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LOCATION Re-Alignment, Black River
Bridge at Matheson to
No of PAGES - Hwy 572

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

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REPORT ON

**FOUNDATION INVESTIGATION AND DESIGN
HIGHWAY 101 RE-ALIGNMENT
BLACK RIVER BRIDGE AT MATHESON
TO HIGHWAY 572
W.P. 258-96-00**

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation along the proposed re-alignment of Highway 101 near Matheson, Ontario. The location of the proposed re-alignment is shown in plan on Figures 1, 2A and 2B.

The purpose of the investigation is to determine the subsurface conditions at cut and fill locations along the re-alignment (designated as Areas 1 to 12) by drilling boreholes, carrying out in-situ tests including piezo-cone penetration tests and performing laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the geotechnical aspects of embankment fill and cut excavation design of the proposed works are provided. Several embankment fill design options were considered for the high fill locations based on stability, settlement and cost criteria. Blasting criteria and monitoring recommendations are also provided for blasting bedrock near a private residence along the proposed re-alignment (Area 11).

The plan and profile of the proposed Highway 101 alignment were provided to Golder by MTO. The centreline and stations of the proposed alignment were surveyed by others prior to commencing the foundation investigation program.

The terms of reference for the scope of work are outlined in Golder's proposal P91-1175, dated April 1999 which forms part of the Consultant's Agreement (Number P.O. 5005A000042) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project, dated June 14, 1999.

2.0 SITE DESCRIPTION

The project area covered by this report extends along the proposed Highway 101 re-alignment route, from approximately Station 12+780 in the Township of Carr to Station 14+880 in the Township of Beatty. The site is situated approximately 40 km east of Timmins, Ontario between the Black River Bridge in Matheson and Highway 572. The project area is divided into twelve Areas, designated Areas 1 to 12, as shown on Figures 2A and 2B.

The proposed construction consists of embankment cuts up to about 7 m, and embankment fills up to about 11 m. Culverts are to be located at two creek locations within high fill embankments at Station 13+040 in the Township of Carr (Area 2) and Station 10+380 in the Township of Beatty (Area 7). The Area locations and proposed construction at each Area are summarized in Table 1. The proposed construction descriptions are as defined by MTO for this project.

The ground surface across the site generally lies between about Elevation 265 m and Elevation 270 m. The ground surface rises to Elevation 280 m in Areas 5 and 6; and up to Elevation 295 m in Areas 11 and 12. The ground surface drops to about Elevation 250 m and Elevation 257 m within the valleys in Area 2 and Area 7, respectively.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out from June 22, 1999 to July 3, 1999. A total of 33 boreholes, 6 piezo-cone penetration tests (CPT) and 4 auger probe holes were advanced along the proposed alignment. A summary of the field investigation program is shown in Table 1. Area locations are shown on Figures 2A and 2B. The investigated locations are shown in plan and profile for each cut and fill area on Figures 3 to 14.

The investigation was carried out using a bombardier mounted CME 55 drill rig supplied and operated by Marathon Drilling Co. Ltd. of Ottawa, Ontario. The boreholes were advanced using 208 mm outside diameter (O.D.) continuous flight hollow stem augers. Soil samples were obtained at regular intervals of depth using a 50 mm O.D. split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures or a 80 mm O.D. thin walled open Shelby tube sampler. In general, the minimum borehole depth was set at the height of fill (for fill locations) and 1.5 times the depth of cut (for cut locations). The boreholes were advanced to depths from 3.5 m to 11.3 m (see Table 1 and Record of Borehole sheets). In order to determine the depth to a dense / very stiff stratum or refusal at the fill locations, dynamic cone penetration tests were carried out from the base of some boreholes (BH99-3, BH99-5, BH99-12, BH99-16, BH99-23, BH99-24 and BH99-39) to depths ranging from 15.3 m (BH99-24 in Area 7) to 27.5 m (BH99-12 in Area 4). The groundwater conditions in the open boreholes were observed during drilling operations and are described on the Record of Borehole sheets that follow the text. A set of groundwater levels in the piezometers installed along the alignment were obtained on July 23, 1999 (about 3 to 4 weeks) after completion of drilling to determine stabilized levels at that time.

Auger probes (BH99-40, BH99-41, BH99-42 and BH99-43) were advanced to refusal in Area 11 to provide further delineation of depth to bedrock along the proposed alignment. The depth to refusal varied from 0.8 m to 1.2 m below existing ground surface.

The piezo-cone penetration (CPT) is a state-of-the-art, in-situ technique for site characterization studies. The CPT consists of a special rod equipped with electronic sensing elements to

continuously measure tip resistance, local side friction on a sleeve and porewater pressure. It is pushed at a constant rate into the ground using a drill rig (ASTM D5778-95). A reliable continuous stratigraphic profile together with engineering properties, such as strength and density, can be interpreted from the results of the CPT.

The CPT equipment was advanced using the hydraulic ram system on the drill rig on June 24 and 25, 1999. The 6 CPTs were advanced to refusal where fill heights are expected to be 5 m or higher. Refusal was encountered at depths from 7.5 m (CPT99-37 in Area 12) to 24.5 m (CPT99-13 in Area 4). Record of Cone Penetration sheets are included with the Record of Borehole sheets that follow the text. The additional parameters of pore pressure ratio (B_q) and friction ratio (f_r), which aide in stratigraphy determination, are shown on the CPT sheets. The pore pressure parameter ratio is calculated using the following equation from Robertson and Campanella (1989)⁽ⁱ⁾, and shown on the Record on Cone Penetration sheets.

$$B_q = (u - u_o) / (q_t - \sigma_{vo})$$

where:

B_q = the pore pressure parameter ratio

u = the measured pore pressure

u_o = the initial pore pressure (calculated from the depth below the water table)

q_t = the corrected tip resistance

σ_{vo} = the total overburden stress (calculated from the unit weight of soil and the depth below ground surface)

(i) Robertson, P.K. and Campanella, R.G. (1989) "Guidelines for Geotechnical Design using CPT and CPT_u", report prepared for PennDOT, Civil Engineering Department, University of British Columbia, Vancouver, British Columbia, Canada.

Normalized friction ratio is also shown (in %) on the Record of Cone Penetration sheets and is calculated using the following equation from Robertson (1990)⁽ⁱⁱ⁾.

$$f_r = [f_s / (q_t - \sigma_{vo})] 100$$

where:

f_r = normalized friction ratio (%)

f_s = the measured friction

q_t = the corrected tip resistance

σ_{vo} = the total overburden stress (calculated from the weight of the soil and the depth below ground surface)

The field work was supervised throughout by a member of our engineering staff, who located the borehole and CPT locations, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil samples. The soil samples were identified in the field, placed in containers, labelled and transported to our Mississauga laboratory. All Shelby tube samples were extruded in Mississauga and soil samples underwent detailed visual examination. Laboratory testing on selected samples included: natural water content determinations, Atterberg limit determinations, grain size analyses, specific gravity, organic content, oedometer (consolidation) tests and triaxial tests. The results of laboratory testing are given on the Record of Borehole sheets and in Appendix A. A summary of laboratory testing carried out is given in Table 2.

All investigation locations were surveyed using the NAD 83 MTM (Zone 12) co-ordinate system and the geodetic datum for elevation. The surveying was carried out by Rody and Quesnel Surveying Inc. O.L.S. of Cochrane, Ontario.

⁽ⁱⁱ⁾ Robertson, P.K. (1990) "Soil Classification Using the Cone Penetration Test", Canadian Geotechnical Journal,

4.0 SUBSURFACE CONDITIONS

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the Record of Borehole sheets and by the laboratory test results in Appendix A. It should be noted that the stratigraphic boundaries indicated on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests (SPTs), Piezo-Cone Penetration Tests (CPTs), and dynamic cone penetration values. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

In general, cohesive deposits of varying composition (i.e., clayey silt, silty clay and clay) and structure (i.e., laminated, varved, interlayered) were encountered across all areas of the investigation. For the purpose of this report, laminated refers to a deposit of uniform composition displaying a finely layered structure. Varved deposits are layered deposits of clay or silty clay with clayey silt or silt, where the layers of the respective constituents repeat in a regular pattern and are less than about 50 mm thick. Interlayered deposits are similar to varved deposits in composition and structure; however, the respective layers are greater than 50 mm in thickness. Seams (less than 1 mm thick) of fine sand, sandy silt and silt were also typically encountered within the cohesive deposits.

It should be noted that, based on the oedometer data, vane shear and CPT data, the clay deposits encountered have a minimum overconsolidation ratio of about 2.0 and are classified as being overconsolidated.

Silty sands and sandy silt deposits were encountered mainly at the east end of the alignment in Areas 11 and 12.

All laboratory test results and grain size distribution curves for the main soil types are included in Appendix A. All laboratory tests were carried out following current ASTM standards.

Note that the CPT tip resistances are generally higher than typical correlations with, say vane shear strengths, would indicate. The CPT data was, therefore, primarily utilised for stratigraphy interpretation.

A general summary of the subsurface conditions at each of the areas is presented below.

4.1 Area 1: Township of Carr, Stations 12+780 to 12+920 (Cut)

A plan and profile showing the borehole locations and stratigraphies for Area 1 is shown on Figure 3.

Boreholes 99-1 and 99-2 were advanced within the limits of Area 1. The ground surface elevation at the borehole locations varies from about Elevation 263.2 m to 263.4 m. The boreholes were sampled to depths ranging from 5.2 m to 8.2 m.

The subsurface consists of 100 mm to 130 mm of topsoil underlain by a brown to grey deposit of silty clay. The upper brown portion of the deposit has a laminated structure. SPT 'N' values ranged from 0 blows (weight of hammer) to 6 blows per 0.3 m of penetration and in-situ vane shear tests results ranged from 46 kPa to >100 kPa, indicating a firm to very stiff consistency. The consistency of this deposit becomes softer with depth. Measured water contents of samples of the silty clay range from 32 percent to 44 percent.

The silty clay deposit grades into a grey clay below Elevation 260.3 m and 259.0 m in Boreholes 99-1 and 99-2, respectively. All SPT 'N' values recorded in the clay were 0 blows (weight of hammer) per 0.3 m of penetration and in-situ vane shear tests results ranged from 42 kPa to 46 kPa. A silt interlayer was encountered within the clay at about Elevation 258.4 m in Borehole 99-2. Measured water contents of samples of the silty clay ranged from 51 percent to

54 percent. Liquid and plastic limits of one sample of the clay were 55 percent and 25 percent, respectively (plasticity index of 30 percent).

A piezometer was installed in Borehole 99-2. The water level in the piezometer was at Elevation 263.1 m on July 3, 1999; and at Elevation 261.8 m on July 23, 1999 (30 days following completion of drilling). The groundwater level is subject to seasonal fluctuations.

4.2 Area 2: Township of Carr, Stations 12+920 to 13+140 (Fill)

A plan and profile showing the borehole locations and stratigraphies for Area 2 is shown on Figure 4.

Boreholes 99-3, 99-5 and 99-7, and two piezo-cones (CPT 99-4 and CPT 99-6) were advanced within the limits of Area 2. The ground surface elevation at the borehole locations varies from about Elevation 250.0 m to 262.6 m. The boreholes were sampled to depths ranging from 5.2 m to 9.8 m.

The subsurface consists of 80 mm to 150 mm of topsoil underlain by fill deposits of very loose to loose brown sand, trace gravel in Borehole 99-3; and firm brown silty clay fill, trace rootlets and wood fragments in Borehole 99-5. SPT 'N' values in the fill ranged from 3 blows to 8 blows per 0.3 m of penetration.

A native deposit of brown to grey silty clay was encountered below the fill in Boreholes 99-3 and 99-5, and topsoil in Borehole 99-7. Sandy silt and clayey silt seams were encountered within the silty clay deposit. SPT 'N' values ranged from 3 blows to 6 blows per 0.3 m of penetration and in-situ vane shear test results ranged from 35 kPa to 88 kPa indicating a firm to stiff consistency. Measured water contents of samples of the silty clay range from 34 percent to 41 percent. Boreholes 99-3 and 99-5 were terminated in this deposit.

Below the brown silty clay in Borehole 99-7 (at about Elevation 249 m), an interlayered deposit of grey silty clay / clayey silt was encountered. In-situ vane shear test results ranged from 30 kPa to

76 kPa indicating a firm to stiff consistency. One measured water content from a clay interlayer was 51 percent. Measured liquid and plastic limits of the clay were 65 percent and 27 percent, respectively (plasticity index 38 percent). Measured liquid and plastic limits of a sample from a clayey silt interlayer were 25 percent and 19 percent, respectively (plasticity index 6 percent). The results of one consolidation test on Sample 4 from Borehole 99-7 is shown in Appendix A.

In Borehole 99-7, a deposit of grey silt containing trace sand and clay was encountered below the interlayered clay and clayey silt / silt at about Elevation 243.8 m. SPT 'N' values ranged from 3 blows to 6 blows per 0.3 m of penetration in the silt indicating a loose state of packing. Measured water contents of two samples from the silt deposit were 26 percent and 29 percent. Borehole 99-7 was terminated in this deposit.

In Boreholes 99-3 and 99-5, dynamic cone penetration tests were advanced to practical refusal. Dynamic penetration blows remained below 10 blows per 0.3 m of penetration up to a depth of about 9.8 m (Elevations 252.8 m and 249.8 m in Boreholes 99-3 and 99-5, respectively), increased to about 20 blows per 0.3 m of penetration at a depth of about 13.7 m (Elevations 248.9 m and 245.6 m in Boreholes 99-3 and 99-5, respectively), then ranged from 20 blows to 45 blows per 0.3 m of penetration to practical refusal at depths of about 19.4 m and 21.1 m (Elevations 243.2 m and 238.5 m) in Boreholes 99-3 and 99-5, respectively.

A summary of geotechnical data from Area 2 is shown on Figure 15.

A piezometer was installed in Borehole 99-7. The water level in the piezometer was at Elevation 250.6 m (0.4 m above the existing ground surface) on July 3, 1999.

4.3 Area 3: Township of Carr, Stations 13+140 to 13+580 (Cut)

A plan and profile showing the borehole locations and stratigraphies for Area 3 is shown on Figures 5a and 5b.

Boreholes 99-8, 99-9, 99-10 and 99-11 were advanced within the limits of Area 3. The ground surface elevation at the borehole locations varies from about Elevation 265.5 m to 268.3 m. The boreholes were sampled to depths ranging from 3.7 m to 11.3 m.

The subsurface consists of 150 mm to 200 mm of topsoil underlain by native brown silty clay. Trace rootlets and organics were encountered in the upper 0.5 m of the silty clay deposit in Boreholes 99-10 and 99-11. Samples of the brown silty clay from Boreholes 99-8, 99-9 and 99-11 were laminated and clayey silt seams were encountered within this deposit in Boreholes 99-9 and 99-11. SPT 'N' values ranged from 2 blows to 8 blows per 0.3 m of penetration and in-situ vane shear test results ranged from 61 kPa to >100 kPa, indicating a firm to very stiff consistency. Measured water contents of samples of the silty clay ranged from 29 percent to 46 percent.

Below the brown silty clay between about Elevation 262 m and 264 m, a deposit of varved grey clay with clayey silt was encountered in Boreholes 99-8 and 99-9. In Boreholes 99-10 and 99-11, samples from this deposit consisted of silty clay to clay and did not display a varved structure. In-situ vane shear test results in the clay / clayey silt deposit ranged from 27 kPa to 65 kPa indicating a firm to stiff consistency. Measured water contents of samples from this deposit ranged from 49 percent to 55 percent.

A piezometer was installed in Borehole 99-9. The water level in the piezometer was at Elevation 259.9 m on July 3, 1999; and at Elevation 259.6 m on July 23, 1999 (29 days following completion of drilling). The groundwater level is subject to seasonal fluctuations.

4.4 Area 4: Township of Carr, Stations 13+580 to 13+700 (Fill)

A plan and profile showing the borehole and piezo-cone test locations and stratigraphies for Area 4 is shown on Figure 6.

Borehole 99-12 and one piezo-cone (CPT 99-13) were advanced within the limits of Area 4. The ground surface elevation at the borehole locations is at about Elevation 265.7 m. Borehole 99-12 was sampled to about depth 4.4 m.

The subsurface at the location of Borehole 12 consists of about 50 mm of topsoil underlain by a brown laminated deposit of silty clay. Two SPT 'N' values of 6 blows per 0.3 m of penetration were measured in the brown silty clay, indicating a firm consistency. Measured water contents of two samples of the silty clay were 23 percent and 41 percent.

Below the brown silty clay in Borehole 12, a deposit of grey clay was encountered. Two SPT 'N' values recorded in the clay were 0 blows (weight of hammer) and 2 blows per 0.3 m of penetration and in-situ vane shear tests results ranged from 19 kPa to 34 kPa indicating a soft to firm consistency. Measured water contents on two samples of the clay from Borehole 12 were 50 percent to 58 percent. Liquid and plastic limits of one sample of the clay were 58 percent and 25 percent, respectively (plasticity index of 33 percent).

In Borehole 99-12, a dynamic cone penetration test was advanced to practical refusal. Dynamic penetration remained below 10 blows per 0.3 m of penetration down to about 14.6 m depth (Elevation 251.1 m), increased to about 20 blows per 0.3 m of penetration at about 18.9 m, then ranged from 20 blows to 49 blows per 0.3 m of penetration to practical refusal at about 27.6 m (Elevation 238.1 m).

A piezometer was installed in Borehole 99-12. The water level in the piezometer was at Elevation 264.8 m on July 3, 1999; and at Elevation 264.7 m on July 23, 1999 (24 days following completion of drilling). The groundwater is subject to seasonal fluctuations.

4.5 Area 5: Township of Carr, Stations 14+060 to 14+260 (Fill)

A plan and profile showing the borehole locations and stratigraphies for Area 5 is shown on Figure 7.

Boreholes 99-14, 99-15, 99-16 and 99-17 were advanced within the limits of Area 5. The ground surface elevation at the borehole locations varies from about Elevation 274.4 m to 276.4 m. The boreholes were sampled to depths ranging from 3.5 m to 5.0 m.

About 90 mm to 120 mm of topsoil was encountered at the borehole locations. In Boreholes 99-15 and 99-16, 0.5 m to 1.1 m of black peat was encountered below the topsoil. In Borehole 99-17, a deposit of firm reddish brown silty clay with trace rootlets was encountered below the topsoil.

Below the surficial deposits in all boreholes, a deposit of brown to grey clay / silty clay with clayey silt / silt was encountered. The structure of the deposit is varved in the Boreholes 99-14, 99-15 and 99-16, and becomes interlayered in the area of Borehole 99-17.

SPT 'N' values in the varved / interlayered deposit ranged from 0 (weight of hammer) to 6 blows per 0.3 m of penetration and in-situ vane shear tests results ranged from 19 kPa to >100 kPa indicating a soft to very stiff consistency. Measured water contents of samples from this deposit ranged from 22 percent to 65 percent. Measured liquid and plastic limits of one sample of the silty clay were 39 percent and 19 percent, respectively (plasticity index of 20 percent).

In Borehole 99-16, a dynamic cone penetration test was advanced to practical refusal. Dynamic penetration remained below 10 blows per 0.3 m of penetration down to about 14.6 m depth (Elevation 259.8 m), increased to 39 blows per 0.3 m of penetration at about 21.0 m, then ranged from 20 blows to 34 blows per 0.3 m of penetration to practical refusal at about 26.4 m (Elevation 248.0 m).

4.6 Area 6: Township of Carr, Stations 14+260 to 14+320 (Cut) Township of Beatty, Stations 10+000 to 10+060 (Cut)

A plan and profile showing the borehole locations and stratigraphies for Area 6 is shown on Figure 8.

Boreholes 99-18 and 99-19 were advanced within the limits of Area 6. The ground surface elevation at the borehole locations varies from about Elevation 278.5 m to 279.3 m. The boreholes were sampled to depths ranging from 4.3 m to 6.7 m.

About 120 mm of topsoil was encountered at the borehole locations underlain by 0.6 m to 1.3 m of brown silty clay to clay (with trace organics and sandy silt seams in Borehole 99-18). This deposit is further underlain by a varved deposit of brown to grey silty clay with silt in Borehole 99-18 and brown silty clay with sandy silt seams in Borehole 99-19. In Borehole 99-19, the deposit becomes interlayered grey clay with clayey silt at about depth 4.4 m (Elevation 274.9 m).

SPT 'N' values in the silty clay / clay with silt / clayey silt deposit ranged from 3 blows to 9 blows per 0.3 m of penetration and in-situ vane shear tests results ranged from 57 kPa to >100 kPa. Measured water contents of samples from this deposit ranged from 26 percent to 42 percent. Measured liquid and plastic limits of one sample of the clay were 56 percent and 25 percent, respectively (plasticity index of 31 percent).

4.7 Area 7: Township of Beatty, Stations 10+200 to 10+480 (Fill)

A plan and profile showing the borehole locations and stratigraphies for Area 7 is shown on Figure 9.

Boreholes 99-20, 99-23 and 99-24, and two piezo-cones (CPT 99-21 and CPT 99-22) were advanced within the limits of Area 7. The ground surface elevation at the borehole locations varies from about Elevation 257.1 m to 265.8 m. The boreholes were sampled to depths ranging from 3.7 m to 9.1 m.

The subsurface consists of 90 mm to 210 mm of topsoil underlain by a deposit of brown silty clay, 2.7 m to 2.8 m thick. Samples of the brown silty clay contained seams of silt / sandy silt in Boreholes 99-20 and 99-23; and trace to some organics in Borehole 99-24. Measured SPT 'N' values in the brown silty clay ranged from 5 blows to 8 blows per 0.3 m of penetration, and in-situ vane shear tests results ranged from about 72 kPa to 95 kPa, indicating a stiff consistency. Measured water contents of samples from this deposit ranged from 23 percent to 42 percent. Measured liquid plastic limits of one sample of the brown silty clay from Borehole 99-24 were 45 percent and 29 percent, respectively (plasticity index of 16 percent).

Below the brown silty clay, a varved deposit of grey silty clay / clay with silt / clayey silt was encountered. One measured SPT 'N' value in this deposit was 1 blow per 0.3 m of penetration and in-situ vane shear test results ranged from about 30 kPa to 57 kPa, indicating a firm to stiff consistency. Measured water contents of samples of the silty clay ranged from 45 percent to 52 percent. Measured liquid and plastic limits of one sample of the clay were 55 percent and 23 percent, respectively (plasticity index of 32 percent). Measured liquid and plastic limits of one sample of the silty clay were 39 percent and 23 percent, respectively (plasticity index of 16 percent).

