FOUNDATION INVESTIGATION AND DESIGN REPORT
SWAMP CROSSINGS AND HIGH FILL EMBANKMENTS
HIGHWAY 69 FOUR-LANING
FROM THE SOUTH JUNCTION OF HIGHWAY 529 NORTHERLY 15 KM
G.W.P. 5076-06-00
NORTH SECTION - NAISCOOT LAKE TO NORTH PROJECT LIMIT
VOLUME 1 of 4

Geocres Number: 41H-99

Report to

MMM Group Limited

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

December 13, 2012
File: 19-5161-21

H:\19\5161\21 Hwy69 N of Hwy529\Reports & Memos\Embankments\Section 2- Naiscoot to\Swamp Crossings & High Fills North Section Final FIDR.doc

TABLE OF CONTENTS

VOLUME 1 of 4

PART 1 FACTUAL INFORMATION

Appendices

VOLUME 2 of 4

Appendix I	Highway 69 SBL, Sta. 24+900 to 25+000 Harrison
Appendix J	Highway 69 SBL, Sta. 25+300 to 25+355 Harrison

VOLUME 3 of 4

Appendix K	Highway 69 NBL & SBL, Sta. 10+330 to 10+585 Wallbridge
Appendix L	Highway 69 NBL, Sta. 12+050 to 12+100 Wallbridge
Appendix M	Harris Lake Road, Sta. 9+800 to 9+930
Appendix N	Harris Lake Road, Sta. 10+085 to 10+280
Appendix O	Rest Area Road, Sta. 10+000 to 10+150
Appendix P	Harris Lake Road: Ramp S-EW, Sta. 12+120 to 12+195 Ramp EW-N, Sta. 11+625 to 11+690
Appendix Q	Harris Lake Road: Ramp EW-S, Sta. 12+070 to 12+110 Ramp N-EW, Sta. 11+650 to 11+690
Appendix R	Harris Lake Road: Ramp N-EW, Sta. 11+840 to 11+910

VOLUME 4 of 4

Appendix S	Harris Lake Road: Ramp N-EW, Sta. 12+030 to 12+120
Appendix T	Harris Lake Road: Ramp EW-N, Sta. 12+070 to 12+120
Appendix U	Highway 69 NBL, Sta. 12+470 to 12+540 Wallbridge
Appendix V	Highway 69 NBL, Sta. 13+130 to 13+190 Wallbridge
Appendix W	Highway 69 NBL, Sta. 13+580 to 13+650 Wallbridge
Appendix X	Highway 69 NBL, Sta. 13+890 to 13+990 Wallbridge
Appendix Y	Highway 69 NBL, Sta. 14+110 to 14+270 Wallbridge
Appendix Z	Highway 69 NBL, Sta. 14+460 to 14+690 Wallbridge
Appendix AA	Highway 69 NBL & SBL, Sta. 15+050 to 15+190 Wallbridge
Appendix BB	Highway 69 NBL, Sta. 15+450 to 15+560 Wallbridge
Appendix CC	Highway 69 NBL, Sta. 15+710 to 15+800 Wallbridge
Appendix DD	Highway 69 NBL, Sta. 15+860 to 15+915 Wallbridge

Appendices B to DD include:

- Record of Borehole Sheets
- Laboratory Test Results
- Borehole Locations and Soil Strata Drawings

FOUNDATION INVESTIGATION AND DESIGN REPORT
SWAMP CROSSINGS AND HIGH FILL EMBANKMENTS
HIGHWAY 69 FOUR-LANING
FROM THE SOUTH JUNCTION OF HIGHWAY 529 TO 15 KM NORTH
G.W.P. 5076-06-00
NORTH SECTION – NAISCOOT LAKE TO NORTH PROJECT LIMIT

Geocres Number: 41H-99

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed swamp crossings and high fill embankments required along a section of the Highway 69 four-laning project extending from just north of Naiscoot Lake (approximately 3.8 km north of Highway 529) northerly to approximately 15 km north of Highway 529.

The report is the second of two reports addressing a larger section of the four-laning project extending from the south junction of Highway 529 northerly for 15 km in the Townships of Harrison and Wallbridge, Ontario. The report deals with the north part of this section; the remaining south part of the section is dealt with in a separate report.

The purpose of the investigation was to explore the subsurface conditions at sites where embankments or swamp crossings are proposed and, based on the data obtained, to provide record of borehole sheets, borehole location plans, stratigraphic profiles, laboratory test results, and a generalized description of the subsurface conditions at each location. This information provides a model of the anticipated geotechnical conditions influencing design and construction of the swamp crossings and high fill embankments.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under the Ministry of Transportation Ontario (MTO) Agreement Number 5006-E-0030.

2 SITE DESCRIPTION

Highway 69 in the study section is currently a two lane undivided roadway. The proposed four-lane alignment will run parallel to the existing alignment, with the new northbound lanes on the existing highway platform on the south part of the study section, and the new southbound lanes on the existing platform along the north part of the section.

The roadway corridor typically has a rolling topography with frequent bedrock outcrops of generally low relief, separated by low-lying swamp areas, water bodies, and small streams. In general, the area is heavily wooded except in swamp areas.

The site lies within the physiographic region known as the Georgian Bay Fringe, characterized by very shallow soils and bare rock knobs and ridges. Where present, the overburden materials consist of sand, silt and clay. Recent organic deposits of peat and muck occur in abundance in bedrock hollows and valleys. The area is underlain by strongly foliated and highly to intermediately deformed rocks of Precambrian age, primarily migmatitic rocks and gneisses.

The locations and existing conditions at each section of swamp and high fill embankment investigated during the current study are summarized below:

Harrison Township

Highway 69 NBL & SBL, Sta. 21+710 to 22+135 – A relatively long, narrow area of swamp and beaver ponds, running roughly parallel to the west side of the existing highway, and widening to a broader area at the north end of the section. The existing highway crosses over the low area near the south end. Bordered by rock outcrops on the east and west sides. Embankment heights of up to 14.1 m are planned.

Highway 69 SBL, Sta. 22+350 to 22+410 – Slight, very narrow dip in the bedrock surface. Embankment fill height will be less than 3.0 m.

Highway 69 SBL, Sta. 22+475 to 22+565 – Short section of swamp in bedrock depression. A fill height of up to 4.2 m is planned.

Highway 69 SBL, Sta. 22+750 to 22+825 – Short section of marsh in bedrock depression. A fill height of up to 3.2 m is planned.

Highway 69 NBL & SBL, Sta. 23+125 to 23+215 – Relatively small area of swamp and beaver pond crossed by existing Highway 69. New embankment fill heights will be up to 6.1 m.

Highway 69 SBL, Sta. 24+000 to 24+040 – Short section of low, wet ground, broadening towards the west. Embankment height will be up to 6.2 m.

Highway 69 NBL & SBL, Sta. 24+400 to 24+600 – Broad area of marsh crossed by existing Highway 69. Fill heights will range from 0.5 to 2.6 m.

Highway 69 SBL, Sta. 24+900 to 25+000 – Relatively broad marsh bordered by rock outcrop on the south and crossed by existing Highway 69. Embankment heights will be up to 6.6 m.

Highway 69 SBL, Sta. 25+300 to 25+355 – Swamp and open water within a relatively narrow channel in the bedrock. An embankment height of up to 6.6 m is planned.

Wallbridge Township

Highway 69 NBL & SBL, Sta. 10+330 to 10+585 – Section includes areas of marsh, rock outcrop and treed terrain. Crossed by existing Highway 69. Fill heights of up to 3.5 m are planned.

Highway 69 NBL, Sta. 12+050 to 12+100 – Partially treed area of low, wet ground and low bedrock outcrops. Fill height will be up to 3.1 m.

Harris Lake Road, Sta. 9+800 to 9+930 – Partially treed area of beaver ponds, marsh, small stream channels, low bedrock outcrops and seasonal flooding. Embankment height will be up to 11.8 m.

Harris Lake Road, Sta. 10+085 to 10+280 – Partially treed area of beaver ponds, marsh, small stream channels, low bedrock outcrops and seasonal flooding. Embankment height will be up to 11.2 m.

Rest Area Road, Sta. 10+000 to 10+150 – Partially treed area of beaver ponds, marsh, small stream channels, low bedrock outcrops and seasonal flooding. Embankment height will be up to 8.6 m.

Harris Lake Road; Ramp S-EW, Sta. 12+120 to 12+195 and Ramp EW-N, Sta. 11+625 to 11+690 - Partially treed area of beaver ponds, marsh, small stream channels, low bedrock outcrops and seasonal flooding. Embankment height will be up to 8.9 m.

Harris Lake Road; Ramp EW-S, Sta. 12+070 to 12+110 and Ramp N-EW, Sta. 11+650 to 11+690 - Partially treed area primarily consisting of a low sloping bedrock outcrop. Embankment height will be up to 8.0 m.

Harris Lake Road; Ramp N-EW, Sta. 11+840 to 11+910 – Localized depression and stream channel within low bedrock outcrops. Fill height will be less than 3.0 m.

Harris Lake Road; Ramp N-EW, Sta. 12+030 to 12+120 - Partially treed area of low, wet ground and low bedrock outcrops. Embankment height will be up to 3.4 m.

Harris Lake Road; Ramp EW-N, Sta. 12+070 to 12+120 - Partially treed area of low, wet ground bordered by low bedrock outcrops. Fill height will be up to 3.0 m.

Highway 69 NBL, Sta. 12+470 to 12+540 – Partially treed section of low, wet ground and bedrock outcrop. Fill heights will be less than 3.0 m.

Highway 69 NBL, Sta. 13+130 to 13+190 – Low, wet, partially treed area with ponded water, between low bedrock outcrops. Fill height will be up to 3.8 m.

Highway 69 NBL, Sta. 13+580 to 13+650 – Low, wet, partially treed and brush covered area with low bedrock outcrop. Fill heights will range up to 3.5 m.

Highway 69 NBL, Sta. 13+890 to 13+990 – Large marsh with several stream channels, crossed by existing Highway 69. Fill heights will be up to 3.2 m.

Highway 69 NBL, Sta. 14+110 to 14+280 – Low marshy areas with low bedrock outcrops and shrubs. Fill heights will be less than 3.0 m.

Highway 69 NBL, Sta. 14+460 to 14+690 – Low, wet areas with marsh and brush. Fill height will be up to 2.4 m.

Highway 69 NBL & SBL, Sta. 15+050 to 15+190 – Low marshy area with brush and some open water. Fill heights will be up to 3.1 m.

Highway 69 NBL, Sta. 15+450 to 15+560 – Marshy areas and some standing water within shallow depressions between bedrock exposures. Fill heights will be up to 2.7 m.

Highway 69 NBL, Sta. 15+710 to 15+800 - Marshy and treed areas with some standing water within depressions in the bedrock surface. Fill heights will be up to 3.0 m.

Highway 69 NBL, Sta. 15+860 to 15+915 – Relatively small marsh with some standing water. Fill heights of up to 2.6 m are planned.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber carried out site investigation and field testing at each swamp crossing and high fill location identified in the Terms of Reference during the periods September 7 to October 30, 2008 and January 27 to February 13, 2009. The limits of the study sections were adjusted during the course of the study to accommodate alignment changes and field observations. Following the initial investigations, the collected subsurface data and detailed contour plans of the corridor were reviewed and a walkover survey of the proposed alignment was carried out. Supplementary field exploration was then conducted in November 2010, February-March 2011 and May-June 2012 to investigate additional or extended areas of swamp identified by the data review, visual observations and/or engineering assessment requirements.

The site investigation and field testing consisted of drilling and sampling boreholes, advancing dynamic cone penetration tests (DCPT), and visual observation or manual excavation at locations where the bedrock surface was either exposed or at very shallow depth. All boreholes and DCPTs were advanced to refusal on probable bedrock.

In general, the boreholes were positioned along the centreline of the embankments/swamp crossings at longitudinal intervals of 25 m for sections extending 250 m or less, and 50 m for sections longer than 250 m. Halfway between these centreline boreholes, one borehole was advanced at the embankment toe location and one DCPT was conducted at the opposite embankment toe location, alternating from side to side.

In addition, subsurface information obtained from the concurrent foundation investigation for design of any structural culverts located within swamp sections has been incorporated into this report. These boreholes are identified by a 'C' series designation.

A summary of the locations and depths of the boreholes and DCPTs carried out in each of the study areas is provided in Table A1, Appendix A. The approximate locations of the boreholes and DCPT tests are shown on the Borehole Locations and Soil Strata Drawings in Appendices B to DD.

The borehole and DCPT locations (stations and offsets from centreline) were established by Thurber relative to centreline staking by MMM Group Limited. Ground elevations at the test locations were approximated from detailed topographic plans provided by MMM Group.

Prior to commencement of drilling, utility clearances were obtained for all borehole and DCPT locations. Road occupancy permits were obtained for boreholes drilled on the existing Highway 69 platform.

In general, the boreholes were advanced using continuous flight hollow stem augers powered by a CME-55 track-mounted drill rig. Wash-boring methods with casing and tripod were employed at locations where work was conducted on ice. A CME-75 truck-mounted drill rig was used for boreholes drilled on the existing Highway 69 platform. Portable split spoon sampling equipment driven with a 22.7 kg hammer was used to advance supplementary explorations in November 2010 and June 2012.

Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils. Where firm to soft cohesive soils were encountered, samples were also obtained using a thin-walled (Shelby) tube sampler. In situ vane shear testing was carried out to assess the undrained shear strength of soft to firm cohesive deposits.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed in selected boreholes to monitor groundwater levels. The standpipe piezometers consisted of 19 mm diameter PVC pipe with a 1.5 m slotted tip enclosed in filter sand. A bentonite seal was placed above the filter sand and the remainder of the borehole was backfilled with bentonite/grout to the ground surface. Details of the piezometer installations are shown on the Record of Borehole sheets in Appendices B to DD and summarized in Table A2, Appendix A.

Boreholes without piezometer installations were backfilled with bentonite/grout and/or auger cuttings upon completion. Completion of the boreholes and standpipe piezometers was carried out in general accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendices B to DD.

Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of the testing program are shown on the Record of Borehole sheets and figures in the respective appendices.

Thin wall tube samples were also selected for Oedometer and Consolidated-Undrained (CU) Triaxial Testing.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings in Appendices B to DD of this report. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following paragraphs. However, the factual data presented in the borehole logs takes precedence over this general description and interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

The specific conditions encountered at individual sites vary. Generalized descriptions of the individual strata at each swamp crossing and high fill embankment are presented below.

5.1 Highway 69 NBL & SBL, Sta. 21+710 to 22+135 Harrison (Appendix B)

General

This section consists of two areas of low wet topography connected by a narrow channel in the bedrock. The channel is occupied by a series of beaver ponds. The existing highway crosses over the low area near the south end. The subsurface stratigraphy generally consists of a surficial layer of organics underlain by silty clay and discontinuous deposits of sandy silt to gravelly sand. Bedrock borders and underlies the site.

Existing Embankment Fill

Borehole C104-2 was drilled on the shoulder of the existing Highway 69 embankment. An approximate 50 mm thick layer of asphalt overlying sand and gravel embankment fill was encountered in this borehole. The embankment fill contains some silt and occasional cobbles. The fill extended to 5.1 m depth (Elev. 184.7 m).

SPT 'N" values obtained in the fill ranged from 5 to 39 blows/0.3 m, indicating a variable loose to dense condition. Moisture contents ranged from 2 to 5%.

The results of a grain size distribution analysis conducted on a fill sample are presented on the Record of Borehole sheet and on Figure B1 of Appendix B. The results are summarized as follows:

Gravel %	32
Sand %	56
Silt & Clay %	12

Locally in Borehole 15A-05R drilled near the toe of the embankment slope, a 1.2 m thick layer of sand fill was encountered below a thin organic layer. The lower boundary of this material was encountered at 1.4 m depth (Elev. 184.8 m). This fill was very loose to loose, based on 'N' values of 2 and 4 blows/0.3 m. A moisture content of 47% was measured.

Peat and Organics

A 50 to 300 mm thick veneer of organic material was encountered surficially in nearly all boreholes drilled at the site. In Boreholes 15-05, 16-06L, 16-10L, C104-1, C105-1 and C105-2, a 0.3 to 1.1 m thick layer of peat and peaty organics was encountered. The thickness of organic material may vary between and beyond the borehole locations.

Moisture contents measured in the peat and organic material ranged from 28 to 106%, with one value of 1578% measured in a sample from Borehole C105-2.

Silty Clay

Native grey silty clay containing trace sand to sandy was the predominant soil type encountered in the boreholes. The silty clay was contacted below the organic deposits in Boreholes 15-01 to 15-03, 15-05, 15-09L, 15A-02L, 15A-03R, 15A-04L, 16-01, 16-06L, 16-10L, C104-1 and C105-1 to C105-3, and below sand/silt layers in Boreholes 15-06R, 16-02L, 16-03, 16-09 and 16-11.

The thickness of the silty clay ranged between 0.7 and 8.9 m. The depth to the base of the silty clay ranged from 0.8 to 9.7 m (Elev. 172.8 to 187.5 m).

The clay layer is very soft to stiff in consistency, based on SPT 'N' values ranging from 0 to 14 blows/0.3 m. 'N' values of up to 26 blows/0.3 m (very stiff) were obtained in Boreholes 15A-02L to 15A-04L.

The undrained shear strength of the clay determined by in situ vane testing was typically in the order of 12 to 32 kPa (soft to firm). Values of 76 and 80 kPa were obtained in the upper 1 m of this deposit in Borehole 16-10L and 16-11. A value of 100 kPa recorded near 6 m depth in Borehole 16-10L may have been affected by sand seams in the clay.

The moisture contents ranged from 19 to 78%, typically about 25 to 55%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures B2 to B6 of Appendix B.

Atterberg Limits test results are presented on Figures B10 to B13 of Appendix B. The results are summarized as follows:

Gravel %	0 to 1
Sand %	1 to 26
Silt %	26 to 65
Clay %	15 to 69
Liquid Limit	25 to 66
Plastic Limit	14 to 25

The above results show that the silty clay varies from low to high plasticity with group symbols of CL to CH.

The results of oedometer (one-dimensional consolidation) testing conducted on a sample of the silty clay are included in Appendix B and summarized in Table 5.1.

Table 5.1 – Consolidation Test Parameters

Borehole	Sample Depth (m)	Soil Type	w_o (%)	γ (kN/m^3)	e_o	p_o' (kPa)	p_c' (kPa)	OCR	C_c	C_r
16-10L	5.3-6.0	CH	52	16.7	1.43	42	65	1.5	0.56	0.03

Comparison of the existing and preconsolidation pressures (p_o' and p_c') derived from the test results indicate that the natural silty clay is slightly overconsolidated. The coefficient of consolidation, c_v, recorded during the test generally varied from 10^{-3} to $8x10^{-4}$ cm^2/s in the normally consolidated range and about $4x10^{-3}$ cm^2/s for the overconsolidated pressure range. The compressibility characteristics will vary with depth in accordance with the moisture content and shear strength profiles.

The results of a Consolidated-Undrained (CU) Triaxial test carried out on a silty clay sample are summarized below and presented in Appendix B.

Table 5.2 – CU Triaxial Test Results

Borehole	Sample Depth (m)	Soil Type	w_o (%)	γ (kN/m^3)	c' (kPa)	ϕ' (deg)
16-10L	5.3-6.0	CH	39	18.3	2	29

Sandy Silt to Sand

A layer of sandy silt to sand was encountered above the silty clay deposit in Boreholes 15-06R, 16-02L, 16-03, 16-09 and 16-11, below the silty clay in Boreholes 15-09L, 16-06L, 16-11 and C104-1, and overlying bedrock in Boreholes 15-08, 15A-05R and

16-08R. A layer of silty sand was also encountered within the clay deposit in Boreholes 15A-02L and 16-11.

The thickness of the sand/silt layers ranged from 0.2 to 2.2 m. The lower boundaries of these layers were encountered at depths of 0.7 to 7.4 m (Elev. 176.2 to 187.5 m).

SPT 'N' values recorded in the silt/sand ranged from 1 to 24 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents generally ranged from 9 to 37%, with local values of 44 to 98% indicative of an organic component.

Grain size distribution curves from samples of the sandy silt to sand are presented on the Record of Borehole sheets and on Figures B7 and B8 of Appendix B. The results are summarized as follows:

	Sandy Silt	Sand
Gravel %	0 to 2	0 to 3
Sand %	30 to 55	78 to 82
Silt %	30 to 55	15 to 21
Clay %	11 to 20	

Sand to Sand and Gravel

Grey sand to gravelly sand containing trace to some silt was contacted below the silty clay in Boreholes C105-1 to C105-3 and below the sand and silt layer in Borehole 16-06L. The thickness of the gravelly sand was 0.6 to 2.2 m. The boreholes were terminated below the gravelly sand layer at depths of 3.3 to 5.9 m (Elev. 178.6 to 182.0 m), upon auger refusal on probable bedrock.

The gravelly sand is very loose to dense in relative density, based on SPT 'N' values of 2 to 45 blows/0.3 m. Natural moisture contents of 10 to 18% were measured.

Grain size distribution curves from samples of the sand/gravely sand are presented on the Record of Borehole sheets and on Figure B9 of Appendix B. The results are summarized as follows:

Gravel %	16 to 31
Sand %	62 to 69
Silt & Clay %	7 to 15

A 0.6 m thick layer of sand and gravel was encountered below the embankment fill in Borehole C104-2. This layer is very dense and contains cobbles. A moisture content of 16% was measured in this layer.

Bedrock

The boreholes and DCPTs were terminated upon refusal on bedrock or probable bedrock at depths of 0.1 to 9.7 m (Elev. 172.8 to 195.8 m). Bedrock was exposed surficially at several locations. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.3.

The presence of rock fill or boulders at the location of Borehole 15A-01 prevented penetration of portable sampling equipment and determination of the probable bedrock level.

Table 5.3 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
15-01	4.4	182.2
15-02R	6.2	180.0
15-03	4.4	182.0
15-04L	0.3	188.7
15-05	1.9	185.0
15-06R	3.1	182.3
15-07	0.1	186.9
15-08	0.7	187.5
15-09L	1.0	187.3
D15-01L	0.6	187.2
D15-02R	3.1	182.6
D15-03L	0.0	190.0
D15-04R	2.7	184.0
15A-02L	2.5	184.1
15A-04L	3.3	182.0
15A-05R	2.4	183.8
D15A-01L	2.4	185.1
D15A-02R	3.4	182.9
D15A-03L	1.5	184.7
D15A-04R	1.4	184.8
D15A-05L	4.6	180.6
16-01	1.2	185.0
16-02L	2.8	184.4
16-03	2.1	182.8
16-04R	0.0	191.4
16-05	0.0	186.7
16-06L	5.9	178.6
16-07	0.1	185.0
16-08R	1.5	187.5
16-09	3.3	180.4
16-10L	9.7	172.8
16-11	7.4	176.2

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
16-12R	0.0	193.9
16-13	0.3	190.1
16-14L	0.0	188.3
D16-01R	6.5	178.6
D16-02L	0.2	185.4
D16-03R	0.0	191.9
D16-04L	6.6	176.3
D16-05R	5.8	185.5
D16-06L	7.3	175.0
D16-07R	0.0	195.8
C104-1	3.9	181.3
C104-2	5.7	184.1
C104-3	0.1	185.8
C105-1	3.6	181.3
C105-2	2.9	182.0
C105-3	4.7	180.5

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 15-02R and 16-11 to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometers are summarized in Table 5.4.

Table 5.4 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
15-01	Feb 7, 2009	2.8	183.8	Open borehole
15-02R	Apr 21, 2009	0.0	186.2	In piezometer
	Jun 4, 2009	0.0	186.2	In piezometer
	Aug 17, 2009	0.1	186.1	In piezometer
	Aug 25, 2009	0.1	186.1	In piezometer
	Oct 27, 2009	0.1	186.1	In piezometer
	Nov 20, 2009	0.3	185.9	In piezometer
15-03	Feb 7, 2009	0.0	186.4	Open borehole
15-06R	Feb 7, 2009	2.6	182.8	Open borehole
15-09L	Nov 12, 2010	0.6	187.7	Open borehole
15A-02L	Nov 12, 2010	0.1	186.5	Open borehole
15A-03R	Nov 13, 2010	0.5	185.3	Open borehole
15A-04L	Nov 12, 2010	0.0	185.3	Open borehole
15A-05R	Nov 13, 2010	0.7	185.5	Open borehole
16-03	Feb 8, 2009	1.2	183.7	Open borehole
16-06L	Feb 8, 2009	1.4	183.1	Open borehole

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
16-09	Feb 8, 2009	1.2	182.5	Open borehole
16-10L	Feb 9, 2009	0.6	181.9	Open borehole
16-11	Apr 21, 2009	0.0	183.6	In piezometer
	Jun 4, 2009	0.0	183.6	In piezometer
	Aug 17, 2009	0.1	183.5	In piezometer
	Aug 25, 2009	0.2	183.4	In piezometer
	Oct 27, 2009	0.2	183.4	In piezometer
	Nov 20, 2009	0.5	183.1	In piezometer
C104-1	Mar 10, 2011	0.3	184.9	Open borehole
C104-2	Jun 14, 2012	5.1	184.7	During drilling
C105-1	Mar 12, 2011	0.9 ags	185.8	During drilling
C105-2	Mar 12, 2011	0.4 ags	185.3	During drilling
C105-3	Mar 9, 2011	0.6 ags	185.8	During drilling

ags = above ground surface

The above values are short-term observations. The depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.2 Highway 69 SBL, Sta. 22+350 to 22+410 Harrison (Appendix C)

General

This site is characterized as exposed bedrock or a thin layer of organics overlying bedrock.

Peat and Organics

A layer of organic material was encountered at the ground surface in all boreholes. The organic layer was typically 25 to 200 mm thick. In Borehole 17-04L located within a bedrock channel, a 600 mm thick layer of peat was encountered. The thickness of the organic deposits may vary between and beyond the borehole locations.

Moisture contents of 61 and 489% were measured in samples of the organic layer and peat, respectively.

Bedrock

The boreholes and DCPTs were terminated upon refusal on bedrock at depths ranging from 0.025 to 0.6 m (Elev. 200.3 to 203.9 m). The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.5.

Table 5.5 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
17-01	0.2	203.3
17-02R	0.025	203.9
17-03	0.025	202.6
17-04L	0.6	200.3
17-05	0.025	203.2
17-06R	0.05	203.1
17-07	0.05	203.1
D17-01L	0.0	203.1
D17-02R	0.4	201.4
D17-03L	0.2	202.9

Groundwater Conditions

Water was not observed in the boreholes during and upon completion of drilling.

Seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

5.3 Highway 69 SBL, Sta. 22+475 to 22+565 Harrison (Appendix D)

General

The subsurface stratigraphy encountered at this site consists of a veneer of organics, peat and/or sand overlying bedrock.

Peat and Organics

A layer of peat and/or organic material was encountered in all boreholes at this site. The peat/organic layer ranged in thickness from 25 to 800 mm. Moisture contents of 44 to 761% were measured in this material.

The thickness of peat and organics may vary between and beyond the borehole locations.

Sand

Native brown sand containing trace to some silt and occasional organics was contacted below the peat and organic deposits in Boreholes 18-01, 18-02L and 18-04R. The thickness of the sand ranged from 0.5 to 1.0 m. The boreholes were terminated below the sand layer at depths ranging from 0.6 to 1.6 m (Elev. 199.6 to 204.4 m), upon auger refusal on probable bedrock.

SPT 'N" values in the sand ranged from 2 to 8 blows/0.3 m, indicating a very loose to loose relative density. The natural moisture contents ranged from 14 to 51%.

A grain size distribution curve of a sand sample is presented on the Record of Borehole sheets and on Figure D1 of Appendix D. The results are summarized as follows:

Gravel %	1
Sand %	88
Silt & Clay %	11

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.025 to 1.8 m (Elev. 199.3 to 204.4 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.6.

Table 5.6 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
18-01	0.7	200.5
18-02L	1.6	199.6
18-03	0.025	203.2
18-04R	0.6	204.4
18-05	0.1	204.4
18-06L	0.025	204.3
18-07	0.8	202.9
18-08R	0.3	203.7
18-09	0.5	203.6
D18-01R	1.8	199.3
D18-02L	0.3	202.9
D18-03R	0.5	203.5
D18-04L	0.6	203.0

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. The water levels observed in the boreholes are summarized in Table 5.7. Water was not observed in the remaining boreholes during drilling.

Table 5.7 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
18-02L	Oct 5, 2008	0.0	201.2	Open borehole
18-07	Oct 5, 2008	0.0	203.7	Open borehole
18-08R	Oct 5, 2008	0.2	203.8	Open borehole

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

5.4 Highway 69 SBL, Sta. 22+750 to 22+825 (Appendix E)

General

The subsurface stratigraphy encountered at this site consists of a veneer of organics, peat and/or sand overlying bedrock.

Peat and Organics

A surficial layer of peat and/or organic material was encountered in all boreholes at this site. The peat/organic layer ranged in thickness from 25 to 700 mm. Moisture contents of 44 to 278% were measured in this material.

The thickness of peat and organics may vary between and beyond the borehole locations.

Silty Sand

Native brown to grey silty sand containing trace clay, trace gravel, and some peat was contacted below the peat at 0.7 m depth (Elev. 200.9 m) in Borehole 19-05. The thickness of the silty sand layer was 1.1 m.

The borehole was terminated below the silty sand layer at 1.8 m depth (Elev. 199.8 m), upon auger refusal on probable bedrock.

An SPT 'N' value of 2 blows/0.3 m was recorded in the silty sand, indicating a very loose relative density. Natural moisture contents were 17% and 24%.

A grain size distribution curve of a silty sand sample is presented on the Record of Borehole sheets and on Figure E1 of Appendix E. The results are summarized as follows:

Gravel %	1
Sand %	67
Silt %	23
Clay %	9

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.0 to 1.8 m (Elev. 199.8 to 204.8 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.8.

Table 5.8 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
19-01	0.025	204.8
19-02L	0.025	204.3
19-03	0.2	203.1
19-04R	0.2	201.5
19-05	1.8	199.8
19-06L	0.025	202.8
19-07	0.3	202.7
D19-01R	0.3	202.7
D19-02L	0.5	201.4
D19-03R	0.0	203.2

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. The water levels observed in the boreholes are summarized in Table 5.9. Water was not observed in the remaining boreholes during drilling.

Table 5.9 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
19-04R	Oct 4, 2008	0.2	201.5	Open borehole
19-05	Oct 5, 2008	0.0	201.6	Open borehole

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

5.5 Highway 69 NBL & SBL, Sta. 23+125 to 23+215 Harrison (Appendix F)

General

The existing Highway 69 crosses a swamp at this location. Much of the swamp site was covered by up to 1.7 m of ice and water at the time of the field investigation. Below the water, the subsurface stratigraphy consisted of discontinuous peat and sand layers underlain by silty clay, overlying probable bedrock.

In boreholes drilled on the existing highway platform, a pavement structure overlying probable rock fill was encountered.

Pavement Structure and Existing Embankment Fill

A pavement structure consisting of approximately 50 to 175 mm of asphalt overlying granular road base (sand and gravel fill) was encountered in Boreholes 20-01 to 20-09 drilled on the existing Highway 69 platform.

The road base/embankment fill consists of brown sand to sand and gravel containing trace to some silt and occasional cobbles and rock fragments. The fill extended to depths of 1.0 to 3.8 m (Elev. 196.3 to 199.6 m), at which depth the boreholes were terminated upon refusal in probable rock fill.

SPT 'N" values obtained in the fill ranged from 13 to 115 blows/0.3 m, indicating a compact to very dense condition. Higher values were obtained at the refusal depths. Moisture contents ranged from 2 to 12%.

The results of grain size distribution analyses conducted on granular fill samples are presented on the Record of Borehole sheets and on Figure F1 of Appendix F. The results are summarized as follows:

Gravel %	19 to 60
Sand %	34 to 70
Silt & Clay %	6 to 11

Peat and Organics

Dark brown to black fibrous peat was contacted below the ice/water in Borehole 21-02R and surficially in Boreholes 20-10R, 20-12R and 20-13L. The peat layer was 175 to 600 mm thick with a lower boundary at Elev. 194.9 to 196.2 m. Locally in Borehole 20-11R, a 1.2 m thick layer of peat was encountered below 0.6 m of silty clay fill. The lower boundary of this peat was at 1.8 m depth (Elev. 194.4 m).

Natural moisture contents of 40 to 77% were measured in the peat.

A 200 mm thick layer of organic material was reported surficially in Borehole 21-07.

The peat and organic thickness may vary between and beyond the borehole locations.

Sand

A layer of grey sand containing some clay and some peat was encountered below the water in Borehole 21-05. Dark brown sand was encountered below the peat in Boreholes 20-10R, 20-12R and 20-13L. Grey and brown sand units were encountered below a clay layer in Boreholes 20-11R and 20-13L, respectively. The sand layers ranged from 0.3 to 1.0 m in thickness, and the lower boundary was encountered at depths of 0.6 to 2.7 m (Elev. 193.5 to 195.8 m).

The sand layers are typically very loose to loose in relative density, based on SPT 'N' values of 3 to 8 blows/0.3 m of penetration. In Borehole 20-13L, higher 'N' values of 26 and 28 blows/0.3 m were obtained, indicating a compact condition. The moisture content ranged from 17 to 32%.

The results of a grain size distribution analysis conducted on a sand sample are presented on the Record of Borehole sheet and on Figure F2 of Appendix F. The results are summarized as follows:

Gravel %	0
Sand %	77
Silt & Clay %	23

Borehole 20-13L was terminated in the sand at 1.8 m depth when the borehole sidewalls collapsed.

Silty Clay

Native grey to brown silty clay containing trace sand to sandy was contacted below the ice/water in Boreholes 21-03 and 21-04L, below the peat in Boreholes 20-11R and 21-02R, and below the sand layer in Boreholes 20-10R to 20-13L and 21-05. The silty clay thickness ranged between 0.2 and 2.8 m. The depth to the base of the silty clay ranged from 2.2 to 4.5 m below the water surface, 0.8 to 3.4 m below the ground surface (Elev. 192.2 to 195.1 m).

The clay layer is generally very soft to stiff in consistency, based on SPT 'N' values of 0 to 14 blows/0.3 m of penetration. The moisture contents ranged from 19 to 62%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure F3 of Appendix F. Atterberg Limits test results are presented on Figure F4. The results are summarized as follows:

Gravel %	0
Sand %	8 to 37
Silt %	33 to 50
Clay %	23 to 44
Liquid Limit	24 to 30
Plastic Limit	14 to 15

The above results show that the silty clay is of low plasticity with a group symbol of CL.

Bedrock

Probable bedrock was contacted at depths of 0.0 to 5.1 m below the ground surface (Elev. 190.9 to 200.6 m) in all of the boreholes and DCPTs advanced off of the existing highway platform. The depths/elevations are listed in Table 5.10.

Table 5.10 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
20-10R	1.6	194.9
20-11R	3.4	192.8
20-12R	1.5	194.4
D20-05L	1.6	194.4
21-01	0.0	196.3
21-02R	1.0	194.5
21-03	2.8	192.2
21-04L	2.4	192.9
21-05	3.3	192.8
21-06R	0.0	200.6
21-07	0.2	200.2
D21-01L	2.2	193.2
D21-02R	5.1	190.9
D21-03L	0.0	198.0

Groundwater Conditions

Boreholes 21-02R to 21-05 were drilled from the ice surface approximately 0.6 to 1.7 m above the ground surface. Water levels were observed in the other boreholes during and upon completion of drilling. A piezometer was installed in Borehole 21-04L to monitor water levels after completion. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.11.

Table 5.11 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
20-10R	Nov 13, 2010	0.2	196.3	Open borehole
20-11R	Nov 13, 2010	1.2	195.0	Open borehole
20-12R	Nov 13, 2010	0.3	195.6	Open borehole
21-04L	Feb 13, 2009	1.4 ags	196.7	Open borehole
	Apr 21, 2009	0.3 ags	195.6	In piezometer
	Jun 5, 2009	0.3 ags	195.6	In piezometer
	Aug 17, 2009	0.0	195.3	In piezometer
	Aug 25, 2009	0.0	195.3	In piezometer
	Oct 27, 2009	0.0	195.3	In piezometer
	Nov 20, 2009	0.0	195.3	In piezometer

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp

outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.6 Highway 69 SBL, Sta. 24+000 to 24+040 Harrison (Appendix G)

General

The subsurface stratigraphy at this site consists of a thin organic layer overlying bedrock, and locally a peat layer over silty sand and silty clay deposits within a depression in the rock surface.

Peat and Organics

A 50 to 125 mm thick layer of organic material was identified at the ground surface in Boreholes 22-01, 22-04R and 22-05. Locally in Borehole 22-02L, a 700 mm thick layer of peat was encountered. The thickness of the organic deposits may vary between and beyond the borehole locations.

An SPT 'N' value of 1 blow/0.3 m was obtained in the peat. The natural moisture content was 302%.

Silty Sand

Native brown to grey silty sand containing trace to some clay and occasional peaty organics was contacted below the peat and organics in Boreholes 22-02L and 22-05, and surficially in Borehole 22-03. The silty sand contained a 400 mm thick layer of silty clay at 2.6 m depth in Borehole 22-02L. The thickness of the silty sand ranged from 0.5 to 3.0 m.

Boreholes 22-02L and 22-05 were terminated below the silty sand layer at 3.7 and 0.6 m depth (Elev. 193.1 and 197.4 m) respectively, upon auger refusal on probable bedrock. In Borehole 22-03, the silty sand extended to 1.4 m depth (Elev. 195.9 m).

SPT 'N' values of the silty sand ranged from 2 to 16 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents generally ranged from 14 to 39%.

Grain size distribution curves of silty sand samples tested are presented on the Record of Borehole sheets and on Figure G1 of Appendix G. The results are summarized as follows:

Gravel %	0 to 5
Sand %	63 to 70
Silt %	20 to 31
Clay %	5 to 6

Silty Clay

Native layers of grey silty clay containing trace sand to sandy were contacted within/below the silty sand at 2.6 and 1.4 m depth in Boreholes 22-02L and 22-03, respectively. The thickness of the silty clay layer was 0.4 and 0.9 m. The lower boundary was at 3.0 and 2.3 m depth (Elev. 193.8 and 195.0 m).

The clay layer is very soft to soft in consistency, based on SPT 'N' values of 1 and 4 blows/0.3 m. The moisture contents were 28% and 50%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure G2 of Appendix G. Atterberg Limits test results are presented on Figure G3. The results are summarized as follows:

Gravel %	0
Sand %	3 to 25
Silt %	49 to 52
Clay %	23 to 48
Liquid Limit	28 to 49
Plastic Limit	13 to 21

The above results show that the silty clay is of low to medium plasticity with group symbols of CL and CI.

Bedrock

Bedrock or probable bedrock was contacted at depths of 0.1 to 5.2 m (Elev. 192.0 to 199.4 m) in all boreholes and DCPTs. The depths and elevations of the bedrock surface are summarized in Table 5.12.

Table 5.12 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
22-01	0.1	198.2
22-02L	3.7	193.1
22-03	2.3	195.0
22-04R	0.05	199.4
22-05	0.6	197.4
D22-01R	5.0	192.8
D22-02L	5.2	192.0

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 22-02L to monitor water levels after

completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.13.

Table 5.13 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
22-02L	Oct 7, 2008	2.1	194.7	Open borehole
	Oct 29, 2008	0.2	196.6	In piezometer
	Feb 19, 2009	0.5	196.3	In piezometer
	Apr 21, 2009	0.0	196.8	In piezometer
	Jun 5, 2009	0.1	196.7	In piezometer
	Aug 17, 2009	0.5	196.3	In piezometer
	Aug 25, 2009	0.5	196.3	In piezometer
	Oct 27, 2009	0.6	196.2	In piezometer
	Nov 20, 2009	0.9	195.9	In piezometer
22-03	Oct 7, 2008	1.2	196.1	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.7 Highway 69 NBL & SBL, Sta. 24+400 to 24+600 Harrison (Appendix H)

General

The existing Highway 69 crosses a swamp at this location. In boreholes drilled from the existing highway platform, a pavement structure overlying probable rock fill was encountered. At one location where the fill was penetrated, it was underlain by silty clay and sand and silt, overlying bedrock.

Much of the swamp site was covered by up to 1.4 m of ice and water at the time of the field investigation. Below the water, the subsurface stratigraphy consisted of a peat layer and/or silty clay deposit underlain and locally overlain by sand and sandy silt layers, overlying probable bedrock.

Pavement Structure and Existing Embankment Fill

A pavement structure consisting of approximately 50 to 250 mm of asphalt overlying granular road base (sand and gravel fill) was encountered in Boreholes 23-01 to 23-09 drilled on the existing Highway 69 platform.

The road base/embankment fill consists of brown sand to sand and gravel containing trace to some silt and occasional cobbles and rock fragments. All boreholes and DCPTs on the road, except for Borehole 23-05 and D23-03L, were terminated in the fill upon refusal on probable rock fill at depths of 0.4 to 2.0 m (Elev. 193.9 to 195.3 m). The fill was fully

penetrated in Borehole 23-05 and the depth to the base of the fill was 3.0 m (Elev. 192.9 m).

SPT 'N" values of the fill ranged from 38 blows/0.3 m to higher than 50 blows/0.125 m, indicating a dense to very dense condition. Moisture contents ranged from 2 to 14%.

The results of grain size distribution analyses conducted on fill samples are presented on the Record of Borehole sheets and on Figure H1 of Appendix H. The results are summarized as follows:

	Sand Fill	Sand & Gravel Fill
Gravel %	5	33 to 50
Sand %	80	42 to 57
Silt & Clay %	15	8 to 10

Peat

Peat was encountered surficially in Boreholes 23-10L to 23-16L and 24-08 to 24-17L. The peat was 150 to 1200 mm thick with a lower boundary at Elev. 192.7 to 194.4 m. The thickness of the peat may vary between and beyond the borehole locations.

SPT 'N' values of 1 to 9 blows/0.3 m were obtained in the peat, indicating a soft to stiff consistency. The natural moisture content ranged from 20 to 104%.

Silty Clay

Native grey to brown silty clay containing trace sand to sandy was contacted below the water in Boreholes 24-02L, 24-04R, 24-05 and 24-07, below peat in Boreholes 23-10L to 23-16L, 24-08 to 24-12R and 24-15R, below a sandy silt/silty sand layer in Boreholes 24-03, 24-06L and 24-14R, and below the embankment fill in Borehole 23-05. The thickness of the silty clay generally ranged from 0.3 to 3.6 m. In Boreholes 23-12R, 23-14L and 24-09R, the clay was 3.6 to 5.3 m thick but contained a 0.4 to 1.3 m thick layer of sand to silt and sand at 0.9 to 2.8 m depth.

The depth to the base of the silty clay ranged from 1.4 to 4.9 m below the ice/water surface, or 0.5 to 6.1 m blow the ground surface (Elev. 188.0 to 194.1 m) in the boreholes drilled off of the road embankment. In Borehole 23-05 drilled through the embankment fill, the lower boundary was at 6.6 m depth (Elev. 189.3 m).

The clay layer is very soft to very stiff in consistency, based on SPT 'N' values of 0 to 23 blows/0.3 m. The undrained shear strength of the clay determined by in situ vane testing ranged from 24 to 40 kPa (soft to firm). Moisture contents ranged from 25 to 68%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures H2 to H5 of Appendix H.

Atterberg Limits test results are presented on Figures H9 to H12 of Appendix H. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2 to 28
Silt %	31 to 59
Clay %	18 to 66
Liquid Limit	28 to 61
Plastic Limit	15 to 23

The above results indicate that the silty clay varies from low to high plasticity with group symbols of CL, CI and CH.

Sandy Silt to Silty Sand

Deposits of grey sandy silt to silty sand were encountered below the ice/water in Boreholes 24-01, 24-03 and 24-06L, below the peat in Boreholes 23-15R and 24-14R, within the silty clay in Borehole 24-09R, and below the silty clay in Boreholes 23-05, 23-11L, 23-12R, 24-03, 24-04R and 24-05. The thickness of these deposits ranged from 0.1 to 2.1 m.

The depth to the base of the upper sand/silt layers ranged from 1.7 to 2.2 m below the water surface, 0.8 to 2.2 m below the ground surface (Elev. 192.0 to 193.8 m). The lower boundary of the sand/silt layer encountered below the silty clay was at 4.3 to 6.4 m below the water surface, 1.0 to 5.7 m below the ground surface (Elev. 188.3 to 193.1 m). In Borehole 23-05, it was at 8.7 m depth below the road surface (Elev. 187.2 m).

The sandy silt is very loose to compact in relative density, based on SPT 'N' values ranging from 0 to 21 blows/0.3 m. The natural moisture content ranged from 16 to 30%, locally 39 to 41% in Boreholes 23-15R and 24-09R.

Grain size distribution curves for samples of the sandy silt to sand and silt are presented on the Record of Borehole sheets and on Figures H6 and H7 of Appendix H. The results are summarized as follows:

Gravel %	0 to 4
Sand %	30 to 50
Silt %	37 to 56
Clay %	3 to 22

Sand to Gravelly Sand

Grey sand containing trace to some silt and trace to some gravel was contacted below the peat in Borehole 24-17L, below the silty clay in Boreholes 23-13R, 24-11 and 24-15R, and below the sandy silt layer in Boreholes 24-04R and 24-05 at depths of 0.2 to 6.4 m. The thickness of the sand layer was 0.2 to 2.0 m.

Brown to grey gravelly sand containing some silt was contacted below the peat in Borehole 24-16 and below the silty clay layer at 2.2 m depth in Borehole 24-07. The thickness of this layer was 1.7 and 0.3 m.

Boreholes 23-13R, 24-04R, 24-05, 24-07, 24-11 and 24-15R to 24-17L were terminated below the sand layers at depths of 1.7 to 8.3 m (Elev. 187.2 to 193.0 m), upon auger refusal on probable bedrock.

SPT 'N' values of 4 to 27 blows/0.3 m were measured in the sand, indicating a loose to compact condition. Moisture contents of 12 to 20% were determined.

Grain size distribution curves for samples of the sand are presented on the Record of Borehole sheets and on Figure H8 of Appendix H. The results are summarized as follows:

Gravel %	1 to 29
Sand %	59 to 91
Silt & Clay %	8 to 14

Bedrock

Probable bedrock was contacted in nearly all boreholes and DCPTs drilled off of the roadway and at two locations on the roadway shoulder (Boreholes 23-05 and D23-03L) at depths of 0.5 to 8.7 m (Elev. 187.2 to 194.1 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.14.

Table 5.14 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
23-05	8.7	187.2
23-10L	1.8	192.2
23-12R	5.7	188.3
23-14L	6.1	188.0
23-15R	1.0	193.1
23-16L	0.5	193.6
D23-03L	5.7	189.8
D23-05L	2.4	191.6
D23-06R	2.7	192.1
D23-07L	4.6	189.6
24-01	0.8	193.8
24-02L	0.8	194.1
24-03	3.2	190.9
24-04R	6.9	187.2
24-05	3.9	190.2
24-06L	1.2	192.9

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
24-07	1.1	193.0
24-08	1.2	193.4
24-09R	4.2	189.9
24-10	2.2	192.1
24-11	1.7	192.8
24-12R	3.9	190.2
24-14R	2.9	191.3
24-15R	3.8	190.6
24-16	1.9	192.6
24-17L	2.2	192.4
D24-01R	4.3	189.6
D24-02L	5.9	188.2
D24-03R	3.1	191.1
D24-04R	1.9	192.4
D24-05L	2.0	192.3

Groundwater Conditions

Much of the site was covered by ice and water at the time of the initial investigation. The depth of the ice/water measured in Boreholes 24-01 to 24-07 was approximately 0.6 to 1.4 m.

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 24-06L and 24-12R to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.15.

Table 5.15 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
23-05	Oct 29, 2008	1.6	194.3	Open borehole
23-10L	Nov 15, 2010	0.0	194.0	Open borehole
23-11L	Nov 14, 2010	0.0	194.0	Open borehole
23-12R	Nov 13, 2010	0.0	194.0	Open borehole
23-13R	Nov 14, 2010	0.0	193.9	Open borehole
23-14L	Nov 14, 2010	0.0	194.1	Open borehole
24-06L	Apr 21, 2009	0.0	194.1	In piezometer
	Jun 5, 2009	0.1	194.2	In piezometer
	Aug 17, 2009	0.0	194.1	In piezometer
	Aug 25, 2009	0.0	194.1	In piezometer
	Oct 27, 2009	0.0	194.1	In piezometer
	Nov 20, 2009	0.0	194.1	In piezometer
24-09R	Feb 15, 2011	1.4	192.7	Open borehole

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
24-10	Feb 15, 2011	0.0	194.3	Open borehole
24-11	Feb 15, 2011	0.0	194.5	Open borehole
24-12R	Feb 22, 2011	0.0	194.1	In piezometer
	Mar 1, 2011	0.0	194.1	In piezometer
	Mar 13, 2011	0.0	194.1	In piezometer
	Apr 27, 2011	0.1	194.0	In piezometer
24-14R	Feb 15, 2011	0.0	194.2	Open borehole
24-15R	Feb 14, 2011	0.0	194.4	Open borehole
24-16	Feb 15, 2011	0.6	193.9	Open borehole
24-17L	Feb 15, 2011	0.4	194.2	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.8 Highway 69 SBL, Sta. 24+900 to 25+000 Harrison (Appendix I)

General

The majority of this site was covered by ice and water at the time of the investigation, and the ice/water was up to 1.4 m deep at the borehole locations. Thick deposits of peat and silty clay were encountered below the ice/water, underlain by a thin sand layer and probable bedrock.

Boreholes drilled on the existing Highway 69 embankment crossing this swamp indicate that the peat and silty clay were largely removed as part of embankment construction.

Pavement Structure and Existing Embankment Fill

A pavement structure consisting of 50 mm of asphalt overlying approximately 1.0 to 1.3 m of granular road base (sand fill) was encountered in Boreholes 26-06 to 26-08, C124-2 and C124-3 drilled on the existing Highway 69 shoulder.

The pavement structure is underlain by rock fill forming the existing road embankment. Rock coring methods were used to penetrate the rock fill. The lower boundary of the rock fill was encountered at depths of 4.9 to 17.4 m (Elev. 192.9 to 180.7 m).

Locally in Borehole 26-06, a zone of sand and gravel fill with occasional cobbles was encountered within the rock fill, between depths of 5.5 and 7.3 m. SPT 'N' values of 11 and 71 blows/0.3 m were obtained in this zone, indicating a compact to very dense condition.

Peat

Dark brown fibrous peat was contacted surficially or below the ice/water in all boreholes drilled off of the existing highway embankment except Borehole 26-04R. The thickness of the peat ranged from 0.2 to 3.9 m. A 0.3 m thick layer of peat was also encountered below the rock fill in Borehole C124-2. The lower boundary of the peat was at Elev. 189.5 to 193.7 m. The peat thickness may vary between and beyond the borehole locations.

The peat is described as very soft to firm, based on SPT 'N' values of 0 to 6 blows/0.3 m. Moisture contents ranged from 51 to 558%.

Sand and Silt

A layer of grey sand and silt containing some organics was contacted below the water in Borehole 26-04R. The thickness of the sand and silt layer was 1.3 m. Borehole 26-04R was terminated below the sand and silt at 2.5 m depth (Elevation 191.6 m), upon auger refusal on probable bedrock.

The sand and silt layer is compact in relative density, based on an SPT 'N' value of 19 blows/0.3 m. Natural moisture contents of 19 and 20% were measured.

A grain size distribution curve for a sample of the sand and silt is presented on the Record of Borehole sheet and on Figure I1 of Appendix I. The results are summarized as follows:

Gravel %	0
Sand %	55
Silt %	40
Clay %	5

Silty Clay

Native grey silty clay containing trace sand to sandy was contacted below the peat in all boreholes drilled off of the highway embankment except Boreholes 26-04R, 26-05 and C125-1. A silty clay layer was also encountered below the rock fill in Boreholes 26-06 to 26-08 drilled on the embankment. The thickness of the silty clay ranged from 1.2 to 12.2 m, and 1.2 to 4.3 where found below the rock fill. The lower boundary of the silty clay was encountered at depths 2.6 to 16.1 m below the ice/water surface, or 1.5 to 16.1 m below the swamp surface (Elev. 177.1 m to 190.7 m).

