



# Terraprobe

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

## FOUNDATION INVESTIGATION & DESIGN REPORT

### CONTRACT 2

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. 2231-09-00

GEOCRES No. 30M3-251

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File No. 1-09-4135  
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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. 231-09-00**  
**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 basins<sup>1</sup>.

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<sup>1</sup> Chapman and Putnam, "The Physiography of South Ontario", 3<sup>rd</sup> 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 Age<sup>2</sup>. 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.

Ground water 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 ground water 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.

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<sup>2</sup> 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.  $\pm 178.3$  m) and 5.1 m (Elev.  $\pm 179.1$  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.  $\pm 184.3$  m) to 8.6 m (Elev.  $\pm 175.6$  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 ground water seepage was observed at a depth of 4.2 m (Elev.  $\pm 177.5$ 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 ground water level at the site generally follows the ground surface topography. At Sta. 13+950 the ground water level exists at elevations ranging between  $\pm 178.3$  m and  $\pm 178.4$  m falling to the south where the ground water level is estimated to exist at Elev.  $\pm 177.5$  at Sta. 13+900 approximately. North of Sta. 13+950 the ground water elevation falls to about Elev.  $\pm 176.5$  m at Sta. 14+020 decreasing further north to elevations ranging from  $\pm 175.9$  m to  $\pm 176.1$  m at Sta. 14+075.

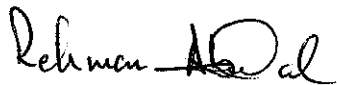
Perched water can also be expected to occur in the fill material where relatively permeable sandy silt and cobble and gravel soils are underlain by more impermeable silty clay soils. All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after 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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**FOUNDATION DESIGN 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 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

## **6 DISCUSSION AND RECOMMENDATIONS**

### **6.1 General**

An earth cut is required on Highway 406 NBL alignment between Sta. 13+900 and Sta. 14+100 approximately. The design grade of the alignment ranges from Elev. 180.7 m at Sta. 13+900 decreasing to Elev. 178.9 m at Sta. 14+100. Based on this profile and the current ground surface it is envisaged that earth cuts up to depths of  $\pm 6.5$  m are required.

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.

The local ground water level at the site generally follows the ground surface topography. At Sta. 13+950 the ground water level exists at elevations ranging between  $\pm 178.3$  m and  $\pm 178.4$  m falling to the south where the ground water level is estimated to exist at Elev.  $\pm 177.5$  at Sta. 13+900 approximately. North of Sta. 13+950 the ground water elevation falls to about Elev.  $\pm 176.5$  m at Sta. 14+020 decreasing further north to elevations ranging from  $\pm 175.9$  m to  $\pm 176.1$  m at Sta. 14+075. These values indicate that the ground water level exists below the proposed pavement subgrade.

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

#### **6.1.1 Design Considerations**

Excavations at this site will expose cohesive silty clay earth fill divided by layers of sandy silt and granular fill consisting of cobbles and gravel and boulders. Due to the inherent cohesive nature of the existing earth fill and the effects of local climate (precipitation, wetting and drying cycles, snow melt, freezing and thawing cycles), side slopes of 3H:1V are recommended in order to minimize shallow surficial failures.



The global, internal and surficial stability of the cut will depend on the slope geometry and also to a large degree on the properties of the existing fill material. For the purpose of embankment stability analyses, the commercially available slope stability program Slide 5.0 developed by Rocscience Inc. was used. The Bishop's simplified method, Janbu and Spencer methods of stability analysis were employed. Tabulated below are the soil parameters used for the slope stability analyses.

Material Type	Short-Term Analysis			Long-Term Analysis		
	$\phi$ (degrees)	c (kPa)	$\gamma$ (kN/m <sup>3</sup> )	$\phi$ (degrees)	c (kPa)	$\gamma$ (kN/m <sup>3</sup> )
Fill – Silty Clay	28	0	19	28	0	19
Fill – Sandy Silt	25	0	18	25	0	18
Fill – Cobbles and Gravel	30	0	19	30	0	19
Silty Clay	0	70–100	20–20.5	27–29	5–7	20–20.5
Soft Silty Clay (Sta.14+075Lt.)	0	25	20	27	5	20
Silt	33	0	19	33	0	19
Silty Clay Till	0	225	21	33	5	21

Stability analyses were conducted at selected sections for short-term and long-term conditions and slope stability models depicting the corresponding factors of safety are provided in Appendix E. A target factor of safety of 1.3 was used for both short term and long term conditions and ditching was also accounted for in the stability analyses. Tabulated below are the minimum factors of safety obtained for potential failure surfaces. .

#### Hwy. 406 NBL Sta.13+900 to Sta.14+100

Location	Design Side Slope	Minimum Factor of Safety Short-Term	Minimum Factor of Safety Long-Term
Sta. 13+950 Lt.	3H:1V	1.6	1.6
Sta. 13+950 Rt.	3H:1V	1.6	1.6
Sta. 14+020 CL	3H:1V	1.6	1.6
Sta. 14+075 Lt.	3H:1V	1.7	1.7
Sta. 14+075 Rt.	3H:1V	1.7	1.7

The analysis indicates that design side slopes of 3H:1V will have acceptable factors of safety of 1.6 or greater with respect to both shallow surficial failures and deep seated failures in the underlying soils.

#### 6.1.2 Property Acquisition (Alternative Solutions)

Additional property will be required between Sta. 13+925 and Sta. 14+025 if cut slopes are constructed at the recommended 3H:1V side slopes in accordance with a standard rural cross-section.

Since property acquisition can be costly, alternative solutions such as constructing a retaining structure within the cut slope were considered in order to mitigate the need for additional property. A number of retaining wall arrangements constructed within the cut were investigated for global stability.



Our analyses reveal that a target factor of safety of 1.3 with respect to global stability can be achieved. However, the structure must be constructed on an approximately 1 - 1.5 m thick Granular 'A' pad (preferably reinforced with a geogrid) and founded at a design subgrade elevation of about Elev. 180.0m. This construction will require excavations of up to 5.5 m (measured from the top of the cut) and a permit will be required to enter private property in order to facilitate this construction.

The design team also considered a subdrain arrangement that conforms in principle to OPSD 200.010, Nov. 2009. This design would maintain the recommended 3H:1V side slope while reducing the lateral extent of the slope such that additional property would not be required.

From a foundation engineering perspective the subdrain design is acceptable since the recommended 3H:1V side slopes will be maintained and reliable drainage will be maintained at the toe of the slope. Moreover, this design is less costly when compared to constructing a retaining structure. Hence, the preferred alternative would be the more economical subdrain design.

The subdrain must be designed to freely drain captured water and must be installed in a 300 mm wide trench below the Granular 'A' material of the sub-excavation. The subdrain should consist of a filter wrapped perforated plastic pipe placed in a trench excavated 300 mm by 300 mm. The trench should be backfilled with 19 mm clear stone. This subdrain arrangement must also be designed to drain to a Subdrain Pipe Connection & Outlet as outlined in OPSD 206.050. A typical subdrain detail is illustrated in Appendix F.

### **6.1.3 Construction Considerations**

It is recommended that the topsoil, any deleterious material and soft/loose and other unsuitable soils be removed within an envelope given by an imaginary slope not steeper than 1H:1V and extending from the left to right toe of the proposed cut. After stripping, the exposed subgrade and face of the cut should be inspected, approved and properly compacted from the surface, using a suitably sized compactor.

Given the variable subsurface conditions and the high probability of encountering rock fill and debris, we recommend excavating an additional 0.5 m below the proposed pavement subgrade across the entire width of the highway i.e. from left to right toe of slope. Refer to Appendix F for a schematic figure illustrating the envelope for removal of unsuitable material.

Excavation should be carried out in about 4 m wide strips parallel to the highway alignment. The subgrade should then be compacted and proofrolled with a heavy rubber tire vehicle (such as a loaded gravel truck) and the subgrade should then be inspected for signs of rutting or displacement. Areas with rutting or displacement should be recompacted and retested or excavated and replaced with well-compacted clean fill.



After proofrolling Granular 'A' or Granular 'B' Type II material should be placed in uncompacted lifts not exceeding 300 mm and each lift should be uniformly compacted to at least 95 % of the material's Standard Proctor Maximum Dry Density (SPMDD). It may be infeasible to effect surface compaction at some locations where relatively weak and/or wet soils are encountered. At these locations the granular fill may need to be thicker than normal (i.e. thicker than 300 mm lifts) in order to achieve compaction while maintaining trafficability of construction equipment.

During construction surface water runoff and perched water in the fill will have to be controlled in order to facilitate construction operations in relatively dry conditions. This can be accomplished by gravity drainage and pumping from strategically positioned sumps as and where required. The design of the unwatering system should be the Contractor's responsibility.

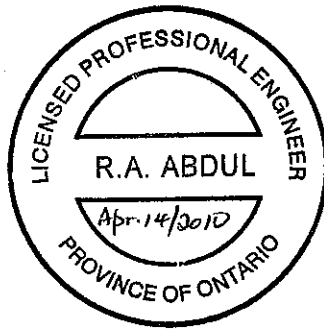
The subsurface data indicates that a layer of very loose and wet sandy silt fill will be exposed at the face of the cut between Sta. 13+910 and Sta. 14+035 approximately. This soil should be removed by excavating laterally into the face of the slope a distance of 1.5 m. Granular 'A' or Granular 'B' Type II material should be used as a replacement. This granular material should be placed in lifts not exceeding 300 mm and uniformly compacted to at least 95 % of the material's Standard Proctor Maximum Dry Density (SPMDD). To prevent water retention in this granular material we recommend sloping the base towards the toe of the cut at a 2% slope. For estimating purposes assume the plan area of the silty sand fill to be excavated is 325m<sup>2</sup>.

Earth cuts should be constructed in accordance with OPSS 201, OPSS 180, OPSS 501 and OPSS 206, as amended by Special Provision "Amendment to OPSS 206, December 1993", dated November 2002. Excavations will encounter boulders, rock fill, debris and unsuitable soils and we recommend including an NSSP in the Contract Documents to alert the Contractor of these subsurface conditions. A suggested NSSP is included in Appendix G.

Proper erosion control measures should be implemented both during construction and permanently. Temporary erosion and sediment control must be provided in accordance with OPSS 577. The slopes and crests of the cut must also be provided with permanent erosion protection in accordance with OPSS 571 and/or OPSS 572.

It is also imperative that the cut be designed to prevent surface water runoff from flowing down the face of the slope. Consideration should therefore be given to grading and shaping the ground surface at the crest of the cut to accomplish this desired effect. Surface water runoff emanating from the top of the cut must be controlled and directed to roadside ditches via armoured outfalls/outlets.





*Rehman Abdul*

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



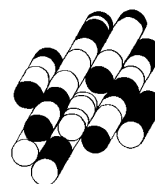
*Michael Tanos*

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



# APPENDICES

**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

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## 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 N.

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

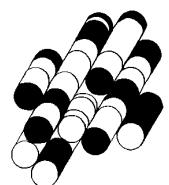
## PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1.0	VOID RATIO	$e_{min}$	1.0	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1.0	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1.0	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>2</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $(w - w_p) / I_p$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_c$	1	CONSISTENCY INDEX = $(w_L - w) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1.0	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>2</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						



# APPENDIX A

**TERRAPROBE INC.**



# RECORD OF BOREHOLE No NBL 13+950Lt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765404.7 E:327115.2 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 <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
166.6 0.0	Ground Surface													
	trace gravel		1	SS	18		186				○			
	----		2	SS	17						○			
	FILL - Silty Clay, trace sand, trace gravel, stiff to very stiff, brown, damp to moist		3	SS	22		185				○			3 6 45 46
			4	SS	23		184				○			
			5	SS	14		183				○			
182.6 4.0	FILL - Sandy Silt, trace clay, trace gravel, very loose, grey / brown, wet		6	SS	1		182				○			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		181				○			
			8	SS	6		180				○			
							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
			11	SS	17		175				○			
			12	TW	PH		174							
							173							
							172		2.7					

Continued Next Page

+3, x3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MÔT 1-09-4135 HWY 406 NBL GFJ ONTARIO MÔT.GDT 01/21/10

## 2 OF 2

## METRIC

SOIL PROFILE	SAMPLES	R	E	DYNAMIC CONE PENETRATION RESISTANCE PLOT			
--------------	---------	---	---	---	--	--	--

+ 3, X 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 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 W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
186.4	Ground Surface							20	40	60	80	100					
0.0	FILL - Silty Clay, trace sand, trace gravel, stiff to hard, brown, damp		1	SS	13		186										
			2	SS	20												3 10 47 40
			3	SS	50		185										
	occasional sand seams		4	SS	18		184										
			5	SS	15		183										
182.4																	
4.0	FILL - Sandy Silt, trace to some clay, very loose, brown, wet		6	SS	1		182										
							181										
180.8																	
5.6	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										0 10 73 17
			8	SS	1		179										
177.8							178										
8.6	SILTY CLAY trace sand, stiff to very stiff, brown, damp		9	SS	18		177										0 1 51 48
			10	SS	22		176										
174.7							175										
11.7	SILT trace clay, dense, brown, wet		11	SS	46		174										
173.2							173										
13.2	SILTY CLAY trace sand, stiff, brown, moist		12	SS	14		172										0 1 63 36

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

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

## 2 OF 2

### METRIC

LOCATION: \_\_\_\_\_ Coords: N:4765407.3 E:327124.1

ORIGINATED BY LY

BOREHOLE TYPE Track-Mounted / Hollow Stem Augers

COMPILED BY DB

DATE 11.16.09

CHECKED BY RA

+ 3, X 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 <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE	
185.7	Ground Surface						20	40	60	80	100	10	20	30	GR SA SI CL			
185.7 0.1	50mm TOPSOIL		1	SS	10													
	FILL - Silty Clay, trace sand, trace gravel, stiff to very stiff, brown, damp		2	SS	12													
			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  SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		8	SS	8													
			9	SS	24										0 1 62 37			
			10	SS	13										Nov.10			
			11	SS	20										Nov.11			
174.0 11.7	SILT trace clay, compact, brown, wet		12	SS	7										0 0 91 9			
172.5 13.2	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist														1 4 72 23			

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

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

## METRIC

CHECKED BY RA

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

# RECORD OF BOREHOLE No NBL 14+075L<sub>t</sub>

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 LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						

181.2	Ground Surface						181							
0.0	25mm TOPSOIL		1	SS	9									
	FILL - Silty Clay, trace to some sand, trace gravel, firm to stiff, brown, damp		2	SS	11		180							
			3	SS	6									
			4	SS	8		179							
178.3			5	SS	5		178							7 13 47 33
2.9	FILL - Cobbles, Sand and Gravel, loose to compact, brown, damp		6	SS	13		177							
			7	SS	3		176							
176.0			8	SS	4		175							
5.2	FILL - Silty Clay, trace sand, trace gravel, soft to firm, brown, damp to moist		9	SS	10		174	2.4						
	soft		10	SS	7		173							
	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist		11	SS	7		172							0 1 74 25
			12	SS	8		171							
							170							1 3 75 21
							169							
							168							
							167							0 2 76 22

Continued Next Page

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



## 2 OF 2

**METRIC**

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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES					
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
							20 40 60 80 100 20 40 60 80 100					
161.7	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist (continued)	[Hatched Pattern]	13	SS	8	[Vertical Scale]	166	>>	1.9			
165							165	1.8				
164			14	SS	4		164		2.0			0 0 71 29
163							163	+ 2.4				
162			15	SS	0		162	2.0				
161							161	>-				
160.9												
20.3	End of Borehole	[Hatched Pattern]	16	SS	48							3 9 67 29

Water level at 9.4m (not stabilized) on completion.

