FOUNDATION INVESTIGATION
AND DESIGN REPORT
HIGHWAY 69, FOUR-LANING
FROM 4KM SOUTH OF ESTAIRE TO 1KM NORTH OF HIGHWAY 537, 12KM
EMBANKMENTS THROUGH SWAMPS 602, 605 AND 613
ONTARIO

G.W.P. 312-99-00 (Swamps 602 and 605)

G.W.P.5249-05-00 (Swamp 613)

Geocres Number: 41I-198

VOLUME 1/2

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

The proposed widening and realignment of Highway 69 over a 12km length, from 4km south of Estaire to 1km north of Highway 537 will include the crossing of low-lying areas referred to as Swamp 602 and Swamp 605, located in the Township of Burwash, close to Estaire, and Swamp 613, located in the Township of Dill, north of the Wanapitei River. The sites are characterized by the presence of low lying and wet areas (swamps) underlain by deep compressible deposits.

This report presents the factual findings obtained from a foundation investigation for the proposed embankments crossing the swamps.

Peto MacCallum (Peto) carried out a preliminary investigation in 2003 at the sites and the factual data from that investigation was available for the current assignment.

The purpose of the current investigation was to supplement the drilling program carried out by Peto and, based on the available data, to provide a borehole location plan, borehole logs, stratigraphic profiles and cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed through considering a combination of the data from the previous Peto report and the data obtained in the course of the present investigation. The foundation investigation for the overpass structure carrying Hwy537 over Hwy69 was not part of this scope of work.

Thurber carried out the investigation as a sub-consultant to Totten Sims Hubicki Associates Ltd. (TSH) in accordance to the terms of reference outlined in a RFP by MTO dated June 2005.

2 SITE DESCRIPTION

The realigned Highway 69 at the subject sites runs in an approximate south-north direction, approximately parallel to the existing Highway 69.

The sites are located within the physiographic region known as the Canadian Shield, locally characterized by Pre-Cambrian bedrock of the Central Gneiss Belt. The bedrock elevation varies significantly in the area. Bedrock outcrops are present at the site but the bedrock is mostly overlain by glacial deposits (till) with particle sizes ranging from silt to boulder size, deep post-glacial lake and river sediments and by organic deposits in the low lying areas.

Swamp 602

The proposed Highway 69 alignment in Swamp 602 is located west of the existing Highway 69 are characterized by undulating terrain with upland areas comprised of bedrock outcrop or overburden soils of granular outwash of variable thickness and standing water in the low-lying areas. There are two swamps in the area, both underlain by compressible deposits: South Swamp, between Stations 12+620 and 12+720 and the North Swamp, between Stations 12+800 and 12+970. Several beaver dams were noted in the South Swamp.

Drainage in the surrounding areas is moderately developed and is comprised of small to medium streams that flow generally to the north. In the areas surrounding the swamps, however, drainage is poor and the groundwater table is at or near the ground surface.

The majority of the land along this section of the proposed alignment is undeveloped forested land covered with mature vegetation and trees.

Swamp 605

Swamp 605 is located west of Highway 69 and is a low-lying, flat, wet and poorly drained area. It intersects the proposed Highway 69 alignment from approximate stations 14+230 to 14+400 on the SBL and between stations 14+280 and 14+480 on the NBL.

Drainage in the surrounding areas is moderate to poor and is comprised of a small stream along the north edge of the swamp which flows to the northeast. Local drainage is poor and groundwater table is near the ground surface.

Beyond the north and south boundaries of the swamp 605, the ground rises gently with a vertical relief of up to 16m above the swamp elevation. The areas to the north and south of the swamp are mostly covered with mature vegetation and trees. Bedrock outcrops are present at the site but the bedrock is mostly overlain by a thin veneer of organic soil.

Swamp 613

Swamp 613 is in a flat terrain northwest of the Wanapitei River along the proposed Highway 69 alignment. The area is crossed by the existing Highway 69 and existing Highway 537.

Drainage in the surrounding areas is moderately well developed and is comprised of ditches and culverts near existing Highway 537 which flow generally towards Wanapitei River.

The majority of the land along this section is undeveloped land covered with low vegetation and scrub. There is one vacant house and a parking lot at the northwest quadrant of the proposed intersection of Highway 69 and Highway 537. The ground rises gently to the northwest with a vertical relief of up to 8m above the swamp elevation. Bedrock outcrops are present at the north end of the site.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation program discussed herein was carried out between October 12 and October 24, 2005. The site investigation consisted of:

- Drilling and sampling seven boreholes as follows:
    - Two boreholes in Swamp 602; both in the North Swamp
    - Two boreholes in Swamp 605
    - Three boreholes in Swamp 613

  The boreholes were advanced to auger refusal or to elevations where compact to very dense cohesionless soils were encountered below the soft to firm cohesive deposits. The borehole depths ranged from 15m to 21m in Swamps 602 and 605 and from 19m to 31m in Swamp 613. The purpose of the boreholes was to confirm the subsurface conditions at locations where the potential for instability during construction and large settlements due to consolidation were considered high and to collect undisturbed soil samples for stability and settlement analysis.

- Advancing fourteen piezocone tests (CPTU) at the centreline of the proposed embankments as follows:
    - Five piezocones in Swamp 602; one in the South Swamp, four in the North Swamp
    - Four piezocones in Swamp 605
    - Five piezocones in Swamp 613

  The CPTUs were advanced to refusal at depths ranging from 4m to 12m in Swamp 602, and from 14m to 26m in Swamps 605 and 613. The purpose of the CPTUs was to provide more detailed information about the stratigraphy and consolidation characteristics of the compressible foundation soils.

The test hole locations, coordinates and elevations are shown on the attached drawings labelled Sheet 602-1, Sheet 605-1 and Sheet 613-1.

Surveyors from Sutcliffe, Rody Quesnell Inc. marked the borehole locations in the field and utility clearances were obtained by Thurber prior to any drilling being carried out. Authorization from land owners to enter their properties to carry out the investigation program was obtained by Thurber.

Preparation of access to the borehole locations was carried out under Thurber's supervision by Weeks Construction Inc. of Parry Sound, Ontario. Authorization to cross wet areas was obtained from the Fisheries and Oceans Canada.

All Terrain Drilling supplied and operated the drilling and sampling equipment, mobilizing from Waterloo, Ontario.

Hollow stem augers were used to advance the boreholes and samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) and thin wall Shelby tubes. Standpipe piezometers were installed in all boreholes. Standpipe installation consisted of 19mm PVC pipe slotted over the bottom 1.5m to 3.0m length. The slotted pipe was surrounded by sand and a bentonite plug with minimum thickness of 0.6m was placed over the sand pack. The remainder of the hole was grouted using a cement-bentonite grout in accordance to O-Reg 128/03. Additional standpipe installation details are provided in the borehole logs in Appendix A.

ConeTec Inc. supplied and operated the piezocone testing, mobilizing from Vancouver, British Columbia. The piezocone testing included standard static penetration with pore pressure measurement and pore pressure dissipation tests at selected depths in order to obtain horizontal coefficient of consolidation values for the design of wick drains. In addition pore pressure dissipation tests were carried out in the cohesionless deposits underlying the silty clay deposit to obtain the piezometric head and the possible presence of artesian pressure at that elevation. A summary of the piezocone locations and results of the pore pressure dissipation tests are provided in ConeTec's reported included in Appendix D.

A member of Thurber's engineering staff supervised the piezocone testing, drilling and sampling operations on a full time basis. The inspector logged the recovered samples and processed them for transport to Thurber's Oakville office. All boreholes were grouted on completion of the drilling program in accordance to O'Reg 128. The access roads, including the corduroy crossings were removed a few weeks after the completion of drilling.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected samples were subjected to gradation analysis (sieve and hydrometer), Atterberg Limit, Oedometer and Consolidated Undrained Triaxial testing. The test results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets for boreholes drilled by Thurber in Appendix A, to the Record of Borehole sheets prepared by Peto MacCallum Ltd. (Peto) included in a report dated May 23, 2003 and to ConeTec's report included in Appendix D. Details of the encountered soil and rock stratigraphy are presented in these appendices and on the attached plan and soil strata drawings. A generalized description of the stratigraphy is given in the following paragraphs. The factual information at the borehole locations governs any interpretation of site conditions.

In general terms, the site was found to be underlain by granitic bedrock of the Canadian Shield. The bedrock is overlain by broadly graded generally compact to dense granular soils including silt, sand, cobbles and boulders, which are overlain by compressible glaciolacutrine and glaciofluvial fine grained soils and organic soils. The glaciolacustrine deposits consist of low to high plastic silty clay and are locally overlain by loose to compact silt or peat deposited in the recent geological past and locally by fill at the existing road alignments.

5.2 Swamp 602

Swamp 602 has two separate areas underlain by compressible soils referred herein as the South Swamp and the North Swamp. The South Swamp is in a topographic depression containing a small creek and the North Swamp is located over a flat, wet low-lying area with standing water. The extent of the swamps along the proposed Highway 69 and the embankment height to the top of pavement are summarized in Table 5.1 below:

Table 5.1 – Boundaries of Swamp 602

Location	Station	Embankment Height (m)
Highway 69 - NBL (South Swamp)	12+620 to 12+720	0.2 to 4.8
Highway 69 - SBL (South Swamp)	12+620 to 12+720	0 to 3.8
Highway 69 – NBL (North Swamp)	12+800 to 12+970	0 to 3.3
Highway 69 – SBL (North Swamp)	12+800 to 12+970	0 to 3.2

5.2.1 South Swamp

Peat

A surficial layer of peat was encountered in the South Swamp. The peat was described as coarse fibrous dark brown to black and varied in thickness from 0 to 1.2m with most values ranging from 0 to 0.4m. The peat was generally very loose to compact.

Upper Silt (ML)

A layer consisting mainly of slightly plastic to non-plastic silt and occasionally consisting of a mixture of sand and silt was encountered underlying the peat. The thickness of this deposit typically ranged from 0 to 4.3m with most values ranging from 0 to 1m. The elevation of the bottom of this deposit typically ranged from EL. 229 and EL. 234. The SPT "N" blow counts in the silt deposit ranged from 11 to 22. Based on the SPT values noted above, the silt layer is described as compact.

The deposit was brown at the top, changing to grey with increasing depth. The natural moisture content of this deposit ranged from 18% to 28%.

Silty Clay (CL to CI)

A deposit of silty clay was encountered in most test holes underlying the peat and the silt deposits. The thickness of the deposit ranged from zero at the south end of the swamp at station 12+640 on SBL, and at station 12+660 on NBL, to a maximum thickness of 6.7m and 6.9m at station 12+660 on SBL and 12+700 on NBL respectively. The elevation of the top of this deposit ranges from approximate EL. 229 to EL. 232. The lowest elevation of the bottom of this deposit was at approximate EL. 225.

The upper 1.5 to 3.5m of this silty clay layer is generally firm to very stiff with SPT blow counts ranging from 6 to 20. This layer, referred herein as "crust", was generally brown in colour with the water content varying from 23% to 44%.

Below the crust and where no crust was noted, the silty clay was brown in the upper part and grading to grey with increasing depth. The water content values for the lower portions of the silty clay deposit varied from 35% to 42%.

The Atterberg Limit test results presented in Peto's 2004 report indicate that the silty clay deposit is generally low to medium plastic and is classified as CL and CI according to the Modified Unified Soil Classification System. Gradation tests carried out on the silty clay samples indicate that the layer consists of 52% to 67% of silt, 30% to 47% of clay and typically less than 4% of sand. The clay content generally varies with plasticity as follows:

- Low plastic silty clay (CL): 30% to 33% clay content
- medium plastic silty clay (CI): 47% clay content

Attached Figures 5.1 and 5.2 present a summary of the SPT and undrained shear strength values measured in the silty clay. Undrained shear strength values (Su) in the crust inferred from in situ vane and the piezocone test were high ranging from 70kPa to 110kPa, with an average value of 80 kPa. This deposit can be generally described as stiff to very stiff.

Undrained shear strength (Su) in the lower silty clay deposit, depending on the thickness of the crust, decreased with depth to values in the order of 45kPa to 90kPa with an average value of 50kPa reflecting firm to stiff conditions. The sensitivity values (S_t: ratio of peak and remoulded undrained shear strength) ranged from 2 to 5 indicating the silty clay deposit is low to medium sensitive.

The over-consolidation ratios (OCR) inferred from piezocone tests show that the silty clay is over-consolidated with an average OCR value of 7 in the crust and 5 in the lower silty clay. The horizontal coefficient of consolidation (Ch) measured in the crust from piezocone was 125m^2/yr.

Lower Silt Unit and Sandy Silt

A silt deposit was encountered underlying the silty clay deposit in most test holes in the South Swamp. The silt was brown to grey in colour and was non-plastic to low plastic, described as ML according to the Unified Soil Classification System. Gradation tests in this material, shown on Peto's 2004 report indicate clay content values ranging from 3% to 10% with the remaining consisting of silt and up to 4% sand. The natural water content ranged from 22% to 31%. The SPT "N" values ranged from 5 to 24 with an average value of 10. This material is described as loose to compact.

Sandy Silt was encountered in some boreholes underlying the lower silt unit. The deposit was generally brown and has SPT "N" values ranged from 3 to 15 indicating very loose to compact conditions. The low values of "N" are attributed to disturbance at the bottom of the borehole caused by drilling. One hydrometer test carried out on this material indicates 57% silt, 31% sand, 9% gravel and 3% clay. The natural water content was 17%.

The elevation of the top of the Lower Silt and Sandy Silt deposit ranged from approximate EL. 224 to EL. 228. The lowest elevation of the bottom of this deposit was at approximate EL. 216.5.

Bedrock

Bedrock of the Canadian Shield was inferred from refusal to auger penetration underlying the soils. The rock is characterized by abrupt changes in elevation within very short distances. The bedrock surface is shallow along the south and north boundaries of the South Swamp, with bedrock rising to EL. 236 both south and north of the swamp. The deepest point of the bedrock surface encountered in the test holes in the south swamp was at approximate EL. 216.5 (Peto's DCPT BH602-8S).

Water Levels

The groundwater levels at this site were generally encountered within 2 m of the ground surface (EL 231.2 to 232 m) as inferred from CPTU pore pressure dissipation test in the silt deposit. There are no standpipe piezometer installations in this swamp to provide medium to long term groundwater levels. The groundwater levels discussed above are short term and do not reflect anticipated seasonal fluctuations.

5.2.2 North Swamp

Topsoil and Peat

A surficial deposit of topsoil, up to 200mm thick was encountered at surface overlying shallow mineral soils and bedrock at the north and south ends of the North Swamp. Topsoil was absent in the boreholes located in the low-lying areas. The topsoil thickness may vary between boreholes and in other areas of the site.

A layer of peat was encountered in the North Swamp. The peat was described as fine to coarse fibrous, locally amorphous, dark brown to black and varied in thickness from 0 to 0.6m with most values from 0 to 0.3m. The peat was generally very loose to loose.

Upper Silt (ML)

A layer of silt was encountered underlying the peat in most boreholes. The thickness of the upper silt varied from 0 to 2.5m. The elevation of the bottom of this deposit typically ranged from EL. 230 to EL. 232.5. The SPT "N" blow counts in the silt deposit ranged from 6 to 21; the silt layer is described as loose to compact.

The deposit was brown to grey in colour. The natural moisture content of this deposit ranged from 16% to 30%.

Silty Clay

A thick deposit of silty clay was encountered in most test holes underlying the peat and the silt deposits. Where the test holes fully penetrated this deposit, its thickness ranged from 0m at the south end of the swamp at 12+810 to a maximum thickness of 14.4m and 13.2m at 12+870 on the SBL and NBL respectively. The elevation of the top of this deposit ranges from approximate EL. 230 to EL. 235. The lowest elevation of the bottom of this deposit was at approximate EL. 218 to EL. 233.5 as the thickness decreases towards the north and south end of the swamp.

The upper 1.2m to 5.9m of this silty clay layer is firm to stiff and is referred to as crust. The SPT blow counts ranged from 4 to 18 between approximate EL. 226 and EL. 235. This layer was generally brown in colour and grading to grey with increasing depth. The water content varied from 18% to 45%, typically 25% to 35%.

A stiffer material with higher silt content, ranging from clayey silt to non-plastic silt, was encountered below the crust in most of the test holes between stations 12+825 to 12+900. The SPT "N" blow counts in the clayey silt to silty clay layer ranged from 7 to 31 between approximate EL. 225 and EL. 230. The thickness of the clayey silt to silt layer typically ranged from 1 to 3m. Dynamic cone penetration tests (DCPT) and piezocone tests indicated high resistance within this deposit. The two piezocone tests conducted at station 12+848 at SBL centreline were unable to penetrate this layer at EL. 227.8m (two attempts:

CPTU602-S3 and CPTU602-S3A). Grinding was also noted while advancing the augers in 602-S1(TEL) from EL. 227.5 to EL 226.5, indicating that gravel and cobbles are likely present in this layer. The water content varied from 23% to 36%.

Below the "stiff zone" described above, the silty clay was grey with SPT "N" blow counts ranged from 0 to 10 indicating a consistency of very soft to stiff. The water content values for the lower portions of the silty clay deposit varied from 25% to 60% with most values from 35% to 60%.

Gradation tests summarized in Figures B1, B2 and B3 in Appendix B and in Record of Boreholes in Appendix A showed that the silty clay has variable amounts of silt and clay, and typically less than 2% of sand. Most samples consisted of 29% to 77% silt and 22% to 70% clay. Locally, in particular in the "stiff zone" and the lower 1.5m of the silty clay deposit, the clay content is low and in the order of 8%.

A series of Atterberg Limit tests, summarized in Figures B1 and B2 in Appendix B, indicated that the silty clay deposit has variable plasticity and is classified according to the Modified Unified Soil Classification System as follows:

- Medium to high plastic silty clay (CI-CH) in the upper crust portion of the deposit: 44% to 70% clay content
- Low plastic silty clay (CL/CL-ML) in the stiff zone below the crust and in the lower 1.5m portion of the deposit: 8% to 33% clay content
- Medium plastic silty clay (CI) in the remaining silty clay deposit below the stiff zone: 31% to 69%.

Liquid Limit values ranged from 26% to 28% in the (CL/CL-ML) and 32% to 53% in the (CI-CH). Plastic Limit values were relatively uniform and ranged from 19% to 23% in both deposits.

Oedometer tests were carried out on four silty clay samples and the results are summarized in Table 5.4. One of the samples was retrieved from the upper crust portion of the silty clay deposit (CI-CH) at EL. 228.5 and three samples were retrieved from the CI deposit between EL. 221.5 to EL. 225.4. The test results are presented in Figures B6, B7 and B8 in Appendix B and summarized in attached Table 5.4. The compression index ratio ($C_{c\varepsilon} = C_c/(1+e_o)$) was 0.09 in the silty clay crust and ranged from 0.16 to 0.23 in the CI silty clay deposit overlying the crust. The recompression index ratio ($C_{s\varepsilon} = C_s/(1+e_o)$) ranged from 0.02 to 0.04 with an average of 0.03. One of the load increments during selected oedometer tests was carried out with constant stress for approximately 48 hours for measurement of the coefficient of secondary consolidation (C_α). The stress value at which this test was carried out was selected based on the anticipated vertical effective stress at the sample elevation after the end of construction of the embankment. The coefficient of secondary consolidation ratio ($C_\alpha/(1+e_o)$) value obtained from the oedometer in the crust was 0.00032. The vertical coefficient of consolidation (C_v) obtained from the oedometer tests at the anticipated working vertical effective stresses after the embankment construction was $63m^2/yr$ in the crust and ranged from 9.5 m^2/yr to 22 m^2/yr in the CI deposit. The horizontal coefficients of consolidation (C_h) obtained from piezocones ranged from 100 to $170m^2/yr$ and from 20 to 45 m^2/yr in the crust and CI deposit, respectively.

Attached Figures 5.3 through 5.6 present a summary of the SPT and undrained shear strength values obtained in the silty clay encountered in the test holes advanced in the North Swamp. Undrained shear strength values in the crust were high near the surface (typically more than 100kPa), reflecting very stiff to hard conditions, and decreased with depth to values in the order of 35kPa at EL 226 to EL. 228, depending on the thickness of the crust. Below the crust the undrained shear strength was typically 35kPa to the bottom of the silty clay deposit. The over-consolidation ratios inferred from piezocone tests show that the silty clay is over-consolidated to approximate EL 223.5 with OCR from 3 to 10 and slightly over-consolidated below EL. 223.5 with an OCR of 1.8. The oedometer tests also show that the soils samples were over-consolidated above EL 221.5 with OCR ranging from 2.1 to 11.9. At EL 221.5, the sample was normally to slightly over consolidated.

Vane tests indicated that the sensitivity ratio of the clay measured using in situ vane tests ranged from 2.4 to 3.3 indicating the silty clay deposit has low sensitivity.

Lower Silt Unit, Sandy Silt and Sand

A silt deposit was encountered underlying the silty clay unit described above in most test holes in the North Swamp. The silt deposit was generally grey in colour and was non-plastic to low plastic, described as ML according to the Unified Soil Classification System. Hydrometer tests conducted by Peto in this material indicate clay content values ranging from 7% to 8% and up to 2% sand. The natural water content ranged from 19% to 32%. The SPT "N" values ranged from 0 to 26 with typical values from 5 to 14. The low values of "N" are probably due to disturbance at the bottom of the borehole caused by drilling. This material is generally described as loose to dense. Sandy silt grading locally into sand was encountered underlying the lower silt unit in some of the test holes.

The elevation of the top of this combined silt and sand deposit ranges from approximate EL. 220 to EL. 224 between stations 12+840 and 12+910. The lowest elevation of the bottom of this deposit was at approximate EL. 206.5.

Bedrock

The bedrock surface is shallow along the south and north boundaries of the North Swamp, rising to EL. 236 south of the swamp. The deepest point of the bedrock surface encountered in the test holes in the North Swamp was at approximate EL. 206.5 in Peto's DCPT BH602-30N.

Water Levels

The piezometric level in the lower silt unit, in two standpipe piezometers installed in boreholes 602-N1 and 602-S1, was at surface, at approximate EL. 232.3 to EL. 232.8. The piezometric levels in the standpipes are consistent with the piezometric levels inferred from piezocone tests presented in Appendix D.

The groundwater levels above are relatively short term and may not be stabilized. Seasonal fluctuations in the groundwater table are also anticipated.

5.3 Swamp 605

Swamp 605 is a flat, wet and low-lying area. The extent of the embankments along Hwy69 and the embankment heights are summarized in Table 5.2 below:

Table 5.2 –Boundaries of Swamp 605

Location	Station	Embankment Height (m)
Highway 69 NBL	14+280 to 14+480	5.0 to 8.9
Highway 69 SBL	12+230 to 12+400	4.8 to 8.1

<u>Peat</u>

A thick layer of peat was encountered at surface at Swamp 605. The peat was described as fine to coarse fibrous and occasionally amorphous. It was generally dark brown to black and varied in thickness from 0.9 to 2.9m. The natural moisture content of this deposit ranged from 117% to 705%. The peat was very loose and offered low resistance to penetration of the SPT split spoon sampler which sank under the weight of the SPT hammer or rods.

<u>Upper Silt (ML)</u>

A silt deposit was encountered underlying the peat in most of the boreholes. The deposit consists of mainly slightly plastic to non-plastic silt. The thickness of the deposit typically ranged from 0.6 to 4.4m with most values ranging from 1.5 to 2.8m. The elevation of the bottom of this deposit was encountered typically between EL. 229.5 and EL. 231. The SPT "N" blow counts in the silt deposit ranged from 0 to 8, typically 2 to 6. Based on the SPT values noted above, the silt layer is described as very loose to loose. The natural moisture content of this deposit ranged from 28% to 35%.

<u>Silty Clay (CL-ML to CH)</u>

A thick deposit of silty clay was encountered in most boreholes and piezocones underlying the peat and the silt deposits. The thickness of the deposit ranged from zero along the south and north edges of the swamp, to a maximum thickness of 12.6m at Station 14+370. The elevation of the top of this deposit ranges from approximate EL. 229.5 to EL. 231.6. The lowest elevation of the bottom of this deposit was at approximate EL. 219.3.

Gradation tests summarized in Figures B10, B11 and B12 in Appendix B and in Record of Boreholes in Appendix A, showed that the silty clay has variable amounts of silt and clay, and typically less than 4% of sand. Most samples tested for gradation consisted of 27% to 76% silt and 23% to 72% clay.

A series of Atterberg Limit tests, summarized in Figures B13 through B14 in Appendix B, indicated that the silty clay deposit has variable plasticity and is classified as follows:

- Low plastic silty clay (CL/CL-ML) in the upper 2m and lower 2 to 5m of the deposit: 23% to 36% clay content
- Medium to high plastic silty clay (CI-CH) in the middle portion of the deposit: 48% to 72% clay content

The water content values for the upper and lower portions of the silty clay deposit, referred herein as CL and CL-ML, respectively, ranged from 22% to 38%. The medium to high plastic silty clay (CI-CH) had moisture content values ranging from 40% to 60%. Liquid Limit values ranged from 23% to 29% in the low to medium plastic clay (CL/CL-ML) and 32% to 53% in the intermediate to high plastic clay (CI-CH). Plastic Limit values ranged from 16% to 23% in both deposits.

The results of four oedometer tests carried out on undisturbed silty clay samples, collected from depths ranging from 5 to 11m, are summarized on the borehole logs and in Table 5.4. The test results are also presented in Figures B15 through B18 in Appendix B. The compression index ratio ($C_{c\varepsilon} = C_c/(1+e_o)$) ranged from 0.09 to 0.10 in the (CL/CL-ML) deposit and from 0.17 to 0.29 in the (CI-CH) deposit. The recompression index ratio ($C_{s\varepsilon} = C_s/(1+e_o)$) ranged from 0.01 to 0.02 in the (CL/CL-ML) deposit and 0.03 to 0.05 in the (CI-CH) deposit. Time dependent tests were carried out for approximately 48 to 843 hours at constant stress values for measurement of coefficient of secondary consolidation (C_α). The coefficient of secondary consolidation ratio ($C_\alpha/(1+e_o)$) values obtained from the oedometer tests was 0.0018 in the (CL/CL-ML) deposit and 0.0022 in the (CI-CH) deposit. The vertical coefficient of consolidation (C_v) obtained from the oedometer tests at the anticipated working vertical effective stresses after the embankment construction ranged from 3.2 to 13.6m^2/yr in the (CL/CL-ML) deposit and from 42.5 to 63 m^2/yr in the (CI-CH) deposit. The horizontal coefficients of consolidation (C_h) obtained from piezocone tests ranged from 35 to 60m^2/yr and from 15 to 25 m^2/yr in the crust and CI deposit, respectively.

Attached Figures 5.7 through 5.11 present a summary of the SPT and undrained shear strength values obtained in the silty clay encountered in the test holes. Undrained shear strength values typically increased with depth and ranged from 20 to 45kPa, reflecting soft to firm conditions. The over-consolidation ratios inferred from piezocone tests show that the silty clay is over-consolidated to approximate EL 227 with OCR of 2 to 5 and slightly over-consolidated to normal-consolidated below EL. 227 with OCR of 1 to 1.1. The oedometer tests also show that the soils samples were over-consolidated above EL 227 with OCR ranging from 1.6 to 1.8. The soil samples at EL. 222.8 and EL. 223.7 were normally to slightly over consolidated.

Vane tests indicated that the sensitivity ratio of the clay measured using in situ vane tests ranged from 2 to 5 indicating that the silty clay deposit is low to medium sensitive. The piezocone tests also detected the presence of sensitive soils the silty clay deposit.

Lower Silt Unit and Sand

A deposit of silt was encountered underlying the silty clay deposit in most test holes advanced in Swamp 605. The silt was non-plastic to low plastic and it is described as ML. Gradation tests in this material, shown on Figure B9 indicate clay content values ranging from 8% to 23% with the remaining consisting of silt and up to 7% sand. The natural water content was uniform and ranged from 20% to 25%. The SPT "N" values ranged from 1 to 26, typically from 6 to 18. The low values of "N" are typically associated with disturbance at the bottom of the borehole caused by drilling. This material is described as loose to compact. A compact to very dense deposit of sand was locally encountered beneath the lower silt unit lying on top of bedrock. The natural water content of the local sand unit ranged from 12% to 26%.

The elevation of the top of this combined silt and sand deposit ranges from approximate EL. 220 to EL. 226. The lowest elevation of the bottom of this deposit was at approximate EL. 206.8.

Bedrock

Bedrock of the Canadian Shield was inferred from refusal to auger penetration underlying the soils. The rock is characterized by abrupt changes in elevation within very short distances. The bedrock surface is shallow along the south and north boundaries of the Swamp and rises to EL. of 248. The deepest point of the bedrock surface encountered in the test holes in the swamp was approximate EL. 206.8 in Peto's DCPT BH605-33N.

Water Levels

The piezometric level in the swamp, measured at the lower silt unit in the two standpipe piezometers installed by Thurber in boreholes 605-N1 and 605-S1, was at surface at approximate EL. 233.8. The groundwater level is consistent with the groundwater levels inferred from piezocone tests, summarized in Appendix D.

The groundwater levels discussed above are relatively short term and may not have stabilized. Seasonal fluctuations in the groundwater table are also anticipated.

5.4 Swamp 613

Swamp 613 is located in a flat land that is bound by the existing Hwy69 to the west and is crossed by the existing Highway 537. The extent and height of the proposed highway embankments that will be founded on compressible soils are summarized in Table 5.3 below:

Table 5.3 –Boundaries in Swamp 613

Location	Station	Embankment Height (m)
Highway 69 NBL	10+400 to 10+640	0 to 5.1
Highway 69 SBL	10+400 to 10+710	0 to 4.7
Highway 537 West Approach	9+880 to 9+960	1.8 to 5.4
Highway 537 East Approach	10+040 to 10+230	0 to 8.2

Fill, Peat and Topsoil

The existing Highway 537 crosses the site on a fill approximately 1 to 1.5m in thickness. Some embankment materials were sampled near the corridor of existing Highway 537. The fill was comprised of sand and gravel to sandy silt with presence of cobbles and boulders and occasionally with clayey silt. The SPT "N" values ranged from 4 to 56 indicating loose to very dense and firm to hard (for cohesive fill) conditions.

A thin layer of topsoil or peat was encountered at surface at most boreholes. The topsoil is described as silty or sandy topsoil and the peat is described as fine to coarse fibrous peat. Occasional rootlets and organics were also noted. The colour varies from dark brown to black. The thickness of topsoil and peat encountered in the boreholes varied from 0 to 500mm, typically 0 to 200mm.

Upper Sand and Silt Unit

An outwash fluvial deposit was encountered underlying a thin layer of topsoil or peat at most boreholes. The deposit consists mainly of non-plastic silt and sand. At the south end of the swamp approximately between station 10+400 of the proposed Highway 69 and Wanapitei River, this unit is the predominant material extending to the bedrock. North of station 10+400, the thickness of the deposit typically ranged from 0 to 3.5m. The elevation of the bottom of this deposit typically ranged from EL. 217.5 to EL. 219.

Interbedded layers of sand and silt of variable thickness are also present in the area of the proposed Highway 537 west approach. The thickness of the interbedded silt and sand deposit ranged from 1 to 7.2m, typically 4 to 7.2m. The elevation of the bottom of this deposit ranged from EL. 217 to EL. 220.5.

The SPT "N" blow counts in the Upper Sand and Silt deposit ranged from 1 to 45 with most values ranging from 5 to 20. Based on the SPT values noted above, the deposit is described as very loose to dense and generally loose to compact.

The deposit was generally brown at the top, grading to grey with increasing depth.

Gradation test results carried out on samples collected from the upper sand and silt deposit are presented in Figures B22 and B23, Appendix B. The test results indicate that the sand/silt deposit is composed of a broad range of sand to clay particle sizes ranging from 10% to 71% sand, 24% to 81% silt and 6% to 9% clay.

The natural moisture content of this deposit ranged from 13% to 33% with typical range of 20% to 30%

Silty Clay (CL to CH)

A thick deposit of silty clay was encountered in most boreholes and piezocones underlying the upper sand and silt unit. The thickness of the deposit ranged from zero along the north edge of the swamp, to a maximum thickness of 12.0m at Station 10+620 on the proposed Highway 69 and 13.8m at Station 9+950 on the proposed Highway 537. The elevation of the top of this deposit ranges from approximate EL. 218 to EL. 221. The lowest elevation of the bottom of this deposit was at approximate EL. 206.3.

The upper portion of this silty clay layer, where situated above groundwater table, is generally desiccated previously and herein referred as crust. The SPT blow counts ranged from 16 to 4 between approximate EL. 221 and EL. 214.5, reflecting consistency of very stiff to firm. This layer was generally brown in colour and grading to grey with increasing depth. The water content varied from 27% to 42%.

Gradation test results summarized in Figures B22, B23 and B24 in Appendix B and in Record of Boreholes in Appendix A, showed that the silty clay has variable amounts of silt and clay, and typically less than 2% of sand. Most samples tested for gradation consisted of 15% to 78% silt and 22% to 85% clay. The deposit is described as low to high plastic silty clay and was found to be locally varved.

A series of Atterberg Limit tests, summarized in Figures B25 through B27 in Appendix B, indicated that the silty clay deposit has variable plasticity and is generally classified as follows:

- Medium to high plastic silty clay (CI-CH) in the upper portion of the deposit including the crust: 32% to 85% clay content
- Low plastic silty clay (CL) towards the bottom portion of the deposit: 22% to 27% clay content

The medium to high plastic silty clay (CI-CH) had moisture content values ranging from 30% to 70%. The water content values for the upper and lower portions of the low plastic silty clay (CL), ranged from 26% to 40%. Liquid limit values ranged from 27% to 29% in the silty clay (CL) and 33% to 71% in the medium to high plastic silty clay (CI-CH). Plastic limit values were uniform ranging from 20% to 27% in both deposits.

Oedometer tests were carried out on three samples. Three undisturbed samples were retrieved from the medium to high plastic silty clay deposit (CI-CH) at depths of 5 to 14m. The test results are presented in Figures B28, B29 and B 30 in Appendix B and summarized in attached Table 5.4. The compression index ratio ($C_{c\varepsilon}=C_c/(1+e_o)$) ranged from 0.22 to 0.33 in the medium to high plastic silty clay deposit (CI-CH) deposit. The recompression index ratio ($C_{s\varepsilon} = C_s/(1+e_o)$) was measured to be from 0.025 to 0.04. Time dependent tests were carried out for approximately 48 hours at constant stress values for measurement of coefficient of secondary consolidation (C_α). The coefficient of secondary consolidation ratio ($C_\alpha/(1+e_o)$) values obtained from the oedometer tests ranged from 0.0018 to 0.0028 in the medium to high plastic silty clay deposit (CI-CH) deposit. The vertical coefficient of consolidation (C_v) obtained from the oedometer tests at the anticipated working vertical effective stresses after the embankment construction ranged from 9.5 to 22m^2/yr in the medium to high plastic silty clay deposit (CI-CH) deposit. The horizontal coefficients of consolidation (C_h) obtained from piezocones was measured 15m^2/yr in the medium to high plastic silty clay deposit (CI-CH) deposit and ranged from 15 to 25 m^2/yr low plastic silty clay deposit(CL).

Multi-stage Consolidated Undrained (CU) triaxial tests were carried out on two samples of the medium to high plastic silty clay (CI-CH) deposit. One sample was retrieved from a depth of 7.3m at the proposed Highway 537 bridge west abutment and the other sample was retrieved from 6.4m below ground surface at the proposed east abutment. Details of the triaxial tests are provided in Figures B31 and B32 in Appendix B and a summary of the results are provided in Table 5.5.

Attached Figures 5.12 through 5.21 present a summary of the SPT and undrained shear strength values obtained in the silty clay encountered in the boreholes and piezocones. Undrained shear strength (Su) inferred from in situ vane and the piezocone tests carried out in the crust was generally greater than 80kPa. This deposit can be generally described as stiff to very stiff. Below the crust the Su values in the silty clay deposit ranged from 30 to 70kPa. This deposit is generally described as firm to stiff.

The over-consolidation ratios inferred from piezocone and vane tests show that the silty clay is generally over-consolidated to approximate EL. 215.5 to EL. 219 with OCR of 1.5 to 8 and slightly over-consolidated to normally-consolidated below EL. 215.5 with OCR of 1 to 1.2. The oedometer tests also show that the soil samples were slightly over-consolidated to normally-consolidated below EL 215.5 with OCR ranging from 1.0 to 1.2.

The sensitivity ratio of the deposit measured using in situ vane tests ranged from 1 to 7, typically 2 to 5, indicating the silty clay deposit has low to medium sensitivity. The piezocone tests also detected the presence of sensitive soils in the bottom half of the silty clay deposit.

Lower Silt

A deposit of silt was encountered underlying the silty clay in most boreholes. The silt was non-plastic to low plastic and it is described as ML. The thickness of the lower silt varies from 3 to 13m. Gradation tests in this material, shown on Figure B21 in Appendix B, indicate clay content values ranging from 8% to 17%, silt ranging from 66% to 92% and sand from 0% to 17%. The natural water content ranged from 18% to 30%. The SPT "N" values ranged from 0 to 31, typically 9 to 28 indicating loose to compact conditions. The low values of "N" are attributed to disturbance at the bottom of the borehole caused by drilling.

The elevation of the top of this Lower Silt deposit gently drops from approximate EL. 217 to EL. 202, dipping south to north on Highway 69. At Highway 537, it generally ranges from EL. 208 to EL. 219. For both Highway 69 and Highway 537, the lowest elevation of the bottom of this deposit was at approximate EL. 195.

Sand

A cohesionless brown to grey sand layer varying from silty sand to gravely sand with cobbles and boulders was encountered underlying the lower silt unit. This deposit overlies bedrock with thickness varying from 3 to 14.3m at the test hole locations. The SPT "N" values were 3 to 75, typically 12 to 43 indicating compact to dense condition. The natural water content ranged from 15% to 25%.

The elevation of the top of the Sand deposit gently drops from approximate EL. 215 to EL. 195, dipping south to north on Highway 69. At Highway 537, it generally ranges from EL. 195 to EL. 208. For both Highway 69 and Highway 537, the lowest elevation of the bottom of this deposit was at approximate EL. 190.5.

Bedrock

Bedrock of the Canadian Shield was inferred from refusal to auger penetration underlying the soils. The rock is characterized by abrupt changes in elevation within very short distances. The bedrock surface is shallow along north boundaries of the Swamp, with bedrock rising to EL. 230. The deepest point of the bedrock surface encountered in the test holes in the swamp was approximate EL. 189 in ST 6-1 in Peto's preliminary report (2003).

Water Levels

The piezometric level in the lower silt and sand unit in the three standpipe piezometers installed by Thurber in boreholes 613-N1, 537-1 and 537-2, was at approximately EL. 215 to EL. 215.4. These piezometric levels are generally consistent with the piezometric levels inferred from piezocone tests, summarized in Appendix D.

The groundwater levels discussed above are relatively short term and may not be stabilized. Seasonal fluctuations in the groundwater table are also anticipated.

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FOUNDATION INVESTIGATION

AND DESIGN REPORT

HIGHWAY 69, FOUR-LANING

FROM 4KM SOUTH OF ESTAIRE TO 1KM NORTH OF HIGHWAY 537, 12KM

EMBANKMENTS THROUGH SWAMPS 602, 605 AND 613

ONTARIO

G.W.P. 312-99-00 (Swamps 602 and 605)

G.W.P.5249-05-00 (Swamp 613)

Geocres Number: 41I-198

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 INTRODUCTION

This part of the report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations to assist TSH to design the embankments through Swamps 602, 605 and 613.

The design of the proposed Highway 69 through the three swamps includes:

- Two parallel embankments for Highway 69, each carrying two lanes of traffic through Swamps 602, 605 and 613
- Approach embankments to a grade separation structure for the proposed Highway 537 over Highway 69 in the area of Swamp 613. The embankments will carry two lanes of traffic
- Two culverts in Swamp 602:
  - Culvert No.3 at Station 12+679 (SBL and NBL)
  - Culvert No.4 at Station 12+882 (SBL and NBL)
- One culvert in Swamp 605:
  - Culvert No.7 at Station 14+427

The stability and time-dependent settlements and the impact on the construction schedule and the long-term performance of the proposed embankments are also analysed in this section of the report.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of this investigation, together with the factual data from a previous investigation by Peto MacCallum Ltd. (Peto).

7 DESIGN METHODOLOGY

7.1 General

The embankments discussed in this report are up to 8.9m high to the top of pavement and will be underlain by foundations soils that include compressible deposits of silty clay. The geotechnical issues associated with the embankments are:

- Embankment stability during construction
- Large time-dependent settlements due to primary and secondary consolidation

Engineering analyses were carried out for different embankment configurations in order to address the geotechnical issues outlined above as follows:

- Selection of cross-sections that represent typical subsurface conditions and embankment geometries;
- Stability analysis to identify the need for stabilizing berms, geosynthetic reinforcement and construction staging;
- Settlement analysis to identify the need for and the spacing of wick drains to accelerate settlement and to accommodate the construction schedule;
- Analysis of post-construction settlements to assess minimum surcharge requirements

These aspects of the design are addressed in the following sections.

7.2 Typical Cross-Sections

The preparation of subsurface models involved a comprehensive compilation and analysis of all borehole logs, field and laboratory tests available at the three swamp crossings.

Typical cross-sections along the proposed alignments have been selected for analysis based on their relatively uniform subsurface conditions and embankment geometry. Relevant properties were selected for each of the soil layers in the sections selected for stability and settlement analysis.

7.3 Stability Analysis

Stability analyses were carried out using Bishop Modified method in the commercially available software G-Slope, developed by Mitre Software, based on the following assumptions:

- Factor of Safety (FS) Requirements:
    - Short Term: $FS_{min} = 1.3$
    - Long Term:

  - FS_{min} = 1.5 for critical slip surfaces passing mainly through cohesive soils
  - FS_{min} = 1.3 for critical slip surfaces passing mainly through cohesionless soils

- Embankment material and fill slopes:
  - Rock fill: 1.25H:1V
  - Granular fill around culverts: 2H:1V
  - Granular fill surcharge: 1.5H:1V
  - Slope flattening fill: 4H:1V
  - EPS replacement backfill, where required

  Generally the body of the embankment in each swamp will be constructed using rock fill to the underside of the pavement structure; above that elevation, to the top of the surcharge, the embankment will be constructed using granular fill. At Swamp 605 slope flattening fill will be placed at 4H:1V against the rock fill slopes.

  At the proposed culvert locations, it has been assumed that the embankment will be constructed using granular fill from ground surface to the top of surcharge.

  The embankment design configurations considered herein are summarized in Table 7.1.

- Surcharge:
  - Surcharges of 2m, 3.5m and 5.0m (5.0m for Swamp 602 – North Swamp only) above the top of pavement were used in the analysis.

- Staging:
  - It was assumed that the embankment construction will be carried out in one or more stages to the top of surcharge as required to maintain a minimum factor of safety of 1.3 during construction, as discussed above.

- Site Preparation:
  - All vegetation, root mats and organic soils will be removed within the footprint of the embankment, slope flattening and side berms

- Soil Shear Strength:
  - The undrained shear strength (S_u) for cohesive soils where the vertical effective stresses (σ'_v) are lower than the pre-consolidation pressure (p'), are assumed to be equal to the S_u values obtained from insitu vane tests and CPTUs. For vertical effective stresses (σ'_v) larger than the pre-consolidation pressure (p'), Su was assumed to be equal to $0.21*\sigma'_v$;

- Drained shear strength (ϕ') for cohesive soils are interpreted from triaxial tests;
- Drained shear strength (ϕ') for cohesionless soils are interpreted from SPT and piezocone tests.

- Pore pressure generation and dissipation:
  - Generation of excess pore pressures (EPP) upon undrained loading of the compressible and cohesive deposits is calculated assuming a Bbar (ratio of EPP over vertical total stress) of 0.9;
  - Dissipation of EPP between loading stages was assumed to be equal to 90%.
- Groundwater Table:
  - The highest groundwater table elevation observed in the standpipe piezometers.

7.4 Settlement Analysis

7.4.1 General

Settlement analyses were carried out for the embankment configurations shown in Table 7.1, as follows:

- Analysis of settlements due to primary consolidation without and with wick drains for Configurations A and C resulting in Configurations B and D after removal of the surcharge, respectively.
- Analysis of settlements due to secondary consolidation for the embankment final configurations after the removal of surcharge (Configurations B and D) and fill replacement with EPS fill (Configuration E, where required).

7.4.2 Primary Consolidation Analysis: No wick drains

Analyses of settlements due to primary consolidation were carried out in order to:

- Assess the total (time-independent) settlement due to primary consolidation
- Analyse the dissipation of pore pressures with time and establish the need for wick drains;
- Provide input for the vertical consolidation component in the wick drain analysis

The analyses were carried out using the finite difference software Consol Version 3.0, developed at Virginia Polytechnic Institute and State University.

7.4.3 Primary Consolidation Analysis: With Wick Drains

The method by Hansbo[1] (1960) was used for the wick drain design. The method takes into account well resistance and disturbance factors due to the wick drain installation. Dissipation of excess pore pressures (EPP) due to vertical drainage was coupled with EPP dissipation due to horizontal drainage into the wick drains according to the following equation:

$$U = 1-(1-U_V)*(1-U_h)$$

Where U is the combined total percentage consolidation and U_v and U_h are the percentage consolidation values due to vertical and horizontal drainage, respectively, divided by 100. Since Hansbo's method does not allow inclusion of horizontal coefficient of consolidation values (C_h) as a function of the pre-consolidation pressure (p') for the horizontal drainage portion of the analysis, the lowest value of C_h has been assumed for a specific test hole location. It has been assumed that the wick drains will be installed in a triangular pattern and spaced to allow 90% of the excess pore pressures to dissipate between construction stages, and 98% of the excess pore pressures to dissipate prior to removal of the surcharge for a total embankment construction time not exceeding 52 weeks. It has been assumed that the wick drains will be terminated within the silt layer that underlies the silty clay deposits.

7.4.4 Secondary Consolidation Analysis

Settlements due to secondary consolidation of the silty clay were calculated using the method by Mesri and Feng[2] (1991).

8 SWAMP 602 - EMBANKMENT DESIGN

8.1 Typical Cross-Sections

Table 8.1 presents the typical cross-sections and soil properties selected for the analysis of the North and South Swamps in the Swamp 602 area.

In the South Swamp four cross-sections were selected for analysis: Two cross-sections at Station 12+660 (SBL) and Station 12+700 (NBL) and two cross-sections along the Culvert #3 alignment, at Station 12+680. The cross-sections were selected based on the thickness of soft to firm soils and embankment height.

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1 Hansbo, S. (1960). Consolidation of clay, with special reference to influence of vertical sand drains. Swedish Geotechnical Institute, Proceedings No.18 (1960)

2 Mesri G and Feng.T.W., 1991. "Surcharge to Reduce Secondary Consolidation" Geo-Coast '91, 3-6 Sept., 1991, Yokohama, pp.359-364

8.2 Stability Analysis

The stability analysis indicated that the embankments in both the South and North Swamp can be constructed in one single stage to the top of a 3.5m surcharge meeting the short and long term stability requirements outlined earlier. The presence of a relatively thick silty clay crust at these sites played a major role in the favourable stability analysis results. The results of selected stability analyses are summarized in Table C1 and shown in Figures C1 through C5, in Appendix C.

Recommendations for the embankment construction using the information provided above are provided in Section 8.6.

8.3 Settlements due to Primary Consolidation

8.3.1 Without Wick Drains

The results of the one-dimensional primary consolidation settlement analysis are presented in Table 8.2 and Figures E1 through E7, Appendix E. The results of the analysis indicate the following:

- In the South Swamp the maximum settlements due to primary consolidation at Stations 12+660 and 12+700, are 35mm and 234mm, respectively, with 2.0m surcharge. These settlement values are reduced to 25mm and 213mm after removal of the surcharge. For 3.5m surcharge the settlements at Stations 12+660 and 12+700 are 43mm and 296mm, respectively, with surcharge and 29mm and 269mm, after removal of surcharge.
- Along Culvert #3 in the South Swamp, for the case where the surcharge is equal to 2.0m, the maximum settlements due to primary consolidation are 146mm at the centreline of the SBL embankment and 44mm at the centreline of the NBL embankment. After removal of the 2.0m surcharge the settlements are reduced to 136mm and 38mm, respectively. For the case with 3.5m surcharge the settlement values are 192mm and 60mm. After removal of the 3.5m surcharge the settlements are reduced to 179mm and 53mm, respectively. The settlements due to primary consolidation at the toe of the embankments, at the ends of Culvert #3 are negligible.
- Along Culvert #4 in the North Swamp, with 2.0m surcharge, the maximum settlements due to primary consolidation are 152mm at the centreline of the SBL embankment and 141mm at the centreline of the NBL embankment. After removal of the 2.0m surcharge the settlements are reduced to 130mm and 123mm, respectively. For the case with 3.5m surcharge the settlement values are 195mm and 199mm. After removal of the 3.5m surcharge, the settlements are reduced to 168mm and 177mm, respectively. For the case with 5.0m surcharge the settlement values are 241mm and 257mm,for the SBL and NBL embankments, respectively. After removal of the 5.0m surcharge, the settlements are reduced to 214mm and

234mm, respectively. The settlements due to primary consolidation at the toe of the embankments, at the ends of Culvert #3 are small and up to 15mm.

- Figures E6 and E7 in Appendix E show the ultimate settlements due to primary consolidation along Culvert #3 and Culvert #4 alignments. Due to the variability of the compressible deposits, relatively large differential settlements and large angular distortions due to primary consolidation are anticipated along the culvert alignments.
- Before the removal of the surcharge, the time required for 98% completion of primary consolidation in the South Swamp, without wick drains, is up to 4 months. Along Culvert #3 this time is 2.5 months. Therefore wick drains will not be required in the South Swamp provided that the time available between the end of the construction of the embankment to the top of surcharge and removal of the surcharge is at least 4 months.
- Assuming that, in order to reduce post-construction settlements Along Culvert #4 in the North Swamp, the surcharge will only be removed when the effective stresses in the foundation soils are equivalent to 98% consolidation of the embankment with 2m surcharge, the required waiting times between the end of construction and removal of surcharge without wick drains are:
  - 2.0m surcharge: 36 months
  - 3.5m surcharge: 6 months
  - 5.0m surcharge: 4 months

  At the North Swamp it is unlikely that the construction schedule will allow for a waiting period of 36 months before removal of the surcharge. Therefore wick drains, 3.5m or 5.0m surcharge will be required in the North Swamp to accelerate the dissipation of excess pore pressures in the silty clay deposit. A discussion on the recommended alternative is presented in Section 8.6 below.

8.3.2 With Wick Drains

Table 8.2 shows the wick drain spacing required for 98% excess pore pressure dissipation before removal of the surcharge for a waiting period not exceeding 6 months. The table shows that the required wick drain spacing ranges from 2.1m to 2.7m. More details about the wick drain design are provided in Section 8.6.

8.4 Settlements due to Secondary Consolidation

The results of the analysis of settlements due to secondary consolidation at Swamp 602, up to 20 years after the end of construction, are shown in Table 8.3 and Figures E6b and E7b. The results show that the anticipated post construction settlements are less than 10mm at the South Swamp and less than 25mm at the North Swamp.

8.5 Embankment Compression

The estimated settlement of earth 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 settlement of rock fill due to re-orientation and degradation of the inter-particle contacts is expected to continue at a decreasing rate for many years. The magnitude of this settlement is expected to be in the order of 0.1% of the embankment height after one year and 0.3% of the embankment height after twenty years.

8.6 Analysis of Design Alternatives and Recommendations

8.6.1 General Embankments

The settlement analysis presented above indicates that relatively large settlements are anticipated during construction. Therefore the platform width should be selected to accommodate the anticipated settlements and to allow for future pavement rehabilitation of 200mm on Hwy 69.

The analysis of settlements due to secondary consolidation indicates that 1.0m to 2.0m surcharge will be sufficient to reduce post-construction settlements in Swamp 602.

The waiting time for the case with 2.0m surcharge without wick drains is too long and is considered impractical. The waiting times for 3.5m and 5.0 m surcharges without wick drains are feasible depending on the available construction schedule. As shown in Table 8.4 the embankment construction costs associated with 3.5m and 5.0m surcharges are $608k and $661k respectively. The risks associated with both alternatives are comparable therefore the 3.5m surcharge should be selected if wick drains are not used.

A comparison of the alternatives that include wick drains (Table 8.4) shows that the embankments can be constructed with a 2m surcharge and wicks spaced at 1.5m or 2m with associated cost of $891k and $730k, respectively. In view of the uncertainties associated with the estimated time for completion of primary consolidation, a wick drain spacing of 1.5m is recommended for design. Although more costly than the alternative without wick drains and with 3.5m surcharge ($608k), the alternative with wick drains is considered less risky and is recommended for the embankment design.

In summary our recommendation is that:

- The embankment in the North Swamp be designed with wick drains spaced at 1.5m and a surcharge 2.0m above the top of pavement
- The embankment in the South Swamp be designed without wick drains and with surcharge 2.0m above the top of pavement

The following presents a summary of the construction stages and recommendations for the general embankment construction (excluding Culverts #3 and #4) in Swamp 602,:

- Removal of vegetation, peat and topsoil within and 5m beyond the footprint embankment. The peat is expected to be typically 0.4m thick but locally up to 1.2m thick; the groundwater level is expected to be close to the ground surface. Therefore removal of organic soils will be carried out at or below the groundwater table.

- Backfilling of the sub-excavation will also be carried out under wet conditions and below the groundwater table. The top of the backfill should be 0.5m above the groundwater table. The North Swamp, between Sta.12+820 and Sta.12+940, where wick drains will be installed, the backfill material should consist of 19mm clear stone, Granular A or Granular B-II and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:

    - 100% shall pass the 37.5 mm sieve;
    - No more than 5% shall pass the 0.075 mm sieve.

  In areas where wick drains are not required, the backfill should consist of OPSS Granular A or Granular B-II without the grain size limitations above.

- Installation of wick drains in the North Swamp, in a triangular pattern with the spacing and locations shown on Figure 8.1 and tip elevations shown in Table 8.5. Pre-augering or vibratory equipment will most likely be required to install the wick drains through a harder soil layer between EL.225 and EL.230.

- Installation of geotechnical monitoring instruments in accordance with Special Provision "Supply and Installation of Monitoring Instruments" (not included in this report).

- Construction of the embankment to the top of surcharge in one single stage.

- The design elevation of the top of the rock fill is 0.5m below the top of pavement elevation. The embankment above the rock fill should consist of granular materials meeting the requirements of OPSS 1010 Granular A or Granular B-II. Waiting periods of approximately 12 to 14 weeks at the South Swamp and 3 to 5 weeks in the North Swamp will be required for dissipation of excess pore pressures before the removal of surcharge.

- Remove the surcharge and construct the pavement structure

8.6.2 Culvert #3 (South Swamp)

Culvert #3 will consist of a 1.2m x 1.2m square non-rigid frame or pre-cast box structure. It is understood that there is a requirement of maintaining creek flow through the embankment during construction.

Relatively large differential settlements due to primary consolidation (up to 200mm) are anticipated along the culvert alignment. Therefore there are two alternatives for the construction of Culvert #3:

- Install the permanent pre-cast concrete culvert articulated and cambered to withstand the differential settlements due to primary and secondary consolidation shown on Figures E6 and E6b or
- Install the permanent Culvert #3 only after the embankment has been constructed to the top of surcharge and most of the settlements due to primary consolidation have occurred. In this case, a temporary CSP culvert will be installed to maintain flow through the embankment prior to installation of the permanent culvert. The embankment surrounding the CSP culvert and the proposed permanent box culvert should consist of granular fill OPSS Granular A or Granular B-II to allow for the embankment removal for the final installation of the concrete box structure and removal of the CSP culvert. The permanent box structure culvert should be designed (camber and articulations) to withstand the differential settlements due to secondary consolidation shown on Figure E6b. Figure E6b shows that post-construction settlements up to 10mm are anticipated along the permanent concrete box culvert alignment.

The following presents a summary of the construction stages and recommendations for the construction of the Culvert #3 using the second of the two alternatives above:

- Removal of vegetation, peat and topsoil within and 5m beyond the footprint of the embankment. The peat is expected to be up to 1.2m deep and the groundwater level close to ground surface. Therefore removal of organic soils will be carried out below the groundwater table
- Backfilling of the sub-excavation will also be carried out below the groundwater table. The top of the backfill should be 300mm below the elevation of the underside of the CSP and the permanent concrete box culverts and it should consist of OPSS Granular A or Granular B-II. Use of rock fill as backfill material is not acceptable to allow for the installation of monitoring instruments.
- Installation of geotechnical monitoring equipment in accordance with Special Provision "Supply and Installation of Monitoring Equipment" (not included in this report)
- Installation of the temporary CSP culvert and creek diversion.
- Construction of the embankment using granular fill (OPSS 1010 Granular A or Granular B-II) to the top of surcharge.

- A waiting period of approximately 5 weeks will be required for dissipation of excess pore pressures before the removal of surcharge (for 1.5m wick drain spacing).
- Removal of the granular fill to 0.3m below the permanent concrete box culvert invert, maintaining the creek diversion through the CSP culvert.
- Construction of the permanent concrete box culvert. A minimum of 300mm thick of OPSS Granular 'A' should be placed as bedding material for the concrete box culvert. The bedding material should be placed in the dry and compacted to 100% of the Standard Proctor Maximum Density (SPMD) in conformance to OPSS 501 (Method A).
- Removal of the CSP culvert and backfilling of the embankment using OPSS 1010 Granular A or Granular B-II to the underside of the pavement structure.
- Construction of the pavement structure

8.6.3 Culvert #4 (North Swamp)

Culvert #4 will consist of a 1.2m x 1.2m square non-rigid frame or pre-cast box structure. It is understood that there is a requirement of maintaining creek flow through the embankment during construction.

Relatively large differential settlements due to primary consolidation (up to 200mm) are anticipated along the culvert alignment. Therefore there are two alternatives for the construction of Culvert #4:

- Install the permanent pre-cast concrete culvert articulated and cambered to withstand the differential settlements due to primary and secondary consolidation shown on Figures E7 and E7b or
- Install the permanent Culvert #4 only after the embankment has been constructed to the top of surcharge and most of the settlements due to primary consolidation have occurred. In this case, a temporary CSP culvert should be installed to allow flow through the embankment prior to installation of the permanent culvert. The embankment surrounding the CSP culvert and the proposed box culvert alignment should consist of granular fill (OPSS Granular A or Granular B-II) to allow for the embankment removal for the final installation of the permanent concrete box structure and removal of the CSP culvert. The permanent box structure culvert should be designed (camber and articulations) to withstand the differential settlements due to secondary consolidation shown on Figure E7b. Figure E7b shows that post-construction settlements up to 20mm (2m surcharge) and 25mm (3.5m surcharge) are anticipated along the concrete box culvert alignment.

The following presents a summary of the construction stages and recommendations for the construction of the Culvert #4 using the second of the two alternatives above:

- Removal of vegetation, peat and topsoil within and 5m beyond the footprint of the embankment. The peat is expected to be up to 1.2m deep and the groundwater level close to ground surface. Therefore removal of organic soils will be carried out below the groundwater table

- Backfilling of the sub-excavation will also be carried out under wet conditions and below the groundwater table. The top of the backfill should be 300mm below the elevation of the underside of the CSP and the permanent concrete box culverts. Wick drains will be installed along Culvert #4 alignment and the backfill material should consist of 19mm clear stone, Granular A or Granular B-II and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:
    - 100% shall pass the 37.5 mm sieve;
    - No more than 5% shall pass the 0.075 mm sieve.

- Installation of wick drains in a triangular pattern with the spacing and locations shown on Figure 8.1 and tip elevations shown in Table 8.5. Pre-augering will most likely be required to install the wick drains through a harder soil layer between EL.225 and EL.230.

- Installation of geotechnical monitoring equipment in accordance with Special Provision "Supply and Installation of Monitoring Equipment" (not included in this report)

- Installation of the temporary CSP culvert and creek diversion.

- Construction of the embankment to the top of surcharge using granular fill OPSS 1010 Granular A or Granular B-II.

- For 1.5m wick drain spacing, a waiting period of approximately 5 weeks will be required for dissipation of excess pore pressures before the removal of surcharge.

- Removal of the granular fill to 0.3m below the permanent concrete box culvert invert, maintaining the creek diversion through the CSP culvert.

- Construction of the permanent concrete box culvert and redirection of creek flow through this culvert. A minimum of 300mm thick of OPSS Granular A should be placed as bedding material for the concrete box culvert. The Granular A bedding should be placed in the dry and compacted to 100% of the Standard Proctor Maximum Density (SPMD) in conformance to OPSS 501 (Method A).

- Removal of the CSP culvert and backfilling of the embankment using OPSS 1010 Granular A or Granular B-II to the underside of the pavement structure.

- Construction of the pavement structure

9 SWAMP 605 - EMBANKMENT DESIGN

9.1 Typical Cross-Sections

Table 9.1 presents typical cross-sections and soil properties selected for the stability and settlement analysis of embankments at Swamp 605.

Three cross-sections were selected based on the thickness of soft to firm soils and embankment height at Stations 14+290, 14+330 and 14+390 and one skewed section was selected along Culvert #7, from Station 14+360 to 14+494.

9.2 Stability Analysis

The results of the stability analysis for Swamp 605 are summarized in Table C.2 and in Figures C6 through C19. The stability analysis results indicate that:

2m Surcharge

NBL Embankment:

- Slope flattening is required along the east slope at typical sections along the NBL embankment.
- North of Station 14+290 the embankment should be constructed in three construction stages.
- There is a requirement that the slope flattening of the median and a minimum of 3.5m to 4.0m of the SBL embankment be in place before the construction of the NBL embankment above 4.0m height. A 3.5m high and 2.0m wide berm beyond the slope flattening fill is required at the east slope at Station 14+330.
- The following presents the maximum embankment height at the end of each construction stage:
    - Station 14+290 — One single stage to top of surcharge
    - Station 14+330: — Stage 1: 0 to 6.3m
      Stage 2: 6.3m to 8.3m
      Stage 3: 8.3m to 9.3m (top of surcharge)
    - Station 14+390: — Stage 1: 0 to 6.9m
      Stage 2: 6.9m to 7.9m
      Stage 3: 7.9m to 9.9m (top of surcharge)

SBL Embankment:

- Slope flattening along the west slope and a minimum of three construction stages are required at all typical sections along the SBL embankment.

- There is a requirement that the slope flattening of the median north of Station 14+290 and a minimum of 3.5m to 4.0m of the NBL embankment be in place before the construction of the SBL embankment above 4.0m height.
- Berms 2.0m wide beyond the slope flattening and up to 4.0m high are required at Stations north of Station 14+290
- The following presents the maximum embankment height at the end of each construction stage:
    - Station 14+290: Stage 1: 0 to 5.0m
      Stage 2: 5.0m to 7.0m
      Stage 3: 7.0m to 9.0m (top of surcharge)
    - Station 14+330: Stage 1: 0 to 6.3m
      Stage 2: 6.3m to 8.3m
      Stage 3: 8.3m to 9.3m (top of surcharge)
    - Station 14+390: (Culvert #7 West End) Stage 1: 0 to 8.0m
      Stage 2: 8.0m to 9.0m
      Stage 3: 9.0m to 10.0m (top of surcharge)

<u>3.5m Surcharge</u>

NBL Embankment:

- Slope flattening along the east slope and a minimum of three construction stages are required at typical sections south of Culvert #7.
- There is a requirement in this area that the slope flattening of the median and a minimum of 3.5m to 4.0m of the SBL embankment be in place before the construction of the NBL embankment advances to above 4.0m height.
- Berms 3.0m to 6.0m wide beyond the slope flattening and up to 4.0m high are required at Stations north of Station 14+290 and south of Culvert #7
- The following presents the maximum embankment height at the end of each construction stage:
    - Station 14+290: One single stage to top of surcharge
    - Station 14+330: Stage 1: 0 to 7.3m
      Stage 2: 7.3m to 9.3m
      Stage 3: 9.3m to 10.8m (top of surcharge)
    - Station 14+390: Stage 1: 0 to 7.9m
      Stage 2: 7.9m to 10.4m

Stage 3: 10.4m to 11.4m (top of surcharge)

SBL Embankment:

- Slope flattening along the west slope and a minimum of three construction stages are required at all typical sections along the SBL embankment. In addition there is a requirement that the slope flattening of the median north of Station 14+290 and a minimum of 3.5m to 4.0m of the NBL embankment be in place before the construction of the SBL embankment advances to above 4.0m height. .
- Berms 5.0m to 7.0m wide beyond the slope flattening and up to 4.0m high are required along the SBL embankment west slope
- The following presents the maximum embankment height at the end of each construction stage:
  - Station 14+290: Stage 1: 0 to 6.0m
    Stage 2: 6.0m to 9.0m
    Stage 3: 9.0m to 10.5m (top of surcharge)
  - Station 14+330: Stage 1: 0 to 7.3m
    Stage 2: 7.3m to 9.3m
    Stage 3: 9.3m to 10.8m (top of surcharge)
  - Station 14+390: (Culvert #7 West End) Stage 1: 0 to 9.0m
    Stage 2: 9.0m to 10.5m
    Stage 3: 10.5m to 11.5m (top of surcharge)

In view of the need to maintain the area open to the traffic of trucks during construction, the following embankment staging is proposed:

- 2m Surcharge case with slope flattening and 4m high x 4m wide berms:

  Stage 1: 0 to 6.5m

  Stage 2: 6.5m to 8.5m

  Stage 3: 8.5m to Top of Surcharge
- 3.5m Surcharge case with slope flattening and 4m high x 8m wide berms:

  Stage 1: 0 to 7.5m

  Stage 2: 7.5m to 9.5m

  Stage 3: 9.5m to Top of Surcharge

Recommendations for the embankment construction are provided in Section 9.6.

9.3 Settlements due to Primary Consolidation

9.3.1 Without Wick Drains

The results of the one-dimensional primary consolidation settlement analysis are presented in Table 9.2 and Figures E8 through E13, Appendix E. The results of the analysis indicate the following:

- The maximum settlements due to primary consolidation south of Culvert #7 are large and up to 1008mm for the case with 2.0m surcharge and 1083mm for the 3.5m surcharge case. After removal of the surcharge, the maximum settlements reduce to 993mm and 1061mm, respectively.
- Along Culvert #7, for the case where the surcharge is equal to 2.0m, the maximum settlements due to primary consolidation are 721mm at the centreline of the SBL embankment and 510mm at the east shoulder of the NBL embankment. After removal of the 2.0m surcharge the settlements are reduced to 714mm and 508mm, respectively. For the case with 3.5m surcharge the settlements due to primary consolidation are 749mm and 537mm. After removal of the 3.5m surcharge the settlements are reduced to 740mm and 533mm, respectively.
- A profile of settlements due to primary consolidation, before the removal of the surcharge, along Culvert #7 is presented in Figure E13. This figure shows that large differential settlements and angular distortions are anticipated along the culvert alignment due to the variability of the elevation of the bedrock surface and variability of the thickness of the compressible soils. Therefore the final installation of Culvert #7 should be either carried out only after the embankments with surcharge are constructed and time-dependent settlements are completed or the culvert should relocated to the north, where the compressible soils are shallower.
- The time required for 90% dissipation of excess pore pressures between intermediate construction stages without wick drains is up to 40 months south of Culvert #7 and up to 21 months along Culvert #7. Therefore wick drains will be required at Swamp 605 to accelerate the dissipation of excess pore pressures in the silty clay deposit.

9.3.2 With Wick Drains

Table 9.2 shows the wick drain spacing required for 98% excess pore pressure dissipation between construction stages before removal of the surcharge for waiting periods not exceeding 6 months. The table shows that the required wick drain spacing ranges from 1.8m to 2.1m. More details about the wick drain design are provided in Table 9.5 and Section 9.6.

9.4 Settlements due to Secondary Consolidation

The results of the analysis of settlements due to secondary consolidation at Swamp 605, up to 20 years after the end of construction, are shown in Table 9.3 and Figure E13b. The results show that the anticipated post construction settlements for the case in which the embankments are constructed with a 2.0m surcharge, are up to 64mm south of Culvert #7 and up to 30mm along Culvert #7. For the case with 3.5m surcharge the post construction settlements are up to 52mm south of Culvert #7 and up to 30mm along Culvert #7.

9.5 Embankment Compression

The estimated settlement of earth 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 settlement of rock fill due to re-orientation and degradation of the inter-particle contacts is expected to continue at a decreasing rate for many years. The magnitude of this settlement is expected to be in the order of 0.1% of the embankment height after one year and 0.3% of the embankment height after twenty years.

9.6 Analysis of Design Alternatives and Recommendations

9.6.1 Embankments South of Culvert #7

The settlement analysis presented above indicates that large settlements are anticipated during construction. Therefore the embankment platform width should be selected in order to accommodate the anticipated settlements and to allow for future pavement rehabilitation of 200mm on Hwy 69.

A comparison of design alternatives is presented in attached Table 9.4. As expected, the alternatives including 3.5m surcharge are more costly than the 2.0m surcharge. The difference between the two is that the 3.5m surcharge results in post-construction settlements of 50mm, slightly smaller than the 65mm settlements anticipated for the 2.0m surcharge. In view of the uncertainties associated with the prediction of long-term settlements of embankments founded on soft deposits and the small difference in settlement prediction, it recommended that the embankment be designed with 2.0m surcharge.

With regards to the wick drain design, we recommend the use of 1.5m spacing. The costs associated with this spacing is $261k higher than the alternative with 2.0m spacing but it offers less risk with regards to construction schedule.

A summary of the design recommendations are presented on Figure 9.1. The wick drain tip elevations are included in Table 9.5.

The following presents a summary of the construction stages and recommendations for the construction of the embankments south of Culvert #7, in Swamp 605:

- Removal of vegetation, peat and topsoil within and 5m beyond the footprint of the embankment and the slope flattening. The peat is expected to be up to 3.0m deep and the groundwater level close to ground surface. Therefore removal of organic soils will be carried out below the groundwater table.
- Backfilling of the sub-excavation will also be carried out below the groundwater table. The backfill will act as a drainage blanket for the wick drains and it should be placed 0.5m above the groundwater table. The backfill material should consist of 19mm clear stone, Granular A or Granular B-II and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:
  - 100% shall pass the 37.5 mm sieve;
  - No more than 5% shall pass the 0.075 mm sieve.
- Installation of wick drains in a triangular pattern with the spacing and locations shown on Figure 9.1 and tip elevations shown in Table 9.5.
- Installation of geotechnical monitoring equipment in accordance with Special Provision "Supply and Installation of Monitoring Equipment" (not included in this report).
- Construction of rock fill to maximum height of 4m, followed by construction of the slope flattening and stabilizing berms where required, as shown in Figure 9.1. Slope flattening and stabilizing berms should be constructed with earth fill materials sloped at 4H:1V and may consist of granular materials and Select Subgrade Material (SSM) in compliance with Special Provision 110F113, "Amendment to OPSS 1010, March 1993". For stability of the inside (median) slope of the embankments, it is critical that the construction of both the NBL and SBL be carried out simultaneously and that the maximum difference in elevation between both embankments does not exceed 4.0m. In addition, it is critical that during fill placement, the difference in elevation between to of fill lifts within the footprint of the embankments do not exceed 4.0m in height. It is critical that the excavation and replacement of the overburden soils for the installation of Culvert #7 be carried out prior to the embankment construction south of Culvert #7.
- Completion of Stages 1 through 3 of the embankment construction to the top of surcharge. The design elevation of the top of the rock fill is 0.5m below the top of pavement elevation. The remaining of the embankment should consist of granular materials meeting the requirements of OPSS 1010-Granular A or Granular B-II. Waiting periods of approximately 6 weeks will be required for dissipation of excess pore pressures between construction stages and approximately 11 weeks before the removal of surcharge.
- Remove the surcharge and construct the pavement structure.

9.6.2 Culvert #7 Embankments

It is understood that Culvert #7 will consist of a 1.2m x 1.2m rigid frame box structure. In view of the large settlement predictions presented above, it is understood that Culvert #7 will be relocated to the north, where the compressible soils are shallower. The compressible soils will be excavated and replaced with granular fill. Therefore installation of wick drains and surcharge is not required in this area.

10 SWAMP 613 - EMBANKMENT DESIGN

10.1 Typical Cross-Sections

Table 10.1 presents the six cross-sections and soil properties selected for the analysis of the embankments along Hwy 69 and Hwy 537, respectively, in Swamp 613.

Two cross-sections were selected along Hwy 69 and four cross-sections along Hwy 537 based on the thickness of firm to stiff soils and embankment height and behind the bridge abutments as follows:

- Hwy 69: Typical Cross-Sections at Stations 10+520 and 10+570
- Hwy 537: Typical Cross-Sections at Stations 9+900, 9+960 (East Bridge Abutment), 10+040 (West Bridge Abutment) and 10+130.

10.2 Stability Analysis

The results of the stability analysis for the embankments in Swamp 613 are summarized in Table C.3 and in Figures C20 through C23 for Hwy 69 embankments and Figures C24 to C28 for embankments along Hwy 537. The stability analysis results indicate that:

- With the exception of the case where 3.5m surcharge is used behind the East Abutment (Station 10+040) of the Overpass Structure along Hwy537, the embankments in this swamp can be constructed in one single stage to the top of the surcharge.
- For the case where 3.5m surcharge is used behind the East Abutment, the embankment should be constructed in two stages as follows:
  - Stage 1: 0m to 10.2m
  - Stage 2: 10.2m to 11.7m (top of surcharge)
- There is no need for slope flattening or berms for stability of the embankments during construction.

10.3 Settlements due to Primary Consolidation

10.3.1 Without Wick Drains

The results of the one-dimensional primary consolidation settlement analysis are presented in Table 10.2 and Figures E14 through E17, Appendix E. The results of the analysis indicate the following:

- The maximum settlements due to primary consolidation along the embankments of the proposed Hwy 69 are large and up to 579mm before the removal of the 2.0m surcharge and up to 703mm before the removal of the 3.5m surcharge.
- Settlements due to primary consolidation along Hwy 537 are large for the cross-sections east of Station 9+900. At the West Abutment (Station 9+960) and East Abutment (Station 10+040) locations the anticipated settlements due to primary consolidation are 457mm and 792mm, respectively, for the case with 2.0m surcharge, and 539mm and 878mm, respectively, for the case with 3.5m surcharge.
- Before the removal of the surcharge, the time required for 98% completion of primary consolidation ranges from 20 months to 110 months. Therefore wick drains will be required to accelerate the dissipation of excess pore pressures in the compressible deposits.

10.3.2 With Wick Drains

Table 10.2 shows the wick drain spacing required for 98% excess pore pressure dissipation before removal of the surcharge for waiting periods not exceeding 6 months. The table shows that the required wick drain spacing ranges from 1.5m to 2.7m. More details about the wick drain design, including the tip elevations, are provided in Tables 10.6 and 10.7 and in Section 10.6.

10.4 Settlements due to Secondary Consolidation and EPS Embankment

The results of the analysis of settlements due to secondary consolidation at Swamp 613, up to 20 years after the end of construction, are shown in Table 10.3.

<u>Hwy 69</u>

The results show that along Hwy 69 the anticipated post construction settlements for the case in which the embankments are constructed with a 2.0m surcharge, are up to 70mm and up to 46mm for the case with 3.5m surcharge. A discussion on the surcharge requirements for these embankments is presented in Section 10.6 below.

<u>Hwy 537</u>

Along Hwy537 the results of analysis of settlements due to secondary consolidation show that the anticipated post construction settlements are large behind the abutments. Therefore, in order to meet MTO requirements for maximum post-construction settlements of 25mm within 30m of the bridge and 50mm beyond 30m from the bridge, replacement of the fill material with EPS will be required after the dissipation of excess pore pressures in the foundation soils. An analysis of fill replaced was carried out and summarized in Table 10.3. Table 10.3 shows the following:

- West Abutment (Embankment Height to top of Pavement: 5.4m)
  - 2.0m Surcharge
    - Fill replacement with EPS for post construction settlement less than 25mm = 3.5m
    - Fill replacement with EPS for post construction settlement less than 50mm = 2.0m
  - 3.5m Surcharge
    - Fill replacement with EPS for post construction settlement less than 25mm = 3.5m
    - Fill replacement with EPS for post construction settlement less than 50mm = 1.5m
- East Abutment (Embankment Height to top of Pavement: 8.2m)
  - 2.0m Surcharge
    - Fill replacement with EPS for post construction settlement less than 25mm = 3.0m
    - Fill replacement with EPS for post construction settlement less than 50mm = 1.5m
  - 3.5m Surcharge
    - Fill replacement with EPS for post construction settlement less than 25mm == 2.5m
    - Fill replacement with EPS for post construction settlement less than 50mm = 1.0m

Details about the embankment construction and selection of depth of EPS replacement are provided in Section 10.6.

10.5 Embankment Compression

The estimated settlement of earth 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 settlement of rock fill due to re-orientation and degradation of the inter-particle contacts is expected to continue at a decreasing rate for many years. The magnitude of this settlement is expected to be in the order of 0.1% of the embankment height after one year and 0.3% of the embankment height after twenty years.

10.6 Analysis of Design Alternatives and Recommendations

10.6.1 Hwy 69

The settlement analysis presented above indicates that relatively large settlements are anticipated during construction. Therefore the embankment platform width should be designed to accommodate the anticipated settlements and to allow for future pavement rehabilitation of 200mm on Hwy 69.

Table 10.4 presents a cost and risk analysis for 3.5m and 2.0m surcharge. The difference in cost between both alternatives is in the order of $140k. In view of the uncertainties associated with the prediction of long term settlements of embankments founded on soft deposits and the small difference in the settlement values associated with both surcharges, the 2.0m surcharge is considered adequate for the embankment design.

Wick drains are required, including the section through the existing Hwy537 embankment. The analysis of Table 10.4 shows that there is a reduction of 9 weeks in total construction time and a cost increase up to $197k if the wick drain spacing is decreased from 2.0m to 1.5m. In view of the uncertainties associated with the estimated time for completion of primary consolidation, a wick drain spacing of 1.5m is recommended for design.

Figure 10.1 shows the proposed design for the embankments along Hwy69. It should be noted that slope flattening, stabilizing berms and construction staging are not required at this swamp although it is understood that there may be a requirement to place slope flattening fill next to the rock fill for disposal of excess material. Additional cost estimates associated with this option, which will require installation of wick drains under the slope flattening fill, is presented in Table 10.4.

The following presents a summary of the construction stages and recommendations for the embankment construction along Hwy 69 through Swamp 613:

- Removal of vegetation, peat and topsoil within and 5m beyond the footprint of the embankment and slope flattening fill, if relevant. The peat is expected to be typically 0.2m thick but locally up to 0.5m thick; the groundwater level is expected to be below the bottom of the organic soils.
- Backfilling of the sub-excavation is anticipated to be carried out in dry conditions provided surface water is diverted from the cleared areas. The backfill should be 0.5m thick. The backfill material should consist of Granular A or Granular B-II and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:
  - o 100% shall pass the 37.5 mm sieve;
  - o No more than 5% shall pass the 0.075 mm sieve.
- Installation of wick drains in a triangular pattern with the spacing and locations shown on Figure 10.1 and tip elevation shown in Table 10.6.

- Installation of monitoring equipment in accordance with Special Provision "Supply and Installation of Monitoring Equipment" (not included in this report).
- Construction of the embankment to the top of surcharge in one single stage.
- The design elevation of the top of the rock fill is 0.5m below the top of pavement elevation. The remaining of the embankment above the rock fill should consist of granular materials meeting the requirements of OPSS 1010 Granular A or Granular B-II
- Waiting period of approximately 11 weeks will be required for dissipation of excess pore pressures before the removal of surcharge.
- Remove the surcharge and construct the pavement structure

10.6.2 Hwy 537

West Approach Embankment:

- Embankment Immediately Behind the West Abutment

  Replacement of the fill with 3.5m of EPS will be required immediately behind the West Abutment to limit the post-construction settlements to 25mm. Typically the top of the EPS fill is 1.5m below the top of pavement. Therefore the depth of excavation behind the West abutment should be 5.0m below the top of pavement for placement of 3.5m of EPS. The embankment height behind the West Abutment, however, is 5.4m to 5.0m; this means that after completion of primary consolidation, the embankment should be completely removed behind the West Abutment for replacement with EPS. It can be concluded that the embankment could be constructed with EPS from the start, without the need for the standard embankment construction followed by fill replacement with EPS. Therefore the only economically feasible alternative that results in maximum post-construction settlements of 25mm within 30m behind the West Abutment includes a full section of EPS within 10m of the abutment and a 5H:1V taper to Sta.9+930.

- Embankment Beyond Sta.9+930

  Beyond Sta.9+930 there are different design alternatives that include 2.0m or 3.5m surcharge and different wick drain spacing. Table 10.5 shows that although there is no significant gain in construction schedule for selecting wick drain spacing less than 2.0m, the use of 1.5m wick drain spacing results in a relatively small cost increment (less than $20k) and is considered a better design alternative. With regards to the surcharge, there is a small increase in post-construction settlements 30m behind the West Abutment: 55mm for 3.5m surcharge versus 60mm for 2.0m surcharge. Therefore it is recommended that the West Approach embankment design be carried out using 1.5m wick drain in the rock fill area, and 2.0m surcharge.

East Approach Embankment

- Embankment Immediately Behind the East Abutment

  For the East Approach, there are two alternatives for the embankment immediately behind the abutment that result in maximum post-construction settlements of 25mm within 30m behind the abutment:

  The first alternative is similar to that described above for the West Approach: Full section of EPS within 10m of the abutment and a 5H:1V taper to Sta. 10+090

  The second alternative includes embankment construction using wick drains, granular fill, surcharge, and fill replacement with EPS. For 2.0m and 3.5m surcharge the fill replacement with EPS are 3.0m and 2.5m, respectively. The EPS replacement will have constant thickness within 25m of the embankment and will taper at 5H:1V beyond 25m, ending at Sta.10+075.

  Both alternatives result in similar post-construction settlements but the risks associated with Alternative a) are lower than b). The costs associated with a) however, are significantly higher than b) (between $760k and $933k difference). Based on this analysis, we recommend alternative b) with wicks spaced at 1.5m, 2.0m surcharge and 3.0m fill replacement with EPS. Figure 10.3 presents a sketch of the proposed embankment design behind the East Abutment after fill replacement with EPS.

- Embankment beyond Sta.10+075 (for alternative "b)" above)

  Beyond Sta.10+075 there are different design alternatives that include 2.0m or 3.5m surcharge and different wick drain spacing. Table 10.5 shows that although there is no significant gain in construction schedule for selecting wick drain spacing less than 2.0m, the use of 1.5m wick drain spacing results in a relatively small cost increment (less than $65k) and is considered a better design alternative, as discussed earlier. With regards to the surcharge, there is only a relatively small increase in post-construction settlements 30m behind the East Abutment: 50mm for 3.5m surcharge versus 60mm for 2.0m surcharge. Therefore, it is recommended that the East Approach embankment design be carried out using 1.5m wick drain spacing in the rock fill area, and 2.0m surcharge. Figure 10.3 presents a sketch of the proposed embankment design. It is understood that the construction of the proposed approach embankment to the bridge will be carried out without interruptions to the traffic along the existing Hwy537. Therefore installation of wick drains and surcharge as recommended above will not be required in the area where the proposed and existing Hwy537 embankments merge. In this case, larger post-construction settlements (in the order of 200mm) should be anticipated by MTO.

Figure 10.2 shows the proposed design for the embankments along Hwy537. It should be noted that slope flattening, stabilizing berms and construction staging are not required along Hwy 537.

The proposed design for the approach embankments will induce very small changes in vertical stresses along the abutment piles, resulting in vertical stresses in the soil lower than the pre-consolidation pressures. Under these conditions the anticipated post-construction settlements and lateral displacements at the pile locations are anticipated to be negligible to very small, resulting in small downdrag forces.

The following presents a summary of the construction stages and recommendations for the embankment construction along Hwy 537 through Swamp 613:

- Removal of vegetation, peat and topsoil within and 5m beyond the footprint of the embankment. The peat is expected to be typically 0.2m thick but locally up to 0.5m thick; the groundwater level is expected to be below the bottom of the organic soils.
- Backfilling of the sub-excavation is anticipated to be carried out in dry conditions provided surface water is diverted from the cleared areas. The backfill should be 0.5m thick. The backfill material should consist of Granular A or Granular B-II and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:
- 100% shall pass the 37.5 mm sieve;
- No more than 5% shall pass the 0.075 mm sieve.
- Installation of wick drains in a triangular pattern with the spacing shown on Figures 10.2 and tip elevations shown on Table 10.7.
- Installation of monitoring equipment in accordance with Special Provision "Supply and Installation of Monitoring Equipment" (not included in this report).
- Construction of the embankment to the top of surcharge in one single stage.
- The design elevation of the top of the rock fill is the elevation of the base of the EPS fill shown on Figure 10.3. The remaining of the embankment should consist of granular materials meeting the requirements of OPSS 1010 – Granular A or Granular B-II.
- Waiting period of approximately 5 weeks will be required for dissipation of excess pore pressures before the removal of surcharge.
- Remove the surcharge to the top of the rock fill and install EPS as shown on Figure 10.3.
- Install abutment piles (East and West Abutments)
- Construct pavement structure.

11 CULVERT DESIGN AND FILL PLACEMENT

The culvert design should be carried out in accordance with the CHBDC 2000, assuming the backfill as Soil Group I (granular backfill) with weight of 22.8kN/m^3. Subgrade preparation, backfill and frost treatment should be carried out in accordance with the Ontario Provincial Standards.

Embankment construction should be carried out in accordance with OPSS 206 as amended by Special Provision "Amendment to OPSS 206, December 1993" dated November 2002.

Granular fill and backfill materials should be compacted to 98% of the Standard Proctor Maximum Density (SPMD) in conformance to OPSS 501 (Method A), unless stated otherwise.

12 EXCAVATION AND UNWATERING OF SWAMPS

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils at this site and any earth fill are classed as Type 4.

Bedding preparation for the culverts in Swamps 602 and 605 should be carried out in the dry. Due to the wet conditions in the swamps, creek diversion in association with unwatering of the swamps in the culvert areas will be required.

The sub-excavations at Swamp 613 should also be kept dry; therefore surface water should be directed away from excavated areas.

13 CONSTRUCTION CONCERNS AND CONCLUDING REMARKS

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

- Wick drain installation encountering obstructions in the foundation soils, in particular at Swamp 602, and installation carried out late in the fall and without enough fill cover for protection against freezing.
- The temporary access roads in the swamp have potential for instability and may require the use of geogrid and other stabilization measures. The design of the temporary access roads embankments should be the Contractor's responsibility and should be designed by a Professional Geotechnical Engineer.
- The results of the embankment monitoring programs will control the construction schedule. Although not anticipated, there is a risk that the pore pressure dissipation in the foundation soils will be slower than anticipated. If this situation occurs, placement of additional fill or the removal of surcharge may be delayed, which may impact the overall construction schedule. A detailed and regular analysis of the monitoring program during construction is considered critical to:
  - Reduce potential of an embankment failure
  - Reduce the risk of a premature removal of the surcharge

During construction, the Contract Administrator should employ experienced high complexity geotechnical staff to implement the geotechnical monitoring program and to observe construction activities related to foundation construction.

The design recommendations provided in this report were based on a comprehensive geotechnical investigation and well known modelling tools. Notwithstanding this fact, it should be recognized that the conditions at the proposed embankments are complex from the geotechnical viewpoint. The presence of very thick compressible clayey deposits, which are locally sensitive and varved, adds uncertainty to the prediction of the performance of the embankment proposed in this project. As a result, the settlement values predicted in this report, in particular the post construction settlements, should be interpreted simply as an index that should be used for the selection of an embankment configuration and construction method that would reduce the potential for the occurrence of large post construction settlements. In addition, it is considered critical that the construction contract includes clauses that allow for a flexible construction schedule to allow for delays associated with dissipation of excess pore pressures in the foundation soils lower than anticipated.

Engineering analysis and report prepared by:

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Report Reviewed by:

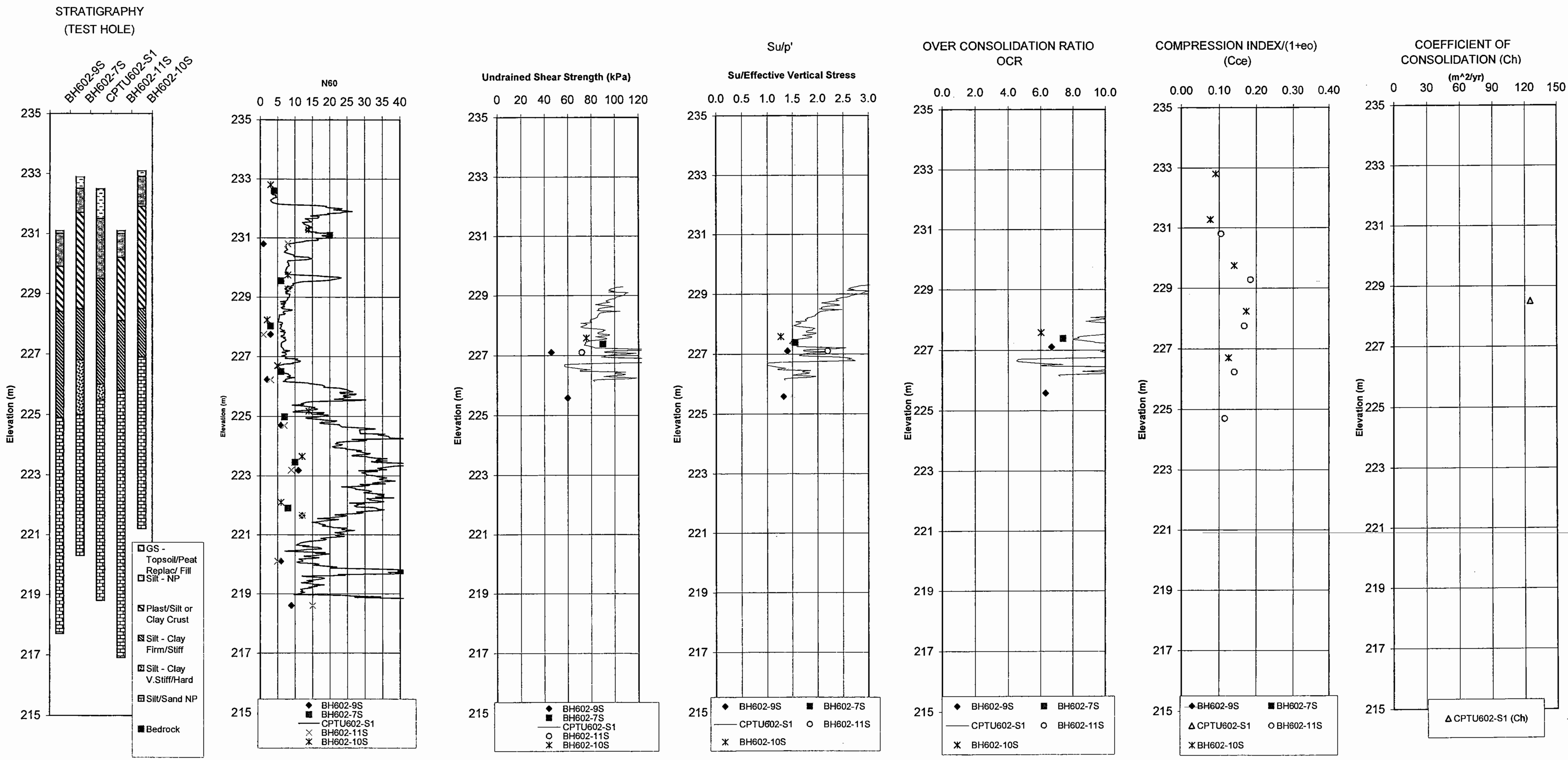
P.K. Chatterji, Ph.D., P.Eng.

Review Principal

REFERENCE

Peto MacCallum Ltd. (2004). Foundation Investigation Report – Swamp and High Fill Crossings for Highway 69 Four-Laning from 4km South of Estaire to 1km north of Highway 537 – GWP 312-99-00 – District 54, Townships of Burwash, Secord and Dill, Sudbury, Ontario, Volumes 1 through 5 November 17, 2004

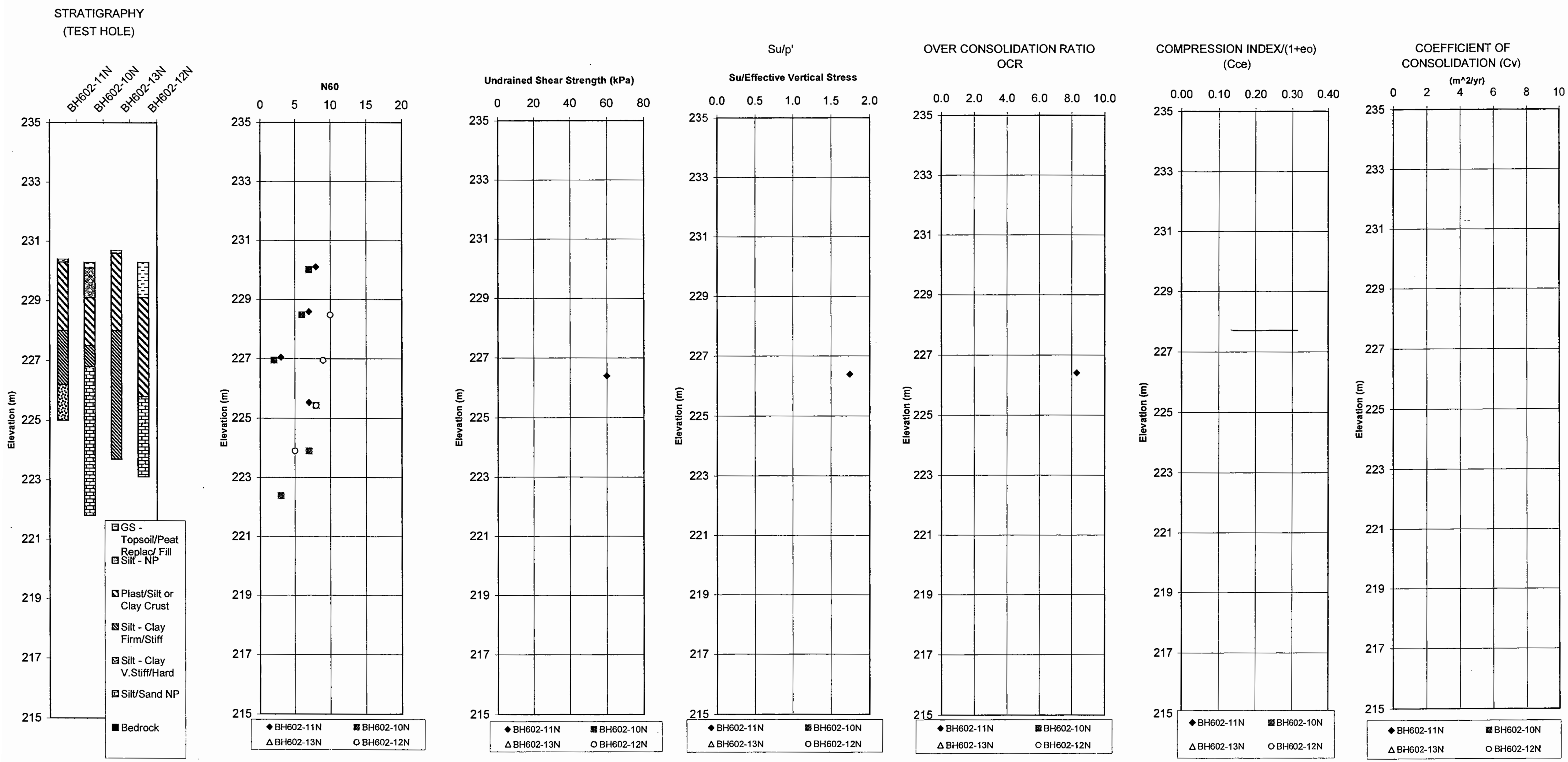
HIGHWAY 69 - Swamp 602 (South Swamp) SBL Sta. 12+660 (12+640 to 12+680)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.1

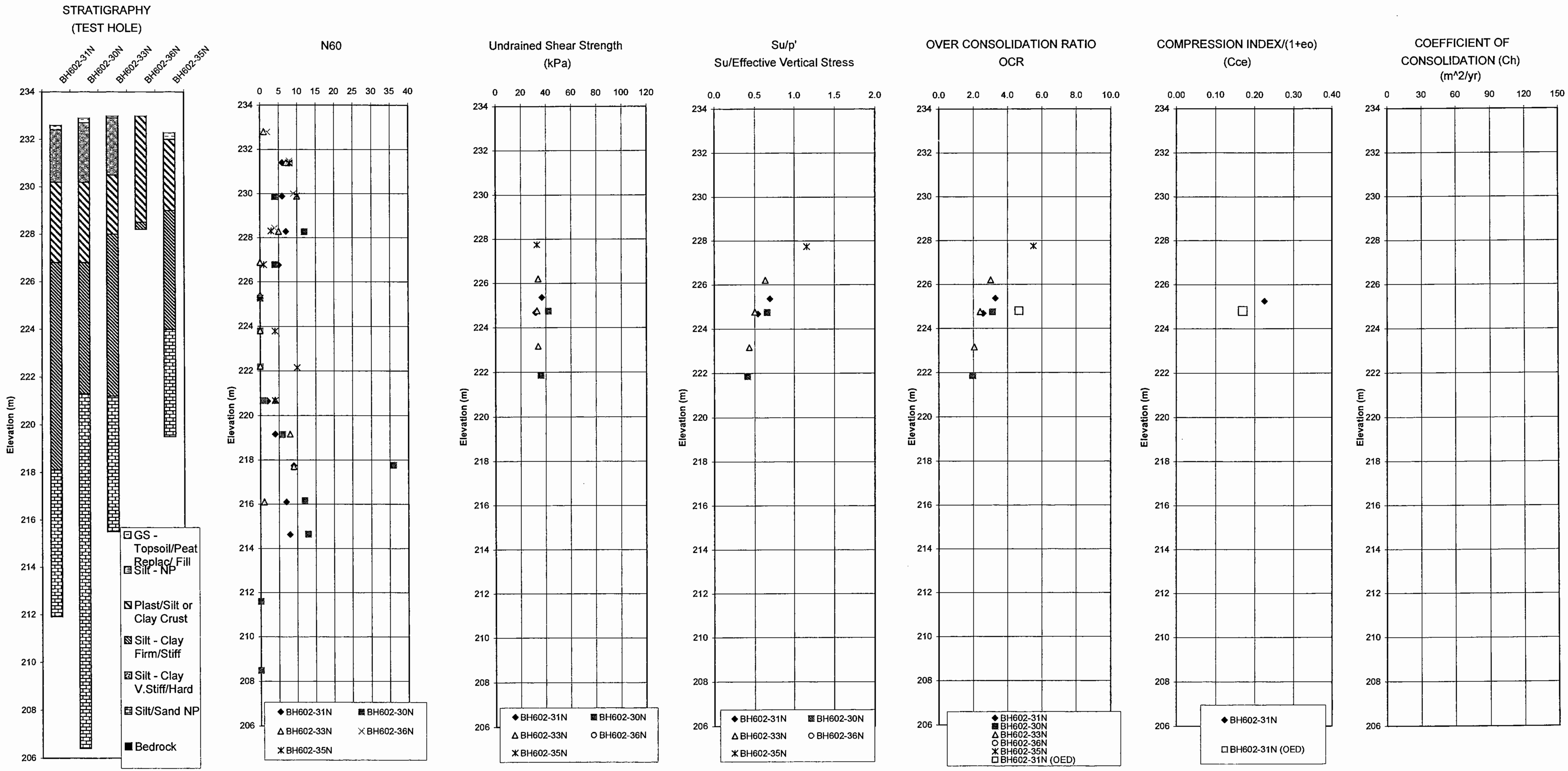
HIGHWAY 69 - Swamp 602 (South Swamp) NBL Sta. 12+700 (12+670 to 12+710)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.2

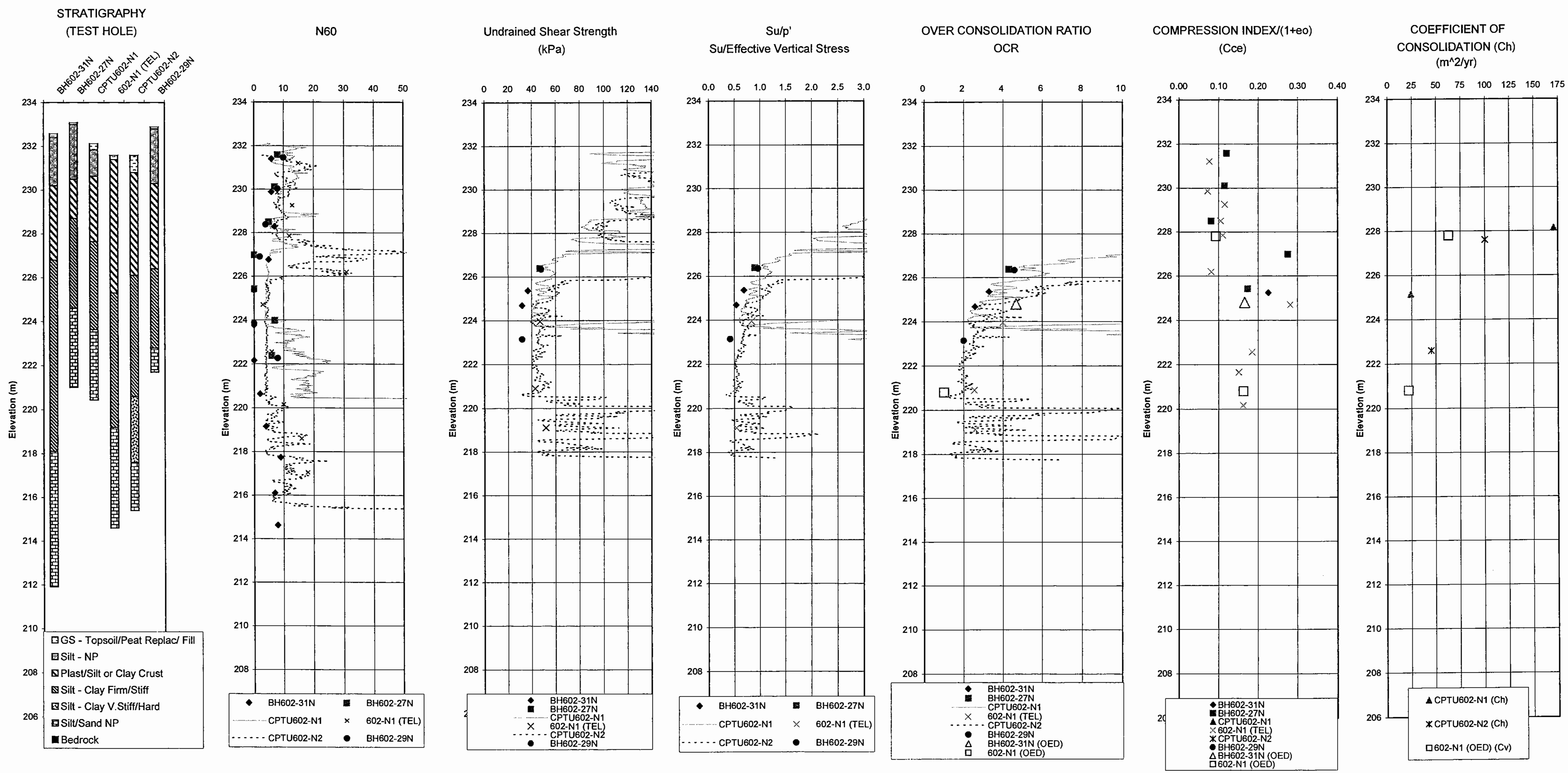
HIGHWAY 69 - Swamp 602 (North Swamp) NBL Sta. 12+890 A (12+880 to 12+920)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.3

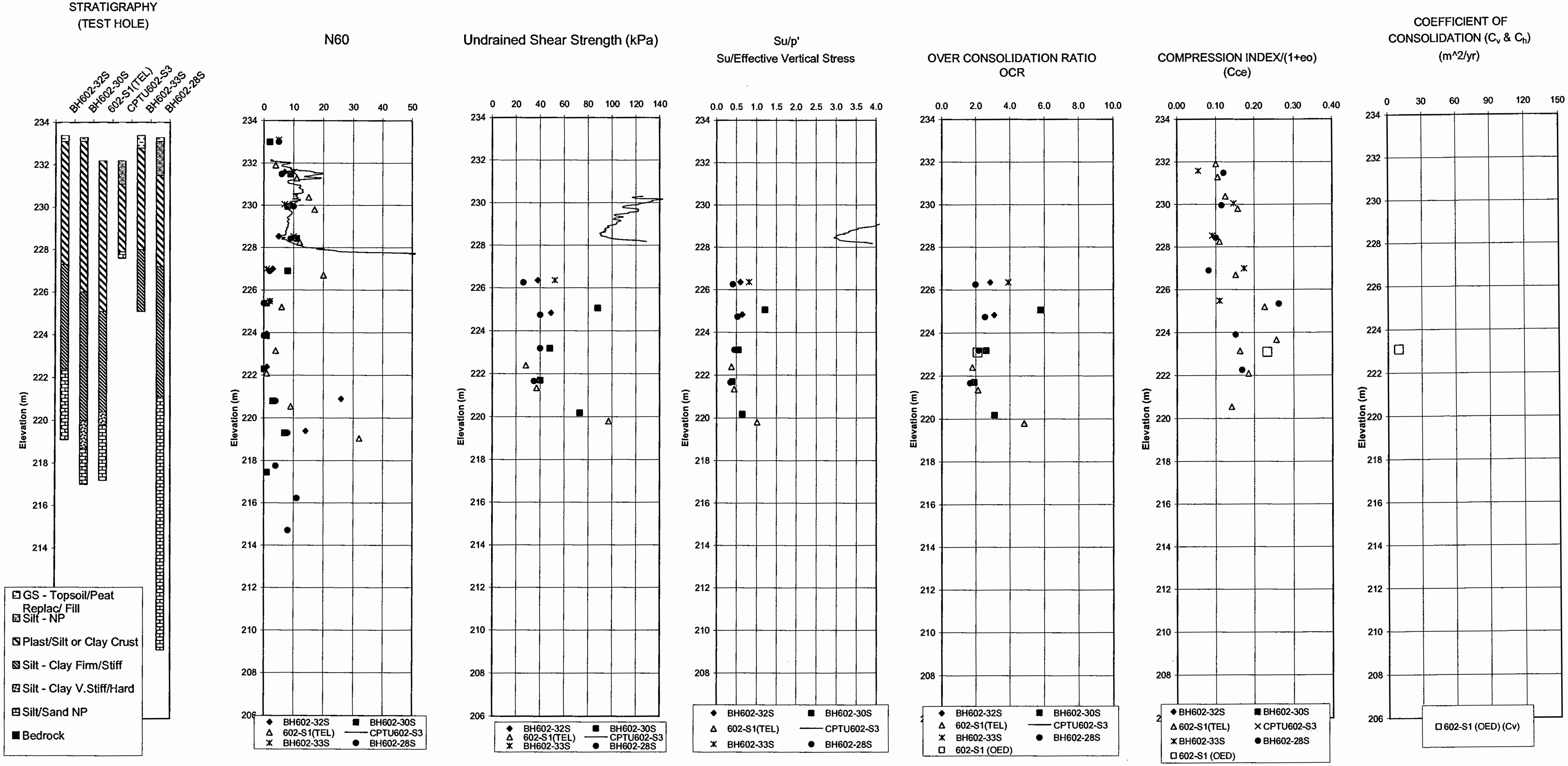
HIGHWAY 69 - Swamp 602 (North Swamp) NBL Sta. 12+890 B (12+840 to 12+880)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.4

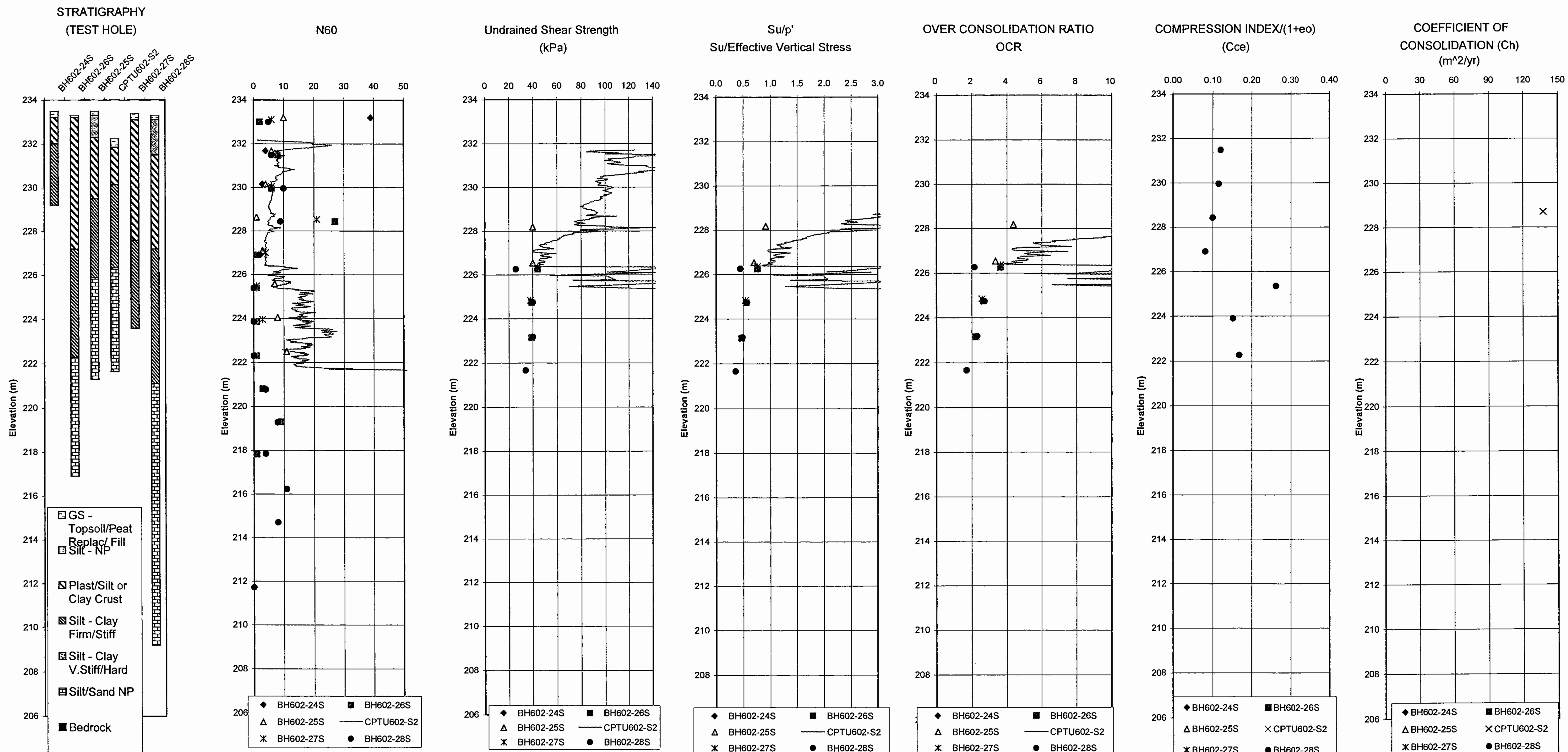
HIGHWAY 69 - Swamp 602 (North Swamp) SBL Sta. 12+890 A (12+870 to 12+900)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.5

HIGHWAY 69 - Swamp 602 (North Swamp) SBL Sta. 12+890 B (12+810 to 12+870)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.6

HIGHWAY 69 - Swamp 605 SBL & NBL Sta. 14+290 (14+262.5 to 14+312.5)
SUMMARY OF SUBSURFACE CONDITIONS

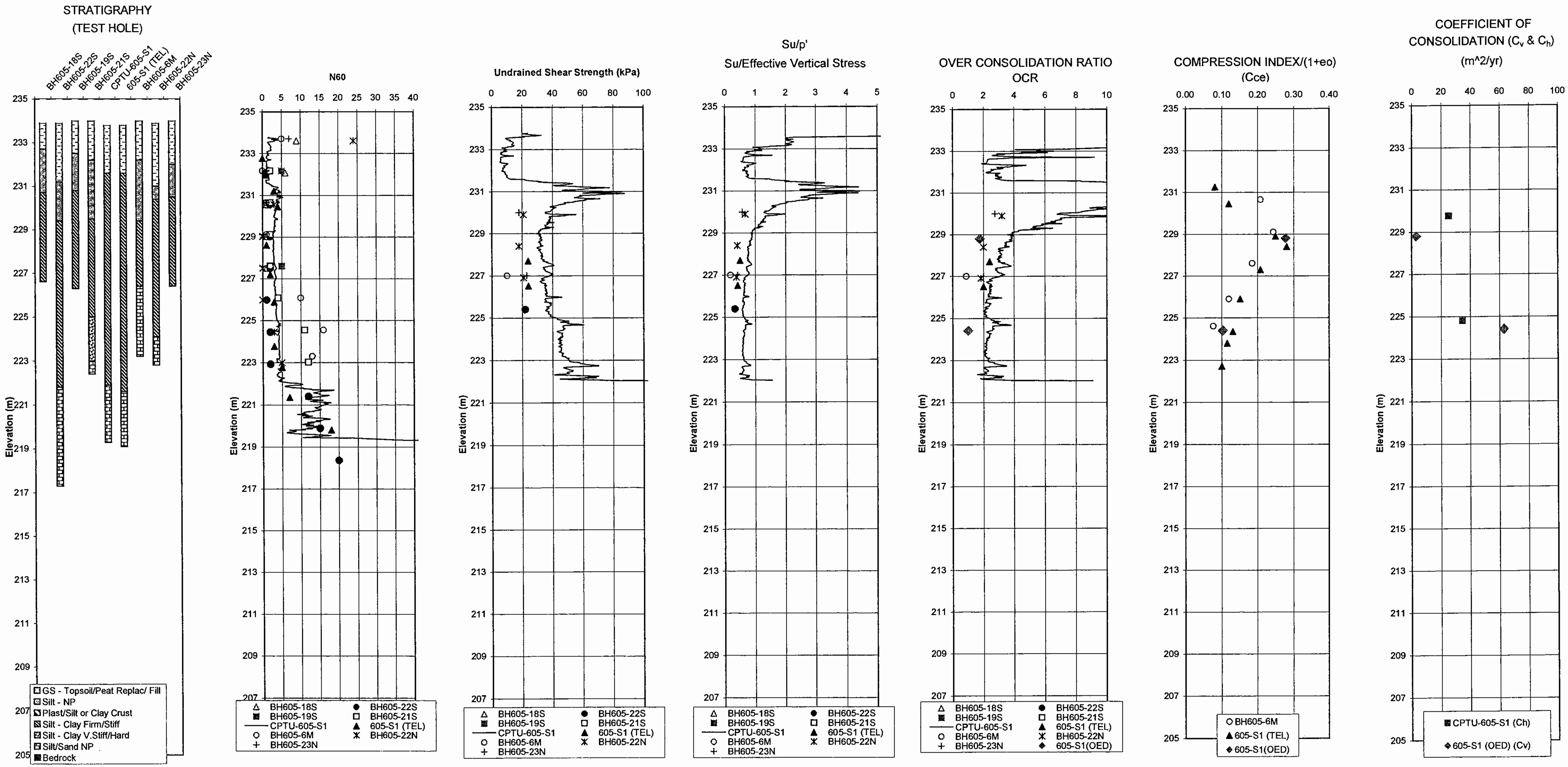
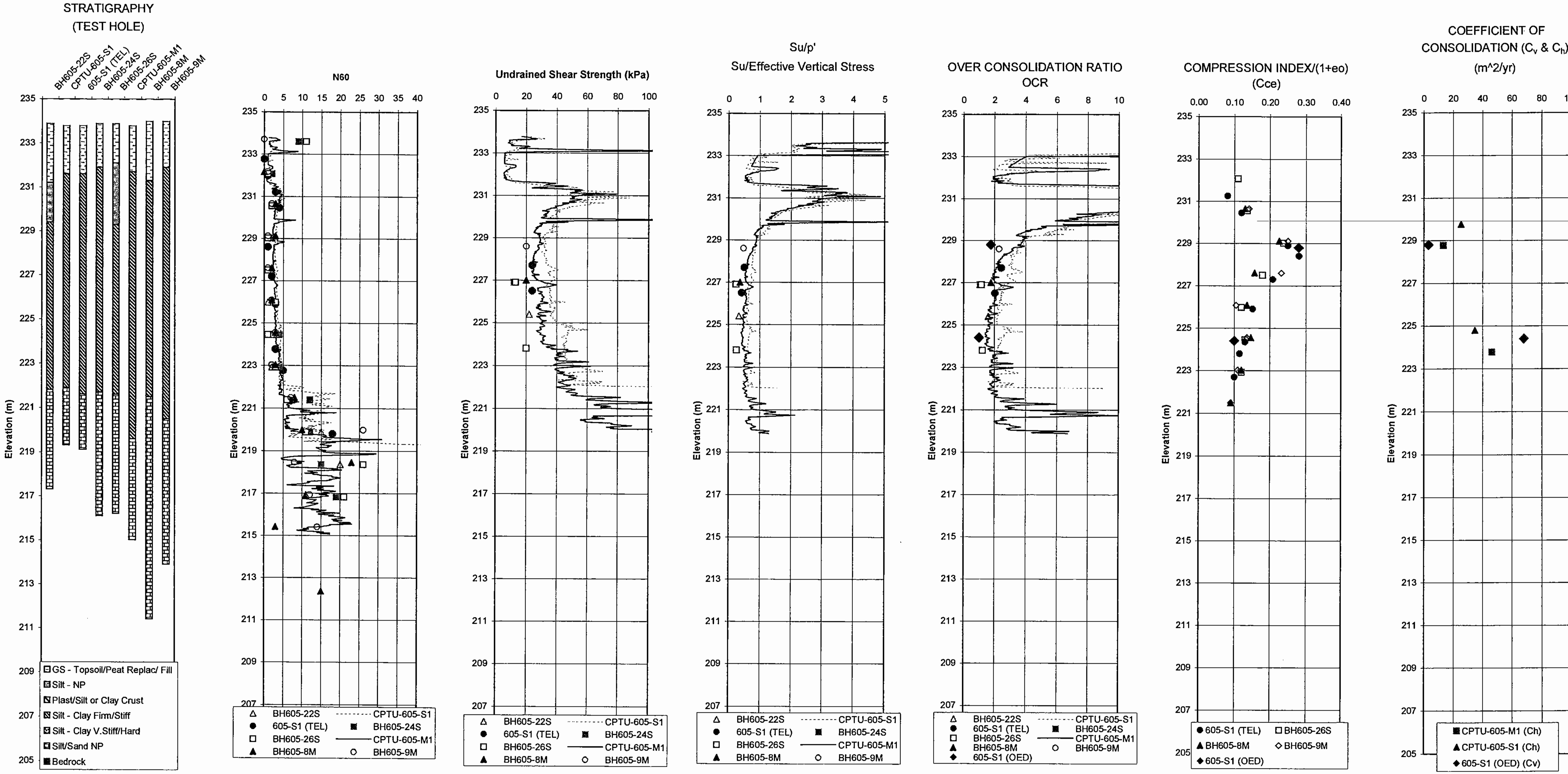


FIGURE 5.7

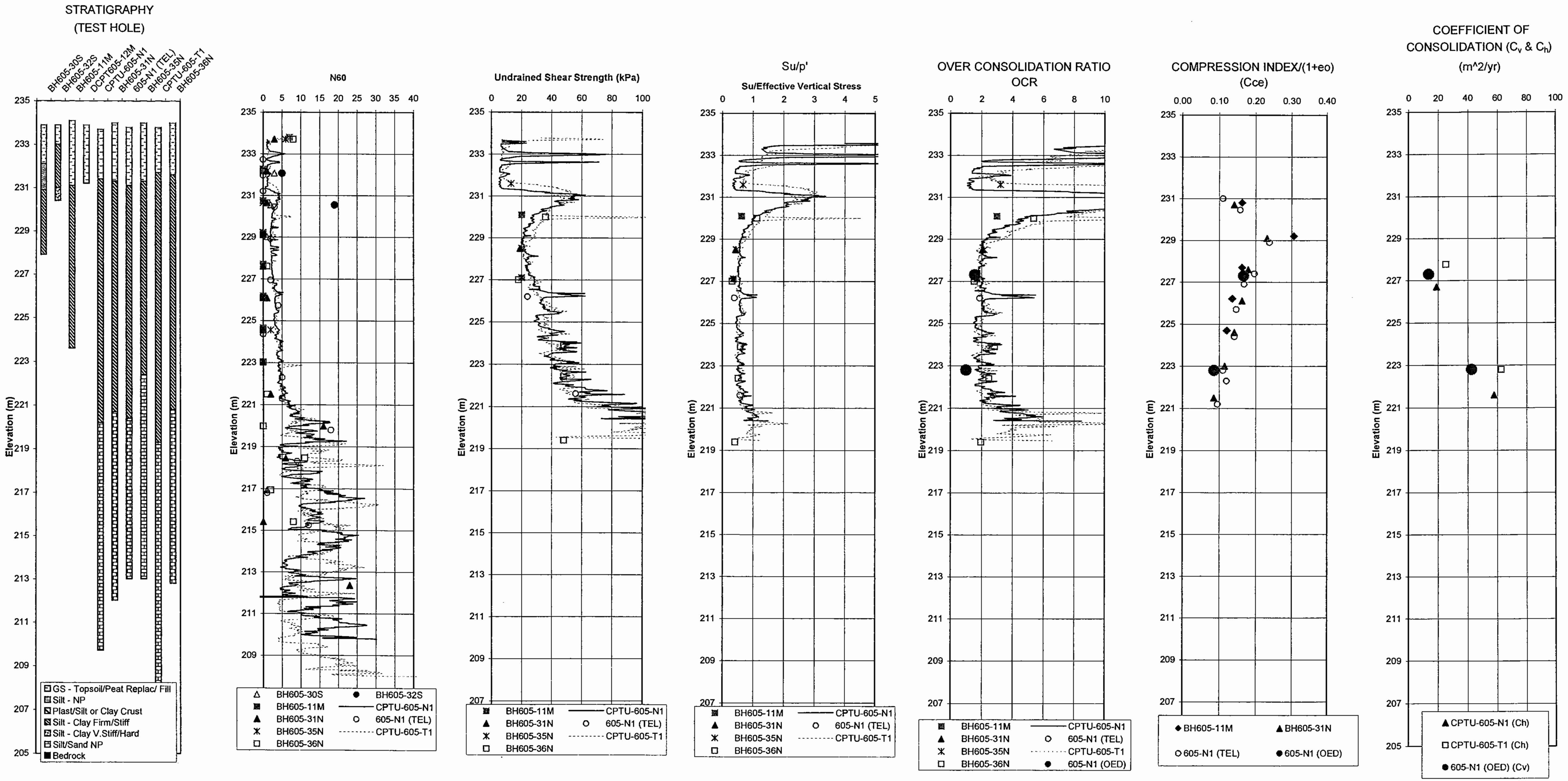
HIGHWAY 69 - Swamp 605 SBL Sta. 14+330 (14+310 to 14+350)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.8

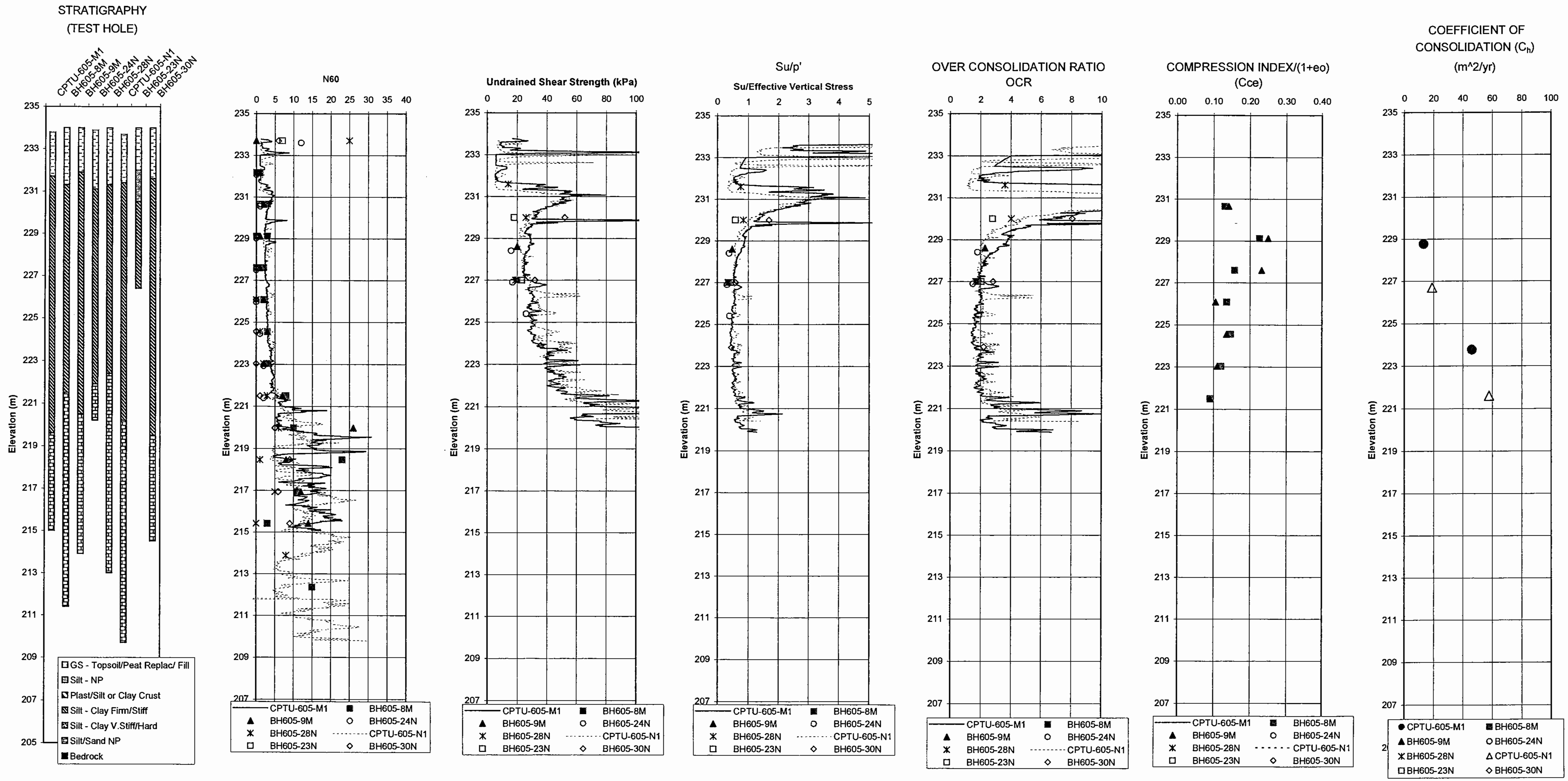
HIGHWAY 69 - Swamp 605 SBL & NBL Sta. 14+390 (14+360 to 14+412.5)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.9

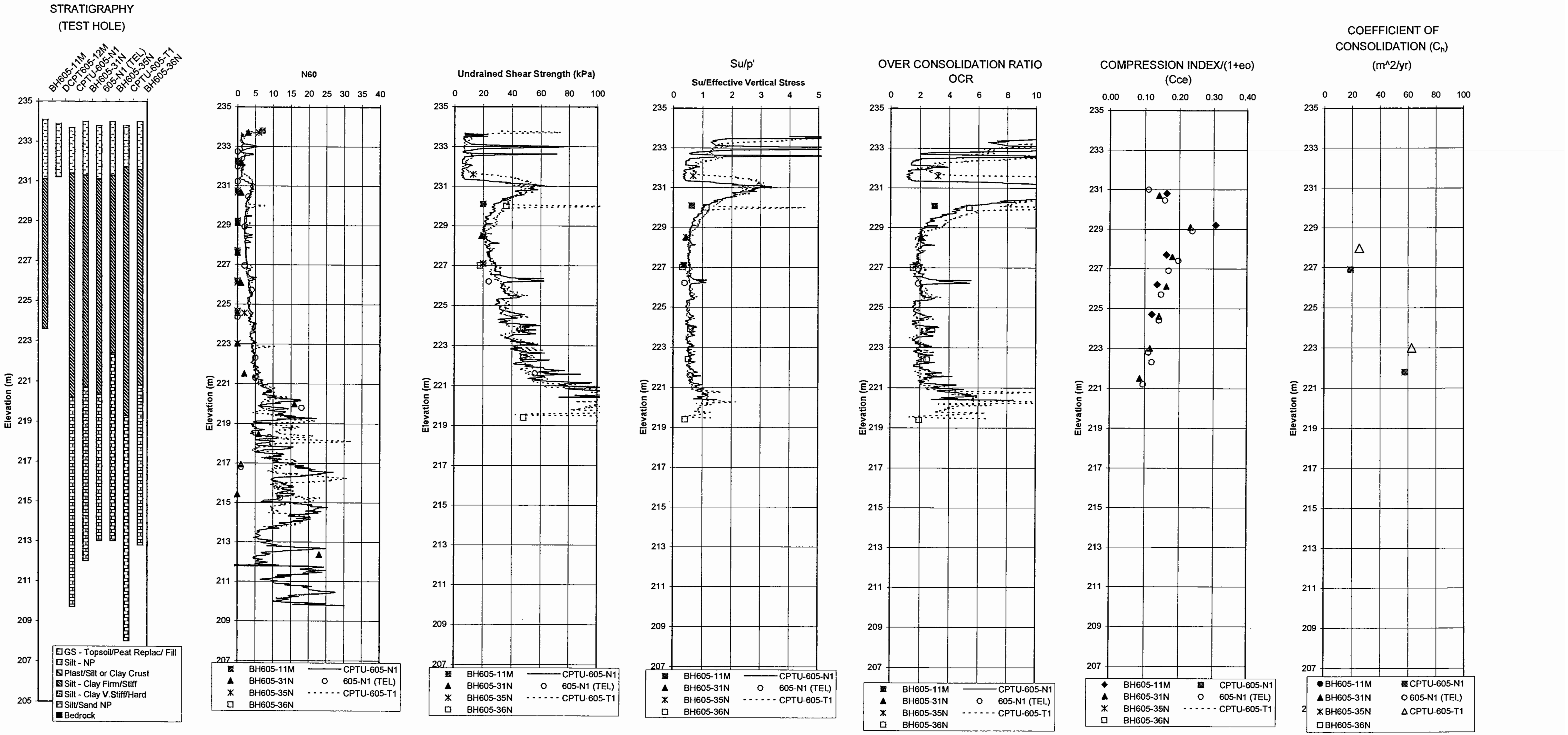
HIGHWAY 69 - Swamp 605 NBL Sta. 14+330 (14+312.5 to 14+362.5)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.10

HIGHWAY 69 - Swamp 605 NBL Sta. 14+360 to 14+412.5
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.11

HIGHWAY 69 - Swamp 605 SBL & NBL Culvert #7
SUMMARY OF SUBSURFACE CONDITIONS

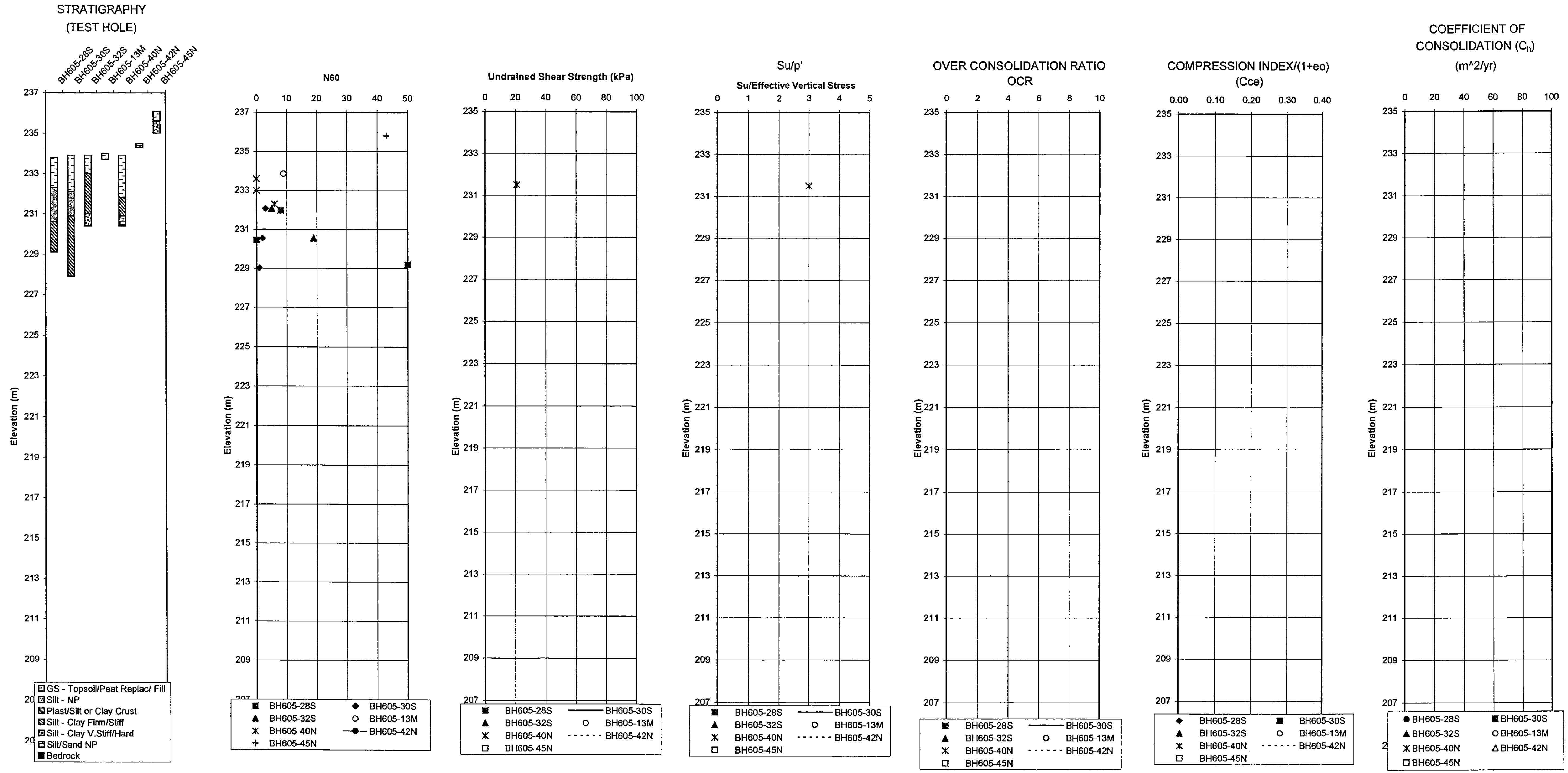
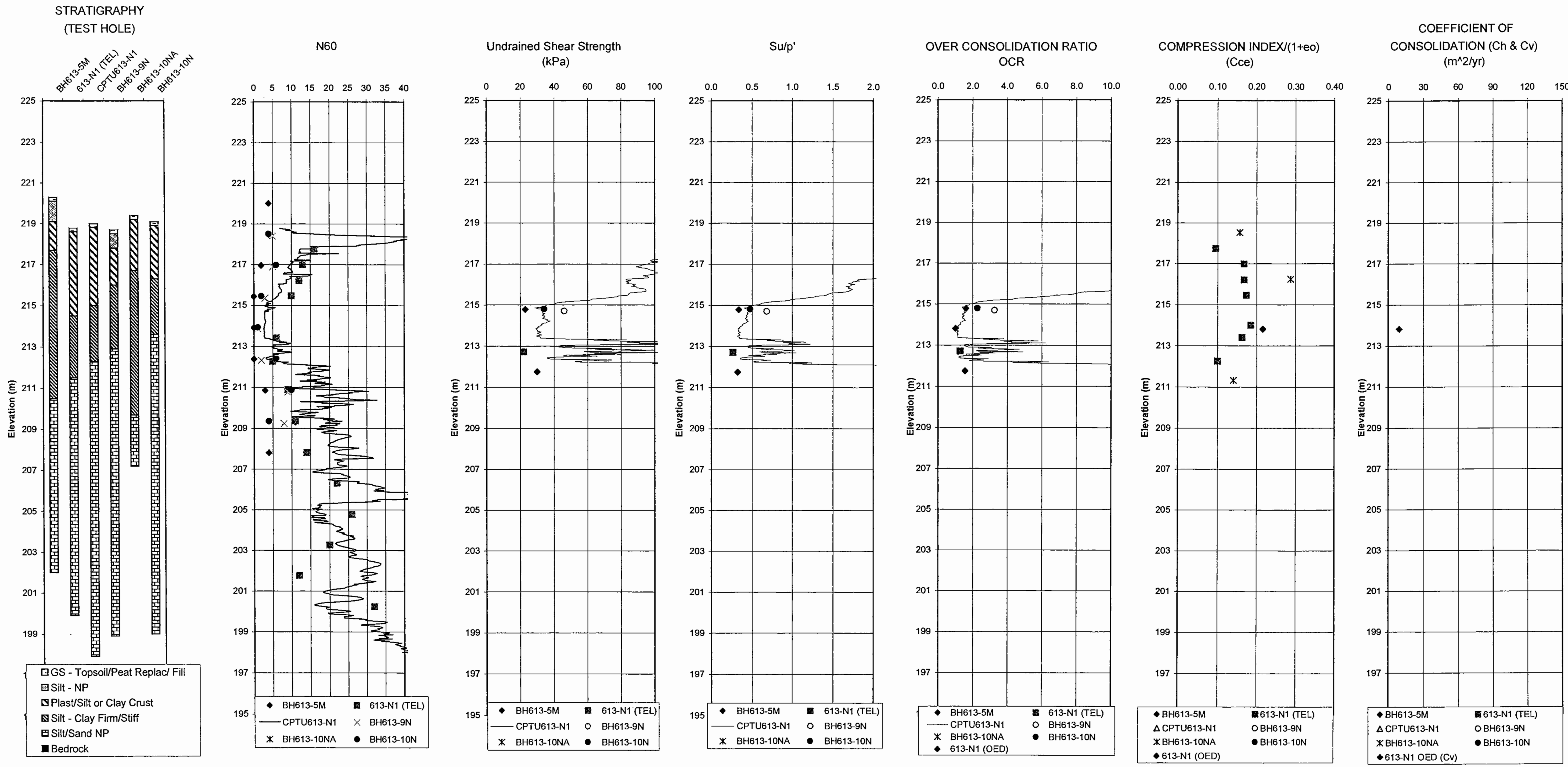


FIGURE 5.12

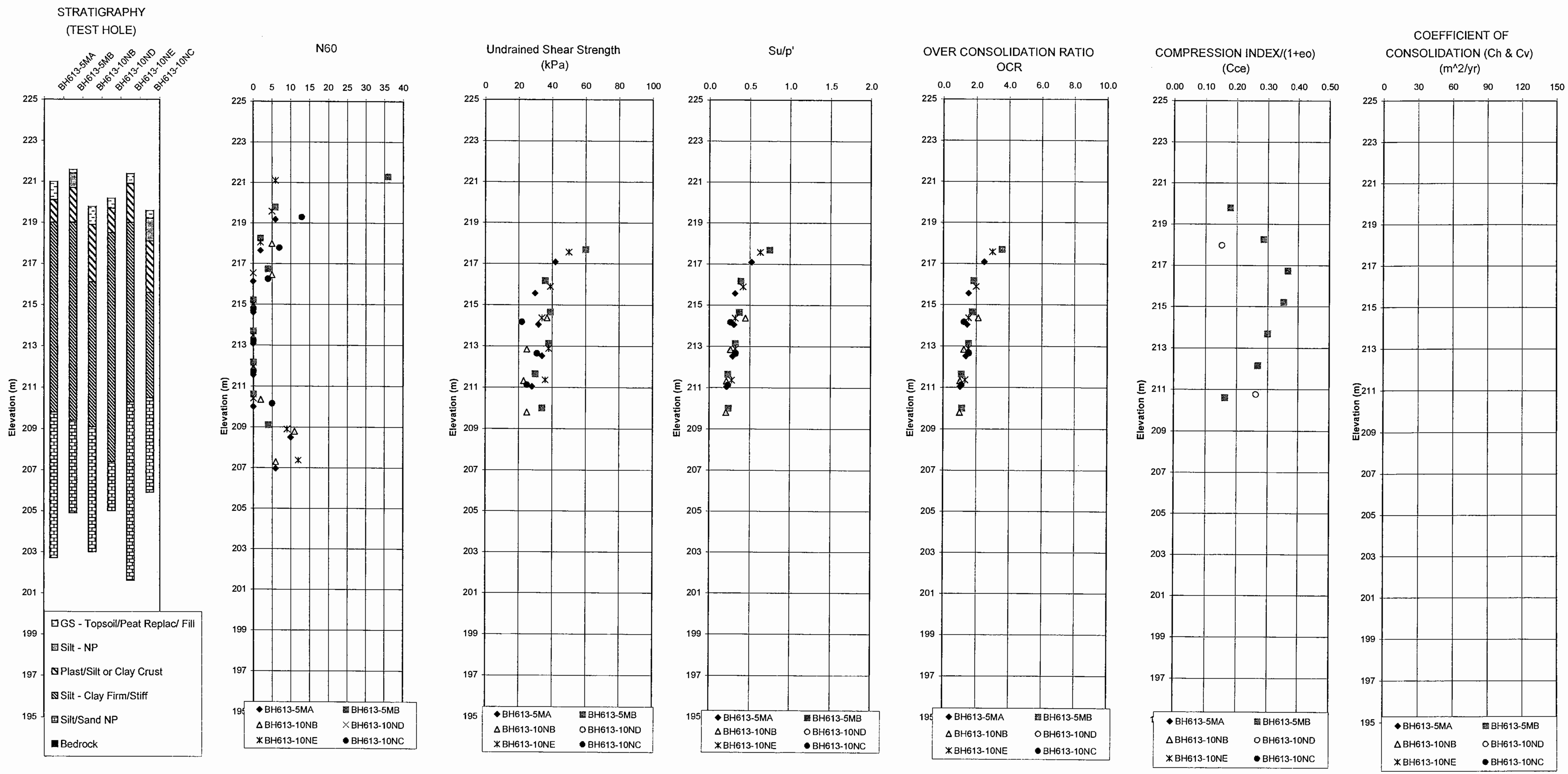
HIGHWAY 69 - Swamp 613 Hwy 69 NBL Sta. 10+520 (10+500 to 10+520)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.13