The split spoon sampler generally sank under the weight of the hammer ('N' value of 0 blows/0.3 m) in the silty clay, indicating a very soft consistency. 'N' values of up to 4 blows/0.3 m were recorded locally. The undrained shear strength of the clay determined by in situ vane testing generally ranged from 10 to 32 kPa (very soft to firm), with one value of 52 kPa (stiff) recorded near the bottom of Borehole 26-01, and several measurements of about 60 kPa below the rock fill in Borehole 26-07. The moisture contents ranged from 20 to 70%, locally 197% in one sample.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures I2 to I5 of Appendix I. Atterberg Limits test results are presented on Figures I6 to I9 of Appendix I. The results are summarized as follows:

Gravel %	0
Sand %	0 to 37
Silt %	26 to 67
Clay %	27 to 72
Liquid Limit	26 to 57
Plastic Limit	15 to 22

The above results show that the silty clay varies from low to high plasticity with group symbols of CL to CH.

The results of oedometer (one-dimensional consolidation) testing conducted on a sample of the silty clay are included in Appendix B and summarized in Table 5.16.

Table 5.16 – Consolidation Test Parameters

Borehole	Sample Depth (m)	Soil Type	w_o (%)	γ (kN/m^3)	e_o	p_o' (kPa)	p_c' (kPa)	OCR	C_c	C_r
26-01	6.1-6.7	CL-CI	41	17.7	1.10	28	40	1.4	0.40	0.05

Comparison of the existing and preconsolidation pressures (p_o' and p_c') derived from the test results indicate that the natural silty clay is slightly overconsolidated. The coefficient of consolidation, c_v, recorded during the test generally was in the order of $6x10^{-3}$ cm^2/s in the overconsolidated range and about 10^{-3} cm^2/s for the normally consolidated pressure range. The compressibility characteristics will vary with depth in accordance with the moisture content and shear strength profiles.

Silty Sand to Sandy Silt

A layer of grey silty sand to sandy silt was contacted below the silty clay in Boreholes 26-06 to 26-08. The thickness of the sand/silt layer was 0.8 to 2.3 m. The boreholes were terminated below the sand/silt at depths of 14.9 to 23.3 m (Elevation 183.5 to 174.8 m), upon auger refusal on probable bedrock.

The silty sand to sandy silt layer is very loose to compact in relative density, based on SPT 'N' values of 3 and 13 blows/0.3 m. Natural moisture contents of 17 to 24% were measured.

A grain size distribution curve for a sample of the silt and sand is presented on the Record of Borehole sheet and on Figure I1 of Appendix I. The results are summarized as follows:

Gravel %	0
Sand %	36
Silt %	59
Clay %	5

Sand to Gravelly Sand

Grey sand, some gravel, to gravelly sand was contacted below the silty clay in Boreholes 26-01, 26-02L and 26-03 at depths of 9.1 to 15.5 m. The thickness of the sand was 0.2 to 1.2 m. The boreholes were terminated below the sand layer at depths of 9.3 to 16.4 m below the ice/water level, 8.0 to 15.4 m below the ground surface (Elev. 177.7 to 184.8 m), upon auger refusal on probable bedrock.

The relative density of the sand varies from very loose ('N' value of 0 blows/0.3 m) in Borehole 26-02L, to very dense ('N' value of 59 blows/0.3 m) in Borehole 26-01. The measured moisture contents ranged from 12 to 20%.

Bedrock

Probable bedrock was contacted in all boreholes and DCPTs at depths of 0.2 to 23.3 m below the ground surface (Elev. 174.8 to 193.7). In Boreholes C124-2 and C124-3, bedrock was confirmed when the final run of core extended through the base of the rock fill and into the underlying bedrock. The depths and elevations of the bedrock/probable bedrock surface are summarized in Table 5.17.

Table 5.17 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
25-01	2.1	190.6
25-02L	2.9	190.1
25-03	9.7	183.4
25-04R	16.1	177.9
D25-01R	8.0	185.4
D25-02L	5.8	187.2
26-01	15.4	177.7
26-01R	13.9	179.9
26-02L	12.2	180.7
26-03	8.0	184.8
26-04R	1.3	191.6
26-05	0.2	193.7
26-06	19.8	178.1
26-07	23.3	174.8

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
26-08	14.9	183.5
D26-01R	15.8	177.1
D26-02L	1.2	191.4
C124-2	6.7	191.1
C124-3	4.9	192.9
C125-1	0.7	192.8
C125-2	1.5	190.7
C125-D1	0.6	193.6
C125-D2	1.8	190.4
C125-D3	0.5	193.5

Groundwater Conditions

The majority of the boreholes/DCPTs were drilled from the ice surface approximately 1.0 to 1.4 m above the ground surface. A standpipe piezometer was installed in Borehole 26-03 to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.18.

Table 5.18 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
25-04R	Nov 16, 2010	1.7	192.3	Open borehole
26-03	Apr 21, 2009	0.0	192.8	In piezometer
	Jun 4, 2009	0.0	192.8	In piezometer
	Aug 17, 2009	0.0	192.8	In piezometer
	Aug 25, 2009	0.0	192.8	In piezometer
	Oct 27, 2009	0.0	192.8	In piezometer
	Nov 20, 2009	0.0	192.8	In piezometer

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.9 Highway 69 SBL, Sta. 25+300 to 25+355 Harrison (Appendix J)

General

The subsurface stratigraphy encountered at this site generally consists of relatively thin deposits of peat, silty clay, and/or sands and silts overlying bedrock and probable bedrock.

Peat and Organics

Brown fibrous peat was encountered surficially in Boreholes 27-03 to 27-05. A layer of organic material was also encountered surficially in Borehole 27-06. The thickness of the peat and organic layer ranged from 200 to 800 mm. The underside of the peat was at Elev. 196.3 to 196.7 m. The thickness of the peat and organic material may vary between and beyond the borehole locations.

The peat is described as very soft, based on SPT 'N' values of 0 and 2 blow/0.3 m of penetration. Moisture contents ranged from 79 to 243%.

Silty Clay

A deposit of brown to grey silty clay containing trace sand to sandy was encountered below the peat in Boreholes 27-03 to 27-05, and below a silty sand layer in Borehole 27-02L. The thickness of the silty clay ranged from 0.8 to 1.9 m. The lower boundary of the silty clay was encountered at depths of 1.2 to 2.6 m (Elev. 194.5 to 195.9 m).

SPT 'N' values obtained in the silty clay ranged from 0 to 25 blows/0.3 m, indicating a very soft to very stiff consistency. Undrained shear strengths of 12 and 16 kPa (soft) were measured by in situ vane testing. The moisture contents ranged from 23 to 43%, with one value of 108% in Borehole 27-04R.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure J1 of Appendix J. Atterberg Limits test results are presented on Figure J3. The results are summarized as follows:

Gravel %	0
Sand %	3 to 25
Silt %	47 to 52
Clay %	28 to 45
Liquid Limit	30 to 39
Plastic Limit	15 to 17

The above results show that the silty clay is of low to medium plasticity with group symbols of CL to CI.

Sand to Sand and Silt

Native grey sand to sand and silt was contacted surficially in Boreholes 27-01 and 27-02L and below the silty clay in Boreholes 27-04R and 27-05. The thickness of the sand/silt layer was 0.6 to 3.0 m. The depth to the base of the sand/silt ranged from 0.6 to 5.0 m (Elev. 192.1 to 197.2 m).

SPT 'N' values of the sand ranged from 2 to 13 blows/0.3 m, indicating a very loose to compact condition. Moisture contents ranged from 20 to 57% with the higher values reflecting an organic component.

A grain size distribution curve for a sample of the sand and silt is presented on the Record of Borehole sheet and on Figure J2 of Appendix J. The results are summarized as follows:

Gravel %	0
Sand %	38
Silt %	45
Clay %	17

Gravelly Sand

Grey gravelly sand was contacted below the sand and silt layer at 5.0 m depth in Borehole 27-04R. The thickness of the gravelly sand was 1.1 m. The borehole was terminated below the gravelly sand at 6.1 m (Elev. 191.0 m), upon auger refusal on probable bedrock.

Based on an SPT 'N' value of 80 blows per 0.225 m of penetration, the gravelly sand is described as very dense in relative density. The moisture content was 12%.

Bedrock

Probable bedrock was contacted in all boreholes and DCPTs at depths of 0.2 to 6.1 m below the ground surface (Elev. 191.0 to 199.4 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.19.

Table 5.19 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
27-01	0.8	197.2
27-02L	2.3	195.5
27-03	2.6	194.5
27-04R	6.1	191.0
27-05	1.9	195.2
27-06	0.2	199.4
D27-01R	0.6	197.1
D27-02L	4.0	193.2

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 27-05 to monitor water levels after completion of drilling. The water levels observed during drilling, and the water levels measured in the piezometer are summarized in Table 5.20.

Table 5.20 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
27-01	Feb 2, 2009	0.3	197.7	Open borehole
27-02L	Feb 2, 2009	0.6	197.2	Open borehole
27-03	Feb 2, 2009	0.0	197.1	Open borehole
27-04R	Feb 2, 2009	0.0	197.1	Open borehole
27-05	Apr 21, 2009	0.0	197.1	In piezometer
	Jun 4, 2009	0.0	197.1	In piezometer
	Aug 17, 2009	0.0	197.1	In piezometer
	Aug 25, 2009	0.0	197.1	In piezometer
	Oct 27, 2009	0.0	197.1	In piezometer
	Nov 20, 2009	0.0	197.1	In piezometer

The above values are short-term observations. The depth to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.10 Highway 69 NBL & SBL, Sta. 10+330 to 10+585 Wallbridge (Appendix K)

General

The existing Highway 69 crosses a swamp at this location. In boreholes drilled from the existing highway platform, a pavement structure overlying probable rock fill was encountered. In the remainder of the boreholes, the subsurface stratigraphy consisted of a surficial layer of peat and organics overlying a variable sequence of sand and silt, silty sand and silty clay deposits, overlying probable bedrock.

Pavement Structure and Existing Embankment Fill

A pavement structure consisting of approximately 40 to 150 mm of asphalt overlying granular road base (sand and gravel fill) was encountered in ten boreholes drilled on the existing Highway 69 platform.

The road base/embankment fill consists of brown sand to sand and gravel containing trace to some silt and occasional cobbles and rock fragments. All boreholes and DCPTs on the road, except for Borehole C200-1 and Cone D28-06L, were terminated in the fill upon refusal on probable rock fill at depths of 0.5 to 1.4 m (Elev. 194.8 to 198.9 m). Borehole C200-1 was extended through the rock fill using rock coring methods and encountered 3.2 m of rock fill with a lower boundary at 4.3 m depth (Elev. 193.4).

SPT 'N" values of the road base fill ranged from 17 blows/0.3 m to 117 blows/0.275 m, indicating a compact to very dense condition or the presence of cobbles/rock fragments in the fill. Moisture contents ranged from 2 to 8%.

The results of a grain size distribution analysis conducted on a fill sample are presented on the Record of Borehole sheet and on Figure K1 of Appendix K. The results are summarized as follows:

Gravel %	35
Sand %	56
Silt & Clay %	9

Peat and Organics

A surficial layer of dark brown to brown fibrous peat or organic material was encountered in 24 of 32 boreholes drilled off of the existing roadway platform. A second, buried peat layer was encountered at 1.8 m depth in Borehole 30-09R. The peat/organic layer was typically 25 to 75 mm thick, however thicknesses of 175 to 1100 mm were measured at eleven borehole locations. A 0.4 m thick layer of buried peat was encountered below the rock fill in Borehole C200-1. The thickness of the peat and organic material may vary between and beyond the borehole locations.

The peat is described as very soft to firm, based on SPT 'N' values of 0 to 5 blow/0.3 m of penetration. Moisture contents ranged from 19 to 326%.

Sand and Silt to Silty Sand

Deposits/layers of brown to grey sand and silt to silty sand were contacted surficially in five boreholes, below the peat/organics in eleven boreholes, and below silty clay in twelve boreholes. The thickness of the sand/silt layers ranged from 0.1 to 4.1 m. The depth to the base of the sand/silt ranged from 0.5 to 8.4 m (Elev. 186.7 to 196.7 m).

SPT 'N' values of the sand ranged from 0 to 23 blows/0.3 m, indicating a very loose to compact condition. The 'N' values were typically less than 10 blows/0.3 m. An SPT 'N' value of 50 blows with no penetration was obtained at 7.6 m depth in Borehole 30-02, indicating a very dense condition or a cobble. Moisture contents ranged from 5 to 59%, typically about 15 to 35%, and locally 153% in one sample, with the higher values reflecting an organic component.

Grain size distribution curves for samples of the sand/silt are presented on the Record of Borehole sheets and on Figures K2 to K4 of Appendix K. The results are summarized as follows:

	Sand & Silt to Silty Sand	Sand
Gravel %	0 to 1	0 to 10
Sand %	38 to 64	70 to 77
Silt %	28 to 50	20 to 23
Clay %	6 to 13	

Silty Clay

Native silty clay containing trace sand to sandy and occasional peaty organics was contacted surficially in Borehole 28-08R, below the peat/organics in ten boreholes, and below a sand/silt layer in eight boreholes. The thickness of the silty clay layers ranged from 0.4 to 6.2 m. The lower boundary of the silty clay was encountered at depths of 0.6 to 7.6 m (Elev. 187.5 to 194.6 m).

SPT 'N' values recorded in the silty clay ranged from 0 to 15 blows/0.3 m, indicating a very soft to stiff consistency. The undrained shear strength of the clay determined by in situ vane testing ranged from 24 to 56 kPa (soft to stiff). The moisture contents typically ranged from 15 to 67%, with four samples indicating 83 to 133%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures K5 to K9 of Appendix K. Atterberg Limits test results are presented on Figures K10 to K12 of Appendix K. The results are summarized as follows:

Gravel %	0 to 1
Sand %	1 to 30
Silt %	33 to 77
Clay %	18 to 65
Liquid Limit	22 to 63
Plastic Limit	12 to 35

The above results show that the silty clay varies from low to high plasticity with group symbols of CL to CH.

The results of oedometer (one-dimensional consolidation) testing conducted on a sample of the silty clay are included in Appendix K and summarized in Table 5.21.

Table 5.21 – Consolidation Test Parameters

Borehole	Sample Depth (m)	Soil Type	w_o (%)	γ (kN/m^3)	e_o	p_o' (kPa)	p_c' (kPa)	OCR	C_c	C_r
30-01	3.8-4.4	CH	62	16.1	1.74	50	125	2.5	0.98	0.06

Comparison of the existing and preconsolidation pressures (p_o' and p_c') derived from the test results indicate that the natural silty clay is overconsolidated. The coefficient of consolidation, c_v, recorded during the test generally was in the order of $9x10^{-3}$ cm^2/s in the overconsolidated range and about $7x10^{-4}$ to 10^{-3} cm^2/s for the normally consolidated pressure range. The compressibility characteristics will vary with depth in accordance with the moisture content and shear strength profiles.

Gravelly Sand

Grey gravelly sand with occasional cobbles was contacted below the silty clay at 3.7 m depth in Borehole 29-05. The thickness of the gravelly sand layer was 100 mm. The moisture content was 17%. Borehole 29-05 was terminated below the gravelly sand layer at 3.8 m depth (Elev. 191.2 m), upon auger refusal on probable bedrock.

Silt to Silty Sand

Grey silt containing some sand was contacted below the silty clay at 3.0 m depth in Borehole 29-12. The thickness of the silt layer was 200 mm. The moisture content was 21%. Borehole 29-12 was terminated below the silt layer at 3.2 m depth (Elev. 192.0 m), upon auger refusal on probable bedrock.

Grey silty sand was contacted below the silty clay at 5.8 m depth in Borehole C200-1. The thickness of the silty sand layer was 800 mm. The moisture content was 15 to 19%. Borehole C200-1 was terminated below the silty sand layer at 6.6 m depth (Elev. 191.1 m), upon auger refusal on probable bedrock.

Bedrock

Probable bedrock was contacted at depths of 0.0 to 8.4 m below the ground surface (Elev. 186.7 to 201.8 m) in all boreholes and DCPTs drilled off of the existing highway. The depths and elevations of the probable bedrock surface are summarized in Table 5.22.

Table 5.22– Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
28-04R	0.3	196.6
28-08R	7.6	187.5
28-11	3.5	192.3
28-12R	4.0	191.2
28-13	3.7	191.7
28-15	1.5	194.2
28-16R	1.4	195.8
28-17	1.1	195.2
D28-01R	0.0	200.0
D28-03R	8.3	187.0
D28-05R	3.6	191.5

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
D28-06L	6.2	191.4
D28-07R	0.1	196.1
29-01	0.0	201.6
29-02L	0.0	201.8
29-03	0.0	200.2
29-04R	0.4	196.9
29-05	3.8	191.2
29-06L	3.3	191.1
29-07	1.6	193.0
29-08R	0.0	196.7
29-09	0.5	196.0
29-10L	0.8	195.9
29-11	1.0	194.4
29-12	3.2	192.0
29-13R	2.3	192.3
29-14R	Borehole caved	-
29-15	Borehole caved	-
D29-01R	0.0	200.5
D29-02L	0.2	199.2
D29-03R	3.2	191.4
D29-04L	1.4	193.9
D29-05R	0.7	195.2
D29-06L	2.5	192.5
30-01	7.2	188.1
30-02	8.4	186.7
30-03L	4.2	191.0
30-04	4.6	190.4
30-05R	4.3	190.7
30-06	3.4	192.1
30-07L	0.6	196.7
30-08	0.3	197.7
30-09R	5.3	190.0
D30-01R	6.4	188.8
D30-02L	7.9	187.1
D30-03R	0.5	196.9
D30-04L	5.1	190.1
C200-1	6.6	191.1

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 28-08R, 29-05 and 30-05R to monitor water levels after completion of drilling. The water levels observed during drilling, and the water levels measured in the piezometers are summarized in Table 5.23.

Table 5.23 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
28-08R	Oct 6, 2008	5.2	189.9	Open borehole
	Oct 29, 2008	0.1	195.0	In piezometer
	Jan 14, 2009	0.5	194.6	In piezometer
	Feb 19, 2009	0.9	194.2	In piezometer
	Apr 21, 2009	0.0	195.1	In piezometer
	Jun 4, 2009	0.0	195.1	In piezometer
	Aug 17, 2009	0.0	195.1	In piezometer
	Aug 25, 2009	0.0	195.1	In piezometer
	Oct 27, 2009	0.0	195.1	In piezometer
	Nov 20, 2009	0.0	195.1	In piezometer
28-12R	Oct 6, 2008	2.9	192.3	Open borehole
28-13	Oct 6, 2008	3.0	192.4	Open borehole
29-05	Sept 25, 2008	Dry	-	Open borehole
	Oct 29, 2008	1.2	193.8	In piezometer
	Jan 15, 2009	0.2	194.8	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.4	194.6	In piezometer
	Jun 4, 2009	0.4	194.6	In piezometer
	Aug 17, 2009	0.6	194.4	In piezometer
	Aug 25, 2009	0.6	194.4	In piezometer
	Oct 27, 2009	0.6	194.4	In piezometer
	Nov 20, 2009	0.9	194.1	In piezometer
29-06L	Sept 25, 2008	2.5	191.9	Open borehole
29-07	Sept 25, 2008	1.5	193.1	Open borehole
29-12	Sept 24, 2008	0.0	195.2	Open borehole
29-13R	Nov 16, 2010	0.4	194.2	Open borehole
29-14R	Nov 15, 2010	1.6	193.6	Open borehole
29-15	Nov 15, 2010	0.0	195.2	Open borehole
30-01	Sept 24, 2008	1.3	194.0	Open borehole
30-02	Sept 24, 2008	1.9	193.2	Open borehole
30-03L	Sept 23, 2008	1.1	194.1	Open borehole
30-04	Sept 23, 2008	0.0	195.0	Open borehole
30-05R	Sept 23, 2008	0.5	194.5	Open borehole
	Oct 29, 2008	0.0	195.0	In piezometer
	Jan 14, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.3 ags	195.3	In piezometer
	Jun 4, 2009	0.1 ags	195.1	In piezometer
	Aug 17, 2009	0.0	195.0	In piezometer
	Aug 25, 2009	0.0	195.0	In piezometer
	Oct 27, 2009	0.0	195.0	In piezometer
	Nov 20, 2009	0.0	195.0	In piezometer
30-06	Sept 23, 2008	1.7	193.8	Open borehole
30-09R	Nov 15, 2010	0.0	195.3	Open borehole

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.11 Highway 69 NBL, Sta. 12+050 to 12+100 Wallbridge (Appendix L)

General

The subsurface stratigraphy at this site consists of a surficial organic layer underlain by sand and silt, overlying probable bedrock.

Organic Material

A 25 to 100 mm thick layer of organic material was encountered at the ground surface in four of six boreholes. The thickness of the organic layer may vary between and beyond the borehole locations.

Sand and Silt

Brown to grey sand and silt, trace clay to clayey, was contacted below the organic layer in Boreholes 31-02L, 31-04R, 31-05 and 31-06L, and surficially in Boreholes 31-01 and 31-03. The boreholes were terminated below the sand and silt layer at depths ranging from 0.2 to 4.4 m (Elev. 191.0 to 195.5 m), upon auger refusal on probable bedrock.

SPT 'N' values of the sand and silt ranged from 2 to 14 blows/0.3 m, indicating a loose to compact relative density. The natural moisture contents ranged from 16 to 42%.

Grain size distribution curves from five sand and silt samples are presented on the Record of Borehole sheets and on Figure L1 of Appendix L. The results are summarized as follows:

Gravel %	0
Sand %	26 to 48
Silt %	37 to 61
Clay %	7 to 18

One sample from a clayey zone was also subjected to Atterberg Limits testing. The results are presented on Figure L2 of Appendix L and were as follows:

Liquid Limit	25
Plastic Limit	15

The above results indicate a low plasticity.

Bedrock

The boreholes and DCPTs were terminated upon refusal on probable bedrock, contacted at depths ranging from 0.2 to 4.4 m (Elev. 191.0 to 195.6 m). The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.24.

Table 5.24 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
31-01	0.6	195.1
31-02L	1.3	194.1
31-03	4.4	191.0
31-04R	2.5	192.7
31-05	2.1	193.5
31-06L	0.2	195.5
D31-01R	0.3	195.6

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 31-03 to monitor water levels after completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometer are summarized in Table 5.25.

Table 5.25 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
31-03	Sept 16, 2008	2.4	193.0	Open borehole
	Sept 24, 2008	3.3	192.1	In piezometer
	Oct 29, 2008	0.4	195.0	In piezometer
	Jan 14, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	195.4	In piezometer
	Jun 4, 2009	0.2	195.2	In piezometer
	Aug 17, 2009	0.3	195.1	In piezometer
	Aug 25, 2009	0.3	195.1	In piezometer
	Oct 27, 2009	0.3	195.1	In piezometer
	Nov 20, 2009	0.5	194.9	In piezometer
31-04R	Sept 16, 2009	2.5	192.7	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp

outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.12 Harris Lake Road, Sta. 9+800 to 9+930 (Appendix M)

General

The stratigraphy at this site generally consists of a veneer of peat and organics overlying sand then probable bedrock. The deposits graded to sand and silt and sandy silt in zones, and contained localized zones of silty clay. The east part of the site was overlain by up to 1.7 m of ice and water at the time of the fieldwork.

Peat and Organics

A 25 to 100 mm thick layer of peat or organic material was encountered surficially in Boreholes 32-01L, 32-03R to 32-06 and 32-09L. The thickness of peat and organics may vary between and beyond the borehole locations.

Sand

Native brown sand containing trace to some silt and occasional peaty organics was contacted surficially or below the water in Boreholes 32-02, 32-07R, 32-08 and 32-13, and below the peat/organics in Boreholes 32-03R, 32-04, 32-06 and 32-09L. In Boreholes 32-08, 32-10, 32-12, and 32-13, sand was also contacted below the sandy silt to sand and silt zone at depths ranging from 3.1 to 4.6 m.

The thickness of the sand layers ranged from 1.2 to 6.5 m. The depths to the base of the sand ranged from 1.2 to 9.8 m (Elev. 183.1 to 191.6 m).

SPT 'N' values of the sand ranged from 1 to 26 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents typically ranged from about 7 to 25%, with higher values of up to 57% in zones containing organics.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets and on Figures M1 and M2 of Appendix M. The results are summarized as follows:

Gravel %	0 to 8
Sand %	79 to 98
Silt & Clay %	2 to 17

Sand and Silt to Sandy Silt

Sand and silt to sandy silt was encountered below the water in Boreholes 32-11R and 32-12, within the sand deposit in Boreholes 32-08 and 32-13, and below a silty clay layer in Boreholes 32-06, 32-09L and 32-10. The thickness of the sand and silt to sandy silt layer ranged from 0.7 to 2.9 m.

The depth to the base of the sand/silt layer ranged from 3.1 to 4.6 m below the ice/water surface, 2.2 to 4.0 m below the ground surface (Elev. 188.2 to 189.7 m).

SPT 'N' values in the sand and silt layer were 2 to 6 blows/0.3 m, indicating very loose to loose conditions. Natural moisture contents of 15 to 22% were measured.

Grain size distribution curves of sand and silt/sandy silt samples are presented on the Record of Borehole sheets and on Figure M3 of Appendix M. The results are summarized as follows:

Gravel %	0
Sand %	23 to 51
Silt %	41 to 64
Clay %	8 to 14

Silty Clay

Brown to grey silty clay containing trace sand to sandy and occasional organics was contacted below the sand at 1.4 and 1.2 m depth in Boreholes 32-06 and 32-09L, and below the water at 1.2 m depth in Borehole 32-10. The thickness of the silty clay ranged from 0.7 to 1.4 m.

The depth to the base of the silty clay ranged from 2.1 to 2.6 m below the ice/water surface, 1.4 to 2.3 m below the ground surface (Elev. 190.2 to 190.9 m).

The silty clay is very soft to stiff in consistency, based on SPT 'N' values ranging from 2 to 13 blows/0.3 m of penetration. The moisture contents ranged from 19 to 32%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure M4 of Appendix M. Atterberg Limits test results are presented on Figure M5. The results are summarized as follows:

Gravel %	0
Sand %	7 to 21
Silt %	54 to 57
Clay %	22 to 39
Liquid Limit	27
Plastic Limit	16

The above results show that the silty clay is of low plasticity with a group symbol of CL.

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.1 to 9.8 m (Elev. 183.1 to 194.0 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.26.

Table 5.26 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
32-01L	0.1	194.0
32-02	2.6	190.5
32-03R	6.6	185.9
32-04	4.6	188.5
32-05L	0.1	194.0
32-06	4.0	189.0
32-07R	3.4	189.0
32-08	9.8	183.1
32-09L	3.0	189.6
32-10	4.1	187.5
32-11R	2.2	189.4
32-12	4.5	186.6
32-13	5.9	186.1
D32-01R	3.7	188.8
D32-02L	0.3	193.7
D32-03R	6.7	185.7
D32-04L	1.8	191.8
D32-05R	3.9	188.3
D32-06L	2.8	188.6

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 32-03R and 32-08 to monitor water levels after completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometers are summarized in Table 5.27.

Table 5.27 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
32-02	Oct 2, 2008	1.1	192.0	Open borehole
32-03R	Oct 2, 2008	5.3	187.2	Open borehole
	Oct 29, 2008	0.8	191.7	In piezometer
	Jan 14, 2009	0.8	191.7	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.2	192.3	In piezometer
	Jun 5, 2009	0.7	191.8	In piezometer
	Aug 20, 2009	0.8	191.7	In piezometer
	Aug 25, 2009	0.8	191.7	In piezometer
	Oct 27, 2009	0.9	191.6	In piezometer
	Nov 20, 2009	1.2	191.3	In piezometer

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
32-04	Oct 1, 2008	1.5	191.6	Open borehole
32-06	Oct 1, 2008	1.3	191.7	Open borehole
32-07R	Oct 1, 2008	3.3	189.1	Open borehole
32-08	Sept 30, 2008	0.9	192.0	Open borehole
	Oct 29, 2008	1.3	191.6	In piezometer
	Jan 14, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.8	192.1	In piezometer
	Jun 5, 2009	0.7	192.2	In piezometer
	Aug 20, 2009	1.2	191.7	In piezometer
	Aug 25, 2009	1.1	191.8	In piezometer
	Oct 27, 2009	1.1	191.8	In piezometer
	Nov 20, 2009	1.4	191.5	In piezometer
32-09L	Oct 1, 2008	0.7	191.9	Open borehole
32-10	Jan 29, 2009	1.2 ags	192.8	Surface water
32-11R	Jan 30, 2009	1.2 ags	192.8	Surface water
32-12	Jan 29, 2009	1.7 ags	192.8	Surface water
32-13	Jan 29, 2009	0.8 ags	192.8	Surface water

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.13 Harris Lake Road, Sta. 10+085 to 10+280 (Appendix N)

General

The stratigraphy at this site generally consists of a veneer of peat and organics overlying a varying succession of sand, sand and silt to sandy silt, and silty clay deposits, overlying probable bedrock.

Peat and Organics

A 25 to 500 mm thick layer of peat or organic material was encountered surficially in Boreholes 33-03, 33-07, 33-11 to 33-14L and 33-16R to 33-18. The thickness of the peat and organics layer may vary between and beyond the borehole locations.

Sand

Native brown sand containing trace to some silt and occasional peaty organics was contacted surficially in Boreholes 33-01, 33-02L, 33-04L, 33-05, 33-09 and 33-15, and below the peat/organics in Boreholes 33-11, 33-13, and 33-17. In Borehole 33-11, sand was also contacted below silty clay at 2.2 m depth.

The thickness of the sand layers ranged from 0.5 to 3.0 m. The depths to the base of the sand ranged from 0.5 to 3.1 m (Elev. 188.8 to 192.8 m).

SPT 'N' values of the sand ranged from 1 to 15 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents typically ranged from about 8 to 25%, with higher values of up to 43% in zones containing organics.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets and on Figure N1 of Appendix N. The results are summarized as follows:

Gravel %	0 to 3
Sand %	75 to 82
Silt & Clay %	15 to 25

Sand and Silt to Sandy Silt

Sand and silt to sandy silt was encountered surficially in Boreholes 33-01R and 33-10L, below the peat/organics in Boreholes 33-14L, 33-16R and 33-18, and below silty clay at depths of 1.4 to 2.7 m in Boreholes 33-13, 33-15, 33-17 and 33-18. The thickness of the sand and silt to sandy silt layer ranged from 0.1 to 4.6 m.

The depth to the base of the sand/silt layer ranged from 0.9 to 4.6 m (Elev. 187.5 to 192.4 m).

SPT 'N' values in the sand and silt layer were 0 to 16 blows/0.3 m, indicating very loose to compact conditions. Natural moisture contents of 10 to 39% were measured.

Grain size distribution curves of sand and silt/sandy silt samples are presented on the Record of Borehole sheets and on Figures N2 and N3 of Appendix N. The results are summarized as follows:

Gravel %	0
Sand %	19 to 63
Silt %	33 to 70
Clay %	4 to 16

Silty Clay

Brown to grey silty clay containing trace sand to sandy was contacted below or within the sand/silt layers at 0.5 to 1.4 m depth in Boreholes 33-11, 33-13, 33-15, 33-17 and 33-18. The thickness of the silty clay ranged from 0.7 to 1.7 m.

The depth to the base of the silty clay ranged from 1.4 to 2.7 m (Elev. 189.7 to 191.3 m).

The silty clay is very soft to stiff in consistency, based on SPT 'N' values ranging from 2 to 14 blows/0.3 m of penetration. The moisture contents ranged from 19 to 42%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures N4 and N5 of Appendix N. Atterberg Limits test results are presented on Figure N6. The results are summarized as follows:

Gravel %	0
Sand %	6 to 23
Silt %	57 to 67
Clay %	20 to 27
Liquid Limit	24 to 28
Plastic Limit	15 to 19

The above results show that the silty clay is of low plasticity with a group symbol of CL.

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.0 to 5.5 m (Elev. 187.5 to 196.3 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.28.

Table 5.28 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
33-01	1.6	190.3
33-01R	0.9	192.4
33-02L	3.3	189.0
33-03	0.1	193.1
33-04L	1.7	190.1
33-05	0.8	192.1
33-06L	0.0	194.9
33-07	0.5	191.9
33-08R	0.0	196.3
33-09	0.6	191.4
33-10L	1.1	191.2
33-11	3.1	188.8
33-12R	0.1	194.8
33-13	2.0	190.5
33-14L	4.6	187.5
33-15	3.8	189.4
33-16R	2.1	192.4
33-17	2.4	191.1
33-18	2.8	190.5
D33-02R	1.2	192.0
D33-03R	0.0	196.2
D33-04L	2.8	189.5
D33-05R	0.5	193.2

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
D33-06L	0.3	192.5
D33-07R	0.0	194.6
D33-08L	5.5	187.7

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 33-14L to monitor water levels after completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometer are summarized in Table 5.29.

Table 5.29 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
33-01	Sept 27, 2008	0.0	191.9	Open borehole
33-02L	Sept 26, 2008	1.2	191.1	Open borehole
33-07	Sept 27, 2008	0.0	192.4	Open borehole
33-09	Sept 27, 2008	0.3	191.7	Open borehole
33-10L	Sept 26, 2008	0.5	191.8	Open borehole
33-11	Sept 27, 2008	0.9	191.0	Open borehole
33-13	Sept 27, 2008	0.0	192.5	Open borehole
33-14L	Sept 27, 2008	0.7	191.4	Open borehole
	Oct 29, 2008	0.2	191.9	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.2 ags	192.3	In piezometer
	Jun 4, 2009	0.1 ags	192.2	In piezometer
	Aug 20, 2009	0.4	191.7	In piezometer
	Aug 25, 2009	0.3	191.8	In piezometer
	Oct 27, 2009	0.4	191.7	In piezometer
	Nov 20, 2009	0.6	191.5	In piezometer
33-15	Sept 27, 2008	2.8	190.4	Open borehole
33-18	Sept 28, 2008	2.7	190.6	Open borehole

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.14 Rest Area Road, Sta. 10+000 to 10+150 (Appendix O)

General

This area consists of low bedrock outcrops with the areas between outcrops in-filled with sand. Ice and water covered much of the site at the time of drilling, and a surficial layer of peat was encountered locally.

Peat

Black fibrous peat was contacted at the ground surface in Borehole 34-06L and below the water in Borehole 34-07. The thickness of the peat was 0.6 and 0.5 m. The peat thickness may vary between and beyond the borehole locations.

A moisture content of 299% was measured in a sample of the peat.

Sand

Native brown sand containing trace to some silt and occasional organic material was contacted surficially or below the peat/ice/water in Boreholes 34-01 to 34-06L. The thickness of the sand layer ranged from 0.9 to 5.2 m.

The boreholes were terminated below the sand layer at depths ranging from 1.5 to 5.2 m (Elev. 187.0 to 190.8 m), upon auger refusal on probable bedrock.

The sand is described as very loose to dense in relative density, based on SPT 'N' values ranging from 1 to 34 blows per 0.3 m of penetration. The moisture contents ranged from 12 to 26%, with one value of 45% measured in a sample containing organics in Borehole 34-02L.

Grain size distribution curves for six sand samples are presented on the Record of Borehole sheets and on Figure O1 of Appendix O. The results were as follows:

Gravel %	0 to 4
Sand %	77 to 98
Silt & Clay %	2 to 19

Bedrock

Probable bedrock was contacted in all of the boreholes and DCPTs at depths of 0.0 to 5.7 m below the ground surface (Elev. 186.2 to 193.7 m). The depths/elevations are listed in Table 5.30.

Table 5.30 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
34-01	2.8	190.2
34-02L	2.3	190.3
34-03	5.2	187.0
34-04R	2.1	189.9
34-05	0.9	190.8
34-06L	3.2	187.8
34-07	0.5	190.9
34-08R	0.0	189.8
34-09	0.0	191.9
34-10L	0.0	191.3
34-11	0.0	192.3
34-12R	0.0	192.8
34-13	0.0	192.2
D34-01R	5.7	186.2
D34-02L	2.7	189.0
D34-03R	0.9	190.5
D34-04L	0.1	192.1
D34-05R	0.0	193.7
D34-06L	0.0	192.0

Groundwater Conditions

Four of the boreholes (34-02, 34-05, 34-07 and 34-08R) were drilled from the ice surface approximately 0.2 to 1.5 m above the ground surface.

Water levels were observed in the boreholes during and upon completion of drilling. The depth of ice and water at the borehole locations and the water levels observed during drilling are summarized in Table 5.31.

Table 5.31 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
34-01	Jan 30, 2009	1.5	191.5	Open borehole
34-02L	Jan 30, 2009	0.2 ags	192.8	Drilling on ice
34-04R	Jan 30, 2009	0.0	192.0	Open borehole
34-05	Jan 30, 2009	0.6 ags	192.3	Drilling on ice
34-06L	Jan 30, 2009	0.0	191.0	Open borehole
34-07	Jan 30, 2009	0.9 ags	192.3	Drilling on ice
34-08R	Jan 30, 2009	1.5 ags	191.3	Drilling on ice

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.15 Harris Lake Road: Ramp S-EW, Sta. 12+120 to 12+195 and Ramp EW-N, Sta. 11+625 to 11+690 (Appendix P)

General

The stratigraphy at this site generally consists of a veneer of peat and organics overlying a varying succession of sand, sand and silt to sandy silt, and silty clay deposits, overlying probable bedrock.

Peat and Organics

A 25 to 200 mm thick layer of organic material was encountered surficially in Boreholes 35-05R, 35-06, 35-08, 36-01 to 36-04, and 36-06 to 36-08. A 700 mm thick layer of dark brown fibrous peat was encountered in Borehole 36-05R. The thickness of the peat and organics layer may vary between and beyond the borehole locations.

Moisture contents of 32 and 116% were measured in single samples of the peat and organic material, respectively.

Sand and Silt to Silty Sand

Deposits of sand and silt to silty sand containing trace to some clay and occasional peaty organics were encountered surficially in Borehole 35-03L, below the peat/organics in seven boreholes, and/or below silty clay in seven boreholes. A possible boulder was encountered in this layer in Borehole 35-03L.

The thickness of the sand and silt to silty sand layers ranged from 0.1 to 2.7 m. The depth to the base of the sand/silt layers ranged from 0.7 to 4.7 m (Elev. 187.6 to 193.1 m).

SPT 'N' values in the sand and silt layers were 0 to 25 blows/0.3 m, indicating very loose to compact conditions. Natural moisture contents of 10 to 32% were measured, typically about 15 to 23%.

Grain size distribution curves of sand and silt/silty sand samples are presented on the Record of Borehole sheets and on Figures P1 and P2 of Appendix P. The results are summarized as follows:

Gravel %	0 to 2
Sand %	26 to 62
Silt %	30 to 63
Clay %	4 to 15

Silty Clay

Brown to grey silty clay containing trace sand to sandy and peaty organic zones was contacted surficially in Boreholes 35-04 and 35-07L, and below the peat and silty sand in Boreholes 35-05R, 35-08, 36-02 to 36-06 and 36-08. A layer of silty clay was also encountered within the sand and silt deposit in Borehole 35-03L.

The thickness of the silty clay ranged from 0.3 to 3.4 m. The depth to the base of the silty clay ranged from 0.6 to 4.1 m (Elev. 187.7 to 192.4 m).

The silty clay is very soft to stiff in consistency, based on SPT 'N' values ranging from 0 to 14 blows/0.3 m of penetration. The moisture contents typically ranged from 18 to 29%. Higher moisture contents of 59 and 158% were measured in samples containing peaty organics from Boreholes 35-03L and 35-05R.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures P3 and P4 of Appendix P. Atterberg Limits test results are presented on Figures P6 and P7. The results are summarized as follows:

Gravel %	0
Sand %	4 to 27
Silt %	46 to 64
Clay %	15 to 46
Liquid Limit	22 to 36
Plastic Limit	14 to 18

The above results show that the silty clay is of low to medium plasticity with group symbols of CL and CI.

Sand

Native brown to grey sand containing trace to some silt was contacted below the sand/silt and silty clay layers in Boreholes 35-03L, 35-04, 35-05R, 36-05R and 36-08 at depths of 1.4 to 2.9 m.

The thickness of the sand layers ranged from 1.5 to 6.2 m. The depths to the base of the sand ranged from 3.7 to 7.6 m (Elev. 186.2 to 188.7 m).

SPT 'N' values of the sand ranged from 0 to 45 blows/0.3 m, indicating a very loose to dense relative density. SPT 'N' values higher than 50 blows per 0.075 m of penetration were measured in Borehole 36-05R. The natural moisture contents typically ranged from about 15 to 23%.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets and on Figure P5 of Appendix P. The results are summarized as follows:

Gravel %	0 to 11
Sand %	80 to 87
Silt & Clay %	6 to 19

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.0 to 7.6 m (Elev. 186.2 to 197.2 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.32.

Table 5.32 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
35-01	0.0	197.2
35-02	0.0	195.4
35-03L	5.2	188.0
35-04	3.7	188.7
35-05R	4.5	188.1
35-06	2.7	189.5
35-07L	2.7	189.9
35-08	2.3	190.0
D35-01R	0.0	194.2
D35-02L	2.1	190.1
D35-03R	0.4	191.6
36-01	0.2	193.4
36-02	2.3	190.9
36-03L	4.1	187.7
36-04	4.7	187.6
36-05R	4.6	187.2
36-06	3.0	189.7
36-07L	2.2	191.1
36-08	7.6	186.2
D36-01R	5.5	187.6
D36-02L	3.0	189.8
D36-03R	6.1	187.3

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 35-05R and 36-05R to monitor water levels after completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometers are summarized in Table 5.33.

Table 5.33 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
35-03L	Sept 29, 2008	1.1	192.1	Open borehole
35-04	Sept 26, 2008	0.8	191.6	Open borehole
35-05R	Oct 29, 2008	0.2	192.4	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	0.2 ags	192.8	In piezometer
	Apr 21, 2009	0.0	192.6	In piezometer
	Jun 4, 2009	0.1 ags	192.7	In piezometer
	Aug 20, 2009	0.3	192.3	In piezometer
	Aug 25, 2009	0.3	192.3	In piezometer
	Oct 27, 2009	0.3	192.3	In piezometer
	Nov 20, 2009	0.5	192.1	In piezometer
35-06	Sept 26, 2008	1.2	191.0	Open borehole
35-07L	Feb 9, 2009	0.0	192.6	Open borehole
35-08	Sept 27, 2008	1.3	191.0	Open borehole
36-02	Sept 28, 2008	1.2	192.0	Open borehole
36-03L	Sept 28, 2008	0.5	191.3	Open borehole
36-04	Sept 28, 2008	0.9	191.4	Open borehole
36-05R	Sept 28, 2008	1.4	190.4	Open borehole
	Oct 29, 2008	0.2	191.6	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.2	191.6	In piezometer
	Jun 4, 2009	0.0	191.8	In piezometer
	Aug 20, 2009	0.1	191.7	In piezometer
	Aug 25, 2009	0.0	191.8	In piezometer
	Oct 27, 2009	0.0	191.8	In piezometer
	Nov 20, 2009	0.2	191.6	In piezometer
36-06	Sept 28, 2008	0.8	191.9	Open borehole
36-08	Sept 29, 2008	2.1	191.7	Open borehole

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.16 Harris Lake Road: Ramp EW-S, Sta. 12+070 to 12+110 and Ramp N-EW, Sta. 11+650 to 11+690 (Appendix Q)

General

This site consists primarily of a bedrock outcrop overlain by a thin layer of organic material and locally a sand layer at the south end of the section.

Organic Material

A 25 to 300 mm thick layer of organic material was encountered over bedrock or localized sand in all but three boreholes drilled at the site. The thickness of organics may vary between and beyond the borehole locations. Moisture contents of 26 to 160% were measured in this layer.

Sand

Native brown sand containing trace to some silt and occasional organics was contacted below the organic layer in Borehole 37-05 and surficially in Borehole 38-01. The sand layer was 1.1 and 0.4 m thick in these boreholes, with a lower boundary at Elev. 192.2 and 193.0 m.

SPT 'N' values of the sand were 4 and 64 blows/per 0.3 m of penetration, indicating a very loose to very dense relative density. The natural moisture contents ranged from 15 to 18%.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets and on Figure Q1 of Appendix Q. The results are summarized as follows:

Gravel %	0 to 4
Sand %	86 to 90
Silt & Clay %	10

Bedrock

Bedrock/probable bedrock was exposed surficially or contacted below the organic layer and sand in all boreholes and DCPTs at depths of 0.0 to 1.2 m (Elev. 192.2 to 198.3 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.34.

Table 5.34 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
37-01	0.0	197.7
37-02	0.1	197.1
37-03L	0.3	195.7
37-04	0.2	193.9

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
37-05	1.2	192.2
D37-01R	0.0	195.4
38-01	0.4	193.0
38-02L	0.0	195.4
38-03	0.1	196.1
38-04R	0.1	197.4
38-05	0.0	198.3
D38-01R	0.0	194.5
D38-02L	0.0	198.1

Groundwater Conditions

Groundwater was not observed in the boreholes during or upon completion of drilling.

The above findings are short-term observations. The water depth will vary depending upon seasonal fluctuations, rainfall patterns and outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.17 Harris Lake Road; Ramp N-EW, Sta. 11+840 to 11+910 (Appendix R)

General

This site consists of exposed bedrock or bedrock with a thin organic cover, and a local depression infilled with silty clay, sand and silt, and sand.

Organic Material

A 20 to 300 mm thick layer of organic material was encountered over bedrock or clay/sand deposits in seven of nine boreholes. The thickness of organics may vary between and beyond the borehole locations. A moisture content of 492% was measured in one sample of the organic material.

Silty Clay

Native brown silty sandy clay was contacted below the organics in Borehole 39-06 and below a sandy silt layer in Borehole 39-08L. The thickness of the silty clay was 1.4 and 1.2 m.

The silty clay is soft to very stiff in consistency, based on SPT 'N' values of 3 to 23 blows/0.3 m of penetration. The moisture contents ranged from 22 to 37%.

The results of a grain size distribution analysis conducted on a sample of the silty clay are presented on the Record of Borehole sheets and on Figure R1 of Appendix R. The results are summarized as follows:

Gravel %	0
Sand %	22 to 33
Silt %	32 to 51
Clay %	27 to 35

Sand and Silt to Sandy Silt

Native brown to grey sand and silt to sandy silt containing some clay was contacted below the organic layer in Borehole 39-08L and below the silty clay at 1.4 m depth in Borehole 39-06. The sand/silt layer was 1.4 and 0.5 m thick, with a lower boundary at 2.8 and 0.6 m depth (Elev. 191.5 and 193.6 m).

SPT 'N' values of 6 and 13 blows/0.3 m were recorded in the sand and silt, indicating a loose to compact relative density. The natural moisture contents were 12 to 33%.

The results of a grain size distribution analysis conducted on a sample of the sand and silt are presented on the Record of Borehole sheet and on Figure R2 of Appendix R. The results are summarized as follows:

Gravel %	0
Sand %	42
Silt %	43
Clay %	15

Sand

Native brown sand containing some silt, trace to some clay and occasional peaty organics was contacted below the organic layer in Borehole 39-07. Sand with trace gravel and silt was encountered below the silty clay in Borehole 39-08L. Boreholes 39-07 and 39-08L were terminated below the sand at 3.5 and 2.3 m depth (Elev. 190.8 and 191.9 m), upon auger refusal on probable bedrock.

SPT 'N' values of the sand ranged from 1 to 16 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents ranged from 12 to 20%.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheet and on Figure R3 of Appendix R. The results are summarized as follows:

Gravel %	0 to 5
Sand %	70 to 91
Silt & Clay %	9 to 25

Bedrock

Bedrock/probable bedrock was exposed surficially or contacted in all boreholes and DCPTs at depths of 0.0 to 3.5 m (Elev. 190.8 to 197.3 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.35.

Table 5.35 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
39-01	0.0	196.5
39-02	0.1	196.2
39-03L	0.3	195.8
39-04	0.0	197.3
39-05R	0.0	194.3
39-06	2.8	191.5
39-07	3.5	190.8
39-08L	2.3	191.9
39-09	0.0	195.0
D39-01R	0.0	196.3
D39-02L	0.0	195.8
D39-03R	1.8	192.4

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 39-07 to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.36.

Table 5.36 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
39-06	Oct 3, 2008	1.3	193.0	Open borehole
39-07	Oct 3, 2009	0.8	193.5	Open borehole
	Oct 29, 2009	0.3	194.0	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.1	194.2	In piezometer
	Jun 4, 2009	0.3	194.0	In piezometer
	Aug 20, 2009	0.4	193.9	In piezometer
	Aug 25, 2009	0.4	193.9	In piezometer
	Oct 27, 2009	0.4	193.9	In piezometer
	Nov 20, 2009	0.6	193.7	In piezometer
39-08L	Nov 16, 2010	0.6	193.6	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.18 Harris Lake Road; Ramp N-EW, Sta. 12+030 to 12+120 (Appendix S)

General

This site consists of a thin organic layer over bedrock, bedrock outcrops, and local depressions infilled by sand and silt, silty clay and sand.

Organic Material

A 75 to 100 mm thick layer of organic material was encountered surficially in Boreholes 40-01, 40-02L, 40-05 and 40-06L. In Borehole 40-04R, a 700 mm thick layer of brown fibrous peat was encountered. The thickness of the peat and organic layers may vary between and beyond the borehole locations.

A moisture content of 50% was measured in one sample of the peat.

Sand and Silt

Native grey sand and silt containing trace to some clay and occasional peaty organics was contacted surficially or below the organic layer in Boreholes 40-01, 40-02L and 40-07. A second layer of sand and silt was encountered below silty clay at 3.0 m depth in Borehole 40-07. The sand and silt layers were 0.7 to 2.5 m thick.

The lower boundary of these deposits was encountered at depths of 0.7 to 5.5 m (Elev. 189.4 to 194.2 m).

SPT 'N' values of 1 to 21 blows/0.3 m were recorded in the sand and silt, indicating a very loose to compact relative density. The natural moisture contents ranged from 17 to 48%.

The results of grain size distribution analyses conducted on the sand and silt are presented on the Record of Borehole sheets and on Figure S1 of Appendix S. The results are summarized as follows:

Gravel %	0 to 11
Sand %	29 to 58
Silt %	33 to 59
Clay %	4 to 12

Silty Clay

Native grey silty clay containing trace to some sand and occasional peaty organics was contacted below the peat in Borehole 40-04R and below the sand and silt layer in Borehole 40-07. The thickness of the silty clay was 1.1 and 2.3 m.

The depth to the base of the silty clay was 1.8 m (Elev. 193.5 m) in Borehole 40-04R and 3.0 m (Elev. 191.9 m) in Borehole 40-07.

The silty clay is very soft to soft in consistency, based on SPT 'N' values of 2 and 3 blows/0.3 m of penetration. The moisture contents ranged from 20 to 33%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure S2 of Appendix S. Atterberg Limits test results are presented on Figure S4. The results are summarized as follows:

Gravel %	0
Sand %	11
Silt %	45 to 55
Clay %	34 to 44
Liquid Limit	48
Plastic Limit	20

The above results show that the silty clay is of medium plasticity with a group symbol of CI.

Sand

Native brown sand containing some silt and occasional peaty organics was contacted surficially in Borehole 40-03 and below the organic layer in Borehole 40-06L. The boreholes were terminated below the sand at 0.8 and 0.6 m depth (Elev. 194.2 and 194.9 m), upon auger refusal on probable bedrock.

SPT 'N' values of 3 and 6 blows/0.3 m were recorded in the sand, indicating a very loose to loose relative density. The natural moisture contents were 25 and 40%.

The results of a grain size distribution analysis conducted on a sample of the sand are presented on the Record of Borehole sheet and on Figure S3 of Appendix S. The results are summarized as follows:

Gravel %	0
Sand %	84
Silt %	12
Clay %	4

Bedrock

Bedrock/probable bedrock was exposed surficially or contacted in all boreholes and DCPTs at depths of 0.0 to 5.5 m below the ground surface (Elev. 189.4 to 198.9). The depths and elevations of the probable bedrock surface are summarized in Table 5.37.