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

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

# 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 <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
184.2	Ground Surface						20 40 60 80 100						
184.1	90mm TOPSOIL						20 40 60 80 100						
0.1	FILL - Silty Clay, trace sand, trace gravel, firm, brown, damp to moist		1	SS	4	184							
			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	FILL - Cobbles and Gravel, trace to some sand, trace clay, loose to compact, brown, damp		7	SS	17	178							8 7 57 28
5.1			8	SS	5	177							
			9	SS	3	176							
175.6	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp		10	SS	3	175							
8.6			11	SS	3	174	2.0						
			12	TW	PH	173	3.0						0 0 82 18
						172	2.0						
						171	1.7						
						170	1.5						

Continued Next Page

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

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

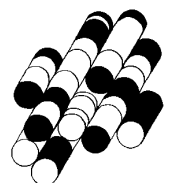
## METRIC

CHECKED BY RA

+3, X3: 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 LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa									
181.7 0.0	Ground Surface						20	40	60	80	100					
	FILL - Silty Clay, trace to some gravel, trace sand, brown, moist		1	CS		181										
179.8 1.9	FILL - Cobbly Sandy Silt, some gravel, grey / brown, damp		2	CS		180										
178.9 2.8	FILL - Cobbles and Boulders					179										
						178										
176.7 176.0 5.2	FILL - Silty Clay, trace sand, trace gravel, trace organics, dark brown / black, moist  End of Test Pit  Ground water seepage at 4.2m below ground surface. Caving in cobbles and boulders layer.		3	CS		177										

# 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 <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
184.7 0.0	Ground Surface															
	FILL - Sandy Silt, some gravel, some cobbles, frequent silty clay inclusions, brown, very moist		1	CS		184										
182.8 1.9	FILL - Silty Sand to Sandy Silt, some gravel, brown, damp		2	CS		183										
181.8 2.9	FILL - Silty Clay, trace gravel, trace organics, brown, moist					182										
						181										
						180										
178.6 6.1	SILTY CLAY brown, moist		3	CS		179										
178.1 6.6	End of Test Pit		4	CS												
	Test Pit was dry and open to full depth after excavation.															

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

# 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 LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa										WATER CONTENT (%)		
							20 40 60 80 100										10 20 30		
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	FILL - Sandy Silt, some gravel, brown, damp		2	CS															
181.2 4.6	FILL - Silty Clay, trace to some sand, brown / grey, moist		3	CS															
179.7 6.1	End of Test Pit		4	CS															
	Test Pit was dry and open to full depth after excavation.																		

MTD TP 1-09-4135 TP GPJ ONTARIO MOT GDT 03/28/10

# 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 w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa										WATER CONTENT (%)
							20 40 60 80 100										
186.2	Ground Surface																
0.0	FILL - Silty Clay, some gravel, some cobbles, brown, moist		1	CS													
183.1	FILL - Sandy Silt, some gravel, brown, moist to wet		2	CS													
3.1	grey																
180.5	grey / black		3	CS													
5.7	End of Test Pit																
	Test Pit was dry after excavation. Moderate caving at 3.1m below ground surface.																

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



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 LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa							WATER CONTENT (%)				
185.5	Ground Surface						20	40	60	80	100							
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														

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



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 12.15.08 CHECKED BY RA

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
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.															

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

# RECORD OF TEST PIT No 1H

1 OF 1

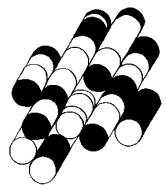
METRIC

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 NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	20	40	60	80	100	10	20	30		
179.1 0.0	Ground Surface																			
	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	CS																
173.0 6.1	End of Test Pit  Test Pit was dry after excavation. Caving in cobbles and boulders layer.																			

# APPENDIX B

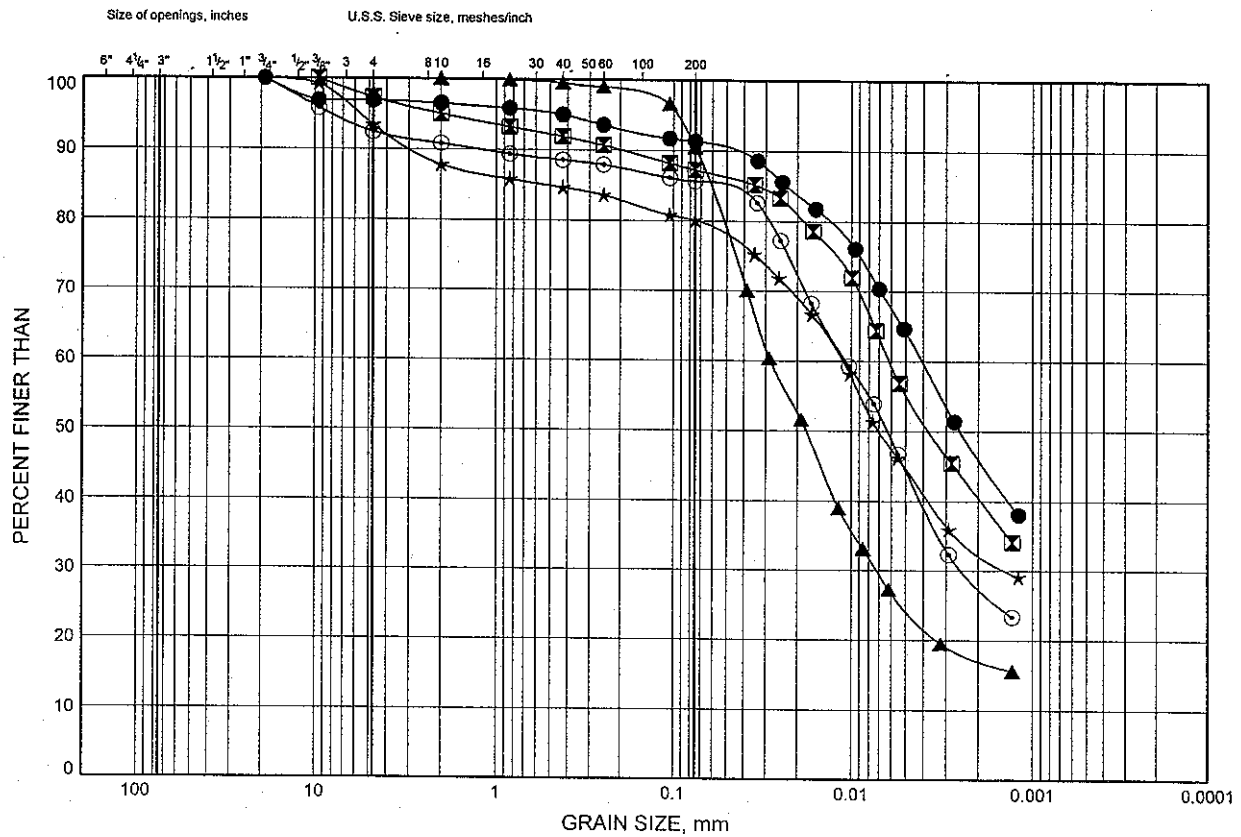
**TERRAPROBE INC.**



# GRAIN SIZE DISTRIBUTION

FIGURE B1

## FILL - Silty Clay

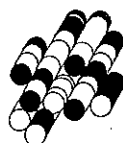


SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	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



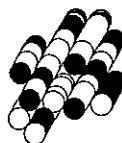
Prep'd DB

Chkd. RA

## FIGURE B2

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

Chkd. .... RA .....



## FIGURE B3

Size of openings, inches

U.S.S. Sieve size, meshes/inch

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	Percent Finer (%)
75	100
47.5	95
30	95
20	95
15	95
10	94
7.5	93
60	73
42.5	64
30	44
20	34
15	27
10	18
7.5	14
60	12
42.5	10
30	8

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

Chkd. .... RA .....

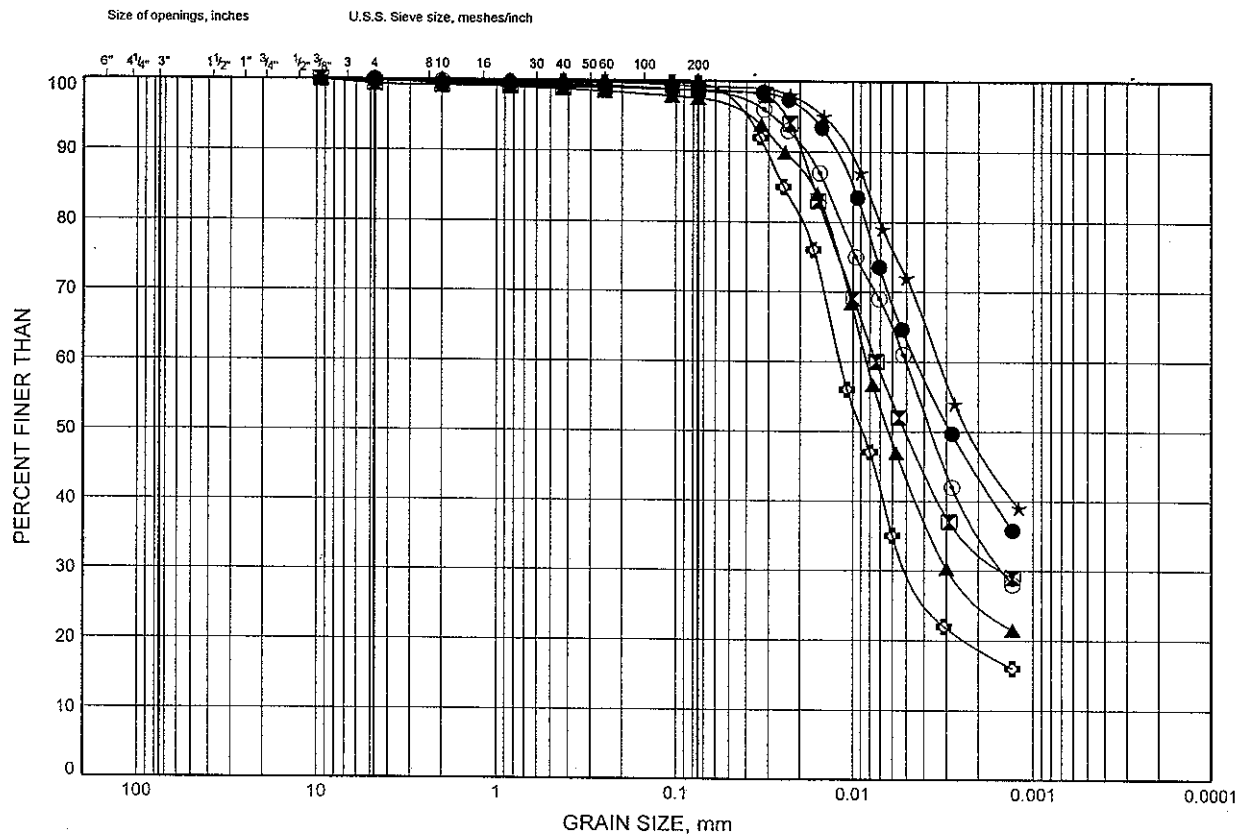




# GRAIN SIZE DISTRIBUTION

FIGURE B4

## SILTY CLAY

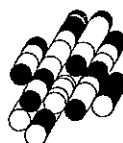


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

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



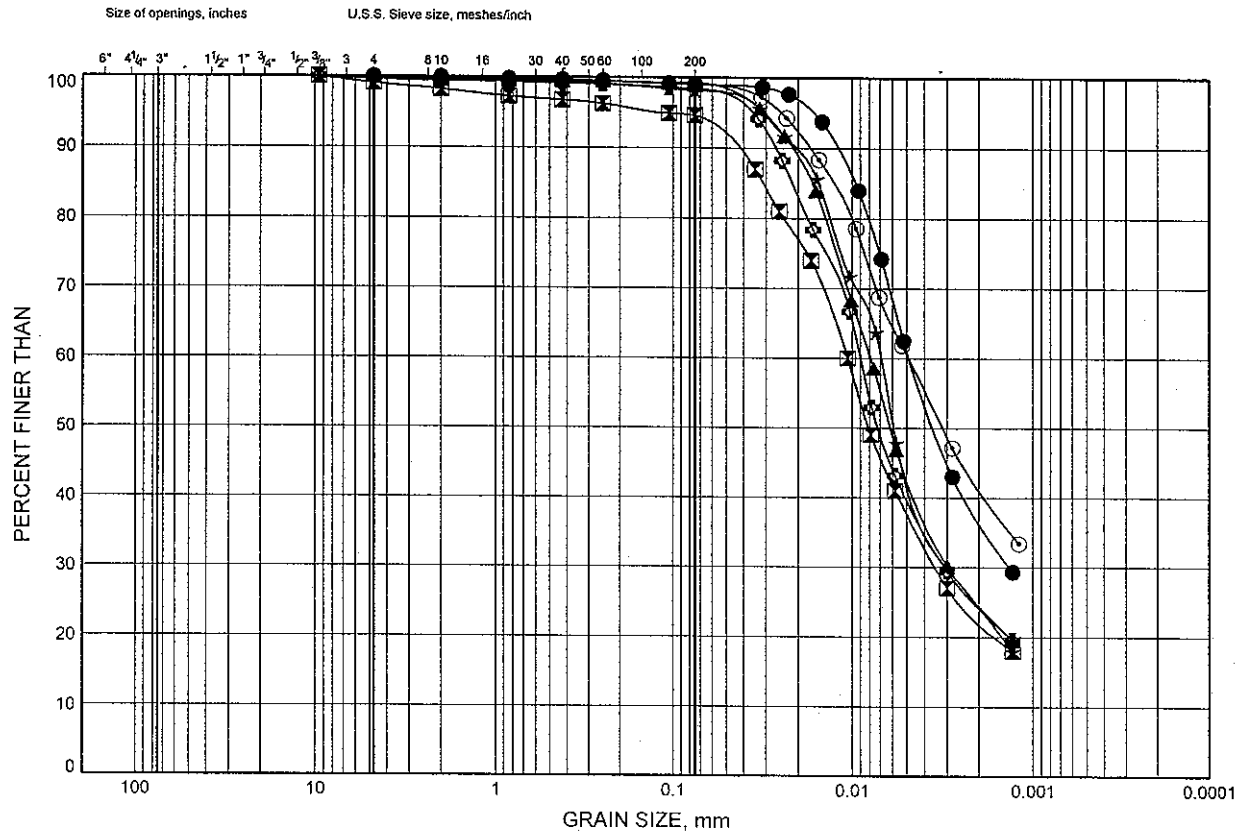
Prep'd DB

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



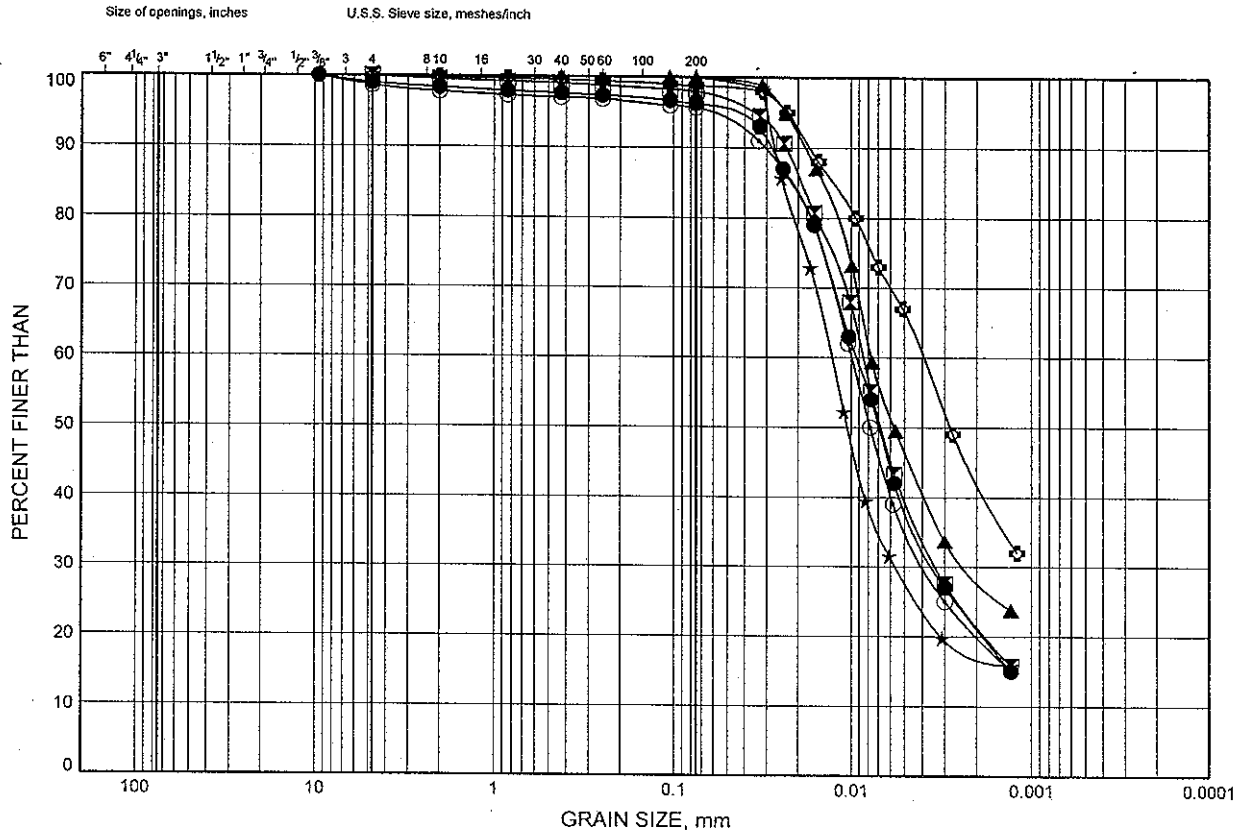
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B6