To determine the compressibility of the varved deposit, three consolidation tests were conducted on Samples 4 and 6 (two tests on Sample 6; one vertical, one horizontal) from Borehole 99-24. To determine the effective shear strength parameters of the deposit, consolidated undrained triaxial tests (with porewater pressure measurements) were conducted on Sample 5 from Borehole 24. The results are shown in Appendix A.

In Boreholes 99-23 and 99-24, dynamic cone penetration tests were advanced to practical refusal. Dynamic penetration remained below 10 blows per 0.3 m of penetration down to about 9.8 m depth (Elevations 252.0 m and 244.4 m in Boreholes 99-23 and 99-24, respectively), then increased to about 20 blows per 0.3 m of penetration between 13.8 m to 17.7 m depths (Elevations 247.1 m and 243.4 m in Boreholes 99-23 and 99-24, respectively). Below these depths, penetration values increase rapidly to practical refusal at about depths of 18.6 m and 15.3 m (Elevations 246.2 m and 241.9 m) in Boreholes 99-23 and 99-24, respectively.

A summary of geotechnical data from Area 7 is shown on Figure 16.

A piezometer was installed in Borehole 99-24. The water level in the piezometer was at Elevation 257.4 m on July 3, 1999; and at Elevation 257.3 m on July 23, 1999 (24 days following completion of drilling). The groundwater level is subject to seasonal fluctuations.

4.8 Area 8: Township of Beatty, Stations 10+480 to 10+600 (Cut)

A plan and profile showing the borehole locations and stratigraphies for Area 8 is shown on Figure 10.

Boreholes 99-25 and 99-26 were advanced within the limits of Area 8. The ground surface elevation at the borehole locations varies from about Elevation 266.9 m to 268.2 m. The boreholes were sampled to depths ranging from 3.8 m to 5.3 m.

A surficial deposit of brown to black topsoil / silty clay with trace rootlets, 0.6 m to 0.8 m thick, was encountered at the borehole locations. Two measured SPT 'N' values in the surficial deposit were 3 blows and 8 blows per 0.3 m of penetration, indicating a stiff consistency.

Below the surficial deposit in Borehole 99-26, a deposit of brown clayey silt containing trace sand was encountered. One SPT 'N' value of 5 blows per 0.3 m of penetration was measured in this deposit. The measured water content of one sample of the clayey silt was about 24 percent.

Below the topsoil in Borehole 99-25 and the clayey silt in Borehole 99-26, a deposit of brown to grey clay / silty clay was encountered between Elevations 266.3 m and 266.6 m. The structure of the deposit is varved in the area of Borehole 99-26 and becomes varved in Borehole 99-25 below about depth 2.9 m (Elevation 264.0 m). A silt interlayer was encountered with the varved clay / silty clay in Borehole 99-25.

SPT 'N' values in the clay / silty clay deposit ranged from 2 blows to 5 blows per 0.3 m of penetration and in-situ vane shear test results ranged from about 38 kPa to 91 kPa, indicating a firm to stiff consistency. Measured water contents of samples from this deposit ranged from 29 percent to 35 percent. Measured liquid and plastic limits of one sample of the silty clay were 32 percent and 18 percent, respectively (plasticity index of 14 percent).

4.9 Area 9: Township of Beatty, Stations 11+560 to 11+880 (Cut)

A plan and profile showing the borehole locations and stratigraphies for Area 9 is shown on Figure 11.

Boreholes 99-27, 99-28 and 99-29 were advanced within the limits of Area 9. The ground surface elevation at the borehole locations varies from about Elevation 269.8 m to 273.7 m. The boreholes were sampled to depths ranging from 3.7 m to 5.3 m.

About 50 mm to 200 mm of topsoil was encountered at the borehole locations underlain by brown silty clay. Sandy silt seams were encountered within silty clay deposit up to about 2.0 m depth in Borehole 99-28. Measured SPT 'N' values in the brown silty clay deposit ranged from 3 blows and 7 blows per 0.3 m of penetration, indicating a firm to stiff consistency. Measured water contents of samples from this deposit ranged from 38 percent to 57 percent.

Below the brown silty clay, a deposit of brown to grey varved clay with silty clay / silt was encountered between Elevations 269.1 m and 272.0 m. Measured in-situ shear vane test results of about 27 kPa to 83 kPa were measured in this deposit indicating a firm to stiff consistency. The measured water content of one sample from this deposit was about 49 percent. Measured liquid and plastic limits of one sample of the clay were 64 percent and 26 percent, respectively (plasticity index of 38 percent).

4.10 Area 10: Township of Beatty, Stations 12+520 to 12+700 (Fill)

A plan and profile showing the borehole locations and stratigraphies for Area 10 is shown on Figure 12.

Boreholes 99-30 and 99-31 were advanced within the limits of Area 10. The ground surface elevation at the borehole locations varies from about Elevation 265.5 m to 267.5 m. The boreholes were sampled to depths ranging from 3.7 m to 4.4 m.

About 90 mm to 300 mm of topsoil was encountered at the borehole locations underlain by brown sand and gravel to sand fill in Borehole 99-30. Two measured SPT 'N' values in the fill deposit were 7 blows and 8 blows per 0.3 m of penetration, indicating a loose state of packing.

Below the sand and gravel fill in Borehole 99-30 and the topsoil in Borehole 99-31, a deposit of brown varved clay with clayey silt was encountered between Elevations 263.7 m and 266.8 m. Two measured SPT 'N' values in the varved deposit were 3 blows and 4 blows per 0.3 m of penetration, and in-situ shear vane test results ranged from about 19 kPa to 80 kPa, indicating a soft to stiff consistency. Measured water contents of samples from this deposit ranged from about 38 percent to 42 percent. Measured liquid and plastic limits of one sample of the clay were 66 percent and 25 percent, respectively (plasticity index of 41 percent).

4.11 Area 11: Township of Beatty, Stations 13+640 to 13+940 (Cut)

A plan and profile showing the borehole locations and stratigraphies for Area 11 is shown on Figure 13.

Boreholes 99-32, 99-33, 99-34 and Auger Probes 99-40, 99-41, 99-42 and 99-43 were advanced within the limits of Area 11. The ground surface elevation at the borehole locations varies from about Elevation 290.2 m to 296.2 m. The boreholes were sampled to depths ranging from 3.8 m to 9.6 m. The auger probes were advanced to refusal without sampling.

About 130 mm to 250 mm of topsoil was encountered at the borehole locations underlain by brown varved clay with silt / clayey silt. Measured SPT 'N' values in the varved clay ranged from 3 blows to 9 blows per 0.3 m of penetration, and in-situ shear vane test results ranged from about 84 kPa to >100 kPa. Measured water contents of samples from this deposit ranged from about 35 percent to 42 percent.

Below the varved clay in Borehole 99-33, a deposit of brown clayey silt was encountered at about Elevation 290.9 m. One measured SPT 'N' value in the clayey silt deposit was 9 blows per 0.3 m

of penetration, indicating a stiff consistency. One measured water content of a sample from this deposit was about 20 percent.

Below the varved clay in Borehole 99-32 and the clayey silt in Borehole 99-33, a deposit of silty sand containing trace clay and gravel was encountered between Elevations 287.9 m and 290.3 m. SPT 'N' values of 12 and 14 were measured in this deposit indicating a compact state of packing. Two measured water contents of samples from this deposit were about 13 percent. Boreholes 99-32 and 99-33 were terminated in this deposit due to auger refusal at Elevation 287.3 m and 289.3 m, respectively.

In Borehole 99-34, a deposit of grey silty clay was encountered below the brown varved deposit at about Elevation 284.9 m. SPT 'N' values of 2 and 5 were measured in this deposit, and in-situ shear vane test results ranged from about 53 kPa to 88 kPa, indicating a firm to stiff consistency. Two measured water contents of a samples from this deposit were about 40 percent and 42 percent. Measured liquid and plastic limits of one sample of the silty clay were 41 percent and 21 percent, respectively (plasticity index of 20 percent).

Below the silty clay in Borehole 99-34 at about Elevation 281.4 m, a deposit of sand and gravel was inferred from drilling observation. Borehole 99-34 was terminated in this deposit at Elevation 280.6 m due to auger refusal.

The auger probes were advanced to refusal at Elevations between 292.2 m and 295.5 m (depths 0.8 m to 1.2 m). Based on drilling observations, the subsurface conditions in the area of Auger Probes 99-40, 99-41, 99-42 and 99-43 consist of sand and gravel from the ground surface to the depth of auger refusal.

A summary of the geotechnical data from Area 11 is shown on Figure 17.

4.12 Area 12: Township of Beatty, Stations 14+460 to 14+880 (Fill)

A plan and profile showing the borehole locations and stratigraphies for Area 12 is shown on Figure 14.

Boreholes 99-35, 99-36, 99-38, 99-39 and one piezo-cone (CPT 99-37) were advanced within the limits of Area 12. The ground surface elevation at the borehole locations varies from about Elevation 286.1 m to 290.4 m. The boreholes were sampled to depths ranging from 3.7 m to 5.3 m.

About 50 mm to 200 mm of topsoil was encountered at the borehole locations underlain by brown silty sand to sandy silt in Boreholes 99-35 and 99-36. Measured SPT 'N' values in the silty sand / sandy silt ranged from 6 blows to 53 blows per 0.3 m of penetration, indicating a loose to very dense state of packing. Measured water contents of samples from this deposit ranged from about 10 percent to 25 percent. Boreholes 99-35 and 99-36 were terminated in this deposit.

Below the topsoil in Borehole 99-38, a deposit brown fine to coarse sand was encountered. Measured SPT 'N' values in the sand ranged from 8 blows to 18 blows per 0.3 m of penetration, indicating a loose to compact state of packing. Measured water contents of samples from this deposit ranged from about 4 percent to 5 percent. Borehole 99-38 was terminated in this deposit.

Below the topsoil in Borehole 99-39, a deposit of brown sand fill about 1.3 m thick, containing some silt and trace gravel was encountered underlain by about 0.5 m of black peat, further underlain by about 0.5 m of sand with trace to some silt. Measured SPT 'N' values through these deposits ranged from 2 to 8 indicating a very loose to loose state of packing.

Below the peat and sand in Borehole 99-39, at about Elevation 285.6 m, a deposit of varved silty clay with silt was encountered. One SPT 'N' value 0 blows (weight of hammer) per 0.3 m of penetration was measured in this deposit, and in-situ shear vane test results ranged from about 42 kPa to 50 kPa, indicating a soft to firm consistency. Two measured water contents of samples

from this deposit were about 51 percent and 73 percent. Representative liquid and plastic limits of the silty clay are 43 percent and 23 percent, respectively (plasticity index of 20 percent).

Stratigraphy interpretation based on the results of CPT 99-13 indicate the presence of a soft / loose deposit extending from the existing ground surface at about Elevation 283.5 m. The soft / loose deposit in CPT 99-13 is underlain by sand; as encountered in Boreholes 35, 36 and 38.

In Borehole 99-39, a dynamic cone penetration test was advanced to practical refusal. Dynamic penetration ranged between 9 blows and 21 blows per 0.3 m of penetration down to about 10.7 m depth (Elevation 277.3 m), then ranged between 28 blows and 65 blows per 0.3 m of penetration until practical refusal at 20.0 m (Elevation 268.0 m).

A summary of geotechnical data for Area 12 is shown on Figure 18.

A piezometer was installed in Borehole 99-36 with tip at Elevation 285.4 m. The water in the piezometer was at Elevation 285.5 m on July 3, 1999, (i.e., only about 0.1 m above the piezometer tip). The piezometer was dry on July 23, 1999. The groundwater level is subject to seasonal fluctuations.

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5.0 DESIGN OPTIONS

Based on the subsurface conditions encountered at the site, and discussions with MTO personnel, seven alternatives for embankment fill material were considered. The selection of alternatives provide relative advantages and disadvantages in terms of weight (i.e., applied load to native sub-strata), construction cost and time, and ease of construction. A summary of the advantages and disadvantages of the alternatives is shown in Table 3, and a comparative cost analysis is provided in Section 6.3 of this report. The following is a brief description of the alternatives considered:

1. Earthfill Embankment

This option assumes that conventional earthfill is used for the embankment. A schematic diagram of this option is shown on Figure 19a. The main advantage of this option is the relative low cost and ease of construction. However, this option does require a large volume of fill and wide right-of-way. Further analysis in terms of stability, settlement and cost of the earthfill option is presented in Section 6.0 of this report.

For this project, earthfill is considered to be suitable imported granular material. Although some of the existing stiffer clay crust material from cut areas may be suitable as earthfill for some portions of the embankment (e.g., the stability berms), the selection of suitable material in the field would be difficult to the point that it probably would be more cost-effective to use imported granular material.

2. Rockfill Embankment

This option uses rockfill in place of earthfill for the embankment. The main advantage of this material is the ability to achieve steeper embankment side slopes. This is useful in areas with limited right-of-ways. However, higher cost and availability of rockfill may be disadvantages of this option. Further analysis in terms of stability, settlement and cost of the rockfill option is presented in Section 6.0 of this report.

3. Composite Earthfill and Lightweight Slag Fill

A schematic diagram of this option is shown on Figure 19b. This option considers the use of earthfill for Stage I of the embankment (up to the first bench level) followed by a lightweight slag (Type I or Type II) for the remainder of the embankment height (Stage II).

The lightweight slag in place of earthfill for Stage II reduces the overall applied load by the embankment on the native subsoils. The reduced load will result in reduced settlements and increased stability, resulting in narrower berm requirements. Right-of-way requirements will also be reduced. A higher cost is associated with lightweight slag versus earthfill. Further analysis in terms of stability, settlement and cost of the composite earthfill and lightweight slag option is presented in Section 6.0 of this report.

For this project, the use of Type I slag material is recommended despite that it is heavier than Type II material. The primary reason is that Type I is about 40 percent cheaper than Type II. The use of the lighter weight Type II material would not produce significantly reduced volumes. Therefore, it is more cost-effective to use Type I slag material.

4. Lightweight Slag Fill

This option considers the use of lightweight slag for most of the embankment fill. A small height of earthfill would still be required at the bottom of the embankment to ensure that the bottom of the slag is kept above the normal ground water level (leachate concerns). A schematic diagram of this option is shown on Figure 19c. This alternative further reduces the applied embankment load, thus reducing the amount of settlement while increasing stability and reducing berm requirements. A much higher cost is associated with lightweight slag versus earthfill. Further analysis in terms of stability, settlement and cost of the lightweight fill option is presented in Section 6.0 of this report.

For this project, the use of Type I slag material is recommended because it is more cost-effective as explained above in Option 3.

5. Composite Earthfill and Extruded Polystyrene

This option considers the use of earthfill for Stage I of the embankment (up to the first bench level) followed by extruded polystyrene for the remainder of the embankment height (Stage II). A schematic diagram of this option is shown on Figure 19d. Extruded polystyrene blocks (approximately 8 feet long by 4 feet wide by 1 foot high) are placed in a staggered formation and must be wrapped in polyethylene and covered with 100 mm of concrete. The granular pavement sub-base can be placed on the concrete surface. This option has the advantage of significantly reducing the applied embankment load compared with the earthfill and / or lightweight slag options. However, there is a disadvantage in terms of high cost and construction complexity. In addition, there may be concerns due to degradation of the polystyrene in the presence of hydrocarbons, and potential icing of the road surface due to the reduced thermal mass property of the polystyrene versus earthfill. Despite these disadvantages, further analysis in terms of stability, settlement and cost of the composite earthfill and extruded polystyrene option is presented in Section 6.0 of this report.

6. Elastizell Fill

This option considers the use of elastizell concrete for the embankment fill. This option has the advantage of significantly reducing the applied embankment load compared with the earthfill and / or lightweight slag; but has the disadvantage of a very high construction cost. Therefore, this alternative was not considered in further analysis.

7. Wick Drains

This option considers the use of drains installed in the native clay deposits to increase the rate of consolidation settlement, thus reducing the time required between construction of the embankment and construction of the roadway, and opening of the road to traffic. Wick drains, however, do not significantly improve the rate of consolidation in overconsolidated clays and in varved clay deposits. This is because the more permeable silt layers of the varved clay will promote radial drainage and increased rate of consolidation settlement. Therefore, this alternative was not considered in further analysis.

6.0 ANALYSIS

6.1 Stability Analysis

Slope stability analyses were carried out on critical cut and fill sections using the commercially available program SLOPE/W (version 4.0). The program has the capability of either using a constant undrained shear strength value or a linear shear strength pattern within a given soil layer. The program uses the general equilibrium method of analysis to calculate the factor of safety of numerous potential trial failure surfaces (both circular and composite) and determine minimum factors of safety. The factor of safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure.

The proposed cut and fill sections must be stable during construction (short-term) and in the long-term. A minimum static factor of safety of 1.3 is considered adequate based on the design requirements and field data available. Geotechnical soil parameters were selected based on in-situ testing and laboratory test results. Both effective stress (drained conditions) and total stress (undrained conditions) were checked to ensure the minimum factor of safety was achieved.

The undrained shear strength profile used in the analysis for fill Areas 2 and 7 is shown on Figure 20. The design strength profile used is less than the measured field vane strengths. The reason for this is that field vane strengths measured in varved and interlayered silt and clay deposits need to be reduced to be more representative for analysis and design purposes to account for the stronger seams of silt within varved / layered clays. The field vane test forces a vertical failure surface through both the softer clay and stronger silty layers, while in reality failure of the soil under embankment loading will be mainly through the softer clay layers (i.e., the failure surface will be along the path of least resistance).

It has been well established in the technical literature, and recently commonly accepted in engineering practice, that a good representative value for the average mobilized undrained shear strength of clays, including varved / layered clays, is given by $0.22 \sigma'_p$ (where σ'_p is the pre-consolidation pressure of the clay). This value for undrained shear strength is also shown on Figure 20 and forms the basis of the design strength profile.

Based on experience with similar soils in the Timmins area, it was found that for analysis and design purposes, the measured field vane strength should be reduced by about 25 percent (i.e., S_u design = $0.75 S_u$ vane). From Figure 20, it is seen that this trend is also approximately observed for the varved / layered clay deposits in this project.

6.1.1 Embankments

Earthfill

Figure 21 shows the stability analysis section and results for the proposed 11 m high earthfill embankment, with 2H:1V side slopes, required at Areas 2 and 7. Typical soil properties were selected for the earthfill and the analysis found that an 11 m high embankment must have a 15 m wide stability berm that is 5 m high. The minimum factor of safety for both circular and composite trial surfaces is 1.3. Stability analyses were carried out for various embankments heights to determine berm configurations resulting in minimum factors of safety greater than 1.3. A 6 m high earthfill embankment with 2H:1V side slopes can be constructed without a berm on the same foundation soils with a minimum factor of safety equal to 1.77 for a deep seated circular trial surface and 2.09 for a composite trial surface. The minimum long-term factor of safety for a 2H:1V earthfill slope is represented by a surficial trial surface with a factor of safety of about 1.4. A unit weight of 20 kN/m^3 was used in the analysis for typical earthfill. Stability of the proposed embankment configurations was checked for an earthfill with a unit weight of 21 kN/m^3 and adequate factors of safety were calculated.

Rockfill

Stability analysis was carried out for rockfill embankment sections assuming a unit weight of 17 kN/m^3 . Embankment stability and minimum berm requirements were evaluated for rockfill construction at Areas 2 and 7. A minimum factor of safety of 1.35 was achieved for an 11 m high embankment with a 5 m high by 5 m wide berm. The berm width can be reduced to 2 m (4 m high) for a 10 m high embankment.

Rockfill is proposed for construction of a maximum 5 m high embankment at Area 12. Stability analysis of a 5 m high embankment with side slopes of 1.25H:1V was carried out. Surficial

stability of the rockfill slope, as expected, resulted in the lowest factors of safety; however, rockfill will be stable at this proposed side slope. Deep, crest to toe, trial surfaces through foundation conditions encountered at Area 12 (3 m of clay with undrained shear strength of 30 kPa overlying sandy silt) resulted in factor of safety values well above 1.3.

Lightweight Slag

A cross-section utilizing lightweight slag fill for the upper 6 m of an 11 m high embankment was developed and slope stability results are shown on Figure 22. The minimum factors of safety for circular and composite trial surfaces are 1.35 and 1.39, respectively. The unit weight of the lightweight slag was set at 14 kN/m³ (Type I slag) and allows the berm width to be reduced to 5 m.

6.1.2 Cuts

For cuts, stability is usually governed by the long-term case using effective shear strength parameters. However, when soft clay deposits are encountered it is also prudent to check if stability is assured in the short-term. For this project, it was found that the proposed 3H:1V cut slopes would be stable in the short-term.

The results of the triaxial testing (Appendix A) on a sample of the varved clay gave effective strength values of effective cohesion, $c' = 5$ kPa and effective friction angle, $\phi' = 26^\circ$. For analysis $c' = 0$ was used. Stability analysis, based on these parameters, showed that the trial failure surfaces with the lowest factor of safety corresponded to shallow surficial sloughing. For trial failure surfaces that extended deeper into the slope, and would involve substantial volumes should failure occur, the computed factors of safety were greater than 1.3.

Surficial stability is essentially controlled by the following factors:

- slope angle;
- effective friction angle of the soil comprising the slope; and
- piezometric conditions near the slope face.
- frost action

For the conditions associated with this project, it will be necessary to have cut slopes not steeper than 3H:1V, otherwise surficial sloughing could be problematic along the alignment. Surficial stability will be enhanced once a strong vegetation cover has been established on the slope face.

6.2 Settlement Analysis

Settlement analyses were carried out for the highest embankment sections at Area 2 and Area 7. The analyses were carried out using simplified stratigraphies based on the field investigation data and the consolidation test data. The commercially available program UNISETTLE (v2.04) produced by Unisoft Limited was used to calculate settlements, cross checks were carried out by hand calculation.

A key element in determining consolidation settlement is the degree to which a clay deposit is overconsolidated. This degree of overconsolidation (OCR) is defined as the ratio of maximum past pressure, that the deposit has experienced, to current effective stress. OCR was determined directly from the consolidation data and indirectly from measured vane shear strengths. In addition cross checking was carried out using the CPT data. OCR plots showing data points, based on consolidation testing and vane strengths, and the design OCR lines are given in Figures 23 and 24.