Table 5.37 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
40-01	2.2	192.6
40-02L	1.4	193.5
40-03	0.8	194.2
40-04R	1.8	193.5
40-05	0.1	195.9
40-06L	0.6	194.9
40-07	5.5	189.4
40-09	0.0	198.9
D40-01R	1.5	193.4
D40-02L	0.1	195.6
D40-03R	0.2	196.8
D40-04L	1.5	194.4

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 40-07 to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.38.

Table 5.38 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
40-01	Oct 3, 2008	0.9	193.9	Open borehole
40-07	Oct 3, 2009	0.0	194.9	Open borehole
	Oct 29, 2009	0.4	194.5	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.4 ags	195.3	In piezometer
	Jun 4, 2009	0.3 ags	195.2	In piezometer
	Aug 20, 2009	0.3	194.6	In piezometer
	Aug 25, 2009	0.3	194.6	In piezometer
	Oct 27, 2009	0.4	194.5	In piezometer
	Nov 20, 2009	0.5	194.4	In piezometer

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.19 Harris Lake Road; Ramp EW-N, Sta. 12+070 to 12+120 (Appendix T)

General

The site consists of a depression in the bedrock surface infilled with deposits of silty sand, silty clay and sand/gravel.

Organics

A 25 to 125 mm thick veneer of organic material was encountered in Boreholes 41-01 to 41-04. The thickness of organic material may vary between and beyond the borehole locations.

Silty Sand

Native brown to grey silty sand containing peaty organics was contacted surficially or below the thin organic layer in Boreholes 41-04 and 41-05R. The thickness of the silty sand layer was 1.4 m.

SPT 'N' values in the silty sand ranged from 3 to 13 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents ranged from 19 to 33%.

Silty Clay

Native brown to grey silty clay containing trace sand to sandy and occasional peaty organics was contacted below the organics in Borehole 41-03L and below the silty sand at 1.4 m depth in Boreholes 41-04 and 41-05R. The thickness of the silty clay ranged from 1.5 to 2.3m.

The lower boundary of the silty clay was at 1.5 to 3.7 m depth (Elev. 191.6 to 193.8 m).

The silty clay is very soft to stiff in consistency, based on SPT 'N' values of 1 to 9 blows/0.3 m. The moisture contents ranged from 21 to 48%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure T1 of Appendix T. Atterberg Limits test results are presented on Figure T3. The results are summarized as follows:

Gravel %	0
Sand %	9 to 26
Silt %	35 to 47
Clay %	36 to 56
Liquid Limit	33 to 54
Plastic Limit	15 to 20

The above results show that the silty clay is of low to high plasticity with group symbols of CL and CH.

Sand to Sand and Gravel

Native grey sand to sand and gravel containing trace to some silt was contacted below the silty clay at 3.7 and 3.0 m depth in Boreholes 41-04 and 41-05R, respectively. The thickness of this layer was 0.9 and 1.5 m. The boreholes were terminated below the sand/gravel at 4.6 and 4.5 m depth (Elev. 190.7 and 191.1 m), upon auger refusal on probable bedrock.

An SPT 'N' value of 20 blows/0.3 m was recorded in the sand, indicating a compact relative density. The natural moisture contents were from 16 to 20%.

The results of a grain size distribution analysis conducted on a sample of the sand and gravel are presented on the Record of Borehole sheet and on Figure T3 of Appendix T. The results are summarized as follows:

Gravel %	42
Sand %	54
Silt & Clay %	4

Bedrock

Bedrock/probable bedrock was exposed surficially or contacted in all boreholes and DCPTs at depths of 0.0 to 5.4 m (Elev. 190.0 to 196.0 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.39.

Table 5.39 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
41-01	0.0	196.0
41-02	0.1	195.5
41-03L	1.5	193.8
41-04	4.6	190.7
41-05R	4.5	191.1
D41-01R	3.8	191.4
D41-02L	5.4	190.0

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 41-04 to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.40.

Table 5.40 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
41-04	Oct 4, 2008	1.2	194.1	Open borehole
	Oct 29, 2008	0.2	195.1	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	195.3	In piezometer
41-05R	Oct 5, 2008	1.2	194.4	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.20 Highway 69 NBL, Sta. 12+470 to 12+540 Wallbridge (Appendix U)

General

The site consists of exposed bedrock or a thin organic layer over bedrock, with depressions in the bedrock surface infilled with sand to sand and silt.

Organic Material

A 25 to 75 mm thick veneer of organic material was encountered in Boreholes 42-01, 42-02L, and 42-04R to 42-06L. The thickness of organic material may vary between and beyond the borehole locations.

Sand and Silt

Native brown to grey sand and silt containing some clay was contacted below the thin organic layer in Borehole 42-02L. The thickness of the sand and silt layer was 2.2 m.

SPT 'N' values in the sand and silt ranged from 0 to 9 blows/0.3 m, indicating a very loose to loose relative density. The natural moisture contents ranged from 18 to 22%.

The results of grain size distribution analyses conducted on the sand and silt are presented on the Record of Borehole sheets and on Figure U1 of Appendix U. The results are summarized as follows:

Gravel %	0
Sand %	29 to 31
Silt %	50 to 56
Clay %	15 to 19

Sand

Native dark brown to grey sand containing some silt and occasional peaty organics was contacted below the organic layer in Borehole 42-01. The sand layer was 1.0 m thick.

SPT 'N' values recorded in the sand were 0 blows/0.3 m (very loose) at the ground surface and 54 blows/0.15 m at the termination depth on bedrock. The natural moisture contents were 22 and 31%.

The results of a grain size distribution analysis conducted on a sample of the sand are presented on the Record of Borehole sheet and on Figure U2 of Appendix U. The results are summarized as follows:

Gravel %	8
Sand %	74
Silt %	14
Clay %	4

Bedrock

Bedrock was exposed or contacted in all boreholes and DCPTs at depths of 0.0 to 2.3 m (Elev. 197.5 to 202.3). The depths and elevations of the probable bedrock surface are summarized in Table 5.41.

Table 5.41 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
42-01	1.0	199.1
42-02L	2.3	197.5
42-03	0.0	201.0
42-04R	0.1	202.3
42-05	0.1	201.4
42-06L	0.0	200.5
D42-01R	0.5	199.2
D42-02L	0.0	201.6
D42-03R	0.5	200.2

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 42-02L to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.42.

Table 5.42 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
42-01	Sept 15, 2008	0.0	200.1	Open borehole
42-02L	Sept 15, 2008	0.0	199.8	Open borehole
	Sept 24, 2008	0.0	199.8	In piezometer
	Oct 29, 2008	0.2	199.6	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	199.8	In piezometer
	Jun 5, 2009	0.0	199.8	In piezometer
	Aug 17, 2009	0.0	199.8	In piezometer
	Aug 25, 2009	0.0	199.8	In piezometer
	Oct 27, 2009	0.0	199.8	In piezometer
	Nov 20, 2009	0.0	199.8	In piezometer

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.21 Highway 69 NBL, Sta. 13+130 to 13+190 Wallbridge (Appendix V)

General

This site consists of a veneer of organic material underlain by localized deposits of silty clay and silty sand, overlying shallow bedrock.

Organic Material

A 25 to 300 mm thick layer of organic material was encountered surficially in all boreholes. Moisture contents of 30 to 111% were measured in this material. The thickness of organics may vary between and beyond the borehole locations.

Silty Clay

A 1.3 m thick layer of silty clay containing some sand and organics was contacted below the organic layer in Borehole 43-04R. The base of the silty clay layer was at Elev. 197.8 m.

The silty clay is stiff in consistency, based on SPT 'N' values of 8 and 9 blows/0.3 m of penetration. The moisture contents ranged from 18 to 32%.

The results of a grain size distribution analysis conducted on the silty clay are presented on the Record of Borehole sheet and on Figure V1 of Appendix V. Atterberg Limits test results are presented on Figure V3. The results are summarized as follows:

Gravel %	0
Sand %	11
Silt %	56
Clay %	33
Liquid Limit	46
Plastic Limit	20

The above results show that the silty clay is of medium plasticity with a group symbol of CI.

Silty Sand

Native brown to grey silty sand containing some clay and occasional peaty organics was contacted below the organic layer in Boreholes 43-01, 43-03 and 43-06L, and below the silty clay in Borehole 43-04R. The silty sand layer was 0.1 to 0.6 m thick with a lower boundary at depths of 0.2 to 2.0 m (Elev. 197.2 to 200.2 m).

SPT 'N' values in the silty sand layer were 1 and 12 blows/0.3 m, indicating very loose and compact conditions. Natural moisture contents of 19 to 37% were measured.

A grain size distribution curve of a silty sand sample is presented on the Record of Borehole sheet and on Figure V2 of Appendix V. The results are summarized as follows:

Gravel %	0
Sand %	68
Silt %	21
Clay %	11

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.0 to 2.0 m (Elev. 197.2 to 200.7 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.43.

Table 5.43 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
43-01	0.8	199.8
43-02L	0.3	199.9
43-03	0.5	200.2
43-04R	2.0	197.2
43-05	0.2	199.6
43-06L	0.2	198.9
D43-01R	0.0	200.6
D43-02L	1.1	197.9
D43-03R	0.0	200.7

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 43-04R to monitor water levels after completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometer are summarized in Table 5.44.

Table 5.44 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
43-04R	Sept 15, 2008	0.0	199.2	Open borehole
	Sept 24, 2008	0.2	199.0	In piezometer
	Oct 29, 2008	0.3	198.9	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	199.2	In piezometer
	Jun 5, 2009	0.2	199.0	In piezometer
	Aug 17, 2009	0.4	198.8	In piezometer
	Aug 25, 2009	0.4	198.8	In piezometer
	Oct 27, 2009	0.5	198.7	In piezometer
	Nov 20, 2009	0.8	198.4	In piezometer
43-06L	Sept 15, 2008	0.1	199.0	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.22 Highway 69 NBL, Sta. 13+580 to 13+650 (Appendix W)

General

The subsurface stratigraphy at this site consists of a surficial organic layer underlain by layers of sand and silt and silty clay, overlying probable bedrock.

Organic Material

A 25 to 700 mm thick layer of organic material was encountered surficially in Boreholes 44-02, 44-06, 44-07, 44-08R and 44-10L. Moisture contents of 45 and 90% were measured in samples of this material. The thickness of organics may vary between and beyond the borehole locations.

Sand and Silt to Sand

Native brown to grey sand and silt to sand containing occasional organics was contacted surficially or below the organic layer in Boreholes 44-03L, 44-05R to 44-08R, and 44-10L.

A second layer of sand and silt was encountered at 2.4 and 2.9 m depth below a silty clay layer in Boreholes 44-03L and 44-06. The thickness of the sand and silt layers ranged from 0.3 to 1.5 m.

SPT 'N' values in the sand and silt ranged from 1 to 11 blows/0.3 m, indicating a very loose to compact relative density. The natural moisture contents ranged from 14 to 31%.

The results of grain size distribution analyses conducted on the sand/silt are presented on the Record of Borehole sheets and on Figure W1 of Appendix W. The results are summarized as follows:

Gravel %	0 to 1
Sand %	53 to 84
Silt %	13 to 43
Clay %	3 to 10

Silty Clay

Grey silty clay containing trace to some sand and decayed wood fragments was encountered below the silt and sand layer in Boreholes 44-03L, 44-05R to 44-08R, and 44-10L. The thickness of the silty clay typically ranged from 0.9 to 3.3 m, locally 7.0 m in Borehole 44-05R.

The depth to the base of the silty clay generally ranged from 2.4 to 4.8 m. Borehole 44-05R was terminated below the silty clay at 8.4 m depth, upon auger refusal on probable bedrock.

The silty clay is typically very soft to firm in consistency, based on SPT 'N' values of 0 to 6 blows/0.3 m of penetration. Higher 'N' values of up to 14 blows/0.3 m (stiff) were obtained in Boreholes 44-08R and 44-10L. The moisture contents ranged from 22 to 60%, locally up to 90% in Borehole 44-05R.

The results of grain size distribution analyses conducted on the silty clay are presented on the Record of Borehole sheet and on Figures W2 and W3 of Appendix W. Atterberg Limits test results are presented on Figure W5. The results are summarized as follows:

Gravel %	0
Sand %	3 to 18
Silt %	27 to 60
Clay %	22 to 69
Liquid Limit	32 to 64
Plastic Limit	15 to 23

The above results show that the silty clay is of low to high plasticity with group symbols of CL to CH.

Sand and Gravel

Grey sand and gravel was contacted below the silty clay layer in Borehole 44-07. The thickness of the sand and gravel layer was 800 mm. Borehole 44-07 was terminated below the sand and gravel layer at 3.7 m depth.

An SPT 'N' value of 8 blows/0.3 m was recorded in the sand and gravel layer, indicating a loose relative density. The natural moisture content was 19%.

The results of a grain size distribution analysis conducted on a sample of the sand and gravel are presented on the Record of Borehole sheet and on Figure W4 of Appendix W. The results are summarized as follows:

Gravel %	41
Sand %	52
Silt & Clay %	7

Bedrock

The boreholes and DCPTs were terminated at depths ranging from 0.0 to 8.4 m (Elev. 186.5 to 196.9 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.45.

Table 5.45 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
44-01	0.0	196.9
44-02	0.3	195.9
44-03L	2.7	193.5
44-05R	8.4	186.5
44-06	3.9	191.1
44-07	3.7	191.4
44-08R	4.8	190.3
44-09	0.0	195.1
44-10L	3.0	192.4
D44-01R	2.7	193.1
D44-02L	4.0	191.0
D44-03L	1.0	194.1
D44-04R	1.1	194.1

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 44-05R to monitor water levels after

completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometer are summarized in Table 5.46.

Table 5.46 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
44-03L	Sept 8, 2008	0.6	195.6	Open borehole
44-05R	Sept 8, 2008	0.9	194.0	Open borehole
	Sept 24, 2008	0.3	194.6	In piezometer
	Oct 29, 2008	0.3	194.6	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	194.9	In piezometer
	Jun 5, 2009	0.0	194.9	In piezometer
	Aug 17, 2009	0.0	194.9	In piezometer
	Aug 25, 2009	0.1	194.8	In piezometer
	Oct 27, 2009	0.1	194.8	In piezometer
	Nov 20, 2009	0.4	194.5	In piezometer
44-06	Sept 7, 2008	0.9	194.1	Open borehole
44-07	Sept 7, 2008	1.5	193.6	Open borehole
44-08R	Nov 11, 2010	0.9	194.2	Open borehole
44-10L	Nov 12, 2010	0.6	194.8	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.23 Highway 69 NBL, Sta. 13+890 to 13+990 Wallbridge (Appendix X)

General

The subsurface stratigraphy at this site consists of a layer of peaty organics underlain by a relatively thick deposit of silty clay, locally overlain by silty sand and underlain by sand. Probable bedrock was encountered below these deposits.

Organics

A layer of peaty organics was encountered at the ground surface in all boreholes. The organic layer ranged in thickness from 25 to 900 mm. The thickness of the organic material may vary between and beyond the borehole locations.

SPT 'N' values 0 to 2 blows/0.3 m were obtained in the organic layer. Natural moisture contents ranged from 20 to 120%.

Silty Sand

Native brown to grey silty sand containing some clay and occasional peaty organics was contacted below the organic layer in all boreholes except Boreholes 45-01, 45-04 and 45-06. Silty sand was also contacted at 1.5 m depth in Borehole 45-02. The silty sand layer was typically 0.2 to 0.6 m thick with a lower boundary at depths of 0.5 to 1.7 m (Elev. 191.1 to 193.0 m). Locally in Borehole 45-09R, it was 2.4 m thick with a lower boundary at Elev. 190.8 m.

SPT 'N' values recorded in the silty sand ranged from 1 to 9 blows/0.3 m, indicating a very loose to loose relative density. An 'N' value of 25 blows/0.3 m was measured in Borehole 45-07L, indicating a compact relative density or a possible obstruction.

The natural moisture contents generally ranged from 14 to 50%. Higher moisture contents of 137 and 200% were measured in two samples from Boreholes 45-08 and 45-09R containing peaty organics.

A grain size distribution curve of a silty sand sample is presented on the Record of Borehole sheet and on Figure X1 of Appendix X. The results are summarized as follows:

Gravel %	0
Sand %	61
Silt %	25
Clay %	14

Silty Clay

Native grey to brown silty clay containing trace to some sand was contacted below the organic layer in Boreholes 45-04 and 45-06, and below the silty sand layer in Boreholes 45-02, 45-03L, 45-05R, 45-08 and 45-09R. The silty clay thickness ranged between 0.6 and 4.7 m. The depth to the base of the silty clay ranged from 1.5 to 5.5 m (Elev. 187.3 to 191.3 m).

The silty clay is very soft to soft in consistency, based on SPT 'N' values of 0 to 4 blows/0.3 m of penetration. The undrained shear strength of the clay determined by in situ vane testing ranged from 16 to 26 kPa (soft to firm). The moisture contents ranged from 16 to 67%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures X2 and X3 of Appendix X. Atterberg Limits test results are presented on Figures X5 and X6. The results are summarized as follows:

Gravel %	0
Sand %	3 to 18
Silt %	34 to 68
Clay %	27 to 62
Liquid Limit	31 to 64
Plastic Limit	17 to 22

The above results show that the silty clay varies from low to high plasticity with group symbols of CL to CH.

Sand

A layer of sand was contacted below the silty clay at depths of 3.0 to 4.6 m in Boreholes 45-06, 45-08 and 45-09R. The thickness of the sand layer ranged from 0.3 to 1.4 m. The depth to the base of the sand deposit ranged from 3.3 to 6.0 m (Elev. 186.5 to 189.9 m).

SPT 'N' values of 26 blows/0.3 m to 51 blows/0.175 m were obtained in the sand, indicating compact to very dense conditions. The natural moisture contents ranged from 9 to 18%.

Grain size distribution curves of three sand samples are presented on the Record of Borehole sheets and on Figure X4 of Appendix X. The results of the laboratory testing are summarized as follows:

Gravel %	0 to 8
Sand %	89 to 96
Silt & Clay %	3 to 4

Bedrock

Probable bedrock was contacted in all of the boreholes and DCPTs at depths of 0.0 to 7.1 m (Elev. 185.6 to 194.2 m). The depths/elevations are listed in Table 5.47.

Table 5.47 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
45-01	0.8	192.3
45-02	1.7	191.1
45-03L	3.2	189.5
45-04	3.4	189.2
45-05R	5.5	187.3
45-06	6.0	186.5
45-07L	1.0	192.0
45-08	3.8	189.1
45-09R	3.3	189.9

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
45-10	0.5	193.0
D45-01R	3.3	189.3
D45-02L	7.1	185.6
D45-03R	2.8	189.7
D45-04L	0.0	194.2

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 45-05R and 45-09R to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometers are summarized in Table 5.48.

Table 5.48 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
45-02	Sept 9, 2008	0.9	191.9	Open borehole
45-03L	Sept 9, 2008	0.3	192.4	Open borehole
45-04	Sept 9, 2008	0.3	192.3	Open borehole
45-05R	Sept 8, 2008	0.3	192.5	Open borehole
	Sept 24, 2008	0.2 ags	193.0	In piezometer
	Oct 29, 2008	0.0	192.8	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.7 ags	193.5	In piezometer
	Jun 4, 2009	0.5 ags	193.3	In piezometer
	Aug 17, 2009	0.6	192.2	In piezometer
	Aug 25, 2009	0.5	192.3	In piezometer
	Oct 27, 2009	0.6	192.2	In piezometer
	Nov 20, 2009	1.0	191.8	In piezometer
45-08	Sept 9, 2008	0.4	192.5	Open borehole
45-09R	Sept 9, 2008	1.0	192.2	Open borehole
	Sept 24, 2008	3.0	190.2	In piezometer
	Oct 29, 2008	0.2	193.0	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.1	193.1	In piezometer
	Jun 5, 2009	0.0	193.2	In piezometer
	Aug 17, 2009	0.2	193.0	In piezometer
	Aug 25, 2009	0.1	193.1	In piezometer
	Oct 27, 2009	0.2	193.0	In piezometer
	Nov 20, 2009	0.6	192.6	In piezometer

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.24 Highway 69 NBL, Sta. 14+110 to 14+280 Wallbridge (Appendix Y)

General

The subsurface stratigraphy at this site consists of relatively thin deposits of peat/organics, silty clay and silty sand underlain by bedrock.

Peat and Organics

A layer of brown fibrous peat and/or organic material was identified at the ground surface in all boreholes except Borehole 46-09. The thickness of the organic layer ranged from 50 to 700 mm. The thickness may vary between and beyond the borehole locations.

SPT 'N' values of 0 to 2 blows/0.3 m were recorded in this layer. Natural moisture contents of 185 to 626% were measured.

Silty Clay

Native grey to brown silty clay containing trace sand to sandy was contacted below the peat layer in Boreholes 46-02, 46-04, 46-07, 46-08R and 46-10L. The thickness of the silty clay was 1.0 to 1.9 m. The lower boundary of the silty clay was at depths of 1.2 to 2.3 m (Elev. 191.5 to 193.5 m).

The silty clay is soft to stiff in consistency, based on SPT 'N' values of 2 to 14 blows/0.3 m of penetration. The moisture contents ranged from 20 to 51%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figure Y1 of Appendix Y. Atterberg Limits test results are presented on Figure Y4. The results are summarized as follows:

Gravel %	0
Sand %	6 to 32
Silt %	39 to 49
Clay %	22 to 55
Liquid Limit	47 to 64
Plastic Limit	20 to 25

The above results show that the silty clay is of medium to high plasticity with group symbols of CI and CH.

Silty Sand

Native brown to grey silty sand containing occasional peaty organics was contacted below the organic layer in Boreholes 46-03L and 46-11, and below the silty clay in Borehole 46-04. The thickness of the silty sand layer was 0.4 to 1.2 m. The boreholes were terminated below the silty sand layer at depths of 0.5 to 2.9 m (Elev. 192.3 to 194.7 m), upon auger refusal on probable bedrock.

SPT 'N' values of 3 to 12 blows/0.3 m (very loose to compact) were recorded in the silty sand in Boreholes 46-04 and 46-11. The natural moisture contents ranged from 13 to 30%.

Grain size distribution curves for silty sand samples are presented on the Record of Borehole sheets and on Figure Y2 of Appendix Y. The results are summarized as follows:

Gravel %	0 to 5
Sand %	49 to 61
Silt %	27 to 35
Clay %	7 to 16

Sand

Brown to grey sand with trace to some silt was encountered below the silty clay in Boreholes 46-07 and 46-10L at depths of 1.8 and 1.2 m. The sand layer was 1.2 m thick in each borehole. The boreholes were terminated below the sand layer at depths of 3.0 and 2.4 m (Elev. 190.9 and 191.6 m), upon auger refusal on probable bedrock.

SPT 'N' values of 13 to 30 blows/0.3 m were obtained in the sand, indicating a generally compact condition. Moisture contents ranged from 11 to 19%.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets and on Figure Y3 of Appendix Y. The results are summarized as follows:

Gravel %	4 to 8
Sand %	84 to 86
Silt & Clay %	6 to 12

Bedrock

Bedrock or probable bedrock was contacted at depths of 0.0 to 3.0 m (Elev. 190.9 to 195.8 m) in all boreholes and DCPTs. The depths and elevations of the bedrock surface are summarized in Table 5.49.

Table 5.49 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
46-01	0.1	195.8
46-02	1.8	193.3
46-03L	0.5	194.7
46-04	2.9	192.3
46-05R	0.5	195.1
46-06	0.2	195.2
46-07	3.0	190.9
46-08R	2.3	191.5
46-09	0.0	193.5
46-10L	2.4	191.6
46-11	1.0	193.7
D46-01R	1.3	193.7
D46-02L	0.9	194.6
D46-03R	1.2	193.1
D46-04L	0.0	195.1
D46-05R	2.4	191.3

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 46-04 to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.50.

Table 5.50 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
46-02	Sept 10, 2008	0.0	195.1	Open borehole
46-03L	Sept 10, 2008	0.0	195.2	Open borehole
46-04	Sept 10, 2008	0.0	195.2	Open borehole
	Sept 24, 2008	0.1	195.1	In piezometer
	Oct 29, 2008	0.2	195.0	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	195.2	In piezometer
	Jun 5, 2009	0.0	195.2	In piezometer
	Aug 17, 2009	0.0	195.2	In piezometer
	Aug 25, 2009	0.0	195.2	In piezometer
	Oct 27, 2009	0.0	195.2	In piezometer
	Nov 20, 2009	0.0	195.2	In piezometer
46-05R	Sept 10, 2008	0.2	195.4	Open borehole
46-06	Sept 10, 2008	0.0	195.4	Open borehole

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
46-07	Dec 2, 2010	1.5	192.4	Open borehole
46-08R	Dec 1, 2010	0.2	193.6	Open borehole
46-10L	Nov 30, 2010	1.8	192.2	Open borehole
46-11	Nov 30, 2010	0.3	194.4	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.25 Highway 69 NBL, Sta. 14+460 to 14+690 Wallbridge (Appendix Z)

General

This site consists of an area of undulating bedrock with depressions in the bedrock surface infilled with silty clay, sand and locally silt or sand and gravel.

Organic Material

A layer of organic material was encountered surficially in 13 of 16 boreholes drilled at the site. The thickness of this layer ranged from 50 to 900 mm. The thickness of organic material may vary between and beyond the borehole locations.

SPT 'N' values of 2 and 5 blows/0.3 m were recorded in the organic layer. The natural moisture contents ranged from 40 to 873%.

Silty Clay

Brown to grey silty clay containing trace sand to sandy and occasional peaty organics was encountered surficially in Boreholes 47-03L and 47-06, below the organic layer in Boreholes 47-04, 47-05R, 47-08 and 47A-05, and below a sand layer in Boreholes 47-01, 47A-01, 47A-02L and 47A-03. The thickness of the silty clay deposit ranged from 0.3 to 2.5 m.

The lower boundary of the silty clay was encountered at depths ranging from 0.6 to 3.2 m (Elev. 191.5 to 194.5 m).

The consistency of the silty clay is variable. SPT 'N' values typically ranged from 0 to 7 blows/0.3 m, indicating a very soft to firm consistency. However, in Boreholes 47-04, 47A-01 and 47A-02L, 'N' values of 19 to 33 blows/0.3 m were recorded, indicating a very stiff to hard condition. Moisture contents ranged from 15 to 70%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures Z1 and Z2 of Appendix Z.

Atterberg Limits test results are presented on Figure Z5. The results are summarized as follows:

Gravel %	0
Sand %	1 to 30
Silt %	28 to 61
Clay %	20 to 68
Liquid Limit	42 to 52
Plastic Limit	16 to 28

The above results indicate that the silty clay is of medium to high plasticity with group symbols of CI and CH.

Sand to Silty Sand

Brown sand with peaty organics, trace silt to silty, was encountered below the organic layer in Boreholes 47-01, 47A-01 to 47A-04, and 47A-06L and below the silty clay at depths of 0.6 to 2.6 m in Boreholes 47-03L, 47-04 and 47A-05. Secondary sand layers were encountered within the clay in Boreholes 47A-02L and 47A-03.

The thickness of the sand layers ranged from 0.3 to 1.9 m. The lower boundary was at depths of 0.6 to 4.3 m (Elev. 190.5 to 194.8 m).

SPT 'N' values of 1 to 16 blows/0.3 were recorded in the sand, indicating a very loose to compact relative density. Moisture contents ranged from 15 to 65%.

Grain size distribution curves for samples of the sand are presented on the Record of Borehole sheets and on Figure Z3 of Appendix Z. The results are summarized as follows:

Gravel %	0 to 4
Sand %	60 to 94
Silt & Clay %	6 to 40

Silt

A 1.3 m thick layer of silt, some sand, was encountered surficially in Borehole 47-09R. This borehole was terminated below the silt upon auger refusal on probable bedrock.

The silt is loose to compact in relative density, based on SPT 'N' values of 5 and 19 blows/0.3 m of penetration.

A grain size distribution curve for a sample of the silt are presented on the Record of Borehole sheet and on Figure Z4 of Appendix Z. The results are summarized as follows:

Gravel %	0
Sand %	16
Silt %	81
Clay %	3

Sand and Gravel

A 0.3 m thick layer of sand and gravel was encountered between the sand unit and probable bedrock in Borehole 47-04. The upper boundary of this unit was at 4.3 m depth (Elev. 190.5 m). A moisture content of 9% was measured.

Bedrock

Probable bedrock was contacted in all boreholes and DCPTs at depths of 0.1 to 5.1 m (Elev. 190.0 to 196.1 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.51.

Table 5.51 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
47-01	1.1	194.3
47-02	0.1	195.3
40-03L	1.2	193.9
47-04	4.6	190.2
47-05R	3.2	191.5
47-06	1.7	193.2
47-07L	0.5	194.6
47-08	1.2	194.2
47-09R	1.3	194.0
47-10	0.1	196.1
D47-01R	2.2	192.6
D47-02L	1.7	193.0
D47-03R	0.2	194.9
D47-04L	0.8	195.2
47A-01	1.8	193.6
47A-02L	2.4	192.7
47A-03	2.4	192.7
47A-04R	0.8	194.3
47A-05	1.2	193.9
47A-06L	2.1	193.6
D47A-01L	0.1	196.0
D47A-02R	2.7	192.4
D47A-03L	0.9	194.2
D47A-04R	0.5	195.0
C236-D1	5.1	190.0

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 47-05R to monitor water levels after

completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.52.

Table 5.52 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
47-03L	Sept 10, 2008	0.0	195.1	Open borehole
47-04	Sept 10, 2008	0.0	194.8	Open borehole
47-05R	Sept 11, 2008	0.0	194.7	Open borehole
	Sept 24, 2008	0.0	194.7	In piezometer
	Oct 29, 2008	0.3	194.4	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	0.2	194.5	In piezometer
	Apr 21, 2009	0.0	194.7	In piezometer
	Jun 5, 2009	0.0	194.7	In piezometer
	Aug 17, 2009	0.0	194.7	In piezometer
	Aug 25, 2009	0.0	194.7	In piezometer
	Oct 27, 2009	0.0	194.7	In piezometer
	Nov 20, 2009	0.0	194.7	In piezometer
47-06	Sept 11, 2008	0.0	194.9	Open borehole
47-07L	Sept 10, 2008	0.0	195.1	Open borehole
47A-02L	Dec 1, 2010	0.4	194.7	Open borehole
47A-03	Dec 1, 2010	1.2	193.9	Open borehole
47A-04R	Dec 1, 2010	0.2	194.9	Open borehole
47A-05	Dec 1, 2010	0.6	194.5	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.26 Highway 69 NBL & SBL, Sta. 15+050 to 15+190 Wallbridge (Appendix AA)

General

The existing Highway 69 crosses a swamp at this location. In boreholes drilled from the existing highway platform, a pavement structure overlying probable rock fill was encountered.

In boreholes drilled off of the road embankment, the subsurface stratigraphy generally consisted of a peat layer overlying silty sand, underlain by a relatively thick deposit of silty clay, overlying sand and probable bedrock.

Pavement Structure and Existing Embankment Fill

A pavement structure consisting of approximately 40 to 50 mm of asphalt overlying granular road base (sand fill) was encountered in Boreholes 49-01, 49-03, 49-04R, 49-05 and C239-2 drilled on the existing Highway 69 platform.

The road base/embankment fill consists of brown sand containing some gravel and occasional rock fragments. All boreholes and DCPTs on the road, except Borehole C239-2, were terminated below the sand fill upon refusal on probable rock fill at depths of 0.6 to 1.2 m (Elev. 192.9 to 193.9 m). Borehole C239-2 was advanced through the rock fill using rock coring methods and encountered a 0.8 m thick layer of rock fill with a lower boundary at 2.2 m depth (Elev. 191.8 m).

SPT 'N" values of 15 blows/0.3 m and 115 blows/0.225 m were recorded in the fill, indicating a compact to very dense condition. Moisture contents ranged from 5 to 8%.

Peat

A layer of peat was encountered at the ground surface in Boreholes 48-04, 48-06, 48-08R to 48-11R, 49-06R to 49-10R, C238-1 and C239-1. The thickness of the peat layer ranged from 0.2 to 1.3 m. The thickness of the peat may vary between and beyond the borehole locations.

SPT 'N' values of 1 and 2 blows/0.3 m were obtained in the peat. Natural moisture contents of 159 and 279% were measured.

Sand to Silty Sand

Native brown to grey silty sand containing some clay and occasional peaty organics was contacted surficially or below the peat in Boreholes 48-01 to 48-10, 49-06R, 49-08R, C238-1 and C239-1, as well as below the rock fill in Borehole C239-2. The sand to silty sand layer was 0.5 to 1.8 m thick with a lower boundary at depths of 0.7 to 3.1 m (Elev. 189.3 to 191.9 m).

SPT 'N' values recorded in the sand to silty sand ranged from 0 to 7 blows/0.3 m, indicating a very loose to loose relative density. An 'N' value of 14 blows/0.3 m (compact) was obtained locally in the buried sand layer in Borehole C239-1. The natural moisture contents ranged from 19 to 48%, with two values of 80 and 82% measured, reflecting the presence of organics.

Grain size distribution curves of samples of the silty sand are presented on the Record of Borehole sheets and on Figure AA1 of Appendix AA. The results are summarized as follows:

Gravel %	0
Sand %	60 to 69
Silt %	26 to 34
Clay %	5 to 11

Silt to Sandy Silt

A layer of silt to sandy silt was encountered surficially in Borehole 49-02L, below the peat in Boreholes 48-11R and 49-09L, and below the sand to silty sand in Boreholes 49-08R and C239-1. The thickness of the silt/sandy silt deposit ranged from 1.2 to 2.6 m. The lower boundary was at 1.6 to 3.7 m depth (Elev. 190.5 to 187.8 m).

A second layer of sandy silt was encountered in Borehole 49-02L, within silty clay at a depth of 5.0 m (Elev. 187.1 m). This stratum was 1.6 m thick with a lower boundary at 6.6 m depth (Elev. 185.5 m).

The silt to sandy silt is very loose to compact in relative density, based on SPT 'N' values ranging from 1 to 21 blows/0.3 m. Moisture contents of 15 to 55%, locally 411% in one sample containing organics, were recorded.

Grain size distribution curves for samples of the silt to sandy silt are presented on the Record of Borehole sheets and on Figures AA2 and AA3 of Appendix AA. The results are summarized as follows:

Gravel %	0
Sand %	5 to 39
Silt %	50 to 79
Clay %	8 to 16

Silty Clay

Native grey to brown silty clay containing trace to some sand was contacted below the sand and silt layers in Boreholes 48-01 to 48-11R, 49-02L, 49-06R to 49-09L, C238-1, C239-1 and C239-2, as well as immediately below the peat in Borehole 49-10R. The upper boundary of this unit was at depths of 0.3 to 3.7 m (Elev. 191.9 to 188.7 m). The thickness of the silty clay ranged from 0.8 to 7.6 m, locally 8.9 m in Borehole 49-02L but interrupted by a 1.6 m thick layer of sandy silt at 5.0 m depth.

The depth to the base of the silty clay ranged from 1.8 to 10.7 m (Elev. 191.1 to 181.6 m).

The clay layer is very soft to stiff in consistency, based on SPT 'N' values of 0 to 8 blows/0.3 m, locally up to 13 blows near the ground surface in Borehole 49-10R. The undrained shear strength of the clay determined by in situ vane testing ranged from 24 to 80 kPa (firm to stiff), with localized measurements of 6 to 8 kPa (very soft) in Borehole 49-02L. Moisture contents ranged from 19 to 62%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on the Record of Borehole sheets and on Figures AA4 to AA8 of Appendix AA. Atterberg Limits test results are presented on Figures AA10 and AA13. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 31
Silt %	26 to 76
Clay %	19 to 70
Liquid Limit	23 to 62
Plastic Limit	13 to 24

The above results indicate that the silty clay varies from low to high plasticity with group symbols of CL, CI and CH.

Sand

Grey sand containing trace silt and gravel was contacted below the silty clay at depths of 3.0 to 10.7 m in Boreholes 48-03L, 48-04, 48-05R, 48-10, 49-08R, C238-1, C239-1 and C239-2. This deposit was identified as silty sand and gravelly sand layers in Borehole 49-02L, and graded to a silt and sand in Borehole 48-11R. The thickness of the sand layer was 1.0 to 4.1 m.

The boreholes were terminated below the sand at depths of 5.1 to 12.5 m (Elev. 187.0 to 179.7 m), upon auger refusal on probable bedrock.

SPT 'N' values measured in the sand typically ranged from 0 to 9 blows/0.3 m, indicating a very loose to loose condition. 'N' values of 12 to 33 blows/0.3 m were obtained in Boreholes 48-10, 49-02L, 49-08R, C238-1, C239-1 and C239-2, indicating a compact to dense condition. One value of 76 blows (very dense) was recorded on Borehole C239-1. Moisture contents ranged from 10 to 30%.

Grain size distribution curves for samples of the sand are presented on the Record of Borehole sheets and on Figure AA9 of Appendix AA. The results are summarized as follows:

	Sand	Silt and Sand
Gravel %	0 to 15	0
Sand %	81 to 98	41
Silt %	2 to 8	47
Clay %		12

Bedrock

Probable bedrock was contacted in all boreholes and DCPTs drilled off of the road platform, at depths of 1.3 to 12.5 m (Elev. 191.2 to 179.7 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.53.

Table 5.53 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
48-01	2.2	190.3
48-02	7.2	185.0
48-03L	9.1	182.8
48-04	7.7	184.1
48-05R	5.1	187.0
48-06	3.8	188.3
48-08R	1.8	191.1
48-09L	3.0	188.9
48-10	5.4	186.6
48-11R	8.7	183.5
D48-01R	11.7	180.4
D48-02L	5.4	186.6
D48-03L	5.4	187.0
D48-04R	5.0	187.2
D48-05L	4.0	188.1
49-02L	12.3	179.8
49-06R	2.2	190.6
49-08R	9.6	182.8
49-09L	6.7	185.2
49-10R	4.3	187.7
D49-02L	4.9	187.3
D49-03R	2.6	191.2
D49-04L	1.3	191.1
D49-05R	7.5	184.5
D49-07R	2.1	190.4
D49-08L	7.6	184.6
C238-1	7.3	184.5
C239-1	12.5	179.7
C239-2	11.8	182.2

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 48-04, 48-10 and C239-1 to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.54.

Table 5.54 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
48-01	Sept 12, 2008	1.9	190.6	Open borehole
48-02	Sept 12, 2008	1.5	190.7	Open borehole
48-03L	Sept 12, 2008	0.9	191.0	Open borehole
48-04	Sept 12, 2008	0.2	191.6	Open borehole
	Oct 29, 2008	0.1	191.7	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.2	191.6	In piezometer
	Jun 5, 2009	0.0	191.8	In piezometer
	Oct 27, 2009	0.3	191.5	In piezometer
48-05R	Sept 13, 2008	0.3	191.8	Open borehole
48-06	Sept 13, 2008	0.0	192.1	Open borehole
48-08R	Feb 13, 2011	0.1 ags	192.9	During drilling
48-09L	Feb 13, 2011	0.3	191.6	Open borehole
48-10	Feb 22, 2011	0.4	191.6	In piezometer
	Mar 1, 2011	0.4	191.6	In piezometer
	Mar 13, 2011	0.0	192.0	In piezometer
	Apr 27, 2011	0.4	192.0	In piezometer
48-11R	Feb 13, 2011	0.9	191.3	Open borehole
49-02L	Feb 9, 2010	0.0	192.1	Open borehole
49-06R	Feb 13, 2011	0.6	192.2	Open borehole
49-08R	Feb 13, 2011	0.7	191.7	Open borehole
49-10R	Feb 13, 2011	2.0	190.0	Open borehole
C238-1	May 23, 2012	0.8	191.0	Open borehole
C239-1	Jun 5, 2012	0.5	191.7	In piezometer
	Jun 21, 2012	0.5	191.7	In piezometer
	Jul 5, 2012	0.5	191.7	In piezometer

ags = above ground surface

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.27 Highway 69 NBL, Sta. 15+450 to 15+560 Wallbridge (Appendix BB)

General

This site consists of an undulating bedrock surface with shallow depressions infilled with organics, silty clay and sand.

Organic Material

A 25 to 75 mm thick layer of organic material was identified at the ground surface in Boreholes 50-04R, 50-07 and 50-08R. The thickness of the organic material may vary between and beyond the borehole locations.

Sand

Brown sand with peaty organics was encountered surficially in Boreholes 50-01, 50-05 and 50-06L. The thickness of the sand layer was 0.3 to 0.5 m.

SPT 'N' values of 1 blow/0.3 m were obtained in the sand, indicating a very loose condition. Moisture contents 43 to 255% were measured, reflecting the high organic content of this layer.

Silty Clay

Grey silty clay containing trace sand to sandy was encountered below the peat and sand layers in Boreholes 50-05 to 50-07. The thickness of the silty clay was 0.9 to 1.4 m, and the lower boundary was encountered at depths of 1.4 to 1.5 m (Elev. 194.6 to 194.8 m).

SPT 'N' values obtained in the silty clay ranged from 1 to 6 blows/0.3 m, indicating a very soft to firm consistency. The moisture contents ranged from 18 to 46%.

The results of grain size distribution analyses conducted on two samples of silty clay are presented on the Record of Borehole sheets and on Figure BB1 of Appendix BB. Atterberg Limits test results are presented on Figure BB2. The results are summarized as follows:

Gravel %	0
Sand %	10 to 25
Silt %	51 to 52
Clay %	24 to 38
Liquid Limit	39
Plastic Limit	17

The above results show that the silty clay is of medium plasticity with a group symbol of CI.

Silty Sand

A 0.4 m thick layer of silty sand was encountered below the silty clay in Borehole 50-05. This borehole was terminated below the silty sand at 1.8 m depth, upon refusal on probable bedrock. A moisture content of 20% was measured.

Sand and Gravel

Grey sand and gravel was contacted below the silty clay at 1.5 m depth in Borehole 50-07. This borehole was terminated below the sand and gravel layer at 2.0 m depth, upon refusal on probable bedrock. A moisture content of 12% was measured.

Bedrock

Probable bedrock was exposed surficially or contacted in all boreholes and DCPTs at depths of 0.0 to 2.0 m (Elev. 194.1 to 197.7). The depths and elevations of the probable bedrock surface are summarized in Table 5.55.

Table 5.55 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
50-01	0.5	195.8
50-02L	0.0	197.4
50-03	0.0	197.3
50-04R	0.0	197.1
50-05	1.8	194.4
50-06L	1.4	194.8
50-07	2.0	194.1
50-08R	0.1	196.7
50-09	0.0	197.7
50-10	0.0	196.9
D50-01R	0.0	196.9
D50-02L	0.0	198.1
D50-03R	0.0	196.1
D50-04L	0.0	197.6

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. The water levels observed during drilling are summarized in Table 5.56.

Table 5.56 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
50-01	Sept 13, 2008	0.0	196.3	Open borehole
50-05	Sept 13, 2008	0.0	196.2	Open borehole
50-06L	Sept 13, 2008	0.0	196.2	Open borehole
50-07	Sept 13, 2008	0.0	196.1	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.28 Highway 69 NBL, Sta. 15+710 to 15+800 Wallbridge (Appendix CC)

General

The subsurface stratigraphy on much of this site consists of a thin layer of organic material overlying bedrock. A bedrock depression at the south end of the site is infilled with silty sand and sand and silt deposits, encasing a thin layer of silty clay.

Organic Material

A layer of dark brown to brown, peaty organic material was identified at the ground surface in Boreholes 51-03, 51-04R, 51-05, 51-07 and 51-08R. The thickness of the organic layer ranged from 150 to 600 mm. The thickness may vary between and beyond the borehole locations.

Natural moisture contents of 50 to 147% were measured in this layer.

Sand to Sand and Silt

Brown to grey silty sand to sand and silt was contacted surficially in Boreholes 51-01 and 51-02L, and below the organic layer in Borehole 51-08R. The sand/silt contains occasional peat layers and decayed wood pieces in Boreholes 51-01 and 51-02L, and a silty clay layer was encountered within the sand/silt in all three boreholes. The upper 1.3 m of this deposit was coarser in Borehole 51-08R, with trace to some silt.

Boreholes 51-01, 51-02L and 51-08R were terminated below the sand/silt at 3.3 to 3.5 m depth (Elev. 191.8 to 192.0 m), upon auger refusal on probable bedrock.

SPT 'N' values in the sand/silt ranged from 2 to 14 blows/0.3 m of penetration, indicating a very loose to compact relative density. The natural moisture contents ranged from 12 to 27%.

Grain size distribution curves of sand and silt samples are presented on the Record of Borehole sheets and on Figure CC1 of Appendix CC. The results are summarized as follows:

	Sand/Silt	Sand
Gravel %	0	0
Sand %	54 to 62	96
Silt %	30 to 37	4
Clay %	8 to 9	

Silty Clay

A 0.2 to 0.4 m thick layer of silty clay was encountered within the sand/silt deposit at 1.8 to 2.2 m depth in Boreholes 51-01, 51-02L and 51-08R. The lower boundary of this layer was at 2.2 to 2.4 m depth (Elev. 192.9 to 193.1 m).

The silty clay is very soft in consistency, based on SPT 'N' values of 1 and 2 blows/0.3 m of penetration. Moisture contents of 28 to 45% were measured.

The results of grain size distribution analyses conducted on two samples of silty clay are presented on the Record of Borehole sheets and on Figure CC2 of Appendix CC. Atterberg Limits test results are presented on Figure CC3. The results are summarized as follows:

Gravel %	0
Sand %	2 to 7
Silt %	27 to 28
Clay %	65 to 71
Liquid Limit	55 to 59
Plastic Limit	22 to 23

The above results show that the silty clay is of high plasticity with a group symbol of CH.

Bedrock

Bedrock or probable bedrock was observed surficially or contacted at depths of 0.0 to 3.5 m (Elev. 191.8 to 196.3 m) in all boreholes and DCPTs. The depths and elevations of the bedrock surface are summarized in Table 5.57.

Table 5.57 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
51-01	3.4	191.9
51-02L	3.5	191.8
51-03	0.3	194.6
51-04R	0.2	195.4
51-05	0.6	194.2
51-06L	0.0	195.8
51-07	0.2	196.3
51-08R	3.3	192.0
D51-01R	0.8	194.5
D51-02L	1.2	193.5
D51-03R	0.2	195.4
D51-04L	0.8	194.8

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 51-02L to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.58.

Table 5.58 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
51-01	Sept 14, 2008	1.1	194.2	Open borehole
51-02L	Sept 14, 2008	2.2	193.1	Open borehole
	Oct 29, 2008	0.3	195.0	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	195.3	In piezometer
	Jun 5, 2009	0.1	195.2	In piezometer
	Aug 17, 2009	0.2	195.1	In piezometer
	Aug 25, 2009	0.2	195.1	In piezometer
	Oct 27, 2009	0.3	195.0	In piezometer
	Nov 20, 2009	0.7	194.6	In piezometer

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

5.29 Highway 69 NBL, Sta. 15+860 to 15+915 Wallbridge (Appendix DD)

General

This site consists of a shallow depression in the bedrock surface infilled with organics and sand.

Organic Material

A layer of dark brown peaty organic material was identified at the ground surface in all boreholes drilled at this site. The thickness of the organic layer ranged from 50 to 800 mm. The thickness may vary between and beyond the borehole locations.

A natural moisture content of 148% was measured in one sample of this material.

Sand

Brown sand was contacted below the organic layer in Boreholes 52-03L and 52-04. The thickness of the sand was 2.5 and 0.6 m. The lower boundary was at 2.6 and 1.4 m depth (Elev. 191.8 and 193.4 m).

SPT 'N' values in the sand ranged from 1 to 7 blows/0.3 m of penetration, indicating a very loose to loose relative density. The natural moisture contents ranged from 21 to 22%.

Grain size distribution curves of two sand samples are presented on the Record of Borehole sheets and on Figure DD1 of Appendix DD. The results are summarized as follows:

Gravel %	0 to 2
Sand %	96 to 98
Silt & Clay %	2

Bedrock

Probable bedrock was contacted in all boreholes and DCPTs at depths of 0.0 to 2.6 m (Elev. 174.9 to 192.7 m). The depths and elevations of the probable bedrock surface are summarized in Table 5.59.

Table 5.59 – Depth/Elevation of Probable Bedrock

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
52-01	0.2	195.8
52-02	0.1	195.1
52-03L	2.6	191.8
52-04	1.4	193.4
52-05R	0.1	196.5
52-06	0.4	197.8
D52-01R	1.5	193.2
D52-02L	0.0	197.5

Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 52-03L to monitor water levels after completion of drilling. The water levels observed during drilling and measured in the piezometer are summarized in Table 5.60.

Table 5.60 – Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
52-03L	Sept 14, 2008	0.0	194.4	Open borehole
	Oct 29, 2008	0.4	194.0	In piezometer
	Jan 16, 2009	Frozen	-	In piezometer
	Feb 19, 2009	Frozen	-	In piezometer
	Apr 21, 2009	0.0	194.4	In piezometer
	Jun 5, 2009	0.1	194.3	In piezometer
	Aug 17, 2009	0.0	194.4	In piezometer
	Aug 25, 2009	0.0	194.4	In piezometer
	Oct 27, 2009	0.0	194.4	In piezometer
	Nov 20, 2009	0.0	194.4	In piezometer
52-04	Sept 14, 2008	0.0	194.8	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

6 MISCELLANEOUS

MMM Group Limited staked the centreline alignment prior to drilling of the boreholes. The borehole locations were established by measuring offset distances from the centreline staking. The approximate ground surface elevations at the boreholes were interpreted from the contour plan provided by MMM Group.

Eastern Ontario Diamond Drilling Ltd. Of Hawkesbury, Ontario supplied and operated the drilling and sampling equipment for the field program. Full time supervision of the field activities, including obtaining utility clearances, was carried out by Mr. Stephane Loranger, Mr. Will Ball, Mr. Luke Gilarski, Mr. Jason Mei and Ms. Eckie Siu of Thurber.

Supervision of the field program, interpretation of the field data, and preparation of the report was performed by Mrs. Rocío Palomeque Reyna, P. Eng. and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer

P.K. Chatterji, P.Eng., Ph.D.
Review Principal

FOUNDATION INVESTIGATION AND DESIGN REPORT
SWAMP CROSSINGS AND HIGH FILL EMBANKMENTS
HIGHWAY 69 FOUR-LANING
FROM THE SOUTH JUNCTION OF HIGHWAY 529 TO 15 KM NORTH
G.W.P. 5076-06-00
NORTH SECTION – NAISCOOT LAKE TO NORTH PROJECT LIMIT

Geocres Number: 41H-99

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents foundation design recommendations for swamp crossings and high fill embankments required for the proposed four-laning of Highway 69.

The overall project consists of widening Highway 69 from a two-lane undivided roadway to a four-lane divided highway. The current widening section extends from the south junction of Highway 529 northerly for 15 km in the Townships of Harrison and Wallbridge in Ontario. This report addresses the northern part of this section, from north of Naiscoot Lake to the north limit, a length of approximately 11.2 km. The remaining part of the section is discussed in a separate report.

Twenty-nine areas of swamp crossing or high fill embankments are addressed in this report. A summary of the sections, including locations, lengths, maximum fill height, generalized stratigraphy and groundwater conditions, is presented on Table A3 in Appendix A. The factual data for each section has been assigned to an appendix, Appendix B through DD, and the respective appendix designation is included in Table A3.

The project information used for preparation of this report, including plans and profiles of the proposed alignments as of July 2010 and cross-sections as of January 2011, was provided by MMM Group. The discussion and recommendations presented in this report are based on the information provided by MMM and the factual data obtained during the course of the investigation.

8 ENGINEERING ANALYSIS METHODOLOGY

8.1 General

The subsurface conditions at the swamp crossing and high fill locations were investigated to assess the stability of proposed embankment slopes, potential embankment settlement issues, and construction concerns. Major factors to be addressed for embankment design on this project include:

- Embankment geometry (height, slope angle, stabilizing berms);
- Embankment material type (rockfill, granular fill or earth fill);
- The extent and thickness of peat, organic, compressible and/or excessively soft/loose soils underlying the embankment footprint;
- The thickness and engineering properties of the foundation soils;
- The elevations and properties of bedrock;
- Post-construction settlement of embankments;
- Construction procedures and groundwater conditions during removal of peat, organic or compressible soils.