## SILTY CLAY

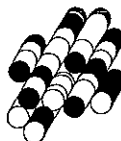


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

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



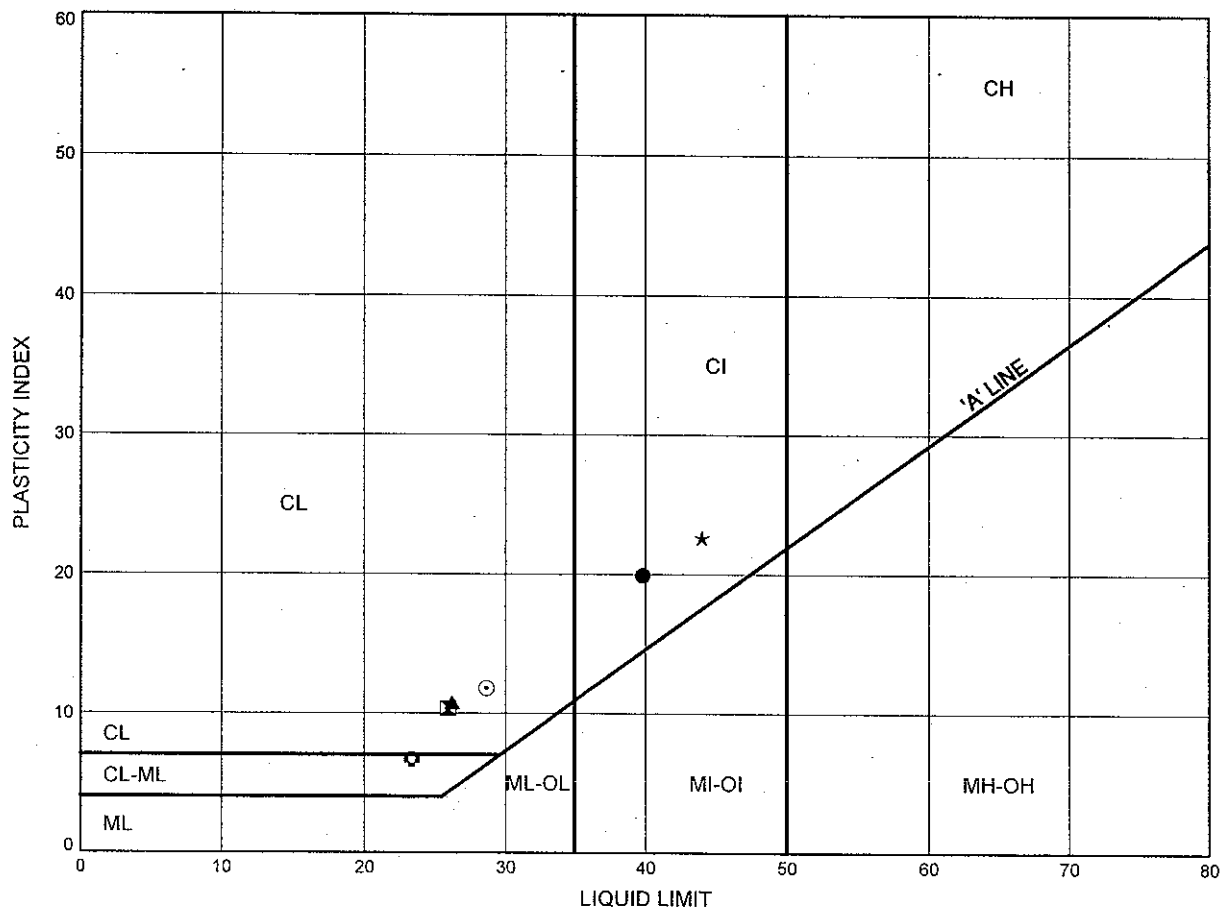
Prep'd DB

Chkd. HA

# 

FIGURE B7

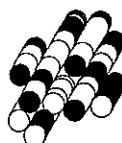
### 



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



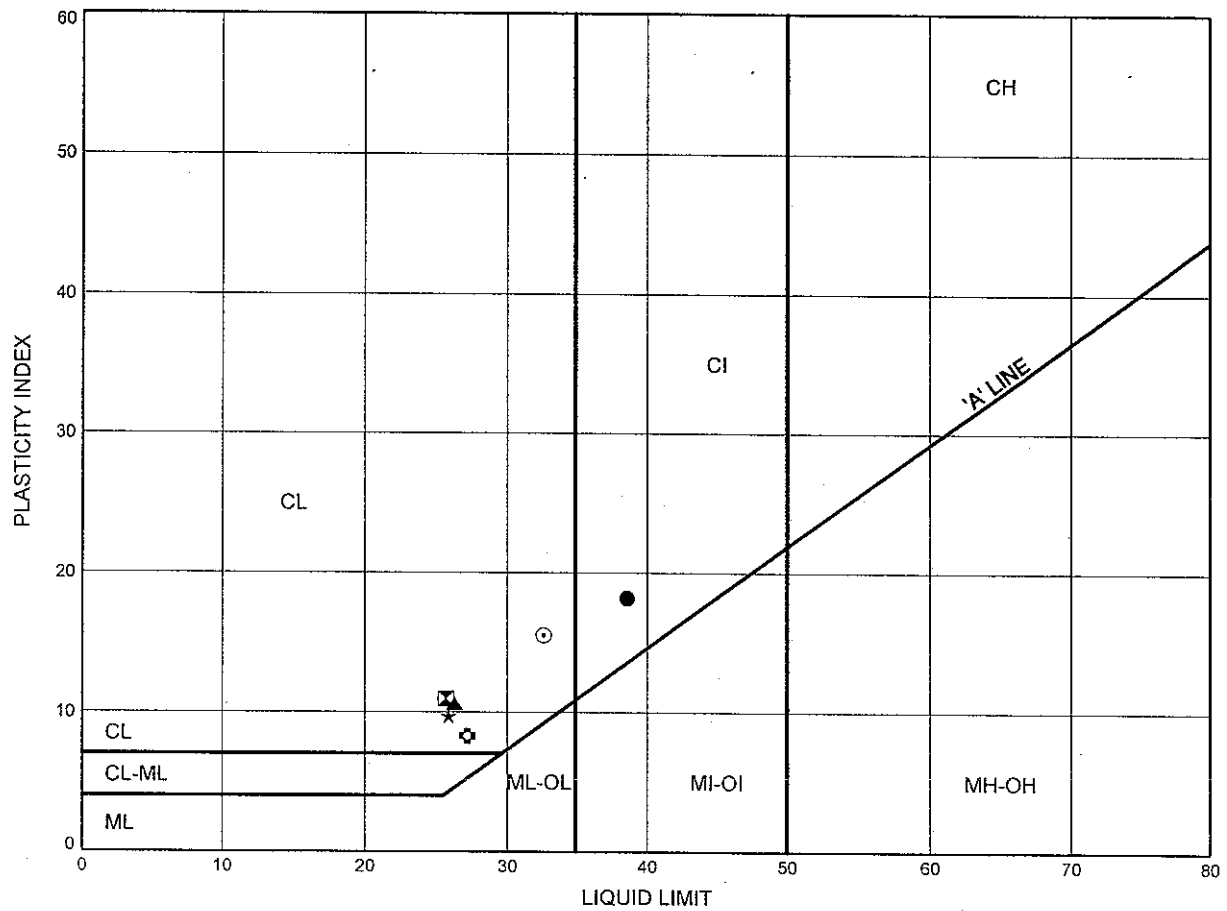
Prep'd DB

Chkd. RA

# 

FIGURE B8

### SILTY CLAY

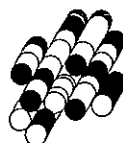


SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	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



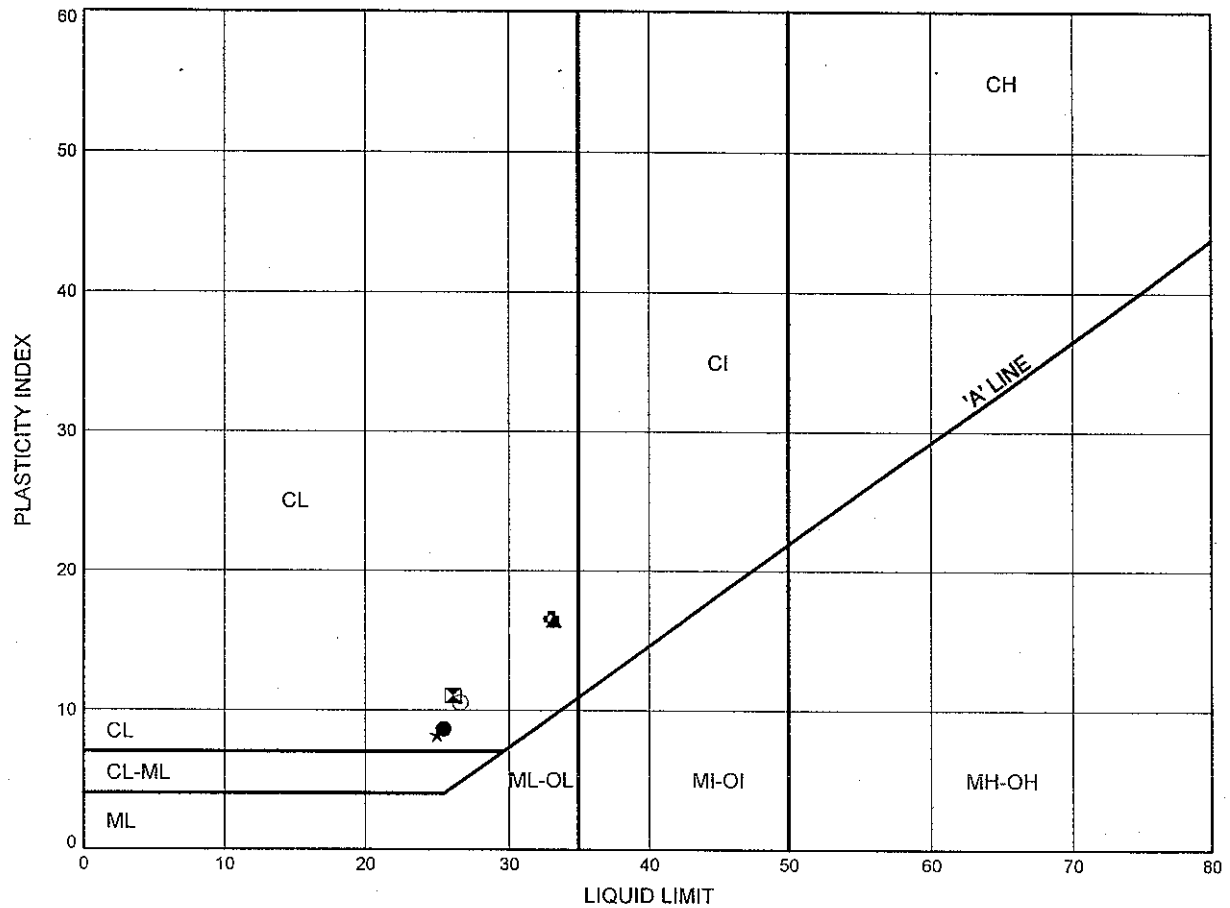
Prep'd DB

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



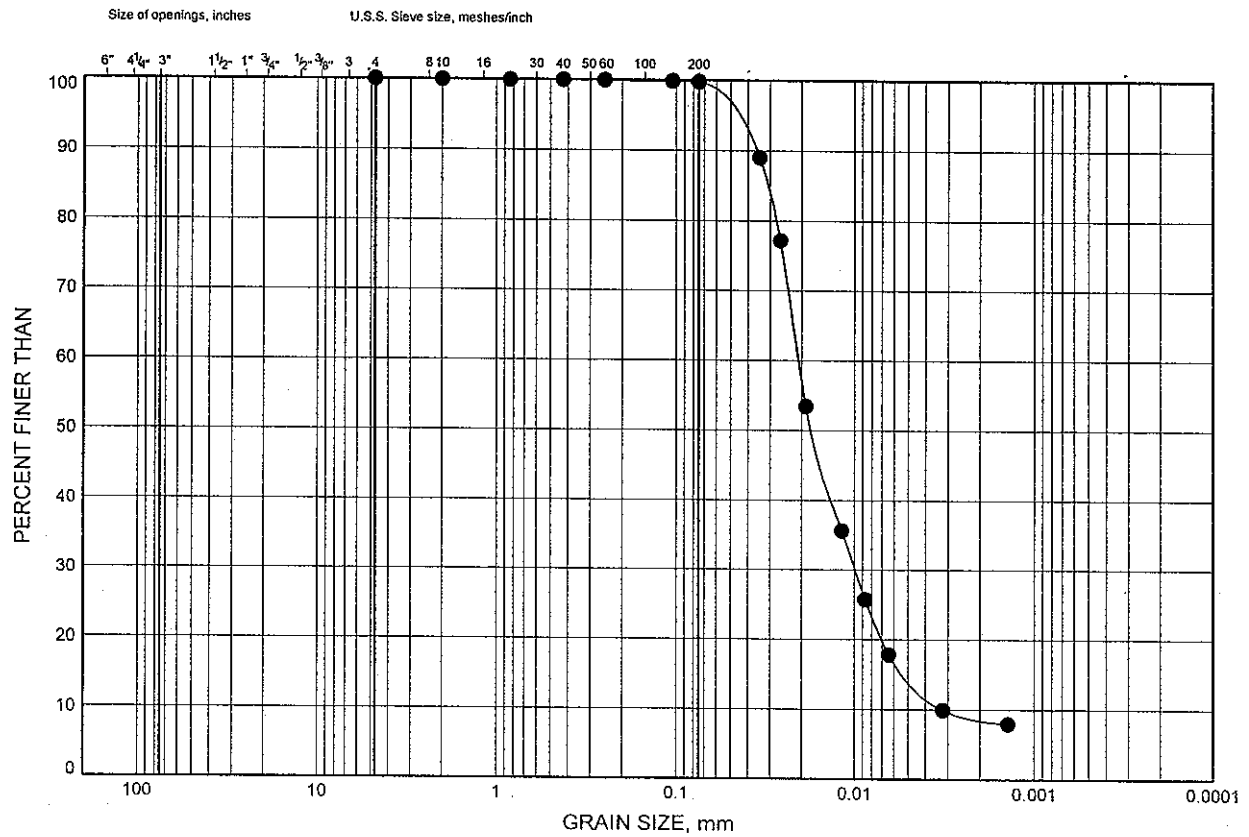
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B10