The consolidation test data for four horizontally trimmed and one vertically trimmed sample is summarized in Appendix A. The vertically trimmed sample (Borehole 99-24, Sample 6 – 8.1 m depth) was tested to provide an indication of the effect of horizontal silt seams on the rate of consolidation. The testing indicated that a vertically trimmed sample had a coefficient of consolidation (c_v) of about one to two orders of magnitude greater than a horizontally trimmed sample. Within the anticipated field stress level, the vertically trimmed sample had a c_v value that is about five to 20 times faster than that of the horizontally trimmed sample. For design, a field coefficient of consolidation of five times the average measured c_v on horizontally trimmed samples was utilized for the appropriate loading range. A summary of the design parameters used in the analysis for each high embankment area is as follows:

<i>Area</i>	<i>Initial Void Ratio, (e_0)</i>	<i>Compression Index, (c_c)</i>	<i>Recompression Index, (c_r)</i>	<i>Field Coefficient of Consolidation (cm^2/s)</i>
2	1.5	0.75	0.035	3.5×10^{-3}
7	1.4	0.65	0.035	5×10^{-3}

A simplified stratigraphic column was developed for both areas, based on the field investigation data for each area as summarized on Figures 4 and 9. Area 2 was modeled using 6.4 m of silty clay underlain by 3.4 m of loose silt. The compression of the loose silt was modeled assuming an elastic compression modulus of 8 MPa. Area 7 was modeled using 10 m of silty clay.

A summary of the analysis results for both areas are given on Figure 25. The figure indicates the settlement increasing with increasing stress change and indicates what stress level change is associated with which design option. A plot showing the variation of settlement under an embankment constructed of earthfill is shown in Figure 26. The stress change for an 11 m embankment constructed of earthfill is about 220 kPa and for a composite earthfill / extruded polystyrene section is about 130 kPa. The plots for both areas are bilinear with a change in gradient at about 100 kPa (Figure 25).

The change in gradient represents the point at which, on average for the analysis section, the stress change moves into the normally consolidated (increased compressibility) portion of the consolidation curve. This point represents an earthfill embankment height of about 5 m and implies that embankments constructed under 5 m are likely to experience settlement of under about 180 mm (if clay thickness is about 10 m). However, because this settlement occurs in the reloading (overconsolidated) portion of the consolidation curve, the coefficient of consolidation is about one order of magnitude higher than the design values given above (which represent normally consolidated compression). Therefore, time rate analyses indicate that embankments constructed under 5 m are likely to reach 90 percent consolidation in under six months.

The following discusses the specific analysis results for each section.

- Area 2

The analysis results indicate that an 11 m embankment would experience a maximum of about 350 mm of settlement, if constructed of earthfill. The time rate analysis indicates that 90 percent of this settlement would be complete in about a year and that future consolidation settlements would be under 100 mm. A time vs settlement plot is shown on Figure 27. The other options for embankment construction should all consolidate in under one year.

- Area 7

The analysis results indicate that an 11 m embankment would experience a maximum of about 660 mm of settlement if constructed of earthfill. The time rate analysis indicates that 90 percent of this settlement would be complete in about a one and a half to two years and that future consolidation settlements would be under 100 mm, see Figure 27. The other options for embankment construction would all consolidate in less time.

We understand that a two year delay following embankment construction is acceptable; therefore, time rate analyses were not carried out for each embankment option.

Note that the use of wick drains to speed consolidation is not considered an option. Wick drains have negligible effect when installed in a interlayered and overconsolidated clay deposit.

6.3 Fill Option Cost Comparison

Table 3 lists and describes the various options considered for construction of the road embankments. Large stability berms or the use of lightweight fills will be required to achieve stable 11 m high embankments at Areas 2 and 7. Several of the options listed (wick drains, elastizell concrete) were discarded for obvious economic or technical reasons. A cost comparison of five fill material options was considered based on geometry requirements from the stability analysis and corresponding material volume requirements (shown on Table 4). The following five options were considered: complete earthfill, complete rockfill, composite earth and lightweight slag

fill, complete lightweight slag fill, and composite earth and extruded polystyrene fill. The volume estimates are approximate and are for comparison purposes only. The comparison found that the cost of using lightweight fills such as slag or extruded polystyrene are significantly higher than conventional earthfill and rockfill. However, the right-of-way requirements and total fill volumes are greater if heavier construction materials are used. The following unit costs were assumed:

- Earthfill (granular) \$ 13 /m³
- Rockfill \$ 15 /m³
- Lightweight Slag \$ 50 /m³
- Extruded Polystyrene \$ 120 /m³

7.0 ENGINEERING RECOMMENDATIONS

7.1 General

The 12 areas considered can be described as either cut excavation or embankments (fill sections).

7.1.1 Cut Excavations

All proposed cut areas should be excavated to achieve 3H:1V slopes. The road geometry at the base of the cuts should be designed to current MTO Standards. Drainage ditches should be constructed on either side of the road surface as per MTO current drainage requirements. Vegetation cover should be established on all slope faces as soon as possible after excavation to protect against surficial sloughing / erosion as per current MTO requirements. Alternatively, an appropriately graded granular blanket could be considered for use as erosion protection. Given the relatively flat (3H:1V) slopes, it is likely that a good, strong vegetation cover would be sufficient for erosion protection. Nevertheless, in localized areas some sloughing could still occur depending on the severity of frost action and groundwater seepage. Such areas would require repair following normal MTO procedures.

7.1.2 Embankments

Various embankment construction options were considered for the 11 m high embankments required at Areas 2 and 7 (discussed in Section 5 and cost compared in Section 6.3). Stability and settlement design criteria can be achieved for all fill sections along the alignment by utilizing earthfill or rockfill embankments with side slopes of 2H:1V that incorporate stability berms for embankments that are greater than 6 m high. Minimum berm configuration requirements for embankments at Areas 2 and 7 are summarized in Table 5.

In general, topsoil and organic deposits should be stripped from within the plan limits of the proposed embankments. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 percent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course

should be placed and compacted to current MTO requirements for pavements. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

Based on the cost comparison described in Section 6.3 it is recommended that the embankments for Areas 2 and 7 be constructed of either earthfill or rockfill. Stability analysis concluded that by using rockfill (with a unit weight of 17 kN/m^3) instead of earthfill (with a unit weight of 19 kN/m^3 to 21 kN/m^3), a reduction in berm width from 15 m to 5 m for an 11 m high embankment is possible. Table 5 details minimum berm requirements for various embankment heights. All embankment construction (i.e. in all fill areas) are subject to these berm recommendations. It is important that effective height of an embankment (change in elevation from crest to toe of slope) be assessed during embankment and berm design (see Table 5).

Typical earthfill and rockfill cross-sections (following Table 5 recommendations) for existing topography at the most critical sections are shown on Figures 28 and 29. Fill volume estimates for Areas 2 and 7 were carried out using surveyed transverse sections every 25 m along the highway re-alignment. For Areas 2 and 7, the estimated total volume of earthfill required for embankment construction is about $86,000 \text{ m}^3$, corresponding to a cost of about \$1.1 million. The respective volume of rockfill required for these two areas is about $82,000 \text{ m}^3$, corresponding to a cost of about \$1.2 million.

7.2 Special Considerations

This section discusses additional design issues.

7.2.1 Culverts

We understand that culverts about 2.4 m high and 2.8 m wide will be required at Stations 13+040 (Area 2) and Station 10+380 (Area 7). The embankment at both these sections is about 11 m in

height. Assuming an earthfill embankment will be used at both sections implies that the culverts will be about 90 m in length.

In both areas, the culverts should be founded on the upper firm to stiff brown silty clay. The culverts should be designed to withstand the appropriate weight of fill and traffic loadings, and frost pressures (where adequate frost cover is not provided). The culvert should be founded on properly prepared subgrade and the base of the excavation should be inspected after reaching the design founding level. The factored geotechnical bearing resistance at ultimate limit states (ULS), for design of the culvert embedded in 11 m of fill, may be taken as 300 kPa.

The results of the settlement analysis, for an earth embankment, are summarised on Figure 26. The results indicate that the culverts will have to withstand maximum centreline settlements of about 345 mm in Area 2 and 660 mm in Area 7. The following placement procedure may be utilized for a culvert to maintain flow (see Figure 30):

- Place culvert at a minimum grade of 0.5 percent (or as required by stream hydraulic requirements) from the intake to the embankment centreline.
- Place culvert from centreline to outlet at minimum grade of 0.5 percent, plus an allowance for maximum centreline settlement. e.g., in Area 2, $\text{grade} = 0.5 + (0.345/45) = 1.27$ percent; Area 7, $\text{grade} = 0.5 + (0.66/45)100 = 1.97$ percent.

The above procedure should maintain flow during and after the period of consolidation settlement.

The settlements that the culverts will have to withstand implies that construction joints will be required for concrete culverts. These construction joints should be located by the culvert designer with reference to the expected settlement profiles, see Figure 26.

Culvert structure options primarily include flexible pipes, concrete rigid frame boxes or open concrete culverts. We understand that a concrete structure is a generally preferred option. An open concrete culvert supported on spread footings would require internal regrading to correct for settlement distortion, as the base of the stream would settle less than the spread footings. In order

to avoid regrading operations, a rigid frame box should be used. The box spreads the load over the base of the culvert and would create an even settlement distribution across the width of the culvert.

The box culvert should be founded on the stiff clay crust material following removal of any organic and other unsuitable materials. The clay crust material could be softened by construction activities and/or weather conditions. Therefore, to preserve the integrity of the clay crust material, a working concrete platform or mud mat should be placed as soon as practicable after reaching the founding elevation and completion of inspection. A thin concrete working mat is recommended instead of a thicker granular pad because it is desirable to keep the foundation as high as possible in the clay crust.

Backfill around the culvert should be carried out as per OPSD 803.02. Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as OPSS Granular 'A' or 'B'. All granular fill should be placed in loose lifts not exceeding 200 mm thickness and compacted to at least 95 percent of its Standard Proctor maximum dry density.

Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. The height of backfill to the culvert walls should be maintained equal on both sides of the structure during all stages of backfill placement. Temporary diversion of surface water flow may be required during culvert installation. Adequate erosion protection, as determined by hydraulic assessment, should be provided to the inlet and outlet slopes, and the channel.

7.2.2 Instrumentation

The settlement of the high embankments and culverts (Areas 2 and 7) should be monitored to confirm expected preload performance. The monitoring will confirm the rate of settlement and provide an estimate of likely maximum settlements. The monitoring should consist of a leveling survey along the embankment centreline at, say, 10 m intervals and occasional section surveys at the crests. One section survey should coincide with the highest embankment section. In addition, monitoring pins should be installed into the wall of the culvert at about 5 m intervals, and on either

side of construction joints. Monitoring of the settlement points within the culverts will be subject to confined space entry health and safety requirements.

A baseline survey should be made following installation of the culvert and following construction of the embankment. The frequency of future readings depends somewhat on the necessity to utilise the embankments as soon as possible. If the embankments can be left for two years then a survey frequency of two months would be adequate. If the embankments are to be in operation 12 to 18 months following construction, then the reading frequency should be increased in the second year to monthly. The data can then be assessed on a month to month basis.

If the culverts cannot be utilized for settlement survey purposes, then settlement plates should be installed at the base of the highest section of embankment in Areas 2 and 7. The settlement plates should be installed at the centre and at each shoulder, following normal MTO installation procedures. The vertical riser pipes of the settlement plates should be contained in a casing. The problem of extending riser pipes during fill placement may be avoided by installation of steel settlement plates prior to fill placement. Following embankment construction, a borehole could be drilled from the embankment surface to 'hit' the buried steel plate. The vertical riser pipe and casing could then be installed. We understand that this procedure has been used successfully by MTO in the past. However, it requires accurate survey control both in terms of plan location and elevation so that the steel plate can be located after fill placement. This procedure should provide information to determine the amount of ground settlement that took place during embankment construction. This data is needed to properly assess the preload performance of the embankment.

The above described procedure will not be suitable if rockfill is used as the embankment material.

Alternatively, special remote settlement cells could be used. These cells would be placed in the original ground with buried tubing/cables leading to beyond the toe of the embankment to a readout station. This type of instrumentation would not interfere with fill placement activities.

7.2.3 Blasting Recommendations (Area 11)

Control over the blasting operations should include three basic activities. These include:

- 1) Completing a pre-blast survey.
- 2) Review of contractor's blast proposal prior to blasting.
- 3) Monitoring ground and air vibration intensities at the closest structure during blasting.

The pre-blast survey is the most practical means of documenting the condition of existing structures and services. They are also useful in providing information about the project to neighbouring residents and are an excellent public relations tool for alleviating any perceived fears about the blasting before they can escalate. The pre-blast survey should be carried out immediately prior to the start of blasting. We recommend carrying out a pre-blast survey of any structure located whole or in part within 100 m of the blast area. The pre-survey should be carried out by an independent qualified professional and would include documenting the existing condition of the adjacent residence, including the use of video and photographic records. Groundwater wells in the area should also be measured and tested for general water quality prior to blasting. A post-blast survey may also be carried out if there is a concern about possible damage claims by the homeowner following construction.

The contractor should submit a complete blast proposal prior to the start of blasting for review by a specialist blast consultant. This would include, but not be limited to, details on the drill pattern, hole size, explosive and initiation products to be used, initiation sequence, and flyrock control measures to be taken during blasting.

Ground and air vibration levels should be monitored at the adjacent residence during all blasting operations to ensure compliance with OPSS 515, which specifies a peak particle velocity of 50 mm/s at the nearest service or structure to construction blasting projects. Monitoring should also be carried out by a qualified professional. The instrumentation should be capable of measuring and recording peak ground vibration intensities in each of three orthogonal directions

and air-blast levels in dBL. Monitoring results should be made available immediately following each blast so the contractor can make any necessary adjustments, as required.

7.2.4 Area 12


The Highway 101 re-alignment in Area 12 passes within close proximity to Leach Lake to the north and Froome Lake to the south. The proposed embankment height through this area is up to 5 m. Embankments with side slopes constructed at 2 horizontal to 1 vertical will encroach into the lakes. It is our understanding that MTO would like to minimize the amount of encroachment. One option would be to use rockfill instead of earthfill for the embankment fill. Rockfill can be placed at an angle as steep as 1.25 horizontal to 1 vertical, thereby reducing the overall width of the embankment and effectively minimizing the amount of encroachment of the embankment into the lakes.

The results of the field investigation indicate that the subsurface in Area 12 consists mainly of sand and silty sand underlain by silty clay. These conditions should present no stability concerns. In Borehole 99-39 and Piezo-Cone Penetration Test 99-37, a soft / loose surficial layer (sand fill and peat in Borehole 99-39) was encountered. As the rockfill is placed, localized failures are likely to occur as the rock sinks into and displaces the soft / loose deposit. This should not significantly impact the construction or final overall stability of the rockfill embankment. Inspection by qualified geotechnical personnel during construction of the rockfill embankment would be required.

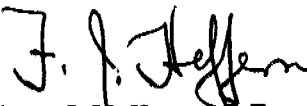
GOLDER ASSOCIATES LTD.



Andrew J. Walker, P.Eng.
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Fintan J. Heffernan, P.Eng.
Designated MTO Contact



BVB/DJ/AJW/DEB/FJH/clg/pds
WORD S/FINAL/DAT/1100/991-1145/911145H1

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Penetration Resistance; N_6 :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I GENERAL

π	= 3.1416
$\ln x$,	natural logarithm of x
$\log_{10} x$ or $\log x$,	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density \times acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_{α}	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio = σ'_p / σ'_{vo}

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

01145001.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378270.6; E 346363.8

RECORD OF BOREHOLE 99-1

BORING DATE: JUNE 22, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT						
				DEPTH (m)				Cu, kPa	nat V	+	Q	•	rem V	•			U	•
								20	40	60	80							
								20	40	60	80							

0	CME-55 POWER AUGER BORING	GROUND SURFACE																
		Topsoil	263.19															
			0.00															
		Silty Clay, trace rootlets	0.13	1	50	6												
		Firm			DO													
		Brown																
			262.50															
			0.69	2	50	5												
1					DO													
		Laminated silty clay																
		Firm to stiff																
		Brown																
2				3	50	4												
					DO													
3			260.29															
			2.60	4	50	WH												
		Clay			DO													
		Soft to firm																
		Grey																
4				5	75	WH												
					TO													
5				6	50	WH												
					DO													
		END OF BOREHOLE (NO REFUSAL)	258.01															
			5.18															
6																		
7																		
8																		
9																		
10																		

Water level at
Elevation 259.8m
in open borehole
immediately upon
completion of
drilling.

Water level at
 Elevation 259.8m
 in open borehole
 immediately upon
 completion of
 drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS JULY 8/99

SOL 46

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5378251.3; E 346399.8

RECORD OF BOREHOLE 99-2

BORING DATE: JUNE 22, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145002 BHS

DATA INPUT: PS AUG. 3/99

SOLIM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
						Cu, kPa	nat V - rem V -	Q - U -	Wp		
0	CME-35 POWER AUGER BORING	GROUND SURFACE		263.38							<div>CONCRETE & CASING</div> <div>BENTONITE SEAL</div> <div></div> <div>NATIVE FILL</div> <div></div> <div>BENTONITE SEAL</div> <div>PEA GRAVEL</div> <div></div> <div>Water level in piezometer at Elevation 263.1m on July 3/99, and at Elevation 261.8m on July 23/99.</div>
		Topsoil		0.00	1 50 DO 2						
				0.10							
1		Laminated silty clay Firm to very stiff Brown			2 50 DO 5						
2					3 50 DO 5						
3				260.48 2.90	4 50 DO 3						
4		Silty Clay Stiff Grey			5 50 DO 3						
5		Clay Firm Grey		259.03 4.35	6 50 DO WH						
		silt interlayer		258.38 5.00							
				258.08 5.30							
6		Clay Firm Grey			7 50 DO WH						
7				8 50 DO WH							
8				9 50 DO WH							
9	END OF BOREHOLE (NO REFUSAL)		255.15 8.23								
10	Note: Vane test results obtained from additional borehole advanced 1m east of BH 99-2.										

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145003.BHS

DATA INPUT: PS AUG. 3/99

SOLM6

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378265.8; E 346443.4

RECORD OF BOREHOLE 99-3

BORING DATE: JULY 3, 1999

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp				
0	CME-55 POWER AUGER BORING	GROUND SURFACE	262.58								
		Topsoil	0.00 0.08	1	50 DO	3					
1		Medium Sand, trace gravel Very loose to loose Brown	261.36 1.22	2	50 DO	8					
2		Silty Clay Firm to stiff Brown		3	50 DO	4					
3				4	50 DO	3					
4				5	75 TO	PH					
5		Silty Clay, clayey silt seams every 10mm to 20mm Firm to stiff Grey	258.77 3.81								
			257.40 5.18								
6											
7											
8											
9											
10											

CONTINUED ON NEXT PAGE

Open borehole dry
upon completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145003 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378265.8; E 346443.4

RECORD OF BOREHOLE 99-3

BORING DATE: JULY 3, 1999

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DATA INPUT: PS AUG.3/99
 SOIL M6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - Cu, kPa	+ rem V - U -			Q - U -	Wp
10	CME-55 POWER AUGER BORING	CONTINUED FROM PREVIOUS PAGE											
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
				243.15 19.43									
		END OF BOREHOLE REFUSAL TO FURTHER PENETRATION CONE ADVANCE PROBABLE BEDROCK											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

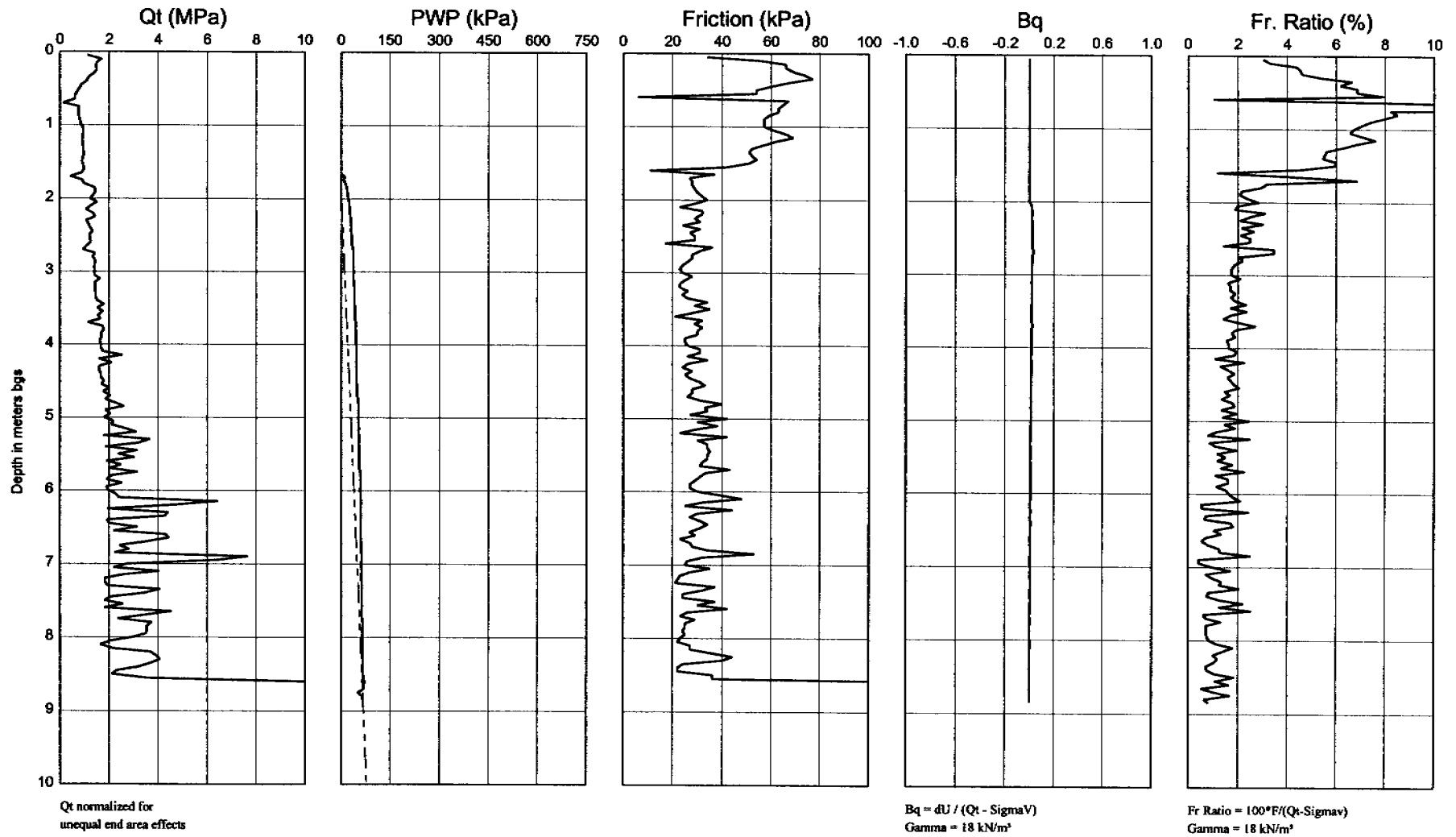
CHECKED: BVB

Cone Penetration Test - 99-4

Test Date : 99/06/24
Location : 5378273.4 N, 346549.8 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 250.03
Water Table Depth : 2.00