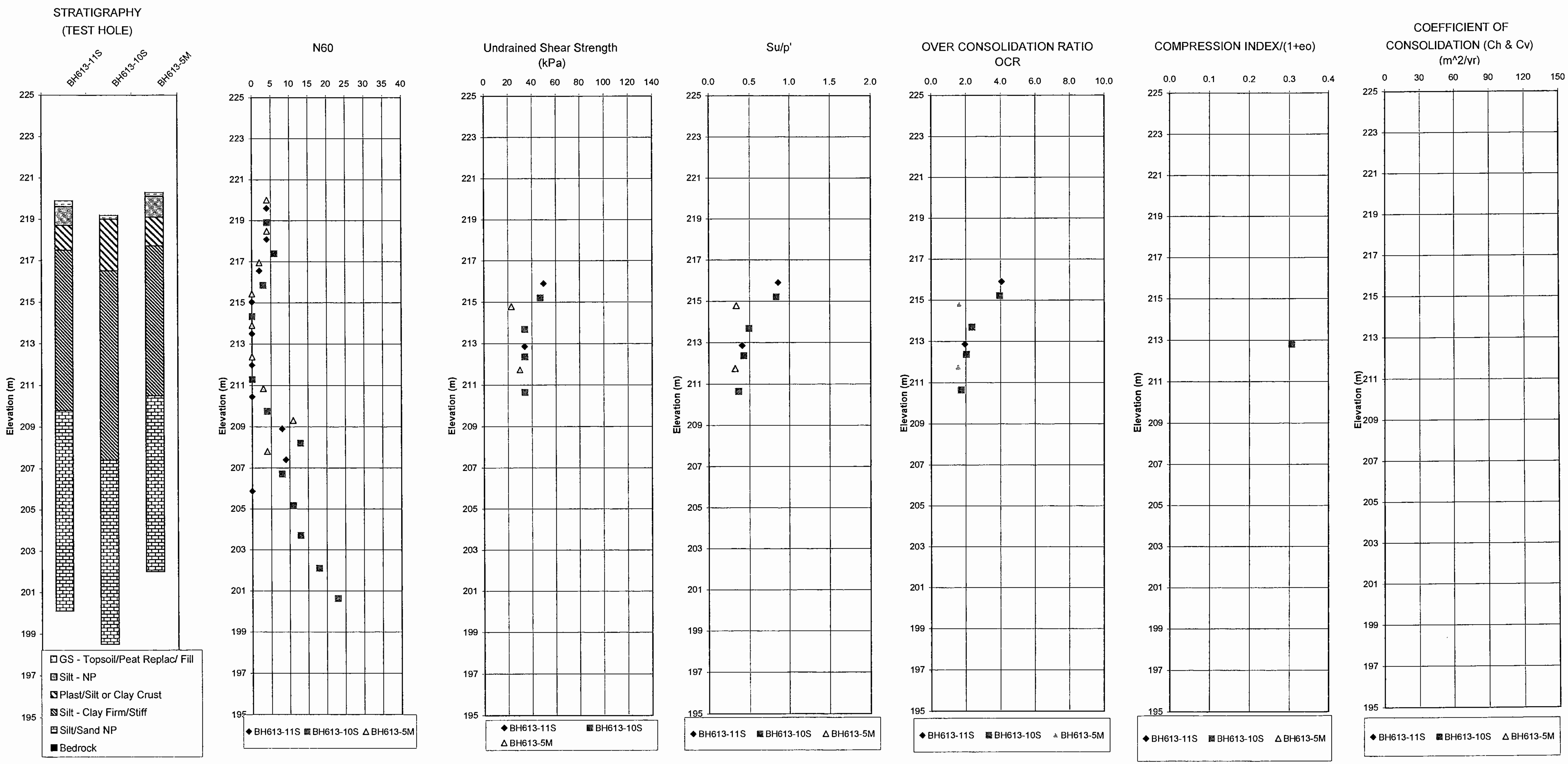
HIGHWAY 69 - Swamp 613 Hwy 69 NBL Sta. 10+570 (10+550 to 10+620)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.14

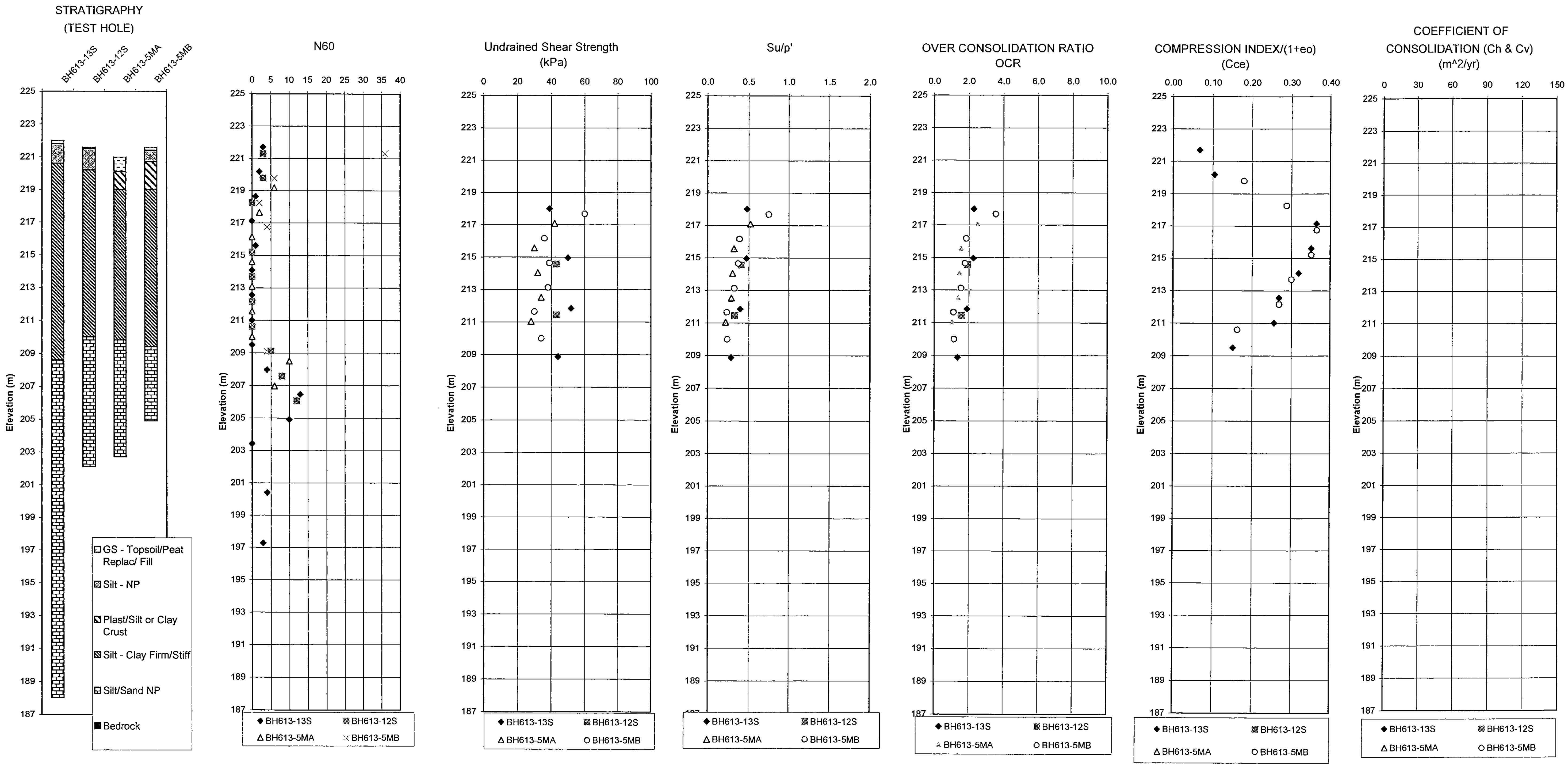
HIGHWAY 69 - Swamp 613 Hwy 69 SBL Sta. 10+520 (10+500 to 10+520)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.15

HIGHWAY 69 - Swamp 613 Hwy 69 SBL Sta. 10+570 (10+570 to 10+630)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.16

HIGHWAY 69 - Swamp 613 Hwy 537 Sta. 9+900 (9+900 to 9+930)
SUMMARY OF SUBSURFACE CONDITIONS

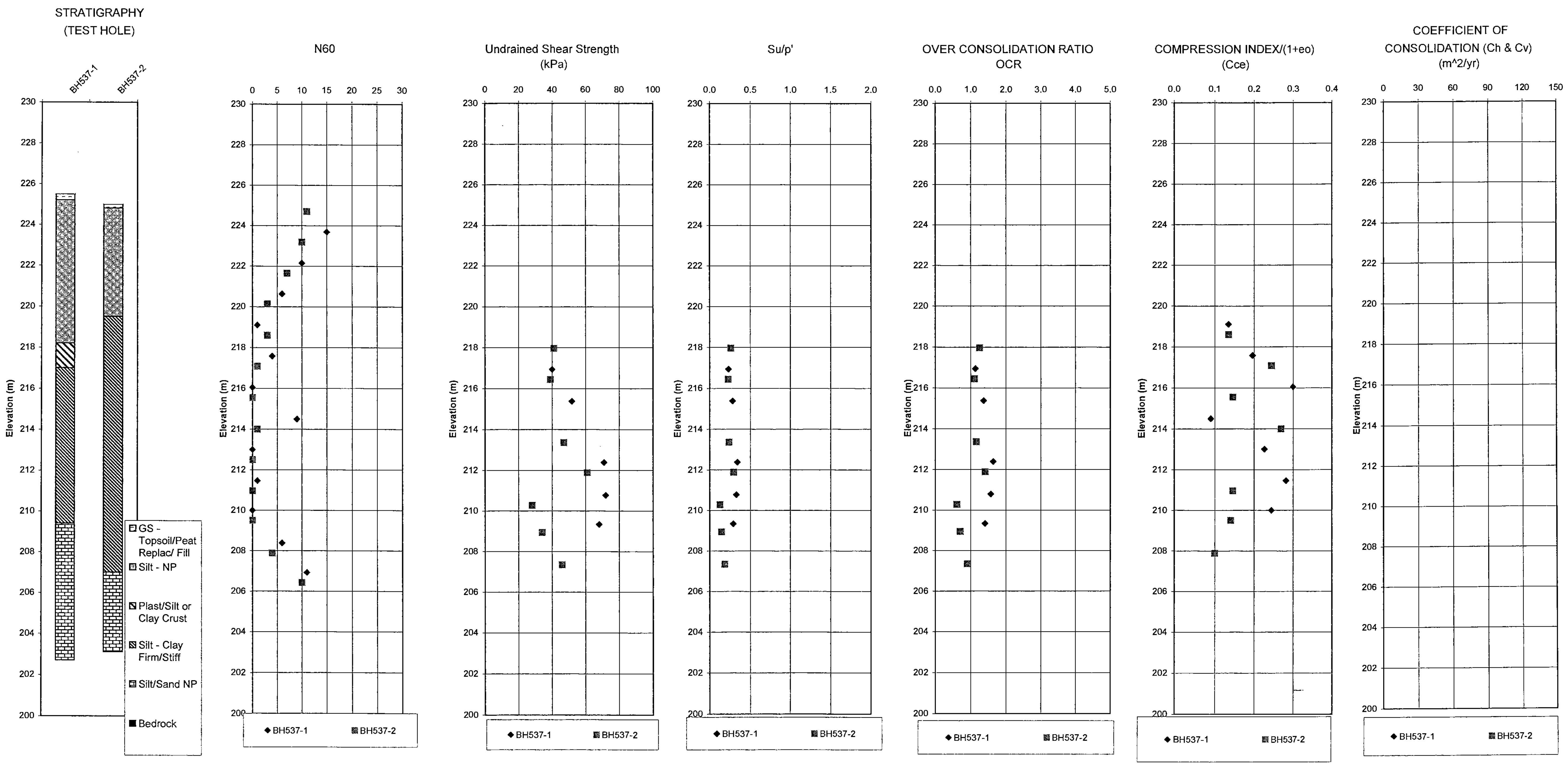
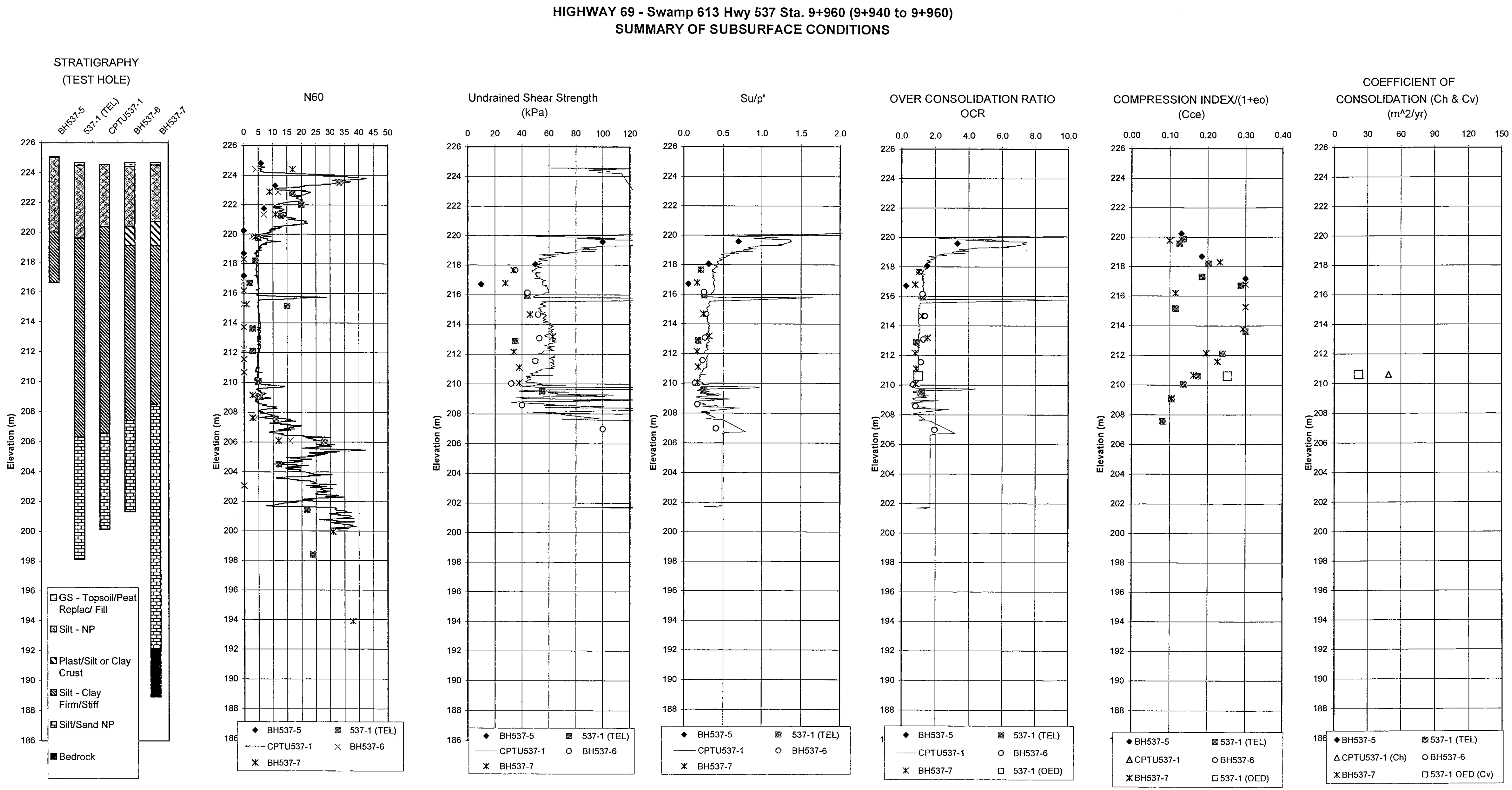


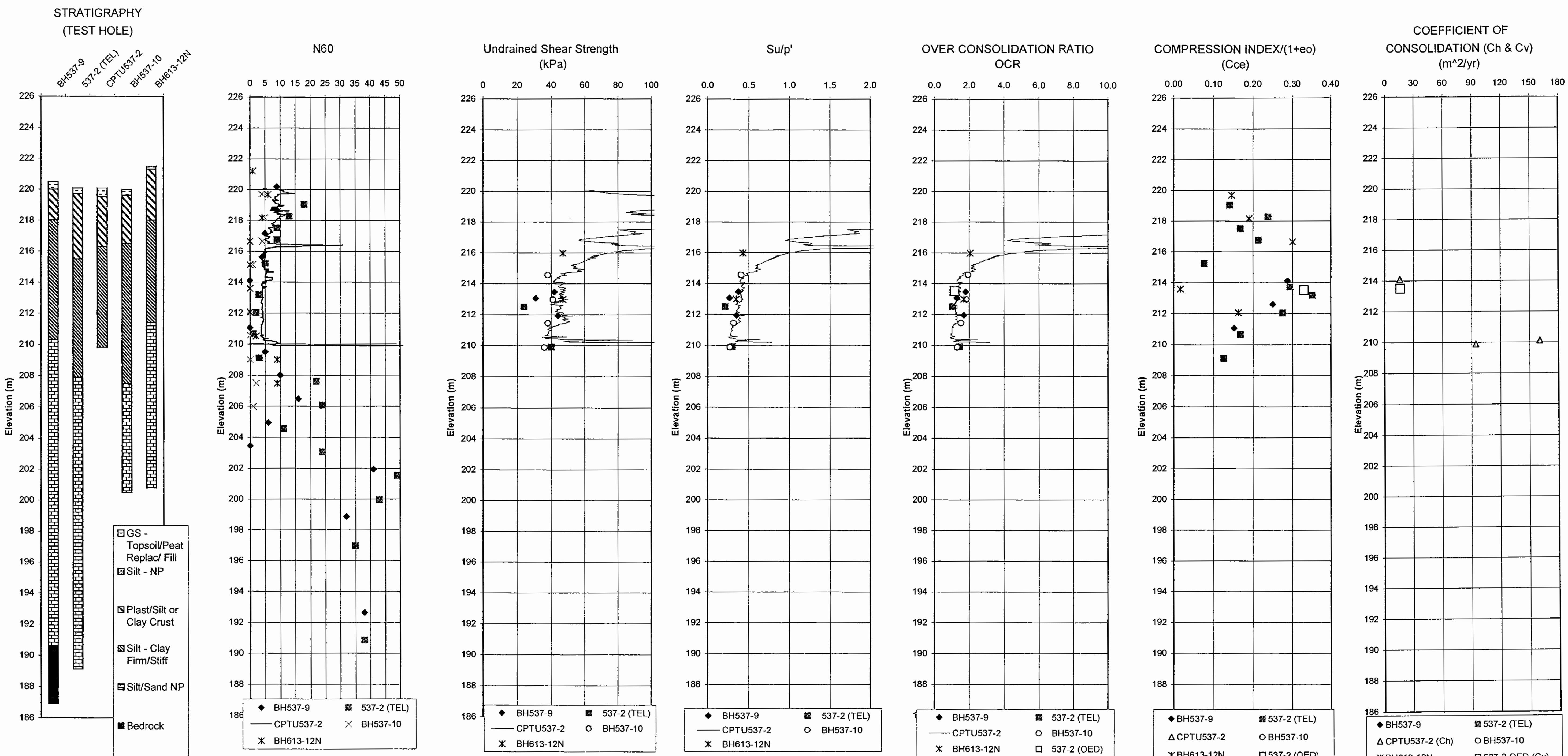
FIGURE 5.17



MASTER PLOT

FIGURE 5.18

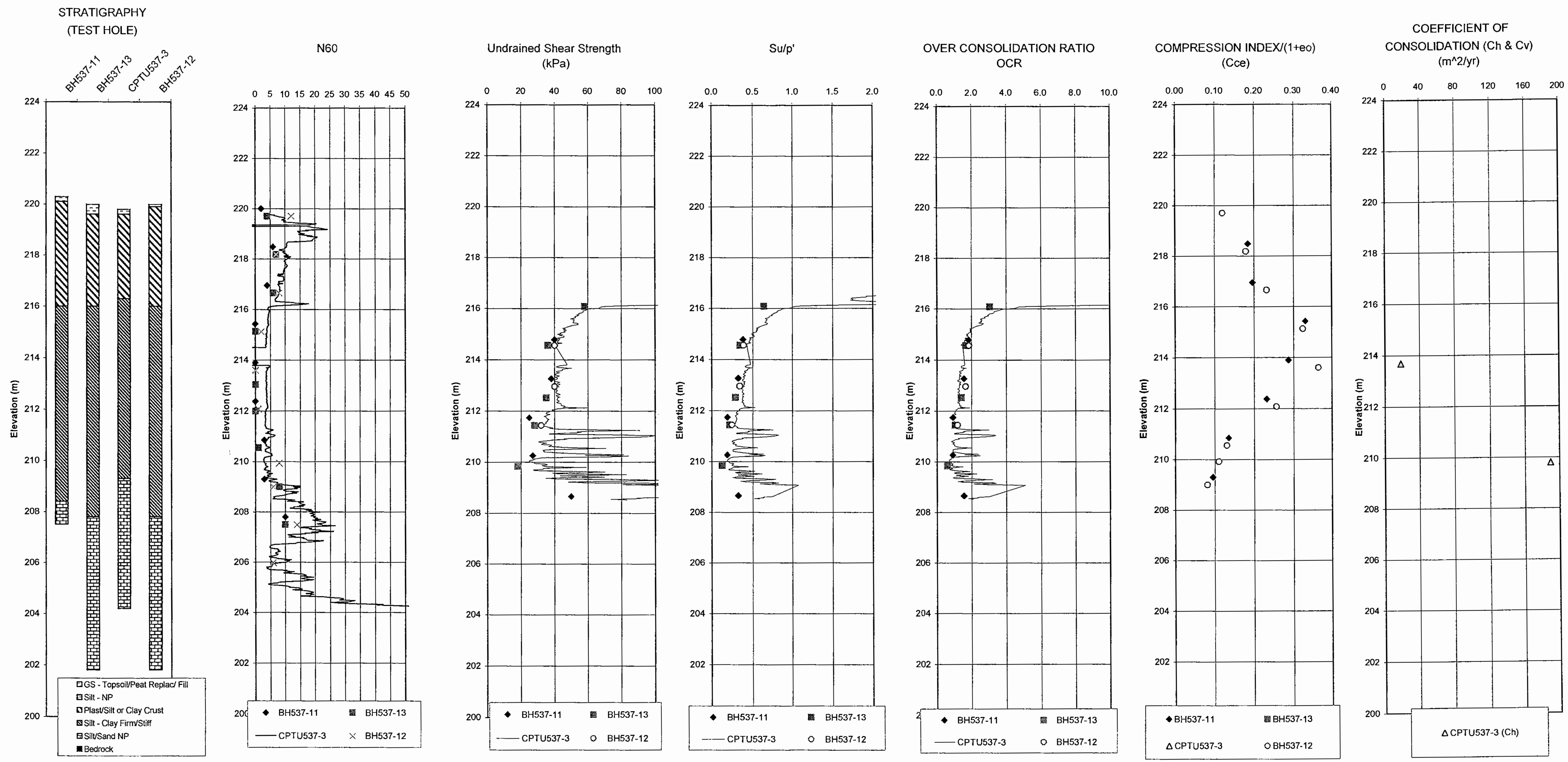
HIGHWAY 69 - Swamp 613 Hwy 537 Sta. 10+040 (10+040 to 10+050)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.19

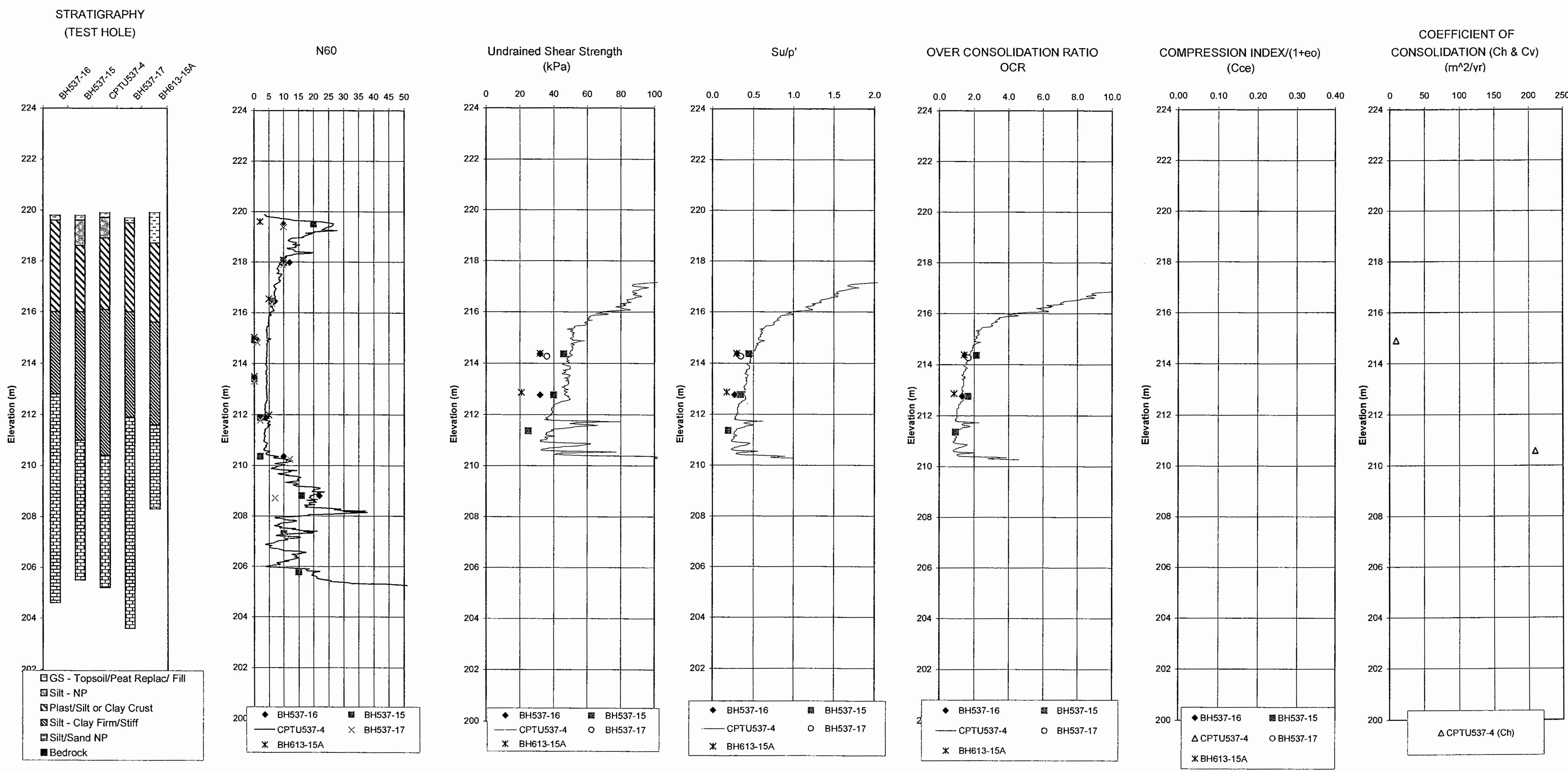
HIGHWAY 69 - Swamp 613 Hwy 537 Sta. 10+040 (10+050 to 10+080)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.20

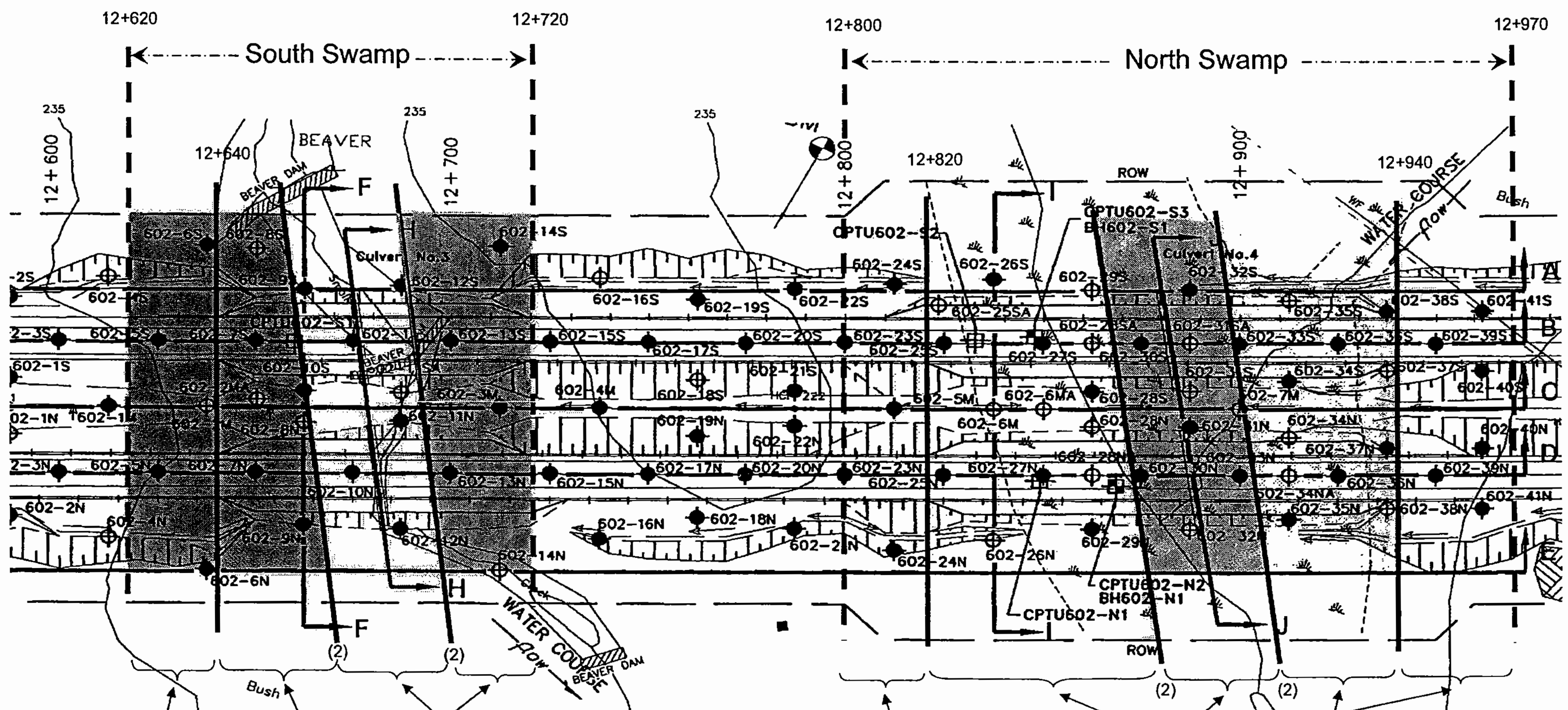
HIGHWAY 69 - Swamp 613 Hwy 537 Sta. 10+130 (10+100 to 10+130)
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.21

SWAMP 602 - EMBANKMENT DESIGN RECOMMENDATIONS

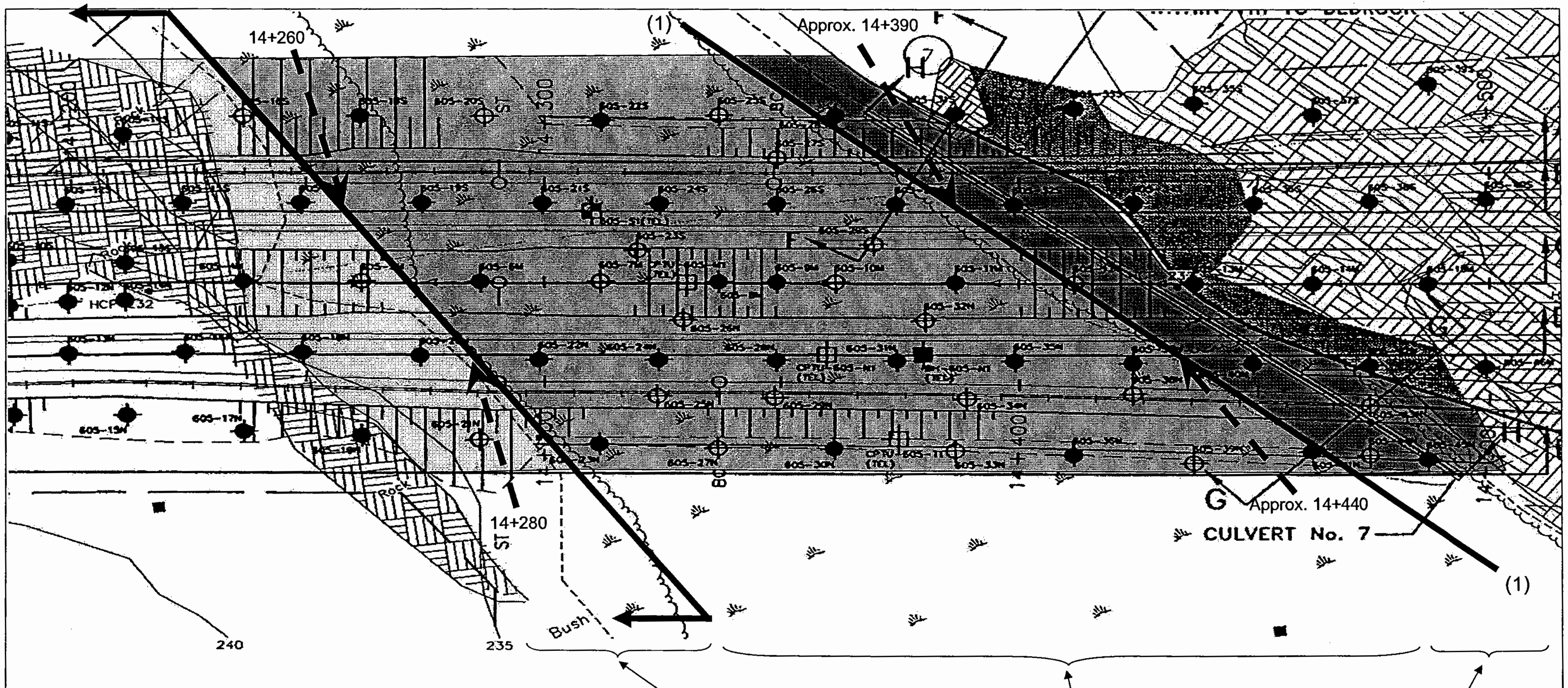


Surcharge			N/R	2.0m	2.0m	1.0m	2.0m	2.0m
Material of Main Embankment			Rockfill (1)	Rockfill (1)	Granular Fill	Rockfill (1)	Granular Fill	Rockfill (1)
Slope Flattening			N/R	N/R	N/R	N/R	N/R	N/R
Stabilizing Berms	NBL-East Slope	Height	N/R	N/R	N/R	N/R	N/R	N/R
		Width	N/R	N/R	N/R	N/R	N/R	N/R
	SBL-West Slope	Height	N/R	N/R	N/R	N/R	N/R	N/R
		Width	N/R	N/R	N/R	N/R	N/R	N/R
Wick drain spacing			N/R	N/R	N/R	N/R	1.5m	1.5m
Construction Stages	Stage 1		0 to top of pavement	0 to top of surcharge	0 to top of surcharge	0 to top of surcharge	0 to top of surcharge	0 to top of surcharge
	Stage 2		N/R	N/R	N/R	N/R	N/R	N/R
	Stage 3		N/R	N/R	N/R	N/R	N/R	N/R
Operation Constraint	Installation of wick drain may encounter refusal in North Swamp prior to reaching desired depth		N/R	N/R	N/R	N/R	Pre-augering or vibratory equipment may be required for installation of wick drains	Pre-augering or vibratory equipment may be required for installation of wick drains

Note:
(1) Embankment consists of rockfill to approximately 0.5m below the top of pavement
(2) Boundaries between rockfill and granular fill surrounding the temporary CSP and the permanent concrete box culvert to be determined by the location and culvert design details

FIGURE 8.1

SWAMP 605 - EMBANKMENT DESIGN RECOMMENDATIONS



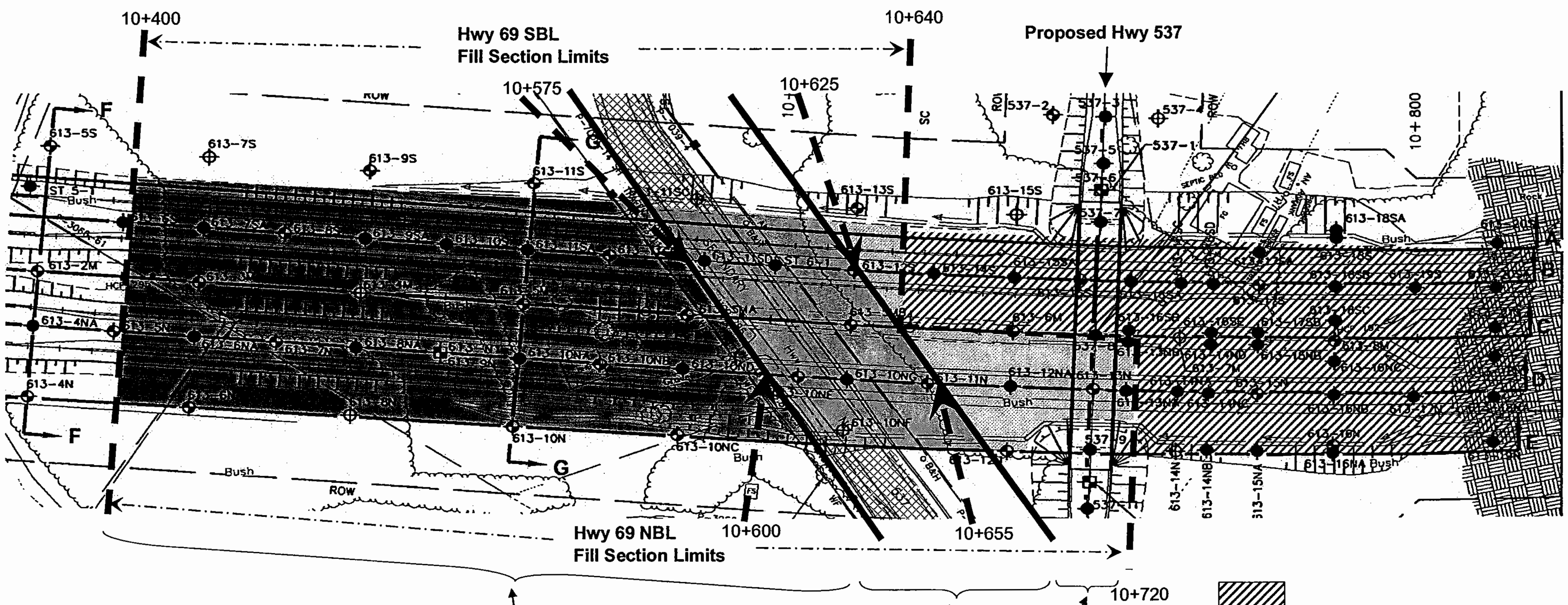
Surcharge (Earth Fill)			2.0m	2.0m
Slope Flattening (Earth Fill) - 4H:1V Slope			Yes	Yes
Stabilizing Berms (Earth Fill) - 4H:1V Slope	NBL-East Slope	Height	N/R	4.0m
		Width	N/R	4.0m
	SBL-West Slope	Height	N/R	4.0m
		Width	N/R	4.0m
Wick drain spacing			N/R	1.5m
Construction Stages (Rockfill to base of Pavement structure)	Stage 1		0 to top of surcharge	0 to 6.5m
	Stage 2		N/R	6.5 to 8.5m
	Stage 3		N/R	8.5m to top of surcharge
Operation Constraint	Maximum difference in elevation during construction between NBL and SBL Embankments		N/R	4.0m

The alignment of Culvert #7 has been relocated 2 to 4m northerly from the location shown above. The overburden soils beneath the culvert will be fully excavated and replaced with granular or rockfill prior to the installation of the permanent box culvert.

Note: (1) The exact boundary between the areas of (rockfill+surcharge+wick drains) and the complete removal of soft soils for the installation of the permanent concrete box culvert to be determined by the location and culvert design details

FIGURE 9.1

SWAMP 613 (Highway 69) - EMBANKMENT DESIGN RECOMMENDATIONS



Proposed Highway 69 in cut section

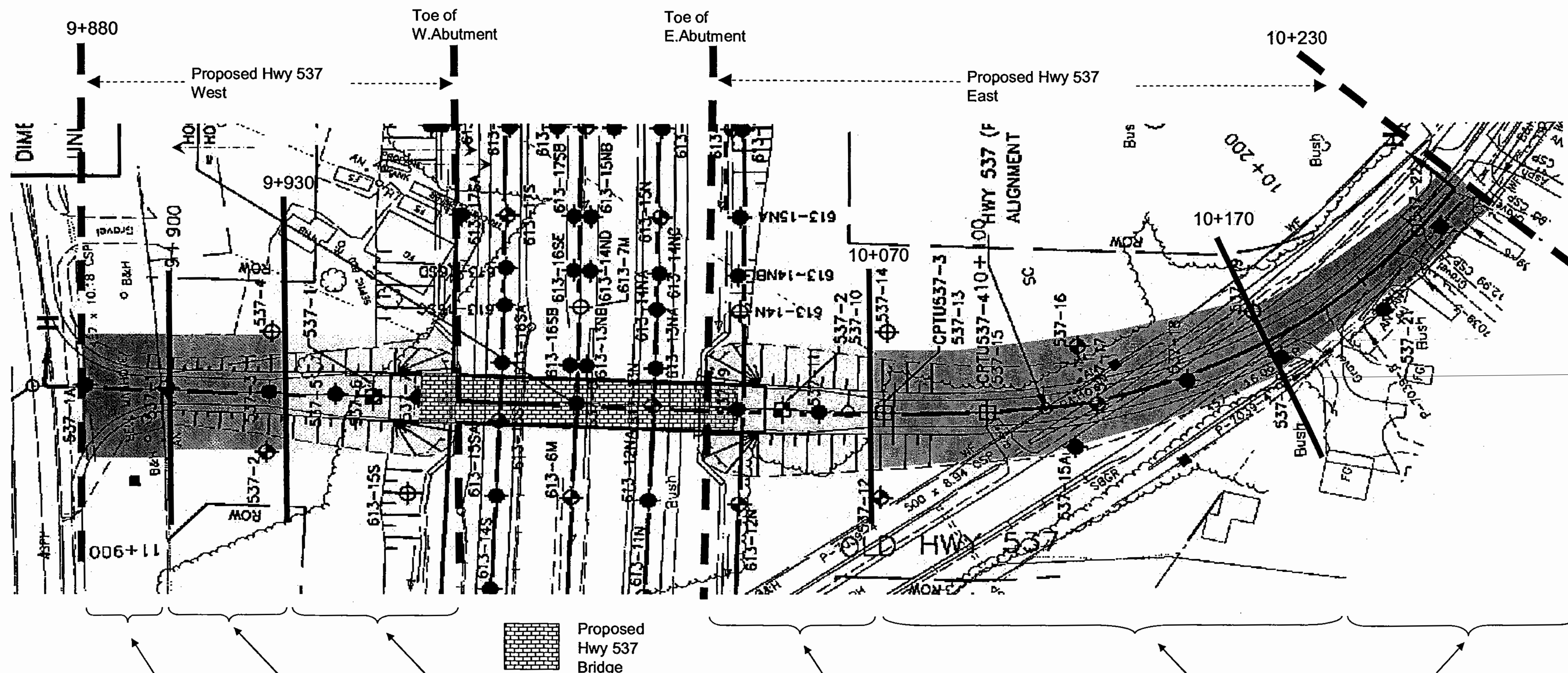
Existing Highway 537 Connection

Surcharge			2.0m	1.0m	No Surcharge
Material of Main Embankment			Rockfill (1)	Granular Fill	Granular Fill
Slope Flattening (Earth Fill) - 4H:1V Slope			Yes	N/R	N/R
Stabilizing Berms	NBL-East Slope	Height	N/R	N/R	N/R
		Width	N/R	N/R	N/R
	SBL-West Slope	Height	N/R	N/R	N/R
		Width	N/R	N/R	N/R
Wick drain spacing			1.5m	1.5m	N/R
Construction Stages	Stage 1		0 to top of surcharge	0 to top of surcharge	0 to top of pavement
	Stage 2		N/R	N/R	N/R
	Stage 3		N/R	N/R	N/R
Operation Constraint			N/R	No need to remove existing Hwy 537	N/R

Note: Embankment consists of rockfill to approximately 0.5m below the top of pavement

FIGURE 10.1

SWAMP 613 (Highway 537) - EMBANKMENT DESIGN RECOMMENDATIONS



Surcharge		No Surcharge	2.0m	No Surcharge	2.0m	2.0m	N/R
Material of Main Embankment		Rockfill (1)	Rockfill (1)	EPS	Rockfill (2)	Rockfill (1)	Rockfill (1)
Slope Flattening		N/R	N/R	N/R	N/R	N/R	N/R
Stabilizing Berms	Height	N/R	N/R	N/R	N/R	N/R	N/R
	Width	N/R	N/R	N/R	N/R	N/R	N/R
Wick drain spacing		N/R	1.5m	1.5m	1.5m	1.5m	N/R
Construction Stages	Stage 1	0 to top of pavement	0 to top of surcharge	0 to top of pavement	0 to top of surcharge	0 to top of surcharge	0 to top of pavement
	Stage 2	N/R	N/R	N/R	N/R	N/R	N/R
	Stage 3	N/R	N/R	N/R	N/R	N/R	N/R
Operation Constraint		N/R	N/R	Sta. 9+930 to 9+960 1.) EPS from base of topsoil stripping to 1m below top of pavement 2.) 1m of granular & pavement structure to top of pavement - Refer to Figure 10.3 for details of construction	10+040 to 10+065 1.) 3m of EPS replacement after removal of surcharge 2.) EPS to 1m below top of pavement 3.) 1m of granular & pavement structure to top of pavement 10+065 to 10+075 EPS (Thickness tapering from 3m to 0m) - Refer to Figure 10.3 for details of construction	N/R	N/R

Note: (1) Embankment consists of rockfill to approxmately 0.5m below the top of pavement
(2) Embankment consists of rockfill to underside of EPS and granular fill for replacement with EPS

FIGURE 10.2

SWAMP 613 (Highway 537) - DESIGN OF APPROACH EMBANKMENTS

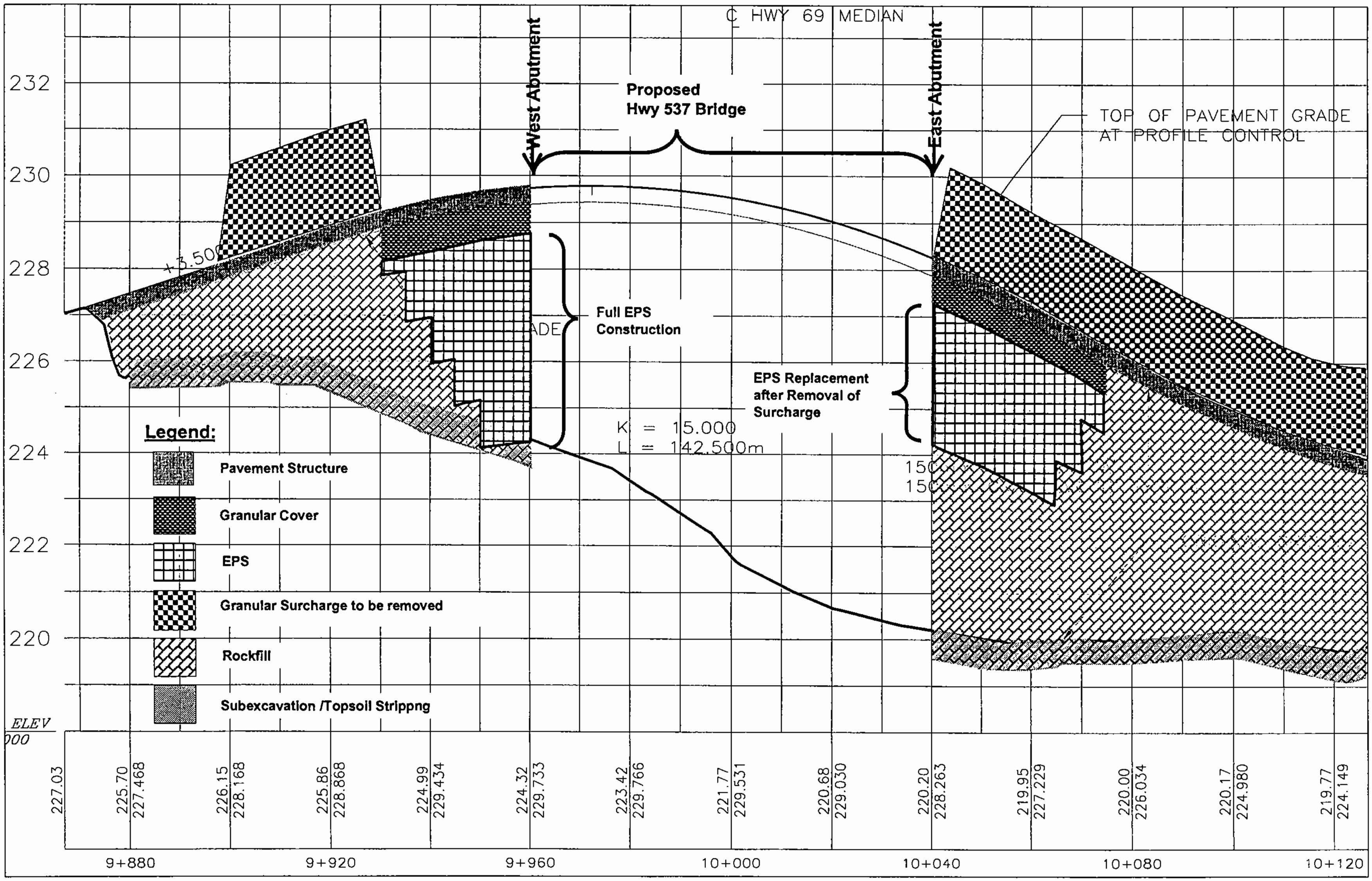


FIGURE 10.3

OEDOMETER TEST RESULTS - SUMMARY

Borehole	602-N1(TEL)	602-N1(TEL)	602-S1(TEL)	605-N1(TEL)	605-N1(TEL)	605-S1(TEL)	605-S1(TEL)	613-N1(TEL)	537-1(TEL)	537-2(TEL)
Sample	ST#1	ST#3	ST#1	ST#1	ST#2	ST#1	ST#2	ST#1	ST#3	ST#1
Depth (m)	3.8	10.8	9.1	6.5	11.0	5.0	9.4	5.0	14.0	6.6
Elevation (m)	228.5	221.5	223.7	227.3	222.8	228.8	224.4	213.8	210.6	213.5
Soil Type	CI	CI	CI	CI	CL-ML	CH	CL	CI	CL	CH
% Clay	44%	42%	59%	56%	27%	72%	28%	61%	50%	76%
W.C. (%)	27.1%	36.3%	53.8%	45.3%	29.2%	53.7%	34.0%	47.9%	39.5%	57.5%
Unit Weight (g) (kN/m^3)	19.49	18.52	16.75	17.22	19.37	16.7	18.68	17.76	16.94	16.5
Specific Gravity (G)	2.77	2.79	2.77	2.67	2.76	2.73	2.75	2.74	2.77	2.75
Initial Void Ratio	0.772	1.015	1.494	1.209	0.805	1.466	0.935	1.314	1.237	1.665
In situ effective vertical stress	26.5	78.6	68	35.7	71.1	27.7	63.6	72.2	223.2	94.2
Preconsolidation Pressure (p')	315	80	146	56	72	49	63	73	220	110
OCR	11.9	1.0	2.1	1.6	1.0	1.8	1.0	1.0	1.0	1.2
Compression Index (Cc)	0.165	0.328	0.58	0.37	0.155	0.685	0.2	0.5	0.565	0.88
Recompression Index (Cr)	0.035	0.037	0.09	0.061	0.023	0.11	0.037	0.058	0.09	0.11
Secondary Compression Index ($C\alpha$)	0.00057	N/A	N/A	N/A	N/A	0.00552	0.0034	0.00525	0.0063	0.0121
Cv at insitu (m^2/yr)	63	22	9.5	13.6	42.5	3.2	63	9.5	22	16.4

TABLE 5.4

TRIAXIAL TEST RESULTS - SUMMARY

Borehole	537-1(TEL)	537-2(TEL)
Sample	ST#1	ST#1
Depth (m)	7.3	6.4
Elevation (m)	217.3	213.7
Soil Type	CI	CH
% Clay	50%	76%
W.C. (%)	46.4%	57.5%
Unit Weight (g) (kN/m3)	17.4	16.5
In situ effective vertical stress (kPa)	143	93.1
Cohesion (c') (kPa)	0	0
Friction Angle (ϕ') (°)	29	31

TABLE 5.5

EMBANKMENT CONFIGURATIONS AND MATERIALS

Initial Configuration (Prior to Removal of Surcharge)		Final Configuration (After Removal of Surcharge)	
A	Rock fill embankment and granular surcharge	B	Rock fill embankment
C	Granular fill embankment with surcharge	D	Granular fill embankment
A	Rock fill embankment and granular surcharge	E	EPS fill with 1.5m granular envelope
E	EPS fill with 1.5m granular envelope (no surcharge)	E	EPS fill with 1.5m granular envelope

TABLE 7.1

HIGHWAY 69 - FOUR LANING - SWAMP 602
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS

Location		Cross-Section	Soil Layer	East Toe EL of top of Layer (m)	East Toe Thickness (m)	Centreline EL of top of Layer (m)	Centreline Thickness (m)	West Toe EL of top of Layer (m)	West Toe Thickness (m)	Unit Weight (kN/m3)	Undrained Shear Strength Cohesion (kPa)	Undrained Shear Strength Friction Angle (deg)	Drained Shear Strength Cohesion (kPa)	Drained Shear Strength Friction Angle (deg)	Poisson's Ratio	Young's Modulus (MPa)	Compression Ratio Cc/(1+eo)	Compression Ratio Cr/(1+eo)	Over Consolidation Ratio (OCR)	Coeff. Of Consolidation (m2/y) Cv O.C.	Cv N.C.	Ch O.C.	Ch N.C.	Secondary Compression Ratio Ca/(1+eo) From	To
			GS - Topsoil/Peat Replac/ Fill	233.1	0.2	232.5	1.4	231.1	0.1	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	SBL	12+660	Silt - ML	232.9	1.0	231.1	2.0	231.0	1.1	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Embankment Height	Silty Clay Crust	231.9	3.4	229.1	2.1	229.9	2.9	18	80	—	—	28	0.49	22	0.18	0.027	7	50	38	120	90	0.0018	0.0072
		= 2.0m	Silty Clay Firm/Stiff	228.5	1.6	227.0	1.9	227.0	2.1	17.5	50	—	—	28	0.49	18	0.12	0.018	5	60	45	150	110	0.0012	0.0048
			Silt - ML	226.9	5.7	225.1	6.7	224.9	7.2	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
SOUTH			Bedrock	221.2	-	218.4	-	217.7	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SWAMP			GS - Topsoil/Peat Replac/ Fill	230.4	0.3	231.1	0.0	231.0	0.3	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
		12+680	Silt - ML	-	-	231.1	0.9	230.7	0.8	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		(Culvert #3)	Silty Clay Crust	230.1	3.1	230.2	2.1	229.9	1.5	18	80	—	—	28	0.49	22	0.18	0.027	7	50	38	120	90	0.0018	0.0072
			Silty Clay Firm/Stiff	-	-	228.1	2.3	228.4	2.4	17.5	50	—	—	28	0.49	18	0.12	0.018	5	60	45	150	110	0.0012	0.0048
		Embankment Height	Silt - ML	227.0	5.1	225.8	8.9	226.0	2.0	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		= 4.8m	Bedrock	221.9	-	216.9	-	224.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			GS - Topsoil/Peat Replac/ Fill	230.3	1.2	230.3	0.2	230.4	0.1	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	NBL	12+680	Silt - ML	-	-	230.1	1.0	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		(Culvert #3)	Silty Clay Crust	229.1	3.3	229.1	1.6	230.3	3.3	18	80	—	—	28	0.49	22	0.18	0.027	7	50	38	120	90	0.0018	0.0072
			Silty Clay Firm/Stiff	-	-	227.5	0.7	227.0	2.0	17.5	50	—	—	28	0.49	18	0.12	0.018	5	60	45	150	110	0.0012	0.0048
		Embankment Height	Silt - ML	225.8	2.7	226.8	5.0	-	-	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		= 4.8m	Bedrock	223.1	-	221.8	-	225.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			GS - Topsoil/Peat Replac/ Fill	230.3	1.2	230.7	0.1	230.4	0.1	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
		12+700	Silty Clay Crust	229.1	3.3	230.6	2.6	230.3	3.3	18	80	—	—	28	0.49	22	0.18	0.027	7	50	38	120	90	0.0018	0.0072
			Silty Clay Firm/Stiff	-	-	228.0	4.3	227.0	2.0	17.5	50	—	—		0.49	18	0.12	0.018	5	60	45	150	110	0.0012	0.0048
		Embankment Height	Silt - ML	225.8	2.7	-	-	-	-	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		= 3.4m	Bedrock	223.1	-	223.7	-	225.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			GS - Topsoil/Peat Replac/ Fill	233.3	1.8	233.3	0.2	233.4	0.3	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	SBL	12+890	Silt - ML	-	-	-	-	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		(Culvert #4)	Silty Clay Crust	231.5	4.6	233.1	5.9	233.1	5.8	18.5	100	—	—	28	0.49	25	0.10	0.015	10	60	45	150	110	0.0010	0.0040
			Silty Clay Firm/Stiff (Top)	226.9	3.4	227.2	3.7	227.3	3.8	17	35	—	—	28	0.49	14	0.25	0.038	3	10	8	25	20	0.0025	0.0100
		Embankment Height	Silty Clay Firm/Stiff (Bot.)	223.5	3.0	223.5	2.1	223.5	1.1	17.5	35	—	—	28	0.49	16	0.15	0.023	2	25	20	60	45	0.0015	0.0060
		= 3.2m	Silt - ML	220.5	6.2	221.4	5.4	222.4	3.3	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
NORTH			Bedrock	214.3	-	216.0	-	219.1	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SWAMP			GS - Topsoil/Peat Replac/ Fill	233.2	0.9	232.9	0.2	232.6	0.2	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	NBL	12+890	Silt - ML	-	-	232.7	2.5	232.4	2.2	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		(Culvert #4)	Silty Clay Crust	232.3	5.3	230.2	2.2	230.2	3.4	18.5	100	—	—	28	0.49	25	0.10	0.015	10	60	45	150	110	0.0010	0.0040
			Silty Clay Firm/Stiff (Top)	227.0	3.5	228.0	4.5	226.8	3.3	17	35	—	—	28	0.49	14	0.25	0.038	3	10	8	25	20	0.0025	0.0100
		Embankment Height	Silty Clay Firm/Stiff (Bot.)	223.5	2.9	223.5	2.3	223.5	5.3	17.5	35	—	—	28	0.49	16	0.15	0.023	2	25	20	60	45	0.0015	0.0060
		= 3.3m	Silt - ML	220.6	6.0	221.2	10.2	218.2	6.3	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
			Bedrock	214.6	-	211.1	-	211.9	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 8.1

SWAMP 602 - SETTLEMENTS DUE TO PRIMARY CONSOLIDATION

				No Wick Drains		With Wick Drains
Cross-Section	Location	Embankment Configuration	Embankment Height (m)	Ultimate Settlement Due to Primary Consolidation (mm)	Time required for >98% Consolidation for Intermediate Stage (months)	Wick Drain Spacing Required for 98 % consolidation in less than 6 months (before removal of surcharge)
2m Surcharge						
South Swamp						
12+660	SBL	A	4.0	35	1.5	-
	CL	B	2.0	25		
12+680 (Culvert #3)	SBL	C	6.8	146	2.5	-
	CL	D	4.8	136		
	SBL	C	6.8	0	0	-
	ET	D	4.8	-1		
	SBL	C	6.8	1	0.5	-
	WT	D	4.8	0		
	NBL	C	6.8	44	0.5	-
	CL	D	4.8	38		
	NBL	C	6.8	1	0.5	-
	ET	D	4.8	-1		
	NBL	C	6.8	1	0.5	-
	WT	D	4.8	-2		
12+700	NBL	A	5.4	234	3.5	-
	CL	B	3.4	213		
North Swamp						
12+890 (Culvert #4)	SBL	C	5.2	152	18	2.7
	CL	D	3.2	130		
	SBL	C	5.2	11	12	2.7
	ET	D	3.2	6		
	SBL	C	5.2	11	18	2.7
	WT	D	3.2	5		
	NBL	C	5.3	141	36	2.1
	CL	D	3.3	123		
	NBL	C	5.3	13	18	2.1
	ET	D	3.3	7		
	NBL	C	5.3	15	20	2.1
	WT	D	3.3	9		
3.5m Surcharge						
South Swamp						
12+660	SBL	A	5.5	43	1.5	-
	CL	B	2.0	29		
12+680 (Culvert #3)	SBL	C	8.3	192	2.5	-
	CL	D	4.8	179		
	SBL	C	8.3	0	0	-
	ET	D	4.8	-4		
	SBL	C	8.3	0	0	-
	WT	D	4.8	-1		
	NBL	C	8.3	60	1	-
	CL	D	4.8	53		
	NBL	C	8.3	1	1	-
	ET	D	4.8	-2		
	NBL	C	8.3	1	0.5	-
	WT	D	4.8	-6		
12+700	NBL	A	6.9	296	4	-
	CL	B	3.4	269		
North Swamp						
12+890 (Culvert #4)	SBL	C	6.7	195	20	2.7
	CL	D	3.2	168		
	SBL	C	6.7	11	20	2.7
	ET	D	3.2	2		
	SBL	C	6.7	10	14	2.7
	WT	D	3.2	0		
	NBL	C	6.8	199	36	2.1
	CL	D	3.3	177		
	NBL	C	6.8	12	14	2.1
	ET	D	3.3	1		
	NBL	C	6.8	15	36	2.1
	WT	D	3.3	4		
5m Surcharge						
North Swamp						
12+890 (Culvert #4)	SBL	C	8.2	241	25	2.7
	CL	D	3.2	214		
	SBL	C	8.2	12	25	2.7
	ET	D	3.2	2		
	SBL	C	8.2	10	19	2.7
	WT	D	3.2	0		
	NBL	C	8.3	257	60	2.1
	CL	D	3.3	234		
	NBL	C	8.3	12	19	2.1
	ET	D	3.3	1		
	NBL	C	8.3	15	25	2.1
	WT	D	3.3	3		

Notes: (*): Due to primary consolidation only

WT West Toe
CL Centreline
ET East Toe
A Rock Fill Embankment with Surcharge
B Rock Fill Embankment without Surcharge (embankment to top of pavement)
C Granular Fill Embankment with Surcharge
D Granular Fill Embankment without Surcharge (embankment to top of pavement)

TABLE 8.2

SWAMP 602 - SETTLEMENTS DUE TO SECONDARY CONSOLIDATION

Area	Cross-Section	Location	Embankment Configurations		Post-Construction Settlements (mm)				
					Time after completion of Primary Consolidation				
			Intermediate	Final	1 year	3 years	6 years	10 years	20 years
2m Surcharge									
SOUTH SWAMP	12+660	SBL	A	B	0	0	0	0	0
	12+680 (Culvert #3)	SBL WT	C	D	0	0	0	0	0
		SBL CL	C	D	1	3	5	6	9
		SBL ET	C	D	0	0	0	0	0
		NBL WT	C	D	0	0	0	0	0
		NBL CL	C	D	0	0	1	2	2
		NBL ET	C	D	0	0	0	0	0
	12+700	NBL	A	B	0	1	2	3	5
NORTH SWAMP	12+890 (Culvert #4)	SBL WT	C	D	0	0	0	0	0
		SBL CL	C	D	3	6	8	10	14
		SBL ET	C	D	0	0	0	0	1
		NBL WT	C	D	0	0	0	0	1
		NBL CL	C	D	3	8	13	17	23
		NBL ET	C	D	0	0	0	0	1
3.5m Surcharge									
SOUTH SWAMP	12+660	SBL	A	B	0	0	0	0	0
	12+680 (Culvert #3)	SBL WT	C	D	0	0	0	0	0
		SBL CL	C	D	0	2	4	6	9
		SBL ET	C	D	0	0	0	0	0
		NBL WT	C	D	0	0	0	0	0
		NBL CL	C	D	0	0	1	2	2
		NBL ET	C	D	0	0	0	0	0
	12+700	NBL	A	B	0	1	2	3	5
NORTH SWAMP	12+890 (Culvert #4)	SBL WT	C	D	0	0	0	0	0
		SBL CL	C	D	1	4	7	10	14
		SBL ET	C	D	0	0	0	0	0
		NBL WT	C	D	0	0	0	0	0
		NBL CL	C	D	2	6	10	14	20
		NBL ET	C	D	0	0	0	0	0
5m Surcharge									
NORTH SWAMP	12+890 (Culvert #4)	SBL WT	C	D	0	0	0	0	0
		SBL CL	C	D	0	3	6	9	13
		SBL ET	C	D	0	0	0	0	0
		NBL WT	C	D	0	0	0	0	0
		NBL CL	C	D	1	5	8	12	18
		NBL ET	C	D	0	0	0	0	0

Notes:

Notes:	WT	West Toe
	WS	West Shoulder
	CL	Centreline
	ES	East Shoulder
	A	Rock Fill Embankment with Surcharge
	B	Rock Fill Embankment after removal of Surcharge (embankment to top of pavement)
	C	Granular Fill Embankment with Surcharge
	D	Granular Fill Embankment after removal of Surcharge (embankment to top of pavement)

TABLE 8.3

Swamp 602 - HWY 69 - DESIGN ALTERNATIVES, APPROXIMATE CONSTRUCTION COSTS AND RISK ASSESSMENT

Swamp	Location	Station	Construction Stages to T.O.S.	Wick Drain Spacing (i) (m)	Waiting Period (vi) (week) U=90% (vii)	Waiting Period (vi) (week) U=98% (viii)	Anticipated Total Construction Time before Removal of Surcharge (ix) (week)	Surcharge Thickness (m)	EPS (Y/N)	Slope Flattening (Y/N)	Stabilizing Berm (Y/N)	Long Term Settlement (mm)	Cost ($)	Total Cost ($)	Risk Assessment	Note
602 (Hwy 69)	SBL	12+620 to 12+720 (South Swamp)	1	N/R	N/R (1 stage)	12 - 14	17 - 19	2m	N	N	N	<25	$139,395	$287,030	LOW	
	NBL								N	N	N	<25	$147,635			
	SBL		1	1m (x)	N/R (1 stage)	1 - 3	6 - 8	2m	N	N	N	<25	$941,460	$1,865,440	LOW	2m Surcharge (w/ wick drain installation+pre-augering)
	NBL								N	N	N	<25	$923,980			
	SBL		1	1.5m (x)	N/R (1 stage)	3 - 5	8 - 10	2m	N	N	N	<25	$564,758	$1,119,950	LOW-MEDIUM	2m Surcharge (w/ wick drain installation+pre-augering)
	NBL								N	N	N	<25	$555,193			
	SBL		1	2m (x)	N/R (1 stage)	7 - 9	12- 14	2m	N	N	N	<25	$432,912	$859,029	MEDIUM	2m Surcharge (w/ wick drain installation+pre-augering)
	NBL								N	N	N	<25	$426,117			
	SBL	12+800 to 12+970 (North Swamp)	1	1m (x)	N/R (1 stage)	1 - 3	6 - 8	2m	N	N	N	<25	$680,666	$1,349,332	LOW	2m Surcharge (w/ wick drain installation+vibratory equipment)
	NBL								N	N	N	<25	$668,666			
	SBL		1	1.5m (x)	N/R (1 stage)	3 - 5	8 - 10	2m	N	N	N	<25	$448,849	$890,569	LOW-MEDIUM	2m Surcharge (w/ wick drain installation+vibratory equipment)
	NBL								N	N	N	<25	$441,719			
	SBL		1	2m (x)	N/R (1 stage)	7 - 9	12- 14	2m	N	N	N	<25	$367,713	$730,001	MEDIUM	2m Surcharge (w/ wick drain installation+vibratory equipment)
	NBL								N	N	N	<25	$362,288			
	SBL		1	N/R	N/R (1 stage)	24 - 26	29- 31	3.5m	N	N	N	<25	$305,991	$608,418	MEDIUM - HIGH	3.5m Surcharge (No wick drains)
	NBL								N	N	N	<25	$302,427			
	SBL		1	N/R	N/R (1 stage)	16 - 18	21- 23	5m	N	N	N	<25	$332,391	$660,888	MEDIUM - HIGH	5m Surcharge (No wick drains)
	NBL								N	N	N	<25	$328,497			

Note
- (i) The wick drain installation includes the construction of drainage blanket (subexcavation & material), vibratory equipment and pre-augering (if required)
- (vi) Time required before removal of surcharge. This is a prediction only. The actual time required will depend on the field monitoring data
- (vii) Waiting period between construction stages (90% of primary consolidation completed between stages)
- (viii) Waiting period after placement of surcharge and before removal of surcharge (98% of primary consolidation completed of 2m Surcharge)
- (ix) Assumed construction time: 5 weeks
- (x) Wick Drain Installation to 5m beyond the TOE of ROCKFILL EMBANKMENT
- N/R Not required
- T.O.S. Top of Surcharge

Assumption:
1.)The Total Cost includes all material and construction costs before pavement construction (i.e. Rockfill as embankment material, Granular B Type II as surcharge material and backfill material in the vicinity of culverts)
2.) The Total Cost does not include embankment fill material placed to compensate for embankment settlement
3.) The Total Cost does not include mobilization cost of construction equipment
4.) The Total Cost does not include construction costs in cut section
5.) Wick Drain Installation cost = $5/m
6.) Pre-augering cost = $8/m
7.) Vibratory Equipement cost = $3/m

TABLE 8.4

WICK DRAIN TIP ELEVATIONS
SWAMP 602 (Hwy 69) - North Swamp

Station	Wick Drain Tip Elevations (m) *				
	SBL-West Toe	SBL-Centreline	Median	NBL-Centreline	NBL-East Toe
10+820	226.0	225.0	225.0	229.0	230.0
10+830	223.0	224.0	223.0	224.0	226.0
10+840	221.0	220.5	219.0	220.5	220.0
10+850	220.5	219.0	220.5	220.5	221.5
10+860	220.0	221.0	220.0	220.0	221.5
10+870	220.5	221.5	220.5	219.0	221.5
10+880	221.0	219.5	222.0	219.0	222.0
10+890	221.0	221.5	223.0	219.5	222.0
10+900	221.0	224.5	223.0	220.0	222.5
10+910	225.0	225.5	224.0	222.0	223.0
10+920	226.0	227.0	228.0	225.0	224.0
10+930	228.0	228.0	229.0	228.0	226.0
10+940	228.5	228.5	229.5	229.0	228.0

Note:

* The anticipated wick drain tip elevations above are interpreted from the available borehole data. It has been assumed that the wick drains will penetrate 1m to 2m in the deposit underlying the clay deposit or that the wick drains will be terminated in bedrock, where bedrock underlies the clay. The elevation of wick drains between or beyond the the reference points above should be obtained by interpolation or extrapolation of the data, respectively.

TABLE 8.5

HIGHWAY 69 - FOUR LANING - SWAMP 605
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS

Cross-Section	Location	Soil Layer	East Toe		Centreline		West Toe		Unit Weight (kN/m3)	Undrained Shear Strength		Drained Shear Strength		Poisson's Ratio	Young's Modulus (MPa)	Compression Ratio		Over Consolidation Ratio (OCR)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio Ca/(1+eo)	
			EL of top of Layer (m)	Thickness (m)	EL of top of Layer (m)	Thickness (m)	EL of top of Layer (m)	Thickness (m)		Cohesion (kPa)	Friction Angle (deg)	Cohesion (kPa)	Friction Angle (deg)			Cc/(1+eo)	Cr/(1+eo)		Cv O.C.	Cv N.C.	Ch O.C.	Ch N.C.	From	To
		GS - Topsoil/Peat	234.0	1.8	234.0	1.8	233.9	2.2	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
14+290	SBL	Silt - ML	232.2	2.8	232.2	2.7	231.7	2.2	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm (Top)	229.4	2.4	229.5	2.5	229.5	2.5	17	22	—	—	28	0.49	9	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Embankment	Silt - Clay Soft/Firm (Bot.)	227.0	0.6	227.0	2.0	227.0	5.1	17.5	25	—	—	28	0.49	10	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
	Height	Silt - Clay Firm/Stiff	-	-	225.0	2.0	-	-	18	35	—	—	28	0.49	14	0.10	0.015	1.1	20	15	50	37.5	0.0010	0.0040
	= 7.0m	Silt/Sand	226.4	3.2	223.0	0.6	-	-	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	223.2	-	222.4	-	221.9	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		GS - Topsoil/Peat	234.0	2.0	234.0	0.1	234.0	1.8	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	NBL	Silt - ML	232.0	1.5	233.9	3.7	232.2	2.8	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm (Top)	230.5	0.6	230.2	2.8	229.4	2.4	17	22	—	—	28	0.49	9	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Embankment	Silt - Clay Soft/Firm (Bot.)	-	-	-	-	227.0	0.6	17.5	25	—	—	28	0.49	10	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
	Height	Silt - Clay Firm/Stiff	-	-	-	-	-	-	18	35	—	—	28	0.49	14	0.10	0.015	1.1	20	15	50	37.5	0.0010	0.0040
	= 7.0m	Silt/Sand	-	-	-	-	226.4	3.2	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	229.9	-	227.4	-	223.2	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		GS - Topsoil/Peat	233.8	2.1	233.8	1.9	233.5	2.3	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
14+330	SBL	Silt - ML	-	-	-	-	231.2	1.7	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm (Top)	231.7	4.7	231.9	4.9	229.5	2.5	17	22	—	—	28	0.49	9	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Embankment	Silt - Clay Soft/Firm (Mid.)	227.0	3.0	227.0	3.0	227.0	3.0	17.5	25	—	—	28	0.49	10	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
	Height	Silt - Clay Soft/Firm (Bot.)	224.0	4.4	224.0	2.3	224.0	2.1	18	35	—	—	28	0.49	14	0.10	0.015	1.1	20	15	50	37.5	0.0010	0.0040
	= 7.3m	Silt/Sand	219.6	4.6	221.7	5.6	221.9	2.3	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	215.0	-	216.1	-	219.6	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		GS - Topsoil/Peat	234.0	2.0	233.9	2.8	233.8	2.1	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	NBL	Silt - ML	232.0	1.5	-	-	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm (Top)	230.5	3.5	231.1	4.1	231.7	4.7	17	22	—	—	28	0.49	9	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Embankment	Silt - Clay Soft/Firm (Mid.)	227.0	3.0	227.0	3.0	227.0	3.0	17.5	25	—	—	28	0.49	10	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
	Height	Silt - Clay Soft/Firm (Bot.)	224.0	1.9	224.0	2.1	224.0	4.4	18	35	—	—	28	0.49	14	0.10	0.015	1.1	20	15	50	37.5	0.0010	0.0040
	= 7.3m	Silt/Sand	222.1	1.1	221.9	1.7	219.6	4.6	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	221.0	-	220.2	-	215.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		GS - Topsoil/Peat	234.1	3.0	233.9	1.8	235.6	0.0	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
14+390	SBL	Silt - ML	-	-	232.1	1.2	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm (Top)	231.1	1.1	230.9	0.9	-	-	17.5	35	—	—	28	0.49	14	0.15	0.023	5	8	6	20	15	0.0015	0.0060
	Embankment	Silt - Clay Soft/Firm (Mid.)	230.0	2.0	230.0	1.6	-	-	17	20	—	—	28	0.49	8	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Height	Silt - Clay Soft/Firm (Bot.)	228.0	2.0	-	-	-	-	17.5	25	—	—	28	0.49	10	0.18	0.027	1.1	8	6	20	15	0.0018	0.0072
	= 8.0m	Silt - Clay Soft/Firm (Base)	226.0	2.4	-	-	-	-	17.5	30	—	—	28	0.49	12	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
		Silt - Clay Firm/Stiff	-	-	-	-	-	-	17.5	45	—	—	28	0.49	18	0.10	0.015	1.1	25	19	60	45	0.0010	0.0040
		Silt/Sand	-	-	-	-	-	-	20		—		32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	223.6	-	228.4	-	235.6	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		GS - Topsoil/Peat	233.9	2.3	233.8	3.3	234.1	3.0	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	NBL	Silt - ML	-	-	-	-	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm (Top)	231.6	1.6	230.5	0.5	231.1	1.1	17.5	35	—	—	28	0.49	14	0.15	0.023	5	8	6	20	15	0.0015	0.0060
	Embankment	Silt - Clay Soft/Firm (Mid.)	230.0	2.0	230.0	2.0	230.0	2.0	17	20	—	—	28	0.49	8	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Height	Silt - Clay Soft/Firm (Bot.)	228.0	2.0	228.0	2.0	228.0	2.0	17.5	25	—	—	28	0.49	10	0.18	0.027	1.1	8	6	20	15	0.0018	0.0072
	= 9.0m	Silt - Clay Soft/Firm (Base)	226.0	3.0	226.0	3.0	226.0	2.4	17.5	30	—	—	28	0.49	12	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
		Silt - Clay Firm/Stiff	223.0	3.8	223.0	2.6	-	-	17.5	45	—	—	28	0.49	18	0.10	0.015	1.1	25	19	60	45	0.0010	0.0040
		Silt/Sand	219.2	12.4	220.4	2.4	-	-	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	206.8	-	218.0	-	223.6	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		Station at point along culvert	14+420		14+400		14+360																	
		GS - Topsoil/Peat	233.9	0.0	233.9	0.4	233.8	1.5	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
Culvert #7	SBL	Silt - ML	-	-	-	-	232.3	1.7	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm	-	-	233.5	2.5	230.6	1.5	17.5	20	—	—	28	0.49	8	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Embankment	Silt - Clay Firm/Stiff	-	-	231.0	0.6	-	-	17.5	30	—	—	28	0.49	12	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
	Height	Silt/Sand	-	-	-	-	-	-	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
	= 8.0m	Bedrock	233.9	-	230.4	-	229.1	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		Station at point along culvert	14+494		14+457		14+420																	
		GS - Topsoil/Peat	236.1	0.4	233.9	2.1	233.9	0.0	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	NBL	Silt - ML	-	-	-	-	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
		Silt - Clay Soft/Firm	-	-	231.8	0.9	-	-	17.5	20	—	—	28	0.49	8	0.25	0.038	2	8	6	20	15	0.0025	0.0100
	Embankment	Silt - Clay Firm/Stiff	235.7	0.7	-	-	-	-	17.5	30	—	—	28	0.49	12	0.15	0.023	1.1	15	11	40	30	0.0015	0.0060
	Height	Silt/Sand	-	-	230.9	0.5	-	-	20	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
	= 8.0m	Bedrock	235.0	-	230.4	-	233.9	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 9.1

SWAMP 605 - SETTLEMENTS DUE TO PRIMARY CONSOLIDATION

Cross-Section	Location	Embankment Configuration	Embankment Height (m)	No Wick Drains: Ultimate Settlement Due to Primary Consolidation (mm)	No Wick Drains: Time required for >90% Consolidation for Intermediate Stage (months)	With Wick Drains: Wick Drain Spacing Required for 98 % consolidation (U%) in less than 6 months (before removal of surcharge)
2m Surcharge						
14+290	SBL	A	9.0	470	21	1.8
	CL	B	7.0	460		
	NBL	A	9.0	293	10	1.8
	CL	B	7.0	286		
14+330	SBL	A	9.3	1008	40	1.8
	CL	B	7.3	993		
	NBL	A	9.3	798	40	1.8
	CL	B	7.3	783		
14+390	SBL	A	10.0	256	8	1.8
	CL	B	8.0	252		
	NBL	A	10.0	747	40	1.8
	CL	B	8.0	738		
Culvert #7	SBL	C	10.0	170	3	N/R
	14+360 WT	D	8.0	170		
	SBL	C	10.0	359	21	1.8
	14+383 WS	D	8.0	357		
	SBL	C	10.0	721	18	1.8
	14+400 CL	D	8.0	714		
	NBL	C	11.0	173	1	N/R
	14+457 CL	D	9.0	171		
	NBL	C	11.0	510	20	2.1
	14+472 ES	D	9.0	508		
3.5m Surcharge						
14+290	SBL	A	10.5	508	21	1.8
	CL	B	7.0	494		
	NBL	A	10.5	317	10	1.8
	CL	B	7.0	308		
14+330	SBL	A	10.8	1083	40	1.8
	CL	B	7.3	1061		
	NBL	A	10.8	867	40	1.8
	CL	B	7.3	848		
14+390	SBL	A	11.5	275	8	1.8
	CL	B	8.0	260		
	NBL	A	11.5	806	40	1.8
	CL	B	8.0	793		
Culvert #7	SBL	C	11.5	160	8	N/R
	14+360 WT	D	8.0	159		
	SBL	C	11.5	386	21	1.8
	14+383 WS	D	8.0	383		
	SBL	C	11.5	749	18	1.8
	14+400 CL	D	8.0	740		
	NBL	C	12.5	181	1	N/R
	14+457 CL	D	9.0	178		
	NBL	C	12.5	537	20	2.1
	14+472 ES	D	9.0	533		

Notes: (*): Due to primary consolidation only
- WT West Toe
- WS West Shoulder
- CL Centreline
- ES East Shoulder
- A Rock Fill Embankment with Surcharge
- B Rock Fill Embankment after removal of Surcharge (embankment to top of pavement)
- C Granular Fill Embankment with Surcharge
- D Granular Fill Embankment after removal of Surcharge (embankment to top of pavement)

TABLE 9.2

SWAMP 605 - SETTLEMENTS DUE TO SECONDARY CONSOLIDATION

Cross-Section	Location	Embankment Configurations		Post-Construction Settlements (mm) Time after completion of Primary Consolidation				
		Intermediate	Final	1 year	3 years	6 years	10 years	20 years
2m Surcharge								
12+290	SBL	A	B	8	16	22	27	35
	NBL	A	B	4	8	12	15	19
12+330	SBL	A	B	15	29	40	49	61
	NBL	A	B	14	26	36	44	55
12+390	SBL	A	B	5	9	12	14	18
	NBL	A	B	19	33	44	52	64
Culvert #7	SBL 14+360 WT	C	D	5	8	11	12	15
	SBL 14+383 WS	C	D	9	16	21	25	30
	SBL 14+400 CL	C	D	4	8	12	15	19
	NBL 14+457 CL	C	D	2	3	5	6	7
	NBL 14+472 ES	C	D	9	16	21	25	30
3.5m Surcharge								
12+290	SBL	A	B	2	7	11	15	21
	NBL	A	B	1	3	6	8	12
12+330	SBL	A	B	6	15	23	31	41
	NBL	A	B	6	14	22	28	38
12+390	SBL	A	B	5	9	12	14	18
	NBL	A	B	12	24	33	41	52
Culvert #7	SBL 14+360 WT	C	D	5	8	11	12	15
	SBL 14+383 WS	C	D	9	16	21	25	30
	SBL 14+400 CL	C	D	1	3	6	8	12
	NBL 14+457 CL	C	D	1	2	2	3	5
	NBL 14+472 ES	C	D	9	16	21	25	30

Notes:

WT	West Toe
WS	West Shoulder
CL	Centreline
ES	East Shoulder
A	Rock Fill Embankment with Surcharge
B	Rock Fill Embankment after removal of Surcharge (embankment to top of pavement)
C	Granular Fill Embankment with Surcharge
D	Granular Fill Embankment after removal of Surcharge (embankment to top of pavement)

TABLE 9.3

Swamp 605 - HWY 69 - DESIGN ALTERNATIVES, APPROXIMATE CONSTRUCTION COSTS AND RISK ASSESSMENT

Swamp	Location	Station	Construction Stages to T.O.S.	Wick Drain Spacing (i) (m)	Waiting Period (vi) (week)		Anticipated Total Construction Time before Removal of Surcharge (ix) (week)	Surcharge Thickness (m)	EPS (Y/N)	Slope Flattening (Y/N)	Stabilizing Berm		Long Term Settlement (mm)	Cost ($)	Total Cost ($)	Risk Assessment	Note
					U=90% (vii)	U=98% (viii)					Height (m)	Width (m)					
605 (Hwy 69) (v)	SBL	14+230 to 14+390	3 (x)	1m (xii)	1 - 4	4 - 6	13 - 21	2m	N	Y (xiii)	4m	4m	<65	$1,824,748	$4,137,723	LOW	2m Surcharge (w/ wick drain installation)
	NBL	14+250 to 14+440							N	Y (xiii)	4m	4m	<65	$2,312,976			
	SBL	14+230 to 14+390	3 (x)	1.5m (xii)	3 - 6	9 - 11	22 - 30	2m	N	Y (xiii)	4m	4m	<65	$1,505,779	$3,392,809	LOW - MEDIUM	2m Surcharge (w/ wick drain installation)
	NBL	14+250 to 14+440							N	Y (xiii)	4m	4m	<65	$1,887,030			
	SBL	14+230 to 14+390	3 (x)	2m (xii)	8 - 11	16 - 18	39 - 47	2m	N	Y (xiii)	4m	4m	<65	$1,394,140	$3,132,089	MEDIUM	2m Surcharge (w/ wick drain installation)
	NBL	14+250 to 14+440							N	Y (xiii)	4m	4m	<65	$1,737,949			
	SBL	14+230 to 14+390	3 (xi)	1m (xii)	1 - 4	4 - 6	13 - 21	3.5m	N	Y (xiv)	4m	8m	<50	$1,974,648	$4,468,575	LOW	3.5m Surcharge (w/ wick drain installation)
	NBL	14+250 to 14+440							N	Y (xiv)	4m	8m	<50	$2,493,927			
	SBL	14+230 to 14+390	3 (xi)	1.5m (xii)	3 - 6	9 - 11	22 - 30	3.5m	N	Y (xiv)	4m	8m	<50	$1,637,332	$3,681,128	LOW - MEDIUM	3.5m Surcharge (w/ wick drain installation)
	NBL	14+250 to 14+440							N	Y (xiv)	4m	8m	<50	$2,043,796			
	SBL	14+230 to 14+390	3 (xi)	2m (xii)	8 - 11	16 - 18	39 - 47	3.5m	N	Y (xiv)	4m	8m	<50	$1,519,271	$3,405,521	MEDIUM	3.5m Surcharge (w/ wick drain installation)
	NBL	14+250 to 14+440							N	Y (xiv)	4m	8m	<50	$1,886,250			

Note

(i)	The wick drain installation includes the construction of drainage blanket (subexcavation & material)
(v)	The estimated costs do not include cost associated with the subexcavation and construction of Culvert #7
(vi)	Time required before removal of surcharge. This is a prediction only. The actual time required will depend on the field monitoring data
(vii)	Waiting period between construction stages (90% of primary consolidation completed between stages)
(viii)	Waiting period after placement of surcharge and before removal of surcharge (98% of primary consolidation completed)
(ix)	Assumed Time for Fill Placement: STAGE 1: 5 weeks; STAGE 2: 1 week; STAGE 3: 1 week
(x)	Construction Stages (2m Surchage): STAGE 1: 0m to 6.5m; STAGE 2: 6.5m to 8.5m; STAGE 3: 8.5m to T.O.S.
(xi)	Construction Stages (3.5m Surchage): STAGE 1: 0m to 7.5m; STAGE 2: 7.5m to 9.5m; STAGE 3: 9.5m to T.O.S.
(xii)	Wick Drain Installation to 5m beyond the TOE of SLOPE FLATTENING
(xiii)	
(xiv)	A 4m high and 8m wide berm is required on the NBL east slope and on the SBL west slope for slope stability
N/R	Not required
T.O.S.	Top of Surcharge

Assumption:
1.)The Total Cost includes all material and construction costs before pavement construction (i.e. Rockfill as embankment material, Granular B Type II as surcharge material and backfill material in the vicinity of culverts)
2.) The Total Cost does not include embankment fill material placed to compensate for embankment settlement
3.) The Total Cost does not include mobilization cost of construction equipment
4.) The Total Cost does not include construction costs in cut section
5.) Wick Drain Installation cost = $5/m
6.) Pre-augering cost = $8/m
7.) Vibratory Equipement cost = $3/m

TABLE 9.4

WICK DRAIN TIP ELEVATIONS
SWAMP 605 (Hwy 69)

	Wick Drain Tip Elevations (m) *				
Station	SBL-West Toe	SBL-Centreline	Median	NBL-Centreline	NBL-East Toe
14+240	228.0	N/R	N/R	N/R	N/R
14+250	226.0	N/R	N/R	N/R	N/R
14+260	226.0	227.0	N/R	N/R	N/R
14+270	225.0	226.0	226.0	N/R	N/R
14+280	223.5	225.0	225.0	225.0	N/R
14+290	222.5	223.0	224.5	223.0	N/R
14+300	221.0	222.5	223.0	222.0	225.0
14+310	220.5	221.0	222.0	221.5	225.0
14+320	221.5	220.5	221.0	221.0	223.5
14+330	223.0	220.0	220.5	221.0	221.0
14+340	223.5	220.0	220.0	221.0	220.0
14+350	224.0	220.0	219.0	220.0	219.0
14+360	227.5	226.0	220.0	219.0	218.5
14+370	228.0	228.5	221.0	219.0	218.0
14+380	(**)	227.5	221.5	219.5	218.0
14+390	(**)	228.0	223.5	221.0	218.5
14+400	(**)	230.0	223.0	223.0	218.5
14+410	N/R	(**)	226.0	225.5	219.0
14+420	N/R	(**)	231.0	227.5	219.5
14+430	N/R	(**)	(**)	229.0	220.0
14+440	N/R	N/R	(**)	230.0	220.5
14+450	N/R	N/R	(**)	230.0	221.0
14+460	N/R	N/R	N/R	(**)	222.0
14+470	N/R	N/R	N/R	(**)	223.5
14+480	N/R	N/R	N/R	(**)	225.5
14+490	N/R	N/R	N/R	N/R	(**)

Note:

* The anticipated wick drain tip elevations above are interpreted from the available borehole data. It has been assumed that the wick drains will penetrate 1m to 2m in the deposit underlying the clay deposit or that the wick drains will be terminated in bedrock, where bedrock underlies the clay. The elevation of wick drains between or beyond the the reference points above should be obtained by interpolation or extrapolation of the data, respectively.

** Soft soils beneath Culvert#7 will be fully excavated. Therefore wick drain are not required.

N/R Not Required

TABLE 9.5

HIGHWAY 69 - FOUR LANING - SWAMP 613
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS

HIGHWAY 69 EMBANKMENTS

Cross-Section	Location	Soil Layer	East Toe		Centreline		West Toe		Unit Weight	Undrained Shear Strength		Drained Shear Strength		Poisson's Ratio	Young's Modulus	Compression Ratio		Over Consolidation Ratio	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio Ca/(1+eo)	
			EL of top of Layer (m)	Thickness (m)	EL of top of Layer (m)	Thickness (m)	EL of top of Layer (m)	Thickness (m)	(kN/m3)	Cohesion (kPa)	Friction Angle (deg)	Cohesion (kPa)	Friction Angle (deg)		(MPa)	Cc/(1+eo)	Cr/(1+eo)	(OCR)	Cv O.C.	N.C.	Ch O.C.	N.C.	From	To
10+520	SBL	GS - Topsoil/Peat Replac/ Fill	220.3	0.2	219.2	-	219.9	0.3	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	Height to	Silt - ML	220.1	1.0	-	-	219.6	0.9	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
	top of	Plast/Silt or Clay Crust	219.1	2.4	219.2	2.7	218.7	1.2	18	80	—	—	28	0.49	20	0.18	0.027	5	15	10	40	30	0.0018	0.0072
	Pavement	Silty Clay (Firm/Stiff)	216.7	6.2	216.5	7.5	217.5	7.7	17.5	30	—	—	28	0.49	12	0.20	0.030	1.1	15	10	40	30	0.0020	0.0080
	2.9m	Silt/Sand	210.5	15.5	209.0	14.0	209.8	14.8	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	195.0	-	195.0	-	195.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NBL	GS - Topsoil/Peat Replac/ Fill	218.8	0.2	219.4	0.2	219.9	0.3	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	Height to	Silt - ML	-	-	-	-	219.6	0.9	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
	top of	Plast/Silt or Clay Crust	218.6	2.6	219.2	2.5	218.7	1.2	18	80	—	—	28	0.49	20	0.18	0.027	5	15	10	40	30	0.0018	0.0072
	Pavement	Silty Clay (Firm/Stiff)	216.0	2.4	216.7	7.0	217.5	7.7	17.5	30	—	—	28	0.49	12	0.20	0.030	1.1	15	10	40	30	0.0020	0.0080
	3.1m	Silt/Sand	213.6	18.6	209.7	14.7	209.8	14.8	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	195.0	-	195.0	-	195.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10+570	SBL	GS - Topsoil/Peat Replac/ Fill	221.0	0.9	221.0	0.9	221.0	0.9	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	Height to	Silt - ML	-	-	-	-	-	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	top of	Plast/Silt or Clay Crust	220.1	1.1	220.1	1.1	220.1	1.1	18	80	—	—	28	0.49	20	0.18	0.027	5	15	10	40	30	0.0018	0.0072
	Pavement	Silty Clay (Firm/Stiff) (Top)	219.0	2.0	219.0	2.0	219.0	2.0	17	40	—	—	28	0.49	14	0.25	0.038	1.5	12	8	32	24	0.0025	0.0100
	0.5m	Silty Clay (Firm/Stiff) (Mid)	217.0	3.0	217.0	3.0	217.0	3.0	17.5	30	—	—	28	0.49	12	0.35	0.053	1.1	10	7	23	17	0.0035	0.0140
		Silty Clay (Firm/Stiff) (Bot)	214.0	4.2	214.0	4.2	214.0	4.2	17.5	30	—	—	28	0.49	12	0.25	0.038	1.1	12	8	32	24	0.0025	0.0100
		Silt/Sand	209.8	9.8	209.8	9.8	209.8	9.8	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	200.0	-	200.0	-	200.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NBL	GS - Topsoil/Peat Replac/ Fill	219.6	0.4	220.2	0.0	221.0	0.9	12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
	Height to	Silt - ML	219.2	1.1	220.2	1.2	-	-	19.5	—	—	2	30	0.35	5	—	—	—	—	—	—	—	—	—
	top of	Plast/Silt or Clay Crust	218.1	2.5	219.0	2.9	220.1	1.8	18	80	—	—	28	0.49	20	0.18	0.027	5	20	15	50	38	0.0018	0.0072
	Pavement	Silty Clay (Firm/Stiff) (Top)	215.6	1.6	216.1	2.1	218.3	4.3	17	30	—	—	28	0.49	12	0.35	0.053	1.5	10	7	23	17	0.0035	0.0140
	2.1m	Silty Clay (Firm/Stiff) (Bot)	214.0	3.5	214.0	6.6	214.0	4.2	17.5	30	—	—	28	0.49	12	0.25	0.038	1.1	12	8	32	24	0.0025	0.0100
		Silt/Sand	210.5	10.5	207.4	7.4	209.8	9.8	19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
		Bedrock	200.0	-	200.0	200.0	200.0	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

HIGHWAY 537 EMBANKMENTS

Cross-Section	Soil Layer	SouthToe		Centreline		North Toe		Unit Weight	Undrained Shear Strength		Drained Shear Strength		Poisson's Ratio	Young's Modulus	Compression Ratio		Over Consolidation Ratio	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio Ca/(1+eo)	
		EL of top of Layer (m)	Thickness (m)	EL of top of Layer (m)	Thickness (m)	EL of top of Layer (m)	Thickness (m)	(kN/m3)	Cohesion (kPa)	Friction Angle (deg)	Cohesion (kPa)	Friction Angle (deg)		(MPa)	Cc/(1+eo)	Cr/(1+eo)	(OCR)	Cv O.C.	N.C.	Ch O.C.	N.C.	From	To
9+900	GS - Topsoil Replac/ Fill	225.0	0.2	225.5	0.3			12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
Height to	Sand	224.8	5.3	225.2	5.9			20	—	—	—	32	0.35	25	—	—	—	—	—	—	—	—	—
top of	Silty Clay - Firm/Stiff (Top)	219.5	3.5	219.3	4.1			17	40	—	—	28	0.49	14	0.20	0.030	2	15	10	40	30	0.1400	0.5600
Pavement	Clayey Silt - Stiff	216.0	1.0	215.2	0.7			18	50	—	—	28	0.49	16	0.15	0.023	1.1	30	20	70	50	0.1600	0.6400
2.1m	Silty Clay - Firm/Stiff (Mid)	215.0	6.5	214.5	3.0			17.5	60	—	—	28	0.49	18	0.25	0.038	1.5	15	10	40	30	0.1800	0.7200
	Silty Clay - Firm/Stiff (Bot)	208.5	1.5	211.5	2.1			17.5	35	—	—	28	0.49	13	0.15	0.023	1	80	60	190	140	0.1300	0.5200
	Silt/Sand	207.0	12.0	209.4	14.4			19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
	Bedrock	195.0	-	195.0	-			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9+960	GS - Topsoil Replac/ Fill			224.6	0.2			12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
Height to	Silt and Sand			224.4	4.8			20	—	—	2	32	0.35	25	—	—	—	—	—	—	—	—	—
top of	Silty Clay - Firm/Stiff (Top)			219.6	2.6			17.5	50	—	—	28	0.49	16	0.20	0.030	2	15	10	40	30	0.1600	0.6400
Pavement	Silty Clay - Firm/Stiff (Mid)			217.0	4.0			17	50	—	—	28	0.49	16	0.30	0.045	1.1	15	10	40	30	0.1600	0.6400
5.4m	Silty Clay - Firm/Stiff (Bot)			213.0	3.0			17	50	—	—	28	0.49	16	0.20	0.030	1.1	30	20	70	50	0.1600	0.6400
	Silty Clay - Firm/Stiff (Base)			210.0	3.7			17.5	70	—	—	28	0.49	19	0.10	0.015	1.1	80	60	190	140	0.1900	0.7600
	Silt/Sand			206.3	14.2			19.5	—	—	—	32	0.30	25	—	—	—	—	—	—	—	—	—
	Bedrock			192.1	-			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10+040	GS - Topsoil/Peat Replac/ Fill	221.5	0.2	220.1	0.4			12	—	—	2	28	0.15	—	—	—	—	—	—	—	—	—	—
Height to	Plast/Silt or Clay Crust	221.3	4.3	219.7	4.2			18	80	—	2	32	0.35	20	0.20	0.030	8	15	10	40	30	0.2000	0.8000
top of	Silty Clay - Firm/Stiff (Top)	217.0	3.0	215.5	1.5			17	50	—	—	28	0.49	16	0.30	0.045	2	15	10	40	30	0.1600	0.6400
Pavement	Silty Clay - Firm/Stiff (Mid)	214.0	2.6	214.0	3.0			17	40	—	—	28	0.49	14	0.30	0.045	1.1	15	10	40	30	0.1400	0.5600
8.2m	Silty Clay - Firm/Stiff (Bot)	-	-	211.0	3.1			17.5	60	—	—	28	0.49	18	0.15	0.023	1.1	80	60	190	140	0.1800	0.7200
	Silt/Sand	211.4	21.4	207.9	18.9			19.5	—	—	—	32	0.30	—	—	—	—	—	—	—	—	—	—
	Bedrock	190.0	-	189.0	-				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10+130	GS - Topsoil/Peat Replac/ Fill			219.7	0.2			12	—	—	—	28	0.15	—	—	—	—	—	—	—	—	—	—
Height to	Plast/Silt or Clay Crust			219.5	3.5			18	80	—	—	32	0.35	20	0.20	0.030	8	15	10	40	30	0.2000	0.8000
top of	Silty Clay - Firm/Stiff (Top)			216.0	2.0			17	40	—	—	28	0.49	14	0.30	0.045	2	15	10	40	30	0.1400	0.5600
Pavement	Silty Clay - Firm/Stiff (Bot)			214.0	2.0			17.5	35	—	—	28	0.49	13	0.15	0.023	1.1	80	60	190	140	0.1300	0.5200
3.9m	Silt/Sand			212.0	9.0			19.5	—	—	—	32	0.30	—	—	—	—	—	—	—	—	—	—
	Bedrock			203.0	-				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 10.1

SWAMP 613 - SETTLEMENTS DUE TO PRIMARY CONSOLIDATION

Cross-Section	Location	Embankment Configuration	Embankment Height (m)	No Wick Drains: Ultimate Settlement Due to Primary Consolidation (mm)	No Wick Drains: Time required for >98% Consolidation for Intermediate Stage (months)	With Wick Drains: Wick Drain Spacing Required for 98 % consolidation (U%) in less than 6 months (before removal of surcharge)
2m Surcharge						
Highway 69						
Sta. 10+520	SBL	A	4.9	579	55	1.8
	CL	B	2.9	559		
	NBL	A	5.1	526	50	1.8
	CL	B	3.1	508		
Sta. 10+570	SBL	C	2.5	360	85	1.5
	CL	D	0.5	313		
	NBL	A	4.1	421	90	1.5
	CL	B	2.1	391		
Highway 537						
Sta. 9+900	CL	A	4.1	67	20	2.4
		B	2.1	56		
Sta. 9+960 (West Abut.)	CL	A	7.4	457	80	2.7
		B	5.4	446		
Sta. 10+040 (East Abut.)	CL	A	10.2	792	55	2.4
		B	8.2	783		
Sta. 10+130	CL	A	5.9	279	20	2.4
		B	3.9	262		
3.5m Surcharge						
Highway 69						
Sta. 10+520	SBL	A	6.4	703	55	1.8
	CL	B	2.9	674		
	NBL	A	6.6	639	50	1.8
	CL	B	3.1	612		
Sta. 10+570	SBL	C	4.0	563	85	1.5
	CL	D	0.5	499		
	NBL	A	5.6	559	90	1.5
	CL	B	2.1	517		
Highway 537						
Sta. 9+900	CL	A	5.6	81	20	2.4
		B	2.1	67		
Sta. 9+960 (West Abut.)	CL	A	8.9	539	80	2.7
		B	5.4	524		
Sta. 10+040 (East Abut.)	CL	A	11.7	878	110	2.4
		B	8.2	859		
Sta. 10+130	CL	A	7.4	349	20	2.4
		B	3.9	328		

Notes: (*): Due to primary consolidation only
- CL Centreline
- A Rock Fill Embankment with Surcharge
- B Rock Fill Embankment without Surcharge (embankment to top of pavement)
- C Granular Fill Embankment with Surcharge
- D Granular Fill Embankment without Surcharge (embankment to top of pavement)

TABLE 10.2

SWAMP 613 - SETTLEMENTS DUE TO SECONDARY CONSOLIDATION

Location	Cross-Section	Location	Embankment Configurations		Post-Construction Settlements (mm) Time after completion of Primary Consolidation				
			Intermediate	Final	1 year	3 years	6 years	10 years	20 years
2m Surcharge									
Hwy 69	10+520	SBL	A	B	11	23	32	39	51
		NBL	A	B	10	21	29	36	47
	10+570	SBL	C	D	4	13	22	30	42
		NBL	A	B	15	31	44	54	70
		NBL	A	E (0.5m EPS)	4	14	23	31	44
Hwy 537	9+900		A	B	5	10	14	18	23
	9+960 (West Abutment)		A	B	32	57	75	89	108
			A	E (2m EPS)	3	12	22	30	43
			A	E (3.5m EPS)	0	5	10	15	24
	10+040 (East Abutment)		A	B	25	46	60	72	89
			A	E (1.5m EPS)	7	19	28	37	50
			A	E (3m EPS)	1	5	10	15	24
	10+130		A	B	7	14	20	25	32
3.5m Surcharge									
Hwy 69	10+520	SBL	A	B	4	12	18	24	34
		NBL	A	B	4	11	17	23	32
	10+570	SBL	C	D	1	6	12	18	28
		NBL	A	B	5	15	25	33	46
Hwy 537	9+900		A	B	5	10	15	18	24
	9+960 (West Abutment)		A	B	30	54	71	84	103
			A	E (1.5m EPS)	4	15	25	33	48
			A	E (3.5m EPS)	0	4	9	14	22
	10+040 (East Abutment)		A	B	21	40	53	64	80
			A	E (1m EPS)	6	16	25	33	46
			A	E (2.5m EPS)	1	5	10	16	24
	10+130		A	B	3	9	14	18	25

Notes:

WT	West Toe
WS	West Shoulder
CL	Centreline
ES	East Shoulder
A	Rock Fill Embankment with Surcharge
B	Rock Fill Embankment after removal of Surcharge (embankment to top of pavement)
C	Granular Fill Embankment with Surcharge
D	Granular Fill Embankment after removal of Surcharge (embankment to top of pavement)
E	Combined Rock Fill & EPS Fill Embankment after removal of Surcharge (embankment to top of pavement)

TABLE 10.3

Swamp 613 - HWY 69 - DESIGN ALTERNATIVES, APPROXIMATE CONSTRUCTION COSTS AND RISK ASSESSMENT

Swamp	Location	Station	Construction Stages to T.O.S.	Wick Drain Spacing (i) (m)	Waiting Period (vi) (week)		Anticipated Total Construction Time before Removal of Surcharge (ix) (week)	Surcharge Thickness (m)	EPS (Y/N)	Slope Flattening (Y/N)	Stabilizing Berm (Y/N)	Long Term Settlement (mm)	Cost ($)	Total Cost ($)	Risk Assessment	Note
					U=90% (vii)	U=98% (viii)										
613 (Hwy 69)	SBL	10+400 to 10+640	1	1m (x)	N/R (1 stage)	3 - 5	8 - 10	2m	N	N	N	<70	$854,736	$1,784,067	LOW	2m Surcharge (w/ wick Drain Installation to TOE of ROCKFILL EMBANKMENT)
	NBL	10+400 to 10+720							N	N	N	<70	$929,331			
	SBL	10+400 to 10+640	1	1.5m (x)	N/R (1 stage)	9 - 11	14 - 16	2m	N	N	N	<70	$641,164	$1,335,681	LOW-MEDIUM	2m Surcharge (w/ wick Drain Installation to TOE of ROCKFILL EMBANKMENT)
	NBL	10+400 to 10+720							N	N	N	<70	$694,517			
	SBL	10+400 to 10+640	1	2m (x)	N/R (1 stage)	18 - 20	23 - 25	2m	N	N	N	<70	$566,414	$1,178,746	MEDIUM	2m Surcharge (w/ wick Drain Installation to TOE of ROCKFILL EMBANKMENT)
	NBL	10+400 to 10+720							N	N	N	<70	$612,332			
	SBL	10+400 to 10+640	1	1m (x)	N/R (1 stage)	3 - 5	8 - 10	3.5m	N	N	N	<50	$918,715	$1,922,130	LOW	3.5m Surcharge (w/ wick Drain Installation to TOE of ROCKFILL EMBANKMENT)
	NBL	10+400 to 10+720							N	N	N	<50	$1,003,416			
	SBL	10+400 to 10+640	1	1.5m (x)	N/R (1 stage)	9 - 11	14 - 16	3.5m	N	N	N	<50	$705,143	$1,473,745	LOW-MEDIUM	3.5m Surcharge (w/ wick Drain Installation to TOE of ROCKFILL EMBANKMENT)
	NBL	10+400 to 10+720							N	N	N	<50	$768,602			
	SBL	10+400 to 10+640	1	2m (x)	N/R (1 stage)	18 - 20	23 - 25	3.5m	N	N	N	<50	$630,393	$1,316,810	MEDIUM	3.5m Surcharge (w/ wick Drain Installation to TOE of ROCKFILL EMBANKMENT)
	NBL	10+400 to 10+720							N	N	N	<50	$686,417			
	SBL	10+400 to 10+640	1	1m (xi)	N/R (1 stage)	3 - 5	8 - 10	2m	N	Y (iv)	N	<70	$1,003,795	$2,093,412	LOW	2m Surcharge (w/ wick Drain Installation to TOE of SLOPE FLATTENING)
	NBL	10+400 to 10+720							N	Y (iv)	N	<70	$1,089,617			
	SBL	10+400 to 10+640	1	1.5m (xi)	N/R (1 stage)	9 - 11	14 - 16	2m	N	Y (iv)	N	<70	$736,155	$1,531,447	LOW-MEDIUM	2m Surcharge (w/ wick Drain Installation to TOE of SLOPE FLATTENING)
	NBL	10+400 to 10+720							N	Y (iv)	N	<70	$795,292			
	SBL	10+400 to 10+640	1	2m (xi)	N/R (1 stage)	18 - 20	23 - 25	2m	N	Y (iv)	N	<70	$642,481	$1,334,759	MEDIUM	2m Surcharge (w/ wick Drain Installation to TOE of SLOPE FLATTENING)
	NBL	10+400 to 10+720							N	Y (iv)	N	<70	$692,278			
	SBL	10+400 to 10+640	1	1m (xi)	N/R (1 stage)	3 - 5	8 - 10	3.5m	N	Y (iv)	N	<50	$1,067,774	$2,231,476	LOW	3.5m Surcharge (w/ wick Drain Installation to TOE of SLOPE FLATTENING)
	NBL	10+400 to 10+720							N	Y (iv)	N	<50	$1,163,702			
	SBL	10+400 to 10+640	1	1.5m (xi)	N/R (1 stage)	9 - 11	14 - 16	3.5m	N	Y (iv)	N	<50	$800,134	$1,669,510	LOW-MEDIUM	3.5m Surcharge (w/ wick Drain Installation to TOE of SLOPE FLATTENING)
	NBL	10+400 to 10+720							N	Y (iv)	N	<50	$869,377			
	SBL	10+400 to 10+640	1	2m (xi)	N/R (1 stage)	18 - 20	23 - 25	3.5m	N	Y (iv)	N	<50	$706,459	$1,472,823	MEDIUM	3.5m Surcharge (w/ wick Drain Installation to TOE of SLOPE FLATTENING)
	NBL	10+400 to 10+720							N	Y (iv)	N	<50	$766,363			

Note

(i)	The wick drain installation includes the construction of drainage blanket (subexcavation & material)
(iv)	Slope flattening is not required for embankment stability but for soil disposal purpose
(vi)	Time required before removal of surcharge. This is a prediction only. The actual time required will depend on the field monitoring data
(vii)	Waiting period between construction stages (90% of primary consolidation completed between stages)
(viii)	Waiting period after placement of surcharge and before removal of surcharge (98% of primary consolidation completed)
(ix)	Assumed Embankment Construction Time: 5 weeks
(x)	Wick Drain Installation to 5m beyond the TOE of ROCKFILL EMBANKMENT
(xi)	Wick Drain Installation to 5m beyond the TOE of SLOPE FLATTENING
N/R	Not required
T.O.S.	Top of Surcharge

Assumption:
1.)The Total Cost includes all material and construction costs before pavement construction (i.e. Rockfill as embankment material, Granular B Type II as surcharge material and backfill material in the vicinity of culverts)
2.) The Total Cost does not include embankment fill material placed to compensate for embankment settlement
3.) The Total Cost does not include mobilization cost of construction equipment
4.) The Total Cost does not include construction costs in cut section
5.) Wick Drain Installation cost = $5/m
6.) Pre-augering cost = $8/m
7.) Vibratory Equipement cost = $3/m

TABLE 10.4

Swamp 613 - HWY 537 - DESIGN ALTERNATIVES, APPROXIMATE CONSTRUCTION COSTS AND RISK ASSESSMENT

Swamp	Location	Station	Construction Stages to T.O.S.	Wick Drain Spacing (i) (m)	Waiting Period (vi) (week) U=90% (vii)	Waiting Period (vi) (week) U=98% (viii)	Anticipated Total Construction Time before Removal of Surcharge (ix) (week)	Surcharge Thickness (m)	EPS (Y/N)	Slope Flattening (Y/N)	Stabilizing Berm (Y/N)	Long Term Settlement (mm)	Cost ($)	Total Cost ($)	Risk Assessment	Note
613 (Hwy 537)	West Approach Embankment	9+880 to 9+960	1	1m (iii)	N/R (1 stage)	1 - 3	6 - 8	2m (iii)	Y (EPS only)	N	N	<25/<60(ii)	$609,332	$2,374,974	LOW	(xi)
	East Approach Embankment	10+040 to 10+230							Y (EPS only)	N	N	<25/<60(ii)	$1,765,642		LOW	(xii)
	West Approach Embankment	9+880 to 9+960	1	1.5m (iii)	N/R (1 stage)	3 - 5	8 - 10	2m (iii)	Y (EPS only)	N	N	<25/<60(ii)	$554,326	$2,238,466	LOW	(xi)
	East Approach Embankment	10+040 to 10+230							Y (EPS only)	N	N	<25/<60(ii)	$1,684,141		LOW	(xii)
	West Approach Embankment	9+880 to 9+960	1	2m (iii)	N/R (1 stage)	6 - 8	11 - 13	2m (iii)	Y (EPS only)	N	N	<25/<60(ii)	$535,073	$2,190,689	LOW	(xi)
	East Approach Embankment	10+040 to 10+230							Y (EPS only)	N	N	<25/<60(ii)	$1,655,615		LOW	(xii)
	West Approach Embankment	9+880 to 9+960	1	1m (iii)	N/R (1 stage)	1 - 3	6 - 8	2m (iii)	Y (EPS only)	N	N	<25/<60(ii)	$609,332	$1,614,855	LOW	(xi)
	East Approach Embankment	10+040 to 10+230						2m	Y (EPS Replac.)	N	N	<25/<60(ii)	$1,005,524		MEDIUM	2m Surcharge with 3m EPS Replac. option behind abutment (with wick drain)
	West Approach Embankment	9+880 to 9+960	1	1.5m (iii)	N/R (1 stage)	3 - 5	8 - 10	2m (iii)	Y (EPS only)	N	N	<25/<60(ii)	$554,326	$1,375,052	LOW	(xi)
	East Approach Embankment	10+040 to 10+230						2m	Y (EPS Replac.)	N	N	<25/<60(ii)	$820,726		MEDIUM	2m Surcharge with 3m EPS Replac. option behind abutment (with wick drain)
	West Approach Embankment	9+880 to 9+960	1	2m (iii)	N/R (1 stage)	6 - 8	11 - 13	2m (iii)	Y (EPS only)	N	N	<25/<60(ii)	$535,073	$1,291,120	LOW	(xi)
	East Approach Embankment	10+040 to 10+230						2m	Y (EPS Replac.)	N	N	<25/<60(ii)	$756,047		MEDIUM	2m Surcharge with 3m EPS Replac. option behind abutment (with wick drain)
	West Approach Embankment	9+880 to 9+960	1	1m (iii)	N/R (1 stage)	1 - 3	6 - 8	3.5m (iii)	Y (EPS only)	N	N	<25/<55(ii)	$617,499	$2,405,581	LOW	(xi)
	East Approach Embankment	10+040 to 10+230							Y (EPS only)	N	N	<25/<50(ii)	$1,788,082		LOW	(xii)
	West Approach Embankment	9+880 to 9+960	1	1.5m (iii)	N/R (1 stage)	3 - 5	8 - 10	3.5m (iii)	Y (EPS only)	N	N	<25/<55(ii)	$562,493	$2,269,074	LOW	(xi)
	East Approach Embankment	10+040 to 10+230							Y (EPS only)	N	N	<25/<50(ii)	$1,706,581		LOW	(xii)
	West Approach Embankment	9+880 to 9+960	1	2m (iii)	N/R (1 stage)	6 - 8	11 - 13	3.5m (iii)	Y (EPS only)	N	N	<25/<55(ii)	$543,241	$2,221,296	LOW	(xi)
	East Approach Embankment	10+040 to 10+230							Y (EPS only)	N	N	<25/<50(ii)	$1,678,055		LOW	(xii)
	West Approach Embankment	9+880 to 9+960	1	1m (iii)	N/R (1 stage)	1 - 3	6 - 8	3.5m (iii)	Y (EPS only)	N	N	<25/<55(ii)	$617,499	$1,611,827	LOW	(xi)
	East Approach Embankment	10+040 to 10+230	2 (x)		1 - 2		8 - 11	3.5m	Y (EPS Replac.)	N	N	<25/<50(ii)	$994,327		MEDIUM	3.5m Surcharge with 2.5m EPS Replac. option behind abutment (with wick drain)
	West Approach Embankment	9+880 to 9+960	1	1.5m (iii)	N/R (1 stage)	3 - 5	8 - 10	3.5m (iii)	Y (EPS only)	N	N	<25/<55(ii)	$562,493	$1,372,023	LOW	(xi)
	East Approach Embankment	10+040 to 10+230	2 (x)		2 - 3		11 - 14	3.5m	Y (EPS Replac.)	N	N	<25/<50(ii)	$809,530		MEDIUM	3.5m Surcharge with 2.5m EPS Replac. option behind abutment (with wick drain)
	West Approach Embankment	9+880 to 9+960	1	2m (iii)	N/R (1 stage)	6 - 8	11 - 13	3.6m (iii)	Y (EPS only)	N	N	<25/<55(ii)	$543,241	$1,288,091	LOW	(xi)
	East Approach Embankment	10+040 to 10+230	2 (x)		4 - 5		16 - 19	3.5m	Y (EPS Replac.)	N	N	<25/<50(ii)	$744,851		MEDIUM	3.5m Surcharge with 2.5m EPS Replac. option behind abutment (with wick drain)

Note

(i) The wick drain installation includes the construction of drainage blanket (subexcavation & material)
(ii) The first number represents the maximum Post-Construction Settlement within 30 m of the proposed abutment, the second number represents the maximum Post-Construction Settlement beyond 30 m of the proposed abutment
(iii) Surcharge and wick drains are not required within sections with EPS only. Where required, wick Drain Installation to 5m beyond the TOE of ROCKFILL EMBANKMENT
(vi) Time required before removal of surcharge. This is a prediction only. The actual time required will depend on the field monitoring data
(vii) Waiting period between construction stages (90% of primary consolidation completed between stages)
(viii) Waiting period after placement of surcharge and before removal of surcharge (98% of primary consolidation completed)
(ix) Assumed Embankment Construction Time: STAGE 1: 5 weeks
STAGE 2: 1 week
(x) 2 Stage construction within 30m of the East Abutment and 1 stage construction beyond this area
STAGE 1: 0m to 10.2m
STAGE 2: 10.2m to T.O.S.
(xi) Full section EPS within 10m behind abutment; 5H:1V combined EPS, Wick Drains and Rockfill to station 9+930; Wick Drains, Rockfill and Surcharge beyond station 9+930
(xii) Same as (xi) but station 10+090
N/R Not required
T.O.S. Top of Surcharge

Assumption:
1.)The Total Cost includes all material and construction costs before pavement construction (i.e. Rockfill as embankment material, Granular B Type II as surcharge material and backfill material in the vicinity of culverts)
2.) The Total Cost does not include embankment fill material placed to compensate for embankment settlement
3.) The Total Cost does not include mobilization cost of construction equipment
4.) The Total Cost does not include construction costs in cut section
5.) Wick Drain Installation cost = $5/m
6.) Pre-augering cost = $8/m
7.) Vibratory Equipement cost = $3/m

TABLE 10.5

WICK DRAIN TIP ELEVATIONS
SWAMP 613 - Highway 69

	Wick Drain Tip Elevations (m) *				
Station	SBL-West Toe	SBL-Centreline	Median	NBL-Centreline	NBL-East Toe
10+400	215.5	215.0	215.0	214.5	215.0
10+410	215.0	214.5	215.0	214.5	214.5
10+420	214.0	214.0	214.5	214.0	214.5
10+430	213.5	213.5	214.0	214.0	214.5
10+440	213.0	213.0	213.5	214.0	214.0
10+450	212.5	212.5	213.0	214.0	214.0
10+460	211.5	211.5	212.5	213.5	214.0
10+470	211.0	210.5	211.5	212.5	213.5
10+480	210.5	210.0	211.0	211.5	213.0
10+490	210.0	209.5	210.5	211.0	213.0
10+500	209.5	209.0	210.0	210.0	213.0
10+510	209.0	209.0	209.5	209.5	212.5
10+520	208.5	208.5	209.0	209.0	212.5
10+530	208.0	208.0	209.0	208.0	212.0
10+540	208.0	208.0	208.5	207.5	211.0
10+550	207.5	207.5	208.5	207.0	210.5
10+560	207.5	207.5	208.5	206.5	210.0
10+570	207.0	207.0	208.0	206.0	209.5
10+580	207.0	207.0	207.0	206.0	209.0
10+590	207.0	207.0	206.0	206.5	208.5
10+600	207.0	207.0	205.5	207.5	208.5
10+610	N/R	207.5	206.0	208.5	208.5
10+620	N/R	207.5	207.0	207.5	209.0
10+630	N/R	N/R	208.0	206.0	209.0
10+640	N/R	N/R	N/R	207.0	209.5
10+650	N/R	N/R	N/R	N/R	209.5
10+660	N/R	N/R	N/R	N/R	N/R
10+670	N/R	N/R	N/R	N/R	N/R
10+680	N/R	N/R	N/R	N/R	N/R
10+690	N/R	N/R	N/R	N/R	N/R
10+700	N/R	N/R	N/R	N/R	N/R
10+710	N/R	N/R	N/R	N/R	N/R
10+720	N/R	N/R	N/R	N/R	N/R

Note:

* The anticipated wick drain tip elevations above are interpreted from the available borehole data. It has been assumed that the wick drains will penetrate 1m to 2m in the deposit underlying the clay deposit or that the wick drains will be terminated in bedrock, where bedrock underlies the clay. The elevation of wick drains between or beyond the the reference points above should be obtained by interpolation or extrapolation of the data, respectively.

N/R Not Required

TABLE 10.6

WICK DRAIN TIP ELEVATIONS
SWAMP 613 - Highway 537

	Wick Drain Tip Elevations (m) *		
Station	South Toe	Centreline	North Toe
9+880	N/R	N/R	N/R
9+890	N/R	N/R	N/R
9+900	206.0	208.0	206.5
9+910	206.0	208.0	206.5
9+920	206.0	208.0	206.5
9+930	206.0	208.0	206.5
9+940	206.0	207.0	206.5
9+950	206.0	206.5	206.5
9+960	206.0	206.5	206.5
9+970	Bridge		
9+980			
9+990			
10+000			
10+010			
10+020			
10+030	209.0	209.0	209.0
10+040	208.0	208.0	208.0
10+050	206.0	206.0	206.0
10+060	206.5	206.5	206.5
10+070	207.0	207.0	207.0
10+080	207.0	207.0	207.0
10+090	208.0	208.0	208.0
10+100	209.0	209.0	209.0
10+110	209.0	209.0	209.0
10+120	210.0	210.0	210.0
10+130	211.0	211.0	211.0
10+140	212.0	212.0	212.0
10+150	213.0	213.0	213.0
10+160	214.0	214.0	214.0
10+170	215.0	215.0	215.0
10+180	N/R	N/R	N/R
10+190	N/R	N/R	N/R
10+200	N/R	N/R	N/R
10+210	N/R	N/R	N/R
10+220	N/R	N/R	N/R
10+230	N/R	N/R	N/R

Note:

* The anticipated wick drain tip elevations above are interpreted from the available borehole data. It has been assumed that the wick drains will penetrate 1m to 2m in the deposit underlying the clay deposit or that the wick drains will be terminated in bedrock, where bedrock underlies the clay. The elevation of wick drains between or beyond the the reference points above should be obtained by interpolation or extrapolation of the data, respectively.

N/R Not Required

TABLE 10.7

SWAMP 602

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

HWY.69
GWP NO. 312-99-00

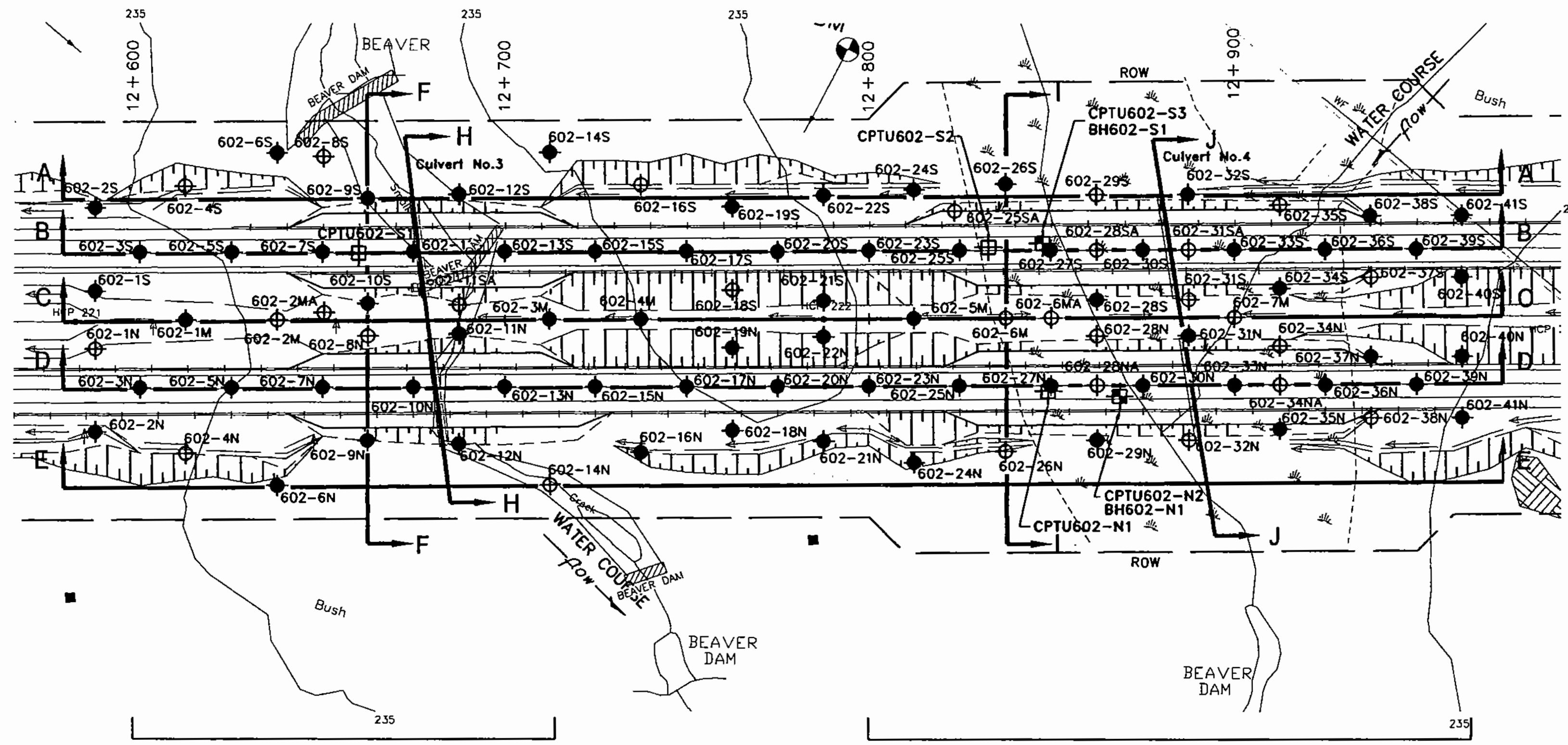
HIGHWAY 69 FOUR-LANING
SWAMP 602, 12+568.5 to 12+966.5
PLAN AND BOREHOLE LOCATIONS

SHEET 602-1

THURBER ENGINEERING LTD.

BOREHOLES BY PETO

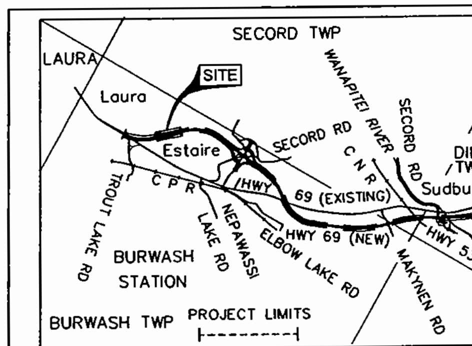
BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
602-1M	235.7	12+612.5	CL
602-2M	233.9	12+637.5	CL
602-2MA	233.7	12+650	2m Lt
602-3M	232.8	12+712.5	CL
602-4M	235.3	12+737.5	CL
602-5M	234.3	12+812.5	CL
602-6M	233.4	12+837.5	CL
602-6MA	233.4	12+850	CL
602-7M	233.3	12+900	CL
602-1N	237.3	12+587.5	8m Rt
602-2N	237.1	12+587.5	31m Rt
602-3N	236.1	12+600	19m Rt
602-4N	235.5	12+612.5	37m Rt
602-5N	234.5	12+625	19m Rt
602-6N	233.5	12+637.5	46m Rt
602-7N	234.2	12+650	19m Rt
602-8N	233.1	12+662.5	4.5m Rt
602-9N	230.8	12+662.5	33.5m Rt
602-10N	230.3	12+675	19m Rt
602-11N	230.4	12+687.5	4m Rt
602-12N	230.3	12+687.5	34.5m Rt
602-13N	230.7	12+700	19m Rt
602-14N	230.0	12+712.5	46m Rt
602-15N	234.0	12+725	19m Rt
602-16N	233.4	12+737.5	37m Rt
602-17N	235.9	12+750	19m Rt
602-18N	234.9	12+762.5	31m Rt
602-19N	236.2	12+762.5	8m Rt
602-20N	235.8	12+775	19m Rt
602-21N	235.4	12+787.5	34m Rt
602-22N	235.8	12+787.5	5m Rt
602-23N	234.8	12+800	19m Rt
602-24N	233.8	12+812.5	40m Rt
602-25N	234.0	12+825	19m Rt
602-26N	233.6	12+837.5	37m Rt
602-27N	233.4	12+850	19m Rt
602-28N	233.3	12+862.5	5m Rt
602-28NA	233.3	12+862.5	19m Rt
602-29N	233.3	12+862.5	34m Rt
602-30N	233.2	12+875	19m Rt
602-31N	233.2	12+887.5	5m Rt
602-32N	233.2	12+887.5	34m Rt
602-33N	233.2	12+900	19m Rt
602-34N	233.4	12+912.5	8m Rt
602-34NA	233.2	12+912.5	19m Rt
602-35N	233.2	12+912.5	31m Rt
602-36N	233.3	12+925	19m Rt
602-37N	233.8	12+937.5	11m Rt
602-38N	233.8	12+937.5	28m Rt
602-39N	235.1	12+950	19m Rt
602-40N	235.9	12+962.5	11m Rt
602-41N	235.5	12+962.5	28m Rt



South Swamp
(Station 12+620 to 12+720)

North Swamp
(Station 12+800 to 12+970)

PLAN
SCALE
20 0 20 40m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water Piezometer	
	Bedrock Outcrop	

(Legend Continued)

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
602-1S	237.3	12+587.5	8m Lt
602-2S	236.8	12+587.5	31m Lt
602-3S	236.2	12+600	19m Lt
602-4S	234.7	12+612.5	37m Lt
602-5S	234.0	12+625	19m Lt
602-6S	231.7	12+637.5	46m Lt
602-7S	232.9	12+650	19m Lt
602-8S	231.5	12+650	45m Lt
602-9S	231.1	12+662.5	34m Lt
602-10S	233.1	12+662.5	4.5m Lt
602-11S	231.1	12+675	19m Lt
602-11SA	230.4	12+687.5	4m Lt
602-12S	230.5	12+687.5	34.5m Lt
602-13S	230.8	12+700	19m Lt
602-14S	235.0	12+712.5	46m Lt
602-15S	235.1	12+725	19m Lt
602-16S	235.3	12+737.5	37m Lt
602-17S	235.4	12+750	19 Lt
602-18S	236.2	12+762.5	8m Lt

(Legend Continued)

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
602-19S	235.2	12+762.5	31m Lt
602-20S	235.5	12+775	19m Lt
602-21S	235.6	12+787.5	5m Lt
602-22S	233.6	12+787.5	34m Lt
602-23S	233.7	12+800	19m Lt
602-24S	233.5	12+812.5	40m Lt
602-25S	233.5	12+825	19m Lt
602-25SA	233.4	12+825	30m Lt
602-26S	233.3	12+837.5	37m Lt
602-27S	233.4	12+850	19m Lt
602-28S	233.3	12+862.5	5m Lt
602-28SA	233.3	12+862.5	19m Lt
602-29S	233.4	12+862.5	34m Lt
602-30S	233.3	12+875	19m Lt
602-31S	233.3	12+887.5	5m Lt
602-31SA	233.3	12+887.5	19m Lt
602-32S	233.4	12+887.5	34m Lt
602-33S	233.4	12+900	19m Lt
602-34S	233.4	12+912.5	8m Lt

(Legend Continued)

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
602-35S	233.5	12+912.5	31m Lt
602-36S	233.7	12+925	19m Lt
602-37S	233.6	12+937.5	11m Lt
602-38S	233.8	12+937.5	28m Lt
602-39S	234.7	12+950	19m Lt
602-40S	235.2	12+962.5	11m Lt
602-41S	234.7	12+962.5	28m Lt

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

BOREHOLES BY THURBER

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
CPTU602-S1	233.5	12+655	18m Rt
CPTU602-S2	233.7	12+832	20m Rt
BH602-S1	233.6	12+847	21m Rt
CPTU602-S3	233.8	12+847	21m Rt
CPTU602-N1	234.7	12+849	20m Lt
BH602-N1	235.2	12+867	22m Lt
CPTU602-N2	234.7	12+867	22m Lt

— NOTE —

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

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 1

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

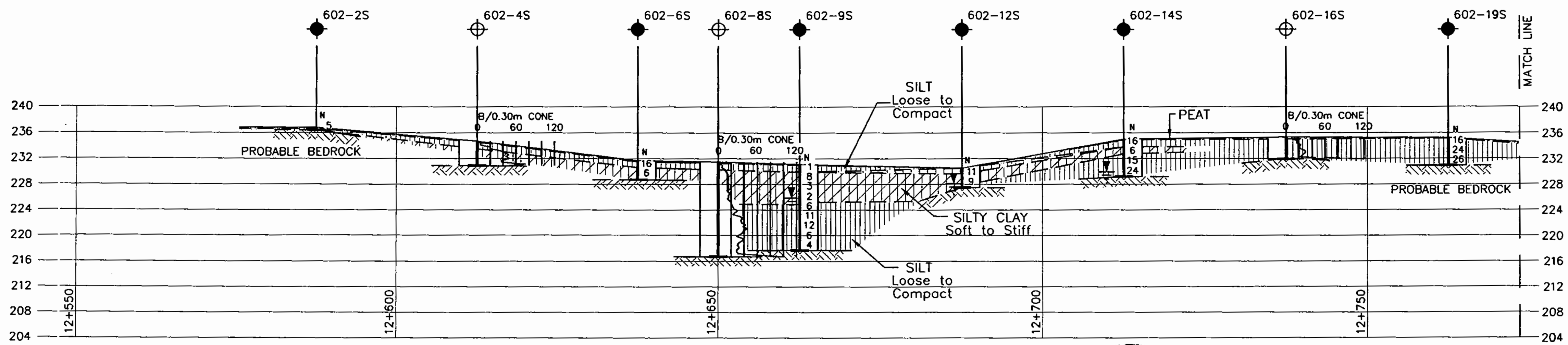
HWY.69

GWP NO. 312–99–00

HIGHWAY 69 FOUR–LANING
SWAMP 602, 12+568.5 to 12+966.5
SOIL STRATA

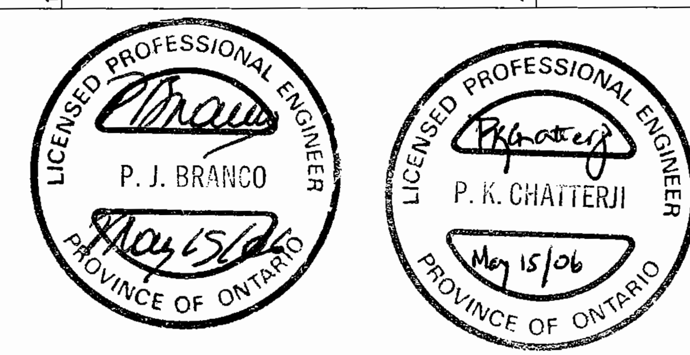
SHEET 602–2

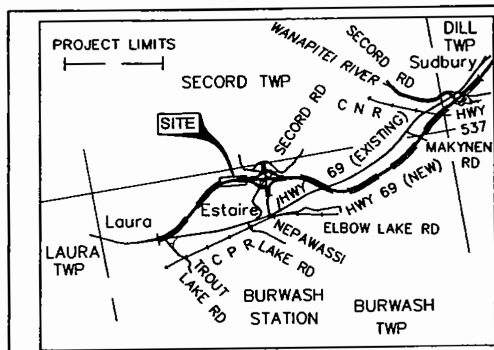
THURBER ENGINEERING LTD.