The geotechnical analyses summarized in this report include assessment of the global stability of fill embankments for both short and long term conditions. Assessment of immediate and long-term settlements, including magnitude and time rate, was also carried out. The analyses were based on the soil profiles and properties encountered at various locations, selected for less favourable conditions.

For the purpose of preparing geotechnical design recommendations, a number of assumptions have been made that are consistent with MTO's standard highway design practices:

- The high fills and embankments crossing swamps will be constructed using rock fill. Sources of earth fill are not expected to be available on this project. Granular fill may be required for surcharge construction.
- High fills will be constructed with side slopes not exceeding 1.25H:1V for rock fill and 2H:1V for granular fill.
- Embankment slopes greater than 10 m high in rock fill will be provided with a 2 m wide mid-height berm.
- Organic deposits, topsoil, peat or other deleterious material will be removed prior to constructing fill embankments.

8.2 Stability Analyses

Where the planned fill height exceeds 4.5 m and the foundation does not consist of bedrock, stability analyses were carried out. The commercially available slope stability program GSLOPE developed by Mitre Software Inc. with the option for Bishop's modified method of slices was used for the limit equilibrium analyses.

Analyses were carried out for rock fill embankments, under static and seismic loading conditions. For cohesive soils, short term (undrained) and long term (effective stress) conditions were assessed. Mid-height berms of 2 m width were applied to all slope heights exceeding 10 m in rock fill.

Based on consideration of the risk involved and past experience with highway embankment design/monitoring, a factor of safety of 1.3 is considered appropriate to achieve both short and long-term stability for embankments founded on cohesionless soils. For cohesive foundation soils, the recommended factor of safety is 1.3 for short-term conditions and 1.5 for long-term conditions.

The input parameters and soil model used in the stability analyses, including soil stratigraphy, engineering properties, groundwater conditions, and embankment geometry, are shown for sample analyses on Figures 15-1 to 48-4 in Appendix A.

8.3 Settlement Analyses

Settlement analysis involved computation of the immediate settlement of the foundation soils under the imposed embankment loading, calculation of long-term consolidation settlement using Terzaghi one-dimensional consolidation theory, and estimation of long-term settlement of embankment fill materials due to compression under self-weight.

Immediate settlements due to compression of the embankment foundation soils have been estimated based on elastic theory as described in CHBDC Commentary Section C6.6.

For cohesive soils, the estimated primary consolidation settlement and time to achieve 98% of the consolidation was calculated based on Terzaghi's one-dimensional vertical consolidation formulation combined with computation of stresses in two-dimensional elastic half-space as described in CHBDC Commentary Section C6.6. The parameters used in the analyses were determined by laboratory oedometer tests conducted during the current study and soil moisture correlations developed during past projects.

Settlement due to secondary consolidation of the cohesive deposits was assessed for a design period of 30 years using the following equation and a secondary compression ratio selected based on soil moisture correlations:

$$S_{creep} = C_{\alpha\varepsilon} H \text{ Log } (t/t_p)$$

where S_{creep} = settlement due to secondary consolidation (m)
$C_{\alpha\varepsilon}$ = secondary compression ratio
H = initial thickness of compressible layer (m)
t = time over which secondary compression is to be calculated
t_p = time to completion of primary consolidation

Settlement of rock fill due to particle re-orientation and degradation of the interparticle contacts is expected to continue at a decreasing rate for many years. In accordance with the MTO document "Post-Construction Rock Fill Settlement and Guidelines for Estimating Rock Fill Quantity" (April 12, 2010), the magnitude of this settlement in compacted rock fill is expected to range from 0.5 to 1.0% of the embankment height within 1 year of embankment construction (90% in the first 6 months), and a further 0.1% after the 1 year period. For dumped rock fill (under the water level), these settlement values would be approximately doubled.

The estimated settlement of granular fill embankments due to compression of the compacted fill is 0.5% of the embankment height and is expected to be completed within one to two years after construction.

The estimated magnitudes and rates of settlement are considered approximate and may vary along and across the highway alignment subject to the thickness of compressible layers at a particular location, variations in the consolidation characteristics of the cohesive deposits with depth and location, layer boundary conditions, variations in the relative density of cohesionless soils, the presence of organics or silt/sand/clay partings within the various strata, the depth to bedrock, the height of embankment fill, and degree of compaction achieved in the fill.

8.4 Design Alternatives

Design alternatives considered during analysis of the embankments would typically include the following:

- Full and/or partial sub-excavation of soft cohesive soils in addition to removal of the peat and organic soils;
- Provision of berms and/or flattening of embankment slopes to improve global stability;
- Ground improvement techniques such as preloading/surcharging and geosynthetic reinforcement;

- Construction techniques such as wick drain installation to accelerate settlement or staged construction to maintain stability;
- Use of lightweight fill.

Based on the investigation findings, the results of the design analyses, and construction scheduling considerations, preference has been given to full excavation of peat and soft soils when selecting the recommended option to address stability and/or settlement issues.

8.5 Seismic Considerations

The following seismic parameters have been considered in design:

Velocity Related Seismic Zone	1
Zonal Velocity Ratio	0.05
Acceleration Related Seismic Zone	1
Zonal Acceleration Ratio	0.05

The soil profile type at all sites except Sta. 24+900 to 25+000 (Appendix I) has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.0 should be used in seismic design.

The thickness of soft clay at Sta. 24+900 to 25+000 exceeds 9 m, and therefore the soil profile is classified as Type III and a Site Coefficient of 1.5 is applicable.

A peak horizontal acceleration (PHA) at the ground surface of 0.08 g, where g is the acceleration due to gravity, has been used. The PHA value corresponds to a probability of exceedance of 10% in 50 years. The foundation soils at the site are assessed as not being prone to liquefaction.

9 EMBANKMENT DESIGN AND CONSTRUCTION (INCLUDING SWAMPS)

The generalized subsurface conditions and embankment heights for the various alignments are summarized on Table A3 of Appendix A. The groundwater level was near the ground surface in most sections of proposed fill.

9.1 Swamp Treatment and Subexcavation of Peat and Soft Soils

It is standard procedure on MTO projects to sub-excavate all peat deposits from within the footprint of the embankment, and backfill the resulting excavation with rock or granular fill. Full peat removal is an economical and efficient method of improving stability during construction and minimizing the potential for large post-construction settlements. It is therefore recommended that all peat and organic soils be sub-excavated from the footprint area of all embankments as per the OPSD 203 series.

In some locations, a layer of very soft silty clay or very loose sand with peat inclusions underlies the peat and organic soils. Full or partial subexcavation of the very soft/loose soil is recommended at selected locations to address stability or settlement issues. Further discussion of these areas is presented in subsequent sections.

The anticipated/recommended depth of sub-excavation for peat, soft clay or organic sand removal along the proposed alignments is summarized in Table A4, Appendix A. The depth of excavation is based on the thickness of organics and soft/organic material noted at the borehole locations. Subexcavation depths may vary at locations between and away from the boreholes.

The subexcavated foundation area should be backfilled with rock or granular material as described later in this report. Placement of rock fill is recommended where standing water is encountered.

In the stability and settlement analyses, it has been assumed that the peat and soft/organic deposits have been removed and replaced with rock or granular material as appropriate.

9.2 Site Specific Discussions and Recommended Treatment

Stability analyses were carried out for fill embankments exceeding 4.5 m in height (including sub-excavation depth) and not founded on bedrock, as well as at selected locations of lower embankments. Eleven areas were identified for analysis. All other fill and swamp section embankments were less than 4.5 m in height and/or founded on bedrock or thin cohesionless deposits overlying bedrock following subexcavation of peat, organics and soft soils. Results of the stability analyses carried out at selected critical locations within the swamp/fill sections analysed are summarized in Table A5.

Settlement analysis involved computation of the immediate (elastic) settlement of the foundation soils, the magnitude and time rate of primary consolidation of fine-grained foundation soils, long-term secondary compression, and the short and long-term compression of fill materials under self-weight. The predicted post-construction settlements for all sites are summarized in Table A6 of Appendix A.

Supplementary analyses were carried out as necessary to assess design alternatives such as full or partial sub-excavation of the soft clay, preloading/surcharging and wick drain installation. Discussions regarding the design alternatives for each specific swamp or high fill embankment section are provided below.

To mitigate the effects of the settlement, it is recommended that the embankments generally be constructed at least six months in advance of pavement construction. Embankment and platform width design should allow for the anticipated foundation and embankment compression settlements.

High Fill at Station 21+710 to 22+135 Harrison (Appendix B)

This area comprises a relatively long, narrow area of swamp and beaver ponds, running roughly parallel to the west side of the existing highway, and widening to a broader area at the north end of the section. It is bordered by rock outcrops on the east and west sides. The existing highway crosses over the low area near the south end.

The subsurface stratigraphy generally consists of a surficial layer of organics underlain by very soft to stiff silty clay and discontinuous deposits of sandy silt to gravelly sand. The silty clay extends to a maximum depth of 9.7 m, and probable bedrock was contacted at depths of up to 9.7 m. The maximum proposed embankment height is about 14.1 m.

For assessment purposes, the swamp has been divided into south and north sections. South of approximate Station 21+925, the maximum depth to probable bedrock was 6.2 m and the maximum embankment height for the new southbound lanes will be about 7.0 m. The existing highway grade will be raised by approximately 2.0 m to form the new northbound lanes. In the broader area north of this station, the probable bedrock depth and embankment height for the southbound lanes reach their respective maximum values of 9.7 and 14.1 m noted above.

a) South Section (Sta. 21+710 to 21+925)

Stability analyses were carried out assuming that the organic material (up to 1.1 m thick) would be removed and the rock fill embankment would be constructed directly over the silty clay. Critical sections at approximate Station 21+760 in both the northbound and southbound lanes were selected for the analyses:

- The factors of safety against slope instability computed for the northbound lanes (Figures 15-1 and 15-2 in Appendix A) were approximately 1.36 for short-term (undrained) conditions with a 2 m high surcharge, and 1.49 for long-term (drained) conditions after surcharge removal. These factors of safety are considered to be acceptable.
- For the southbound lanes, the computed factors of safety were 1.14 and 1.62 for short-term and long-term conditions (Figures 15-3 and 15-4), respectively. To increase the short-term factor to the accepted value of at least 1.3, a stabilizing berm must be provided by infilling of the median ditch to Elev. 187.5 m (Figure 15-5).

For the case where all peat and soft clay is excavated (maximum 6.2 m depth) and the rock fill embankment is constructed over bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for an embankment constructed on the clay, for cases with and without a surcharge load, as well as an embankment constructed after full excavation of the clay, produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Construction over clay, no surcharge, 12 month preload	415	110	50	10	120
Construction over clay, 2m surcharge for 12 months	515	60	50	10	70
Full subexcavation of clay	-	-	140	20	20

Based on the above figures, construction of the southbound embankment over the silty clay deposit, application of a 2 m surcharge for a period of at least twelve months, and provision of a temporary median berm (infill to Elev. 187.5 m) is considered a practical option to limit long-term settlements. Maximum settlement within the first year of embankment construction including surcharge is expected to be in the order of 515 mm. Post-construction settlement of the embankment constructed over clay is estimated to be in the order of 70 mm. Monitoring will be required to confirm the magnitude and time-rate of settlement if the fill is placed over the clay layer.

It is noted however that the west side of the southbound embankment will be constructed essentially over bedrock outcrop while the east (median) side will be placed over the deeper clay deposits. As a result, differential settlement may occur transversely across the southbound lanes in addition to longitudinally. To reduce the potential for differential settlement and eliminate the need for surcharging, full excavation of the clay is the recommended alternative for the southbound lanes.

To minimize the potential for disturbance of the existing northbound lanes, the excavation should not extend below a line inclined downward at 1H:1V from the toe of the existing embankment slope. Further, the excavation and backfilling adjacent to the highway must be carried out in sections no longer than 20 m unless roadway protection is provided. A NSSP should be included in the Contract to specify the excavation limitations.

Widening of the existing Highway 69 platform to accommodate the proposed grade raise for the new northbound lanes should be carried out as per OPSD 203.030 including excavation of the peat, organics and soft silty clay from the toe of the existing embankment.

b) North Section (Sta. 21+925 to 22+135)

Stability analyses were initially carried out assuming the peat (up to 1.1 m thick) was removed and the rock fill embankment was constructed directly over the underlying silty

clay. A critical section at Station 22+050 was selected for the analysis (Figure 16-1). The resulting factor of safety against slope instability was less than 1.0, indicating that standard embankment construction is not feasible at this location.

Supplementary analyses were carried out to assess design alternatives such as staged construction, stabilizing berms and full or partial sub-excavation of the soft clay. An iterative approach was applied to produce a practical and cost-efficient solution achieving acceptable factors of safety against slope instability and limiting post-construction settlement to acceptable levels. The need for surcharging and/or waiting periods between successive lifts of staged construction was given consideration in assessing the various options.

The alternative design options and findings of the analyses were as follows:

i. Staged embankment construction without subexcavation of the soft clay was considered. However, it was found that acceptable factors of safety could not be achieved for a reasonable staging program and time frame.

ii. Staged embankment construction in conjunction with a stabilizing berm, with and without a 2m high surcharge load was evaluated. The results indicated that two-stage construction could be considered, however the construction period would exceed two years

iii. Staged construction in conjunction with a stabilizing berm and wick drain installation was found to be feasible. The approach would be as follows:

- install wick drains;
- place rock fill to the final top of subgrade level, including a 20 m wide by 4.5 m high stabilizing berm at the toe;
- provide an 8 month waiting period for dissipation of pore pressures and increase in strength of the clay foundation;
- place a 2m high surcharge;
- provide a 4 month waiting period;
- remove surcharge.

The computed factors of safety at the completion of each stage of fill placement were in the order of 1.3 for this methodology (Figures 16-2 and 16-3). The long-term factor of safety was about 1.5 (Figure 16-4). Comments regarding post-construction settlement are provided below.

iv. Analysis was carried out assuming that the clay was partially subexcavated to a depth of about 4.5 m below the swamp surface (Elev. 177.5 m). This option would leave a maximum of approximately 4.5 m of clay below the rock fill. This analysis indicated that construction of the embankment to final grade plus a 2 m surcharge

would result in factors of safety of about 1.29 and 1.57 for short-term and long-term conditions, respectively (Figures 16-5 and 16-6).

v. For the case where all peat and soft clay is excavated (maximum 9.7 m depth) and the rock fill embankment is constructed over bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for the feasible embankment construction methods outlined above produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Two stage construction with stabilizing berm and wick drains, 8 month preload then 2m surcharge for 4 months	1000	50	130	15	65
One stage construction with partial subexcavation of clay, 24 month preload	525	75	220	25	110
One stage construction with partial subexcavation of clay, 2m surcharge for 24 months	550	25	220	25	50
Full subexcavation of clay	-	-	325	35	35

Based on the anticipated post-construction settlements presented in the above table, the feasible foundation treatment alternatives at this site are: two-staged construction with a 2 m surcharge (four months), stabilizing berm and wick drains; one stage construction with partial excavation of the soft clay and a 2 m surcharge (24 months); and full excavation of the soft clay. To reduce the complexity and duration of construction, one stage construction with full subexcavation of the clay is the recommended treatment option.

Swamp Crossing at Station 22+350 to 22+410 Harrison (Appendix C)

The site stratigraphy generally consists of exposed bedrock or a thin layer of organics overlying bedrock contacted at depths of up to 0.6 m. The maximum proposed embankment height is about 3.0 m.

After removal of the peat and organics layer, the embankment foundation will primarily comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern. Foundation settlement is expected to be negligible.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 22+475 to 22+565 Harrison (Appendix D)

The site stratigraphy generally consists of a veneer of organics, peat and/or sand to a maximum depth of 1.8 m, overlying bedrock. The peat/organic layer was up to 0.8 m thick. The maximum proposed embankment height is about 4.2 m.

After removal of the peat and organics layer, the embankment foundation will essentially comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern. Where localized deposits of sand remain, foundation settlements should be less than 25 mm and occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 22+750 to 22+825 Harrison (Appendix E)

The site stratigraphy generally consists of a veneer of organics, peat and/or sand to a maximum depth of 1.8 m, overlying bedrock. The peat/organic layer was up to 0.7 m thick. The maximum proposed embankment height is about 3.2 m.

After removal of the peat and organics layer, the embankment foundation will essentially comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern. Where localized deposits of sand remain, foundation settlements should be less than 25 mm and occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

High Fill / Swamp Crossing at Station 23+125 to 23+215 Harrison (Appendix F)

The site stratigraphy consists of discontinuous peat and sand layers underlain by very soft to stiff silty clay, overlying probable bedrock at depths of up to 5.1 m. The peat/organic layer was up to 1.2 m thick. The maximum proposed embankment height is about 6.1 m above the existing swamp surface.

The existing Highway 69 crosses the swamp at this location. In boreholes drilled on the existing highway platform, a pavement structure overlying probable rock fill was encountered. Minimal grade revision is planned to form the new northbound lanes.

Stability analyses were initially carried out assuming that the peat would be removed and the rock fill embankment for the southbound lanes would be constructed directly over the very soft clay. A critical section at approximate Station 23+170 was selected for the analysis (Figure 21-1). The computed factor of safety against slope instability for the short-term (undrained) condition was less than 1.0.

Considering the relatively short length of this section and the limited thickness of clay, complete subexcavation of the clay is recommended (maximum 5.1 m depth). After

removal of the peat and clay, the embankment foundation will essentially comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern (Figures 21-2 and 21-3). Settlement due to compression of the rock fill material is expected to be approximately 90 mm in the first year and less than 25 mm in the subsequent 20 years.

Widening of the existing Highway 69 platform to accommodate the new northbound lanes should be carried out as per OPSD 203.030 including stripping of organic/swamp material adjacent to the existing embankment.

High Fill / Swamp Crossing at Station 24+000 to 24+040 Harrison (Appendix G)

This site stratigraphy generally consists of a thin organic layer, and locally a peat layer (up to 0.7 m thick) over silty sand and very soft to soft silty clay deposits, overlying bedrock. The depth to bedrock was up to 5.2 m. The maximum proposed embankment height is about 6.2 m.

It is recommended that the peat, organics, sand with peaty organics, and soft to very soft silty clay deposits be excavated prior to embankment construction (maximum 5.2 m depth). After removal of these materials, the embankment foundation will essentially comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern. Where localized deposits of sand remain, foundation settlements are expected to be less than 25 mm and occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 24+400 to 24+600 Harrison (Appendix H)

The site stratigraphy consists of a peat layer and very soft to very stiff silty clay deposit underlain and locally overlain by sand and sandy silt layers, overlying probable bedrock at a maximum depth of 8.7 m. The peat layer was up to 1.2 m thick, and the clay extended to depths of up to 6.6 m. The maximum proposed embankment height is about 2.6 m.

The existing Highway 69 crosses the swamp at this location. In boreholes drilled from the existing highway platform, a pavement structure overlying probable rock fill was encountered. The existing embankment will be nominally widened for the new northbound lanes. The maximum finished embankment height is about 3.6 m.

Stability analyses were carried out assuming that the organic material would be removed and the rock fill embankment for the new southbound lanes would be constructed over the silty clay and sands/silts. A critical section at approximate Station 24+540 was selected for the analysis (Figures 24-1 and 24-2). The computed factors of safety against slope instability were approximately 1.4 for short-term (undrained) conditions with a 1 m high surcharge, and 1.6 for long-term (drained) conditions after surcharge removal. These factors of safety are considered to be acceptable.

For the case where all peat and soft clay is excavated (maximum 6.1 m depth) and the rock fill embankment is constructed over bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for an embankment constructed on the clay and sand/silt, for cases with and without a surcharge load, as well as an embankment constructed after full excavation of the clay, produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Construction over sand/silt and clay, no surcharge, 6 month preload	150	30	15	10	65
Construction over sand/silt and clay, 1m surcharge for 6 months	270	25	15	10	35
Full subexcavation of clay	-	-	100	20	20

Based on the above figures, construction of the embankment directly over the silty clay deposit is considered feasible. To reduce long-term settlements, it is recommended that a 1m surcharge be applied for a period of at least six months. Monitoring will be required to confirm the magnitude and time-rate of settlement if the fill is placed over the clay layer.

Full excavation of the clay would add additional construction cost, and particular attention will be required to avoid impacting the existing lanes of Highway 69, which appear to be constructed over the clay. However, this option would reduce the magnitude of long-term embankment settlement and eliminate the need for a surcharge stage and settlement monitoring. Therefore full excavation of the soft silty clay and replacement with rock fill is the recommended option for this site.

Widening of the existing Highway 69 platform for the new northbound lanes should be carried out as per OPSD 203.030 including stripping of organic/swamp material adjacent to existing embankment. Excavation of the silty clay prior to placement of new fill is not required.

High Fill / Swamp Crossing at Station 24+900 to 25+000 Harrison (Appendix I)

The site stratigraphy generally consists of up to 3.6 m of peat underlain by very soft to firm silty clay extending to a maximum depth of 16.1 m below the swamp surface. Probable bedrock was encountered at depths of 0.2 to 23.3 m. The maximum proposed embankment height at this site is about 6.6 m.

Stability analyses were initially carried out assuming the peat was removed and the rock fill embankment was constructed directly over the underlying silty clay. A critical section at Station 24+960 was selected for the analysis (Figure 26-1). The resulting factor of safety against slope instability was less than 1.0, indicating that standard embankment construction is not feasible at this location.

Supplementary analyses were carried out to assess design alternatives such as staged construction, stabilizing berms and full or partial sub-excavation of the soft clay. An iterative approach was used to produce a practical and cost-efficient solution achieving acceptable factors of safety against slope instability and limiting post-construction settlement to acceptable levels. The need for surcharging and/or waiting periods between successive lifts of staged construction was given consideration in assessing the various options.

The alternative design options and findings of the analyses were as follows:

i. Staged embankment construction without subexcavation of the soft clay was considered. However, it was found that acceptable factors of safety could not be achieved for a reasonable staging program and time frame.

ii. Staged embankment construction in conjunction with a stabilizing berm, with and without a 2m high surcharge load was evaluated. The results indicated that two-stage construction could be considered, however the construction period would exceed two years.

iii. Staged construction in conjunction with a stabilizing berm and wick drain installation was found to be feasible. The approach would be as follows:
   - install wick drains;
   - place rock fill to the final top of subgrade level, concurrently with a 20 m wide by 2.6 m high stabilizing berm at the left (outside) toe and temporary infill of the median to Elev. 195.1 m;
   - provide a 6 month waiting period for dissipation of pore pressures and increase in strength of the clay foundation;
   - place a 2m high surcharge;
   - provide a 6 month waiting period;
   - remove surcharge, temporary median infill and stabilizing berm if necessary.

   The computed factors of safety at the completion of each stage of fill placement were in the order of 1.3 to 1.7 for this methodology (Figures 16-2 to 16-4). The long-term factor of safety was about 1.5 (Figure 26-5). Comments regarding post-construction settlement are provided below.

iv. Analysis was carried out assuming that the clay was partially subexcavated to a depth of about 7 m below the swamp surface (Elev. 186.0 m). This option would

leave a maximum of approximately 7 m of clay below the rock fill. This analysis indicated that construction of the embankment to final grade plus a 2 m surcharge would result in factors of safety of about 1.30 and 1.47 for short-term and long-term conditions, respectively (Figures 26-6 and 26-7).

v. For the case where all peat and soft clay is excavated (maximum 16.1 m depth) and the embankment is constructed over bedrock, the short-term and long-term factors of safety will exceed the respective values of 1.3 and 1.5 required.

Estimation of the total and post-construction settlements to be expected for the feasible embankment construction methods outlined above produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Two stage construction with stabilizing berm and wick drains, 6 month preload then 2m surcharge for 6 months	1200	40	95	15	55
One stage construction with partial subexcavation of clay, 2m surcharge for 24 months	500	75	200	20	110
Full subexcavation of clay	-	-	330	35	35

Based on the anticipated post-construction settlements presented in the above table, the feasible foundation treatment alternatives at this site are: two-staged construction with a 2 m surcharge (six months), stabilizing berm and wick drains; and full excavation of the soft clay. From a construction scheduling and staging viewpoint, full excavation of the silty clay is preferred and has been selected as the recommended option. It must be noted however that the required excavation depth may be beyond the reach of most available equipment and specialized equipment may be required.

The stability of the existing Highway 69 embankment during excavation of the peat and silty clay was assessed. The computed factor of safety for undrained conditions was less than 1.0 (Figure 26-8) if all peat and clay is removed prior to placement of the new southbound embankment fill. To reduce the potential for instability of the existing embankment slope, it is recommended that peat/clay removal within 10 m of the existing slope toe be followed closely by backfilling to 1m above the existing ground surface (to minimum Elev.195.1 m, Figure 26-9), such that no more than 10 m length of excavation is left open adjacent to the highway at any time. Otherwise, roadway protection must be provided.

Construction of the new embankment may result in disturbance and settlement of the existing Highway 69 embankment. The existing embankment should be visually

monitored during construction of the new southbound lanes and maintenance provided as required to repair any cracks or settled areas that develop on the highway surface.

High Fill / Swamp Crossing at Station 25+300 to 25+355 Harrison (Appendix J)

The site stratigraphy generally consists of relatively thin deposits of peat, very soft to very stiff silty clay and/or sands/silts overlying probable bedrock. The peat/organic layer was up to 0.8 m thick, and the clay extended to a maximum depth of 2.6 m. The depth to probable bedrock was locally up to 6.1 m. The maximum proposed embankment height is about 6.6 m.

To minimize the potential for instability and settlement of the foundation soils, it is recommended that the peat and silty clay layer be excavated prior to construction of the rock fill embankment at this site. The maximum excavation depth to remove these soils is expected to be in the order of 2.6 m.

The embankment foundation remaining after peat and silty clay removal will essentially comprise bedrock, locally overlain by up to about 4 m of sand/silt and gravelly sand. Stability of the rock fill embankment slopes constructed over this material is not a concern. Where localized deposits of sand/silt remain, foundation settlements are expected to be in the order of 30 mm and occur essentially as the embankment fill is placed.

Swamp Crossing at Station 10+330 to 10+585 Wallbridge (Appendix K)

The subsurface stratigraphy generally consisted of a layer of peat and organics underlain by a variable sequence of silty clay, sand and silt, and silty sand deposits overlying bedrock at a maximum depth of 8.4 m. The peat/organic layer was up to 1.1 m thick, and the clay layers ranged from 0.4 to 6.2 m thick with a lower boundary at a maximum depth of 7.6 m. The maximum proposed embankment height is about 3.5 m.

The existing Highway 69 crosses the swamp at this location. In boreholes drilled from the existing highway platform, a pavement structure overlying probable rock fill was encountered. The existing embankment will be widened as the new northbound lanes will veer to the east of the existing platform at this location.

Stability analyses were carried out assuming that the organic material would be removed and the rock fill embankment would be constructed directly over the silty clay. Critical sections at approximate Stations 10+410 NBL and 10+520 SBL were selected for the analyses (Figures 28-1 and 28-2). The computed factors of safety against slope instability for both cases were approximately 1.3 for short-term (undrained) conditions with a 2 m high surcharge, and 1.5 for long-term (drained) conditions after surcharge removal. These factors of safety are considered to be acceptable.

For the case where all peat and soft clay is excavated (maximum 7.6 m depth) and the rock fill embankment is constructed over bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for an embankment constructed on the clay, for cases with and without a surcharge load, as well as an embankment constructed after full excavation of the clay, produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Sta. 10+410 NBL: Construction over clay, no surcharge, 6 month preload	140	80	20	10	100
Sta. 10+410 NBL: Construction over clay, 2m surcharge for 6 months	265	25	20	10	40
Sta. 10+520 SBL: Construction over clay, no surcharge, 6 month preload	35	40	15	10	65
Sta. 10+520 SBL: Construction over clay, 1m surcharge for 6 months	90	25	15	10	35
Full subexcavation of clay	-	-	130	20	20

Based on the above figures, construction of the embankments directly over the silty clay deposit is considered feasible. To reduce long-term settlements, it is recommended that a 2m surcharge be applied over the northbound embankment and a 1m surcharge be placed over the southbound embankment for a period of at least six months. Monitoring will be required to confirm the magnitude and time-rate of settlement if the fill is placed over the clay layer.

Full excavation of the clay would reduce the magnitude of long-term embankment settlement and eliminate the need for a surcharge stage and settlement monitoring. From a construction scheduling and staging viewpoint, full excavation of the silty clay and replacement with rock fill is preferred and has therefore been selected as the recommended option. Particular attention will be required to avoid impacting the existing lanes of Highway 69, which appear to be constructed over the clay.

Widening of the existing Highway 69 platform for the new northbound lanes should be carried out as per OPSD 203.030 including excavation of the peat, organics and soft silty clay from the toe of the existing embankment.

It must be noted that the existing Highway 69 platform appears to have been constructed at least partially over the clay. Construction of the new embankment and widening of the

existing embankment may result in disturbance and settlement of the existing Highway 69 embankment. The existing embankment should be visually monitored during construction of the new southbound lanes and maintenance provided as required to repair any cracks or settled areas that develop on the highway surface. Further, excavation of peat/clay from adjacent to the toe of the existing embankment should be followed closely by backfilling to 1m above the existing ground surface such that no more than 10 m length of excavation is left open adjacent to the highway at any time.

Swamp Crossing at Station 12+050 to 12+100 Wallbridge (Appendix L)

The site stratigraphy generally consists of a surficial organic layer (up to 0.1 m thick) underlain by sand and silt, overlying bedrock at depths locally up to 4.4 m. The maximum proposed embankment height is about 3.1 m.

After removal of the organic layer, the embankment foundation will primarily comprise bedrock and a pocket of sand and silt overlying bedrock. Stability of a low rock fill embankment constructed over these foundation conditions is not a concern. Where the deeper sand/silt deposits are present, foundation settlements are expected to be less than 25 mm and occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

High Fill at Harris Lake Road, Station 9+800 to 9+930 Wallbridge (Appendix M)

The site stratigraphy generally consists of a veneer of peat and organic material (up to 0.1 m thick), overlying sand then probable bedrock at depths of up to 9.8 m. The sand grades to sandy silt in zones and contains localized zones of very soft to stiff silty clay. The maximum proposed embankment height is about 11.8 m.

After removal of peat and organic material, the embankment foundation will generally comprise very loose to compact sands over bedrock. Stability analyses conducted for a representative section of rock fill overlying sand indicated a factor of safety in the order of 1.4 (Figure 32-1), exceeding the minimum acceptable value or 1.3 for this type of analysis.

Where the deeper sand deposits are present below the peat, foundation settlements in the order of 100 mm should be anticipated, and these settlements are expected to occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Harris Lake Road, Station 10+085 to 10+280 Wallbridge (Appendix N)

This site stratigraphy generally consists of a veneer of peat and organics (up to 0.5 m thick) overlying a varying succession of sand/sandy silt and silty clay deposits, overlying probable bedrock at a maximum depth of 5.5 m. The maximum proposed embankment height is about 11.2 m.

After removal of peat and organic material, the embankment foundation will generally comprise thin deposits of very loose to compact sands/silts and soft to stiff silty clay over bedrock. Stability of a rock fill embankment constructed over these foundation conditions is not a concern.

Where the deeper sand deposits are present below the peat, foundation settlements in the order of 75 mm should be anticipated, and these settlements are expected to occur primarily as the embankment fill is placed, continuing for about three months after completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

High Fill at Rest Area Road, Station 10+000 to 10+150 Wallbridge (Appendix O)

The site stratigraphy generally consists of localized peat (up to 0.6 m thick) and a variable thickness of sand overlying probable bedrock at depths of up to 5.7 m. The maximum proposed embankment height is about 8.6 m.

After removal of peat, the embankment foundation will generally comprise very loose to dense sand in the north part of the section and bedrock in the south. Stability analyses conducted for a representative section of rock fill overlying the sand indicated a factor of safety in the order of 1.4 (Figure 34-1), exceeding the minimum acceptable value or 1.3 for this type of analysis.

Where the deeper sand deposits are present below the peat, foundation settlements in the order of 40 mm should be anticipated, and these settlements are expected to occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

High Fill at Harris Lake Road, Station 12+120 to 12+195 S-EW Ramp, and Station 11+625 to 11+690 EW-N Ramp Wallbridge (Appendix P)

This site stratigraphy generally consists of a veneer of peat and organics (up to 0.7 m thick) overlying a varying succession of sand/sandy silt and silty clay deposits, overlying probable bedrock at a maximum depth of 7.6 m. The maximum proposed embankment height is about 8.9 m.

After removal of peat and organic material, the embankment foundation will generally comprise relatively thin deposits of very loose to dense sands/silts and very soft to stiff silty clay over bedrock. Stability analyses conducted for a representative section indicated a factor of safety in the order of 1.4 (Figure 36-1), exceeding the minimum acceptable value or 1.3 for this type of analysis.

Where the deeper sand/silt and clay deposits are present below the peat, foundation settlements in the order of 75 mm should be anticipated, and these settlements are expected to occur essentially as the embankment fill is placed and continue for about three months after completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

High Fill at Harris Lake Road, Station 12+070 to 12+110 EW-S Ramp, and Station 11+650 to 11+690 N-EW Ramp Wallbridge (Appendix Q)

The site stratigraphy generally consists of a bedrock outcrop overlain by a thin layer of organic material (up to 0.3 m thick) and localized sand. The maximum depth to bedrock was 1.2 m. The maximum proposed embankment height is about 8.0 m.

After removal of organic material, the embankment foundation will generally comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern. Foundation settlement is expected to be negligible.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Harris Lake Road, Station 11+840 to 11+910 N-EW Ramp Wallbridge (Appendix R)

The site stratigraphy generally consists of exposed bedrock and a thin organic layer (up to 0.3 m thick), with a local depression infilled with silty clay, sand and silt, and sand to a maximum depth of 3.5 m. The maximum proposed embankment height is about 3.0 m.

After removal of peat and organics, the embankment foundation will vary from bedrock to localized silty clay and sand/silt. Stability of a low rock fill embankment constructed over these foundation conditions is not a concern. Where the deeper clay and and/silt deposits are present, foundation settlements are expected to be in the order of 25 mm and occur largely as the embankment fill is placed, continuing for about three months after completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Harris Lake Road, Station 12+030 to 12+120 N-EW Ramp Wallbridge (Appendix S)

The site stratigraphy generally consists of bedrock outcrops overlain by a thin layer of peat and organics (up to 0.7 m thick), with depressions in the bedrock surface infilled with sand and silt, silty clay and sand. The maximum depth to bedrock was 5.5 m. The maximum proposed embankment height is about 3.4 m.

After removal of peat and organics, the embankment foundation will vary from bedrock to very loose to compact sand/silt and very soft to soft silty clay. Stability of a low rock fill embankment constructed over these foundation conditions is not a concern. Where the deeper sand/silt and clay deposits are present, foundation settlements are expected to be less than 75 mm and occur largely as the embankment fill is placed, continuing for about three months after completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Harris Lake Road, Station 12+070 to 12+120 EW-N Ramp Wallbridge (Appendix T)

The site stratigraphy generally consists of a bedrock depression infilled with deposits to a maximum depth of 5.4 m of very loose to compact silty sand, very soft to stiff silty clay, and sand and gravel. The surficial organic layer is up to 0.2 m thick. The maximum proposed embankment height is about 3.0 m.

After removal of peat and organics, the embankment foundation will vary from bedrock to relatively thin deposits of silty sand, silty clay and sand and gravel. Stability of a low rock fill embankment constructed over these foundation conditions is not a concern. Where the deeper sand and clay deposits are present, foundation settlements are expected to be in the order of 50 mm and occur largely as the embankment fill is placed, continuing for about three months after completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 12+470 to 12+540 Wallbridge (Appendix U)

The site stratigraphy generally consists of bedrock outcrops with depressions infilled with sand to sand and silt. The maximum depth to bedrock was 2.3 m. The surficial organic layer is up to 0.1 m thick. The maximum proposed embankment height is about 3.0 m.

After removal of organic material, the embankment foundation will essentially consist of bedrock and therefore stability of a low rock fill embankment is not a concern. Where the sand/silt deposits are present, foundation settlements are expected to be less than 25 mm and occur largely as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 13+130 to 13+190 Wallbridge (Appendix V)

The site stratigraphy generally consists of a veneer of organic material (up to 0.3 m thick) underlain by localized deposits of silty clay and silty sand to a maximum depth of 2.0 m, overlying bedrock. The maximum proposed embankment height is about 3.8 m.

After removal of organic material, the embankment foundation will essentially comprise bedrock and therefore stability of the rock fill embankment slopes is not a concern. Where localized deposits of clay or silty sand are present, foundation settlements should be less than 25 mm and occur primarily as the embankment fill is placed, possibly continuing for a period of about three months following completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 13+580 to 13+650 Wallbridge (Appendix W)

This site stratigraphy generally consists of a surficial organic layer (up to 0.7 m thick) underlain by layers of sand and silt and silty clay, overlying bedrock at a maximum depth of 8.4 m. The maximum proposed embankment height is about 3.5 m.

Stability analyses were carried out assuming that the organic material would be removed and the rock fill embankment would be constructed over the sands/silts and silty clay. A critical section at approximate Station 13+620 was selected for the analysis (Figures 44-1 and 44-2). The computed factors of safety against slope instability were approximately 1.38 for short-term (undrained) conditions with a 1 m high surcharge, and 1.5 for long-term (drained) conditions after surcharge removal. These factors of safety are considered to be acceptable.

For the case where all peat and soft clay is excavated (maximum 8.4 m depth) and the rock fill embankment is constructed over bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for an embankment constructed on the sand/silt and clay, for cases with and without a surcharge load, as well as an embankment constructed after full excavation of the clay, produced the following:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Construction over sand/silt and clay, no surcharge, 6 month preload	230	40	15	10	70
Construction over sand/silt and clay, 1m surcharge for 6 months	275	30	15	10	40
Full subexcavation of clay	-	-	100	20	20

Based on the above figures, construction of the embankment directly over the sand/silt and silty clay deposit is considered feasible. To reduce long-term settlements, it is recommended that a 1m surcharge be applied for a period of at least six months. Monitoring will be required to confirm the magnitude and time-rate of settlement if the fill is placed over the clay layer.

Full excavation of the clay would reduce the magnitude of long-term embankment settlement and eliminate the need for a surcharge stage and settlement monitoring. From a construction scheduling and staging viewpoint, full excavation of the silty clay and replacement with rock fill is preferred and has therefore been selected as the recommended option.

Swamp Crossing at Station 13+890 to 13+990 Wallbridge (Appendix X)

The subsurface stratigraphy at this site generally consists of a layer of peaty organics underlain by a silty clay deposit, locally overlain by silty sand or underlain by sand. The organic layer was up to 0.9 m thick, and the clay layer ranged from 0.6 to 4.7 m thick with a lower boundary to 5.5 m depth. Probable bedrock was encountered at a maximum depth of 7.1 m. The maximum proposed embankment height is about 3.2 m.

Stability analyses were carried out assuming that the organic material would be removed and the rock fill embankment would be constructed over the silty clay. A critical section at approximate Station 13+950 was selected for the analysis (Figures 45-1 and 45-2). The computed factors of safety against slope instability were approximately 1.45 for short-term (undrained) conditions with a 1 m high surcharge, and 1.65 for long-term (drained) conditions after surcharge removal. These factors of safety are considered to be acceptable.

For the case where all peat and soft clay is excavated (maximum 5.5 m depth) and the rock fill embankment is constructed over sand and bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for an embankment constructed on the sand/silt and clay, for cases with and without a surcharge load, as well as an embankment constructed after full excavation of the clay, produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Construction over clay, no surcharge, 12 month preload	175	80	15	10	130
Construction over clay, 1m surcharge for 12 months	250	30	15	10	40
Full subexcavation of clay	-	-	100	15	15

Based on the above figures, construction of the embankment directly over the silty clay deposit is considered feasible. To reduce long-term settlements, it is recommended that a 1m surcharge be applied for a period of at least twelve months. Monitoring will be required to confirm the magnitude and time-rate of settlement if the fill is placed over the clay layer.

Full excavation of the clay would reduce the magnitude of long-term embankment settlement and eliminate the need for a surcharge stage and settlement monitoring. From a construction scheduling and staging viewpoint, full excavation of the silty clay and replacement with rock fill is preferred and has therefore been selected as the recommended option.

Swamp Crossing at Station 14+110 to 14+280 Wallbridge (Appendix Y)

The site stratigraphy generally consists of relatively thin deposits of peat/organics (up to 0.7 m thick), silty clay, sand and silty sand overlying bedrock at a maximum depth of 3.0 m. The maximum proposed embankment height is about 3.0 m.

After removal of peat and organics, the embankment foundation will comprise relatively thin layers of very loose to compact sands and soft to stiff clays over/or bedrock. Stability of a low rock fill embankment over these foundations conditions is not a concern. Where localized deposits of sand or silty clay are present, foundation settlements should be less than 25 mm and these settlements are expected to occur essentially as the embankment fill is placed or up to three months thereafter.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 14+460 to 14+690 Wallbridge (Appendix Z)

The site stratigraphy generally consists of a surficial organic layer (up to 0.9 m thick) overlying a variable sequence of silty clay, sand and locally silt or sand and gravel, infilling depressions in the bedrock surface. The maximum depth to probable bedrock was 5.1 m. The maximum proposed embankment height is about 2.4 m.

After removal of the organic materials and soft to very soft silty clay, the embankment foundation will comprise relatively thin deposits of very loose to compact sands and very stiff to hard clays over/or bedrock. Stability of a low rock fill embankment over these foundations conditions is not a concern. Where deposits of sand or silty clay are present, foundation settlements in the order of 25 mm should be anticipated. These settlements are expected to occur essentially as the embankment fill is placed and continue for up to three months following completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 15+050 to 15+190 Wallbridge (Appendix AA)

The subsurface stratigraphy generally consists of a peat layer overlying silty sand, underlain by a relatively thick deposit of silty clay, overlying sand and probable bedrock. The peat layer was up to 1.3 m thick. The clay layer was 0.8 to 7.6 m thick, locally 8.9 m thick but interrupted by a 1.6 m thick layer of sandy silt. The maximum depth to bedrock was 12.5 m. The maximum proposed embankment height is about 3.1 m.

In boreholes drilled from the existing highway platform, a pavement structure overlying probable rock fill was encountered. The existing embankment will be nominally widened for the new southbound lanes.

Stability analyses were carried out assuming that the organic material would be removed and the rock fill embankment for the new northbound lanes would be constructed over the silty clay and sands/silts. A critical section at approximate Station 15+110 was selected for the analysis (Figures 48-1 to 48-4). The minimum computed factors of safety against slope instability were approximately 1.35 for short-term (undrained) conditions with a 1 m high surcharge, and 1.54 for long-term (drained) conditions after surcharge removal. These factors of safety are considered to be acceptable.

For the case where all peat and soft clay is excavated (maximum 10.5 m depth) and the rock fill embankment is constructed over bedrock, the factors of safety for short-term and long-term conditions would exceed the required values of 1.3 and 1.5, respectively.

Estimation of the total and post-construction settlements to be expected for an embankment constructed on the clay and sand/silt, for cases with and without a surcharge load, as well

as an embankment constructed after full excavation of the clay, produced the following results:

Method	Estimated Settlement (mm)				
	Primary Consolidation	Secondary Compression	Fill Compression		Total Long-term
			Short term	Long term	
Construction over sand/silt and clay, no surcharge, 12 month preload	135	80	15	10	95
Construction over sand/silt and clay, 1m surcharge for 12 months	190	10	15	10	20
Full subexcavation of clay	-	-	175	25	25

Based on the above figures, construction of the embankment directly over the silty clay deposit is considered feasible. To reduce long-term settlements, it is recommended that a 1m surcharge be applied for a period of at least twelve months. Monitoring will be required to confirm the magnitude and time-rate of settlement if the fill is placed over the clay layer.

Full excavation of the clay would reduce the magnitude of long-term embankment settlement and eliminate the need for a surcharge stage and settlement monitoring. From a construction scheduling and staging viewpoint, full excavation of the silty clay and replacement with rock fill is preferred and has therefore been selected as the recommended option.

Widening of the existing Highway 69 platform for the new southbound lanes should be carried out as per OPSD 203.030 including stripping of organic/swamp material adjacent to existing embankment. Excavation of the silty clay prior to placement of new fill is not required.

Swamp Crossing at Station 15+450 to 15+560 Wallbridge (Appendix BB)

The site stratigraphy generally consists of an undulating bedrock surface with shallow depression infilled with organics, silty clay and sand to a maximum depth of 2.0 m. The maximum proposed embankment height is about 2.7 m.

Peaty organics were noted in the surficial 0.3 to 0.5 m thick layer of silty sand layer encountered in several of the boreholes. It is recommended that this layer be removed prior to construction of the rock fill embankment at this site.

The embankment foundation remaining after removal of the organic material will essentially comprise bedrock locally overlain by thin sand or clay deposits. Stability of a low rock fill embankment constructed over these foundation materials is not a concern.

Where localized deposits of sand or clay remain, foundation settlements should be less than 25 mm and occur essentially as the embankment fill is placed, continuing for up to three months after completion.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 15+710 to 15+800 Wallbridge (Appendix CC)

The site stratigraphy generally consists of exposed bedrock, a thin layer of organic material (up to 0.6 m thick) over bedrock, and deposits to a maximum depth of 3.5 m of very loose to compact sand to sand and silt sandwiching a thin layer of very soft silty clay. The maximum proposed embankment height is about 3.0 m.

After removal of organics and soft soils, the embankment foundation will comprise relatively thin deposits of sand/silt and silty clay over bedrock. Stability of the low rock fill embankment over these foundation conditions is not a concern. Where deposits of sand and clay are present, foundation settlements in the order of 25 mm should be anticipated, and these settlements are expected to occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

Swamp Crossing at Station 15+860 to 15+915 Wallbridge (Appendix DD)

The site generally consists of a shallow depression in the bedrock surface infilled with organics (up to 0.8 m thick) and sand. The maximum bedrock depth was 2.6 m. The maximum proposed embankment height is about 2.6 m.

After removal of the organic material, the embankment foundation will comprise bedrock with localized very loose to loose sand deposits. Stability of a low rock fill embankment on this foundation is not a concern. Where the sand deposits are present, foundation settlements are expected to be less than 25 mm and occur essentially as the embankment fill is placed.

Based on the above, specialized construction procedures will not be required to address stability or settlement issues at this site.

9.3 Summary of Site-Specific Recommendations

A summary of the primary recommendations for each specific area of high fill or swamp crossing is presented on Table A7 in Appendix A. The summary is based on the discussions presented above, and these discussions should be referenced for further detail.

The anticipated and/or recommended depth of subexcavation of peat, organics and soft soils at all sites is summarized in Table A4, Appendix A.

10 SEISMIC CONSIDERATIONS

Provided embankment construction is carried out in accordance with the site-specific recommendations provided above, a minimum factor of safety of 1.0 was computed for seismic loading conditions at all sites. This value is considered acceptable for seismic design.

Based on the subsurface conditions encountered at the embankment locations, the potential for liquefaction of the foundation soils during a seismic event is considered to be low in accordance with CHBDC Section C4.6. Some local liquefaction and resulting toe failure may occur during a seismic event, but this is expected to be readily repaired.

11 EMBANKMENT CONSTRUCTION

Embankment construction should be carried out in accordance with SP 206S03. Earth fill may consist of granular materials and Select Subgrade Material (SSM) in compliance with Special Provision 110S13. Rock size should be controlled in accordance with SP 206S03.

Construction of new embankments over swamp should be carried out in accordance with OPSS 209 "Construction Specification for Embankments Over Swamps", March 1998, with specific reference to OPSD 203.010 "Embankments Over Swamp, New Construction".

In areas where staged construction, surcharging and/or preloading is recommended, a monitoring program will be required to confirm the duration of staging and the magnitude and rate of foundation settlements. Further recommendations and a suggested NSSP for monitoring will be prepared when the selected treatment options have been established. Embankment construction in areas requiring treatment should commence at the beginning of the contract period.

Water levels at all sites were generally at or above the ground surface at the time of the field investigations. Removal of peat and subexcavation of soft soils will generally be carried out below the surface water and groundwater levels. Construction operations should include measures such a temporary dewatering and drainage/lowering of ponded water wherever practical (for example, where excavation depths are small), and provision of equipment suitable for excavation of soft materials below the water level where dewatering is not practical. The surface water depths and depths to groundwater at the time of construction will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams.

At the pavement subgrade level or if granular/earth fill is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and covered by a minimum 150 mm thickness of OPSS Granular B Type II fill (or as recommended in the Pavement Design Report).

Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments with heights exceeding 8 m in earth fill and 10 m in rockfill. Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface, the existing earth or fill slope must be benched in accordance with OPSD 208.010.

In accordance with Northern Region policy (Directive NRE 98-200), the embankment platform should be widened in swamp areas by a minimum 2.0 m on both sides of Highway 69 and 1.0 m on both sides of other roads to accommodate consolidation of embankment materials (rockfill), consolidation of foundation soils, and future pavement overlays.

Earth slopes must be provided with erosion protection in accordance with OPSS 804.

12 CONSTRUCTION CONCERNS

During construction, qualified geotechnical staff should be retained to observe activities related to embankment construction and advise the Contract Administrator on construction concerns or issues related to embankment stability or settlement.

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

- The thickness and presence of organic deposits were investigated at the borehole locations only. Organic deposits may extend to greater depths or be encountered at other locations between boreholes.
- Geotechnical confirmation is required that all organics, peat and soft silt/clay materials within the proposed embankment footprint are sub-excavated and replaced with approved backfill.
- Movement of construction equipment may be difficult in areas of organic or excessively soft, loose and/or saturated subgrade. Disturbance of the subgrade by construction traffic should be minimized.
- Bedrock elevations may vary between and beyond the borehole locations. The limits of sub-excavation may require modification during construction based on the conditions encountered in the field.