W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5378266.4; E 346615.2

RECORD OF BOREHOLE 99-5

BORING DATE: JUNE 28, 1999

SHEET 1 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



01145003 BHS

DATA INPUT: PS AUG 3/99

SOIL#6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp — W — Wi			
0	CME-55 POWER AUGER BORING	GROUND SURFACE	259.84								
		Topsoil	0.00								
		Silty Clay, trace rootlets and wood fragments	0.09	1	50 DO	7					
		Brown Firm (FILL)	0.61								
1				2	50 DO	8					
2				3	50 DO	4					
				4	50 DO	PH					
3											
4				5	75 TO	PH					
5											
		START OF DYNAMIC CONE PENETRATION TEST	254.46 5.18								
6											
7											
8											
9											
10											

CONTINUED ON NEXT PAGE

Open borehole dry upon completion of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BYB

O1145005 BHS

W.P. 258-96-00

RECORD OF BOREHOLE 99-5

SHEET 2 OF 3

DIST. NEW LISKEARD

BORING DATE: JUNE 28, 1999

DATUM: GEODETIC

LOCATION: N 5378266.4; E 346615.2

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○			Wp	W
10		CONTINUED FROM PREVIOUS PAGE											
11													
12													
13													
14													
15													
16													
17													
18													
19													
20		CONTINUED ON NEXT PAGE											

DATA INPUT: PS AUG 3/99

SOLM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145005 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378266.4; E 346615.2

RECORD OF BOREHOLE 99-5

BORING DATE: JUNE 28, 1999

SHEET 3 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○			Wp	W
20		CONTINUED FROM PREVIOUS PAGE											
21				238.53									
22		END OF BOREHOLE REFUSAL TO FURTHER PENETRATION CONE ADVANCE		21.11									
23													
24													
25													
26													
27													
28													
29													
30													

DATA INPUT: PS AUG.3/99

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

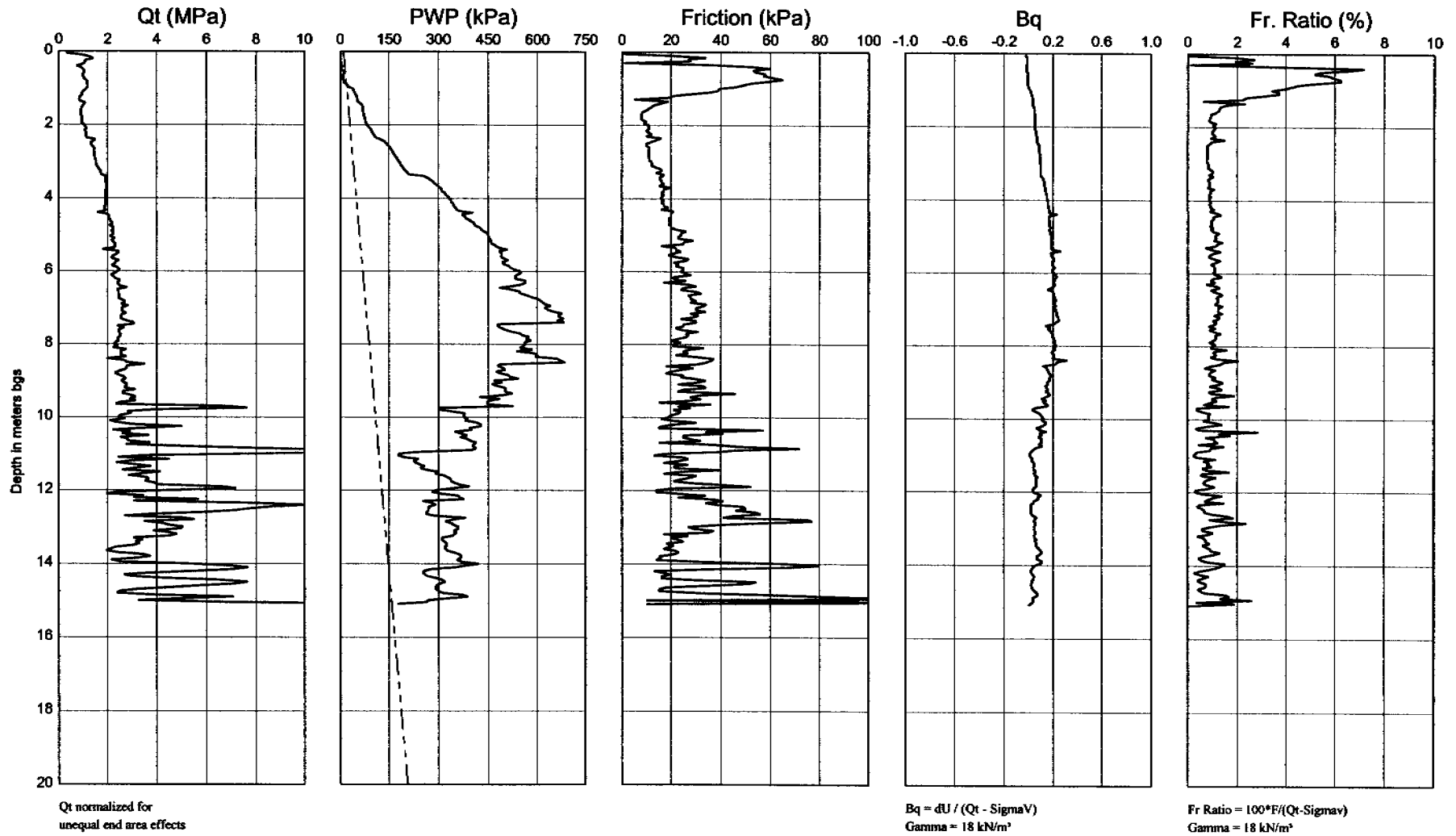
CHECKED: BVB

Cone Penetration Test - 99-6

Test Date : 99/06/24
Location : 5378262.9 N, 346644.0 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 254.55
Water Table Depth : -1.00



01145007.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378267.2; E 346565.8

RECORD OF BOREHOLE 99-7

BORING DATE: JUNE 24, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
								Cu, kPa		nat V - + Q - ● rem V - ⊕ U - ○		Wp — W — Wi					
								20	40	60	80						
								20	40	60	80						

0	CME-55 POWER AUGER BORING	GROUND SURFACE		250.22											
		Topsoil		250.09											
				0.15											
		Silty Clay Firm Brown													
1					1	75 TO	PH								
					248.82										
					1.40										
2					2	75 TO	PH								
		Interlayered silty clay/clayey silt Firm to stiff Grey													
3				3	75 TO	PH									
4															
5				4	75 TO	PH									
6															
7				5	75 TO	PH									
8		Silt, trace clay, trace sand Loose Grey		6	50 DO	5									
9															
10		END OF BOREHOLE (NO REFUSAL)		7	50 DO	4									

CONCRETE & CASING

BENTONITE SEAL

NATIVE FILL

MH
SG
C

BENTONITE SEAL

PEA GRAVEL

MH

Water level at
Elevation 250.5m
(0.4m above
ground surface)
on July 23/99.

DATA INPUT: PS AUG 3/99

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

• BORING DATE: JUNE 22, 1999

DATUM: GEODETIC

PROJECT: 991-1145

O1145008.BHS

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
				DEPTH (m)				Cu, kPa	nat V - rem V -	+ ⊕	Q - ● U - ○	Wp	W	Wi			
0	CME-55 POWER AUGER BORING	GROUND SURFACE		265.49													
		Topsoil		0.00													
				0.20	1	50 DO	5										
1		Laminated silty clay Firm to stiff Brown			2	50 DO	8										
					3	50 DO	6										
2																	
					4	50 DO	4										
3																	
4				261.79 3.70	5	50 DO	PH										
5		5mm to 10mm layers clay/clayey silt, varved Soft to firm Grey			6	50 DO	WH										
6																	
7					7	75 TO	PH										
		END OF BOREHOLE (NO REFUSAL)		258.79 6.70													
8																	
9																	
10																	

Water level at
Elevation 259.9m
in open borehole
upon completion
of drilling.

DATA INPUT: PS AUG.3/99

SOIL M5

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145009.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378313.5; E 346809.7

RECORD OF BOREHOLE 99-9

BORING DATE: JUNE 22&23, 1999

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 991-1145


 DATA INPUT: PS AUG.3.99
 SOIL#6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT
				DEPTH (m)				Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○			
0	CME-55 POWER AUGER BORING	GROUND SURFACE		268.04								
		Topsoil		0.00								
				0.15	1	50 DO	5					
1			Laminated silty clay, sandy silt seams every 5mm to 10mm Stiff to very stiff Brown		2	50 DO	7					
					3	50 DO	5	⊕		100	○	
2					4	50 DO	4	⊕		+		
3								⊕		+		
					264.34							
4					3.70	5	75 TO	PH				
5					6	50 DO	WH	⊕	+		○	
6								⊕	+			
7			5mm to 30mm layers of clay/clayey silt, varved Soft to stiff Grey		7	50 DO	WH	⊕	+		○	
									⊕	+		
8									⊕	+		
9								⊕	+			
10					8	75 TO	PH	⊕				
								⊕	+			
CONTINUED ON NEXT PAGE												

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

PROJECT: 991-1145

DATA INPUT: PS AUG.3/99

CHECKED: BVB

01145010.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378347.3; E 346877.0

RECORD OF BOREHOLE 99-10

BORING DATE: JUNE 23, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
								Cu, kPa	nat V - + rem V - ⊕	Q - ● U - ○			Wp — W — Wl
0	CME-55 POWER AUGER BORING	GROUND SURFACE		267.42									
		Topsoil		0.00									
		Silty Clay, trace sand, trace organics		0.15	1	50 DO	5						
		Firm											
		Brown/grey		266.72									
				0.70									
1			Silty Clay		2	50 DO	5						
			Firm to very stiff										
			Brown/grey										
2				265.22									
				2.20									
		Silty Clay/Clay		3	50 DO	3							
		Firm											
3		Brown to grey											
				263.76	4	50 DO	2						
				3.66									
4		END OF BOREHOLE (NO REFUSAL)											
5													
6													
7													
8													
9													
10													

Open borehole dry upon completion of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG. 3/99

SOILM6

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5378398.4; E 346964.7

RECORD OF BOREHOLE 99-11

BORING DATE: JUNE 23, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145011.BHS

DATA INPUT: PS AUG 3/99

SOILM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
				DEPTH (m)				Cu, kPa	nat V - 20	+ 40	Q - ● rem V - ⊗ 60	U - ○ 80	Wp	W			Wl
0	CME-55 POWER AUGER BORING	GROUND SURFACE		268.26													
		Topsoil		0.00													
				0.15	1	50 DO	8										
		Silty Clay, trace rootlets Firm Dark brown		267.57													
				0.69													
1					2	50 DO	8										
		Laminated Silty Clay, clayey silt seams Stiff to firm Brown			3	50 DO	7										
2																	
					4	50 DO	4										
3																	
				5	50 DO	2											
4																	
		Clay, silt seams Stiff Grey															
5				6	75 TO	PH											
		END OF BOREHOLE (NO REFUSAL)		263.08													
				5.18													
6																	
7																	
8																	
9																	
10																	

Water level at
Elevation 264.5m
in open borehole
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145012.BHS

DATA INPUT: PS AUG 3/99

SOLM6

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378432.9; E 347100.5

RECORD OF BOREHOLE 99-12

BORING DATE: JUNE 28, 1999

SHEET 1 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT DEPTH (m)	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - +	rem V - +			Wp	W
0	CME-55 POWER AUGER BORING	GROUND SURFACE		265.69									
		Topsoil		8.05									
1		Laminated Silty Clay Firm Brown			1	55 DO	6						
					2	55 DO	6						
					3	55 DO	2						
2				264.24		1.45							
		Clay Soft to firm Grey			4	55 DO	WH						
					5	75 TO	PH						
3													
4													
5		END OF BOREHOLE (NO REFUSAL)		261.27		4.42							
6													
		START DYNAMIC PENETRATION CONE TEST		259.69		6.00							
7													
8													
9													
10													

NOTE:
 Dynamic cone penetration and
 vane test results obtained from
 additional borehole advanced
 about 1m east of BH 99-12.

CONTINUED ON NEXT PAGE

 CONCRETE
 & CASING

 BENTONITE
 SEAL

 NATIVE
 BACKFILL

 BENTONITE
 SEAL

 PEA
 GRAVEL

Water level in
 piezometer at
 Elevation 264.8m
 on July 3/99
 and at
 Elevation 264.7m
 on July 23/99.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145012.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378432.9; E 347100.5

RECORD OF BOREHOLE 99-12

BORING DATE: JUNE 28, 1999

SHEET 2 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - + Cu, kPa	Q - ● rem V - ⊕ U - ○			Wp	W
10		CONTINUED FROM PREVIOUS PAGE											
11													
12													
13													
14													
15													
16													
17													
18													
19													
20		CONTINUED ON NEXT PAGE											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVV

DATA INPUT: PS AUG.3/99

SOLM6

01145012.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378432.9; E 347100.5

RECORD OF BOREHOLE 99-12

BORING DATE: JUNE 28, 1999

SHEET 3 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○			Wp	W
20		CONTINUED FROM PREVIOUS PAGE											
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													

238.11
27.58

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG.3/99

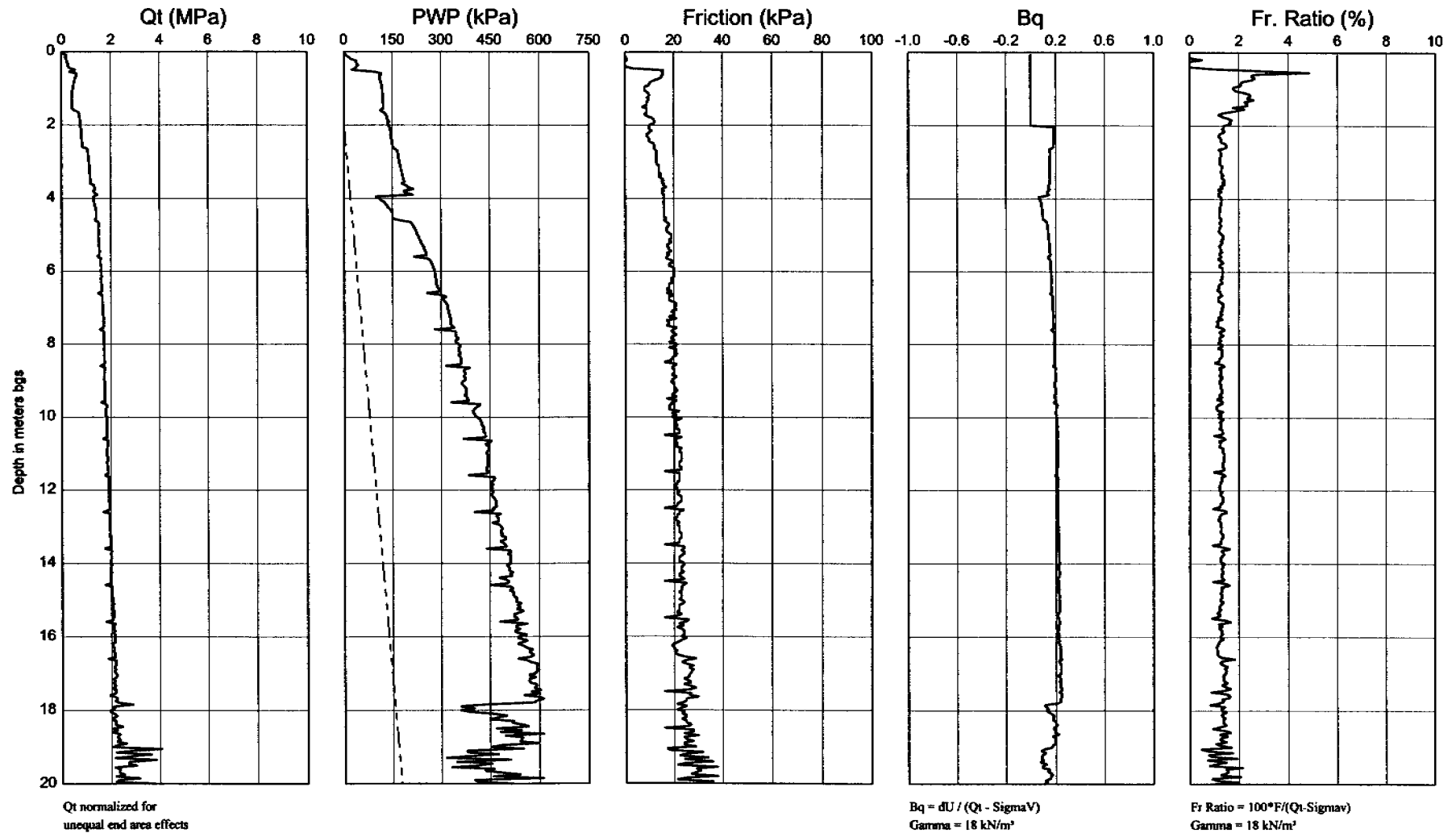
SOLM6

Cone Penetration Test - 99-13

Test Date : 99/06/25
Location : 5378436.9 N, 347164.2 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 265.68
Water Table Depth : 2.00

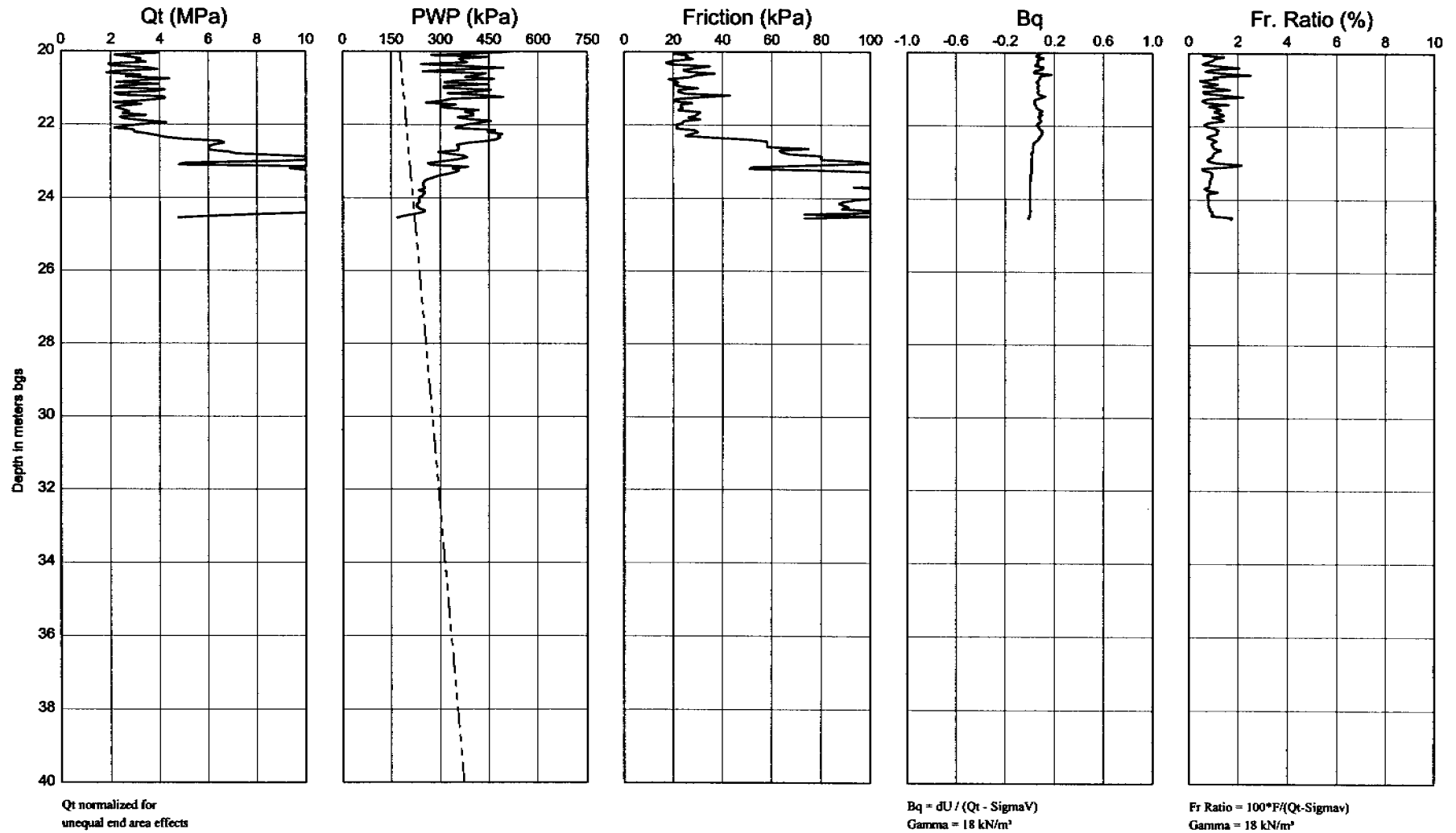


Cone Penetration Test - 99-13

Test Date : 99/06/25
Location : 5378436.9 N, 347164.2 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 265.68
Water Table Depth : 2.00



01145015.BHS

BORING DATE: JUNE 28, 1999

DATUM: GEODETIC

DATA INPUT: PS AUG.3/99

SOIL M6

Golder Associates

CHECKED: BVB

01145016 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378231.2; E 347613.5

RECORD OF BOREHOLE 99-16

BORING DATE: JUNE 28, 1999

SHEET 1 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
								Cu, kPa		nat V - + rem V - ⊕		O - ● U - ○				Wp — W — Wi	
							20	40	60	80							
							20	40	60	80							

0	CME-55 POWER AUGER BORING	GROUND SURFACE	274.43												
		Topsoil	0.00												
		Peat Black	0.12	1	50 DO	1									
1				2	50 DO	WH									
			273.21 1.22												
2		10mm to 25mm layers clay/silty clay, varved Very stiff to soft Grey		3	50 DO	5	⊕				100	○		MH	
				4	50 DO	2	⊕			+					
3				5	50 DO	WH	⊕			+		○			
4				6	75 TO	PH	⊕			+					
							⊕			+					
5			269.40 5.03				⊕			+					
		END OF BOREHOLE (NO REFUSAL)													Water level at Elevation 272.4m in open borehole upon completion of drilling.
6		START OF DYNAMIC PENETRATION CONE TEST	268.33 6.10				⊕		+						
7							⊕		+						
8		NOTE: Vane and Dynamic Cone Penetration test obtained from additional borehole advanced about 1m west of BH 99-16.													
9															
10		CONTINUED ON NEXT PAGE													

DATA INPUT: PS AUG.3/99

SOIL#6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145016.BHS

W.P. 258-96-00

RECORD OF BOREHOLE 99-16

SHEET 2 OF 3

DIST. NEW LISKEARD

BORING DATE: JUNE 28, 1999

DATUM: GEODETIC

LOCATION: N 5378231.2; E 347613.5

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - Cu, kPa	+ rem V - U - O			Q - ● U - O	Wp
10		CONTINUED FROM PREVIOUS PAGE											
11													
12													
13													
14													
15													
16													
17													
18													
19													
20		CONTINUED ON NEXT PAGE											

DATA INPUT: PS AUG 3/99

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145016 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378231.2; E 347613.5

RECORD OF BOREHOLE 99-16

BORING DATE: JUNE 28, 1999

SHEET 3 OF 3

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	rem V - + Q - ● ⊗ U - ○			Wp	W
20		CONTINUED FROM PREVIOUS PAGE											
21													
22													
23													
24													
25													
26													
27		END OF DYNAMIC CONE TEST REFUSAL TO FURTHER PENETRATION		248.03 28.40									
28													
29													
30													

DATA INPUT: PS AUG 3/99

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

W.P. 258-96-00

RECORD OF BOREHOLE 99-17

SHEET 1 OF 1

DIST. NEW LISKEARD

BORING DATE: JUNE 28, 1999

DATUM: GEODETIC

LOCATION: N 5378179.6; E 347641.6

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat V - + rem V - ⊕ 20 40 60 80			U - ● U - ○ 20 40 60 80	Wp
0	CME-55 POWER AUGER BORING	GROUND SURFACE		278.44									
		Topsoil		0.00									
		Silty Clay, trace rootlets Firm Reddish brown		0.12	1	50	6						
				275.74									
1		Interlayered silty clay/silt Firm to stiff Brown		0.70	2	50	6						
2					3	50	5						
3					4	50	PH						
4		END OF BOREHOLE (NO REFUSAL)		272.78									
				3.66									
5													
6													
7													
8													
9													
10													

Open borehole dry
upon completion
of drilling.