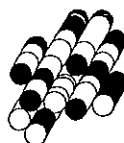
## SILT



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

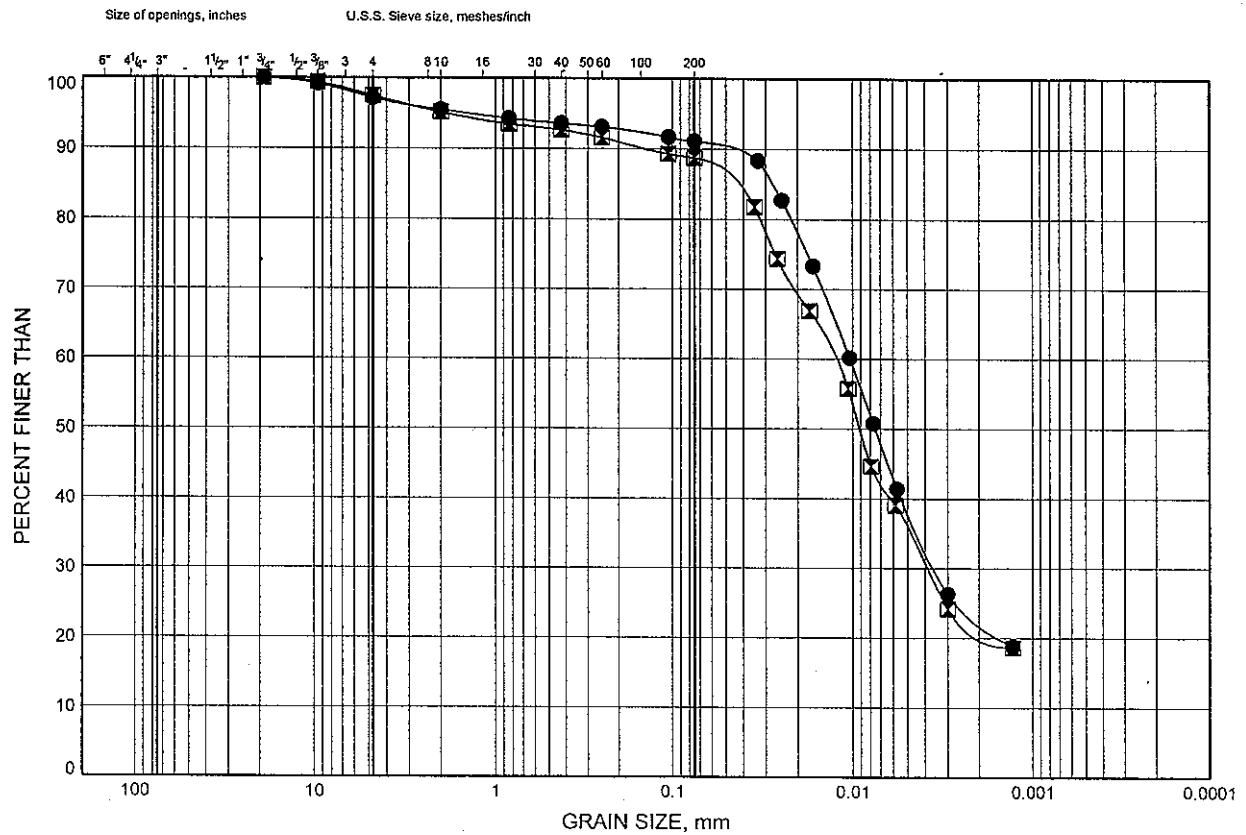


Prep'd DB  
Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B11

## SILTY CLAY TILL

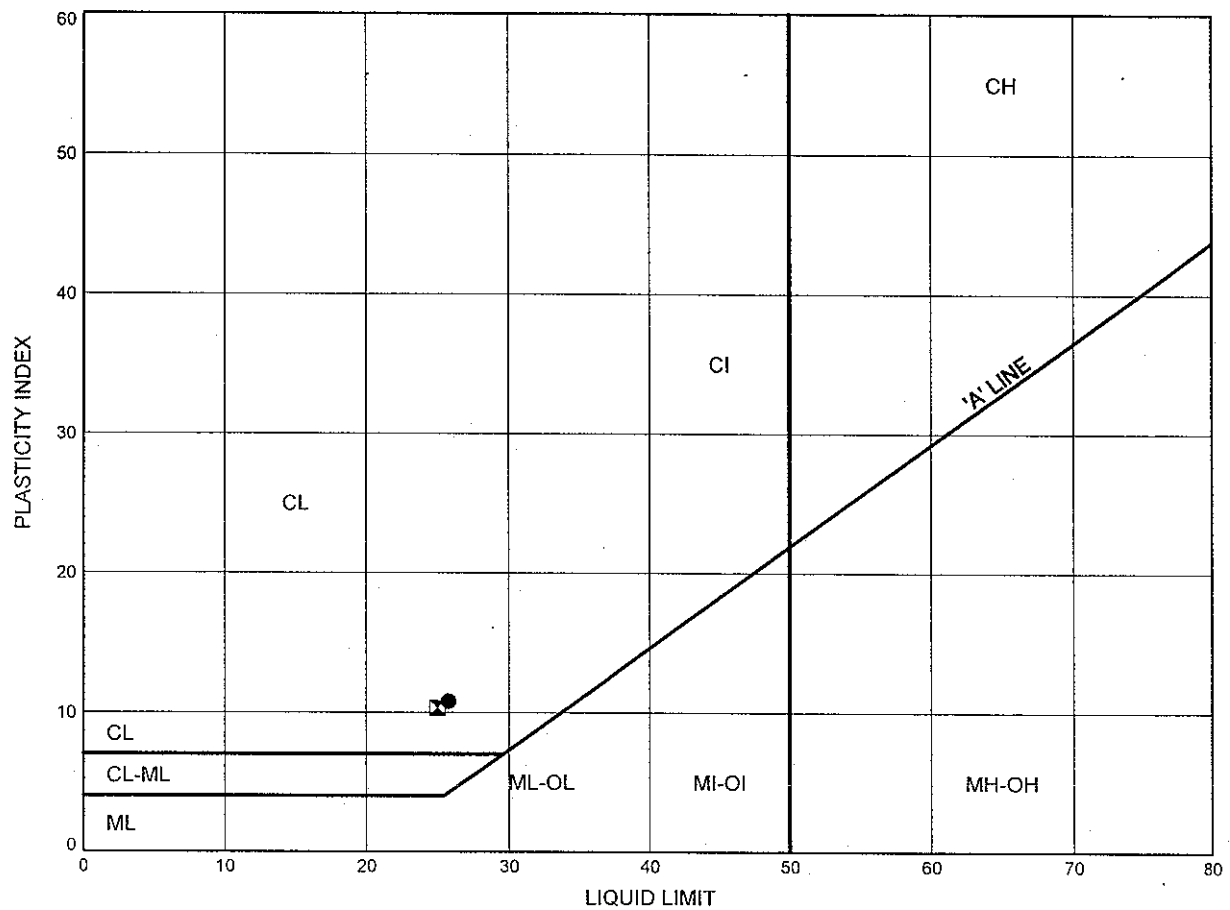




# ATTERBERG LIMITS TEST RESULTS

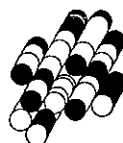
FIGURE B12

## SILTY CLAY TILL



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

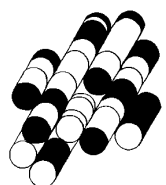
Date March 2010  
 Project 1-09-4135



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)**



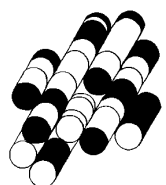


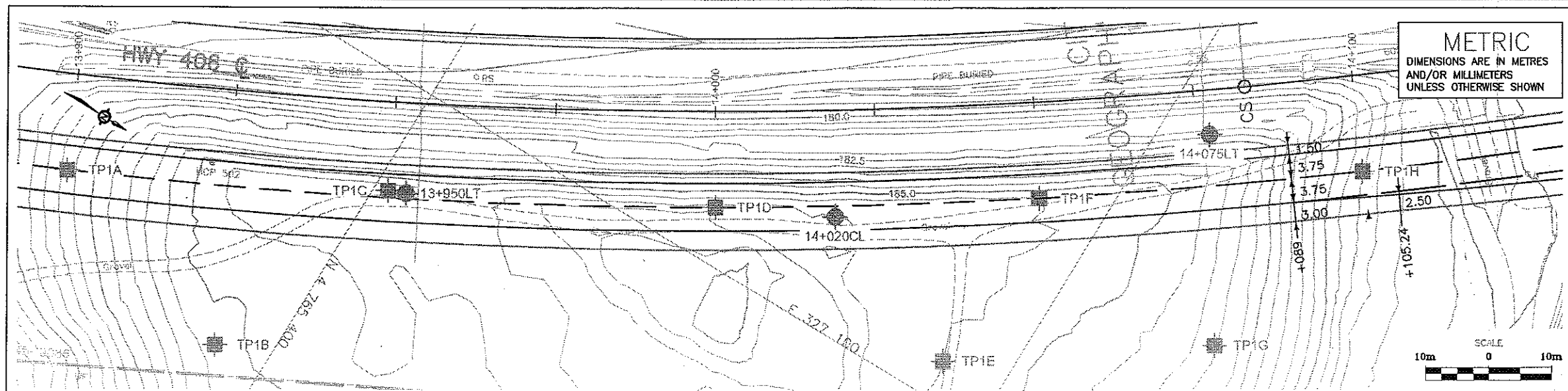
**Test Pit 1H (Sta. 14+100 NBL CL)**



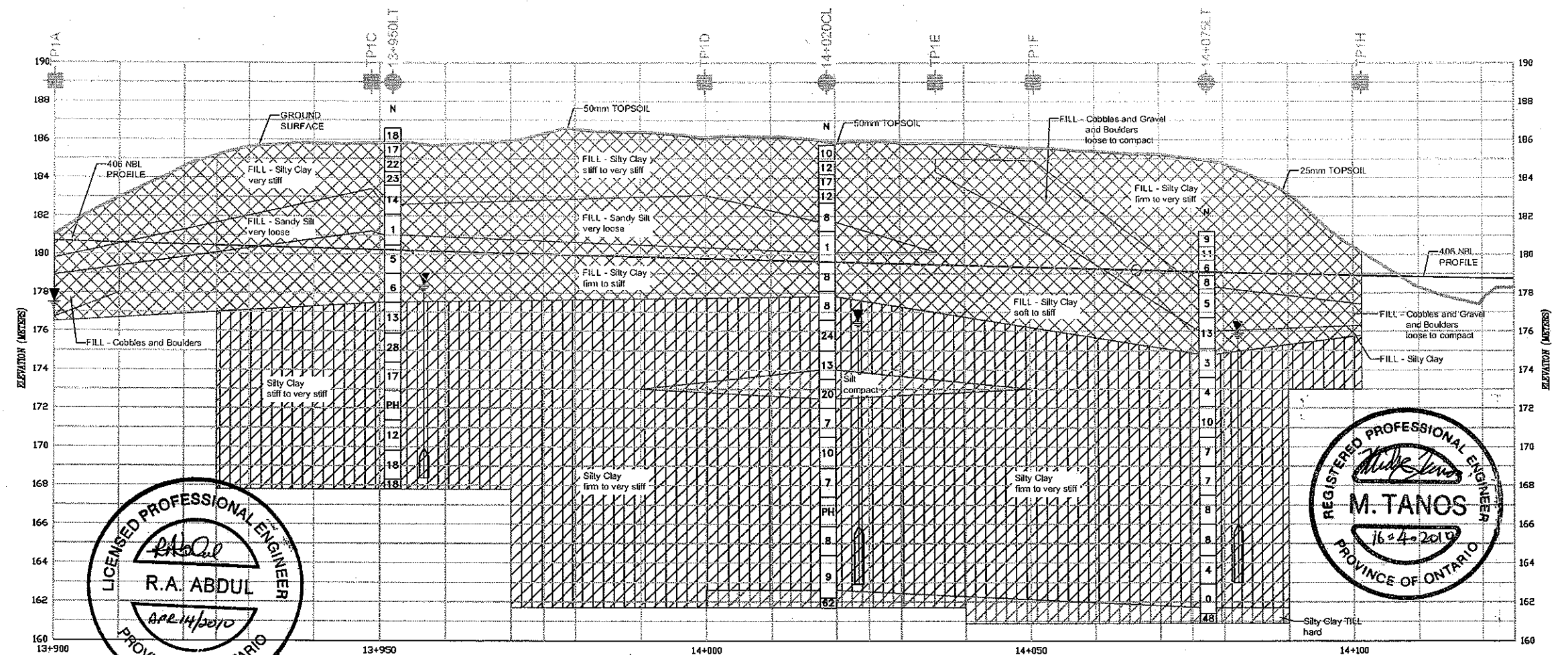
# APPENDIX D

**TERRAPROBE INC.**





406 NBL PLAN - LEFT OF CENTRE LINE



406 NBL PROFILE - LEFT OF CENTRE LINE

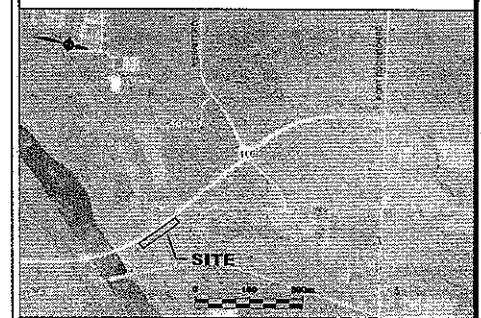
CONT No  
WP No 280-99-00



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



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

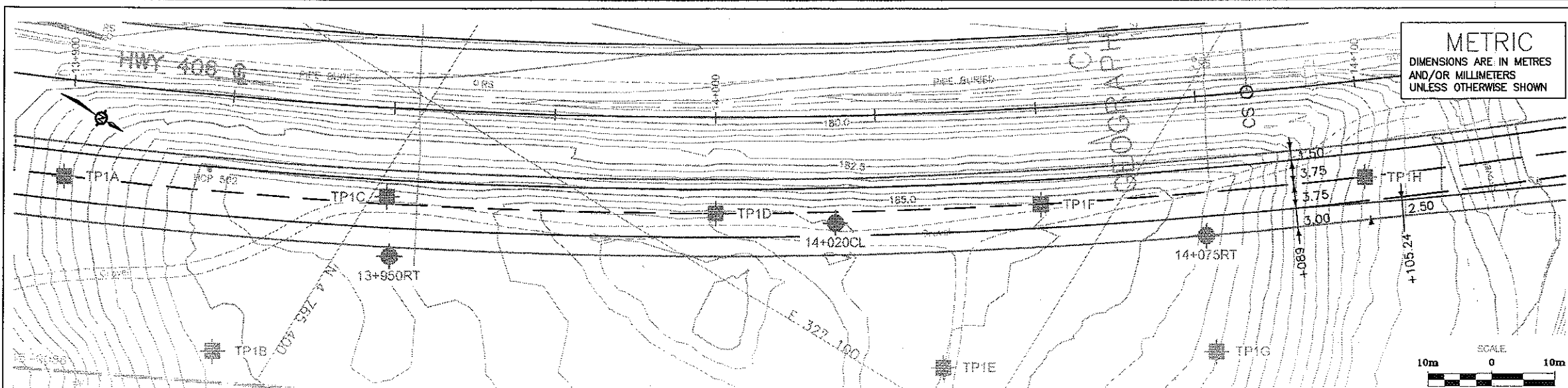
No	ELEV.	COORDINATES	
		NORTHING	EASTING
NBL 13+950LT	186.6	4765404.7	327115.2
NBL 14+020CL	185.7	4765463.9	327083.3
NBL 14+075LT	181.2	4765507.4	327041.7
TP1A	181.7	4765357.6	327139.9
TP1B	184.7	4765391.7	327151.1
TP1C	185.8	4765402.1	327116.3
TP1D	186.2	4765447.1	327091.8
TP1E	185.5	4765490.1	327093.9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