SECTION A–A

8 4 0 8 16m





KEYPLAN

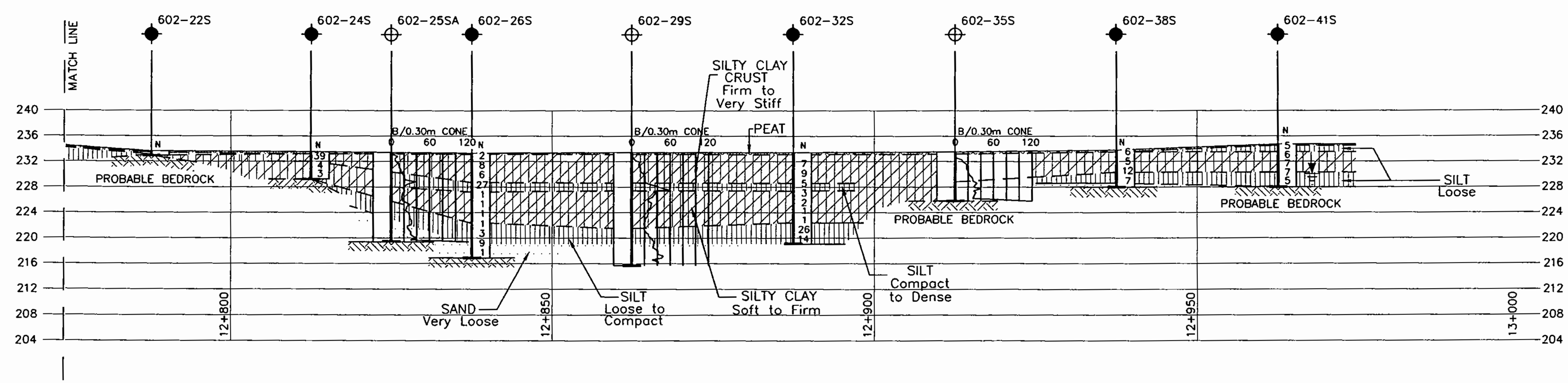
LEGEND

	Bore Hole	Thurber
	Piezocone	
	Bore Hole & Piezocone	
	Bore Hole	Peto
	Dynamic Cone Penetration Test	
	Bore Hole & Cone	
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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



SECTION A–A (Continued)

8 4 0 8 16m

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 2

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

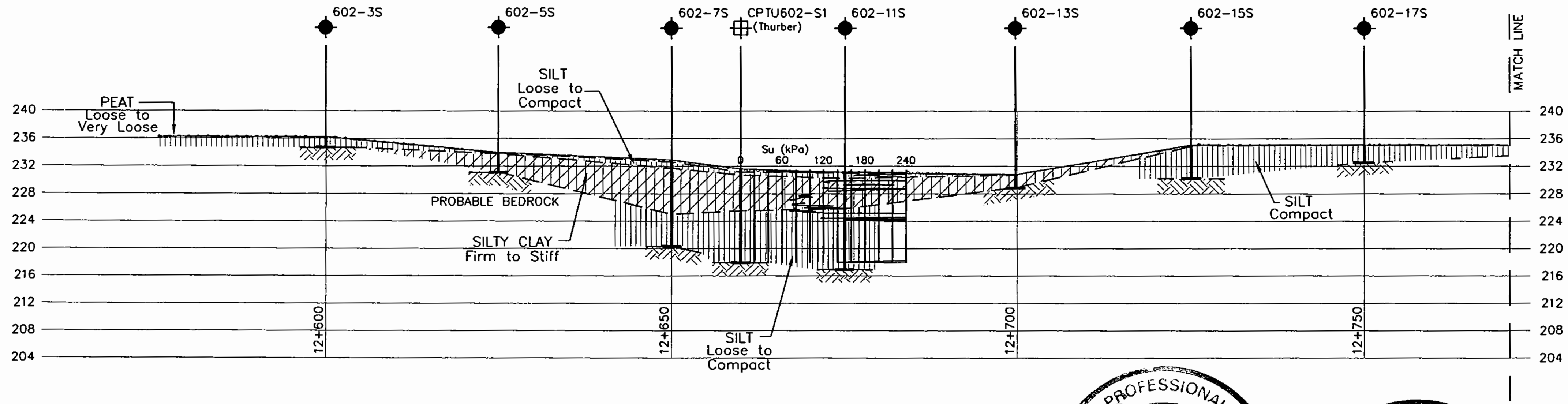
HWY.69

GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 602, 12+568.5 to 12+966.5
SOIL STRATA

SHEET 602-3

THURBER ENGINEERING LTD.

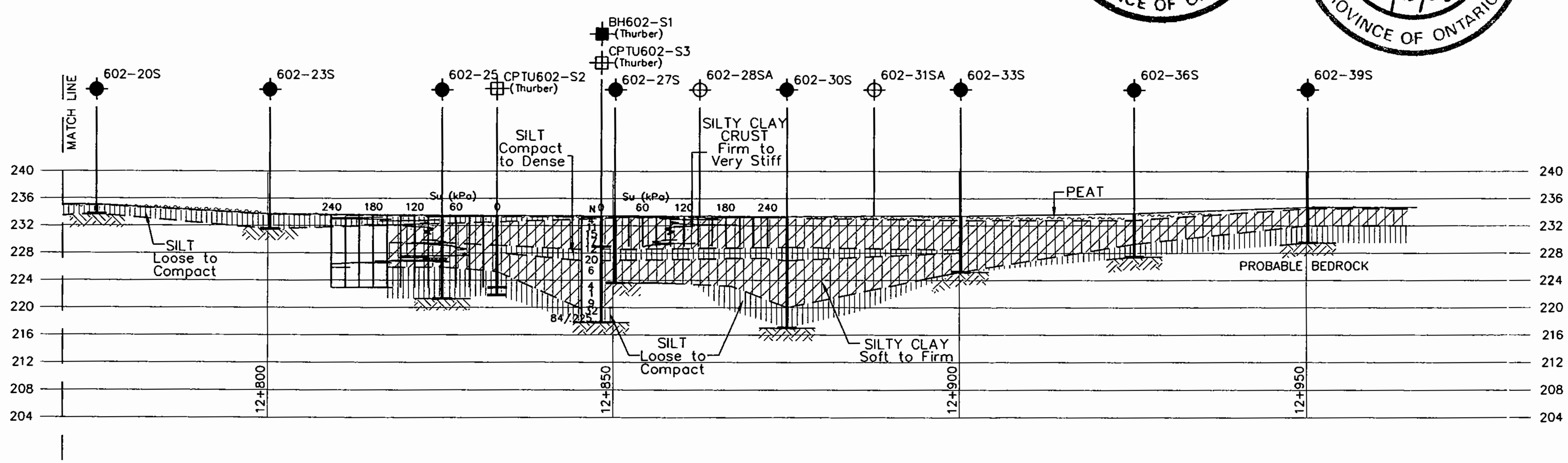


SECTION B-B

8 4 0 8 16m

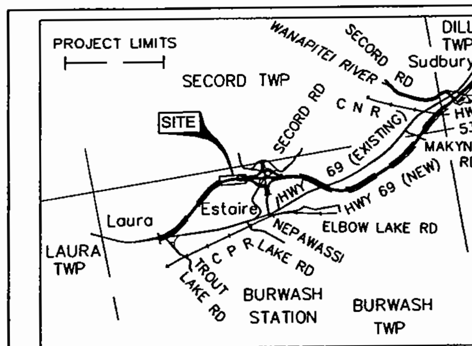
LICENSED PROFESSIONAL ENGINEER P. J. BRANCO May 15/06 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI May 15/06 PROVINCE OF ONTARIO



B-B
(Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezoone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60' Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 3

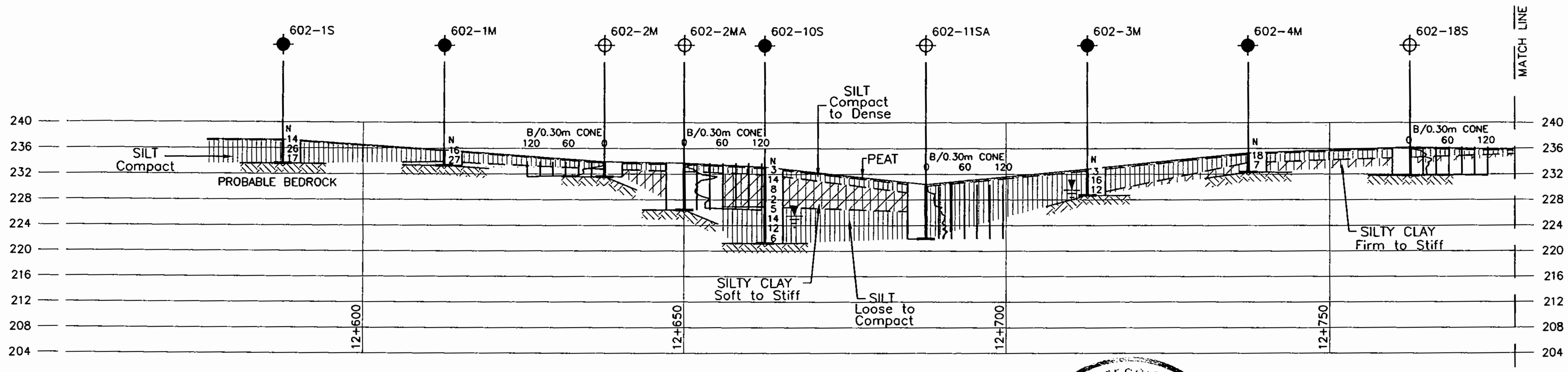
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

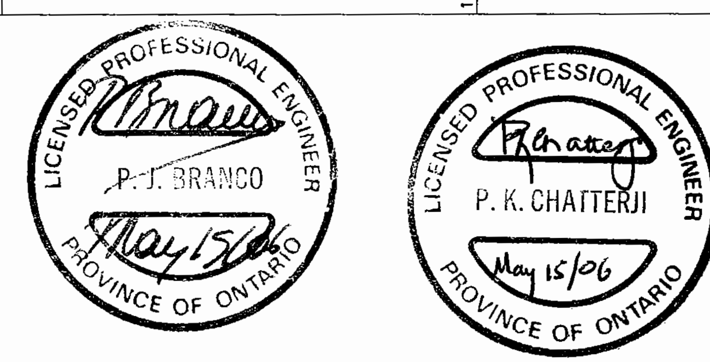
HIGHWAY 69 FOUR-LANING
SWAMP 602, 12+568.5 to 12+966.5
SOIL STRATA

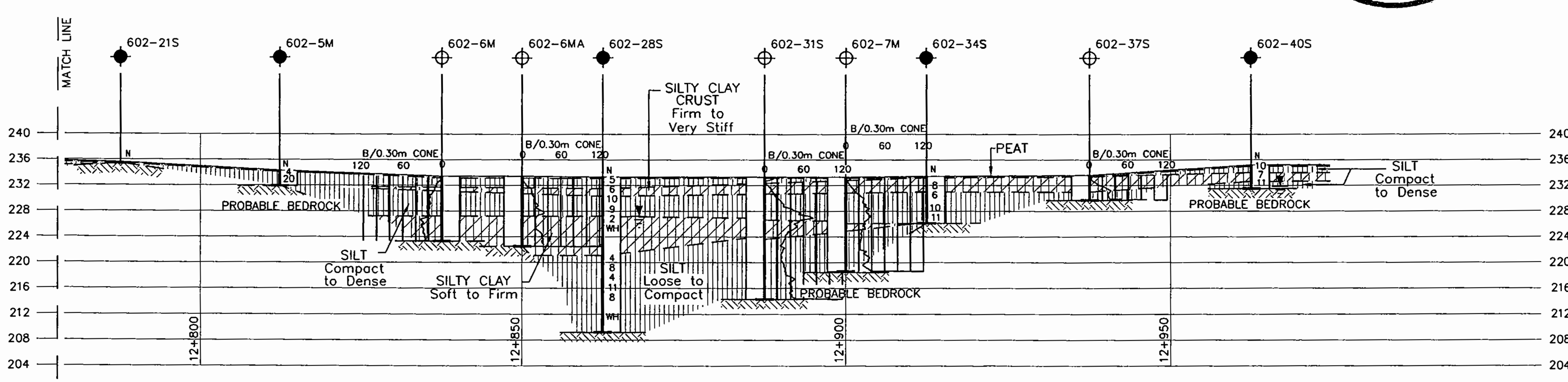
SHEET 602-4

THURBER ENGINEERING LTD.

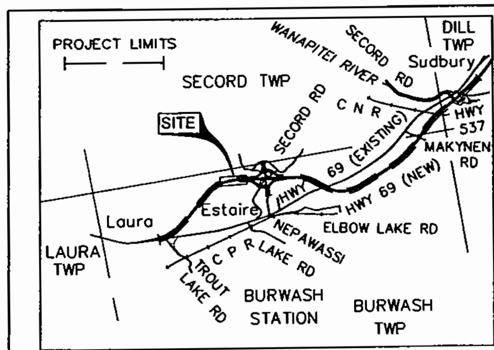


SECTION C-C





SECTION C-C (Continued)



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesion Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 4

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

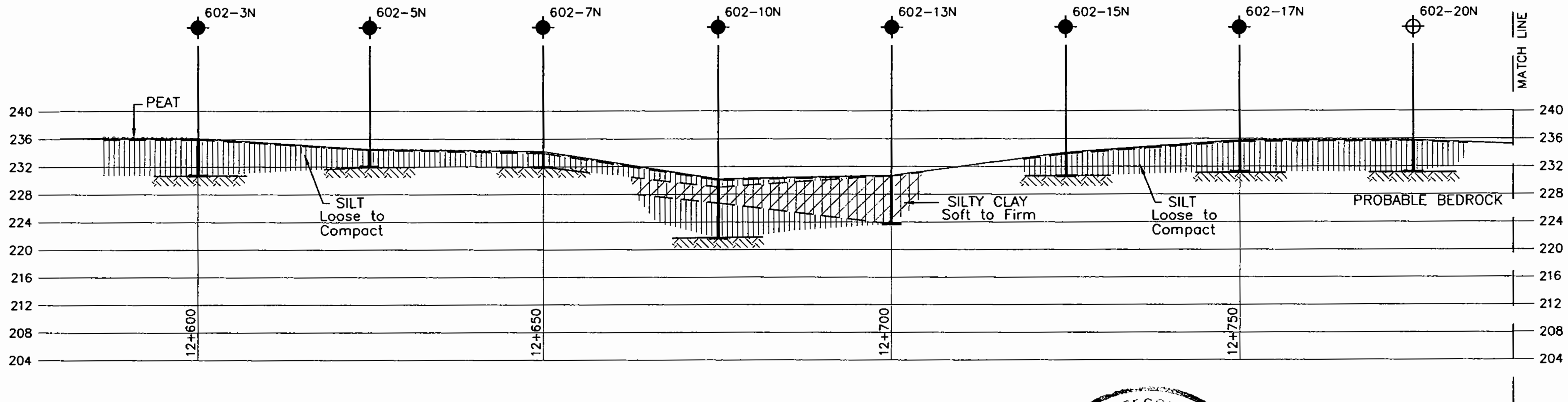
HWY.69

GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 602, 12+568.5 to 12+966.5
SOIL STRATA

SHEET 602-5

THURBER ENGINEERING LTD.

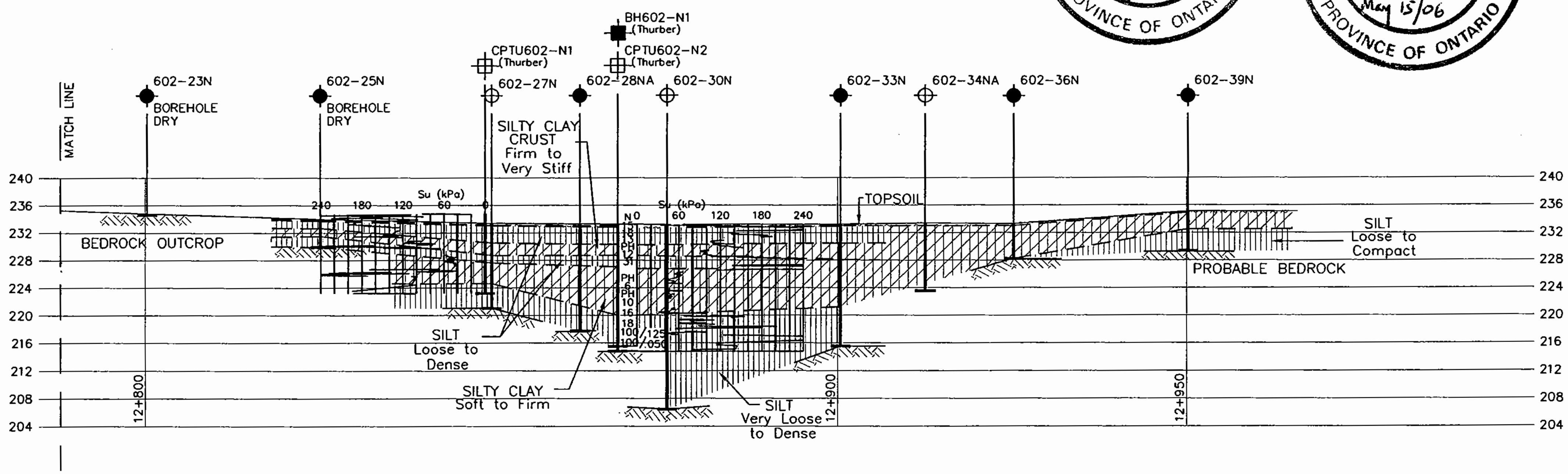


SECTION D-D

8 4 0 8 16m

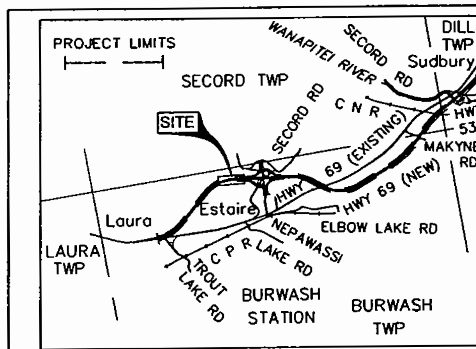
LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



SECTION D-D
(Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

	Bore Hole	Thurber
	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
	Bore Hole	Peto
	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

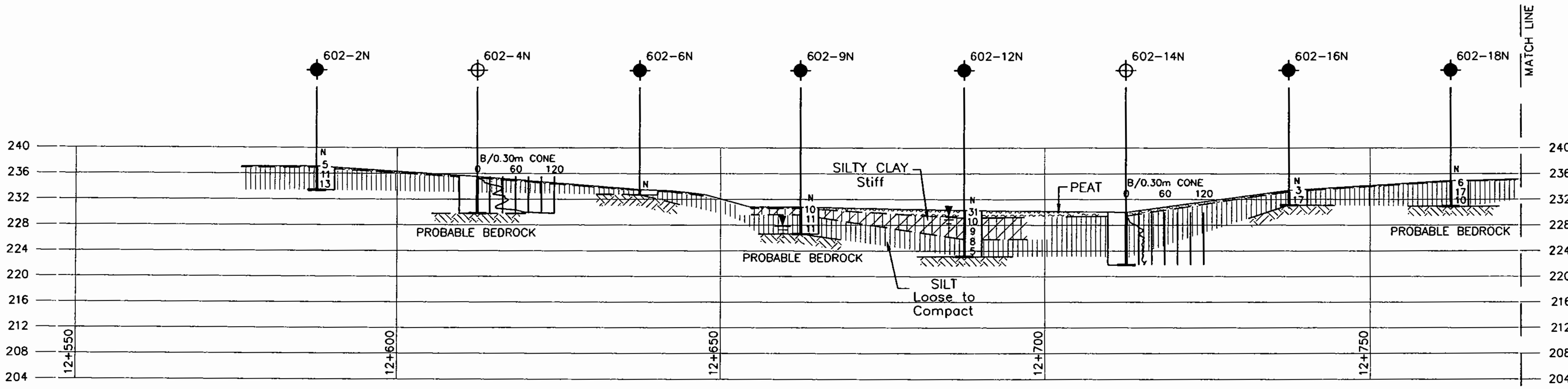
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 5

METRIC DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN	HWY.69 GWP NO. 312-99-00
HIGHWAY 69 FOUR-LANING SWAMP 602, 12+568.5 to 12+966.5 SOIL STRATA	SHEET 602-6

THURBER ENGINEERING LTD.

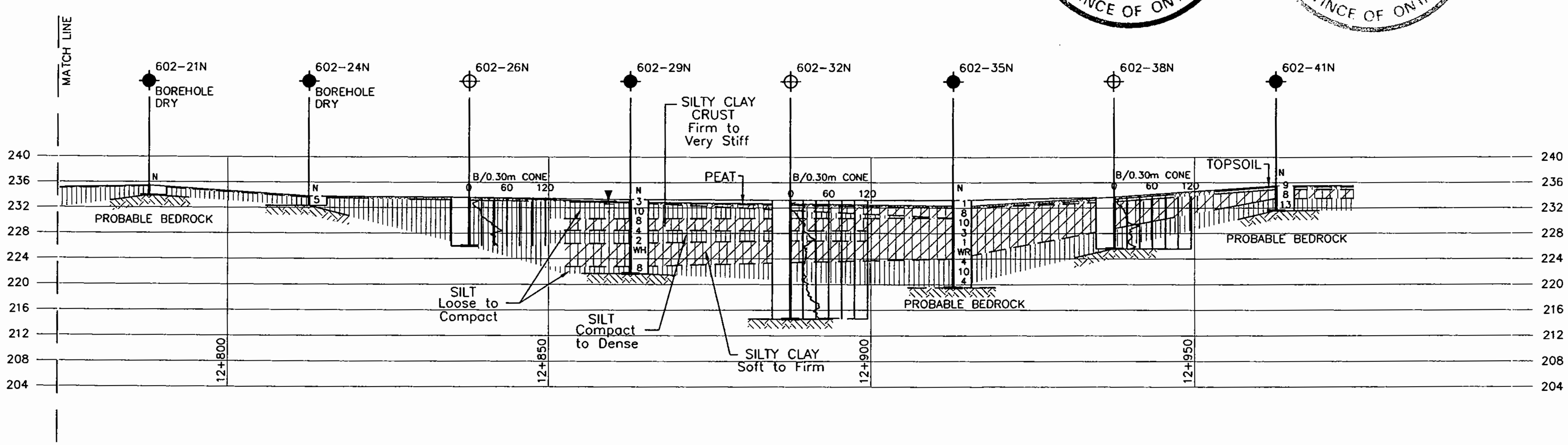


SECTION E-E

8 4 0 8 16m

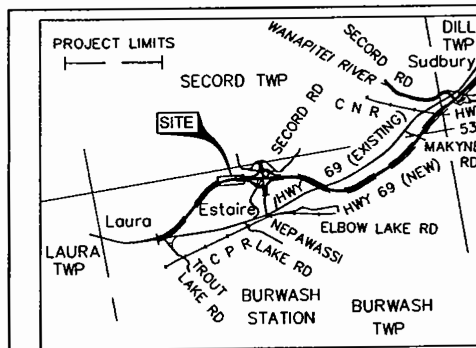
LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



SECTION E-E
(Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

■	Bore Hole	Thurber
⊕	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynomic Cone Penetrotion Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer ot Time of Investigotion (Dote)	
	Heod Artesion Woter	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

The boundaries between soil strota have been estoblished only ot Bore Hole locotions. Between Bore Holes the boundaries ore assumed from geological evidence.

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN	CHK	CODE CHBDC	LOAD	DATE		
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 6	

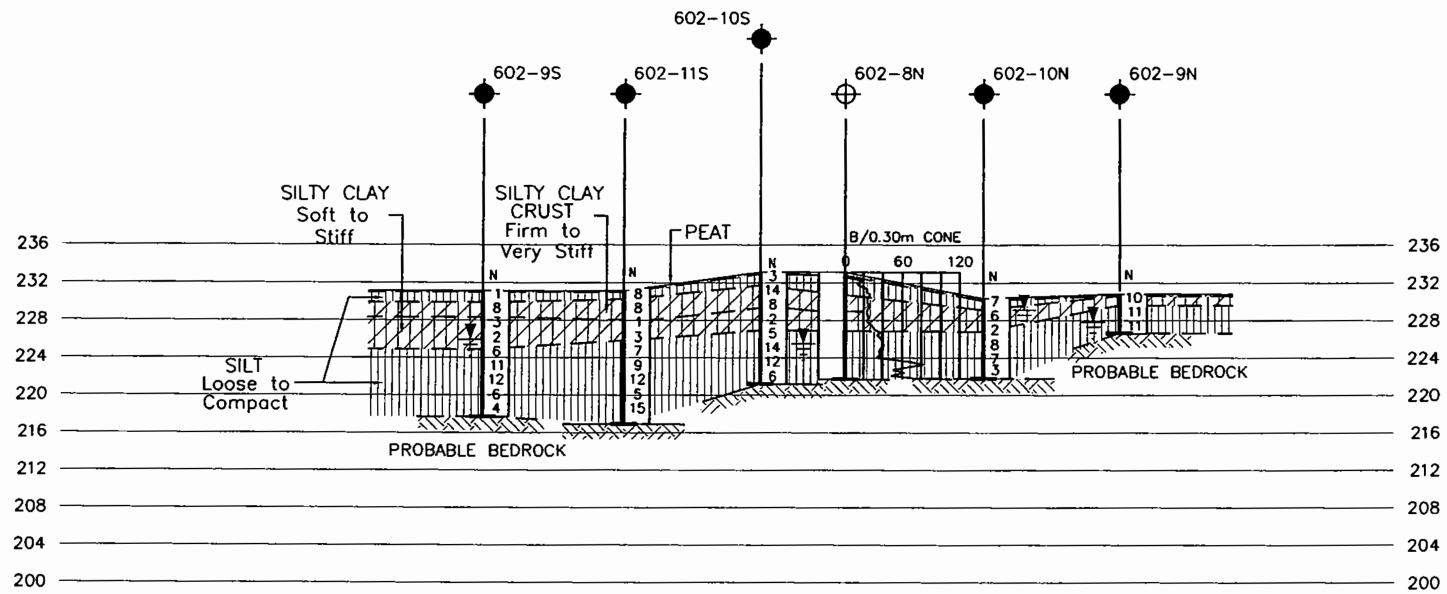
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 602, 12+568.5 to 12+966.5
SOIL STRATA

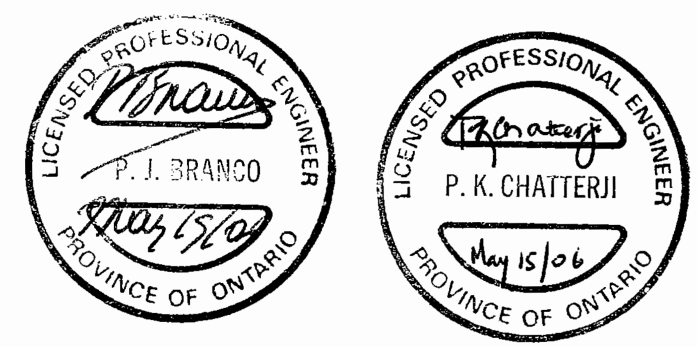
SHEET 602-7

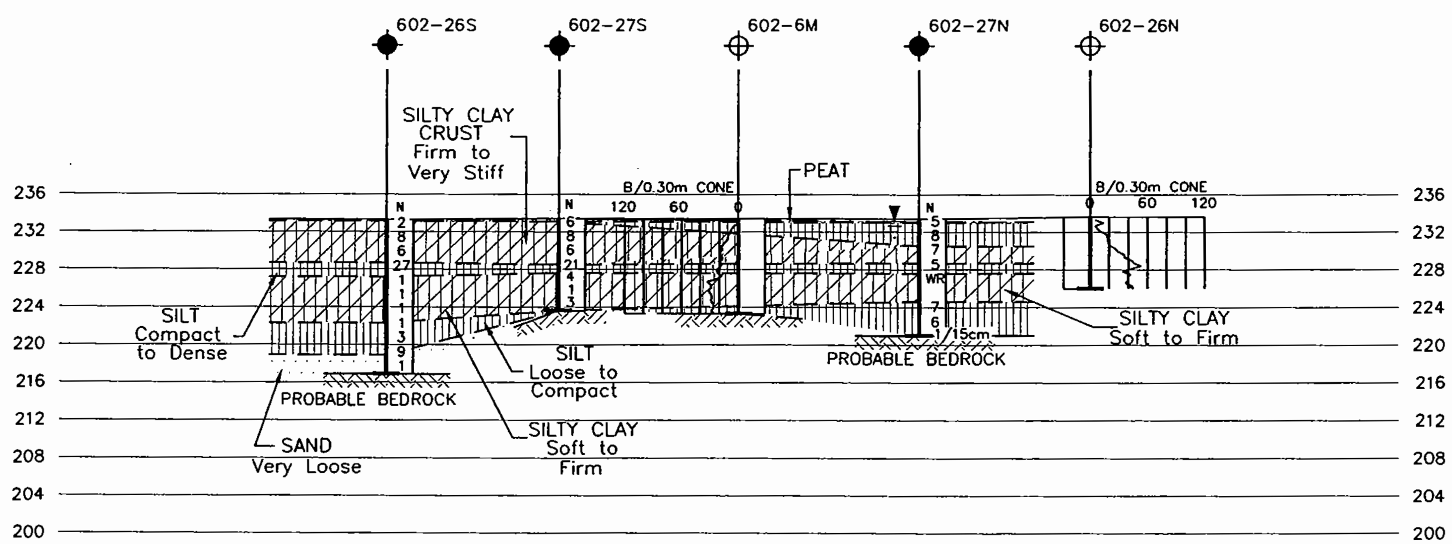
THURBER ENGINEERING LTD.



SECTION F-F

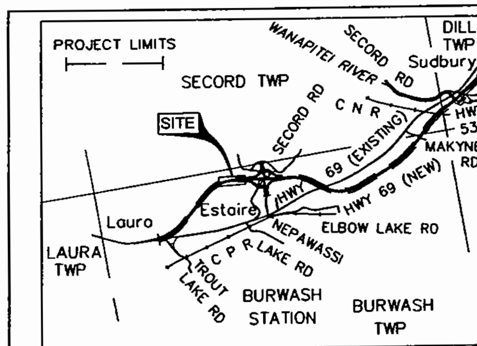
8 4 0 8 16m





SECTION G-G

8 4 0 8 16m



KEYPLAN

LEGEND

Bore Hole		Thurber
Piezocone		Thurber
Bore Hole & Piezocone		Thurber
Bore Hole		Peto
Dynamic Cone Penetration Test		Peto
Bore Hole & Cone		Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesion Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

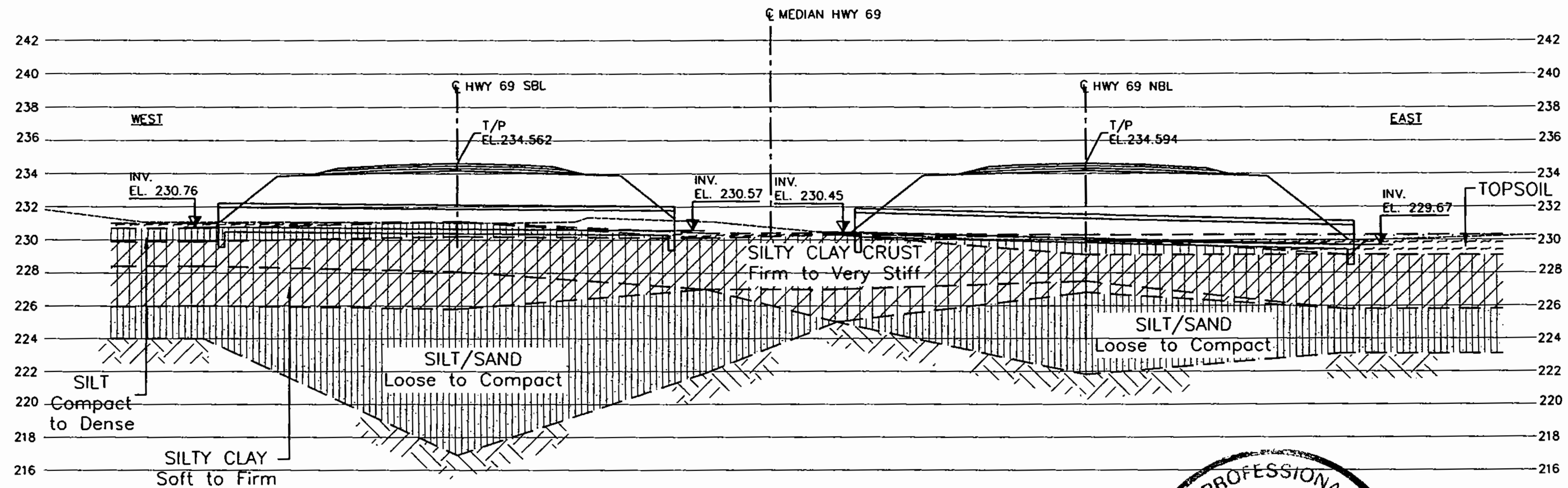
— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN	CHK	CODE CHBDC	LOAD	DATE		
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 7	

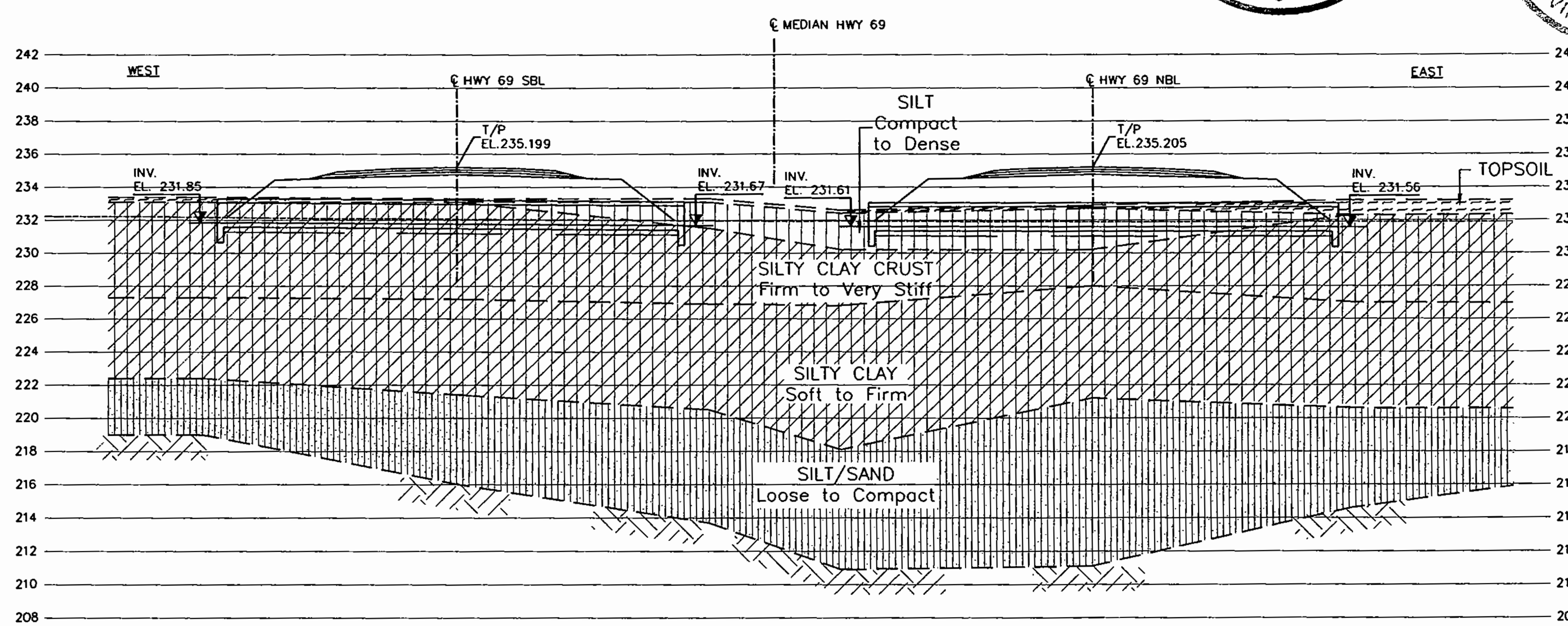
CULVERT No.3



SECTION H–H

4 2 0 4 8m

CULVERT No.4



SECTION I–I

4 2 0 4 8m

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

LICENSED PROFESSIONAL ENGINEER — P. J. BRANCO — May 15/06 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — P. K. CHATTERJI — May 15/06 — PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

METRIC

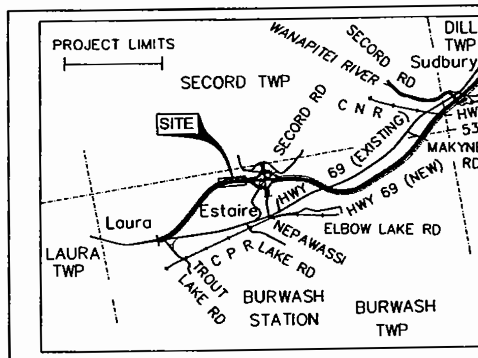
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312–99–00

HIGHWAY 69 FOUR–LANING
SWAMP 602, 12+568.5 to 12+966.5
CULVERT No.3 & CULVERT No.4

SHEET 602–8

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

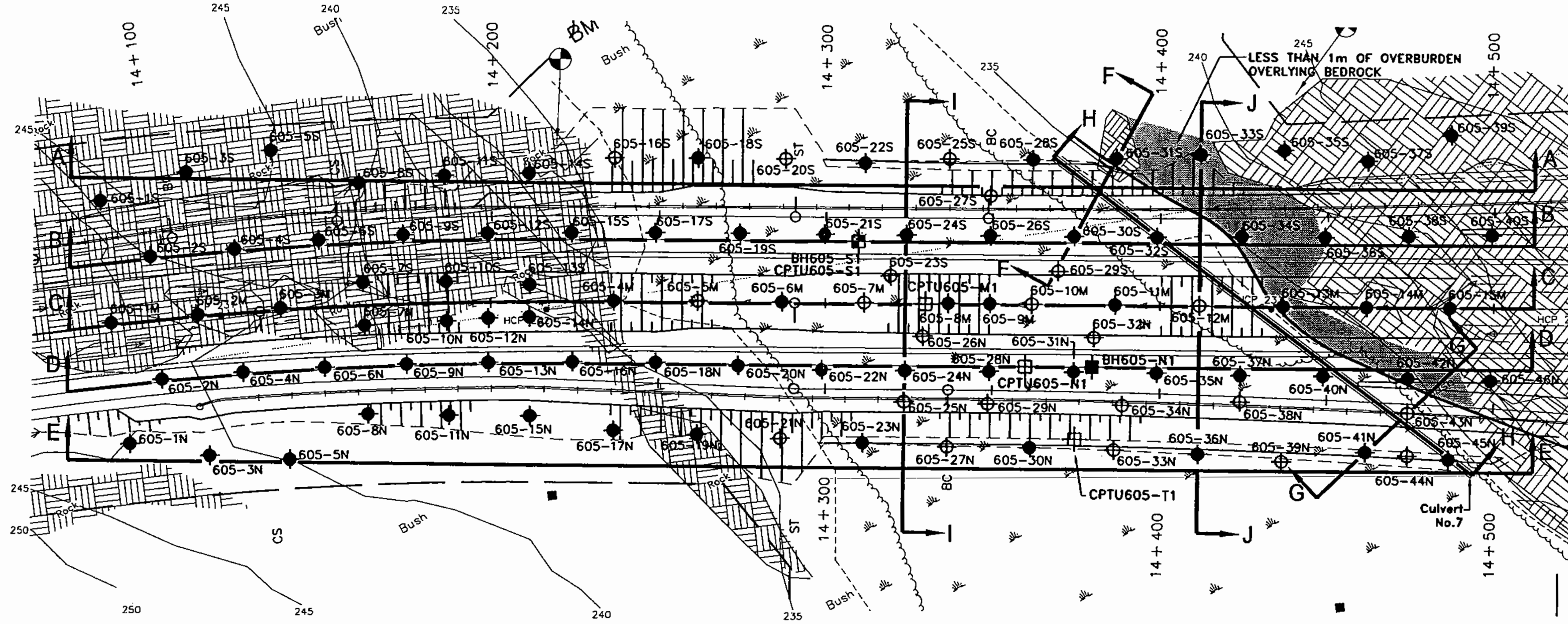
REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 8

SWAMP 605

BOREHOLES BY PETO

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
605-1M	242.2	14+087.5	CL
605-2M	240.6	14+112.5	CL
605-3M	238.4	14+137.5	CL
605-4M	234.3	14+237.5	CL
605-5M	234.0	14+262.5	CL
605-6M	234.0	14+287.5	CL
605-7M	234.0	14+312.5	CL
605-8M	234.0	14+337.5	CL
605-9M	234.0	14+350	CL
605-10M	233.9	14+362.5	CL
605-11M	234.1	14+387.5	CL
605-12M	233.9	14+412.5	CL
605-13M	234.0	14+437.5	CL
605-14M	237.1	14+462.5	CL
605-15M	240.7	14+487.5	CL
605-1N	239.0	14+087.5	37m Rt
605-2N	238.7	14+100	19m Rt
605-3N	239.8	14+112.5	43m Rt
605-4N	237.9	14+125	19m Rt
605-5N	239.6	14+137.5	46m Rt
605-6N	237.6	14+150	19m Rt
605-7N	239.3	14+162.5	6.5m Rt
605-8N	237.9	14+162.5	34m Rt
605-9N	237.1	14+175	19m Rt
605-10N	236.8	14+187.5	6m Rt
605-11N	237.6	14+187.5	35m Rt
605-12N	236.7	14+200	5m Rt
605-13N	236.4	14+200	19m Rt
605-14N	237.3	14+212.5	5m Rt
605-15N	236.9	14+212.5	35m Rt
605-16N	237.3	14+225	19m Rt
605-17N	237.1	14+237.5	40m Rt
605-18N	234.0	14+250	20m Rt
605-19N	236.8	14+262.5	41m Rt
605-20N	234.2	14+275	20m Rt
605-21N	233.9	14+287.5	41m Rt
605-22N	233.9	14+300	20.5m Rt
605-23N	234.0	14+312.5	42m Rt
605-24N	233.9	14+325	20.5m Rt
605-25N	234.0	14+325	30m Rt
605-26N	234.0	14+330	10m Rt
605-27N	234.0	14+337.5	43m Rt
605-28N	234.0	14+350	20.5m Rt
605-29N	234.0	14+350	30m Rt
605-30N	234.0	14+362.5	43m Rt
608-31N	234.0	14+375	20.5m Rt
605-32N	233.8	14+380	10m Rt
605-33N	233.9	14+387.5	44m Rt
605-34N	233.9	14+390	30m Rt
605-35N	234.0	14+400	20.5m Rt
605-36N	234.0	14+412.5	45m Rt
605-37N	233.9	14+425	21m Rt
605-38N	233.9	14+425	28m Rt
605-39N	234.0	14+437.5	47m Rt
605-40N	233.9	14+450	21m Rt
605-41N	234.0	14+462.5	44m Rt
605-42N	234.5	14+475	21.5m Rt
605-43N	234.5	14+475	32m Rt
605-44N	234.4	14+475	45m Rt



PLAN
SCALE
20 0 20 40m

(Legend Continued)

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
605-45N	236.1	14+487.5	46m Rt
605-46N	241.7	14+500	22m Rt
605-1S	242.2	14+087.5	37m Lt
605-2S	241.5	14+100	19m Lt
605-3S	244.5	14+112.5	43m Lt
605-4S	242.7	14+125.5	19m Lt
605-5S	246.7	14+137.5	47.5m Lt
605-6S	241.5	14+150	20m Lt
605-7S	239.4	14+162.5	6.5m Lt
605-8S	241.6	14+162.5	37m Lt
605-9S	238.1	14+175	21m Lt
605-10S	236.5	14+187.5	6m Lt
605-11S	241.4	14+187.5	38m Lt
605-12S	238.7	14+200	21m Lt
605-13S	236.7	14+212.5	5m Lt
605-14S	238.0	14+212.5	39m Lt

(Legend Continued)

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
605-15S	236.8	14+225	21m Lt
605-16S	233.9	14+237.5	42.5m Lt
605-17S	233.8	14+250	20.5m Lt
605-18S	233.9	14+262.5	42.5m Lt
605-19S	234.0	14+275	20.5m Lt
605-20S	233.9	14+287.5	42.5m Lt
605-21S	234.0	14+300	20.5m Lt
605-22S	233.9	14+312.5	42m Lt
605-23S	234.0	14+320	8m Lt
605-24S	233.9	14+325	20.5m Lt
605-25S	233.9	14+337.5	43m Lt
605-26S	233.9	14+350	20.5m Lt
605-27S	233.9	14+350	32m Lt
605-28S	233.8	14+362.5	43m Lt
605-29S	233.9	14+370	10m Lt
605-30S	233.9	14+375	20.5m Lt
605-31S	235.6	14+387.5	44m Lt

(Legend Continued)

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
605-32S	233.9	14+400	20.5m Lt
605-33S	238.2	14+412.5	45.5m Lt
605-34S	235.3	14+425	21m Lt
605-35S	241.8	14+437.5	47m Lt
605-36S	237.8	14+450	21m Lt
605-37S	243.8	14+462.5	44m Lt
605-38S	240.3	14+475	21.5m Lt
605-39S	247.9	14+487.5	52m Lt
605-40S	246.5	14+500	22m Lt

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO

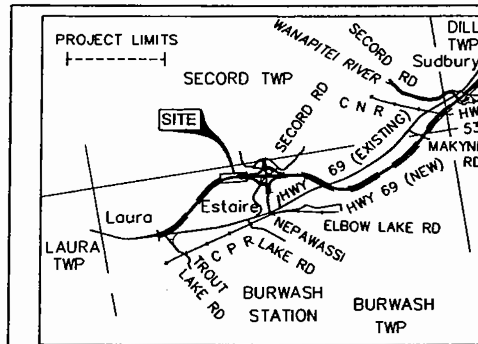
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
PLAN AND BOREHOLE LOCATIONS

SHEET 605-1

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	
	Shallow Bedrock	
	Bedrock Outcrop	

BOREHOLES BY THURBER

BH No	ELEVATION	STA BURWASH TWP	o/s CL MED
CPTU605-M1	233.8	14+330	CL
CPTU605-T1	233.8	14+373	41m Rt
BH605-N1	233.8	14+380	9m Rt
CPTU605-N1	233.7	14+362	9m Lt
BH605-S1	233.8	14+305.5	9m Lt
CPTU605-S1	233.8	14+305.5	9m Lt

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

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 1

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

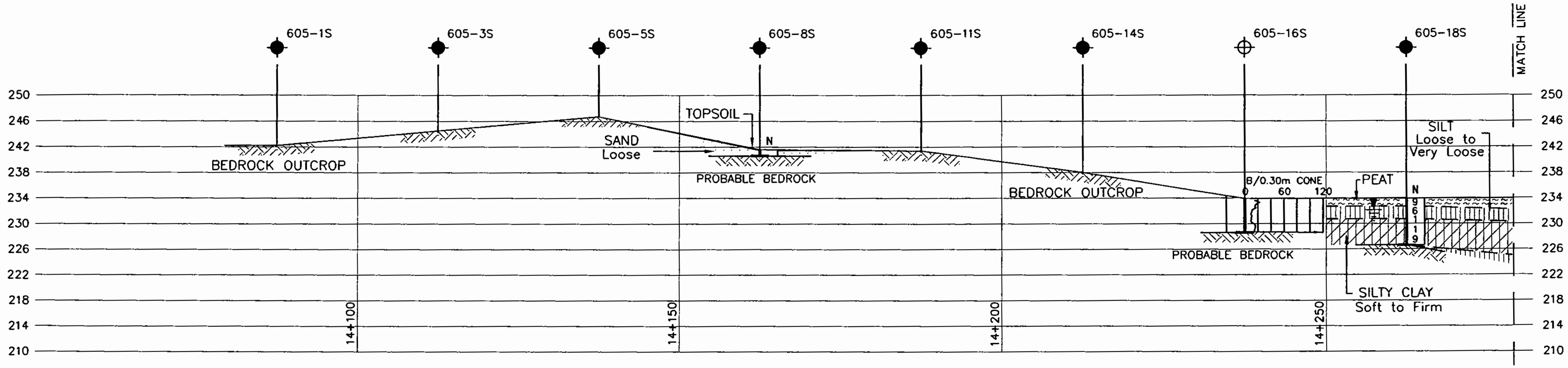
HWY.69

GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
SOIL STRATA

SHEET 605-2

THURBER ENGINEERING LTD.

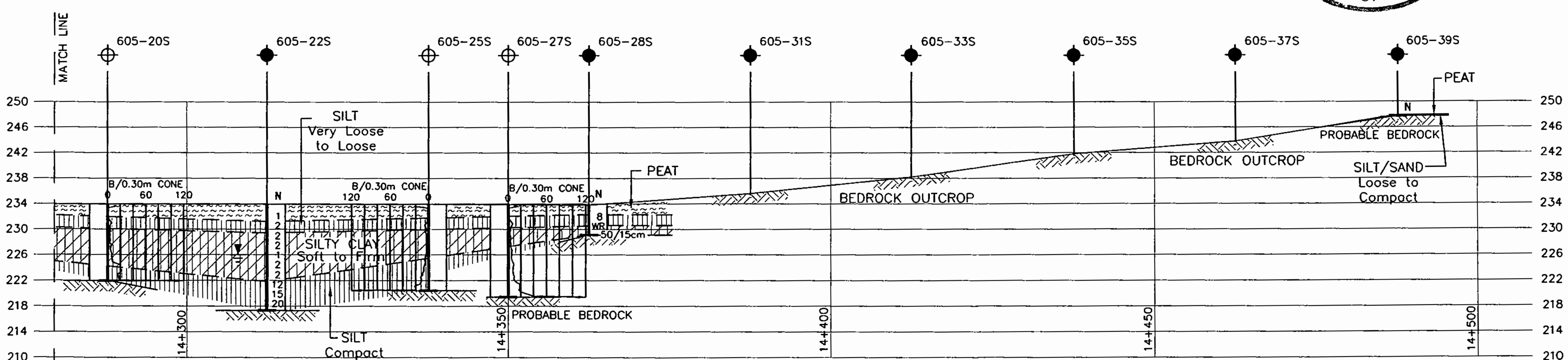


SECTION A-A

8 4 0 8 16m

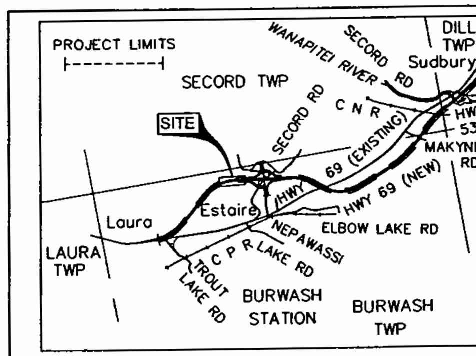
LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



SECTION A-A
(Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 2

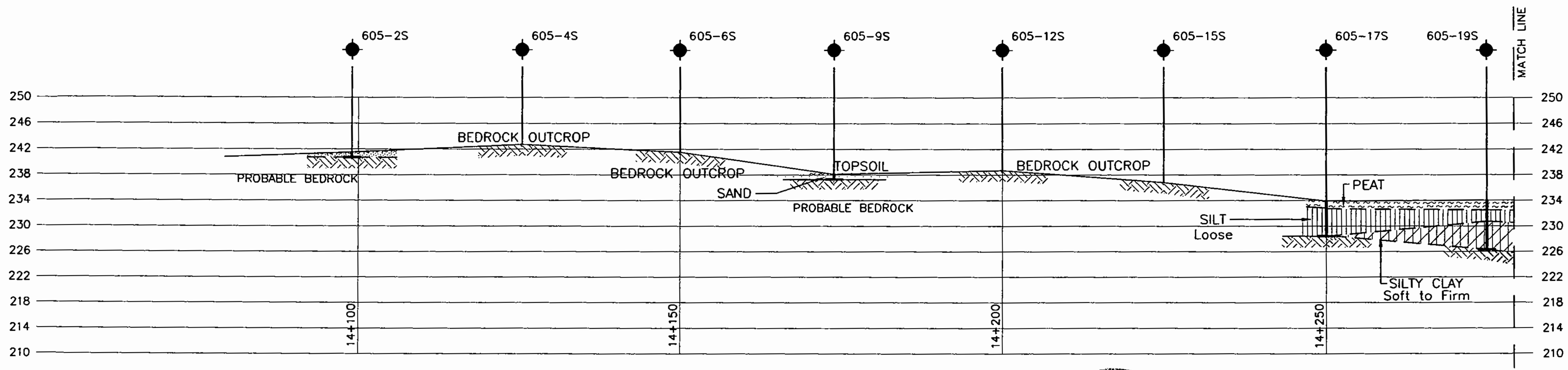
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
SOIL STRATA

SHEET 605-3

THURBER ENGINEERING LTD.

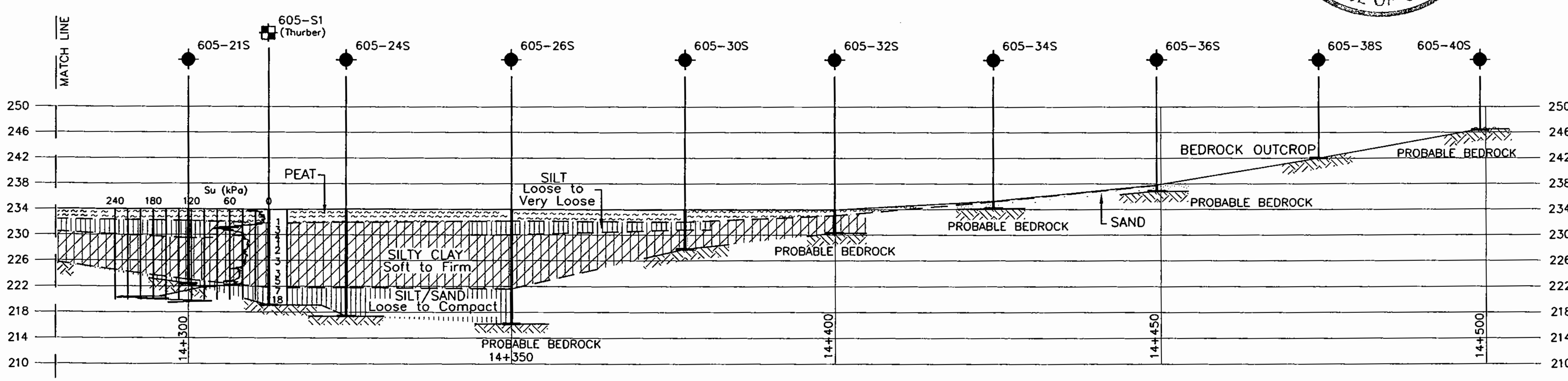


SECTION B-B

8 4 0 8 16m

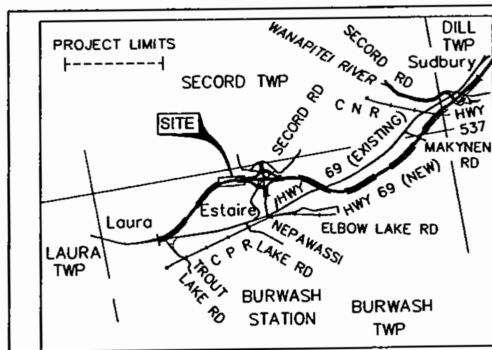
LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



SECTION B-B (Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

■	Bore Hole	Thurber
⊞	Piezocone	
	Bore Hole & Piezocone	
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	
	Bore Hole & Cone	
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesion Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 3

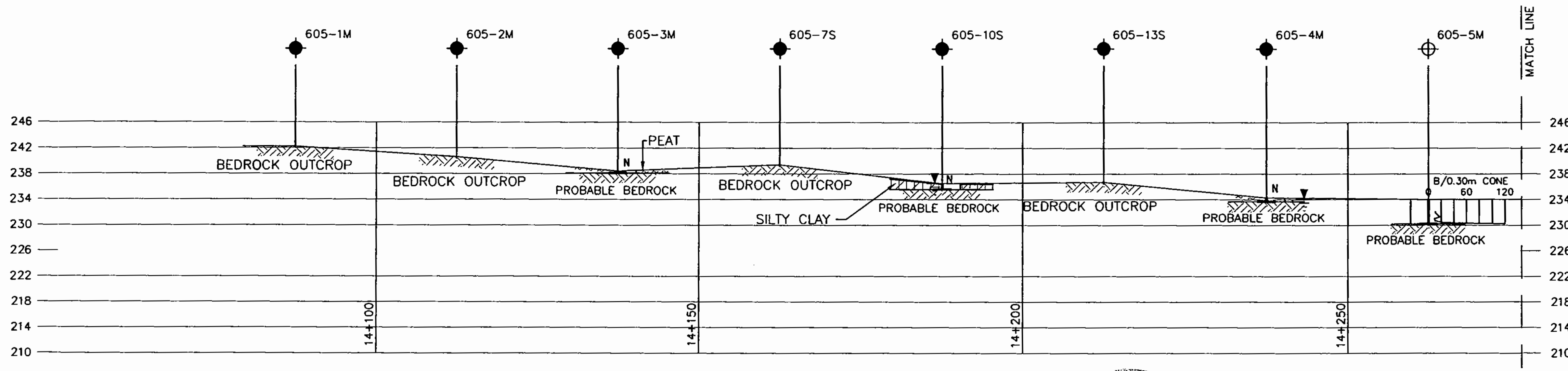
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
SOIL STRATA

SHEET 605-4

THURBER ENGINEERING LTD.

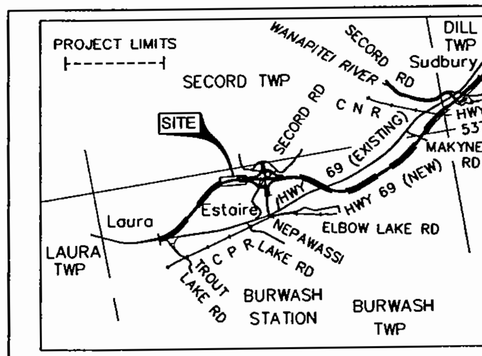


SECTION C–C

8 4 0 8 16m

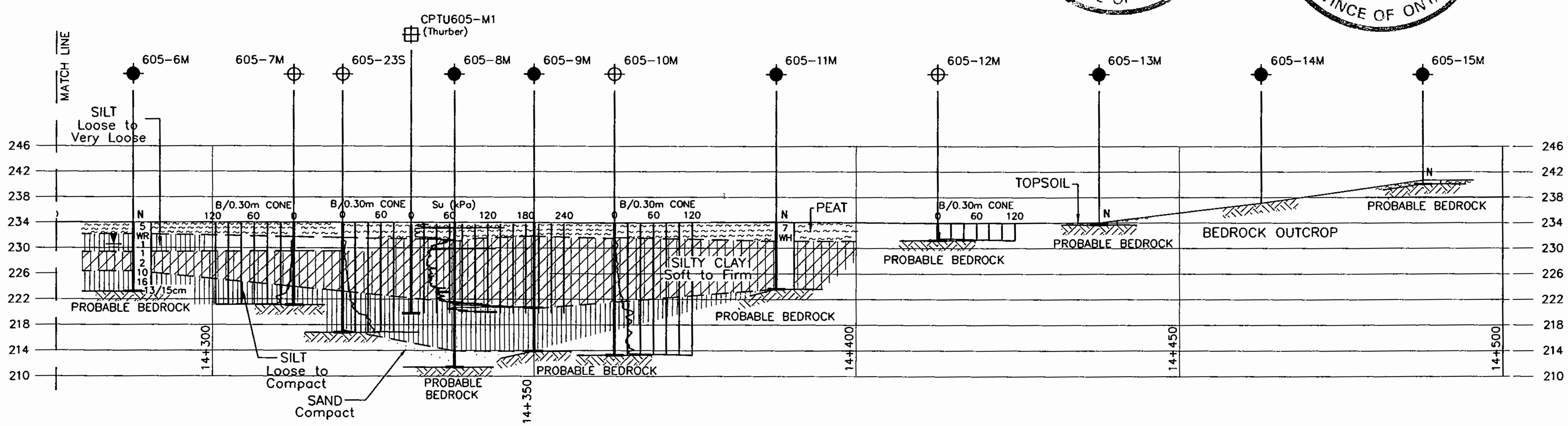
LICENSED PROFESSIONAL ENGINEER P. J. BRANCO May 15/06 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI May 15/06 PROVINCE OF ONTARIO



KEYPLAN

LEGEND		
	Bore Hole	Thurber
	Piezocone	
	Bore Hole & Piezocone	
	Bore Hole	Peto
	Dynamic Cone Penetration Test	
	Bore Hole & Cone	
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	



NO	STATION	OFFSET FROM CL

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

SECTION C–C (Continued)

8 4 0 8 16m

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 4

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

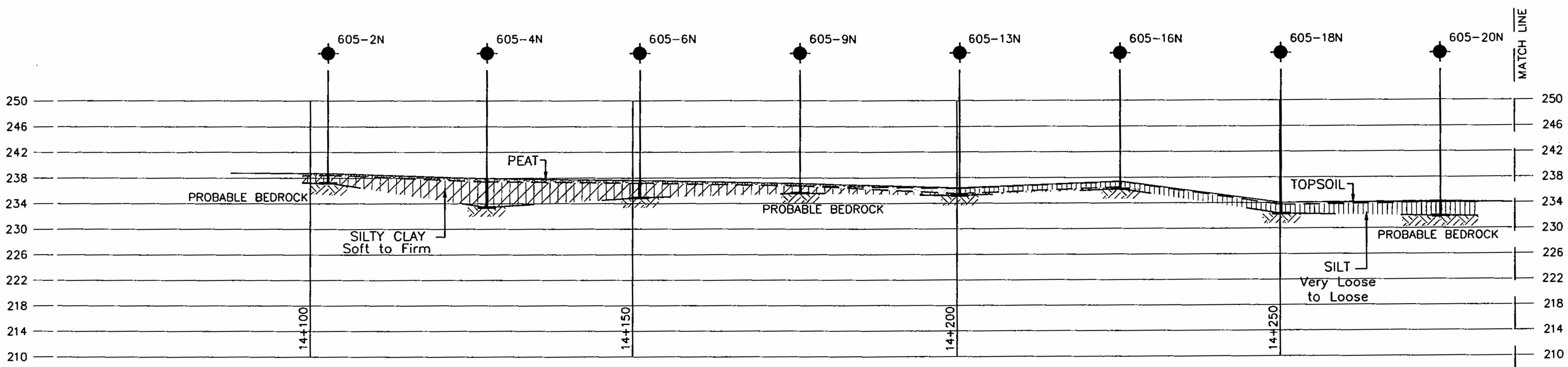
HWY.69

GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
SOIL STRATA

SHEET 605-5

THURBER ENGINEERING LTD.

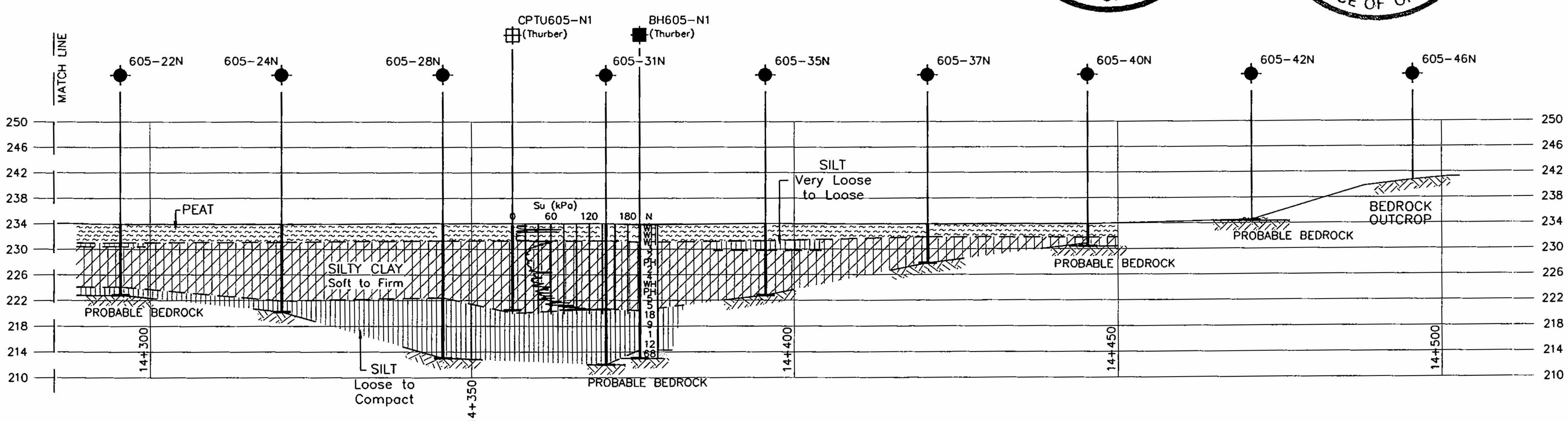


SECTION D-D

8 4 0 8 16m

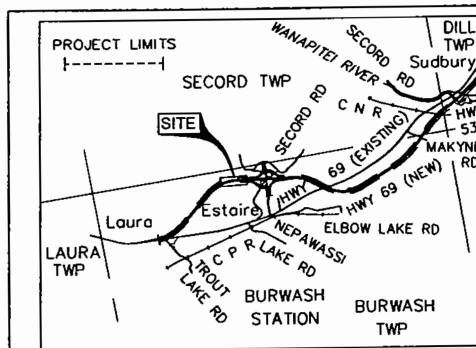
LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



SECTION D-D
(Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS | DATE | BY | DESCRIPTION

DESIGN | CHK | CODE CHBDC | LOAD | DATE
DRAWN | CHK | SITE | STRUCT | SCHEME | DWG 5

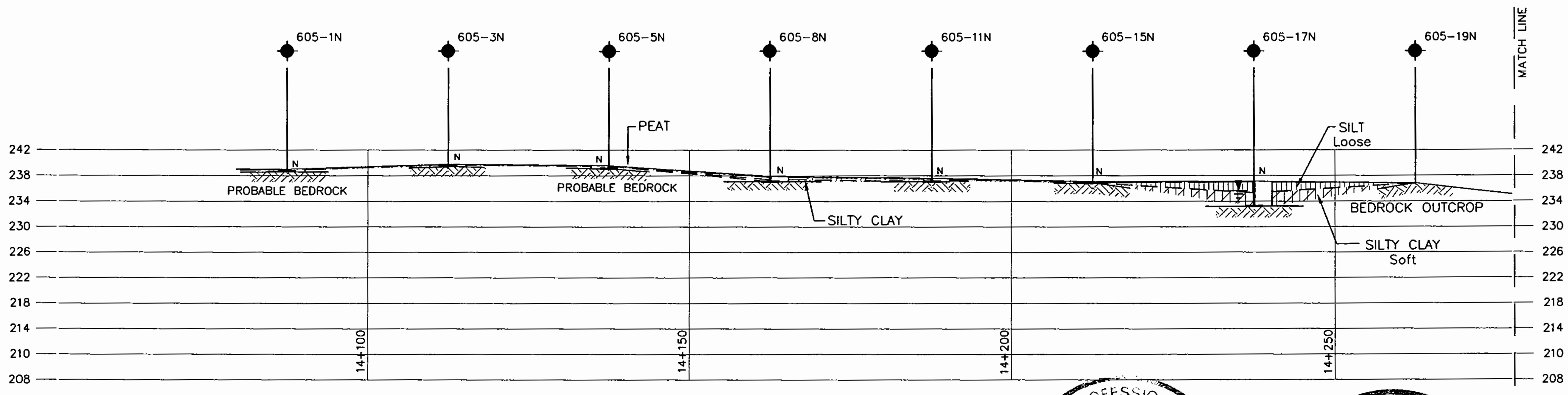
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
SOIL STRATA

SHEET 605-6

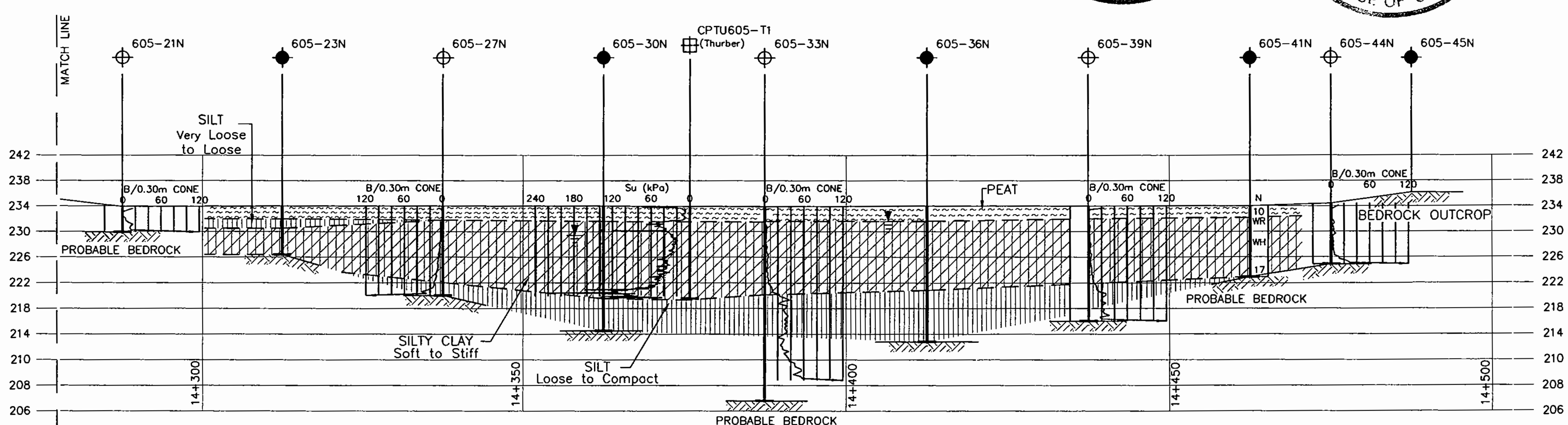
THURBER ENGINEERING LTD.



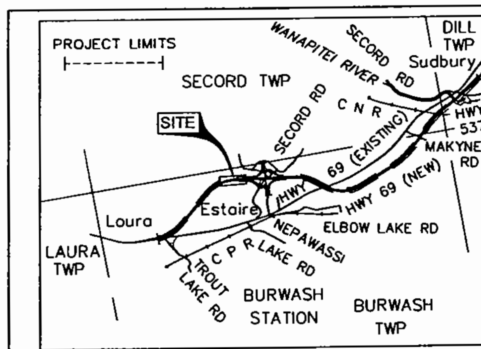
SECTION E-E
8 4 0 8 16m

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



SECTION E-E
(Continued)
8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
	Bore Hole	Thurber
	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
	Bore Hole	Peto
	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS | DATE | BY | DESCRIPTION
DESIGN | CHK | CODE CHBDC | LOAD | DATE
DRAWN | CHK | SITE | STRUCT | SCHEME | DWG 6

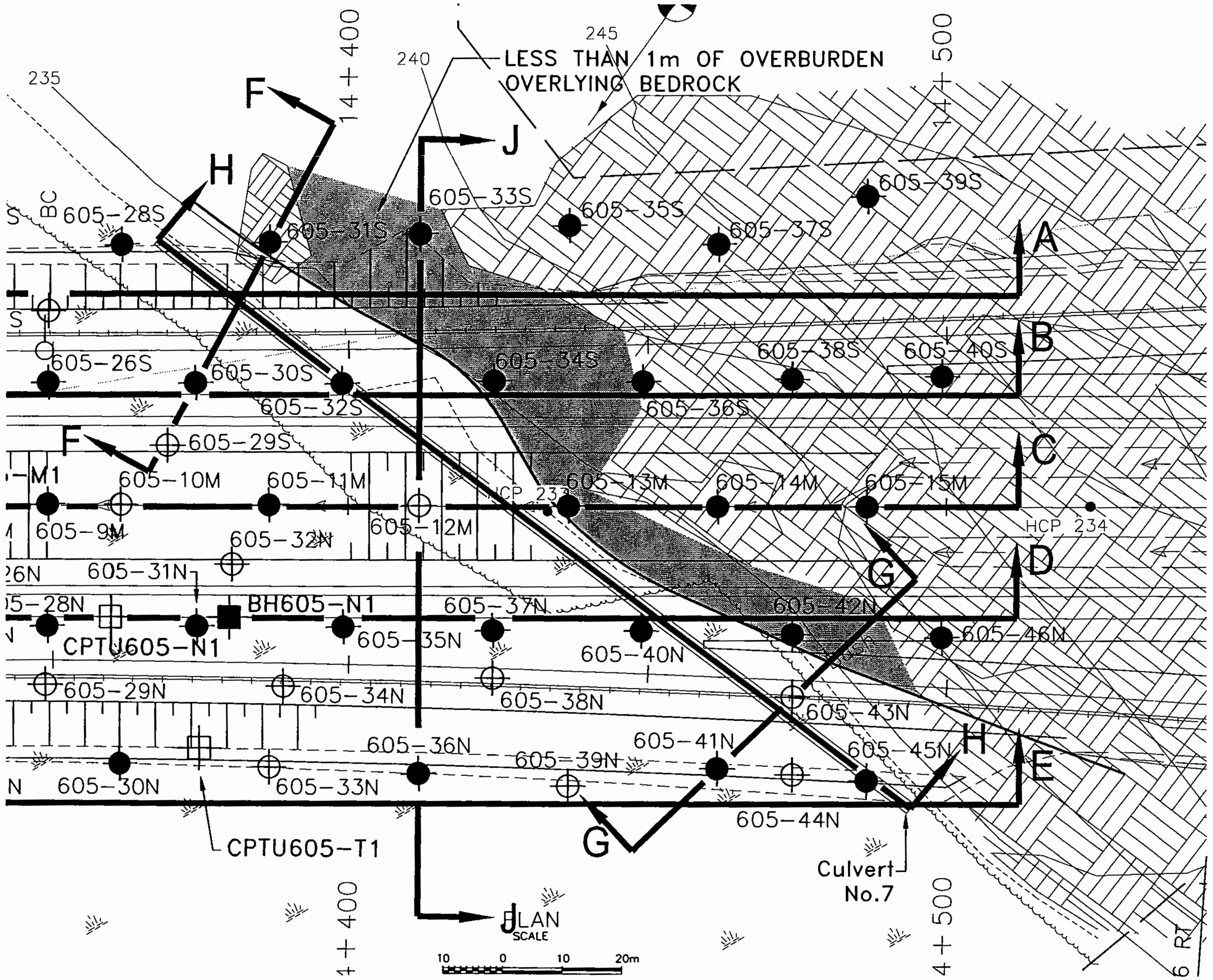
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

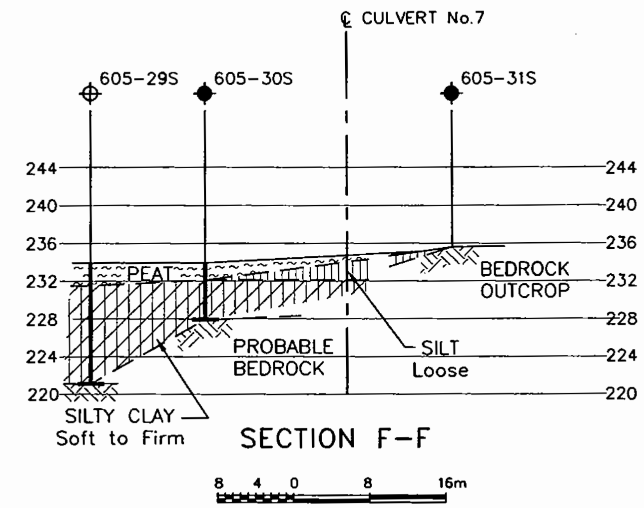
HWY.69
GWP NO. 312-99-00

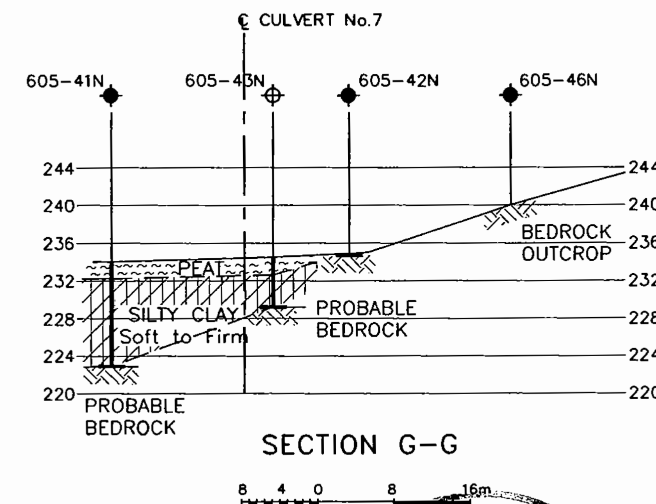
SHEET 605-7

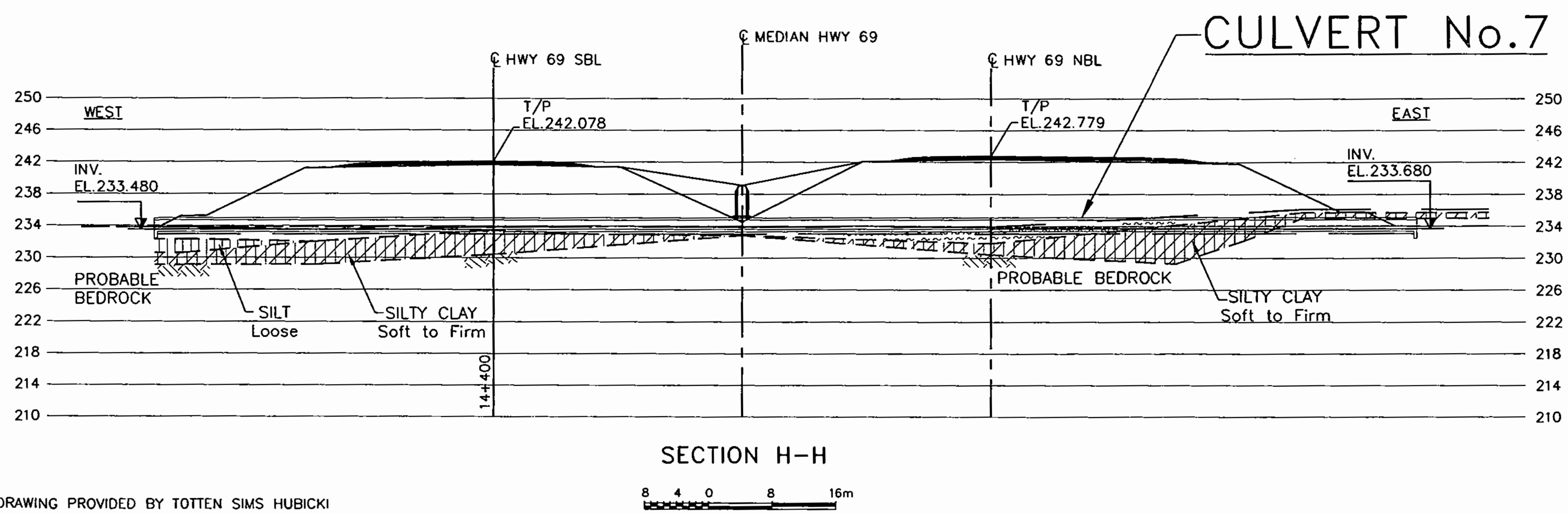
HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
BOREHOLE LOCATION AND STRATIGRAPHIC PROFILE ALONG CULVERT No.7

THURBER ENGINEERING LTD.







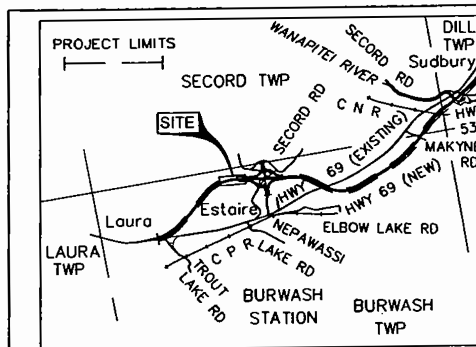


NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



KEYPLAN

LEGEND

Symbol	Description	
	Bore Hole	Thurber
	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
	Bore Hole	Peto
	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water Piezometer	
	Shallow Bedrock	
	Bedrock Outcrop	

NO	STATION	OFFSET FROM CL

— NOTE —
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REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 7

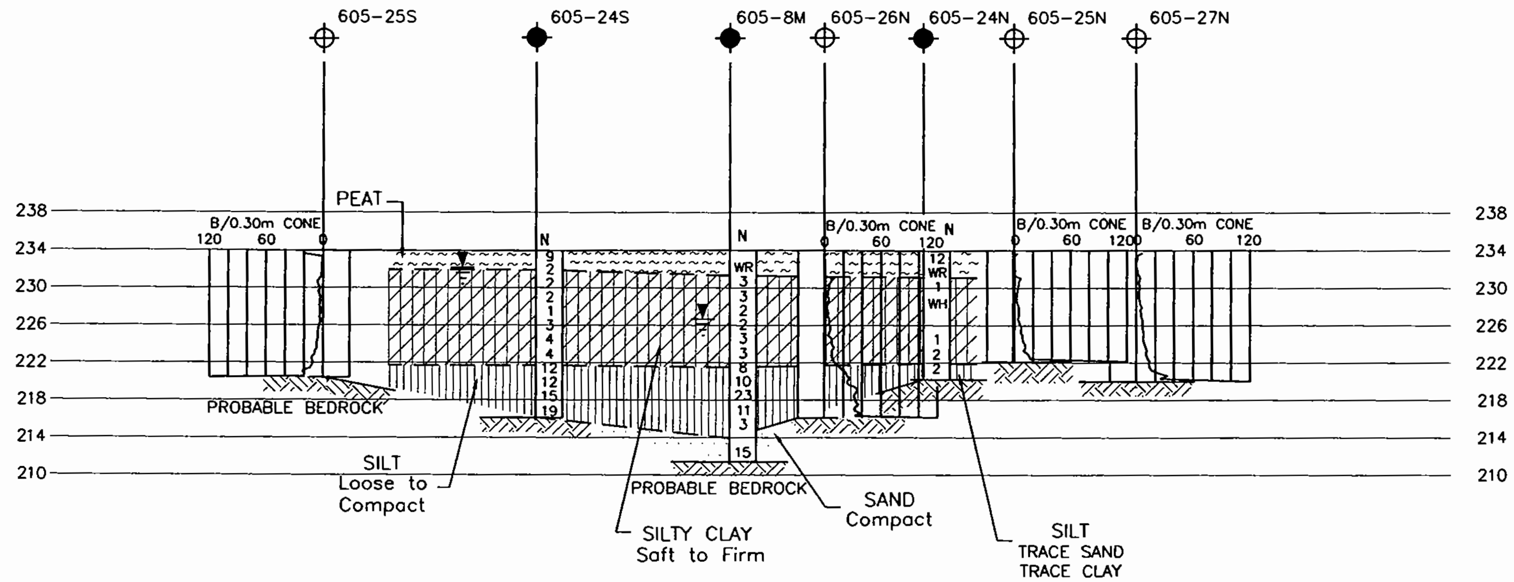
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 605, 14+086.5 to 14+506.5
SOIL STRATA

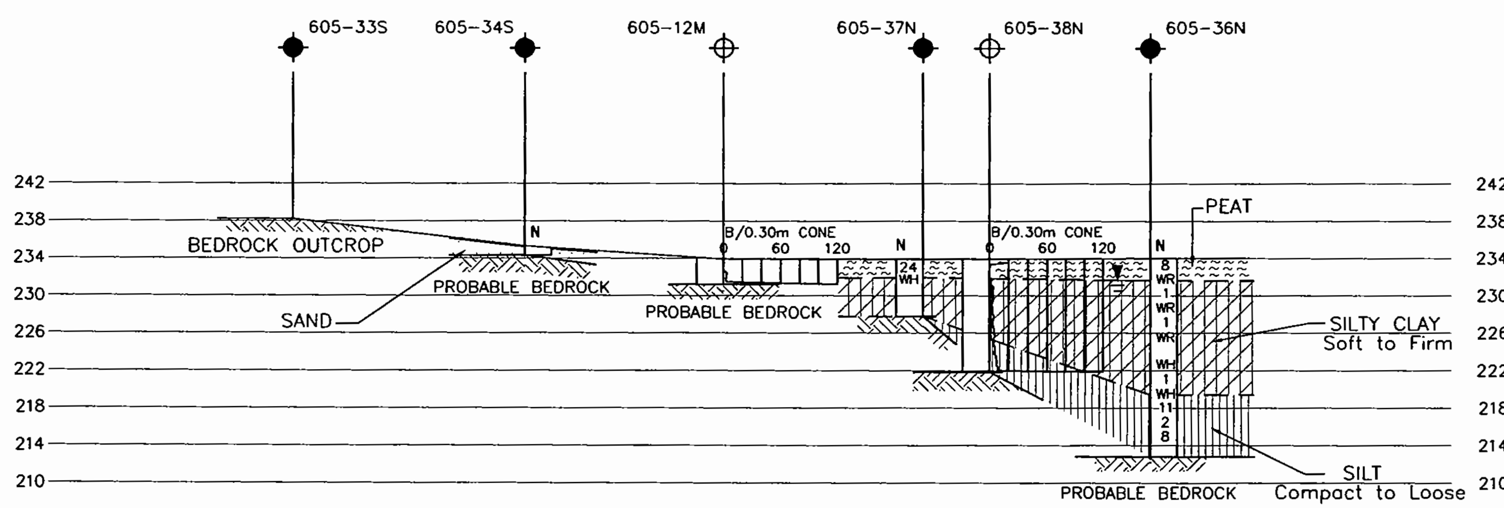
SHEET 605-8

THURBER ENGINEERING LTD.



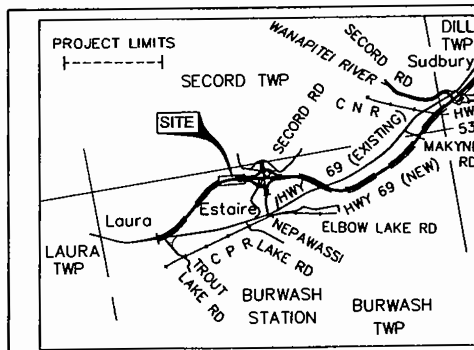
SECTION I-I

8 4 0 8 16m



SECTION J-J

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesion Woter	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

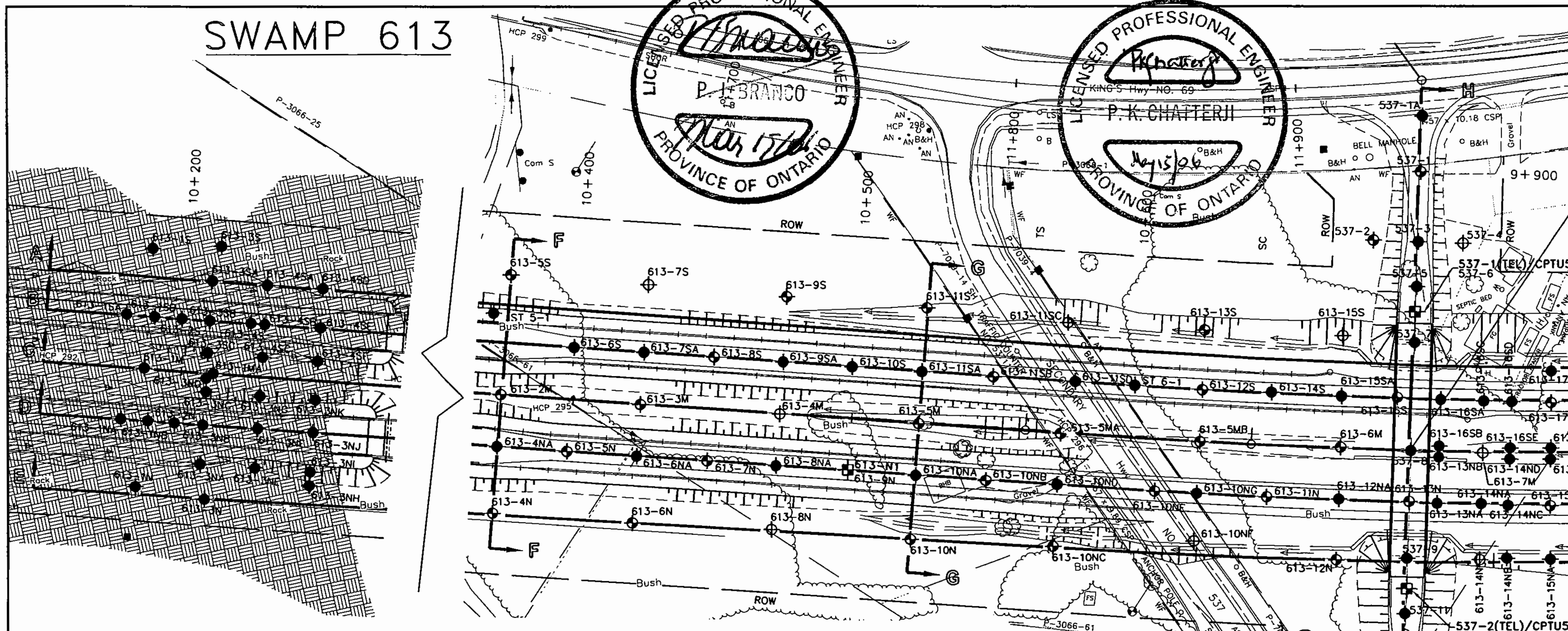
NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

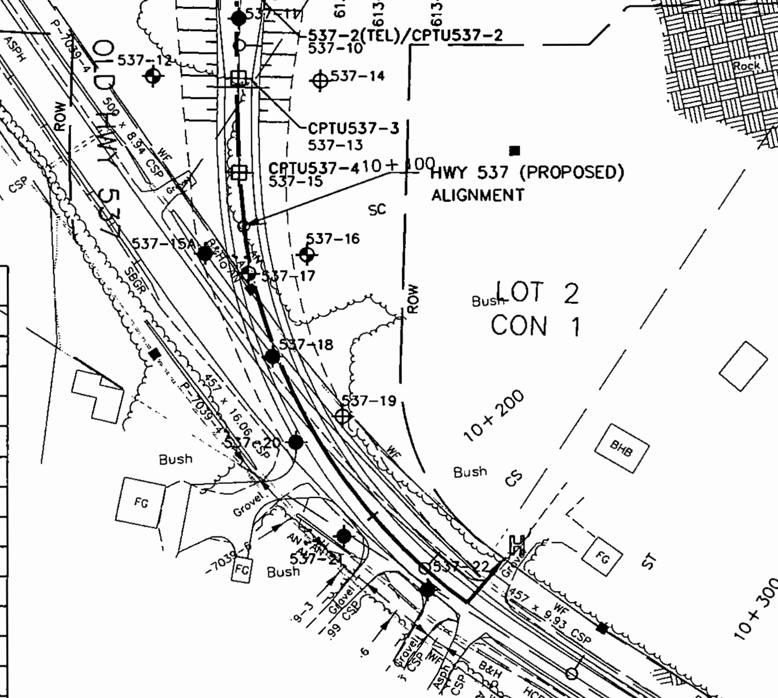
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 8

SWAMP 613





PLAN
SCALE
20 0 20 40m

BOREHOLES BY PETO

BH No	ELEVATION	STA DILL TWP	o/s CL MED
613-1M	228.2	10+187.5	CL
613-1MA	224.0	10+212.5	CL
613-2M	219.0	10+375	CL
613-3M	218.4	10+425	CL
613-4M	218.5	10+475	CL
613-5M	220.3	10+525	CL
613-5MA	221.0	10+575	CL
613-5MB	221.6	10+625	CL
613-6M	221.8	10+675	CL
613-7M	223.9	10+725	CL
613-8M	225.2	10+775	CL
613-1N	229.0	10+187.5	43m Rt
613-1NA	228.5	10+180	19m Rt
613-1NB	232.8	10+190	19m Rt
613-2N	229.4	10+200	19m Rt
613-3N	228.2	10+212.5	46m Rt
613-3NA	223.6	10+210	33m Rt
613-3NB	224.1	10+210	19m Rt
613-3NC	224.2	10+210	7m Rt
613-3ND	224.1	10+210	2m Rt
613-3NE	223.3	10+230	33m Rt
613-3NF	223.3	10+230	19m Rt
613-3NG	223.5	10+230	7m Rt
613-3NH	223.8	10+250	38m Rt
613-3NI	219.0	10+250	33m Rt
613-3NJ	219.2	10+250	19m Rt
613-3NK	221.9	10+250	7m Rt
613-4N	218.7	10+375	43m Rt
613-4NA	218.9	10+375	19m Rt
613-5N	219.1	10+400	19m Rt
613-6N	218.8	10+425	43m Rt
613-6NA	218.7	10+425	19m Rt
613-7N	218.4	10+450	19m Rt
613-8N	218.7	10+475	42m Rt

(Legend Continued)

BH No	ELEVATION	STA DILL TWP	o/s CL MED
613-8NA	218.6	10+475	19m Rt
613-9N	218.7	10+500	19m Rt
613-10N	218.8	10+525	42m Rt
613-10NA	219.4	10+525	19m Rt
613-10NB	219.8	10+550	19m Rt
613-10NC	219.6	10+575	41m Rt
613-10ND	220.2	10+575	19m Rt
613-10NE	221.4	10+610	19m Rt
613-10NF	221.1	10+625	36m Rt
613-10NG	221.4	10+625	19m Rt
613-11N	221.5	10+650	19m Rt
613-12N	221.5	10+675	40.5m Rt
613-12NA	221.7	10+675	19m Rt
613-13N	222.2	10+700	19m Rt
613-13NA	221.2	10+710	19m Rt
613-13NB	222.5	10+710	2m Rt
613-14N	223.0	10+725	39m Rt
613-14NA	223.4	10+725	19m Rt
613-14NB	223.0	10+735	38m Rt
613-14NC	222.4	10+735	19m Rt
613-14ND	223.8	10+735	2m Rt
613-15N	224.6	10+750	19m Rt
613-15NA	223.5	10+750	38m Rt
613-15NB	224.5	10+750	2m Rt
613-16N	223.8	10+775	35.5m Rt
613-16NA	223.7	10+775	38m Rt
613-16NB	224.8	10+775	19m Rt
613-16NC	224.9	10+775	7m Rt
613-17N	225.0	10+800	19m Rt
613-18N	228.8	10+825	5m Rt
613-18NA	228.7	10+825	19m Rt
613-19N	228.6	10+825	34m Rt
613-1S	225.7	10+187.5	43m Lt
613-1SA	227.6	10+180	19m Lt
613-1SB	226.6	10+190	19m Lt

(Legend Continued)

BH No	ELEVATION	STA DILL TWP	o/s CL MED
613-2S	224.9	10+200	19m Lt
613-3S	229.6	10+212.5	46m Lt
613-3SA	227.7	10+210	33m Lt
613-3SB	226.3	10+210	19m Lt
613-3SC	224.2	10+210	7m Lt
613-4S	226.6	10+225	19m Lt
613-4SA	232.7	10+230	33m Lt
613-4SB	230.4	10+230	19m Lt
613-4SC	225.8	10+230	7m Lt
613-4SD	226.2	10+250	33m Lt
613-4SE	224.7	10+250	19m Lt
613-4SF	222.6	10+250	7m Lt
613-5S	218.5	10+375	43m Lt
613-6S	218.4	10+400	19m Lt
613-7S	218.3	10+425	43m Lt
613-7SA	218.4	10+425	19m Lt
613-8S	218.3	10+450	19m Lt
613-9S	220.0	10+475	42m Lt
613-9SA	218.9	10+475	19m Lt
613-10S	219.2	10+500	19m Lt
613-11S	219.9	10+525	42m Lt
613-11SA	220.0	10+525	19m Lt
613-11SB	220.5	10+550	19m Lt
613-11SC	221.0	10+575	40m Lt
613-11SD	221.9	10+579	19m Lt
613-12S	221.6	10+625	19m Lt
613-13S	222.0	10+625	40.5m Lt
613-14S	221.7	10+650	19m Lt
613-15S	222.0	10+675	40.5m Lt
613-15SA	222.0	10+675	19m Lt
613-16S	223.2	10+695	19m Lt
613-16SA	223.8	10+710	19m Lt
613-16SB	222.5	10+710	2m Lt
613-16SC	225.0	10+725	19m Lt
613-16SD	224.7	10+735	19m Lt

(Legend Continued)

BH No	ELEVATION	STA DILL TWP	o/s CL MED
613-16SE	223.9	10+735	2m Lt
613-17S	225.5	10+750	19m Lt
613-17SA	226.0	10+750	30m Lt
613-17SB	224.6	10+750	2m Lt
613-18S	227.0	10+775	35.5m Lt
613-18SA	227.0	10+775	38m Lt
613-18SB	225.9	10+775	19m Lt
613-18SC	225.5	10+775	7m Lt
613-19S	226.1	10+800	19m Lt
613-20S	230.7	10+825	34m Lt
613-20SA	230.5	10+825	19m Lt
613-21S	230.0	10+825	5m Lt
ST 5-1	218.0	10+370	28.5m Lt
ST 6-1	221.7	10+600.5	19m Lt

HIGHWAY 537

BH No	ELEVATION	STA DILL TWP	o/s CL
537-1A	226.7	9+880	CL
537-1	225.5	9+900	CL
537-2	225.0	9+925	16m Rt
537-3	225.5	9+925	CL
537-4	225.0	9+925	16m Lt
537-5	225.1	9+941	CL
537-6	224.7	9+950	CL
537-7	224.7	9+961	CL
537-8	222.1	10+000	CL
537-9	220.5	10+039	CL
537-10	220.0	10+050	CL
537-11	220.3	10+059	CL

(Legend Continued)

BH No	ELEVATION	STA DILL TWP	o/s CL
537-12	220.0	10+075	22m Rt
537-13	220.0	10+075	CL
537-14	219.8	10+075	22m Lt
537-15	219.8	10+100	CL
537-15A	219.9	10+120	10m Rt
537-16	219.8	10+125	16m Lt
537-17	219.7	10+127	CL
537-18	220.0	10+150	CL
537-19	221.7	10+175	10m Lt
537-20	220.3	10+175	4m Rt
537-21	221.4	10+200	8m Rt
537-22	222.9	10+225	2m Rt

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

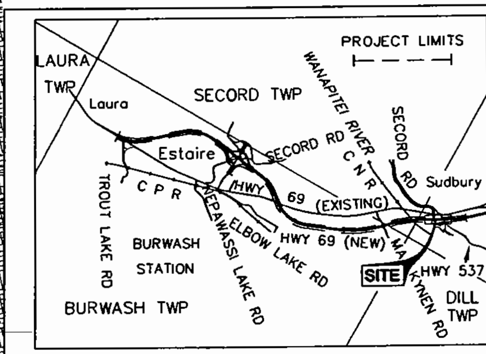
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
PLAN AND BOREHOLE LOCATIONS

SHEET
613-1

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

(symbol)	Bore Hole — Thurber
(symbol)	Piezocone — Thurber
(symbol)	Bore Hole & Piezocone — Thurber
(symbol)	Bore Hole — Peto
(symbol)	Dynomic Cone Penetration Test — Peto
(symbol)	Bore Hole & Cone — Peto
N	Blows/0.3m (Std pen Test, 475J/blow)
CONE	Blows/0.3m (60° Cone, 475J/blow)
(symbol)	WL in Piezometer at Time of Investigotion (Date)
(symbol)	Head Artesian Water Piezometer
(symbol)	Bedrock

BOREHOLES BY THURBER

BH No	ELEVATION	STA DILL TWP	o/s CL
613-N1	218.7	10+500	19m Rt
537-1(TEL)/ CPTU537-1	224.7	9+950	CL
537-2(TEL)/ CPTU537-2	220.0	10+050	CL
CPTU537-3	220.0	10+075	CL
CPTU537-4	219.8	10+100	CL

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

REVISIONS DATE	BY	DESCRIPTION			
DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 1

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

HWY.69
GWP NO. 312-99-00

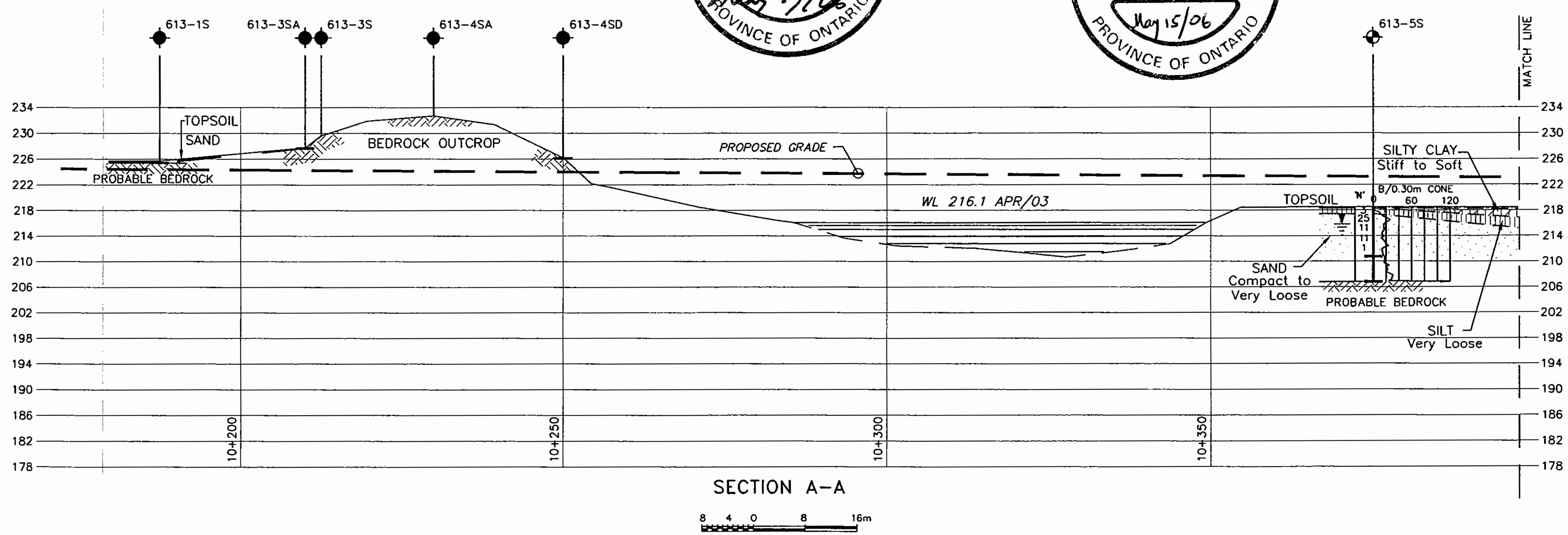
HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 613-2

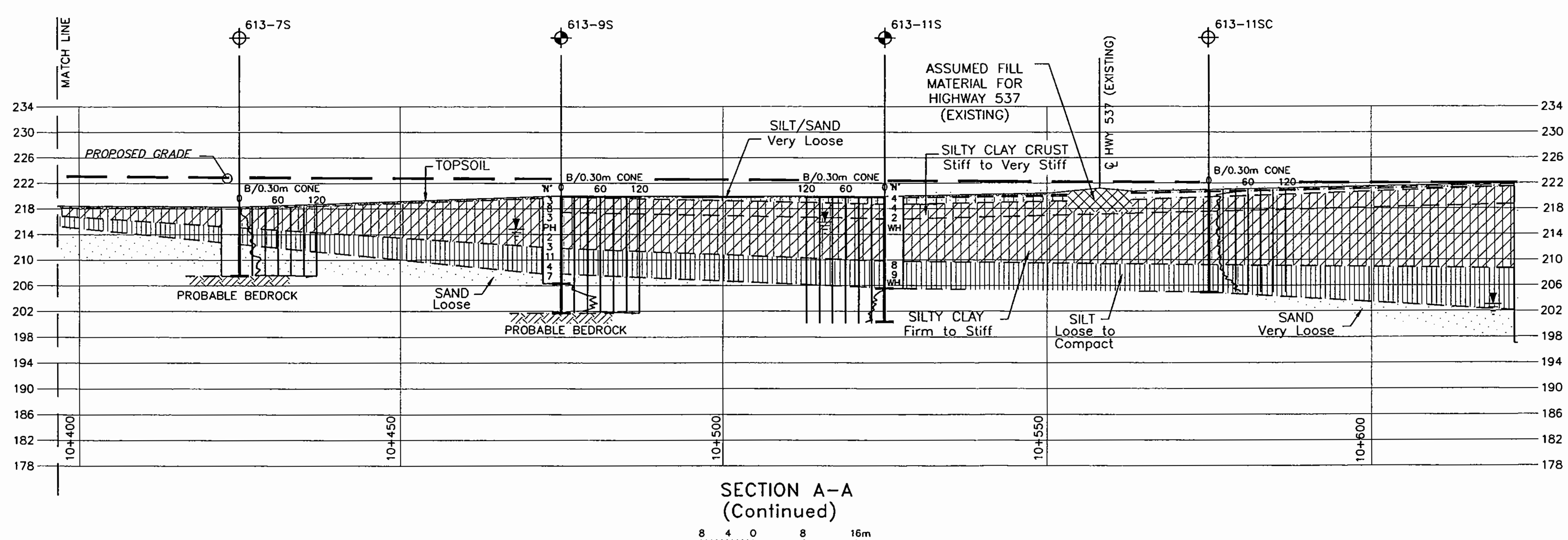
THURBER ENGINEERING LTD.

LICENSED PROFESSIONAL ENGINEER P. J. BRANCO May 15/06 PROVINCE OF ONTARIO

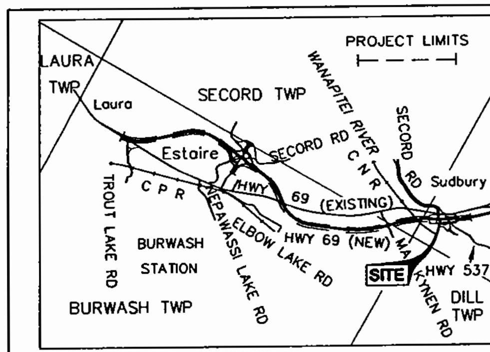
LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI May 15/06 PROVINCE OF ONTARIO



SECTION A-A



SECTION A-A (Continued)



KEYPLAN

LEGEND		
Bore Hole		Thurber
Piezocone		Thurber
Bore Hole & Piezocone		Thurber
Bore Hole		Peto
Dynamic Cone Penetration Test		Peto
Bore Hole & Cone		Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS | DATE | BY | DESCRIPTION
DESIGN | CHK | CODE CHBDC | LOAD | DATE
DRAWN | CHK | SITE | STRUCT | SCHEME | DWG 2

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO

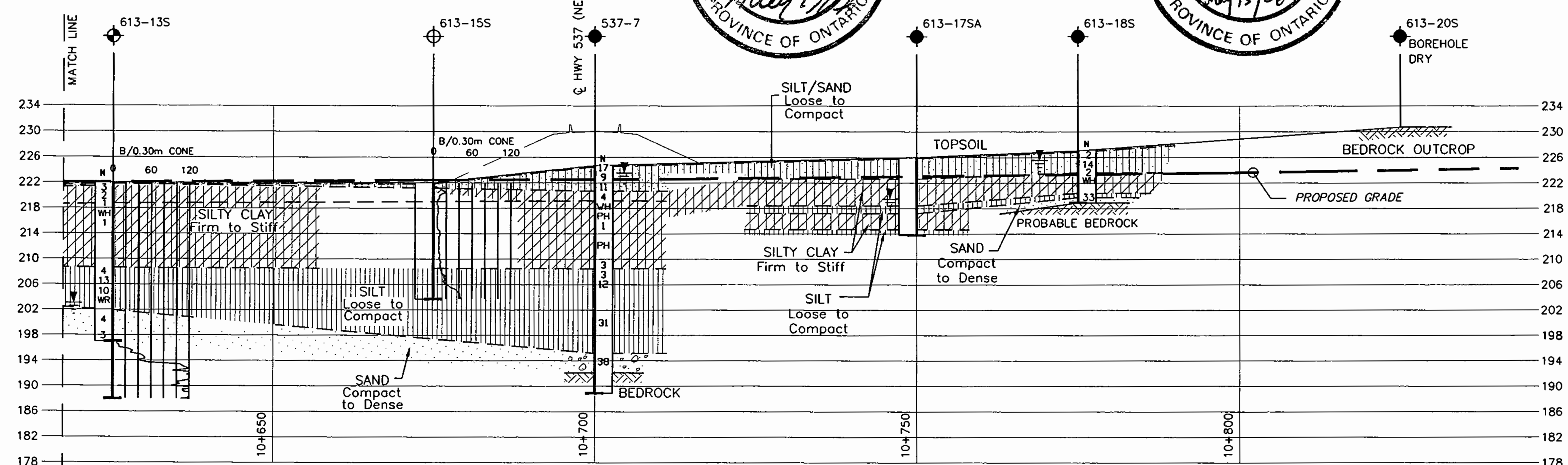
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

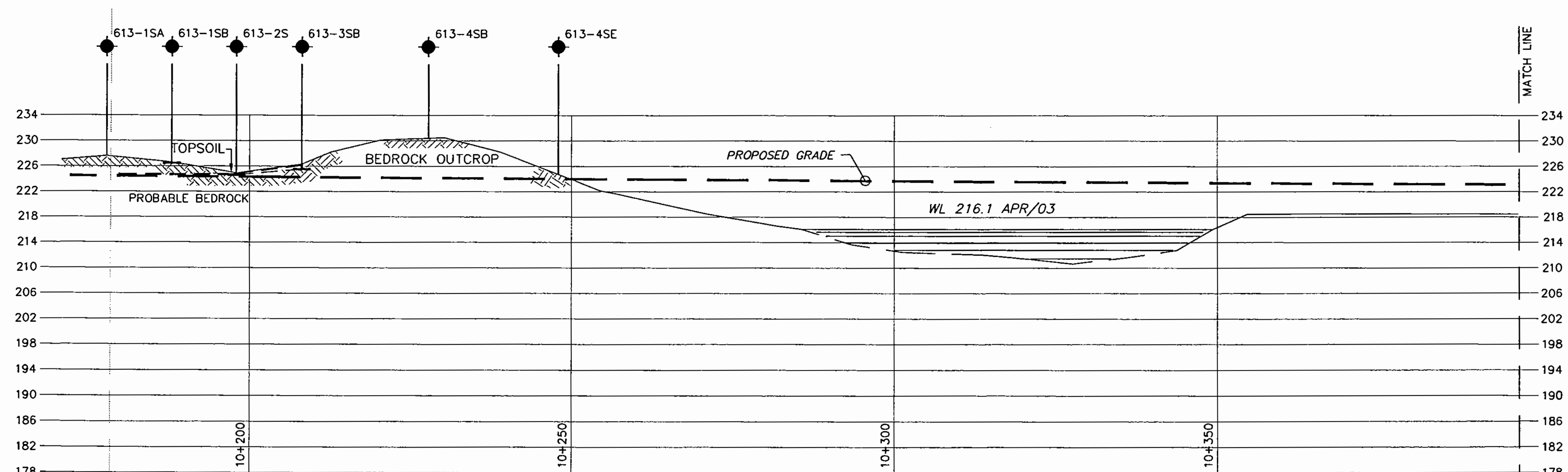
SHEET 613-3

THURBER ENGINEERING LTD.



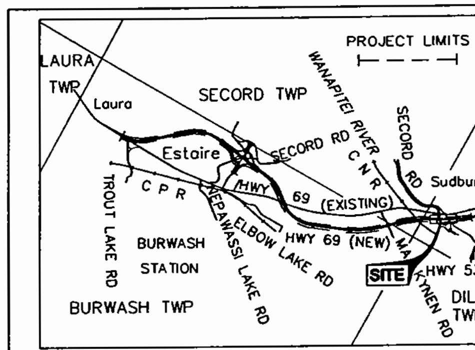
SECTION A-A
(Continued)

8 4 0 8 16m



SECTION B-B

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 3

METRIC

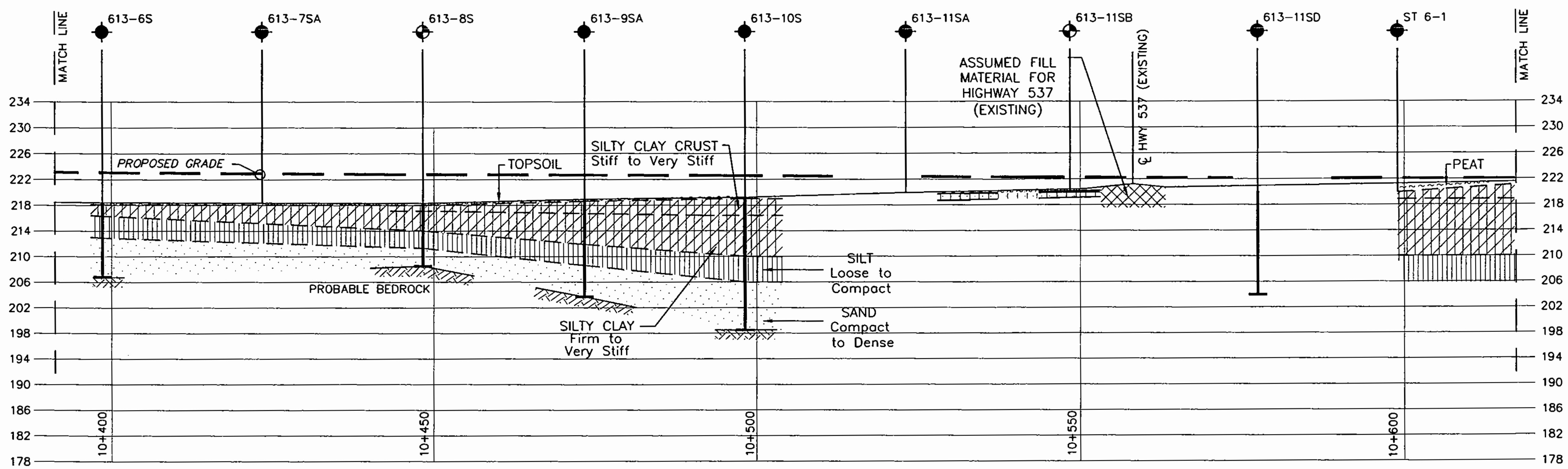
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

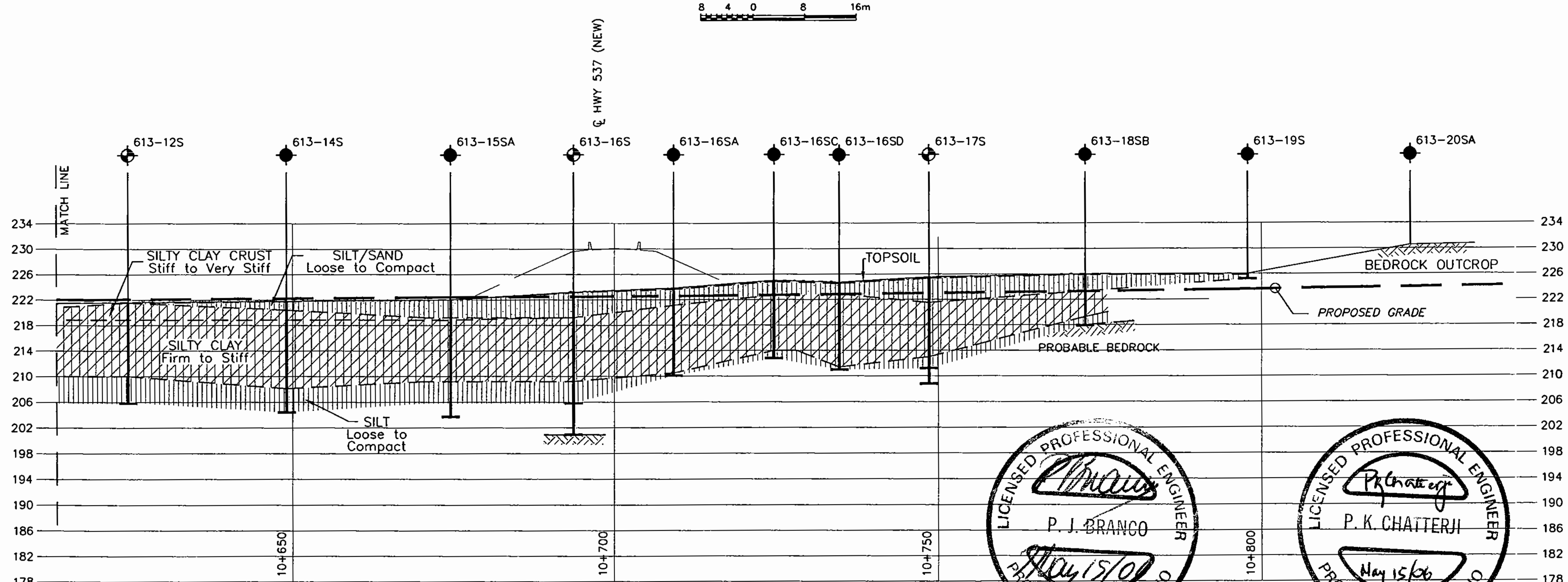
SHEET 613-4

THURBER ENGINEERING LTD.



SECTION B–B
(Continued)

8 4 0 8 16m

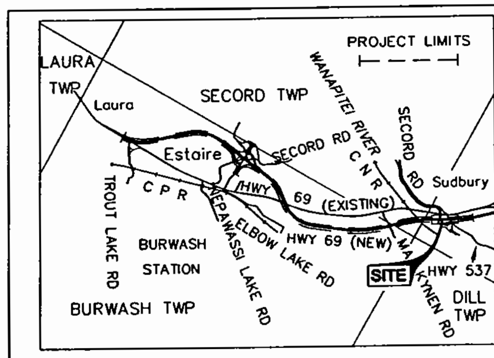


SECTION B–B
(Continued)

8 4 0 8 16m

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO



KEYPLAN

L E G E N D

■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

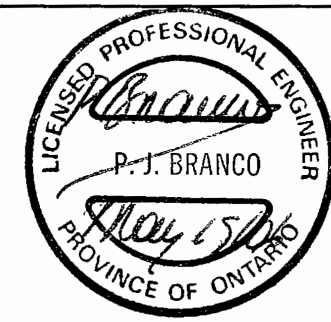
— NOTE —

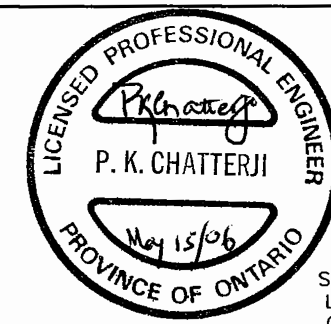
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 4





METRIC

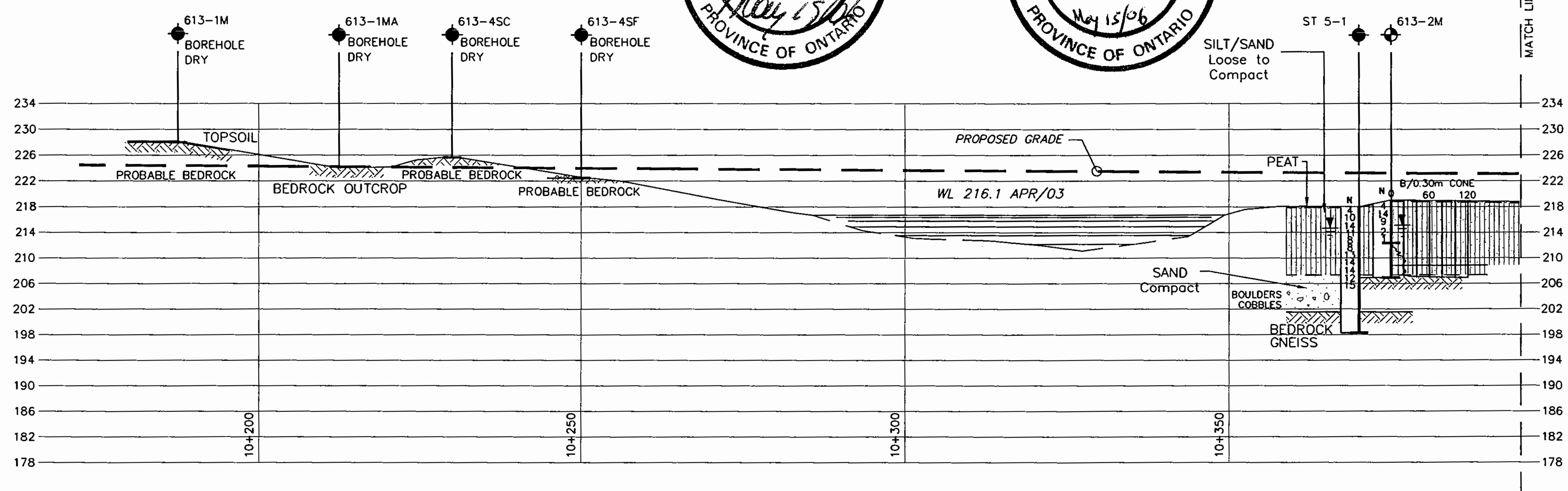
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY. 69
GWP NO. 312-99-00

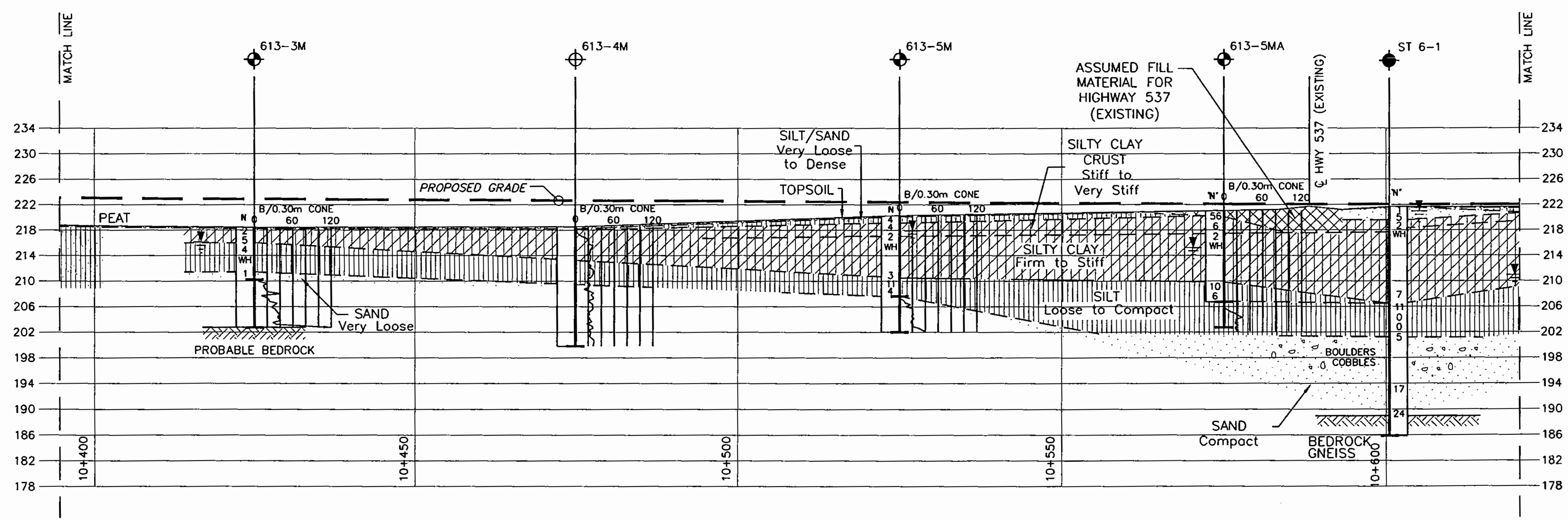
HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 613-5

THURBER ENGINEERING LTD.



SECTION C-C



SECTION C-C
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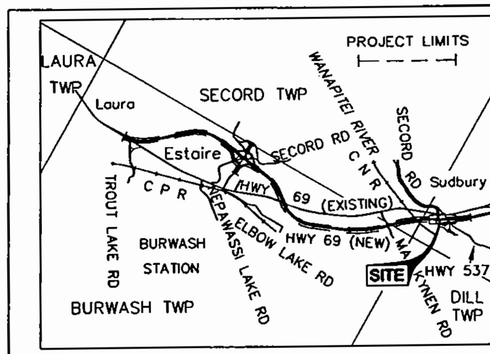


KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesion Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 5

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO

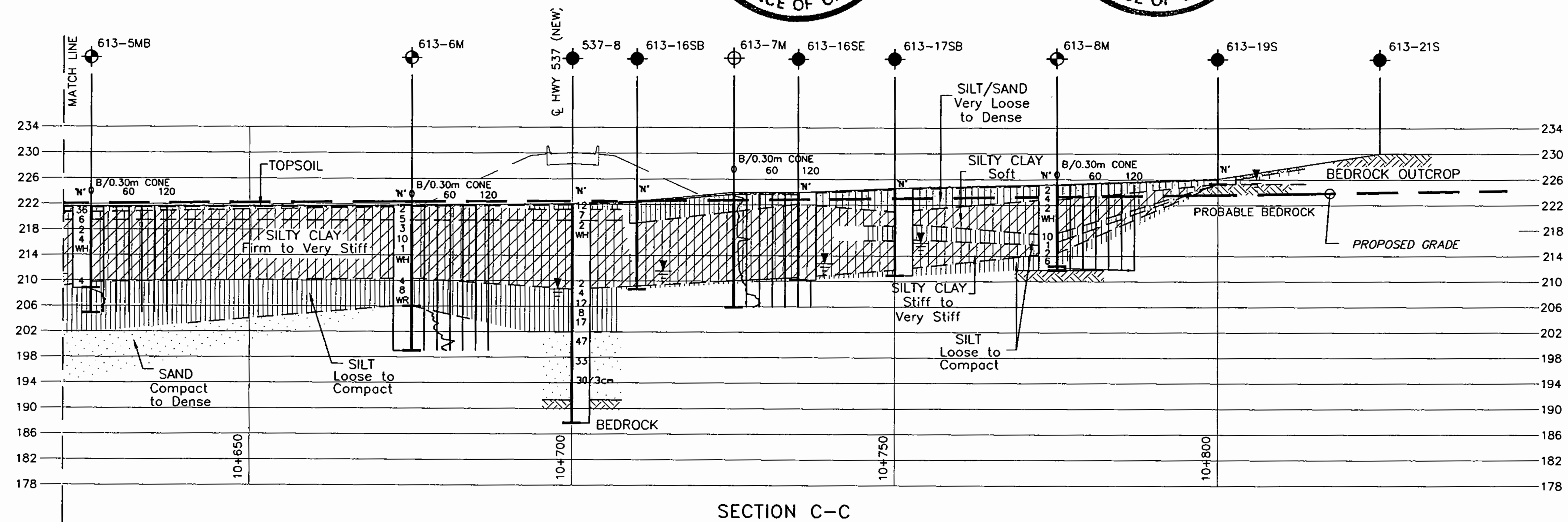
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

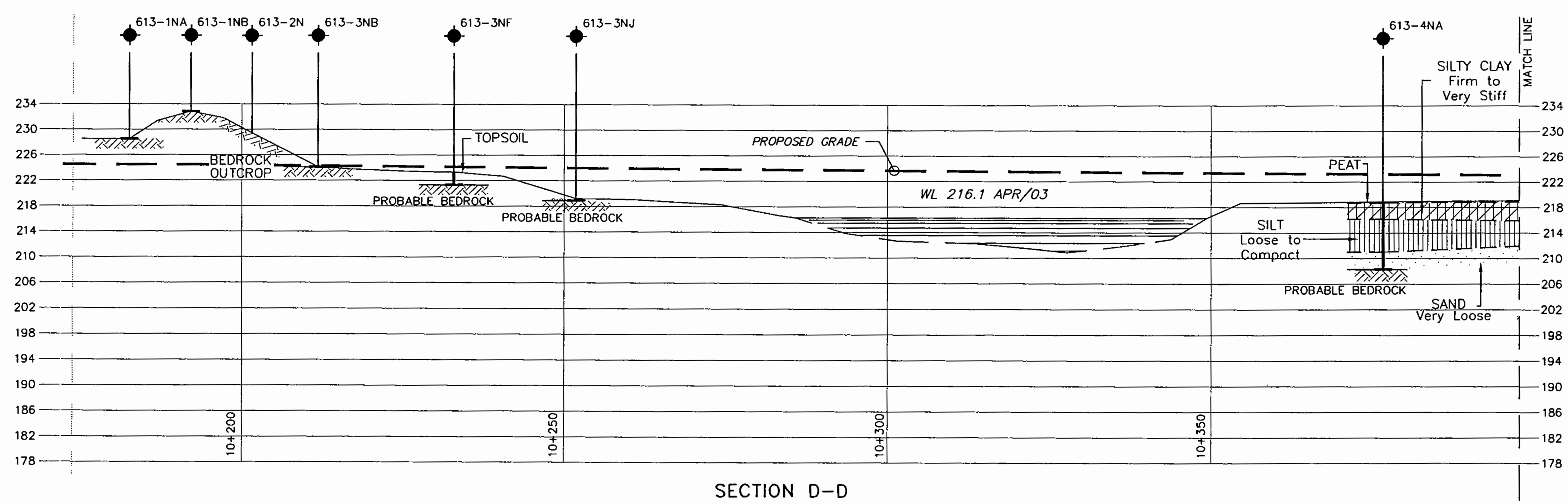
SHEET 613-6

THURBER ENGINEERING LTD.



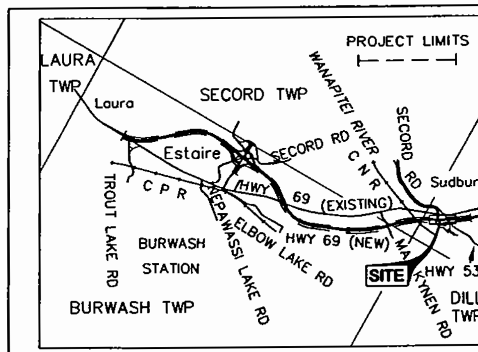
SECTION C–C (Continued)

8 4 0 8 16m



SECTION D–D

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
	Bore Hole	Thurber
	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
	Bore Hole	Peto
	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN	CHK	CODE CHBDC	LOAD	DATE	
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 6

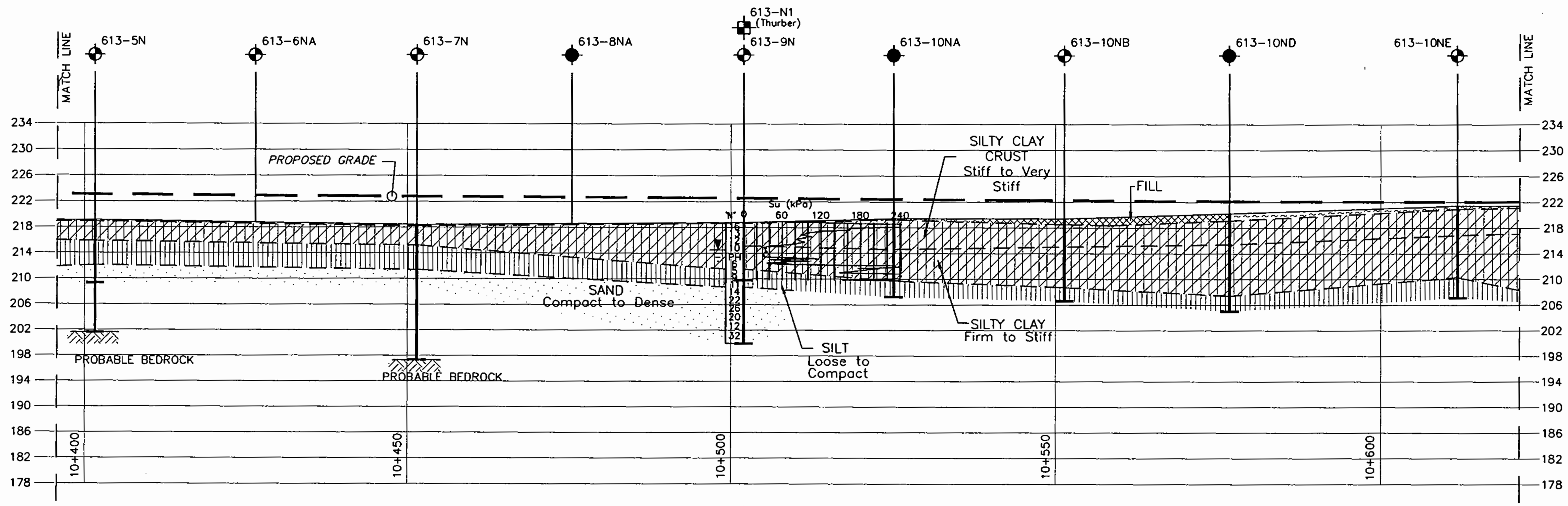
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

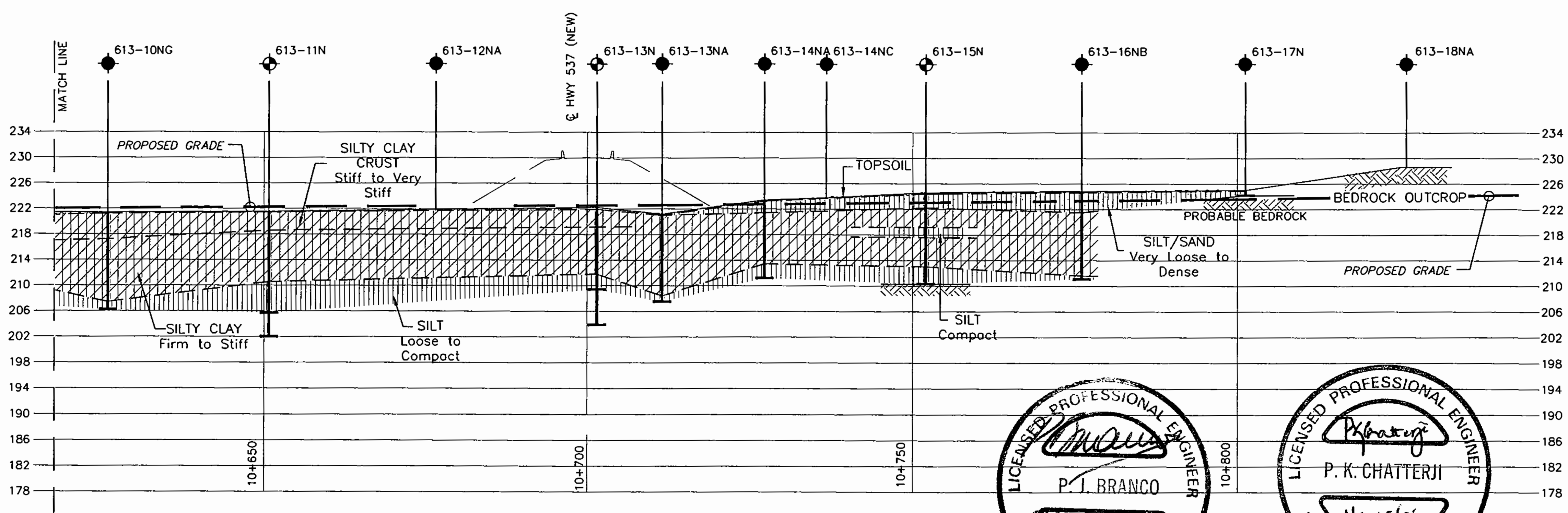
HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 613-7

THURBER ENGINEERING LTD.



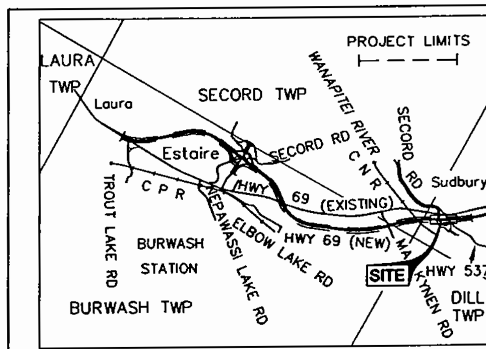
SECTION D-D
(Continued)



SECTION D-D
(Continued)

LICENSED PROFESSIONAL ENGINEER P. J. BRANCO May 15/06 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI May 15/06 PROVINCE OF ONTARIO



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 7

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

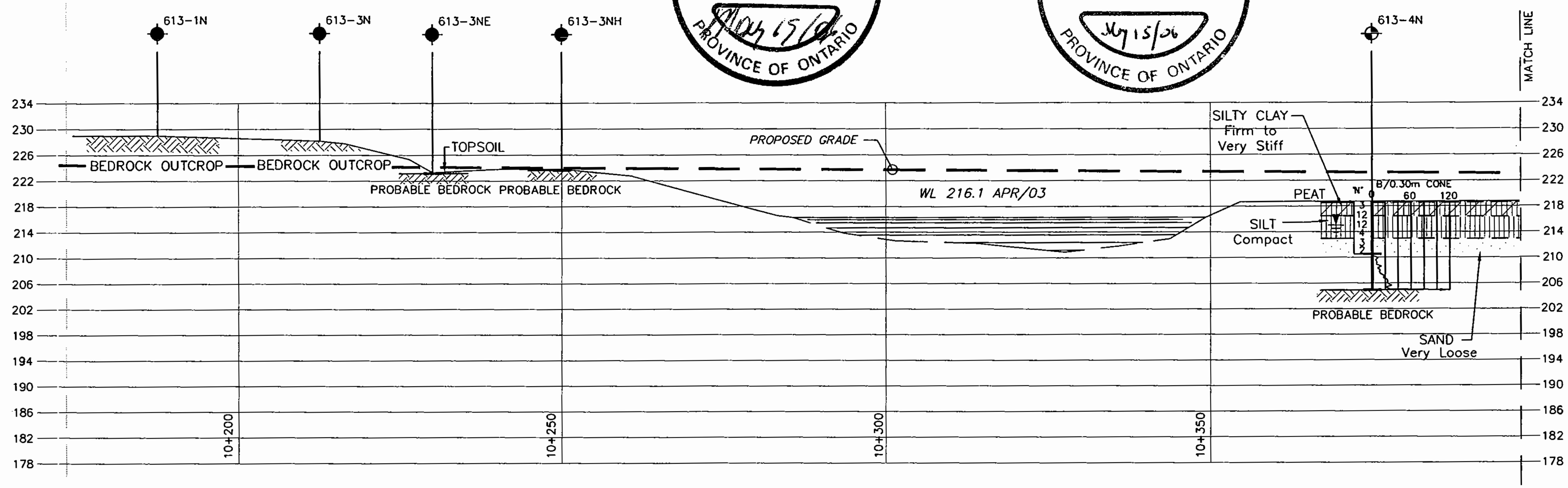
HWY.69
GWP NO. 312-99-00

SHEET 613-8

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

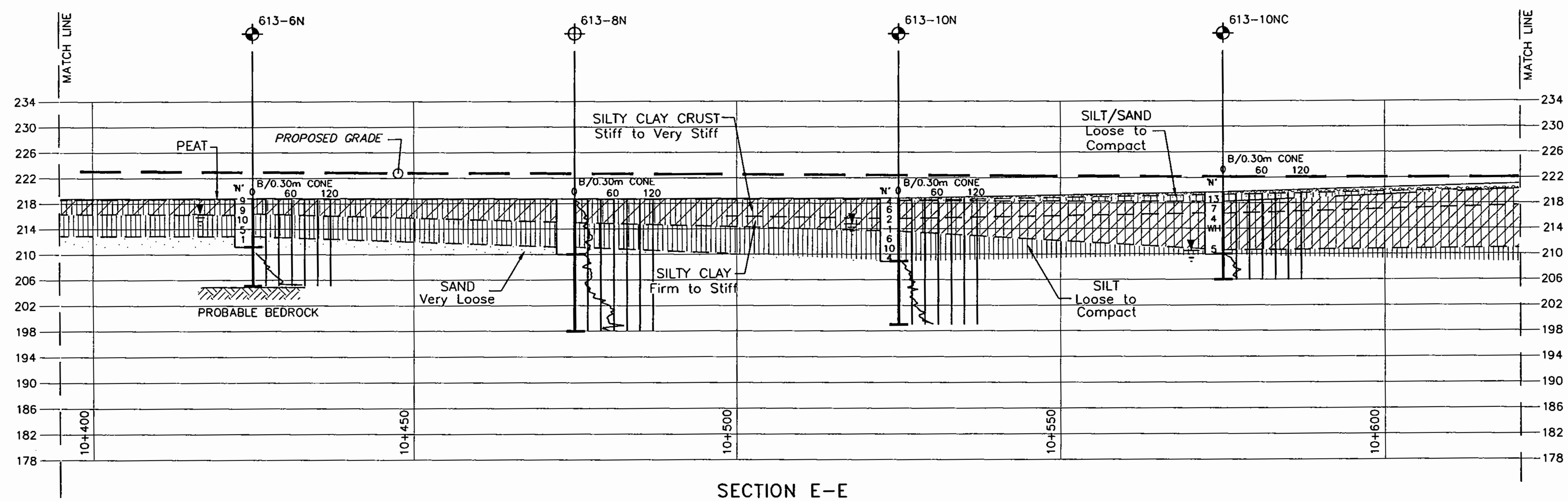
LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
PROVINCE OF ONTARIO



SECTION E-E

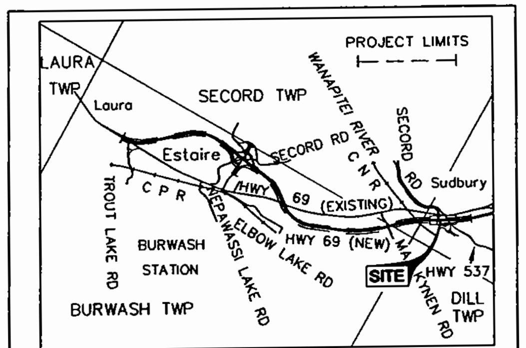
8 4 0 8 16m



SECTION E-E
(Continued)

8 4 0 8 16m

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

Symbol	Description	
	Bore Hole	Thurber
	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
	Bore Hole	Peto
	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesion Water Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 8

METRIC

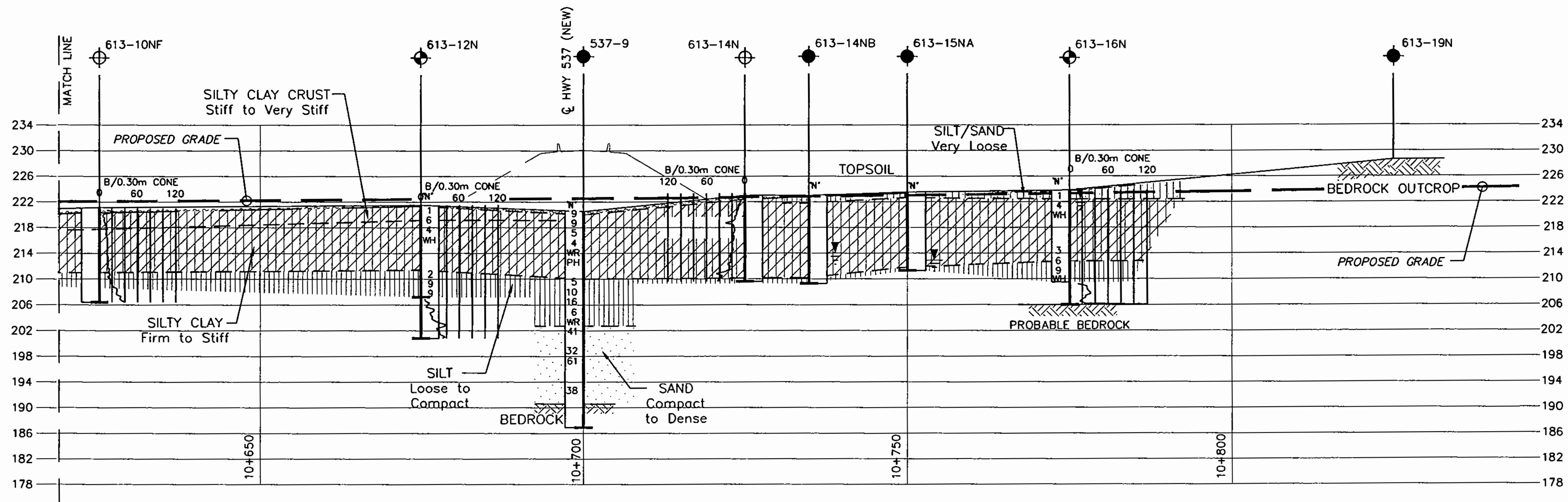
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

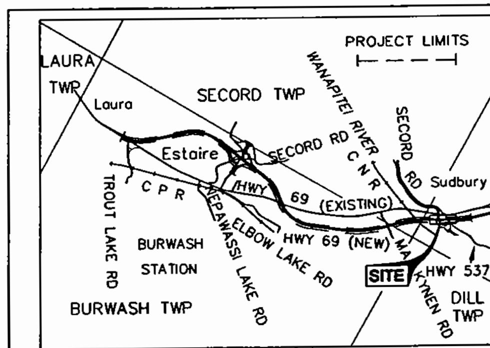
SHEET 613-9

THURBER ENGINEERING LTD.