DEPTH SCALE

LOGGED: MSB

1 to 50

Golder Associates

CHECKED: BVB

01145017 BHS

DATA INPUT: PS AUG.3/99

SOILM6

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5378139.8; E 347696.6

RECORD OF BOREHOLE 99-18

BORING DATE: JUNE 17, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145018.BHS

DATA INPUT: PS AUG-3-99

SOIL M6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	rem V - U - O	Wp			W
0	CME-55 POWER AUGER BORING	GROUND SURFACE		278.49								
		Topsoil		0.00								
		Silty Clay, trace organics, sandy silt seams		0.12	1	50 DO	3					
		Firm Brown		277.79								
				0.70								
1			10mm to 15mm silty clay layers, 5mm to 10mm silt layers, varved Firm to stiff Brown to grey		2	50 DO	7					
					3	75 TO	6					
2					4	50 DO	5					
3					5	50 DO	PH					
4												
4		END OF BOREHOLE (NO REFUSAL)		274.22								
				4.27								
5												
6												
7												
8												
9												
10												

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

Open borehole dry
upon completion
of drilling.

DIST. NEW LISKEARD

BORING DATE: JUNE 27, 1999

DATUM: GEODETIC

PROJECT: 991-1145

[illegible]

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

O1145020.BHS

DATA INPUT: PS AUG.3/99

SOIL M6

W.P.: 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377922.8; E 347897.5

RECORD OF BOREHOLE 99-20

BORING DATE: JUNE 26, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat V - + rem V - ⊕			Q - ● U - ○	Wp
0	CME-55 POWER AUGER BORING	GROUND SURFACE		285.80									
		Topsoil		0.00									
				0.21	1	55 DO	7						
1		Silty Clay, silt seams every 10mm to 20mm Firm to stiff Brown			2	55 DO	6						
2													
3		Clay Firm Grey		262.90 2.90									
4		END OF BOREHOLE (NO REFUSAL)		262.14 3.66									
5													
6													
7													
8													
9													
10													

Open borehole dry
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

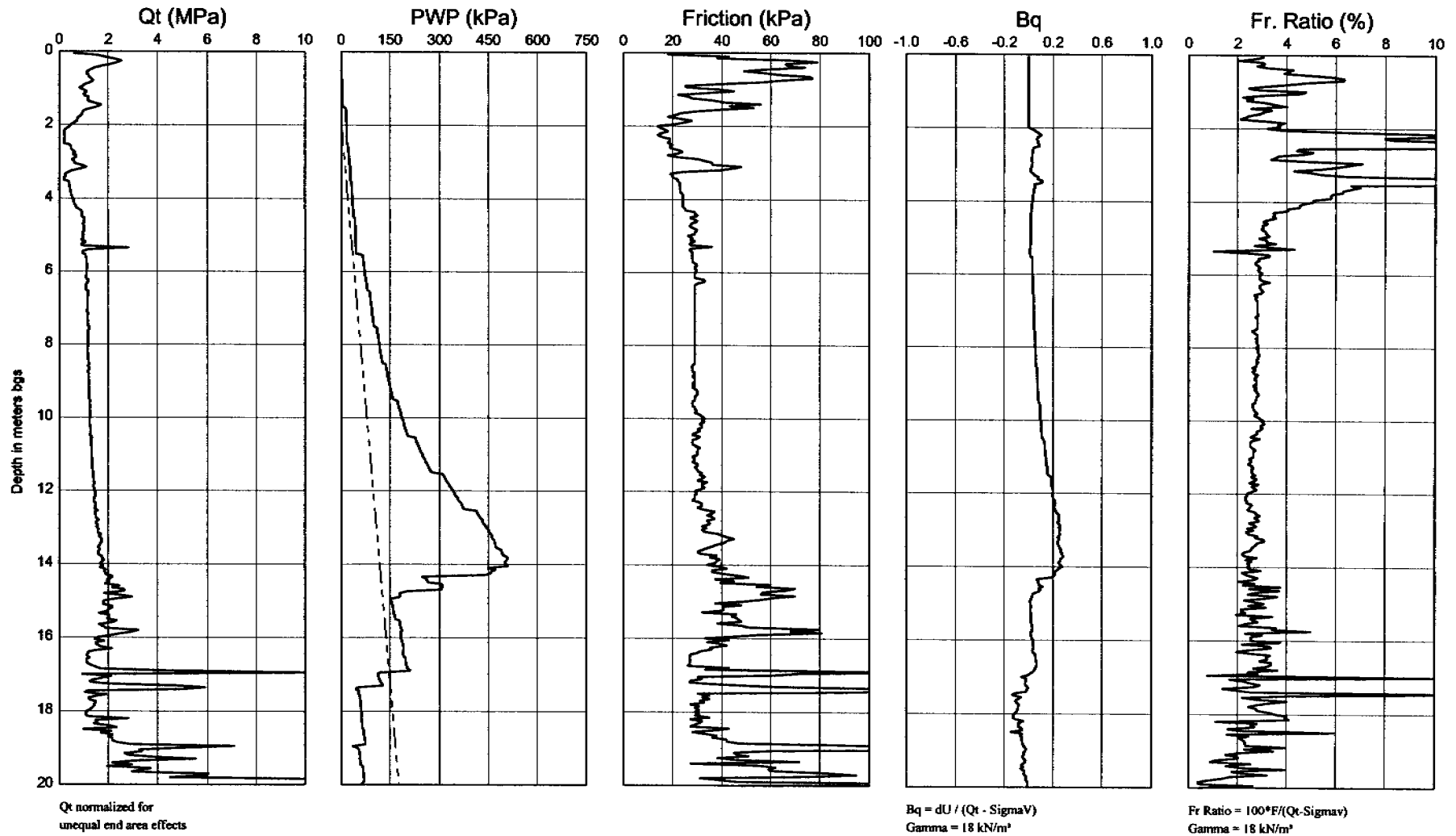
CHECKED: BVB

Cone Penetration Test - 99-21

Test Date : 99/06/25
Location : 5377900.5 N, 347946.7 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 263.26
Water Table Depth : 2.00

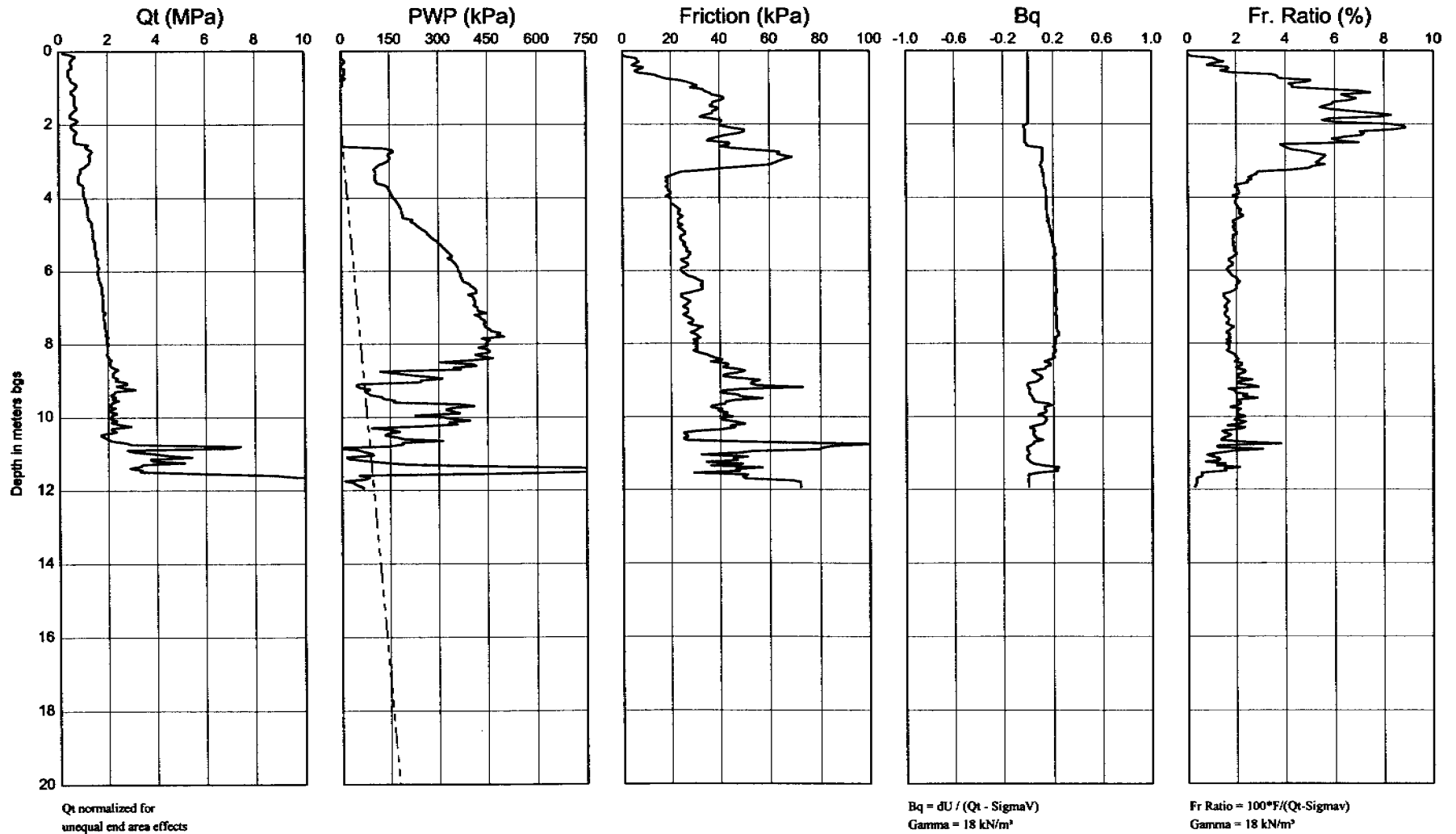


Cone Penetration Test - 99-22

Test Date : 99/06/25
Location : 5377890.2 N, 347982.4 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 257.07
Water Table Depth : 2.00



01145023.BHS

DATA INPUT: PS AUG.4/99

CHECKED: BVB

01145023 BHS

DATA INPUT: PS AUG. 4/99

SOLM6

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377885.2; E 348062.6

RECORD OF BOREHOLE 99-23

BORING DATE: JULY 1, 1999

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT					
								CU, kPa	rem V -	nat V -	Wp	W	Wi		
10		CONTINUED FROM PREVIOUS PAGE													
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															

END OF BOREHOLE
 REFUSAL TO FURTHER
 DYNAMIC CONE
 ADVANCE
 PROBABLE BEDROCK

246.22
 18.59

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

0115024 BHS

DATA INPUT: PS AUG 4/99

SOLM6

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377892.4; E 347995.5

RECORD OF BOREHOLE 99-24

BORING DATE: JUNE 25&26, 1999

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH						WATER CONTENT, PERCENT	
								Cu, kPa	20	40	60			80	nat V - + rem V - ⊕ U - ○
0	CME-55 POWER AUGER BORING	GROUND SURFACE		257.20									<div>CONCRETE & CASING</div> <div>BENTONITE SEAL</div> <div>NATIVE BACKFILL</div> <div>BENTONITE SEAL</div> <div>PEA GRAVEL</div> <div>Water level in piezometer at Elevation 257.4m on July 3/99 and at Elevation 257.3m on July 23/99.</div>		
		Topsoil		0.00 0.08											
1		Silty Clay, trace to some organics Firm to stiff Dark brown		1	75 TO	PH					10			OC	
2				2	75 TO	PH									
3														MH SG C	
4		15mm to 25mm layers clay, 5mm to 10mm layers silt/clayey silt/ silty clay, varved Firm to stiff Grey		3	75 TO	PH									
5					4	75 TO	PH					40			
6														CIU	
7				5	75 TO	PH									
8														MH SG C	
9			6	75 TO	PH					40					
10	DYNAMIC CONE	START OF DYNAMIC CONE @ 9.14m DEPTH.		248.06 9.14											
		CONTINUED ON NEXT PAGE													

Water level in
 piezometer at
 Elevation 257.4m
 on July 3/99
 and at
 Elevation 257.3m
 on July 23/99.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145024 BHS

W.P. 258-98-00
 DIST. NEW LISKEARD
 LOCATION: N 5377892.4; E 347995.5

RECORD OF BOREHOLE 99-24

BORING DATE: JUNE 25&26, 1999

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								20	40			60	80
10	DYNAMIC CONE	CONTINUED FROM PREVIOUS PAGE											
11													
12													
13													
14													
15													
16													
17													
18													
19													
20		END OF BOREHOLE REFUSAL TO FURTHER DYNAMIC CONE ADVANCE		241.88 15.32									

DATA INPUT: PS AUG 4/99

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145025.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377885.5; E 348138.8

RECORD OF BOREHOLE 99-25

BORING DATE: JULY 1, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat V - + rem V - ⊕			Q - ● U - ○	Wp
0	CME-55 POWER AUGER BORING	GROUND SURFACE		266.88 0.00									
		Topsoil Black		266.27 0.61	1	50 DO	8						
1		Silty Clay Firm to stiff Brown			2	50 DO	4						
2					3	50 DO	3						
3				263.98 2.90									
		silt layer		263.38 3.50	4	75 TO	PH						
				3.66									
4		15mm to 25mm layers clay/silty clay, varved Firm Grey											
5													
			261.55 5.33										
	END OF BOREHOLE (NO REFUSAL)												
6													
7													
8													
9													
10													

Open borehole dry
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG 4/99

SOL M6

01145026.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377867.3; E 348188.8

RECORD OF BOREHOLE 99-26

BORING DATE: JULY 1, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
								Cu, kPa		c, kPa		Wp		W			
								20	40	60	80	20	40	60	80		
0	CME-55 POWER AUGER BORING	GROUND SURFACE		268.15													
		Topsoil		0.00													
		Silty Clay, trace rootlets Stiff Brown		0.13	1	50 DO	3										
1		Clayey Silt, trace sand Stiff Brown		267.33 0.82	2	50 DO	5										
				266.63 1.52													
2		Clay/silty clay, varved Stiff to firm Brown			3	50 DO	2										MH
3																	
4		END OF BOREHOLE (NO REFUSAL)		264.34 3.81													Open borehole dry upon completion of drilling.
5																	
6																	
7																	
8																	
9																	
10																	

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG 4/99

SOIL M6

Open borehole dry
upon completion
of drilling.

01145027 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377896.0; E 349269.4

RECORD OF BOREHOLE 99-27

BORING DATE: JULY 1, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	20	40	60	80			20
0	CME-55 POWER AUGER BORING	GROUND SURFACE	273.71									
		Topsoil	0.00									
			0.20	1	50 DO	6						
1		Silty Clay Stiff Brown		2	50 DO	7						
			272.01									
2		1.70										
		5mm to 10mm layers of silty clay with 1mm to 3mm layers of silt, varved Stiff to firm Brown		3	75 TO PH							
3												
4		END OF BOREHOLE (NO REFUSAL)	270.05									
			3.66									
5												
6												
7												
8												
9												
10												

Water level at
Elevation 270.8m
in open borehole
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG. 4/99

SOLW6

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5377876.3; E 349339.1

RECORD OF BOREHOLE 99-28

BORING DATE: JULY 1, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145028 BHS

DATA INPUT: PS AUG 4/99

SOIL M6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							nat V - Cu, kPa	rem V - U - O	Wp			W
0	CME-55 POWER AUGER BORING	GROUND SURFACE		273.80								
		Topsoil		0.00	1	50 DO	3					
1		Silty Clay with sandy silt seams every 5mm to 12mm Firm to stiff Brown			2	50 DO	5					
2												
2			271.60	2.00	3	50 DO	2					
3	5mm to 10mm layers of clay with 2mm layers of silty clay, varved Stiff Brown to grey											
4				4	75 TO	PH						
5												
5		268.42	5.18									
		END OF BOREHOLE (NO REFUSAL)										
6												
7												
8												
9												
10												

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

Open borehole dry
upon completion
of drilling.

01145029 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377898.1; E 349419.6

RECORD OF BOREHOLE 99-29

BORING DATE: JULY 1, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT
				DEPTH (m)				Cu, kPa	nat V - + Q - ● rem V - ⊗ U - ○			
0	CME-55 POWER AUGER BORING	GROUND SURFACE		269.77								
		Topsoil		0.00								
		Silty Clay, trace rootlets Firm Brown		0.08	1	50 DO	5					
1				269.07								
		Silty Clay/ Clayey Silt, varved Firm to stiff Brown		0.70	2	50 DO	4					
2				267.27								
				2.50	3	75 TO	PH					
3												
4		Clay/Silty Clay, varved Firm Grey										
5												
		END OF BOREHOLE (NO REFUSAL)		264.44								
				5.33								
6												
7												
8												
9												
10												

Water level at
Elevation 267.0m
in open borehole
upon completion
of drilling.

Water level at
 Elevation 267.0m
 in open borehole
 upon completion
 of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG. 4/99

SOILM6

01145030 BHS

DATA INPUT: PS JULY 12/99

SOLM6

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377888.4; E 350186.6

RECORD OF BOREHOLE 99-30

BORING DATE: JULY 2, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	20	40	60	80			20
0	CME-55 POWER AUGER BORING	GROUND SURFACE	265.50									
		Topsoil	0.00 0.09	1	50 DO	8						
1		Sand and gravel to sand Loose Brown (FILL)		2	50 DO	7						
2			263.67 1.83	3	50 DO	4						
3		15mm to 20mm layers clay with 10mm layers clayey silt, varved Stiff to firm Brown		4	75 TO	PH						
4												
5		END OF BOREHOLE (NO REFUSAL)	261.08 4.42									
6												
7												
8												
9												
10												

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVV

Water level at
Elevation 262.6m
in open borehole
upon completion
of drilling.

01145031.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377910.6; E 350277.8

RECORD OF BOREHOLE 99-31

BORING DATE: JULY 2, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								20	40			60	80
0	CME-55 POWER AUGER BORING	GROUND SURFACE		267.49									
		Topsoil		0.00									
				267.19									
		Silty Clay		0.30	1	50 DO	3						
		Soft to firm											
		Brown		266.80									
				0.69									
1					2	50 DO	3						
2			15mm to 20mm layers clay with 5mm to 10mm layers clayey silt, varved					⊕	+				
			Soft to firm					⊕	+				
		Brown											
3				3	75 TO PH		⊕	+					
4		END OF BOREHOLE (NO REFUSAL)		263.83			⊕	+					
				3.66									
5													
6													
7													
8													
9													
10													

Open borehole dry upon completion of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG. 4/99

SOLM6

01145032 BHS

DATA INPUT: PS AUG-4/99

SOLM6

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377896.4; E 351290.9

RECORD OF BOREHOLE 99-32

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	20 40 60 80	20 40 60 80	20 40 60 80		
0	CME-55 POWER AUGER BORING	GROUND SURFACE	291.13								
		Topsoil	0.00								
		Silty Clay, trace rootlets	0.13	1	50 DO	3					
		Firm	290.53								
		Brown	0.60								
1		5mm to 10mm layers of silty clay with 2mm to 5mm layers of clayey silt, varved Stiff to very stiff Brown		2	50 DO	6					
				3	50 DO	7					
2		Silty Sand, trace gravel, trace clay Compact Brown									
				4	50 DO	14					
3			287.93								
			3.20								
4		END OF BOREHOLE (REFUSAL)	287.32								
			3.81								
5											
6											
7											
8											
9											
10											

Open borehole dry
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377896.0; E 351453.7

RECORD OF BOREHOLE 99-33

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145033.BHS

DATA INPUT: PS AUG. 4/99

SOILM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH						WATER CONTENT, PERCENT	
				DEPTH (m)				Cu, kPa	nat V - rem V -	+ ⊕	Q - ● U - ○			Wp	W
0	CME-55 POWER AUGER BORING	GROUND SURFACE		293.07											
		Topsoil		0.00											
				0.15	1	50 DO	6								
1		10mm layers of silty clay with 5mm layers of silt, varved Stiff Brown			2	50 DO	9								
2					3	50 DO	7								
		Clayey Silt Stiff Brown		290.94											
				2.13											
				290.33	4	50 DO	9								
				2.74											
3	Silty fine sand, trace gravel, trace clay Compact Brown			5	50 DO	12									
4	END OF BOREHOLE REFUSAL TO FURTHER AUGER ADVANCE PROBABLE BEDROCK		289.26												
			3.81												
5															
6															
7															
8															
9															
10															

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

Water level at
Elevation 290.5m
in open borehole
upon completion
of drilling.