NOTE

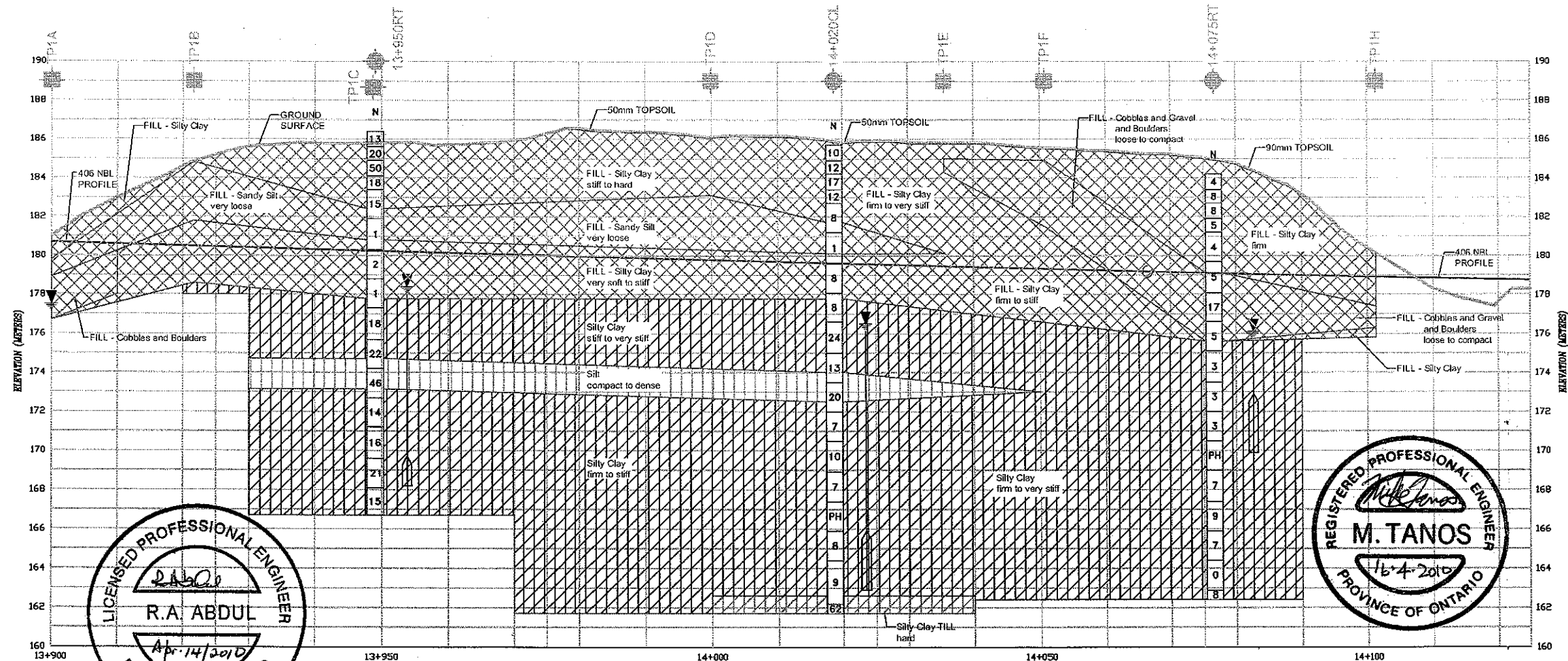
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

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





406 NBL PLAN - RIGHT OF CENTRE LINE



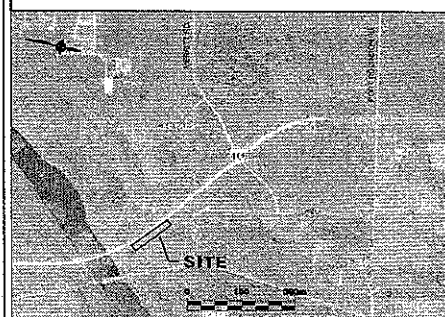
406 NBL PROFILE - RIGHT OF CENTRE LINE

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

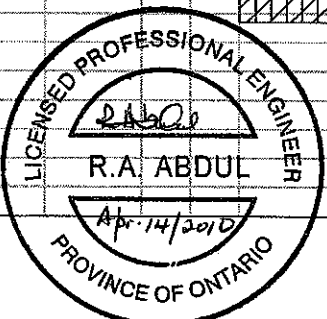
- Bore Hole
- ⊕ Dynamic Cone Penetration Test
- ⊙ Bore Hole And Cone
- ⊠ Test PR
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- ⬇ WL at Time of Investigation
- ⬇ WL in Piezometer
- ⬇ Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

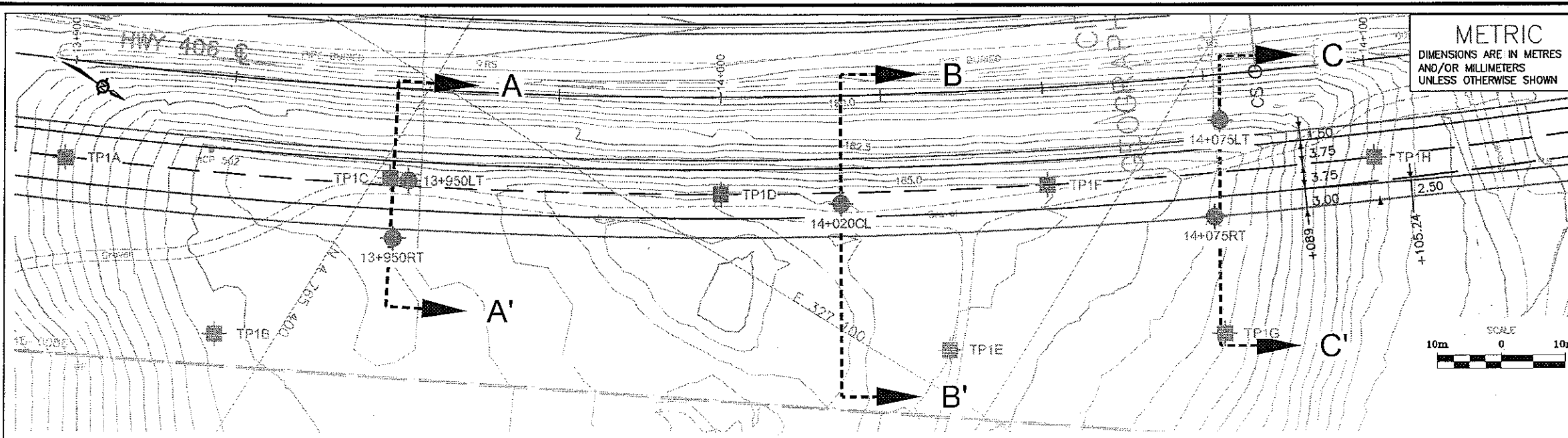
No	ELEV.	COORDINATES	
		NORTHING	EASTING
NBL 13+950RT	186.4	4765407.3	327124.1
NBL 14+020CL	185.7	4765463.9	327083.3
NBL 14+075RT	184.2	4765514.4	327054.9
TP1A	181.7	4765357.6	327139.9
TP1B	184.7	4765391.7	327151.1
TP1C	185.8	4765402.1	327116.3
TP1D	186.2	4765447.1	327091.8
TP1E	185.5	4765490.1	327093.9
TP1F	185.4	4765489.7	327084.1
TP1G	183.5	4765525.2	327069.6
TP1H	179.1	4765530.7	327034.1

NOTE

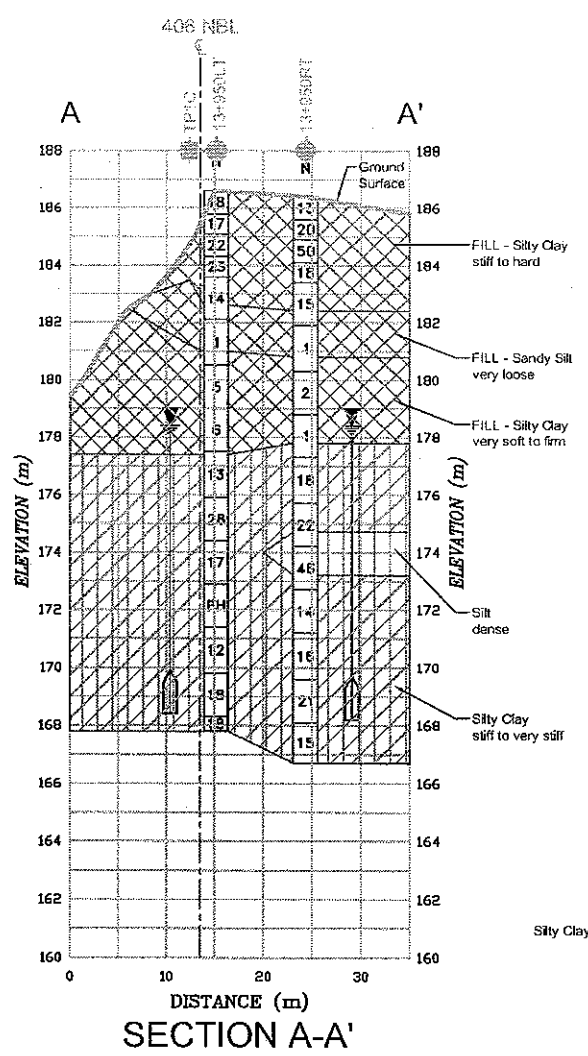
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

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

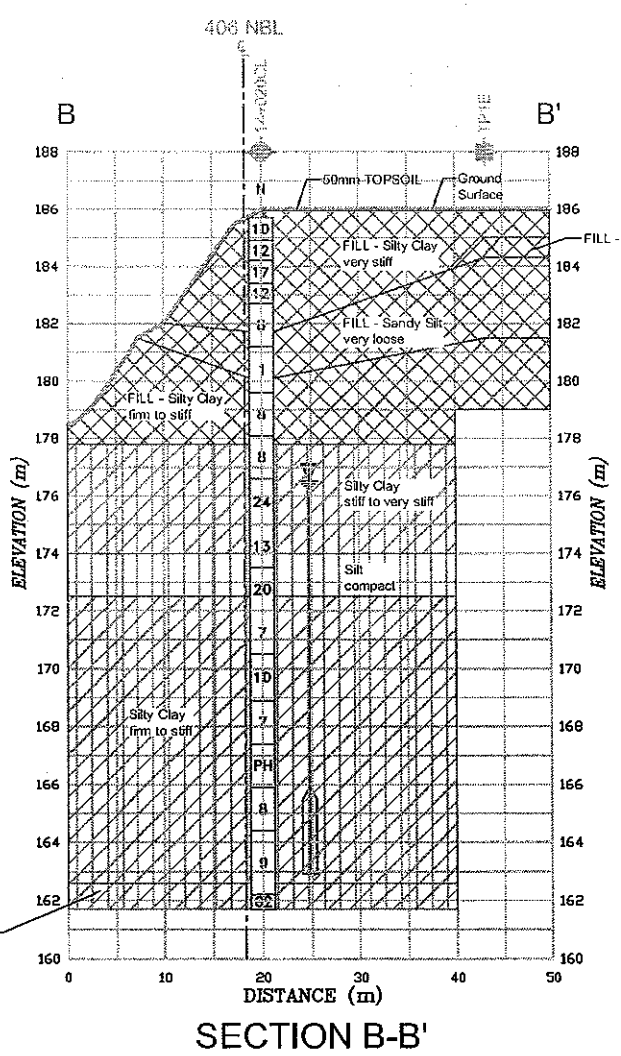




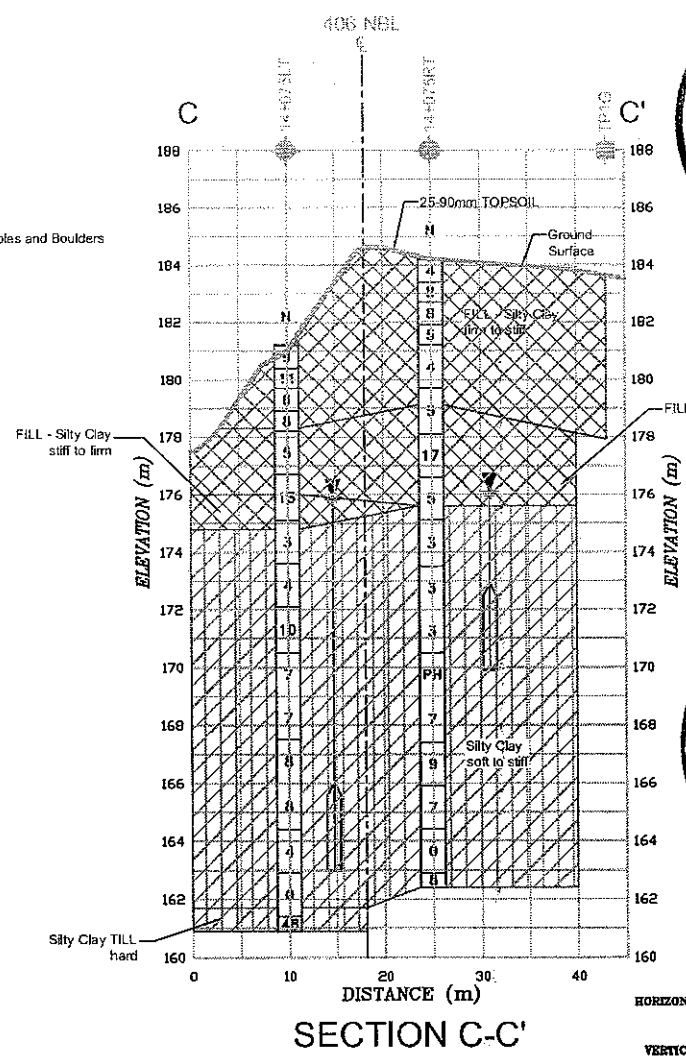
406 NBL PLAN



SECTION A-A'

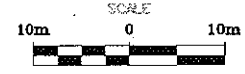


SECTION B-B'



SECTION C-C'

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



CONT No  
WP No 280-99-00

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

Giffels Associates Limited  
Consulting Engineers and Architects  
An IBI Group Company

SHEET  
1 OF

**Terraprobe**  
Consulting Geotechnical & Environmental Engineering  
Construction Science 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 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	4765357.6	327139.9
TP1B	184.7	4765391.7	327161.1
TP1C	185.8	4765402.1	327116.3
TP1D	186.2	4765447.1	327091.8
TP1E	185.5	4765490.1	327083.9
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
DRAWN B.S.			LOAD DATE MAR, 2010
			STRUCT

# APPENDIX E

**TERRAPROBE INC.**

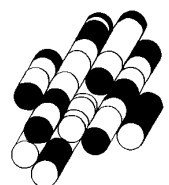


FIGURE 1A - BH 13+950 Lt

**Terraprobe**

Job No.: 1-09-4135  
Section: NBL 13+950  
Method: Bishop simplified  
Slope: 3H:1V  
Condition: Undrained

**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 28 deg
- 2 Material: Sandy Silt Fill  
Unit Weight: 18 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 25 deg
- 3 Material: Silty Clay  
Unit Weight: 20.5 kN/m<sup>3</sup>  
Cohesion: 100 kPa  
Friction Angle: 0 deg