13 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer

P.K. Chatterji, P.Eng., Ph.D.
Review Principal

Appendix A

Tables and Figures

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Hwy 69 NBL & SBL, Sta. 21+710 to 22+135 Harrison					
15-01	21+751	CL	SBL	centreline	4.4
15-02R	21+763.5	11.5 RT	SBL	right toe of slope	6.2
15-03	21+776	CL	SBL	centreline	4.4
15-04L	21+788.5	11.4 LT	SBL	left toe of slope	0.3
15-05	21+801	CL	SBL	centreline	1.9
15-06R	21+806	11.8 RT	SBL	right toe of slope	3.1
15-07	21+811	CL	SBL	centreline	0.1
15-08	21+725	CL	SBL	centreline	0.7
15-09L	21+737.5	12.0 LT	SBL	left toe of slope	1.0
D15-01L	21+763.5	11.5 LT	SBL	DCPT, left toe of slope	0.6
D15-02R	21+788.5	11.4 RT	SBL	DCPT, right toe of slope	3.1
D15-03L	21+806	11.8 LT	SBL	DCPT, left toe of slope	0.0
D15-04R	21+737.5	12.0 RT	SBL	DCPT, right toe of slope	2.7
15A-01R	21+710	16.0 RT	NBL	right toe of slope	0.0
15A-02L	21+750	16.0 LT	NBL	left toe of slope	2.5
15A-03R	21+760	16.0 RT	NBL	right toe of slope	3.0
15A-04L	21+800	16.0 LT	NBL	left toe of slope	3.3
15A-05R	21+810	16.0 RT	NBL	right toe of slope	2.4
D15A-01L	21+725	16.0 LT	NBL	DCPT, left toe of slope	2.4
D15A-02R	21+735	16.0 RT	NBL	DCPT, right toe of slope	3.4
D15A-03L	21+775	16.0 LT	NBL	DCPT, left toe of slope	1.5
D15A-04R	21+785	16.0 RT	NBL	DCPT, right toe of slope	1.4
D15A-05L	21+825	16.0 LT	NBL	DCPT, left toe of slope	4.6
16-01	21+826	CL	SBL	centreline	1.2
16-02L	21+851	13.3 LT	SBL	left toe of slope	2.8
16-03	21+876	CL	SBL	centreline	2.1
16-04R	21+901	14.6 RT	SBL	right toe of slope	0.0
16-05	21+926	CL	SBL	centreline	0.0
16-06L	21+951	12.3 LT	SBL	left toe of slope	5.9
16-07	21+976	CL	SBL	centreline	0.1
16-08R	22+001	18.4 RT	SBL	right toe of slope	1.5
16-09	22+026	CL	SBL	centreline	3.3
16-10L	22+051	20.3 LT	SBL	left toe of slope	9.7
16-11	22+076	CL	SBL	centreline	7.4
16-12R	22+101	19.3 RT	SBL	right toe of slope	0.0
16-13	22+126	CL	SBL	centreline	0.3
16-14L	22+136	13.1 LT	SBL	left toe of slope	0.0
D16-01R	21+851	13.3 RT	SBL	DCPT, right toe of slope	6.5
D16-02L	21+901	14.6 LT	SBL	DCPT, left toe of slope	0.2
D16-03R	21+951	12.3 RT	SBL	DCPT, right toe of slope	0.0

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
D16-04L	22+001	18.4 LT	SBL	DCPT, left toe of slope	6.6
D16-05R	22+051	20.3 RT	SBL	DCPT, right toe of slope	5.8
D16-06L	22+101	19.3 LT	SBL	DCPT, left toe of slope	7.3
D16-07R	22+136	13.1 RT	SBL	DCPT, right toe of slope	0.0
C104-1	21+798	18.0 LT	NBL	culvert	3.9
C104-2	21+800	CL	NBL	culvert	5.7
C104-3	21+802	19.0 RT	NBL	culvert	0.1
C105-1	21+935	22.0 LT	SBL	culvert	4.5
C105-2	21+893	3.0 LT	SBL	culvert	3.3
C105-3	21+850	18.0 RT	SBL	culvert	5.3
Hwy 69 SBL, Sta. 22+350 to 22+410 Harrison					
17-01	22+351	CL	SBL	centreline	0.2
17-02R	22+363.5	6.3 RT	SBL	right toe of slope	0.1
17-03	22+376	CL	SBL	centreline	0.1
17-04L	22+388.5	7.9 LT	SBL	left toe of slope	0.6
17-05	22+401	CL	SBL	centreline	0.1
17-06R	22+406	7.6 RT	SBL	right toe of slope	0.1
17-07	22+411	CL	SBL	centreline	0.1
D17-01L	22+363.5	6.3 LT	SBL	DCPT, left toe of slope	0.0
D17-02R	22+388.5	7.9 RT	SBL	DCPT, right toe of slope	0.4
D17-03L	22+406	7.6 LT	SBL	DCPT, left toe of slope	0.2
Hwy 69 NBL, Sta. 22+475 to 22+565 Harrison					
18-01	22+476	CL	SBL	centreline	0.7
18-02L	22+488.5	11.3 LT	SBL	left toe of slope	1.6
18-03	22+501	CL	SBL	centreline	0.1
18-04R	22+513.5	7.7 RT	SBL	right toe of slope	0.6
18-05	22+526	CL	SBL	centreline	0.1
18-06L	22+538.5	8.4 LT	SBL	left toe of slope	0.1
18-07	22+551	CL	SBL	centreline	0.8
18-08R	22+556	8.5 RT	SBL	right toe of slope	0.3
18-09	22+566	CL	SBL	centreline	0.5
D18-01R	22+488.5	11.3 RT	SBL	DCPT, right toe of slope	1.8
D18-02L	22+513.5	7.7 LT	SBL	DCPT, left toe of slope	0.3
D18-03R	22+538.5	8.4 RT	SBL	DCPT, right toe of slope	0.5
D18-04L	22+556	8.5 LT	SBL	DCPT, left toe of slope	0.6

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Hwy 69 SBL, Sta. 22+750 to 22+825 Harrison					
19-01	22+751	CL	SBL	centreline	0.1
19-02L	22+763.5	7.8 LT	SBL	left toe of slope	0.1
19-03	22+776	CL	SBL	centreline	0.2
19-04R	22+788.5	9.9 RT	SBL	right toe of slope	0.2
19-05	22+801	CL	SBL	centreline	1.8
19-06L	22+813.5	7.1 LT	SBL	left toe of slope	0.1
19-07	22+826	CL	SBL	centreline	0.3
D19-01R	22+763.5	7.8 RT	SBL	DCPT, right toe of slope	0.3
D19-02L	22+788.5	9.9 LT	SBL	DCPT, left toe of slope	0.5
D19-03R	22+813.5	7.1 RT	SBL	DCPT, right toe of slope	0.0
Hwy 69 NBL & SBL, Sta. 23+125 to 23+215 Harrison					
20-01	23+126	CL	NBL	on existing Hwy 69	1.2
20-02R	23+138.5	6.8 RT	NBL	on existing Hwy 69	3.8
20-03	23+151	CL	NBL	on existing Hwy 69	2.7
20-04L	23+163.5	7.0 LT	NBL	on existing Hwy 69	1.0
20-05	23+176	CL	NBL	on existing Hwy 69	1.8
20-06R	23+188.5	6.9 RT	NBL	on existing Hwy 69	2.7
20-07	23+201	CL	NBL	on existing Hwy 69	2.2
20-08L	23+206	6.6 LT	NBL	on existing Hwy 69	1.0
20-09	23+211	CL	NBL	on existing Hwy 69	1.3
20-10R	23+125	18.0 RT	NBL	right toe of slope	1.6
20-11R	23+150	18.0 RT	NBL	right toe of slope	3.4
20-12R	23+175	18.0 RT	NBL	right toe of slope	1.5
20-13L	23+177.5	18.0 LT	NBL	left toe of slope	1.8
D20-01L	23+138.5	6.8 LT	NBL	on existing Hwy 69	2.3
D20-02R	23+163.5	7.0 RT	NBL	on existing Hwy 69	1.3
D20-03L	23+188.5	6.9 LT	NBL	on existing Hwy 69	4.1
D20-04R	23+206	6.6 RT	NBL	on existing Hwy 69	1.0
D20-05L	23+155	18.0 LT	NBL	DCPT, left toe of slope	1.6
21-01	23+151	CL	SBL	centreline	0.0
21-02R	23+163.5	13.0 RT	SBL	right toe of slope	2.2
21-03	23+176	CL	SBL	centreline	4.5
21-04L	23+188.5	13.1 LT	SBL	left toe of slope	3.8
21-05	23+201	CL	SBL	centreline	3.9
21-06R	23+213.5	6.4 RT	SBL	right toe of slope	0.0
21-07	23+216	CL	SBL	centreline	0.2
D21-01L	23+163.5	13.0 LT	SBL	DCPT, left toe of slope	2.2
D21-02R	23+188.5	13.1 RT	SBL	DCPT, right toe of slope	5.1
D21-03L	23+213.5	6.4 LT	SBL	DCPT, left toe of slope	0.1

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Hwy 69 SBL, Sta. 24+000 to 24+040 Harrison					
22-01	24+001	CL	SBL	centreline	0.1
22-02L	24+013.5	13.0 LT	SBL	left toe of slope	3.7
22-03	24+026	CL	SBL	centreline	2.3
22-04R	24+031	12.8 RT	SBL	right toe of slope	0.1
22-05	24+036	CL	SBL	centreline	0.6
D22-01R	24+013.5	13.0 RT	SBL	DCPT, right toe of slope	5.0
D22-02L	24+031	12.8 LT	SBL	DCPT, left toe of slope	5.2
Hwy 69 NBL & SBL, Sta. 24+400 to 24+600 Harrison					
23-01	24+481	CL	NBL	on existing Hwy 69	2.0
23-02R	24+488.5	7.9 RT	NBL	on existing Hwy 69	0.4
23-03	24+501	CL	NBL	on existing Hwy 69	2.0
23-04L	24+513.5	8.1 LT	NBL	on existing Hwy 69	1.1
23-05	24+526	CL	NBL	on existing Hwy 69	8.7
23-06R	24+538.5	8.1 RT	NBL	on existing Hwy 69	0.9
23-07	24+551	CL	NBL	on existing Hwy 69	1.2
23-08L	24+563.5	8.0 LT	NBL	on existing Hwy 69	0.8
23-09	24+576	CL	NBL	on existing Hwy 69	0.9
23-10L	24+429	19.0 LT	NBL	left toe of slope	1.8
23-11L	24+480	19.0 LT	NBL	left toe of slope	2.7
23-12R	24+495	16.0 RT	NBL	right toe of slope	5.7
23-13R	24+520	16.0 RT	NBL	right toe of slope	4.3
23-14L	24+530	19.0 LT	NBL	left toe of slope	6.1
23-15R	24+545	16.0 RT	NBL	right toe of slope	1.0
23-16L	24+555	19.0 LT	NBL	left toe of slope	0.5
D23-01L	24+488.5	7.9 LT	NBL	on existing Hwy 69	1.3
D23-02R	24+513.5	8.1 RT	NBL	on existing Hwy 69	0.9
D23-03L	24+538.5	8.1 LT	NBL	on existing Hwy 69	5.7
D23-04R	24+563.5	8.0 RT	NBL	on existing Hwy 69	0.6
D23-05L	24+454	19.0 LT	NBL	DCPT, left toe of slope	2.4
D23-06R	24+470	16.0 RT	NBL	DCPT, right toe of slope	2.7
D23-07L	24+505	19.0 LT	NBL	DCPT, left toe of slope	4.6
24-01	24+506	CL	SBL	centreline	1.7
24-02L	24+513.5	6.7 LT	SBL	left toe of slope	1.4
24-03	24+526	CL	SBL	centreline	4.6
24-04R	24+538.5	6.5 RT	SBL	right toe of slope	8.3
24-05	24+551	CL	SBL	centreline	5.3
24-06L	24+561	6.4 LT	SBL	left toe of slope	2.6
24-07	24+566	CL	SBL	centreline	2.5
24-08	24+406	CL	SBL	centreline	1.2
24-09R	24+418.5	6.5 RT	SBL	right toe of slope	4.2

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
24-10	24+431	CL	SBL	centreline	2.2
24-11	24+456	CL	SBL	centreline	1.7
24-12R	24+468.5	6.5 RT	SBL	right toe of slope	3.9
24-14R	24+493.5	6.5 RT	SBL	right toe of slope	2.9
24-15R	24+576	6.5 RT	SBL	right toe of slope	3.8
24-16	24+586	CL	SBL	centreline	1.9
24-17L	24+598	6.4 LT	SBL	left toe of slope	2.2
D24-01R	24+513.5	6.7 RT	SBL	DCPT, right toe of slope	4.3
D24-02L	24+538.5	6.5 LT	SBL	DCPT, left toe of slope	5.9
D24-03R	24+561	6.4 RT	SBL	DCPT, right toe of slope	3.1
D24-04R	24+443.5	6.5 RT	SBL	DCPT, right toe of slope	1.9
D24-05L	24+576	6.5 LT	SBL	DCPT, left toe of slope	2.0
Hwy 69 SBL, Sta. 24+900 to 25+000 Harrison					
25-01	24+901	CL	SBL	centreline	3.5
25-02L	24+913.5	6.3 LT	SBL	left toe of slope	4.0
25-03	24+926	CL	SBL	centreline	10.7
25-04R	24+937.5	10.0 RT	SBL	right toe of slope	16.1
D25-01R	24+913.5	6.3 RT	SBL	DCPT, right toe of slope	8.0
D25-02L	24+937.5	7.0 LT	SBL	DCPT, left toe of slope	5.8
26-01	24+951	CL	SBL	centreline	16.4
26-01R	24+950	10.0 RT	SBL	right toe of slope	13.9
26-02L	24+963.5	6.4 LT	SBL	left toe of slope	13.4
26-03	24+976	CL	SBL	centreline	9.3
26-04R	24+988.5	6.3 RT	SBL	right toe of slope	2.5
26-05	25+001	CL	SBL	centreline	0.2
26-06	24+907.5	4.5 LT	NBL	on existing Hwy 69	19.8
26-07	24+932.5	4.5 LT	NBL	on existing Hwy 69	23.3
26-08	24+957.5	4.5 LT	NBL	on existing Hwy 69	14.9
D26-01R	24+963.5	6.4 RT	SBL	DCPT, right toe of slope	17.0
D26-02L	24+988.5	6.3 LT	SBL	DCPT, left toe of slope	1.2
C124-2	24+885	5.0 LT	NBL	culvert	7.3
C124-3	24+880.5	5.0 LT	NBL	culvert	5.8
C125-1	24+893	18.0 RT	SBL	culvert	0.7
C125-2	24+910	17.0 LT	SBL	culvert	2.6
C125-D1	24+886	16.0 RT	SBL	culvert	0.6
C125-D2	24+905	20.0 LT	SBL	culvert	2.4
C125-D3	24+895	2.0 LT	SBL	culvert	0.5

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Hwy 69 SBL, Sta. 25+300 to 25+355 Harrison					
27-01	25+306	CL	SBL	centreline	0.8
27-02L	25+313.5	6.9 LT	SBL	left toe of slope	2.3
27-03	25+326	CL	SBL	centreline	2.6
27-04R	25+341.5	7.0 RT	SBL	right toe of slope	6.1
27-05	25+351	CL	SBL	centreline	1.9
27-06	25+356	CL	SBL	centreline	0.2
D27-01R	25+313.5	6.9 RT	SBL	DCPT, right toe of slope	0.6
D27-02L	25+341.5	7.0 LT	SBL	DCPT, left toe of slope	4.0
Hwy 69 NBL & SBL, Sta. 10+330 to 10+585 Wallbridge					
28-01	10+330	CL	NBL	on existing Hwy 69	0.5
28-02L	10+337.5	6.4 LT	NBL	on existing Hwy 69	0.7
28-03	10+350	CL	NBL	on existing Hwy 69	1.2
28-04R	10+362.5	6.4 RT	NBL	right toe of slope	0.3
28-05	10+375	CL	NBL	on existing Hwy 69	1.1
28-06L	10+387.5	6.6 LT	NBL	on existing Hwy 69	1.2
28-07	10+400	CL	NBL	on existing Hwy 69	0.9
28-08R	10+412.5	6.6 RT	NBL	right toe of slope	7.6
28-09	10+425	CL	NBL	on existing Hwy 69	1.4
28-10L	10+437.5	7.1 LT	NBL	on existing Hwy 69	1.4
28-11	10+450	CL	NBL	centreline	3.5
28-12R	10+462.5	7.0 RT	NBL	right toe of slope	4.0
28-13	10+475	CL	NBL	centreline	3.7
28-14L	10+487.5	6.3 LT	NBL	on existing Hwy 69	1.0
28-15	10+500	CL	NBL	centreline	1.5
28-16R	10+510	6.3 RT	NBL	right toe of slope	1.4
28-17	10+515	CL	NBL	centreline	1.1
D28-01R	10+337.5	6.4 RT	NBL	DCPT, right toe of slope	0.0
D28-02L	10+362.5	6.4 LT	NBL	on existing Hwy 69	1.0
D28-03R	10+387.5	6.6 RT	NBL	DCPT, right toe of slope	8.3
D28-04L	10+412.5	6.6 LT	NBL	on existing Hwy 69	0.9
D28-05R	10+437.5	7.1 RT	NBL	DCPT, right toe of slope	3.6
D28-06L	10+462.5	7.0 LT	NBL	on existing Hwy 69	6.2
D28-07R	10+487.5	6.3 RT	NBL	DCPT, right toe of slope	0.1
D28-08L	10+510	6.3 LT	NBL	on existing Hwy 69	0.9
29-01	10+365	CL	SBL	centreline	0.0
29-02L	10+367.5	6.3 LT	SBL	left toe of slope	0.1
29-03	10+375	CL	SBL	centreline	0.1
29-04R	10+387.5	6.3 RT	SBL	right toe of slope	0.4
29-05	10+400	CL	SBL	centreline	3.8
29-06L	10+412.5	9.5 LT	SBL	left toe of slope	3.3
29-07	10+425	CL	SBL	centreline	1.6

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
29-08R	10+437.5	7.6 RT	SBL	right toe of slope	0.0
29-09	10+450	CL	SBL	centreline	0.5
29-10L	10+462.5	6.4 LT	SBL	left toe of slope	0.8
29-11	10+475	CL	SBL	centreline	1.0
29-12	10+480	CL	SBL	centreline	3.2
29-13R	10+402.5	7.0 RT	SBL	right toe of slope	2.3
29-14R	10+487.5	7.0 RT	SBL	right toe of slope	3.7
29-15	10+495	CL	SBL	centreline	4.3
D29-01R	10+367.5	6.3 RT	SBL	DCPT, right toe of slope	0.0
D29-02L	10+387.5	6.3 LT	SBL	DCPT, left toe of slope	0.2
D29-03R	10+412.5	9.5 RT	SBL	DCPT, right toe of slope	3.2
D29-04L	10+437.5	7.6 LT	SBL	DCPT, left toe of slope	1.4
D29-05R	10+462.5	6.4 RT	SBL	DCPT, right toe of slope	0.7
D29-06L	10+487.5	7.0 LT	SBL	DCPT, left toe of slope	2.5
30-01	10+510	CL	SBL	centreline	7.2
30-02	10+520	CL	SBL	centreline	8.4
30-03L	10+532.5	6.3 LT	SBL	left toe of slope	4.2
30-04	10+545	CL	SBL	centreline	4.6
30-05R	10+557	6.3 RT	SBL	right toe of slope	4.3
30-06	10+570	CL	SBL	centreline	3.4
30-07L	10+580	6.3 LT	SBL	left toe of slope	0.6
30-08	10+585	CL	SBL	centreline	0.3
30-09R	10+507.5	7.0 RT	SBL	right toe of slope	5.3
D30-01R	10+532.5	6.3 RT	SBL	DCPT, right toe of slope	6.4
D30-02L	10+557	6.3 LT	SBL	DCPT, left toe of slope	7.9
D30-03R	10+580	6.3 RT	SBL	DCPT, right toe of slope	0.5
D30-04L	10+512.5	7.0 LT	SBL	DCPT, left toe of slope	5.1
C200-1	10+415	CL	NBL	culvert	6.6
Hwy 69 NBL, Sta. 12+050 to 12+100 Wallbridge					
31-01	12+055	CL	NBL	centreline	0.6
31-02L	12+062.5	8.1 LT	NBL	left toe of slope	1.3
31-03	12+075	CL	NBL	centreline	4.4
31-04R	12+087.5	9.1 RT	NBL	right toe of slope	2.5
31-05	12+100	CL	NBL	centreline	2.1
31-06L	12+087.5	9.1 LT	NBL	left toe of slope	0.2
D31-01R	12+062.5	8.1 RT	NBL	DCPT, right toe of slope	0.3
Harris Lake Road, Sta. 9+800 to 9+930					
32-01L	9+790	14.8 LT	-	left toe of slope	0.1
32-02	9+800	CL	-	centreline	2.6
32-03R	9+812.5	15.0 RT	-	right toe of slope	6.6
32-04	9+825	CL	-	centreline	4.6
32-05L	9+837.5	15.9 LT	-	left toe of slope	0.1

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
32-06	9+850	CL	-	centreline	4.0
32-07R	9+862.5	17.1 RT	-	right toe of slope	3.4
32-08	9+875	CL	-	centreline	9.8
32-09L	9+887.5	18.3 LT	-	left toe of slope	3.0
32-10	9+900	CL	-	centreline	5.3
32-11R	9+912.5	19.1 RT	-	right toe of slope	3.4
32-12	9+925	CL	-	centreline	6.2
32-13	9+930	CL	-	centreline	6.7
D32-01R	9+790	14.8 RT	-	DCPT, right toe of slope	3.7
D32-02L	9+812.5	15.0 LT	-	DCPT, left toe of slope	0.3
D32-03R	9+837.5	15.9 RT	-	DCPT, right toe of slope	6.7
D32-04L	9+862.5	17.1 LT	-	DCPT, left toe of slope	1.8
D32-05R	9+887.5	18.3 RT	-	DCPT, right toe of slope	4.5
D32-06L	9+912.5	19.1 LT	-	DCPT, left toe of slope	4.2
Harris Lake Road, Sta. 10+085 to 10+280					
33-01	10+085	CL	-	centreline	1.6
33-01R	10+087.5	18.6 RT	-	right toe of slope	0.9
33-02L	10+087.5	18.6 LT	-	left toe of slope	3.3
33-03	10+100	CL	-	centreline	0.1
33-04L	10+112.5	17.4 LT	-	left toe of slope	1.7
33-05	10+125	CL	-	centreline	0.8
33-06L	10+137.5	17.1 LT	-	left toe of slope	0.0
33-07	10+150	CL	-	centreline	0.5
33-08R	10+162.5	16.6 RT	-	right toe of slope	0.0
33-09	10+175	CL	-	centreline	0.6
33-10L	10+187.5	16.0 LT	-	left toe of slope	1.1
33-11	10+200	CL	-	centreline	3.1
33-12R	10+212.5	15.4 RT	-	right toe of slope	0.1
33-13	10+225	CL	-	centreline	2.0
33-14L	10+237.5	14.0 LT	-	left toe of slope	4.6
33-15	10+250	CL	-	centreline	3.8
33-16R	10+262.5	12.6 RT	-	right toe of slope	2.1
33-17	10+275	CL	-	centreline	2.4
33-18	10+280	CL	-	centreline	2.8
D33-02R	10+112.5	17.4 RT	-	DCPT, right toe of slope	1.2
D33-03R	10+137.5	17.1 RT	-	DCPT, right toe of slope	0.0
D33-04L	10+162.5	16.6 LT	-	DCPT, left toe of slope	2.8
D33-05R	10+187.5	16.0 RT	-	DCPT, right toe of slope	0.5
D33-06L	10+212.5	15.4 LT	-	DCPT, left toe of slope	0.3
D33-07R	10+237.5	14.0 RT	-	DCPT, right toe of slope	0.0
D33-08L	10+262.5	12.6 LT	-	DCPT, left toe of slope	5.5

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Rest Area Road, Sta. 10+000 to 10+150					
34-01	10+000	CL	-	centreline	2.8
34-02L	10+012.5	15.3 LT	-	left toe of slope	2.5
34-03	10+025	CL	-	centreline	5.2
34-04R	10+037.5	15.6 RT	-	right toe of slope	2.1
34-05	10+050	CL	-	centreline	1.5
34-06L	10+062.5	15.1 LT	-	left toe of slope	3.2
34-07	10+063	CL	-	centreline	1.4
34-08R	10+112.5	14.9 RT	-	right toe of slope	1.5
34-09	10+100	CL	-	centreline	0.0
34-10L	10+112.5	14.9 LT	-	left toe of slope	0.0
34-11	10+125	CL	-	centreline	0.0
34-12R	10+137.5	12.4 RT	-	right toe of slope	0.0
34-13	10+150	CL	-	centreline	0.0
D34-01R	10+012.5	15.3 RT	-	DCPT, right toe of slope	6.3
D34-02L	10+037.5	15.6 LT	-	DCPT, left toe of slope	2.7
D34-03R	10+062.5	15.1 RT	-	DCPT, right toe of slope	1.5
D34-04L	10+087.5	13.0 LT	-	DCPT, left toe of slope	0.1
D34-05R	10+087.5	13.0 RT	-	DCPT, right toe of slope	0.0
D34-06L	10+137.5	12.4 LT	-	DCPT, left toe of slope	0.0
Harris Lake Road; Ramp S-EW, Sta. 12+120 to 12+195 and Ramp EW-N, Sta. 11+625 to 11+690					
35-01	12+120	CL	S-EW	centreline	0.0
35-02	12+125	CL	S-EW	centreline	0.0
35-03L	11+685	6.7 LT	EW-N	left shoulder	5.2
35-04	12+150	CL	S-EW	centreline	3.7
35-05R	12+162.5	12.5 RT	S-EW	right toe of slope	4.5
35-06	12+175	CL	S-EW	centreline	2.7
35-07L	11+635	4.5 LT	EW-N	left shoulder	2.7
35-08	12+190	CL	S-EW	centreline	2.3
D35-01R	12+137.5	10.5 RT	S-EW	DCPT, right toe of slope	0.0
D35-02L	11+660	4.7 LT	EW-N	DCPT, left shoulder	2.1
D35-03R	12+187.5	12.8 RT	S-EW	DCPT, right toe of slope	0.4
36-01	11+620	CL	EW-N	centreline	0.2
36-02	11+625	CL	EW-N	centreline	2.3
36-03L	12+185	5.0 LT	S-EW	left shoulder	4.1
36-04	11+650	CL	EW-N	centreline	4.7
36-05R	11+662.5	13.8 RT	EW-N	right toe of slope	4.6
36-06	11+675	CL	EW-N	centreline	3.0
36-07L	12+135	7.0 LT	S-EW	left shoulder	2.2
36-08	11+690	CL	EW-N	centreline	7.6

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
D36-01R	11+637.5	13.5 RT	EW-N	right toe of slope	5.5
D36-02L	12+160	4.7 LT	S-EW	left shoulder	3.0
D36-03R	11+687.5	10.3 RT	EW-N	right toe of slope	6.1
Harris Lake Road; Ramp EW-S, Sta. 12+070 to 12+110 and Ramp N-EW, Sta. 11+650 to 11+690					
37-01	12+070	CL	EW-S	centreline	0.0
37-02	12+075	CL	EW-S	centreline	0.1
37-03L	12+087.5	7.1 LT	EW-S	left toe of slope	0.3
37-04	12+100	CL	EW-S	centreline	0.2
37-05	12+110	CL	EW-S	centreline	1.2
D37-01R	12+087.5	9.4 RT	EW-S	DCPT, right toe of slope	0.0
38-01	11+650	CL	N-EW	centreline	0.4
38-02L	11+662.5	9.4 LT	N-EW	left toe of slope	0.1
38-03	11+675	CL	N-EW	centreline	0.1
38-04R	11+687.5	7.4 RT	N-EW	right toe of slope	0.1
38-05	11+690	CL	N-EW	centreline	0.1
D38-01R	11+662.5	11.6 RT	N-EW	DCPT, right toe of slope	0.1
D38-02L	11+687.5	5.1 LT	N-EW	DCPT, left toe of slope	0.1
Harris Lake Road; Ramp N-EW, Sta. 11+840 to 11+910					
39-01	11+840	CL	N-EW	centreline	0.0
39-02	11+850	CL	N-EW	centreline	0.1
39-03L	11+862.5	6.3 LT	N-EW	left toe of slope	0.3
39-04	11+875	CL	N-EW	centreline	0.1
39-05R	11+887.5	6.3 RT	N-EW	right toe of slope	0.0
39-06	11+900	CL	N-EW	centreline	2.8
39-07	11+910	CL	N-EW	centreline	3.5
39-08L	11+907.5	7.0 LT	N-EW	left toe of slope	2.3
39-09	11+920	CL	N-EW	centreline	0.0
D39-01R	11+862.5	6.3 RT	N-EW	DCPT, right toe of slope	0.0
D39-02L	11+887.5	6.3 LT	N-EW	DCPT, left toe of slope	0.0
D39-03R	11+907.5	7.0 RT	N-EW	DCPT, right toe of slope	1.8
Harris Lake Road; Ramp N-EW, Sta. 12+030 to 12+120					
40-01	12+035	CL	N-EW	centreline	2.2
40-02L	12+037.5	6.4 LT	N-EW	left toe of slope	1.4
40-03	12+050	CL	N-EW	centreline	0.8
40-04R	12+062.5	8.5 RT	N-EW	right toe of slope	1.8
40-05	12+075	CL	N-EW	centreline	0.1
40-06L	12+087.5	6.1 LT	N-EW	left toe of slope	0.6
40-07	12+100	CL	N-EW	centreline	5.5
40-09	12+120	CL	N-EW	centreline	0.0
D40-01R	12+037.5	8.6 RT	N-EW	DCPT, right toe of slope	1.5
D40-02L	12+062.5	6.2 LT	N-EW	DCPT, left toe of slope	0.1

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
D40-03R	12+087.5	8.4 RT	N-EW	DCPT, right toe of slope	0.2
D40-04L	12+112.5	7.4 LT	N-EW	DCPT, left toe of slope	1.5
Harris Lake Road; Ramp EW-N, Sta. 12+070 to 12+120					
41-01	12+070	CL	EW-N	centreline	0.1
41-02	12+075	CL	EW-N	centreline	0.1
41-03L	12+087.5	5.4 LT	EW-N	left toe of slope	1.5
41-04	12+100	CL	EW-N	centreline	4.6
41-05R	12+110	8.5 RT	EW-N	right toe of slope	4.5
D41-01R	12+087.5	7.6 RT	EW-N	DCPT, right toe of slope	3.8
D41-02L	12+110	6.2 LT	EW-N	DCPT, median centreline	5.4
Hwy 69 NBL, Sta. 12+470 to 12+540 Wallbridge					
42-01	12+490	CL	NBL	centreline	1.0
42-02L	12+500	8.6 LT	NBL	left toe of slope	2.3
42-03	12+512.5	CL	NBL	centreline	0.0
42-04R	12+525	8.1 RT	NBL	right toe of slope	0.1
42-05	12+537.5	CL	NBL	centreline	0.1
42-06L	12+540	8.2 LT	NBL	left toe of slope	0.1
D42-01R	12+500	8.6 RT	NBL	DCPT, right toe of slope	0.5
D42-02L	12+525	8.1 LT	NBL	DCPT, left toe of slope	0.0
D42-03R	12+540	8.2 RT	NBL	DCPT, right toe of slope	0.5
Hwy 69 NBL, Sta. 13+130 to 13+190 Wallbridge					
43-01	13+130	CL	NBL	centreline	0.8
43-02L	13+137.5	9.7 LT	NBL	left toe of slope	0.3
43-03	13+150	CL	NBL	centreline	0.5
43-04R	13+162.5	9.8 RT	NBL	right toe of slope	2.0
43-05	13+175	CL	NBL	centreline	0.2
43-06L	13+185	7.5 LT	NBL	left toe of slope	0.2
D43-01R	13+137.5	9.7 RT	NBL	DCPT, right toe of slope	0.0
D43-02L	13+162.5	9.8 LT	NBL	DCPT, left toe of slope	1.1
D43-03R	13+185	7.5 RT	NBL	DCPT, right toe of slope	0.0
Hwy 69 NBL, Sta. 13+580 to 13+650 Wallbridge					
44-01	13+580	CL	NBL	centreline	0.0
44-02	13+585	CL	NBL	centreline	0.3
44-03L	13+597.5	9.8 LT	NBL	left toe of slope	2.7
44-05R	13+622.5	10.1 RT	NBL	right toe of slope	8.4
44-06	13+635	CL	NBL	centreline	3.9
44-07	13+640	CL	NBL	centreline	3.7
44-08R	13+605	10.0 RT	NBL	right toe of slope	4.8
44-09	13+610	CL	NBL	centreline	0.0
44-10L	13+645	10.0 LT	NBL	left toe of slope	3.0
D44-01R	13+587.5	9.8 RT	NBL	DCPT, right toe of slope	2.7

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
D44-02L	13+612.5	10.1 LT	NBL	DCPT, left toe of slope	4.0
D44-03L	13+622.5	10.0 LT	NBL	DCPT, left toe of slope	1.0
D44-04R	13+645	10.0 RT	NBL	DCPT, right toe of slope	1.1
Hwy 69 NBL, Sta. 13+890 to 13+990 Wallbridge					
45-01	13+895	CL	NBL	centreline	0.8
45-02	13+900	CL	NBL	centreline	1.7
45-03L	13+912.5	9.0 LT	NBL	left toe of slope	3.2
45-04	13+925	CL	NBL	centreline	3.4
45-05R	13+937.5	8.8 RT	NBL	right toe of slope	5.5
45-06	13+950	CL	NBL	centreline	6.0
45-07L	13+962.5	8.1 LT	NBL	left toe of slope	1.0
45-08	13+975	CL	NBL	centreline	3.8
45-09R	13+987.5	7.1 RT	NBL	right toe of slope	3.3
45-10	13+990	CL	NBL	centreline	0.5
D45-01R	13+912.5	9.0 RT	NBL	DCPT, right toe of slope	3.3
D45-02L	13+937.5	8.8 LT	NBL	DCPT, left toe of slope	7.1
D45-03R	13+962.5	8.1 RT	NBL	DCPT, right toe of slope	2.8
D45-04L	13+987.5	7.1 LT	NBL	DCPT, left toe of slope	0.0
Hwy 69 NBL, Sta. 14+110 to 14+280 Wallbridge					
46-01	14+225	CL	NBL	centreline	0.1
46-02	14+235	CL	NBL	centreline	1.8
46-03L	14+247.5	6.7 LT	NBL	left toe of slope	0.5
46-04	14+255	CL	NBL	centreline	2.9
46-05R	14+269	8.2 RT	NBL	right toe of slope	0.5
46-06	14+273	CL	NBL	centreline	0.2
46-07	14+122.5	CL	NBL	centreline	3.0
46-08R	14+135	8.0 RT	NBL	right toe of slope	2.3
46-09	14+147.5	CL	NBL	centreline	0.0
46-10L	14+160	8.0 LT	NBL	left toe of slope	2.4
46-11	14+172.5	CL	NBL	centreline	1.0
D46-01R	14+247.5	6.7 RT	NBL	DCPT, right toe of slope	1.3
D46-02L	14+263.8	8.2 LT	NBL	DCPT, left toe of slope	0.9
D46-03R	14+110	8.0 RT	NBL	DCPT, right toe of slope	1.2
D46-04L	14+135	8.0 LT	NBL	DCPT, left toe of slope	0.0
D46-05R	14+160	8.0 RT	NBL	DCPT, right toe of slope	2.4

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Hwy 69 NBL, Sta. 14+460 to 14+690 Wallbridge					
47-01	14+460	CL	NBL	centreline	1.1
47-02	14+465	CL	NBL	centreline	0.1
47-03L	14+477.5	6.3 LT	NBL	left toe of slope	1.2
47-04	14+490	CL	NBL	centreline	4.6
47-05R	14+502.5	7.2 RT	NBL	right toe of slope	3.2
47-06	14+515	CL	NBL	centreline	1.7
47-07L	14+527.5	8.4 LT	NBL	left toe of slope	0.5
47-08	14+540	CL	NBL	centreline	1.2
47-09R	14+547.5	8.3 RT	NBL	right toe of slope	1.3
47-10	14+560	CL	NBL	centreline	0.1
D47-01R	14+477.5	6.3 RT	NBL	DCPT, right toe of slope	2.2
D47-02L	14+502.5	7.2 LT	NBL	DCPT, left toe of slope	1.7
D47-03R	14+527.5	8.5 RT	NBL	DCPT, right toe of slope	0.2
D47-04L	14+547.5	8.3 LT	NBL	DCPT, left toe of slope	0.8
47A-01	14+625	CL	NBL	centreline	1.8
47A-02L	14+637.5	11.0 LT	NBL	left toe of slope	2.4
47A-03	14+650	CL	NBL	centreline	2.4
47A-04R	14+662.5	11.0 RT	NBL	right toe of slope	0.8
47A-05	14+675	CL	NBL	centreline	1.2
47A-06L	14+687.5	11.0 LT	NBL	left toe of slope	2.1
D47A-01L	14+612.5	11.0 LT	NBL	DCPT, left toe of slope	0.0
D47A-02R	14+637.5	11.0 RT	NBL	DCPT, right toe of slope	2.7
D47A-03L	14+662.5	11.0 LT	NBL	DCPT, left toe of slope	0.9
D47A-04R	14+687.5	11.0 RT	NBL	DCPT, right toe of slope	0.5
C236-D1	14+646	14.0 RT	NBL	culvert	5.1
Hwy 69 NBL & SBL, Sta. 15+050 to 15+190 Wallbridge					
48-01	15+095	CL	NBL	centreline	2.2
48-02	15+100	CL	NBL	centreline	7.2
48-03L	15+112.5	9.4 LT	NBL	left toe of slope	9.1
48-04	15+125	CL	NBL	centreline	7.7
48-05R	15+130	9.2 RT	NBL	right toe of slope	5.1
48-06	15+135	CL	NBL	centreline	3.8
48-08R	15+087.5	11.0 RT	NBL	right toe of slope	1.8
48-09L	15+147.5	9.0 LT	NBL	left toe of slope	3.0
48-10	15+160	CL	NBL	centreline	5.4
48-11R	15+172.5	11.0 RT	NBL	right toe of slope	8.7
D48-01R	15+112.5	9.4 RT	NBL	DCPT, right toe of slope	11.7
D48-02L	15+130	9.2 LT	NBL	DCPT, left toe of slope	5.4
D48-03L	15+087.5	9.0 LT	NBL	DCPT, left toe of slope	5.4
D48-04R	15+147.5	11.0 RT	NBL	DCPT, right toe of slope	5.0

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
D48-05L	15+172.5	9.0 LT	NBL	DCPT, left toe of slope	4.0
49-01	15+080	4.0 LT	SBL	on existing Hwy 69	0.6
49-02L	15+087.5	12.5 LT	SBL	left toe of slope	12.3
49-03	15+100	4.0 LT	SBL	on existing Hwy 69	0.7
49-04R	15+112.5	3.0 RT	SBL	on existing Hwy 69	1.2
49-05	15+125	3.0 RT	SBL	on existing Hwy 69	1.1
49-06R	15+075	16.0 RT	SBL	right toe of slope	2.2
49-08R	15+125	16.0 RT	SBL	right toe of slope	9.6
49-09L	15+150	13.0 LT	SBL	left toe of slope	6.7
49-10R	15+175	18.0 RT	SBL	right toe of slope	4.3
D49-01R	15+087.5	4.0 RT	SBL	on existing Hwy 69	0.8
D49-02L	15+112.5	12.5 LT	SBL	left toe of slope	4.9
D49-03R	15+050	16.0 RT	SBL	right toe of slope	2.6
D49-04L	15+067.5	13.0 LT	SBL	left toe of slope	1.3
D49-05R	15+100	16.0 RT	SBL	right toe of slope	7.5
D49-07R	15+150	16.0 RT	SBL	right toe of slope	2.1
D49-08L	15+175	13.0 LT	SBL	left toe of slope	7.6
C238-1	15+122	15.0 RT	NBL	culvert	7.3
C239-1	15+113	17.0 RT	SBL	culvert	12.5
C239-2	15+108	3.0 RT	SBL	culvert	11.8
Hwy 69 NBL, Sta. 15+450 to 15+560 Wallbridge					
50-01	15+450	CL	NBL	centreline	0.5
50-02L	15+462.5	7.2 LT	NBL	left toe of slope	0.0
50-03	15+475	CL	NBL	centreline	0.0
50-04R	15+487.5	8.8 RT	NBL	right toe of slope	0.1
50-05	15+500	CL	NBL	centreline	1.8
50-06L	15+512.5	8.7 LT	NBL	left toe of slope	1.4
50-07	15+525	CL	NBL	centreline	2.0
50-08R	15+537.5	7.3 RT	NBL	right toe of slope	0.1
50-09	15+550	CL	NBL	centreline	0.0
50-10	15+560	CL	NBL	centreline	0.0
D50-01R	15+462.5	9.5 RT	NBL	DCPT, right toe of slope	0.0
D50-02L	15+487.5	8.8 LT	NBL	DCPT, left toe of slope	0.0
D50-03R	15+512.5	8.7 RT	NBL	DCPT, right toe of slope	0.0
D50-04L	15+537.5	7.3 LT	NBL	DCPT, left toe of slope	0.0

Table A1

Borehole Summary

Borehole	Station	Offset (m)	Direction	Description	Depth (m)
Hwy 69 NBL, Sta. 15+710 to 15+800 Wallbridge					
51-01	15+725	CL	NBL	centreline	3.4
51-02L	15+737.5	9.5 LT	NBL	left toe of slope	3.5
51-03	15+750	CL	NBL	centreline	0.3
51-04R	15+762.5	9.7 RT	NBL	right toe of slope	0.2
51-05	15+775	CL	NBL	centreline	0.6
51-06L	15+787.5	7.8 LT	NBL	left toe of slope	0.0
51-07	15+795	CL	NBL	centreline	0.2
51-08R	15+712.5	10.0 RT	NBL	right toe of slope	3.3
D51-01R	15+737.5	9.5 RT	NBL	DCPT, right toe of slope	0.8
D51-02L	15+762.5	9.7 LT	NBL	DCPT, left toe of slope	1.2
D51-03R	15+787.5	7.8 RT	NBL	DCPT, right toe of slope	0.2
D51-04L	15+712.5	10.0 LT	NBL	DCPT, left toe of slope	0.8
Hwy 69 NBL, Sta. 15+860 to 15+915 Wallbridge					
52-01	15+860	CL	NBL	centreline	0.2
52-02	15+865	CL	NBL	centreline	0.1
52-03L	15+877.5	8.0 LT	NBL	left toe of slope	2.6
52-04	15+890	CL	NBL	centreline	1.4
52-05R	15+902.5	6.6 RT	NBL	right toe of slope	0.1
52-06	15+915	CL	NBL	centreline	0.4
D52-01R	15+877.5	8.0 RT	NBL	DCPT, right toe of slope	1.5
D52-02L	15+902.5	6.6 LT	NBL	DCPT, left toe of slope	0.0

Table A2

Piezometer Installation Details

Borehole	Piezometer Tip Depth (m)	Installation Details
15-02R	6.2	Piezometer with 1.5 m slotted screen installed, sand filter from 6.2 to 4.4 m, bentonite seal from 4.4 m to ground surface.
16-11	7.4	Piezometer with 1.5 m slotted screen installed, sand filter from 7.4 to 5.6 m, bentonite seal from 5.6 m to ground surface.
21-04L	3.8	Piezometer with 1.5 m slotted screen installed, sand filter from 3.8 to 2.1 m, bentonite seal from 2.1 m to ground surface.
22-02L	3.6	Piezometer with 1.5 m slotted screen installed, sand filter from 3.6 to 1.8 m, bentonite seal from 1.8 m to ground surface.
24-12R	3.9	Piezometer with 1.5 m slotted screen installed, sand filter from 3.9 to 1.7 m, bentonite seal from 1.7 to 0.6 m, cuttings to ground surface.
24-06L	2.6	Piezometer with 1.5 m slotted screen installed, sand filter from 2.6 to 1.2 m, bentonite seal from 1.2 to 0.9 m, cuttings to ground surface.
26-03	9.1	Piezometer with 1.5 m slotted screen installed, sand filter from 9.1 to 7.0 m, bentonite seal from 7.0 to 3.7 m, cuttings to ground surface.
27-05	1.9	Piezometer with 1.5 m slotted screen installed, sand filter from 1.9 to 0.4 m, bentonite seal from 0.4 m to ground surface.
28-08R	5.8	Piezometer with 1.5 m slotted screen installed, sand filter from 5.8 to 3.6 m, bentonite seal from 3.6 m to ground surface.
29-05	3.8	Piezometer with 1.5 m slotted screen installed, sand filter from 3.8 to 2.1 m, bentonite seal from 2.1 m to ground surface.
30-05R	4.3	Piezometer with 1.5 m slotted screen installed, sand filter from 4.3 to 2.4 m, bentonite seal and grout from 2.4 m to ground surface.
31-03	4.4	Piezometer with 1.5 m slotted screen installed, sand filter from 4.4 to 2.5 m, bentonite seal and grout from 2.5 m to ground surface.
32-03R	6.6	Piezometer with 1.5 m slotted screen installed, sand filter from 6.6 to 4.0 m, bentonite seal from 4.0 m to ground surface.
32-08	9.8	Piezometer with 1.5 m slotted screen installed, sand filter from 9.8 to 7.6 m, bentonite seal from 7.6 m to ground surface.
33-14L	4.0	Piezometer with 1.5 m slotted screen installed, sand filter from 4.0 to 2.2 m, bentonite grout from 2.2 m to ground surface.
35-05R	4.5	Piezometer with 1.5 m slotted screen installed, sand filter from 4.5 to 2.6 m, bentonite seal from 2.6 m to ground surface.
36-05R	4.5	Piezometer with 1.5 m slotted screen installed, sand filter from 4.5 to 2.4 m, bentonite seal from 2.4 m to ground surface.
39-07	3.5	Piezometer with 1.5 m slotted screen installed, sand filter from 3.5 to 1.5 m, bentonite grout from 1.5 m to ground surface.
40-07	5.5	Piezometer with 1.5 m slotted screen installed, sand filter from 5.5 to 3.7 m, bentonite seal from 3.7 m to ground surface.
41-04	4.6	Piezometer with 1.5 m slotted screen installed, sand filter from 4.6 to 2.6 m, bentonite seal from 2.6 m to ground surface.
42-02L	2.3	Piezometer with 1.5 m slotted screen installed, sand filter from 2.3 to 0.9 m, bentonite seal from 0.9 m to ground surface.
43-04R	2.0	Piezometer with 1.5 m slotted screen installed, sand filter from 2.0 to

Table A2

Piezometer Installation Details

Borehole	Piezometer Tip Depth (m)	Installation Details
		0.3 m, bentonite seal from 0.3 m to ground surface.
44-05R	8.4	Piezometer with 1.5 m slotted screen installed, sand filter from 8.4 to 6.4 m, bentonite seal from 6.4 m to ground surface.
45-05R	5.5	Piezometer with 1.5 m slotted screen installed, sand filter from 5.5 to 3.7 m, bentonite seal from 3.7 m to ground surface.
45-09R	3.3	Piezometer with 1.5 m slotted screen installed, sand filter from 3.3 to 1.2 m, bentonite seal from 1.2 m to ground surface.
46-04	2.9	Piezometer with 1.5 m slotted screen installed, sand filter from 2.9 to 1.2 m, bentonite seal from 1.2 m to ground surface.
47-05R	3.2	Piezometer with 1.5 m slotted screen installed, sand filter from 3.2 to 1.1 m, bentonite seal from 1.1 m to ground surface.
48-04	7.7	Piezometer with 1.5 m slotted screen installed, sand filter from 7.7 to 6.0 m, bentonite seal from 6.0 m to ground surface.
48-10	5.4	Piezometer with 1.5 m slotted screen installed, sand filter from 5.4 to 3.1 m, bentonite seal from 3.1 to 2.5 m, cuttings from 2.5 to 0.6 m, bentonite seal from 0.6 to 0.3 m, cuttings to ground surface.
51-02L	3.5	Piezometer with 1.5 m slotted screen installed, sand filter from 3.5 to 1.2 m, bentonite seal from 1.2 m to ground surface.
52-03L	2.6	Piezometer with 1.5 m slotted screen installed, sand filter from 2.6 to 0.6 m, bentonite seal from 0.6 m to ground surface.
C239-1	12.2	Piezometer with 1.5 m slotted screen installed, sand filter from 12.2 to 9.7 m, bentonite seal from 9.7 to 2.0 m, cuttings from 2.0 to 0.8 m, bentonite seal from 0.8 to 0.2 m, cuttings to ground surface.

Table A3

Summary of Swamp Crossings/High Fill Embankment Locations and Conditions

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height (m)	Boreholes and Cones (D)	Generalized Stratigraphy	Groundwater Conditions
B	Hwy 69 NBL & SBL	21+710 to 22+135	425	High Fill	14.1	15-01 to 15-09L 15A-01R to 15A-05R 16-01 to 16-14L D15-01L to D15-04R C104-1 to C104-3 C105-1 to C105-3 D15A-01L to D15A-05L D16-01R to D16-07R	PEAT and ORGANICS, 50 to 1100 mm thick; over CLAY, silty, very soft to stiff, 0.7 to 8.9 m thick; under or over SILT, sandy to SAND, very loose to compact, 0.2 to 2.2 m thick; over SAND, gravelly to SAND and GRAVEL, very loose to dense, 0.6 to 2.2 m thick; over PROBABLE BEDROCK at 0.1 to 9.7 m depth.	Water at 0.0 to 2.8 m depth in 13 open boreholes, at 0.4 to 0.9 m above the ground surface at three borehole locations, and at 0.0 to 0.5 m depth in two piezometers.
C	Hwy 69 SBL	22+350 to 22+410	60	Swamp Crossing	3.0	17-01 to 17-07 D17-01L to D17-03L	PEAT and ORGANICS, 25 to 600 mm thick; over BEDROCK at 0.0 to 0.6 m depth.	Groundwater was not observed during fieldwork.
D	Hwy 69 SBL	22+475 to 22+565	90	Swamp Crossing	4.2	18-01 to 18-09 D18-01R to D18-04L	PEAT and ORGANICS, 25 to 800 mm thick; over SAND and SILT, very loose to loose, 0.5 to 1.0 m thick (three boreholes); over PROBABLE BEDROCK at 0.0 to 1.8 m depth.	Water at 0.0 to 0.2 m depth in three open boreholes.
E	Hwy 69 SBL	22+750 to 22+825	75	Swamp Crossing	3.2	19-01 to 19-07 D19-01R to D19-03R	PEAT and ORGANICS, 25 to 700 mm thick; over SAND, silty, very loose, 1.1 m thick (one borehole); over BEDROCK at 0.0 to 1.8 m depth.	Water at 0.0 to 0.2 m depth in two open boreholes.
F	Hwy 69 NBL & SBL	23+125 to 23+215	90	High Fill / Swamp Crossing	6.1	20-01 to 20-13L 21-01 to 21-07 D20-01L to D20-05L D21-01L to D21-03L	PAVEMENT STRUCTURE and FILL (on existing highway platform), sand and gravel, compact to very dense, 1.0 to 3.8 m thick; over PROBABLE ROCK FILL; or PEAT and ORGANICS, 0.2 to 1.2 m thick (two boreholes); or SAND, very loose to loose, 0.3 to 1.0 m thick; or/over CLAY, silty, very soft to stiff, 0.2 to 2.8 m thick; over PROBABLE BEDROCK at 0.0 to 5.1 m depth.	Much of the site was overlain by up to 1.7 m of ice and water during fieldwork. Water at 0.0 to 0.3 m above ground surface in piezometer.
G	Hwy 69 SBL	24+000 to 24+040	40	High Fill / Swamp Crossing	6.2	22-01 to 22-05 D22-01R, D22-02L	PEAT and ORGANICS, 50 to 700 mm thick; over/or SAND, silty, very loose to compact, 0.5 to 3.0 m thick; over CLAY, silty, very soft to soft, 0.4 to 0.9 m thick (two boreholes); over PROBABLE BEDROCK at 0.1 to 5.2 m depth.	Water at 1.2 to 2.1 m depth in two open boreholes, and at 0.0 to 0.9 m depth in piezometer.
H	Hwy 69 NBL & SBL	24+400 to 24+600	200	Swamp Crossing	2.6	23-01 to 23-16L 24-01 to 24-12R 24-14R to 24-17L D23-01L to D23-07L D24-01R to D24-05L	PAVEMENT STRUCTURE and FILL (on existing highway platform), sand and gravel, dense to very dense, 0.4 to 3.0 m thick; over PROBABLE ROCK FILL; or PEAT, 0.2 to 1.2 m thick; over/or CLAY, silty, very soft to very stiff, 0.3 to 3.6 m thick; and/or SILT, sandy to SAND, silty, very loose to compact, 0.1 to 2.1 m thick; over SAND, gravelly, loose to compact, 0.2 to 2.0 m thick; over PROBABLE BEDROCK at 0.5 to 8.7 m depth.	Much of the site was overlain by up to 1.4 m of ice and water during fieldwork. Water at 0.0 to 1.6 m depth in 13 open boreholes, and at 0.0 to 0.1 m depth in two piezometers.