01145034.BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377873.6; E 351273.9

RECORD OF BOREHOLE 99-34

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT					
								Cu, kPa	net V - rem V -	+ ⊕	Q - ● U - ○	Wp	W		
0	CME-55 POWER AUGER BORING	GROUND SURFACE		290.24											
		Topsoil		0.00											
				289.99											
				0.25	1	50 DO	9								
1					2	50 DO	8								
2			10mm to 20mm layers silty clay with 1mm to 5mm layers silt, varved Stiff to firm Brown		3	50 DO	6								
					4	50 DO	4								
3															
4					5	50 DO	3								
5				6	50 DO	PH									
6															
7		Silty Clay Stiff to firm Grey		7	50 DO	2									
8				8	50 DO	5									
9		Probable sand and gravel													
10		END OF BOREHOLE REFUSAL TO FURTHER AUGER ADVANCE PROBABLE BEDROCK													

DATA INPUT: PS AUG.4/93

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

DATA INPUT: PS AUG. 4/99

SOIL M6

Water level at
 Elevation 282.8m
 in open borehole
 upon completion
 of drilling.

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5378035.6; E 352230.4

RECORD OF BOREHOLE 99-35

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145035 BHS

DATA INPUT: PS JULY 13/99

SOILM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT					
								20 40 60 80	20 40 60 80	20 40 60 80	20 40 60 80				
0	CMESS POWER AUGER BORING	GROUND SURFACE		290.44											
		Topsoil		0.00											
				0.20	1	50 DO	13								
1					2	50 DO	53								
					3	50 DO	34								
2		Sandy Silt Compact to very dense Light brown		288.24 2.20										MH	
					4	50 DO	29							MH	
3		Silty fine sand Compact Light brown													
					5	50 DO	19								
4		END OF BOREHOLE (NO REFUSAL)		286.78 3.68											Open borehole dry upon completion of drilling.
5															
6															
7															
8															
9															
10															

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145036 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378061.6; E 352264.2

RECORD OF BOREHOLE 99-36

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
								Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	Wp			W
0	CME-55 POWER AUGER BORING	GROUND SURFACE		288.48									
		Topsoil		0.00									
				0.12	1	SO	2						
1		Silty Sand, trace to some silt Very loose to loose Brown			2	SO	9						
					3	SO	6						
2				288.35									
				2.13	4	SO	9						
3		Sandy Silt Loose to compact Red			5	SO	13						
				284.82									
				3.68									
4		END OF BOREHOLE (NO REFUSAL)											
5													
6													
7													
8													
9													
10													

CONCRETE
& CASINGBENTONITE
SEALNATIVE
FILLBENTONITE
SEALPEA
GRAVEL

MH

Water level in
piezometer at
Elevation 285.5m
on July 3/88 and
piezometer dry
on July 23/99.

DATA INPUT: PS AUG 4/99

SOILMS

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

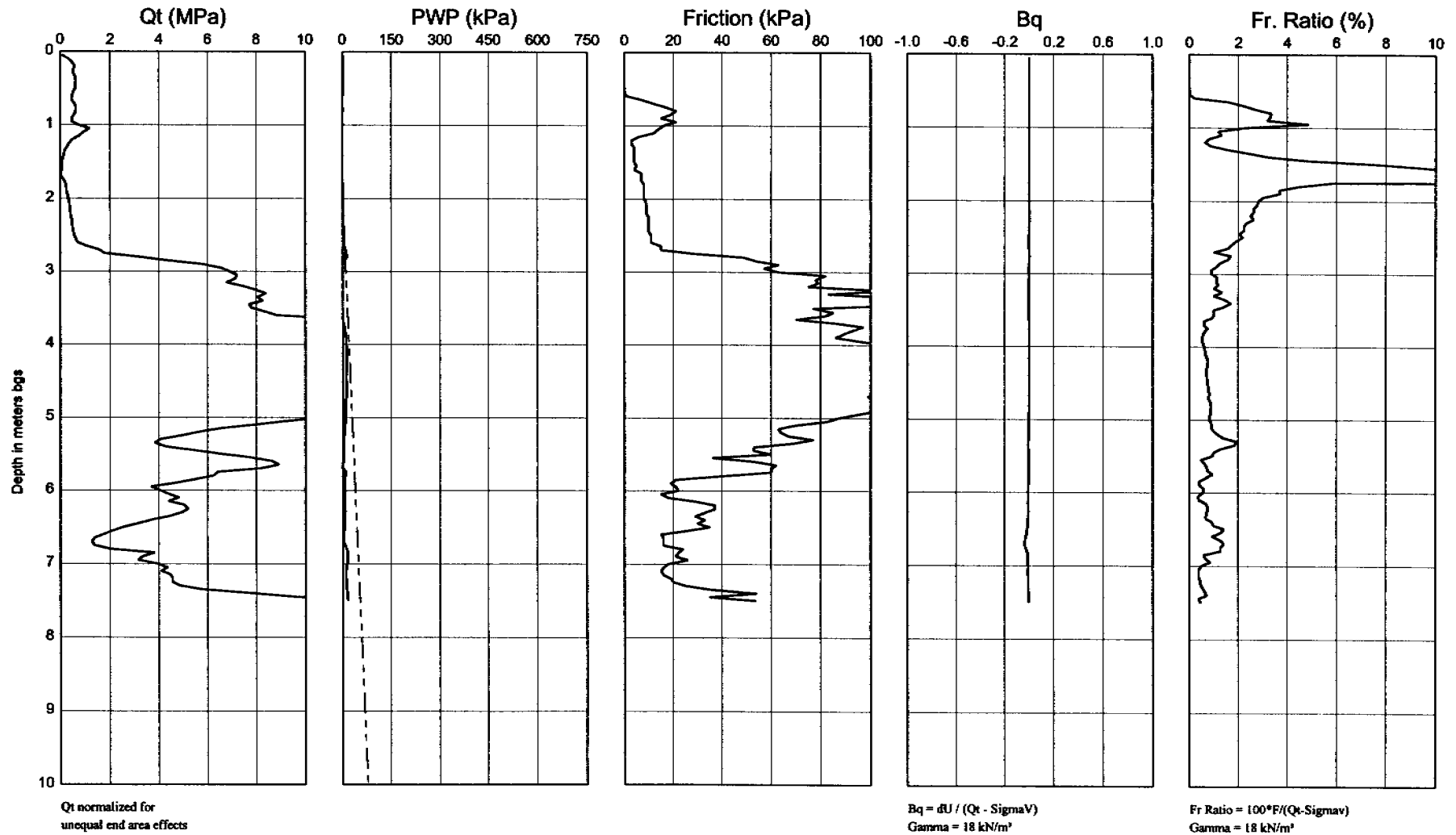
CHECKED: BVB

Cone Penetration Test - 99-37

Test Date : 99/06/25
Location : 5378076.1 N, 352304.4 E

Operator : GOLDER ASSOCIATES

Ground Surf. Elev. : 286.09
Water Table Depth : 2.00



W.P. 258-96-00
DIST. NEW LISKEARD

RECORD OF BOREHOLE 99-38

BORING DATE: JUNE 29, 1999

SHEET 1 OF 1

DATUM: GEODETIC



LOCATION: N 5378104.4; E 352345.9

PROJECT: 991-1145

01145038 BHS

DATA INPUT: PS JULY 13/99

SOILM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	Wp			W
0	CME-55 POWER AUGER BORING	GROUND SURFACE		287.48								
		Topsoil		8.89	1	50 DO	11					
1		Fine to coarse Sand, trace silt Loose to compact Brown			2	50 DO	18					
2				3	50 DO	8						
				4	50 DO	9						
3			5	50 DO	9							
4		END OF BOREHOLE (NO REFUSAL)		283.80 3.66								
5												
6												
7												
8												
9												
10												

Open borehole dry
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145039 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5378121.8; E 352379.4

RECORD OF BOREHOLE 99-39

BORING DATE: JUNE 29, 1999

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	U, kPa	Wp			W
0	CME-55 POWER AUGER BORING	GROUND SURFACE	287.93									
		Topsoil	0.00									
		Fine Sand, some silt, trace gravel Loose to very loose Brown (FILL)	0.08	1	50 DO	8						
1				2	50 DO	2						
		Peat Black	1.37									
			286.56									
			286.10									
2		Fine Sand, trace to some silt Very loose Brown	1.83	3	50 DO	2						
			285.64									
			2.29									
				4	50 DO	WH						
3												
				5	75 TO	PH						
		10mm to 20mm layers silty clay/ silt, varved Soft to firm Grey										
4												
5												
			282.60									
			5.33									
6	DYNAMIC CONE	START OF DYNAMIC CONE PENETRATION TEST										
7												
8												
9												
10												
		CONTINUED ON NEXT PAGE										

Open borehole dry
upon completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVV

DATA INPUT: PS AUG. 4/99

SOLM8

01145039.BHS
DATA INPUT: PS AUG 4/99
SOL16

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5378121.8; E 352379.4

RECORD OF BOREHOLE 99-39

BORING DATE: JUNE 29, 1999

SHEET 2 OF 2

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	nat V - + Q - ● rem V - ⊗ U - ○	Wp			W
10		CONTINUED FROM PREVIOUS PAGE										
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
		END OF BOREHOLE REFUSAL TO FURTHER DYNAMIC CONE ADVANCE PROBABLE BEDROCK										

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BV8

W.P. 258-96-00

DIST. NEW LISKEARD

LOCATION: N 5377899.2; E 351429.6

RECORD OF BOREHOLE 99-40

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



O1145040 BHS

DATA INPUT: PS JULY 8/99

SOIL M6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
							Cu, kPa		rem V -		Wp		Wi			
0	CME-55 POWER AUGER BORING	GROUND SURFACE	293.44													
		Sand and Gravel	0.00													
1			292.22													
2		END OF AUGER PROBE (REFUSAL)	1.22													
3																
4																
5																
6																
7																
8																
9																
10																

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145041 LBHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377901.1; E 351369.9

RECORD OF BOREHOLE 99-41

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							20 40 60 80	20 40 60 80	Wp W Wi			
0	CME-55 POWER AUGER BORING	GROUND SURFACE	296.24									
		Sand and Gravel	0.00									
1		END OF AUGER PROBE (REFUSAL)	295.48									
2												
3												
4												
5												
6												
7												
8												
9												
10												

DATA INPUT: PS JULY 8/99

SOIL M6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

W.P. 258-96-00
DIST. NEW LISKEARD
LOCATION: N 5377901.0; E 351344.1

RECORD OF BOREHOLE 99-42

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



01145042 BHS

DATA INPUT: PS JULY 8/99

SOILM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT
								CU, kPa	Wp			
0	CME-53 POWER AUGER BORING	GROUND SURFACE		295.57								
		Sand and Gravel		0.00								
1		END OF AUGER PROBE (REFUSAL)		294.81								
				0.76								
2												
3												
4												
5												
6												
7												
8												
9												
10												

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

01145043 BHS

W.P. 258-96-00
 DIST. NEW LISKEARD
 LOCATION: N 5377900.6; E 351313.7

RECORD OF BOREHOLE 99-43

BORING DATE: JUNE 30, 1999

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 991-1145



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	rem V - \oplus U - \circ	Wp			W
0	CME-55 POWER AUGER BORING	GROUND SURFACE	293.93									
		Sand and Gravel	0.00									
1		END OF AUGER PROBE (REFUSAL)	293.02									
2												
3												
4												
5												
6												
7												
8												
9												
10												

DATA INPUT: PS JULY 6/99

SOLM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: MSB

CHECKED: BVB

TABLE 1
Summary of Areas and Field Investigation Program
Highway 101 (W.P. 258-96-00)

Area	Proposed Construction	Identification	Approximate Station	Township	Northing (MTM Zone 12)	Easting (MTM Zone 12)	Ground Elevation (m)	Depth of Borehole (m)
1	Cut excavation up to 5 m.	BH99- 1	12+840	Carr	5378270.6	346363.8	263.19	5.2
		BH99- 2	12+875	Carr	5378251.3	346399.8	263.38	8.2
2	Fill embankment up to 11 m.	BH99- 3	12+970	Carr	5378265.8	346443.4	262.58	5.2
		CPT99- 4	13+020	Carr	5378273.4	346549.8	250.03	8.7
		BH99- 5	13+090	Carr	5378266.4	346615.2	259.64	5.2
		CPT99- 6	13+120	Carr	5378262.9	346644	254.55	15.1
		BH99- 7	13+040	Carr	5378267.2	346565.8	250.22	9.8
3	Cut excavation up to 7 m.	BH99- 8	13+210	Carr	5378282.7	346732.2	265.49	6.7
		BH99- 9	13+293	Carr	5378313.5	346809.7	268.04	11.3
		BH99- 10	13+370	Carr	5378347.3	346877	267.42	3.7
		BH99- 11	13+470	Carr	5378398.4	346964.7	268.26	5.2
4	Fill embankment up to 5 m.	BH99- 12	13+620	Carr	5378432.9	347100.5	265.69	4.4
		CPT99- 13	13+650	Carr	5378436.9	347164.2	265.68	24.5
5	Fill embankment up to 3.5 m.	BH99- 14	14+090	Carr	5378272.7	347554.9	274.9	3.5
		BH99- 15	14+120	Carr	5378255.9	347579.8	274.35	3.7
		BH99- 16	14+160	Carr	5378231.2	347613.5	274.43	5.0
		BH99- 17	14+220	Carr	5378179.6	347641.6	276.44	3.7
6	Cut excavation up to 4 m.	BH99- 18	14+280	Carr	5378139.8	347696.6	278.49	4.3
		BH99- 19	10+010	Beatty	5378109	347714.9	279.32	6.7
7	Fill embankment up to 11 m.	BH99- 20	10+270	Beatty	5377922.8	347897.5	265.8	3.7
		CPT99- 21	10+320	Beatty	5377900.5	347946.7	263.26	20.1
		CPT99- 22	10+370	Beatty	5377890.2	347982.4	257.07	12.0
		BH99- 23	10+440	Beatty	5377885.2	348062.6	264.81	5.3
		BH99- 24	10+380	Beatty	5377892.4	347995.5	257.2	9.1
8	Cut excavation up to 3 m.	BH99- 25	10+520	Beatty	5377885.5	348138.8	266.88	5.5
		BH99- 26	10+570	Beatty	5377867.3	348188.8	268.15	3.8
9	Cut excavation up to 3 m.	BH99- 27	11+650	Beatty	5377896	349269.4	273.71	3.7
		BH99- 28	11+720	Beatty	5377876.3	349339.1	273.6	5.2
		BH99- 29	11+800	Beatty	5377898.1	349419.6	269.77	3.7
10	Fill embankment up to 2 m.	BH99- 30	12+570	Beatty	5377888.4	350186.6	265.5	4.4
		BH99- 31	12+640	Beatty	5377910.6	350277.8	267.49	3.7
11	Cut excavation up to 6 m.	BH99- 32	13+670	Beatty	5377896.4	351290.9	291.13	3.8
		BH99- 43	13+694	Beatty	5377900.6	351313.7	293.93	0.9
		BH99- 42	13+725	Beatty	5377901	351344.1	295.57	0.8
		BH99- 41	13+750	Beatty	5377901.1	351369.9	296.24	0.8
		BH99- 40	13+810	Beatty	5377899.2	351429.6	293.44	1.2
		BH99- 33	13+830	Beatty	5377896	351453.7	293.07	3.8
		BH99- 34	near house	Beatty	5377873.6	351273.9	290.24	9.6
12	Fill embankment up to 5 m.	BH99- 35	14+625	Beatty	5378035.6	352230.4	290.44	3.7
		BH99- 36	14+660	Beatty	5378061.6	352264.2	288.48	3.7
		CPT99- 37	14+710	Beatty	5378076.1	352304.4	286.09	7.5
		BH99- 38	14+760	Beatty	5378104.4	352345.9	287.46	3.7
		BH99- 39	14+810	Beatty	5378121.8	352379.4	287.93	5.3

TABLE 2
Summary of Laboratory Tests
Highway 101 (W.P. 258-96-00)

AREA	Description	Borehole No.	Sample No.	Soil Description	Water Content	Atterberg Limits	Grain Size	Specific Gravity	Other Tests
1	CUT 5 m	99-1	2	laminated brown silty clay	x				
			5	grey clay	x				
		99-2	2	laminated brown silty clay	x				
			3	laminated brown silty clay	x				
			4	laminated brown silty clay	x				
			5	grey silty clay	x				
			6	grey silty clay	x				
			7	grey clay	x	x	x		
			8	grey clay	x				
2	FILL 11 m	99-3	3	brown silty clay	x				
			4	brown silty clay	x				
		99-5	2	brown silty clay	x				
		99-7	4	interlayered grey clay/silt	x	x	x	x	1 consolidation
			4	interlayered grey clay/silt	x	x	x	x	
			6	grey silt	x				
			7	grey silt	x		x		
3	CUT 7 m	99-8	3	laminated brown silty clay	x				
			6	varved grey clay/clayey silt	x				
		99-9	3	laminated brown silty clay	x				
			6	varved grey clay/clayey silt	x				
			7	varved grey clay/clayey silt	x				
			9	varved grey clay/clayey silt	x				
		99-10	1	grey silty clay	x				
			2	brown/gray silty clay	x	x	x		
			3	grey silty clay to clay	x				
			4	grey silty clay to clay	x				
		99-11	2	laminated brown silty clay	x				
			5	laminated brown silty clay	x				
4	FILL 5 m	99-12	1	laminated brown silty clay	x				
			2	laminated brown silty clay	x				
			3	grey clay	x	x	x		
			4	grey clay	x				

TABLE 2
Summary of Laboratory Tests
Highway 101 (W.P. 258-96-00)

AREA	Description	Borehole No.	Sample No.	Soil Description	Water Content	Atterberg Limits	Grain Size	Specific Gravity	Other Tests
5	FILL 3.5 m	99-14	2	varved grey clay/silt	x				
			3	varved grey clay/silt	x				
		99-15	2	varved grey clay/clayey silt	x				
			4	varved grey clay/clayey silt	x				
		99-16	3	varved grey clay/silty clay	x	x	x		
			5	varved grey clay/silty clay	x				
		99-17	1	brown silty clay	x				
			2	interlayered grey silty clay/silt	x				
			3	interlayered grey silty clay/silt	x				
6	CUT 4 m	99-18	2	varved grey clay/silty clay	x				
			4	varved grey clay/silty clay	x				
		99-19	1	brown silty clay to clay	x				
			2	brown silty clay to clay	x	x	x		
			3	brown silty clay	x				
			4	brown silty clay	x				
7	FILL 11 m	99-20	2	brown silty clay	x				
			4	grey clay	x				
		99-23	2	brown silty clay	x				
			3	brown silty clay	x				
		99-24	1	dark brown silty clay	x	x			1 total organic content
			4	varved grey clay/silt	x	x	x	x	1 consolidation
			5	varved grey clay/silt	x x x				3 shear strength
8	CUT 3 m		6	varved grey clay/silt	x	x	x	x	2 consolidation
		99-25	2	brown silty clay	x				
			3	brown silty clay	x				
		99-26	2	brown clayey silt	x				
9	CUT 3 m		3	varved grey clay/silty clay	x	x	x		
		99-27	2	brown silty clay	x				
		99-28	2	brown silty clay	x				
			3	brown silty clay	x	x	x		
10	FILL 2 m	99-29	2	varved brown silty clay/clayey silt	x				
		99-30	3	varved grey clay/clayey silt	x				
		99-31	2	varved grey clay/clayey silt	x	x	x		

TABLE 2
Summary of Laboratory Tests
Highway 101 (W.P. 258-96-00)

AREA	Description	Borehole No.	Sample No.	Soil Description	Water Content	Atterberg Limits	Grain Size	Specific Gravity	Other Tests
11	CUT 6 m	99-32	3	brown varved silty clay/clayey silt	x				
			4	brown silty sand	x		x		
		99-33	2	brown varved silty clay/silt	x				
			3	brown varved silty clay/silt	x				
			4	brown clayey silt	x				
		99-34	3	brown varved silty clay/silt	x				
			4	brown varved silty clay/silt	x				
			5	brown varved silty clay/silt	x				
			7	grey silty clay	x				
			8	grey silty clay	x	x	x		
12	FILL 5 m	99-35	1	brown sandy silt	x				
			2	brown sandy silt	x				
			4	brown silty fine sand	x		x		
			5	brown silty fine sand	x				
		99-36	2	brown silty sand	x				
			3	brown silty sand	x		x		
			4	red sandy silt	x		x		
			5	red sandy silt	x				
		99-38	2	brown sand	x				
			4	brown sand	x				
			5	brown sand	x				
		99-39	2	brown fine sand	x				
			4	varved grey silty clay/silt	x	x	x		
			5	varved grey silty clay/silt	x	x	x	x	1 consolidation

SUMMARY OF NUMBER OF TESTS

Natural Water Content	91
Atterberg Limits	16
Grain Size Distribution	20
Specific Gravity	5
Shear Strength (triaxial)	3
Consolidation (oedometer)	5
Total Organic Content	1

TABLE 3
Summary of Fill Options Considered
Highway 101 (W.P. 258-96-00)

Option	Purpose/Description	Benefit/Positive	Concern/Negative	Areas Considered
Earthfill	Achieve road grade with conventional fill	Low unit cost and ease of construction	Greatest right-of-way requirement and volume of fill	2,4,5,7,10,12
Rockfill	Achieve road grade with conventional material	Suitable for fill alignment beside lakes. Reduced embankment load and reduced right of way requirements.	Availability of material	2,4,5,7,10,12
Composite Earthfill and Lightweight Slag	Construct embankment by placing 6m of lightweight slag fill over a berm	Reduced embankment load results in reduced berm volume requirements and reduced settlement	High cost of lightweight slag fill and potential environmental concerns due to possible leaching action	2,7
Lightweight Slag	Maximize use of lightweight slag fill as an embankment construction material	Reduced embankment load results in reduced berm (volume) requirements and reduced settlement	High cost of lightweight slag fill and potential leaching of metals from slag causing environmental concerns	2,7
Composite Earth and Extruded Polystyrene	Construct 11 m embankment by placing 6m of extruded polystyrene blocks over a 5 m high Granular "B" fill berm	Highly reduced embankment load results in minimal berm requirements and settlement	Bearing capacity of the extruded polystyrene and degradation due to hydrocarbons. Potential road surface icing problems	2,7
Elastizell Embankment Construction	Construct embankment by pouring elastizell concrete in formwork	Lightweight embankment resulting in reduced settlement and reduced berm (volume) requirements	High construction materials and labour costs	2,7
Install wick drains in combination with one of the fill options	Reduce the consolidation drainage path in the soft clay deposit	Reduced time period required for consolidation settlement	Wick drains do not significantly improve rate of consolidation in overconsolidated and varved clays	2,7

TABLE 4
Embankment Volume and Cost Comparison (Areas 2 and 7)
Highway 101 (W.P. 258-96-00)