SECTION E–E
(Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

Symbol	Description	
■	Bore Hole	Thurber
⊞	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
●	Bore Hole	Peto
⊕	Dynomic Cone Penetrotion Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer ot Time of Investigotion (Date)	
	Head Artesian Woter	
	Piezometer	

NO	STATION	OFFSET FROM CL

— NOTE —

The boundaries between soil strota hove been established only ot Bore Hole locotions. Between Bore Holes the boundaries ore ossumed from geologicol evidence.

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
May 15/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 9

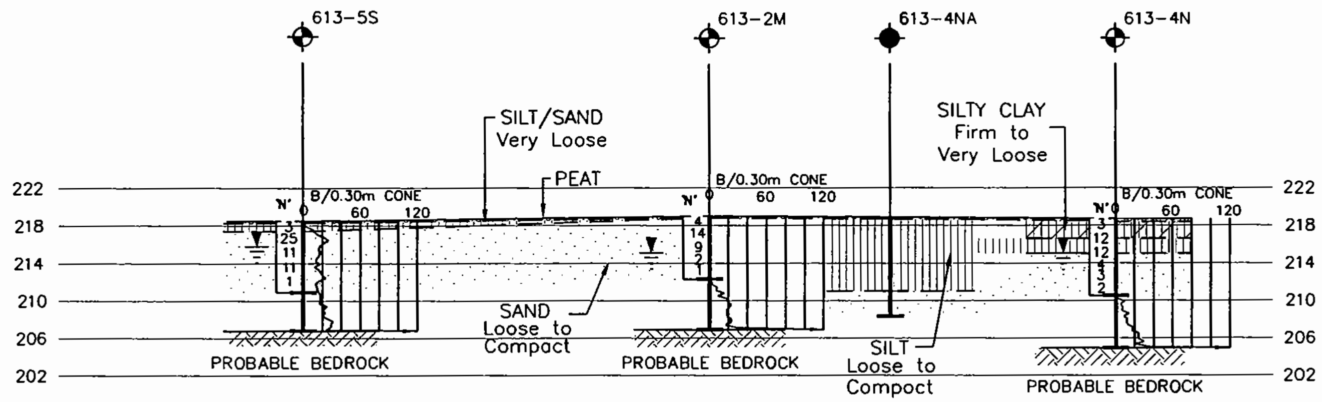
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY.69
GWP NO. 312-99-00

HIGHWAY 69 FOUR-LANING
SWAMP 613, 10+178 to 10+838 DILL TWP
BOREHOLE LOCATIONS AND SOIL STRATA

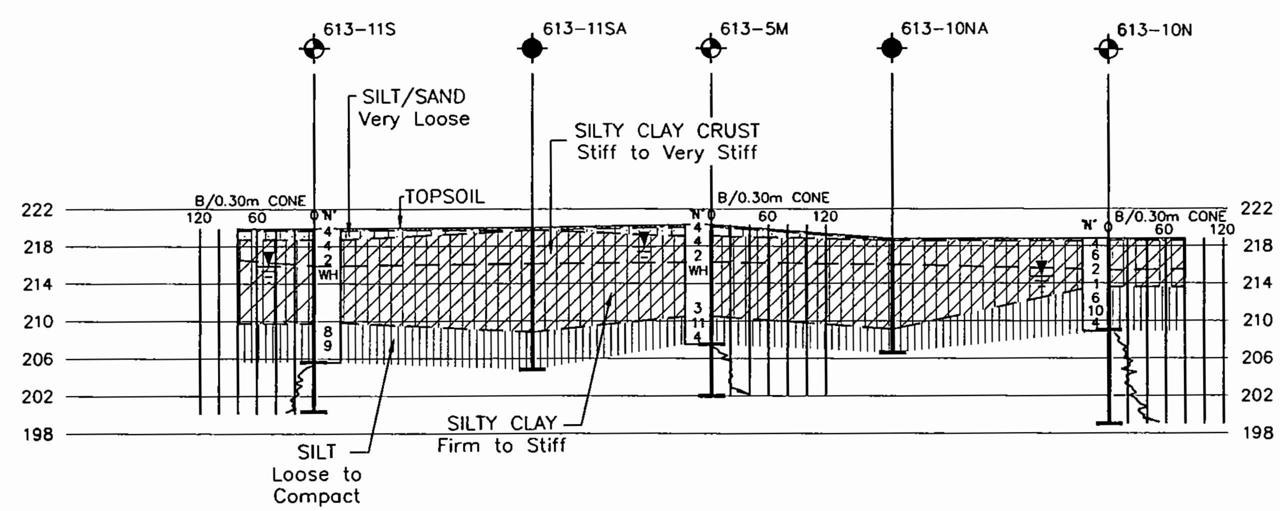
SHEET 613-10

THURBER ENGINEERING LTD.



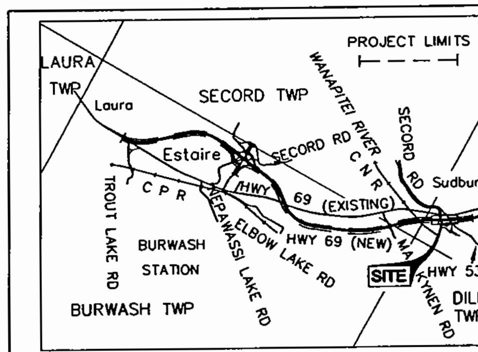
SECTION F-F

8 4 0 8 16m



SECTION G-G

8 4 0 8 16m



KEYPLAN

LICENSED PROFESSIONAL ENGINEER
P. J. BRANCO
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 15/06
PROVINCE OF ONTARIO

LEGEND

	Bore Hole	Thurber
	Piezocone	Thurber
	Bore Hole & Piezocone	Thurber
	Bore Hole	Peto
	Dynamic Cone Penetration Test	Peto
	Bore Hole & Cone	Peto
N	Blows/0.3m (Std pen Test, 475J/blow)	
CONE	Blows/0.3m (60° Cone, 475J/blow)	
	WL in Piezometer at Time of Investigation (Date)	
	Head Artesian Water	
	Piezometer	

NO	STATION	OFFSET FROM CL

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

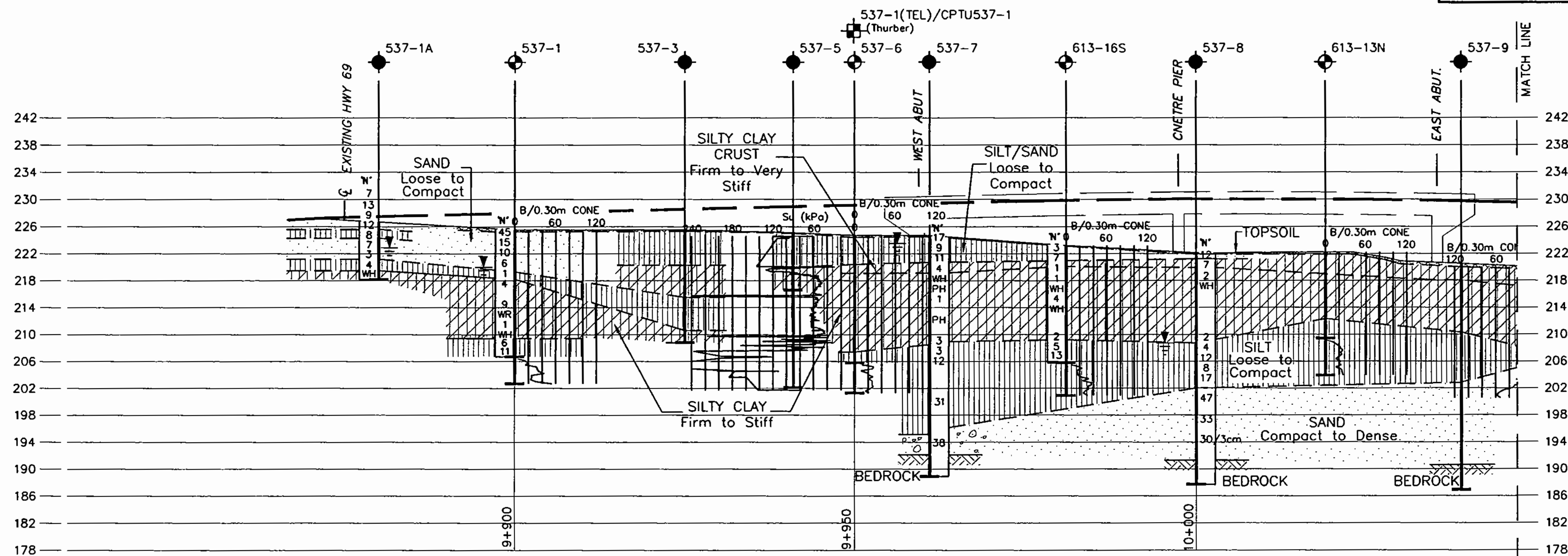
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS | DATE | BY | DESCRIPTION
DESIGN | CHK | CODE CHBDC | LOAD | DATE
DRAWN | CHK | SITE | STRUCT | SCHEME | DWG 10

METRIC	HWY.69 GWP NO. 312-99-00
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN	HIGHWAY 537 SWAMP 613, 9+880 to 10+230 BOREHOLE LOCATIONS AND SOIL STRATA

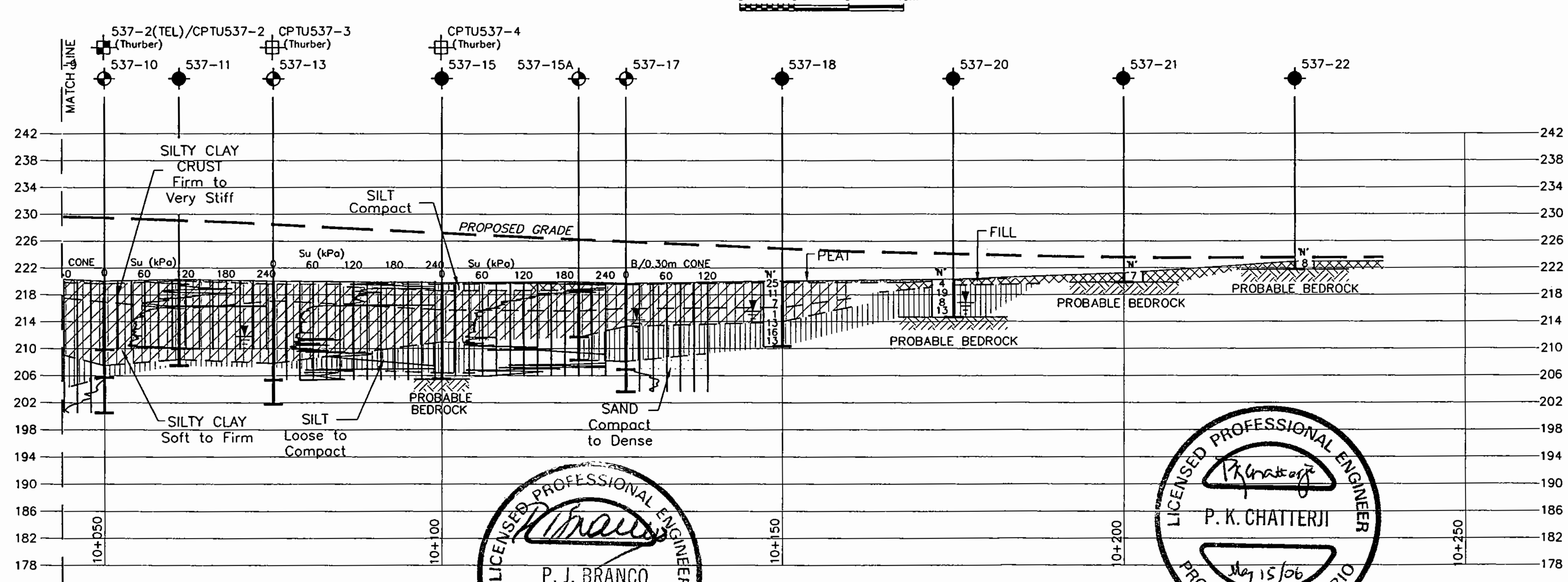
SHEET 613-11

THURBER ENGINEERING LTD.



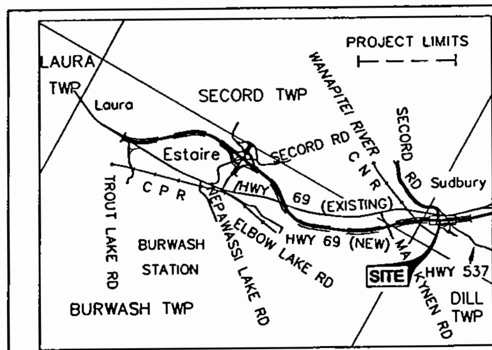
SECTION H-H

8 4 0 8 16m



SECTION H-H (Continued)

8 4 0 8 16m



KEYPLAN

LEGEND

- Bore Hole — Thurber
- Piezocone — Thurber
- Bore Hole & Piezocone — Thurber
- Bore Hole — Peto
- Dynamic Cone Penetration Test — Peto
- Bore Hole & Cone — Peto
- N — Blows/0.3m (Std pen Test, 475J/blow)
- CONE — Blows/0.3m (60° Cone, 475J/blow)
- WL in Piezometer at Time of Investigation (Date)
- Head Artesian Water
- Piezometer

NO	STATION	OFFSET FROM CL

— NOTE —

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

NOTE:
BASE DRAWING PROVIDED BY TOTTEN SIMS HUBICKI

LICENSED PROFESSIONAL ENGINEER — P. J. BRANCO — May 15/06 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — P. K. CHATTERJI — May 15/06 — PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC	LOAD	DATE
DRAWN	CHK	SITE	STRUCT	SCHEME	DWG 11

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

- SS Split Spoon Sample
- WS Wash Sample
- AS Auger (Grab) Sample
- TW Thin Wall Shelby Tube Sample
- TP Thin Wall Piston Sample
- PH Sampler Advanced by Hydraulic Pressure
- PM Sampler Advanced by Manual Pressure
- WH Sampler Advanced by Self Static Weight
- RC Rock Core
- SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

SYMBOLS

- CLAYSTONE
- SILTSTONE
- SANDSTONE
- COAL
- Bedrock (general)

DISCONTINUITY SPACING

Bedding	**Bedding Plane Spacing**
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength** (MPa)	(psi)	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 602-N1

METRIC

W.P.	19-2805-2	LOCATION	SWAMP 602, N 5 128 847.10 E 319 737.75	ORIGINATED BY	SLL
HWY	69	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	16.10.05 - 16.10.05	CHECKED BY	JPL

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV / DEPTH	DESCRIPTION
232.3 / 0.0	**WATER**
231.6 / 0.7	**PEAT**, fibrous Black
231.5 / 0.9	Silty **CLAY**, trace sand, some rootlets, some silt pockets Stiff to Very Stiff Grey occasional silty sand pockets occasional silt seams, trace rooltets
227.1 / 5.2	Becoming Hard
225.3 / 7.0	Becoming Firm (CI)

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%)
1	SS	15	
2	SS	18	
3	SS	13	
1	TW	PH	0 1 55 44 Oedometer test: e_0 = 0.772 p' = 315 KPa C_c = 0.165 C_R = 0.035 G = 2.77
4	SS	12	
5	SS	31	0 2 84 14
6	SS	3	0 0 48 52
2	TW	PH	No Recovery in TW #2
7	SS	6	

Elevation scale: 232, 231, 230, 229, 228, 227, 226, 225, 224, 223

Shear strength plot value at approx. El. 224: 3.0

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

ONTMT4S 8052.GPJ 17/02/06

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 602-N1

METRIC

W.P. 19-2805-2 | LOCATION SWAMP 602, N 5 128 847.10 E 319 737.75 | ORIGINATED BY SLL

HWY 69 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM

DATUM Geodetic | DATE 16.10.05 - 16.10.05 | CHECKED BY JPL

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					222			0 1 57 42
		3	TW	PH				Oedometer test: e_0 = 1.015, p' = 80 KPa, C_c = 0.328, C_R = 0.037, G = 2.79
					221	+ 2.4		
220.4 / 11.9	Becoming Stiff (CL)	8	SS	10				0 1 91 8
					220	+ 3.3		
219.2 / 13.1	SILT, trace clay, trace sand, trace gravel, interbedded with slightly and non-plastic silt layers. Very Stiff to Hard/Compact to Dense. Grey (ML)	9	SS	16	219			
					218			
		10	SS	18	217			
		11	SS	100/ .125	216			
	grinding during augering from 16.61 to 17.68 m				215			
214.6 / 17.7		12	SS	100/ .050				No Recovery in SS #12

END OF BOREHOLE AT 17.73 m. AUGER REFUSAL AT 17.73 m ON PROBABLE BEDROCK OR BOULDER.
Piezometer installation consists of 19 mm diameter schedule 40 PVC pipe with a 3.05 m slotted screen.

WATER LEVEL READINGS:

DATE	DEPTH (m)
17.10.05	0.13
18.10.05	0.16
25.10.05	0.15
29.10.05	0.15
09.11.05	0.00

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; UNIT WEIGHT γ kN/m³

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 602-S1

METRIC

W.P. 19-2805-2	LOCATION SWAMP 602, N 5 128 803.44 E 319 719.51	ORIGINATED BY SLL
HWY 69	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 20.10.05 - 20.10.05	CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
232.8 0.0	WATER						
232.2 0.6	Silty **CLAY**, trace sand, trace rootlets Firm to Very Stiff Brown	1	SS	4	232	o	
		2	SS	11		o	
					231		
		3	SS	15		o	
		4	SS	17	230	wP–w–wL	0 1 36 63
					229		
		5	SS	12	228	o	
227.6 5.2	trace gravel, occasional cobbles Becoming Very Stiff from 5.2m to 6.1m (grinding during augering)				227		
226.6 6.1	Stiff to Firm Becoming Grey (CI)	6	SS	20		o	
					226		
		7	SS	6	225	wP–w/wL	0 1 31 68
					224		0 0 41 59
		1	TW	PH		wP–wL o	Oedometer test: e_0 = 1.494, p' = 146 KPa, C_c = 0.58, C_R = 0.09, G = 2.77
		8	SS	4	223	o	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

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Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 602-S1

METRIC

W.P. 19-2805-2 LOCATION SWAMP 602, N 5 128 803.44 E 319 719.51 ORIGINATED BY SLL

HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 20.10.05 - 20.10.05 CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa (field vane, sensitivity)	WATER CONTENT (%)	GR	SA	SI	CL
						+ 2.8					
		9	SS	1	222			0	0	68	32
						+ 2.7					
221.1 11.7	Becoming Stiff (CL)				221						
		10	SS	9				0	1	77	22
219.8 13.0	**SILT**, trace clay, trace sand, with thin sand layers, interbedded with slightly and non-plastic silt layers Hard/Dense Grey Wet (ML)				220	+ 2.2					
		11	SS	32	219						
					218						
217.8 14.9	**SILT**, trace to some sand, trace gravel, occasional cobbles Very Dense Grey Wet	12	SS	84/ .225							
217.2 15.6	END OF BOREHOLE AT 15.57 m. AUGER REFUSAL AT 15.57 m ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)
25.10.05	0.17
29.10.05	0.15
09.11.05	0.00

$+^3, \times^3$: Numbers refer to Sensitivity

15-⌀-5 (20 / 10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 605-N1

METRIC

W.P. 19-2805-2 | LOCATION SWAMP 605, N 5 130 158.84 E 319 202.17 | ORIGINATED BY SLL

HWY 69 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM

DATUM Geodetic | DATE 19.10.05 - 19.10.05 | CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
233.8 / 0.0	**PEAT**, fibrous Very Loose Black					
		1	SS	WH	233	
		2	SS	WH	232	
231.1 / 2.7		3	SS	WH	231	
	Silty **CLAY**, trace sand, occasional silt seams Soft to Firm Grey	4	SS	3	230	0 1 75 24
		5	SS	2	229	
		1	TW	PH	228	0 2 42 56 Oedometer test: e_0 = 1.209 p' = 56 KPa C_c = 0.37 C_R = 0.061 G = 2.67
		6	SS	2	227	
		7	SS	4	226, 225	
		8	SS	WH	224	

Water content plot values annotated: 705, 502, 117. Field vane: 2.0 (approx. elev. 226.3).

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 – 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 8052.GPJ 17/02/06

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 605-N1

METRIC

W.P. 19-2805-2 | LOCATION SWAMP 605, N 5 130 158.84 E 319 202.17 | ORIGINATED BY SLL

HWY 69 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM

DATUM Geodetic | DATE 19.10.05 - 19.10.05 | CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
								0 1 72 27
		2	TW	PH	223			Oedometer test: e_0 = 0.805, p' = 72 KPa, C_c = 0.156, C_R = 0.023, G = 2.76
		9	SS	5	222			
						+ 25		
		10	SS	5	221			
220.4 / 13.4	**SILT**, trace to some clay, trace sand, trace gravel, interbedded with slightly and non-plastic silt layers Very Stiff to Stiff/Loose to Compact Grey (ML)							
		11	SS	18	220			0 3 87 10
		12	SS	9	219 / 218			
		13	SS	1	217			No Recovery in SS #13
	Becoming Stiff/Compact	14	SS	12	216 / 215			1 9 82 8
214.3 / 19.5	**SAND**, some gravel, trace silt Very Dense Grey				214			

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 605-N1

METRIC

W.P.	19-2805-2	LOCATION	SWAMP 605, N 5 130 158.84 E 319 202.17	ORIGINATED BY	SLL
HWY	69	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	19.10.05 - 19.10.05	CHECKED BY	JPL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Wet		15	SS	68						
213.0 20.8	END OF BOREHOLE AT 20.80 m. AUGER REFUSAL AT 20.80 m ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 25.10.05 0.03 29.10.05 0.03 09.11.05 0.00						213				

+ ³, × ³: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 605-S1

METRIC

W.P.	19-2805-2	LOCATION	SWAMP 605, N 5 130 094.52 E 319 155.59	ORIGINATED BY	SLL
HWY	69	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	20.10.05 - 20.10.05	CHECKED BY	JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
233.8 / 0.0	**PEAT**, fibrous, Very Loose, Black							
		1	SS	WH	233			No Recovery in SS #1
		2	SS	1	232		573	
231.6 / 2.2	Silty **CLAY**, some silty sand seams, trace rootlets, Soft to Firm, Grey							
		3	SS	3				0 4 71 24
		4	SS	4	231 / 230			
		1	TW	PH	229			0 1 27 72; Oedometer test: e_0 = 1.466, p' = 49 KPa, C_c = 0.685, C_R = 0.11, G = 2.73
		5	SS	1				
					228	2.7 (field vane)		
		6	SS	2	227			
						2.5 (field vane)		
		7	SS	3	226			0 1 63 36
					225			
		2	TW	PH	224			1 1 70 28; Oedometer test: e_0 = 0.935, p' = 63 KPa, C_c = 0.20, C_R = 0.037, G = 2.75

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ◈ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 605-S1

METRIC

W.P. 19-2805-2 | LOCATION SWAMP 605, N 5 130 094.52 E 319 155.59 | ORIGINATED BY SLL

HWY 69 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM

DATUM Geodetic | DATE 20.10.05 - 20.10.05 | CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		8	SS	3				
					223	+ 3.3		
		9	SS	5			⊢○	
					222			
221.6 12.2	**SILT**, trace clay, trace sand, occasional sand seams, interbedded with slightly and non-plastic silt layers Stiff to Very Stiff/Loose to Compact Grey Wet (ML)	10	SS	7			○	0 3 89 8
					221			
					220			
		11	SS	18			○	
219.1 14.7	END OF BOREHOLE AT 14.71 m. AUGER REFUSAL AT 14.71 m ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.							

WATER LEVEL READINGS:

DATE	DEPTH (m)
25.10.05	0.17
29.10.05	0.17
09.11.05	0.00

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

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

UNIT WEIGHT γ kN/m³

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 613-N1

METRIC

W.P. 19-2805-2 LOCATION SWAMP 613, N 5 136 364.29 E 319 058.74 ORIGINATED BY SLL

HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 27.10.05 - 27.10.05 CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
218.8						
0.0	TOPSOIL, rootlets					
0.2	Silty CLAY, trace sand, occasional sand seams Very Stiff to Stiff Brown (CH to CI)					
		1	SS	16	218	
		2	SS	13	217	0 0 20 80
		3	SS	12	216	
		4	SS	10	215	
		1	TW	PH	214	0 0 39 61 Oedometer test: e_0 = 1.314 p' = 73 KPa C_c = 0.50 C_R = 0.058 G = 2.74
213.6 5.2	Becoming Soft to Firm (CL)	5	SS	6		0 0 73 27
					213	
		6	SS	5	212	0 0 78 22
211.5 7.3	SILT, trace clay, interbedded wiht slightly and non-plastic silt layers Stiff to Very Stiff/Loose to Compact Grey Wet (ML)					
		7	SS	9	211	0 0 92 8
					210	
		8	SS	11	209	

Field vane reading at approx. elev. 212.8: 4.4 (sensitivity)

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100

Shear Strength kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

Plastic limit w_P, Natural moisture content w, Liquid limit w_L — Water Content (%) 20 40 60

Unit Weight γ kN/m³

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 613-N1

METRIC

W.P. 19-2805-2	LOCATION SWAMP 613, N 5 136 364.29 E 319 058.74	ORIGINATED BY SLL
HWY 69	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 27.10.05 - 27.10.05	CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
208.8 10.1	**SAND,** trace to some silt, trace to some gravel Compact Grey Wet						
		9	SS	14	208	o	
					207		
		10	SS	22	206		No Recovery in SS #10
		11	SS	26	205	o	
					204		
		12	SS	20	203	o	
		13	SS	12	202	o	5 88 8 (SI+CL)
					201		
	Becoming Dense	14	SS	32		o	
199.9 18.9	END OF BOREHOLE AT 18.90 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 3.05 m slotted screen.				200		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

THURBER

RECORD OF BOREHOLE No 613-N1

METRIC

W.P. 19-2805-2	LOCATION SWAMP 613, N 5 136 364.29 E 319 058.74	ORIGINATED BY SLL
HWY 69	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 27.10.05 - 27.10.05	CHECKED BY JPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	WATER LEVEL READINGS: DATE DEPTH (m) 28.10.05 4.05 09.11.05 3.42										

$+^3, \times^3$: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below): (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 537-1

METRIC

W.P. 19-2805-2 | LOCATION HIGHWAY 537, N 5 136 503.07 E 317 900.76 | ORIGINATED BY SLL

HWY 69 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM

DATUM Geodetic | DATE 28.10.05 - 28.10.05 | CHECKED BY JPL

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100)

SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE (20, 40, 60, 80, 100)

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20, 40, 60)

UNIT WEIGHT γ kN/m³

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
224.6 / 0.0	**TOPSOIL**				
0.2	Sandy **SILT**, occasional topsoil staining; Dense to Compact; Brown; Moist to Wet	1	SS	33	
		2	SS	17	
222.3 / 2.3	Silty **SAND**, trace clay; Compact; Brown; Wet	3	SS	20	0 71 24 6
		4	SS	13	
220.0 / 4.6	**SILT**, some sand, trace clay; Loose; Brown; Wet	5	SS	5	0 10 81 9
219.6 / 5.1	Silty **CLAY**, trace sand, varved; Firm; Grey; (CI)	6	SS	4	
		1	TW	PH	0 0 50 50; Triaxial test: c' = 0 KPa; Ø' = 29°
		7	SS	2	
215.8 / 8.8	Becoming Stiff	2	TW	PH	Unable to advance Shelby Tube at 9.14m (TW #2)
		8	SS	15	0 4 72 24

Elevation scale: 224, 223, 222, 221, 220, 219, 218, 217, 216, 215

Field vane at approx. 216: 4.5

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 537-1

METRIC

W.P. 19-2805-2	LOCATION HIGHWAY 537, N 5 136 503.07 E 317 900.76	ORIGINATED BY SLL
HWY 69	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 28.10.05 - 28.10.05	CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
214.3 / 10.3	Becoming Firm (CH)				214				
		9	SS	3					0 1 24 75
					213	+ 2.9			
		10	SS	3	212				
210.9 / 13.7	Becoming Firm to Stiff (CI)				211				0 0 50 50
		3	TW	PH					Oedometer test: e_0 = 1.237, p' = 220 KPa, C_c = 0.565, C_R = 0.09, G = 2.77
		11	SS	5	210				
						+ 4.6			
209.4 / 15.2	(CL)								
		12	SS	5	209				0 0 76 24
					208				
		13	SS	11	207				
206.3 / 18.3	**SILT**, trace clay, trace sand, interbedded with slightly and non-plastic silt layers Stiff to Very Stiff/Compact Grey (ML)	14	SS	28	206				
					205				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

15-20-5-10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 537-1

METRIC

W.P.	19-2805-2	LOCATION	HIGHWAY 537, N 5 136 503.07 E 317 900.76	ORIGINATED BY	SLL
HWY	69	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	28.10.05 - 28.10.05	CHECKED BY	JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
		15	SS	12	
					204
					203
					202
		16	SS	22	
					201
200.2 / 24.4	**SAND**, trace silt Compact Grey/Brown Wet				
					200
					199
		17	SS	24	
198.1 / 26.5	END OF BOREHOLE AT 26.52 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 2.44 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 09.11.05 9.56				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ONTMT4S 8052.GPJ 17/02/06

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 537-2

METRIC

W.P. 19-2805-2 LOCATION HIGHWAY 537, N 5 136 554.99 E 317 986.22 ORIGINATED BY SLL

HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 21.10.05 - 24.10.05 CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
220.1 / 0.0	**TOPSOIL**				220	
219.7 / 0.4	Silty **CLAY**, occasional topsoil stained, some silt seams Very Stiff to Stiff Brown (CH)	1	SS	18	219	
		2	SS	13	218	0 0 30 70
		3	SS	9	217	
		4	SS	9	216	0 0 15 85
215.5 / 4.6	Becoming Firm	5	SS	5	215	
214.0 / 6.1	Becoming Grey and Soft	1	TW	PH	214	0 0 24 76 Oedometer test: e_0 = 1.665 74 p' = 110 KPa C_c = 0.88 C_R = 0.11 G = 2.75 Triaxial test: c' = 0 KPa Ø' = 29°
		6	SS	3	213	
		7	SS	2	212	
210.9 / 9.1	Becoming Firm (CI)	8	SS	1	211	0 0 68 32

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 537-2

METRIC

W.P. 19-2805-2 LOCATION HIGHWAY 537, N 5 136 554.99 E 317 986.22 ORIGINATED BY SLL

HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 21.10.05 - 24.10.05 CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					210		
		9	SS	3	209	○ (~26)	
207.9 / 12.2	**SILT**, trace to some sand, trace clay, interbedded with slightly and non-plastic silt layers Stiff to Very Stiff/Compact Grey Moist (ML)				208		
		10	SS	22		○ (~21)	
					207		
		11	SS	24	206	○ (~23)	
					205		
		12	SS	11		○ (~21)	0 17 75 8
203.4 / 16.7	**SAND**, trace silt to silty Compact to Dense Grey Wet				204		
		13	SS	24	203	○ (~19)	
					202		
		14	SS	49		○ (~20)	
					201		

Shear strength annotation near elev. 210: 2.9

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 537-2

METRIC

W.P.	19-2805-2	LOCATION	HIGHWAY 537, N 5 136 554.99 E 317 986.22	ORIGINATED BY	SLL
HWY	69	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	21.10.05 - 24.10.05	CHECKED BY	JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
		15	SS	43	200	~19
					199	
					198	
		16	SS	35	197	~19
					196	
					195	
	Becoming Very Dense	17	SS	75	194	~20
					193	
					192	
	Becoming Dense	18	SS	38	191	~20

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15-⌖-5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 537-2

METRIC

W.P.	19-2805-2	LOCATION	HIGHWAY 537, N 5 136 554.99 E 317 986.22	ORIGINATED BY	SLL
HWY	69	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	21.10.05 - 24.10.05	CHECKED BY	JPL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
							190				
189.1 31.0	END OF BOREHOLE AT 30.99 m. AUGER REFUSAL AT 30.99 m ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 28.10.05 5.48 09.11.05 4.81										

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

THURBER

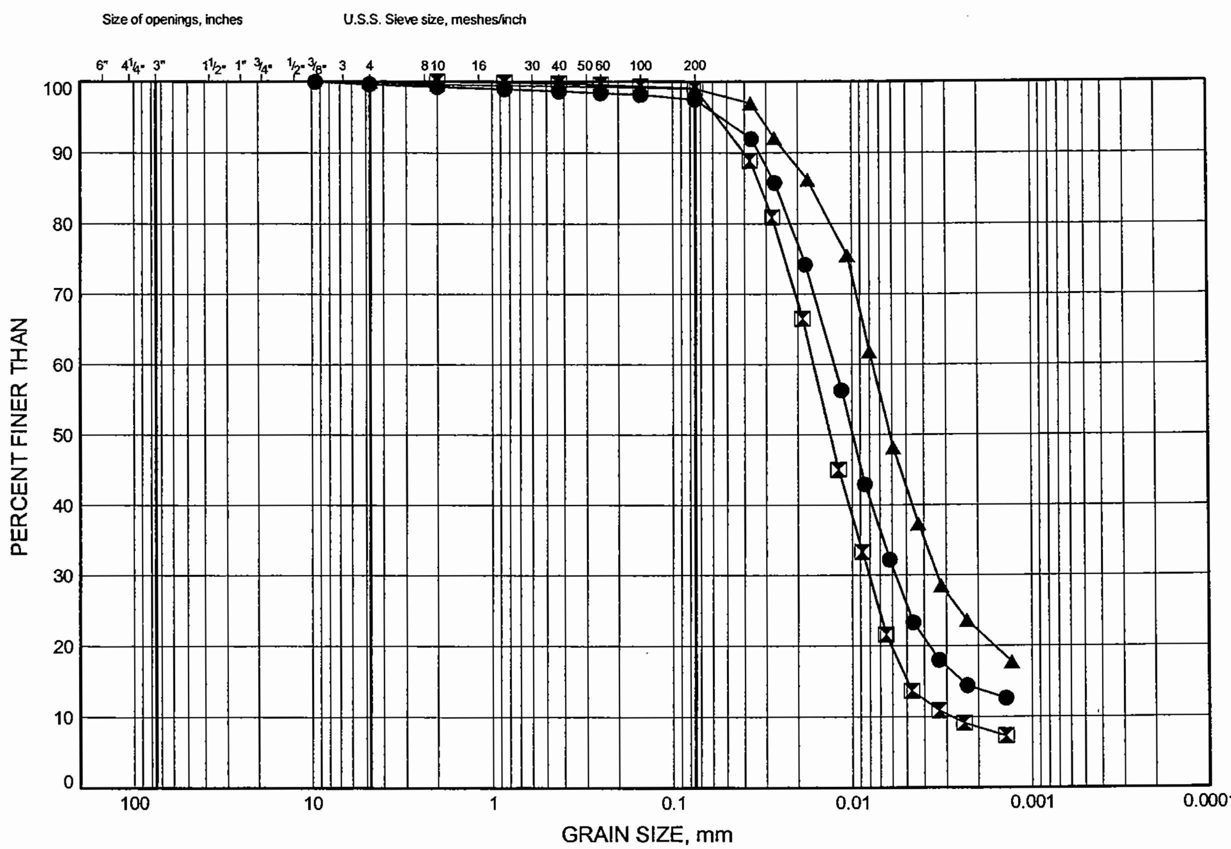
SWAMP 602

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B1

SWAMP 602 - SILTY CLAY (CL/CL-ML)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	602-N1	6.10	226.22
⊠	602-N1	12.19	220.13
▲	602-S1	12.19	220.57

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

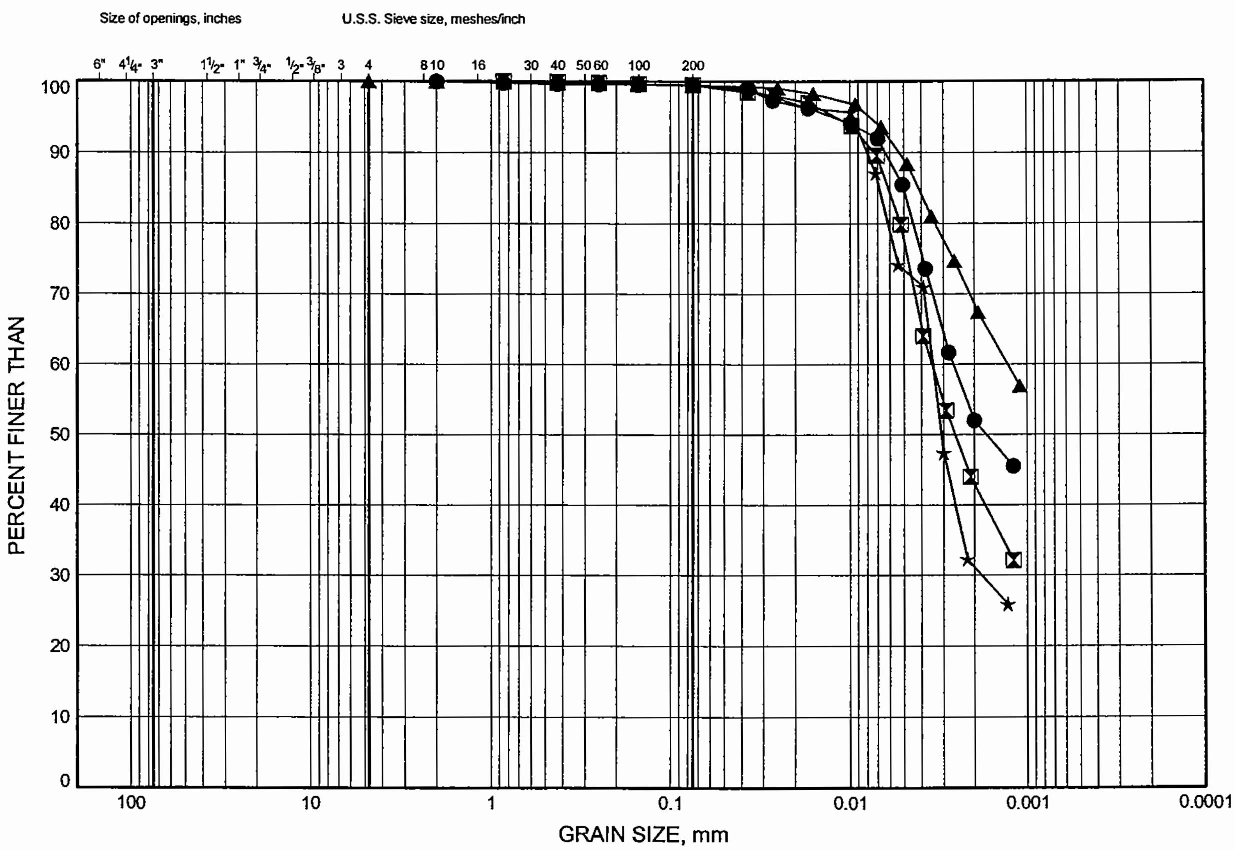
THURBGSD 8052.GPJ 20/03/06

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B2

SWAMP 602 - SILTY CLAY (CI)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	602-N1	7.62	224.70
⊠	602-N1	10.67	221.65
▲	602-S1	7.62	225.14
★	602-S1	10.67	222.09

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

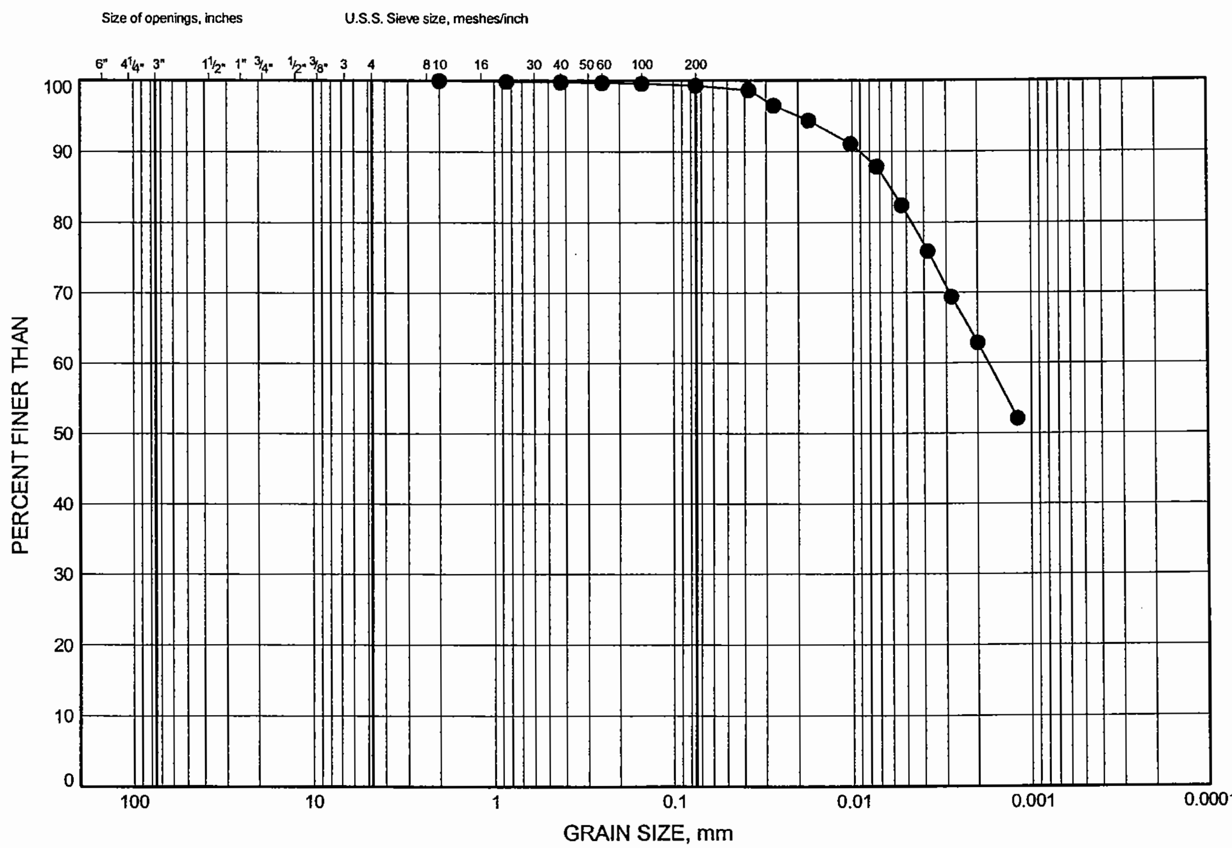
THURBGSD 8052.GPJ 20/03/06

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B3

SWAMP 602 - SILTY CLAY (CH)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	602-S1	3.05	229.71

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

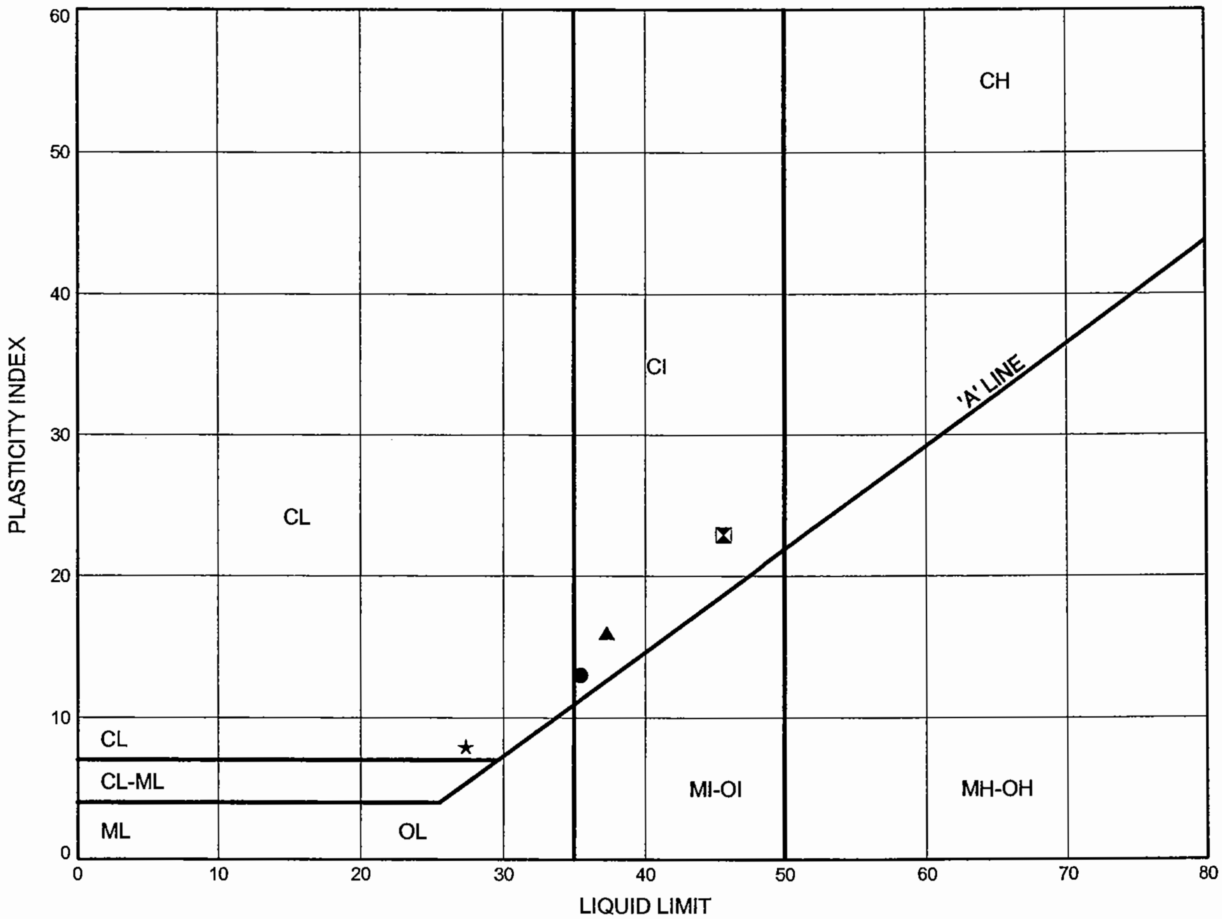
THURBGSD 8052.GPJ 20/03/06

HWY 69

ATTERBERG LIMITS TEST RESULTS

FIGURE B4

SWAMP 602 - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	602-N1	3.81	228.51
⊠	602-N1	7.62	224.70
▲	602-N1	10.67	221.65
★	602-N1	12.19	220.13

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

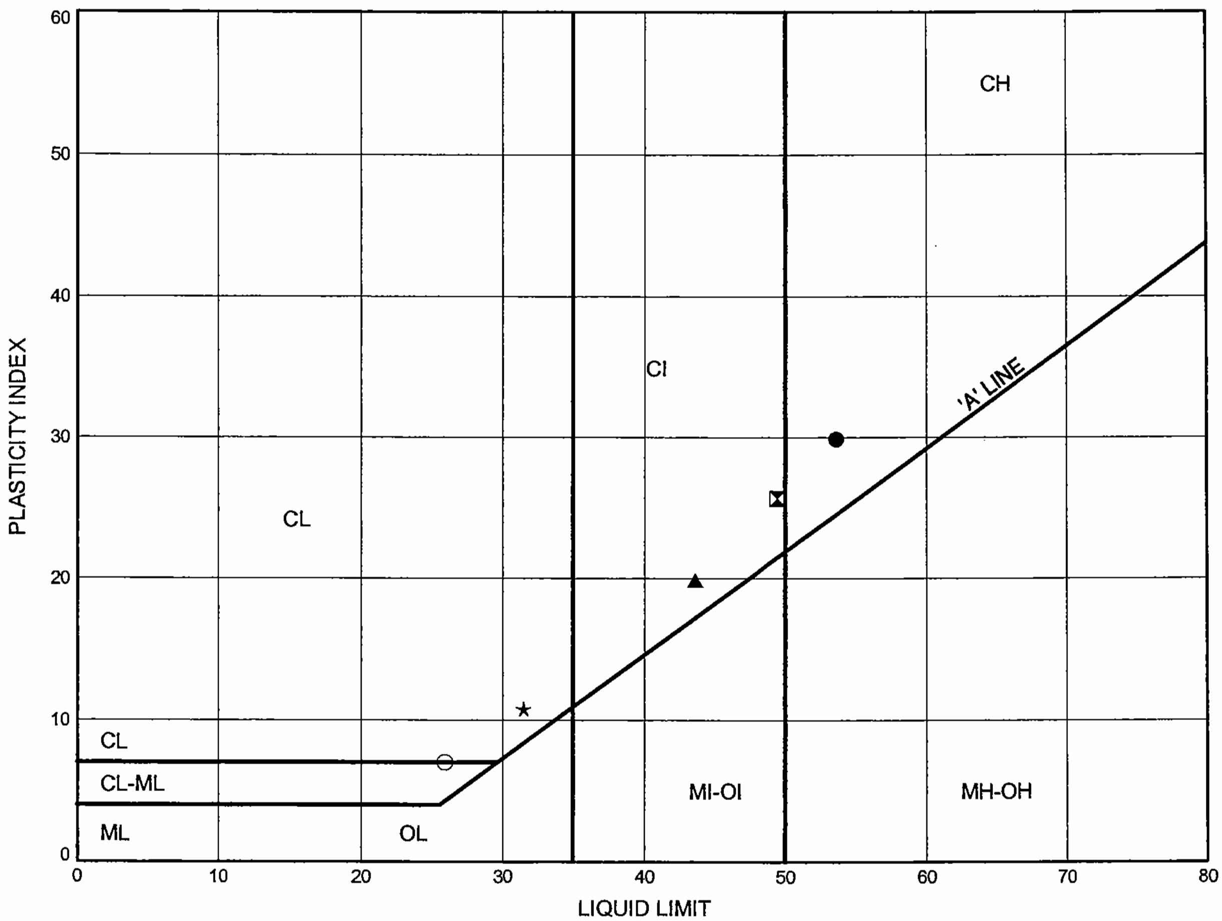
Chkd. JPL

THURBALT 8052.GPJ 20/03/06

HWY 69
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

SWAMP 602 - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	602-S1	3.05	229.71
⊠	602-S1	7.62	225.14
▲	602-S1	9.14	223.62
★	602-S1	10.67	222.09
⊙	602-S1	12.19	220.57

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

THURBALT 8052.GPJ 20/03/06

OEDOMETER TEST RESULTS

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B6(a)

SAMPLE IDENTIFICATION

Project Number	05-1116-043	Sample Number	ST1
Borehole Number	602-N1	Sample Depth, m	3.5-4.1

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	(24-48)
Oedometer Number	9		
Date Started	11/25/2005		
Date Completed	12/08/2005		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.92	Unit Weight, kN/m^3	19.49
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	15.33
Area, cm^2	31.52	Specific Gravity, measured	2.77
Volume, cm^3	60.36	Solids Height, cm	1.081
Water Content, %	27.12	Volume of Solids, cm^3	34.07
Wet Mass, g	119.96	Volume of Voids, cm^3	26.29
Dry Mass, g	94.37	Degree of Saturation, %	97.3

TEST COMPUTATIONS

	Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
	0.00	1.915	0.772	1.915				
	4.72	1.912	0.769	1.914	9	8.62E-02	3.32E-04	2.81E-06
	9.58	1.909	0.766	1.911	2	3.87E-01	3.22E-04	1.22E-05
	19.59	1.903	0.761	1.906	31	2.48E-02	3.13E-04	7.62E-07
	38.82	1.895	0.753	1.899	49	1.56E-02	2.17E-04	3.32E-07
48 hours	77.80	1.882	0.741	1.889	37	2.04E-02	1.74E-04	3.49E-07
	155.54	1.865	0.725	1.874	53	1.40E-02	1.14E-04	1.57E-07
	310.75	1.841	0.703	1.853	40	1.82E-02	8.07E-05	1.44E-07
	621.60	1.808	0.673	1.825	33	2.14E-02	5.54E-05	1.16E-07
	1243.58	1.760	0.628	1.784	60	1.12E-02	4.03E-05	4.44E-08
	2485.83	1.703	0.576	1.732	68	9.35E-03	2.40E-05	2.19E-08
	1243.58	1.713	0.585	1.708				
	310.75	1.732	0.602	1.723				
	77.80	1.756	0.625	1.744				
	19.37	1.778	0.645	1.767				
	4.72	1.796	0.662	1.787				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.80	Unit Weight, kN/m^3	20.34
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.35
Area, cm^2	31.52	Specific Gravity, measured	2.77
Volume, cm^3	56.61	Solids Height, cm	1.081
Water Content, %	24.40	Volume of Solids, cm^3	34.07
Wet Mass, g	117.40	Volume of Voids, cm^3	22.54
Dry Mass, g	94.37		

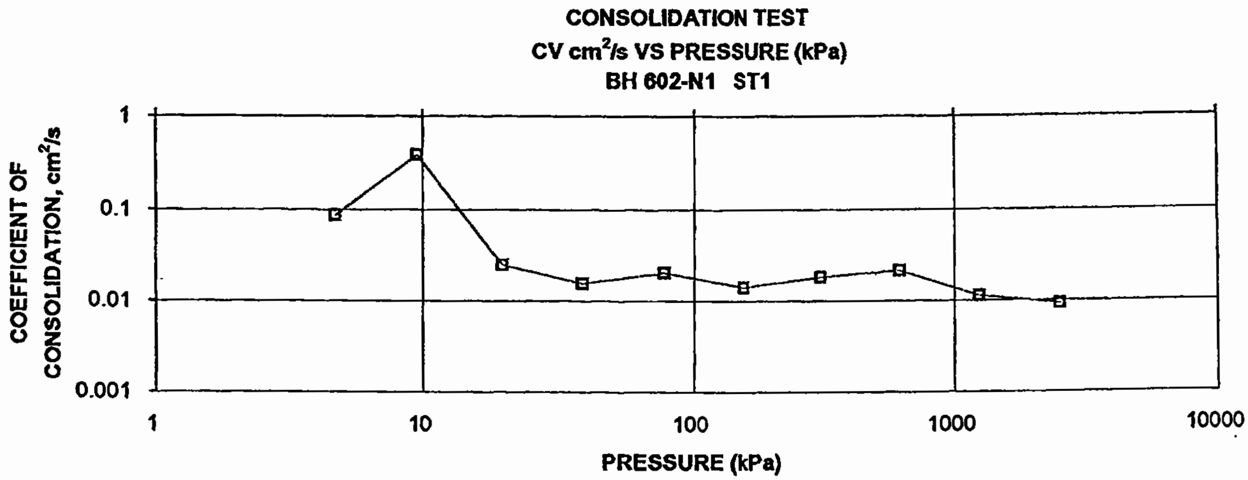
Prepared By: LFG

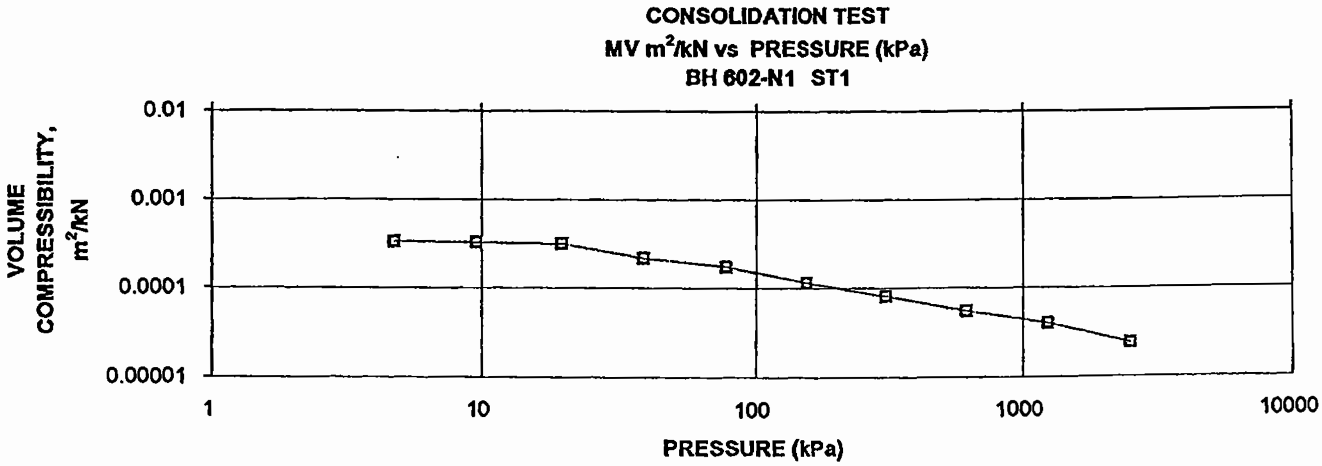
Golder Associates

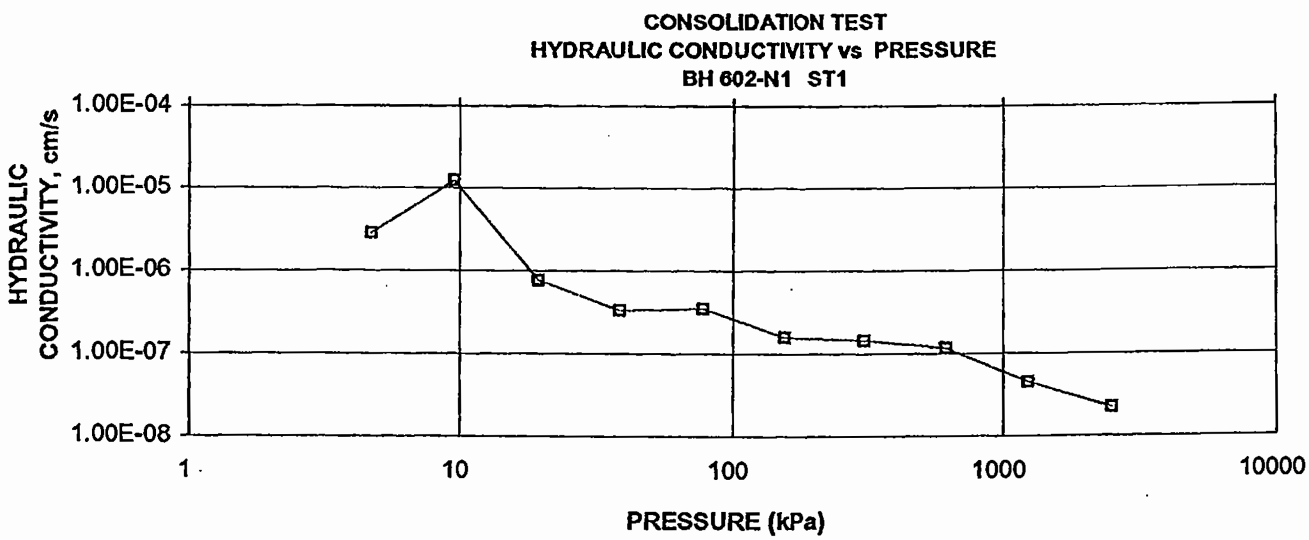
Checked By: MM

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B6(b)







Project No. 05-1116-043

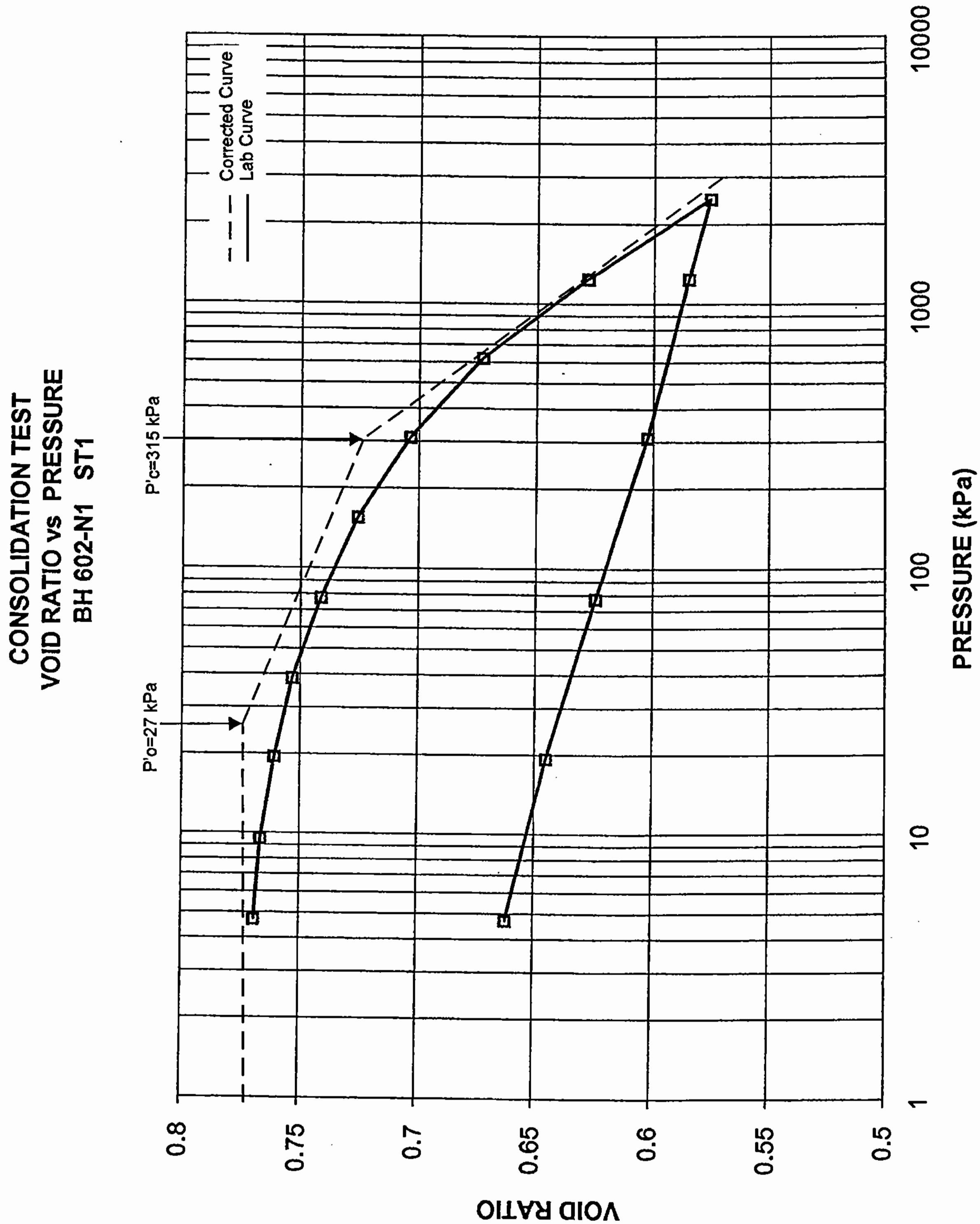
Prepared By: LFG

Golder Associates

Checkey By: MM

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B6(c)



Project No. 05-1116-043

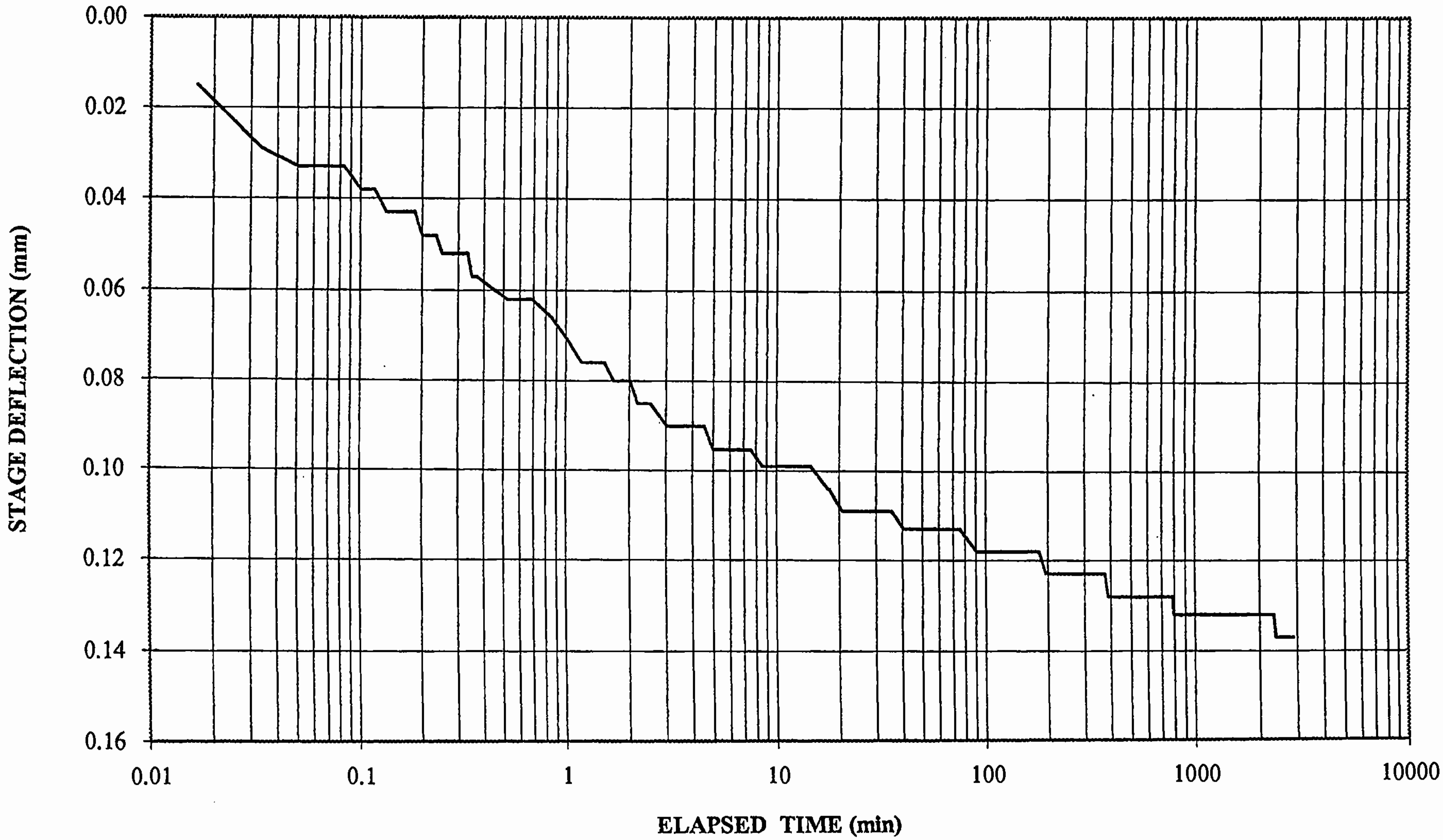
Prepared By: LFG

Golder Associates

Checked By: MM

BOREHOLE 602-N1 SAMPLE NUMBER ST1 FIGURE B6(d)

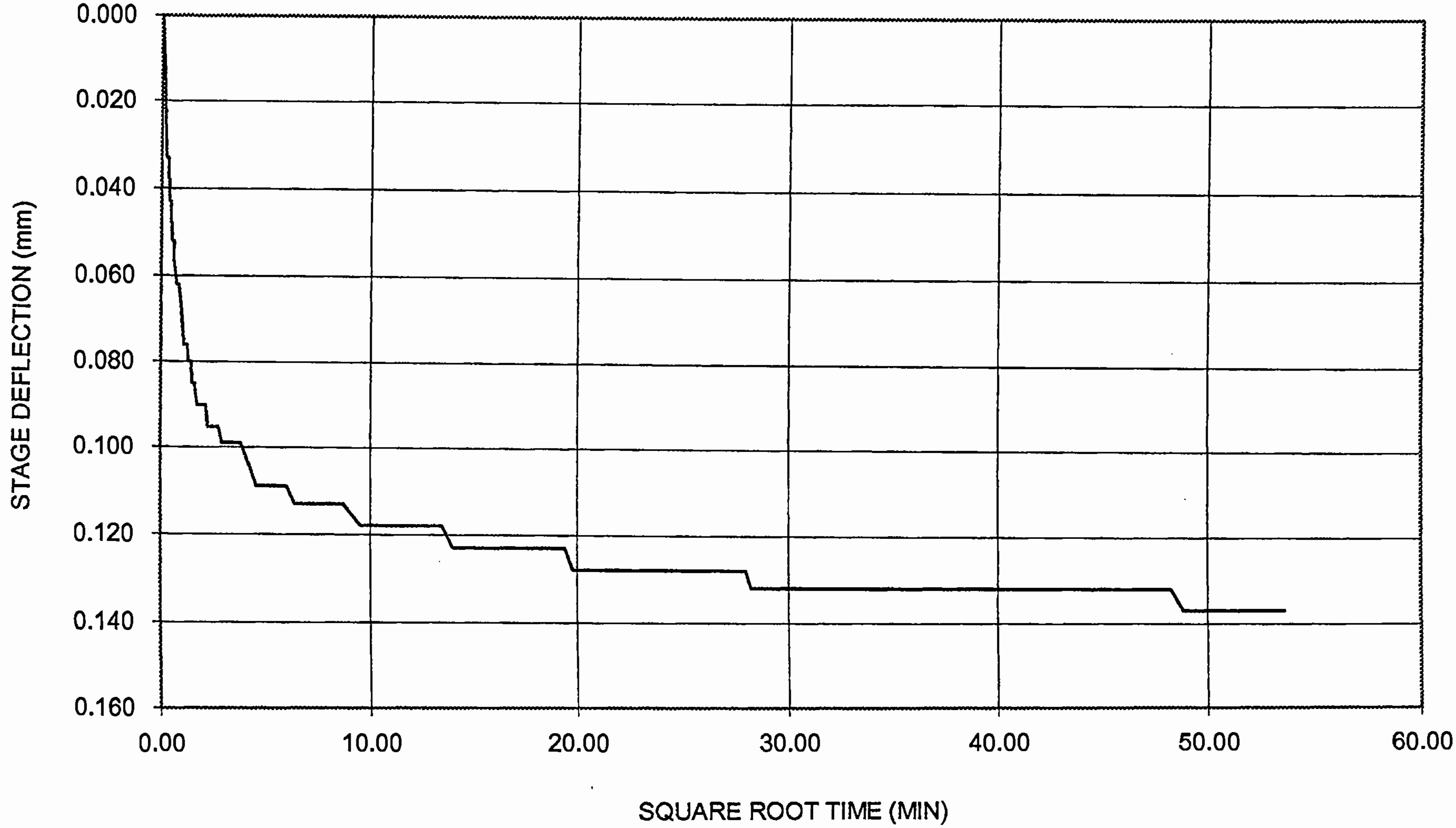
APPLIED PRESSURE = 77.8 kPa



BOREHOLE 602-N1 SAMPLE NUMBER ST1

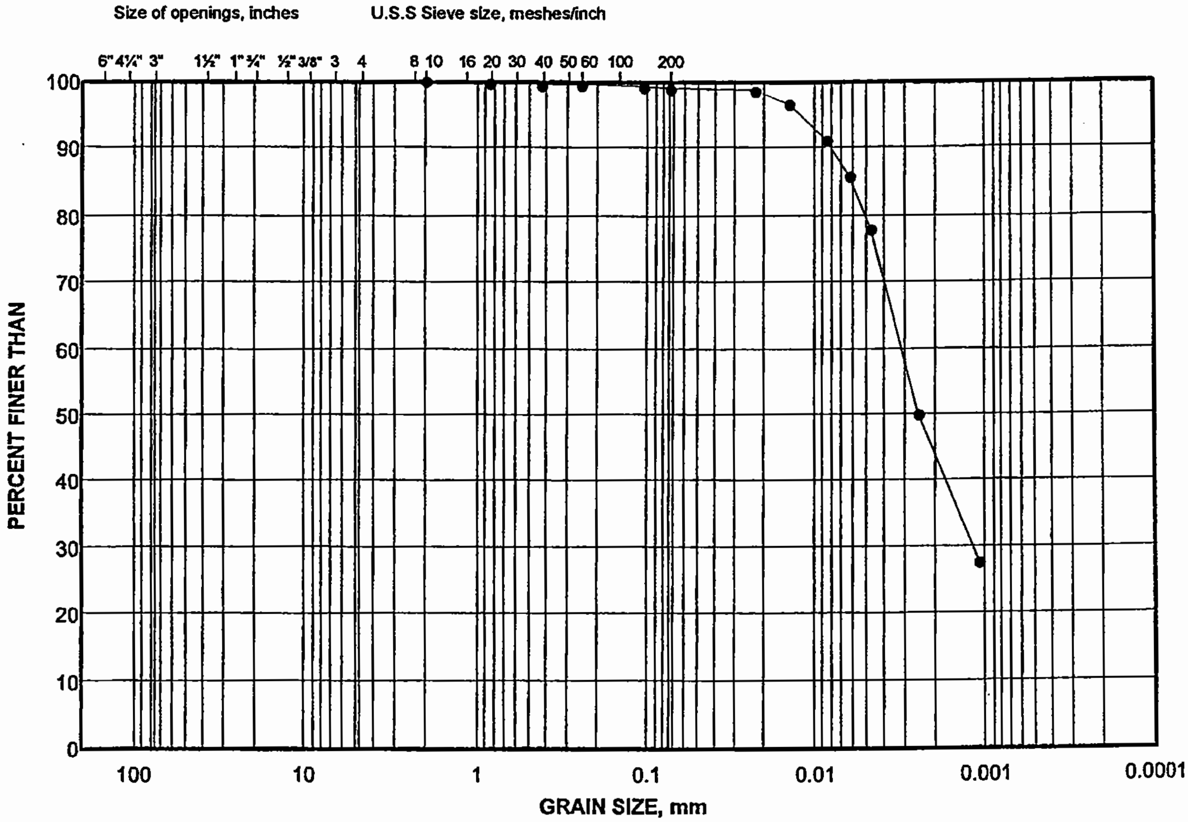
FIGURE B6(e)

APPLIED PRESSURE = 77.8 kPa



GRAIN SIZE DISTRIBUTION	FIGURE B6(f)

SWAMP 602 - SILTY CLAY (CI)



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
•	602-N1	ST1	3.5-4.1

Project Number: 05-1116-043

Checked By: [signature]

Golder Associates

Date: 17-Nov-05

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Consolidation Test Report

CLIENT:	**Totten Sims Hubicki (TSH)**	FILE NUMBER:	19-2805-2
PROJECT:	Highway 69 - Swamp 602	REPORT DATE:	28-Nov-05

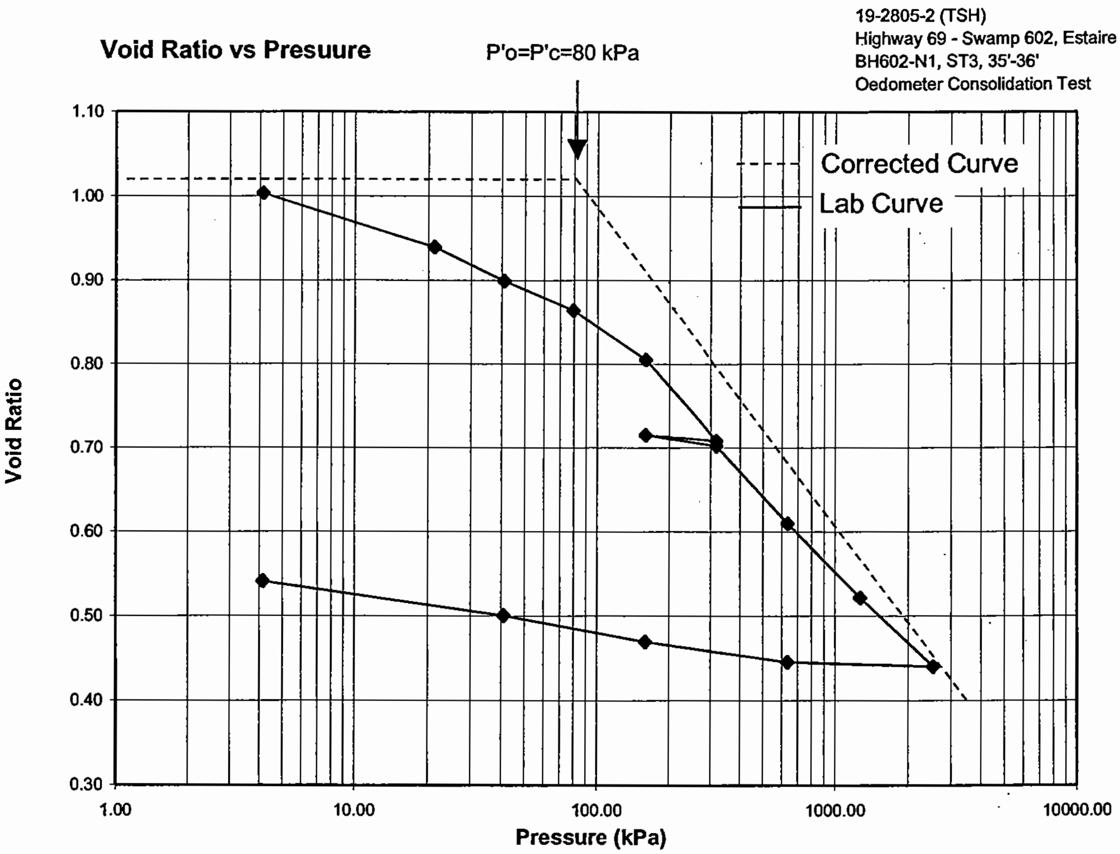
TEST DATES: October 28, 2005 - November 14, 2005

SAMPLE: BH602-N1-ST3, 35'-36'
Silty Clay, grey, uniform, plastic, (CI), Lab Vane: 26 - 34 kPa (Firm)
Grain Size: 42 % Clay, 57 % Silt & 1 % Sand

PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	Start of Test	End of Test
Wet Dens. (kg/m^3)	1887.5	2268.5
Dry Dens. (kg/m^3)	1384.7	1802.6
Moisture Cont. (%)	36.3	25.8
Void Ratio	1.015	0.548
Saturation (%)	99.8	

Note: A Specific Gravity of 2.79 was measured for the void ratio and saturation calculations



TEST DONE BY: EA
REVIEWED BY: JPL

Consolidation Test Report

Highway 69 - Swamp 602
19-2805-2

BH602-N1-ST3, 35'-36'

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

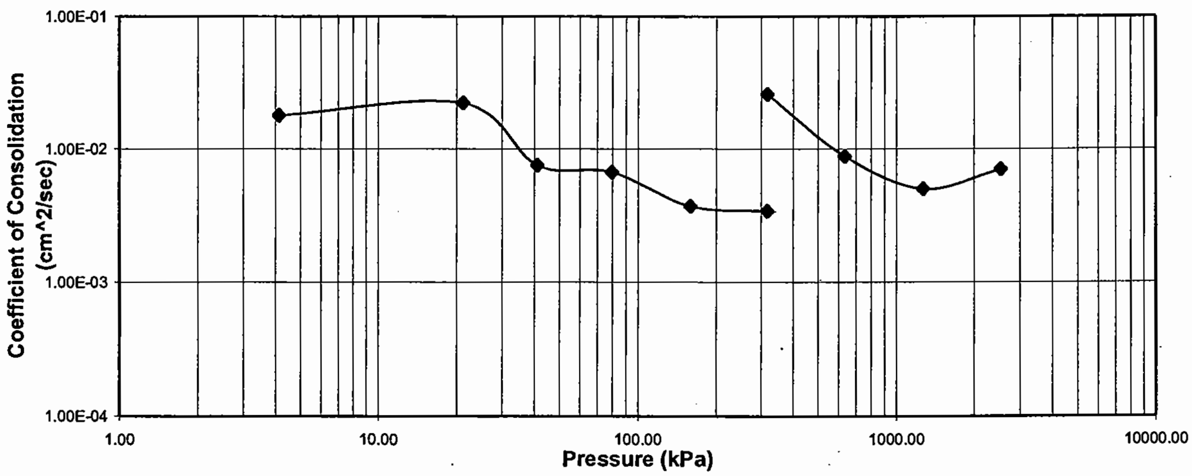
LOADING: A seating load of 4.13 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hours except the intermediate rebound loading was 96 hours for Secondary

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	T90 (min)	Cv (cm^2/sec)	Void Ratio	mv (m^2/kN)	k (cm/s)
0.00	19.150	19.150			1.015		
4.13	19.042	19.096	0.72	1.79E-02	1.004	1.87E-03	3.28E-06
21.16	18.433	18.738	0.56	2.22E-02	0.939	1.00E-03	2.17E-06
41.06	18.052	18.243	1.56	7.54E-03	0.899	4.51E-04	3.33E-07
79.54	17.720	17.886	1.69	6.69E-03	0.864	3.68E-04	2.42E-07
159.00	17.160	17.440	2.89	3.72E-03	0.805	3.05E-04	1.11E-07
317.36	16.236	16.698	2.89	3.41E-03	0.708	4.16E-05	1.39E-08
159.00	16.304	16.270			0.715		
317.36	16.178	16.241	0.36	2.59E-02	0.702	1.45E-04	3.67E-07
634.00	15.302	15.769	1.00	8.79E-03	0.610	6.91E-05	5.95E-08
1267.52	14.465	14.883	1.56	5.02E-03	0.522	3.20E-05	1.57E-08
2534.97	13.689	14.077	1.00	7.00E-03	0.440	1.47E-06	1.01E-09
634.00	13.743	13.716			0.446		
159.00	13.970	13.856			0.470		
41.06	14.262	14.116			0.500		
4.13	14.648	14.455			0.541		

Coefficient of Consoildation vs Pressure

19-2805-2 (TSH)
Highway 69 - Swamp 602, Estaire
BH602-N1, ST3, 35'-36'
Oedometer Consolidation Test



Notes: Cv and k calculated using t_{90} values

TEST DONE BY: EA
REVIEWED BY: JPL

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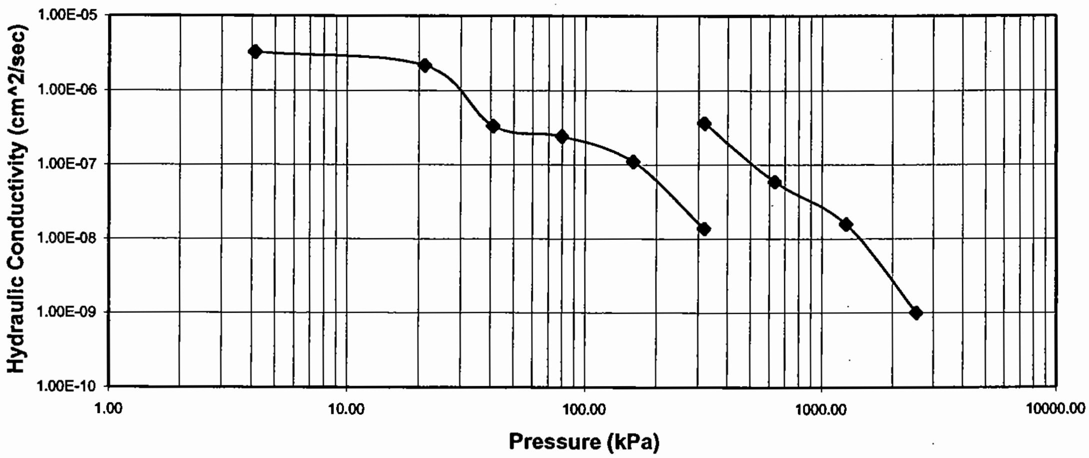
Consolidation Test Report

Highway 69 - Swamp 602
19-2805-2

BH602-N1-ST3, 35'-36'

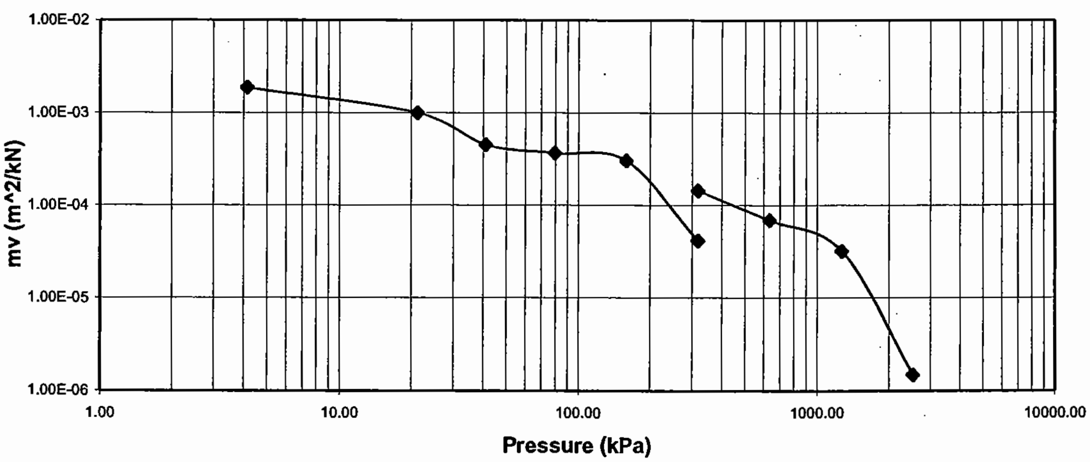
Hydraulic Conductivity vs Pressure

19-2805-2 (TSH)
Highway 69 - Swamp 602, Estaire
BH602-N1, ST3, 35'-36'
Oedometer Consolidation Test



mv vs Pressure

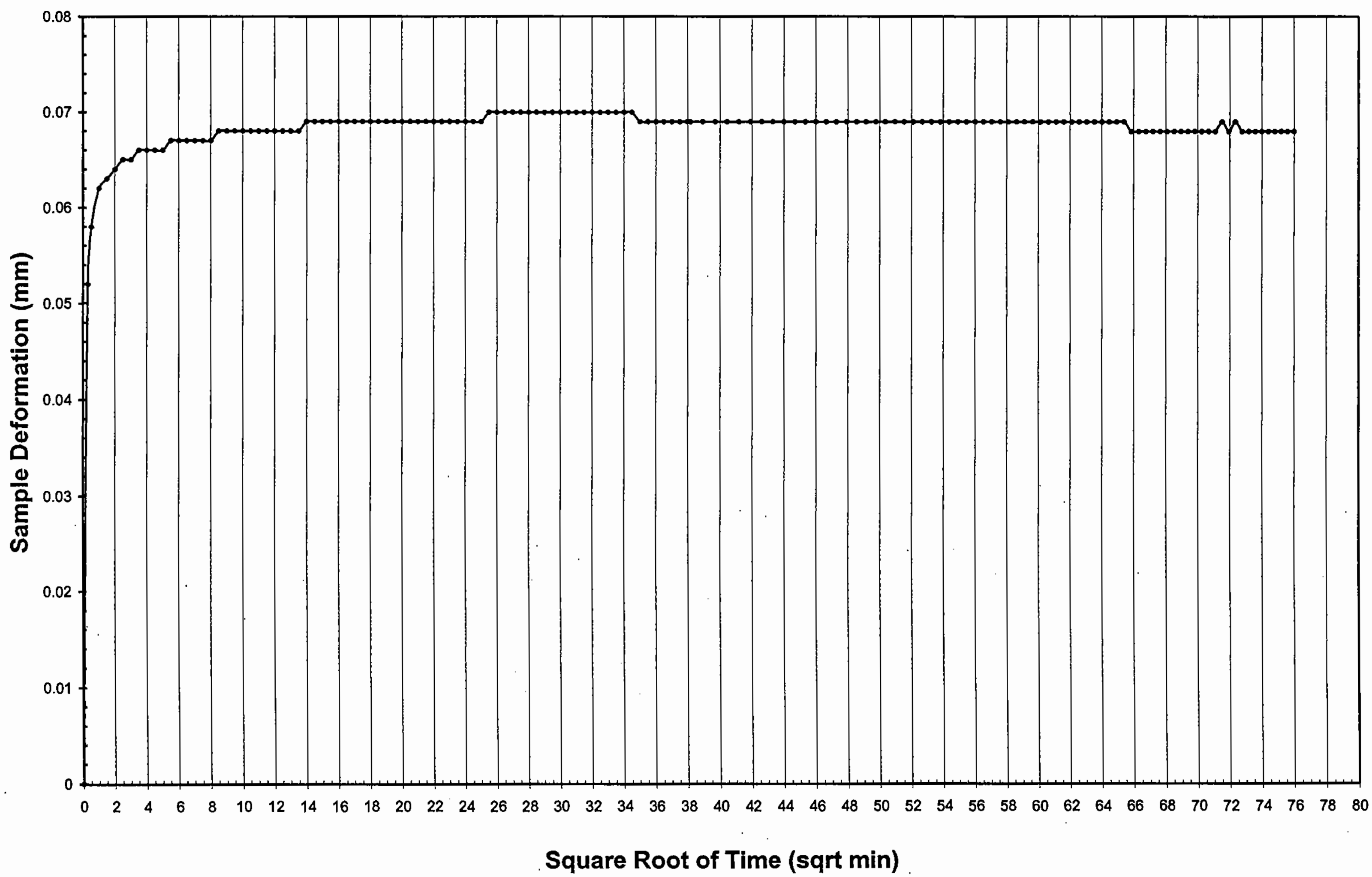
19-2805-2 (TSH)
Highway 69 - Swamp 602, Estaire
BH602-N1, ST3, 35'-36'
Oedometer Consolidation Test



TEST DONE BY: EA
REVIEWED BY: JPL

SAMPLE DEFORMATION vs TIME (1st rebound: 158.55kPa)
Load Duration:96 hrs

19-2805-2 (TSH)
Highway 69 - Swamp 602, Estaire
BH602-N1, ST3, 35'-36'
Oedometer Consolidation Test



TEST DONE BY:EA
REVIEWED BY: JPL

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B8(a)

SAMPLE IDENTIFICATION

Project Number	05-1116-043	Sample Number	ST1
Borehole Number	602-S1	Sample Depth, m	8.8-9.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	6		
Date Started	10/28/2005		
Date Completed	11/12/2005		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m^3	16.75
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	10.89
Area, cm^2	31.67	Specific Gravity, measured	2.77
Volume, cm^3	60.17	Solids Height, cm	0.762
Water Content, %	53.82	Volume of Solids, cm^3	24.12
Wet Mass, g	102.78	Volume of Voids, cm^3	36.05
Dry Mass, g	66.82	Degree of Saturation, %	99.8

TEST COMPUTATIONS

	Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
	0.00	1.900	1.494	1.900				
	4.75	1.896	1.489	1.898	6	1.27E-01	4.43E-04	5.53E-06
	9.54	1.891	1.483	1.894	146	5.21E-03	5.49E-04	2.80E-07
	19.25	1.882	1.471	1.887	271	2.78E-03	4.88E-04	1.33E-07
	38.68	1.868	1.452	1.875	199	3.75E-03	3.79E-04	1.39E-07
	77.38	1.848	1.426	1.858	211	3.47E-03	2.72E-04	9.25E-08
	154.68	1.813	1.380	1.831	154	4.61E-03	2.38E-04	1.08E-07
	308.93	1.680	1.206	1.747	246	2.63E-03	4.54E-04	1.17E-07
48 hours	154.68	1.690	1.219	1.685				
	309.39	1.668	1.190	1.679	47	1.27E-02	7.48E-05	9.33E-08
	618.67	1.518	0.993	1.593	714	7.53E-04	2.55E-04	1.88E-08
	1237.55	1.408	0.848	1.463	342	1.33E-03	9.35E-05	1.22E-08
	2477.92	1.310	0.720	1.359	277	1.41E-03	4.16E-05	5.76E-09
	1237.55	1.324	0.738	1.317				
	309.39	1.355	0.779	1.340				
	77.38	1.396	0.833	1.376				
	19.25	1.446	0.898	1.421				
	4.75	1.481	0.944	1.464				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.48	Unit Weight, kN/m^3	19.00
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	13.97
Area, cm^2	31.67	Specific Gravity, measured	2.77
Volume, cm^3	46.90	Solids Height, cm	0.762
Water Content, %	36.01	Volume of Solids, cm^3	24.12
Wet Mass, g	90.88	Volume of Voids, cm^3	22.78
Dry Mass, g	66.82		

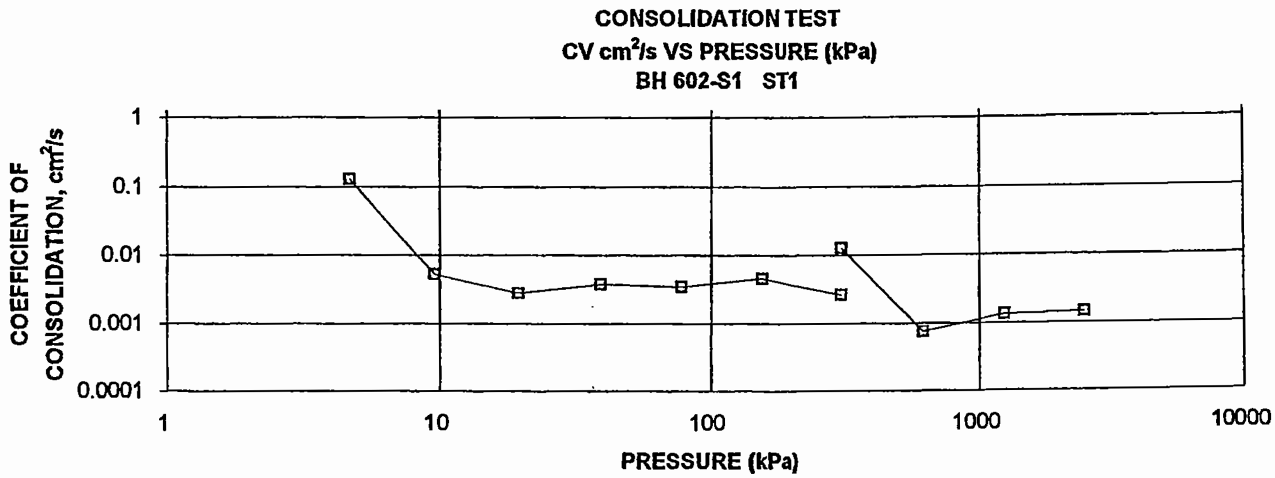
Prepared By: LFG

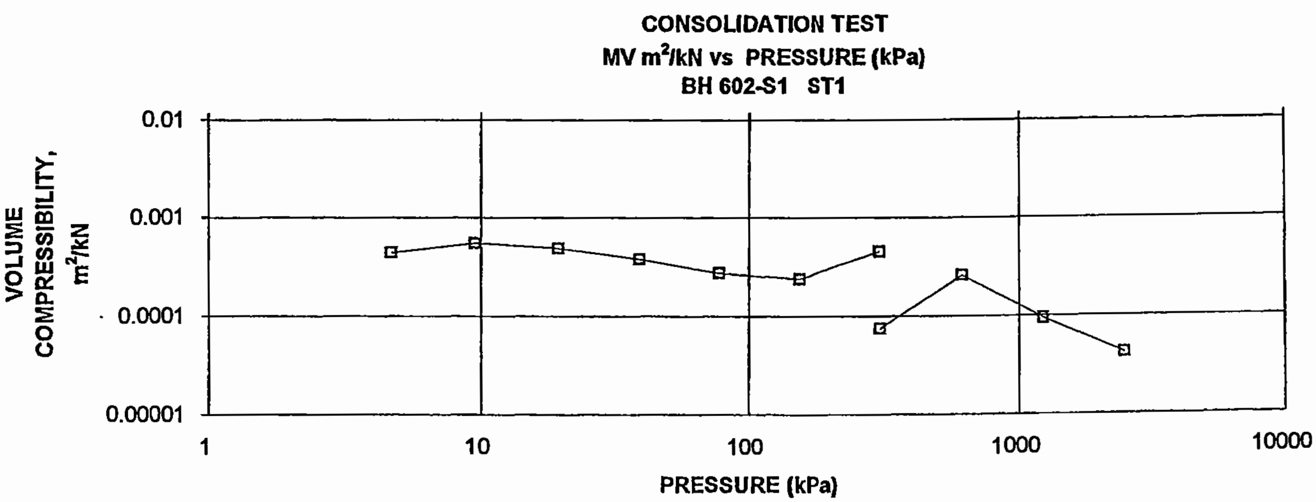
Golder Associates

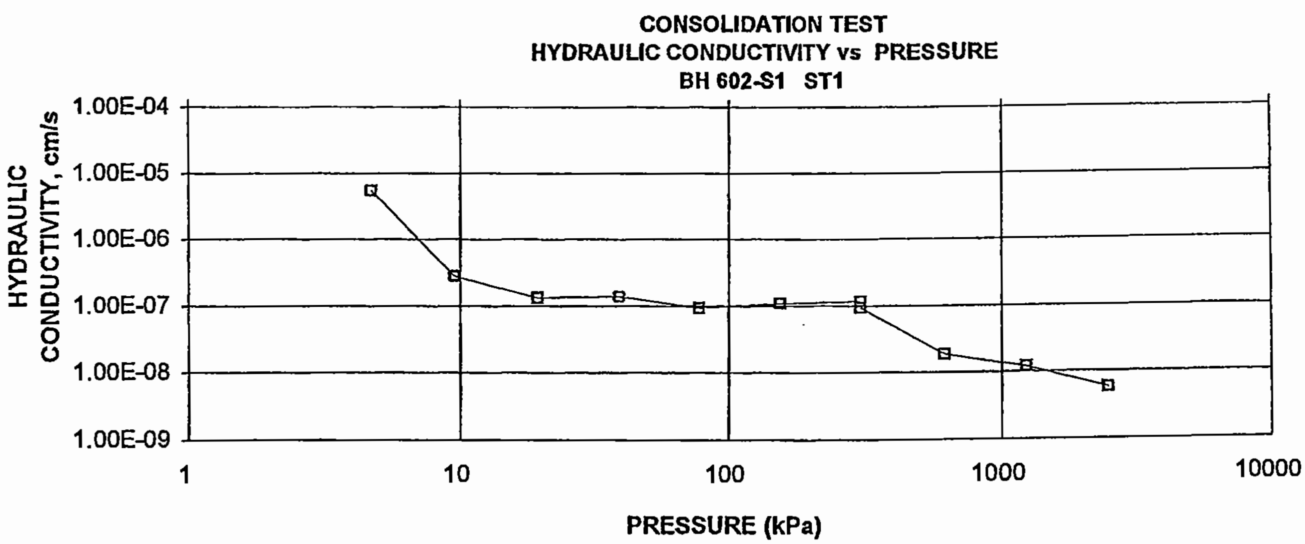
Checked By: MM

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B8(b)







Project No. 05-1116-043

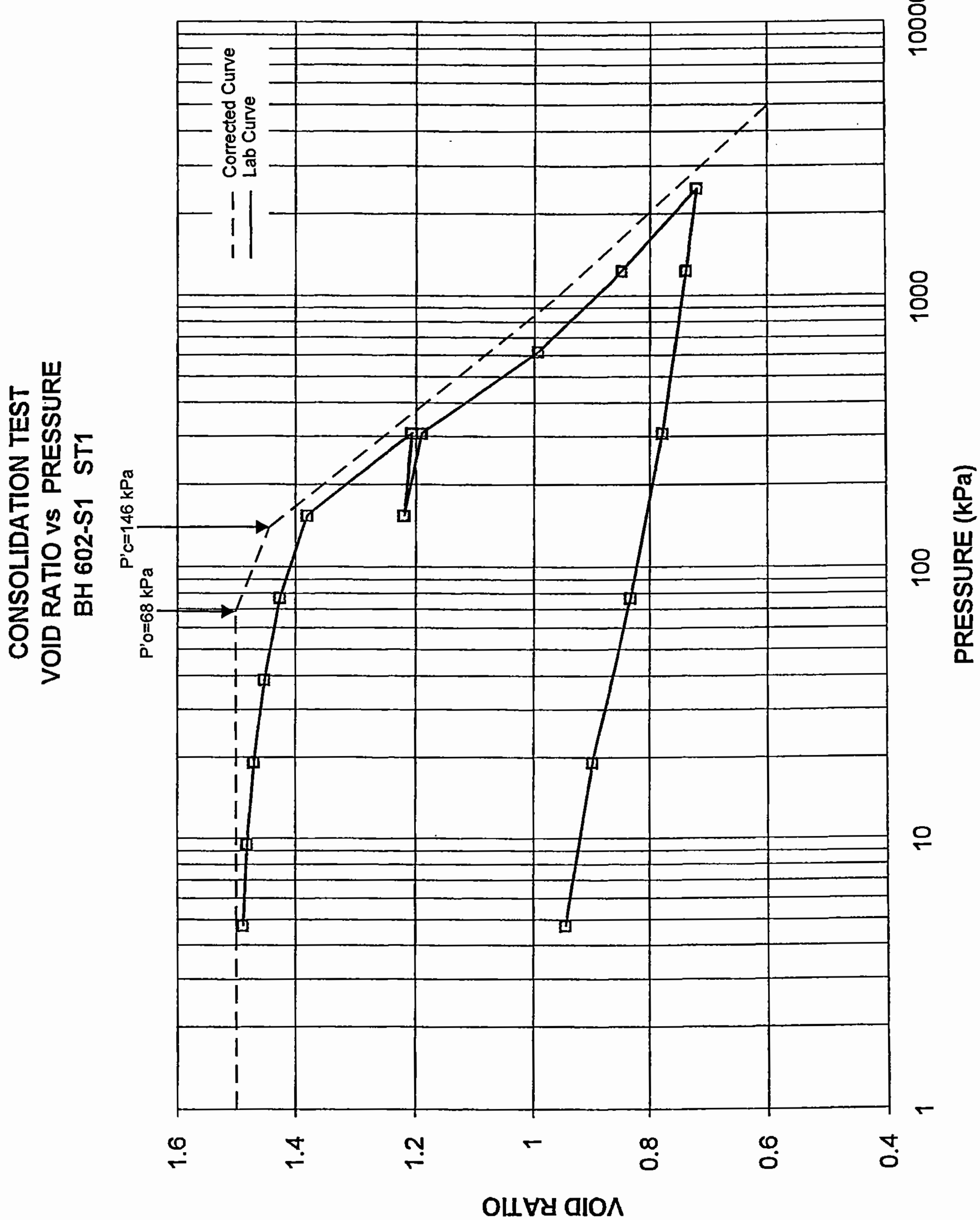
Prepared By: LFG

Golder Associates

Checkey By: MM

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B8(c)



Project No. 05-1116-043
Prepared By: LFG

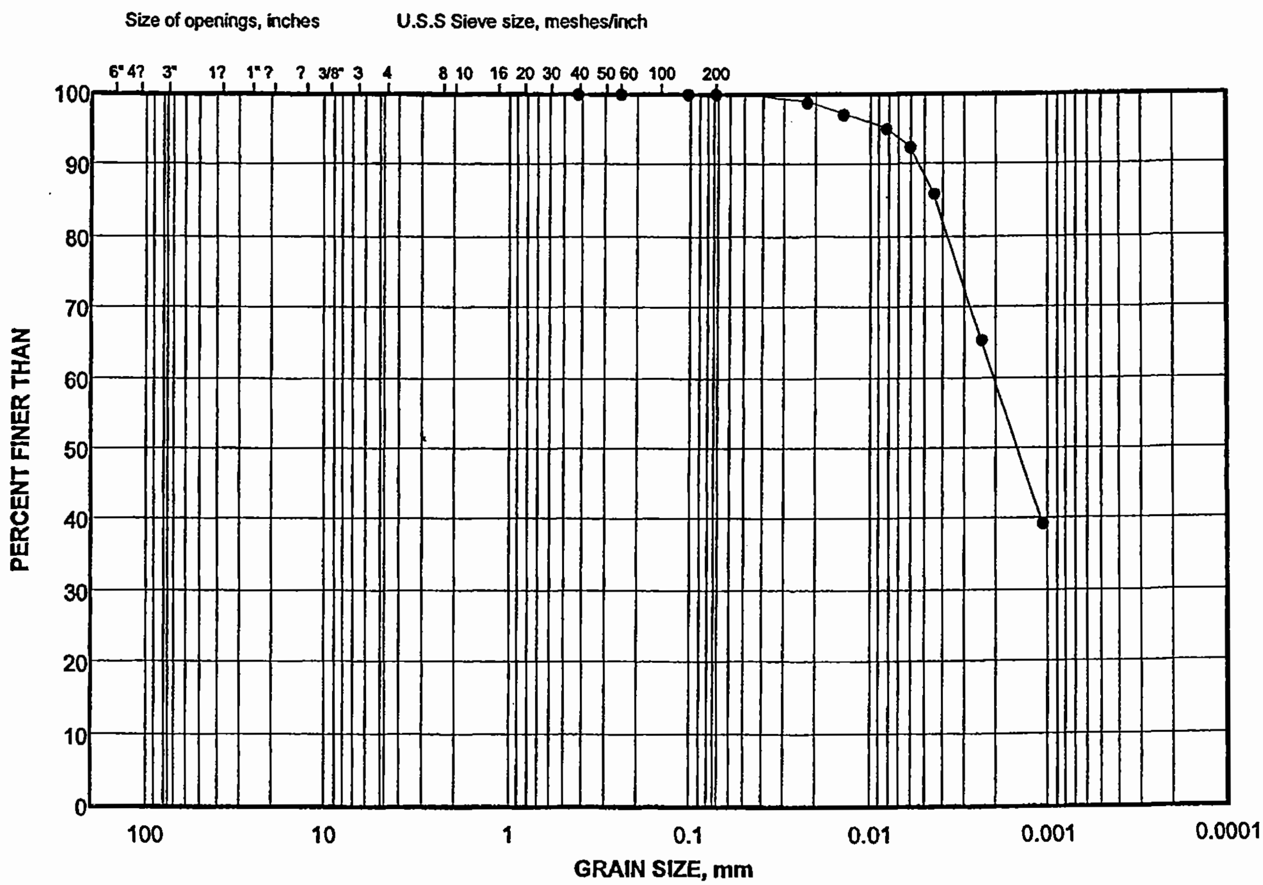
Golder Associates

Checked By: MM

GRAIN SIZE DISTRIBUTION

FIGURE B8(d)

SWAMP 602 - SILTY CLAY (CI)



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	602-S1	ST1	8.8-9.4

Project Number: 05-1116-043

Checked By: ______________________

Golder Associates

Date: 17-Nov-05

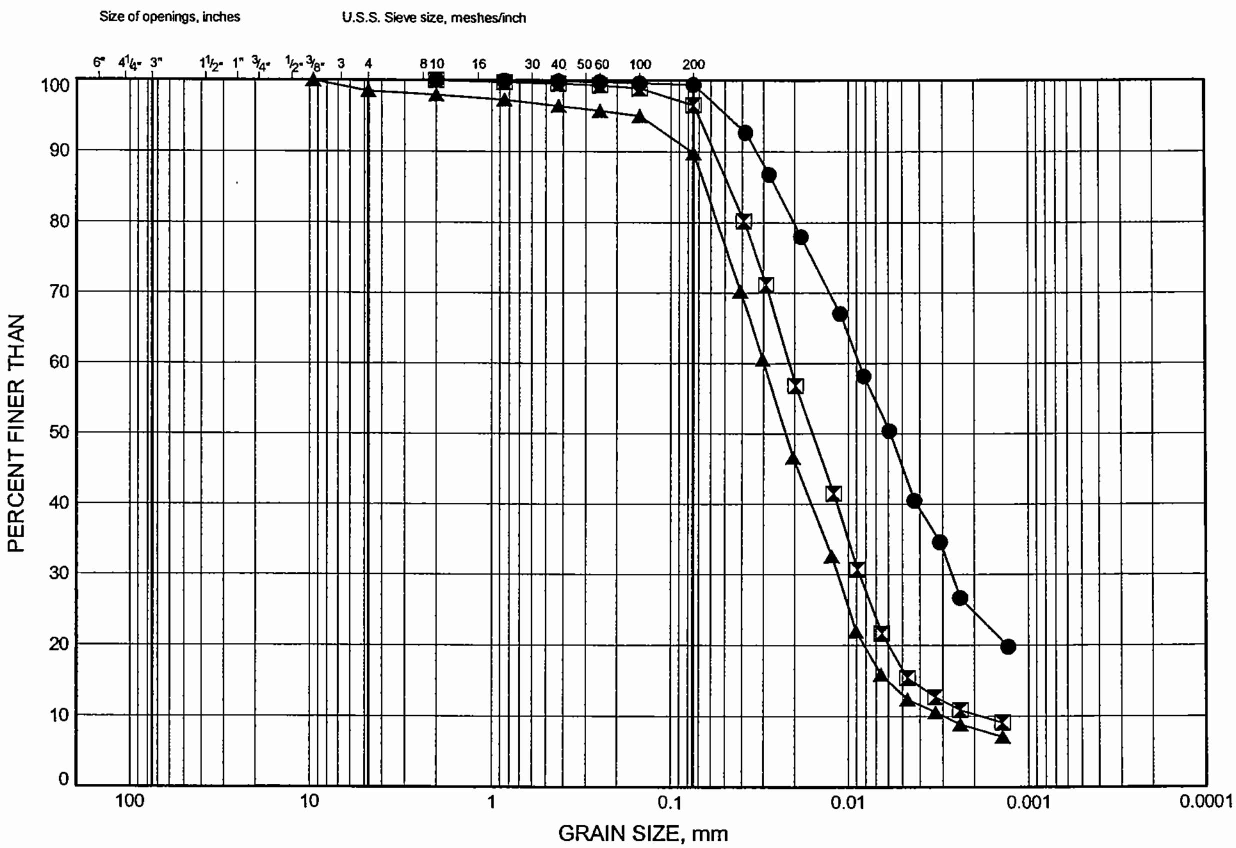
SWAMP 605

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B9

SWAMP 605 - LOWER SILT (ML)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	605-N1	3.28	230.49
⊠	605-N1	14.02	219.75
▲	605-N1	18.59	215.18

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Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

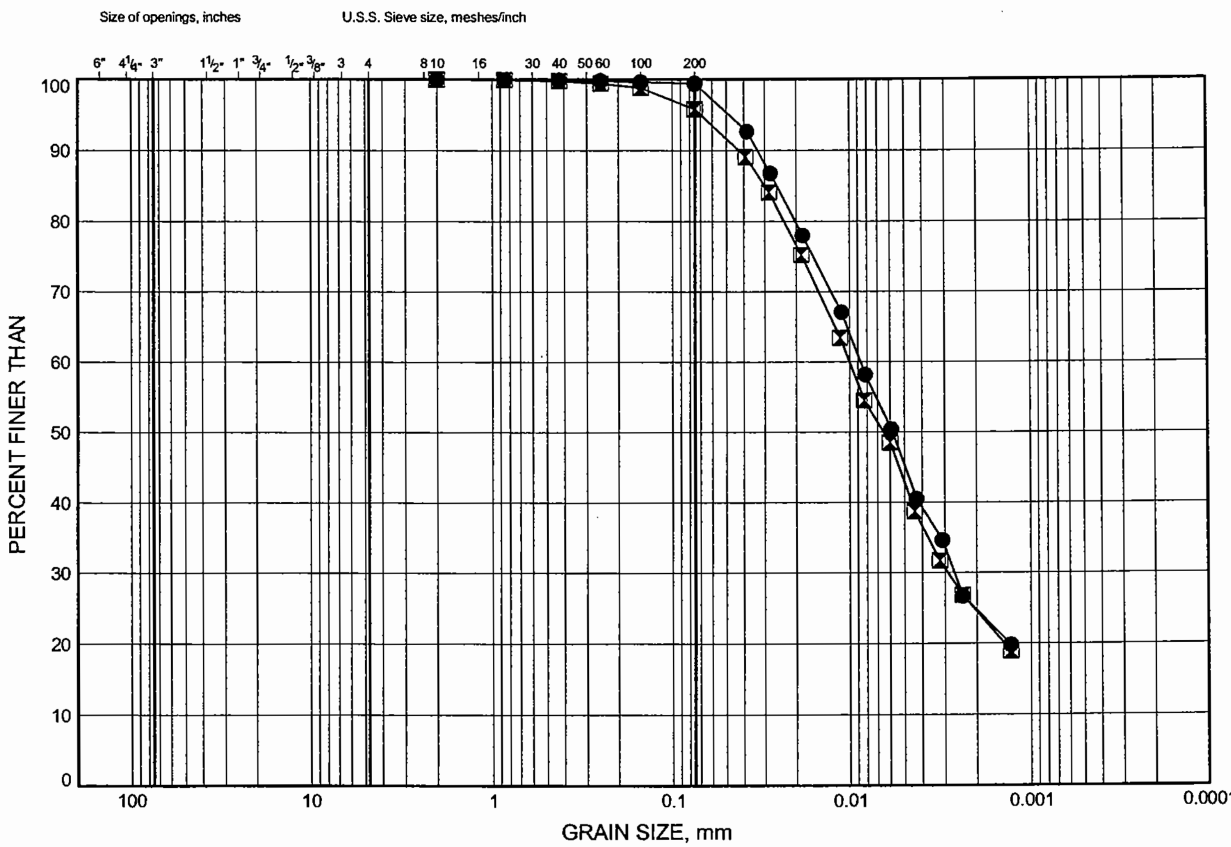
Chkd. JPL

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B10

SWAMP 605 - SILTY CLAY (CL/CL-ML)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	605-N1	3.28	230.49
⊠	605-S1	2.59	231.18

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

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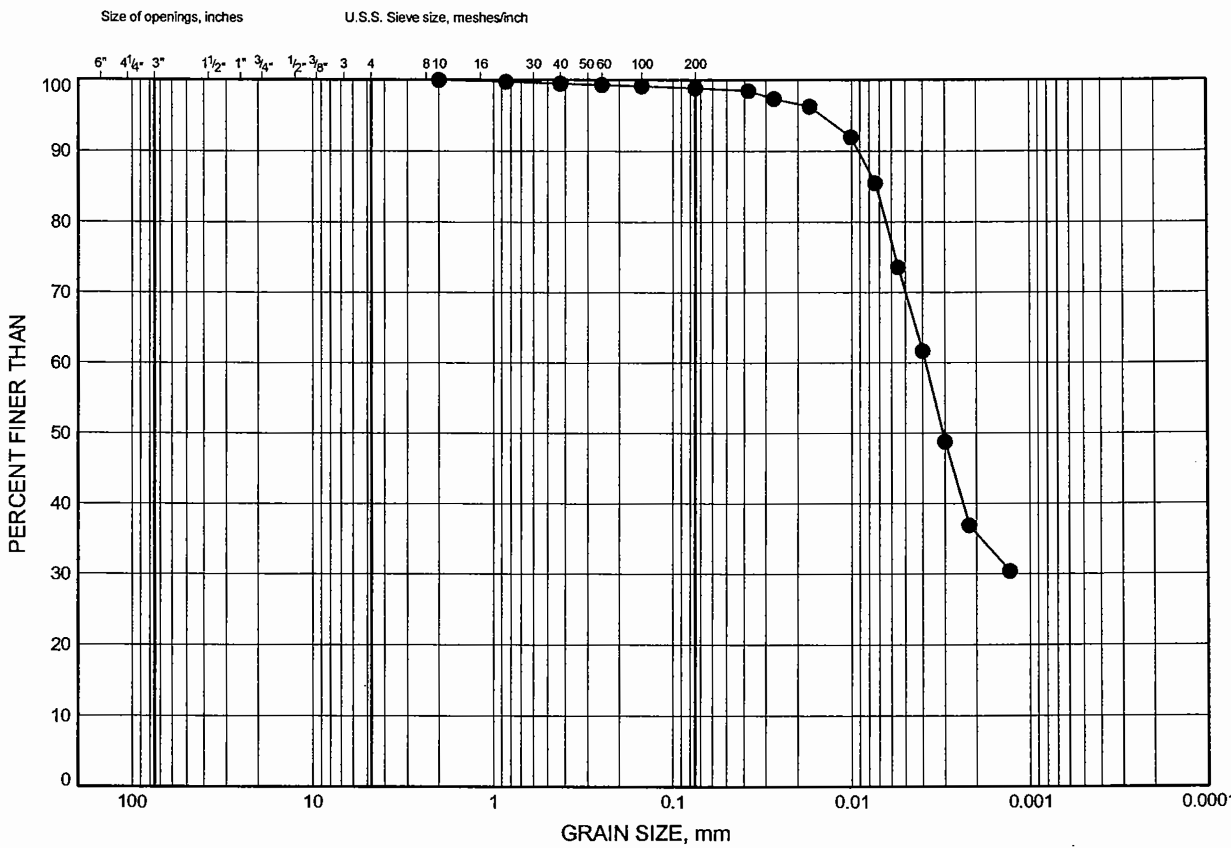
HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B11

SWAMP 605 - SILTY CLAY (CI)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	605-S1	7.92	225.85

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

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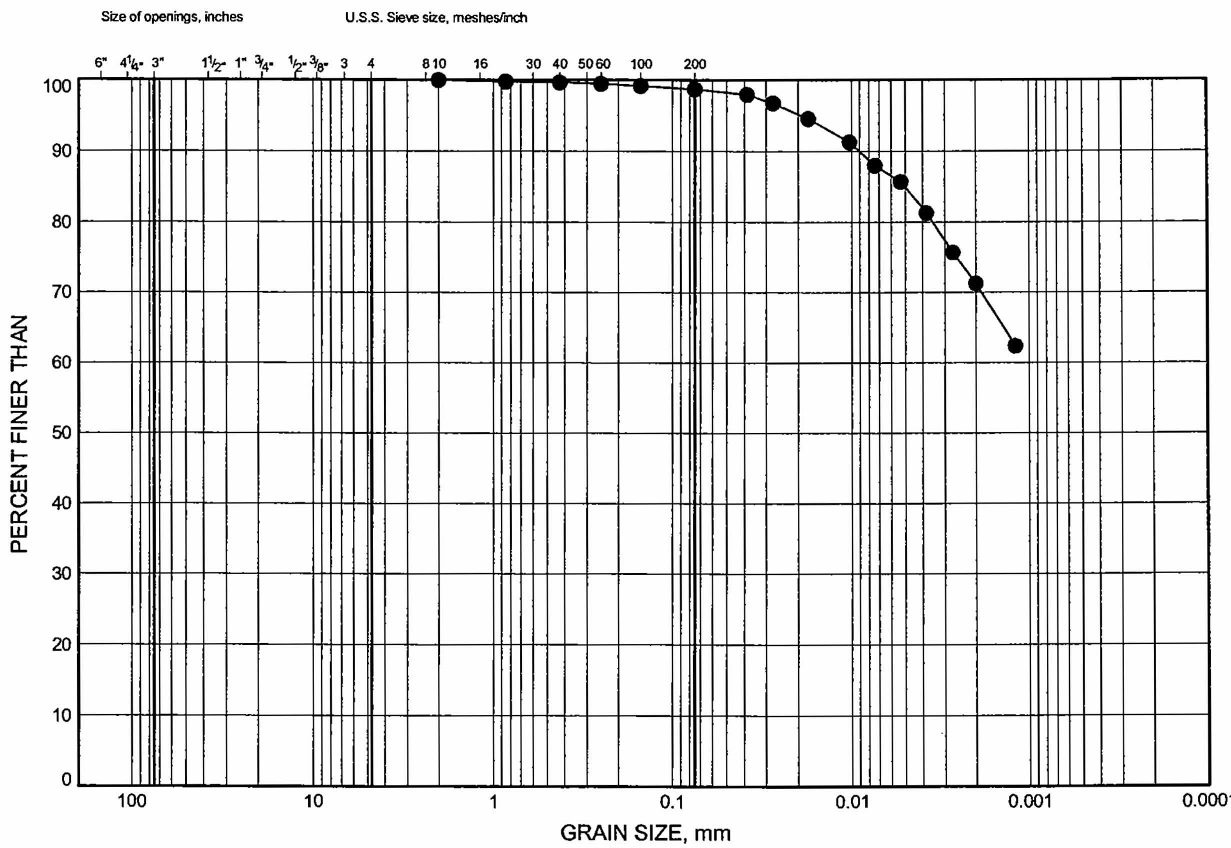
THURBGSD 8052.GPJ 21/03/06

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B12

SWAMP 605 - SILTY CLAY (CH)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	605-S1	4.88	228.90

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

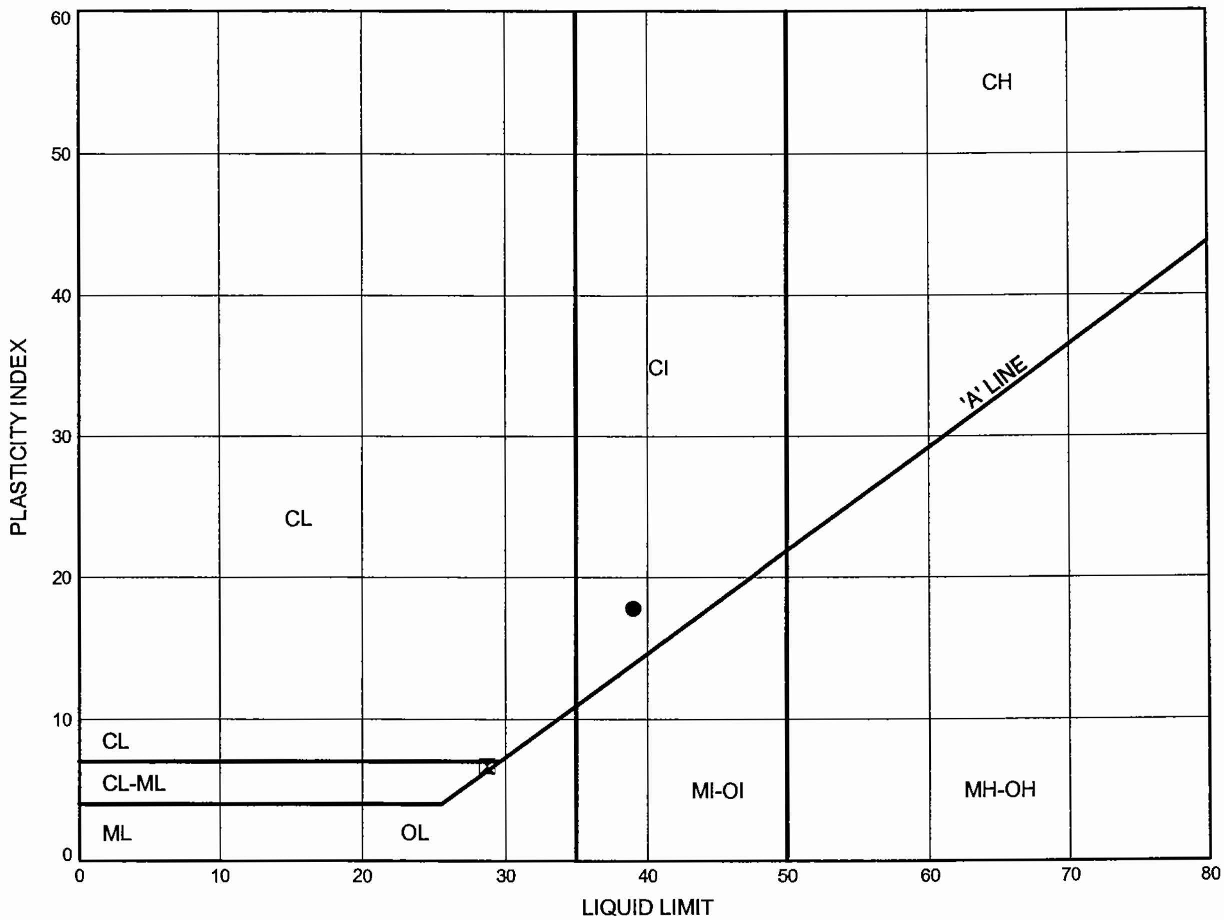
THURBGSD 8052.GPJ 21/03/06

HWY 69

ATTERBERG LIMITS TEST RESULTS

FIGURE B13

SWAMP 605 - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	605-N1	6.40	227.37
⊠	605-N1	10.97	222.80

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

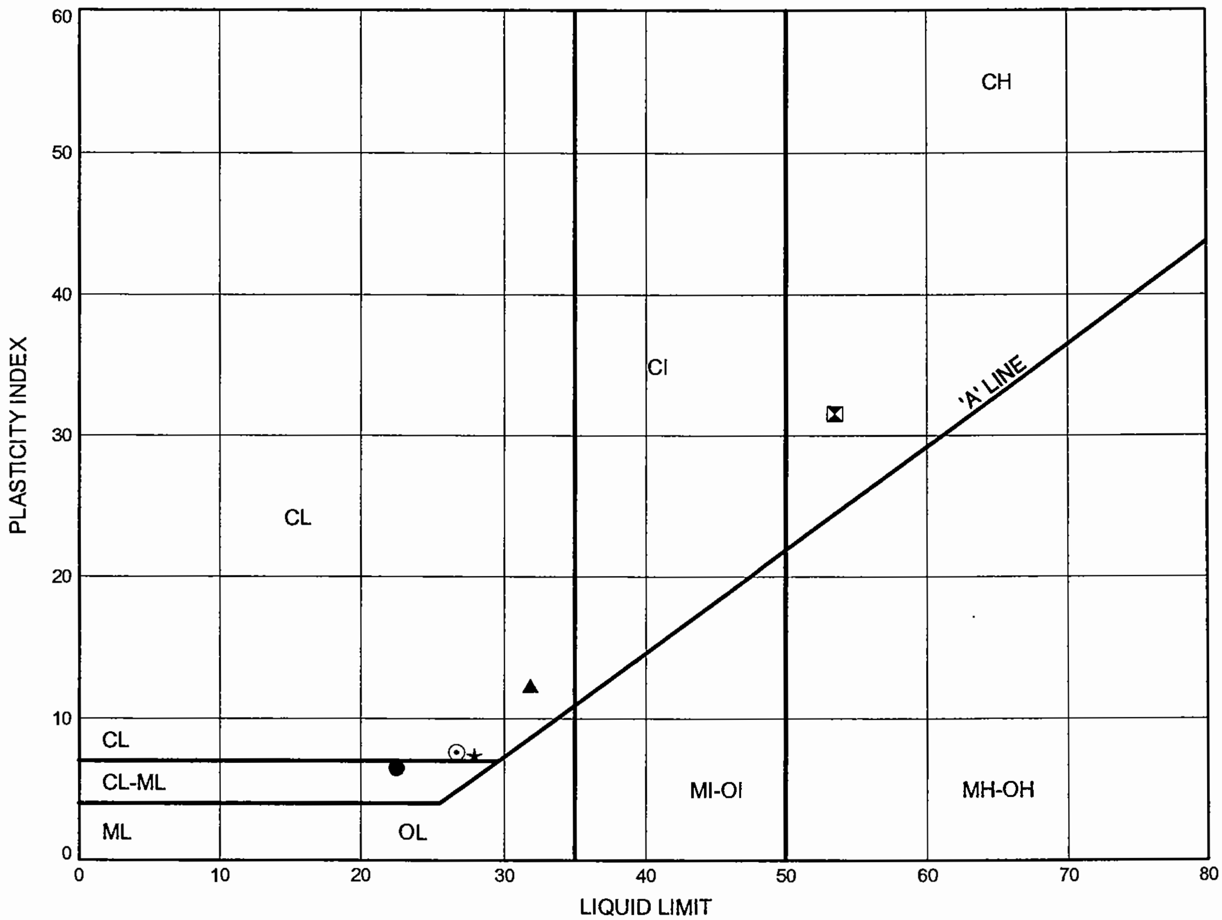
Chkd. JPL

HWY 69

ATTERBERG LIMITS TEST RESULTS

FIGURE B14

SWAMP 605 - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	605-S1	2.59	231.18
⊠	605-S1	4.88	228.90
▲	605-S1	7.92	225.85
★	605-S1	9.45	224.33
⊙	605-S1	11.13	222.65

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

THURBALT 8052.GPJ 21/03/06

OEDOMETER TEST RESULTS

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B15(a)

SAMPLE IDENTIFICATION

Project Number	05-1116-043	Sample Number	ST1
Borehole Number	605-N1	Sample Depth, m	6.1-6.7

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	10/28/2005		
Date Completed	11/12/2005		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.92	Unit Weight, kN/m^3	17.22
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	11.85
Area, cm^2	31.67	Specific Gravity, measured	2.67
Volume, cm^3	60.65	Solids Height, cm	0.867
Water Content, %	45.29	Volume of Solids, cm^3	27.46
Wet Mass, g	106.51	Volume of Voids, cm^3	33.19
Dry Mass, g	73.31	Degree of Saturation, %	100.0

TEST COMPUTATIONS

	Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
	0.00	1.915	1.209	1.915				
	4.85	1.899	1.190	1.907	53	1.45E-02	1.72E-03	2.46E-06
	9.50	1.891	1.181	1.895	60	1.27E-02	8.98E-04	1.12E-06
	19.40	1.876	1.164	1.884	135	5.57E-03	7.91E-04	4.32E-07
	38.64	1.853	1.137	1.865	171	4.31E-03	6.24E-04	2.64E-07
	77.43	1.786	1.060	1.820	197	3.56E-03	9.02E-04	3.15E-07
	154.66	1.661	0.916	1.724	816	7.72E-04	8.45E-04	6.39E-08
	309.38	1.561	0.800	1.611	454	1.21E-03	3.38E-04	4.01E-08
48 hours	154.66	1.567	0.807	1.564				
	309.38	1.556	0.795	1.562	17	3.04E-02	3.71E-05	1.11E-07
	616.93	1.475	0.701	1.516	171	2.85E-03	1.38E-04	3.84E-08
	1234.84	1.395	0.609	1.435	146	2.99E-03	6.76E-05	1.98E-08
	2472.53	1.320	0.523	1.358	146	2.68E-03	3.16E-05	8.30E-09
	1234.84	1.328	0.532	1.324				
	309.38	1.349	0.556	1.339				
	77.43	1.376	0.587	1.363				
	19.40	1.408	0.624	1.392				
	4.85	1.440	0.661	1.424				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.44	Unit Weight, kN/m^3	20.24
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	15.76
Area, cm^2	31.67	Specific Gravity, measured	2.67
Volume, cm^3	45.60	Solids Height, cm	0.867
Water Content, %	28.39	Volume of Solids, cm^3	27.46
Wet Mass, g	94.12	Volume of Voids, cm^3	18.15
Dry Mass, g	73.31		

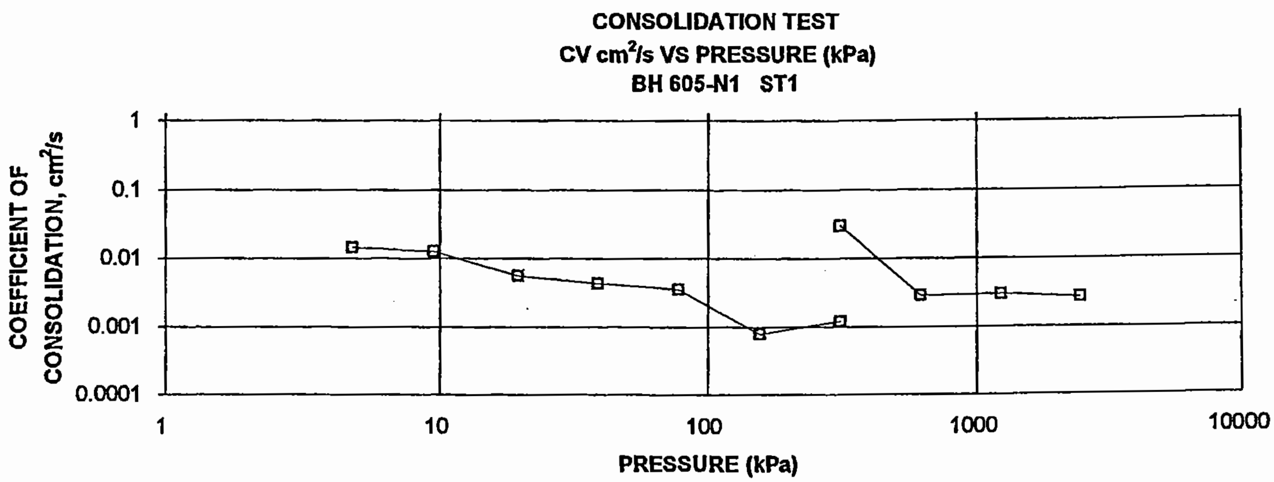
Prepared By: LFG

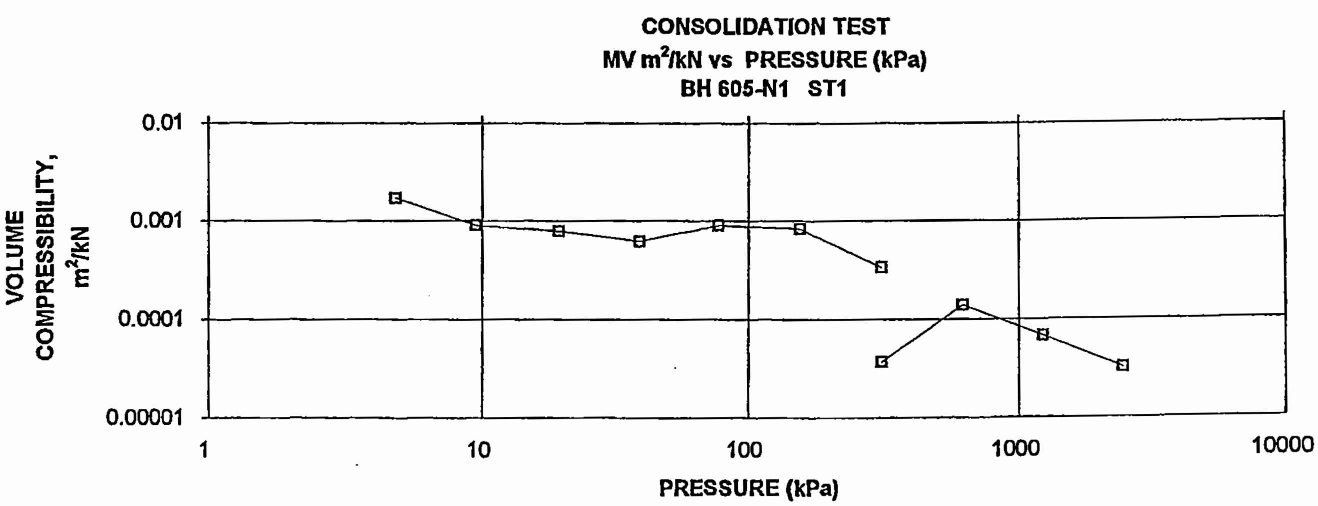
Golder Associates

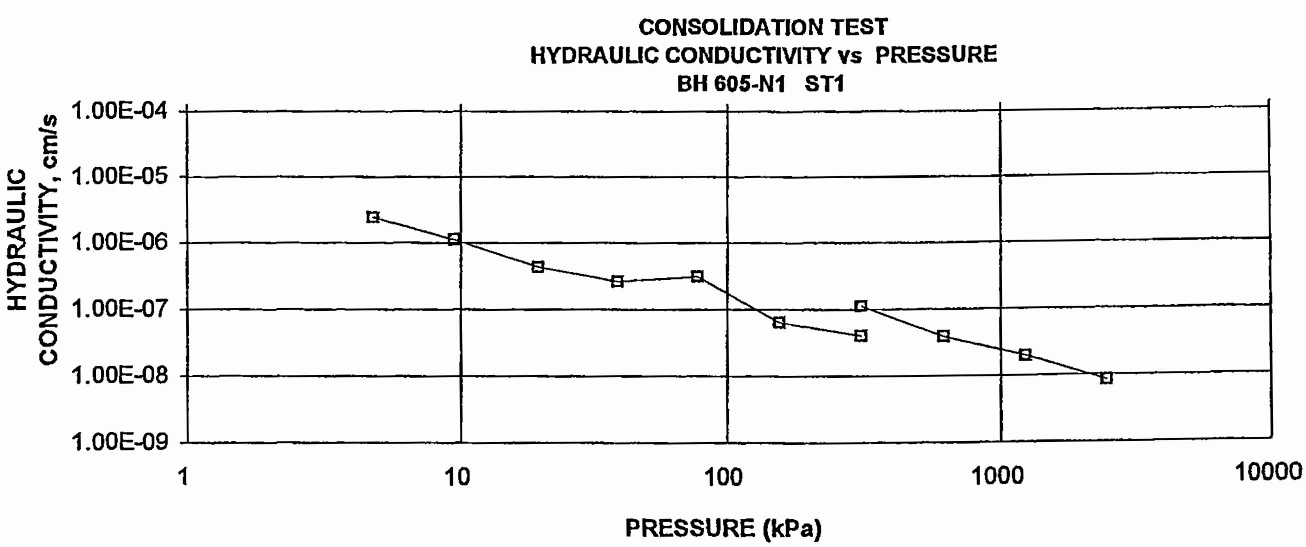
Checked By: MM

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B15(b)







Project No. 05-1116-043

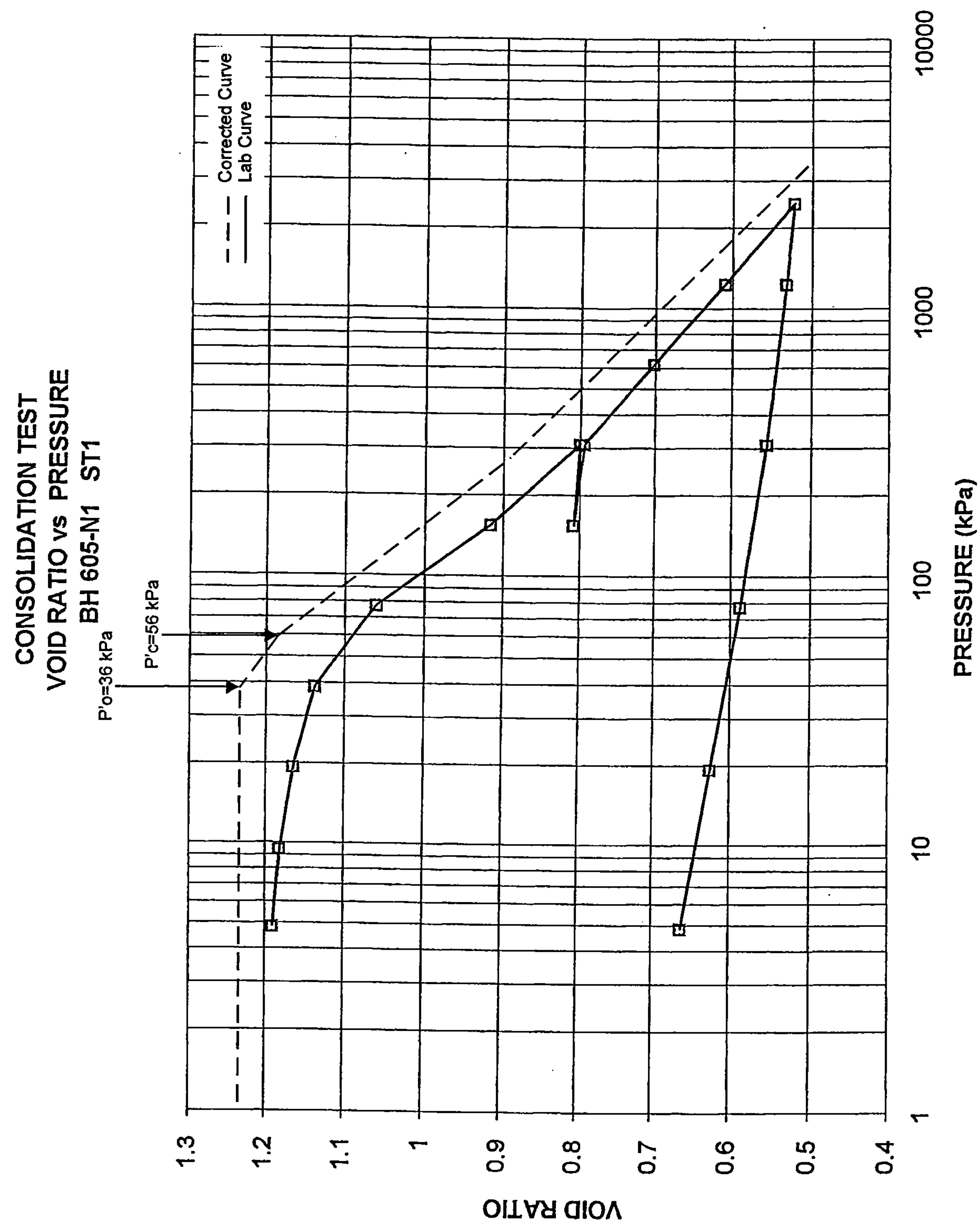
Prepared By: LFG

Golder Associates

Checkey By: MM

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B15(c)



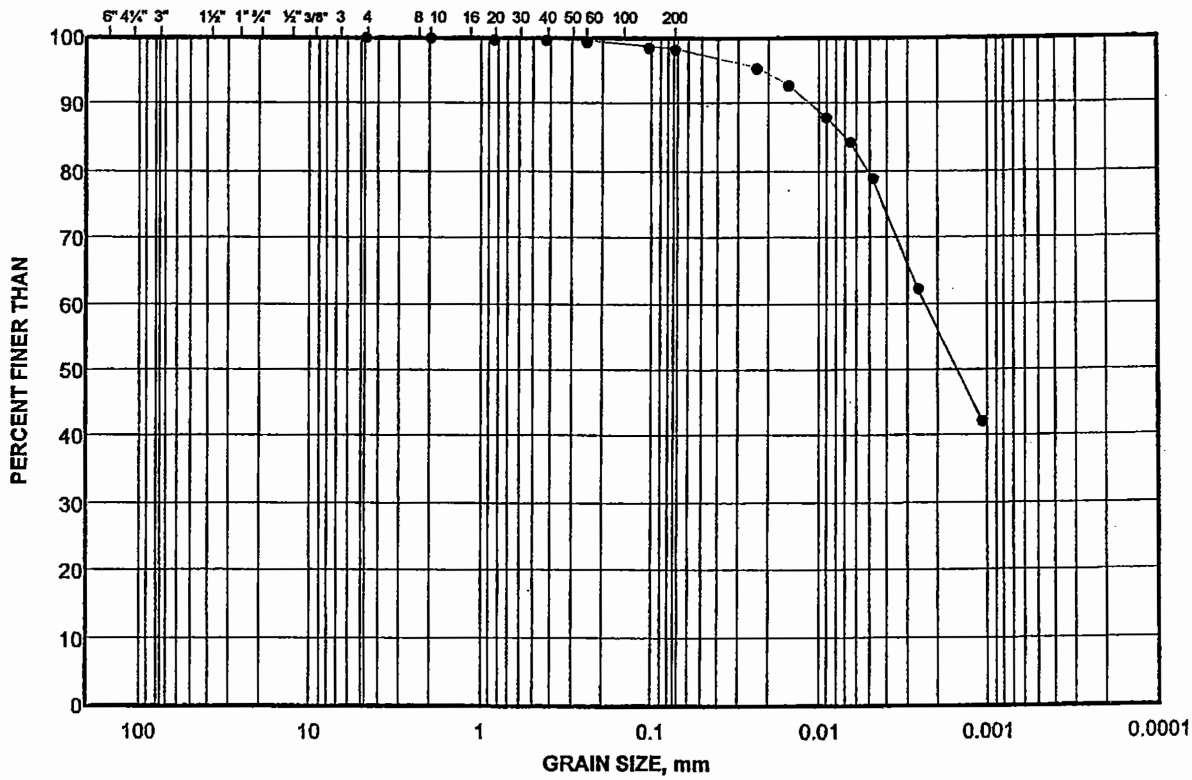
Project No. 05-1116-043
Prepared By: LFG

Golder Associates

Checked By: MM

GRAIN SIZE DISTRIBUTION	FIGURE B15(d)

SWAMP 605 - SILTY CLAY (CI)



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	605-N1	ST1	6.1-6.7

Project Number: 05-1116-043

Checked By: ______________

Golder Associates

Date: 17-Nov-05

OEDOMETER CONSOLIDATION SUMMARY FIGURE B16(a)

SAMPLE IDENTIFICATION

Project Number	05-1116-043	Sample Number	ST2
Borehole Number	605-N1	Sample Depth, m	10.7-11.3

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	9		
Date Started	10/28/2005		
Date Completed	11/12/2005		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.92	Unit Weight, kN/m^3	19.37
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	15.00
Area, cm^2	31.52	Specific Gravity, measured	2.76
Volume, cm^3	60.36	Solids Height, cm	1.061
Water Content, %	29.16	Volume of Solids, cm^3	33.45
Wet Mass, g	119.24	Volume of Voids, cm^3	26.91
Dry Mass, g	92.32	Degree of Saturation, %	100.0

TEST COMPUTATIONS

	Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
	0.00	1.915	0.805	1.915				
	4.72	1.889	0.780	1.902	413	1.86E-03	2.88E-03	5.23E-07
	9.50	1.879	0.771	1.884	152	4.95E-03	1.09E-03	5.30E-07
	19.59	1.865	0.757	1.872	124	5.99E-03	7.25E-04	4.25E-07
	39.07	1.848	0.741	1.857	85	8.60E-03	4.56E-04	3.84E-07
	77.88	1.824	0.719	1.836	53	1.35E-02	3.23E-04	4.27E-07
	155.30	1.793	0.690	1.809	56	1.24E-02	2.09E-04	2.54E-07
	310.62	1.758	0.657	1.776	28	2.39E-02	1.18E-04	2.75E-07
48 hours	155.30	1.762	0.660	1.760				
	310.62	1.755	0.654	1.759	13	5.04E-02	2.35E-05	1.16E-07
	621.64	1.720	0.621	1.738	19	3.37E-02	5.88E-05	1.94E-07
	1243.40	1.680	0.583	1.700	13	4.71E-02	3.36E-05	1.55E-07
	2485.12	1.635	0.541	1.658	40	1.46E-02	1.89E-05	2.70E-08
	1243.40	1.644	0.549	1.640				
	310.62	1.660	0.564	1.652				
	77.88	1.674	0.577	1.667				
	19.59	1.688	0.591	1.681				
	4.72	1.705	0.607	1.697				

Note:
k calculated using cv based on t_{90} values.