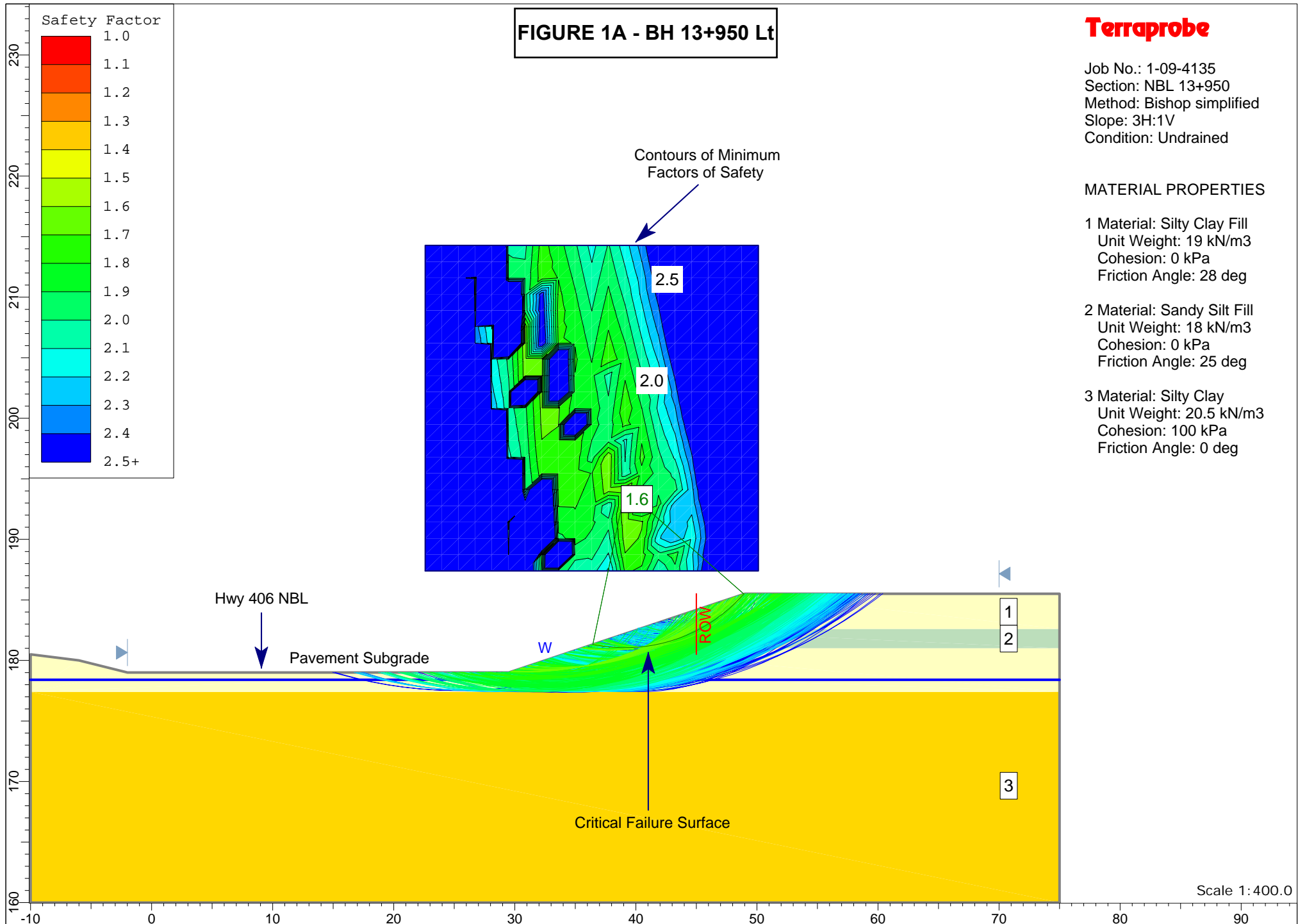




FIGURE 1B - BH 13+950 Lt

**Terraprobe**

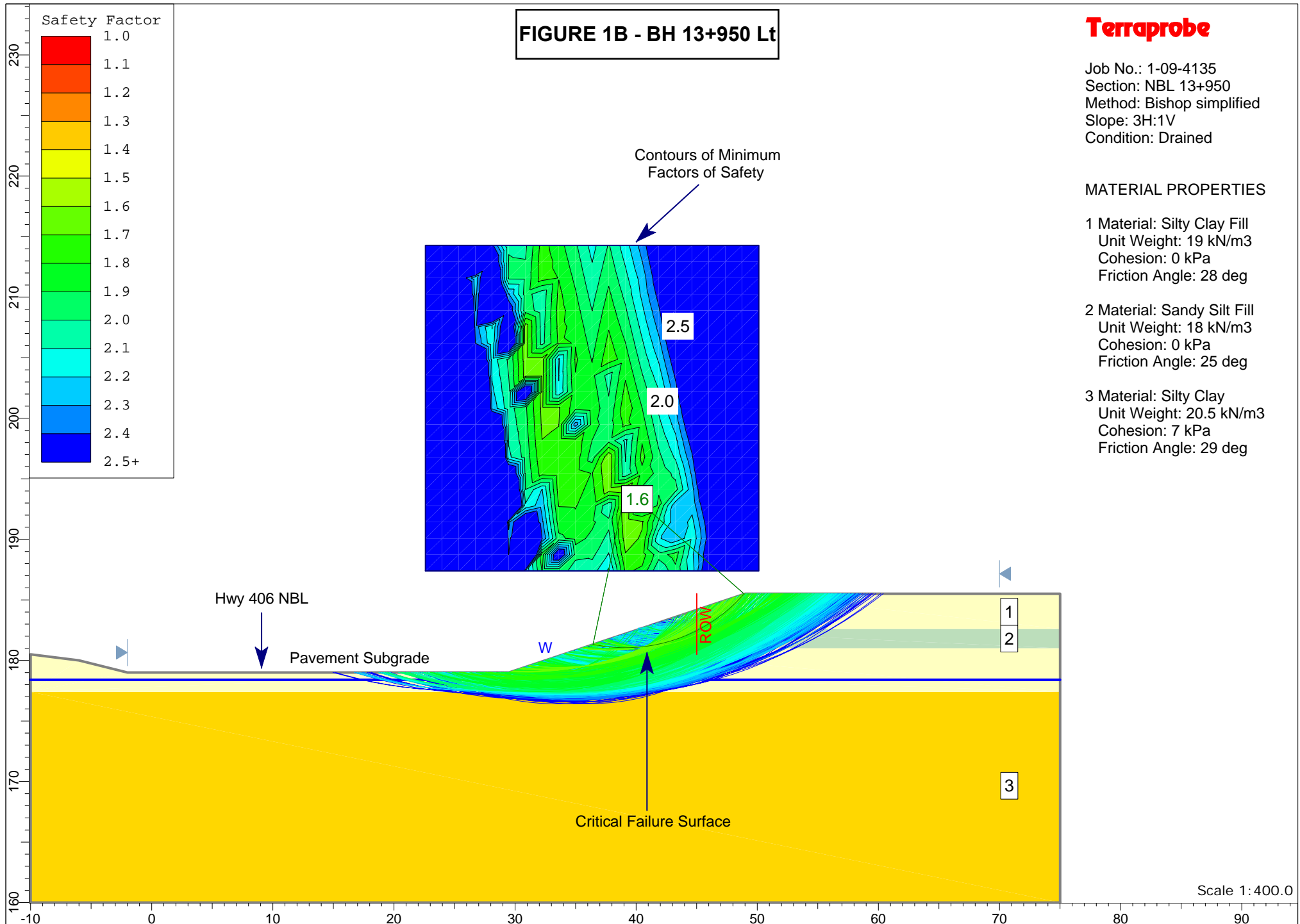
Job No.: 1-09-4135  
Section: NBL 13+950  
Method: Bishop simplified  
Slope: 3H:1V  
Condition: Drained

**MATERIAL PROPERTIES**

1 Material: Silty Clay Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 28 deg

2 Material: Sandy Silt Fill  
Unit Weight: 18 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 25 deg

3 Material: Silty Clay  
Unit Weight: 20.5 kN/m<sup>3</sup>  
Cohesion: 7 kPa  
Friction Angle: 29 deg



**FIGURE 2A - BH 13+950 Rt**

**Terraprobe**

Job No.: 1-09-4135  
 Section: NBL 13+950  
 Method: Bishop simplified  
 Slope: 3H:1V  
 Condition: Undrained

**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 28 deg
- 2 Material: Sandy Silt Fill  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 25 deg
- 3 Material: Silty Clay  
 Unit Weight: 20.5 kN/m<sup>3</sup>  
 Cohesion: 100 kPa  
 Friction Angle: 0 deg
- 4 Material: Silt  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 33 deg
- 5 Material: Silty Clay  
 Unit Weight: 20.5 kN/m<sup>3</sup>  
 Cohesion: 75 kPa  
 Friction Angle: 0 deg

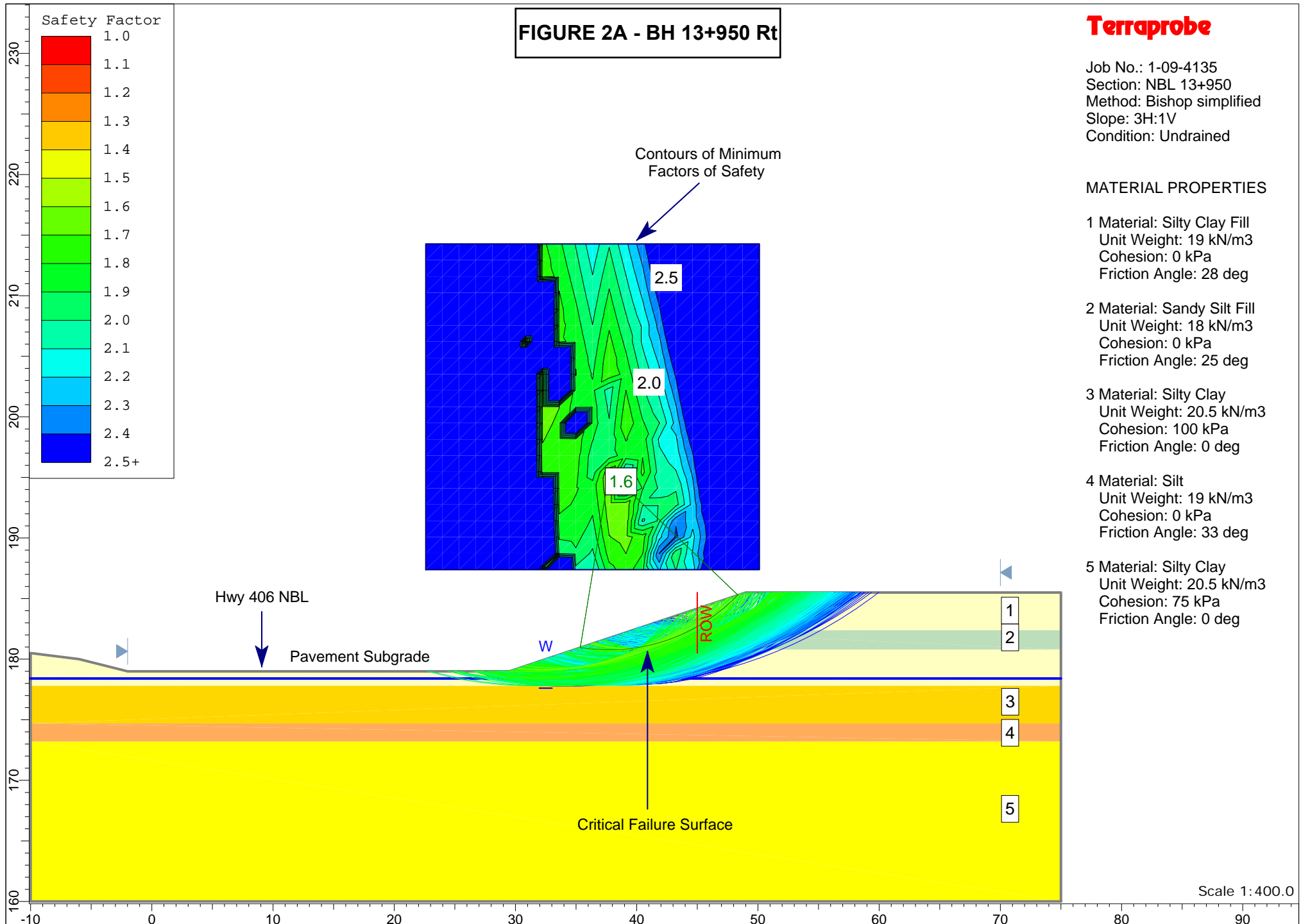


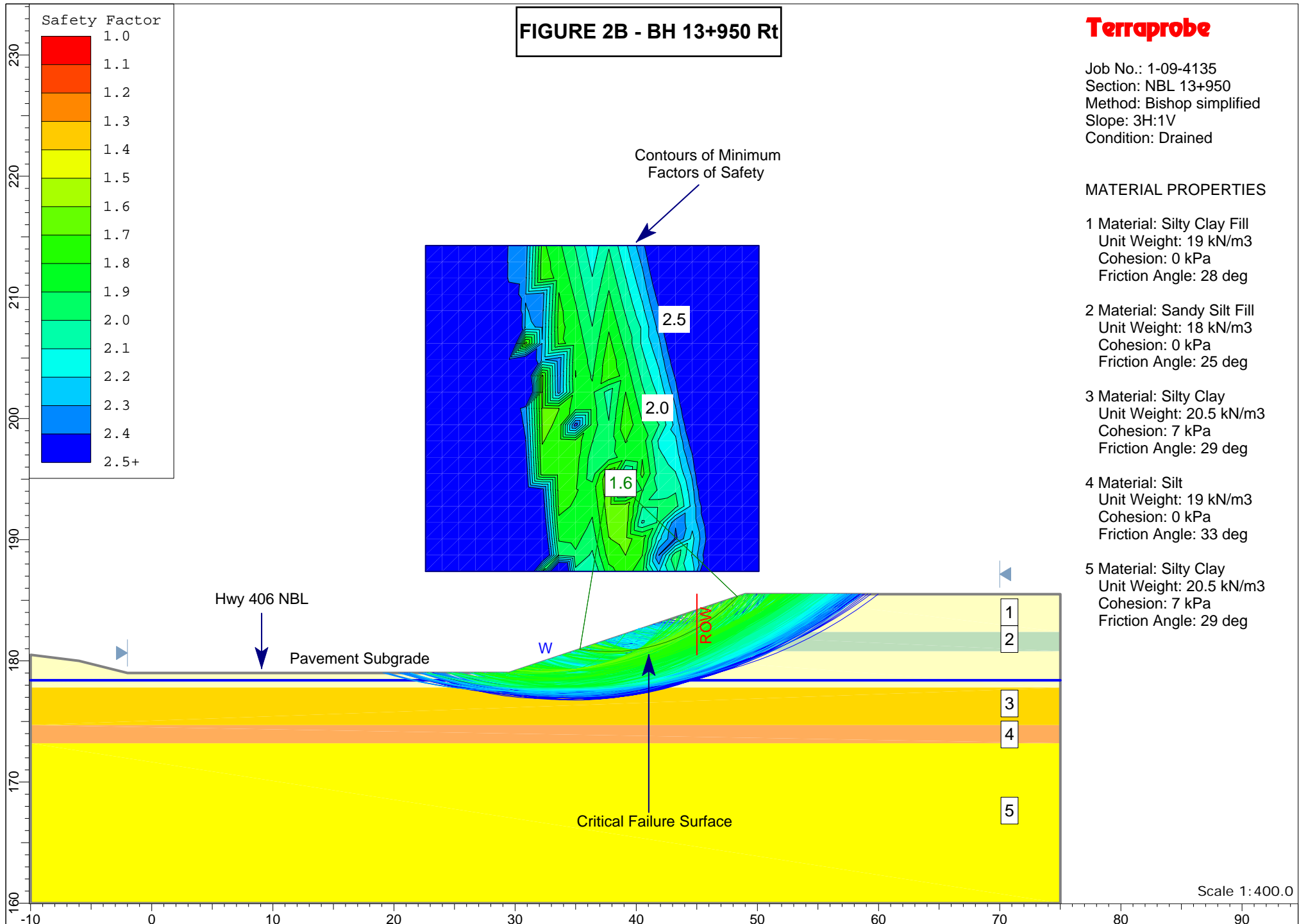
FIGURE 2B - BH 13+950 Rt

**Terraprobe**

Job No.: 1-09-4135  
Section: NBL 13+950  
Method: Bishop simplified  
Slope: 3H:1V  
Condition: Drained

**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 28 deg
- 2 Material: Sandy Silt Fill  
Unit Weight: 18 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 25 deg
- 3 Material: Silty Clay  
Unit Weight: 20.5 kN/m<sup>3</sup>  
Cohesion: 7 kPa  
Friction Angle: 29 deg
- 4 Material: Silt  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 33 deg
- 5 Material: Silty Clay  
Unit Weight: 20.5 kN/m<sup>3</sup>  
Cohesion: 7 kPa  
Friction Angle: 29 deg



