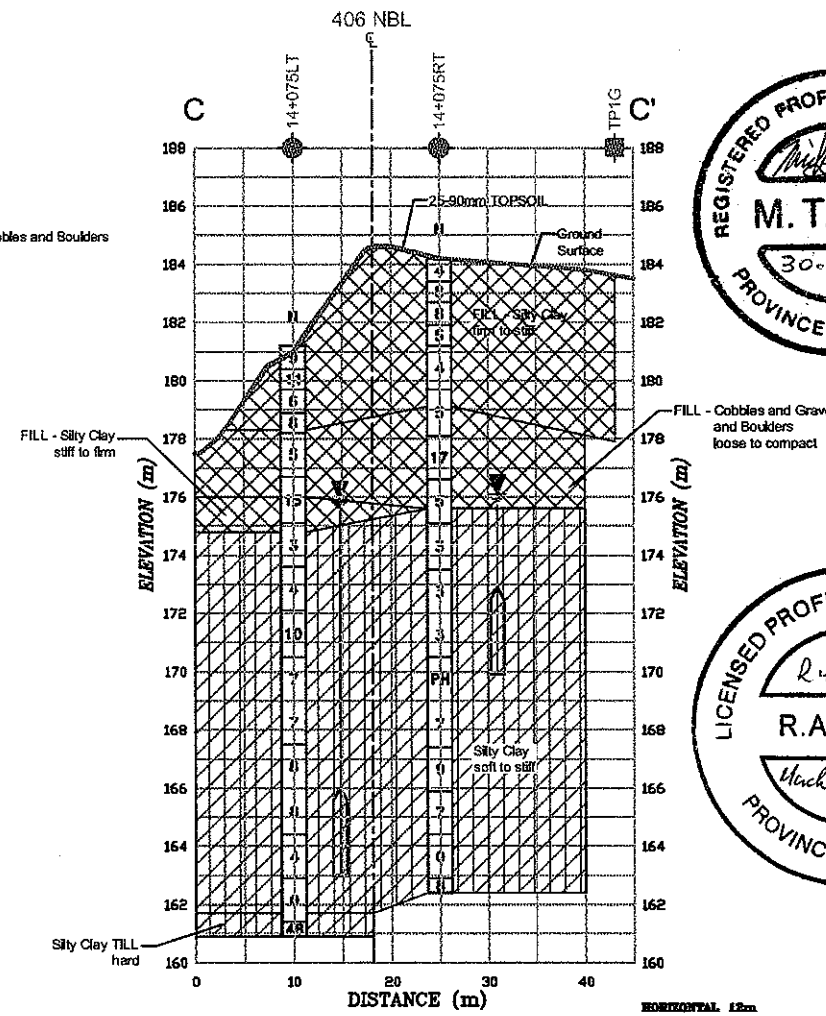
406 NBL PLAN



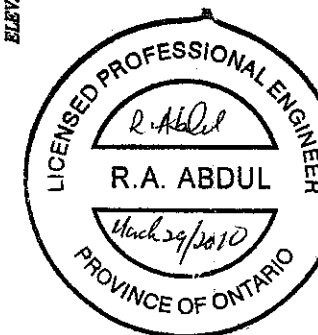
SECTION A-A'



SECTION B-B'



SECTION C-C'



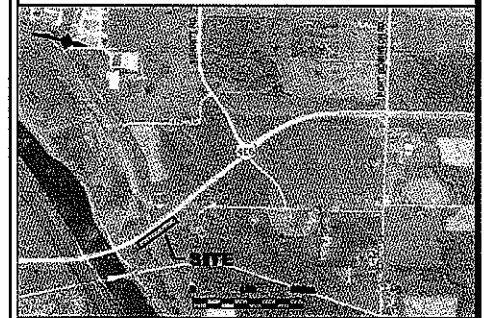
CONT No
WP No 280-99-00



HIGHWAY 406
CUT SECTION
STA. 13+900 TO STA. 14+100

SHEET
1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company



KEY PLAN

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

No	ELEV.	COORDINATES	
		NORTHING	EASTING
NBL 13+950LT	186.6	4765404.7	327115.2
NBL 13+950RT	186.4	4765407.3	327124.1
NBL 14+020CL	185.7	4765463.9	327083.3
NBL 14+075LT	181.2	4765507.4	327041.7
NBL 14+075RT	184.2	4765514.4	327054.9
TP1A	181.7	4765367.6	327139.9
TP1B	184.7	4765391.7	327151.1
TP1C	185.8	4765402.1	327116.3
TP1D	186.2	4765447.1	327091.8
TP1E	185.5	4765490.1	327093.9
TP1F	185.4	4765489.7	327064.1
TP1G	183.5	4765525.2	327069.6
TP1H	179.1	4765530.7	327034.1

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

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN R.A.	CODE CHBDC2006	LOAD	DATE MAR, 2010
DRAWN B.S.	CHK R.A.	STRUCT	