	Earthfill Option	Rockfill Option	Composite Earth and Lightweight Slag Fill Option	Lightweight Slag Fill Option	Composite Earth and Extruded Polystyrene Fill Option
Geometry					
Sideslopes	2H:1V	2H:1V	2H:1V	2H:1V	2H:1V
Maximum Berm Width (m)	15	5	5	2	2
Base Width (m)	90	70	70	64	64
Maximum Cross Section Area					
Earthfill (m2)	568	0	300	120	270
Rockfill (m2)	0	468	0	0	0
Light Weight Slag (m2)	0	0	168	318	0
Extruded Polystyrene (m2)	0	0	0	0	168
Total (m2)	568	468	468	438	438
Length of Alignment with fill height >6m					
Area 2 (m)	80	80	80	80	80
Area 7 (m)	150	150	150	150	150
Total Length of Fill Alignment					
Area 2 (m)	205	205	205	205	205
Area 7 (m)	290	290	290	290	290
Volume of Construction Material					
Earthfill (m3)	129,775	0	82,825	52,555	76,930
Rockfill (m3)	0	110,125	0	0	0
Light Weight Slag (m3)	0	0	27,300	51,675	0
Extruded Polystyrene (m3)	0	0	0	0	27,300
Total Fill (m3)	129,775	110,125	110,125	104,230	104,230
Cost Estimate					
Earthfill (\$13/m3)	\$1,687,075	\$0	\$1,076,725	\$683,215	\$1,000,090
Rockfill (\$15/m3)	\$0	\$1,651,875	\$0	\$0	\$0
Light Weight Slag (\$50/m3)	\$0	\$0	\$1,365,000	\$2,583,750	\$0
Extruded Polystyrene (\$120/m3)	\$0	\$0	\$0	\$0	\$3,276,000
Total	\$1,687,075	\$1,651,875	\$2,441,725	\$3,266,965	\$4,276,090

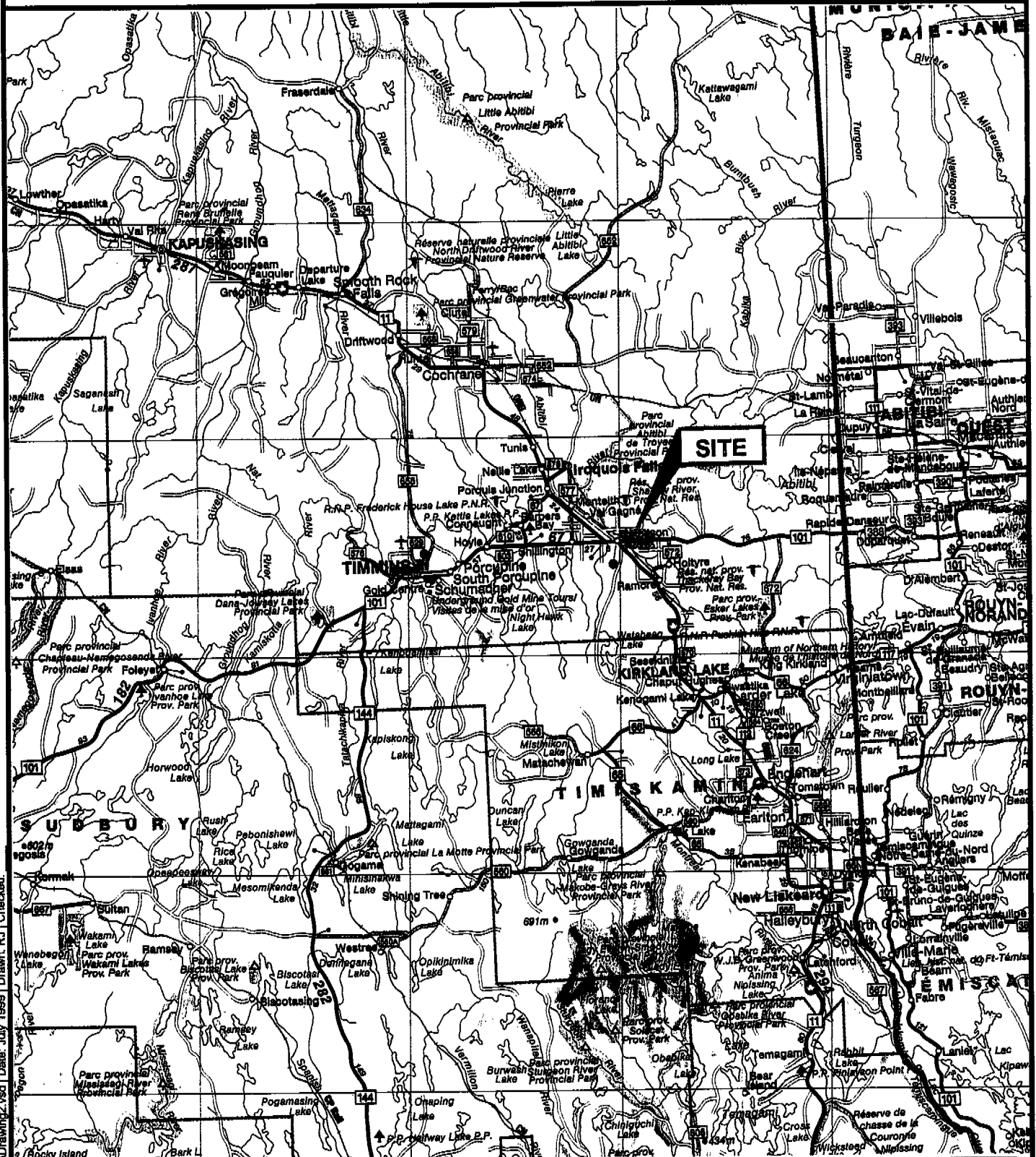
TABLE 5
Summary of Recommendations (Fill Areas)
Highway 101 (W.P. 258-96-00)

Fill Material	Sideslope	Minimum Berm Requirements		
		Effective Embankment Height (m)	Berm Height (m)	Berm Width (m)
Earthfill	2H:1V	11	5	15
		10	4	10
		9	3	5
		8	2	2
		7	1	2
		<=6	Berm Not Required	
Rockfill	2H:1V	11	5	5
		10	4	2
		9	3	2
		8	2	2
		7	1	2
		<=6	Berm Not Required	

Note: Effective embankment height is the difference in elevation from crest to toe of embankment slope.

SITE LOCATION MAP HIGHWAY 101 RE-ALIGNMENT MATHESON, ONTARIO

FIGURE 1



REFERENCE
THIS FIGURE WAS CREATED FROM A MAPART
PUBLISHING MAP TITLED "ONTARIO" 1997 EDITION.

SCALE 1 : 725 000

Date JULY, 1999
Project 991-1145



Golder Associates

Drawn R.J.
Chkd. BVB

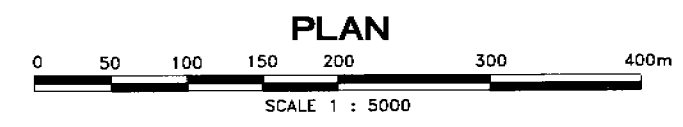
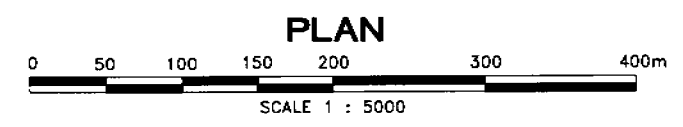
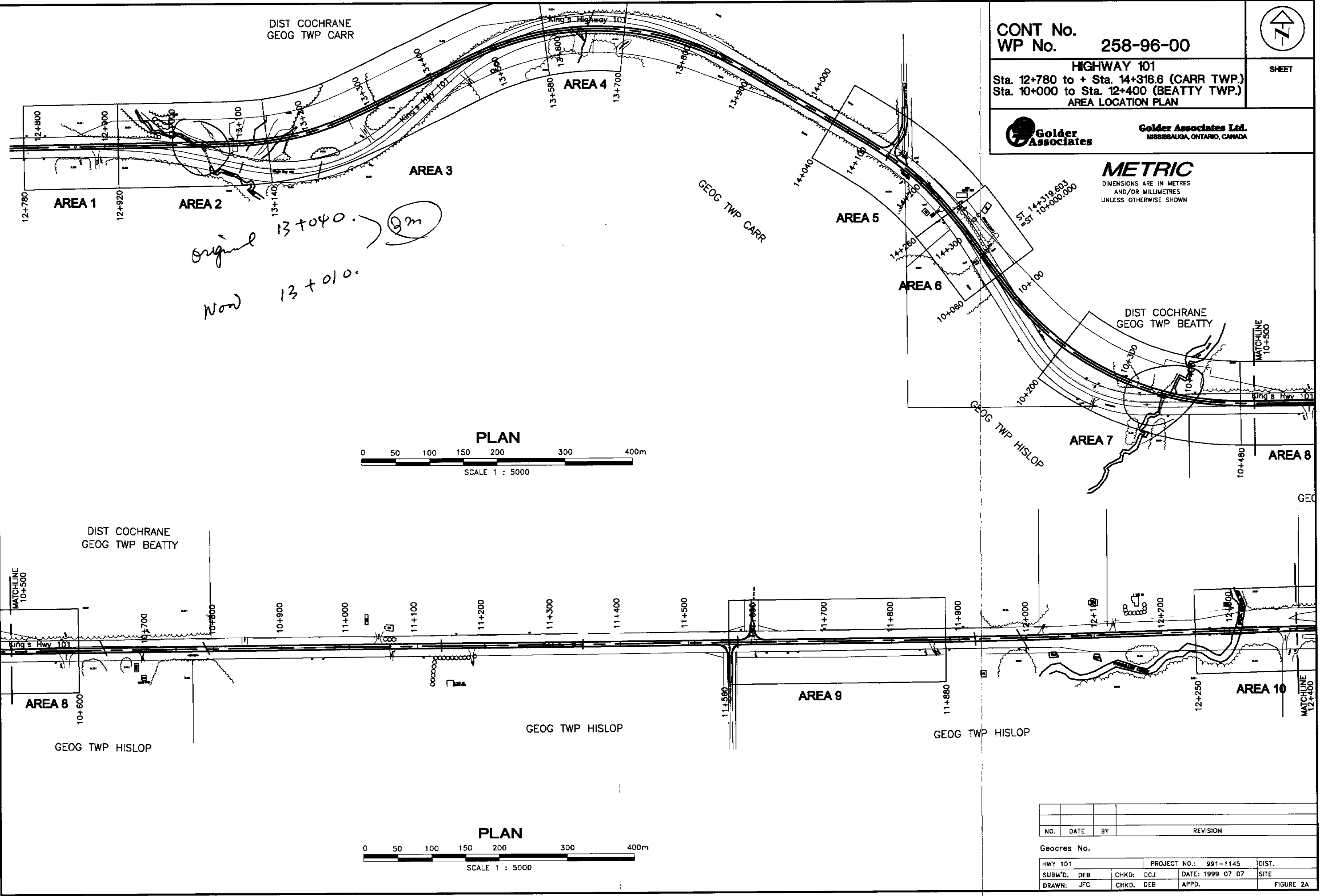
CONT No.
WP No. 258-96-00



HIGHWAY 101
Sta. 12+780 to + Sta. 14+316.6 (CARR TWP.)
Sta. 10+000 to Sta. 12+400 (BEATTY TWP.)
AREA LOCATION PLAN

Golder Associates
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MISSISSAUGA, ONTARIO, CANADA

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



NO.	DATE	BY	REVISION
Geocres No.			
HWY 101	PROJECT NO.: 991-1145	DIST.	
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07	SITE
DRAWN: JFC	CHKD: DEB	APPD.	FIGURE 2A

N1145E01.DWG

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

CONT No.
WP No. 258-96-00

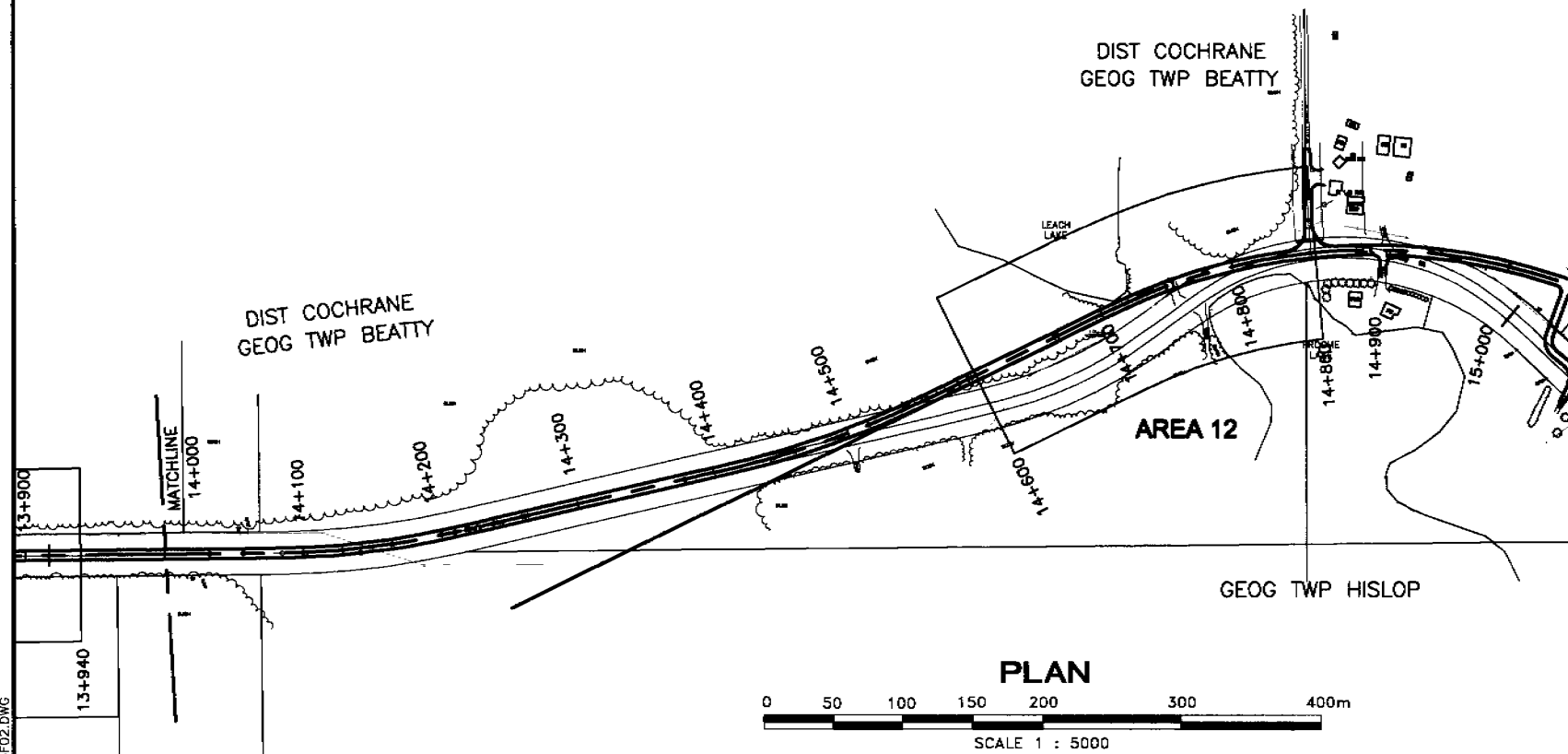
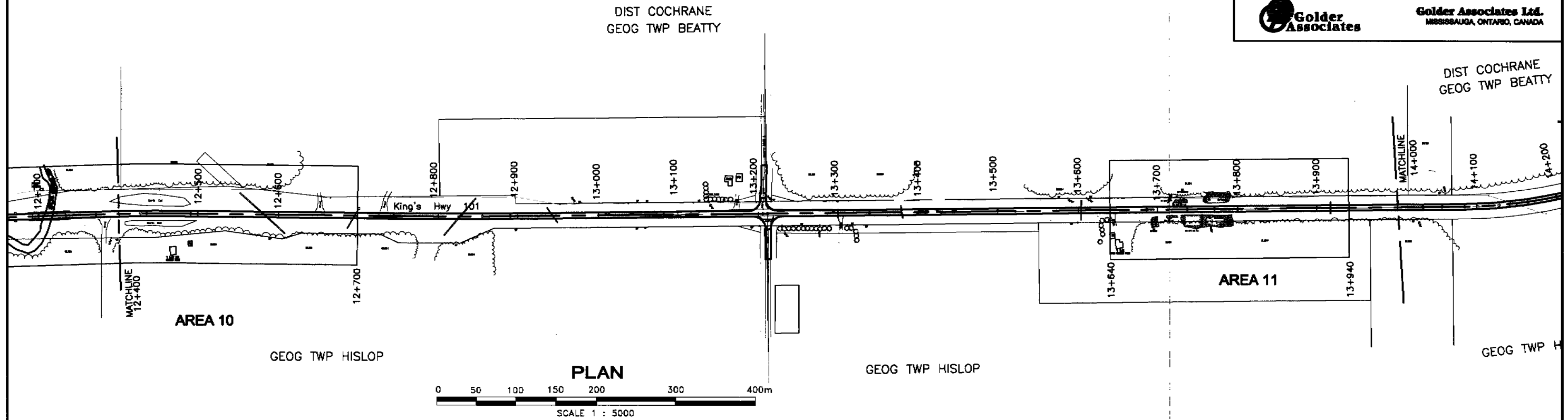


HIGHWAY 101
Sta. 12+400 to Sta. 15+000
(BEATTY TWP.)
AREA LOCATION PLAN

SHEET



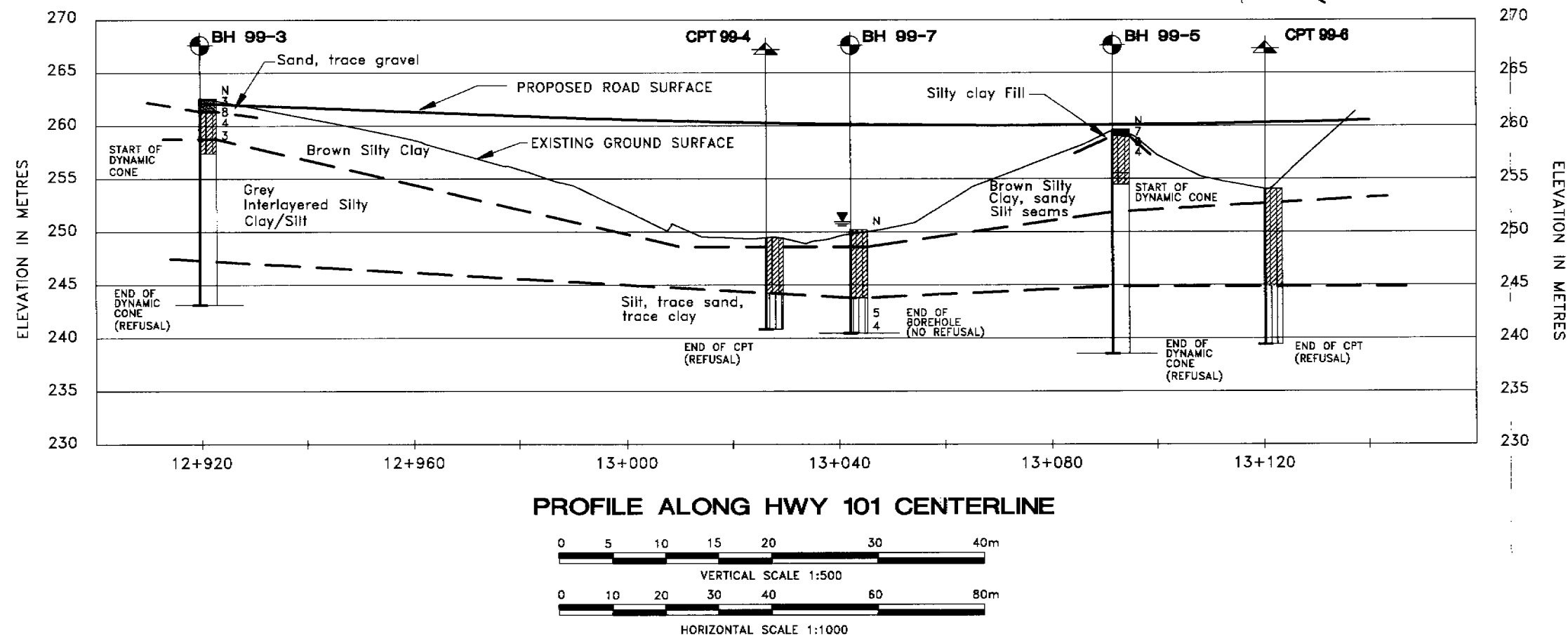
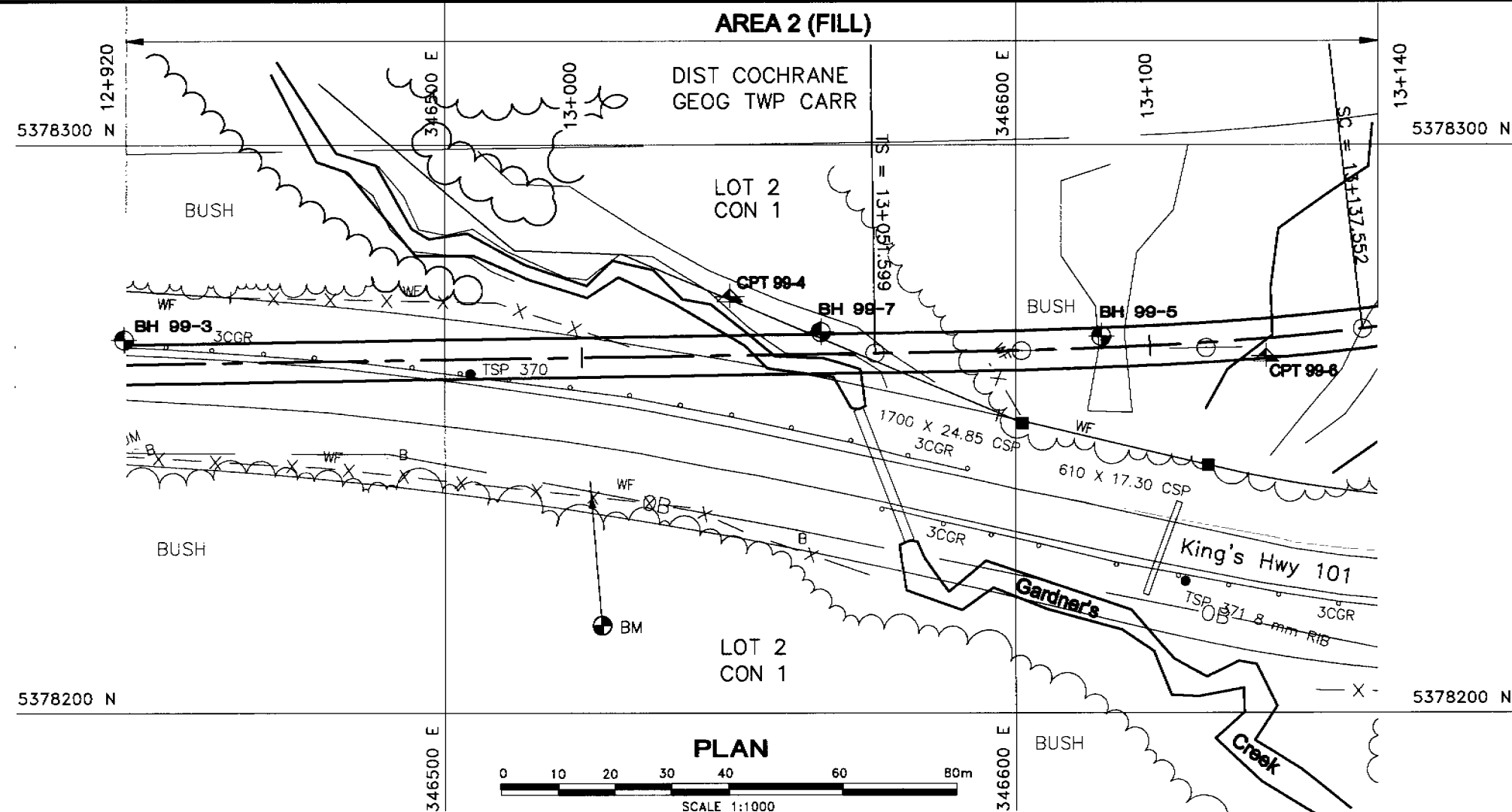
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



NO.	DATE	BY	REVISION

Geocres No.