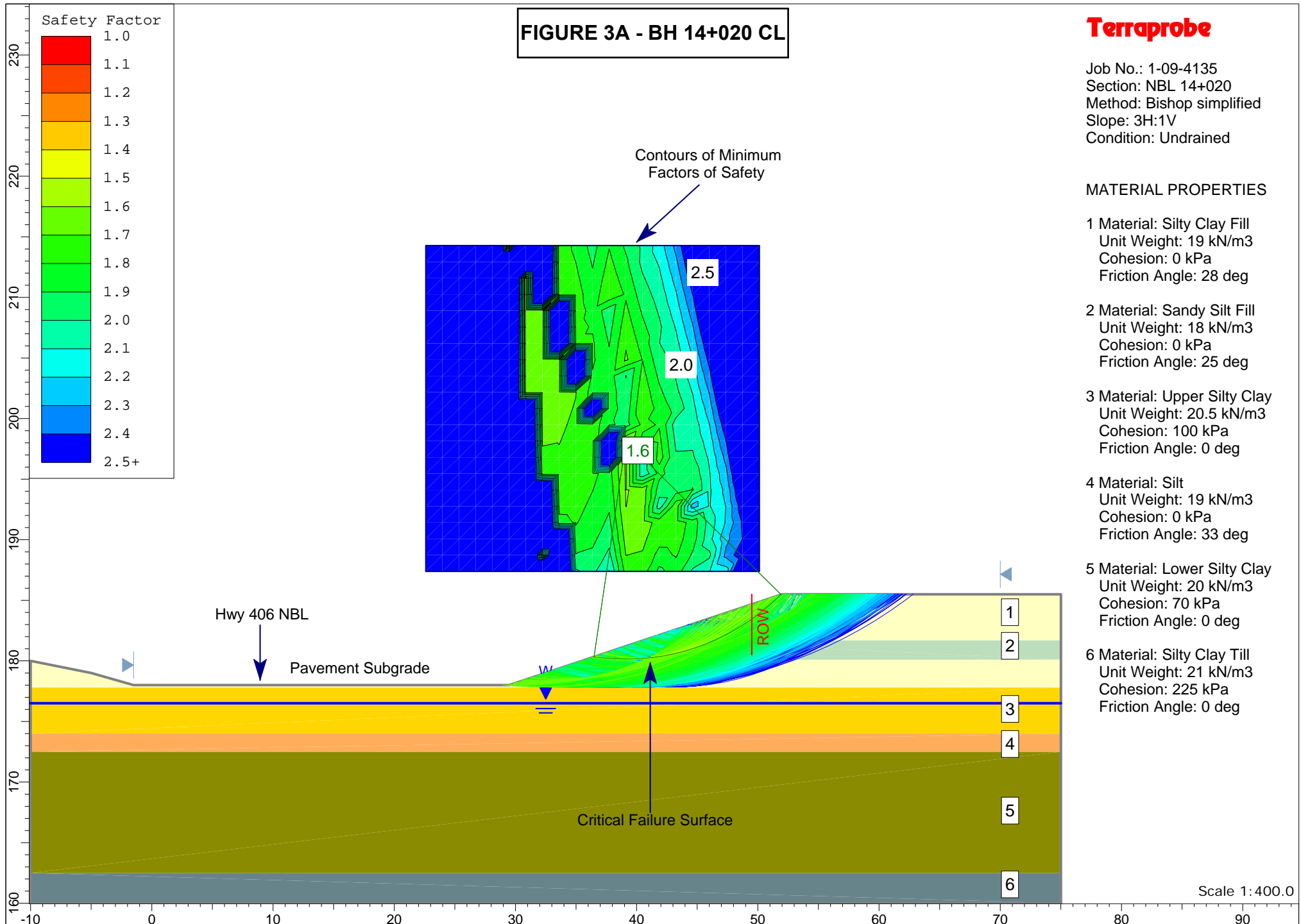
**FIGURE 3A - BH 14+020 CL**

**Terraprobe**

Job No.: 1-09-4135  
 Section: NBL 14+020  
 Method: Bishop simplified  
 Slope: 3H:1V  
 Condition: Undrained

**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 28 deg
- 2 Material: Sandy Silt Fill  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 25 deg
- 3 Material: Upper Silty Clay  
 Unit Weight: 20.5 kN/m<sup>3</sup>  
 Cohesion: 100 kPa  
 Friction Angle: 0 deg
- 4 Material: Silt  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 33 deg
- 5 Material: Lower Silty Clay  
 Unit Weight: 20 kN/m<sup>3</sup>  
 Cohesion: 70 kPa  
 Friction Angle: 0 deg
- 6 Material: Silty Clay Till  
 Unit Weight: 21 kN/m<sup>3</sup>  
 Cohesion: 225 kPa  
 Friction Angle: 0 deg



**FIGURE 3B - BH 14+020 CL**

**Terraprobe**

Job No.: 1-09-4135  
 Section: NBL 14+020  
 Method: Bishop simplified  
 Slope: 3H:1V  
 Condition: Drained

**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 28 deg
- 2 Material: Sandy Silt Fill  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 25 deg
- 3 Material: Upper Silty Clay  
 Unit Weight: 20.5 kN/m<sup>3</sup>  
 Cohesion: 7 kPa  
 Friction Angle: 29 deg
- 4 Material: Silt  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Friction Angle: 33 deg
- 5 Material: Lower Silty Clay  
 Unit Weight: 20 kN/m<sup>3</sup>  
 Cohesion: 5 kPa  
 Friction Angle: 27 deg
- 6 Material: Silty Clay Till  
 Unit Weight: 21 kN/m<sup>3</sup>  
 Cohesion: 5 kPa  
 Friction Angle: 33 deg

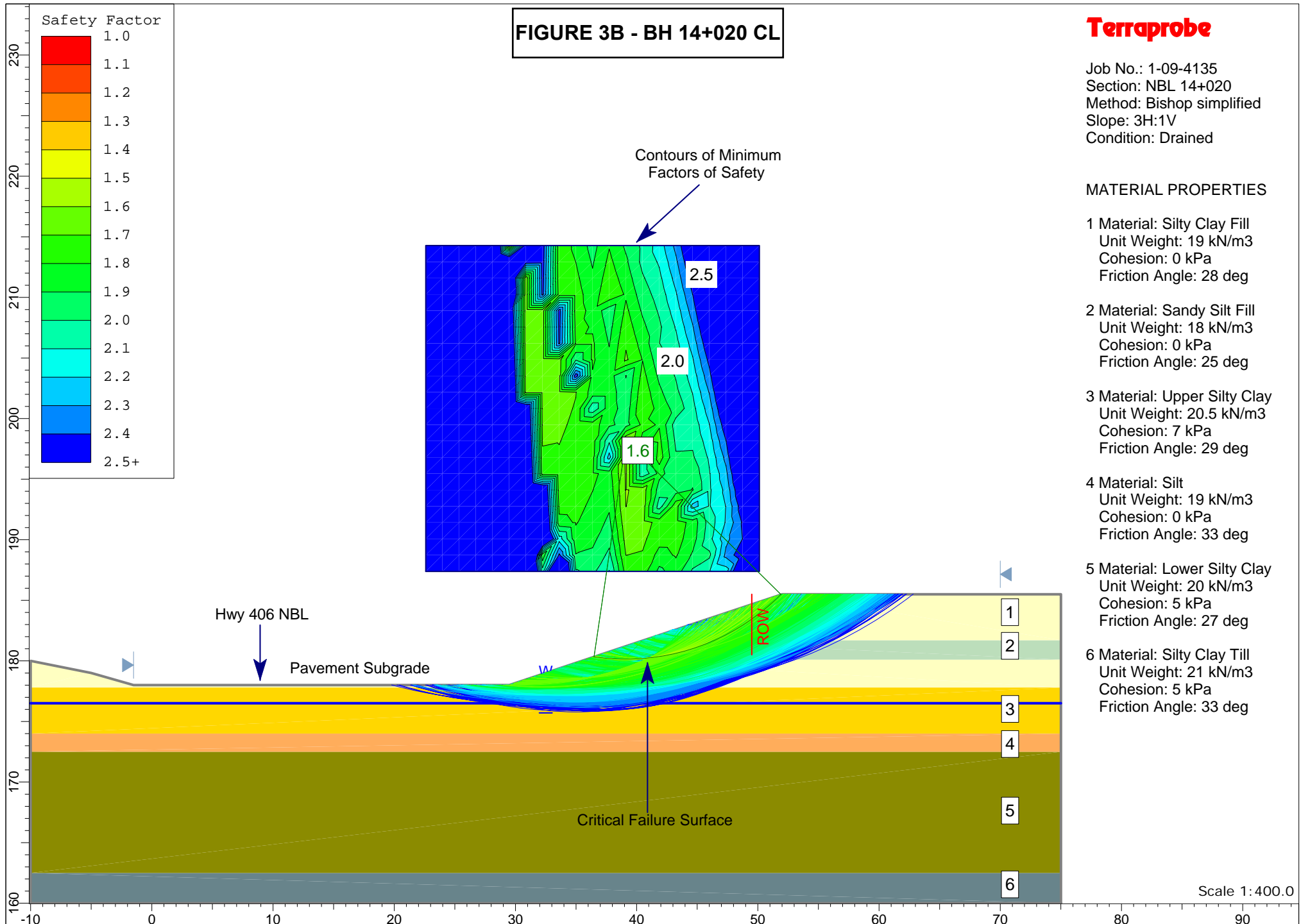


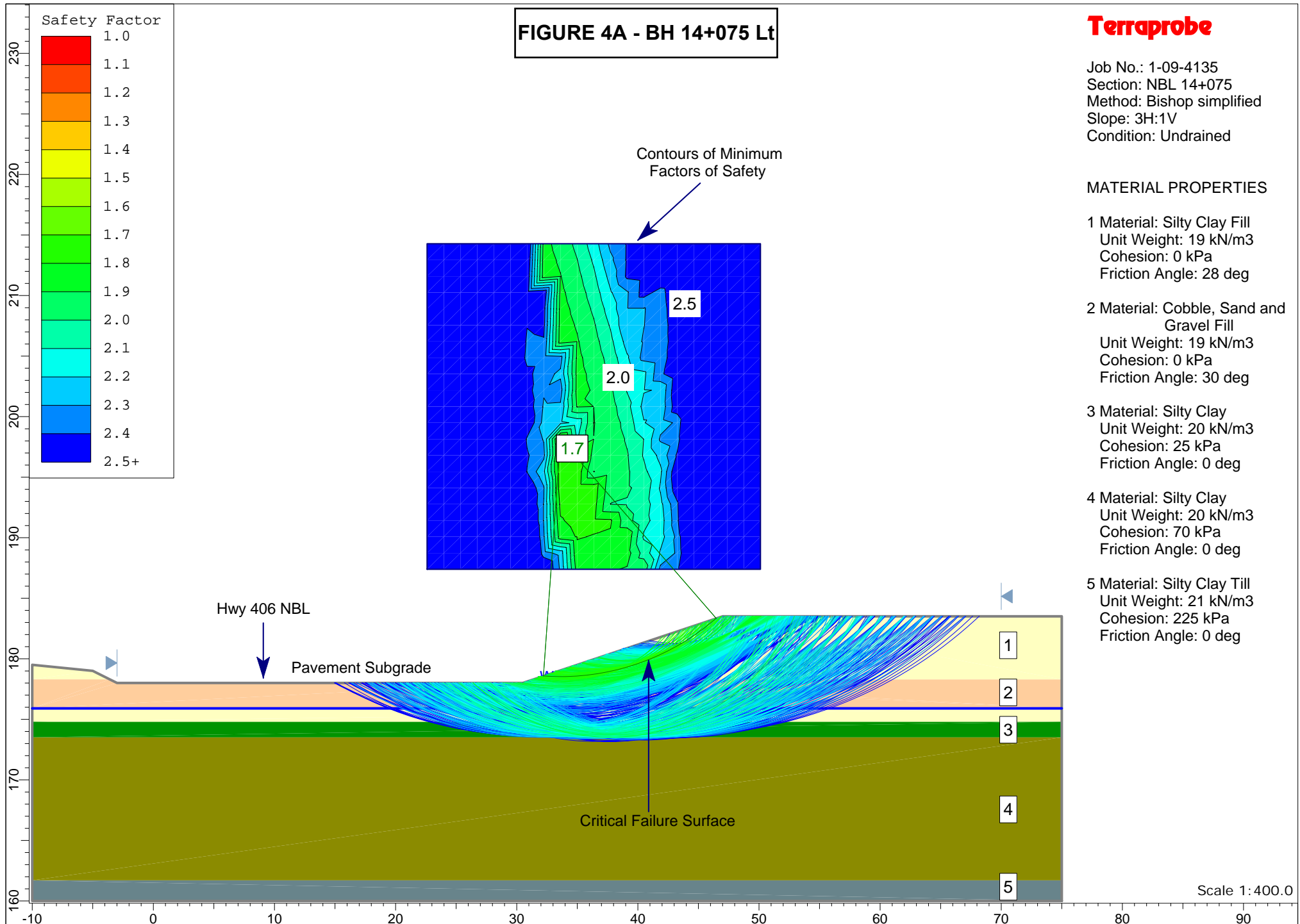
FIGURE 4A - BH 14+075 Lt

**Terraprobe**

Job No.: 1-09-4135  
Section: NBL 14+075  
Method: Bishop simplified  
Slope: 3H:1V  
Condition: Undrained

**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 28 deg
- 2 Material: Cobble, Sand and Gravel Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 30 deg
- 3 Material: Silty Clay  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 25 kPa  
Friction Angle: 0 deg
- 4 Material: Silty Clay  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 70 kPa  
Friction Angle: 0 deg
- 5 Material: Silty Clay Till  
Unit Weight: 21 kN/m<sup>3</sup>  
Cohesion: 225 kPa  
Friction Angle: 0 deg