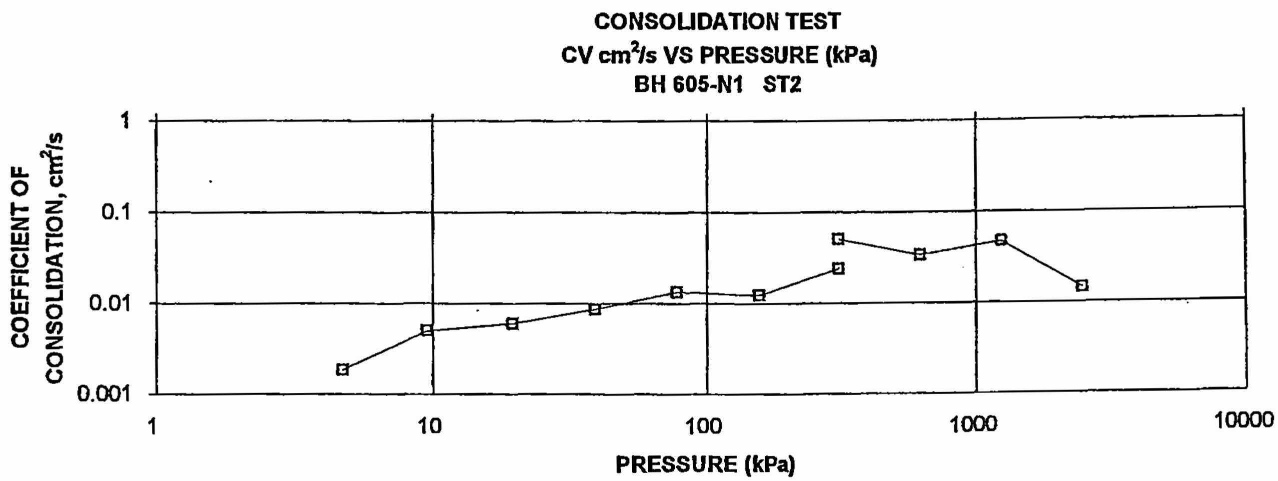
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

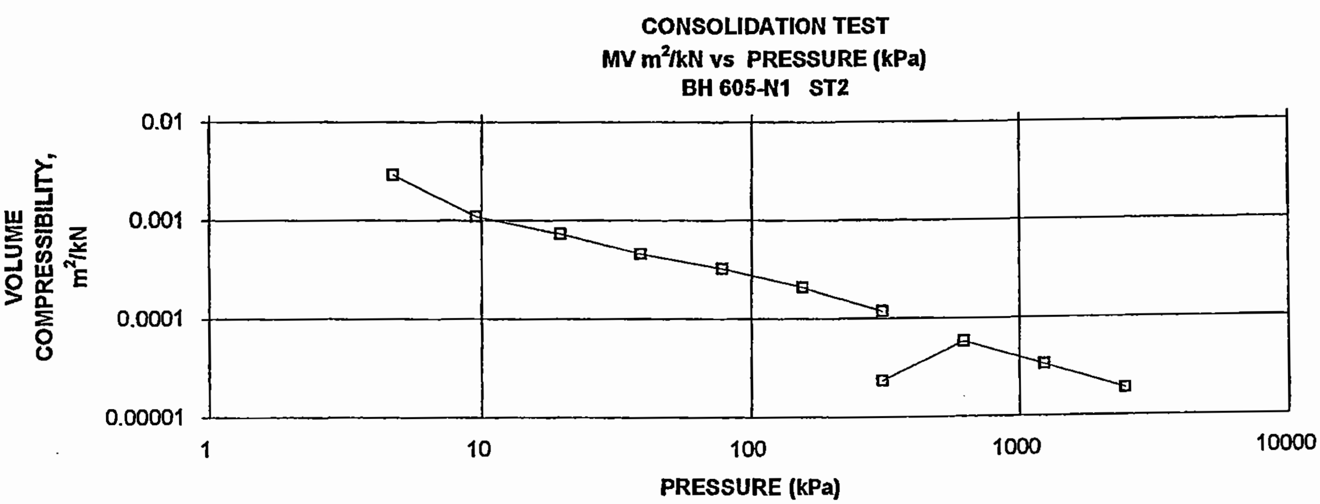
Sample Height, cm	1.71	Unit Weight, kN/m^3	20.84
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.85
Area, cm^2	31.52	Specific Gravity, measured	2.76
Volume, cm^3	53.74	Solids Height, cm	1.061
Water Content, %	23.70	Volume of Solids, cm^3	33.45
Wet Mass, g	114.20	Volume of Voids, cm^3	20.29
Dry Mass, g	92.32		

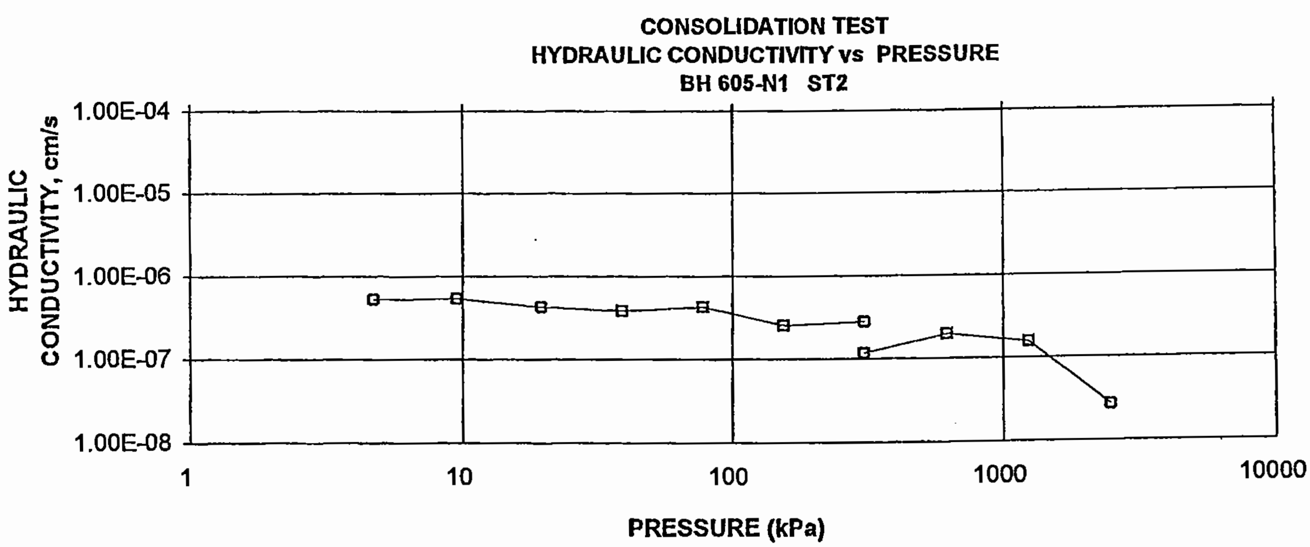
Prepared By: LFG **Golder Associates** Checked By: MM

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B16(b)







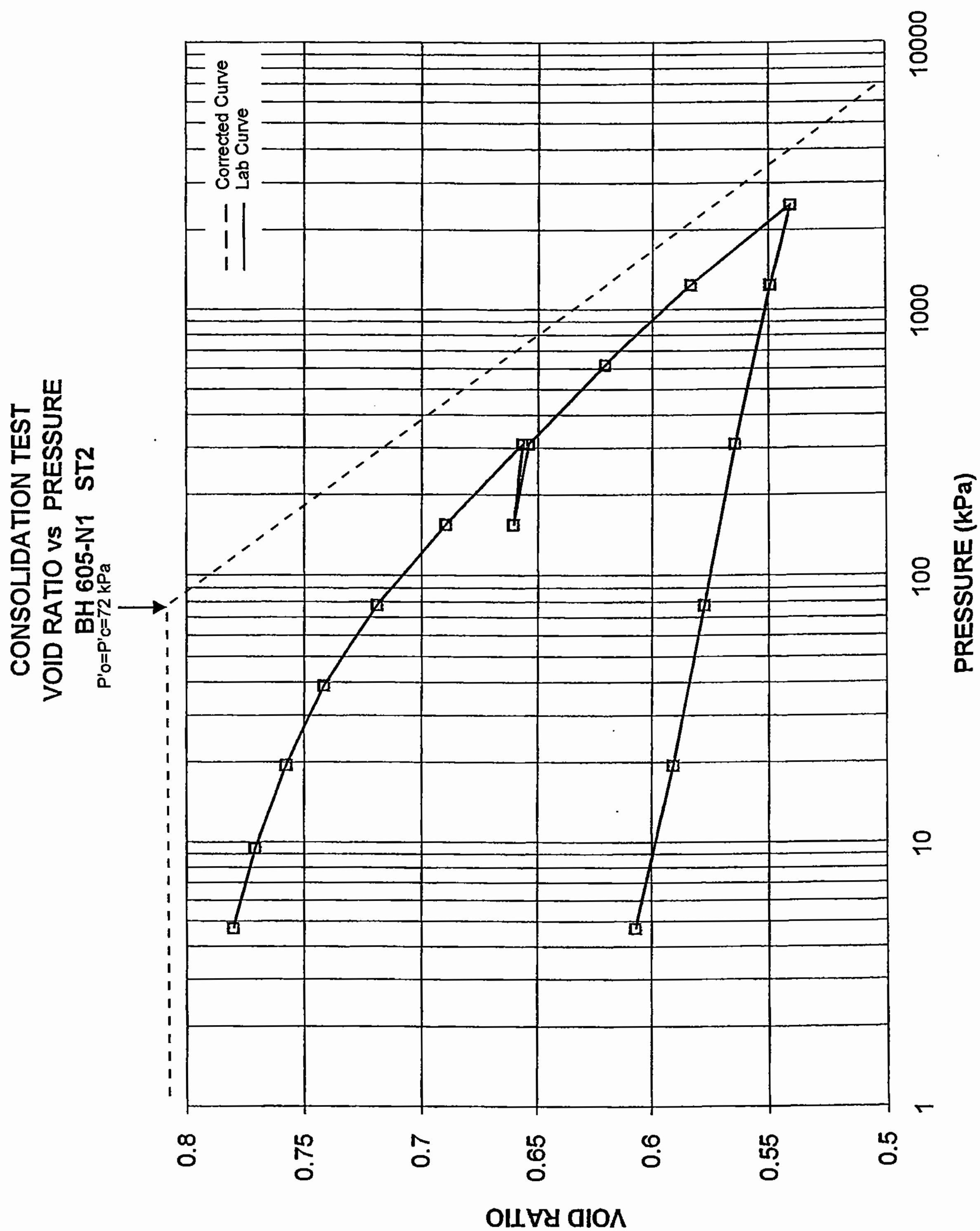
Project No. 05-1116-043

Prepared By: LFG

Golder Associates

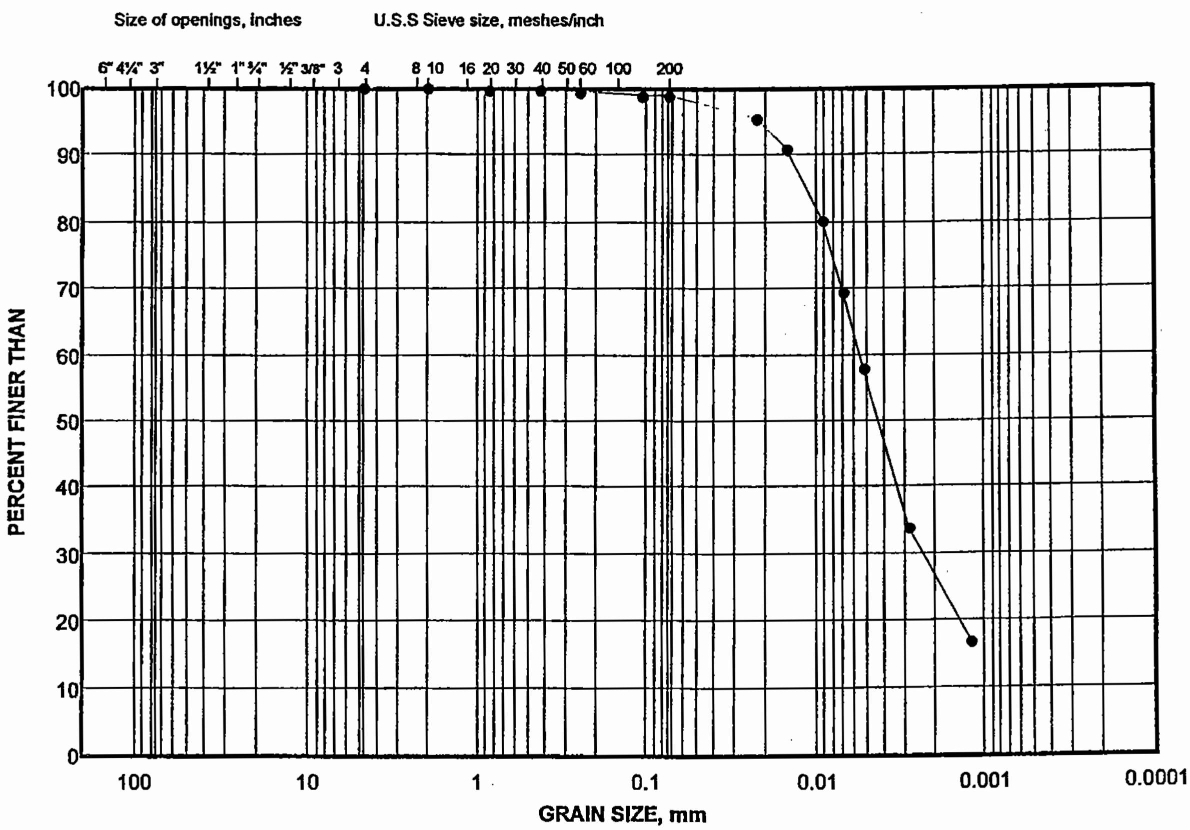
Checkey By: MM

CONSOLIDATION TEST VOID RATIO VS. LOG PRESSURE	FIGURE B16(c)



GRAIN SIZE DISTRIBUTION	FIGURE B16(d)

SWAMP 605 - SILTY CLAY (CL-ML)



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	605-N1	ST2	10.7-11.3

Project Number: 05-1116-043

Checked By: [signature]

Golder Associates

Date: 17-Nov-05

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

CLIENT:	**Totten Sims Hubicki (TSH)**	FILE NUMBER:	19-2805-2
PROJECT:	Highway 69 - Swamp 605	REPORT DATE:	28-Nov-05

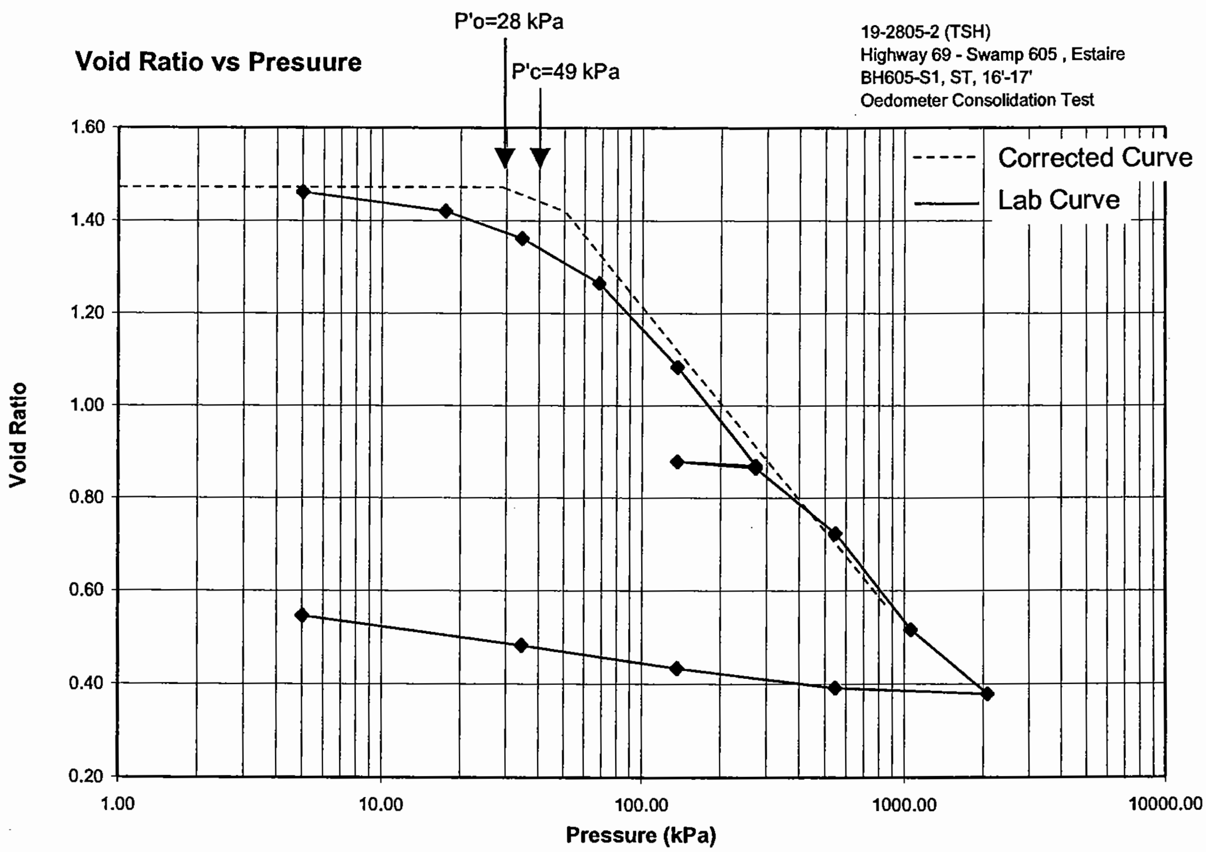
TEST DATES: October 27, 2005 - November 11, 2005

SAMPLE: BH605-S1, ST1, 16'-17'
Silty Clay, grey, uniform, plastic, (CH), Lab Vane: 15-30 kPa (Soft to Firm)
Grain Size: 72 % Clay, 25 % Silt & 1 % Sand

PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	Start of Test	End of Test
Wet Dens. (kg/m^3)	1701.9	2308.5
Dry Dens. (kg/m^3)	1107.2	1748.7
Moisture Cont. (%)	53.7	32.0
Void Ratio	1.466	0.561
Saturation (%)	100.0	

Note: A Specific Gravity of 2.73 was measured for the void ratio and saturation calculations



TEST DONE BY: EA
REVIEWED BY: JPL

Consolidation Test Report

Highway 69 - Swamp 605
19-2805-2

BH605-S1, ST1, 16'-17'

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

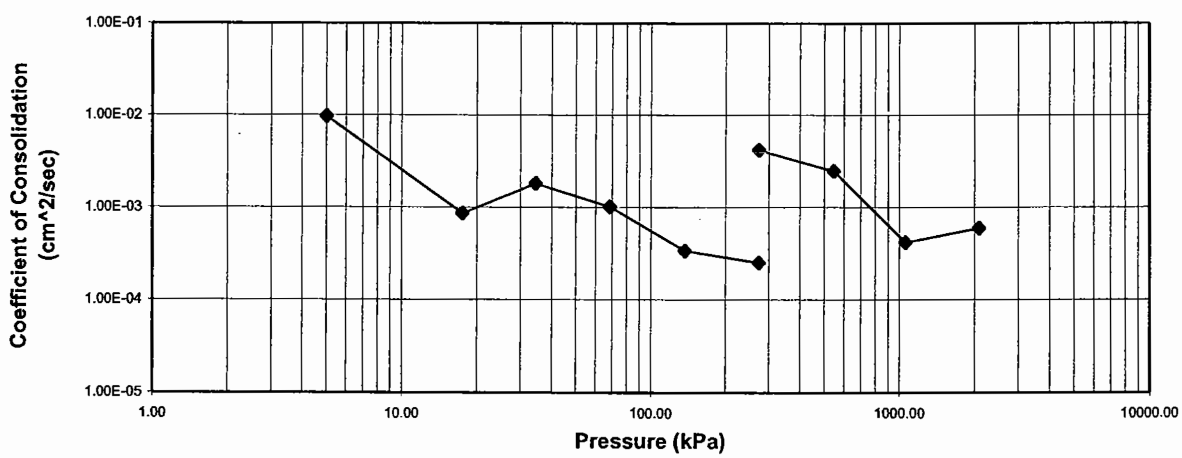
LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hrs except the intermediate rebound loading was 48 hrs for Secondary Compression Calculations.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	T90 (min)	Cv (cm^2/sec)	Void Ratio	mv (m^2/kN)	k (cm/s)
0.00	19.900	19.900			1.466		
5.00	19.873	19.887	1.44	9.70E-03	1.462	1.36E-03	1.29E-06
17.49	19.542	19.707	16.00	8.58E-04	1.420	1.40E-03	1.17E-07
34.46	19.080	19.311	7.29	1.81E-03	1.362	1.15E-03	2.03E-07
68.42	18.319	18.699	12.25	1.01E-03	1.266	1.08E-03	1.07E-07
136.78	16.880	17.599	32.49	3.37E-04	1.084	6.35E-04	2.09E-08
273.12	15.193	16.036	36.00	2.52E-04	0.870	4.06E-05	1.01E-09
136.78	15.260	15.227			0.879		
273.12	15.152	15.206	1.96	4.17E-03	0.865	2.10E-04	8.59E-08
545.39	14.036	14.594	3.06	2.46E-03	0.724	1.64E-04	3.95E-08
1057.63	12.398	13.217	14.82	4.16E-04	0.517	5.46E-05	2.23E-09
2080.12	11.309	11.854	8.41	5.90E-04	0.379	3.31E-06	1.91E-10
545.39	11.408	11.359			0.392		
136.78	11.744	11.576			0.434		
34.46	12.133	11.939			0.483		
5.00	12.634	12.384			0.547		

Coefficient of Consoildation vs Pressure

19-2805-2 (TSH)
Highway 69 - Swamp 605 , Estaire
BH605-S1, ST, 16'-17'
Oedometer Consolidation Test



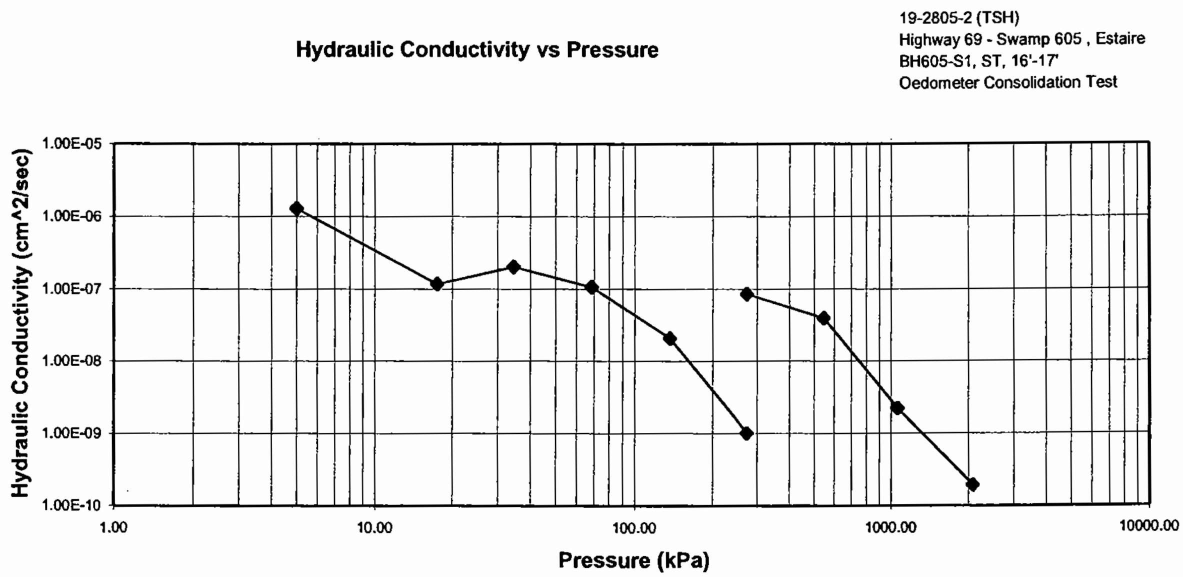
Notes: Cv and k calculated using t_{90} values

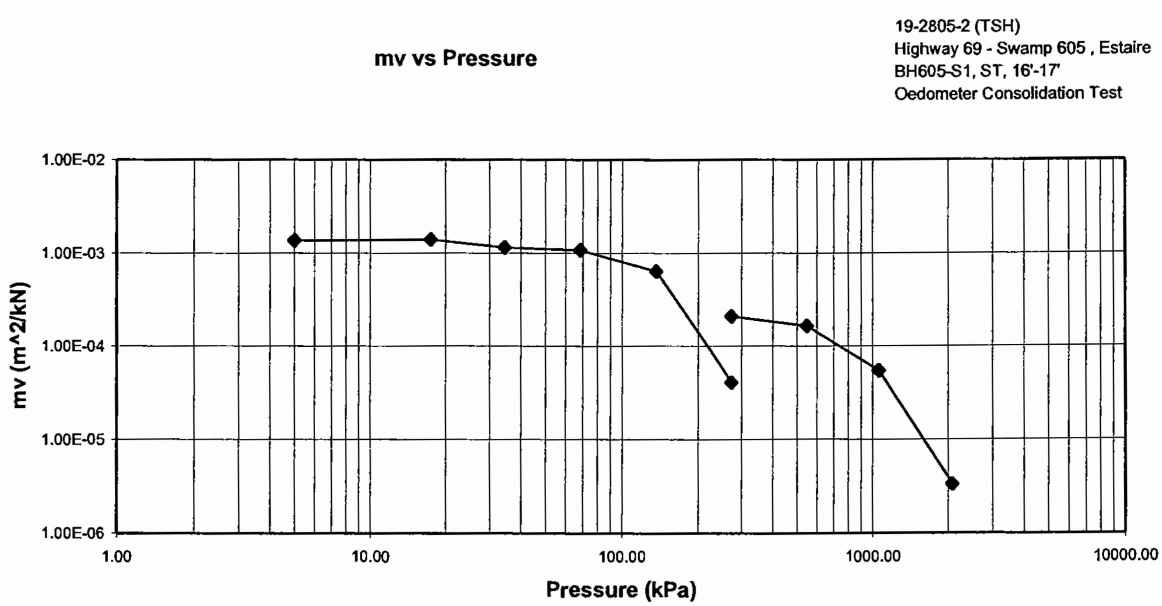
TEST DONE BY: EA
REVIEWED BY: JPL

Consolidation Test Report

Highway 69 - Swamp 605
19-2805-2

BH605-S1, ST1, 16'-17'

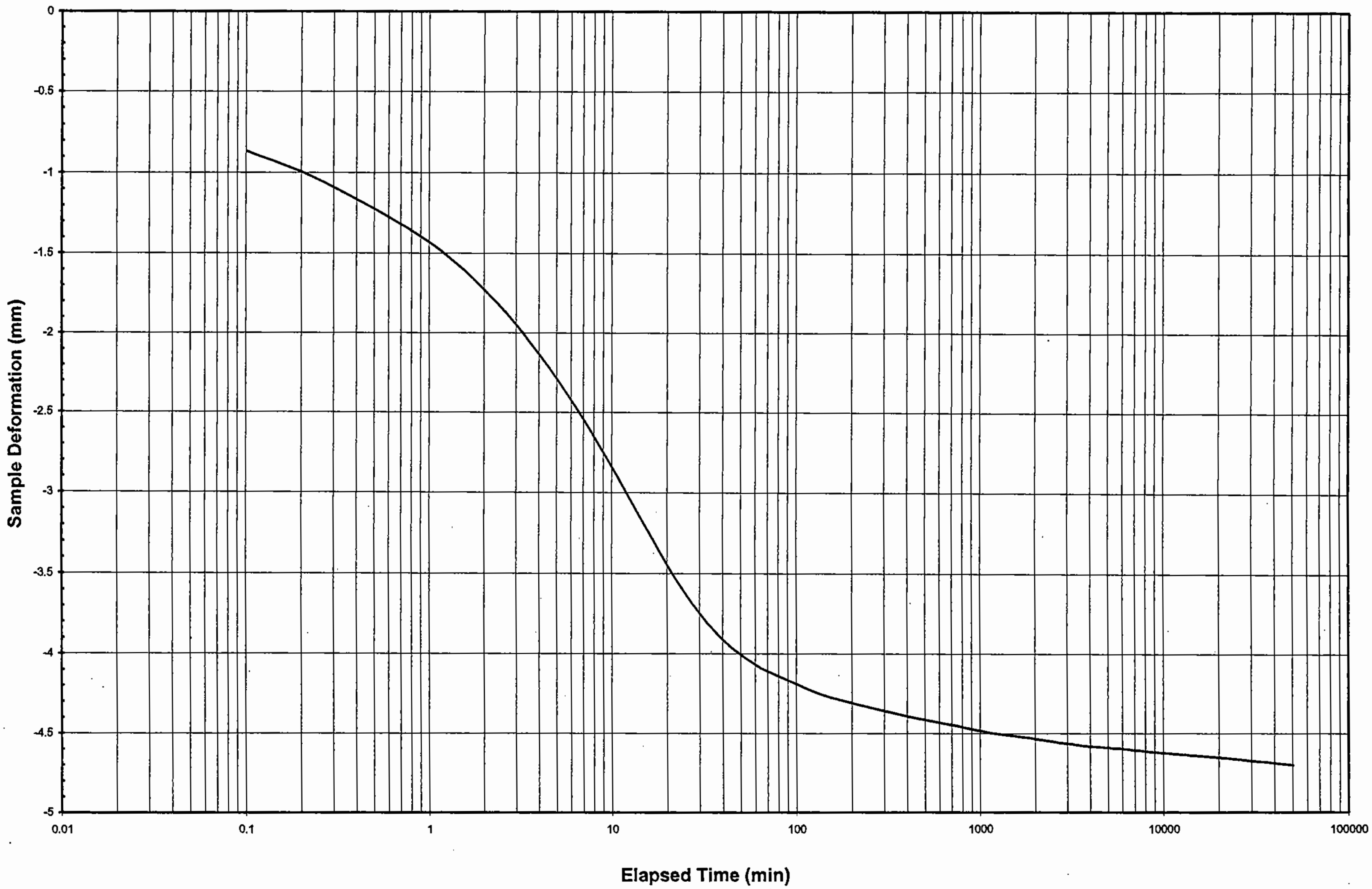




TEST DONE BY: EA
REVIEWED BY: JPL

SAMPLE DEFORMATION vs TIME (6th load: 273.12 kPa)
Load Duration: 843 hrs

19-2805-2 (TSH)
Highway 69 - Swamp 605 , Estaire
BH605-S1, ST, 16'-17'
Oedometer Consolidation Test



TEST DONE BY: EA
REVIEWED BY:JPL

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B18(a)

SAMPLE IDENTIFICATION

Project Number	05-1116-043	Sample Number	ST2
Borehole Number	605-S1	Sample Depth, m	9.1-9.8

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	10/31/2005		
Date Completed	11/13/2005		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m³	18.68
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m³	13.94
Area, cm²	31.65	Specific Gravity, measured	2.75
Volume, cm³	60.13	Solids Height, cm	0.982
Water Content, %	33.97	Volume of Solids, cm³	31.08
Wet Mass, g	114.52	Volume of Voids, cm³	29.05
Dry Mass, g	85.48	Degree of Saturation, %	100.0

TEST COMPUTATIONS

	Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm²/s	mv m²/kN	k cm/s
	0.00	1.900	0.935	1.900				
	4.83	1.884	0.918	1.892	49	1.55E-02	1.74E-03	2.65E-06
	9.46	1.876	0.910	1.880	23	3.26E-02	9.09E-04	2.90E-06
	19.51	1.863	0.897	1.870	36	2.06E-02	6.81E-04	1.37E-06
	38.91	1.846	0.880	1.855	25	2.92E-02	4.61E-04	1.32E-06
	77.38	1.818	0.851	1.832	51	1.40E-02	3.83E-04	5.24E-07
	154.87	1.770	0.802	1.794	69	9.89E-03	3.26E-04	3.16E-07
48 hours	309.92	1.714	0.745	1.742	42	1.53E-02	1.90E-04	2.85E-07
	619.25	1.666	0.696	1.690	40	1.51E-02	8.17E-05	1.21E-07
	1237.70	1.615	0.644	1.641	34	1.68E-02	4.34E-05	7.14E-08
	2478.85	1.557	0.585	1.586	34	1.57E-02	2.46E-05	3.78E-08
	1237.70	1.566	0.594	1.562				
	309.92	1.583	0.612	1.575				
	77.48	1.601	0.630	1.592				
	19.51	1.612	0.641	1.607				
	4.83	1.632	0.662	1.622				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.63	Unit Weight, kN/m³	20.31
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m³	16.23
Area, cm²	31.65	Specific Gravity, measured	2.75
Volume, cm³	51.65	Solids Height, cm	0.982
Water Content, %	25.12	Volume of Solids, cm³	31.08
Wet Mass, g	106.95	Volume of Voids, cm³	20.57
Dry Mass, g	85.48		

Prepared By: LFG

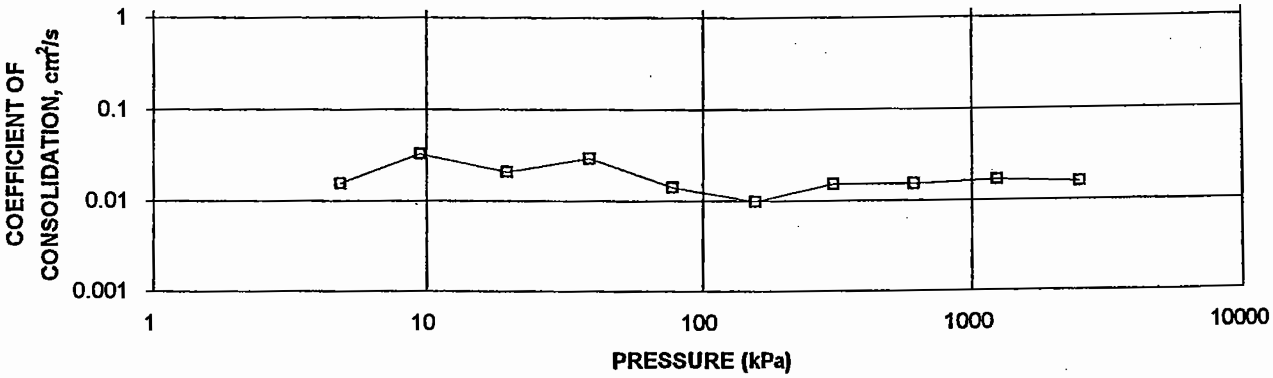
Golder Associates

Checked By: MM

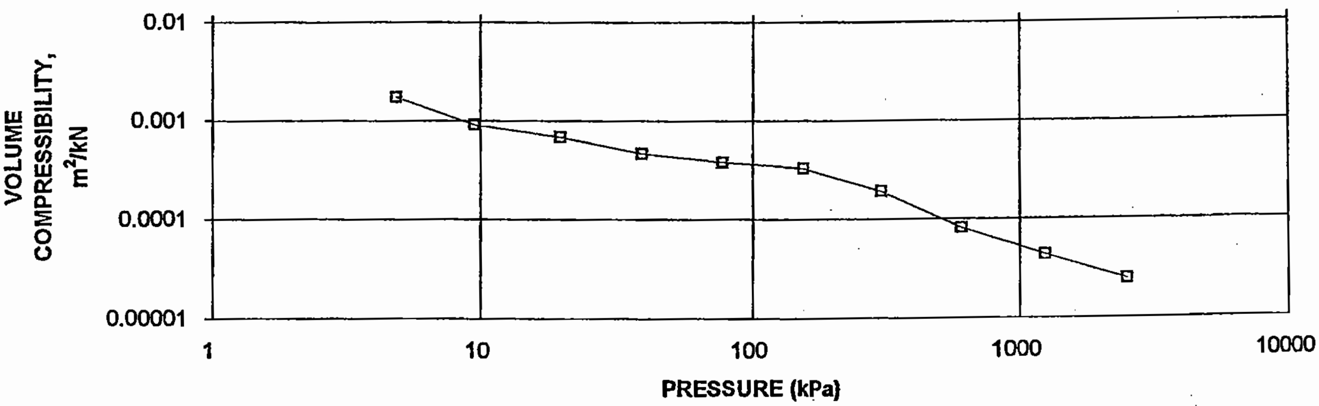
OEDOMETER CONSOLIDATION SUMMARY

FIGURE B18(b)

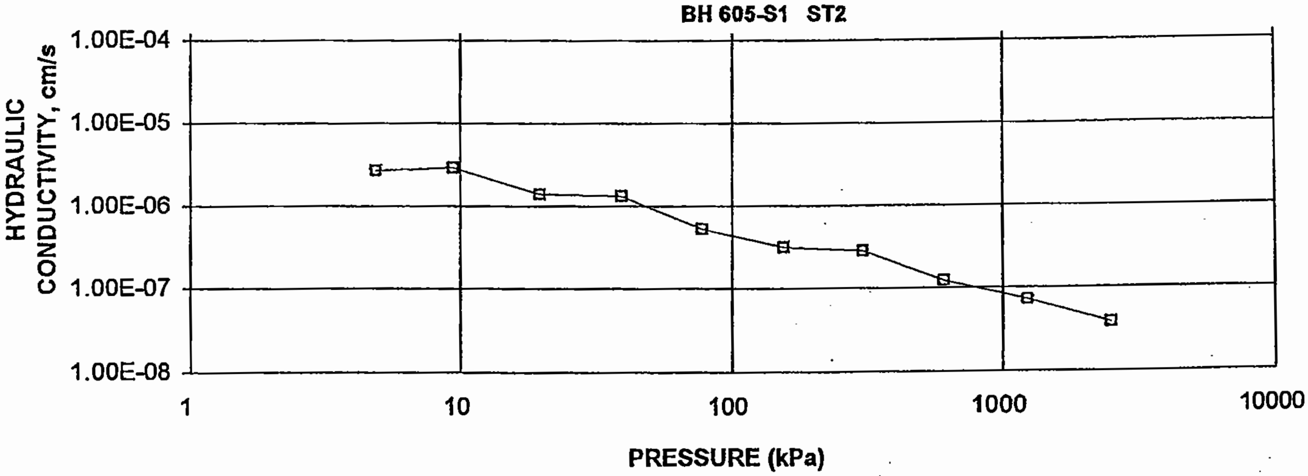
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH 605-S1 ST2



CONSOLIDATION TEST
MV m²/kN vs PRESSURE (kPa)
BH 605-S1 ST2



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH 605-S1 ST2



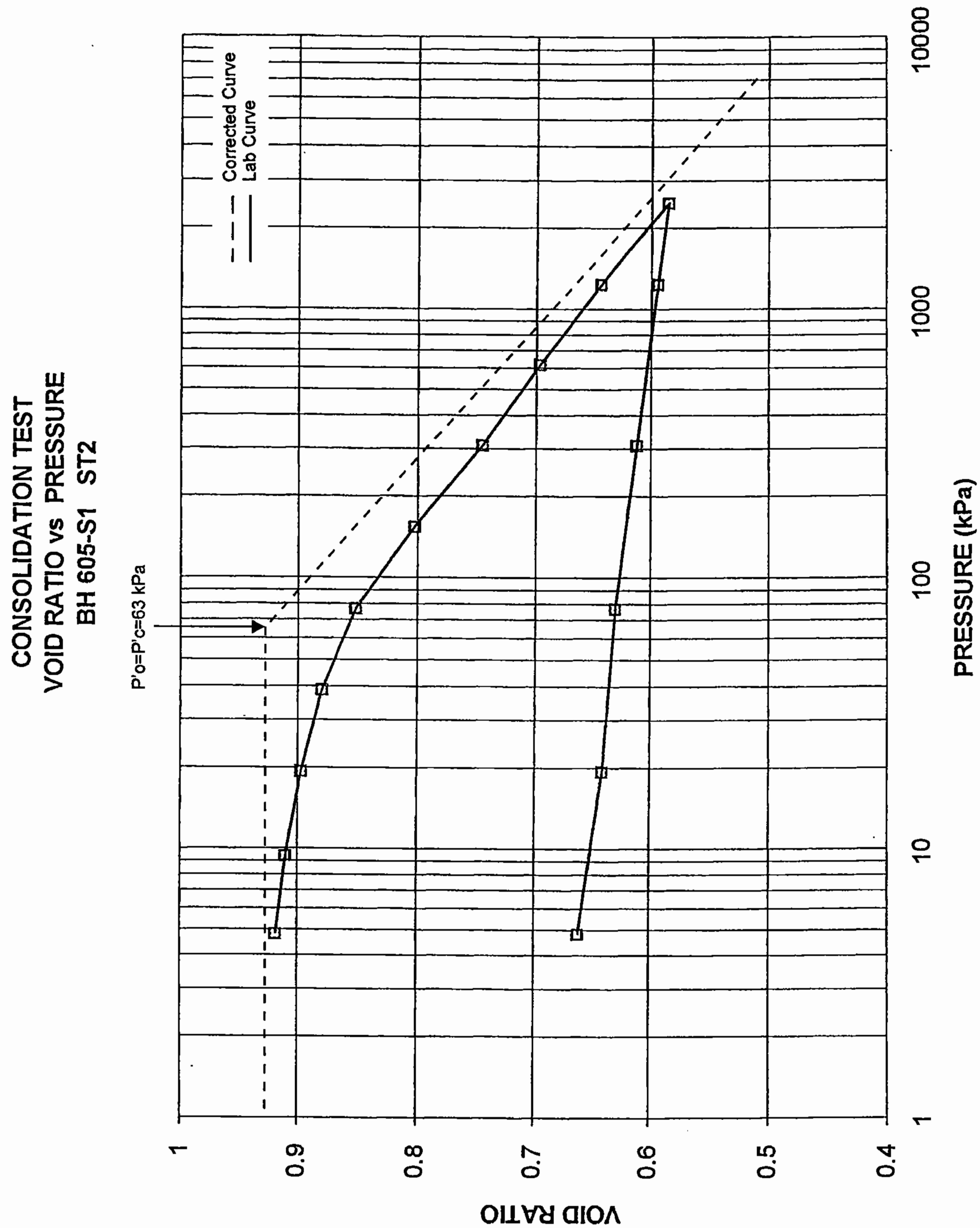
Project No. 05-1116-043
Prepared By: LFG

Golder Associates

Checkey By: MM

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B18(c)



Project No. 05-1116-043
Prepared By: LFG

Golder Associates

Checked By: MM

BOREHOLE 605-S1 SAMPLE NUMBER ST2

APPLIED PRESSURE = 309.9 kPa

FIGURE B18(d)

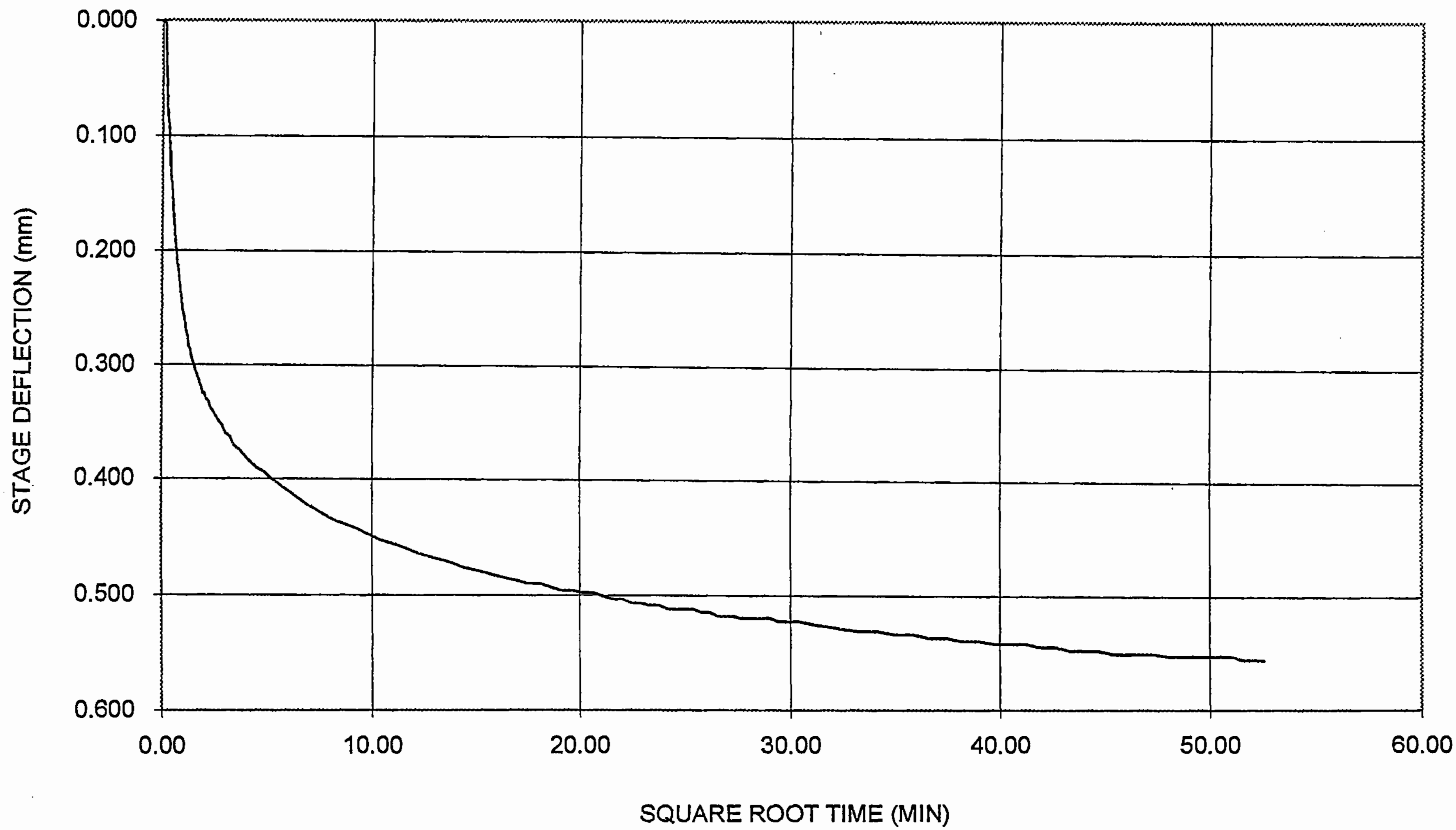
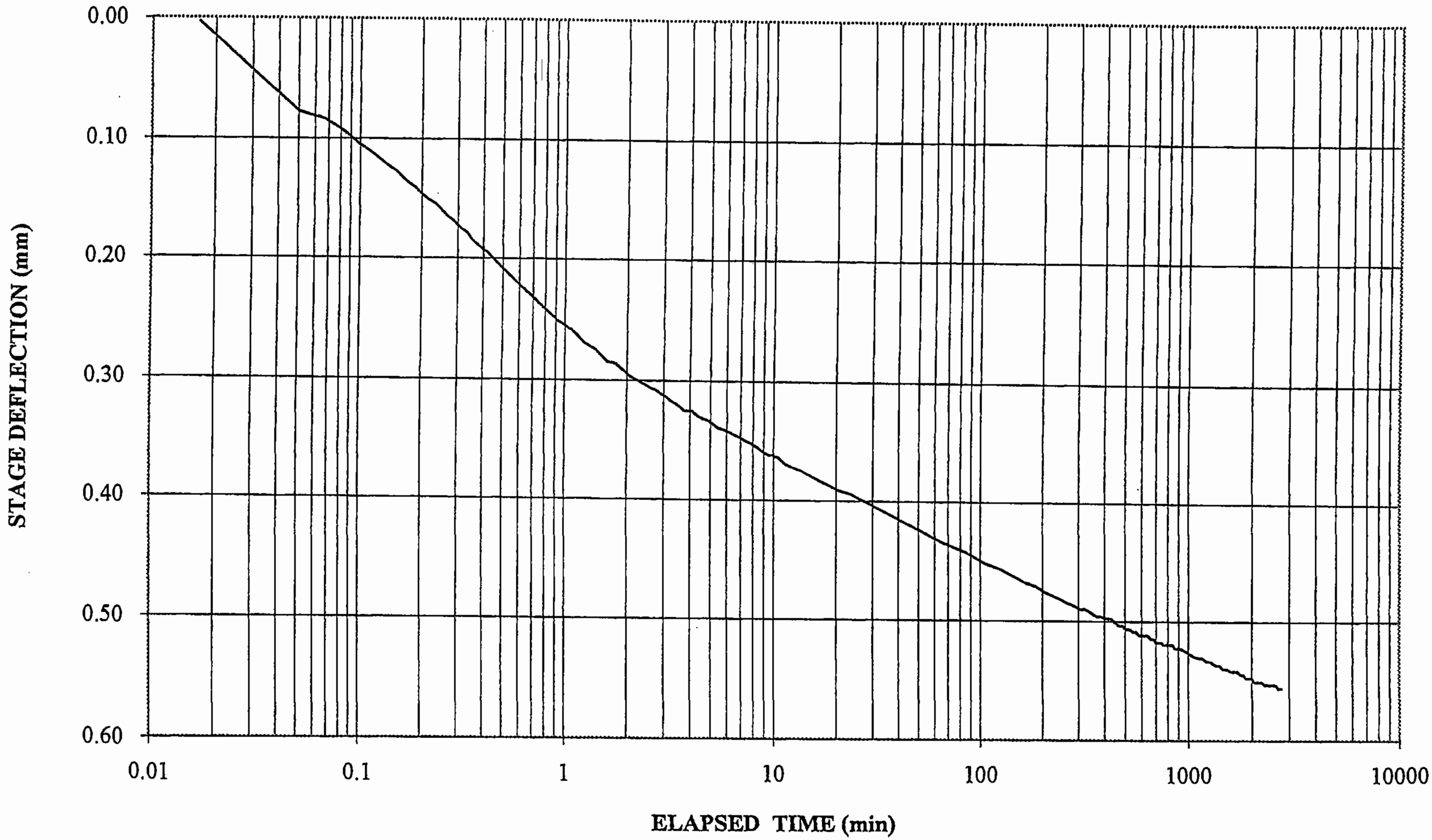


FIGURE B18(e)

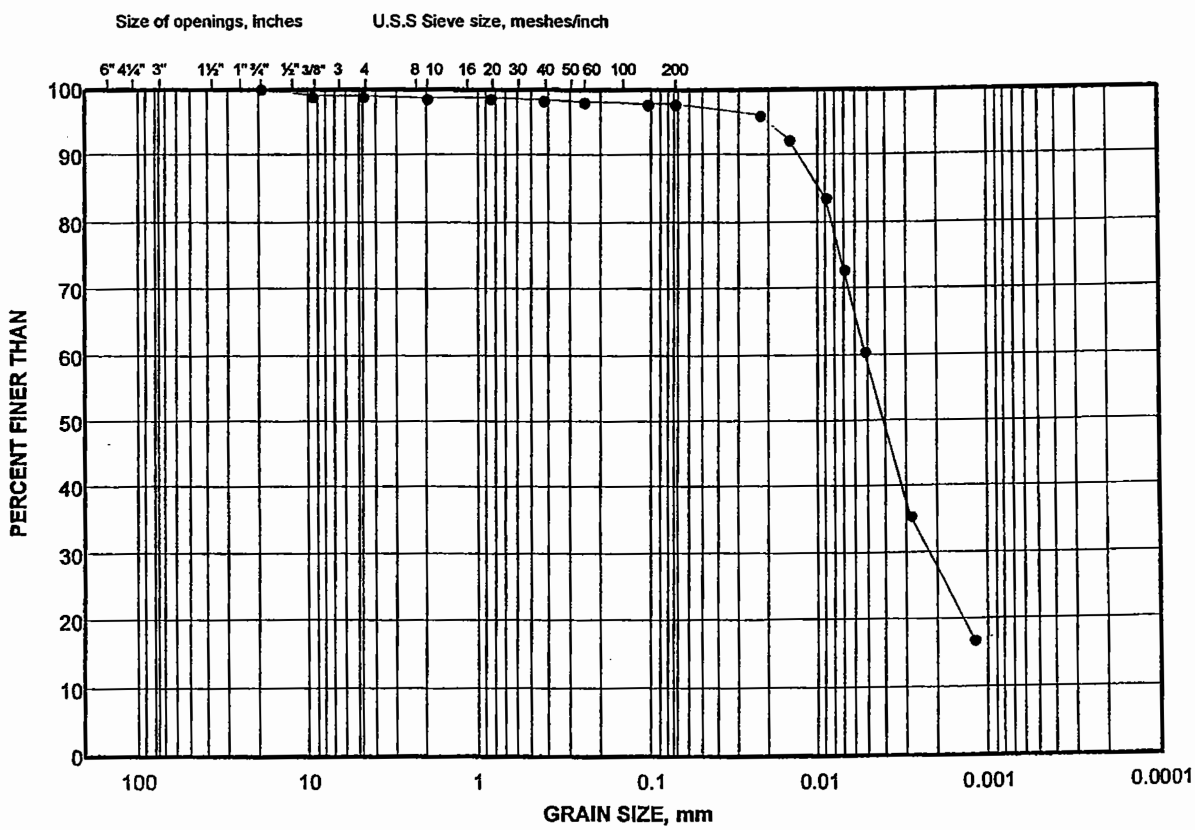
BOREHOLE 605-S1 SAMPLE NUMBER ST2

APPLIED PRESSURE = 309.9 kPa



GRAIN SIZE DISTRIBUTION	FIGURE B18(f)

SWAMP 605 - SILTY CLAY (CL)



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	605-S1	ST2	9.1-9.8

Project Number: 05-1116-043

Checked By: ____

Golder Associates

Date: 17-Nov-05

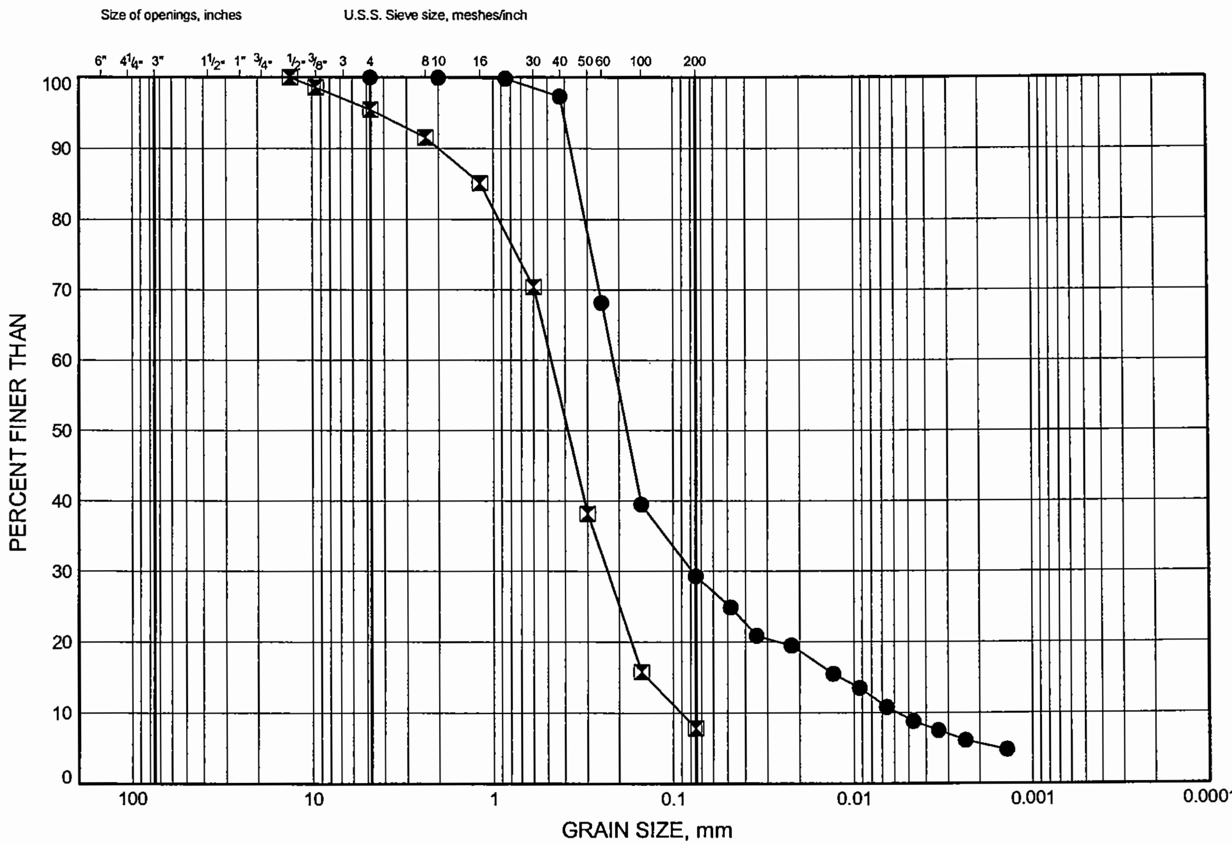
SWAMP 613

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B19

SWAMP 613 - SAND AND SILTY SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-1	2.59	222.02
⊠	613-N1	17.07	201.74

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

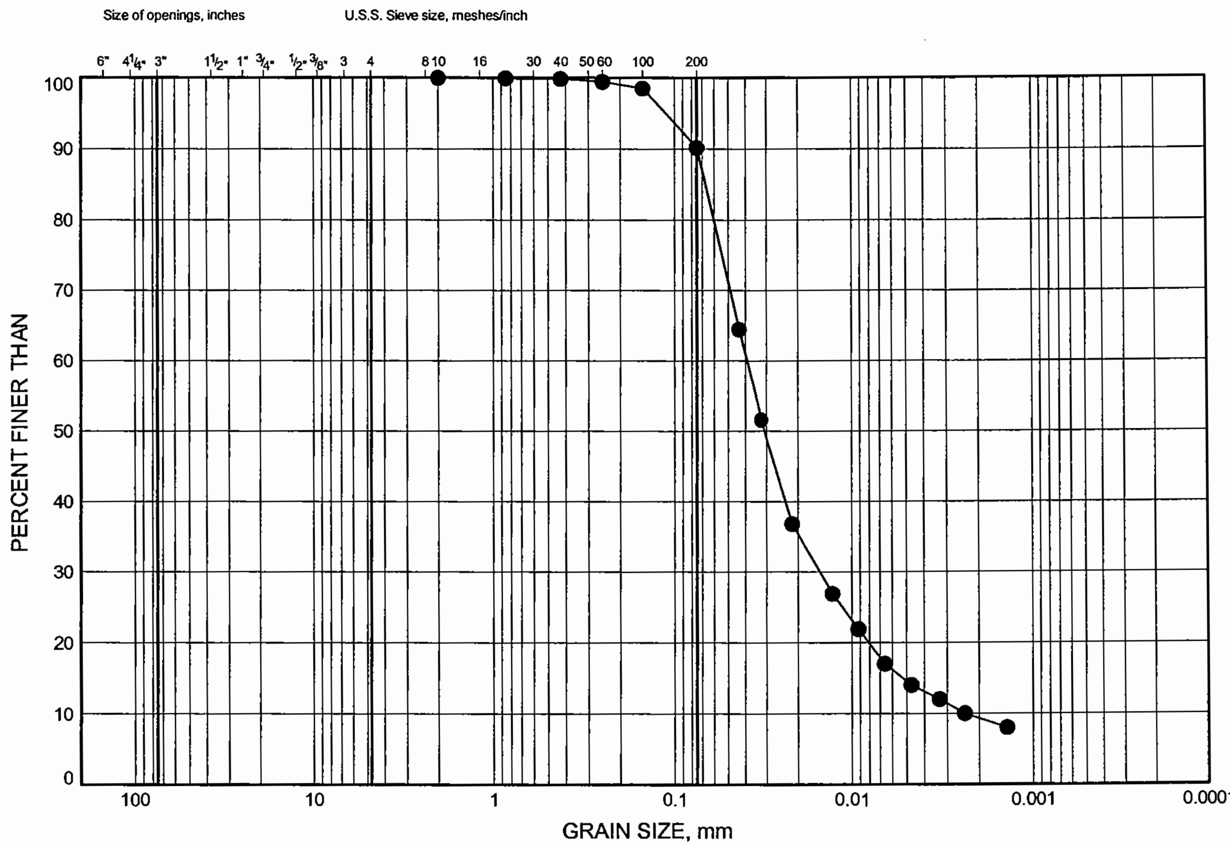
THURBGSD 8052.GPJ 21/03/06

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B20

SWAMP 613 - UPPER SILT (ML)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-1	4.72	219.89

THURBGSD 8052.GPJ 21/03/06

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

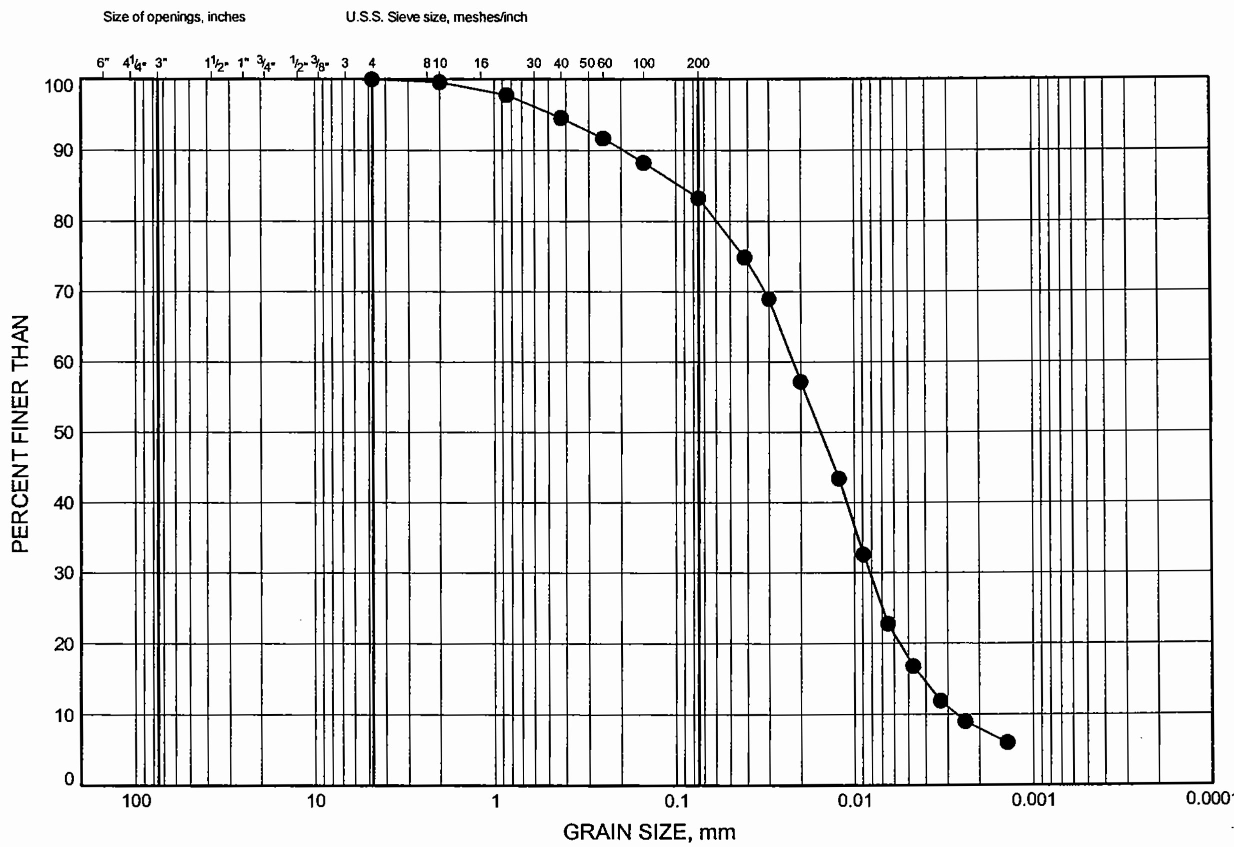
Chkd. JPL

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B21

SWAMP 613 - LOWER SILT (ML)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-2	15.54	204.51

THURBGSD 8052.GPJ 21/03/06

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

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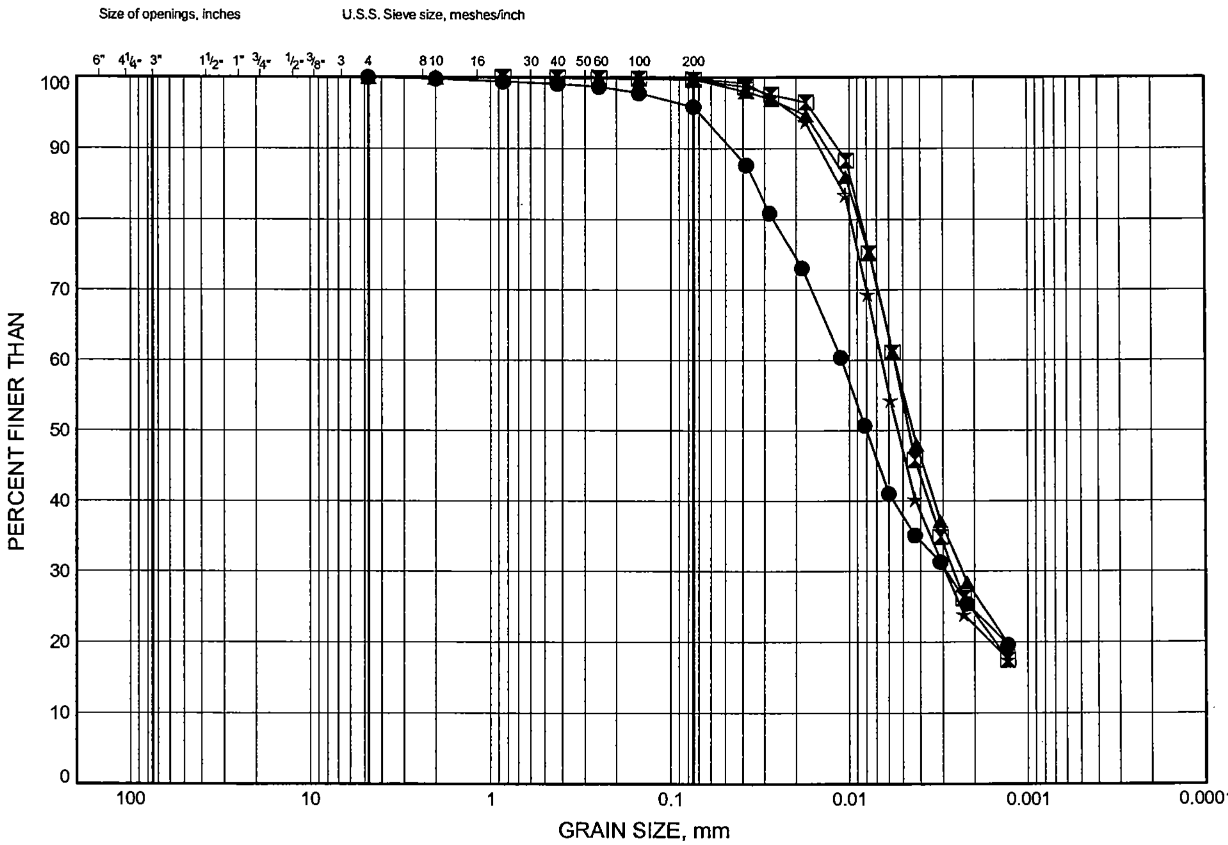
HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B22

SWAMP 613 - SILTY CLAY (CL)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-1	9.45	215.16
⊠	537-1	15.54	209.07
▲	613-N1	5.41	213.40
★	613-N1	6.55	212.26

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

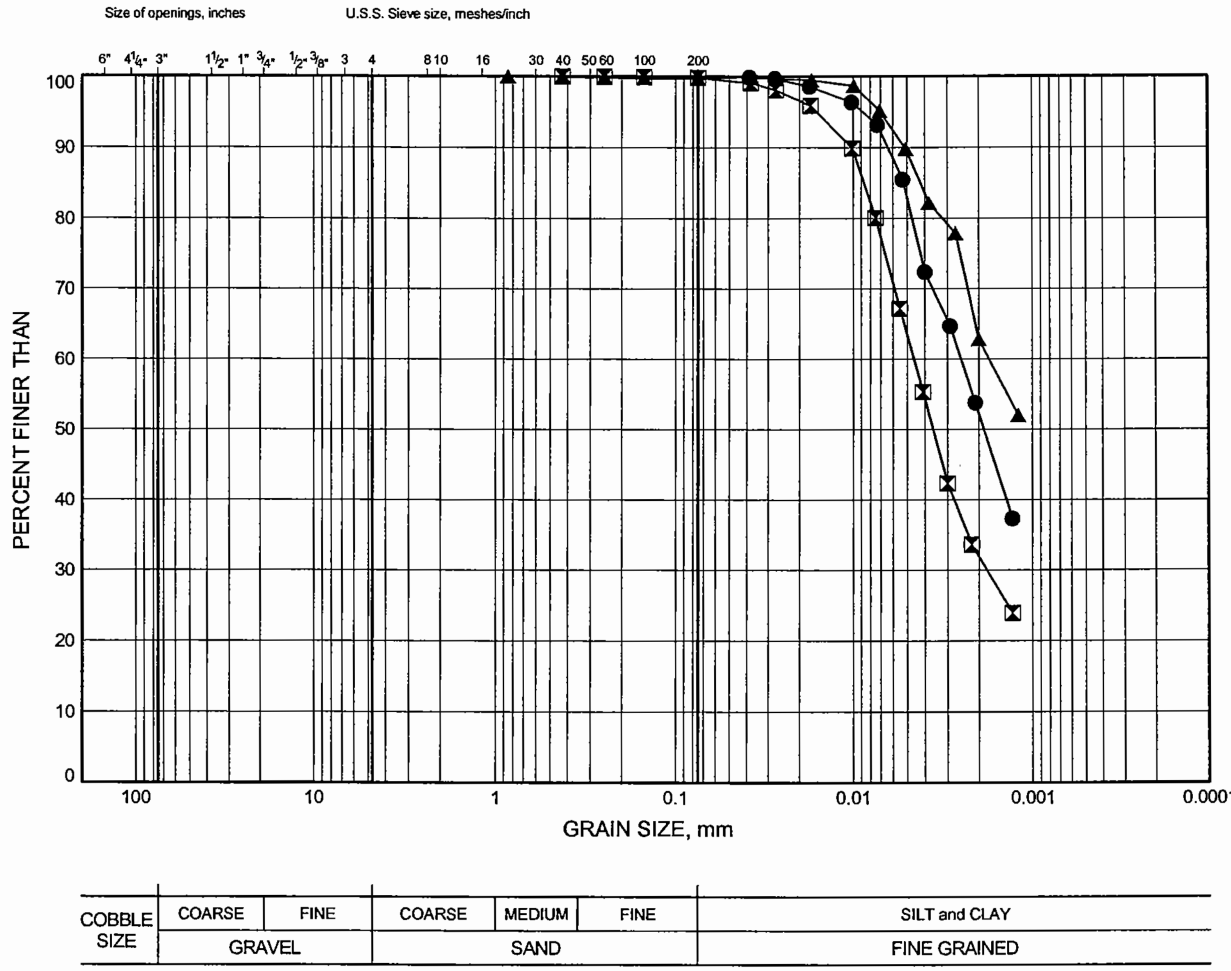
Chkd. JPL

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B23

SWAMP 613 - SILTY CLAY (CI)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-1	7.32	217.30
⊠	537-2	9.45	210.60
▲	613-N1	5.03	213.78

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

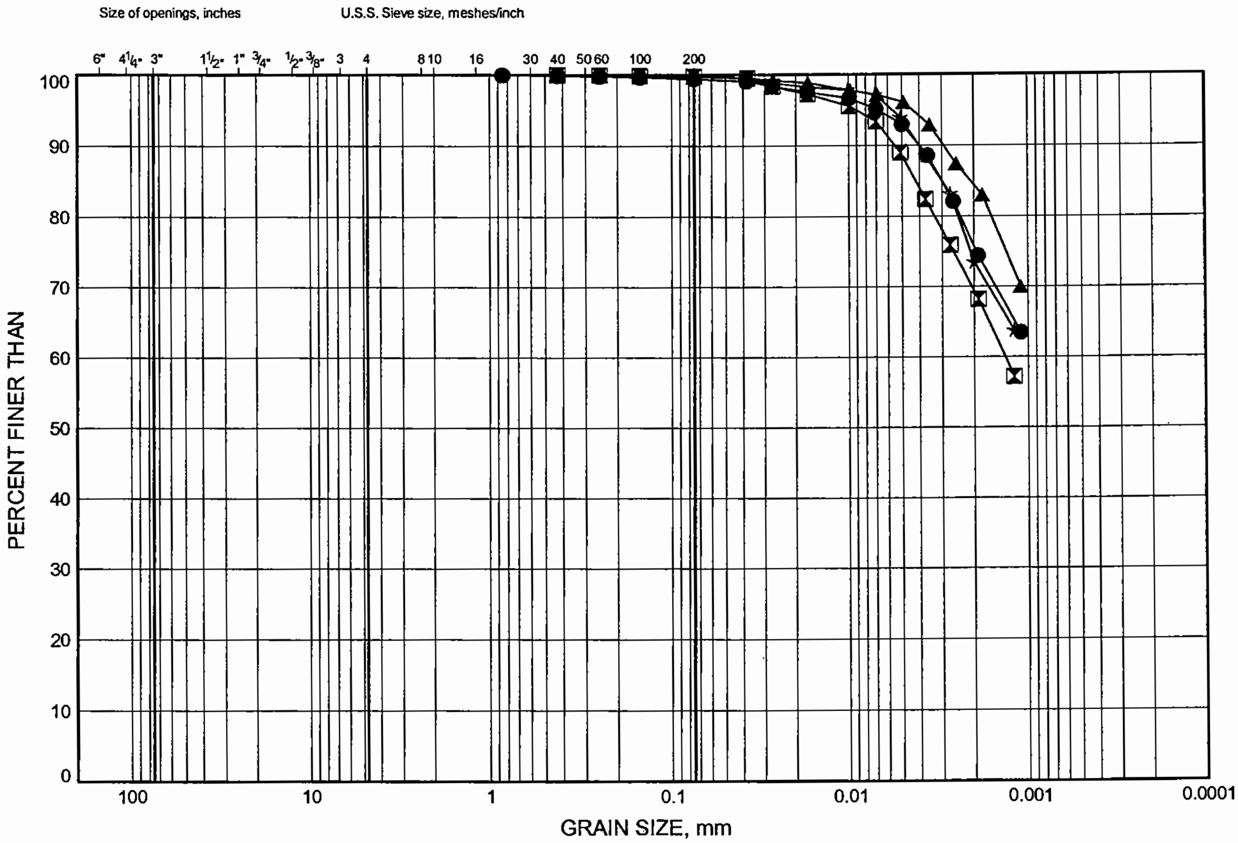
THURBGSD 8052.GPJ 21/03/06

HWY 69

GRAIN SIZE DISTRIBUTION

FIGURE B24

SWAMP 613 - SILTY CLAY (CH)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-1	10.97	213.64
⊠	537-2	1.83	218.22
▲	537-2	3.35	216.70
★	537-2	6.40	213.65

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

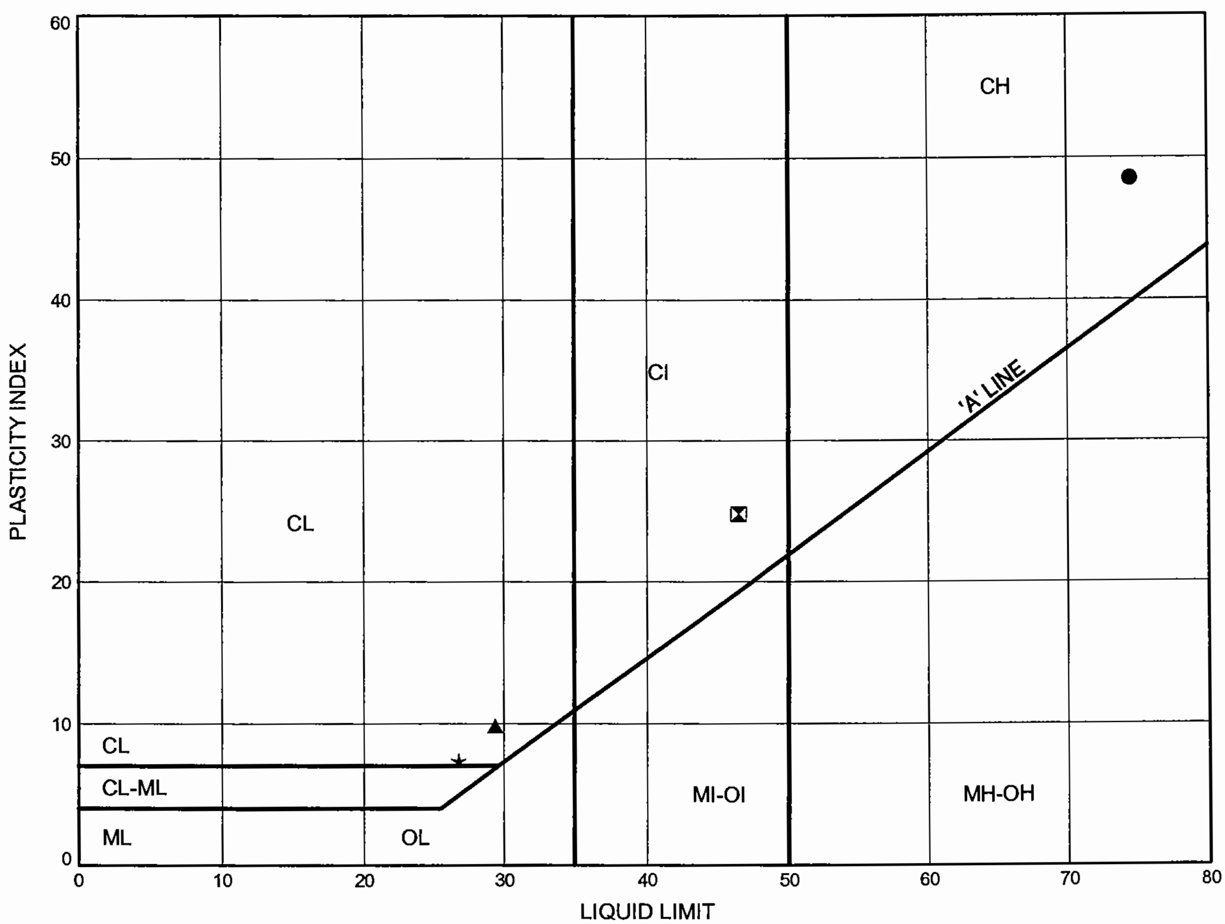
THURBGSD 8052.GPJ 21/03/06

HWY 69

ATTERBERG LIMITS TEST RESULTS

FIGURE B25

SWAMP 613 - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	613-N1	1.83	216.98
⊠	613-N1	5.03	213.78
▲	613-N1	5.41	213.40
★	613-N1	6.55	212.26

Date March 2006

Project 19-2805-2

THURBER

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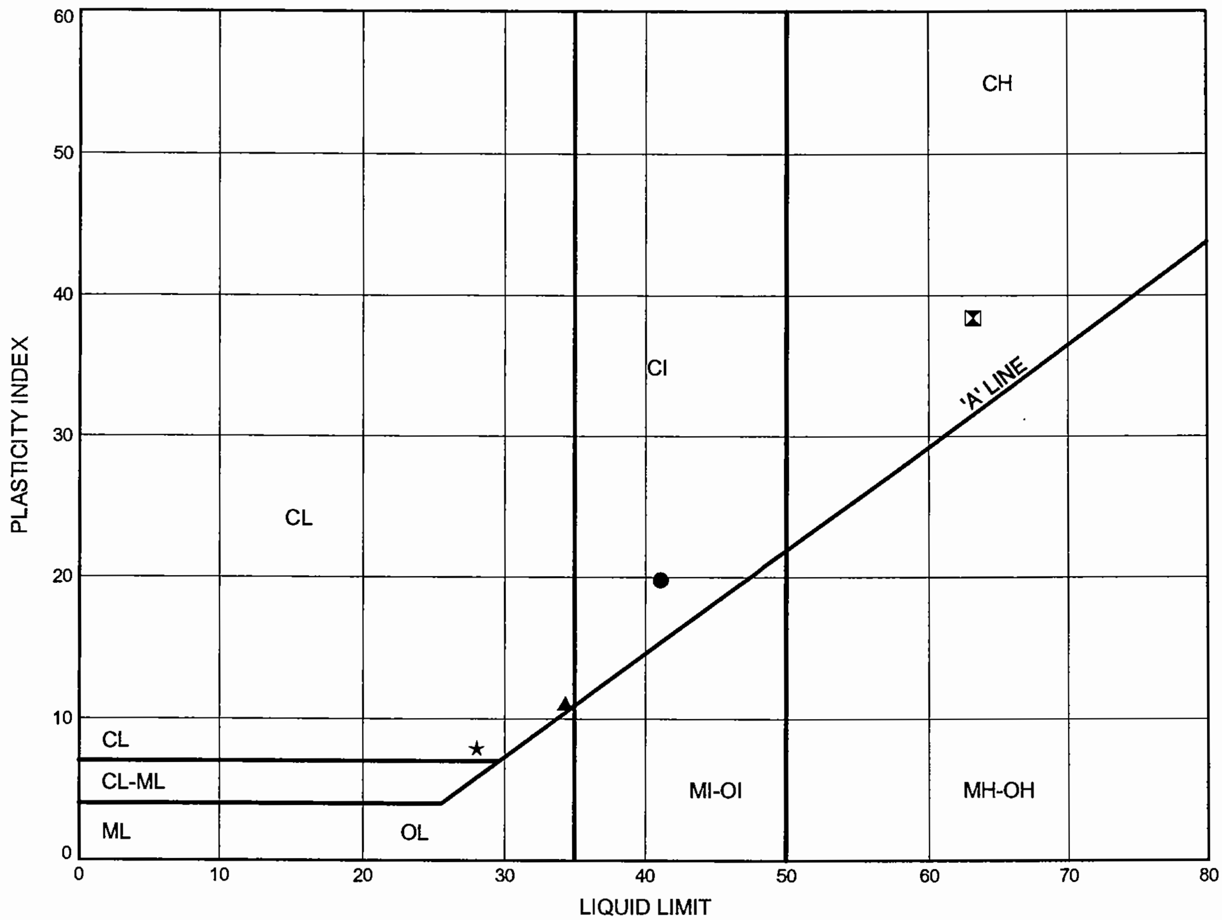
THURBALT 8052.GPJ 21/03/06

HWY 69

ATTERBERG LIMITS TEST RESULTS

FIGURE B26

SWAMP 613 (HWY 537) - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-1	7.39	217.22
⊠	537-1	10.97	213.64
▲	537-1	14.02	210.59
★	537-1	15.54	209.07

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

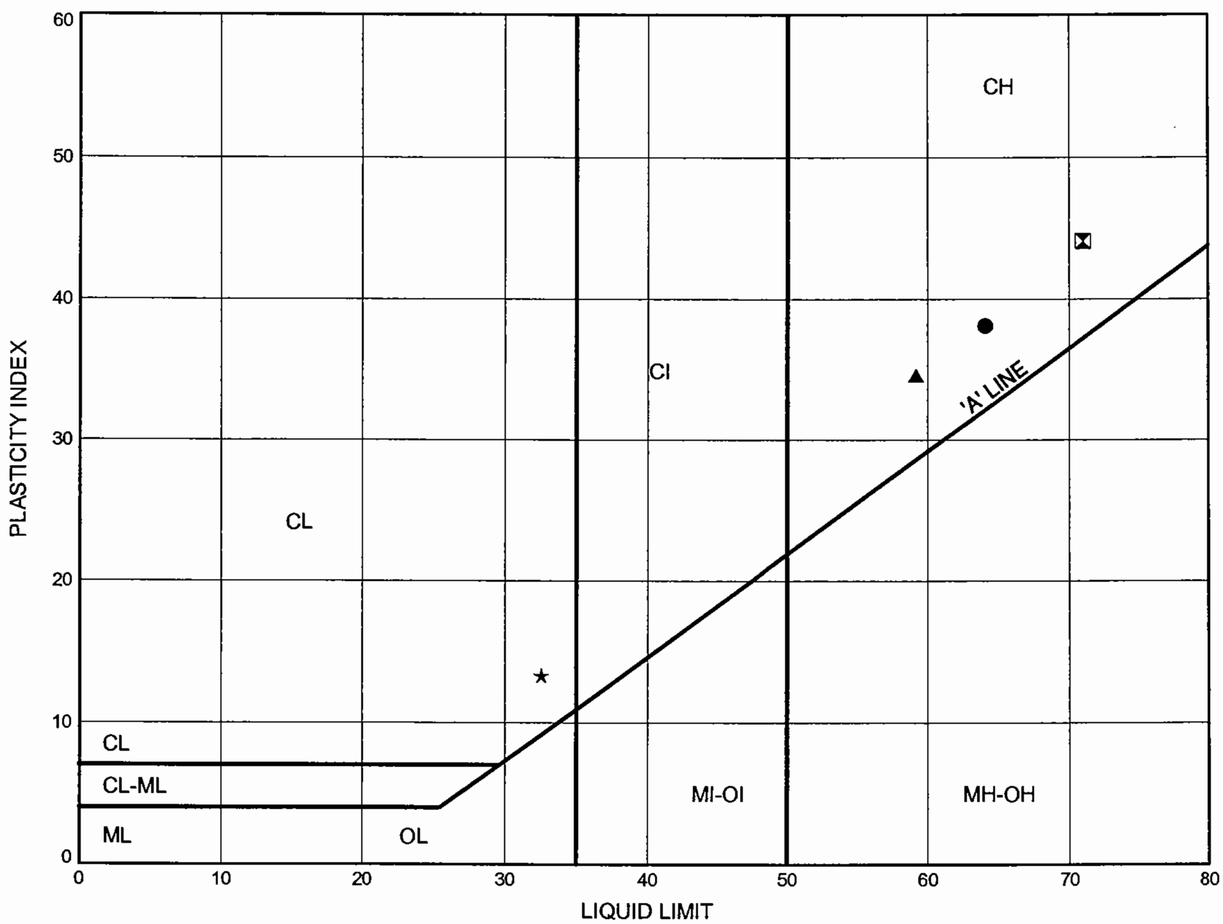
THURBALT 8052.GPJ 21/03/06

HWY 69

ATTERBERG LIMITS TEST RESULTS

FIGURE B27

SWAMP 613 (HWY 537) - SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	537-2	1.83	218.22
⊠	537-2	3.35	216.70
▲	537-2	6.40	213.65
★	537-2	9.45	210.60

THURBALT 8052.GPJ 21/03/06

Date March 2006

Project 19-2805-2

THURBER

Prep'd JHL

Chkd. JPL

OEDOMETER & TRIAXIAL TEST RESULTS

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

CLIENT: **Totten Sims Hubicki (TSH)** FILE NUMBER: 19-2805-2

PROJECT: Highway 69 - Swamp 613 REPORT DATE: 20-Jan-06

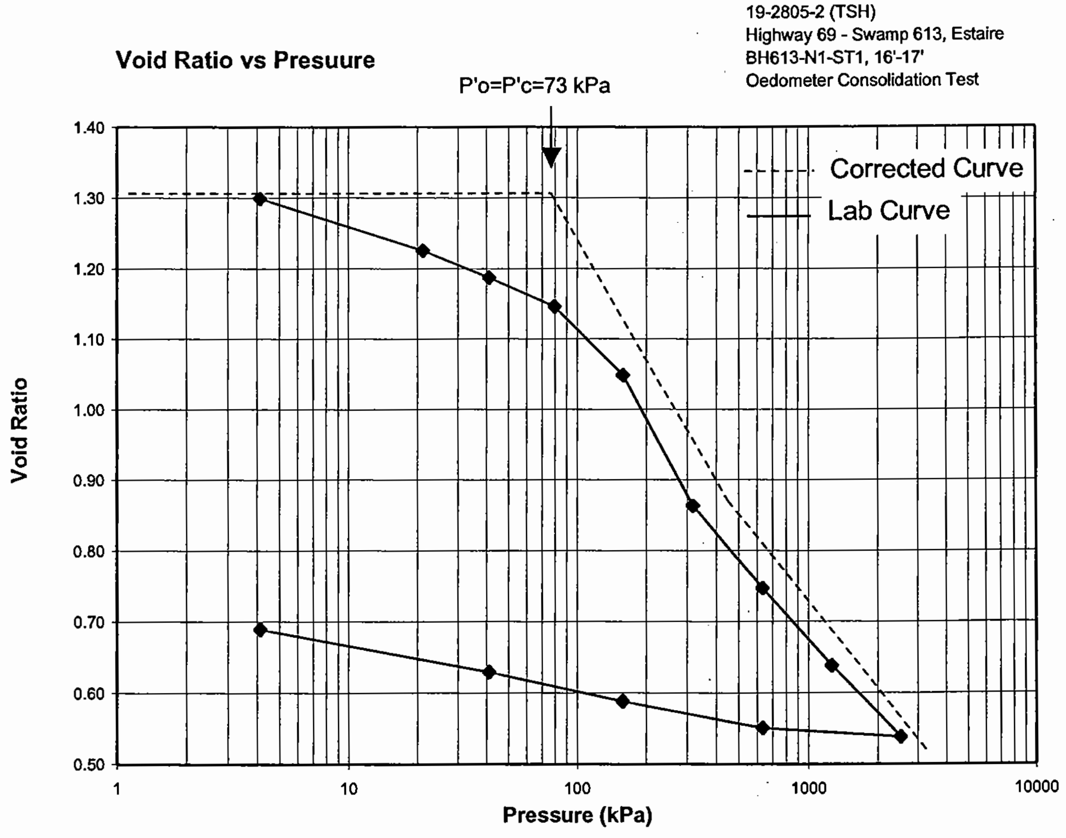
TEST DATES: January 5, 2006 - January 18, 2006

SAMPLE: BH613-N1-ST1, 16'-17'
Silty Clay, grey with brown silt lenses, varved, plastic, (CI)
Lab Vane: 17-29 kPa (Soft to Firm), Grain Size: 61 % Clay & 39 % Silt

PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	Start of Test	End of Test
Wet Dens. (kg/m^3)	1810.5	2129.8
Dry Dens. (kg/m^3)	1224.2	1619.5
Moisture Cont. (%)	47.9	31.5
Void Ratio	1.314	0.692
Saturation (%)	99.9	

Note: A Specific Gravity of 2.74 was measured for the void ratio and saturation calculations



TEST DONE BY: EA
REVIEWED BY: JPL

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

Highway 69 - Swamp 613
19-2805-2

BH613-N1-ST1, 16'-17'

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

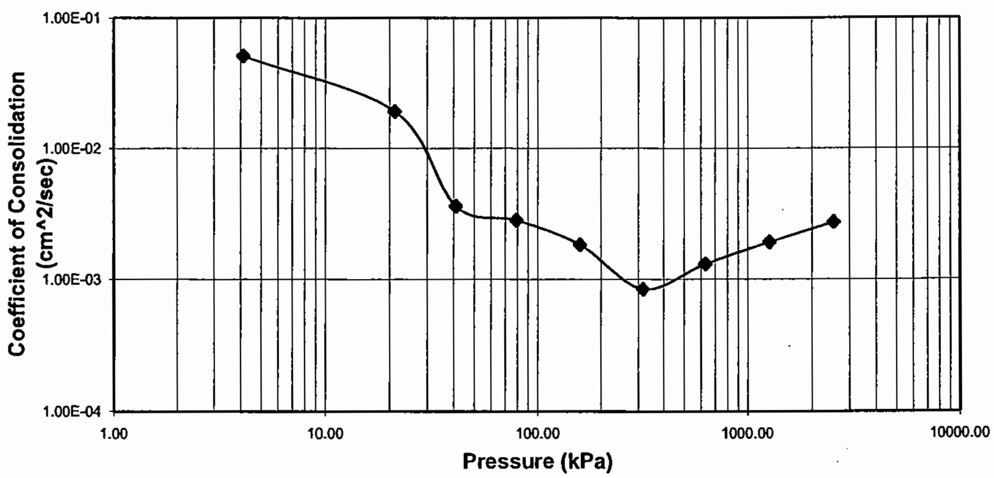
LOADING: A seating load of 4.13 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hours except the 6th loading was 48 hours for Secondary Compression Calculations.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	T90 (min)	Cv (cm^2/sec)	Void Ratio	mv (m^2/kN)	k (cm/s)
0.00	19.050	19.050			1.314		
4.13	18.935	18.993	0.25	5.10E-02	1.299	1.88E-03	9.38E-06
21.11	18.338	18.637	0.64	1.92E-02	1.226	8.32E-04	1.56E-06
40.95	18.029	18.184	3.24	3.61E-03	1.187	4.66E-04	1.65E-07
79.32	17.694	17.862	4.00	2.82E-03	1.146	5.31E-04	1.47E-07
158.55	16.906	17.300	5.76	1.84E-03	1.049	5.07E-04	9.12E-08
316.46	15.408	16.157	10.89	8.47E-04	0.863	1.59E-04	1.32E-08
632.19	14.467	14.938	6.00	1.31E-03	0.747	7.46E-05	9.61E-09
1263.90	13.585	14.026	3.61	1.93E-03	0.638	3.43E-05	6.47E-09
2527.73	12.773	13.179	2.25	2.73E-03	0.538	2.95E-06	7.87E-10
632.19	12.878	12.825			0.551		
158.55	13.180	13.029			0.588		
40.95	13.513	13.346			0.629		
4.13	13.998	13.755			0.689		

Coefficient of Consoildation vs Pressure

19-2805-2 (TSH)
Highway 69 - Swamp 613, Estaire
BH613-N1-ST1, 16'-17'
Oedometer Consolidation Test



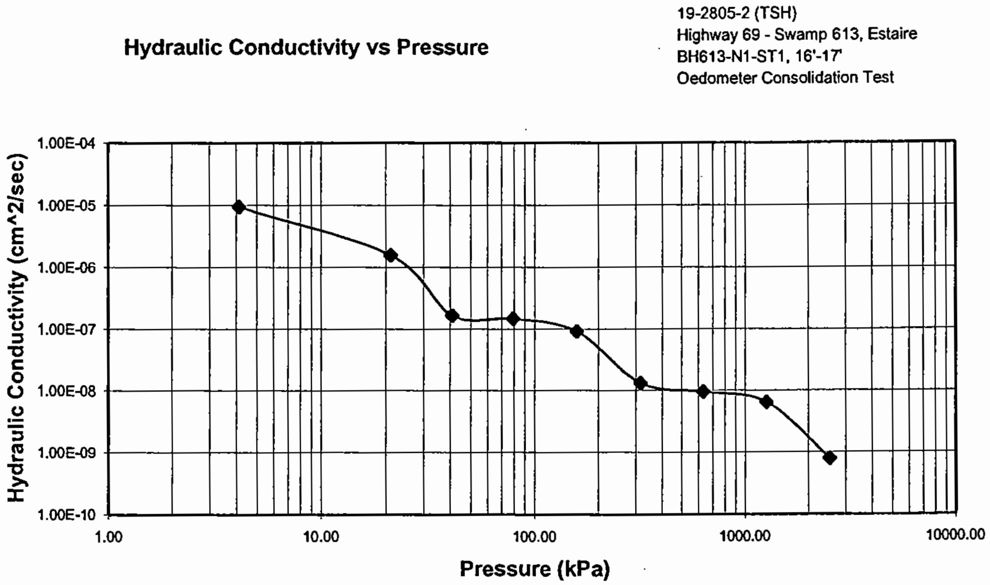
Notes: Cv and k calculated using t_{90} values

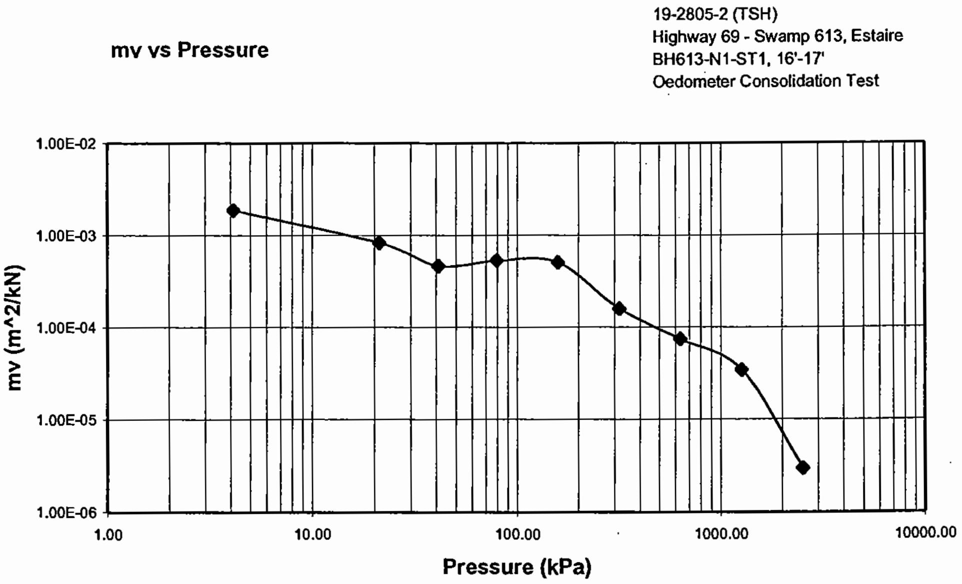
TEST DONE BY: EA
REVIEWED BY: JPL

Consolidation Test Report

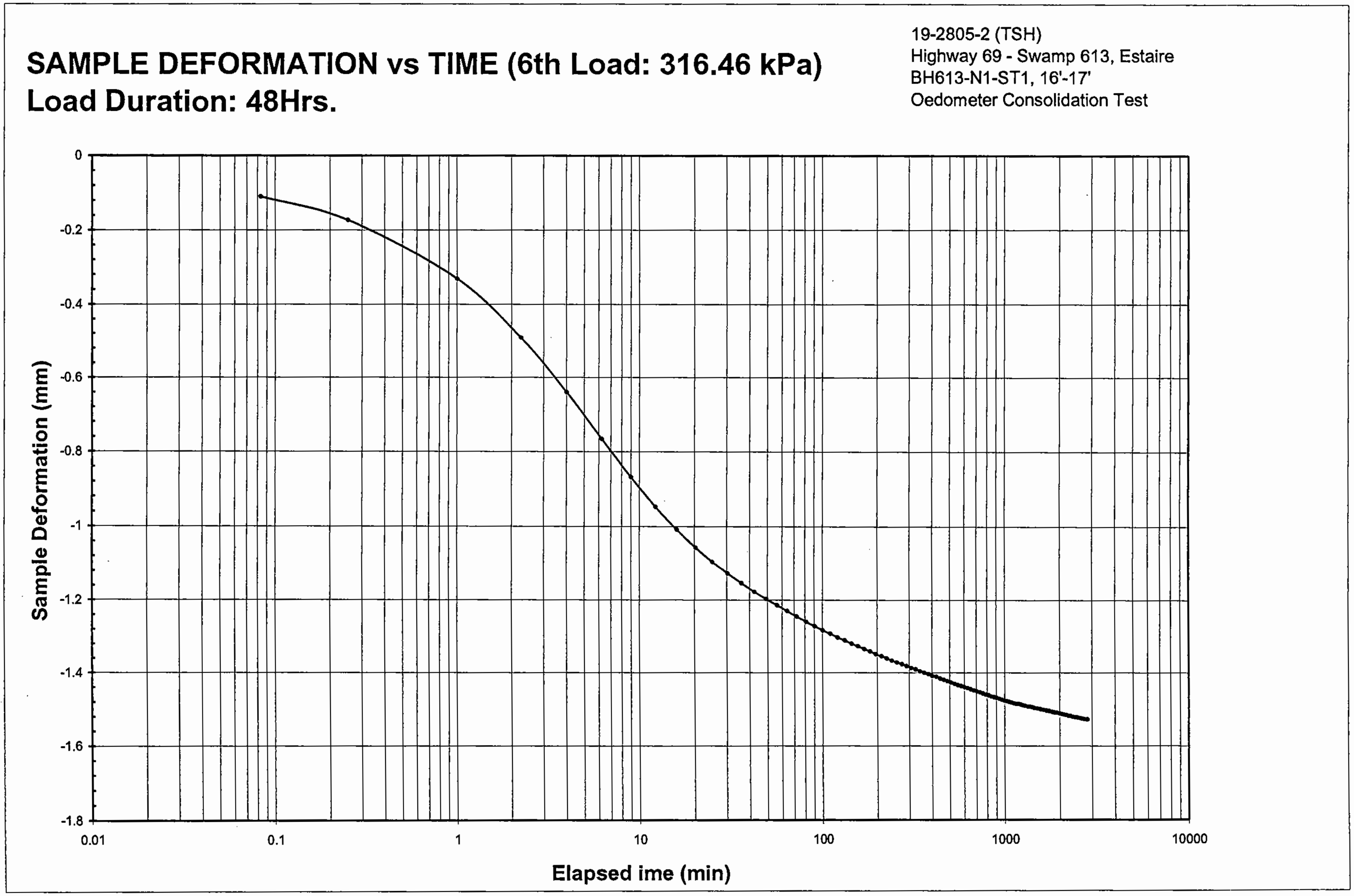
Highway 69 - Swamp 613
19-2805-2

BH613-N1-ST1, 16'-17'





TEST DONE BY: EA
REVIEWED BY: JPL



TEST DONE BY: EA
REVIEWED BY: JPL

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

CLIENT:	**Totten Sims Hubicki (TSH)**	FILE NUMBER:	18-45-1 / 19-2805-2
PROJECT:	Highway 69 - Swamp 613 (Hwy 537)	REPORT DATE:	22-Mar-06

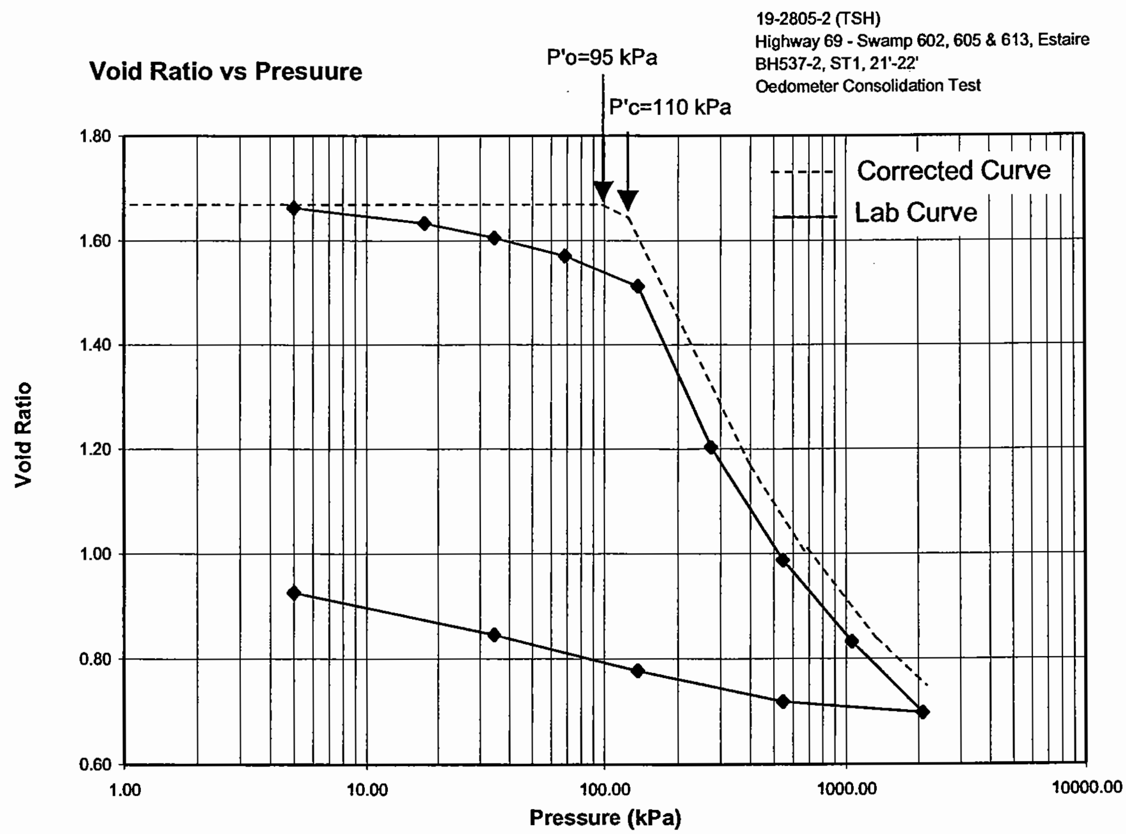
TEST DATES: November 16, 2005 - November 30, 2005

SAMPLE: BH537-2, ST1, 21'-22'
Silty Clay, brownish grey, varved, plastic, (CH), Lab Vane: 20 - 25 kPa (Soft)
Grain Size: 76 % Clay, 23 % Silt & 1 % Sand

PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	Start of Test	End of Test
Wet Dens. (kg/m^3)	1655.4	1991.1
Dry Dens. (kg/m^3)	1031.8	1427.3
Moisture Cont. (%)	60.4	39.5
Void Ratio	1.665	0.927
Saturation (%)	99.8	

Note: A Specific Gravity of 2.75 was measured for the void ratio and saturation calculations



TEST DONE BY: EA
REVIEWED BY: JPL

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

Highway 69 - Swamp 613 (Hwy 537)
18-45-1 / 19-2805-2 BH537-2, ST1, 21'-22'

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

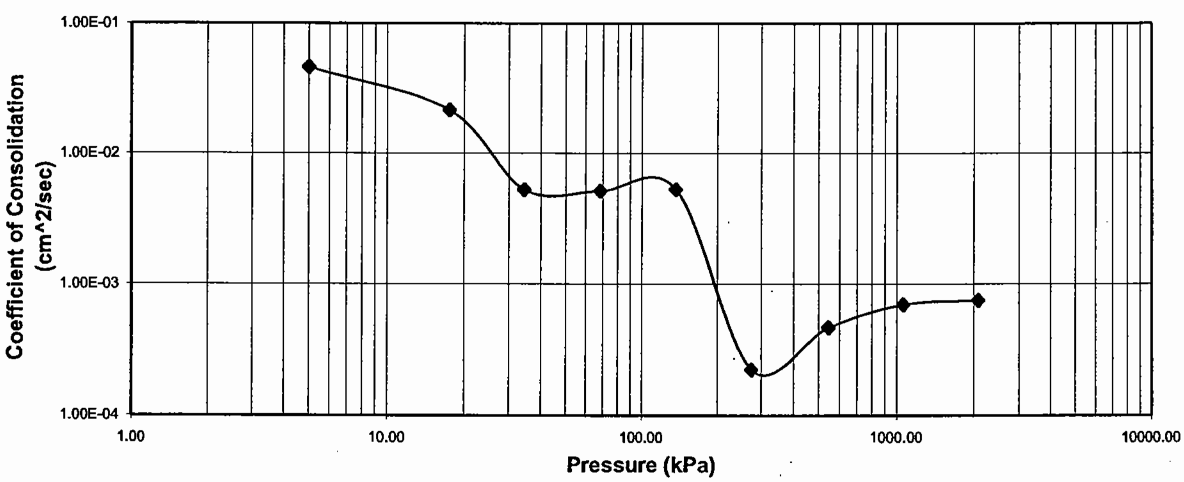
LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hrs except the 6th loading was 48 hours for Secondary Compression Calculations.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	T90 (min)	Cv (cm^2/sec)	Void Ratio	mv (m^2/kN)	k (cm/s)
0.00	19.850	19.850			1.665		
5.00	19.830	19.840	0.30	4.60E-02	1.662	8.77E-04	3.95E-06
17.49	19.613	19.721	0.64	2.15E-02	1.633	6.24E-04	1.31E-06
34.46	19.403	19.508	2.56	5.25E-03	1.605	3.79E-04	1.95E-07
68.42	19.147	19.275	2.56	5.13E-03	1.571	3.19E-04	1.61E-07
136.78	18.714	18.930	2.40	5.28E-03	1.513	8.49E-04	4.39E-07
273.12	16.415	17.564	49.00	2.22E-04	1.204	2.98E-04	6.50E-09
545.39	14.804	15.610	18.49	4.66E-04	0.988	1.14E-04	5.19E-09
1057.63	13.647	14.226	10.24	6.98E-04	0.832	4.95E-05	3.39E-09
2080.12	12.642	13.145	8.12	7.52E-04	0.697	5.28E-06	3.89E-10
545.39	12.803	12.723			0.719		
136.78	13.240	13.022			0.778		
34.46	13.749	13.495			0.846		
5.00	14.346	14.048			0.926		

Coefficient of Consoildation vs Pressure

19-2805-2 (TSH)
Highway 69 - Swamp 602, 605 & 613, Estaire
BH537-2, ST1, 21'-22'
Oedometer Consolidation Test



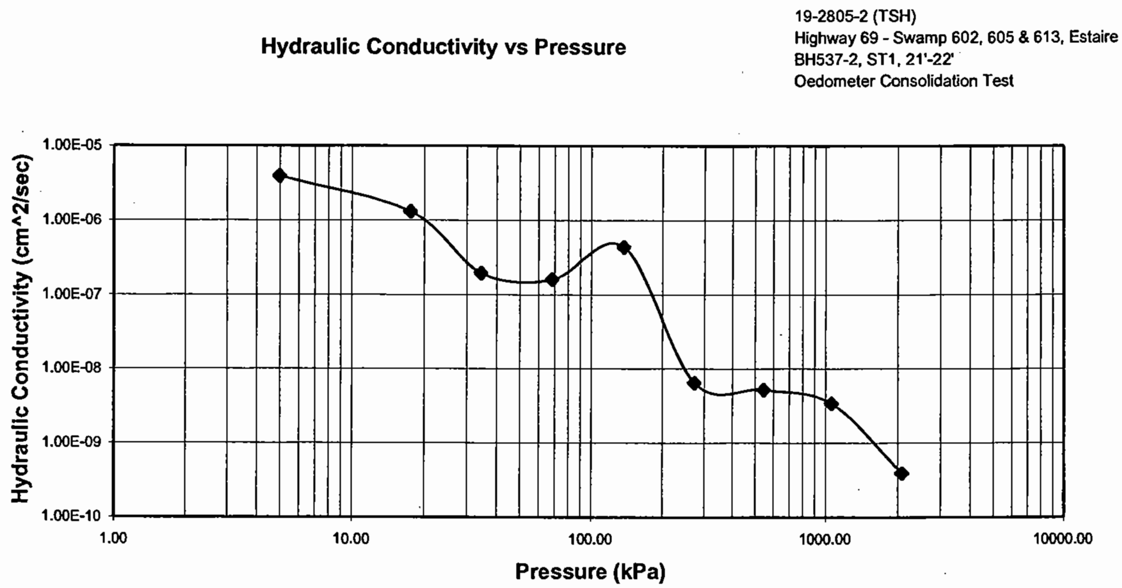
Notes: Cv and k calculated using t_{90} values

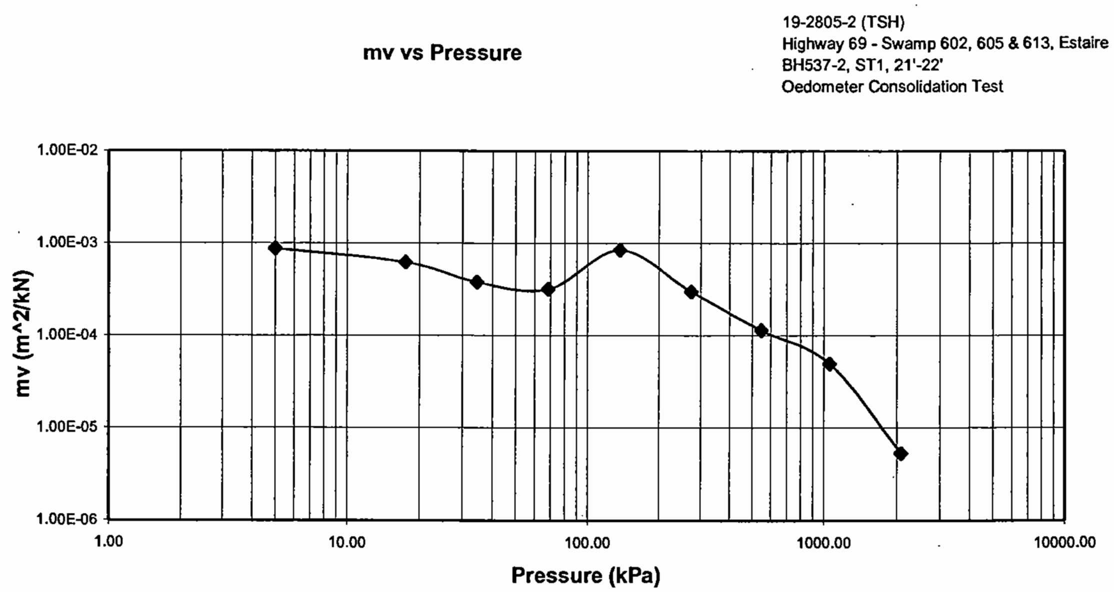
TEST DONE BY: EA
REVIEWED BY: JPL

Consolidation Test Report

Highway 69 - Swamp 613 (Hwy 537)
18-45-1 / 19-2805-2

BH537-2, ST1, 21'-22'

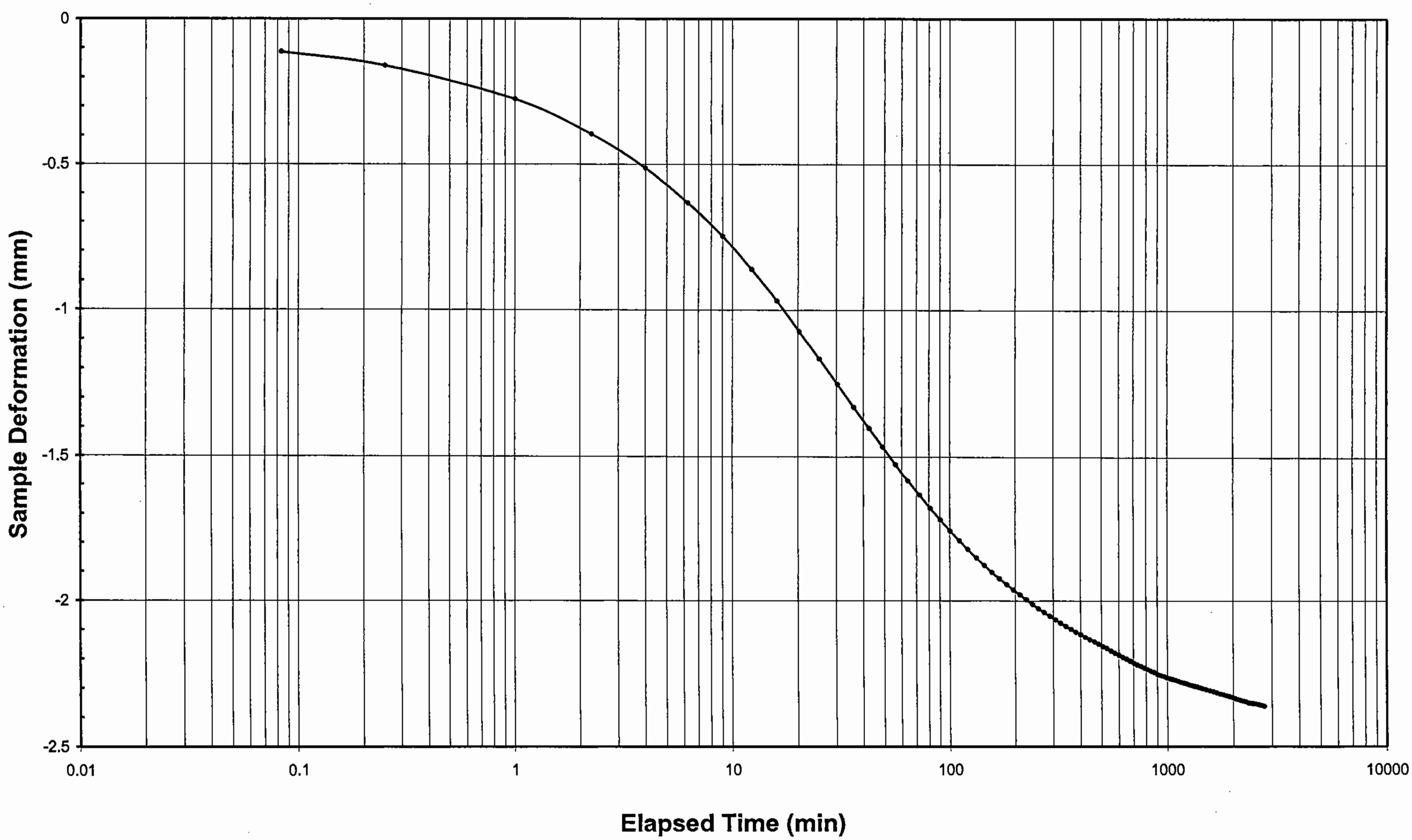




TEST DONE BY: EA
REVIEWED BY: JPL

SAMPLE DEFORMATION vs TIME (6th Load: 273.12 kPa)
Load Duration:48 hrs

19-2805-2 (TSH)
Highway 69 - Swamp 602, 605 & 613, Estaire
BH537-2, ST1, 21'-22'
Oedometer Consolidation Test



TEST DONE BY: EA
REVIEWED BY: JPL

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B30(a)

SAMPLE IDENTIFICATION

Project Number	05-1116-043	Sample Number	ST3
Borehole Number	537-1	Sample Depth, m	13.7-14.3

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24-48
Oedometer Number	5		
Date Started	11/25/2005		
Date Completed	12/09/2005		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m^3	16.94
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	12.14
Area, cm^2	31.65	Specific Gravity, measured	2.77
Volume, cm^3	60.45	Solids Height, cm	0.854
Water Content, %	39.52	Volume of Solids, cm^3	27.02
Wet Mass, g	104.43	Volume of Voids, cm^3	33.43
Dry Mass, g	74.85	Degree of Saturation, %	88.5

TEST COMPUTATIONS

	Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
	0.00	1.910	1.237	1.910				
	4.85	1.907	1.234	1.909	3	2.57E-01	3.24E-04	8.17E-06
	9.55	1.904	1.230	1.906	60	1.28E-02	3.34E-04	4.20E-07
	19.26	1.897	1.222	1.901	53	1.44E-02	3.77E-04	5.34E-07
	38.70	1.875	1.196	1.886	28	2.69E-02	5.84E-04	1.54E-06
	77.43	1.862	1.181	1.869	53	1.40E-02	1.80E-04	2.46E-07
	154.78	1.831	1.145	1.847	60	1.20E-02	2.10E-04	2.48E-07
48 hours	308.01	1.755	1.056	1.793	146	4.67E-03	2.60E-04	1.19E-07
	617.31	1.598	0.872	1.677	658	9.06E-04	2.66E-04	2.36E-08
	1236.15	1.484	0.738	1.541	304	1.66E-03	9.64E-05	1.57E-08
	2473.64	1.389	0.627	1.437	240	1.82E-03	4.02E-05	7.18E-09
	1236.15	1.400	0.640	1.395				
	309.26	1.437	0.683	1.419				
	77.43	1.479	0.732	1.458				
	19.26	1.539	0.803	1.509				
	4.76	1.589	0.861	1.564				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.59	Unit Weight, kN/m^3	18.53
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	14.60
Area, cm^2	31.65	Specific Gravity, measured	2.77
Volume, cm^3	50.29	Solids Height, cm	0.854
Water Content, %	26.95	Volume of Solids, cm^3	27.02
Wet Mass, g	95.02	Volume of Voids, cm^3	23.27
Dry Mass, g	74.85		

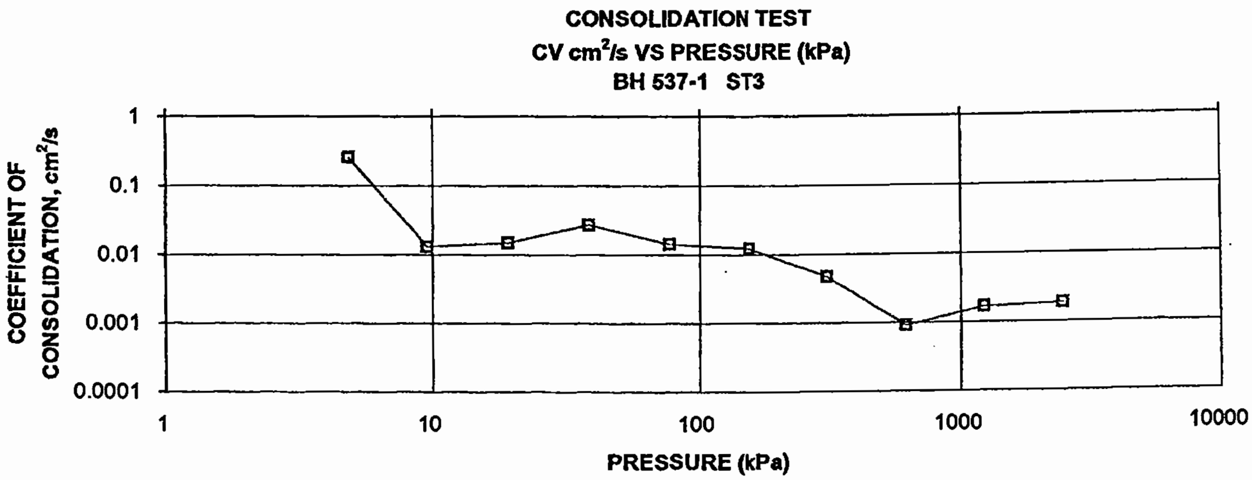
Prepared By: LFG

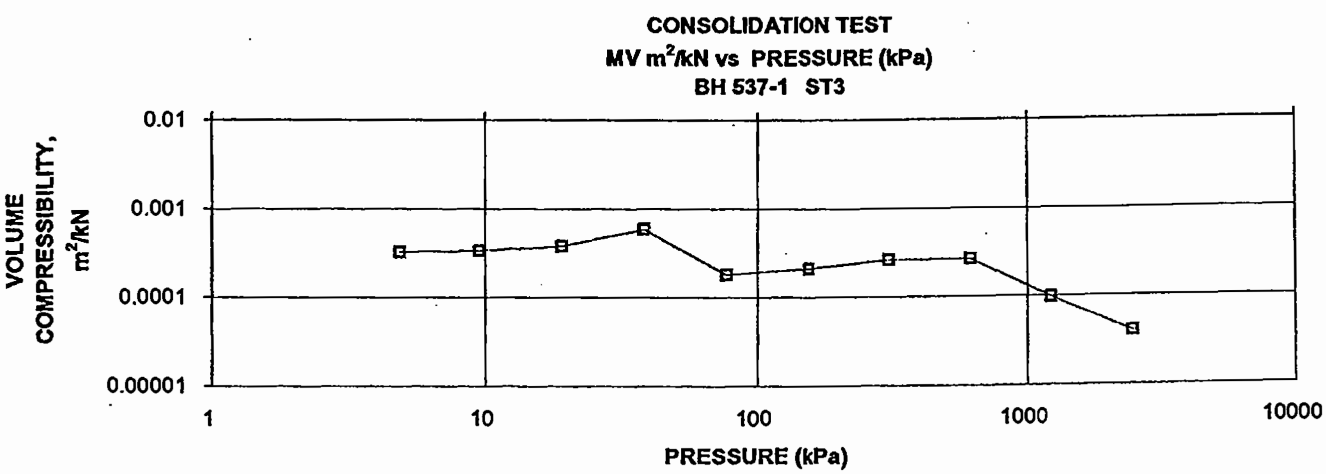
Golder Associates

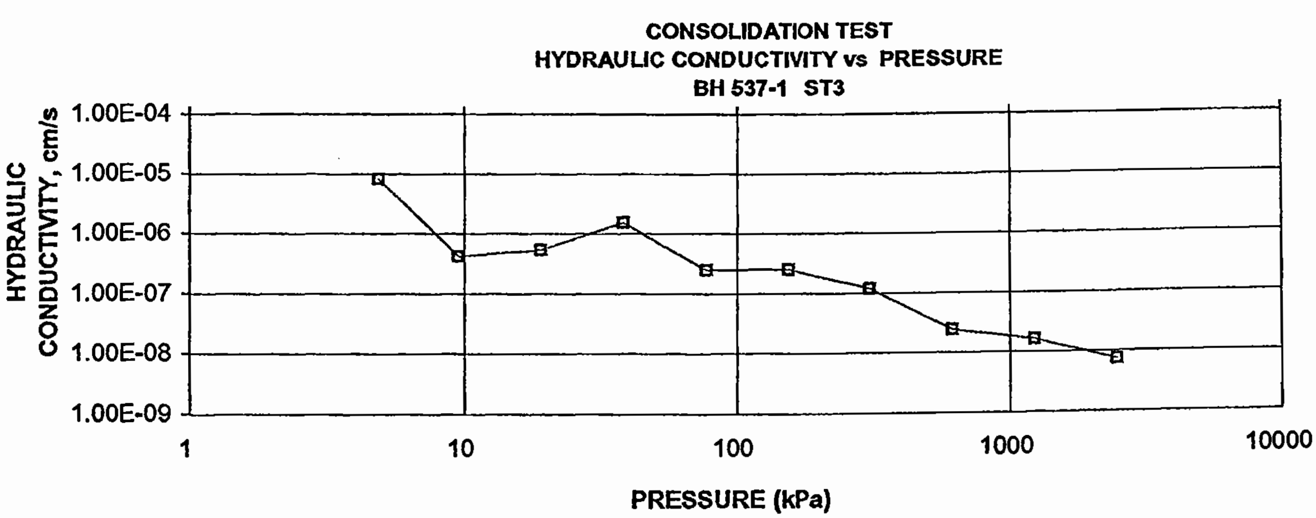
Checked By: MM

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B30(b)







Project No. 05-1116-043

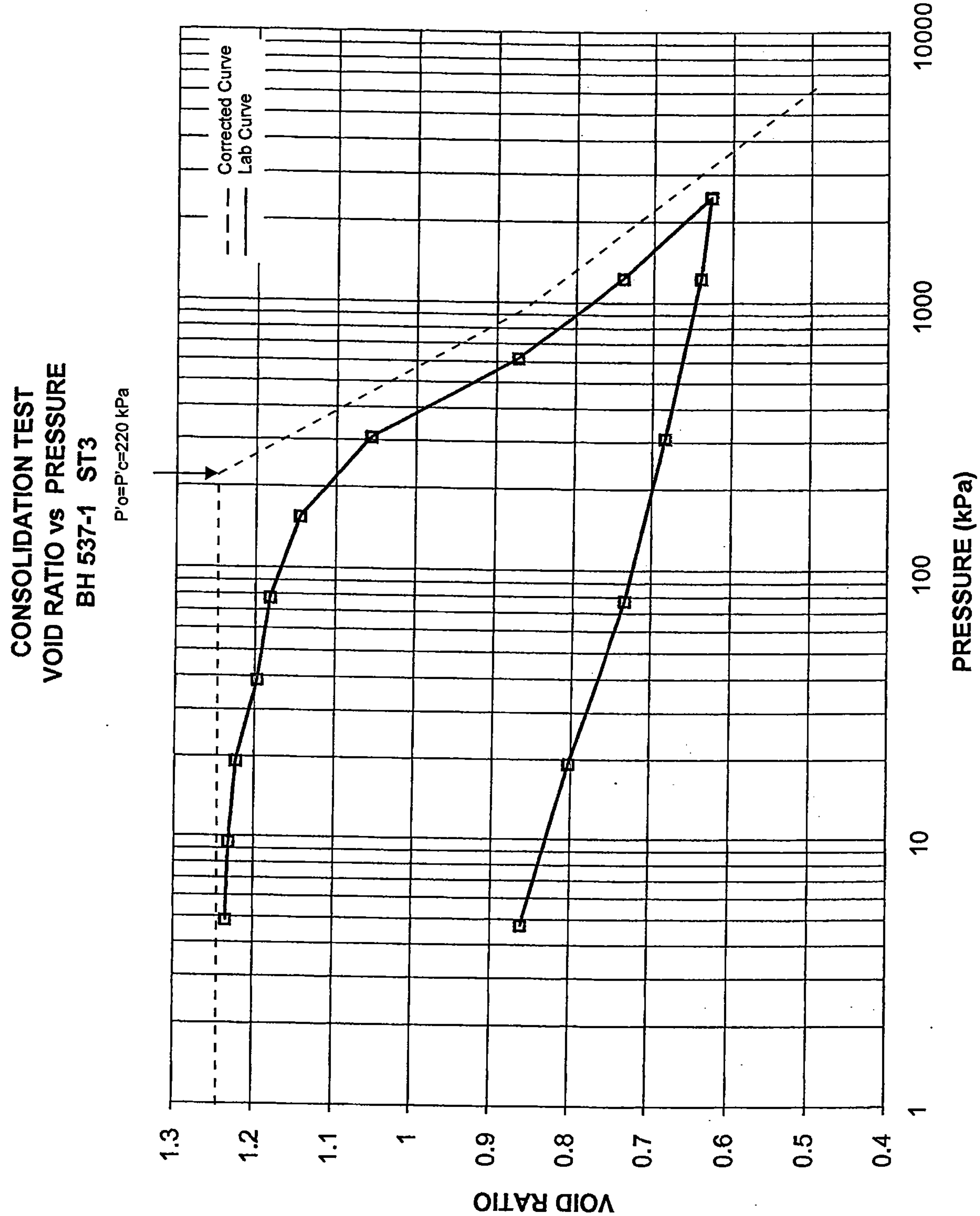
Prepared By: LFG

Golder Associates

Checkey By: MM

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B30(c)



Project No. 05-1116-043
Prepared By: LFG

Golder Associates

Checked By: MM

CONSOLIDATION TEST

PROJECT NUMBER	05-1116-043	**Repeat**	STAGE NUMBER	7
BOREHOLE NUMBER	537-1		SAMPLE DEPTH, m	13.7-14.3
SAMPLE NUMBER	ST3		OEDOMETER	5
HEIGHT, mm	19.10		TRANSDUCER	23.659
DIAMETER, mm	63.48		APPLIED PRESSURE, kPa	308.01
AREA, mm^2	3165.04		FINAL HEIGHT, mm	17.55
VOLUME, m^3	0.06		APPLIED LOAD, Kg	9.0371

Date	Clock	Elapsed Time Sec	Square Root Min.	Transducer Reading mm	Stage Total Deflect. mm	Test Total Deflect. mm	Stage Deflect. mm	Height Change mm	Stage Ratio t/d
12/1/2005	4:16:10 PM	0	0.00	22.871	0.000	0.788	-22.871	18.312	0.000
12/1/2005	4:16:11 PM	1	0.13	22.862	0.009	0.797	-22.862	18.303	1.852
12/1/2005	4:16:12 PM	2	0.18	22.834	0.037	0.825	-22.834	18.275	0.901
12/1/2005	4:16:13 PM	3	0.22	22.815	0.056	0.844	-22.815	18.256	0.893
12/1/2005	4:16:14 PM	4	0.26	22.806	0.065	0.853	-22.806	18.247	1.026
12/1/2005	4:16:15 PM	5	0.29	22.806	0.065	0.853	-22.806	18.247	1.282
12/1/2005	4:16:16 PM	6	0.32	22.796	0.075	0.863	-22.796	18.237	1.333
12/1/2005	4:16:17 PM	7	0.34	22.796	0.075	0.863	-22.796	18.237	1.556
12/1/2005	4:16:18 PM	8	0.37	22.787	0.084	0.872	-22.787	18.228	1.587
12/1/2005	4:16:19 PM	9	0.39	22.778	0.093	0.881	-22.778	18.219	1.613
12/1/2005	4:16:20 PM	10	0.41	22.778	0.093	0.881	-22.778	18.219	1.792
12/1/2005	4:16:21 PM	11	0.43	22.778	0.093	0.881	-22.778	18.219	1.971
12/1/2005	4:16:22 PM	12	0.45	22.768	0.103	0.891	-22.768	18.209	1.942
12/1/2005	4:16:23 PM	13	0.47	22.768	0.103	0.891	-22.768	18.209	2.104
12/1/2005	4:16:24 PM	14	0.48	22.768	0.103	0.891	-22.768	18.209	2.265
12/1/2005	4:16:25 PM	15	0.50	22.768	0.103	0.891	-22.768	18.209	2.427
12/1/2005	4:16:26 PM	16	0.52	22.759	0.112	0.900	-22.759	18.200	2.381
12/1/2005	4:16:27 PM	17	0.53	22.759	0.112	0.900	-22.759	18.200	2.530
12/1/2005	4:16:28 PM	18	0.55	22.759	0.112	0.900	-22.759	18.200	2.679
12/1/2005	4:16:29 PM	19	0.56	22.759	0.112	0.900	-22.759	18.200	2.827
12/1/2005	4:16:30 PM	20	0.58	22.749	0.122	0.910	-22.749	18.190	2.732
12/1/2005	4:16:31 PM	21	0.59	22.749	0.122	0.910	-22.749	18.190	2.869
12/1/2005	4:16:32 PM	22	0.61	22.749	0.122	0.910	-22.749	18.190	3.005
12/1/2005	4:16:33 PM	23	0.62	22.74	0.131	0.919	-22.740	18.181	2.926
12/1/2005	4:16:34 PM	24	0.63	22.74	0.131	0.919	-22.740	18.181	3.053
12/1/2005	4:16:35 PM	25	0.65	22.74	0.131	0.919	-22.740	18.181	3.181
12/1/2005	4:16:36 PM	26	0.66	22.74	0.131	0.919	-22.740	18.181	3.308
12/1/2005	4:16:37 PM	27	0.67	22.731	0.140	0.928	-22.731	18.172	3.214
12/1/2005	4:16:38 PM	28	0.68	22.731	0.140	0.928	-22.731	18.172	3.333
12/1/2005	4:16:39 PM	29	0.70	22.731	0.140	0.928	-22.731	18.172	3.452
12/1/2005	4:16:40 PM	30	0.71	22.731	0.140	0.928	-22.731	18.172	3.571
12/1/2005	4:16:41 PM	31	0.72	22.731	0.140	0.928	-22.731	18.172	3.690
12/1/2005	4:16:42 PM	32	0.73	22.721	0.150	0.938	-22.721	18.162	3.556
12/1/2005	4:16:43 PM	33	0.74	22.721	0.150	0.938	-22.721	18.162	3.667
12/1/2005	4:16:44 PM	34	0.75	22.721	0.150	0.938	-22.721	18.162	3.778
12/1/2005	4:16:45 PM	35	0.76	22.721	0.150	0.938	-22.721	18.162	3.889
12/1/2005	4:16:46 PM	36	0.77	22.721	0.150	0.938	-22.721	18.162	4.000
12/1/2005	4:16:47 PM	37	0.79	22.721	0.150	0.938	-22.721	18.162	4.111
12/1/2005	4:16:48 PM	38	0.80	22.712	0.159	0.947	-22.712	18.153	3.983
12/1/2005	4:16:53 PM	43	0.85	22.712	0.159	0.947	-22.712	18.153	4.507