Table A3

Summary of Swamp Crossings/High Fill Embankment Locations and Conditions

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height (m)	Boreholes and Cones (D)	Generalized Stratigraphy	Groundwater Conditions
I	Hwy 69 SBL	24+900 to 25+000	100	High Fill / Swamp Crossing	6.6	25-01 to 25-04R 26-01 to 26-08 C124-2, C124-3 C125-1, C125-2 D25-01R, D25-02L D26-01R, D26-02L C125-D1 to C125-D3	PEAT, 0.2 to 3.6 m thick; over CLAY, silty, very soft to firm, 1.2 to 12.2 m thick; over SAND, gravelly, very loose to very dense, 0.2 to 1.2 m thick (three boreholes); over PROBABLE BEDROCK at 0.2 to 23.3 m depth.	Much of the site was overlain by up to 1.4 m of ice and water during fieldwork. Water at 1.7 m depth in one open borehole and at ground surface in piezometer.
J	Hwy 69 SBL	25+300 to 25+355	55	High Fill / Swamp Crossing	6.6	27-01 to 27-06 D27-01R, D27-02L	PEAT and ORGANICS, 200 to 800 mm thick; over CLAY, silty, very soft to very stiff, 0.8 to 1.9 m thick; and/or SAND to SAND and SILT, very loose to compact, 0.6 to 3.0 m thick; over SAND, gravelly, very dense, 1.1 m thick (one borehole); over PROBABLE BEDROCK at 0.2 to 6.1 m depth.	Water at 0.0 to 0.6 m depth in four open boreholes, and at ground surface in piezometer.
K	Hwy 69 NBL & SBL	10+330 to 10+585	255	Swamp Crossing	3.5	28-01 to 28-17 29-01 to 29-15 30-01 to 30-09R C200-1 D28-01R to D28-08L D29-01R to D29-06L D30-01R to D30-04L	PAVEMENT STRUCTURE and FILL (on existing highway platform), sand and gravel, compact to very dense, 0.5 to 1.4 m thick; over PROBABLE ROCK FILL; or PEAT and ORGANICS, 25 to 1100 mm thick; over SAND and SILT to SAND, silty, very loose to compact, 0.1 to 4.1 m thick; over/under CLAY, silty, very soft to stiff, 0.4 to 6.2 m thick; over PROBABLE BEDROCK at 0.0 to 8.4 m depth.	Water at 0.0 to 5.2 m depth in 16 open boreholes, and at 0.3 m above to 1.2 m below ground surface in piezometers.
L	Hwy 69 NBL	12+050 to 12+100	50	Swamp Crossing	3.1	31-01 to 31-06L D31-01R	ORGANICS, 25 to 100 mm thick; over SAND and SILT, loose to compact, 0.2 to 4.4 m thick; over BEDROCK at 0.2 to 4.4 m depth.	Water at 2.4 to 2.5 m depth in two open boreholes, and at 0.0 to 3.3 m depth in piezometer.
M	Harris Lake Road	9+800 to 9+930	130	High Fill	11.8	32-01L to 32-13 D32-01R to D32-06L	PEAT and ORGANICS, 25 to 100 mm thick; over/or SAND, very loose to compact, 1.2 to 6.5 m thick; over/under/or SAND and SILT to SILT, sandy, very loose to loose, 0.7 to 2.9 m thick; over/or CLAY, silty, very soft to stiff, 0.7 to 1.4 m thick (three boreholes); over PROBABLE BEDROCK at 0.1 to 9.8 m depth.	Part of the site was overlain by up to 1.7 m of ice and water during fieldwork. Water at 0.7 to 5.3 m depth in seven open boreholes, and at 0.2 to 1.4 m depth in piezometers.
N	Harris Lake Road	10+085 to 10+280	195	High Fill	11.2	33-01 to 33-18 D33-02R to D33-08L	PEAT and ORGANICS, 25 to 500 mm thick; over/or SAND, very loose to compact, 0.5 to 3.0 m thick; or SAND and SILT to SILT, sandy, very loose to compact, 0.1 to 4.6 m thick; over/under CLAY, silty, very soft to stiff, 0.7 to 1.7 m thick; over PROBABLE BEDROCK at 0.0 to 5.5 m depth.	Water at 0.0 to 2.8 m depth in ten open boreholes, and at 0.2 m above to 0.6 m below ground surface in piezometer.
O	Rest Area Road	10+000 to 10+150	150	High Fill	8.6	34-01 to 34-13 D34-01R to D34-06L	PEAT, 500 to 600 mm thick (two boreholes); or SAND, very loose to dense, 0.9 to 5.2 m thick; over PROBABLE BEDROCK at 0.0 to 5.7 m depth.	Part of the site was overlain by up to 1.5 m of ice and water during fieldwork. Water at 0.0 to 1.5 m depth in three open boreholes.

Table A3

Summary of Swamp Crossings/High Fill Embankment Locations and Conditions

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height (m)	Boreholes and Cones (D)	Generalized Stratigraphy	Groundwater Conditions
P	Harris Lake Road: Ramp S-EW Ramp EW-N	 12+120 to 12+195 11+625 to 11+690	 75 65	High Fill	8.9	35-01 to 35-08 36-01 to 36-08 D35-01R to D35-03R D36-01R to D36-03R	PEAT and ORGANICS, 25 to 700 mm thick; over/or SAND and SILT to SAND, silty, very loose to compact, 0.1 to 2.7 m thick; over/under/or CLAY, silty, very soft to stiff, 0.3 to 3.4 m thick; over SAND, very loose to dense, 1.5 to 6.2 m thick; over PROBABLE BEDROCK at 0.0 to 7.6 m depth.	Water at 0.0 to 2.1 m depth in eleven open boreholes, and at 0.2 m above to 0.5 m below ground surface in piezometers.
Q	Harris Lake Road: Ramp EW-S Ramp N-EW	 12+070 to 12+110 11+650 to 11+690	 40 40	High Fill	8.0	37-01 to 37-05 38-01 to 38-05 D37-01R D38-01R, D38-02L	ORGANICS, 25 to 300 mm thick; over/or SAND, very loose to very dense, 0.4 to 1.1 m thick (two boreholes); over BEDROCK at 0.0 to 1.2 m depth.	Groundwater was not observed during fieldwork.
R	Harris Lake Road: Ramp N-EW	11+840 to 11+910	70	Swamp Crossing	3.0	39-01 to 39-09 D39-01R to D39-03R	ORGANICS, 20 to 300 mm thick; over CLAY, silty, soft to very stiff, 1.2 to 1.4 m thick (two boreholes); over SAND and SILT, loose to compact, 0.5 to 1.4 m thick (two boreholes); over/or SAND, very loose to compact, 2.3 to 3.5 m thick (two boreholes); over PROBABLE BEDROCK at 0.0 to 3.5 m depth.	Water at 0.6 to 1.3 m depth in three open boreholes, and at 0.1 to 0.6 m depth in piezometer.
S	Harris Lake Road: Ramp N-EW	12+030 to 12+120	90	Swamp Crossing	3.4	40-01 to 40-09 D40-01R to D40-04L	ORGANICS, 75 to 700 mm thick; over/or SAND and SILT, very loose to compact, 0.7 to 2.5 m thick; over/under CLAY, silty, very soft to soft, 1.1 to 2.3 m thick (two boreholes); or SAND, very loose to loose, 0.6 to 0.8 m thick (two boreholes); over PROBABLE BEDROCK at 0.0 to 5.5 m depth.	Water at 0.0 to 0.9 m depth in two open boreholes, and at 0.4 m above to 0.5 m below ground surface in piezometer.
T	Harris Lake Road: Ramp EW-N	12+070 to 12+120	50	Swamp Crossing	3.0	41-01 to 41-05R D41-01R, D41-02L	ORGANICS, 25 to 125 mm thick; over/or SAND, silty, very loose to compact, 1.4 m thick (two boreholes); over CLAY, silty, very soft to stiff, 1.5 to 2.3 m thick; over SAND to SAND and GRAVEL, compact, 0.9 to 1.5 m thick (two boreholes); over PROBABLE BEDROCK at 0.0 to 5.4 m depth.	Water at 1.2 m depth in two open boreholes, and at 0.0 to 0.2 m depth in piezometer.
U	Hwy 69 NBL	12+470 to 12+540	70	Swamp Crossing	3.0	42-01 to 42-06L D42-01R to D42-03R	ORGANICS, 25 to 75 mm thick; over SAND and SILT, very loose to loose, 2.2 m thick (one borehole); or SAND, very loose, 1.0 m thick (one borehole); over PROBABLE BEDROCK at 0.0 to 2.3 m depth.	Water at ground surface in two open boreholes, and at 0.0 to 0.2 m depth in piezometer.
V	Hwy 69 NBL	13+130 to 13+190	60	Swamp Crossing	3.8	43-01 to 43-06L D43-01R to D43-03R	ORGANICS, 25 to 300 mm thick; over CLAY, silty, stiff, 1.3 m thick (one borehole); over SAND, silty, very loose to compact, 0.1 to 0.6 m thick; over PROBABLE BEDROCK at 0.0 to 2.0 m depth.	Water at 0.0 to 0.1 m depth in two open boreholes, and at 0.0 to 0.8 m depth in piezometer.

Table A3

Summary of Swamp Crossings/High Fill Embankment Locations and Conditions

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height (m)	Boreholes and Cones (D)	Generalized Stratigraphy	Groundwater Conditions
W	Hwy 69 NBL	13+580 to 13+650	70	Swamp Crossing	3.5	44-01 to 44-10L D44-01R to D44-04R	ORGANICS, 25 to 700 mm thick; over/or SAND and SILT, very loose to compact, 0.3 to 1.5 m thick; over/under CLAY, silty, very soft to firm, 0.9 to 7.0 m thick, over SAND and GRAVEL, loose, 0.8 m thick (one borehole); over PROBABLE BEDROCK at 0.0 to 8.4 m depth.	Water at 0.6 to 1.5 m depth in six open boreholes, and at 0.0 to 0.4 m depth in piezometer.
X	Hwy 69 NBL	13+890 to 13+990	100	Swamp Crossing	3.2	45-01 to 45-10 D45-01R to D45-04L	ORGANICS, 25 to 900 mm thick; over SAND, silty, very loose to compact, 0.2 to 2.4 m thick; over CLAY, silty, very soft to soft, 0.6 to 4.7 m thick; over SAND, compact to very dense, 0.3 to 1.4 m thick; over PROBABLE BEDROCK at 0.0 to 7.1 m depth.	Water at 0.3 to 1.0 m depth in six open boreholes, and at 0.7 m above to 1.0 m below ground surface in piezometer.
Y	Hwy 69 NBL	14+110 to 14+280	170	Swamp Crossing	3.0	46-01 to 46-11 D46-01R to D46-05R	PEAT and ORGANICS, 50 to 700 mm thick; over CLAY, silty, soft to stiff, 1.0 to 1.9 m thick; over/or SAND, silty to SAND, very loose to compact, 0.4 to 1.2 m thick; over PROBABLE BEDROCK at 0.0 to 3.0 m depth.	Water at 0.0 to 1.5 m depth in nine open boreholes, and at 0.0 to 0.2 m depth in piezometer.
Z	Hwy 69 NBL	14+460 to 14+690	230	Swamp Crossing	2.4	47-01 to 47-10 47A-01 to 47A-06L D47-01R to D47-04L D47A-01L to D47A-04R, C236-D1	ORGANICS, 50 to 900 mm thick; over/or CLAY, silty, very soft to hard, 0.3 to 2.5 m thick; over/or SAND to SAND, silty, very loose to compact, 0.3 to 1.9 m thick; over PROBABLE BEDROCK at 0.1 to 5.1 m depth.	Water at 0.0 to 1.2 m depth in nine open boreholes, and at 0.0 to 0.3 m depth in piezometer.
AA	Hwy 69 NBL & SBL	15+050 to 15+190	140	Swamp Crossing	3.1	48-01 to 48-06 48-08R to 48-11R 49-01 to 49-06R 49-08R to 49-10R C238-1 C239-1, C239-2 D48-01R to D48-05L D49-01R to D49-05R D49-07R, D49-08L	PAVEMENT STRUCTURE and FILL (on existing highway platform), sand, very dense, 0.6 to 1.2 m thick; over PROBABLE ROCK FILL; or PEAT, 200 to 1300 mm thick; over SAND, silty to SAND, very loose to loose, 0.5 to 1.8 m thick; or SILT, sandy to SILT, very loose to compact, 1.2 to 2.6 m thick; over CLAY, silty, very soft to stiff, 0.8 to 8.9 m thick; over SAND, very loose to compact, 1.0 to 4.1 m thick; over PROBABLE BEDROCK at 1.3 to 12.5 m depth.	Water at 0.0 to 2.0 m depth in 12 open boreholes, at 0.1 m above the ground surface at one borehole location, and at 0.0 to 0.5 m depth in three piezometers.
BB	Hwy 69 NBL	15+450 to 15+560	110	Swamp Crossing	2.7	50-01 to 50-10 D50-01R to D50-04L	ORGANICS, 25 to 75 mm thick; or SAND, very loose, 0.3 to 0.5 m thick; over CLAY, silty, very soft to firm, 0.9 to 1.4 m thick; over PROBABLE BEDROCK at 0.0 to 2.0 m depth.	Water at ground surface in four open boreholes.
CC	Hwy 69 NBL	15+710 to 15+800	90	Swamp Crossing	3.0	51-01 to 51-08R D51-01R to D51-04L	ORGANICS, 150 to 600 mm thick; or/over SAND, silty, to SAND and SILT, very loose to compact, 1.8 to 2.0 m thick (three boreholes); over CLAY, silty, very soft, 0.2 to 0.4 m thick (three boreholes); over PROBABLE BEDROCK at 0.0 to 3.5 m depth.	Water at 1.1 to 2.2 m depth in two open boreholes, and at 0.0 to 0.7 m depth in piezometer.
DD	Hwy 69 NBL	15+860 to 15+915	65	Swamp Crossing	2.6	52-01 to 52-06 D52-01R, D52-02L	ORGANICS, 50 to 800 mm thick; over SAND, very loose to loose, 0.6 to 2.5 m thick (two boreholes); over PROBABLE BEDROCK at 0.0 to 2.6 m depth.	Water at ground surface in two open boreholes, and at 0.0 to 0.4 m depth in piezometer.

Table A4

Anticipated/Recommended Depth of Peat and Soft Soil Subexcavation

Appendix	Alignment	Stations	Maximum Embankment Height (m)	Maximum Depth of Subexcavation to Remove Peat, Organics and Soft Soil (m)
B	Hwy 69 NBL	21+710 to 21+925	6.6	3.0
	Hwy 69 SBL	21+710 to 21+925	7.0	6.2
		21+925 to 22+135	14.1	9.7
C	Hwy 69 SBL	22+350 to 22+410	3.0	0.6
D	Hwy 69 SBL	22+475 to 22+565	4.2	0.8
E	Hwy 69 SBL	22+750 to 22+825	3.2	0.7
F	Hwy 69 NBL	23+125 to 23+215	6.1	1.8
	Hwy 69 SBL	23+125 to 23+215	6.1	5.1
G	Hwy 69 SBL	24+000 to 24+040	6.2	5.2
H	Hwy 69 NBL	24+400 to 24+600	3.6	1.2
	Hwy 69 SBL	24+400 to 24+600	2.6	6.1
I	Hwy 69 SBL	24+900 to 25+000	6.6	16.1
J	Hwy 69 SBL	25+300 to 25+355	6.6	2.6
K	Hwy 69 NBL	10+330 to 10+585	3.4	8.3
	Hwy 69 SBL	10+330 to 10+585	3.5	7.6
L	Hwy 69 NBL	12+050 to 12+100	3.1	0.1
M	Harris Lake Road	9+800 to 9+930	11.8	0.3
N	Harris Lake Road	10+085 to 10+280	11.2	0.5
O	Rest Area Road	10+000 to 10+150	8.6	0.6
P	Harris Lake Road: Ramp S-EW	12+120 to 12+195	8.9	0.7
	Ramp EW-N	11+625 to 11+690		

THURBER

Table A4

Anticipated/Recommended Depth of Peat and Soft Soil Subexcavation

Appendix	Alignment	Stations	Maximum Embankment Height (m)	Maximum Depth of Subexcavation to Remove Peat, Organics and Soft Soil (m)
Q	Harris Lake Road: Ramp EW-S Ramp N-EW	12+070 to 12+110 11+650 to 11+690	8.0	0.3
R	Harris Lake Road: Ramp N-EW	11+840 to 11+910	3.0	0.3
S	Harris Lake Road: Ramp N-EW	12+030 to 12+120	3.4	0.7
T	Harris Lake Road: Ramp EW-N	12+070 to 12+120	3.0	0.2
U	Hwy 69 NBL	12+470 to 12+540	3.0	0.1
V	Hwy 69 NBL	13+130 to 13+190	3.8	0.3
W	Hwy 69 NBL	13+580 to 13+650	3.5	8.4
X	Hwy 69 NBL	13+890 to 13+990	3.2	6.2
Y	Hwy 69 NBL	14+110 to 14+280	3.0	0.9
Z	Hwy 69 NBL	14+460 to 14+690	2.4	3.2
AA	Hwy 69 NBL	15+050 to 15+190	3.1	7.2
	Hwy 69 SBL	15+050 to 15+190	3.1	1.5
BB	Hwy 69 NBL	15+450 to 15+560	2.7	0.5
CC	Hwy 69 NBL	15+710 to 15+800	3.0	0.6
DD	Hwy 69 NBL	15+860 to 15+915	2.6	0.8

Table A5

Results of Stability Analyses

Appendix	Alignment	Analysis Profile Location	Embankment Height (m)	Condition	Computed Factor of Safety	Figures in Appendix A
B	Hwy 69 SBL	21+760	7.0	South Section, NBL:		
				Short-term (undrained analysis) with 2m surcharge	1.36	15-1
				Long-term (drained analysis) after surcharge removal	1.49	15-2
				South Section, SBL:		
				Short-term (undrained analysis) with 2m surcharge	1.14	15-3
				Long-term (drained analysis) after surcharge removal	1.62	15-4
				Short-term (undrained analysis) with median infill	1.40	15.5
		22+050	14.1	North Section:		
				Short-term (undrained analysis) with no surcharge	0.96	16-1
				Staged construction with stabilizing berm		
				Stage 1 - short-term to profile grade	1.30	16-2
				Stage 2 - short-term with 2m surcharge	1.29	16-3
				Long-term - after berm and surcharge removal	1.51	16-4
				Partial subexcavation of clay (one stage, no surcharge)		
				Short-term	1.29	16-5
				Long-term	1.57	16-6

Table A5

Results of Stability Analyses

Appendix	Alignment	Analysis Profile Location	Embankment Height (m)	Condition	Computed Factor of Safety	Figures in Appendix A
F	Hwy 69 NBL & SBL	23+170	6.1	Short-term (undrained analysis)	0.81	21-1
				Full subexcavation of clay (one stage, no surcharge)		
				Short-term (undrained analysis)	1.65	21-2
				Long-term (drained analysis)	1.53	21-3
H	Hwy 69 NBL & SBL	24+540	2.6	Short-term (undrained analysis) with 2 m surcharge	1.40	24-1
				Long-term (drained analysis) after surcharge removal	1.60	24-2
I	Hwy 69 SBL	24+960	6.6	Short-term (undrained analysis)	1.1	26-1
				Staged construction with stabilizing berm		
				Stage 1 - short-term to profile grade	1.47	26-2
				Stage 2 - short-term with 2m surcharge, left	1.29	26-3
				Stage 2 – short-term with 2m surcharge, right	1.67	26-4
				Long-term - after berm and surcharge removal	1.54	26-5
				Partial subexcavation of clay (one stage)		
				Short-term (undrained analysis) with 2 m surcharge	1.30	26-6
				Long-term (drained analysis) after surcharge removal	1.47	26-7
				Existing embankment with peat and clay excavation	0.55	26-8
				Existing with peat and clay excavation and backfill	1.33	26-9
K	Hwy 69 NBL Hwy 69 SBL	10+410 10+520	3.5	Short-term (undrained analysis) with 2 m surcharge	1.34	28-1
				Long-term (drained analysis) after surcharge removal	1.50	28-2

Table A5

Results of Stability Analyses

Appendix	Alignment	Analysis Profile Location	Embankment Height (m)	Condition	Computed Factor of Safety	Figures in Appendix A
M	Harris Lake Road	9+800 to 9+930	11.8	Short-term and long-term conditions	1.38	32-1
O	Rest Area Road	10+000 to 10+150	8.6	Short-term and long-term conditions	1.43	34-1
P	Harris Lake Road: Ramp S-EW Ramp EW-N	 12+120 to 12+195 11+625 to 11+690	8.9	Short-term and long-term conditions	1.36	36-1
W	Hwy 69 NBL	13+620	3.5	Short-term (undrained analysis) with 1 m surcharge Long-term (drained analysis) after surcharge removal	1.38 1.50	44-1 44-2
X	Hwy 69 NBL	13+950	3.2	Short-term (undrained analysis) with 1 m surcharge Long-term (drained analysis) after surcharge removal	1.45 1.65	45-1 45-2
AA	Hwy 69 NBL & SBL	15+110	3.1	Short-term (undrained analysis) with 1 m surcharge, Rt Short-term (undrained analysis) with 1 m surcharge, Lt Long-term (drained analysis) after surcharge removal, Rt Long-term (drained analysis) after surcharge removal, Lt	1.45 1.35 1.84 1.54	48-1 48-2 48-3 48-4

THURBER

Table A6

Results of Settlement Analyses

Appendix	Alignment	Analysis Profile Location (Sta.)	Embankment Height (m)	Foundation Treatment*			Elastic Settlement (mm)	Primary Consolidation		Secondary Compression (mm)	Embankment Compression (mm)		Total Post-Construction Settlement (mm)
				Foundation Soil Type	Surcharge Height (m)	Duration of Preload/ Surcharge (months)		During Preload/ Surcharge (mm)	After Preload/ Surcharge (mm)		Short-term	Long-term	
B	Hwy 69 NBL & SBL	21+760	6.7	Up to 6.0m of silty clay and/or up to 1.4m of sandy silt to sand over bedrock	0	10	< 25	415	0	110	50	10	120
					2	12	< 25	515	0	60	50	10	70
				OR									
				As above but with complete subexcavation of clay	-	-	< 25	-	-	-	140	20	< 25
		22+050	11.3	Up to 8.9 m of silty clay over up to 2.2m of sandy silt to gravelly sand, over bedrock	2	8 + 4	35	1000	0	50	130	15	65
				OR									
				As above but with partial (4.5m) subexcavation of clay (up to 3.7m of clay remaining)	0	24	35	525	10	75	220	25	110
					2	24	35	550	0	25	220	25	50
				OR									
				As above but with complete subexcavation of clay	-	-	35	-	-	-	325	35	35
C	Hwy 69 SBL	22+350 to 22+410	3.0	Bedrock	-	-	-	-	-	-	20	< 10	< 25
D	Hwy 69 SBL	22+475 to 22+565	4.2	Up to 1.0m of sand and silt over bedrock	-	-	< 25	-	-	-	25	< 10	< 25
E	Hwy 69 SBL	22+750 to 22+825	3.2	Up to 1.1m of silty sand over bedrock	-	-	< 25	-	-	-	20	< 10	< 25
F	Hwy 69 NBL & SBL	23+170	6.1	Bedrock (after subexcavation of clay)	-	-	-	-	-	-	90	25	25
G	Hwy 69 SBL	24+000 to 24+040	6.2	Up to 3.0m of silty sand over bedrock (after subexcavation of clay)	-	-	< 25	-	-	-	125	20	< 25
H	Hwy 69 NBL & SBL	24+400 to 24+600	2.6	Up to 3.7m of silty clay and/or up to 2.1m of silty sand to gravelly sand, over bedrock	0	6	< 25	150	25	30	15	10	65
					1	6	< 25	270	0	25	15	10	35
				OR									
				As above but with complete subexcavation of clay	-	-	< 25	-	-	-	100	20	< 25

* Note: Where more than one option is shown, the recommended foundation type/treatment is italicized/bold.

THURBER

Table A6

Results of Settlement Analyses

Appendix	Alignment	Analysis Profile Location (Sta.)	Embankment Height (m)	Foundation Treatment*			Elastic Settlement (mm)	Primary Consolidation		Secondary Compression (mm)	Embankment Compression (mm)		Total Post-Construction Settlement (mm)
				Foundation Soil Type	Surcharge Height (m)	Duration of Preload/ Surcharge (months)		During Preload/ Surcharge (mm)	After Preload/ Surcharge (mm)		Short-term	Long-term	
I	Hwy 69 SBL	24+960	6.6	Up to 12.2m of silty clay over up to 1.2m of gravelly sand, over bedrock OR As above but with partial (3.7m) subexcavation of clay (up to 7.0m of clay remaining) OR ***As above but with complete subexcavation of clay***	2 2 -	6 + 6 24 -	< 25 < 25 < 25	1200 500 -	0 15 -	40 75 -	95 200 330	15 20 35	55 110 35
J	Hwy 69 SBL	25+300 to 25+355	6.6	Up to 3.0m of sand to sand and silt, over bedrock (after subexcavation of clay)	-	-	30	-	-	-	90	15	< 25
K	Hwy 69 NBL & SBL	10+410 NBL	3.5	Up to 5.5m of silty clay and/or up to 2.1m of sand and silt, over bedrock OR ***As above but with complete subexcavation of clay***	0 2 -	6 6 -	< 25 < 25 < 25	140 265 -	10 5 -	80 25 -	20 20 130	10 10 20	100 40 < 25
		10+520 SBL	3.5	Up to 6.2m of silty clay and/or up to 4.1m of sand to silt and sand, over bedrock OR ***As above but with complete subexcavation of clay***	0 1 -	6 6 -	25 25 25	35 90 -	15 0 -	40 25 -	15 15 130	10 10 20	65 35 < 25
L	Hwy 69 NBL	12+050 to 12+100	3.1	Up to 4.4m of sand and silt, over bedrock	-	-	< 25	-	-	-	15	< 10	< 25
M	Harris Lake Road	9+800 to 9+930	11.8	Up to 9.8m of sand to sandy silt, over bedrock	-	-	100	-	-	-	120	15	< 25
N	Harris Lake Road	10+085 to 10+280	11.2	Up to 4.5m of sand to sandy silt, over bedrock	-	-	75	-	-	-	115	15	< 25

* Note: Where more than one option is shown, the recommended foundation type/treatment is italicized/bold.

Table A6

Results of Settlement Analyses

Appendix	Alignment	Analysis Profile Location (Sta.)	Embankment Height (m)	Foundation Treatment*			Elastic Settlement (mm)	Primary Consolidation		Secondary Compression (mm)	Embankment Compression (mm)		Total Post-Construction Settlement (mm)
				Foundation Soil Type	Surcharge Height (m)	Duration of Preload/ Surcharge (months)		During Preload/ Surcharge (mm)	After Preload/ Surcharge (mm)		Short-term	Long-term	
O	Rest Area Road	10+000 to 10+150	8.6	Up to 5.2m of sand, over bedrock	-	-	40	-	-	-	65	< 10	< 25
P	Harris Lake Road: Ramp S-EW Ramp EW-N	12+120 to 12+195 11+625 to 11+690	8.9	Up to 2.7m of sand to silt and sand, and/or up to 3.4m of silty clay, over up to 6.2m of sand, over bedrock	-	-	75	-	-	-	70	< 10	< 25
Q	Harris Lake Road: Ramp EW-S Ramp N-EW	12+070 to 12+110 11+650 to 11+690	8.0	Up to 1.1m of sand, over bedrock	-	-	< 25	-	-	-	60	< 10	< 25
R	Harris Lake Road: Ramp N-EW	11+840 to 11+910	3.0	Up to 1.4m of silty clay, 1.4m of sand and silt, or 3.5m of sand, over bedrock	-	-	25	-	-	-	15	< 10	< 25
S	Harris Lake Road: Ramp N-EW	12+030 to 12+120	3.4	Up to 2.5m of sand and silt, and/or up to 3.0m of silty clay, or up to 0.8m of sand, over bedrock	-	-	75	-	-	-	20	< 10	< 25
T	Harris Lake Road: Ramp EW-N	12+070 to 12+120	3.0	Up to 1.4m of silty sand, over up to 2.3m of silty clay, over up to 1.5m of sand/gravel, over bedrock	-	-	50	-	-	-	15	< 10	< 25
U	Hwy 69 NBL	12+470 to 12+540	3.0	Up to 2.2m of sand and silt to sand, over bedrock	-	-	< 25	-	-	-	15	< 10	< 25
V	Hwy 69 NBL	13+130 to 13+190	3.8	Up to 1.3m of silty clay over up to 0.6m of silty sand, over bedrock	-	-	< 25	-	-	-	20	< 10	< 25

* Note: Where more than one option is shown, the recommended foundation type/treatment is italicized/bold.

Table A6

Results of Settlement Analyses

Appendix	Alignment	Analysis Profile Location (Sta.)	Embankment Height (m)	Foundation Treatment*			Elastic Settlement (mm)	Primary Consolidation		Secondary Compression (mm)	Embankment Compression (mm)		Total Post-Construction Settlement (mm)
				Foundation Soil Type	Surcharge Height (m)	Duration of Preload/ Surcharge (months)		During Preload/ Surcharge (mm)	After Preload/ Surcharge (mm)		Short-term	Long-term	
W	Hwy 69 NBL	13+620	3.5	Up to 1.5m of sand and silt and up to 7.0m of silty clay, over bedrock	0	6	< 25	230	20	40	15	10	70
					1	6	< 25	275	0	30	15	10	40
				OR									
				As above but with complete subexcavation of clay	-	-	< 25	-	-	-	100	20	< 25
X	Hwy 69 NBL	13+950	3.2	Up to 2.4m of silty sand over up to 4.7m of silty clay over up to 4.6m of sand, over bedrock	0	12	40	175	40	80	15	10	130
					1	12	40	250	0	30	15	10	40
				OR									
				As above but with complete subexcavation of clay	-	-	40	-	-	-	100	15	< 25
Y	Hwy 69 NBL	14+110 to 14+280	3.0	Up to 4.5m of sand to sandy silt, over up to 1.7m of silty clay, over bedrock	-	-	< 25	-	-	-	15	< 10	< 25
Z	Hwy 69 NBL	14+460 to 14+690	2.4	Up to 2.5m of silty clay over up to 1.7m of sand or silt, over bedrock	-	-	25	-	-	-	15	< 10	< 25
AA	Hwy 69 NBL & SBL	15+110	3.1	Up to 1.7m of silty sand to sandy silt, over up to 8.9m of silty clay, over up to 2.1m of silty to gravelly sand, over bedrock	0	12	30	135	5	80	15	10	95
					1	12	30	190	0	10	15	10	< 25
				OR									
				As above but with complete subexcavation of clay	-	-	30	-	-	-	175	25	25
BB	Hwy 69 NBL	15+450 to 15+560	2.7	Up to 0.5m of sand, over up to 1.4m of silty clay, over bedrock	-	-	< 25	-	-	-	15	< 10	< 25
CC	Hwy 69 NBL	15+710 to 15+800	3.0	Up to 1.8m of silty sand, over 0.4m of silty clay, over up to 1.3m of sand and silt, over bedrock	-	-	25	-	-	-	15	< 10	< 25
DD	Hwy 69 NBL	15+860 to 15+915	2.6	Up to 2.5m of sand, over bedrock	-	-	< 25	-	-	-	15	< 10	< 25

* Note: Where more than one option is shown, the recommended foundation type/treatment is italicized/bold.

Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
B	Hwy 69 NBL	21+710 to 21+925	215	High Fill	6.6	**Swamp Treatment:** Excavate peat, organics and soft silty clay from toe of existing embankment and replace with rock fill prior to embankment widening. Maximum anticipated depth of peat and soft silty clay is 3.0 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. Existing embankment slope should be benched prior to new fill placement. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
	Hwy 69 SBL	21+710 to 21+925	215	High Fill	7.0	**Swamp Treatment:** Excavate peat, organics and soft silty clay prior to embankment construction. Maximum anticipated depth of peat and soft silty clay is 6.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
		21+925 to 22+135	210	High Fill	14.1	**Swamp Treatment:** Excavate peat, organics and soft silty clay prior to embankment construction. Maximum anticipated depth of peat and soft silty clay is 9.7 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill in conjunction with mid-height berms should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
C	Hwy 69 SBL	22+350 to 22+410	60	Swamp Crossing	3.0	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat and organics is 0.6 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Embankment foundation will consist of bedrock. Settlement of the foundation is expected to be negligible. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
D	Hwy 69 SBL	22+475 to 22+565	90	Swamp Crossing	4.2	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat and organics is 1.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
E	Hwy 69 SBL	22+750 to 22+825	75	Swamp Crossing	3.2	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat and organics is 0.7 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill are considered suitable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
F	Hwy 69 NBL	23+125 to 23+215	90	High Fill / Swamp Crossing	6.1	**Swamp Treatment:** Excavate peat and organics from toe of existing embankment and replace with rock fill prior to embankment widening. Maximum anticipated depth of peat and organics is 1.8 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. Existing embankment slopes should be benched prior to new fill placement. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
	Hwy 69 SBL	23+125 to 23+215	90	High Fill / Swamp Crossing	6.1	**Swamp Treatment:** Excavate peat, organics and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of peat and silty clay is 5.1 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
G	Hwy 69 SBL	24+000 to 24+040	40	High Fill / Swamp Crossing	6.2	**Swamp Treatment:** Excavate peat, organics and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of peat and silty clay is 5.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
H	Hwy 69 NBL	24+400 to 24+600	200	Swamp Crossing	3.6	**Swamp Treatment:** Excavate peat and organics from toe of existing embankment prior to embankment widening. Maximum anticipated depth of peat and organics is 1.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. Existing embankment slope should be benched prior to new fill placement. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
	Hwy 69 SBL	24+400 to 24+600	200	Swamp Crossing	2.6	**Swamp Treatment:** Excavate peat, organics and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of peat and silty clay is 6.1 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
I	Hwy 69 SBL	24+900 to 25+000	100	High Fill / Swamp Crossing	6.6	**Swamp Treatment:** Excavate peat, organics and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of peat and silty clay is 16.1 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill in conjunction with a stabilizing berm should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
J	Hwy 69 SBL	25+300 to 25+355	55	High Fill / Swamp Crossing	6.6	**Swamp Treatment:** Excavate peat and soft silty clay prior to embankment construction. Maximum anticipated depth of peat and silty clay is 2.6 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to be in the order of 30 mm and occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
K	Hwy 69 NBL	10+330 to 10+585	255	Swamp Crossing	3.4	**Swamp Treatment:** Excavate peat, organics and silty clay from toe of existing embankment in short sections, and replace with rock fill prior to embankment widening. Maximum anticipated depth of peat and silty clay is 8.3 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. Existing embankment slopes should be benched prior to new fill placement. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
	Hwy 69 SBL	10+330 to 10+585	255	Swamp Crossing	3.5	**Swamp Treatment:** Excavate peat, organics and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of peat and silty clay is 7.6 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
L	Hwy 69 NBL	12+050 to 12+100	50	Swamp Crossing	3.1	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.1 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
M	Harris Lake Road	9+800 to 9+930	130	High Fill	11.8	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat and organics is 0.3 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill in conjunction with mid-height berms should be stable. **Settlement**: Settlement of foundation soils is expected to be in the order of 100 mm and occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
N	Harris Lake Road	10+085 to 10+280	195	High Fill	11.2	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat is 0.5 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill in conjunction with mid-height berms are considered suitable. **Settlement**: Settlement of foundation soils is expected to be in the order of 75 mm and occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
O	Rest Area Road	10+000 to 10+150	150	High Fill	8.6	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat is 0.6 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill in conjunction with mid-height berms should be stable. **Settlement**: Settlement of foundation soils is expected to be in the order of 40 mm and occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
P	Harris Lake Road: Ramp S-EW Ramp EW-N	 12+120 to 12+195 11+625 to 11+690	 75 65	High Fill	8.9	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat and organics is 0.7 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill in conjunction with mid-height berms are considered suitable. **Settlement**: Settlement of foundation soils is expected to be in the order of 75 mm and occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
Q	Harris Lake Road: Ramp EW-S Ramp N-EW	 12+070 to 12+110 11+650 to 11+690	 40 40	High Fill	8.0	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.3 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
R	Harris Lake Road: Ramp N-EW	11+840 to 11+910	70	Swamp Crossing	3.0	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.3 m. **Stability:** Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement:** Settlement of foundation soils is expected to be in the order of 25 mm and occur largely as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
S	Harris Lake Road: Ramp N-EW	12+030 to 12+120	90	Swamp Crossing	3.4	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.7 m. **Stability:** Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement:** Settlement of foundation soils is expected to be in the order of 75 mm and occur largely as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
T	Harris Lake Road: Ramp EW-N	12+070 to 12+120	50	Swamp Crossing	3.0	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.2 m. **Stability:** Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement:** Settlement of foundation soils is expected to be in the order of 50 mm and occur largely as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
U	Hwy 69 NBL	12+470 to 12+540	70	Swamp Crossing	3.0	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.1 m. **Stability:** Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement:** Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
V	Hwy 69 NBL	13+130 to 13+190	60	Swamp Crossing	3.8	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.3 m. **Stability:** Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement:** Settlement of foundation soils is expected to occur largely as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
W	Hwy 69 NBL	13+580 to 13+650	70	Swamp Crossing	3.5	**Swamp Treatment:** Excavate organic layer and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of organics and silty clay is 8.4 m. **Stability:** Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement:** Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
X	Hwy 69 NBL	13+890 to 13+990	100	Swamp Crossing	3.2	**Swamp Treatment:** Excavate organic layer and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of organics and silty clay is 6.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
Y	Hwy 69 NBL	14+110 to 14+280	170	Swamp Crossing	3.0	**Swamp Treatment:** Excavate peat and organics prior to embankment construction. Maximum anticipated depth of peat and organics is 0.9 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
Z	Hwy 69 NBL	14+460 to 14+690	100	Swamp Crossing	2.4	**Swamp Treatment:** Excavate organic layer and soft to very soft silty clay prior to embankment construction. Maximum anticipated depth of organics and silty clay is 3.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
AA	Hwy 69 NBL	15+050 to 15+190	140	Swamp Crossing	3.1	**Swamp Treatment:** Excavate peat and silty clay, and replace with rock fill prior to embankment construction. Maximum anticipated depth of peat and silty clay is 7.2 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
	Hwy 69 SBL	15+050 to 15+190	140	Swamp Crossing	3.1	**Swamp Treatment:** Excavate peat from toe of existing embankment prior to widening of embankment. Maximum anticipated depth of peat is 1.5 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. Existing embankment slopes should be benched prior to new fill placement. **Settlement**: Post-construction settlement of the foundation soils and embankment fill is expected to be less than 25 mm. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

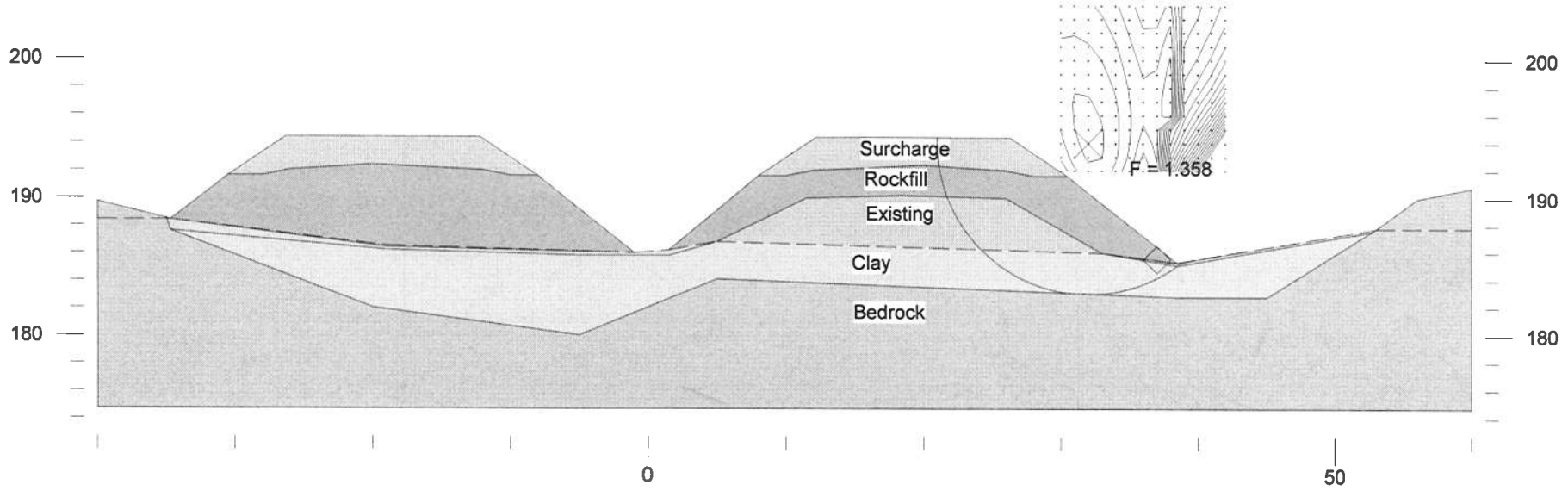
Table A7

Summary of Recommendations for Embankment Construction and Swamp Treatments

Appendix	Alignment	Stations	Length of Section (m)	Section Type	Maximum Embankment Height or Cut Depth (m)	Summarized Recommendations
BB	Hwy 69 NBL	15+450 to 15+560	110	Swamp Crossing	2.7	**Swamp Treatment:** Excavate organic layer and sand with peaty organics prior to embankment construction. Maximum anticipated depth of organics is 0.5 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur largely as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
CC	Hwy 69 NBL	15+710 to 15+800	110	Swamp Crossing	3.0	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.6 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.
DD	Hwy 69 NBL	15+860 to 15+915	65	Swamp Crossing	2.6	**Swamp Treatment:** Excavate organic layer prior to embankment construction. Maximum anticipated depth of organics is 0.8 m. **Stability**: Standard embankment sideslopes of 1.25H:1V in rock fill and 2H:1V in earth fill should be stable. **Settlement**: Settlement of foundation soils is expected to occur essentially as embankment construction proceeds. Embankment construction should be carried out at least six months in advance of pavement construction to allow for compression of embankment materials.

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	21	0	38	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Clay	18	40	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 15 - 21+760 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of surcharge (194.4m)

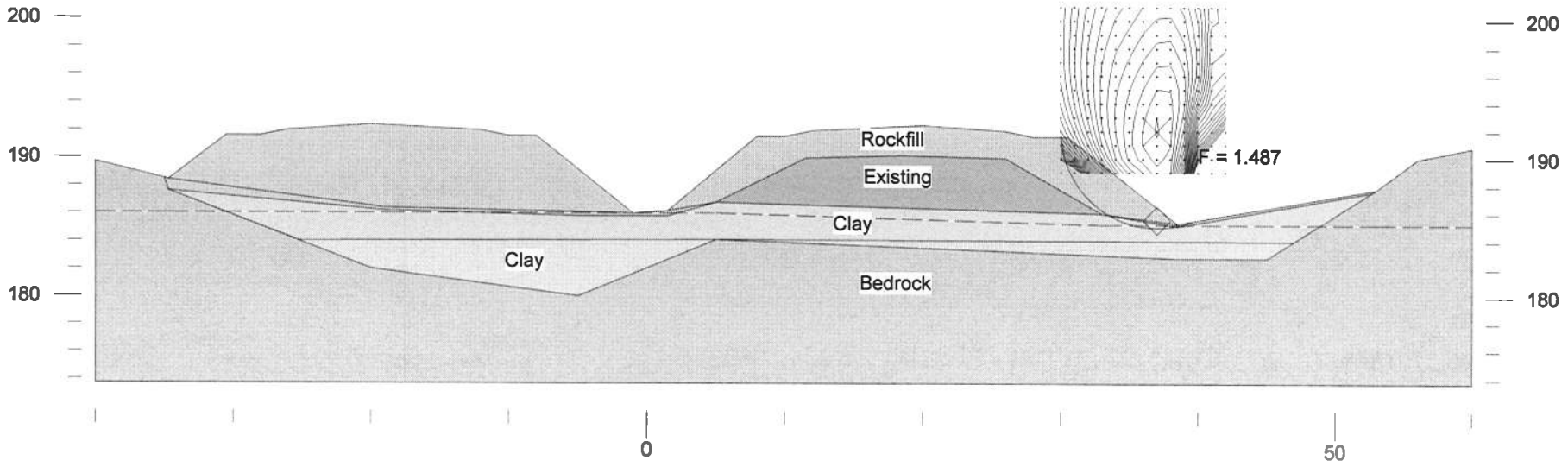


4/14/2011 8:42:05 PM C:\PROGRA~1\GSLOPE\69HWY155.GSL Thurber Engineering Ltd. - Toronto F = 1.358

Figure 15-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Clay	19	2	29	0	1
Clay	18	1	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 15 - 21+760 - Effective Stress Analysis (Bbar = 0.0)
Long term (192.4m)

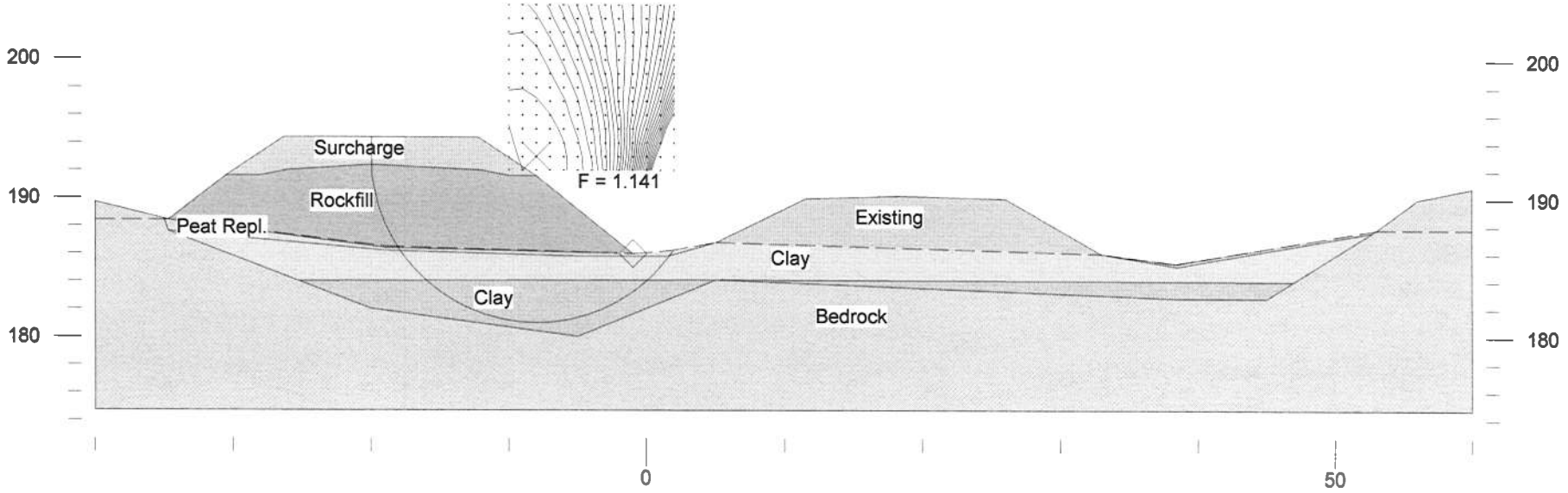


4/14/2011 8:31:17 PM C:\PROGRA~1\GSLOPE\69HWY154.GSL Thurber Engineering Ltd. - Toronto F = 1.487

Figure 15-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	21	0	38	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Clay	18	50	0	0	1
Clay	18	25	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 15 - 21+760 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of surcharge (194.4m)

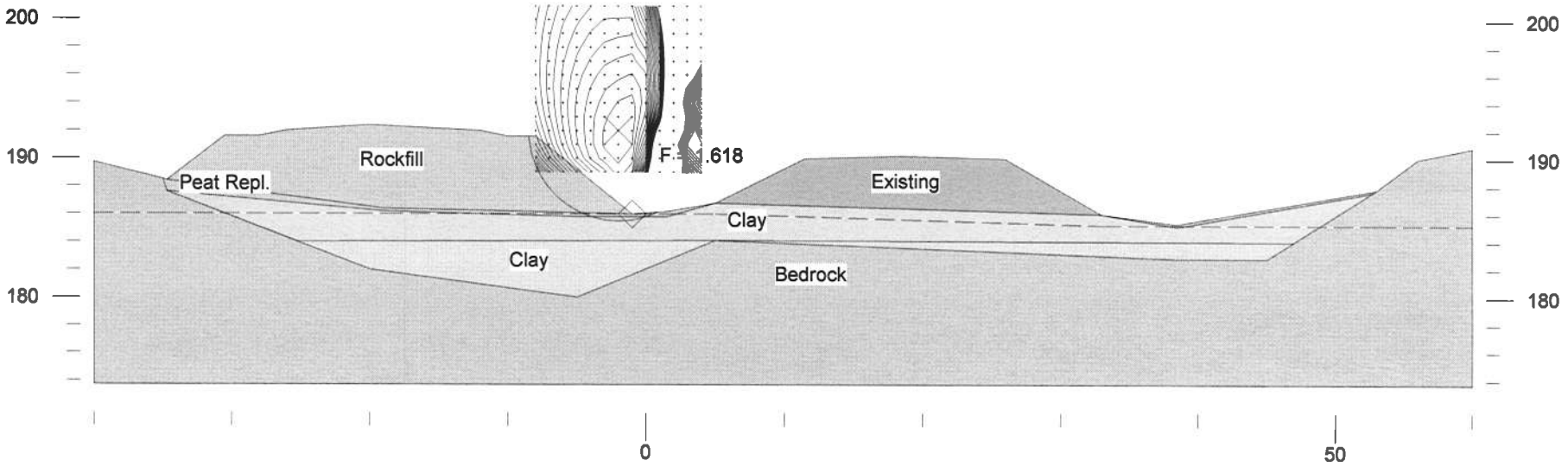


4/14/2011 8:17:06 PM C:\PROGRA~1\GSLOPE\69HWY151.GSL Thurber Engineering Ltd. - Toronto F = 1.141

Figure 15-3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Clay	19	2	29	0	1
Clay	18	1	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 15 - 21+760 - Effective Stress Analysis (Bbar = 0.0)
Long term (192.4m)

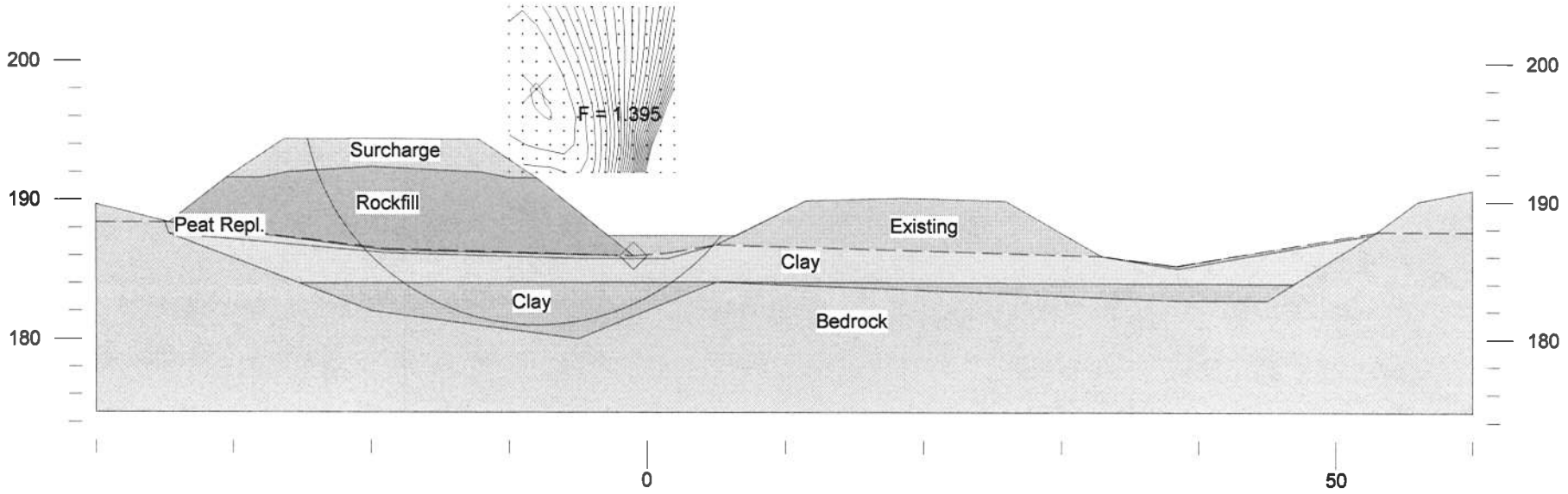


4/14/2011 8:27:52 PM C:\PROGRA~1\GSLOPE\69HWY153.GSL Thurber Engineering Ltd. - Toronto F = 1.618

Figure 15-4

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	21	0	38	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Clay	18	50	0	0	1
Clay	18	25	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 15 - 21+760 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of surcharge (194.4m)