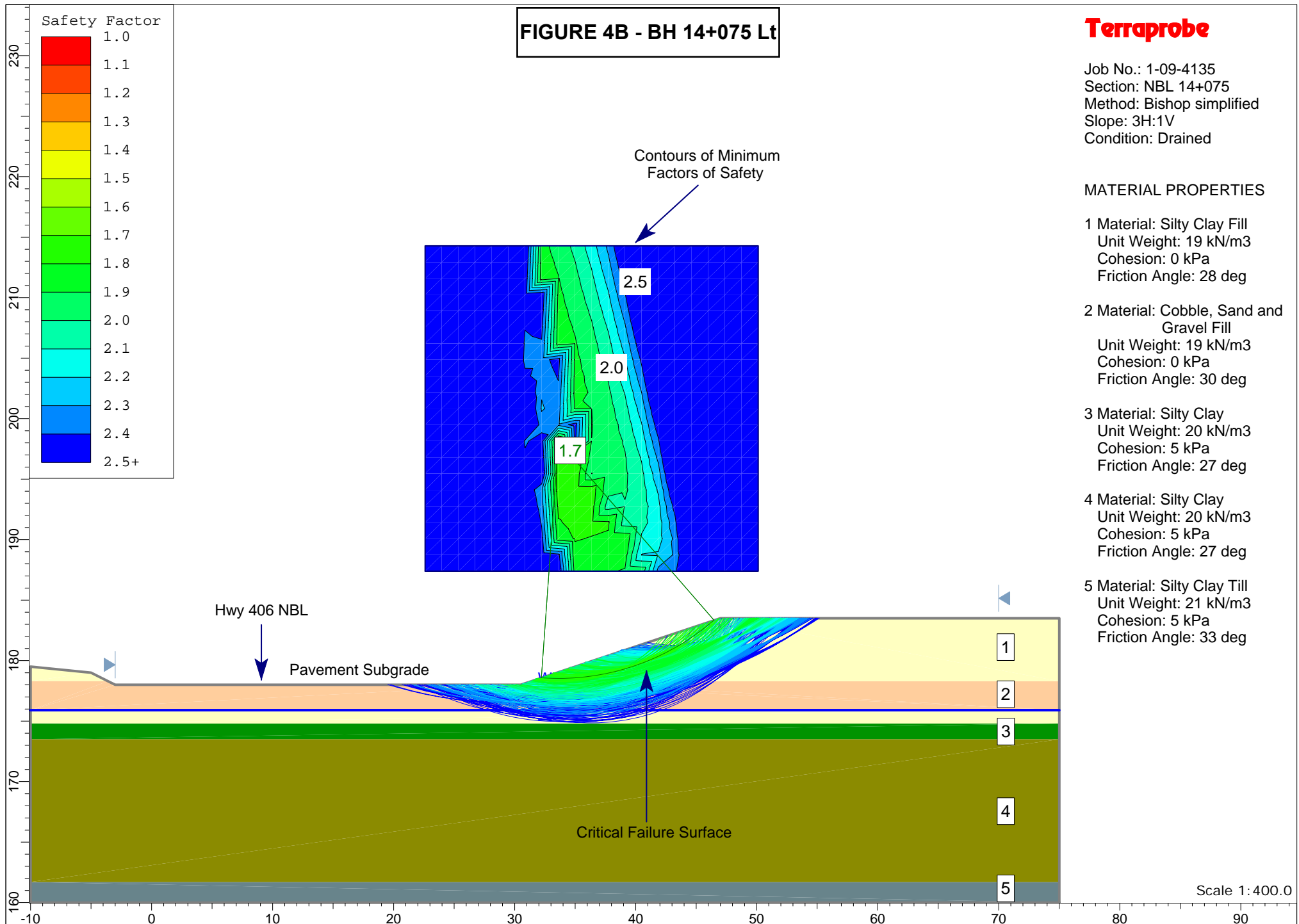


FIGURE 5A - BH 14+075 Rt

**Terraprobe**

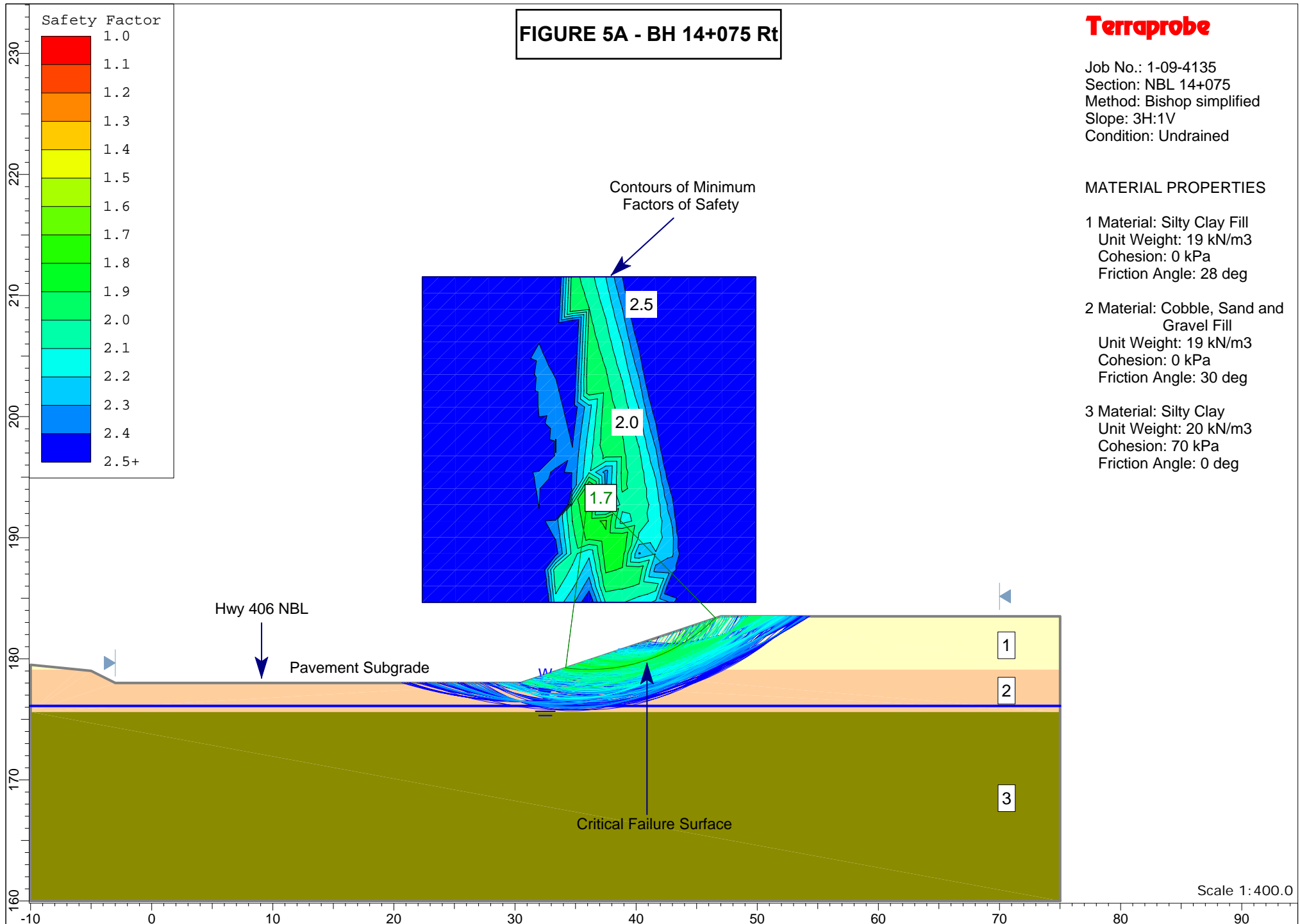
Job No.: 1-09-4135  
Section: NBL 14+075  
Method: Bishop simplified  
Slope: 3H:1V  
Condition: Undrained

**MATERIAL PROPERTIES**

1 Material: Silty Clay Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 28 deg

2 Material: Cobble, Sand and  
Gravel Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 30 deg

3 Material: Silty Clay  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 70 kPa  
Friction Angle: 0 deg



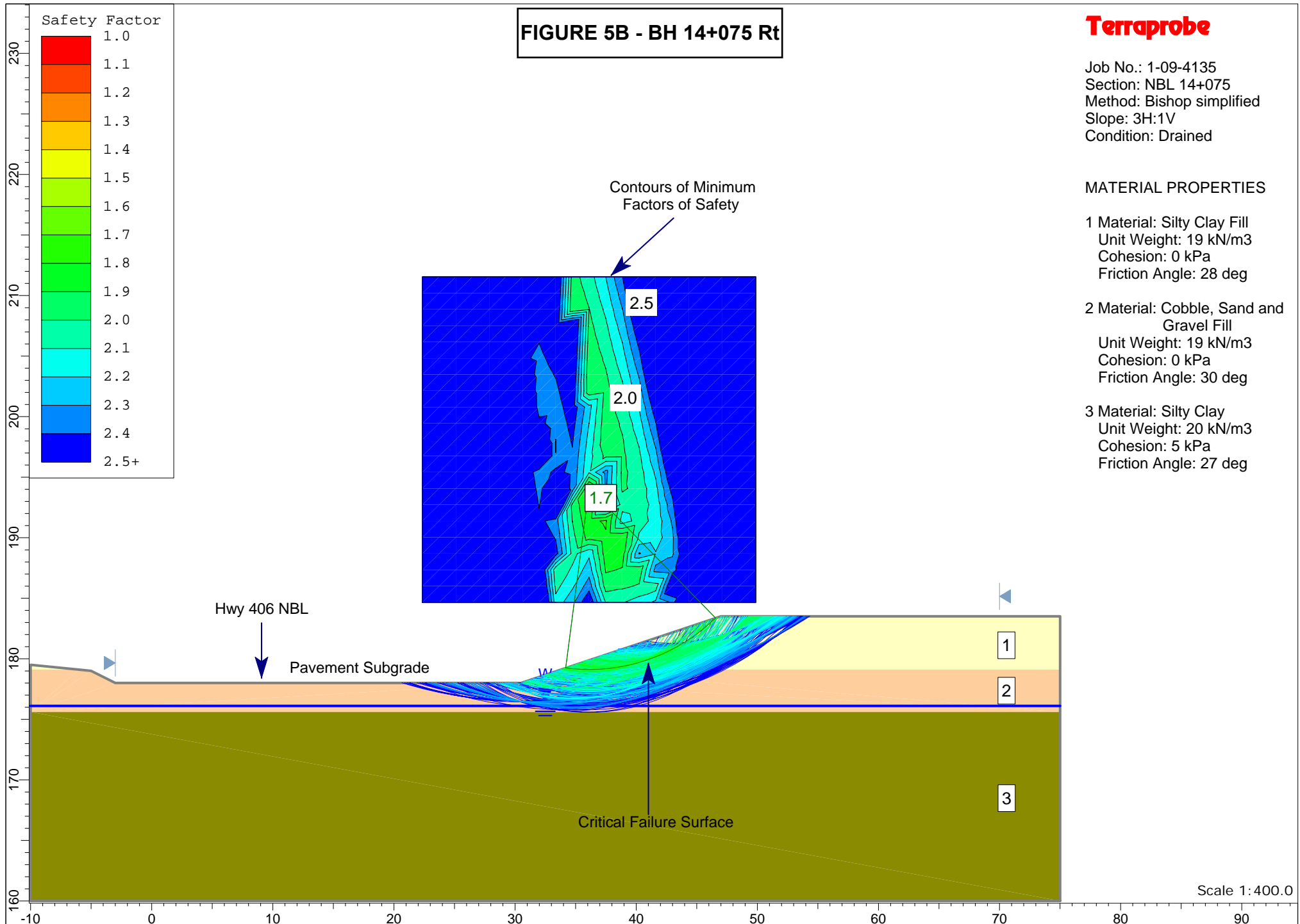
**FIGURE 5B - BH 14+075 Rt**

**Terraprobe**

Job No.: 1-09-4135  
Section: NBL 14+075  
Method: Bishop simplified  
Slope: 3H:1V  
Condition: Drained

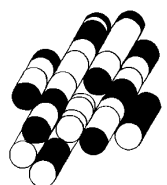
**MATERIAL PROPERTIES**

- 1 Material: Silty Clay Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 28 deg
- 2 Material: Cobble, Sand and Gravel Fill  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Friction Angle: 30 deg
- 3 Material: Silty Clay  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 5 kPa  
Friction Angle: 27 deg

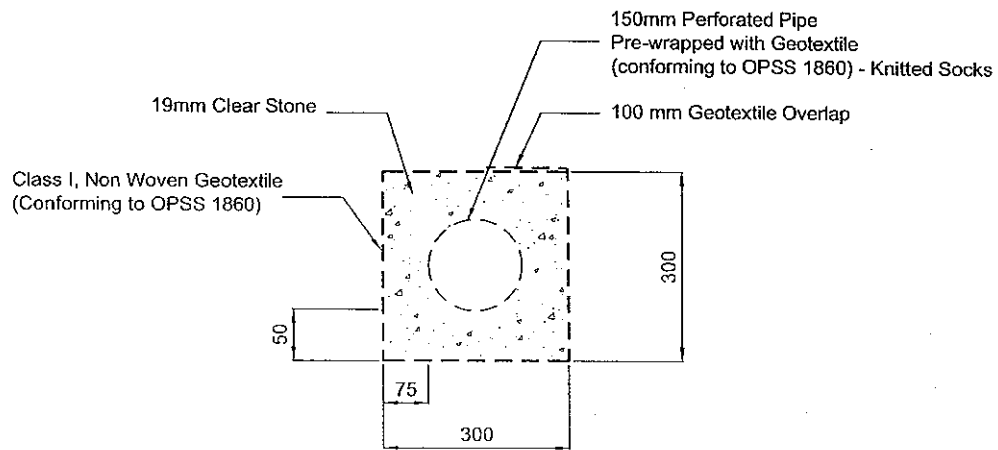


# APPENDIX F

**TERRAPROBE INC.**

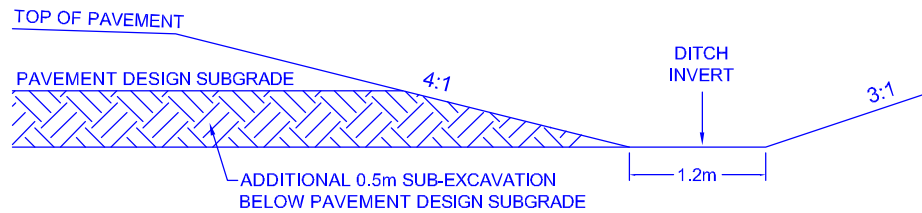
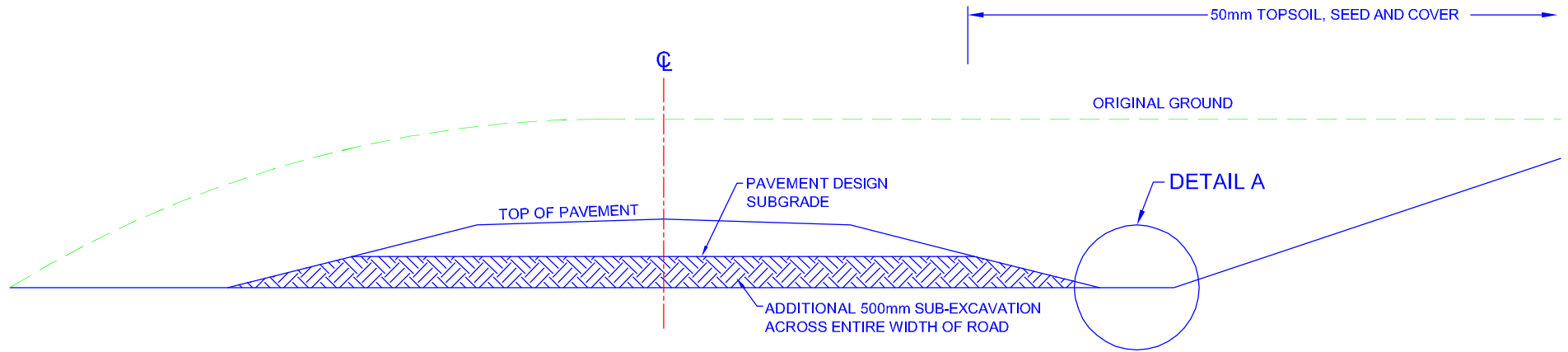


## SUBDRAIN DETAILS



150 mm SUBDRAIN

C:\Documents and Settings\BRANDON\My Documents\1-08-4-05 HWY 406 - NORTH BOUND LANE CUT SECTION.dwg, BRANDON



DETAIL A

N.T.S.

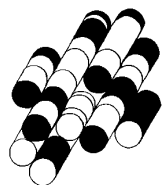
SUB-EXCAVATION DETAILS - HWY 406 CUT SECTION (STA 13+900 TO 14+100)

TERRAPROBE



# APPENDIX G

**TERRAPROBE INC.**



## **EARTH EXCAVATION (GRADING) – Item No.**

---

### **Special Provision**

---

#### **SCOPE**

This non standard special provision covers the requirements for inspecting, sorting and disposing of unsuitable material contained within existing fill that will be excavated.

The alignment extends through a man-made high ground area north of the Old Welland Canal. An earth cut is required along this section of the Highway 406 NBL alignment.

#### **Cobbles/Boulders/Rock Fill/Obstructions**

The Contractor is informed that the soils at this site may contain cobbles, boulders, rock fill and other obstructions that could impede the progress of earth excavations. The soil conditions are described in the Foundation Investigation Report prepared for this site.

#### **Unsuitable fill**

Unsuitable material exists within this cut section. This unsuitable material may include topsoil, organics, soft soils, large boulders and other deleterious material.

#### **Certification of Fill Material for Re-use**

All salvaged material must be approved for re-use as fill material by the Contractor's qualified "geotechnical" Quality Verification Engineer. Unsuitable/rejected material that cannot be accommodated in embankments and other fill areas shall be managed as per OPSS 180.

#### **DEFINITIONS**

Section 206.03 of OPSS 206, December 1993, is amended by the addition of the following:

Geotechnical Quality Verification Engineer: means an Engineer with a minimum of five (5) years experience related to the investigation, classification and testing of excavated materials acceptable for re-use as fill material, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work on a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to approve for re-use as fill material all excavated material. Certificate(s) of conformance are to be issued for approved material which will remain on the site in general conformance with the contract documents.

#### **BASIS OF PAYMENT**

Payment at the Contract price for the above tender item shall be full compensation for all Labour, Equipment and Material necessary to do the work.