CONSOLIDATION TEST

PROJECT NUMBER	05-1116-043	**Repeat**	STAGE NUMBER	7
BOREHOLE NUMBER	537-1		SAMPLE DEPTH, m	13.7-14.3
SAMPLE NUMBER	ST3		OEDOMETER	5
HEIGHT, mm	19.10		TRANSDUCER	23.659
DIAMETER, mm	63.48		APPLIED PRESSURE, kPa	308.01
AREA, mm^2	3165.04		FINAL HEIGHT, mm	17.55
VOLUME, m^3	0.06		APPLIED LOAD, Kg	9.0371

Date	Clock	Elapsed Time Sec	Square Root Min.	Transducer Reading mm	Stage Total Deflect. mm	Test Total Deflect. mm	Stage Deflect. mm	Height Change mm	Stage Ratio t/d
12/1/2005	4:17:03 PM	53	0.94	22.693	0.178	0.966	-22.693	18.134	4.963
12/1/2005	4:17:13 PM	63	1.02	22.674	0.197	0.985	-22.674	18.115	5.330
12/1/2005	4:17:23 PM	73	1.10	22.665	0.206	0.994	-22.665	18.106	5.906
12/1/2005	4:17:33 PM	83	1.18	22.656	0.215	1.003	-22.656	18.097	6.434
12/1/2005	4:17:43 PM	93	1.24	22.646	0.225	1.013	-22.646	18.087	6.889
12/1/2005	4:17:53 PM	103	1.31	22.646	0.225	1.013	-22.646	18.087	7.630
12/1/2005	4:18:03 PM	113	1.37	22.628	0.243	1.031	-22.628	18.069	7.750
12/1/2005	4:18:13 PM	123	1.43	22.628	0.243	1.031	-22.628	18.069	8.436
12/1/2005	4:18:23 PM	133	1.49	22.618	0.253	1.041	-22.618	18.059	8.762
12/1/2005	4:18:33 PM	143	1.54	22.618	0.253	1.041	-22.618	18.059	9.420
12/1/2005	4:18:43 PM	153	1.60	22.609	0.262	1.050	-22.609	18.050	9.733
12/1/2005	4:18:53 PM	163	1.65	22.599	0.272	1.060	-22.599	18.040	9.988
12/1/2005	4:19:03 PM	173	1.70	22.599	0.272	1.060	-22.599	18.040	10.600
12/1/2005	4:19:13 PM	183	1.75	22.59	0.281	1.069	-22.590	18.031	10.854
12/1/2005	4:19:23 PM	193	1.79	22.59	0.281	1.069	-22.590	18.031	11.447
12/1/2005	4:19:33 PM	203	1.84	22.581	0.290	1.078	-22.581	18.022	11.667
12/1/2005	4:19:43 PM	213	1.88	22.581	0.290	1.078	-22.581	18.022	12.241
12/1/2005	4:19:53 PM	223	1.93	22.571	0.300	1.088	-22.571	18.012	12.389
12/1/2005	4:20:03 PM	233	1.97	22.571	0.300	1.088	-22.571	18.012	12.944
12/1/2005	4:20:13 PM	243	2.01	22.571	0.300	1.088	-22.571	18.012	13.500
12/1/2005	4:20:23 PM	253	2.05	22.562	0.309	1.097	-22.562	18.003	13.646
12/1/2005	4:20:33 PM	263	2.09	22.562	0.309	1.097	-22.562	18.003	14.186
12/1/2005	4:20:43 PM	273	2.13	22.562	0.309	1.097	-22.562	18.003	14.725
12/1/2005	4:20:53 PM	283	2.17	22.553	0.318	1.106	-22.553	17.994	14.832
12/1/2005	4:21:03 PM	293	2.21	22.553	0.318	1.106	-22.553	17.994	15.356
12/1/2005	4:21:13 PM	303	2.25	22.553	0.318	1.106	-22.553	17.994	15.881
12/1/2005	4:21:23 PM	313	2.28	22.543	0.328	1.116	-22.543	17.984	15.904
12/1/2005	4:21:24 PM	314	2.29	22.543	0.328	1.116	-22.543	17.984	15.955
12/1/2005	4:21:53 PM	343	2.39	22.543	0.328	1.116	-22.543	17.984	17.429
12/1/2005	4:22:23 PM	373	2.49	22.534	0.337	1.125	-22.534	17.975	18.447
12/1/2005	4:22:53 PM	403	2.59	22.524	0.347	1.135	-22.524	17.965	19.356
12/1/2005	4:23:23 PM	433	2.69	22.524	0.347	1.135	-22.524	17.965	20.797
12/1/2005	4:23:53 PM	463	2.78	22.515	0.356	1.144	-22.515	17.956	21.676
12/1/2005	4:24:23 PM	493	2.87	22.506	0.365	1.153	-22.506	17.947	22.511
12/1/2005	4:24:53 PM	523	2.95	22.506	0.365	1.153	-22.506	17.947	23.881
12/1/2005	4:25:23 PM	553	3.04	22.506	0.365	1.153	-22.506	17.947	25.251
12/1/2005	4:25:53 PM	583	3.12	22.496	0.375	1.163	-22.496	17.937	25.911
12/1/2005	4:26:53 PM	643	3.27	22.487	0.384	1.172	-22.487	17.928	27.908
12/1/2005	4:27:53 PM	703	3.42	22.477	0.394	1.182	-22.477	17.918	29.738
12/1/2005	4:28:53 PM	763	3.57	22.477	0.394	1.182	-22.477	17.918	32.276

CONSOLIDATION TEST

PROJECT NUMBER	05-1116-043	**Repeat**	STAGE NUMBER	7
BOREHOLE NUMBER	537-1		SAMPLE DEPTH, m	13.7-14.3
SAMPLE NUMBER	ST3		OEDOMETER	5
HEIGHT, mm	19.10		TRANSDUCER	23.659
DIAMETER, mm	63.48		APPLIED PRESSURE, kPa	308.01
AREA, mm^2	3165.04		FINAL HEIGHT, mm	17.55
VOLUME, m^3	0.06		APPLIED LOAD, Kg	9.0371

Date	Clock	Elapsed Time Sec	Square Root Min.	Transducer Reading mm	Stage Total Deflect. mm	Test Total Deflect. mm	Stage Deflect. mm	Height Change mm	Stage Ratio t/d
12/3/2005	3:40:53 AM	127483	46.09	22.131	0.740	1.528	-22.131	17.572	2871.239
12/3/2005	4:10:53 AM	129283	46.42	22.121	0.750	1.538	-22.121	17.562	2872.956
12/3/2005	4:40:53 AM	131083	46.74	22.121	0.750	1.538	-22.121	17.562	2912.956
12/3/2005	5:10:53 AM	132883	47.06	22.121	0.750	1.538	-22.121	17.562	2952.956
12/3/2005	5:40:53 AM	134683	47.38	22.121	0.750	1.538	-22.121	17.562	2992.956
12/3/2005	6:10:53 AM	136483	47.69	22.121	0.750	1.538	-22.121	17.562	3032.956
12/3/2005	6:40:53 AM	138283	48.01	22.121	0.750	1.538	-22.121	17.562	3072.956
12/3/2005	7:10:53 AM	140083	48.32	22.121	0.750	1.538	-22.121	17.562	3112.956
12/3/2005	7:40:53 AM	141883	48.63	22.121	0.750	1.538	-22.121	17.562	3152.956
12/3/2005	8:10:53 AM	143683	48.94	22.121	0.750	1.538	-22.121	17.562	3192.956
12/3/2005	8:40:53 AM	145483	49.24	22.121	0.750	1.538	-22.121	17.562	3232.956
12/3/2005	9:10:53 AM	147283	49.55	22.121	0.750	1.538	-22.121	17.562	3272.956
12/3/2005	9:40:53 AM	149083	49.85	22.121	0.750	1.538	-22.121	17.562	3312.956
12/3/2005	10:10:53 AM	150883	50.15	22.121	0.750	1.538	-22.121	17.562	3352.956
12/3/2005	10:40:53 AM	152683	50.45	22.121	0.750	1.538	-22.121	17.562	3392.956
12/3/2005	11:10:53 AM	154483	50.74	22.112	0.759	1.547	-22.112	17.553	3392.249
12/3/2005	11:40:53 AM	156283	51.04	22.112	0.759	1.547	-22.112	17.553	3431.774
12/3/2005	12:10:53 PM	158083	51.33	22.112	0.759	1.547	-22.112	17.553	3471.300
12/3/2005	12:40:53 PM	159883	51.62	22.112	0.759	1.547	-22.112	17.553	3510.826
12/3/2005	1:03:02 PM	161212	51.83	22.112	0.759	1.547	-22.112	17.553	3540.009
12/3/2005	1:03:03 PM	161213	51.84	22.112	0.759	1.547	-22.112	17.553	3540.031
12/3/2005	1:03:04 PM	161214	51.84	22.112	0.759	1.547	-22.112	17.553	3540.053
12/3/2005	1:03:05 PM	161215	51.84	22.112	0.759	1.547	-22.112	17.553	3540.075
12/3/2005	1:03:07 PM	161217	51.84	22.112	0.759	1.547	-22.112	17.553	3540.119
12/3/2005	1:03:07 PM	161217	51.84	22.112	0.759	1.547	-22.112	17.553	3540.119
12/3/2005	1:03:08 PM	161218	51.84	22.112	0.759	1.547	-22.112	17.553	3540.141
12/3/2005	1:03:09 PM	161219	51.84	22.112	0.759	1.547	-22.112	17.553	3540.162
12/3/2005	1:03:10 PM	161220	51.84	22.112	0.759	1.547	-22.112	17.553	3540.184
12/3/2005	1:03:11 PM	161221	51.84	22.112	0.759	1.547	-22.112	17.553	3540.206
12/3/2005	1:03:12 PM	161222	51.84	22.112	0.759	1.547	-22.112	17.553	3540.228
12/3/2005	1:03:13 PM	161223	51.84	22.112	0.759	1.547	-22.112	17.553	3540.250
12/3/2005	1:03:14 PM	161224	51.84	22.112	0.759	1.547	-22.112	17.553	3540.272
12/3/2005	1:03:15 PM	161225	51.84	22.112	0.759	1.547	-22.112	17.553	3540.294
12/3/2005	1:03:16 PM	161226	51.84	22.112	0.759	1.547	-22.112	17.553	3540.316
12/3/2005	1:03:17 PM	161227	51.84	22.112	0.759	1.547	-22.112	17.553	3540.338
12/3/2005	1:03:18 PM	161228	51.84	22.112	0.759	1.547	-22.112	17.553	3540.360
12/3/2005	1:03:19 PM	161229	51.84	22.112	0.759	1.547	-22.112	17.553	3540.382
12/3/2005	1:03:20 PM	161230	51.84	22.112	0.759	1.547	-22.112	17.553	3540.404
12/3/2005	1:03:21 PM	161231	51.84	22.112	0.759	1.547	-22.112	17.553	3540.426
12/3/2005	1:03:22 PM	161232	51.84	22.112	0.759	1.547	-22.112	17.553	3540.448

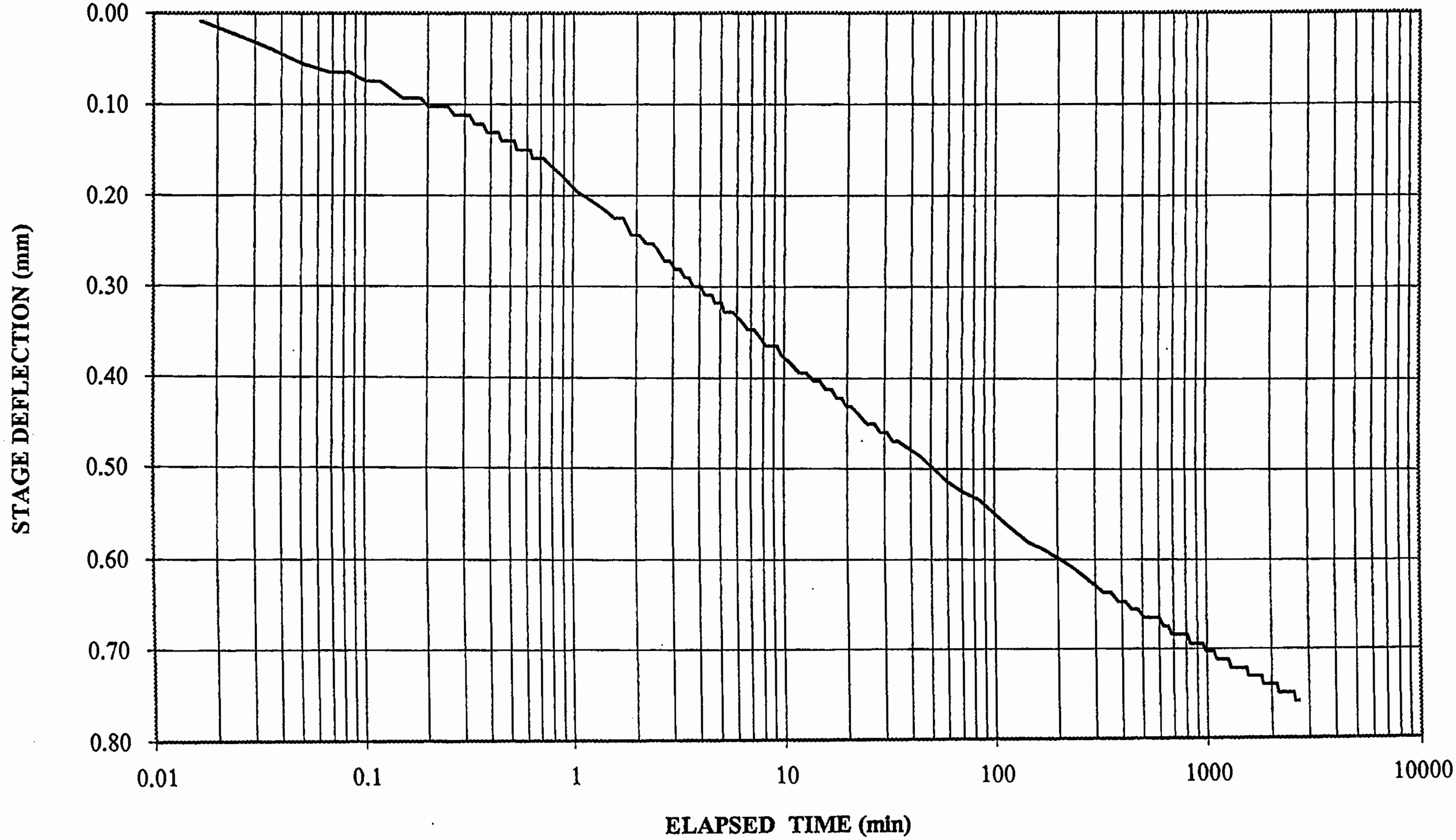
CONSOLIDATION TEST

PROJECT NUMBER	05-1116-043	**Repeat**	STAGE NUMBER	7
BOREHOLE NUMBER	537-1		SAMPLE DEPTH, m	13.7-14.3
SAMPLE NUMBER	ST3		OEDOMETER	5
HEIGHT, mm	19.10		TRANSDUCER	23.659
DIAMETER, mm	63.48		APPLIED PRESSURE, kPa	308.01
AREA, mm^2	3165.04		FINAL HEIGHT, mm	17.55
VOLUME, m^3	0.06		APPLIED LOAD, Kg	9.0371

Date	Clock	Elapsed Time Sec	Square Root Min.	Transducer Reading mm	Stage Total Deflect. mm	Test Total Deflect. mm	Stage Deflect. mm	Height Change mm	Stage Ratio t/d
12/3/2005	1:03:23 PM	161233	51.84	22.112	0.759	1.547	-22.112	17.553	3540.470

BOREHOLE 537-1 SAMPLE NUMBER ST3 FIGURE B30(d)

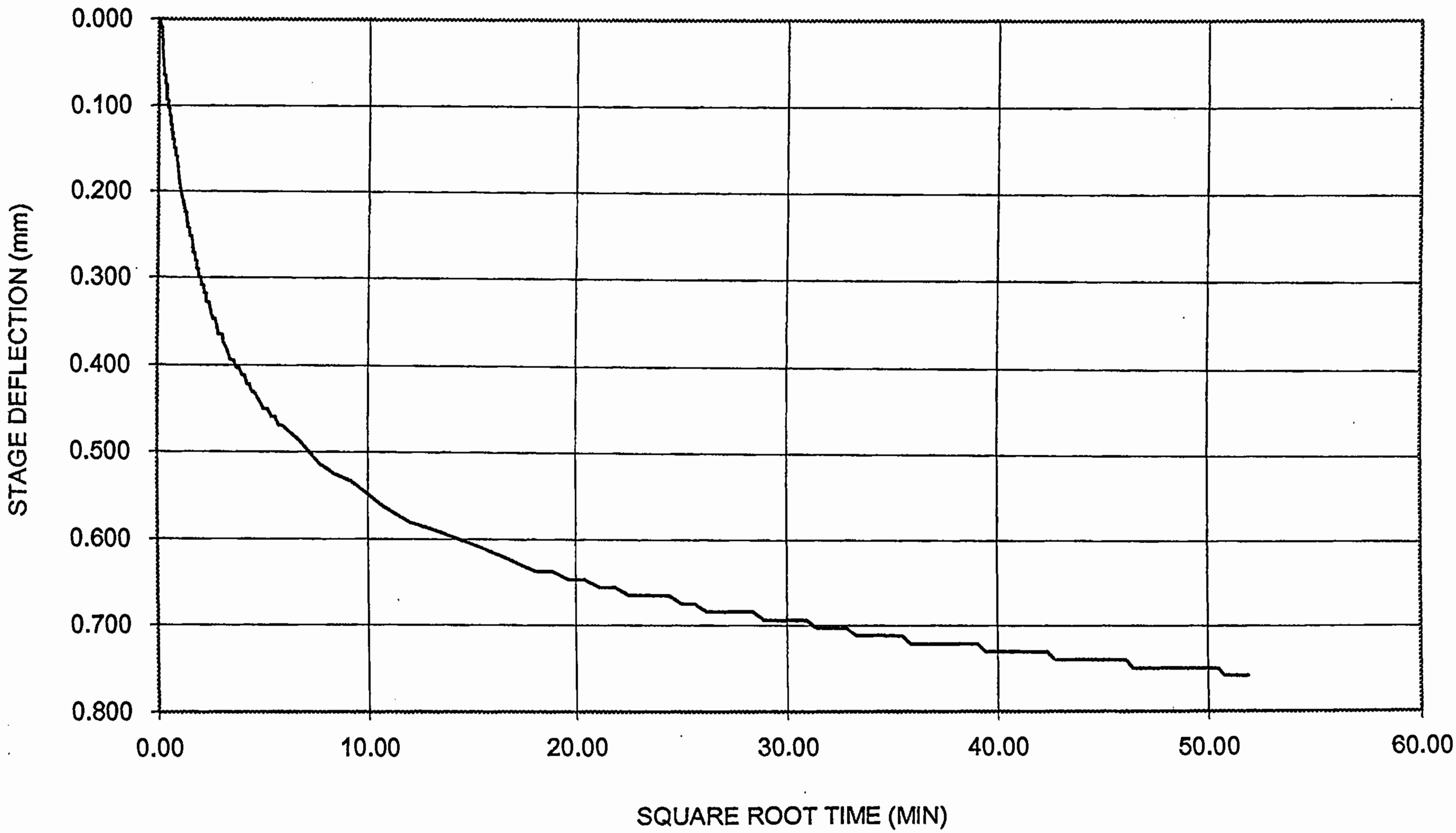
APPLIED PRESSURE = 308.0 kPa



BOREHOLE 537-1 SAMPLE NUMBER ST3

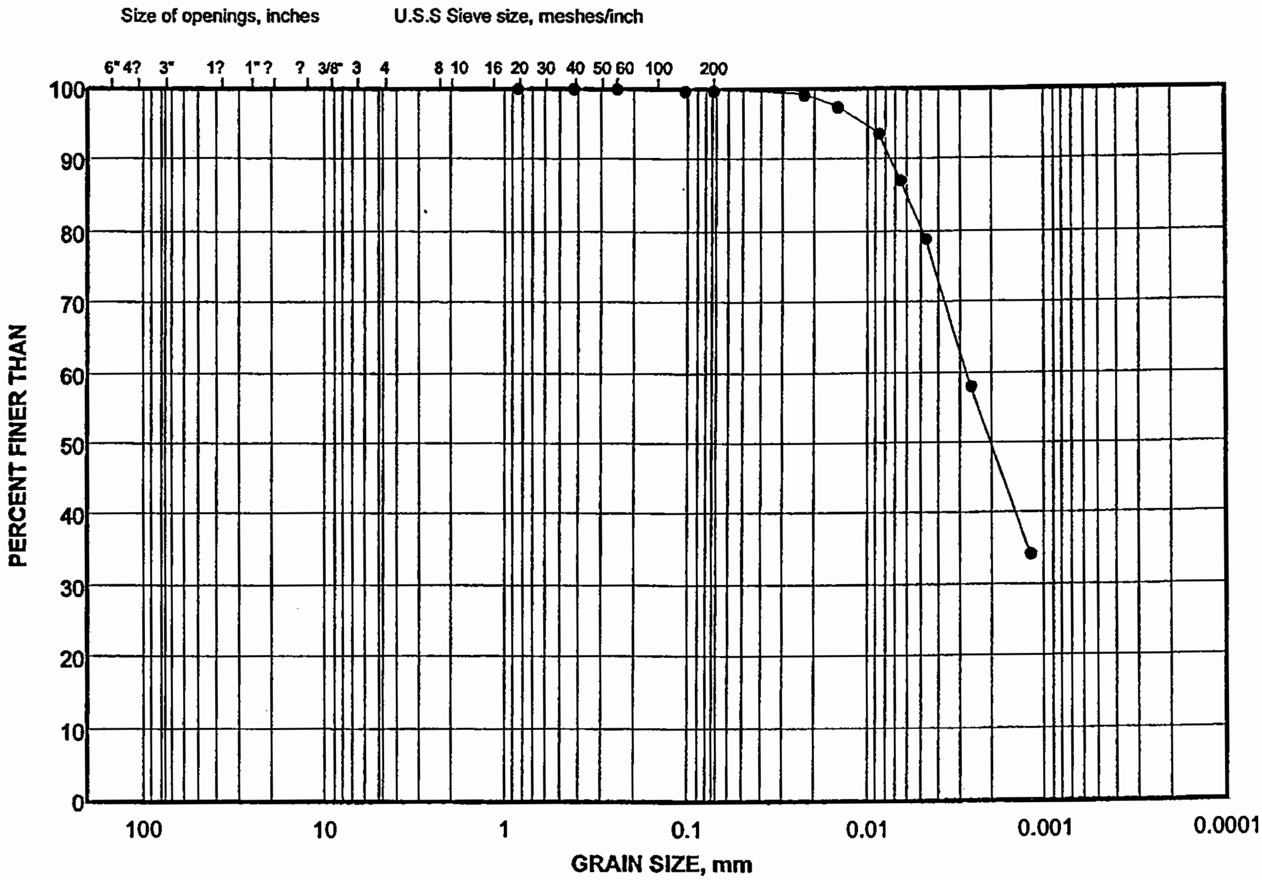
FIGURE B30(e)

APPLIED PRESSURE = 308.0 kPa



GRAIN SIZE DISTRIBUTION	FIGURE B30(f)

SWAMP 613 (HWY 537) - SILTY CLAY (CI)



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	537-1	ST3	13.7-14.3

Project Number: 05-1116-043

Checked By: ____________________

Golder Associates

Date: 17-Nov-05

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FIGURE B31(a)

MULTI STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST REPORT

CLIENT: **Totten Sims Hubicki** FILE NUMBER: 18-45-1 / 19-2805-2

PROJECT: Highway 69 - Swamp 613 (Hwy 537) REPORT DATE: 22-Mar-06

TEST DATES: November 10, 2005 - November 23, 2005

SAMPLE: BH537-1, ST1, 23'-25'
Silty Clay, grey, varved, plastic, (CI), Lab Vane: 27 kPa (Firm)
Grain Size: 49% Clay & 51% Silt, Gs=2.76

	As Set Up	After Satur. Stage	After Consol. Stage 1	After Consol. Stage 2	After Consol. Stage 3
Cell Pressure, s_3 (kPa)		165.0	165.0	330.0	580.0
Back Pressure (kPa)		155.0	40.0	80.0	80.0
Consolidation Pressure, s_c (kPa)		10.0	125.0	250.0	500.0
Sample Height (mm):	139.98	138.76	137.03	134.43	125.61
Wet Weight (g):	933.70	944.57	924.17	897.17	860.37
Pore Water Volume Change (ml):		10.9	-20.4	-27.0	-36.8
Wet Density (kg/cu.m.):	1,735	1,756	1,786	1,829	1,896
Dry Density (kg/cu.m.):	1,207	1,185	1,232	1,300	1,405
Moisture Content:	46.4%	48.1%	44.9%	40.7%	34.9%
Void Ratio:	1.329	1.328	1.240	1.123	0.964
Saturation:	96.4%	100.0%	100.0%	100.0%	100.0%
Pore Press. Parameter B:		0.983	0.983	0.985	0.988

Maximum Stress Ratio (s1/s3)

	Stage 1	Stage 2	Stage 3
Axial Strain:	2.4%	1.6%	3.7%
Deviator Stress (kPa):	110.5	138.7	241.9
Stress Ratio:	4.16	2.66	2.91
Change in Pore Pressure (kPa):	88.7	168.3	372.1
Rate of Displacement (%/hr):	0.337	0.337	0.337

Maximum Deviator Stress (s1-s3)

	Stage 3
Axial Strain:	4.0%
Deviator Stress (kPa):	243.4
Stress Ratio:	2.84
Change in Pore Pressure (kPa):	368.4
Rate of Displacement (%/hr):	0.337

Notes: **A shear plane developed in the middle of the specimen.**
The angle of failure is approx. 50 degrees.

TEST DONE BY: JPL
REVIEWED BY: JPL

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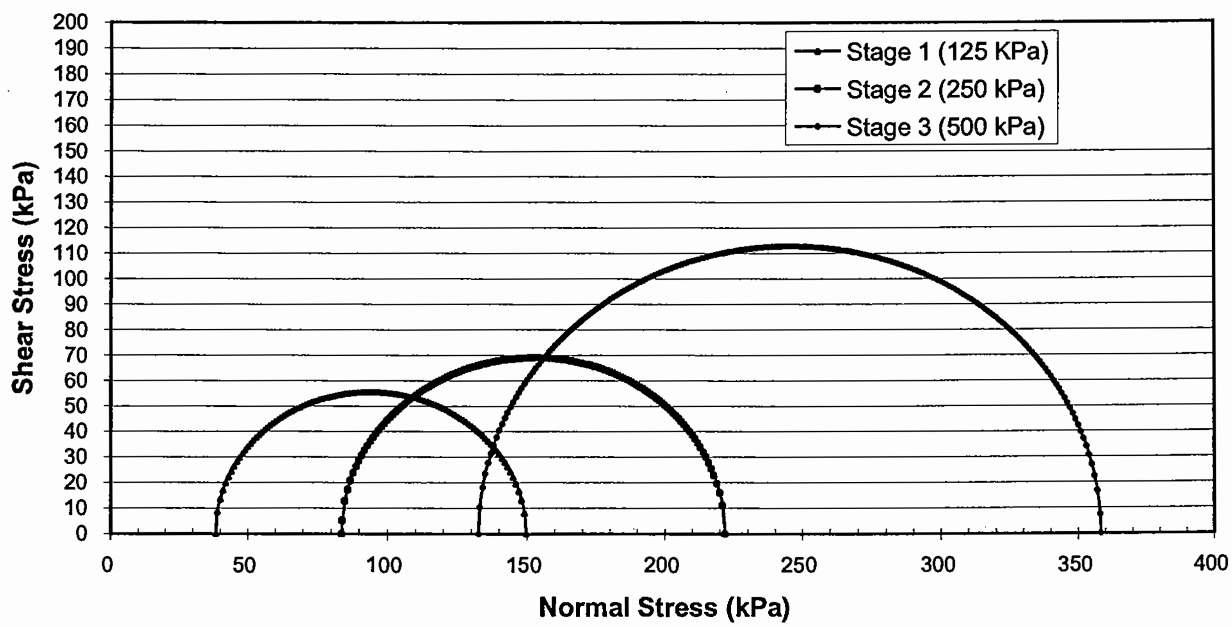
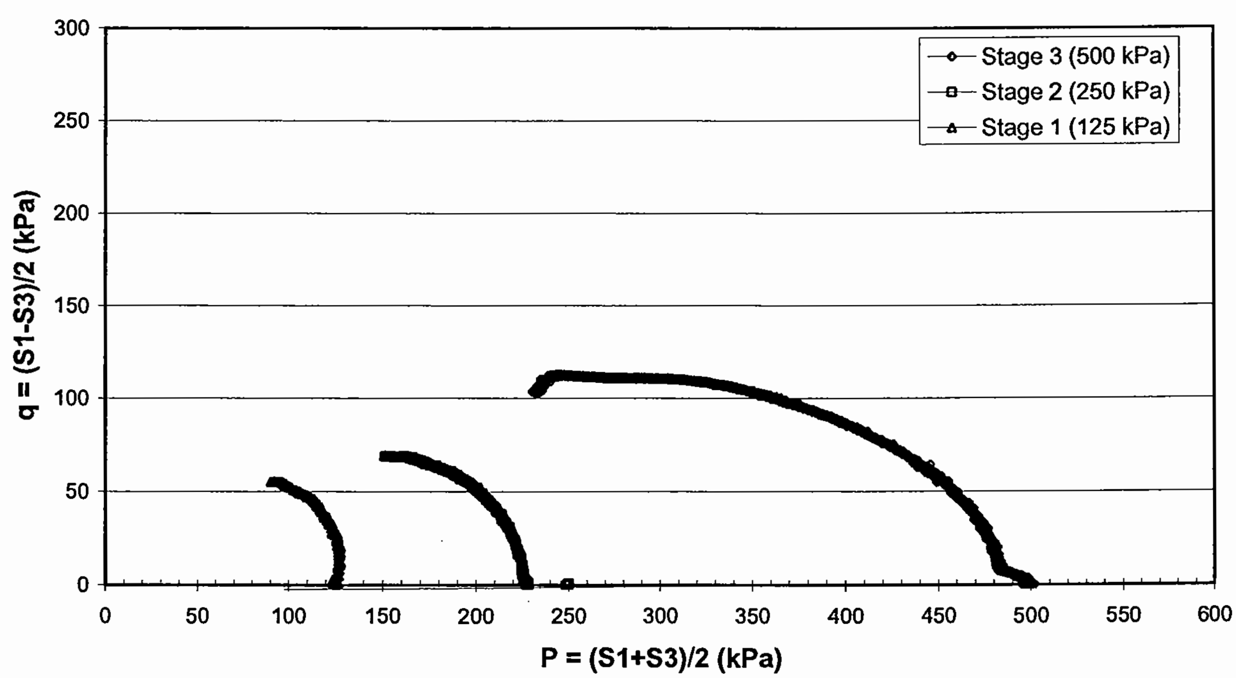
MULTI STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST REPORT

Highway 69 - Swamp 613 (Hwy 537)
18-45-1 / 19-2805-2 BH537-1, ST1, 23'-25'

BH 537-1 ST1





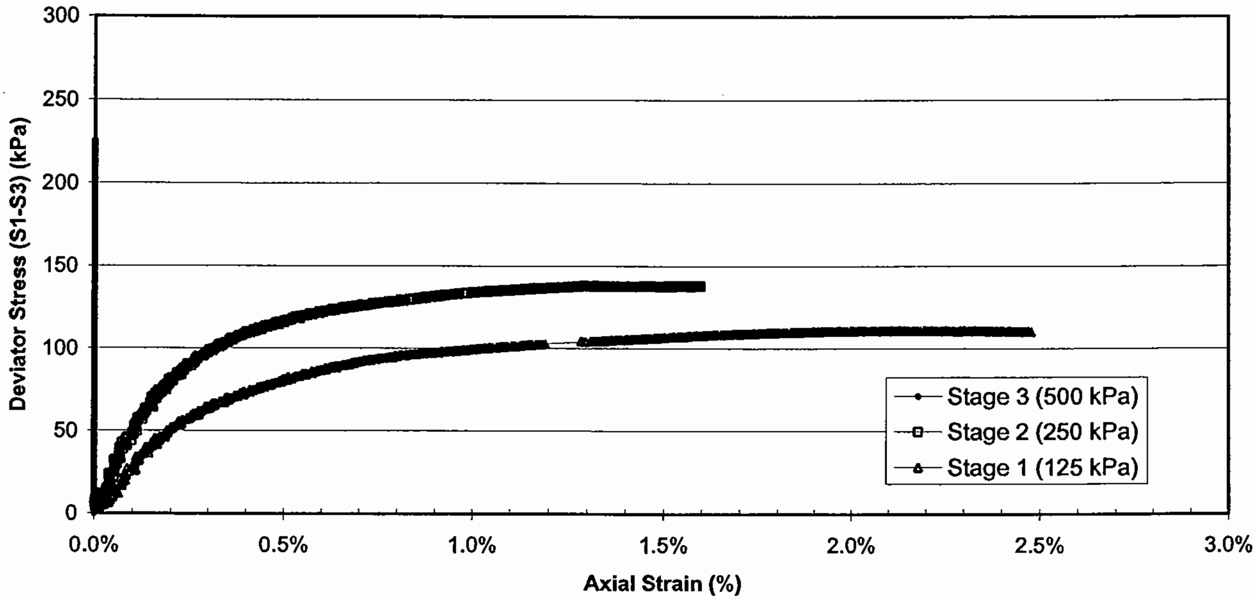
TEST DONE BY: JPL
REVIEWED BY: JPL

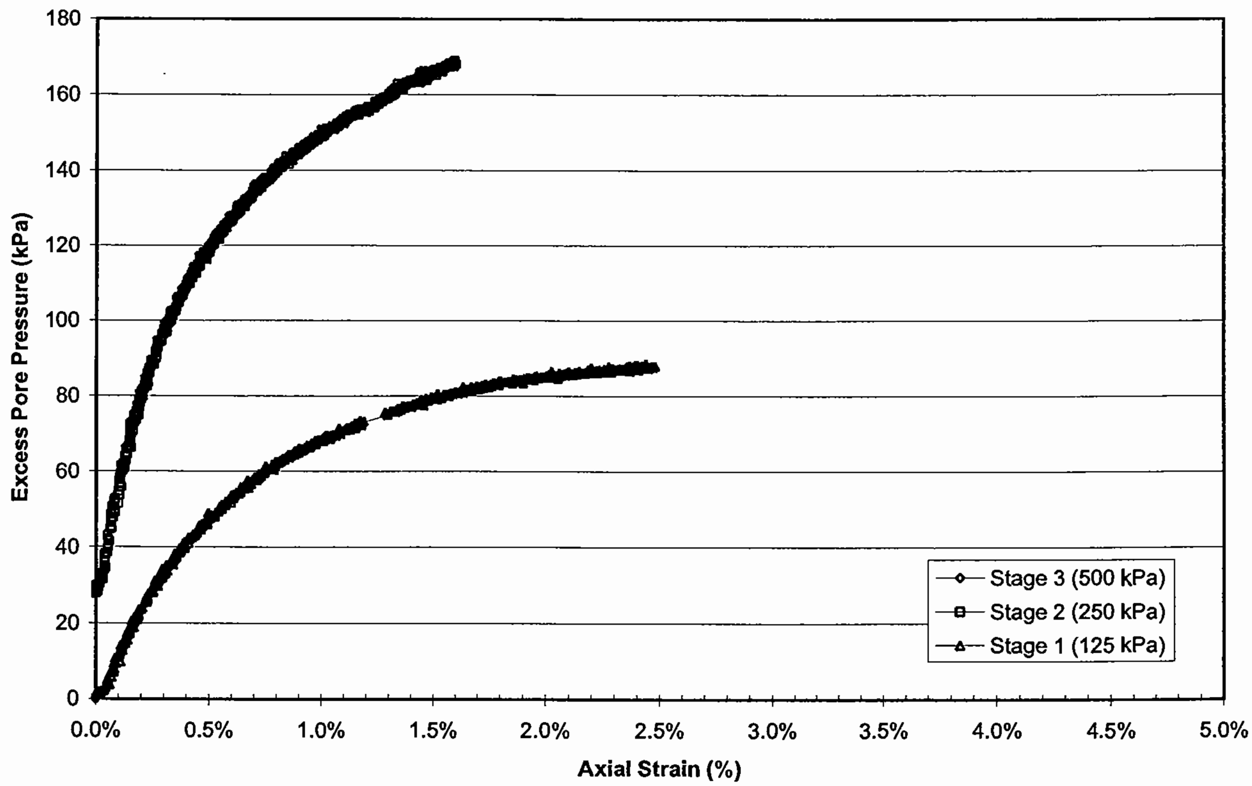
MULTI STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST REPORT

Highway 69 - Swamp 613 (Hwy 537)
18-45-1 / 19-2805-2

BH537-1, ST1, 23'-25'

BH 537-1 ST1





TEST DONE BY: JPL
REVIEWED BY: JPL

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MULTI STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST REPORT

CLIENT:	**Totten Sims Hubicki**	FILE NUMBER:	18-45-1 / 19-2805-2
PROJECT:	Highway 69 - Swamp 613 (Hwy 537)	REPORT DATE:	2-Feb-06

TEST DATES: December 2, 2005 - December 15, 2005

SAMPLE: BH537-2, ST1, 20'6"-21'3"
Silty Clay, grey, varved, plastic, (CH), Lab Vane: 27.5 kPa (Firm)
Grain Size: 76% Clay, 23% Silt & 1% Sand, Gs=2.75

	As Set Up	After Satur. Stage	After Consol. Stage 1	After Consol. Stage 2	After Consol. Stage 3
Cell Pressure, s3 (kPa)		300.0	415.0	700.0	950.0
Back Pressure (kPa)		290.0	290.0	300.0	300.0
Consolidation Pressure, sc (kPa)		10.0	125.0	400.0	650.0
Height (mm):	139.98	139.88	136.70	126.15	121.80
Wet Weight (g):	894.50	895.12	866.32	783.62	759.32
Pore Water Volume Change (ml):		0.6	-28.8	-82.7	-24.3
Wet Density (kg/cu.m.):	1,661	1,679	1,718	1,859	1,912
Dry Density (kg/cu.m.):	1,068	1,065	1,126	1,347	1,429
Moisture Content:	57.5%	57.6%	52.6%	38.0%	33.7%
Void Ratio:	1.618	1.591	1.451	1.049	0.931
Saturation:	98.1%	100.0%	100.0%	100.0%	100.0%
Pore Press. Parameter B:		0.980	0.980	0.990	0.990

Maximum Stress Ratio (s_1/s_3)

	Stage 1	Stage 2	Stage 3
Axial Strain:	2.3%	2.3%	1.7%
Deviator Stress (kPa):	97.4	125.9	229.3
Stress Ratio:	3.28	1.81	1.76
Change in Pore Pressure (kPa):	79.1	230.7	343.9
Rate of Displacement (%/hr):	0.337	0.337	0.337

Maximum Deviator Stress (s_1-s_3)

	Stage 3
Axial Strain:	1.7%
Deviator Stress (kPa):	229.3
Stress Ratio:	1.76
Change in Pore Pressure (kPa):	343.6
Rate of Displacement (%/hr):	0.337

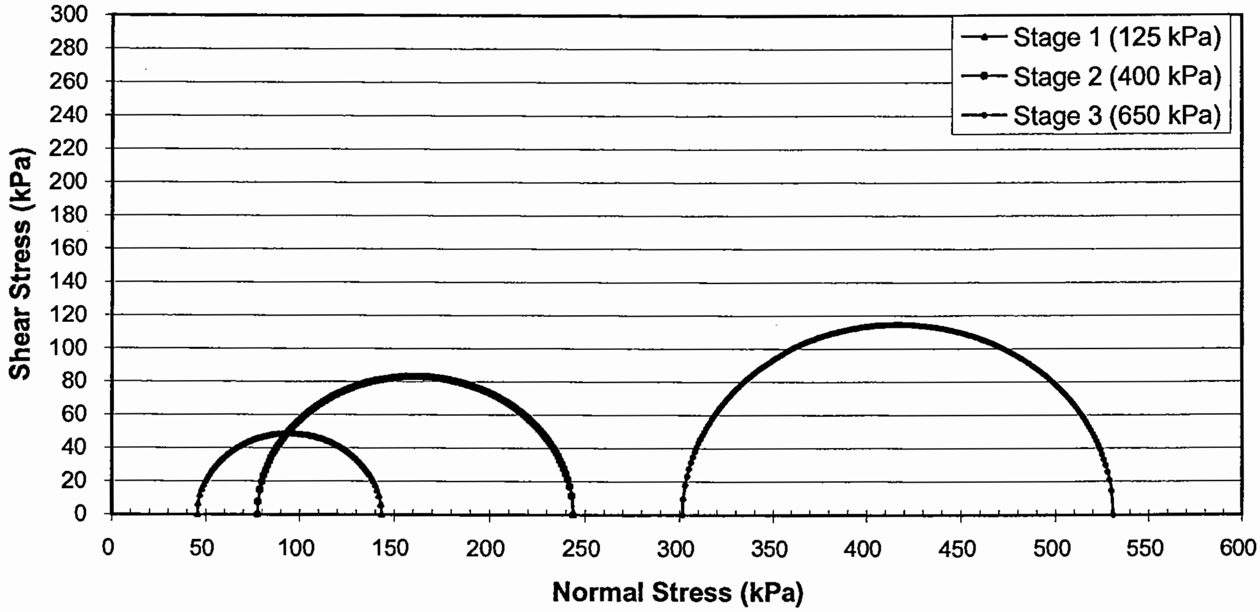
Notes: **Error occurred during Stage 3 shearing**
Insufficient pressure supply

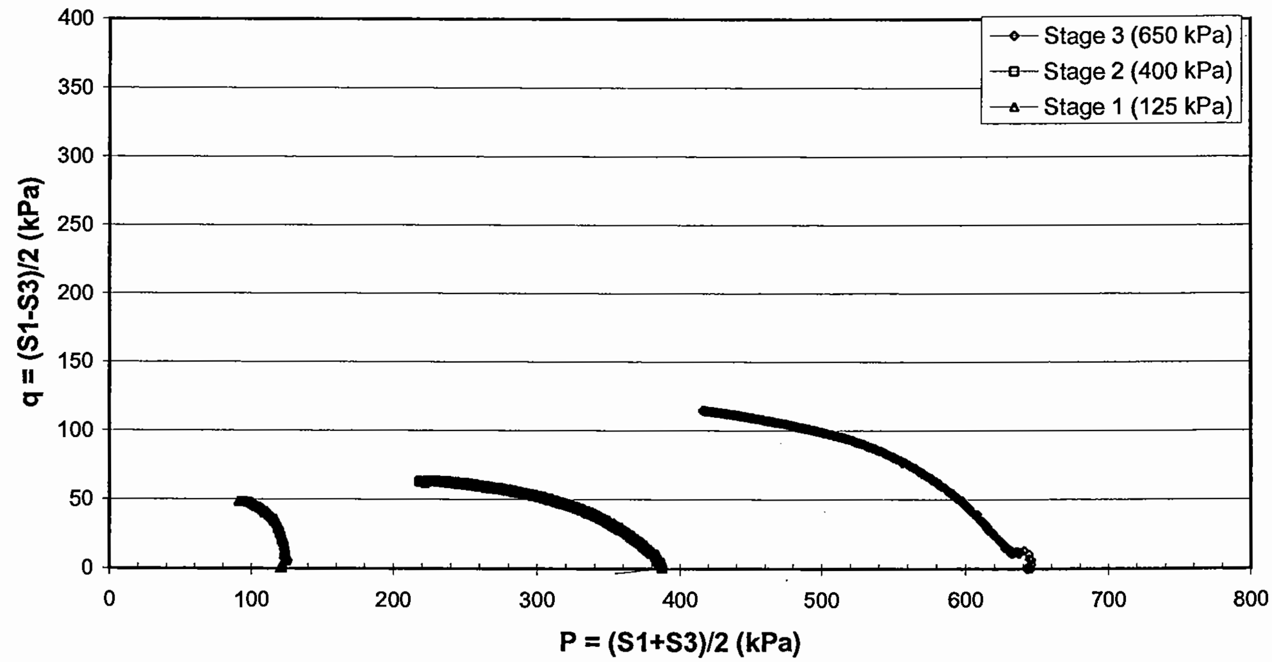
TEST DONE BY: JPL
REVIEWED BY: JPL

MULTI STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST REPORT

Highway 69 - Swamp 613 (Hwy 537)
18-45-1 / 19-2805-2 BH537-2, ST1, 20'6"-21'3"

BH 537-2 ST1





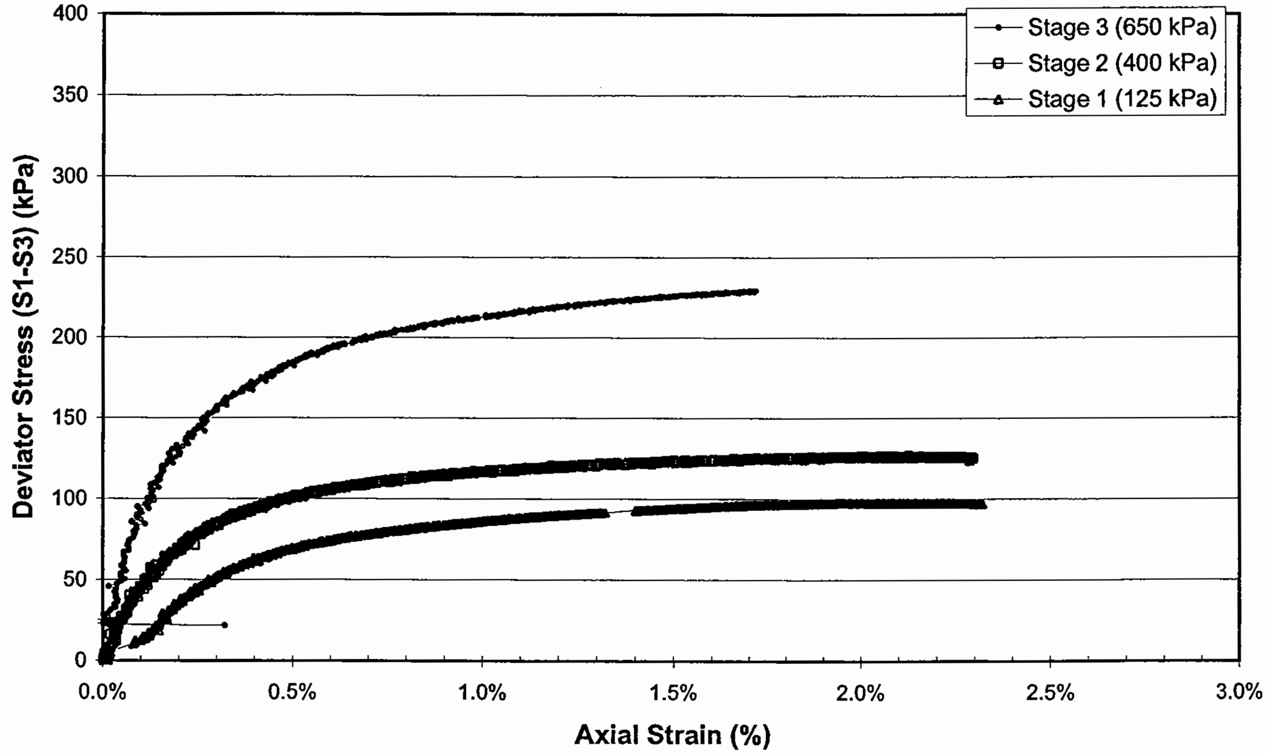
TEST DONE BY: JPL
REVIEWED BY: JPL

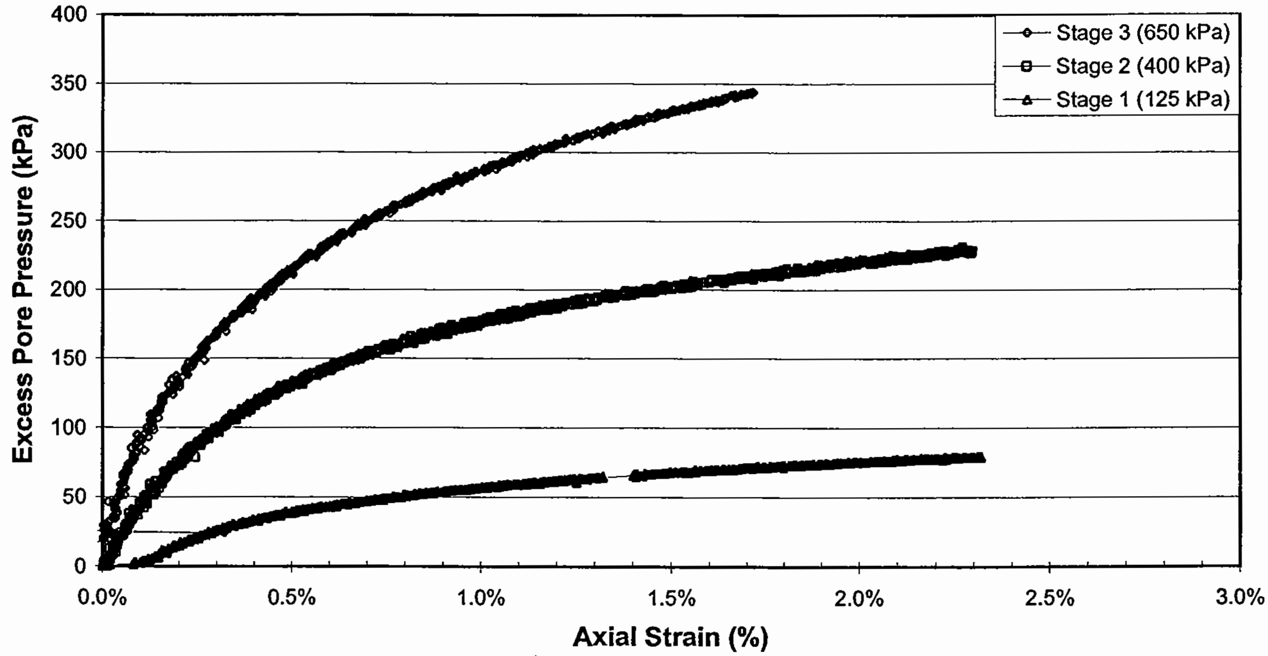
THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

MULTI STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST REPORT

Highway 69 - Swamp 613 (Hwy 537)
18-45-1 / 19-2805-2 BH537-2, ST1, 20'6"-21'3"

BH 537-2 ST1





TEST DONE BY: JPL
REVIEWED BY: JPL

FOUNDATION INVESTIGATION
AND DESIGN REPORT
HIGHWAY 69, FOUR-LANING
FROM 4KM SOUTH OF ESTAIRE TO 1KM NORTH OF HIGHWAY 537, 12KM
EMBANKMENTS THROUGH SWAMPS 602, 605 AND 613
ONTARIO

G.W.P. 312-99-00 (Swamps 602 and 605)

G.W.P.5249-05-00 (Swamp 613)

Geocres Number: 41I-198

VOLUME 2/2

Report to

Totten Sims Hubicki Associates Ltd.

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May 15, 2006

Appendix C

Limit Equilibrium Analysis

THURBER

HIGHWAY 69 - FOUR LANING - SWAMP 602
STABILITY ANALYSIS - SUMMARY (2m SURCHARGE)

Fill Material	Station	Study Area (SBL / Median / NBL)	Main Embankment			Slope Flattening		Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (3)
			Maximum Height (m)		Slope Inclination (H:V)	Required for Stability (Yes/No)	Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)				
			Top of Pavement Height (m)	Top of Surcharge (m)										
Rock Fill	12+660	SBL West Toe	2.0	4.0	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	4.0	0.0	0.9
SSM Fill	12+680 (Culvert 3)	SBL West Toe	4.8	6.8	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.8	0.0	0.9
	12+680 (Culvert 3)	SBL East Toe	4.8	6.8	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.8	0.0	0.9
	12+680 (Culvert 3)	NBL West Toe	4.8	6.8	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.3	0.0	0.9
	12+680 (Culvert 3)	NBL East Toe	4.8	6.8	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.8	0.0	0.9
Rock Fill	12+700	NBL West Toe	3.4	5.4	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.4	0.0	0.9
	12+700	NBL East Toe	3.4	5.4	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.4	0.0	0.9
SSM Fill	12+890 (Culvert 4)	SBL West Toe	3.2	5.2	2:1	No	4:1	N/R	N/R	N/R	1 of 1	5.2	0.0	0.9
	12+890 (Culvert 4)	NBL West Toe	3.3	5.3	2:1	No	4:1	N/R	N/R	N/R	1 of 1	5.3	0.0	0.9
	12+890 (Culvert 4)	NBL East Toe	3.3	5.3	2:1	No	4:1	N/R	N/R	N/R	1 of 1	5.3	0.0	0.9

STABILITY ANALYSIS - SUMMARY (3.5m SURCHARGE)

Fill Material	Station	Study Area (SBL / Median / NBL)	Main Embankment			Slope Flattening		Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (3)
			Maximum Height (m)		Slope Inclination (H:V)	Required for Stability (Yes/No)	Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)				
			Top of Pavement Height (m)	Top of Surcharge (m)										
Rock Fill	12+660	SBL West Toe	2.0	5.5	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.5	0.0	0.9
SSM Fill	12+680 (Culvert 3)	SBL West Toe	4.8	8.3	2:1	No	4:1	N/R	N/R	N/R	1 of 1	8.3	0.0	0.9
	12+680 (Culvert 3)	SBL East Toe	4.8	8.3	2:1	No	4:1	N/R	N/R	N/R	1 of 1	8.3	0.0	0.9
	12+680 (Culvert 3)	NBL West Toe	4.8	8.3	2:1	No	4:1	N/R	N/R	N/R	1 of 1	8.3	0.0	0.9
	12+680 (Culvert 3)	NBL East Toe	4.8	8.3	2:1	No	4:1	N/R	N/R	N/R	1 of 1	8.3	0.0	0.9
Rock Fill	12+700	NBL West Toe	3.4	6.9	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	6.9	0.0	0.9
	12+700	NBL East Toe	3.4	6.9	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	6.9	0.0	0.9
SSM Fill	12+890 (Culvert 4)	SBL West Toe	3.2	6.7	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.7	0.0	0.9
	12+890 (Culvert 4)	NBL West Toe	3.3	6.8	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.8	0.0	0.9
	12+890 (Culvert 4)	NBL East Toe	3.3	6.8	2:1	No	4:1	N/R	N/R	N/R	1 of 1	6.8	0.0	0.9

Notes:

(1) 0.9 / 0.1 / 0.01 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage

N/R Not Required for stability

TABLE C.1

HIGHWAY 69 - FOUR LANING - SWAMP 605
STABILITY ANALYSIS - SUMMARY (2m SURCHARGE)

Fill Material	Station	Study Area (SBL / Median / NBL)	Main Embankment: Maximum Height (m): Top of Pavement Height (m)	Main Embankment: Maximum Height (m): Top of Surcharge (m)	Main Embankment: Slope Inclination (H:V)	Slope Flattening: Required for Stability (Yes/No)	Slope Flattening: Slope Inclination (H:V)	Berm: Top Width (m)	Berm: Height (m)	Berm: Slope Inclination (H:V)	Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (1)
Rock Fill	14+290	SBL West Toe	7.0	9.0	1.25:1	Yes (3)	4:1	N/R	N/R	N/R	1 of 3	5.0	0.0	0.9
											2 of 3	7.0	5.0	0.9/0.1
											3 of 3	9.0	7.0	0.9/0.1/0.01
		NBL East Toe	7.1	9.1	1.25:1	Yes (4)	4:1	N/R	N/R	N/R	1 of 1	9.1	0.0	0.9
	14+330	Median	7.3	9.3	1.25:1	Yes (5)	4:1	4.0	3.5	4:1	1 of 3	6.3	0.0	0.9
											2 of 3	8.3	6.3	0.9/0.1
											3 of 3	9.3	8.3	0.9/0.1/0.01
		SBL West Toe and NBL East Toe	7.3	9.3	1.25:1	Yes (5)	4:1	2.0	3.5	4:1	1 of 3	6.3	0.0	0.9
											2 of 3	8.3	6.3	0.9/0.1
											3 of 3	9.3	8.3	0.9/0.1/0.01
	14+390	NBL East Toe (2)	7.9	9.9	1.25:1	Yes (6)	4:1	N/R	N/R	N/R	1 of 3	6.9	0.0	0.9
											2 of 3	7.9	6.9	0.9/0.1
											3 of 3	9.9	7.9	0.9/0.1/0.01
		Median	8.0	10.0	1.25:1	No (7)	4:1	22.0	4.0	1.25:1	1 of 3	7.0	0.0	0.9
											2 of 3	9.0	7.0	0.9/0.1
											3 of 3	10.0	9.0	0.9/0.1/0.01
Granular Fill	Culvert 7	SBL West Toe	8.0	10.0	2:1	Yes (8)	4:1	2.0	4.0	4:1	1 of 3	8.0	0.0	0.9
											2 of 3	9.0	8.0	0.9/0.1
											3 of 3	10.0	9.0	0.9/0.1/0.01
		NBL East Toe	9.0	11.0	2:1	No	4:1	N/R	N/R	N/R	1 of 1	11.0	0.0	0.9

STABILITY ANALYSIS - SUMMARY (3.5m SURCHARGE)

Fill Material	Station	Study Area (SBL / Median / NBL)	Main Embankment: Maximum Height (m): Top of Pavement Height (m)	Main Embankment: Maximum Height (m): Top of Surcharge (m)	Main Embankment: Slope Inclination (H:V)	Slope Flattening: Required for Stability (Yes/No)	Slope Flattening: Slope Inclination (H:V)	Berm: Top Width (m)	Berm: Height (m)	Berm: Slope Inclination (H:V)	Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (1)
Rock Fill	14+290	SBL West Toe	7.0	10.5	1.25:1	Yes (3)	4:1	5.0	3.5	4:1	1 of 3	6.0	0.0	0.9
											2 of 3	9.0	6.0	0.9/0.1
											3 of 3	10.5	9.0	0.9/0.1/0.01
		NBL East Toe	7.1	10.6	1.25:1	Yes (4)	4:1	N/R	N/R	N/R	1 of 1	10.6	0.0	0.9
	14+330	Median	7.3	10.8	1.25:1	Yes (5)	4:1	10.0	3.5	4:1	1 of 3	7.3	0.0	0.9
											2 of 3	9.3	7.3	0.9/0.1
											3 of 3	10.8	9.3	0.9/0.1/0.01
		SBL West Toe and NBL East Toe	7.3	10.8	1.25:1	Yes (5)	4:1	6.0	3.5	4:1	1 of 3	7.3	0.0	0.9
											2 of 3	9.3	7.3	0.9/0.1
											3 of 3	10.8	9.3	0.9/0.1/0.01
	14+390	NBL East Toe (2)	7.9	11.4	1.25:1	Yes (6)	4:1	3.0	4.0	4:1	1 of 3	7.9	0.0	0.9
											2 of 3	10.4	7.9	0.9/0.1
											3 of 3	11.4	10.4	0.9/0.1/0.01
		Median	8.0	11.5	1.25:1	No (7)	4:1	25.0	4.0	1.25:1	1 of 3	8.0	0.0	0.9
											2 of 3	10.0	8.0	0.9/0.1
											3 of 3	11.5	10.0	0.9/0.1/0.01
Granular Fill	Culvert 7	SBL West Toe	8.0	11.5	2:1	Yes (8)	4:1	7.0	4.0	4:1	1 of 3	9.0	0.0	0.9
											2 of 3	10.5	9.0	0.9/0.1
											3 of 3	11.5	10.5	0.9/0.1/0.01
		NBL East Toe	9.0	12.5	2:1	No	4:1	N/R	N/R	N/R	1 of 1	12.5	0.0	0.9
Rock Fill	Culvert 7 (Forward Slope)	SBL West Toe	8.0	11.5	1.25:1	-	-	-	-	-	-	11.5	-	-

Notes:

(1) 0.9 / 0.1 / 0.01 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
(2) SBL West Toe at Sta. 14+390 is the location of the west end of Culvert #7
(3) Construction of slope flattening to be carried out in conjunction with the embankment main body fill (rock fill or granular fill) with maximum difference in elevation between the slope flattening and the embankment main body fill equal to 1m
(4) The rock fill may be constructed without slope flattening to 6.1m high. Beyond this height the elevation of the top of the slope flattening should be kept within 1m of the rock fill top elevation.
(5) The rock fill may be constructed without slope flattening to 4.0m high. Beyond this height the elevation of the top of the slope flattening should be kept within 1m of the rock fill top elevation.
(6) The rock fill may be constructed without slope flattening to 6.9m high. Beyond this height the elevation of the top of the slope flattening should be kept within 1m of the rock fill top elevation.
(7) The rock fill may be constructed without slope flattening to 4.5m high. Beyond this height the elevation of the top of the slope flattening should be kept within 1m of the rock fill top elevation.
(8) The main body of the embankment granular fill may be constructed without slope flattening to 4.0m high. Beyond this height the elevation of slope flattening should be kept within 1m of the embankment main body elevation.
N/R Not Required for stability

TABLE C.2

HIGHWAY 69 - FOUR LANING - SWAMP 613
STABILITY ANALYSIS - SUMMARY (2m SURCHARGE)

Fill Material	Station	Study Area (SBL / Median / NBL)	Main Embankment			Slope Flattening		Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (3)	Geosynthetic Reinforcement (kN)
			Maximum Height (m)		Slope Inclination (H:V)	Required for Stability (Yes/No)	Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)					
			Top of Pavement Height (m)	Top of Surcharge (m)											
Rock Fill	Hwy 69 10+520	SBL West Toe	2.9	4.9	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	4.9	0.0	0.9	0
	Hwy 69 10+520	NBL West Toe	3.1	5.1	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.1	0.0	0.9	0
	Hwy 69 10+520	NBL East Toe	3.1	5.1	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.1	0.0	0.9	0
SSM Fill	Hwy 69 10+570	SBL West Toe	0.5	2.5	2:1	No	4:1	N/R	N/R	N/R	1 of 1	2.5	0.0	0.9	0
Rock Fill	Hwy 69 10+570	NBL West Toe	2.1	4.1	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	4.1	0.0	0.9	0
	Hwy 69 10+570	NBL East Toe	2.1	4.1	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	4.1	0.0	0.9	0
	Hwy 537 9+900	North/South Toe	2.1	4.1	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	4.1	0.0	0.9	0
	Hwy 537 9+960	North/South Toe	5.4	7.4	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	7.4	0.0	0.9	0
SSM Fill	Hwy 537 9+960	North/South Toe	5.4	7.4	2:1	No	4:1	N/R	N/R	N/R	1 of 1	7.4	0.0	0.9	0
Rock Fill	Hwy 537 10+040	North/South Toe	8.2	10.2	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	10.2	0.0	0.9	0
SSM Fill	Hwy 537 10+040	North/South Toe	8.2	10.2	2:1	No	4:1	N/R	N/R	N/R	1 of 1	10.2	0.0	0.9	0
Rock Fill	Hwy 537 10+130	North/South Toe	3.9	5.9	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.9	0.0	0.9	0

STABILITY ANALYSIS - SUMMARY (3.5m SURCHARGE)

Fill Material	Station	Study Area (SBL / Median / NBL)	Main Embankment			Slope Flattening		Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (3)	Geosynthetic Reinforcement (kN)
			Maximum Height (m)		Slope Inclination (H:V)	Required for Stability (Yes/No)	Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)					
			Top of Pavement Height (m)	Top of Surcharge (m)											
Rock Fill	Hwy 69 10+520	SBL West Toe	2.9	4.9	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	4.9	0.0	0.9	0
	Hwy 69 10+520	NBL West Toe	3.1	6.6	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	6.6	0.0	0.9	0
	Hwy 69 10+520	NBL East Toe	3.1	6.6	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	6.6	0.0	0.9	0
SSM Fill	Hwy 69 10+570	SBL West Toe	0.5	4.0	2:1	No	4:1	N/R	N/R	N/R	1 of 1	4.0	0.0	0.9	0
Rock Fill	Hwy 69 10+570	NBL West Toe	2.1	5.6	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.6	0.0	0.9	0
	Hwy 69 10+570	NBL East Toe	2.1	5.6	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.6	0.0	0.9	0
	Hwy 537 9+900	North/South Toe	2.1	5.6	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	5.6	0.0	0.9	0
	Hwy 537 9+960	North/South Toe	5.4	8.9	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	8.9	0.0	0.9	0
SSM Fill	Hwy 537 9+960	North/South Toe	5.4	8.9	2:1	No	4:1	N/R	N/R	N/R	1 of 1	8.9	0.0	0.9	0
Rock Fill	Hwy 537 10+040	North/South Toe	8.2	11.7	1.25:1	No	4:1	N/R	N/R	N/R	1 of 2	10.2	0.0	0.9	0
											2 of 2	11.7	10.2	0.9/0.1	0
SSM Fill	Hwy 537 10+040	North/South Toe	8.2	11.7	2:1	No	4:1	N/R	N/R	N/R	1 of 2	10.2	0.0	0.9	0
											2 of 2	11.7	10.2	0.9/0.1	0
Rock Fill	Hwy 537 10+130	North/South Toe	3.9	7.4	1.25:1	No	4:1	N/R	N/R	N/R	1 of 1	7.4	0.0	0.9	0

Notes:

(1) 0.9 / 0.1 / 0.01 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
N/R Not Required for stability

TABLE C.3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18	80	0	.21	2
Sty Clay Fm-Stif	17.5	50	0	.21	3
Silt-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 14, 2006
Swamp 602 - Station 12+660, SBL, West Toe
3.5m Surcharge - Short Term

H=2.0 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 1 m
Granular Fill to 2 m
Surcharge to 5.5 m

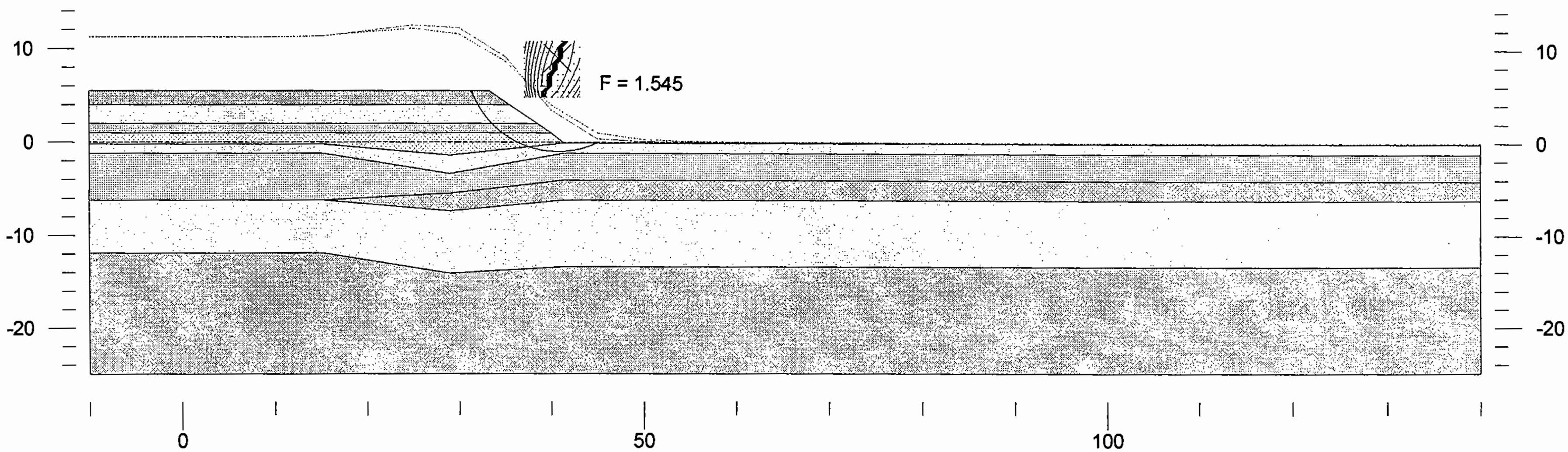

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Figure C1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18	80	0	.21	2
Sty Clay Fm-Stif	17.5	50	0	.21	3
Silt-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 14, 2006
Swamp 602 - Station 12+680 (Culvert 3), SBL West Toe
3.5m Surcharge - Short Term

H = 4.8 m to Top of Pavement
3.5 m of Surcharge
STAGE 1: SSM Fill to 4.8 m
Surcharge to 8.3 m

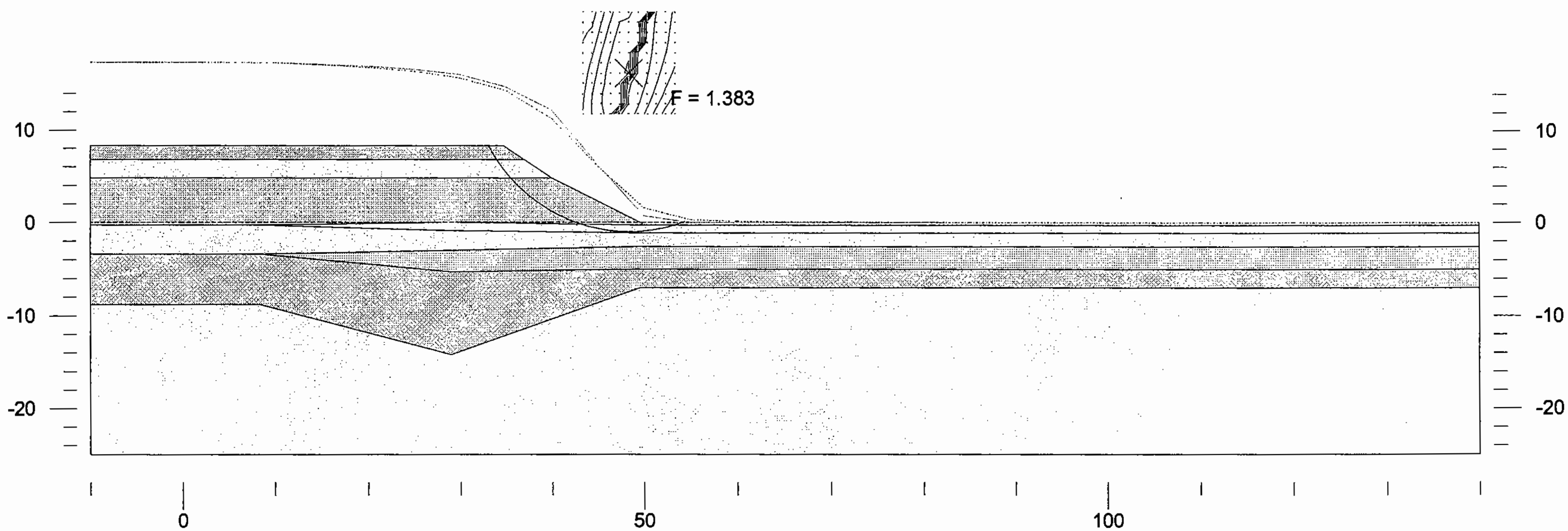

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Figure C2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18	80	0	.21	2
Sty Clay Fm-Stif	17.5	50	0	.21	3
Silt-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 14, 2006
Swamp 602 - Station 12+680 (Culvert 3), NBL East Toe
3.5 m Surcharge - Short Term

H = 4.8m to Top of Pavement
3.5 m Surcharge
STAGE 1: SSM Fill to 4.8 m
Surcharge to 8.3 m

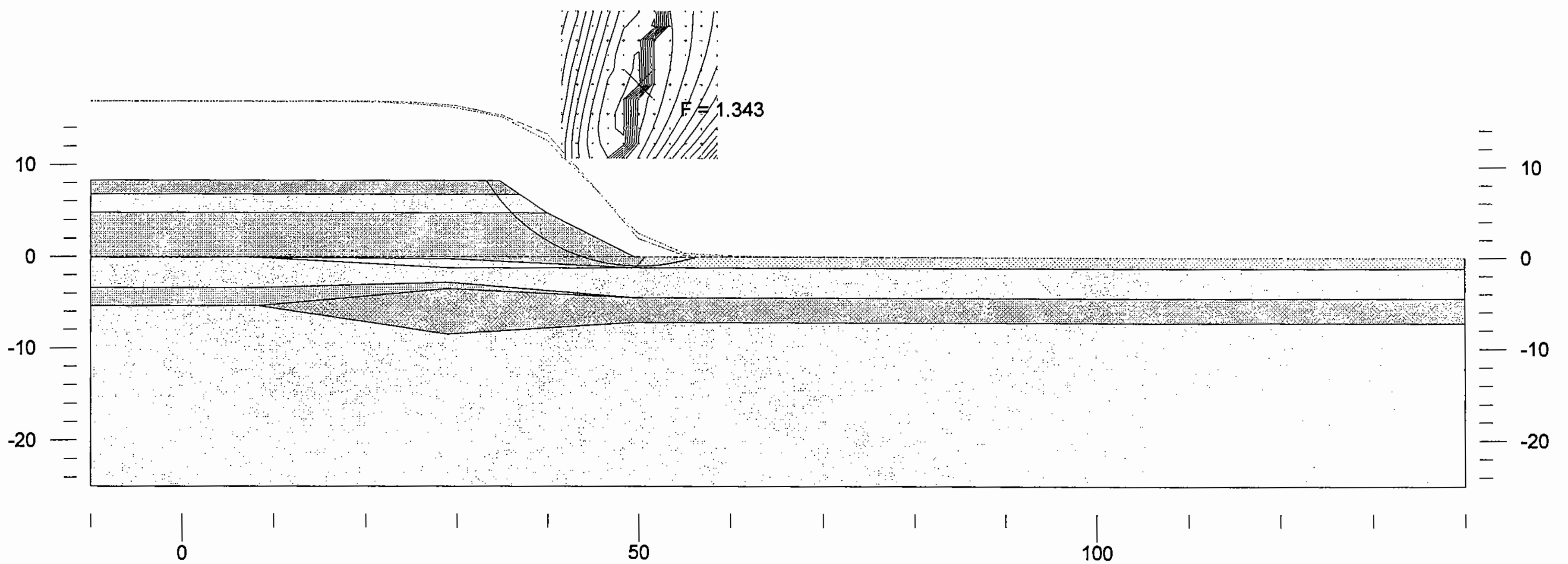

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Figure C3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silty Clay Crust	18	80	0	.21	2
Sty Clay Fm-Stif	17.5	50	0	.21	3
Silt-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 14, 2006
Swamp 602 - Station 12+700, NBL, East Toe
3.5m Surcharge - Short Term

H = 3.4 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 2.4 m
Granular Fill to 3.4 m
Surcharge to 6.9 m

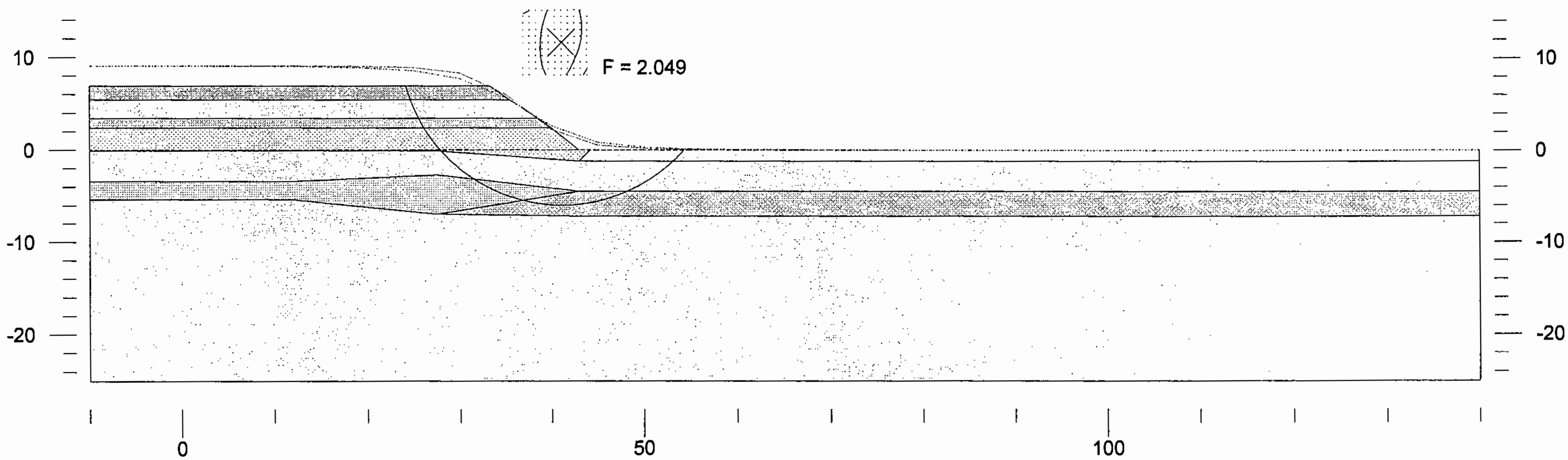

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Figure C4

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18.5	100	0	.21	2
Clay Fm-Stif Top	17	35	0	.21	3
Clay Fm-Stif Bot	17.5	35	0	.21	4
Silt-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 14, 2006
Swamp 602 - Station 12+890 (Culvert 4), NBL West Toe
3.5m Surcharge - Short Term

H = 3.3 m to Top of Pavement
3.5 m Surcharge
STAGE 1: SSM Fill to 3.3 m
Surcharge to 6.8 m

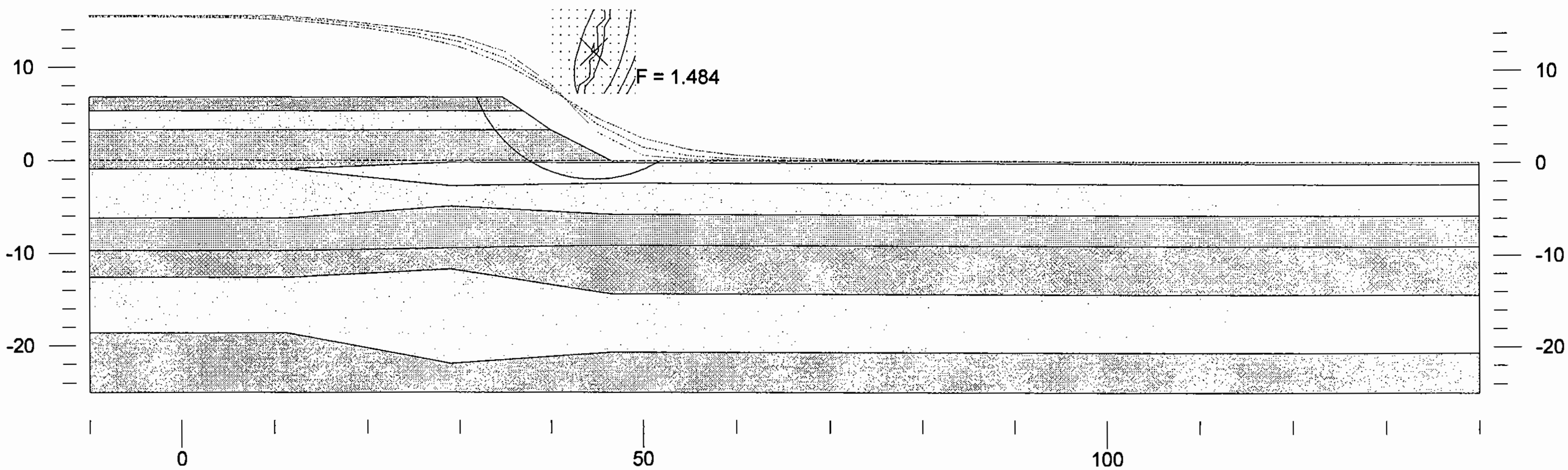

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Figure C5

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Sl. Flat. Top	19	0	30	0	1
Granular Fill	22	0	32	0	1
Sl. Flat. Middle	19	0	30	0	1
Rock Fill Top	20	0	42	0	1
Sl. Flat. Bottom	19	0	30	0	1
Rock Fill Bottom	20	0	42	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay (Top)	17	22	0	.21	2
Silty Clay (Bot)	17.5	25	0	.21	3
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 9, 2006
Swamp 605 - Station 14+290, SBL, West Toe
Short Term - Stage 3

H = 7.0 m to Top of Pavement
2 m of Surcharge
STAGE 1: Rock Fill + Slope Flattening to 5 m
STAGE 2: Rock Fill, Granular + Slope Flattening to 7 m
STAGE 3: Surcharge to 9 m

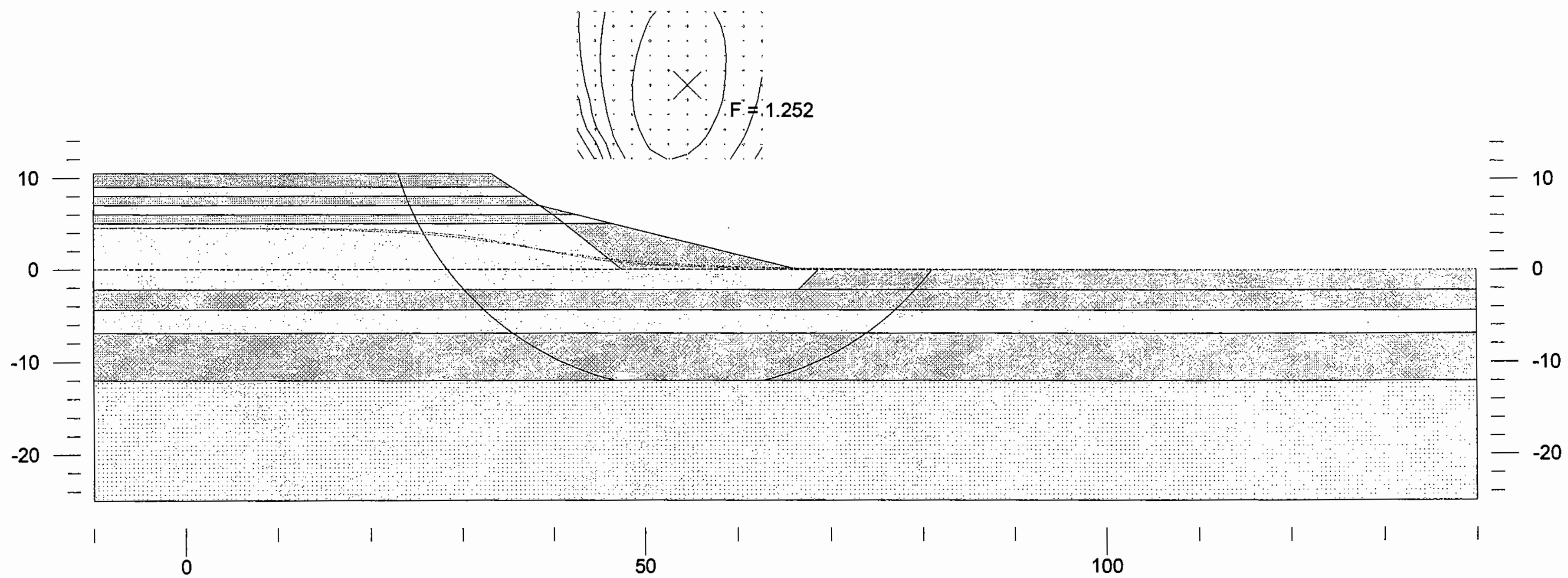

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Figure C6

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 9, 2006
Swamp 605 - Station 14+290, SBL, West Toe
Short Term - Stage 3

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Sl. Flat. Top	19	0	30	0	1
Granular Fill	22	0	32	0	1
Sl. Flat. Middle	19	0	30	0	1
Rock Fill Top	20	0	42	0	1
Sl. Flat. Bottom	19	0	30	0	1
Rock Fill Bottom	20	0	42	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay (Top)	17	22	0	.21	2
Silty Clay (Bot)	17.5	25	0	.21	3
Bedrock	(Infinitely Strong)				

H = 7.0 m to Top of Pavement
3.5 m Surcharge
5 m wide x 3.5 m high Berm
STAGE 1: Rock Fill + Slope Flattening to 6 m
STAGE 2: Granular / Slope Flattening / Surcharge to 9 m
STAGE 3: Surcharge to 10.5 m

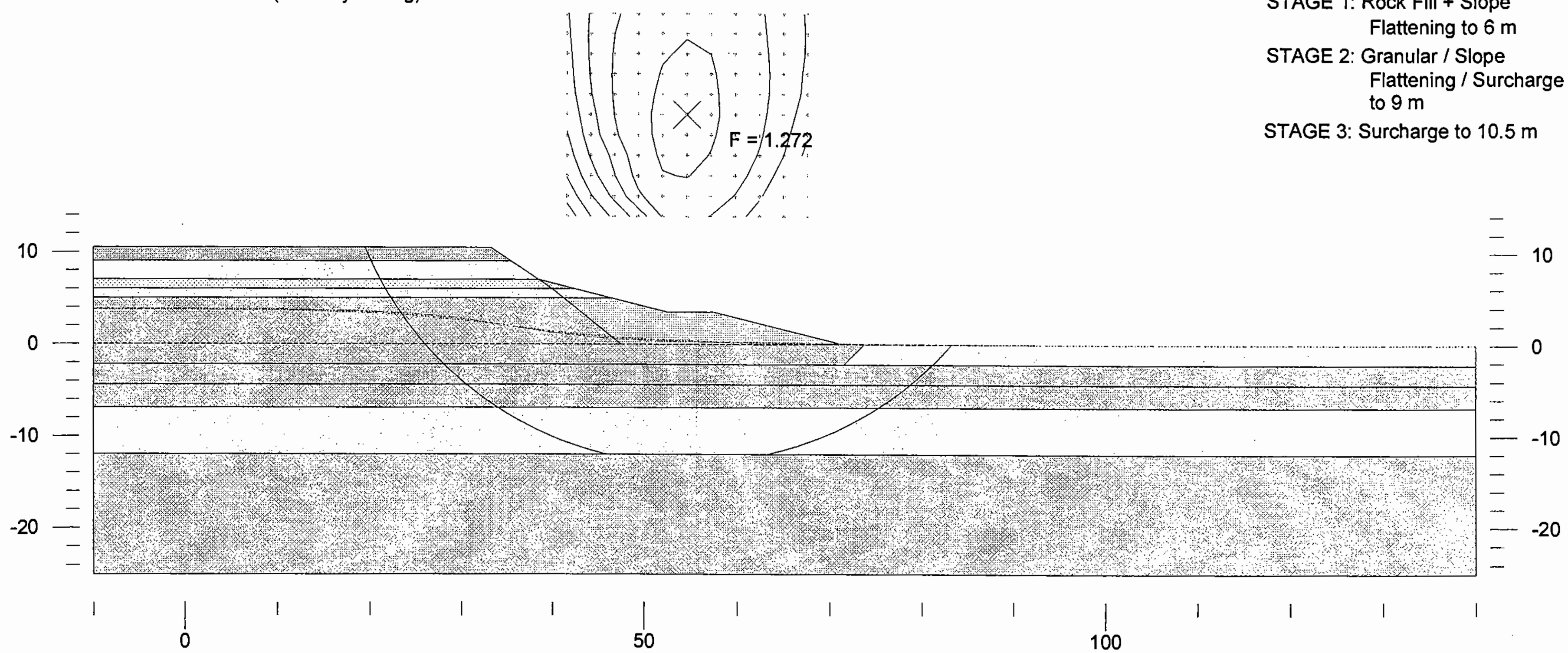

Figure C7

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silty Clay (Top)	17	22	0	.21	2
Silty Clay (Mid)	17.5	25	0	.21	3
Silty Clay (Bot)	18	35	0	.21	4
Silt/Sand-NP	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 10, 2006
Swamp 605 - Station 14+330, Median
Short term - Stage 3

H = 7.3 m to Top of Pavement
2 m Surcharge
3.5 m high x 4 m wide Berm
STAGE 1: Rock Fill to 6.3 m + Slope Flattening
STAGE 2: Granular to 7.3 m + Surcharge to 8.3 m
STAGE 3: Surcharge to 9.3 m

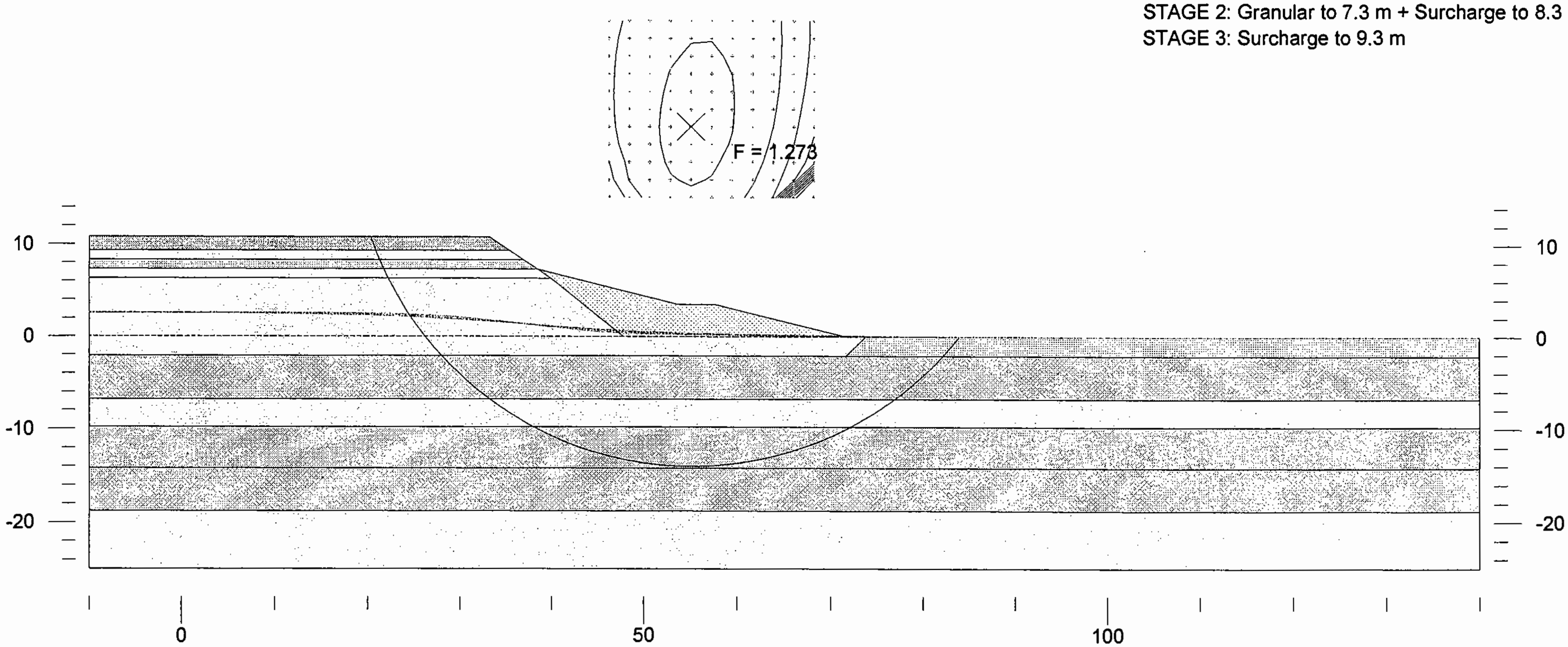

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Figure C8

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silty Clay (Top)	17	22	0	.21	2
Silty Clay (Mid)	17.5	25	0	.21	3
Silty Clay (Bot)	18	35	0	.21	4
Silt/Sand-NP	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 11, 2006
Swamp 605 - Station 14+330, Median
Short term - Stage 3

H = 7.3 m to Top of Pavement
3.5 m Surcharge
3.5 m high x 10 m wide Berm
STAGE 1: Rock Fill to 6.3 m, Granular to 7.3 m, + Slope Flattening
STAGE 2: Surcharge to 9.3 m
STAGE 3: Surcharge to 10.8 m

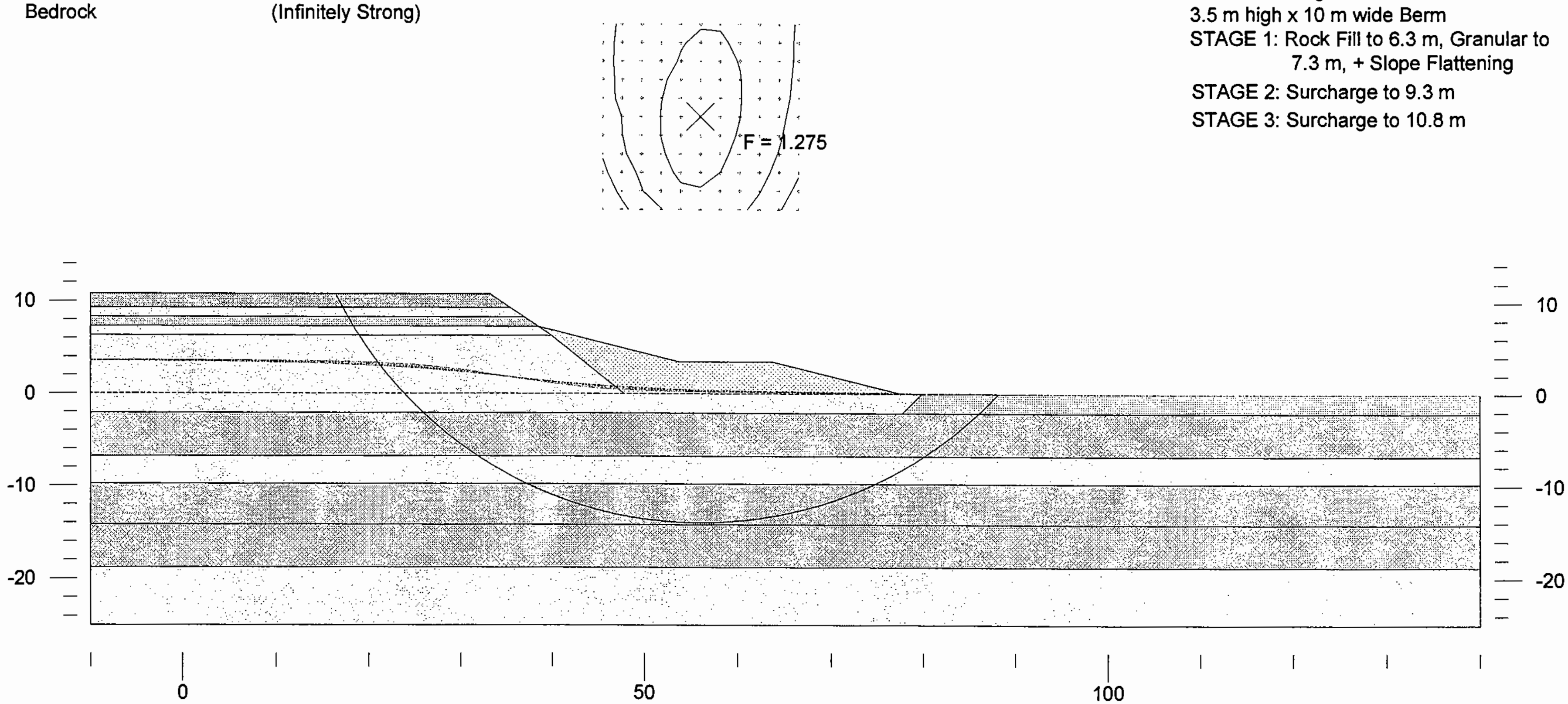

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Figure C9

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt - ML	19.5	2	30	0	2
Silty Clay (Top)	17	22	0	.21	3
Silty Clay (Mid)	17.5	25	0	.21	4
Silty Clay (Bot)	18	35	0	.21	5
Silt/Sand-NP	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 10, 2006
Swamp 605 - Station 14+330, SBL West Toe + NBL East Toe
Short Term - Stage 3

H = 7.3 m to Top of Pavement
2 m Surcharge
3.5 m high x 2 m wide berm
STAGE 1: Rock Fill to 6.3 m + Slope Flattening
STAGE 2: Granular to 7.3 m / Surcharge to 8.3 m
STAGE 3: Surcharge to 9.3 m

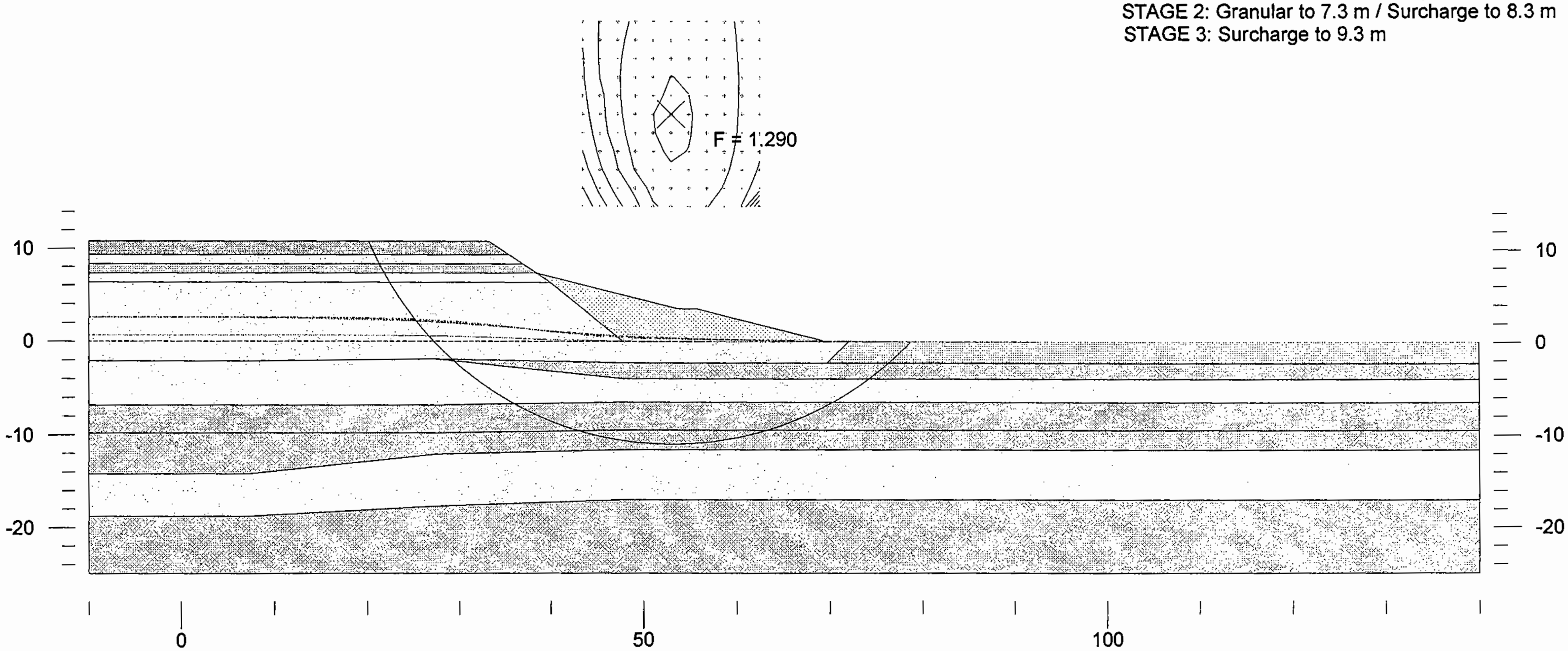

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Figure C10

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt - ML	19.5	2	30	0	2
Silty Clay (Top)	17	22	0	.21	3
Silty Clay (Mid)	17.5	25	0	.21	4
Silty Clay (Bot)	18	35	0	.21	5
Silt/Sand-NP	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 11, 2006
Swamp 605 - Station 14+330, SBL West Toe
Short Term - Stage 3

H = 7.3 m to Top of Pavement
3.5 m Surcharge
3.5 m high x 6 m Berm
STAGE 1: Rock Fill to 6.3 m / Granular to 7.3 m
+ Slope Flattening
STAGE 2: Surcharge to 9.3 m
STAGE 3: Surcharge to 10.8 m

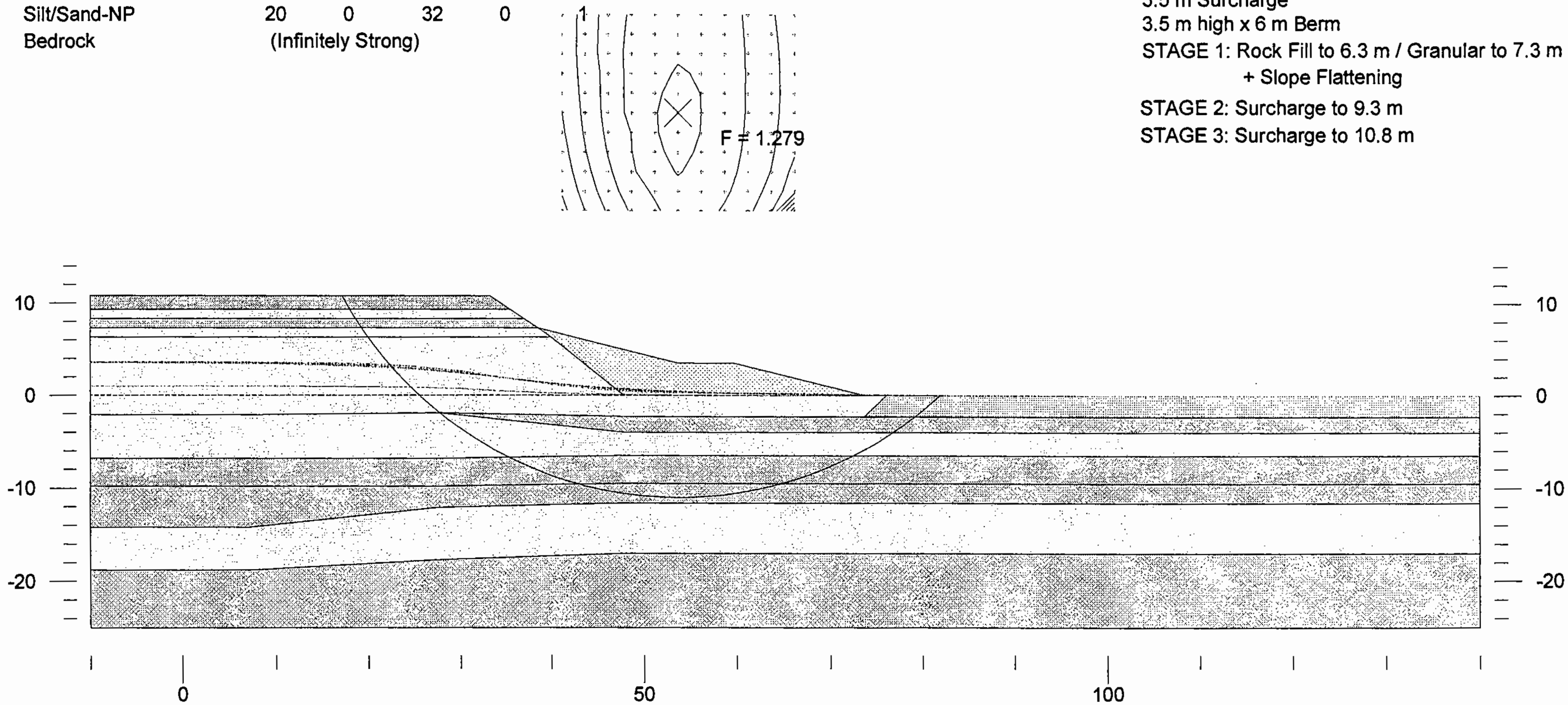

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Figure C11

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-Clay (Top)	17.5	35	0	.21	2
Silt-Clay (Mid)	17	20	0	.21	3
Silt-Clay (Bot)	17.5	25	0	.21	4
Silt-Clay (Base)	17.5	30	0	.21	5
St-Clay Fm/Stif	17.5	45	0	.21	6
Silt-Sand (NP)	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 13, 2006
Swamp 605 - Stn 14+390 - NBL East Toe
Short Term - Stage 3

H = 7.9 m to Top of Pavement
2 m Surcharge
4:1 Slope Flattening
STAGE 1: Rock Fill to 6.9 m
STAGE 2: Granular Fill to 7.9 m
+ Slope Flattening
STAGE 3: Surcharge to 9.9 m

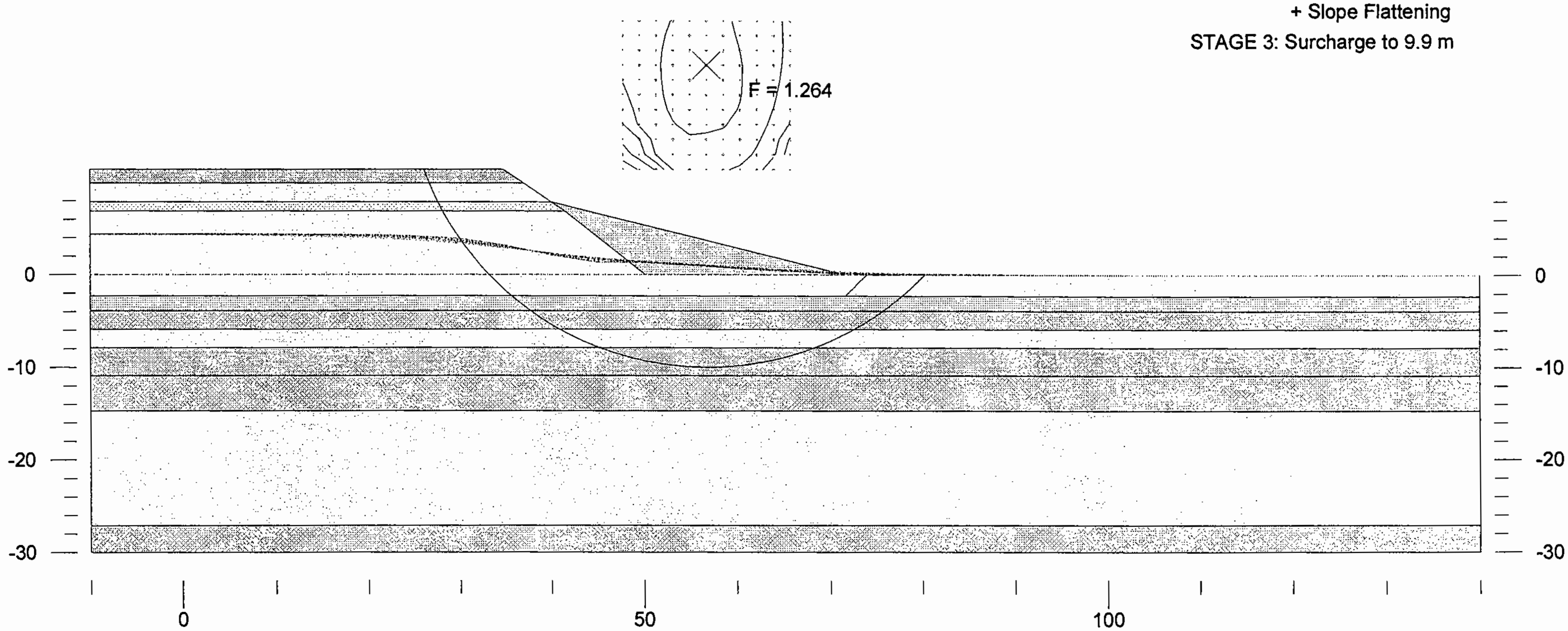

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Figure C12

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-Clay (Top)	17.5	35	0	.21	2
Silt-Clay (Mid)	17	20	0	.21	3
Silt-Clay (Bot)	17.5	25	0	.21	4
Silt-Clay (Base)	17.5	30	0	.21	5
St-Clay Fm/Stif	17.5	45	0	.21	6
Silt-Sand (NP)	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 13, 2006
Swamp 605 - Stn 14+390 - NBL East Toe
Short Term - Stage 3

H = 7.9 m to Top of Pavement
3.5 m Surcharge
4:1 Slope Flattening with 4 m high x 3 m wide berm
STAGE 1: Rock Fill to 6.9 m / Granular to 7.9 m / Slope Flattening
STAGE 2: Surcharge to 10.4 m
STAGE 3: Surcharge to 11.4 m

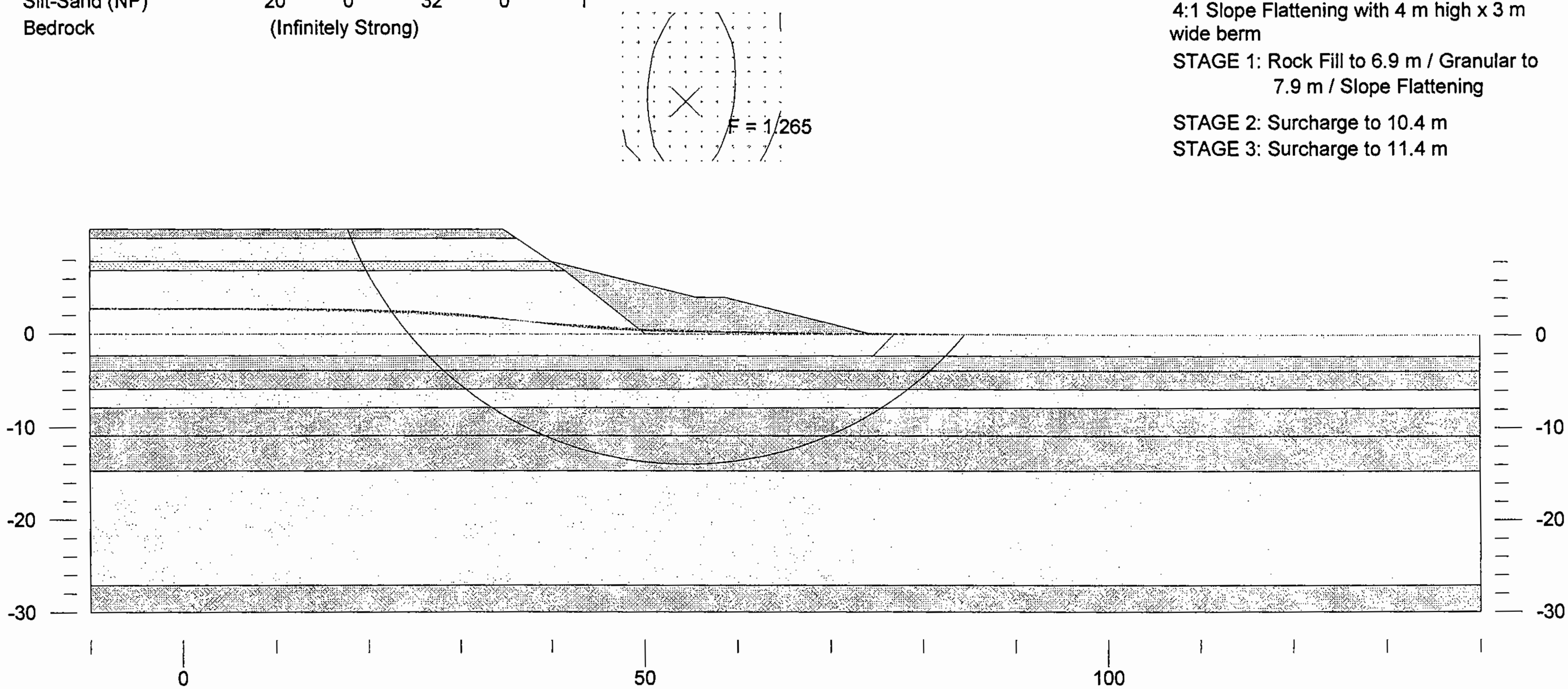

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Figure C13

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-Clay (Top)	17.5	35	0	.21	2
Silt-Clay (Mid)	17	20	0	.21	3
Silt-Clay (Bot)	17.5	25	0	.21	4
Silt-Clay (Base)	17.5	30	0	.21	5
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 13, 2006
Swamp 605 - Stn 14+390 - Median
Short Term - Stage 3

H = 8.0 m to Top of Pavement
2 m Surcharge
4 m high x 22 m wide Berm
STAGE 1: Rock Fill to 7 m
STAGE 2: Granular Fill to 8 m
/ Surcharge to 9 m
STAGE 3: Surcharge to 10 m

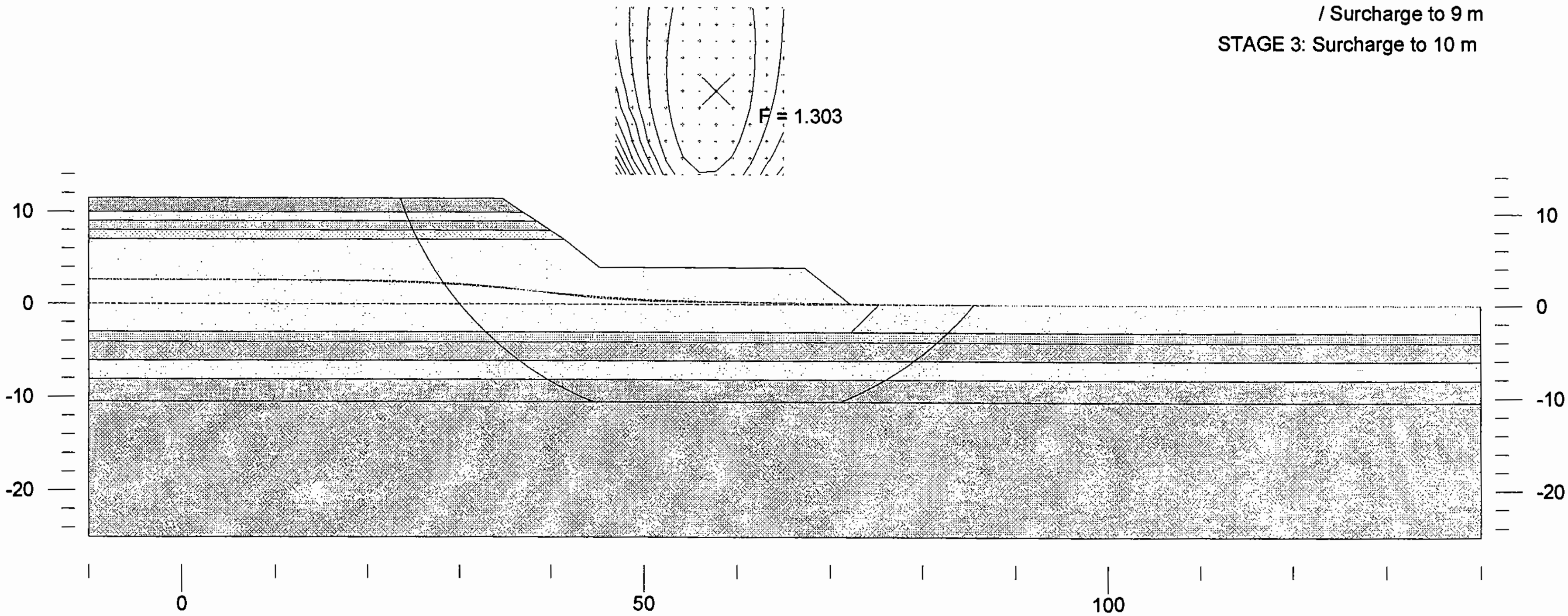

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Figure C14

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-Clay (Top)	17.5	35	0	.21	2
Silt-Clay (Mid)	17	20	0	.21	3
Silt-Clay (Bot)	17.5	25	0	.21	4
Silt-Clay (Base)	17.5	30	0	.21	5
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 13, 2006
Swamp 605 - Stn 14+390 - Median
Short Term - Stage 3

H = 8 m to Top of Pavement
3.5 m Surcharge
4 m high x 25 m wide Berm

STAGE 1: Rock Fill to 7 m, Granular to 8 m
STAGE 2: Surcharge to 10 m
STAGE 3: Surcharge to 11.5 m

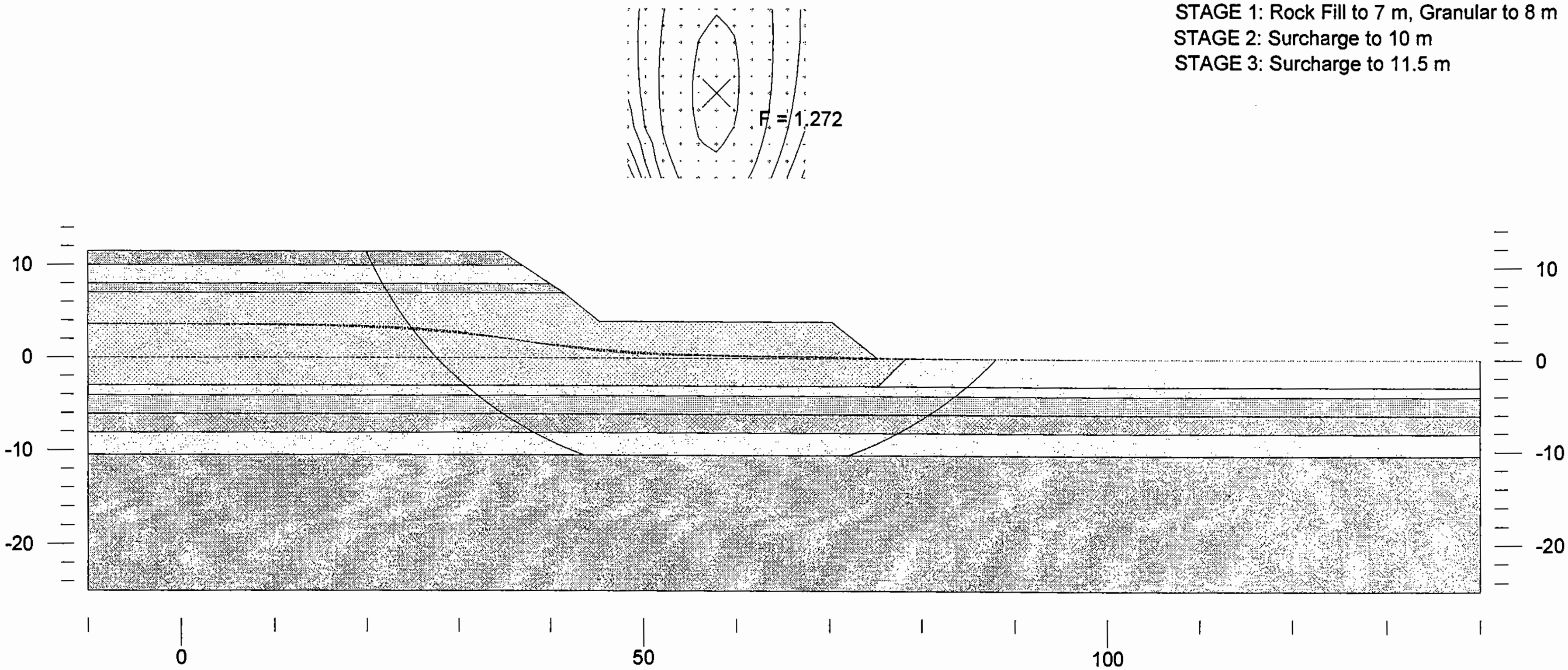

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Figure C15

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
Silt - ML	19.5	2	30	0	1
St-Clay Sft/Fm	17.5	20	0	.21	2
St-Clay Fm/Stif	17.5	30	0	.21	3
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 12, 2006
Swamp 605 - Culvert 7 - SBL West Toe
Short Term - Stage 3

H = 8.0 m to Top of Pavement
4 m wide x 2 m high Berm
2 m Surcharge
STAGE 1: SSM to 8 m + Slope Flattening
STAGE 2: Surcharge to 9 m
STAGE 3: Surcharge to 10 m

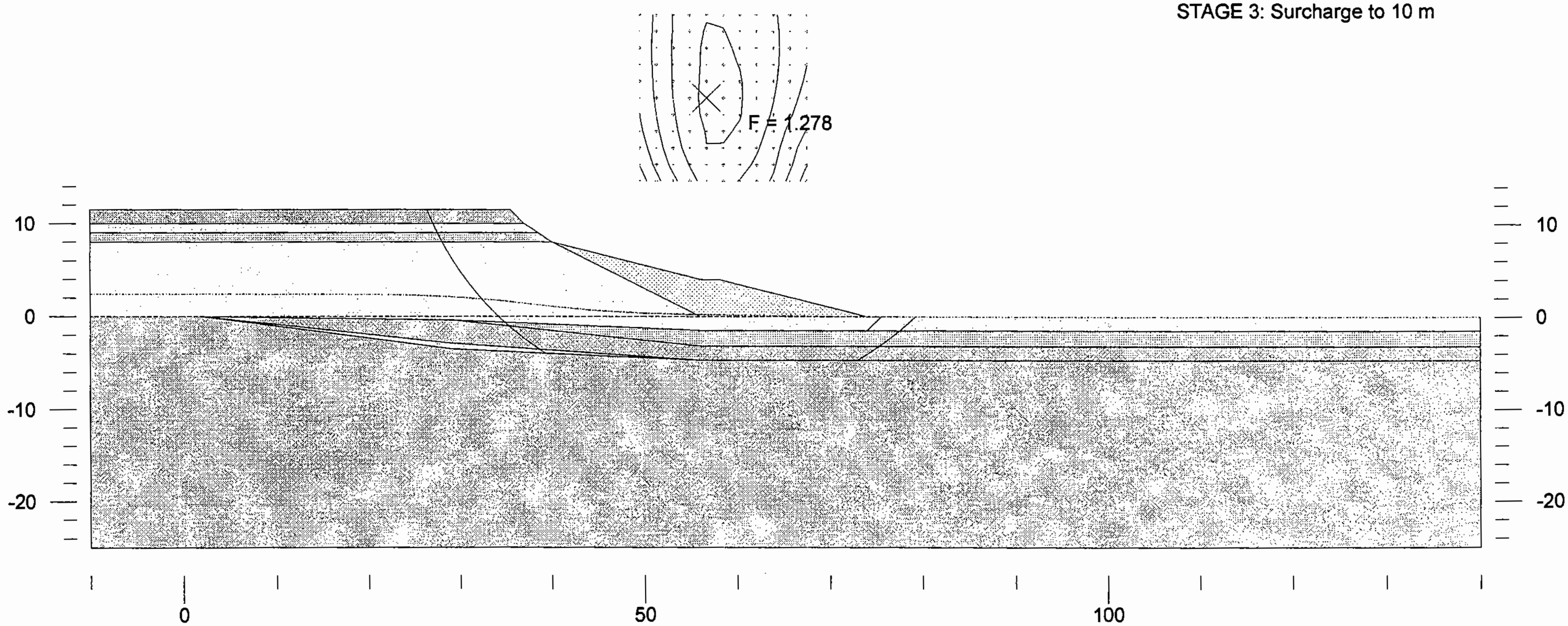

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Figure C16

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge middle	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Slope Flattening	19	0	30	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
Silt - ML	19.5	2	30	0	1
St-Clay Sft/Fm	17.5	20	0	.21	2
St-Clay Fm/Stif	17.5	30	0	.21	3
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 12, 2006
Swamp 605 - Culvert 7 - SBL West Toe
Short Term - Stage 3

H = 8.0 m to Top of Pavement
4 m high x 7 m wide Berm
3.5 m Surcharge
STAGE 1: SSM to 8 m / Surcharge to 9 m + Slope Flattening
STAGE 2: Surcharge to 10.5 m
STAGE 3: Surcharge to 11.5 m

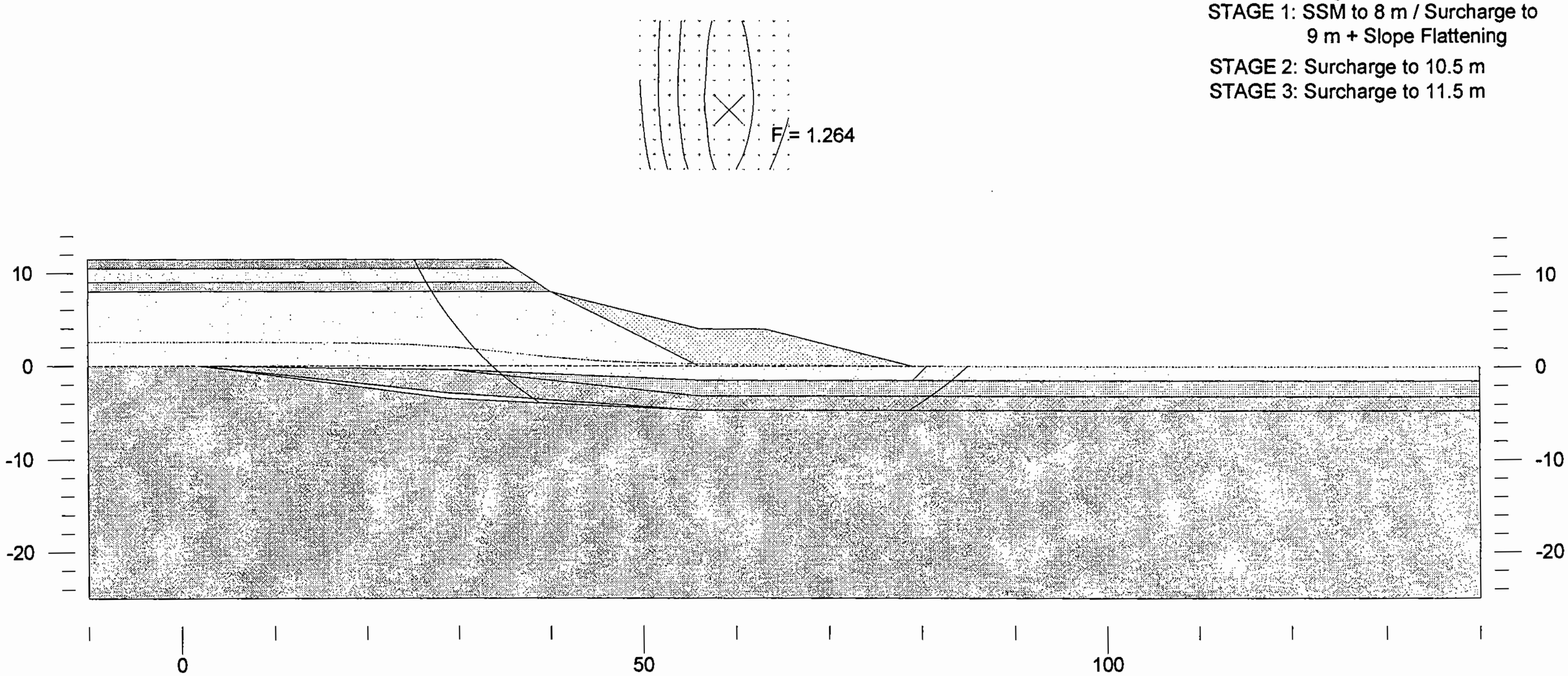

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Figure C17

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge bottom	22	0	32	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
St-Clay Sft/Fm	17.5	20	0	.21	2
St-Clay Fm/Stif	17.5	30	0	.21	3
Silt/Sand-NP	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 12, 2006
Swamp 605 - Culvert 7 - NBL East Toe
Short Term - Single Stage

H = 9 m to Top of Pavement
2m Surcharge
STAGE 1: SSM to 9 m, Surcharge to 11 m

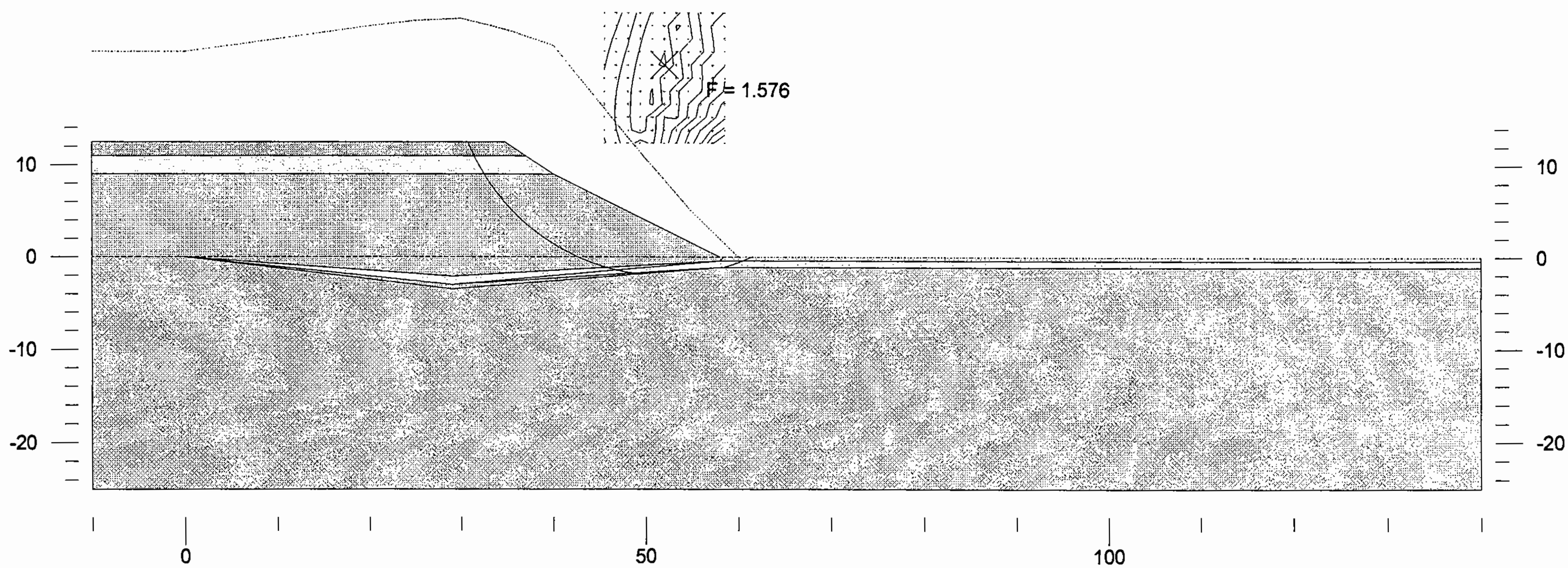

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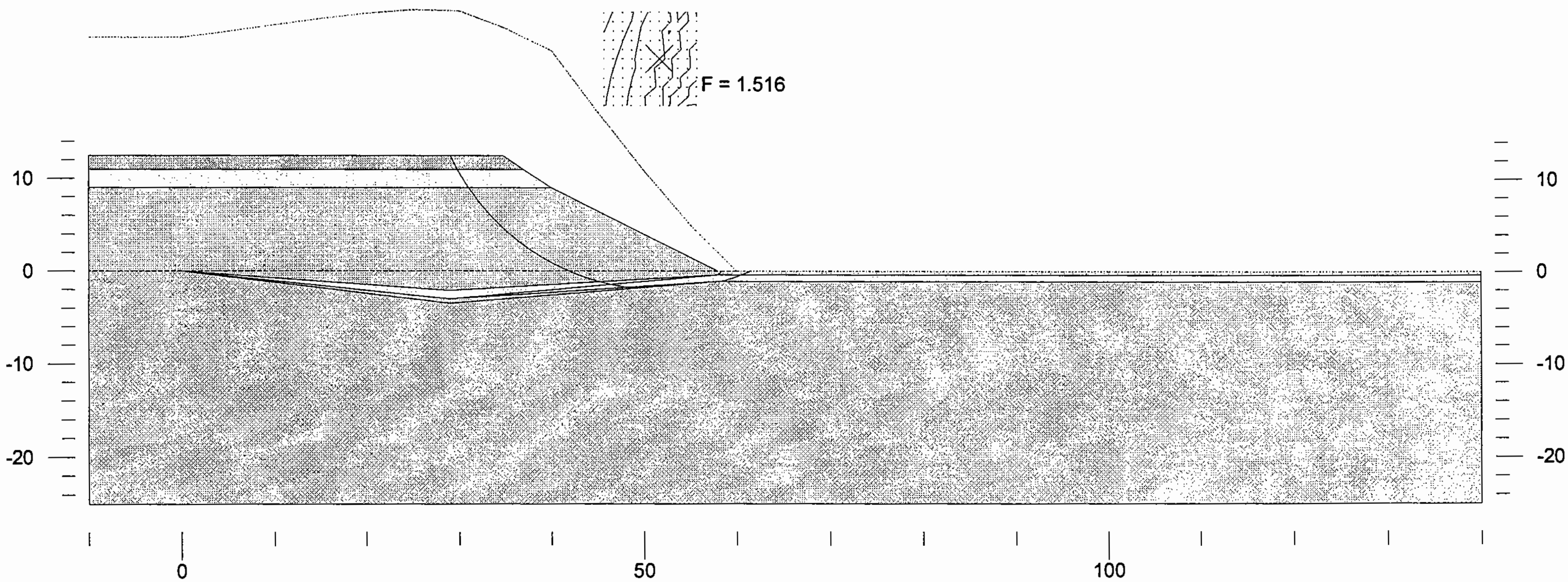
Figure C18

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
St-Clay Sft/Fm	17.5	20	0	.21	2
St-Clay Fm/Stif	17.5	30	0	.21	3
Silt/Sand-NP	20	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 12, 2006
Swamp 605 - Culvert 7 - NBL East Toe
Short Term - Single Stage

H = 9 m to Top of Pavement
3.5 m Surcharge
STAGE 1: SSM to 9 m
Surcharge to 12.5 m



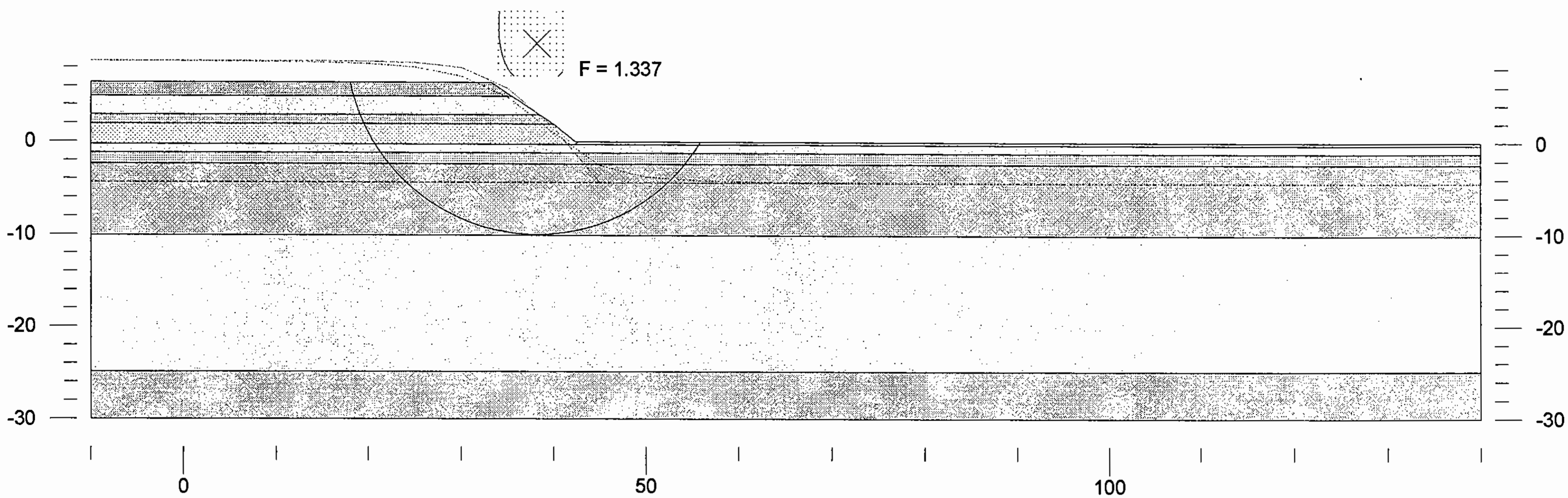
22/02/2006 12:47:17 PM C:\WINDOWS\DESKTOP\SLOPES~1\605\CULVER~1\605S3H01.GSL Thurber Engineering Ltd. - Toronto F = 1.516

Figure C19

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18	80	0	.21	2
Sty Clay Fm-Stif	17.5	30	0	.21	3
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 15, 2006
Swamp 613 - Hwy 69 Stn 10+520, SBL West Toe
3.5m Surcharge - Short Term

H = 2.9 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 1.9 m
Granular Fill to 2.9 m
Surcharge to 6.4 m



22/02/2006 12:50:08 PM C:\WINDOWS\DESKTOP\SLOPES~1\613\HWY691~1\613R3A01.GSL Thurber Engineering Ltd. - Toronto F = 1.337

Figure C20

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18	80	0	.21	2
Sty Clay Fm-Stif	17.5	30	0	.21	3
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 15, 2006
Swamp 613 - Hwy 69 Stn 10+520, NBL West Toe
3.5m Surcharge - Short Term

H = 3.1 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 2.1 m
Granular Fill to 3.1 m
Surcharge to 6.6 m

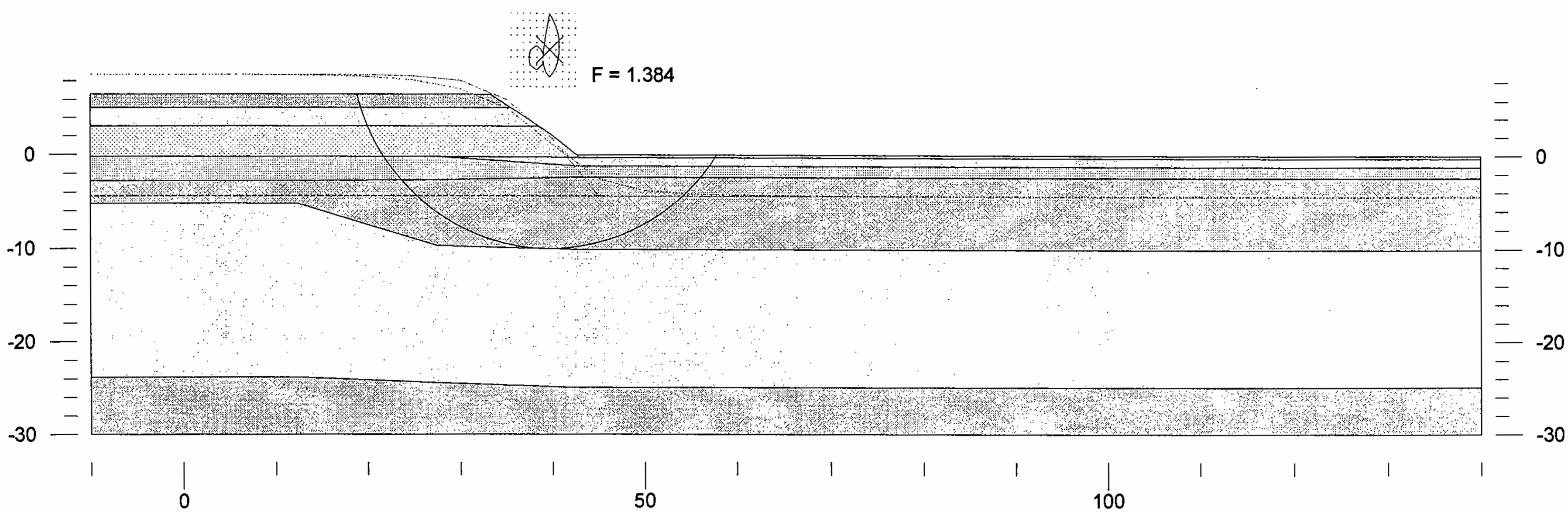


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Figure C21

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
SSM Fill	22	0	32	0	1
Peat	12	2	28	0	1
Silty Clay Crust	18	80	0	.21	2
Clay Fm-Stif Top	17	40	0	.21	3
Clay Fm-Stif Mid	17.5	30	0	.21	4
Clay Fm-Stif Bot	17.5	30	0	.21	5
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 69 Stn 10+570, SBL West Toe
3.5m Surcharge - Short Term

H = 0.5 m to Top of Pavement
3.5 m Surcharge
STAGE 1: SSM Fill to 0.5 m Surcharge to 4 m