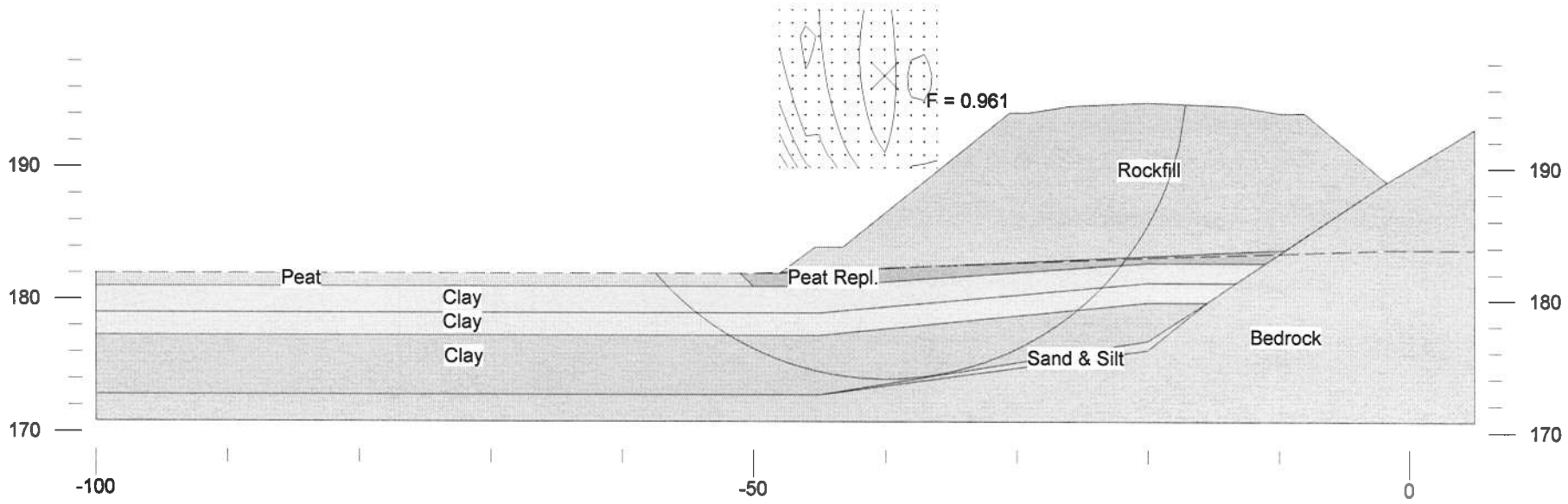


4/14/2011 8:27:08 PM C:\PROGRA~1\GSLOPE\69HWY152.GSL Thurber Engineering Ltd. - Toronto F = 1.395

Figure 15-5

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay (silty)	18	75	0	0	1
Clay (sandy)	19	50	0	0	1
Clay (silty)	18	32	0	0	1
Sand and Silt	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 16 - 22+050 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of embankment (195 m)

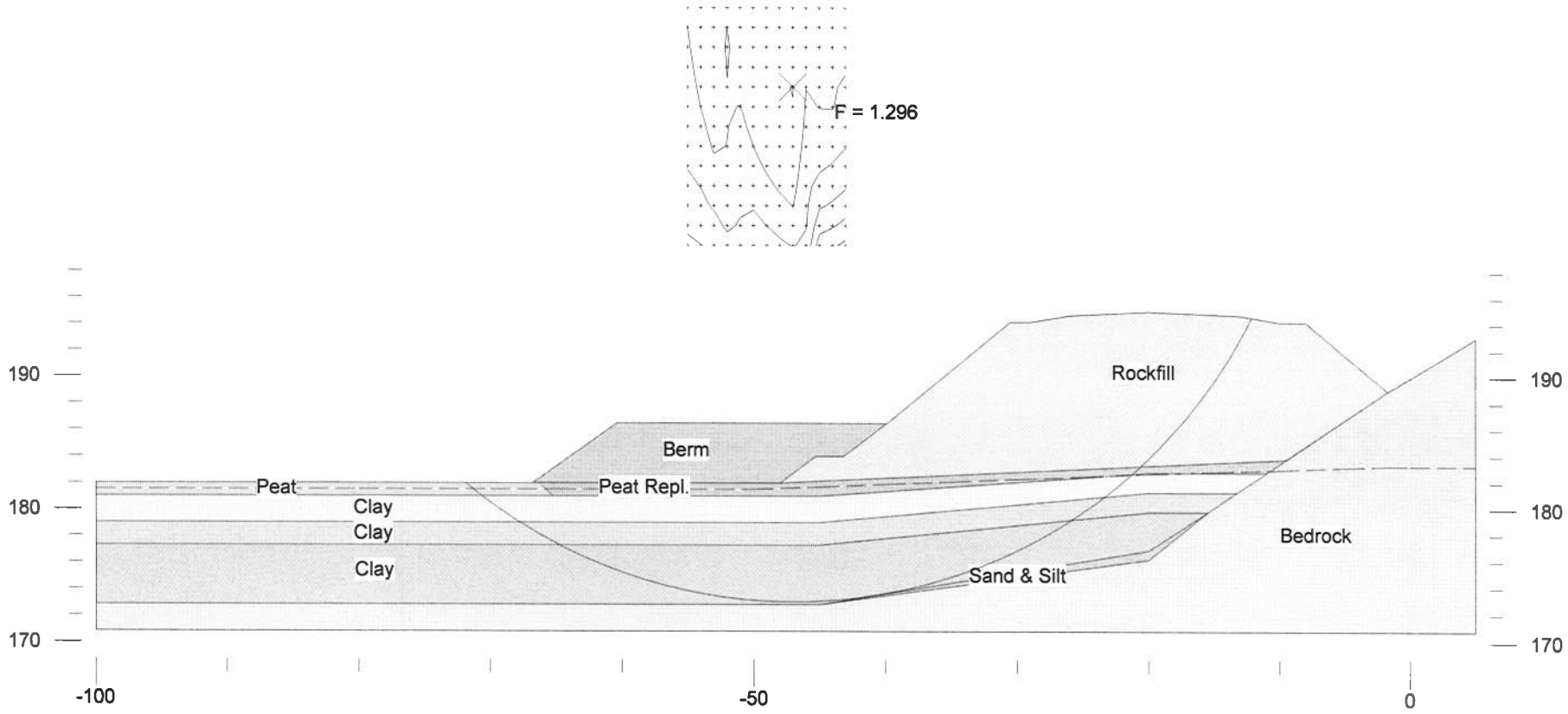


4/15/2011 8:09:33 AM C:\PROGRA~1\GSLOPE\69HWY161.GSL Thurber Engineering Ltd. - Toronto F = 0.961

Figure 16-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
berm	19	0	42	0	1
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay (silty)	19	75	0	0	1
Clay (sandy)	18	50	0	0	1
Clay (silty)	19	32	0	0	1
Sand and Silt	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 16 - 22+050 - Total Stress Analysis (Bbar = 0.0)
1st stage construction to elev 195 m

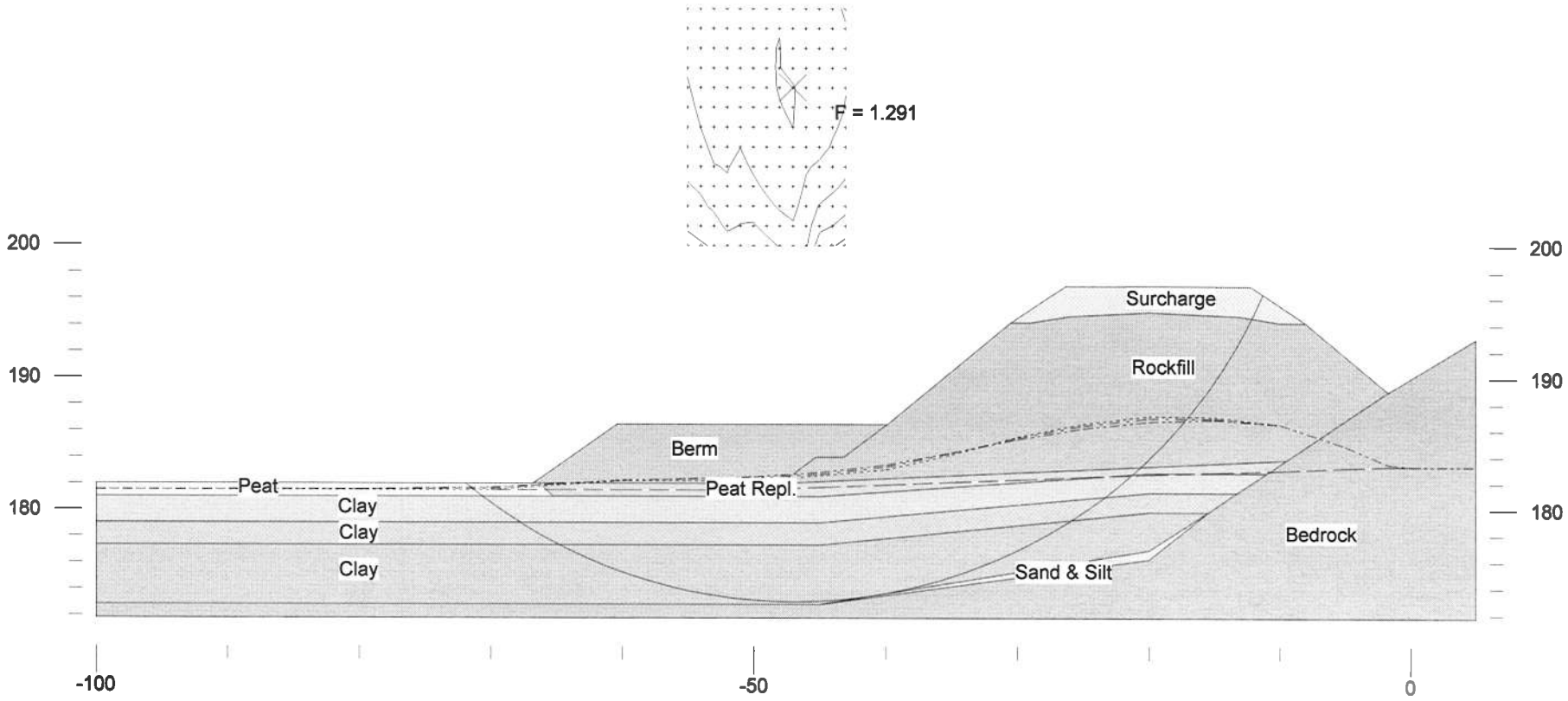


4/15/2011 8:59:12 AM C:\PROGRA~1\GSLOPE\69HWY162.GSL Thurber Engineering Ltd. - Toronto F = 1.296

Figure 16-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
berm	19	0	42	0	1
Surcharge2	20	0	38	0	1
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay (silty)	19	75	0	.22	2
Clay (sandy)	18	50	0	.22	3
Clay (silty)	19	32	0	.22	4
Sand and Silt	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site - 16 22+050 - Undrained Strength Analysis (Bbar = 0.9 for 2m surcharge, Bbar = 0.075 for fills below surcharge)
2nd stage construction to elev. 195 m plus 2 m surcharge

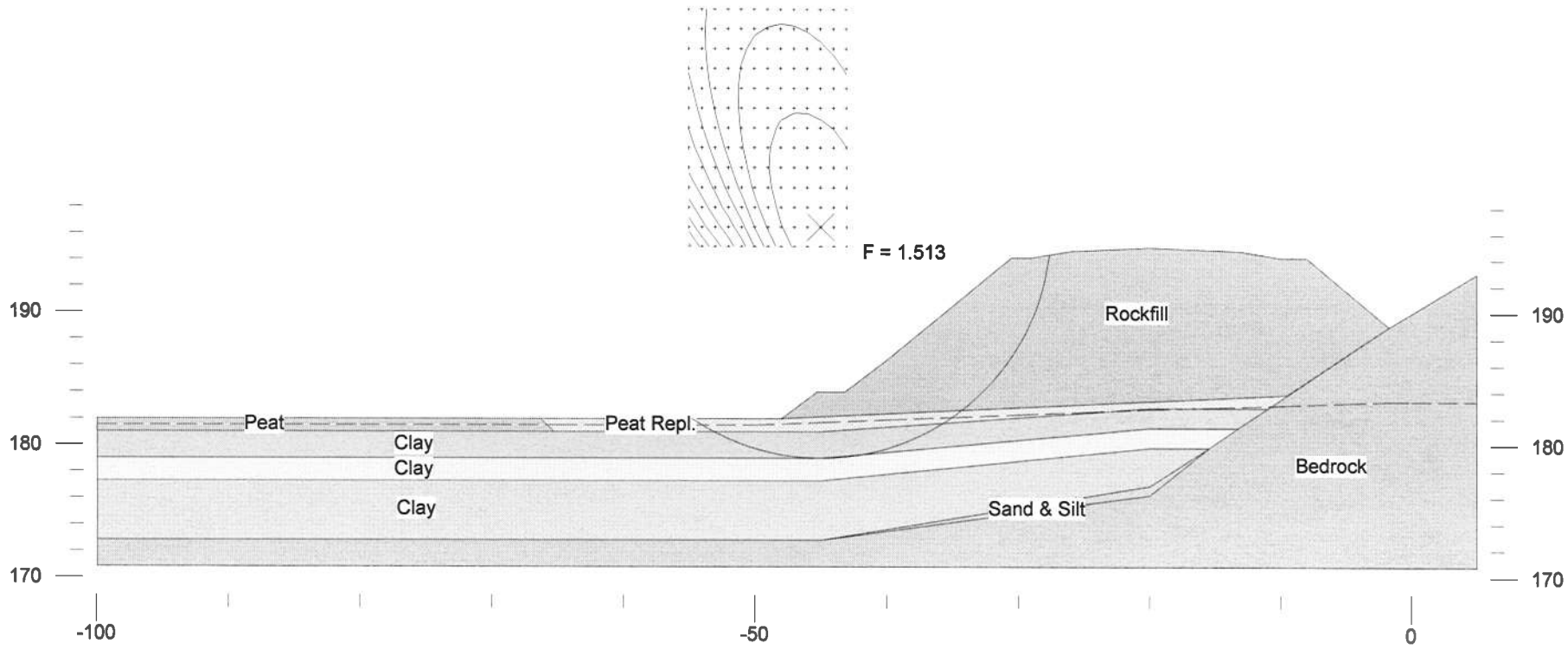


4/15/2011 9:07:20 AM C:\PROGRA~1\GSLOPE\69HWY163.GSL Thurber Engineering Ltd. - Toronto F = 1.291

Figure 16-3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	2	29	0	1
Clay (silty)	19	0	28	0	1
Clay (sandy)	18	0	28	0	1
Clay (silty)	19	0	28	0	1
Sand and Silt	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 16 - 22+050 - Total Stress Analysis (Bbar = 0.0)
Long term (elev. 195m)

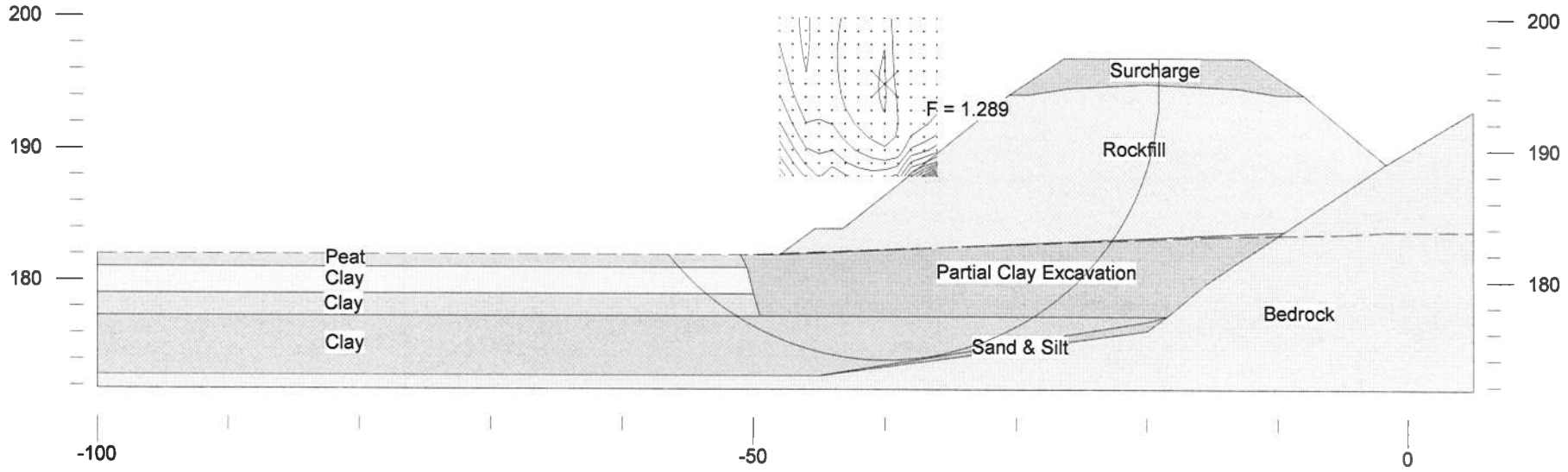


4/15/2011 9:17:19 AM C:\PROGRA~1\GSLOPE\69HWY164.GSL Thurber Engineering Ltd. - Toronto F = 1.513

Figure 16-4

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay (silty)	18	75	0	0	1
Clay (sandy)	19	50	0	0	1
Clay (silty)	18	32	0	0	1
Sand and Silt	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 16 - 22+050 - Total Stress Analysis (Bbar = 0.0)
Single stage of construction with 2m surcharge

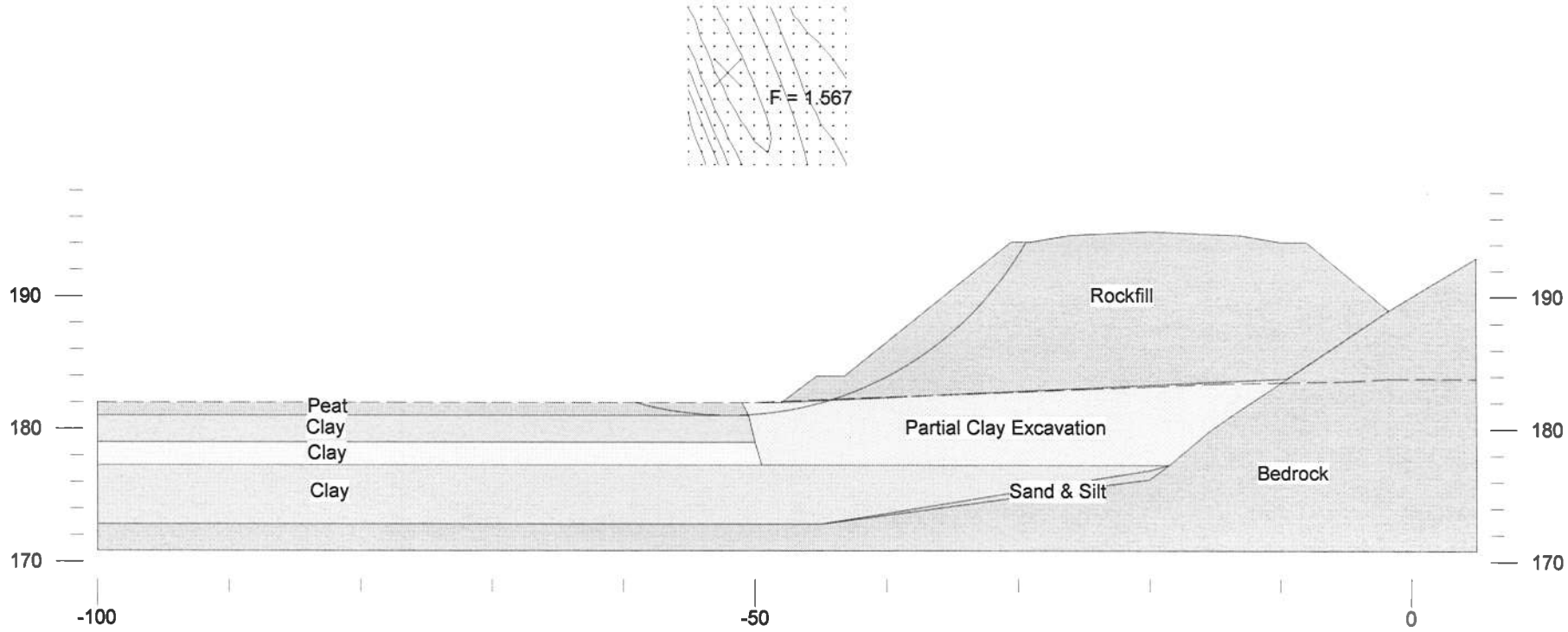


4/15/2011 8:40:47 AM C:\PROGRA~1\GSLOPE\69HWY165.GSL Thurber Engineering Ltd. - Toronto F = 1.289

Figure 16-5

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	2	29	0	1
Clay (silty)	18	0	28	0	1
Clay (sandy)	19	0	28	0	1
Clay (silty)	18	0	28	0	1
Sand and Silt	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 16 - 22+050 - Effective Stress Analysis (Bbar = 0.0)
Long term (195m)



4/15/2011 8:39:32 AM C:\PROGRA~1\GSLOPE\69HWY166.GSL Thurber Engineering Ltd. - Toronto F = 1.567

Figure 16-6

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Rockfill	19	0	42	0	1
Rockfill (sub.)	19	0	42	0	1
Sand	19	0	30	0	1
Clay	18	10	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 21 - 23+170 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 200.9 m

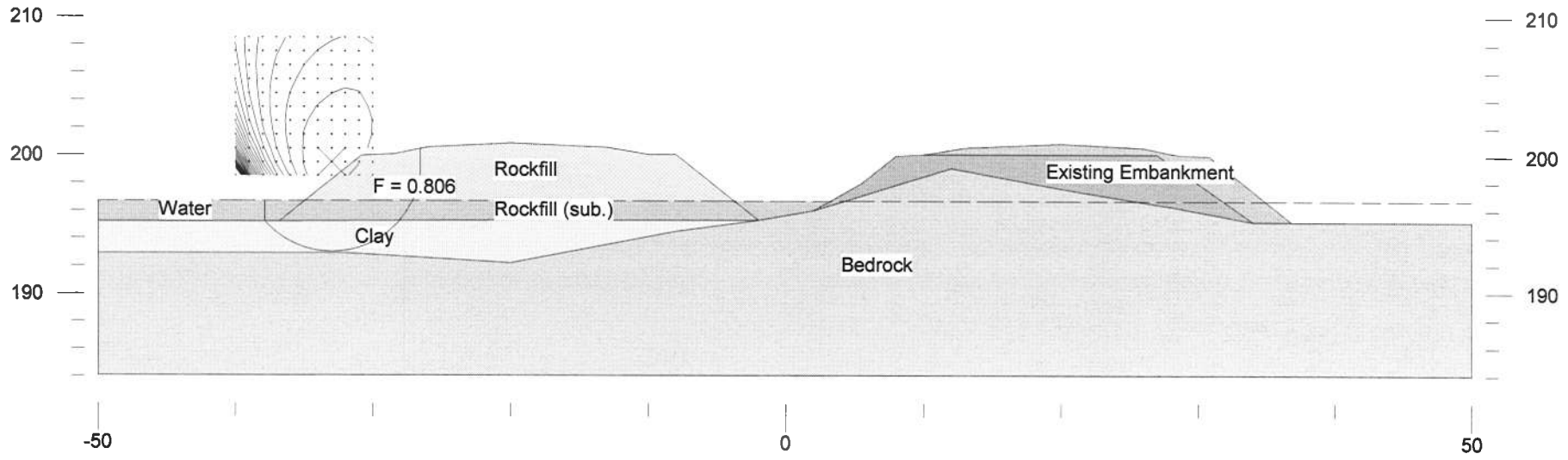
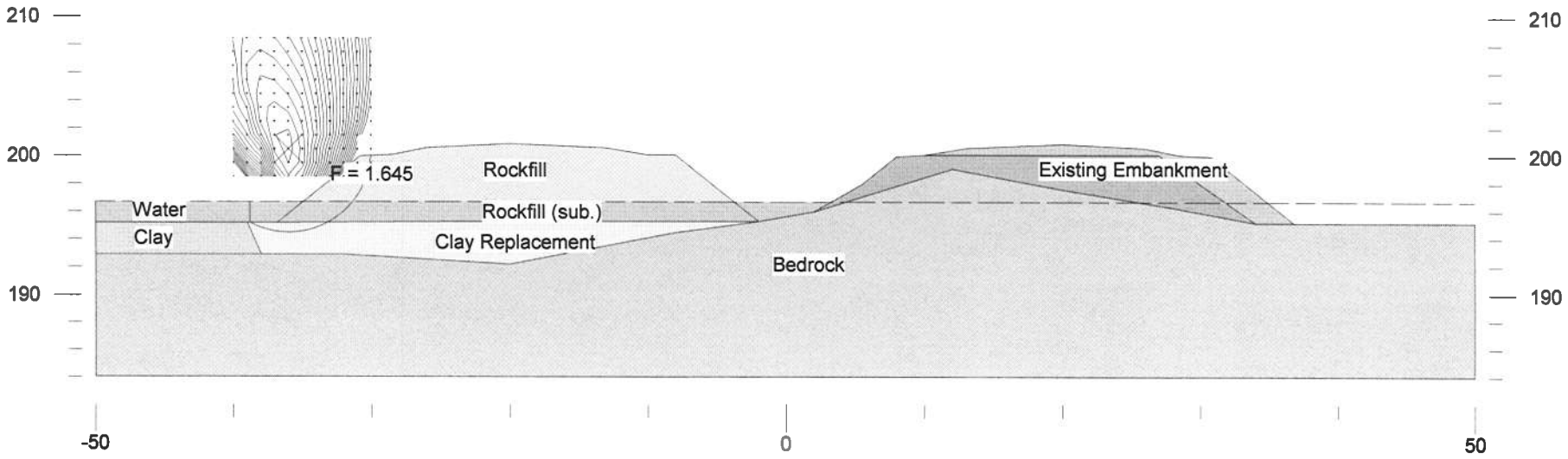


Figure 21-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Roakfill	19	0	42	0	1
Rockfill (sub.)	19	0	42	0	1
Sand	19	0	30	0	1
Clay Replacement	19	0	42	0	1
Clay	18	10	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site - 21 23+170 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 200.9 m

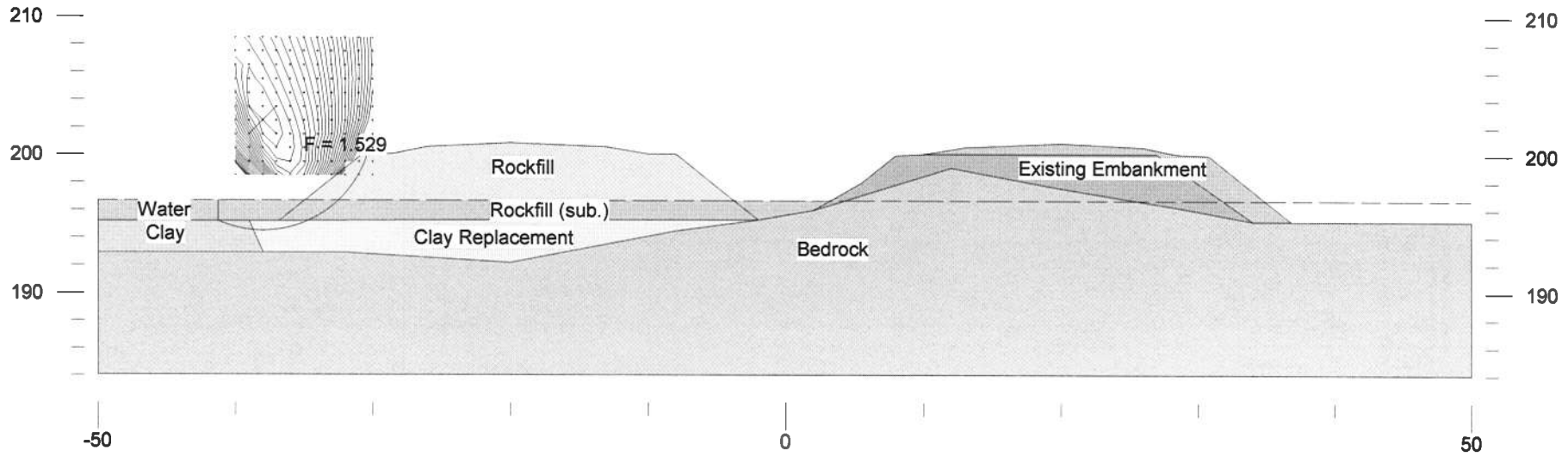


4/15/2011 9:28:59 AM C:\PROGRA~1\GSLOPE\69HWY212.GSL Thurber Engineering Ltd. - Toronto F = 1.645

Figure 21-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Roakfill	19	0	42	0	1
Rockfill (sub.)	19	0	42	0	1
Sand	19	0	30	0	1
Clay Replacement	19	0	42	0	1
Clay	18	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 21 - 23+170 - Effective Stress Analysis (Bbar = 0.0)
Long term (200.9 m)

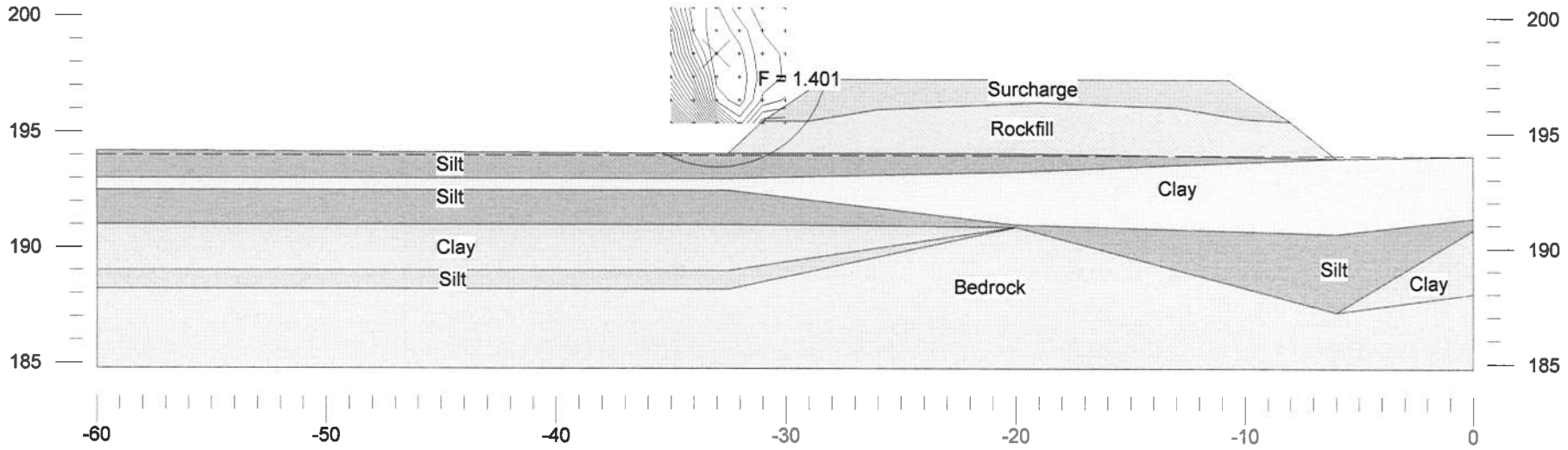


4/15/2011 9:33:43 AM C:\PROGRA~1\GSLOPE\69HWY213.GSL Thurber Engineering Ltd. - Toronto F = 1.529

Figure 21-3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	32	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Silt	19	0	28	0	1
Clay	19	20	0	0	1
Silt	19	0	28	0	1
Clay	19	20	0	0	1
Silt	19	0	28	0	1
EOH	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
Highway 69 - Four Laning
April 2011
Site 24 - 24+540 - Total Stress Analysis (Bbar = 0.0)
Single stage construction (196.3 m)

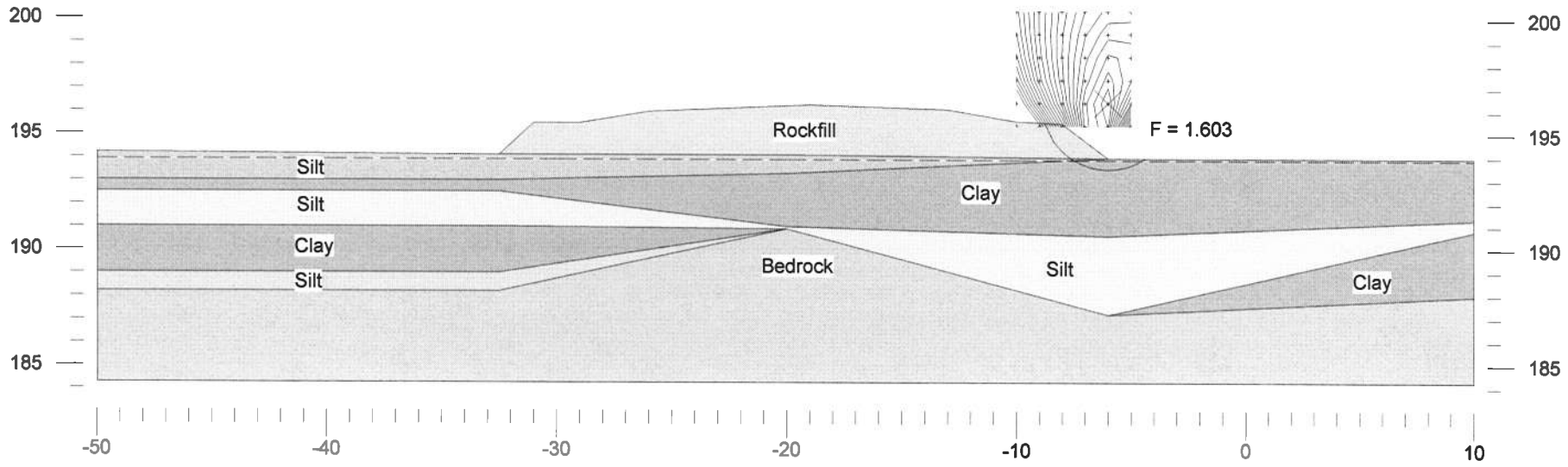


4/15/2011 9:46:47 AM C:\PROGRA~1\GSLOPE\69HWY241.GSL Thurber Engineering Ltd. - Toronto F = 1.401

Figure 24-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Silt	19	0	28	0	1
Clay	19	0	28	0	1
Silt	19	0	28	0	1
Clay	19	0	28	0	1
Silt	19	0	28	0	1
EOH	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
Highway 69 - Four Laning
April 2011
Site 24 - 24+540 - Effective Stress Analysis (Bbar = 0.0)
Long term (196.3 m)

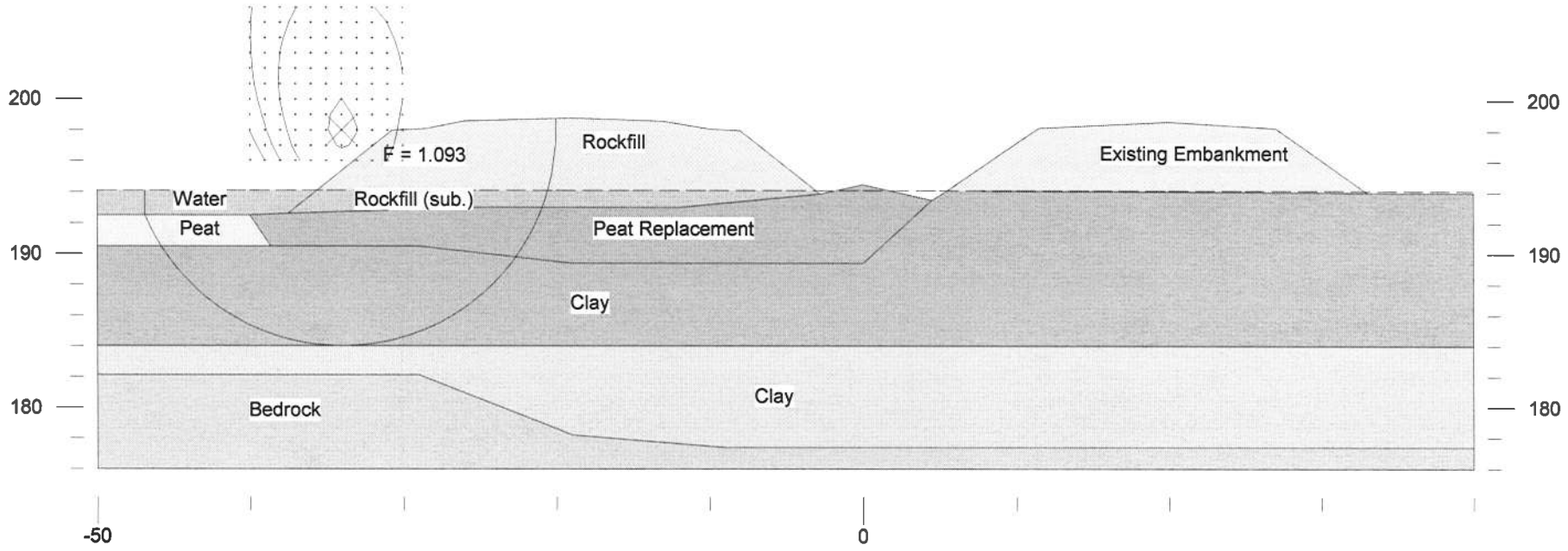


4/15/2011 9:50:46 AM C:\PROGRA~1\GSLOPE\69HWY242.GSL Thurber Engineering Ltd. - Toronto F = 1.603

Figure 24-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Rockfill	19	0	42	0	1
Rockfill (sub.)	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay	18	20	0	0	1
Clay	18	24	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 198.8 m

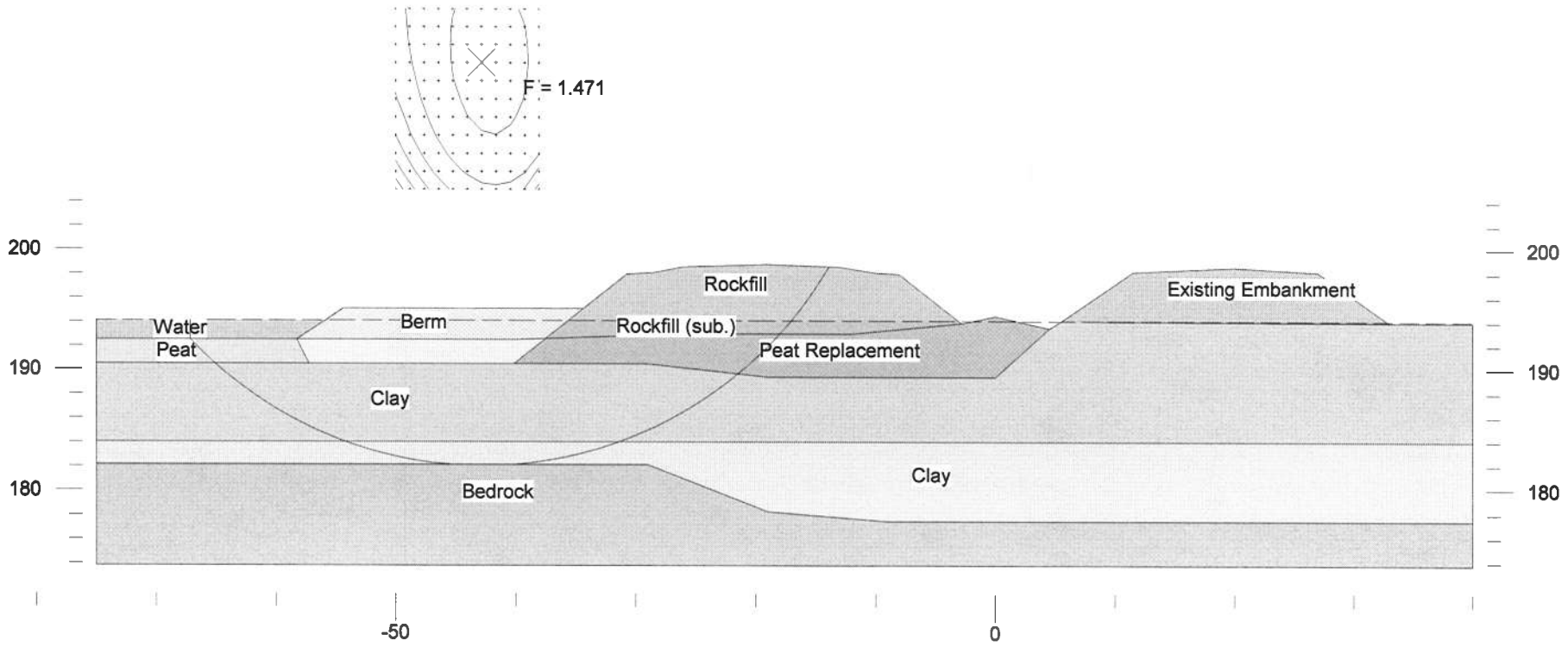


4/15/2011 10:00:08 AM C:\PROGRA~1\GSLOPE\69HWY261.GSL Thurber Engineering Ltd. - Toronto F = 1.093

Figure 26-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Berm	19	0	42	0	1
Rockfill	19	0	42	0	1
Rockfill (sub.)	21	0	32	0	1
Peat Replacement	19	0	42	0	1
Peat Repl. (DB)	21	0	32	0	1
Peat	13	10	0	0	1
Clay	18	20	0	0	1
Clay	18	24	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Total Stress Analysis (Bbar = 0.0)
1st stage construction to elev. 198.8 m

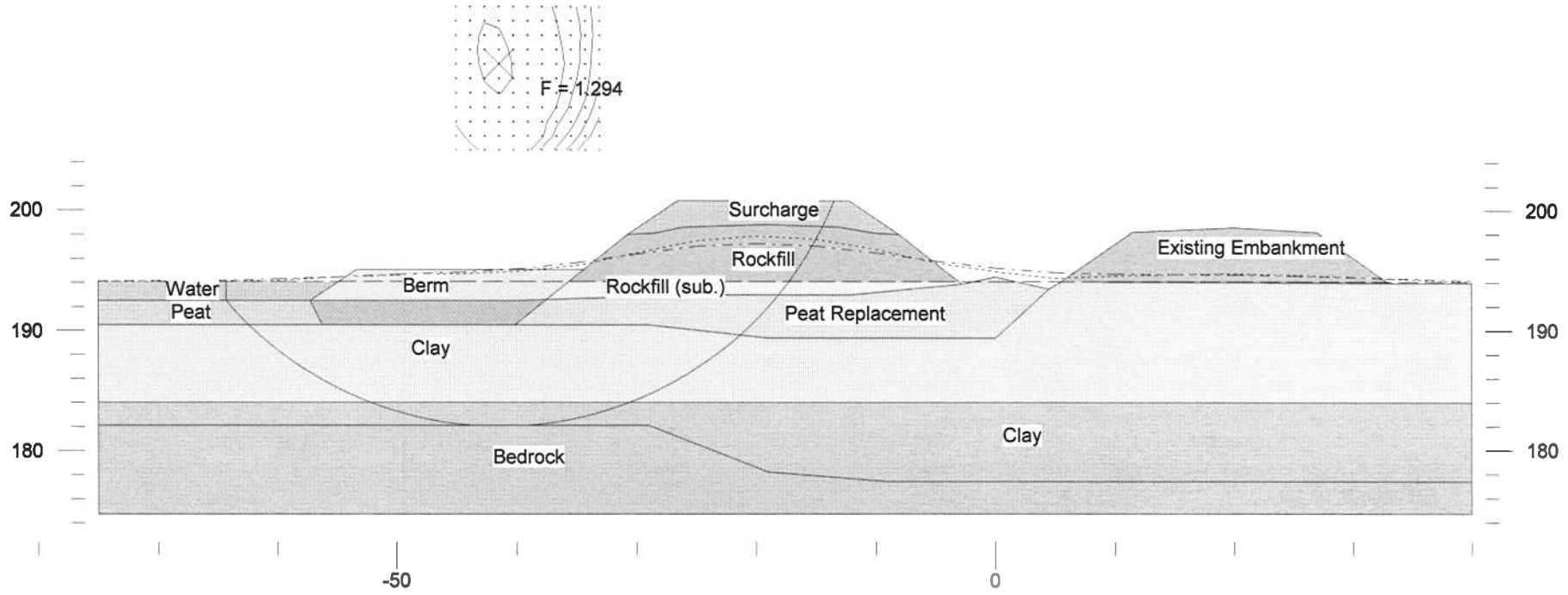


4/15/2011 11:29:41 AM C:\PROGRA~1\GSLOPE\69HWY262.GSL Thurber Engineering Ltd. - Toronto F = 1.471

Figure 26-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Berm	19	0	42	0	1
Surcharge	20	0	38	0	
Rockfill	19	0	42	0	1
Rockfill (sub.)	21	0	32	0	1
Peat Replacement	19	0	42	0	1
Peat Repl. (DB)	21	0	32	0	1
Peat	13	10	0	0	1
Clay	18	20	0	.22	2
Clay	18	24	0	.22	3
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Undrained Strength Analysis (Bbar = 0.9 for surcharge, Bbar = 0.075 for fills below surcharge)
2nd stage construction to elev. 198.8 m plus 2 m surcharge



4/15/2011 11:28:48 AM C:\PROGRA~1\GSLOPE\69HWY263.GSL Thurber Engineering Ltd. - Toronto F = 1.294

Figure 26-3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Berm	19	0	42	0	1
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Rockfill (sub.)	21	0	32	0	1
Peat Replacement	19	0	42	0	1
Peat Repl. (DB)	21	0	32	0	1
Peat	13	10	0	0	1
Clay	18	20	0	.22	2
Clay	18	24	0	.22	3
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Undrained Strength Analysis (Bbar = 0.9 for surcharge, Bbar = 0.075 for fills below surcharge)
2nd stage construction to elev. 198.8 m plus 2 m surcharge

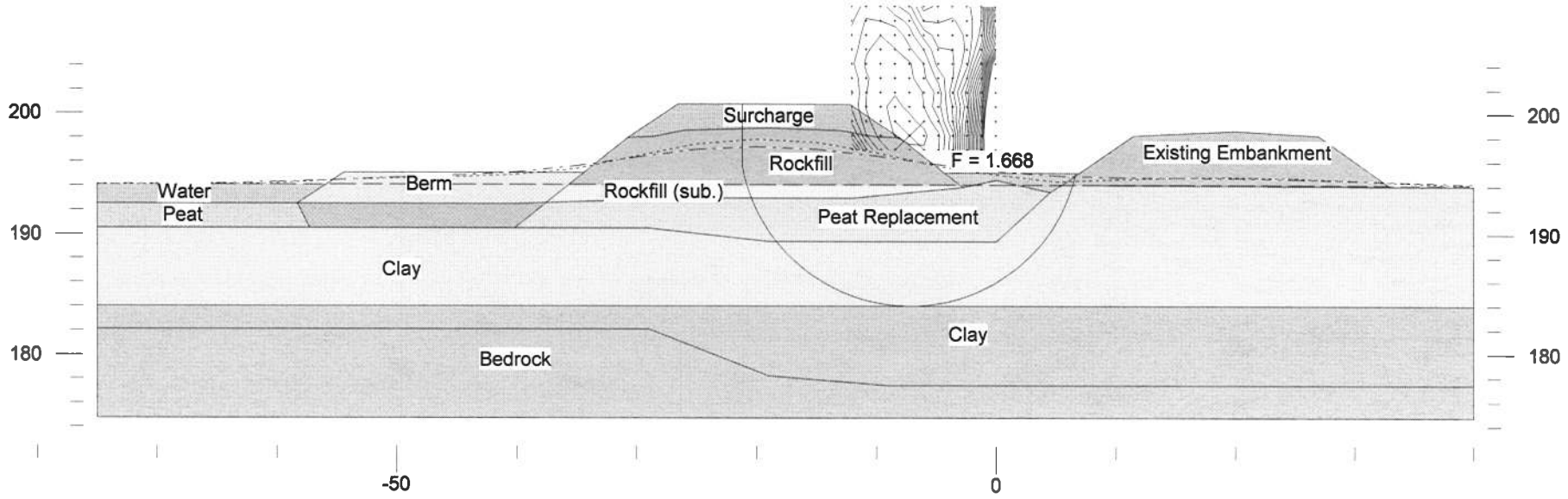
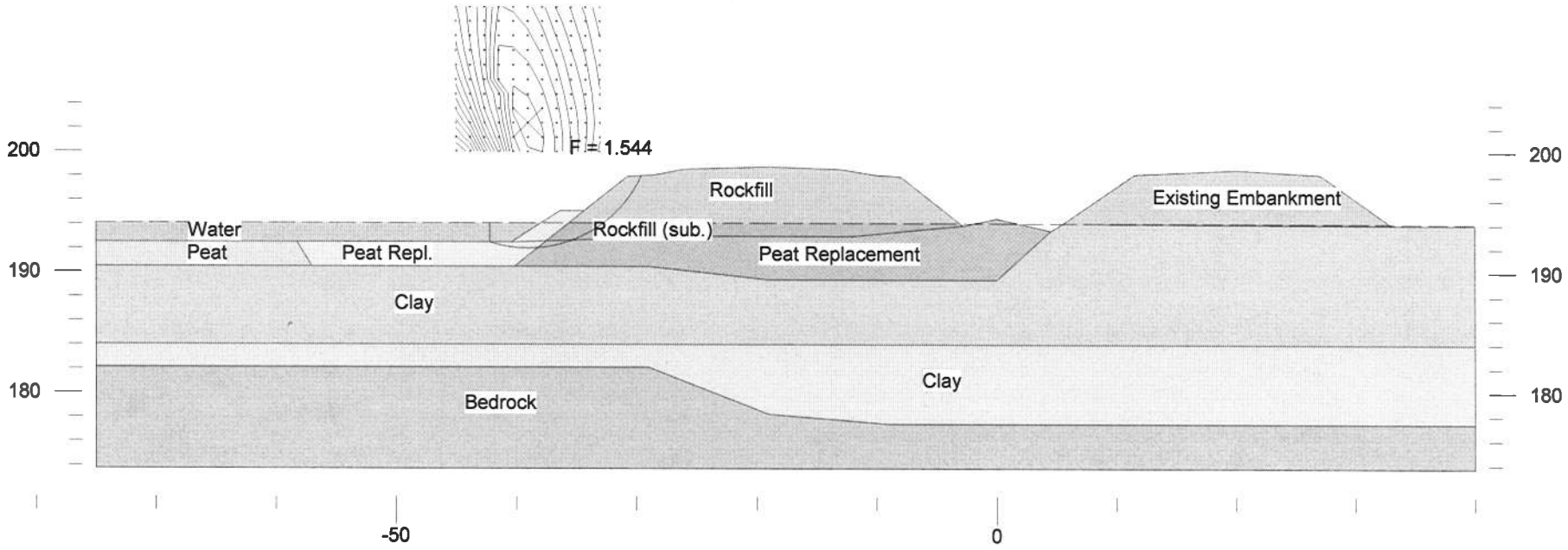


Figure 26-4

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Berm	19	0	42	0	1
Rockfill	19	0	42	0	1
Rockfill (sub.)	21	0	32	0	1
Peat Replacement	19	0	42	0	1
Peat Repl. (DB)	21	0	32	0	1
Peat	13	2	29	0	1
Clay	18	0	28	0	1
Clay	18	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Effective Stress Analysis (Bbar = 0.0)
Long Term (elev. 198.8m)