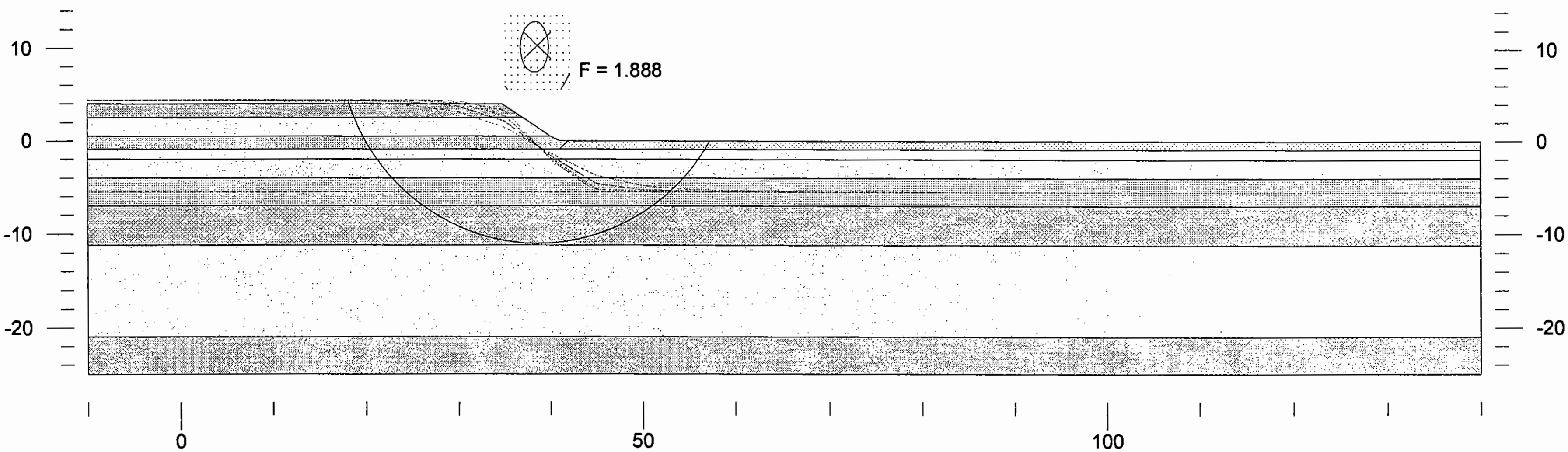

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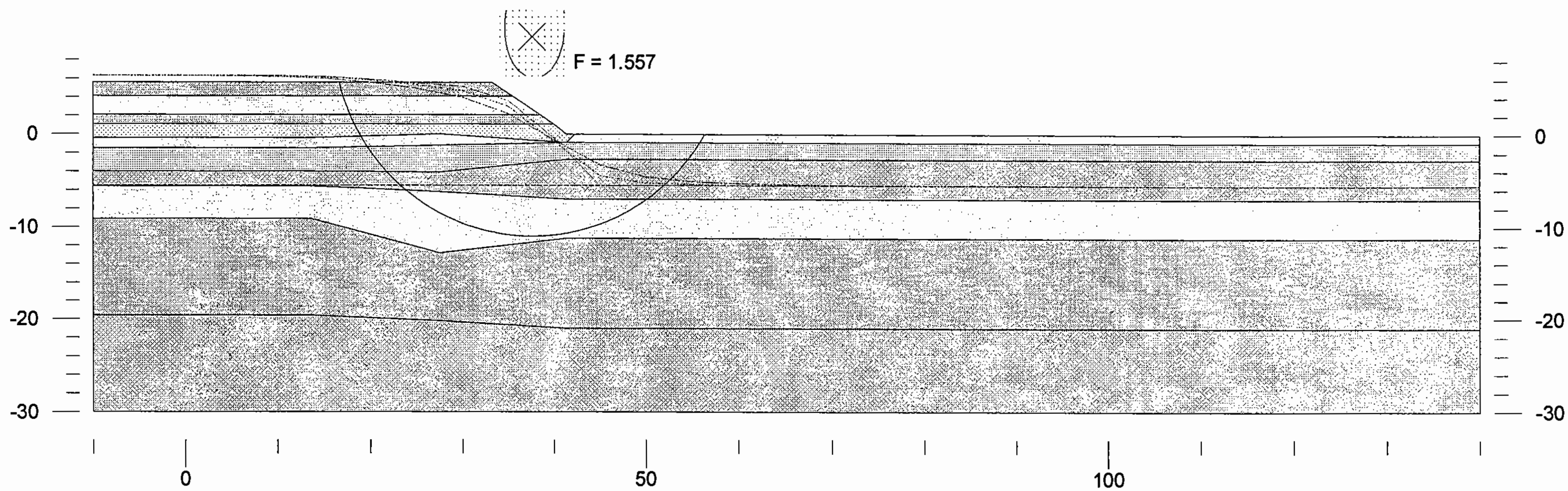
Figure C22

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	0	42	0	1
Peat	12	2	28	0	1
Silt-ML	19.5	2	30	0	1
Silty Clay Crust	18	80	0	.21	2
Clay Fm-Stif Top	17	30	0	.21	3
Clay Fm-Stif Bot	17.5	30	0	.21	4
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 69 Stn 10+570, NBL West Toe
3.5 m Surcharge - Short Term

H = 2.1 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 1.1 m
Granular Fill to 2.1 m
Surcharge to 5.6 m



22/02/2006 1:24:38 PM C:\WINDOWS\DESKTOP\SLOPES~1\613\HWY691~2\613R3D01.GSL Thurber Engineering Ltd. - Toronto F = 1.557

Figure C23

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	2	42	0	1
Peat	12	2	28	0	1
Sand	20	0	32	0	1
Clay Fm-Stif Top	17	40	0	.21	2
Clayey Silt Stif	18	50	0	.21	3
Clay Fm-Stif Mid	17.5	60	0	.21	4
Clay Fm-Stif Bot	17.5	35	0	.21	5
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 537 Stn 9+900
3.5m Surcharge - Short Term

H = 2.1 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 1.1 m
Granular Fill to 2.1 m
Surcharge to 5.6 m

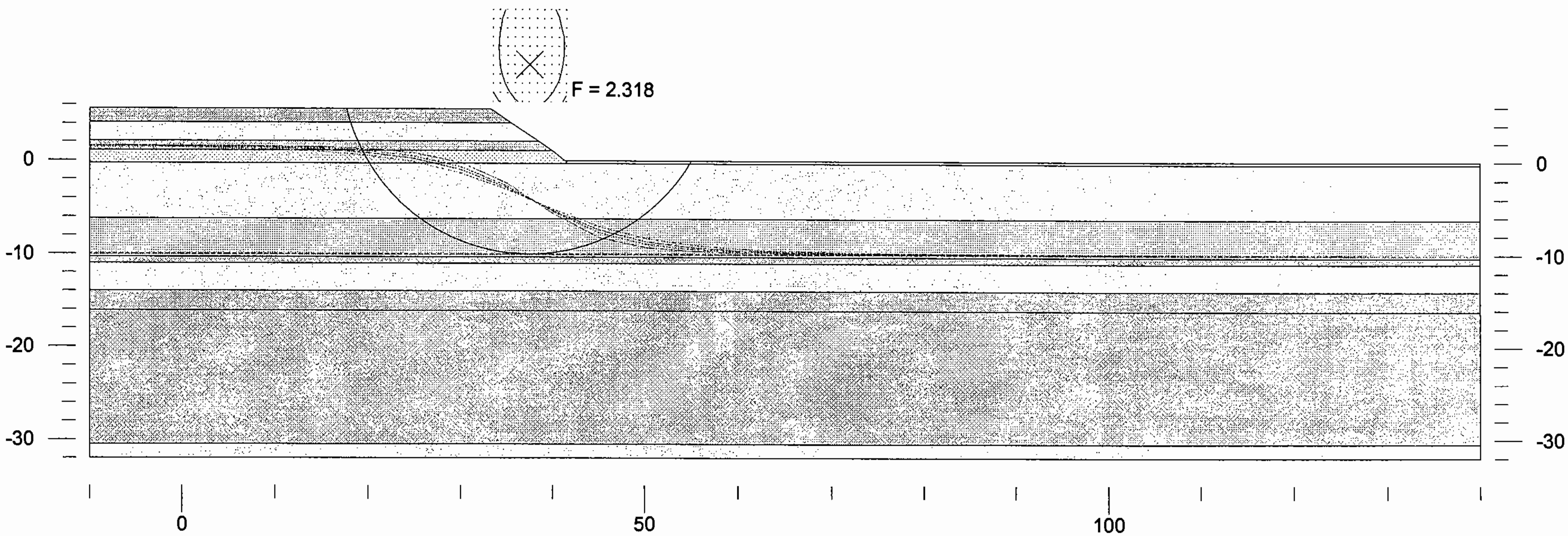


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Figure C24

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	2	42	0	1
Peat	12	2	28	0	1
Silt and Sand	20	2	32	0	1
Clay Fm-Stif Top	17.5	50	0	.21	2
Clay Fm-Stif Mid	17	50	0	.21	3
Clay Fm-Stif Bot	17	50	0	.21	4
Cly Fm-Stif Base	17.5	70	0	.21	5
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 537 Stn 9+960
3.5m Surcharge - Short Term

H = 5.4 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 4.4 m
Granular Fill to 5.4 m
Surcharge to 8.9 m

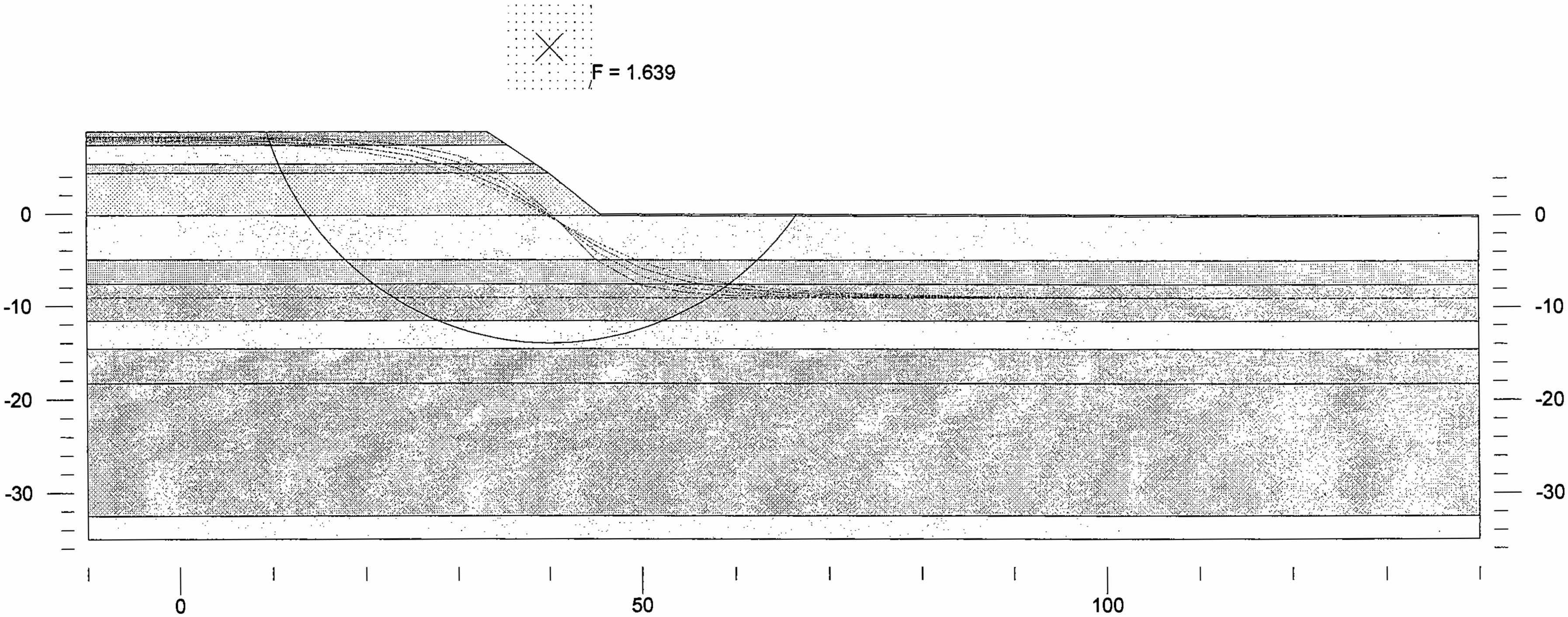

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Figure C25

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	.01	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	2	42	0	1
Peat	12	2	28	0	1
Silty Clay Crust	18	80	0	.21	2
Clay Fm-Stif Top	17	50	0	.21	3
Clay Fm-Stif Mid	17	40	0	.21	4
Clay Fm-Stif Bot	17.5	60	0	.21	5
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 537 Stn 10+040
2m Surcharge - Short Term

H = 8.2 m to Top of Pavement
2 m Surcharge
STAGE 1: Rock Fill to 7.2 m
Granular Fill to 8.2 m
Surcharge to 10.2 m

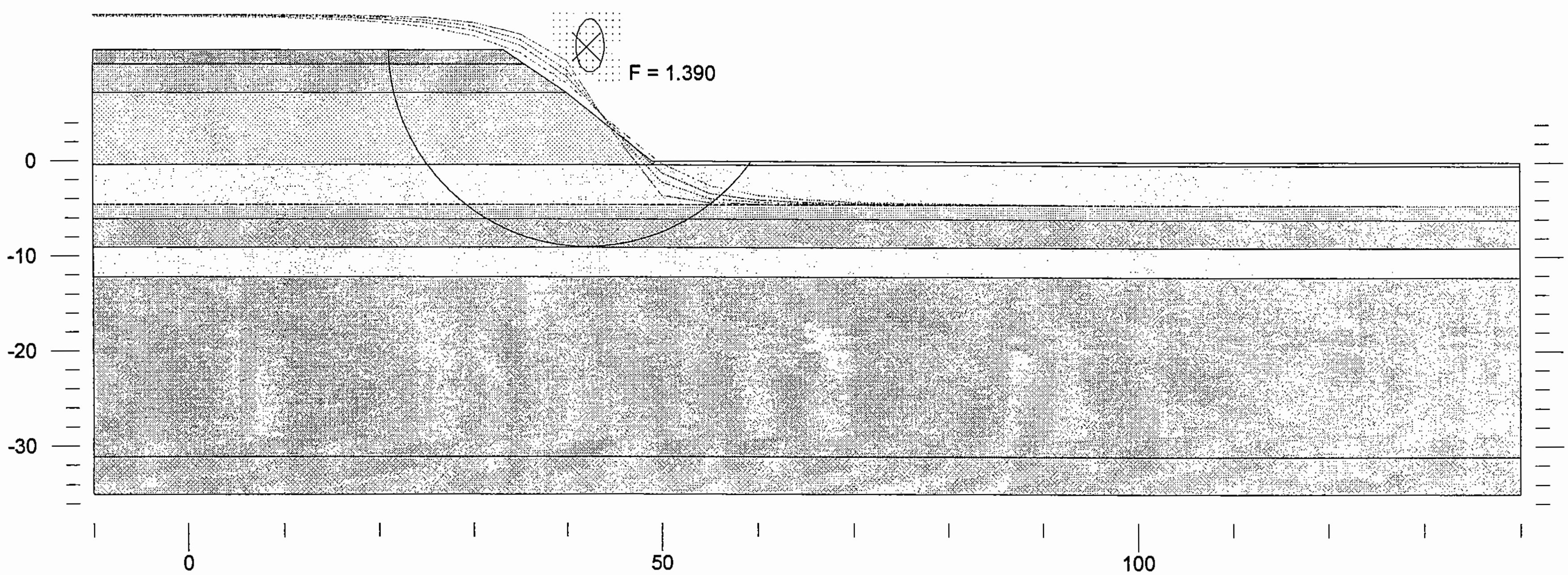

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Figure C26

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	2	42	0	1
Peat	12	2	28	0	1
Silty Clay Crust	18	80	0	.21	2
Clay Fm-Stif Top	17	50	0	.21	3
Clay Fm-Stif Mid	17	40	0	.21	4
Clay Fm-Stif Bot	17.5	60	0	.21	5
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 537 Stn 10+040
3.5 m Surcharge - Short Term

H = 8.2 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 7.2 m
Granular Fill to 8.2 m
Surcharge to 10.2 m
STAGE 2: Surcharge to 11.7 m

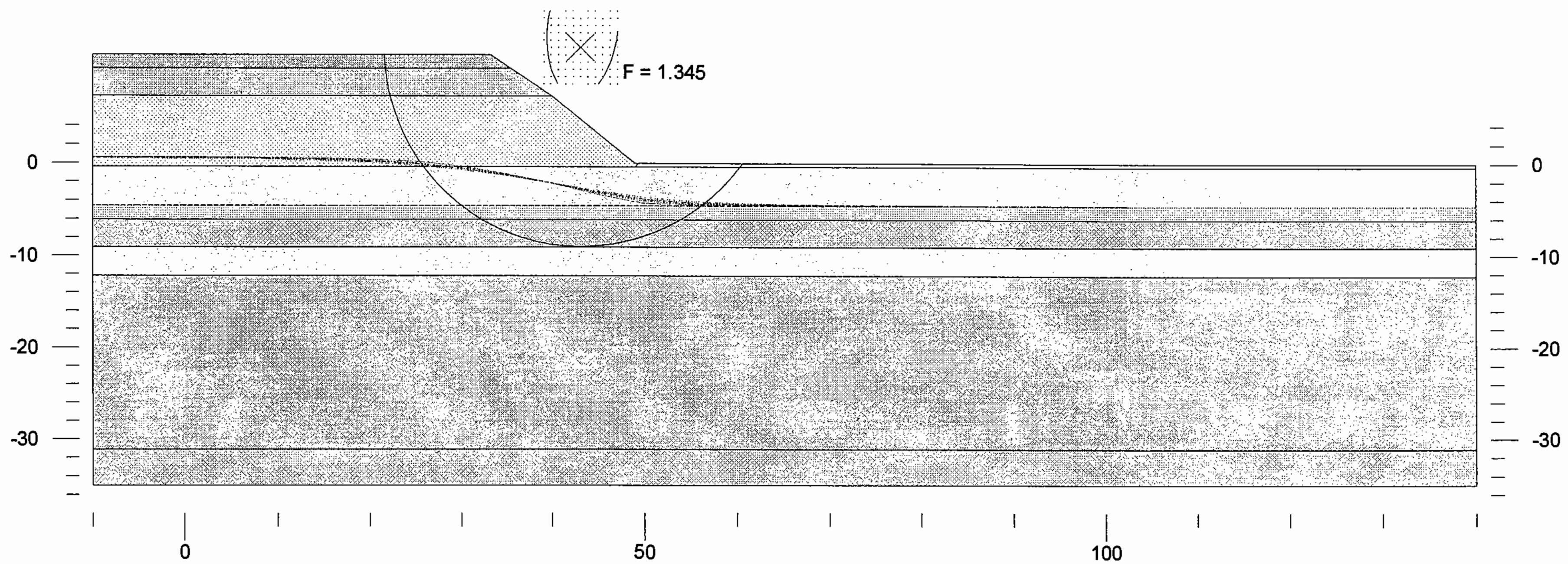

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Figure C27

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge top	22	0	32	0	1
Surcharge bottom	22	0	32	0	1
Granular Fill	22	0	32	0	1
Rock Fill	20	2	42	0	1
Peat	12	2	28	0	1
Silty Clay Crust	18	80	0	.21	2
Clay Fm-Stif Top	17	40	0	.21	3
Clay Fm-Stif Bot	17.5	35	0	.21	4
Silt/Sand-NP	19.5	0	32	0	1
Bedrock	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
19-2805-2
Hwy 69 - Three Swamps
Feb 16, 2006
Swamp 613 - Hwy 537 Stn 10+130
3.5m Surcharge - Short Term

H = 3.9 m to Top of Pavement
3.5 m Surcharge
STAGE 1: Rock Fill to 2.9 m
Granular Fill to 3.9 m
Surcharge to 7.4 m

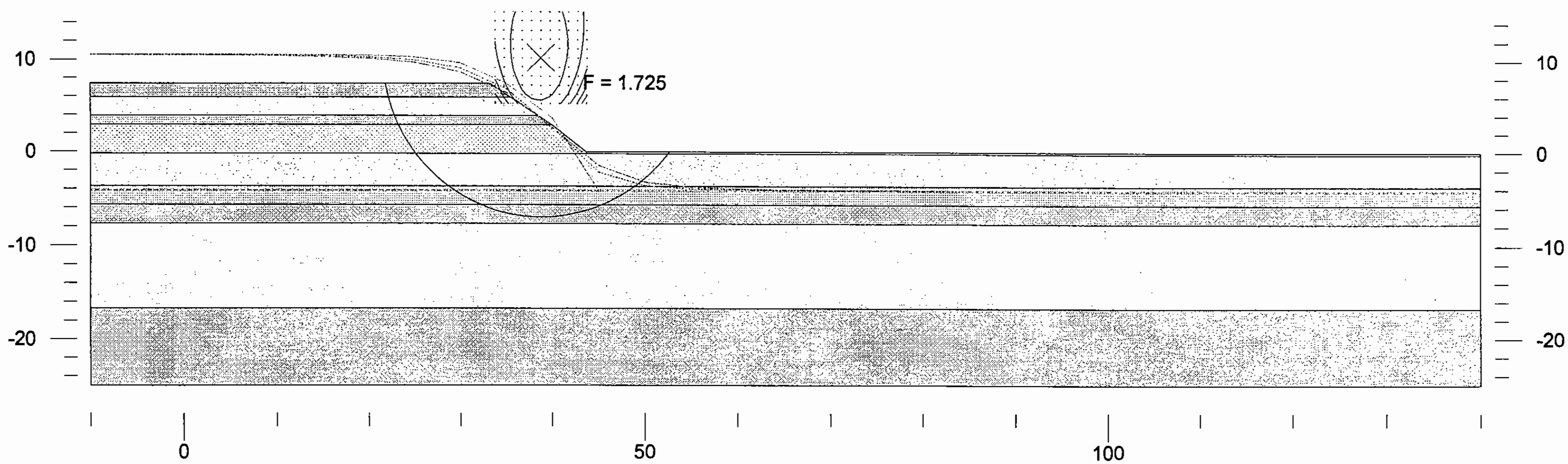

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Figure C28

Appendix D

ConeTec Inc. Piezocone Data Report

CONETEC

Job No:	05-263
Client:	Thurber Engineering
Project:	Hwy 69, Estaire, Ontario
Date:	October 12th to 15th, 2005

CPT SUMMARY

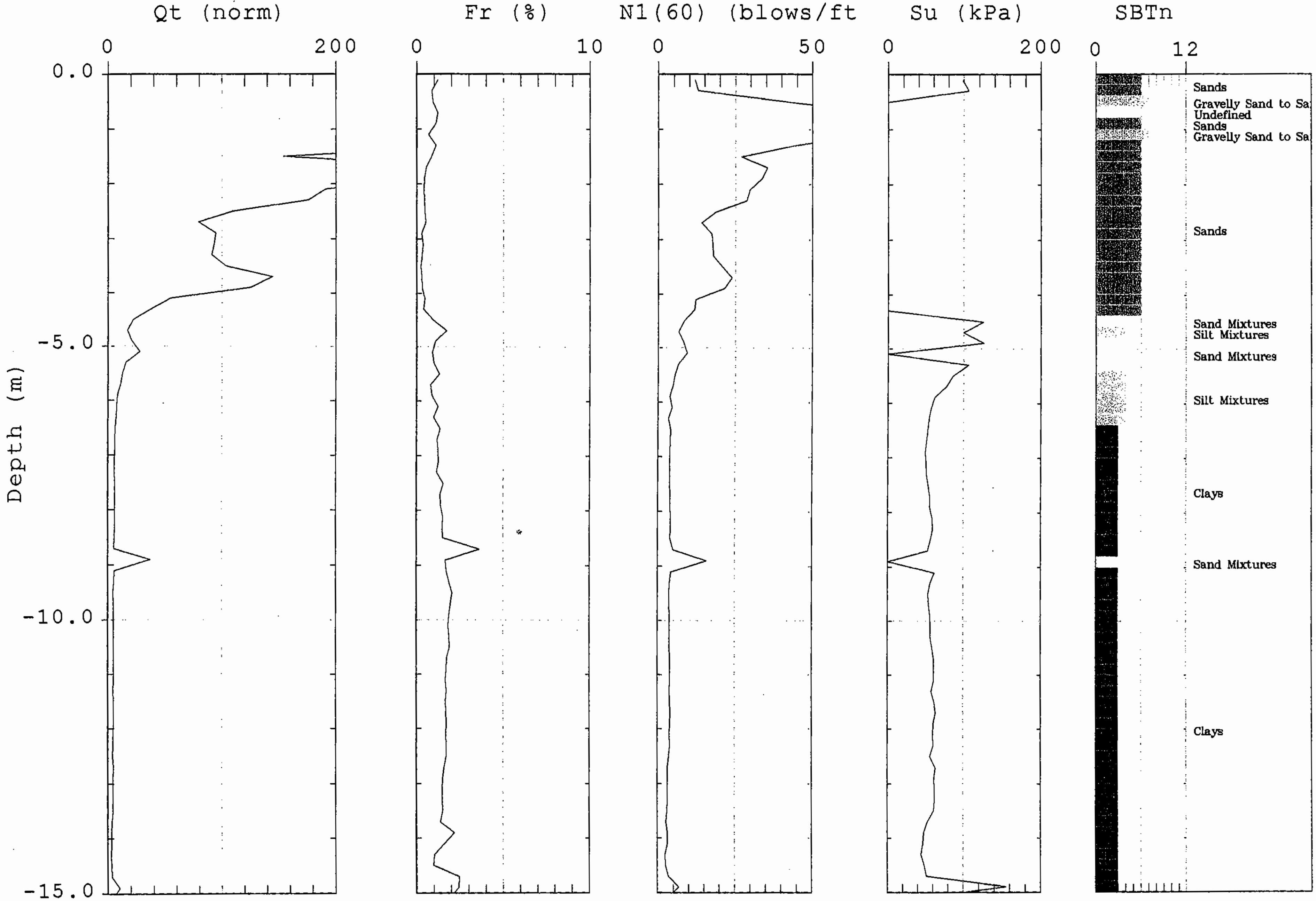
CPT Sounding	Filename	Date	Type Of Cone	Final Depth (m)	Assumed Water Table (m)
CPTU 537-1	2635371.cor	10/12/05	10 ton -10 cm^2	24.48	10.0
CPTU 537-2	2635372.cor	10/12/05	10 ton -10 cm^2	10.23	5.8
CPTU 537-3	2635373.cor	10/12/05	10 ton -10 cm^2	15.55	5.6
CPTU 537-4	2635374.cor	10/12/05	10 ton -10 cm^2	14.70	6.3
CPTU 605-M1	263605M.cor	10/13/05	10 ton -10 cm^2	18.75	0.2
CPTU 605-N1	263605N.cor	10/13/05	10 ton -10 cm^2	23.92	0.6
CPTU 605-S1	263605S.cor	10/14/05	10 ton -10 cm^2	14.52	0.4
CPTU 605-T1	263605T.cor	10/13/05	10 ton -10 cm^2	25.80	0.0
CPTU 613-N1	263613N.cor	10/13/05	10 ton -10 cm^2	20.90	5.0
CPTU 602-N1	263CPN1.cor	10/14/05	10 ton -10 cm^2	11.70	0.0
CPTU 602-N2	263CPN2.cor	10/14/05	10 ton -10 cm^2	16.23	-0.9
CPTU 602-S1	263CPS1.cor	10/14/05	10 ton -10 cm^2	13.68	0.9
CPTU 602-S2	263CPS2.cor	10/15/05	10 ton -10 cm^2	10.55	-0.6
CPTU 602-S3	263CPS3.cor	10/15/05	10 ton -10 cm^2	4.62	-0.6
CPTU 602-S3B	263CS3B.cor	10/15/05	10 ton -10 cm^2	5.00	-0.6

CONETEC

Thurber

Site: CPTU 537-1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:12:05 11:41



Max. Depth: 24.48 (m)
Depth Inc.: 0.025 (m)

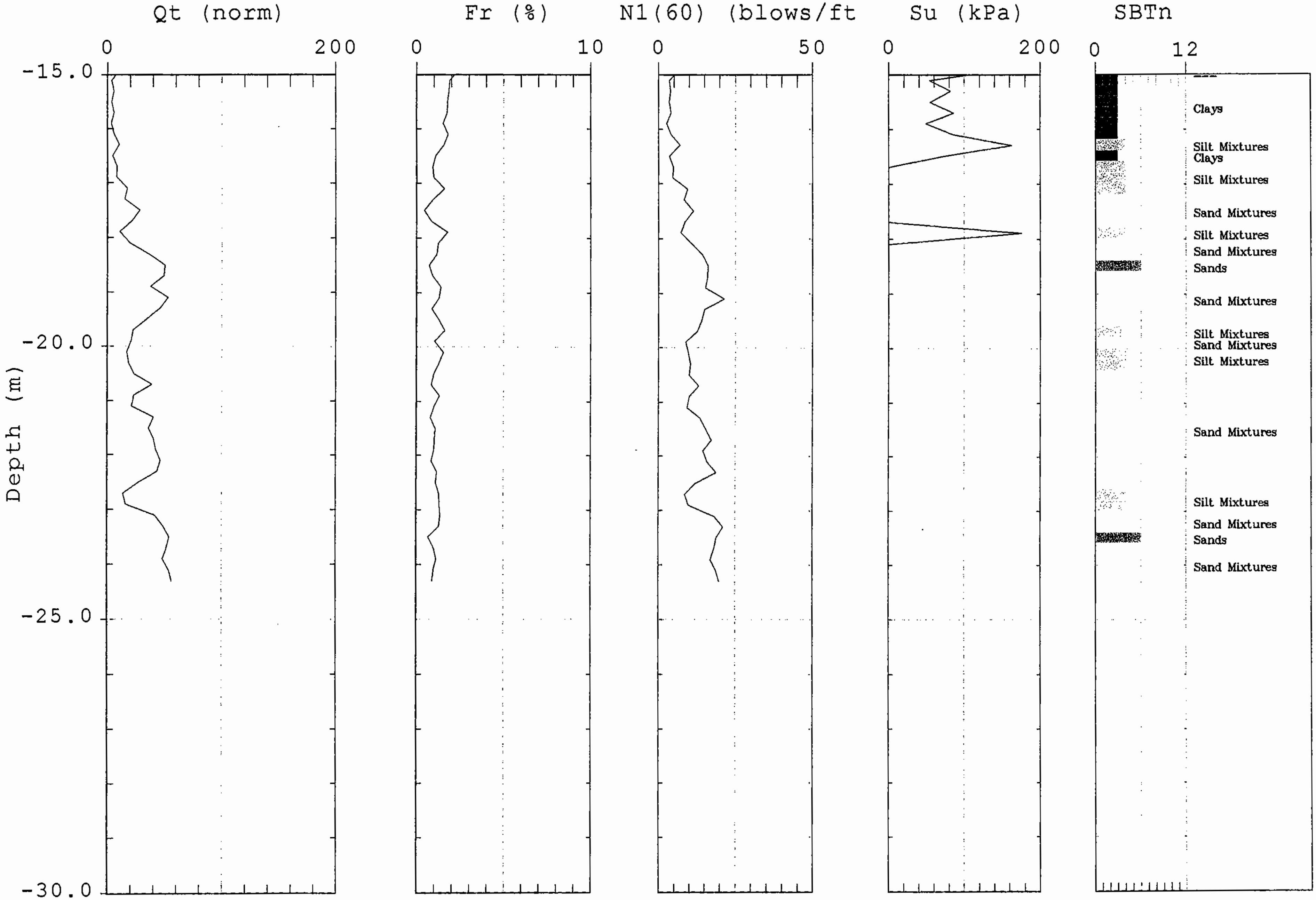
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 537-1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:12:05 11:41



Max. Depth: 24.48 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

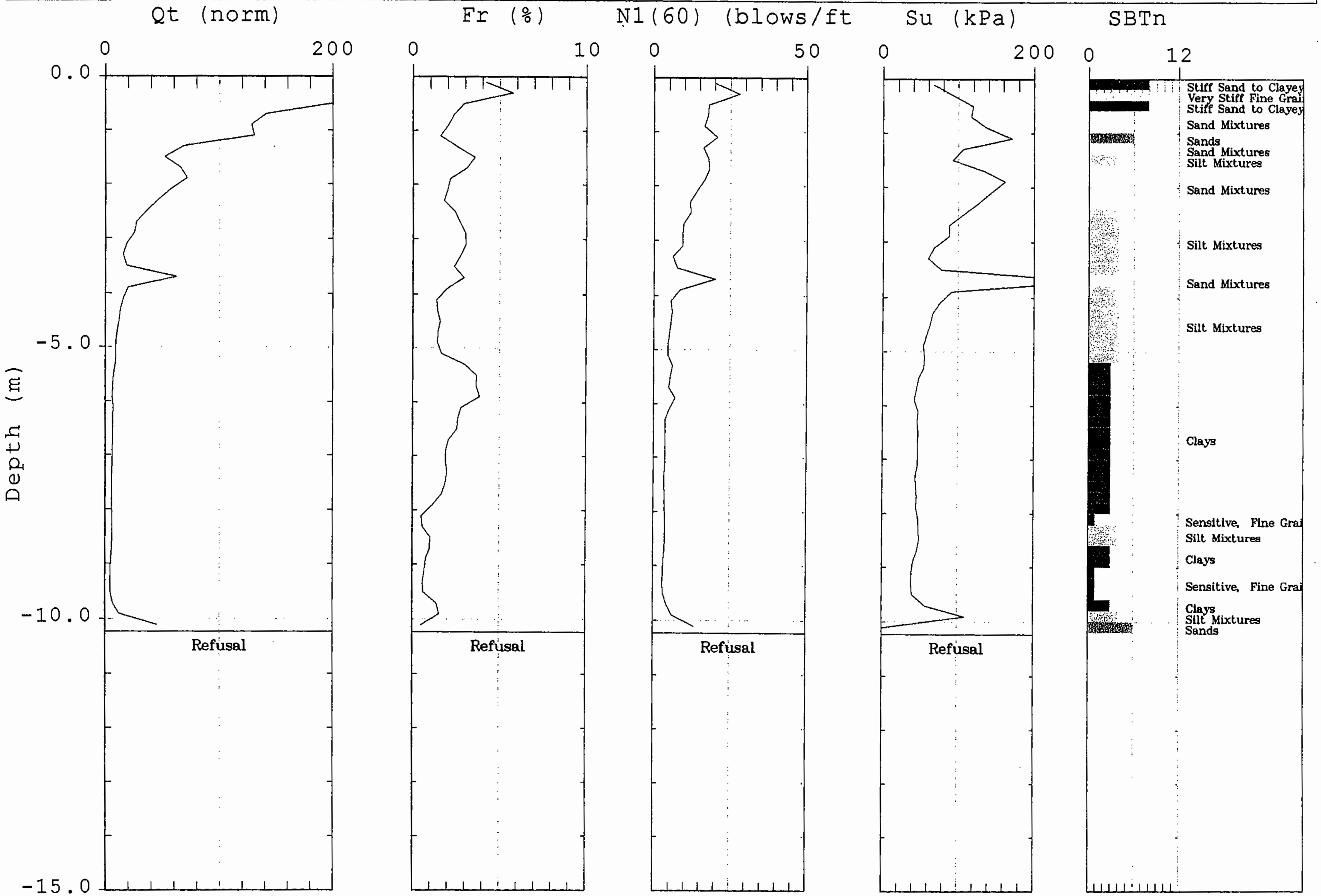
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 537-2
Location: HWY 63, ESTAIRE

Cone: 10 Ton St 028
Date: 10:12:05 15:31



Max. Depth: 10.23 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

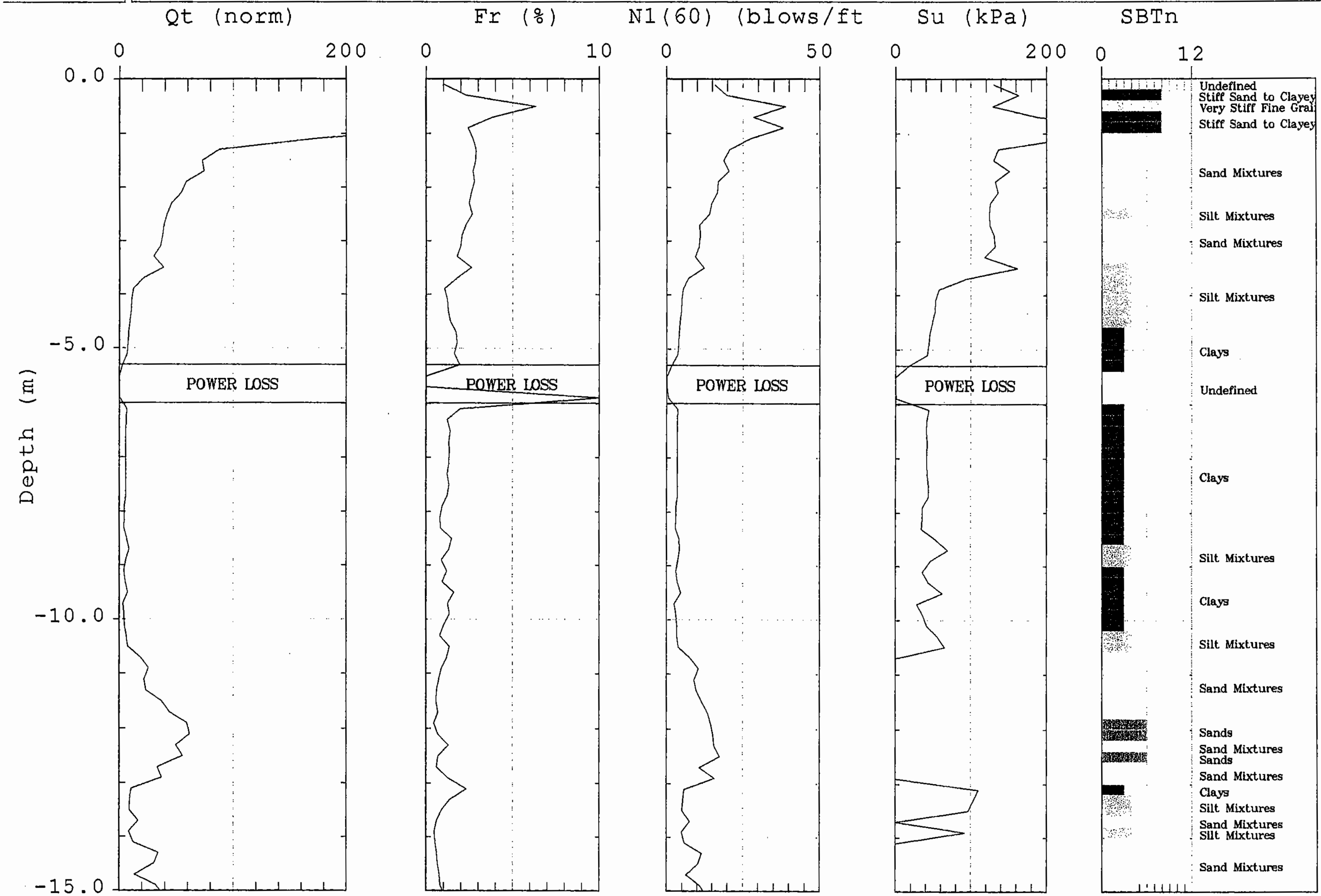
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 537-3
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:12:05 16:57



Max. Depth: 15.55 (m)
Depth Inc.: 0.025 (m)

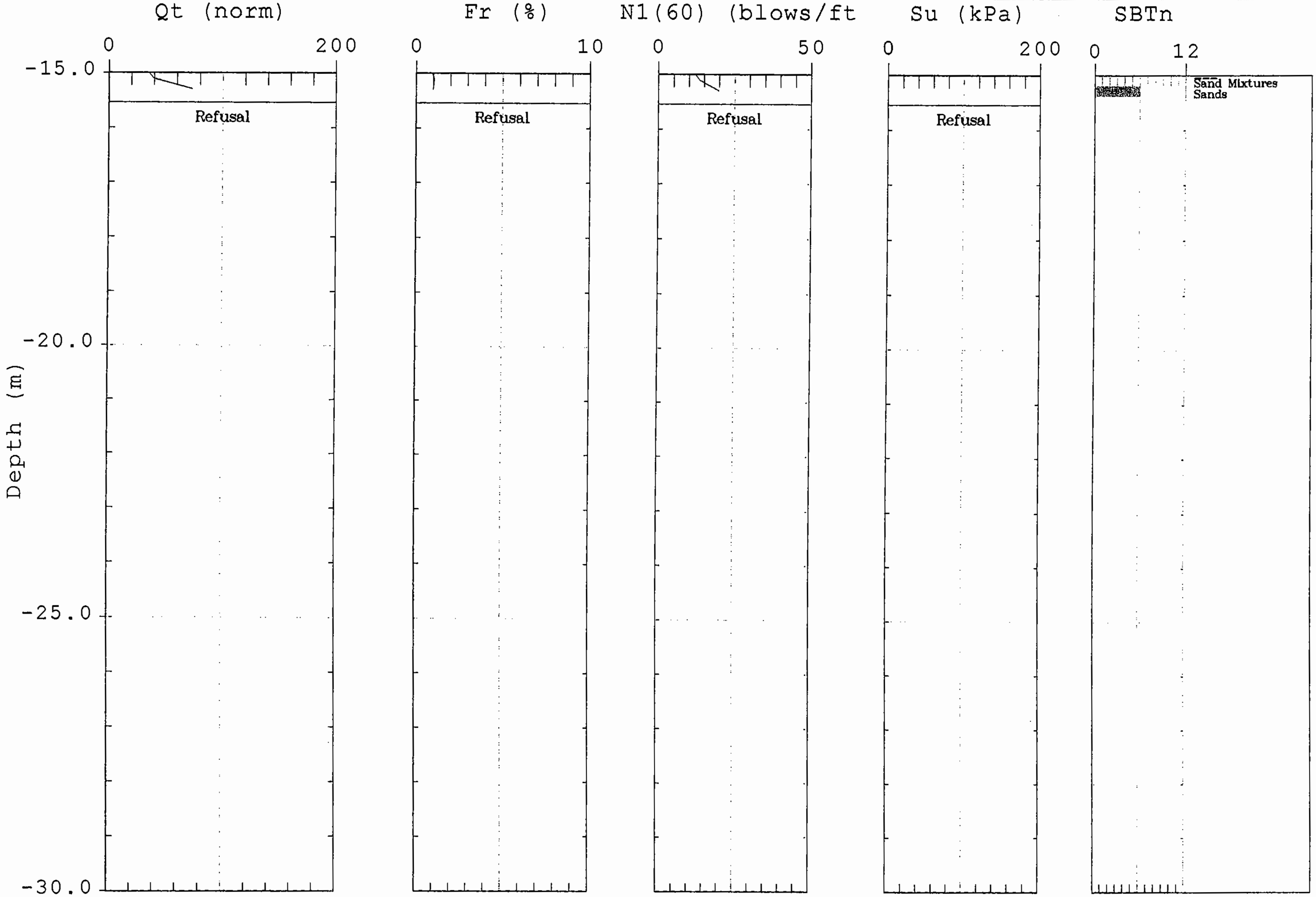
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 537-3
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:12:05 16:57



Max. Depth: 15.55 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

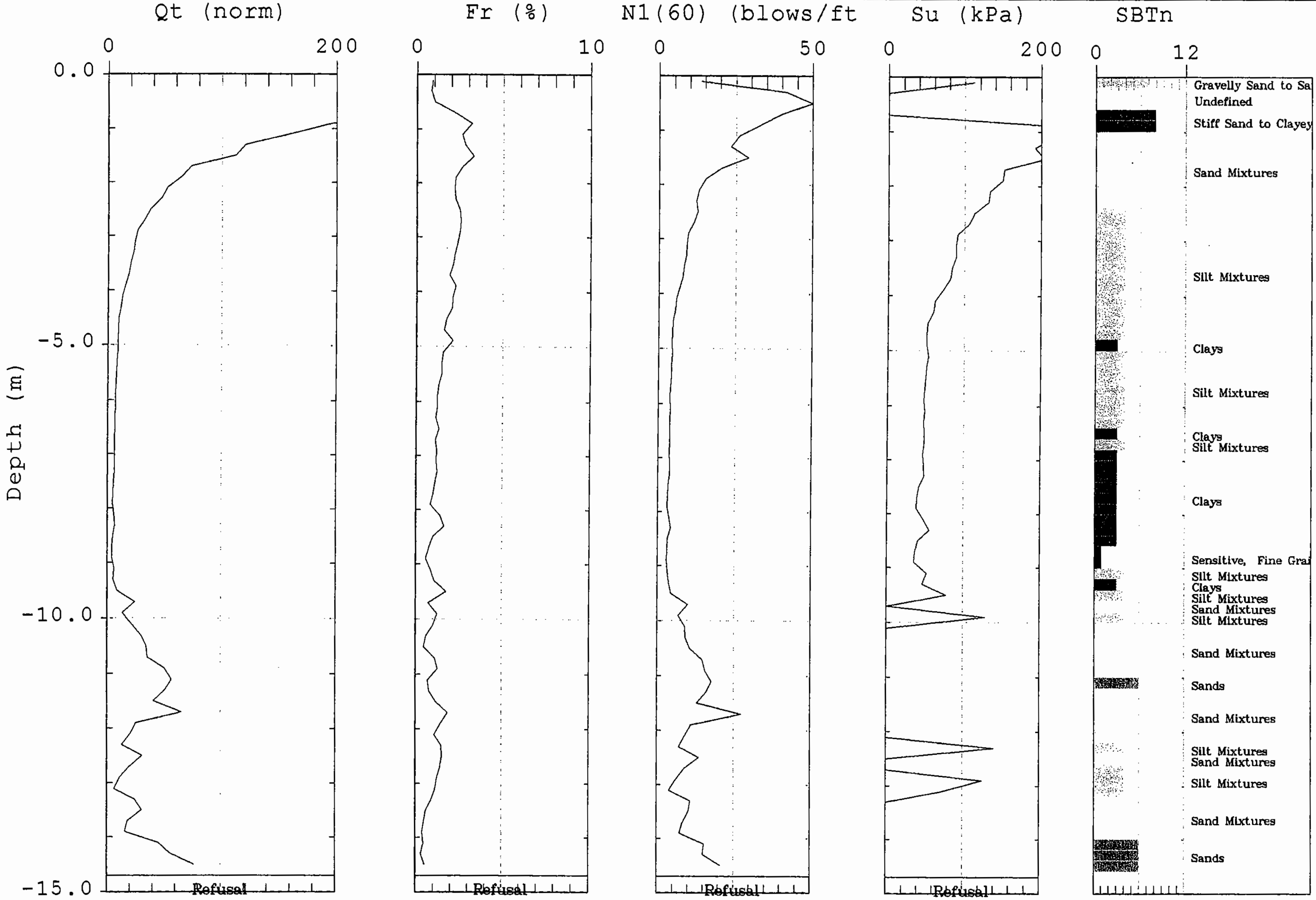
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 537-4
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:12:05 18:55



Max. Depth: 14.70 (m)
Depth Inc.: 0.025 (m)

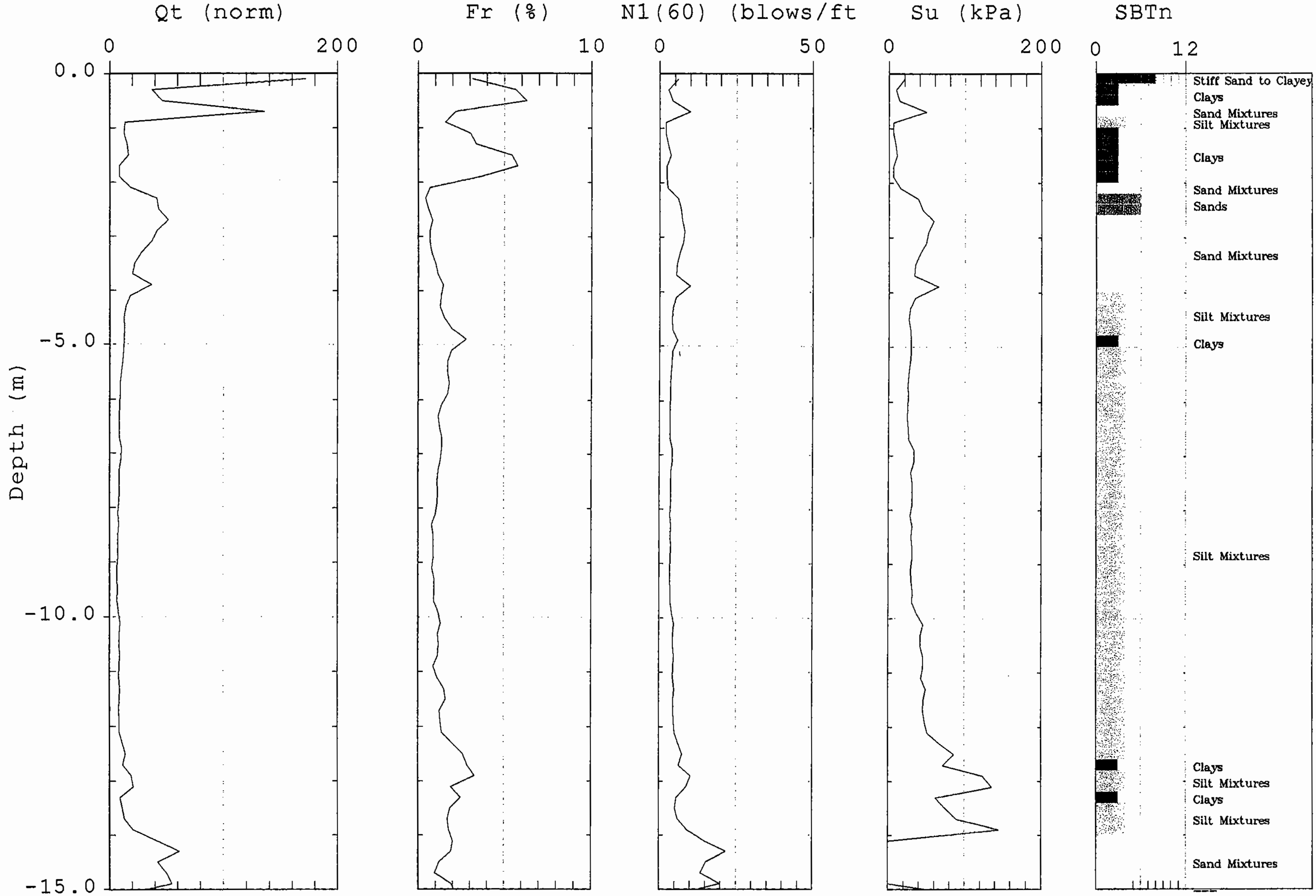
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 605-M1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 15:56



Max. Depth: 18.75 (m)
Depth Inc.: 0.025 (m)

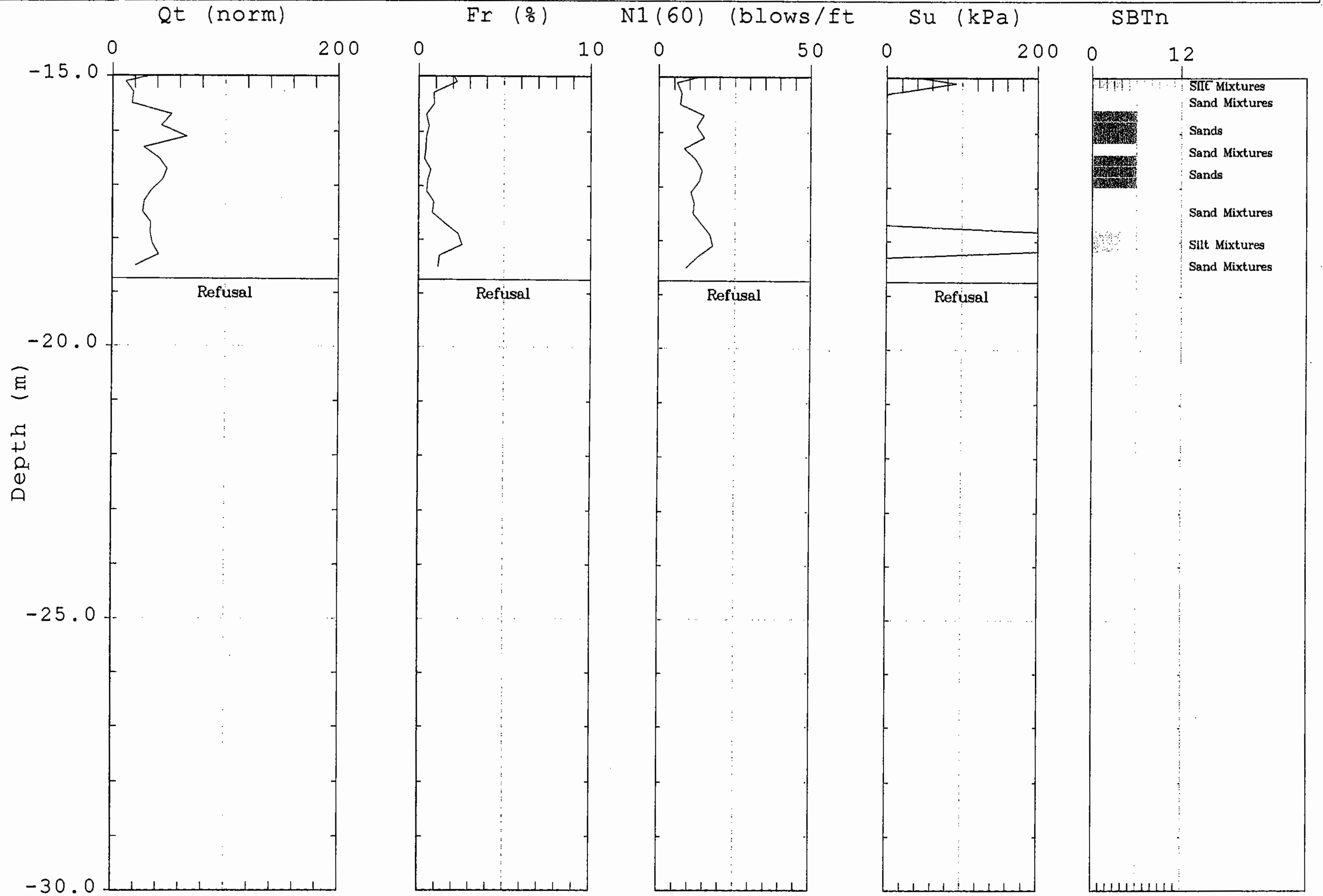
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 605-M1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 15:56



Max. Depth: 18.75 (m)
Depth Inc.: 0.025 (m)

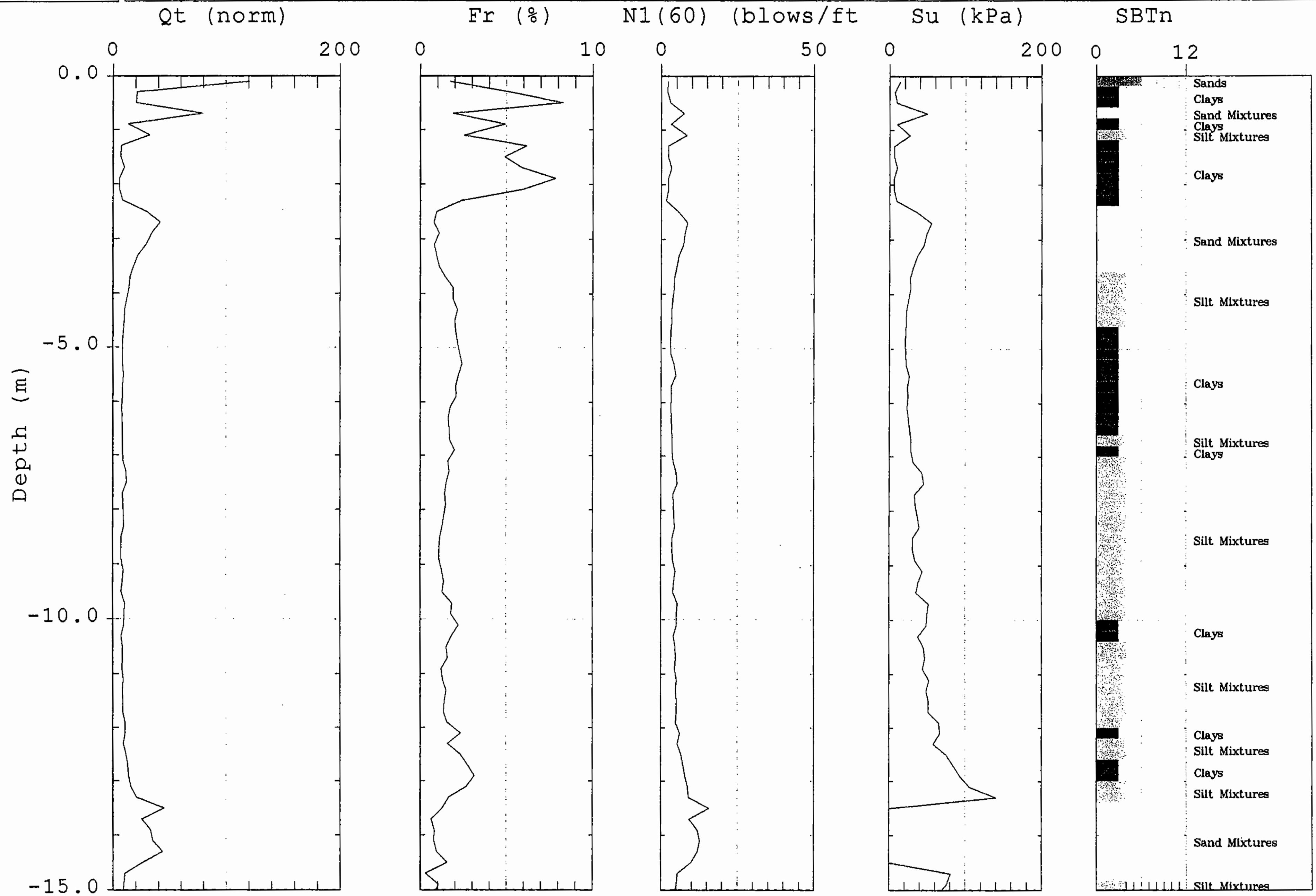
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 605-N1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 14:15



Max. Depth: 23.92 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

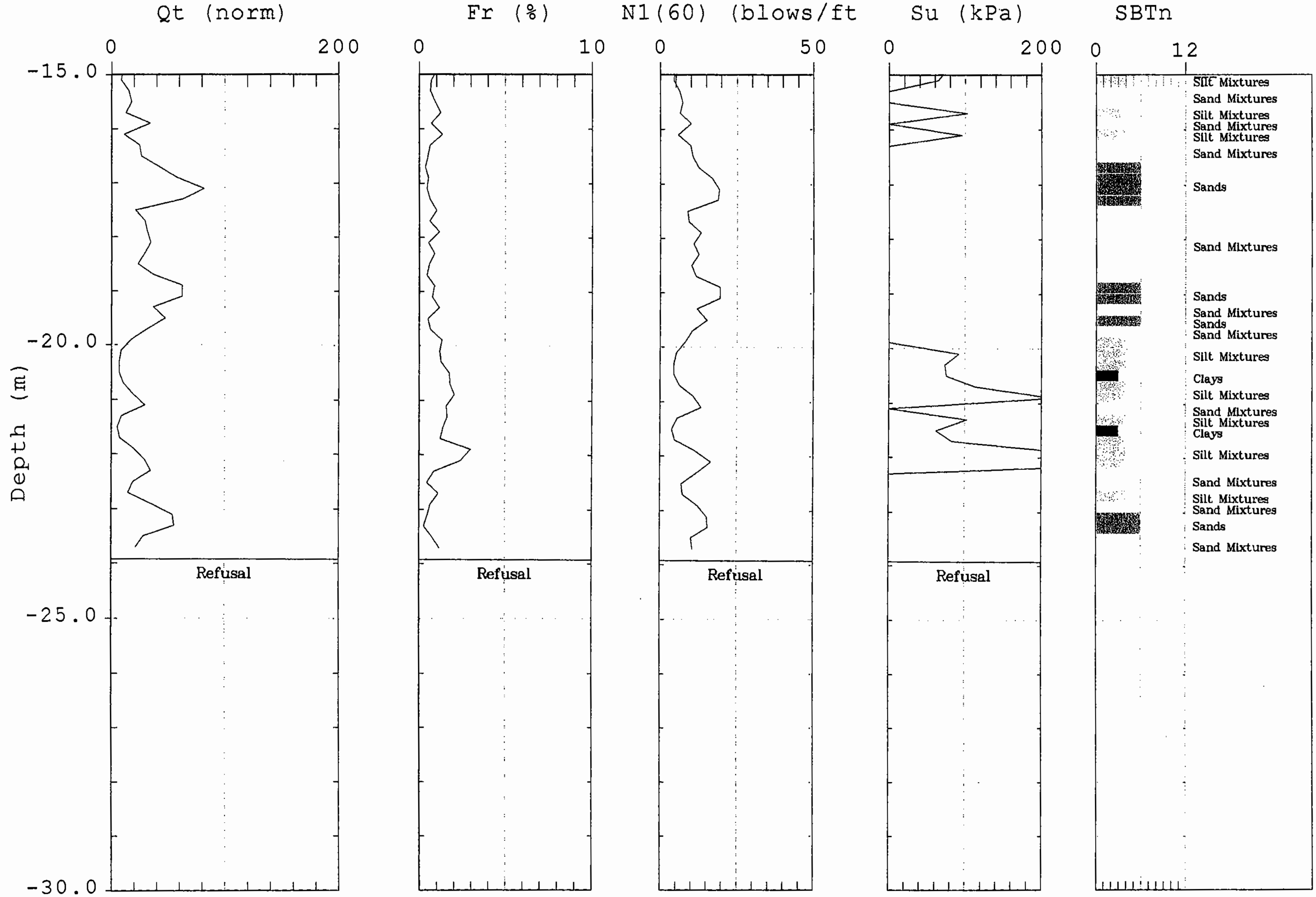
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 605-N1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 14:15



Max. Depth: 23.92 (m)
Depth Inc.: 0.025 (m)

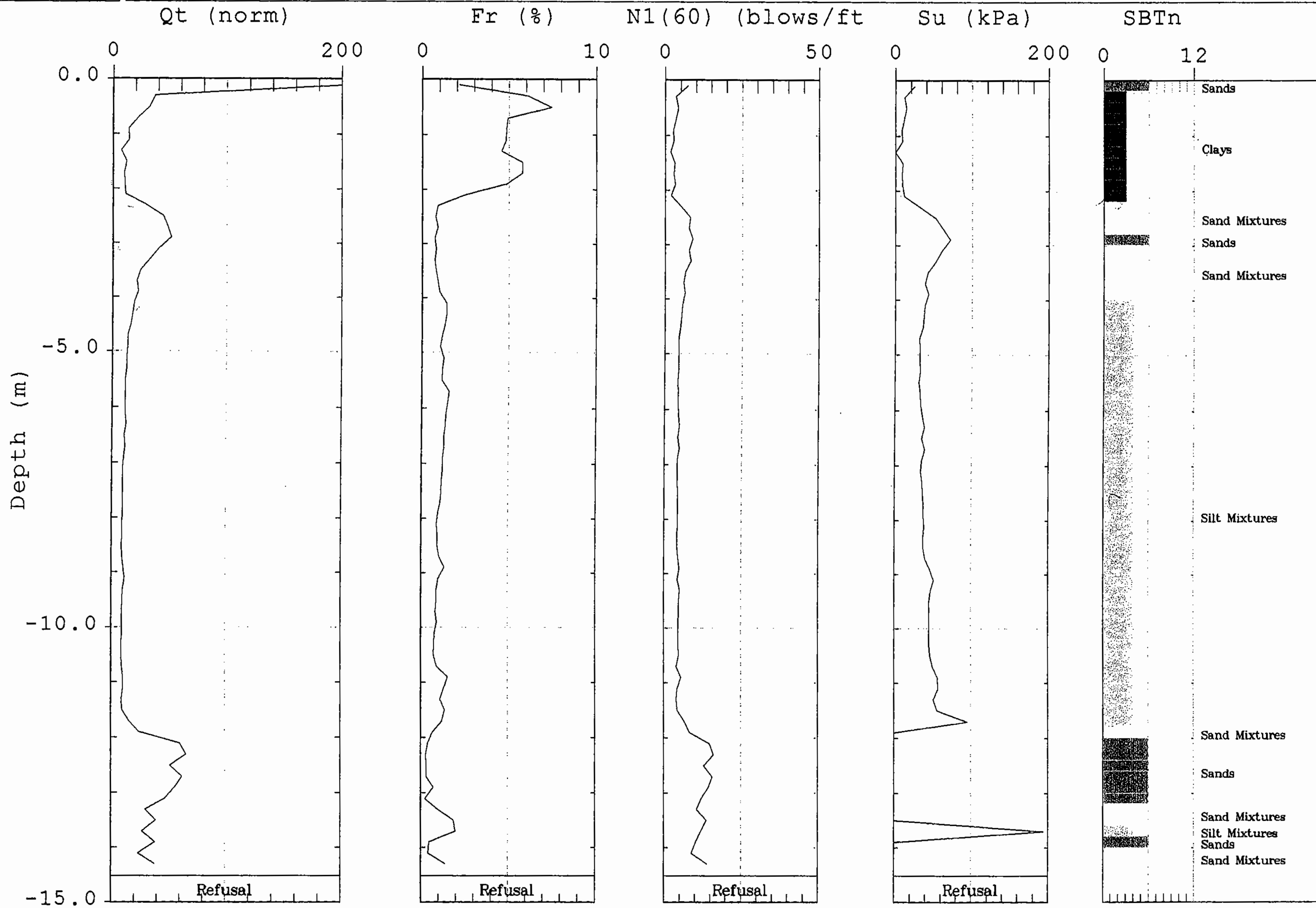
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 605-S1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:14:05 07:48



Max. Depth: 14.52 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

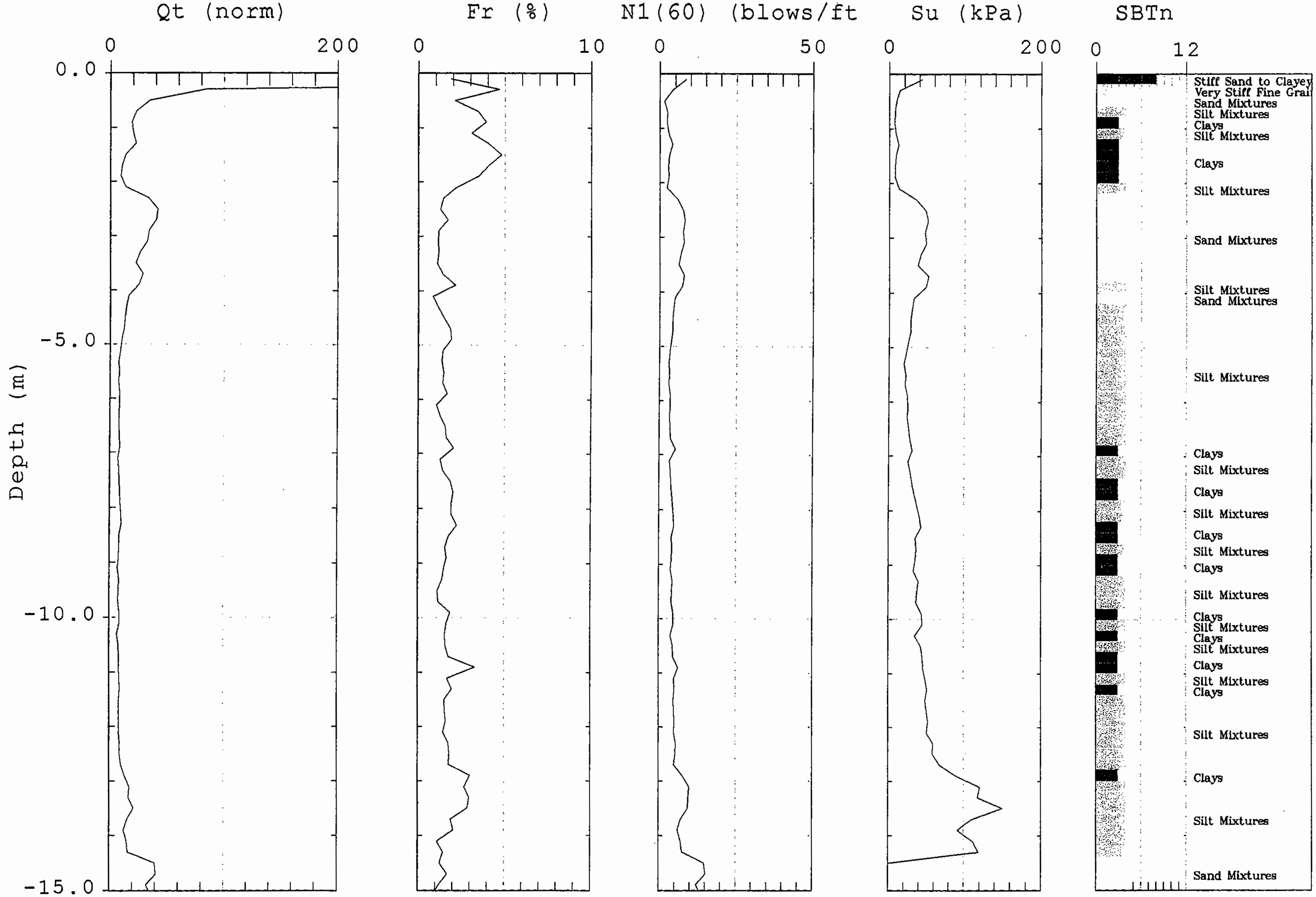
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 605-T1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 11:26



Max. Depth: 25.80 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

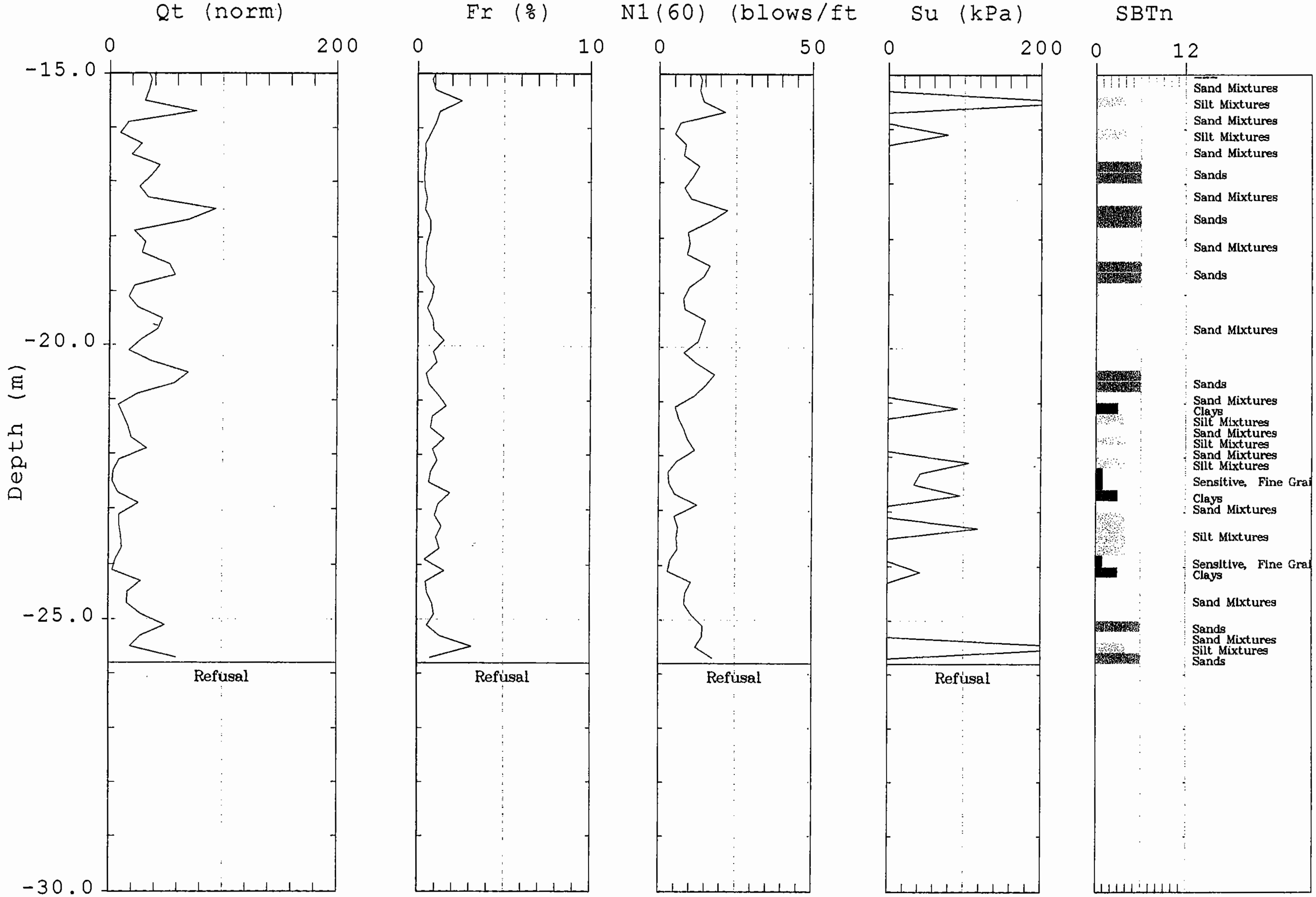
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 605-T1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 11:26



Max. Depth: 25.80 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

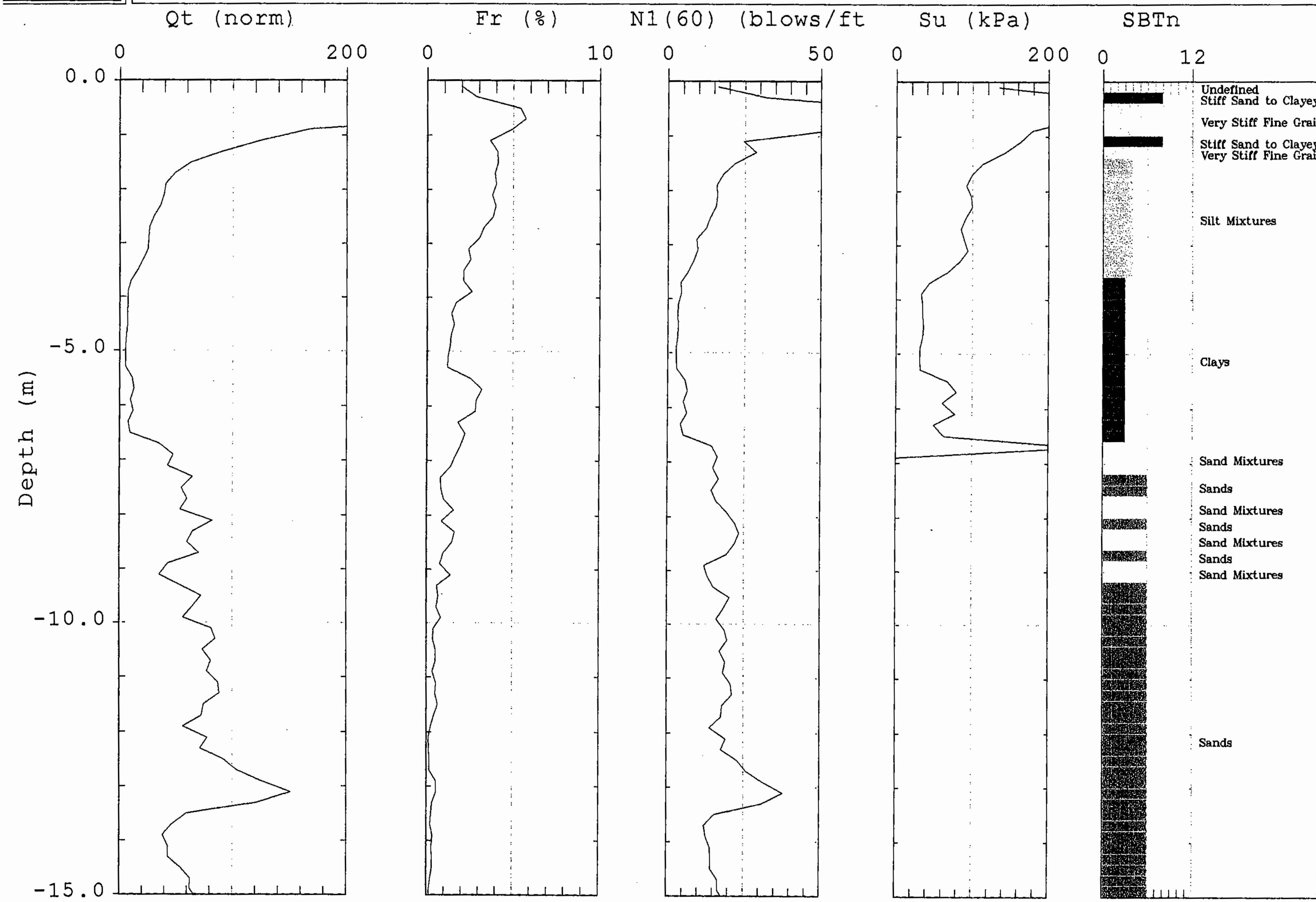
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 613-N1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:13:05 08:00

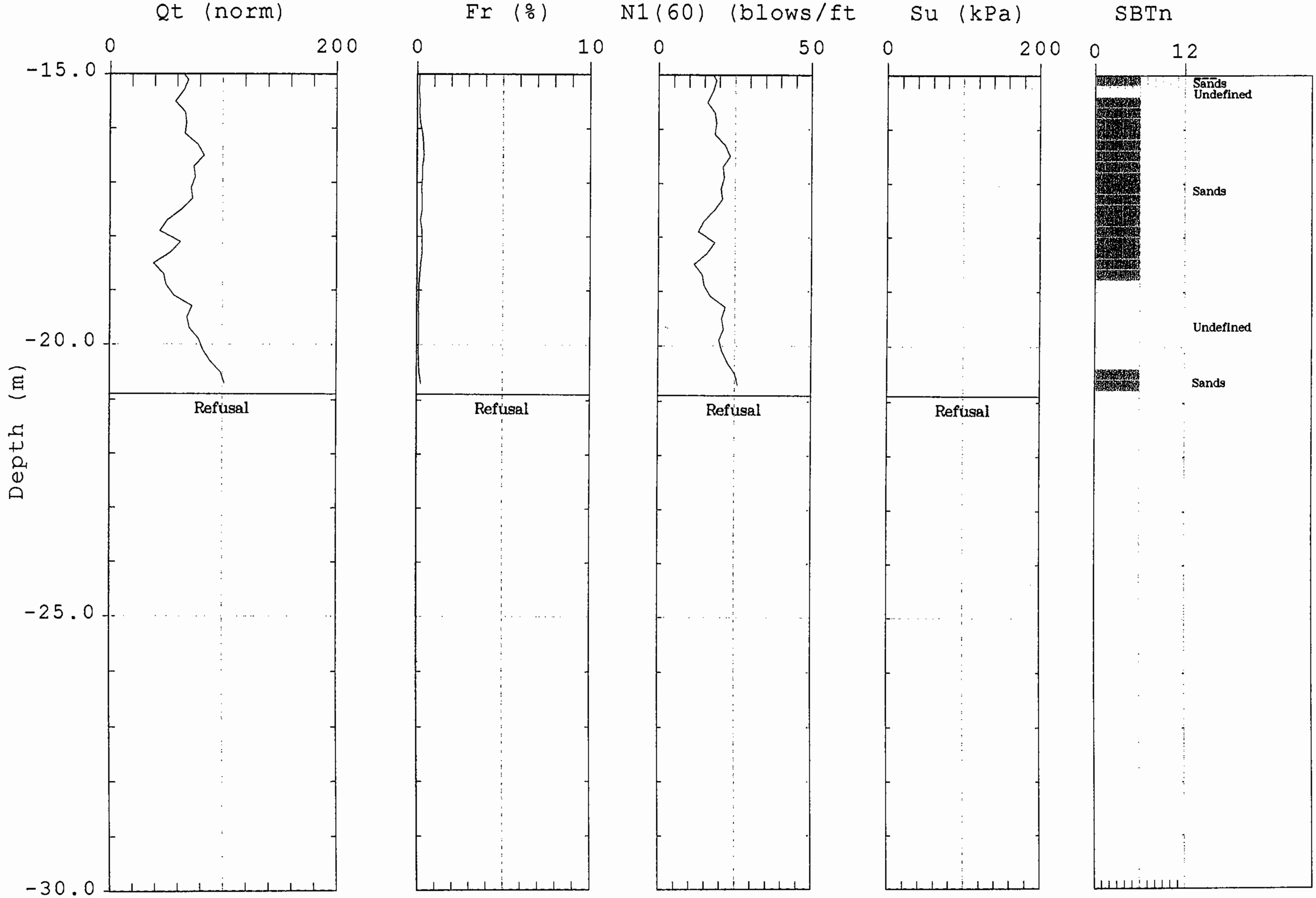


Max. Depth: 20.90 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

CONETEC | *Thurber* | Site: CPTU 613-N1 | Location: HWY 69, ESTAIRE | Cone: 10 Ton St 028 | Date: 10:13:05 08:00



Max. Depth: 20.90 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

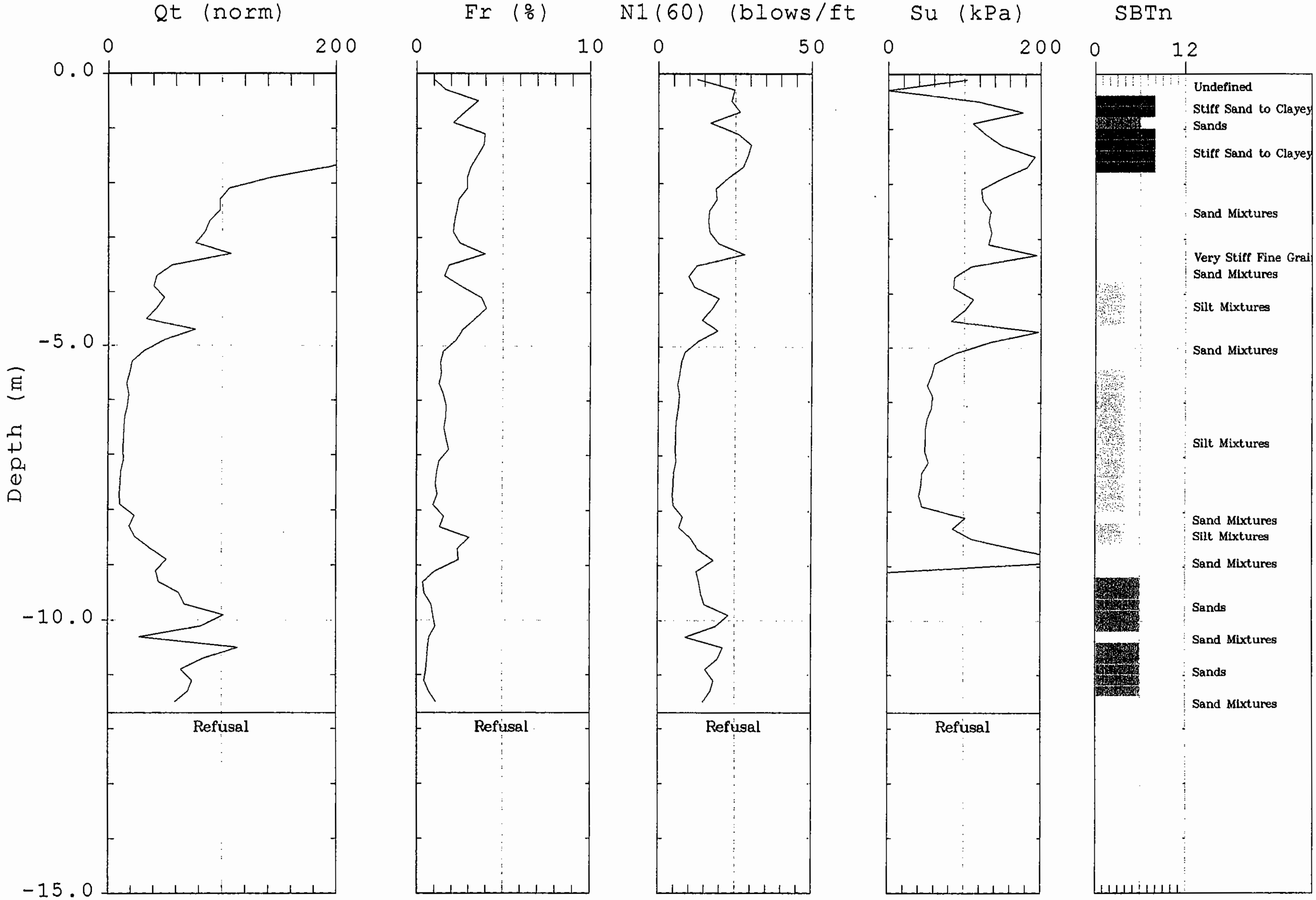
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 602-N1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:14:05 16:48



Max. Depth: 11.70 (m)
Depth Inc.: 0.025 (m)

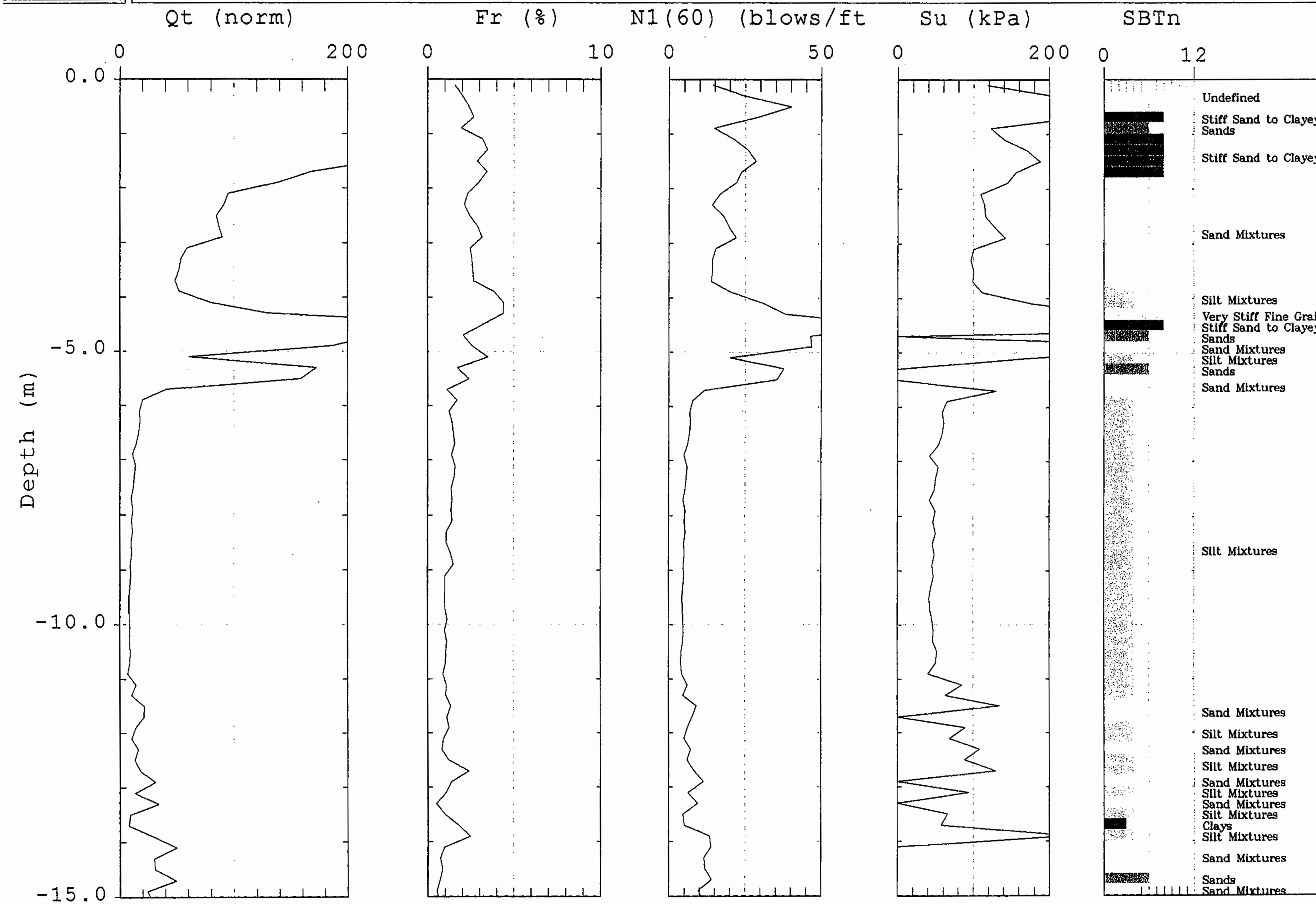
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 602-N2
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:14:05 14:56



Max. Depth: 16.23 (m)
Depth Inc.: 0.025 (m)

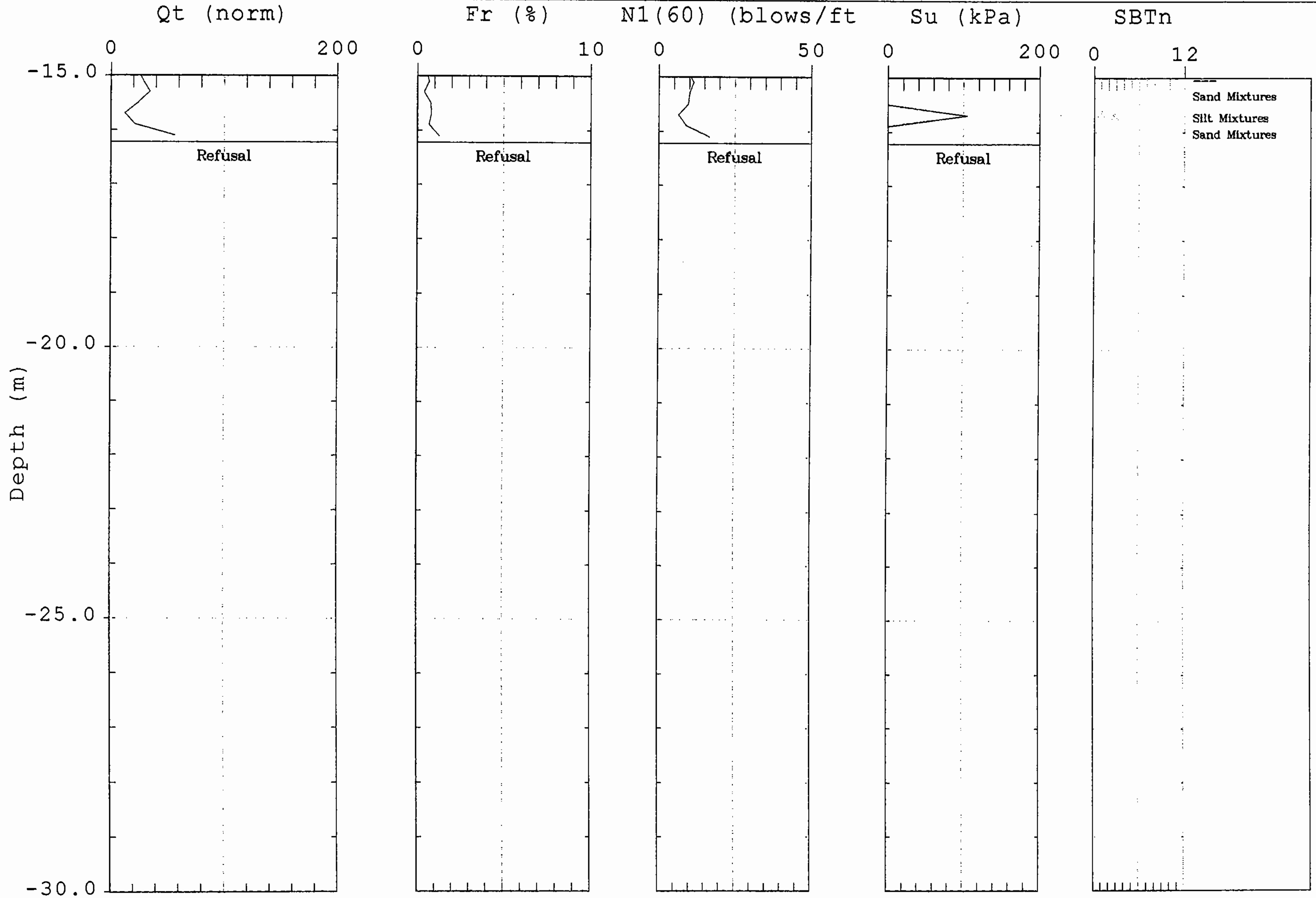
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 602-N2
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:14:05 14:56



Max. Depth: 16.23 (m)
Depth Inc.: 0.025 (m)

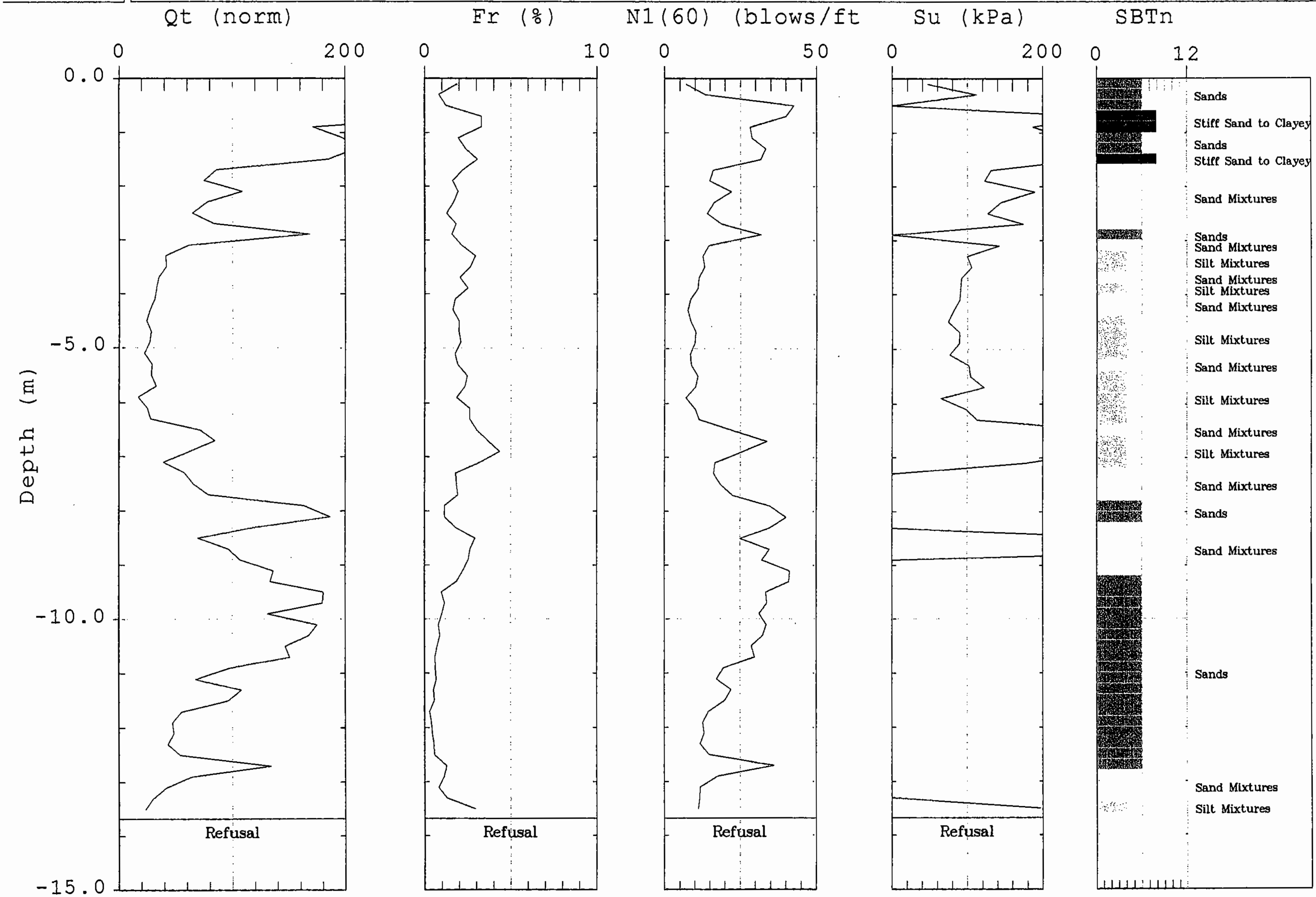
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 602-S1
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:14:05 13:28



Max. Depth: 13.68 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

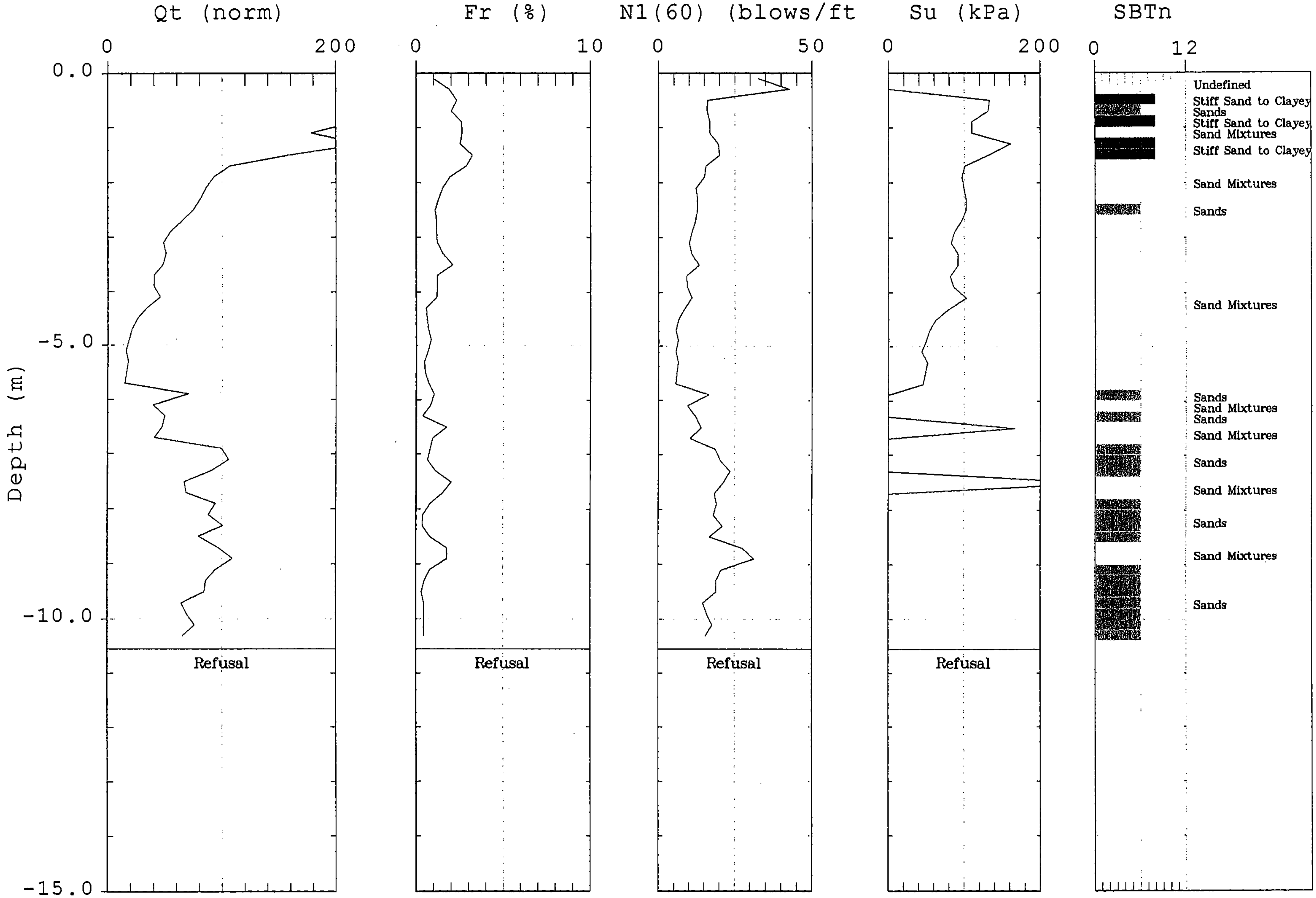
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 602-S2
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:15:05 09:03



Max. Depth: 10.55 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

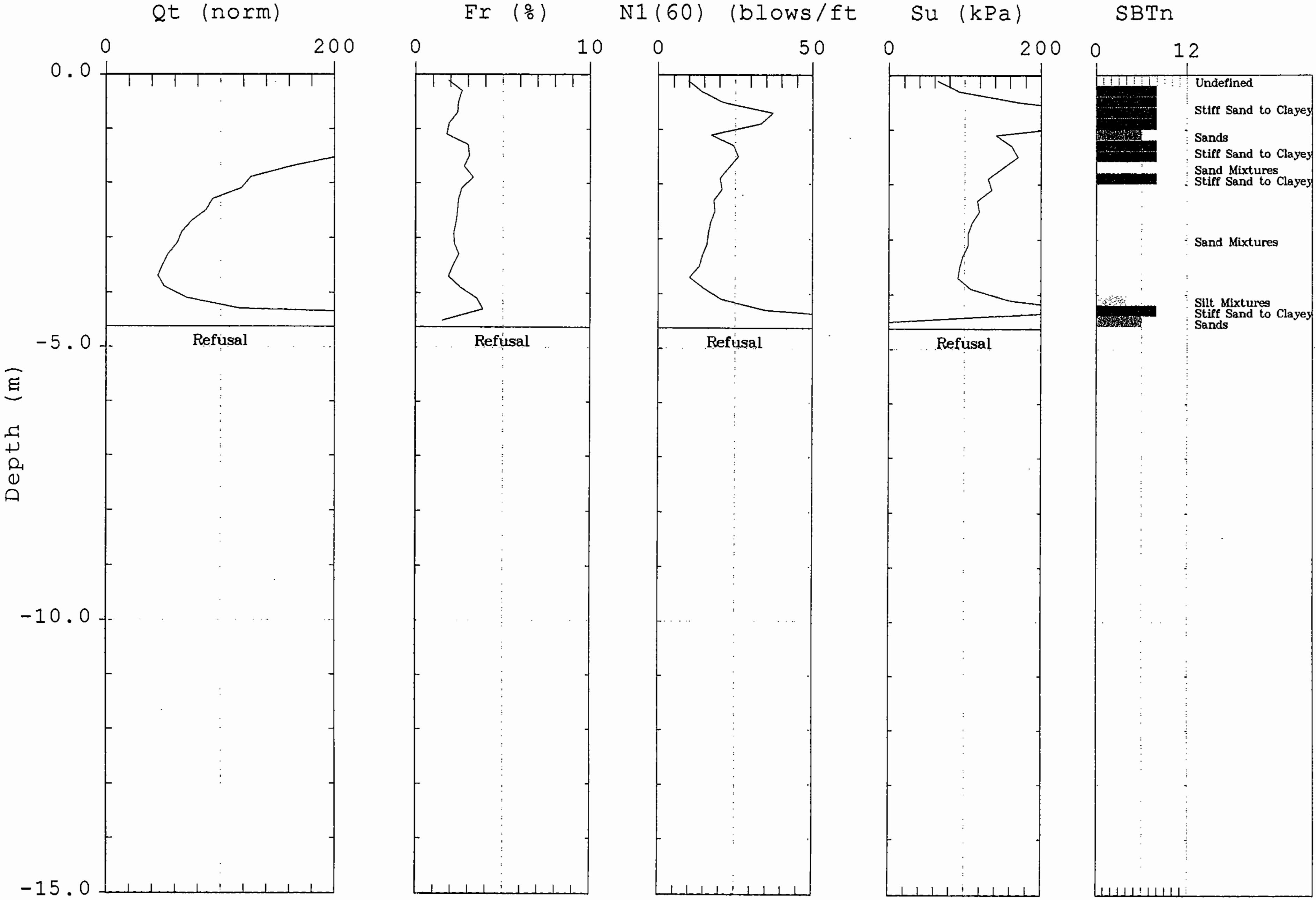
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Thurber

Site: CPTU 602-S3
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:15:05 08:18



Max. Depth: 4.62 (m)
Depth Inc.: 0.025 (m)

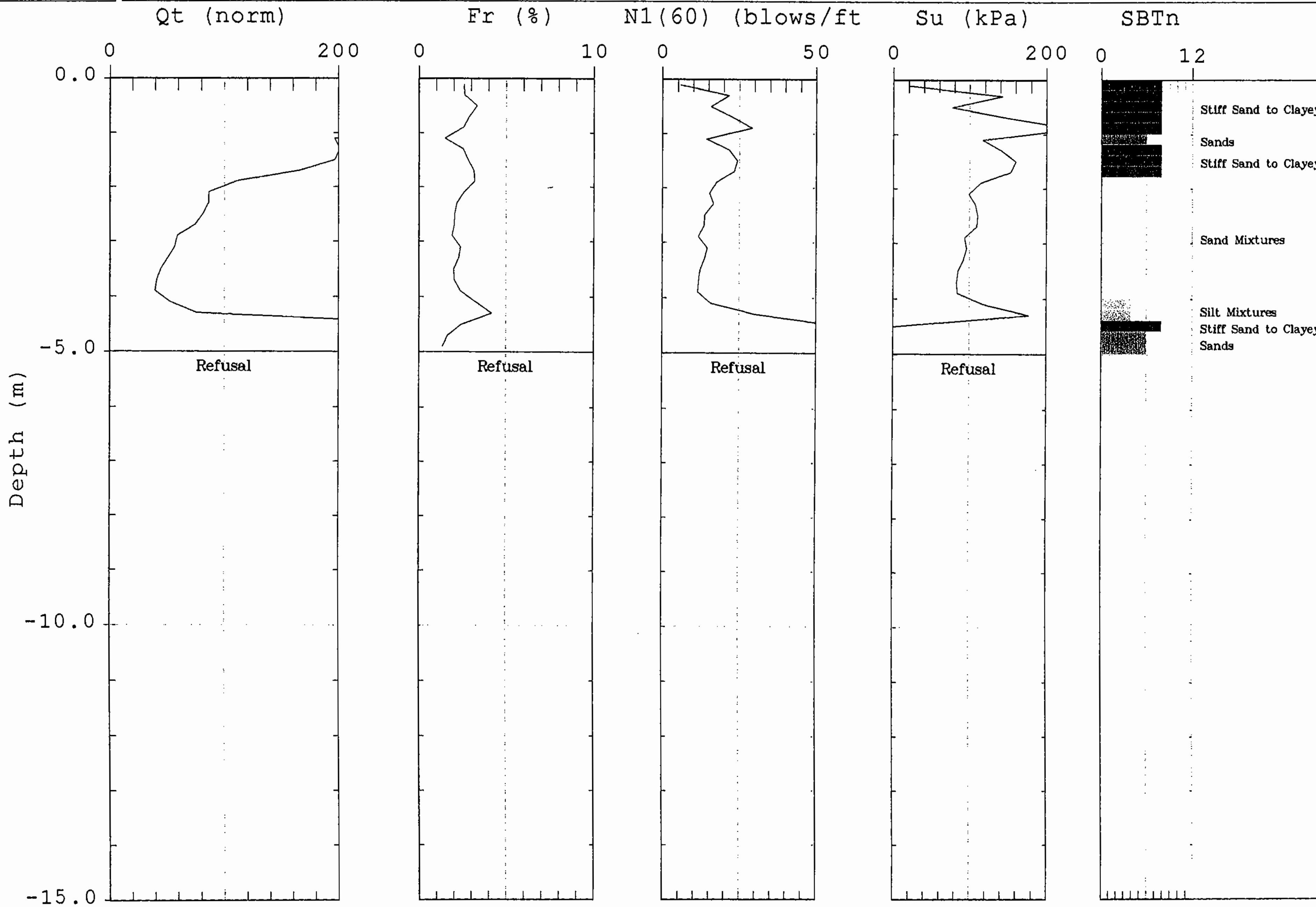
Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

Thurber

Site: CPTU 602-S3B
Location: HWY 69, ESTAIRE

Cone: 10 Ton St 028
Date: 10:15:05 09:55



Max. Depth: 5.00 (m)
Depth Inc.: 0.025 (m)

Su Nkt: 15.0

SBT: Soil Behavior Type (Robertson 1990)

ConeTec

Job No: 05-236
Client: Thurber Engineering
Project: Hwy 69, Estaire, Ontario
Date: October 12th to 15th, 2005

PPD SUMMARY

Input G/Su (Ir): Ir = 100

CPT Sounding	Filename	Duration (sec)	Test Depth (m)	Estimated Equilibrium (m)*	Calculated Phreatic Surface (m)	t_{50} (sec)	Ch (cm^2/min) (Inter. Ir)
CPTU 537-1	2635371.ppd	900	9.00	-	-	-	-
		4240	14.00	-	-	505	0.93
		1410	24.02	14.0	10.1	-	-
		200	24.48	14.1	10.4	-	-
CPTU 537-2	2635372.ppd	2100	6.00	-	-	1565	0.30
		400	10.00	-	-	153	3.06
		400	10.23	-	-	260	1.80
CPTU 537-3	2635373.ppd	2100	6.12	-	-	1324	0.35
		610	10.00	-	-	130	3.60
		300	15.57	10.0	5.6	-	-
CPTU 537-4	2635374.ppd	2800	5.00	-	-	2592	0.18
		400	9.32	-	-	117	3.99
		200	14.70	8.4	6.3	-	-
CPTU 605-M1	263605M.ppd	2300	5.03	-	-	1842	0.25
		800	10.03	-	-	533	0.88
		200	16.00	16.0	0.0	-	-
		200	18.75	18.3	0.4	-	-
CPTU 605-N1	263605N.ppd	1500	7.00	-	-	1294	0.36
		900	12.10	-	-	424	1.10
		200	18.00	17.7	0.3	-	-
		200	23.93	23.1	0.8	-	-
CPTU 605-S1	263605S.ppd	1200	4.03	-	-	976	0.48
		900	9.00	-	-	710	0.66
		900	14.53	14.2	0.4	-	-
CPTU 605-T1	263605T.ppd	1500	6.03	-	-	974	0.48
		4275	11.00	-	-	394	1.19
		200	18.00	18.1	-0.1	-	-
		200	25.80	25.4	0.4	-	-

Job No: 05-236
Client: Thurber Engineering
Project: Hwy 69, Estaire, Ontario
Date: October 12th to 15th, 2005

PPD SUMMARY

CPT Sounding	Filename	Duration (sec)	Test Depth (m)	Estimated Equilibrium (m)*	Calculated Water Table (m)	t_{50} (sec)	Ch (cm^2/min)
CPTU 613-N1	263613N.ppd	2500	4.00	-	-	-	-
		200	10.00	5.1	4.9	-	-
		300	20.90	15.8	5.1	-	-
CPTU 602-N1	263CPN1.ppd	300	4.00	-	-	144	3.25
		1200	7.00	-	-	1026	0.46
		805	11.70	11.7	0.0	-	-
CPTU 602-N2	263CPN2.ppd	300	4.00	-	-	245	1.91
		800	9.00	-	-	546	0.86
		805	16.23	17.1	-0.9	-	-
CPTU 602-S1	263CPS1.ppd	300	4.00	-	-	197	2.38
		800	8.10	7.6	0.5	-	-
		200	13.68	12.4	1.3	-	-
CPTU 602-S2	263CPS2.ppd	410	3.50	-	-	179	2.62
		400	8.00	9.0	-1.0	-	-
		200	10.55	10.8	-0.3	-	-
CPTU 602-S3B	263CS3B.ppd	1000	5.00	7.5	-2.5	-	-

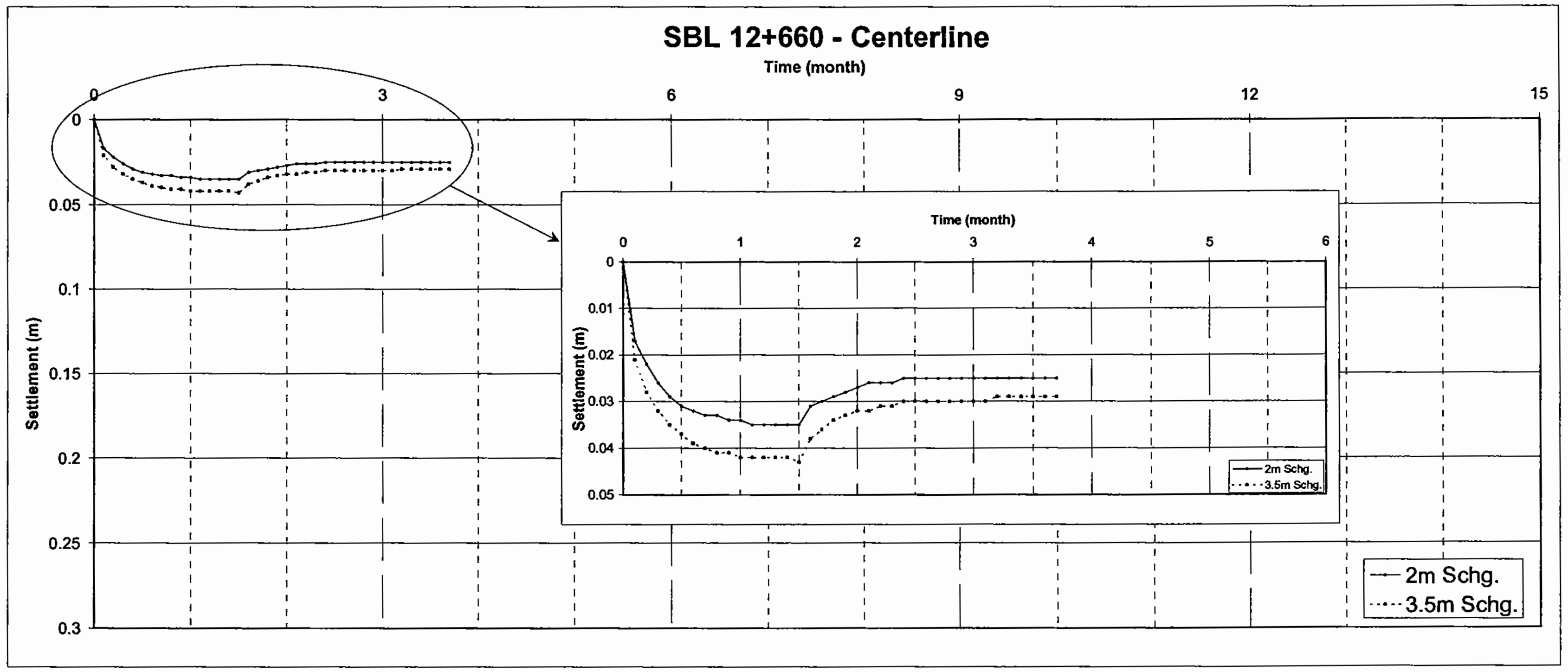
* Equilibrium values based on pore pressure dissipation tests

Appendix E

Primary Consolidation Analysis Results

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 602 (South Swamp) - Sta. 12+660 & 12+700

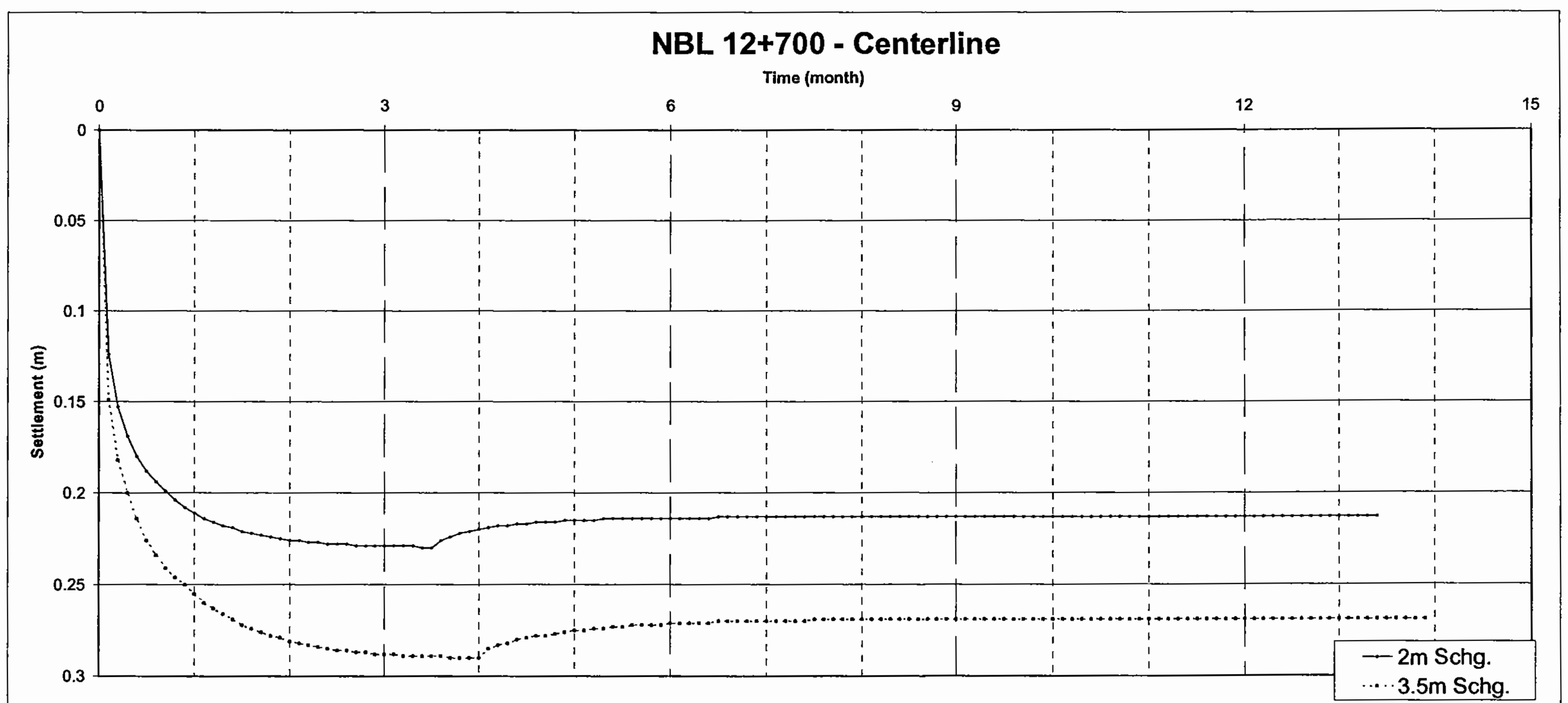


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	4	0
2	2	1.5
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.5	0
2	2	6
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.4	0
2	3.4	3.5
3		
4		

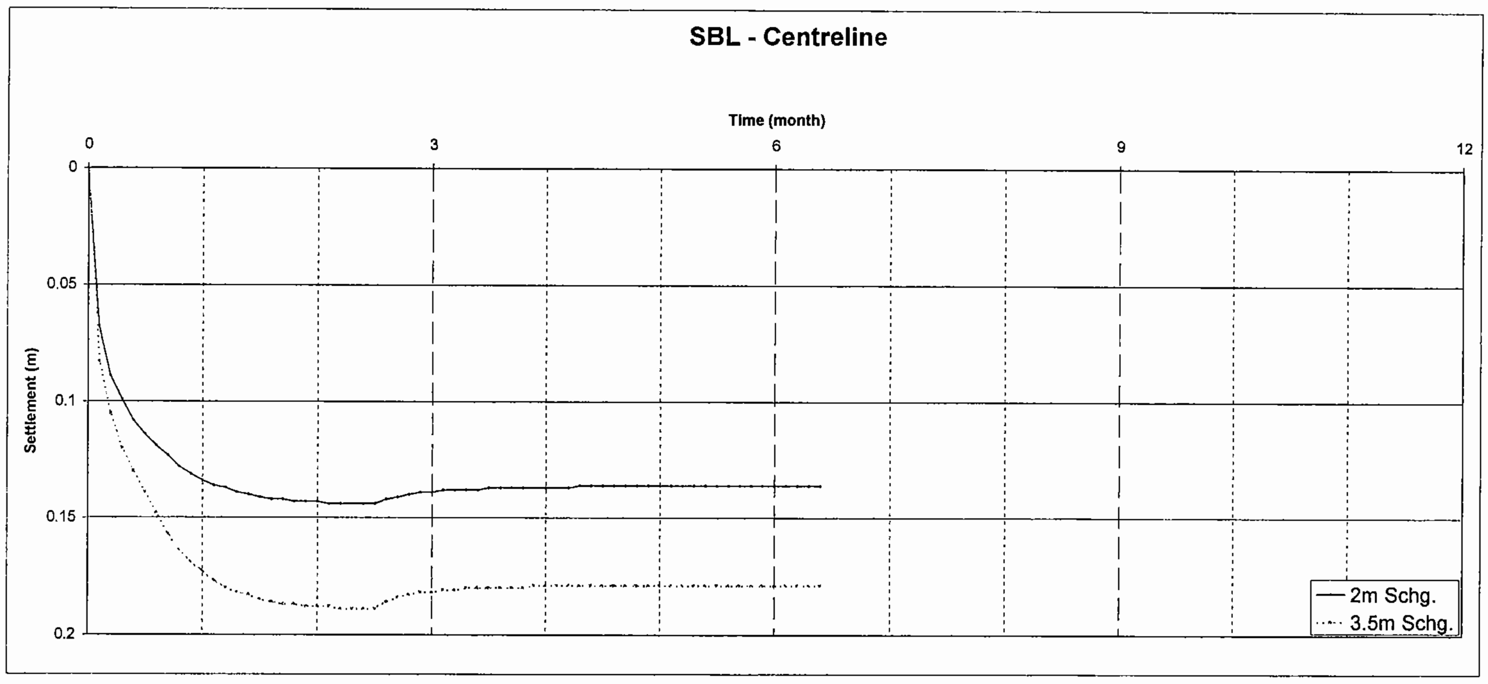
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.9	0
2	3.4	4
3		
4		

FIGURE E1

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 602 (South Swamp) - SBL Sta. 12+680 - Culvert 3

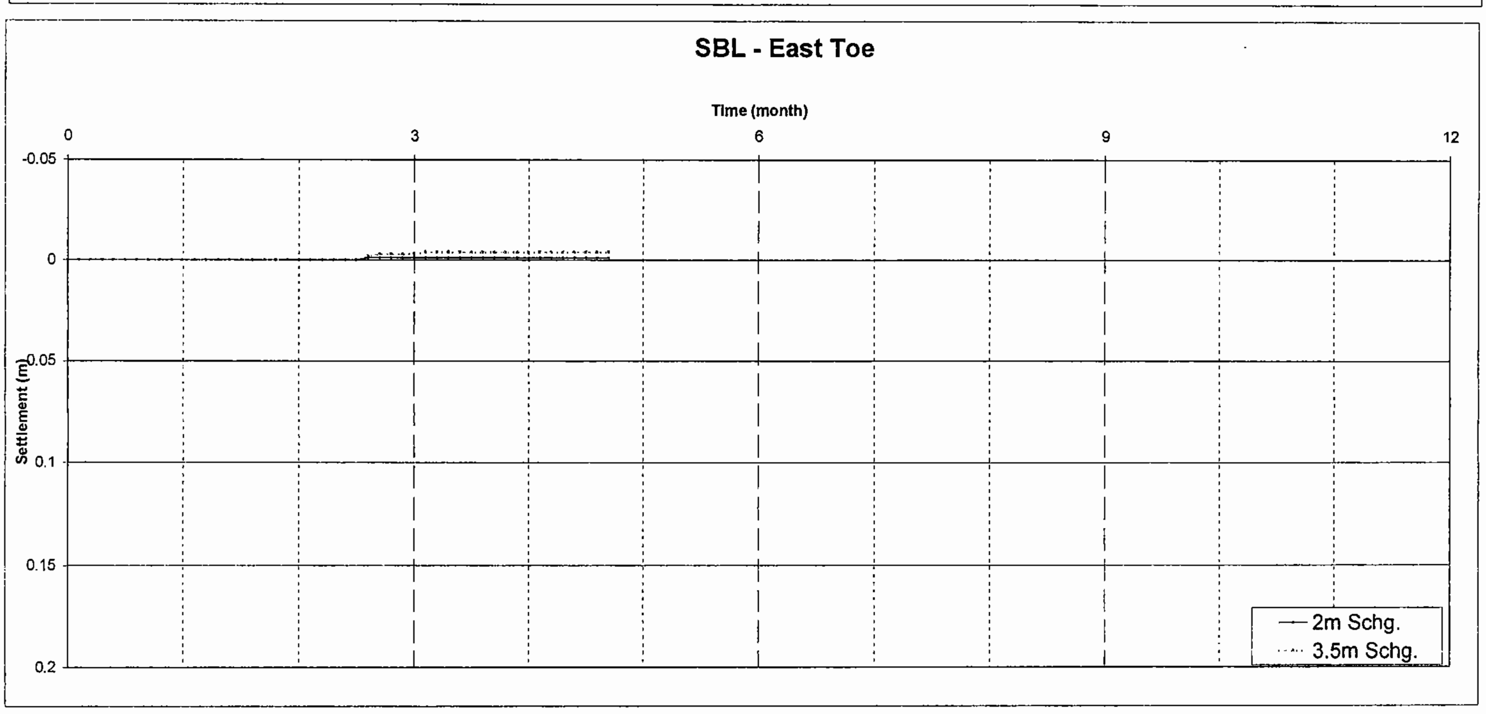


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	4.8	2.5
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	4.8	2.5
3		
4		

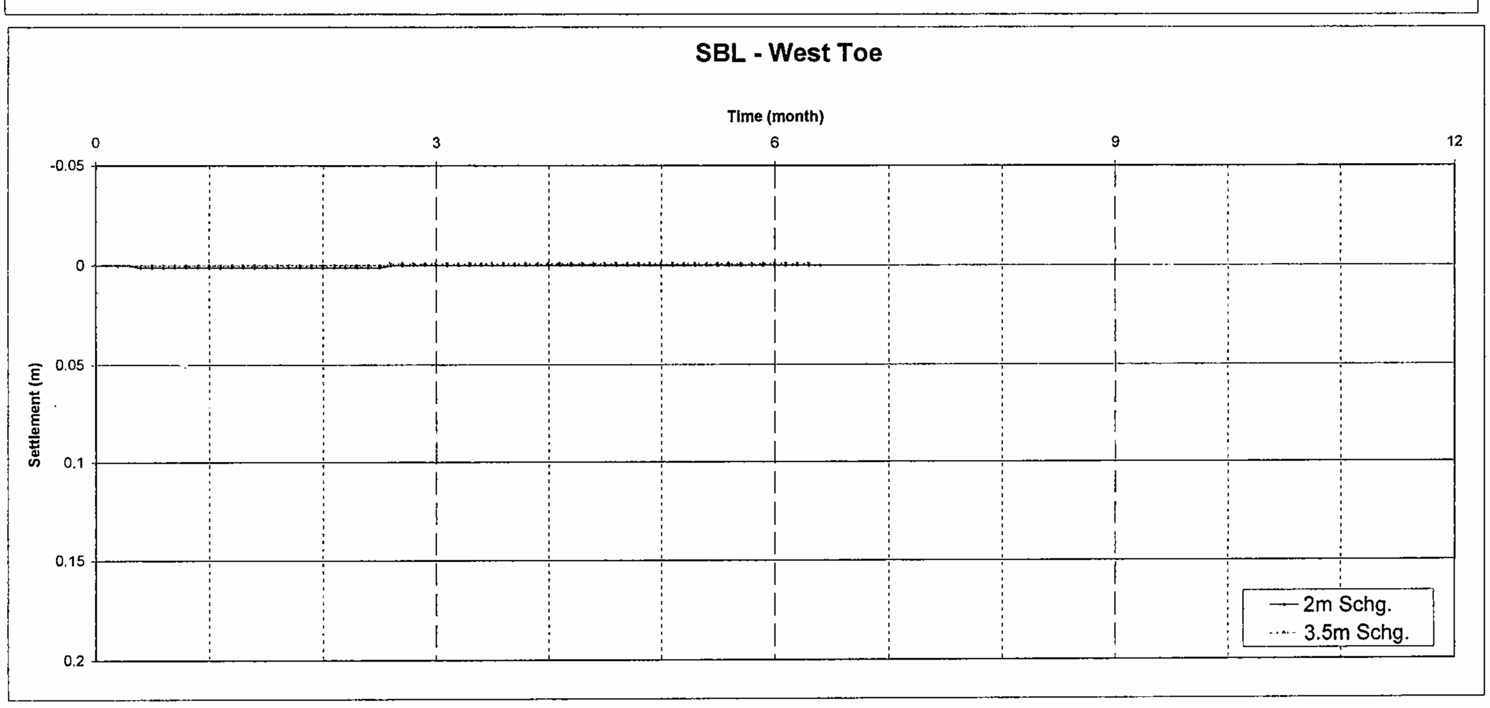


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	4.8	2.5
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	4.8	2.5
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	4.8	2.5
3		
4		

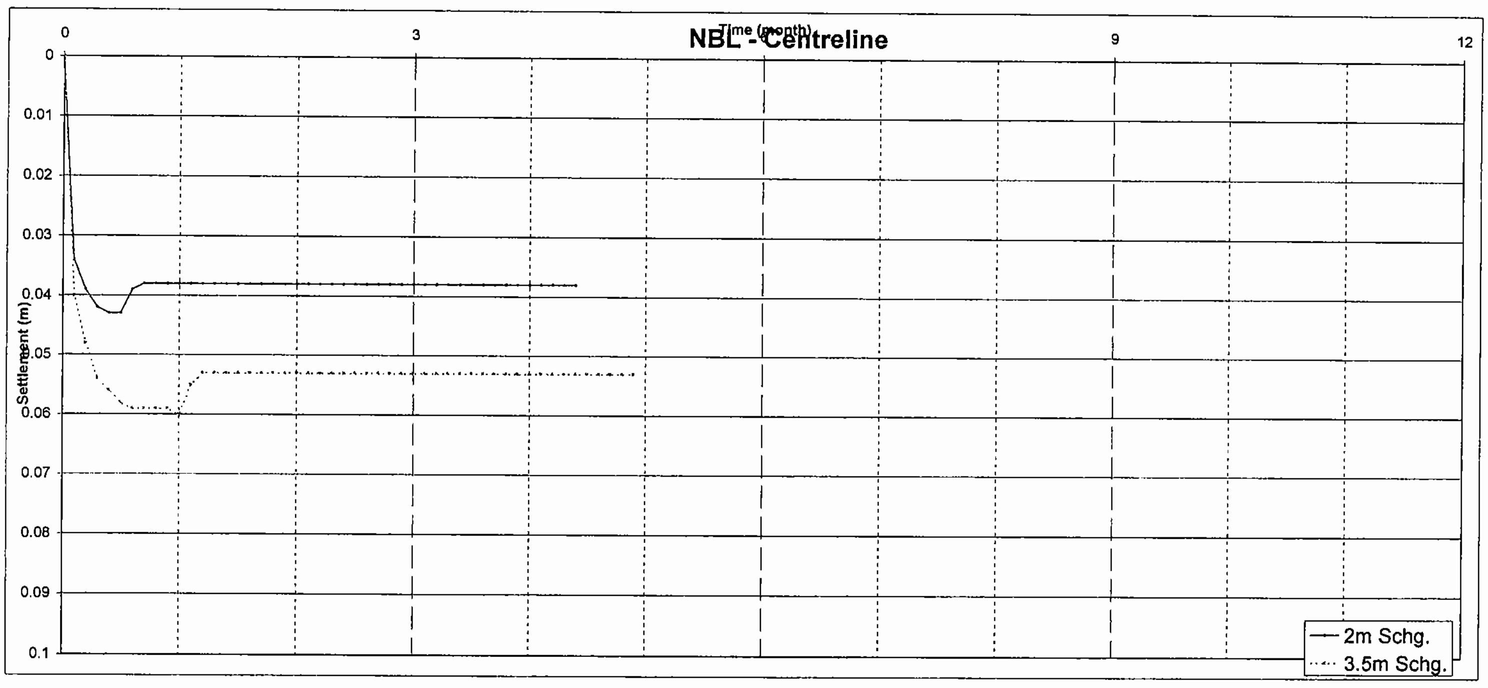
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	4.8	2.5
3		
4		

FIGURE E2

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 602 (South Swamp) - NBL Sta. 12+680 - Culvert 3

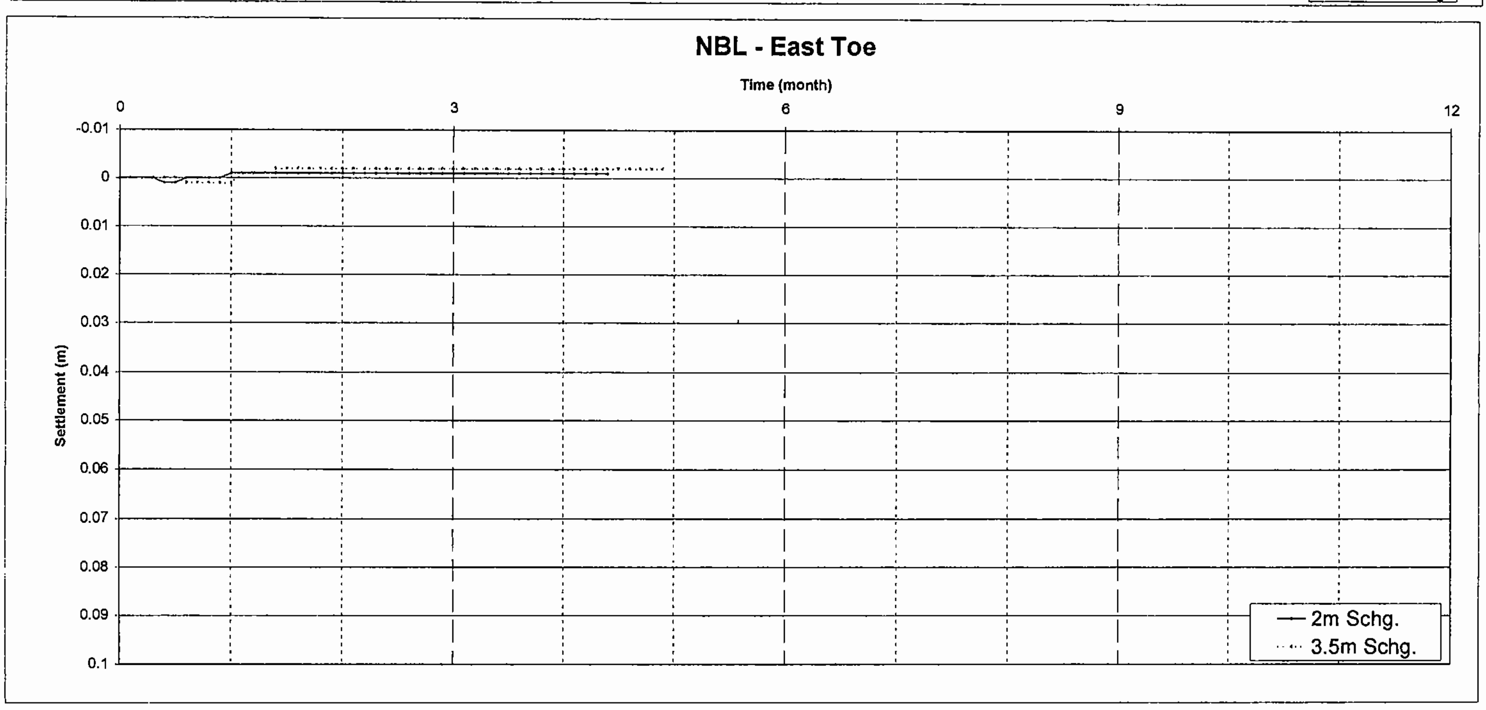


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	4.8	0.5
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	4.8	1
3		
4		

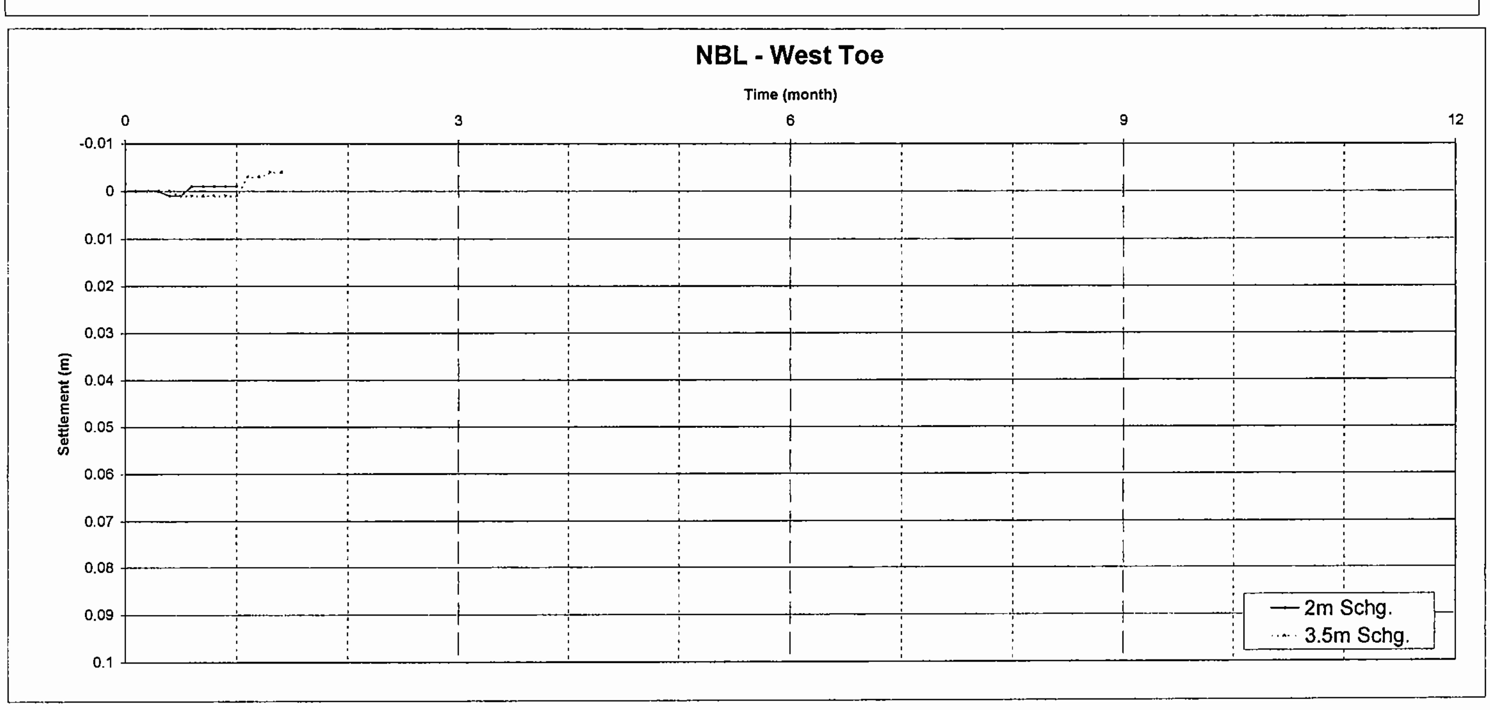


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	4.8	0.5
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	4.8	1
3		
4		



2m Surcharge

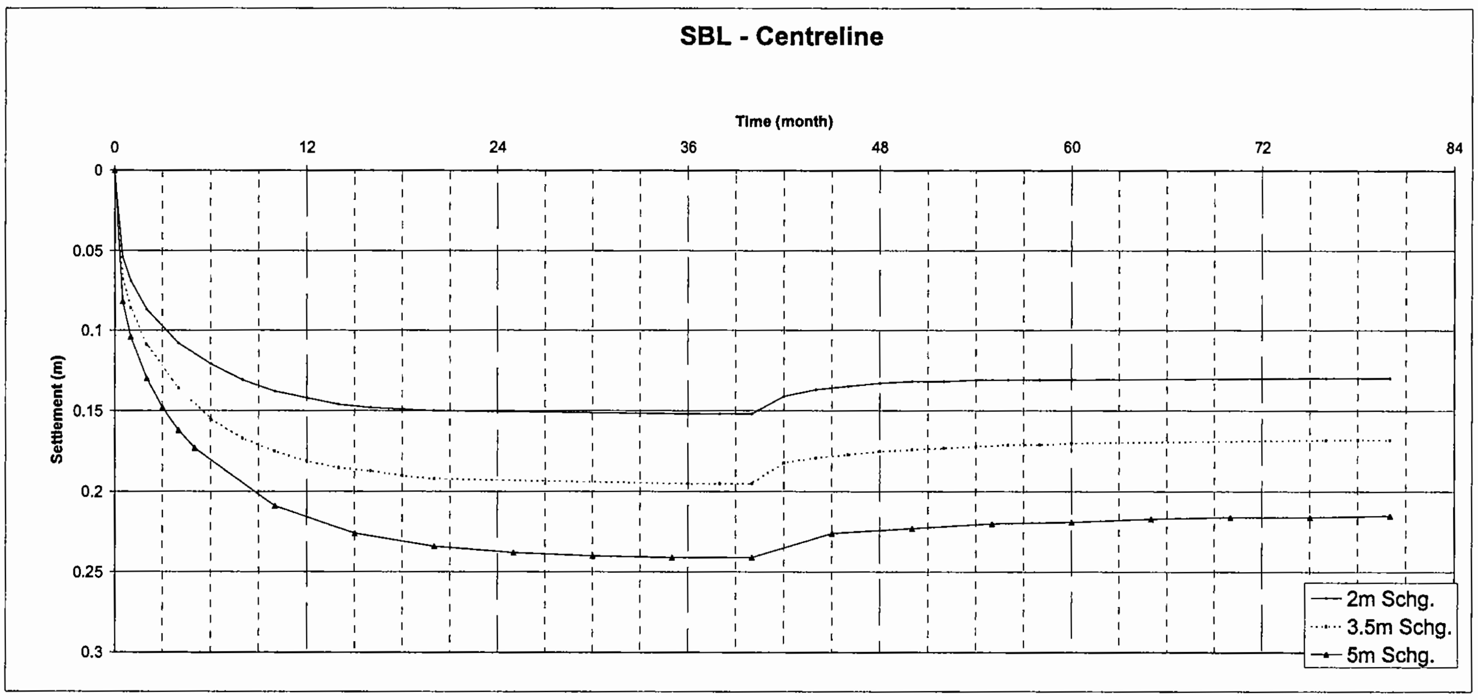
Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	4.8	0.5
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	4.8	1
3		
4		

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 602 (North Swamp) - SBL Sta. 12+890 - Culvert 4



2m Surcharge

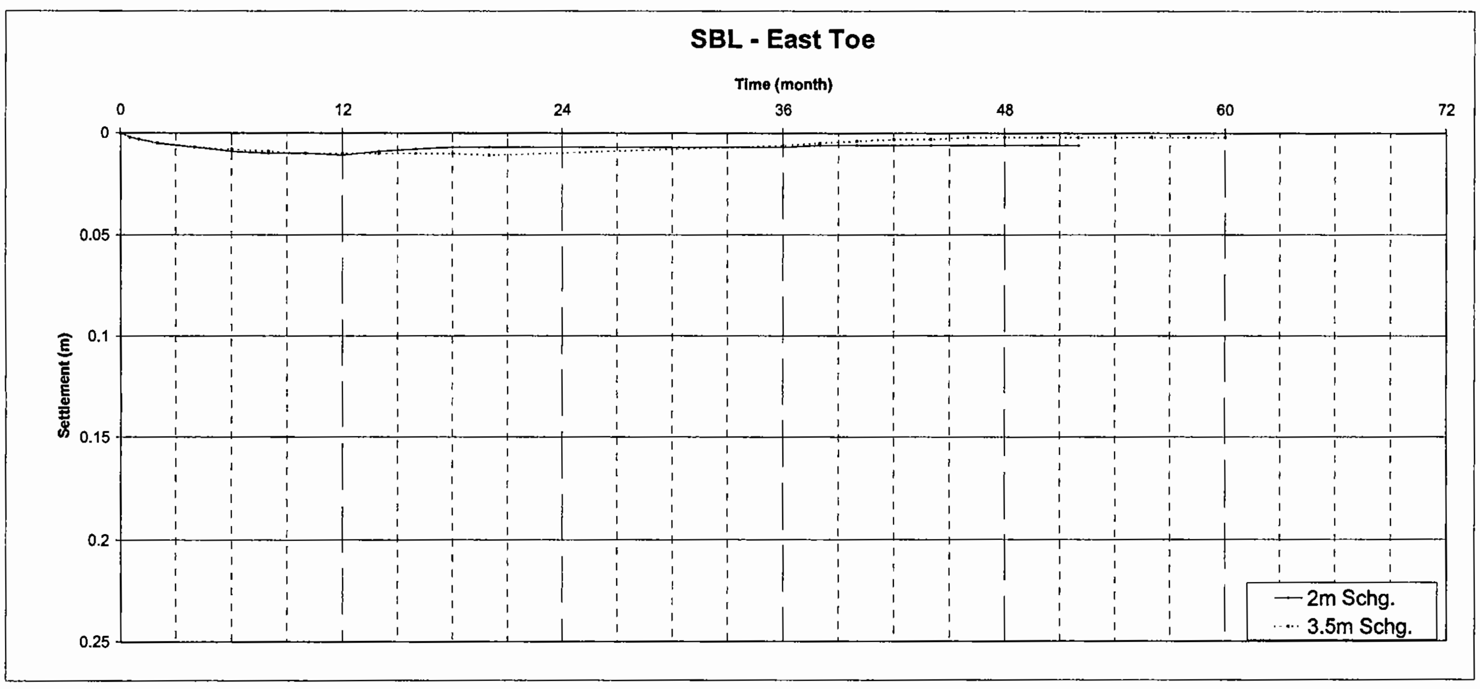
Stage	Ht. of Emb. (m)	@ t (month)
1	5.2	0
2	3.2	40
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.7	0
2	3.2	40
3		
4		

5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.2	0
2	3.2	40
3		
4		

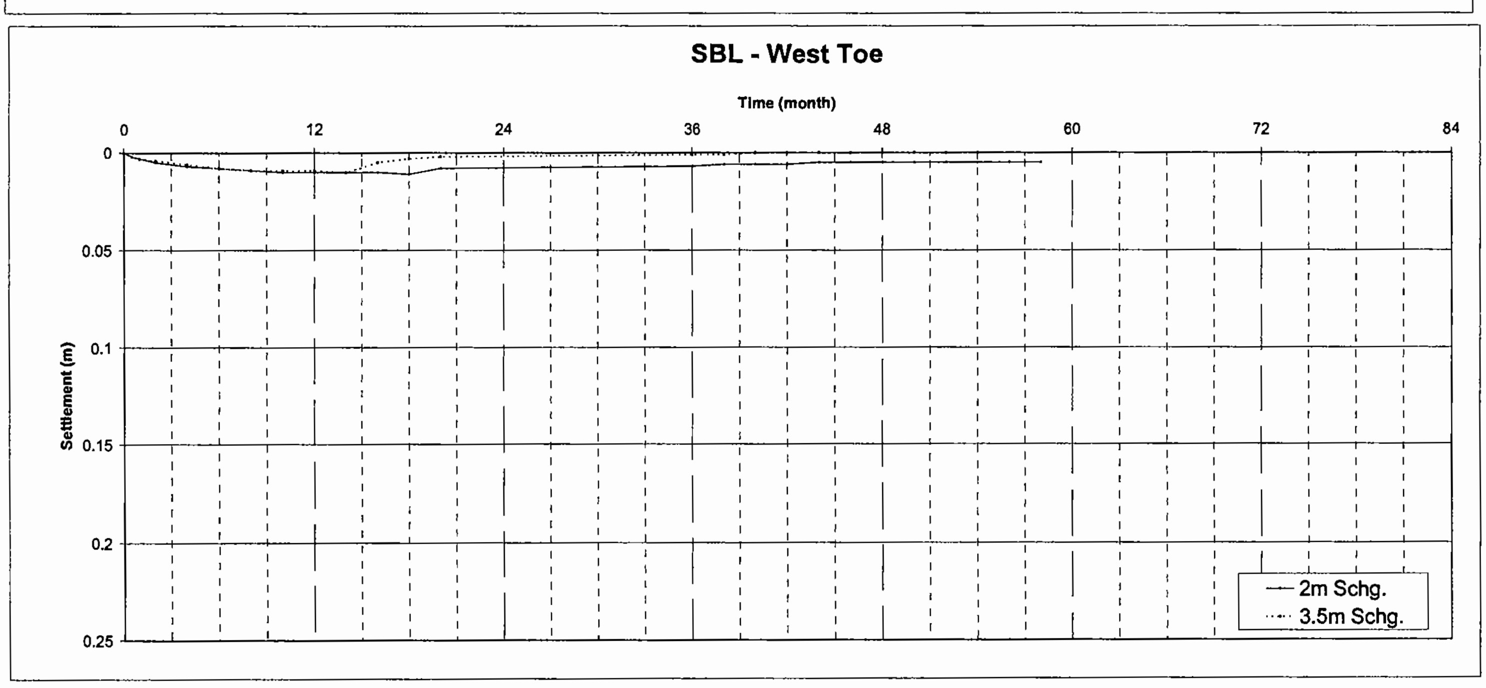


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.2	0
2	3.2	12
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.7	0
2	3.2	20
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.2	0
2	3.2	18
3		
4		

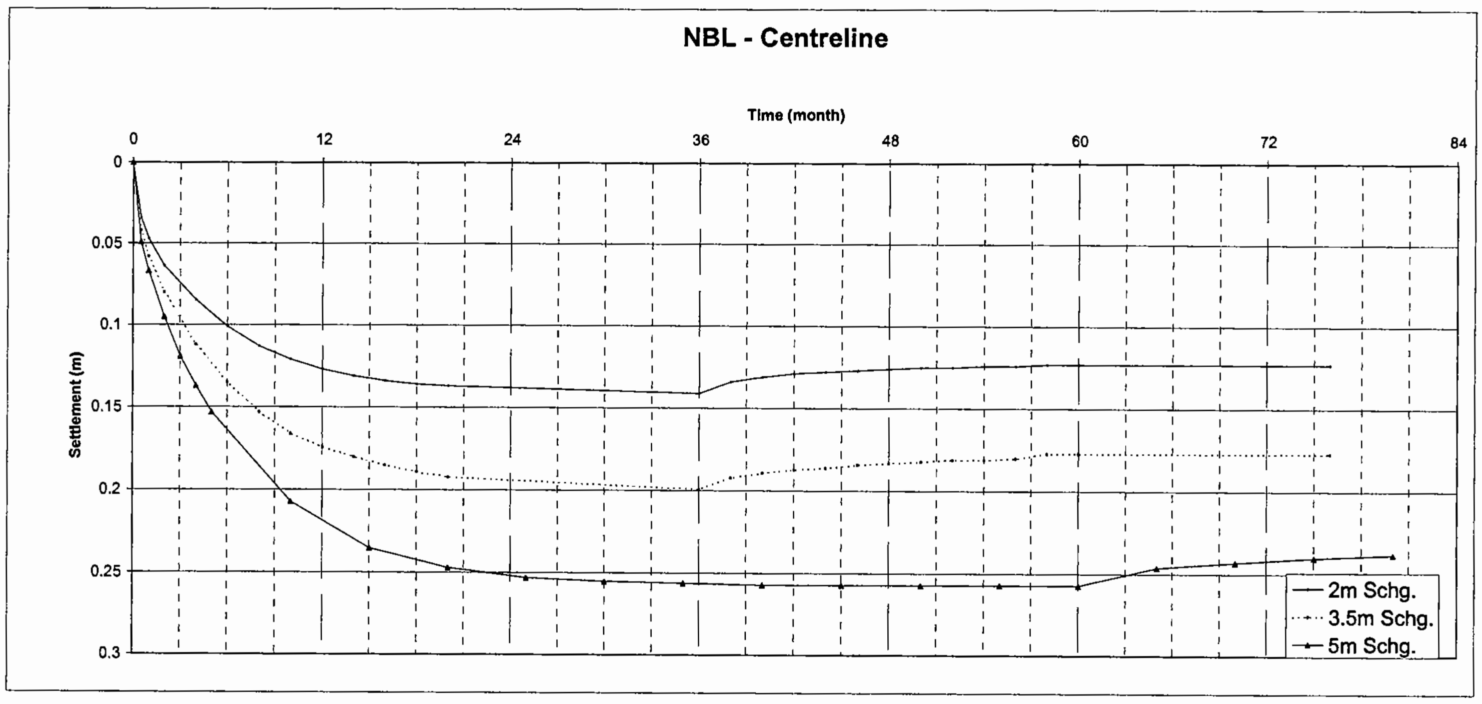
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.7	0
2	3.2	14
3		
4		

FIGURE E4

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 602 (North Swamp) - NBL Sta. 12+890 - Culvert 4



2m Surcharge

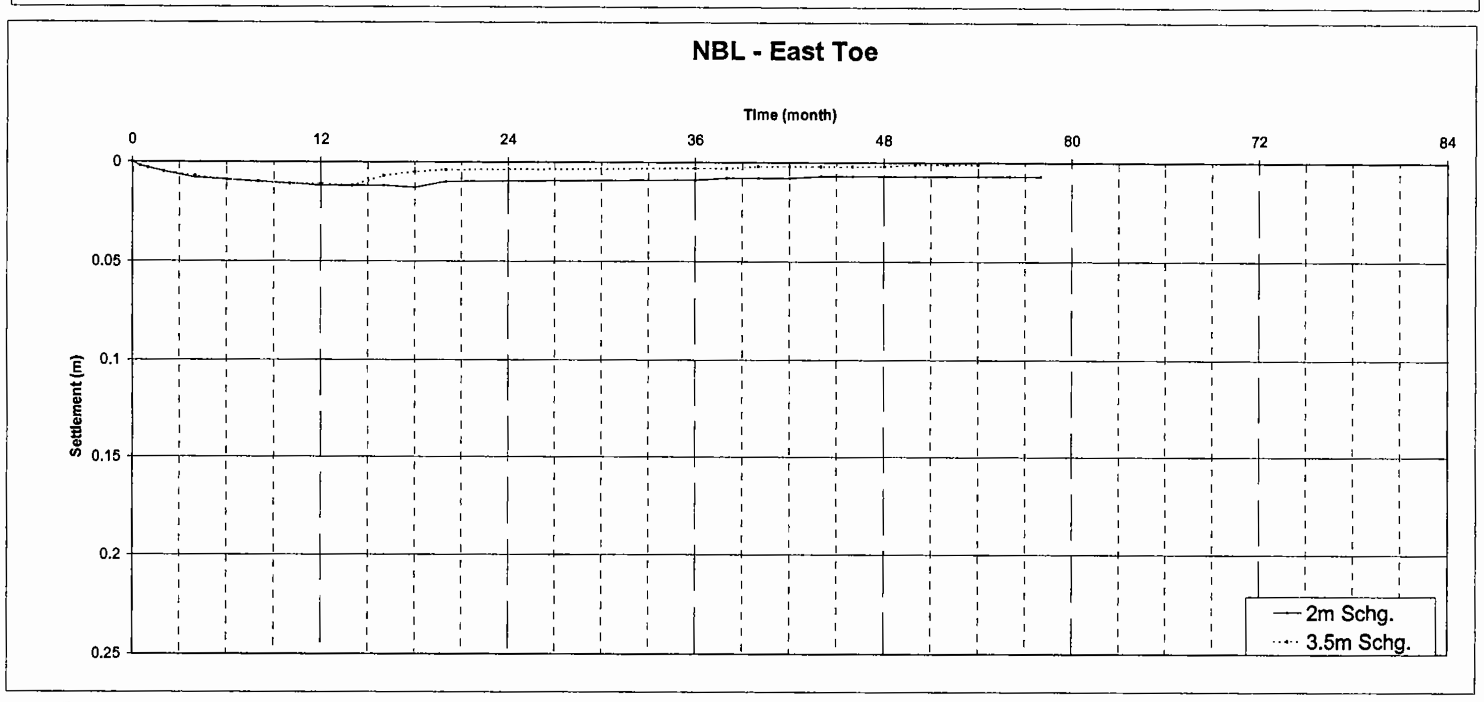
Stage	Ht. of Emb. (m)	@ t (month)
1	5.3	0
2	3.3	36
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	3.3	36
3		
4		

5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.3	0
2	3.3	60
3		
4		

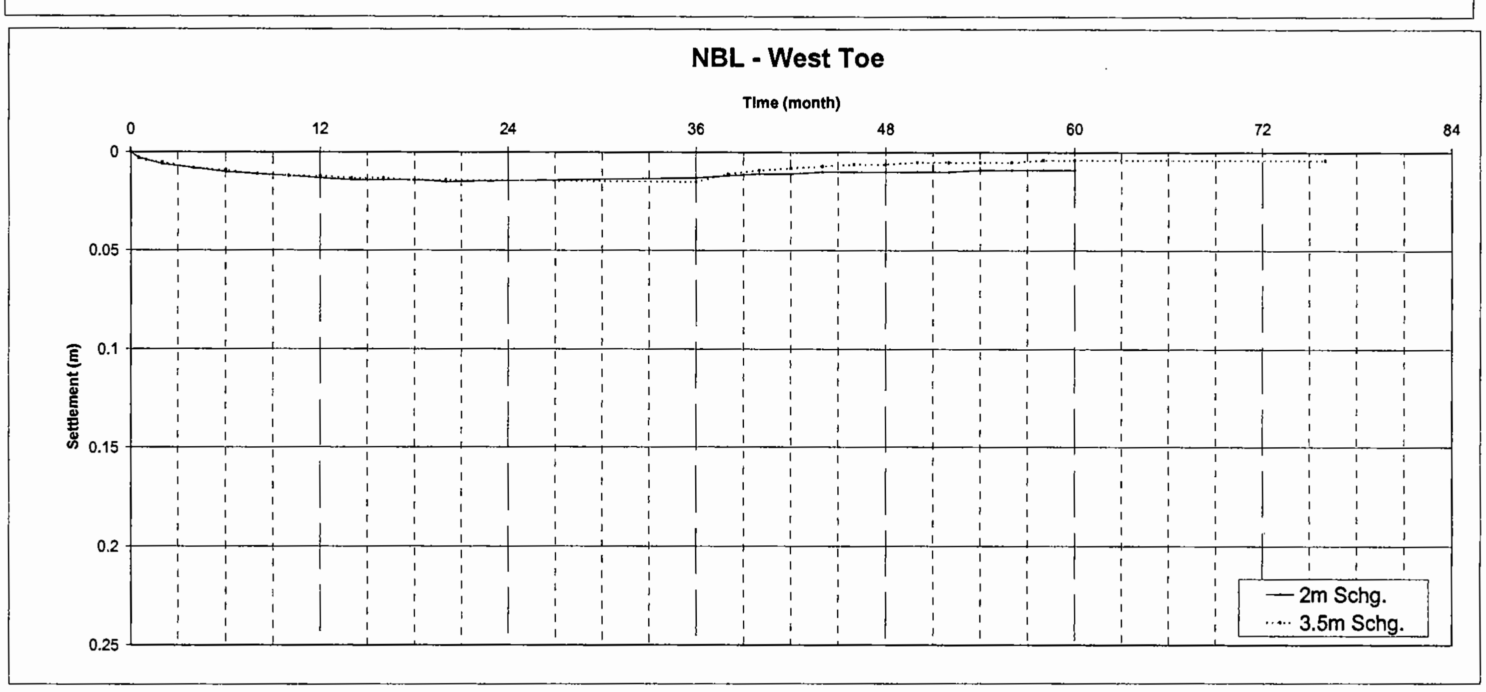


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.3	0
2	3.3	18
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	3.3	14
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.3	0
2	3.3	20
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.8	0
2	3.3	36
3		
4		

FIGURE E5

SWAMP 602 (CULVERT 3) - SETTLEMENTS DUE TO PRIMARY CONSOLIDATION

(Before the removal of surcharge)

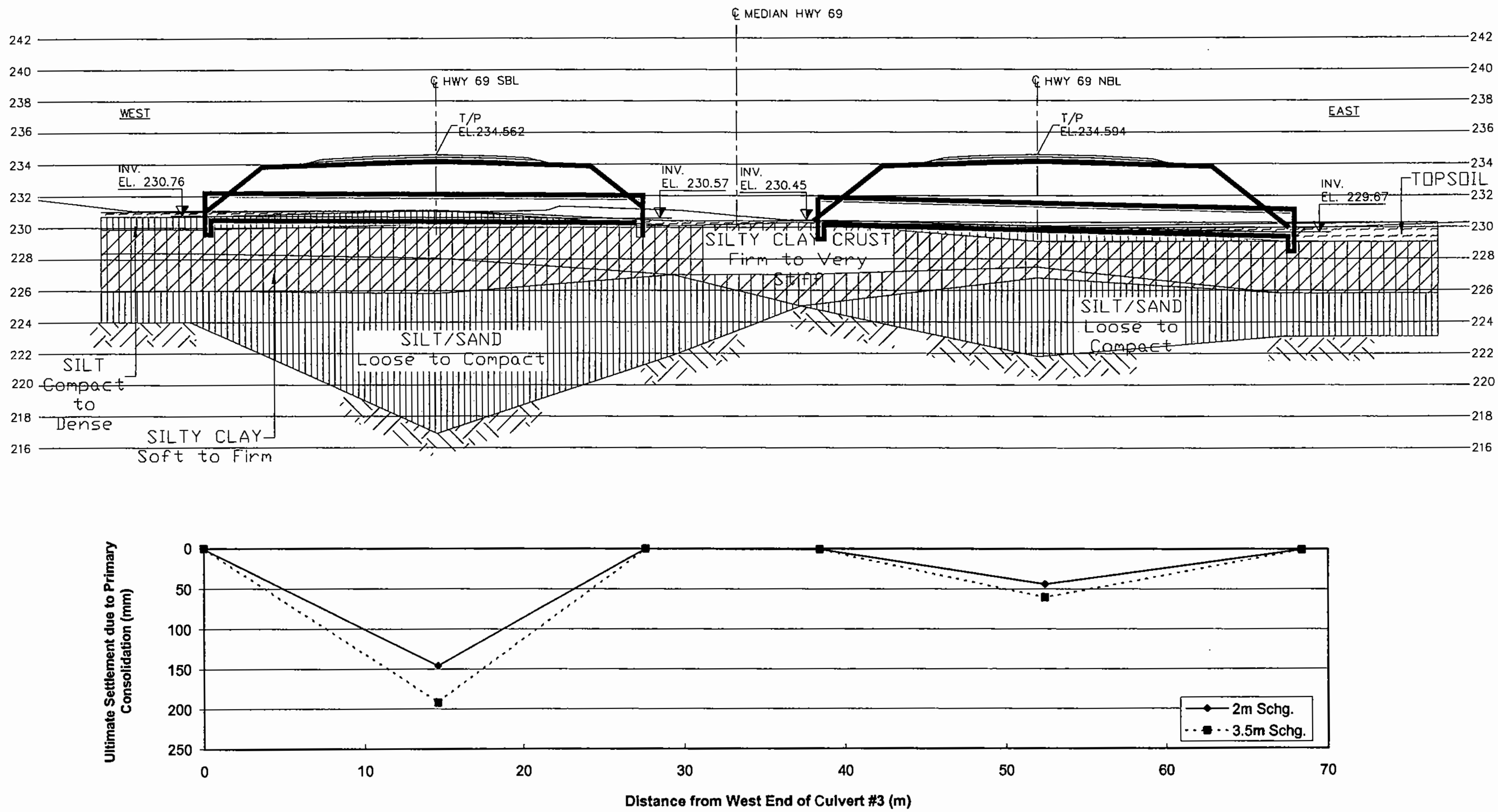
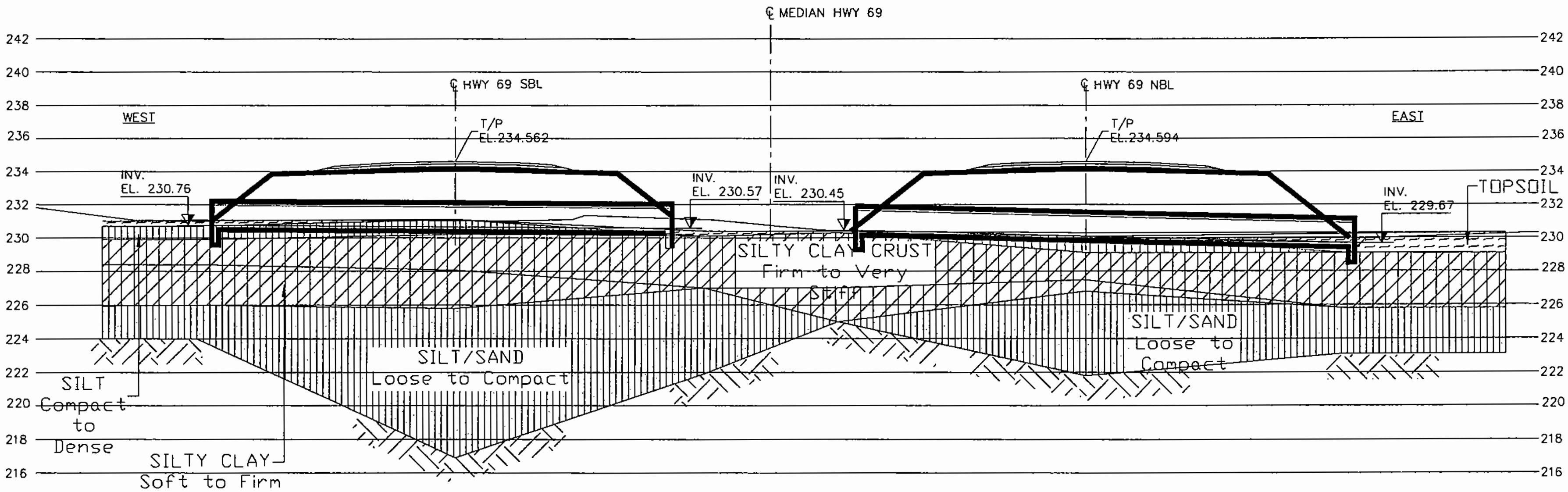


FIGURE E6

SWAMP 602 - CULVERT #3
LONG TERM SETTLEMENTS DUE TO SECONDARY CONSOLIDATION



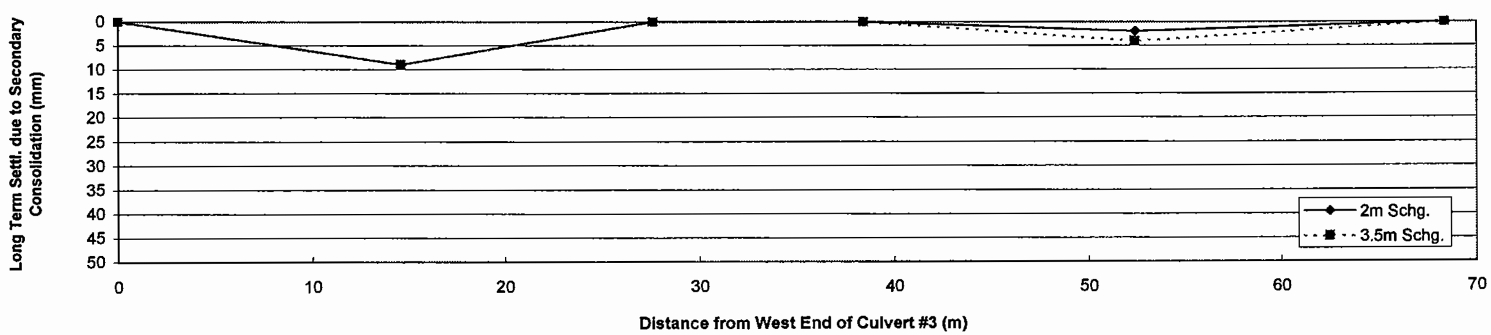
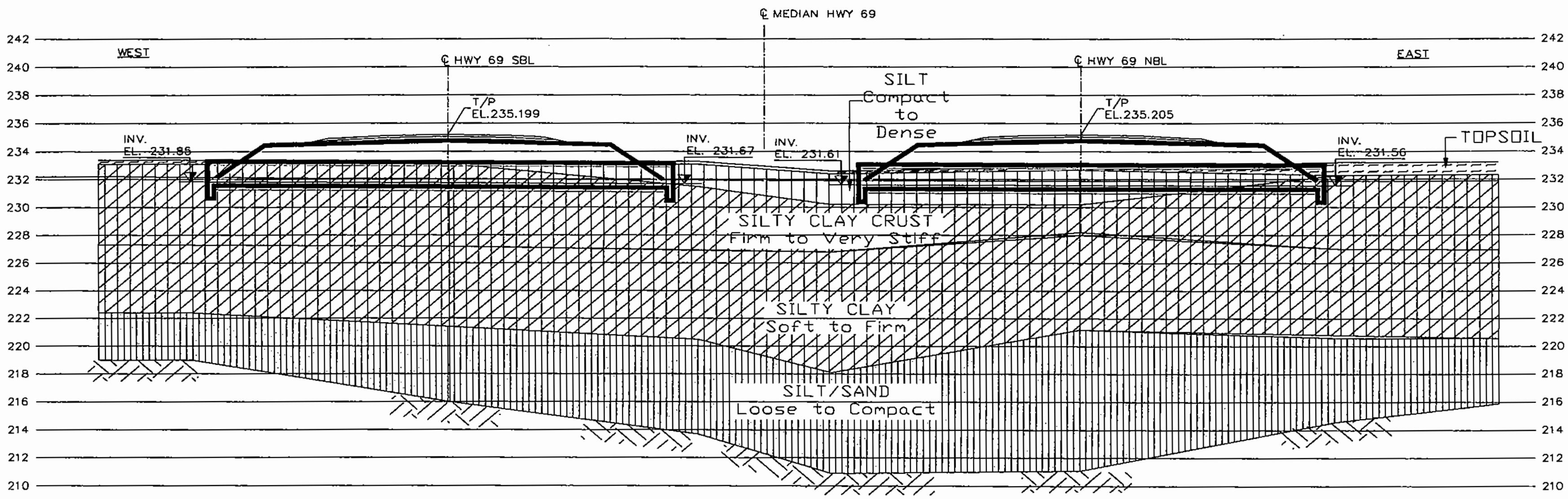


FIGURE E6b

SWAMP 602 (CULVERT 4) - SETTLEMENTS DUE TO PRIMARY CONSOLIDATION

(Before the removal of surcharge)



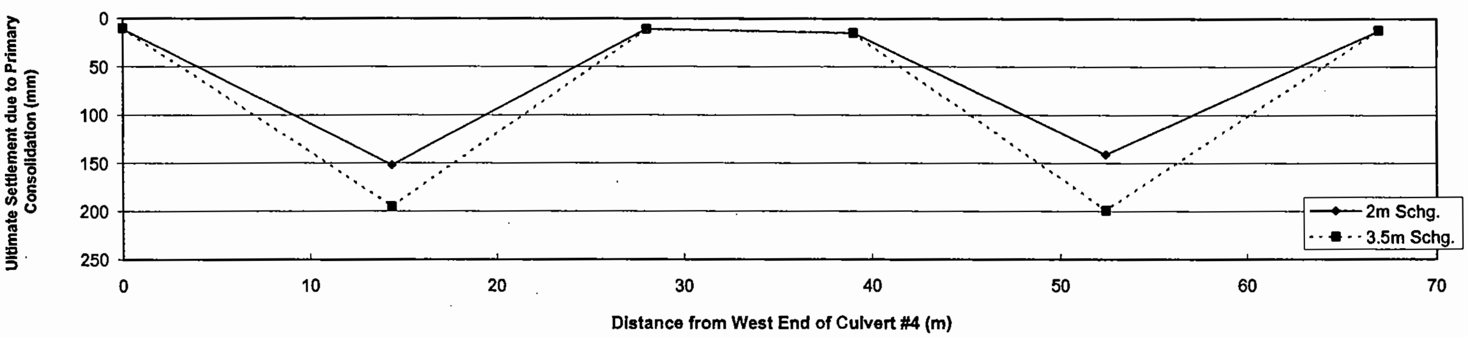
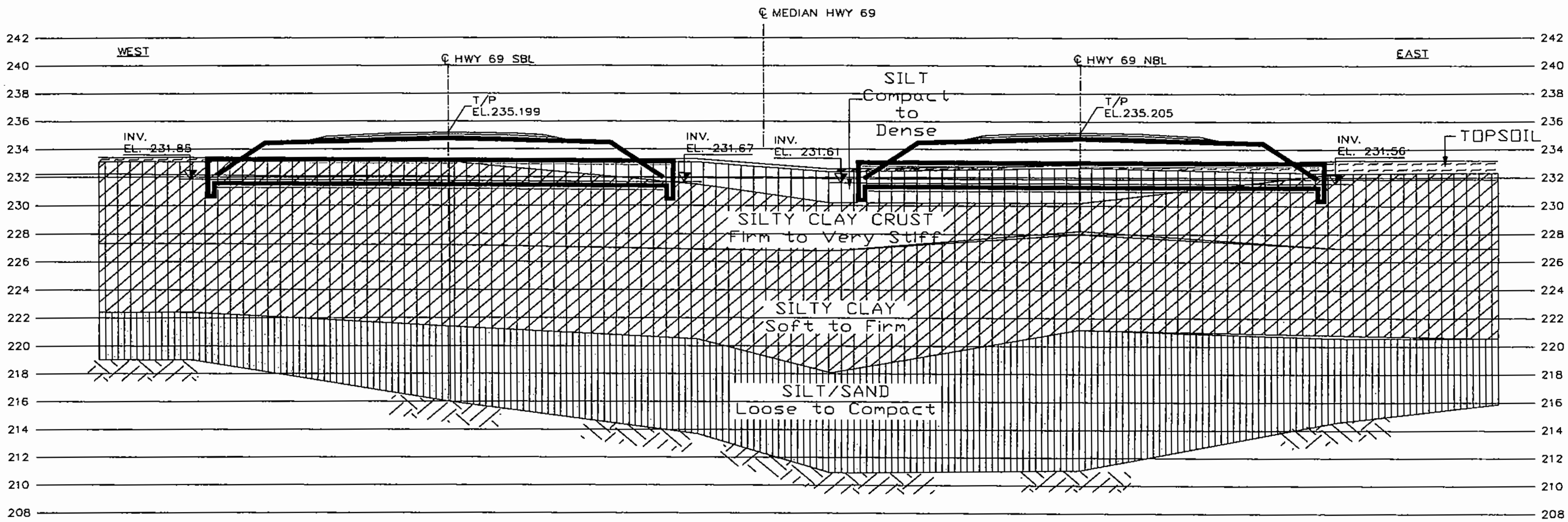


FIGURE E7

SWAMP 602 - CULVERT #4
LONG TERM SETTLEMENTS DUE TO SECONDARY CONSOLIDATION



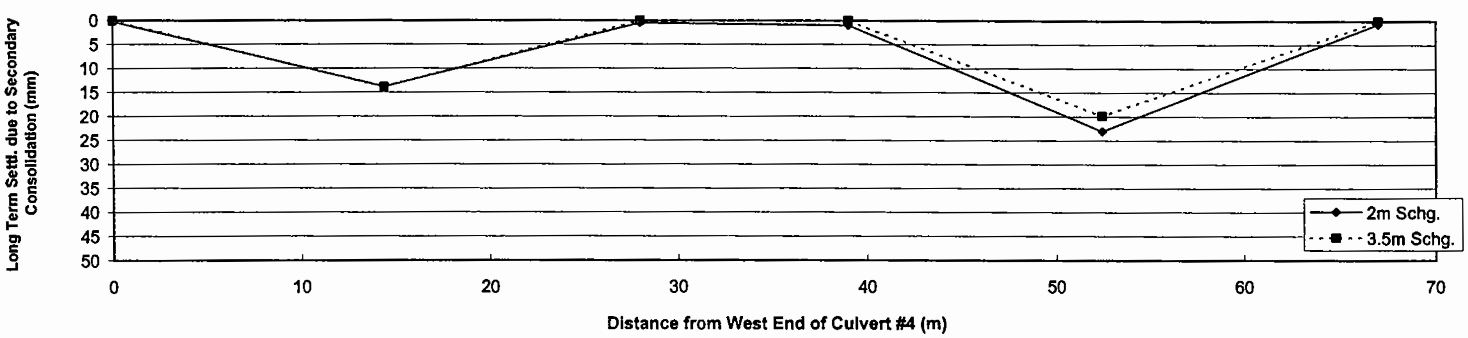
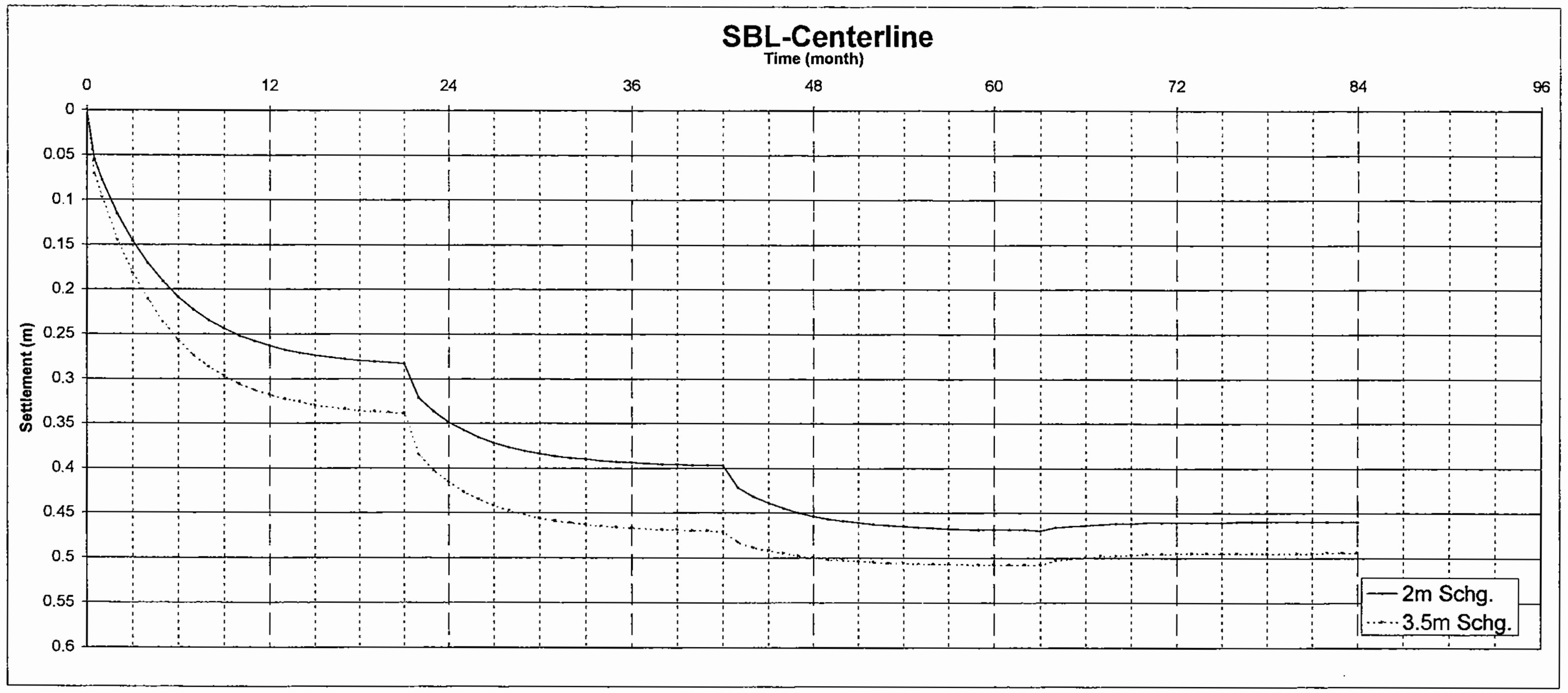


FIGURE E7b

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 605 - Sta. 14+290

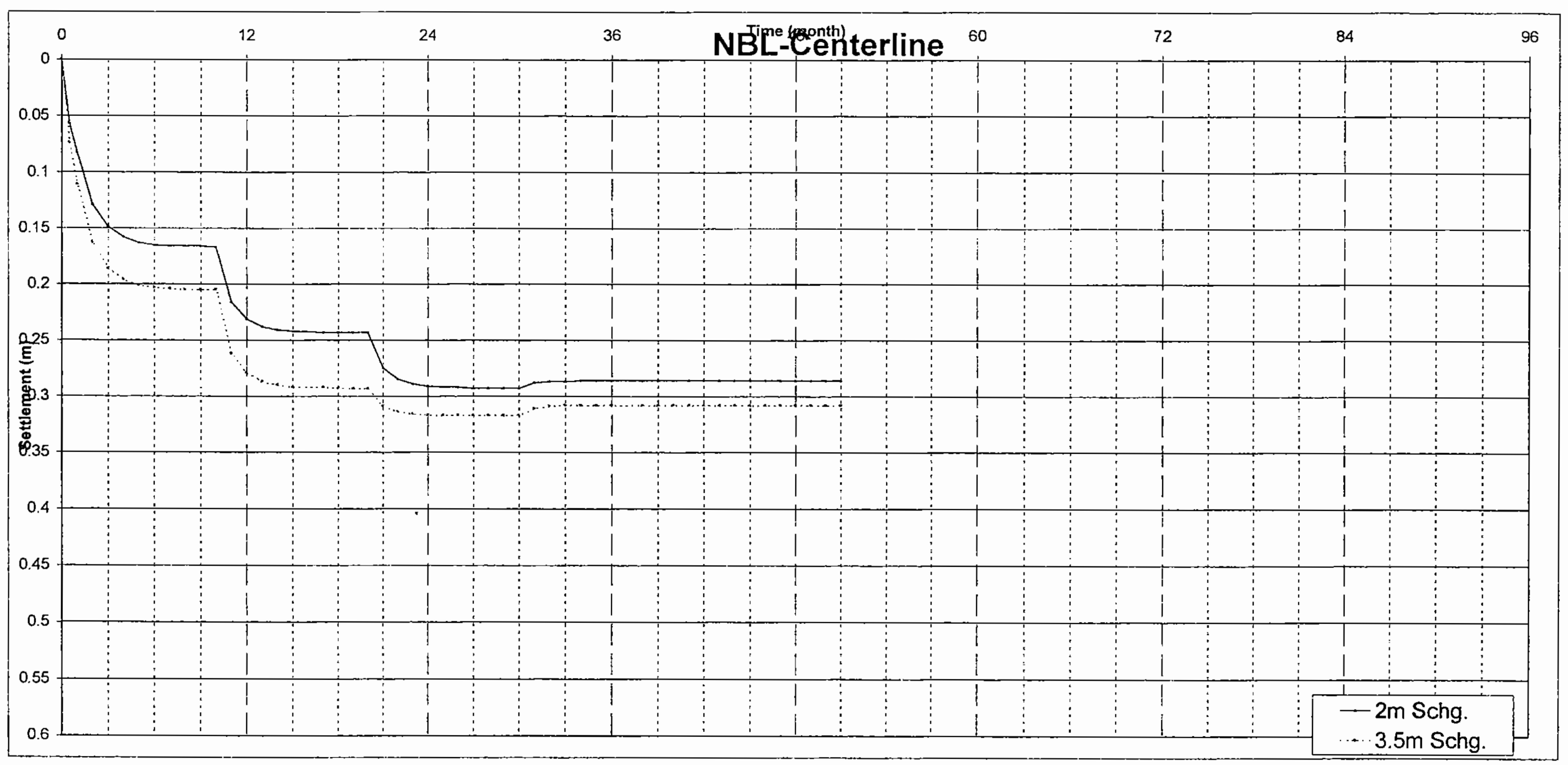


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5	0
2	7	21
3	9	42
4	7	63

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6	0
2	9	21
3	10.5	42
4	7	63



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5	0
2	7	10
3	9	20
4	7	30

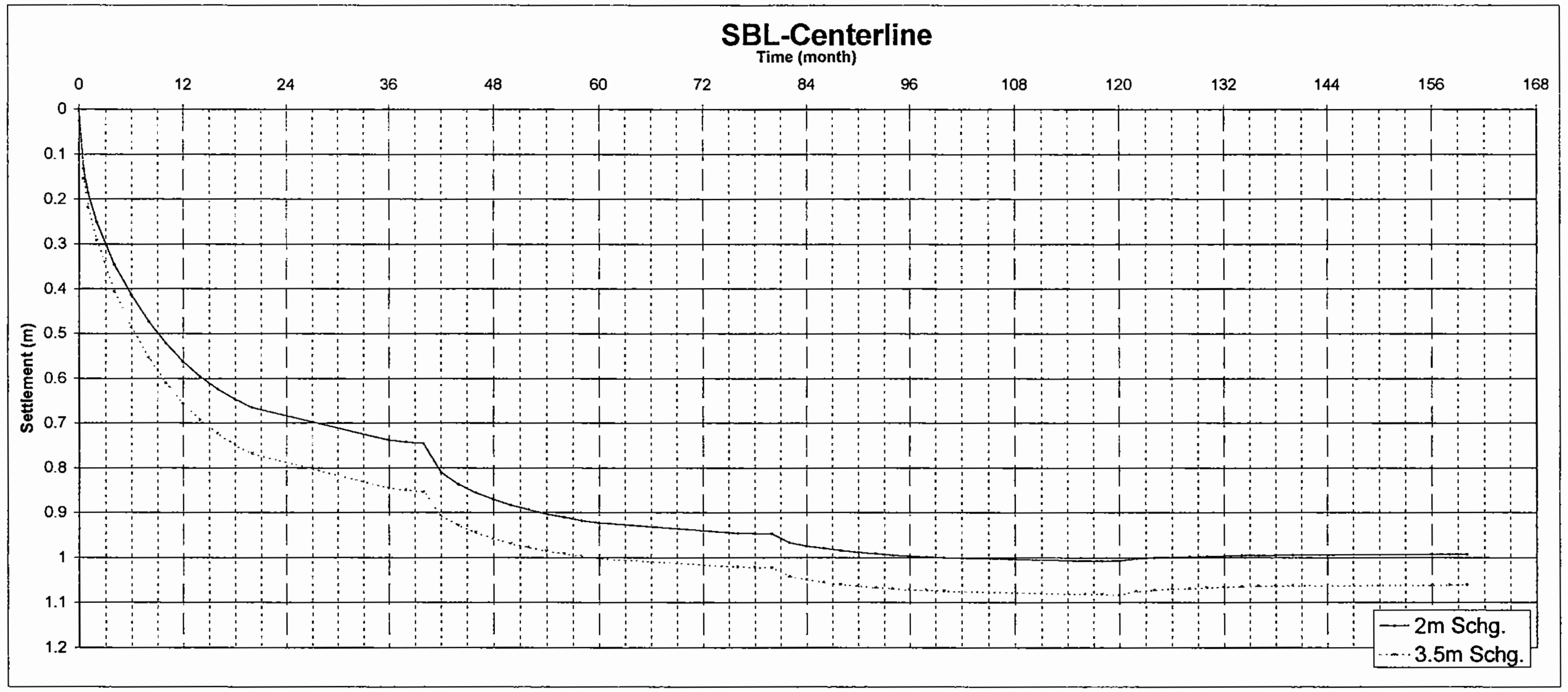
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6	0
2	9	10
3	10.5	20
4	7	30

FIGURE E8

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 605 - Sta. 14+330

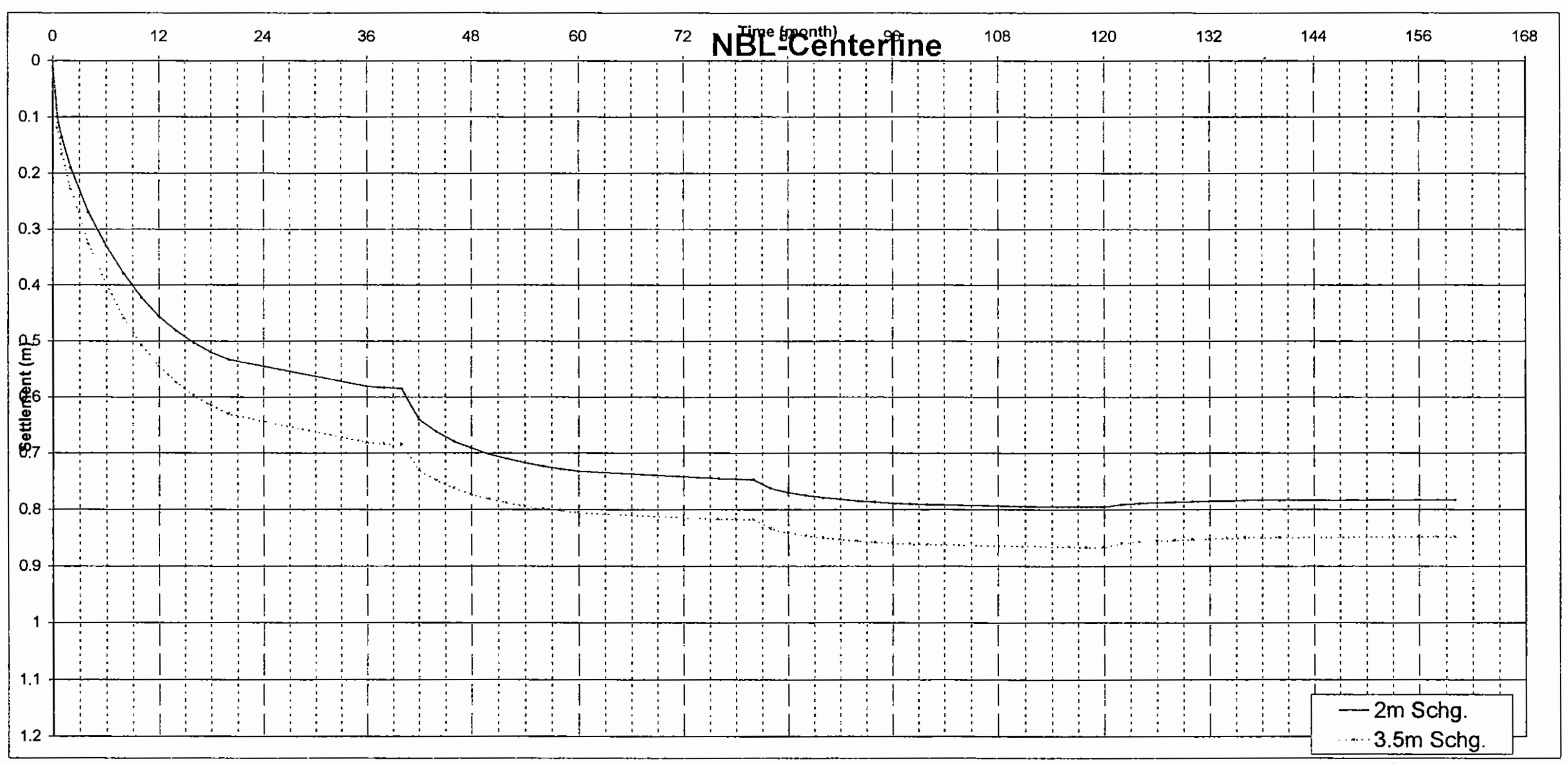


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.3	0
2	8.3	40
3	9.3	80
4	7.3	120

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	7.3	0
2	9.3	40
3	10.8	80
4	7.3	120



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.3	0
2	8.3	40
3	9.3	80
4	7.3	120

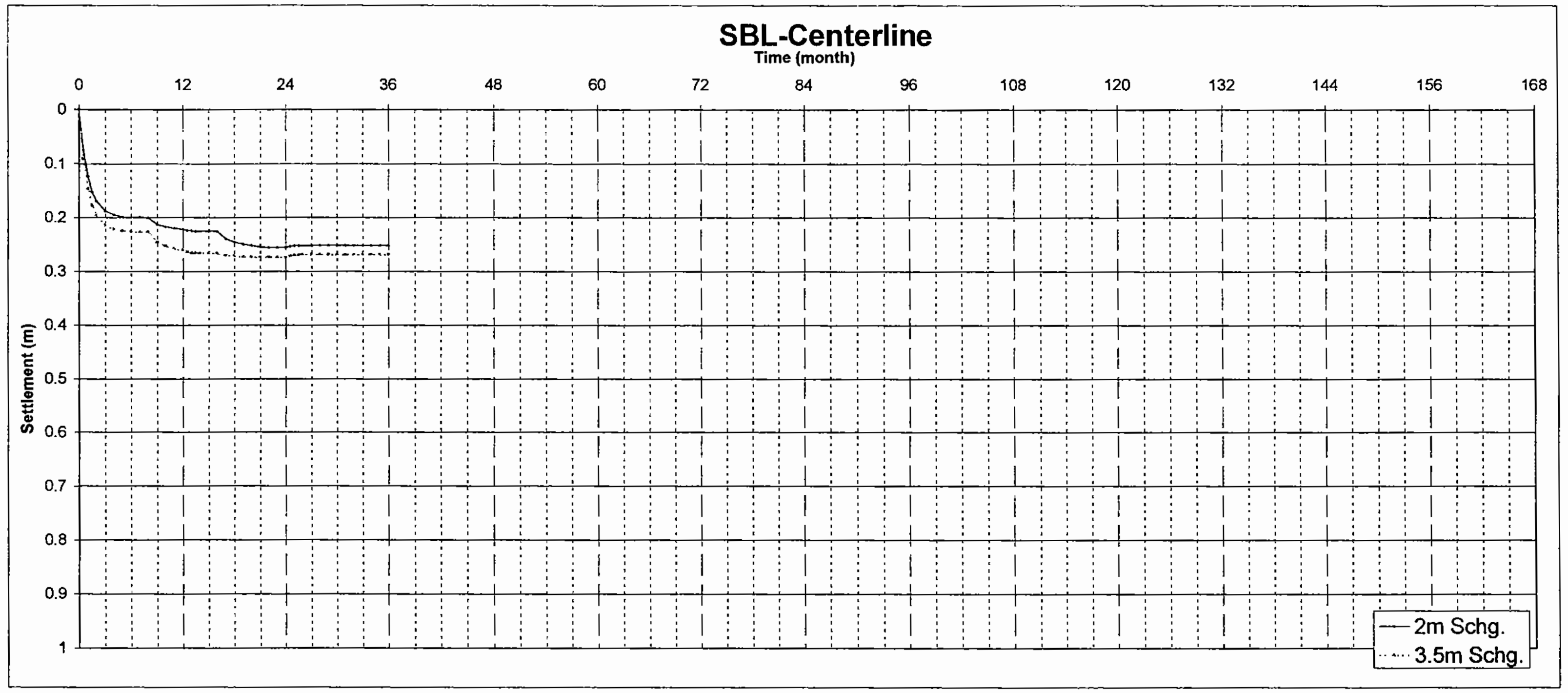
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	7.3	0
2	9.3	40
3	10.8	80
4	7.3	120

FIGURE E9

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 605 - Sta. 14+390

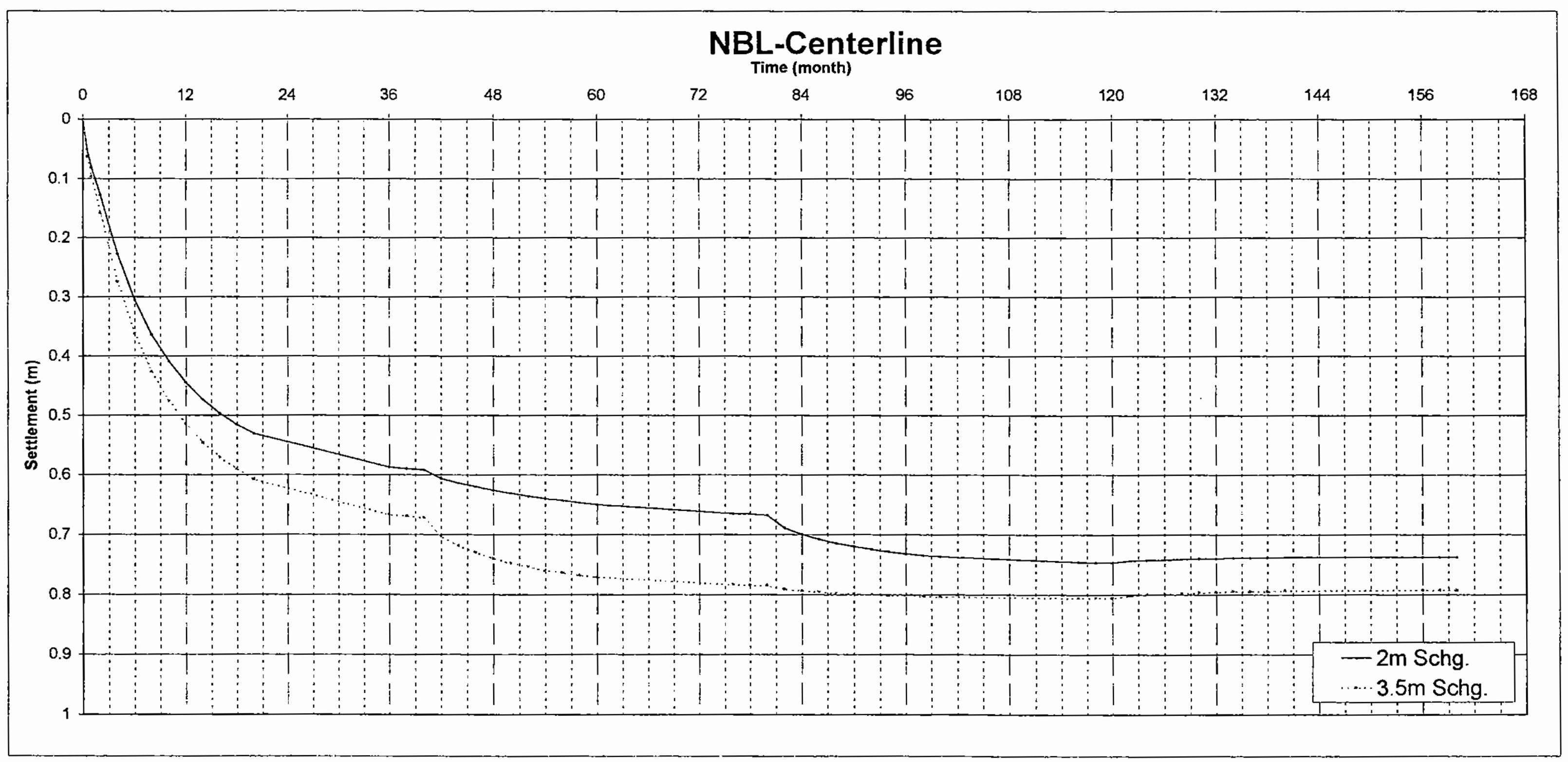


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	7	0
2	8	8
3	10	16
4	8	24

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	10.5	8
3	11.5	16
4	8	24



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	7	0
2	8	40
3	10	80
4	8	120

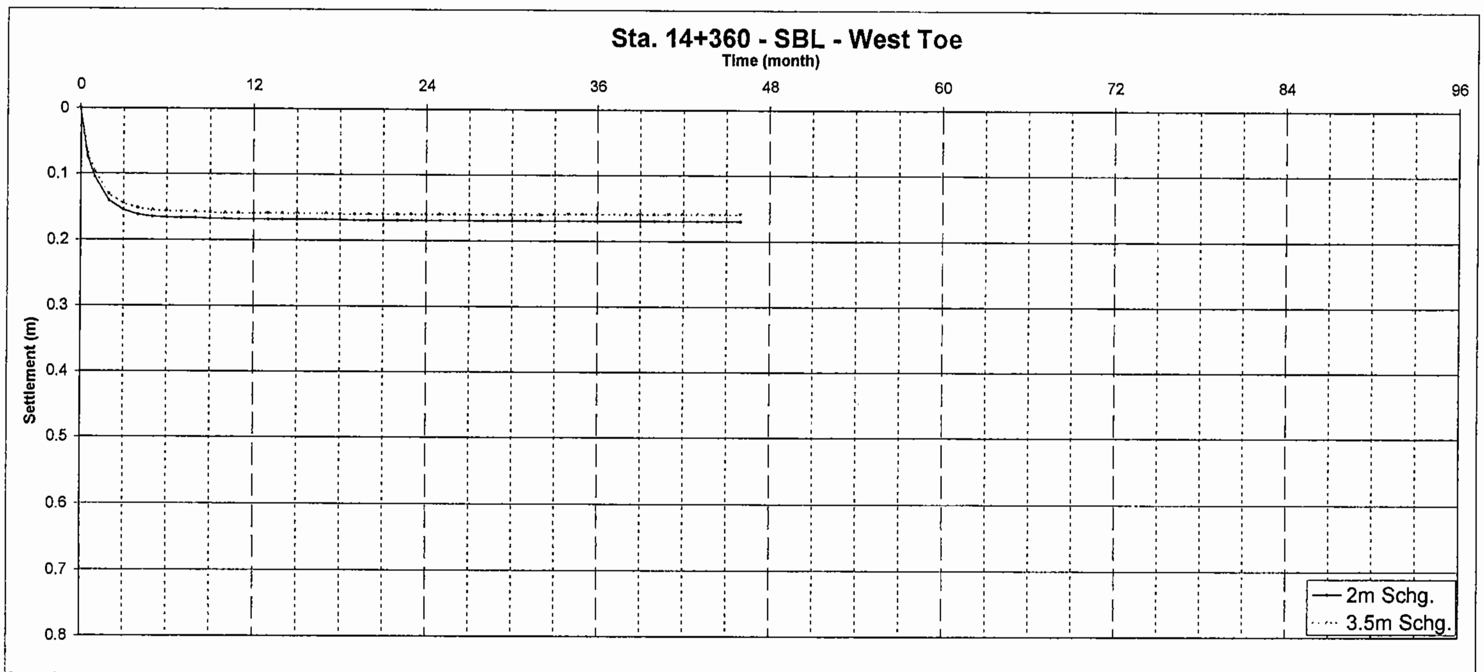
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	10.5	40
3	11.5	80
4	8	120

FIGURE E10

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 605 - SBL Sta. 14+360 to 14+400 - Culvert 7

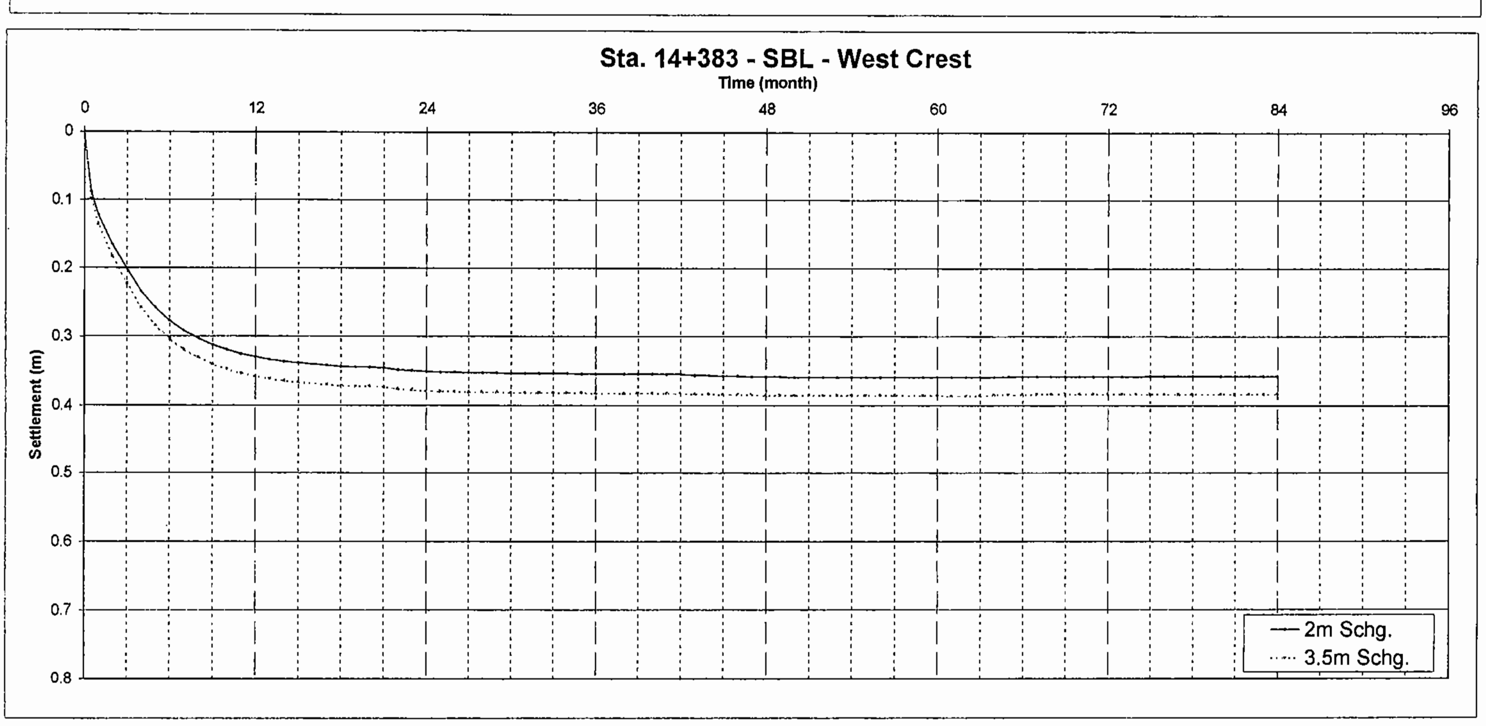


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	9	8
3	10	16
4	8	24

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	9	0
2	10.5	8
3	11.5	16
4	8	24

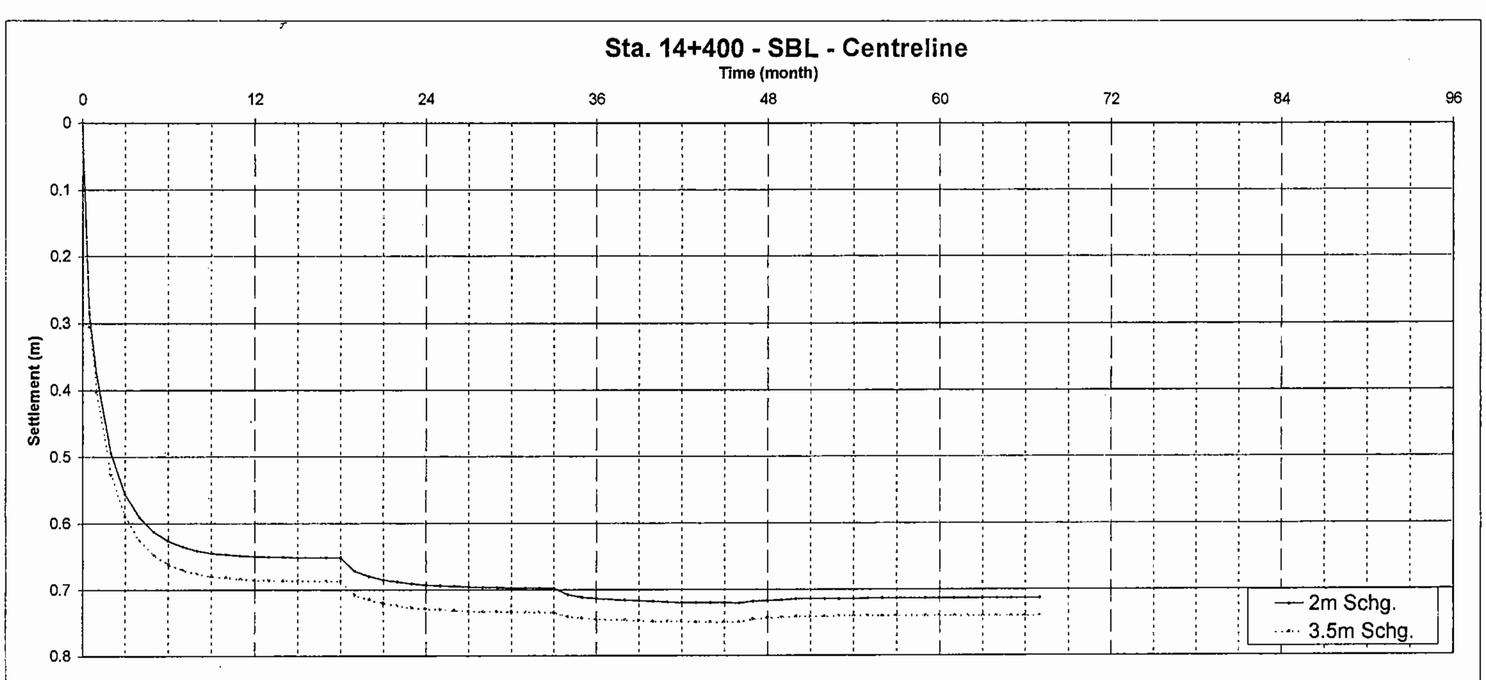


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	9	21
3	10	42
4	8	63

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	10.5	21
3	11.5	42
4	8	63



2m Surcharge

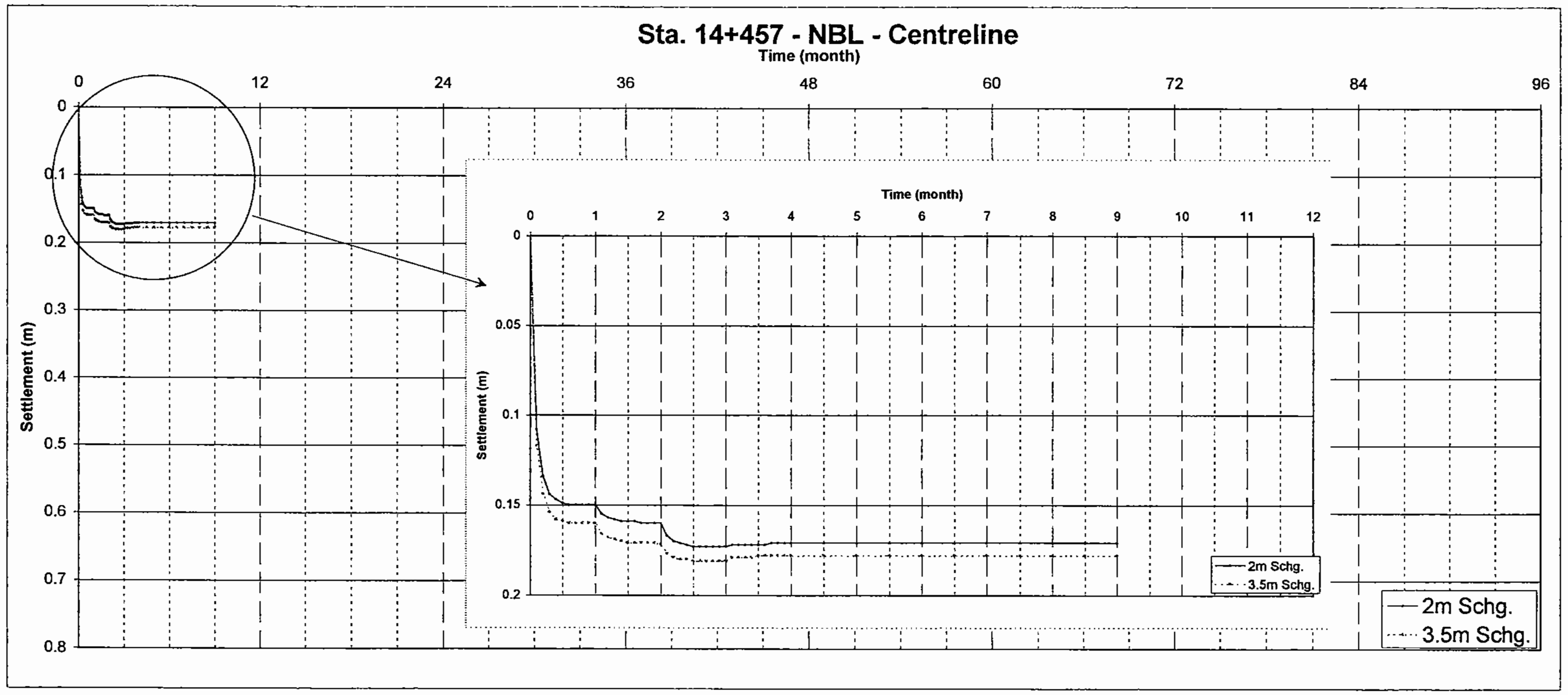
Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	9	18
3	10	36
4	8	54

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	10.5	18
3	11.5	36
4	8	54

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 605 - NBL Sta. 14+457 to 14+472 - Culvert 7

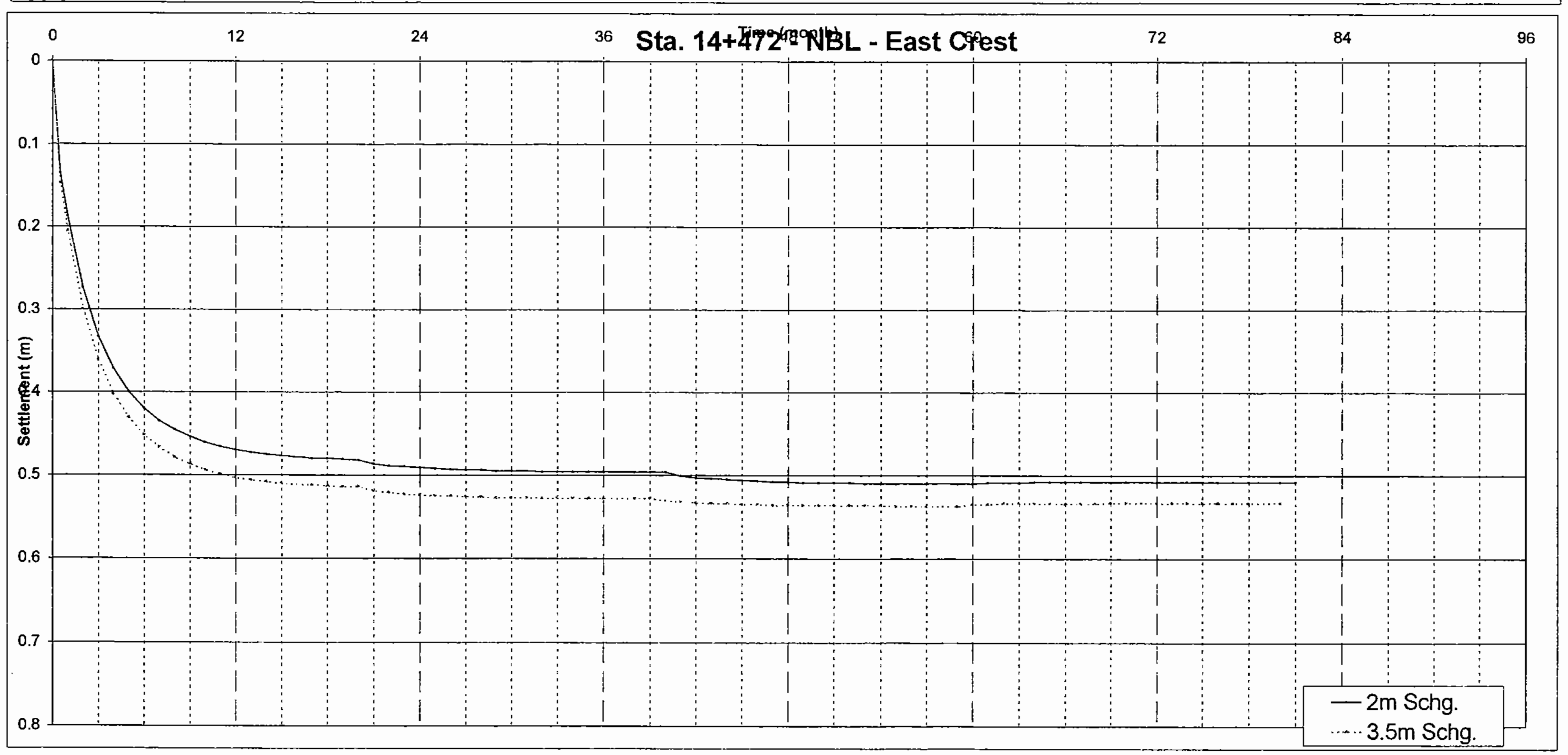


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	9	1
3	11	2
4	9	3

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	9	0
2	10.5	1
3	12.5	2
4	9	3



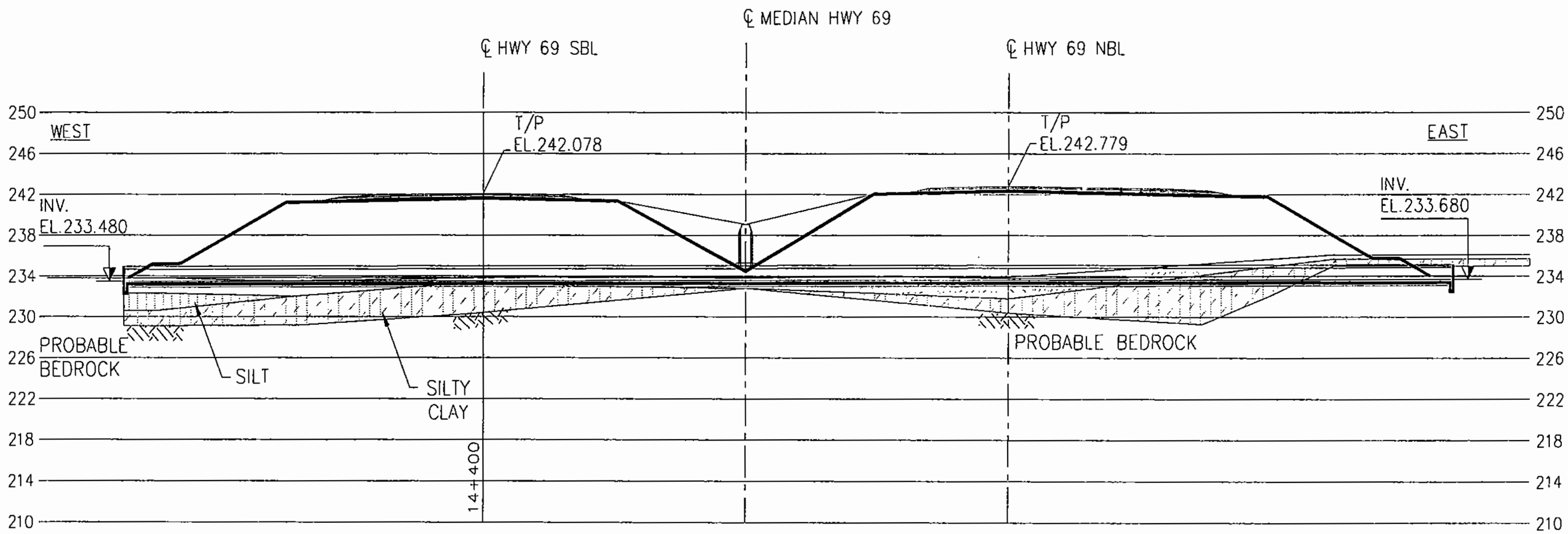
2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8	0
2	9	20
3	11	40
4	9	60

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	9	0
2	10.5	20
3	12.5	40
4	9	60

SWAMP 605 - CULVERT #7
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION BEFORE THE REMOVAL OF SURCHARGE



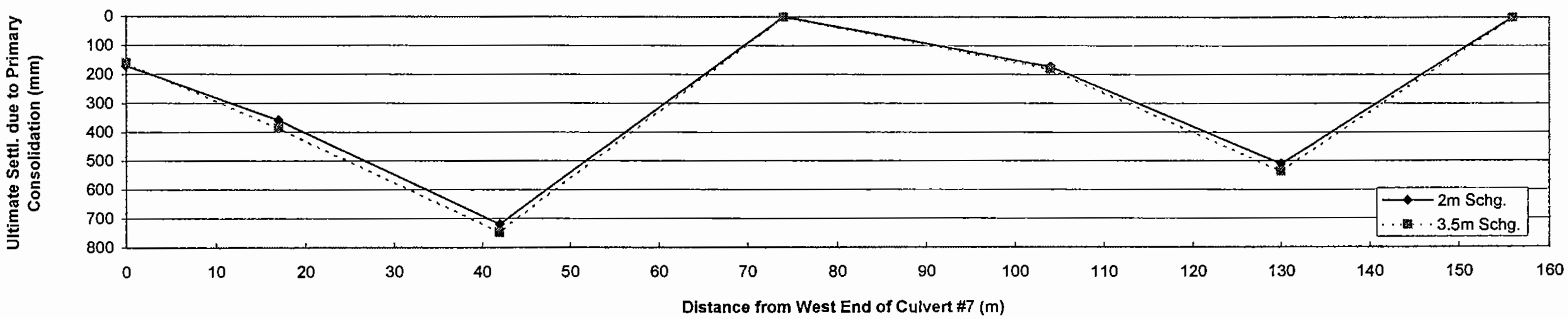


FIGURE E13

SWAMP 605 - CULVERT #7
LONG TERM SETTLEMENTS DUE TO SECONDARY CONSOLIDATION

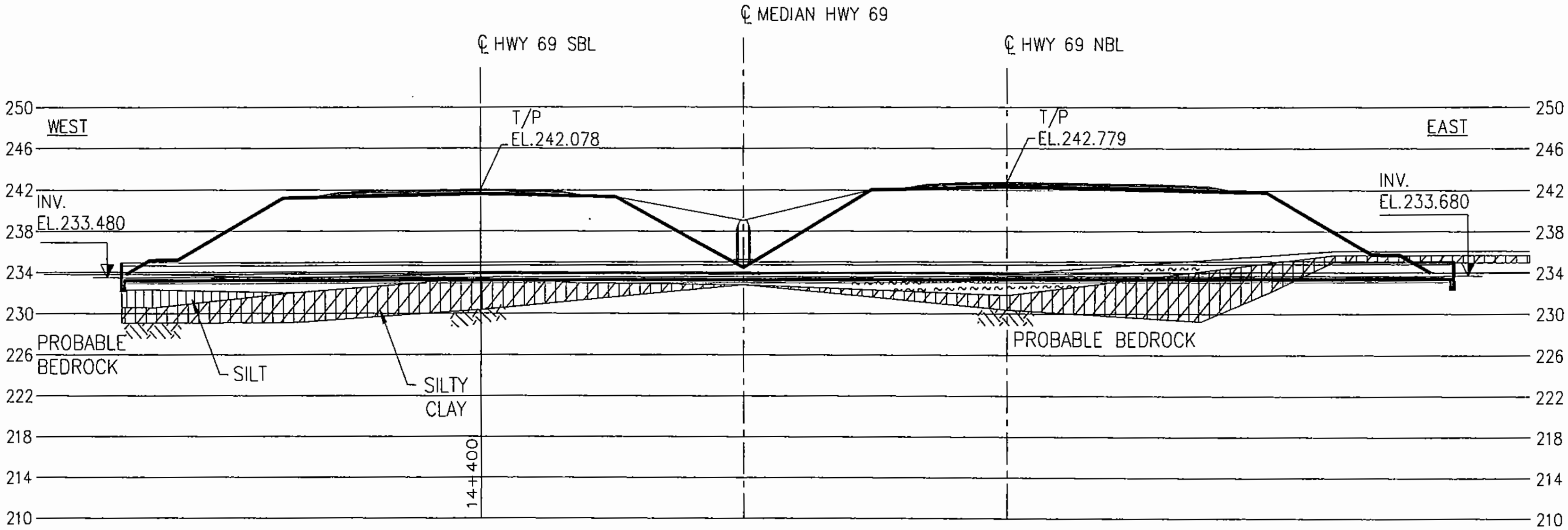
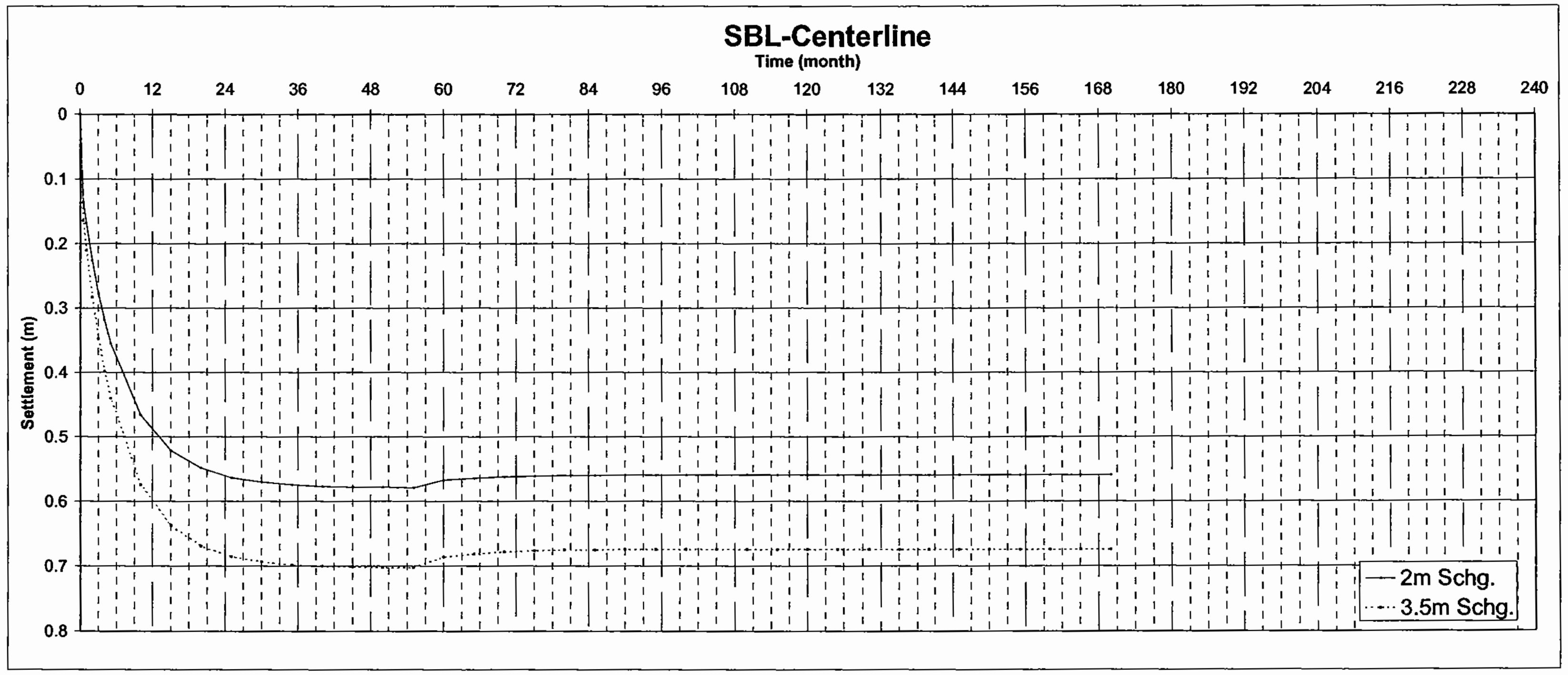


FIGURE E13b

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 613 - Sta. 10+520

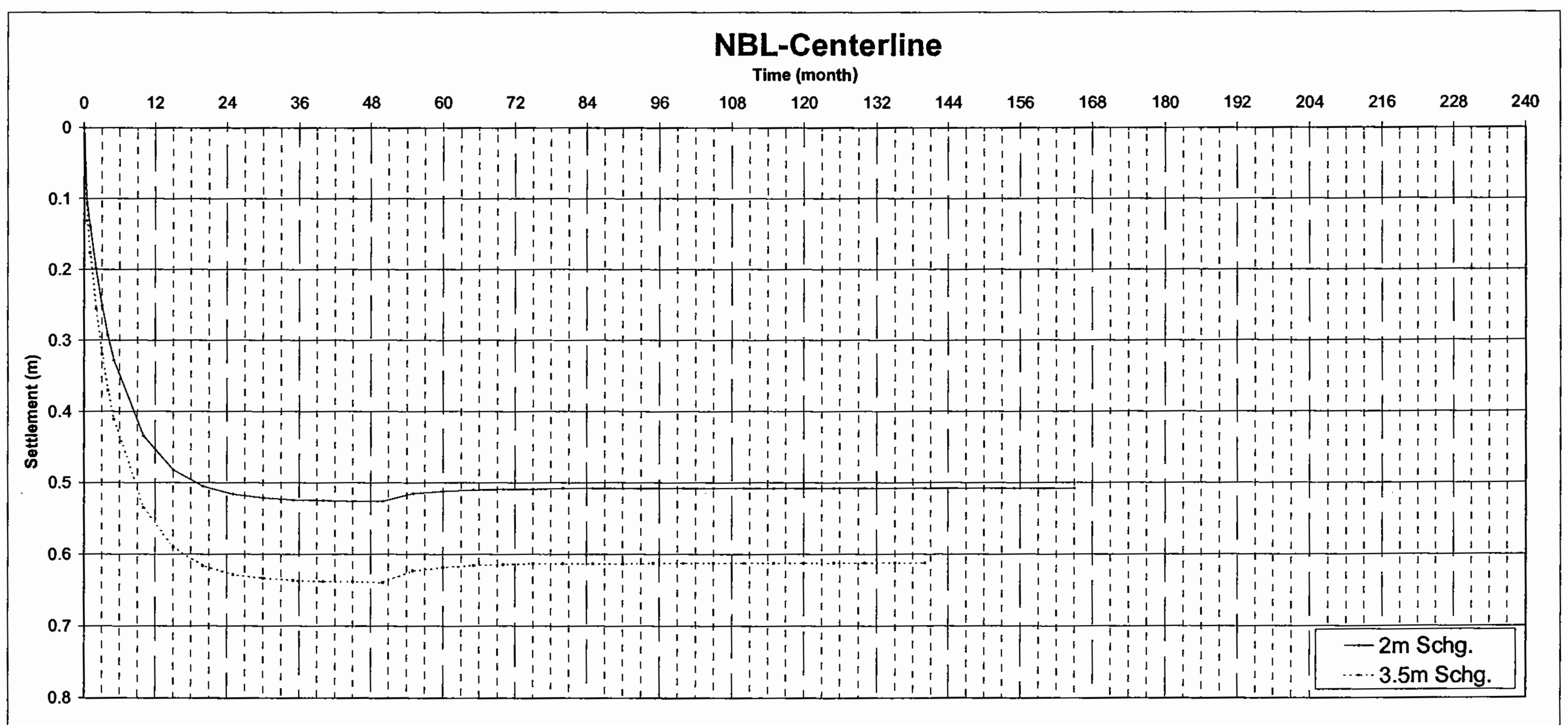


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	4.9	0
2	2.9	55
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.4	0
2	2.9	55
3		
4		



2m Surcharge

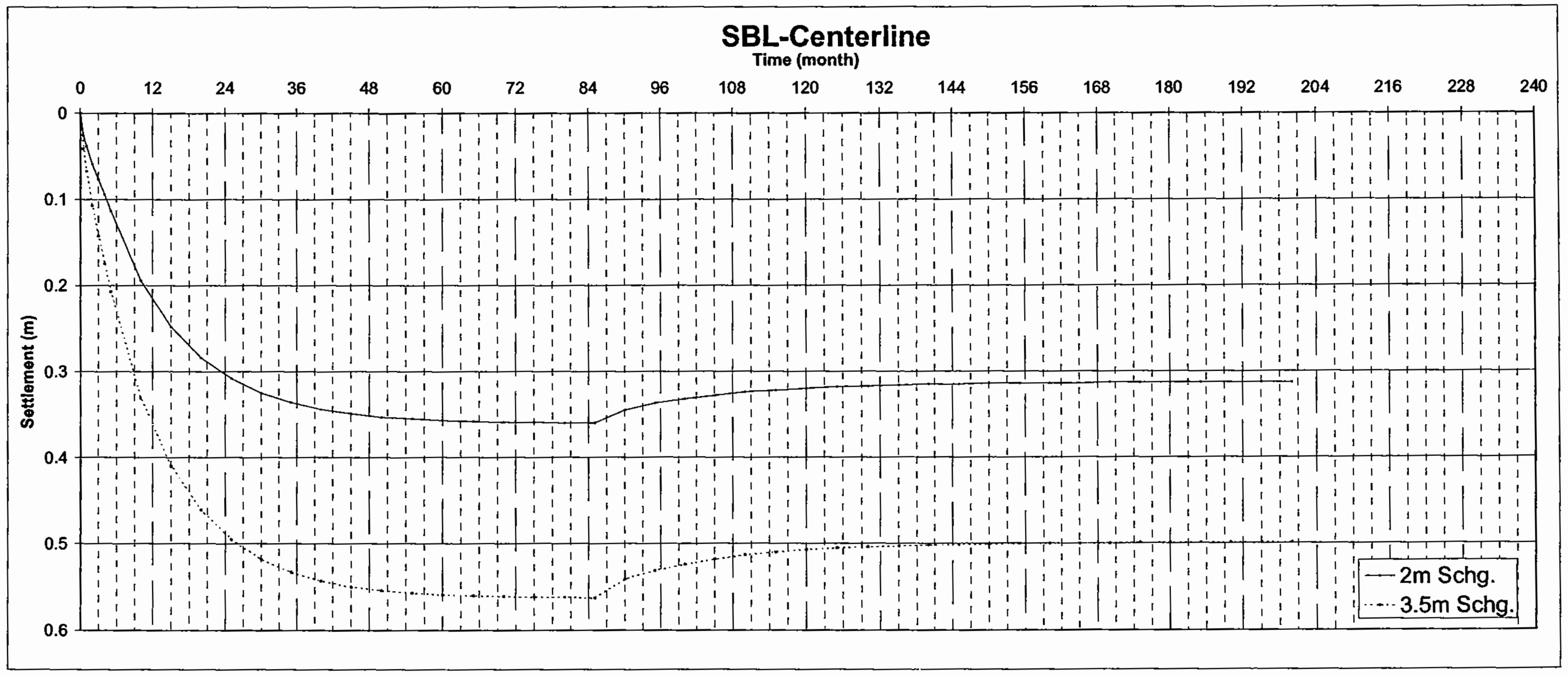
Stage	Ht. of Emb. (m)	@ t (month)
1	5.1	0
2	3.1	50
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.6	0
2	3.1	50
3		
4		

Primary Compression vs. Time (without wick drains)

Highway 69 - Swamp 613 - Sta. 10+570

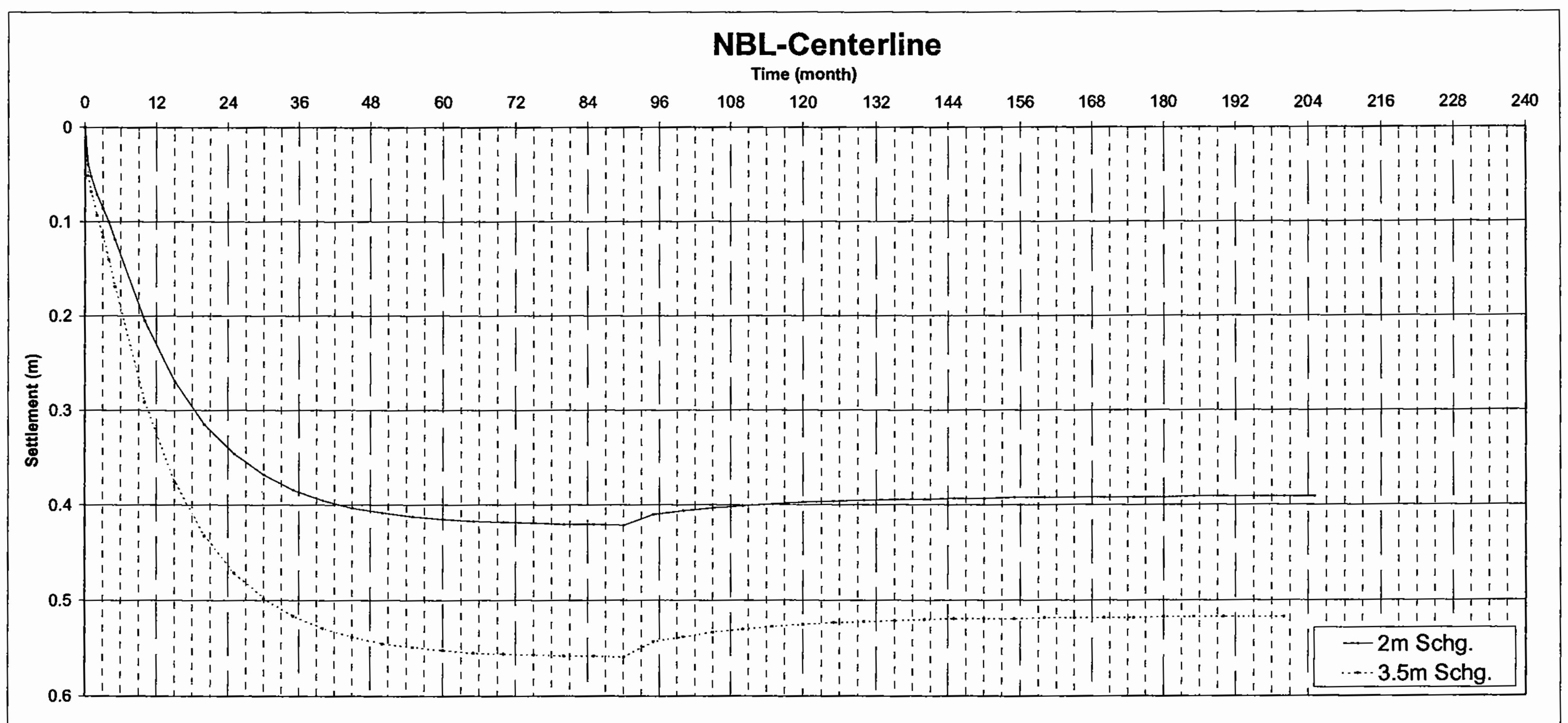


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	2.5	0
2	0.5	85
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	4	0
2	0.5	85
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.1	0
2	3.1	90
3		
4		

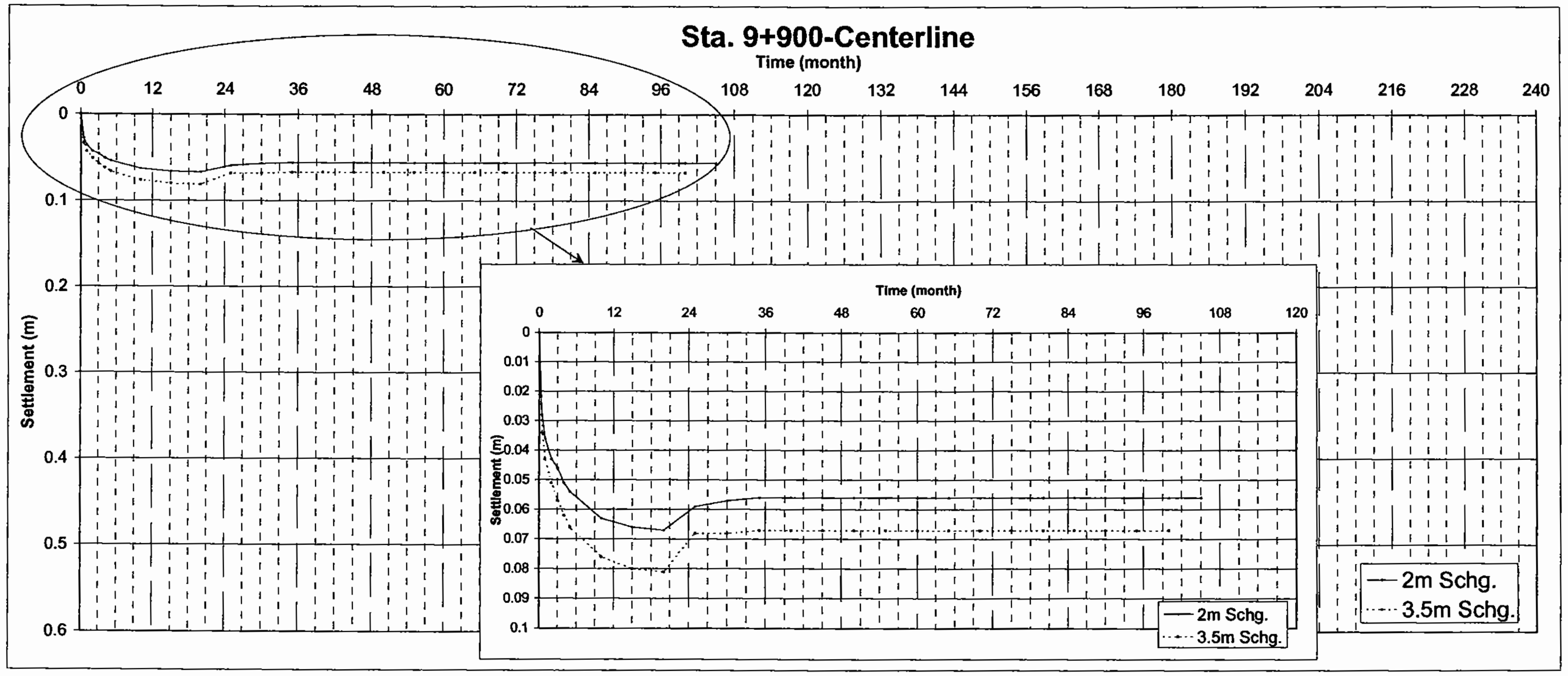
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	6.6	0
2	3.1	90
3		
4		

FIGURE E15

Primary Compression vs. Time (without wick drains)

Highway 537 - Swamp 613 - West Approach Embankment

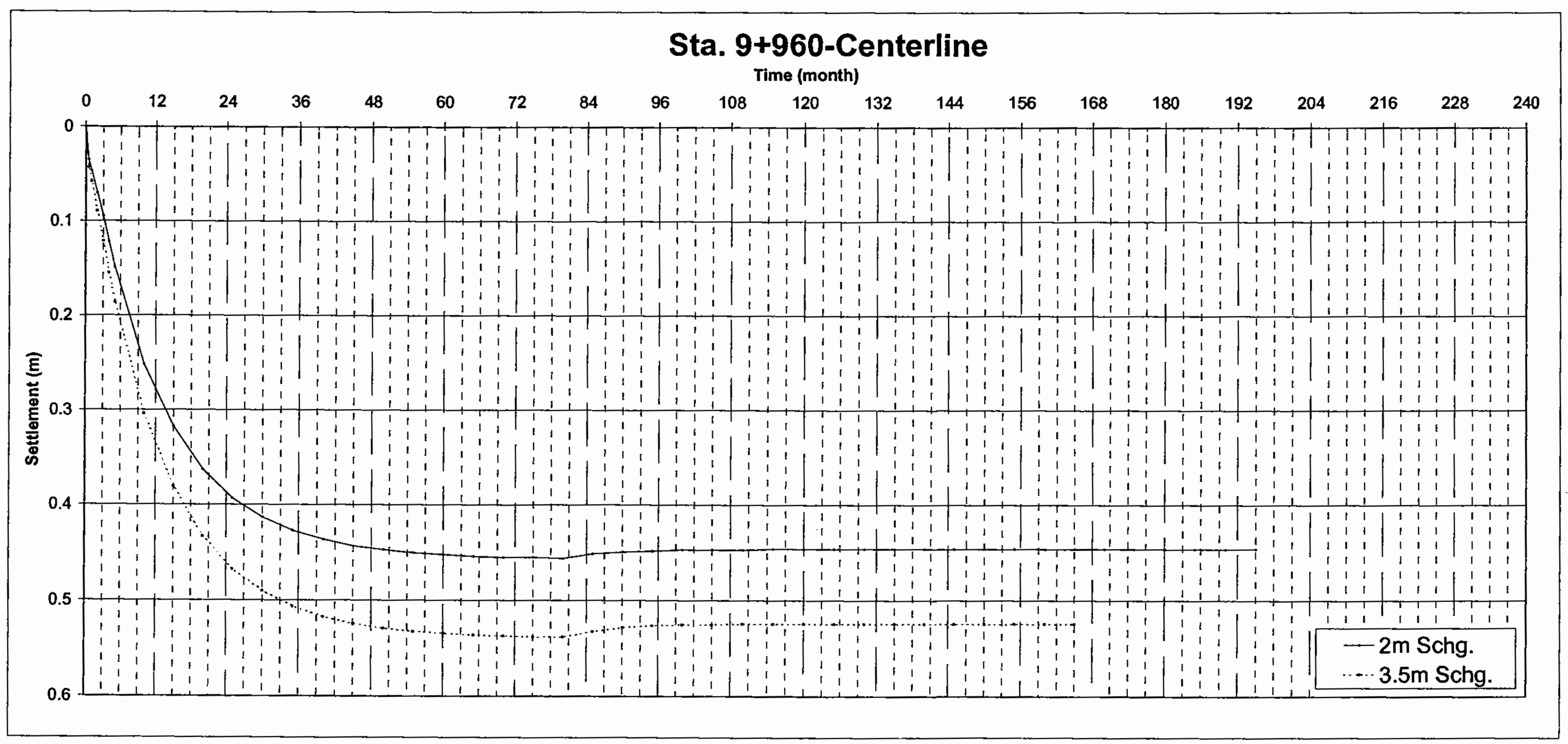


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	4.1	0
2	2.1	20
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.6	0
2	2.1	20
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	7.4	0
2	5.4	80
3		
4		

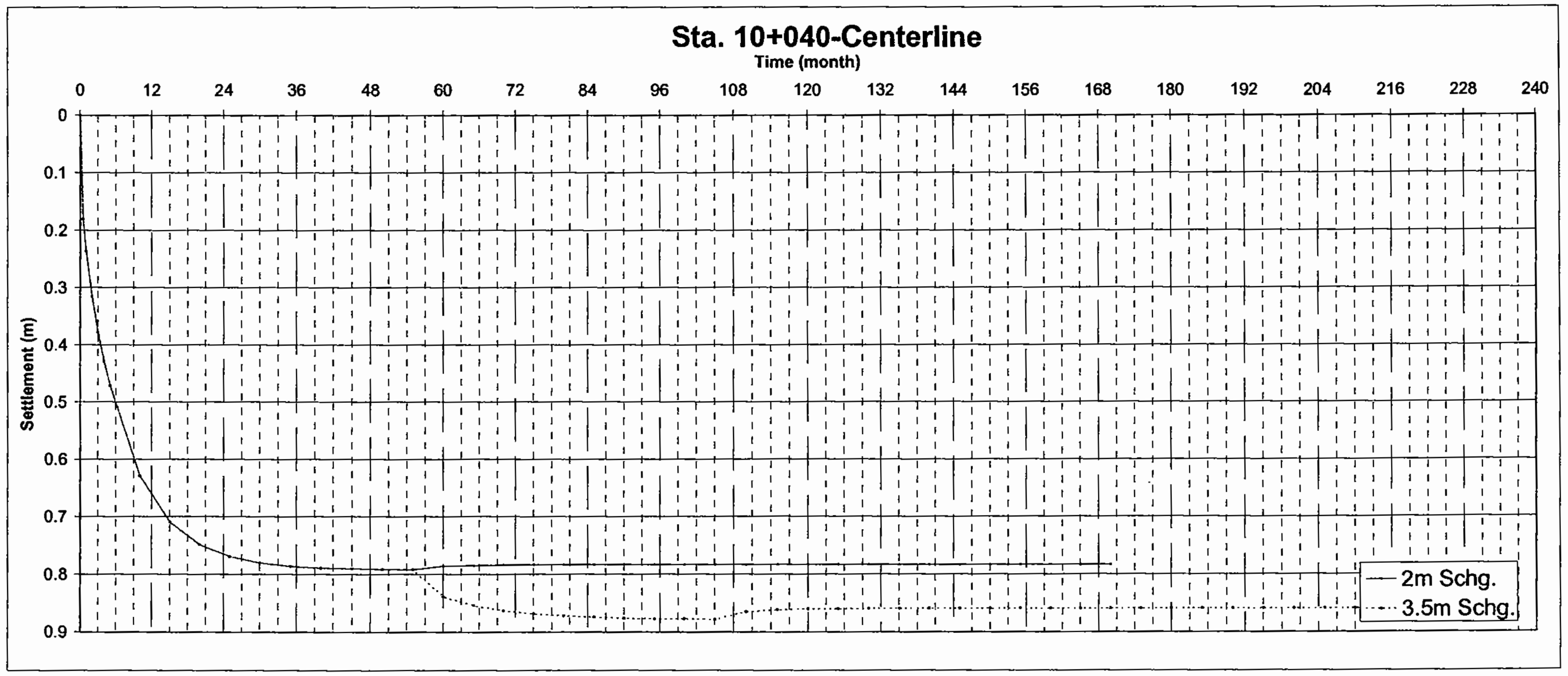
3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.9	0
2	5.4	80
3		
4		

FIGURE E16

Primary Compression vs. Time (without wick drains)

Highway 537 - Swamp 613 - East Approach Embankment

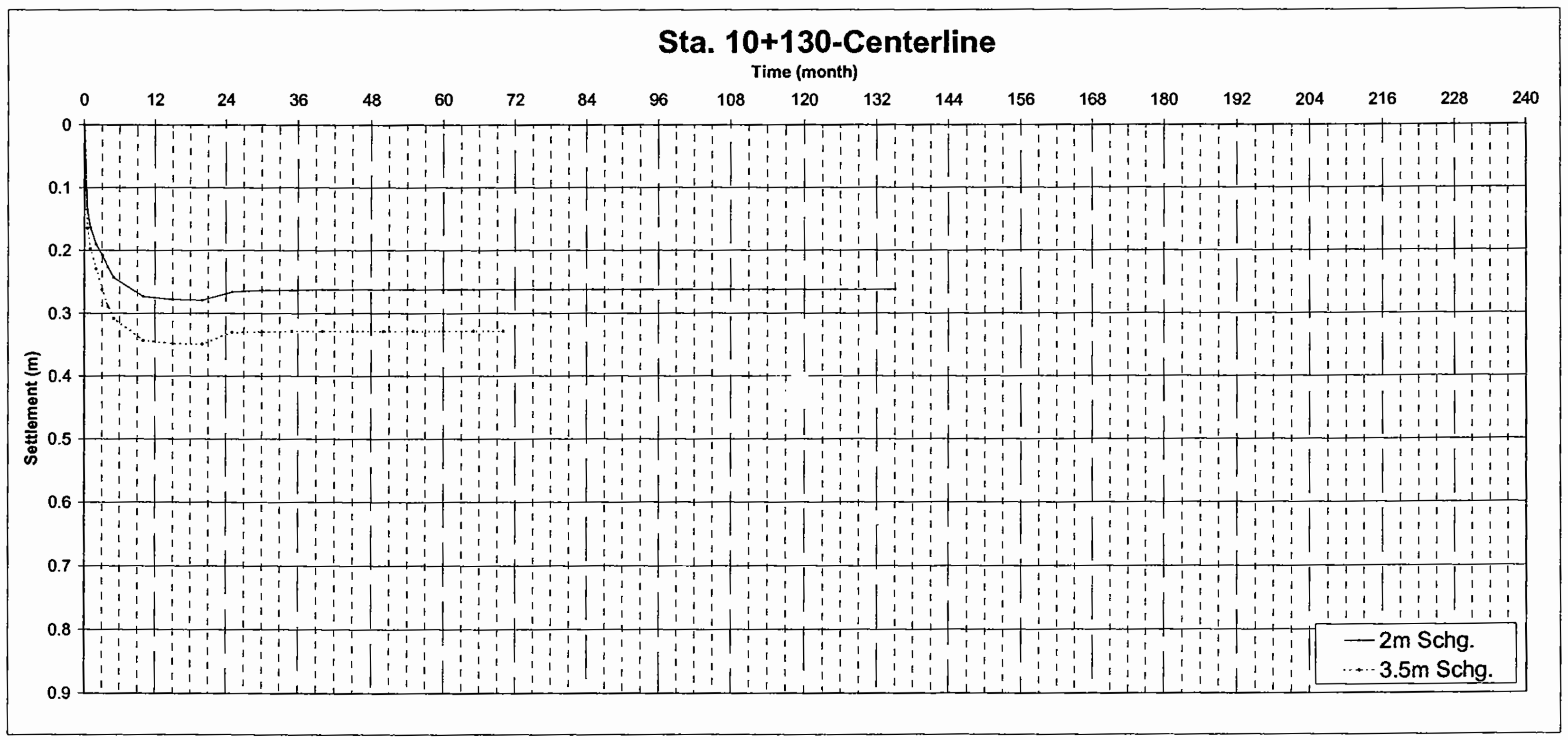


2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	4.1	0
2	2.1	20
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	5.6	0
2	2.1	20
3		
4		



2m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	7.4	0
2	5.4	80
3		
4		

3.5m Surcharge

Stage	Ht. of Emb. (m)	@ t (month)
1	8.9	0
2	5.4	80
3		
4		

FIGURE E17

Appendix F

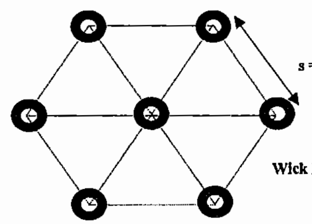
Wick Drain Analysis Results

NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

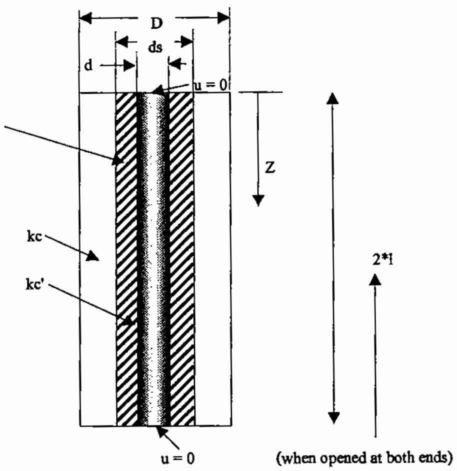
Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: North Swamp 602
Sub-case: Station 12+890 (Culvert #4) - SBL, CL, 2 m & 3.5 m Surcharge

INPUT PARAMETERS

D	2.835	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.70 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 40.5
C_H	2.25E-06	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	9.27E-07	m^2/s	determined by the oedometer test
λ	9.27E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	11.70	m	length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	11.70	m	
Settlement due to Primary Consolidation	152	mm	
n	41		(D/d; should always be >12)
α	0.3535251		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View



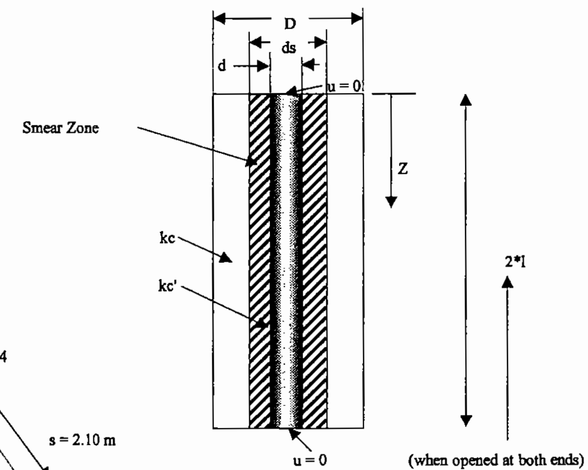
Time Increment for table below = 0.10 month
Resultant Maximum Time = 6.10 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.20	0.20
25	0.30	0.30
90	2.00	2.20
98	3.40	3.70

FIGURE F1

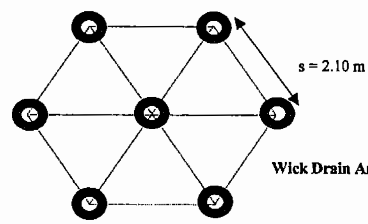
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: North Swamp 602
Sub-case: Station 12+890 - NBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

Parameter	Value	Unit	Description
D	2.205	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.10 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 31.5
C_H	1.56E-06	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	6.47E-07	m^2/s	determined by the oedometer test
λ	6.47E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	9.00	m	length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	9.00	m	
Settlement due to Primary Consolidation	141	mm	
n	32		(D/d; should always be >12)
α	0.328038		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

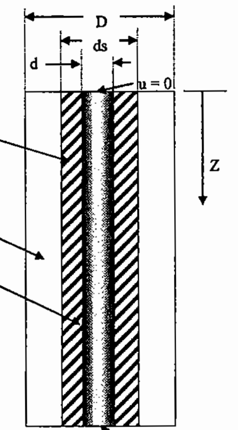
Time Increment for table below = 0.20 month
Resultant Maximum Time = 12.20 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.20	0.20
25	0.20	0.40
90	1.60	1.80
98	2.80	3.00

FIGURE F2

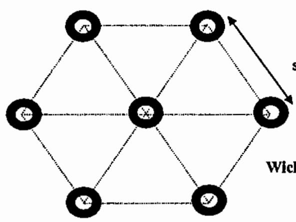
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 605
Sub-case: Station 14+290 - SBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 27.0
C_H	8.53E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	3.32E-07	m^2/s	determined by the oedometer test
λ	3.32E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	6.50	m	length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	3.25	m	
Settlement due to Primary Consolidation	470	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

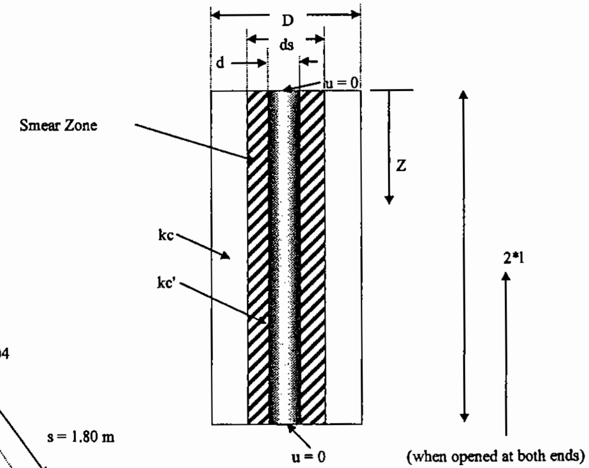
Time Increment for table below = 0.19 month
Resultant Maximum Time = 11.59 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.19	0.19
25	0.19	0.38
90	1.71	2.28
98	3.04	3.80

FIGURE F3

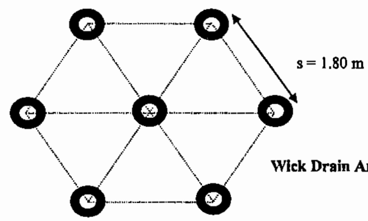
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 605
Sub-case: Station 14+290 - NBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 27.0
C_H	4.83E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	1.93E-07	m^2/s	determined by the oedometer test
λ	1.93E-07	m^2/s	$=k_h/(\gamma_w*m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	2.80	m	{ length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	1.40	m	
Settlement due to Primary Consolidation	293	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



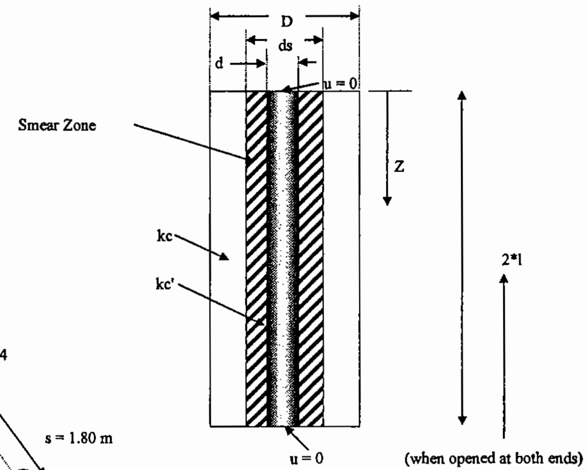
Wick Drain Arrangement - Plan View

Time Increment for table below = **0.34 month**
Resultant Maximum Time = **20.74 months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.34	0.34
25	0.34	0.68
90	1.70	4.08
98	3.06	6.80

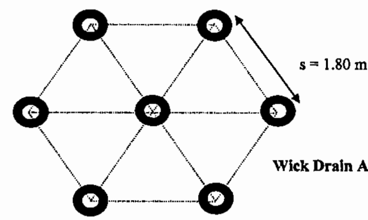
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 605
Sub-case:	Station 14+330 - SBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 27.0
C_H	7.89E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	3.06E-07	m^2/s	determined by the oedometer test
λ	3.06E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	10.20	m	{ length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	5.10	m	
Settlement due to Primary Consolidation	1008	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

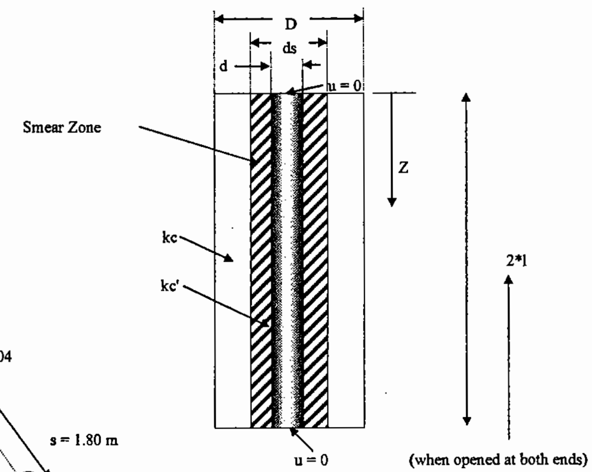
Time Increment for table below = 0.21 **month**
Resultant Maximum Time = 12.81 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.21	0.21
25	0.21	0.42
90	2.10	2.52
98	3.78	4.20

FIGURE F5

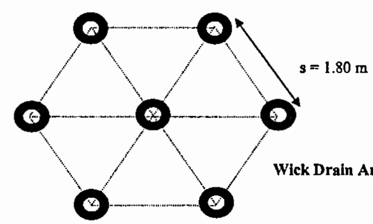
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 605
Sub-case:	Station 14+330 - NBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 27.0
C_H	8.05E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	3.12E-07	m^2/s	determined by the oedometer test
λ	3.12E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	9.20	m	length of the drain when open at one end only; half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	4.60	m	
Settlement due to Primary Consolidation	798	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

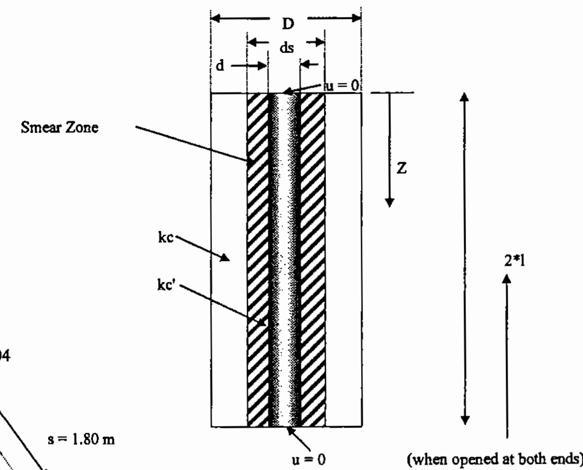
Time Increment for table below = 0.21 **month**
Resultant Maximum Time = 12.81 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.21	0.21
25	0.21	0.42
90	2.10	2.52
98	3.57	4.20

FIGURE F6

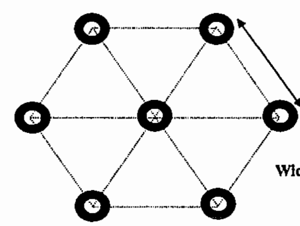
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 605
Sub-case: Station 14+390 - SBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	**m**	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	**m**	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 27.0
C_H	4.83E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	1.93E-07	m^2/s	determined by the oedometer test
λ	1.93E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	**m**	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	**m/s**	undisturbed soil permeability
k'_c	3.33E-09	**m/s**	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	2.50	**m**	{ length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	**kPa**	
Drainage Path (m)	1.75	**m**	
Settlement due to Primary Consolidation	256	**mm**	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

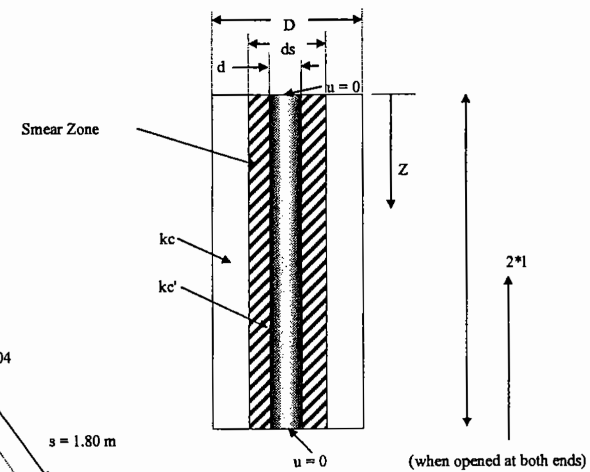
Time Increment for table below = 0.34 **month**
Resultant Maximum Time = 20.74 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.34	0.34
25	0.34	0.68
90	2.38	4.08
98	3.74	6.80

FIGURE F6

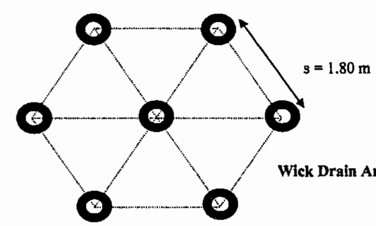
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 605
Sub-case:	Station 14+390 - SBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	**m**	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	**m**	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 27.0
C_H	4.83E-07	**m^2/s**	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	1.93E-07	**m^2/s**	determined by the oedometer test
λ	1.93E-07	**m^2/s**	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	**m**	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	**m/s**	undisturbed soil permeability
k'_c	3.33E-09	**m/s**	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	**m^3/s**	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	2.50	**m**	{ length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	**kPa**	
Drainage Path (m)	1.75	**m**	
Settlement due to Primary Consolidation	256	**mm**	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



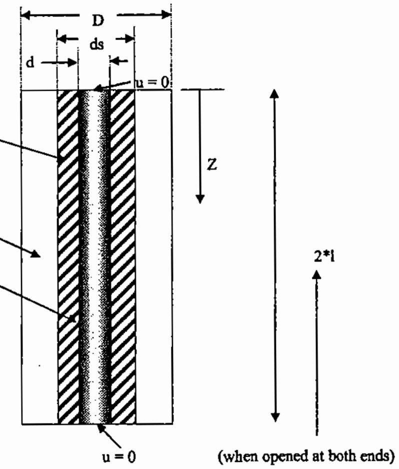
Wick Drain Arrangement - Plan View

Time Increment for table below = 0.34 **month**
Resultant Maximum Time = 20.74 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.34	0.34
25	0.34	0.68
90	2.38	4.08
98	3.74	6.80

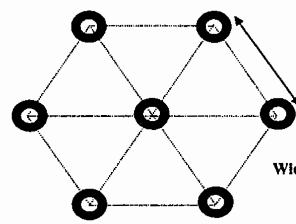
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 605
Sub-case:	Station 14+390 - NBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 27.0
C_H	8.76E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	3.48E-07	m^2/s	determined by the oedometer test
λ	3.48E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	10.10	m	length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	5.05	m	
Settlement due to Primary Consolidation	747	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



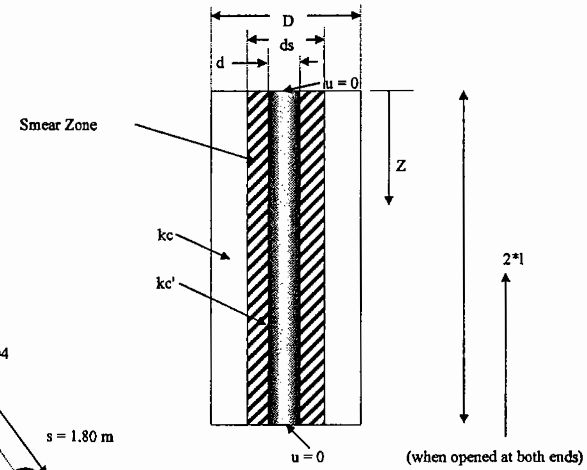
Wick Drain Arrangement - Plan View

Time Increment for table below = 0.19 month
Resultant Maximum Time = 11.59 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.19	0.19
25	0.19	0.38
90	1.90	2.28
98	3.42	3.80

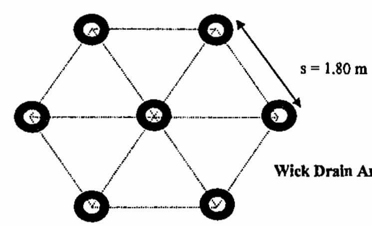
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 605
Sub-case:	Culvert #7 - SBL, WS, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 27.0
C_H	4.83E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	1.93E-07	m^2/s	determined by the oedometer test
λ	1.93E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	3.00	m	length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	1.50	m	
Settlement due to Primary Consolidation	359	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

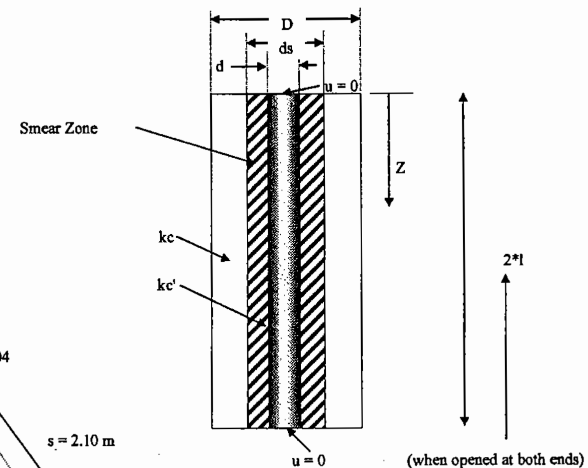
Time Increment for table below = 0.34 month
Resultant Maximum Time = 20.74 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.34	0.34
25	0.34	0.68
90	2.04	4.08
98	3.40	6.80

FIGURE F8

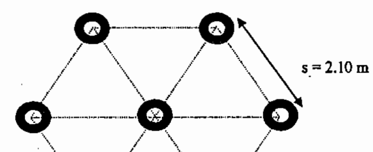
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 605
Sub-case: Culvert #7 - NBL, ES, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	2.205	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.10 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 31.5
C_H	6.63E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	2.54E-07	m^2/s	determined by the oedometer test
λ	2.54E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	3.50	m	{ length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	1.75	m	
Settlement due to Primary Consolidation	510	mm	
n	32		(D/d; should always be >12)
α	0.328038		f(D/d); regression from Figure 3 of the paper)



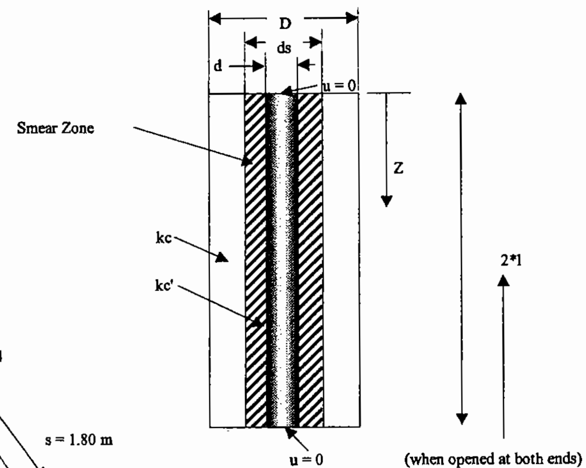
Wick Drain Arrangement - Plan View

Time Increment for table below = 0.25 **month**
Resultant Maximum Time = 15.25 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.25	0.50
25	0.25	0.50
90	2.00	4.00
98	3.50	6.75

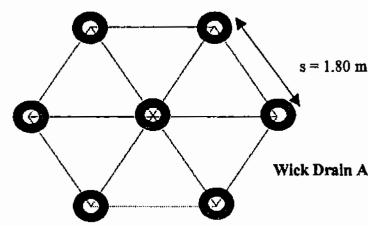
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 613
Sub-case:	Hwy 69 Station 10+520 - SBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.89	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.80 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi t$; n = 27.0
C_H	9.66E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	3.22E-07	m^2/s	determined by the oedometer test
λ	3.22E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	10.20	m	{ length of the drain when open at one end only half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	10.20	m	
Settlement due to Primary Consolidation	579	mm	
n	27		(D/d; should always be >12)
α	0.3093293		f(D/d); regression from Figure 3 of the paper)



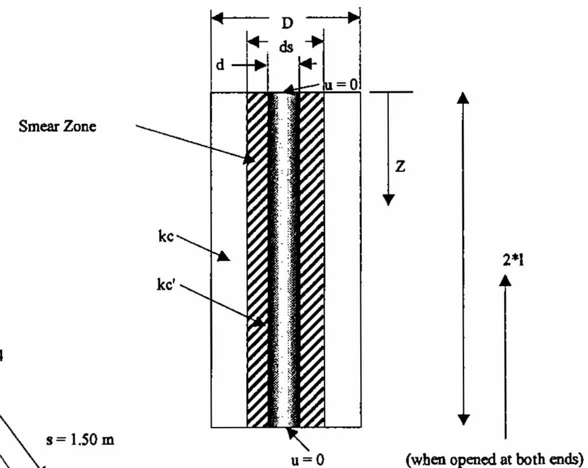
Wick Drain Arrangement - Plan View

Time Increment for table below = **0.18 month**
Resultant Maximum Time = **10.98 months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.18	0.18
25	0.36	0.36
90	1.98	2.16
98	3.24	3.42

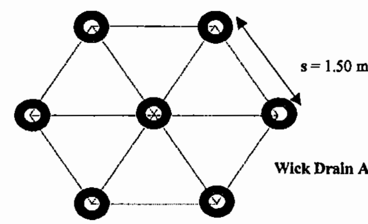
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number:	19-2805-2
Title:	Hwy 69 - Three Swamps
Case:	Swamp 613
Sub-case:	Hwy 69 Station 10+570 - SBL, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	1.575	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 1.50 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 22.5
C_H	7.28E-07	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	2.54E-07	m^2/s	determined by the oedometer test
λ	2.54E-07	m^2/s	$=k_h/(\gamma_w{*}m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	10.30	m	{ length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	10.30	m	
Settlement due to Primary Consolidation	360	mm	
n	23		(D/d; should always be >12)
α	0.2850248		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

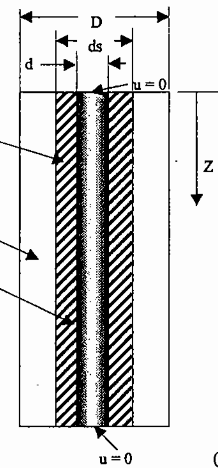
Time Increment for table below = 0.23 **month**
Resultant Maximum Time = 14.03 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.23	0.23
25	0.23	0.23
90	1.84	1.84
98	2.99	3.22

FIGURE F11

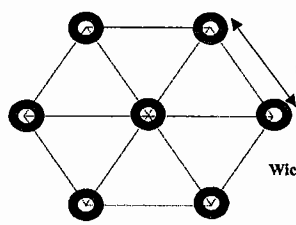
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 613
Sub-case: Hwy 537 Station 9+900, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	2.52	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.40 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 36.0
C_H	1.76E-06	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	6.86E-07	m^2/s	determined by the oedometer test
λ	6.86E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	9.90	m	length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	9.90	m	
Settlement due to Primary Consolidation	67	mm	
n	36		(D/d; should always be >12)
α	0.3424394		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

Time Increment for table below = 0.10 **month**
Resultant Maximum Time = 6.10 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.20	0.20
25	0.20	0.30
90	1.90	2.10
98	3.30	3.60

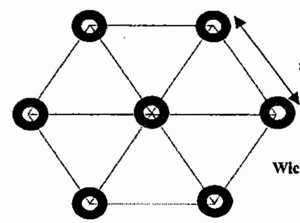
FIGURE F12

NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

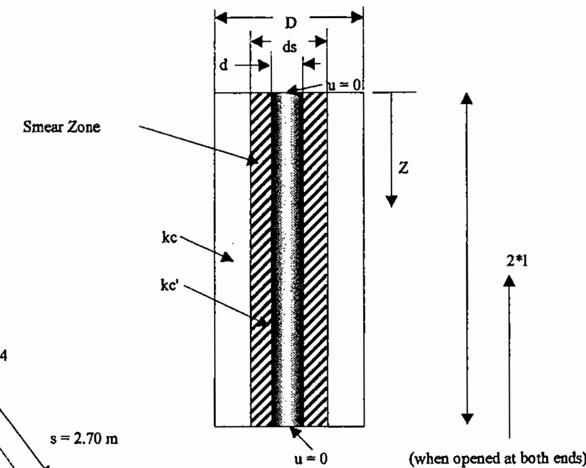
Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 613
Sub-case: Hwy 537 Station 9+960, CL, 2 m & 3.5 m Surcharge

INPUT PARAMETERS

Parameter	Value	Unit	Description
D	2.835	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.70 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 40.5
C_H	2.10E-06	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	8.44E-07	m^2/s	determined by the oedometer test
λ	8.44E-07	m^2/s	$=k_h/(\gamma_w*m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	13.30	m	length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	13.30	m	
Settlement due to Primary Consolidation	457	mm	
n	41		(D/d; should always be >12)
α	0.3535251		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View



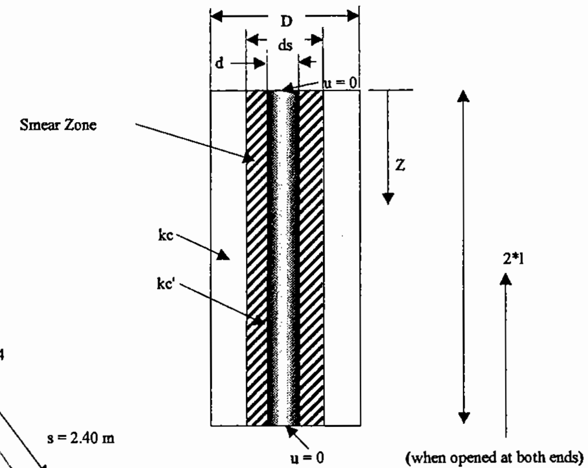
Time Increment for table below = 0.09 month
Resultant Maximum Time = 5.49 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.18	0.18
25	0.27	0.36
90	2.16	2.34
98	3.69	3.96

FIGURE F13

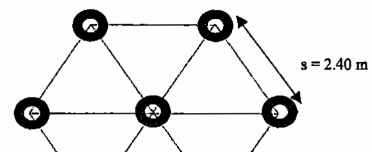
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 613
Sub-case: Hwy 537 Station 10+040, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	2.52	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.40 m)
d	0.07	m	equivalent diameter of band-shaped drain: 2(b+t)/π; n = 36.0
C_H	1.90E-06	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	7.44E-07	m^2/s	determined by the oedometer test
λ	7.44E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	11.80	m	{ length of the drain when open at one end only / half length of the drain when open at both ends
Wick drainage (one end:1; two ends:2):	1		
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	11.80	m	
Settlement due to Primary Consolidation	792	mm	
n	36		(D/d; should always be >12)
α	0.3424394		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

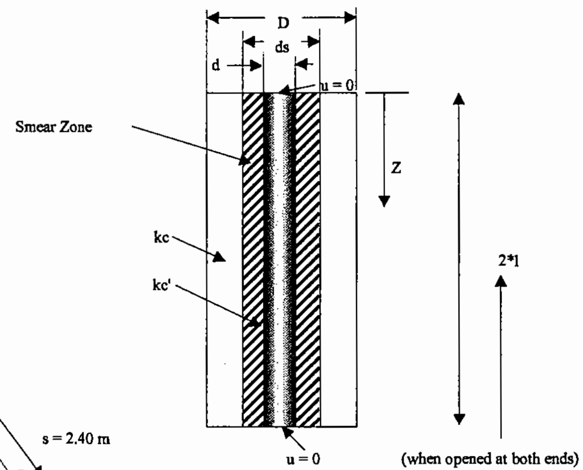
Time Increment for table below = 0.11 **month**
Resultant Maximum Time = 6.71 **months**

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.11	0.22
25	0.22	0.33
90	1.87	1.98
98	3.19	3.41

FIGURE F14

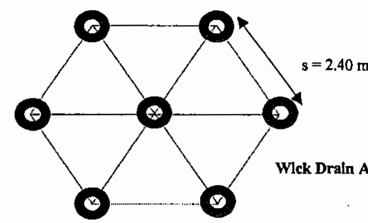
NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

Job Number: 19-2805-2
Title: Hwy 69 - Three Swamps
Case: Swamp 613
Sub-case: Hwy 537 Station 10+130, CL, 2 m & 3.5 m Surcharge



INPUT PARAMETERS

D	2.52	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, s = 2.40 m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; n = 36.0
C_H	1.91E-06	m^2/s	consider reducing c_h to account for smear; Ch/Cv is often 2 to 5
C_V	7.50E-07	m^2/s	determined by the oedometer test
λ	7.50E-07	m^2/s	$=k_h/(\gamma_w * m_v)$; or λ = Cv obtained from the oedometer test (Hansbo 1979)
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); s=ds/d = 3
k_c	1.00E-08	m/s	undisturbed soil permeability
k'_c	3.33E-09	m/s	soil permeability within the smear zone; kc/k'c = 3.00
q_w	1.00E-05	m^3/s	drain discharge capacity; kc/qw = 1.00E-03 ;well resistance cannot be ignored if kc/qw>3.33e-04
l	7.50	m	length of the drain when open at one end only
Wick drainage (one end:1; two ends:2):	1		half length of the drain when open at both ends
Layer	CL		
Surcharge (kPa)	40.00	kPa	
Drainage Path (m)	7.50	m	
Settlement due to Primary Consolidation	279	mm	
n	36		(D/d; should always be >12)
α	0.3424394		f(D/d); regression from Figure 3 of the paper)



Wick Drain Arrangement - Plan View

Time Increment for table below = 0.11 month
Resultant Maximum Time = 6.71 months

% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.11	0.22
25	0.22	0.33
90	1.65	1.98
98	2.86	3.19

FIGURE F15