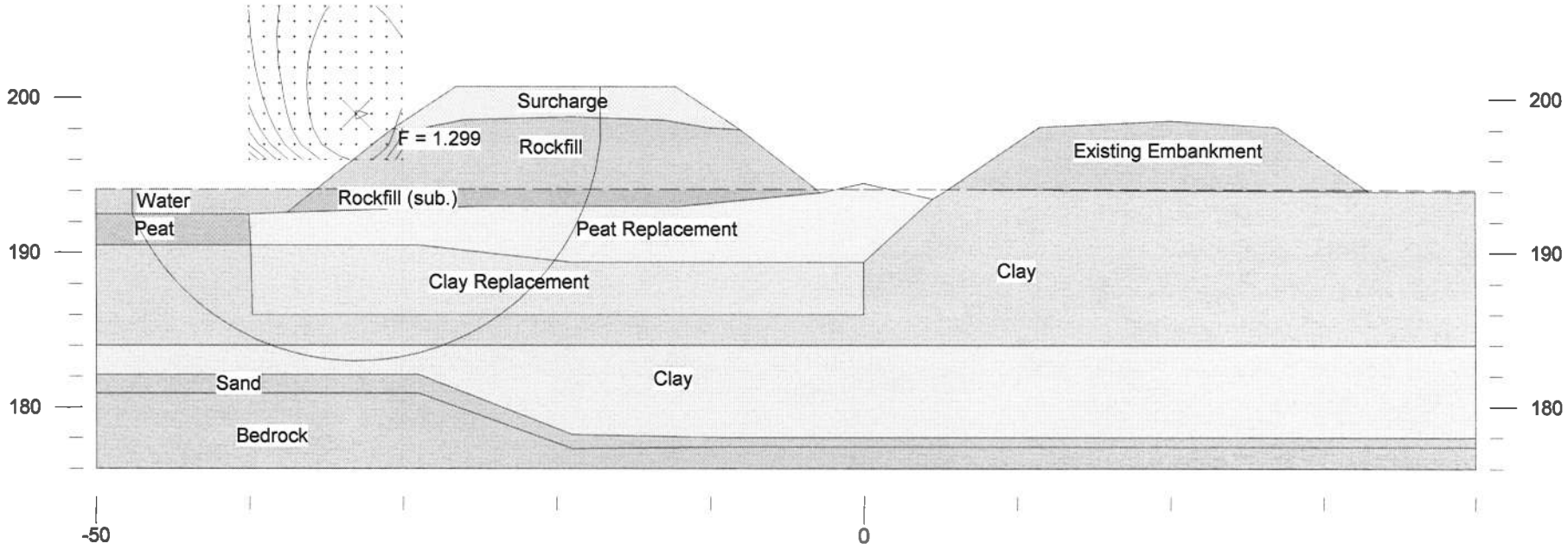


4/15/2011 11:42:40 AM C:\PROGRA~1\GSLOPE\69HWY265.GSL Thurber Engineering Ltd. - Toronto F = 1.544

Figure 26-5

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Rockfill (sub.)	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay Replacement	19	0	42	0	1
Clay	18	20	0	0	1
Clay	18	24	0	0	1
Sand	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 198.8 m plus 2 m surcharge

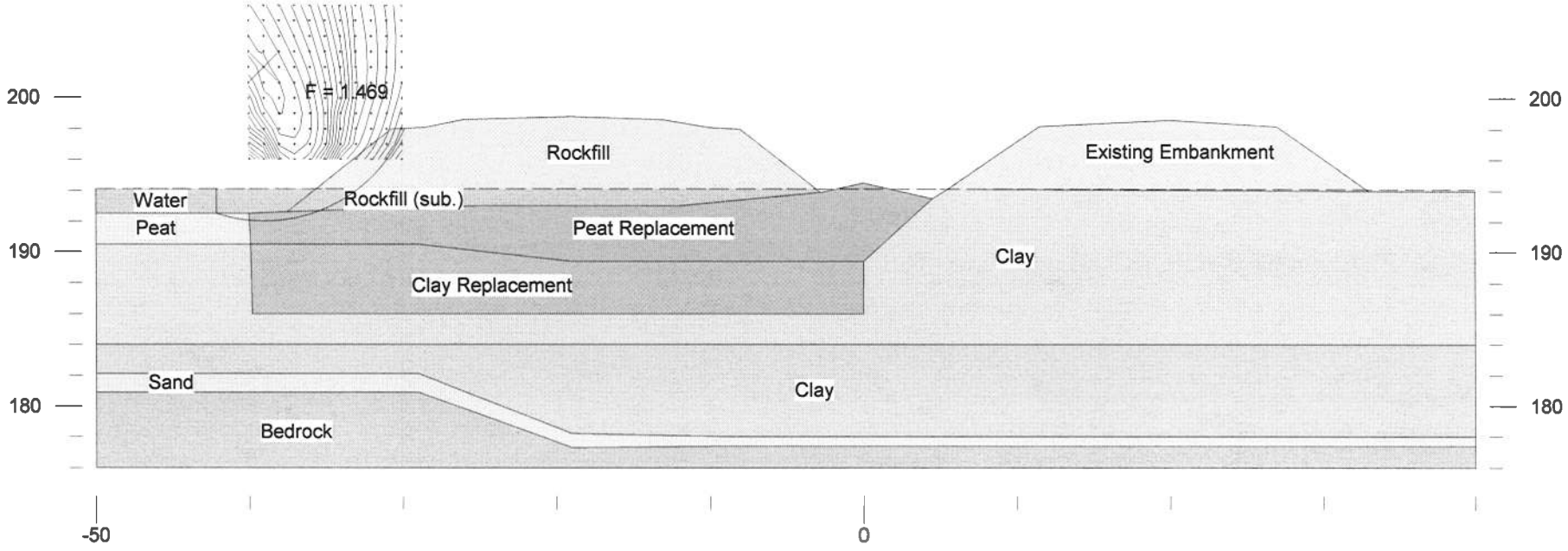


4/15/2011 12:42:18 PM C:\PROGRA~1\GSLOPE\69HWY266.GSL Thurber Engineering Ltd. - Toronto F = 1.299

Figure 26-6

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Rockfill	19	0	42	0	1
Rockfill (sub.)	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	2	29	0	1
Clay Replacement	19	0	42	0	1
Clay	18	0	28	0	1
Clay	18	0	28	0	1
Sand	19	0	30	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 26 - 24+960 - Effective Stress Analysis (Bbar = 0.0)
Long term (198.8m)



4/15/2011 12:46:50 PM C:\PROGRA~1\GSLOPE\69HWY267.GSL Thurber Engineering Ltd. - Toronto F = 1.469

Figure 26-7

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Rockfill	19	0	42	1
Peat	13	10	0	1
Clay	18	20	0	1
Clay	18	24	0	1
Bedrock	(Infinitely Strong)			

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
November 2012
Site 26 - 24+960 - Total Stress Analysis (Bbar = 0.0)
Peat & Clay Excavation Adjacent to Existing Embankment

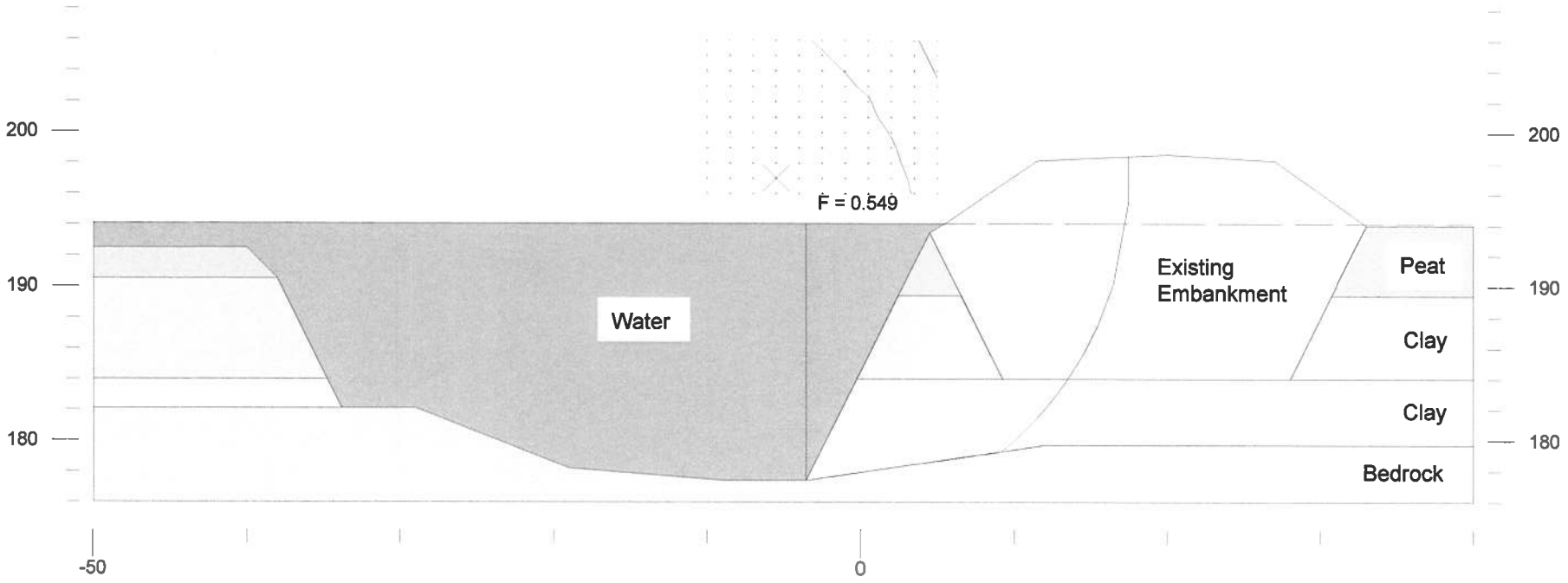


Figure 26-8

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Backfill	19	0	42	1
Rockfill	19	0	42	1
Peat	13	10	0	1
Clay	18	20	0	1
Clay	18	24	0	1
Bedrock	(Infinitely Strong)			

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
November 2012
Site 26 - 24+960 - Total Stress Analysis (Bbar = 0.0)
Peat & Clay Excavation Adjacent to Existing Embankment

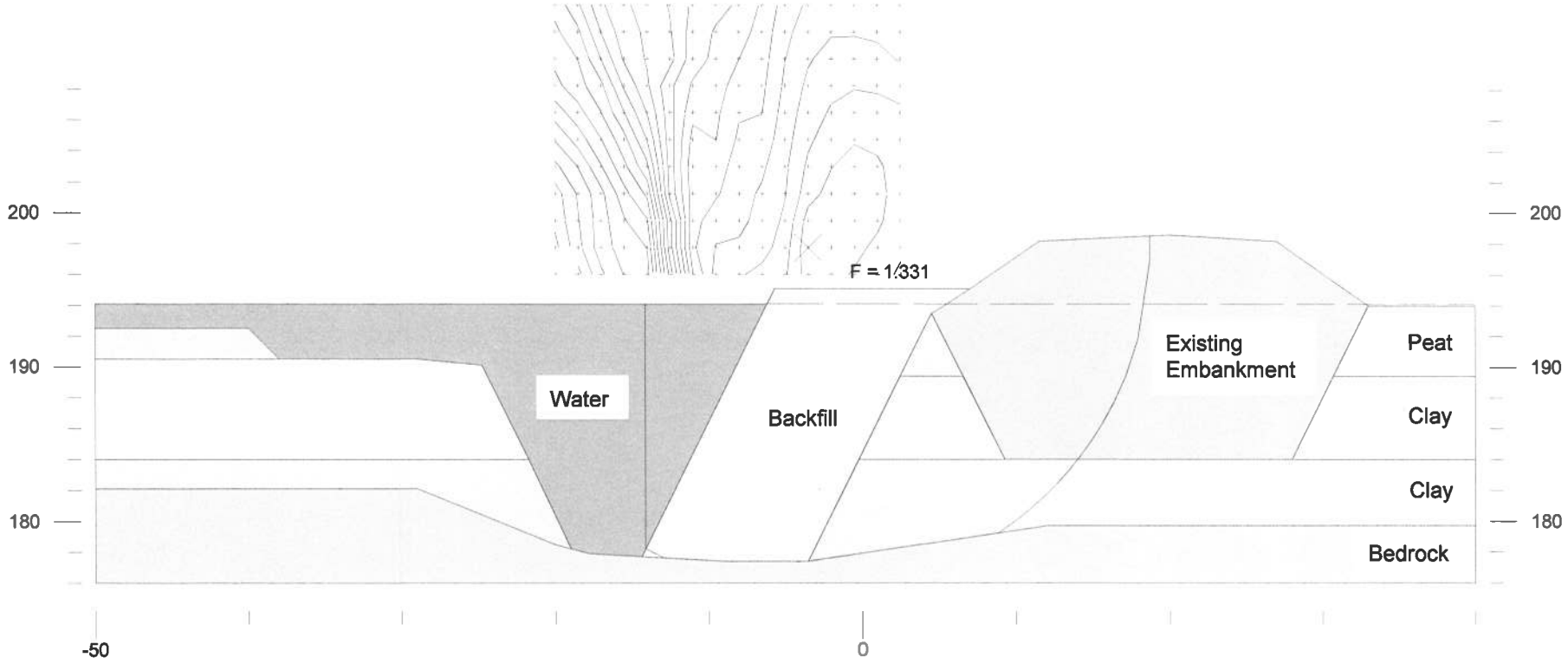
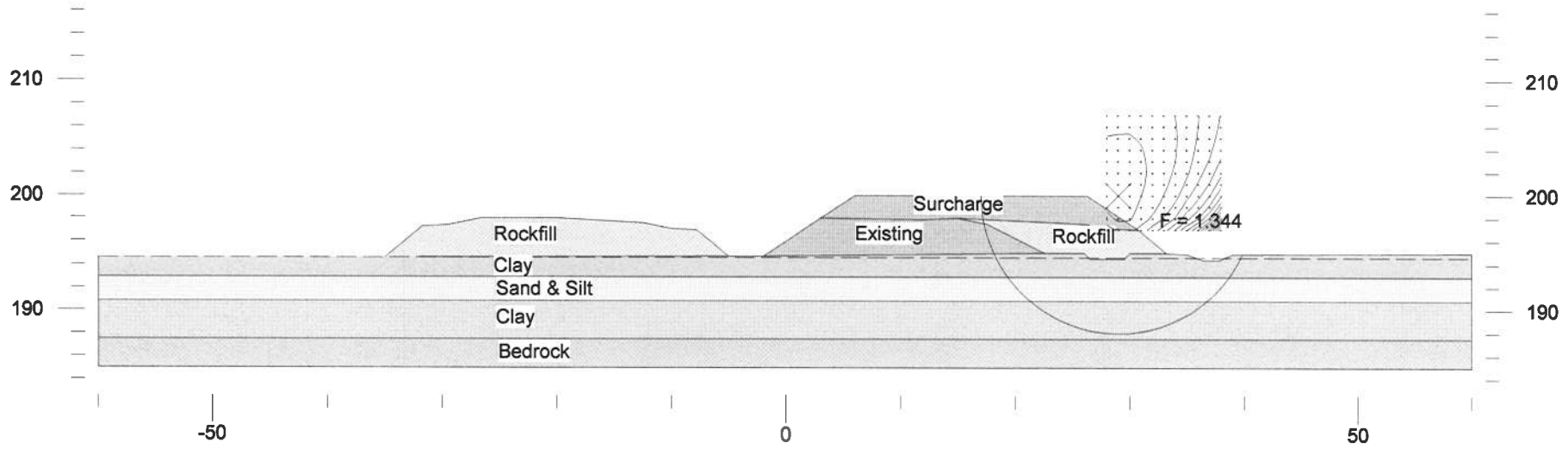


Figure 26-9

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Clay	19	25	0	0	1
Sand and Silt	19	0	30	0	1
Clay	19	20	0	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 28 - 10+410 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 198 m plus 2 m surcharge

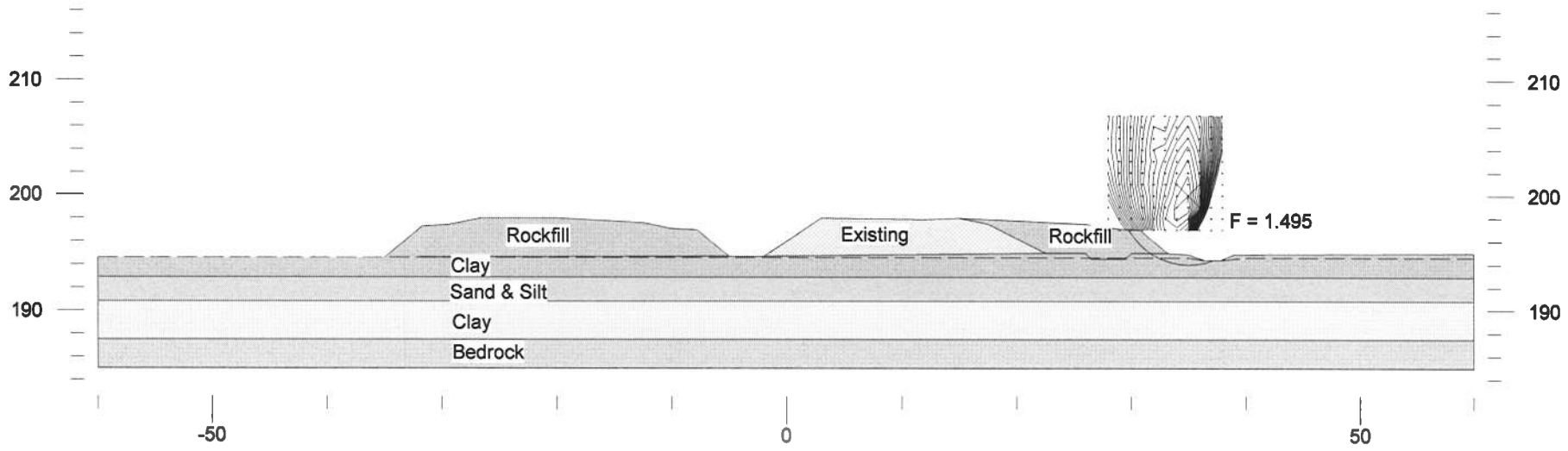


4/15/2011 1:59:05 PM C:\PROGRA~1\GSLOPE\69HWY281.GSL Thurber Engineering Ltd. - Toronto F = 1.344

Figure 28-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Clay	19	0	28	0	1
Sand and Silt	19	0	30	0	1
Clay	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site - 28 10+410 - Effective Stress Analysis (Bbar = 0.0)
Long Term (elev. 198.0 m)



4/15/2011 1:57:56 PM C:\PROGRA~1\GSLOPE\69HWY282.GSL Thurber Engineering Ltd. - Toronto F = 1.495

Figure 28-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	0
Rockfill	19	0	42	0	0
Sand and silt	19	0	31	0	1
Sand	19	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
Highway 69 Four Laning
April 2011
Site 32 - 9+800 to 9+930 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of embankment (203.1m)

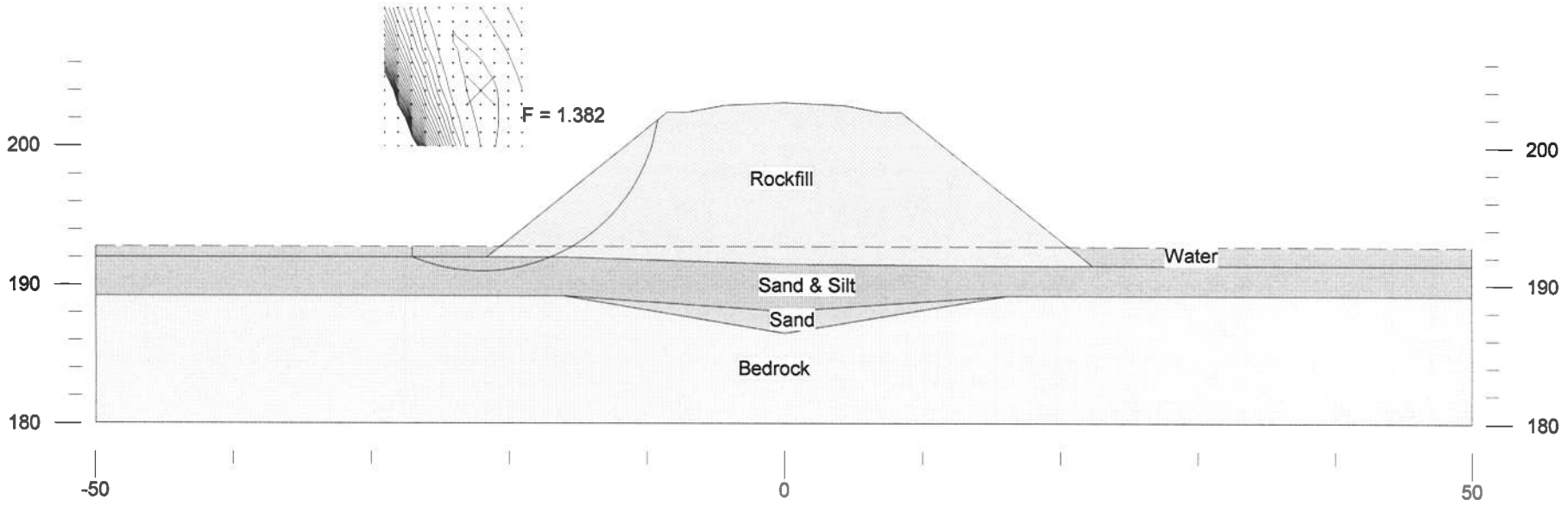
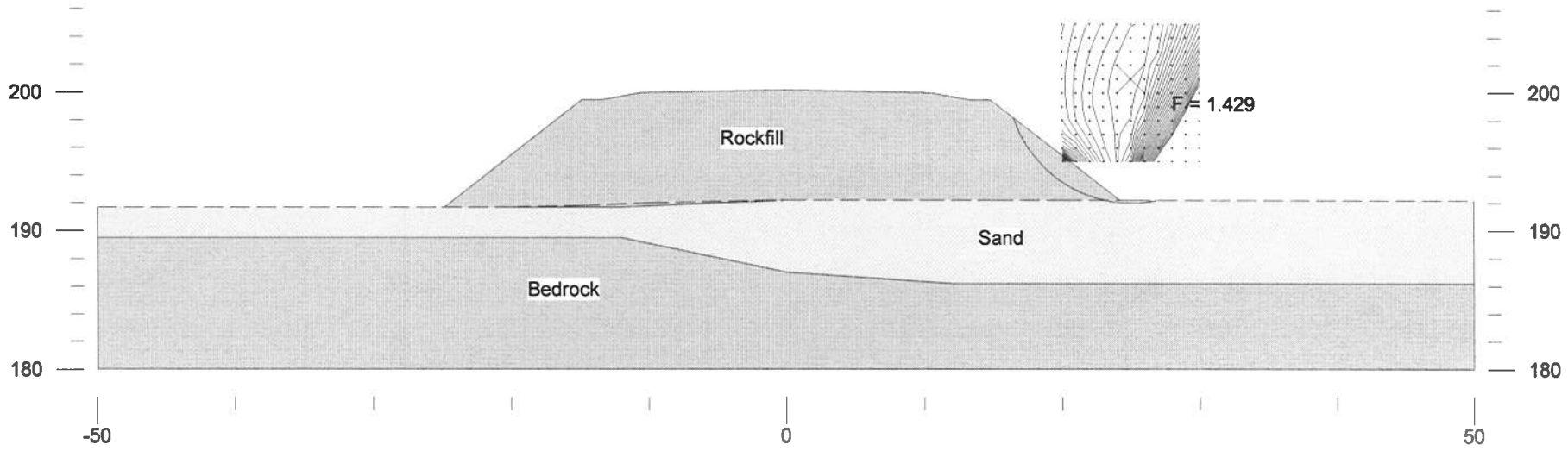


Figure 32-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	0
Sand	19	0	33	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
Highway 69 Four Laning
April 2011
Site 34 - 10+000 to 10+150 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of embankment (200.2m)

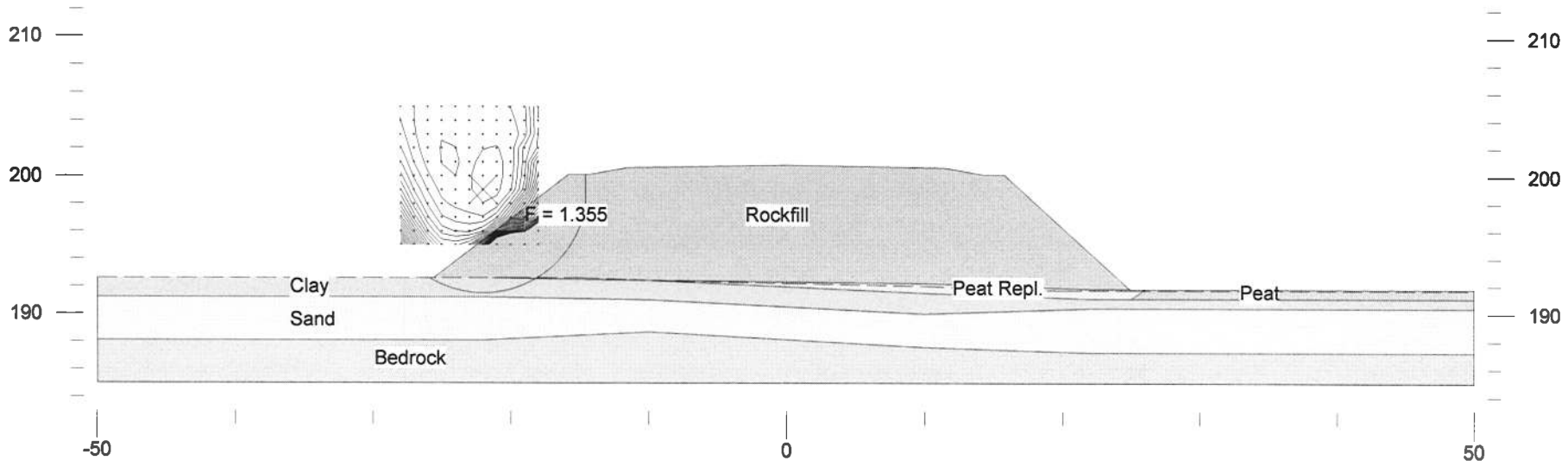


4/15/2011 2:23:32 PM C:\PROGRA~1\GSLOPE\69HWY341.GSL Thurber Engineering Ltd. - Toronto F = 1.429

Figure 34-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Clay	17	20	0	0	1
Sand	19	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
Highway 69 Four Laning
April 2011
Site 36 - 12+120 to 12+195 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to top of embankment (200.2m)

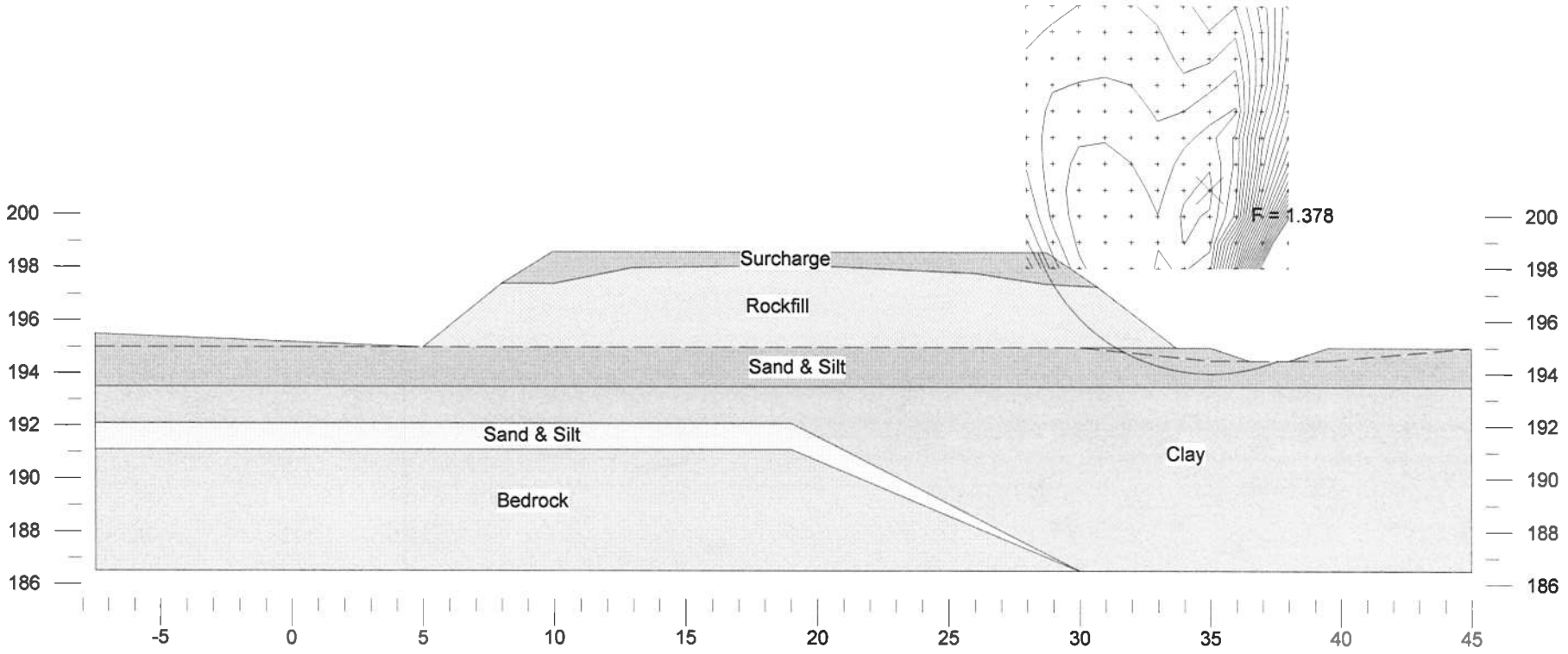


4/15/2011 2:40:35 PM C:\PROGRA~1\GSLOPE\69HWY361.GSL Thurber Engineering Ltd. - Toronto F = 1.355

Figure 36-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Sand and Silt	19	0	28	0	1
Clay	19	20	0	0	1
Sand and Silt	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 44 - 13+620 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elevl. 198.1 m plus 0.5m surcharge

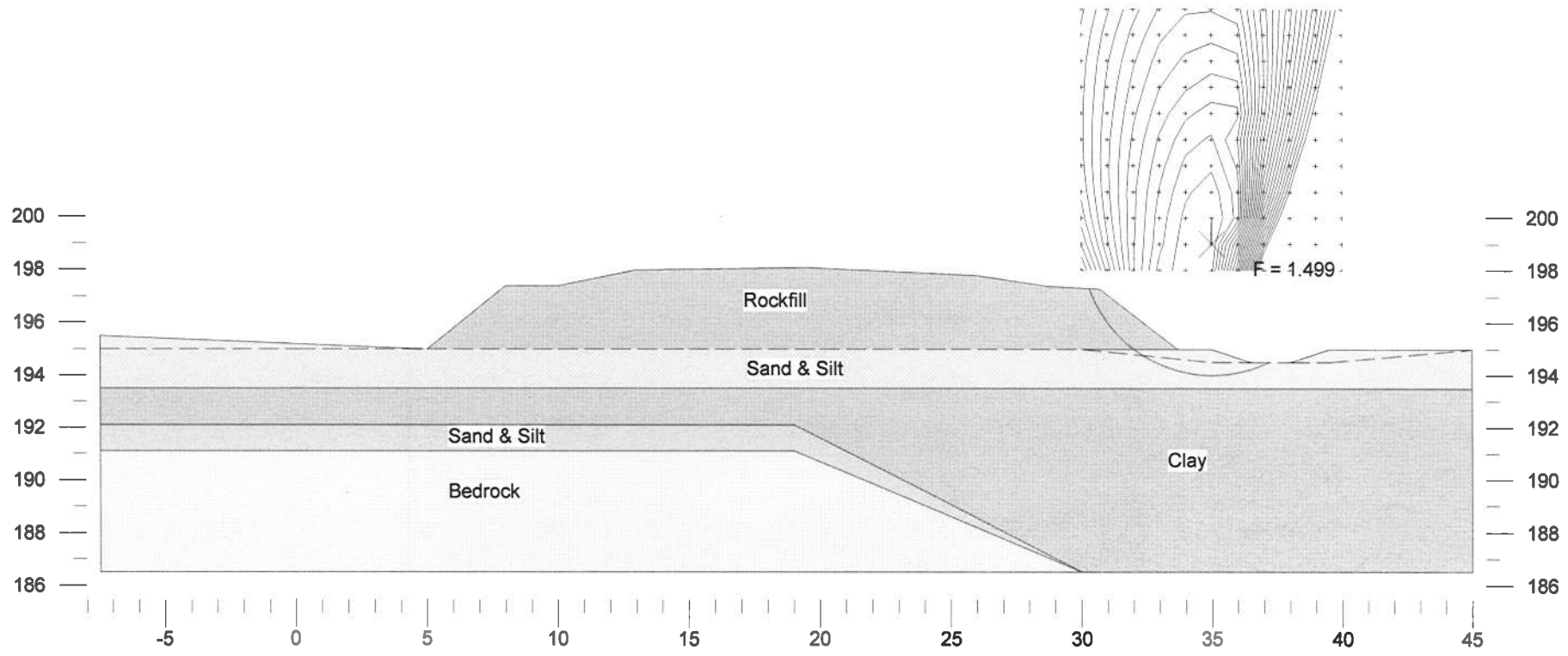


4/15/2011 2:46:38 PM C:\PROGRA~1\GSLOPE\69HWY441.GSL Thurber Engineering Ltd. - Toronto F = 1.378

Figure 44-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Sand and Silt	19	0	28	0	1
Clay	19	0	28	0	1
Sand and Silt	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 44 - 13+620 - Effective Stress Analysis (Bbar = 0.0)
Long term (elev. 198.1 m)

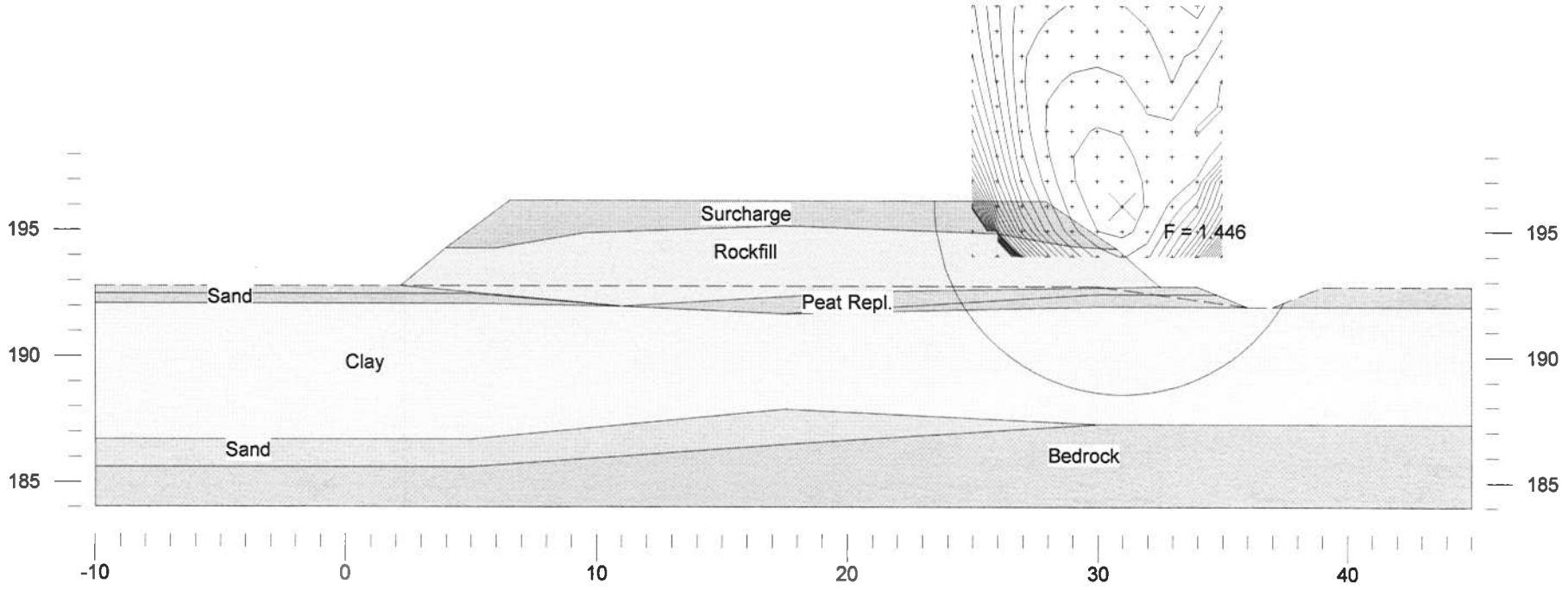


4/15/2011 2:49:22 PM C:\PROGRA~1\GSLOPE\69HWY442.GSL Thurber Engineering Ltd. - Toronto F = 1.499

Figure 44-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Peat replacement	19	0	42	0	1
Sand	19	0	28	0	1
Clay	19	20	0	0	1
Sand	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 45 - 13+950 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 195.2 m plus 1 m surcharge

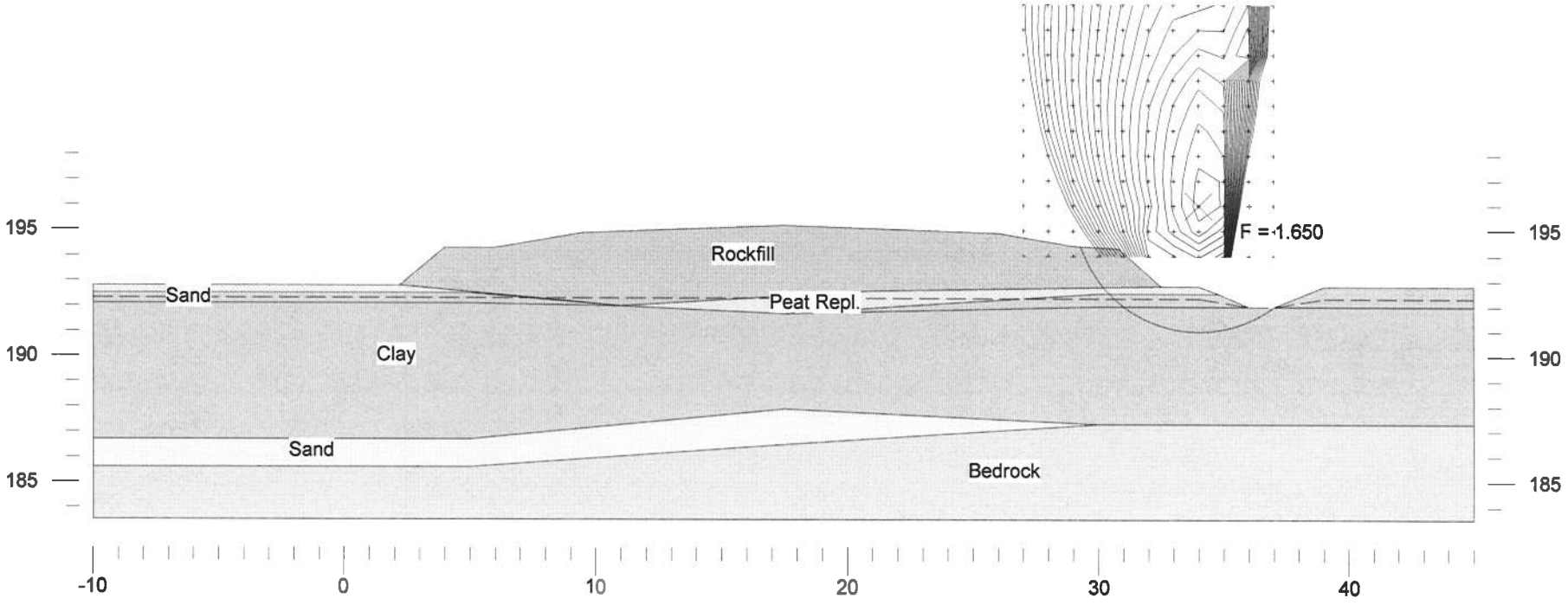


4/15/2011 3:17:07 PM C:\PROGRA~1\GSLOPE\69HWY451.GSL Thurber Engineering Ltd. - Toronto F = 1.446

Figure 45-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Sand	19	0	28	0	1
Clay	19	0	28	0	1
Sand	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 45 - 13+950 - Effective Stress Analysis (Bbar = 0.0)
Long term (elev. 195.2 m)

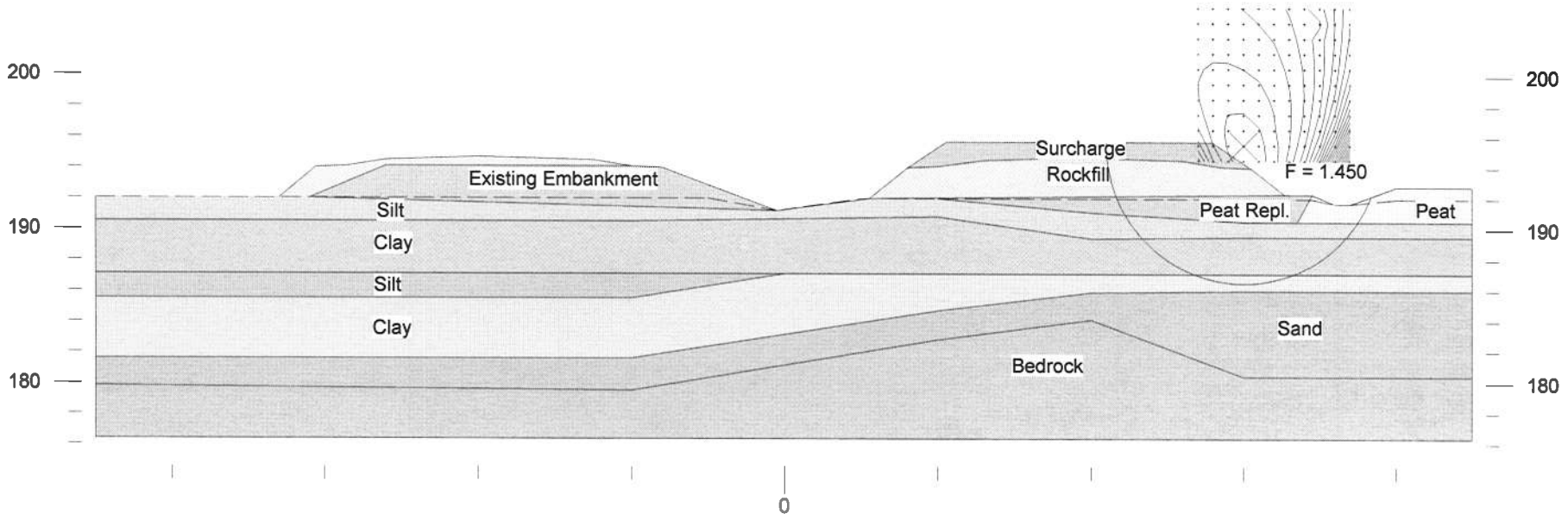


4/15/2011 3:21:06 PM C:\PROGRA~1\GSLOPE\69HWY452.GSL Thurber Engineering Ltd. - Toronto F = 1.650

Figure 45-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Silt	19	0	28	0	1
Clay	19	20	0	0	1
Silt	19	0	28	0	1
Clay	19	20	0	0	1
Sand	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 48 - 15+110 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 194.7 m plus 1 m surcharge

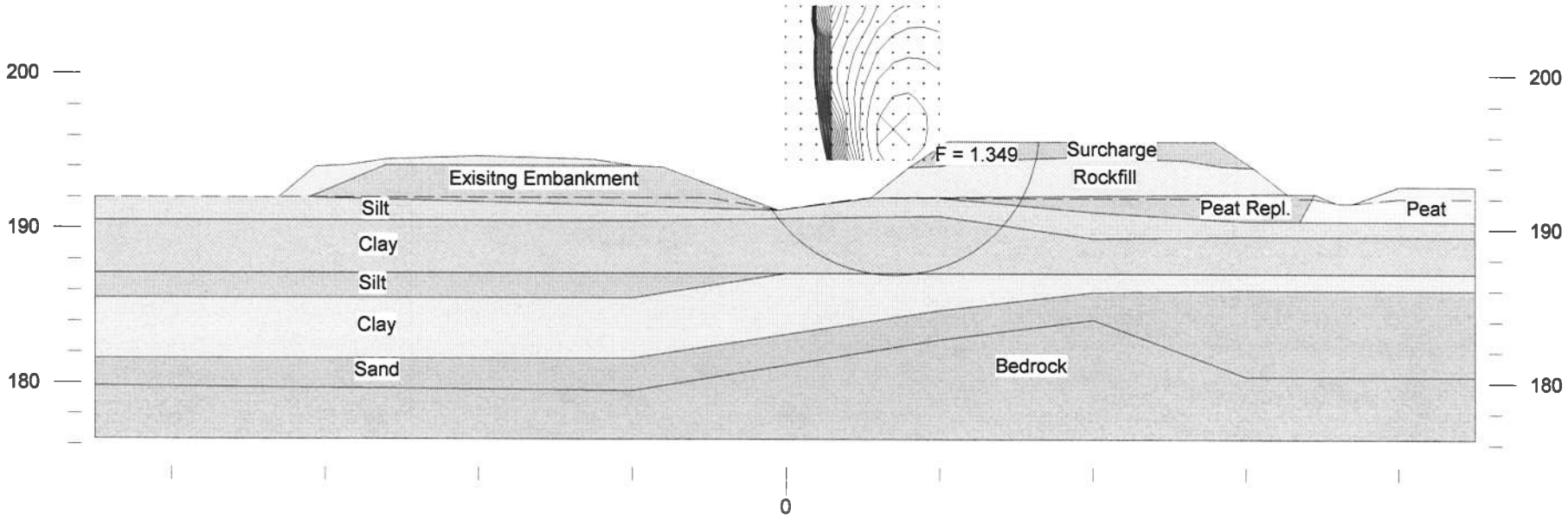


4/15/2011 3:28:14 PM C:\PROGRA~1\GSLOPE\69HWY481.GSL Thurber Engineering Ltd. - Toronto F = 1.450

Figure 48-1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	20	0	38	0	1
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	10	0	0	1
Silt	19	0	28	0	1
Clay	19	20	0	0	1
Silt	19	0	28	0	1
Clay	19	20	0	0	1
Sand	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 48 - 15+110 - Total Stress Analysis (Bbar = 0.0)
Single stage construction to elev. 194.7 m plus 1 m surcharge

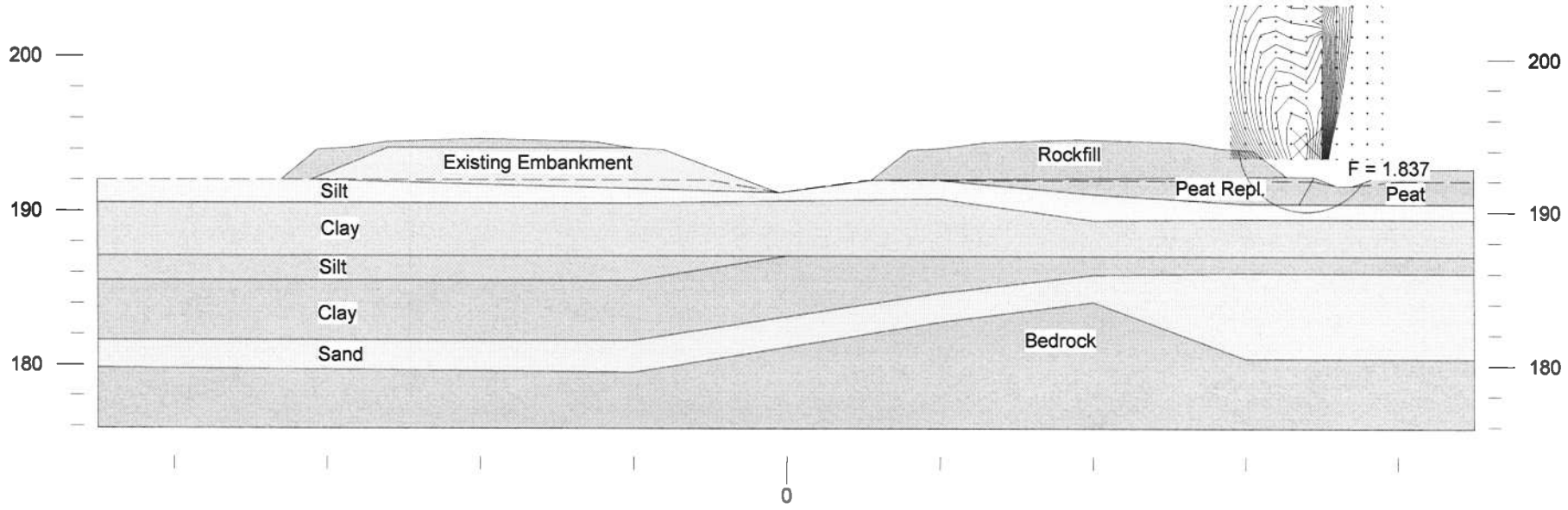


4/15/2011 3:32:06 PM C:\PROGRA~1\GSLOPE\69HWY482.GSL Thurber Engineering Ltd. - Toronto F = 1.349

Figure 48-2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	2	29	0	1
Silt	19	0	28	0	1
Clay	19	0	28	0	1
Silt	19	0	28	0	1
Clay	19	0	28	0	1
Sand	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 48 - 15+110 - Effective Stress Analysis (Bbar = 0.0)
Long term (elev. 194.7 m)

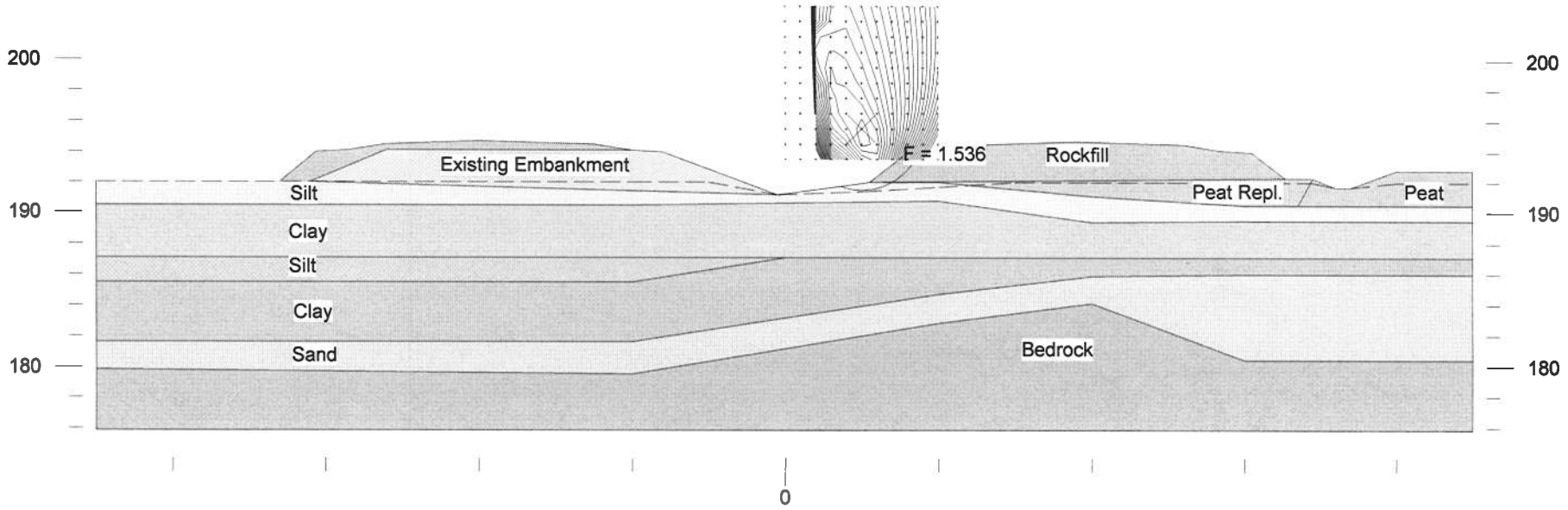


4/15/2011 3:46:30 PM C:\PROGRA~1\GSLOPE\69HWY483.GSL Thurber Engineering Ltd. - Toronto F = 1.837

Figure 48-3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Rockfill	19	0	42	0	1
Existing	19	0	42	0	1
Peat Replacement	19	0	42	0	1
Peat	13	2	29	0	1
Silt	19	0	28	0	1
Clay	19	0	28	0	1
Silt	19	0	28	0	1
Clay	19	0	28	0	1
Sand	19	0	28	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-5161-21
HWY 69 Four Laning
April 2011
Site 48 - 15+110 - Effective Stress Analysis (Bbar = 0.0)
Long term (elev. 194.7 m)



4/15/2011 3:43:11 PM C:\PROGRA~1\GSLOPE\69HWY484.GSL Thurber Engineering Ltd. - Toronto F = 1.536

Figure 48-4