HWY 101	PROJECT NO.:		991-1145	DIST.
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07	SITE	
DRAWN: JFC	CHKD. DEB	APPD.	FIGURE 2B	



CONT No.
WP No. 258-96-00

HIGHWAY 101
Sta. 12+920 to Sta. 13+140
BOREHOLE LOCATIONS & SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

STRATIGRAPHY LEGEND

	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

NOTES:

- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
- BOREHOLES 3 AND 5 DRY UPON COMPLETION OF DRILLING
- STRATIGRAPHIES FOR CPT 99-4 AND CPT 99-6 INTERPRETED FROM CPT RESULTS.

LEGEND

	Borehole
	CPT
	Blows/0.3m (Std. Pen. Test, 475 j/blow)
	WL in piezometer on July 23, 1999
	WL in open borehole upon completion of drilling

No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH-3	262.58	5378265.8	346443.4
BH-5	259.64	5378266.4	346615.2
BH-7	250.22	5378267.2	346565.8
CPT 4	250.03	5378273.4	346549.8
CPT 6	254.55	5378262.9	346644.0

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.

HWY 101	PROJECT NO.: 991-1145	DIST.
SUBM'D. DEB	CHKD. DCJ	DATE: 1999 07 07
DRAWN: JFC	CHKD. DEB	APPD.
		SITE
		FIGURE 4

CONT No.
WP No. 258-96-00



HIGHWAY 101
Sta. 13+140 to Sta. 13+375
BOREHOLE LOCATIONS & SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

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

STRATIGRAPHY LEGEND

- | | |
|-----------------------|-------------------------------------|
| FILL/TOPSOIL | SILT |
| SAND | VARVED/INTERLAYERED CLAYS AND SILTS |
| SILTY SAND/SANDY SILT | SILTY CLAY |
| SAND AND GRAVEL | CLAY |

NOTES:

- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
- BOREHOLE 10 DRY UPON COMPLETION OF DRILLING

LEGEND

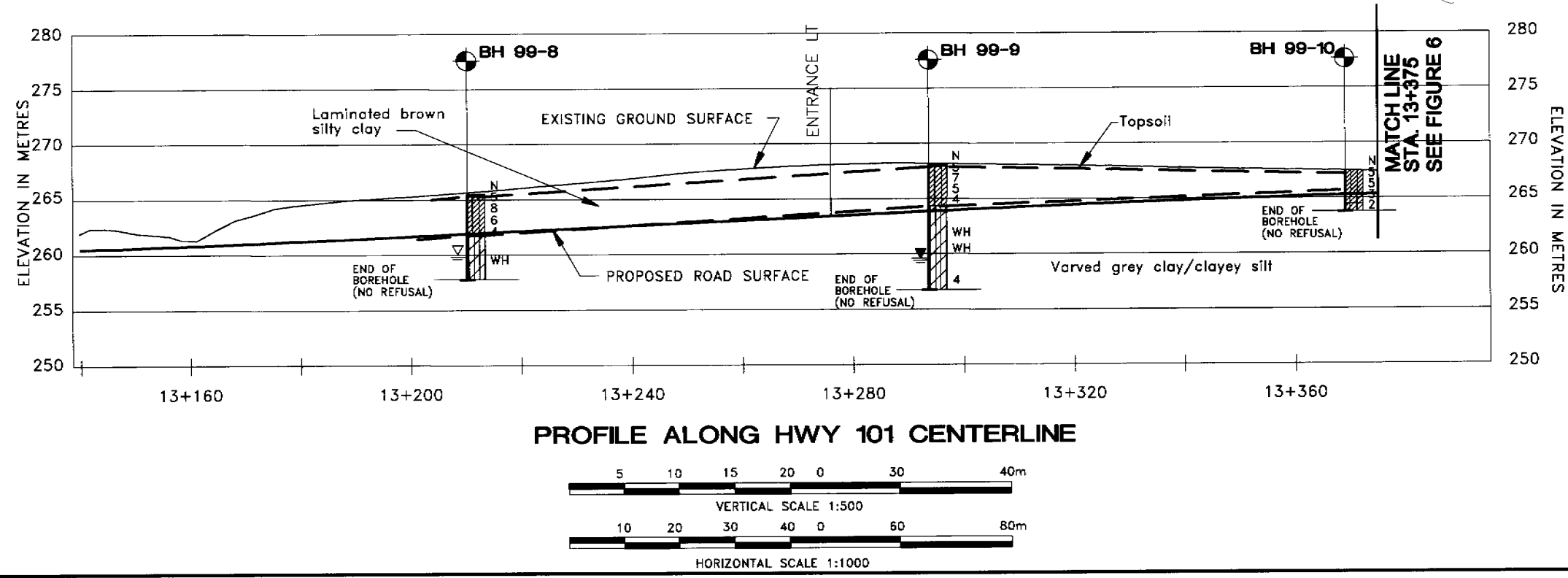
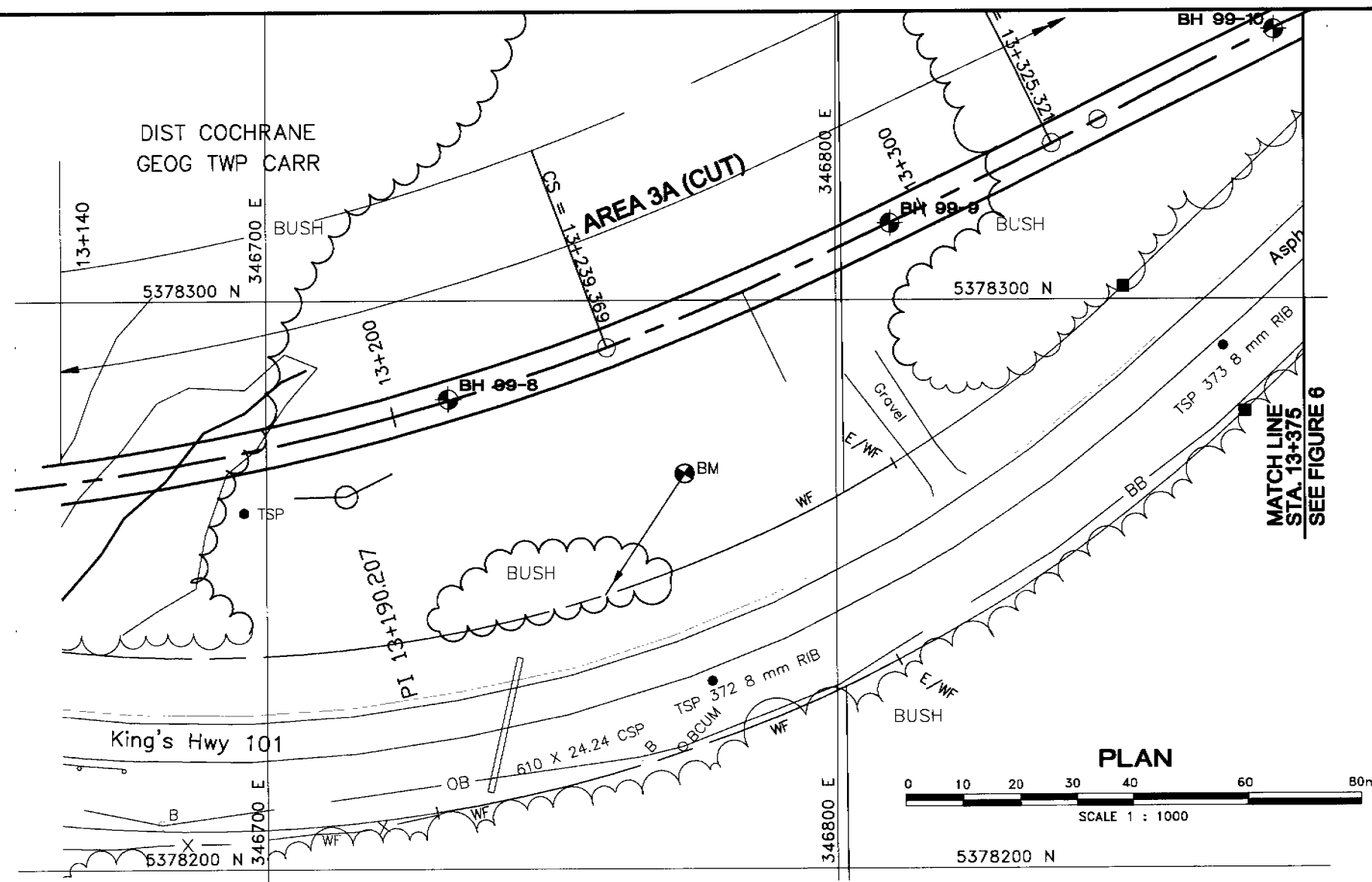
- | | |
|--|---|
| | Borehole |
| | CPT |
| | Blows/0.3m (Std. Pen. Test, 475 l/blow) |
| | WL in piezometer on July 23, 1999 |
| | WL in open borehole upon completion of drilling |

No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-8	265.49	5378282.7	346732.2
BH 99-9	268.04	5378313.5	346809.7
BH 99-10	297.42	5378347.3	346877.0

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.				DATE	BY	REVISION
Geocres No.						
HWY 101		PROJECT NO.: 991-1145		DIST.		
SUBM'D. DEB		CHKD: DCJ		DATE: 1999 07 07		SITE
DRAWN: JFC		CHKD: DEB		APPD.		FIGURE 5A



N1145F05.DWG

CONT No.
WP No. 258-96-00



HIGHWAY 101
Sta. 13+375 to Sta. 13+580
BOREHOLE LOCATIONS & SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

STRATIGRAPHY LEGEND

- | | |
|-----------------------|-------------------------------------|
| FILL/TOPSOIL | SILT |
| SAND | VARVED/INTERLAYERED CLAYS AND SILTS |
| SILTY SAND/SANDY SILT | SILTY CLAY |
| SAND AND GRAVEL | CLAY |

NOTE:

FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS
REFER TO RECORD OF BOREHOLE SHEETS.

LEGEND

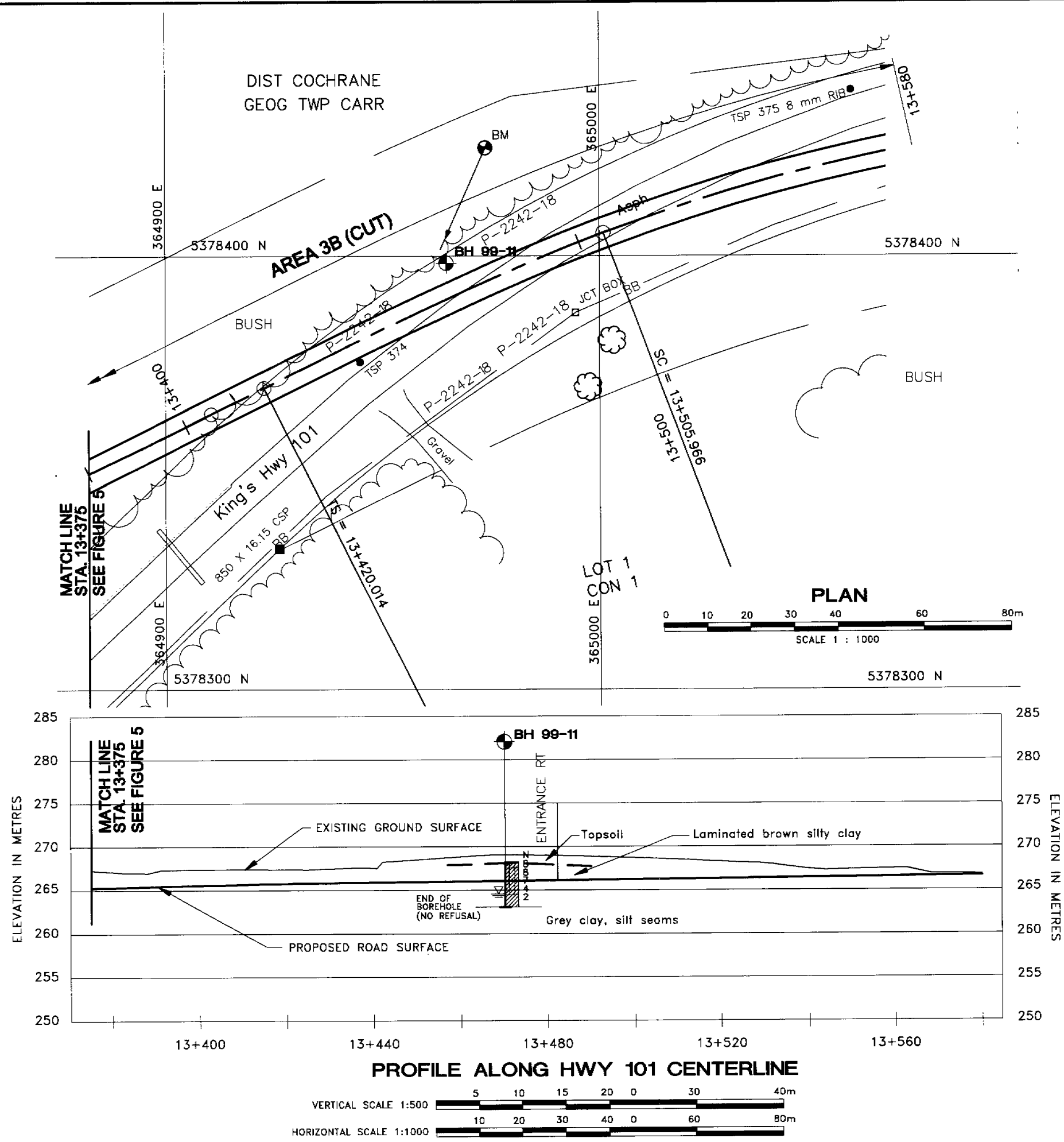
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|---|
| Borehole |
| CPT |
| N Blows/0.3m (Std. Pen. Test, 475 j/blow) |
| WL in piezometer on July 23, 1999 |
| WL in open borehole upon completion of drilling |

No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-11	268.26	5378398.4	346964.7

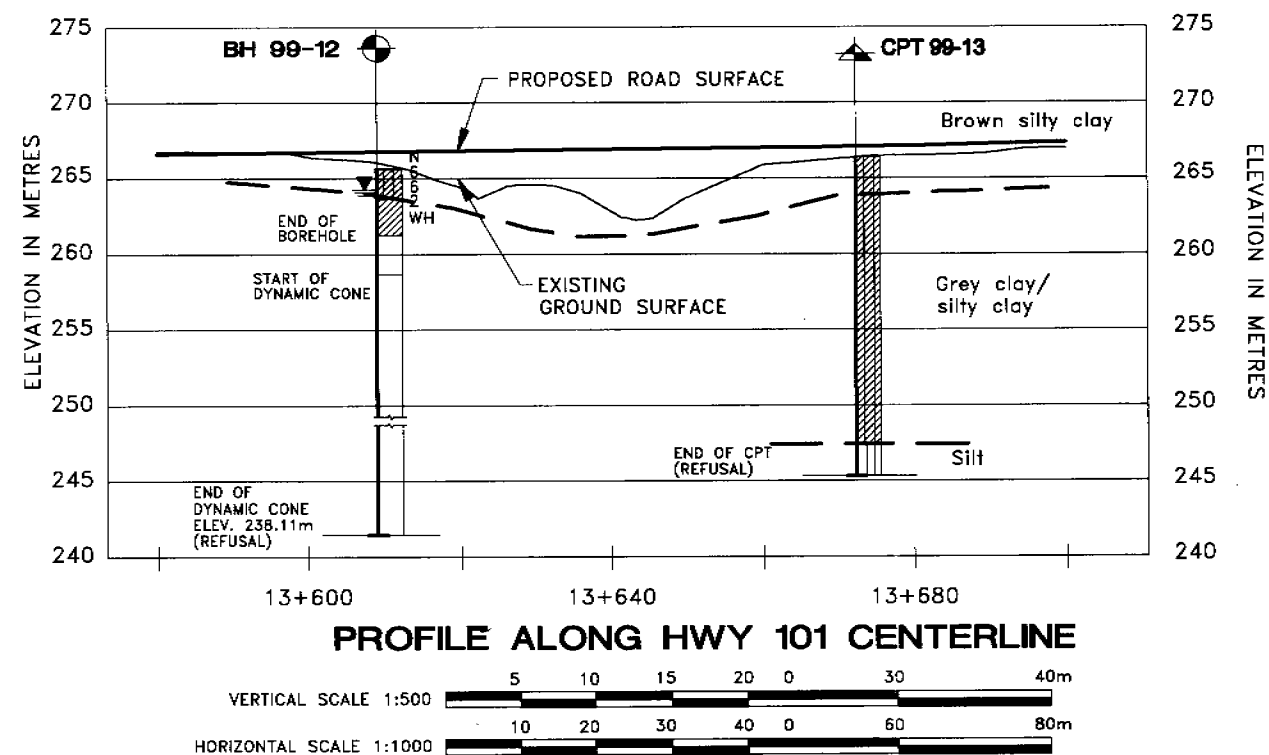
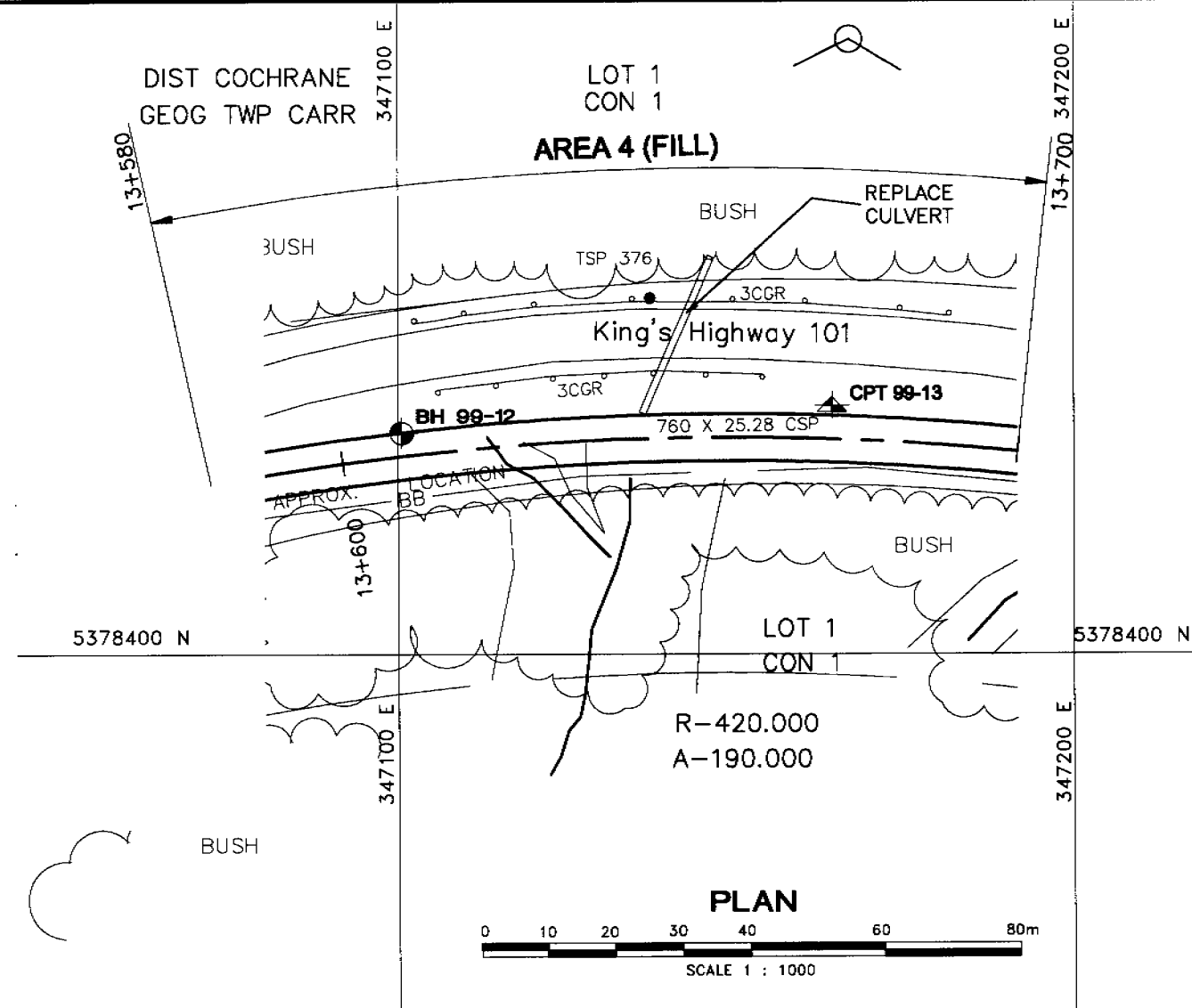
NOTES

The boundaries between soil strata have been established
only at Borehole locations. Between Boreholes the
boundaries are assumed from geological evidence.

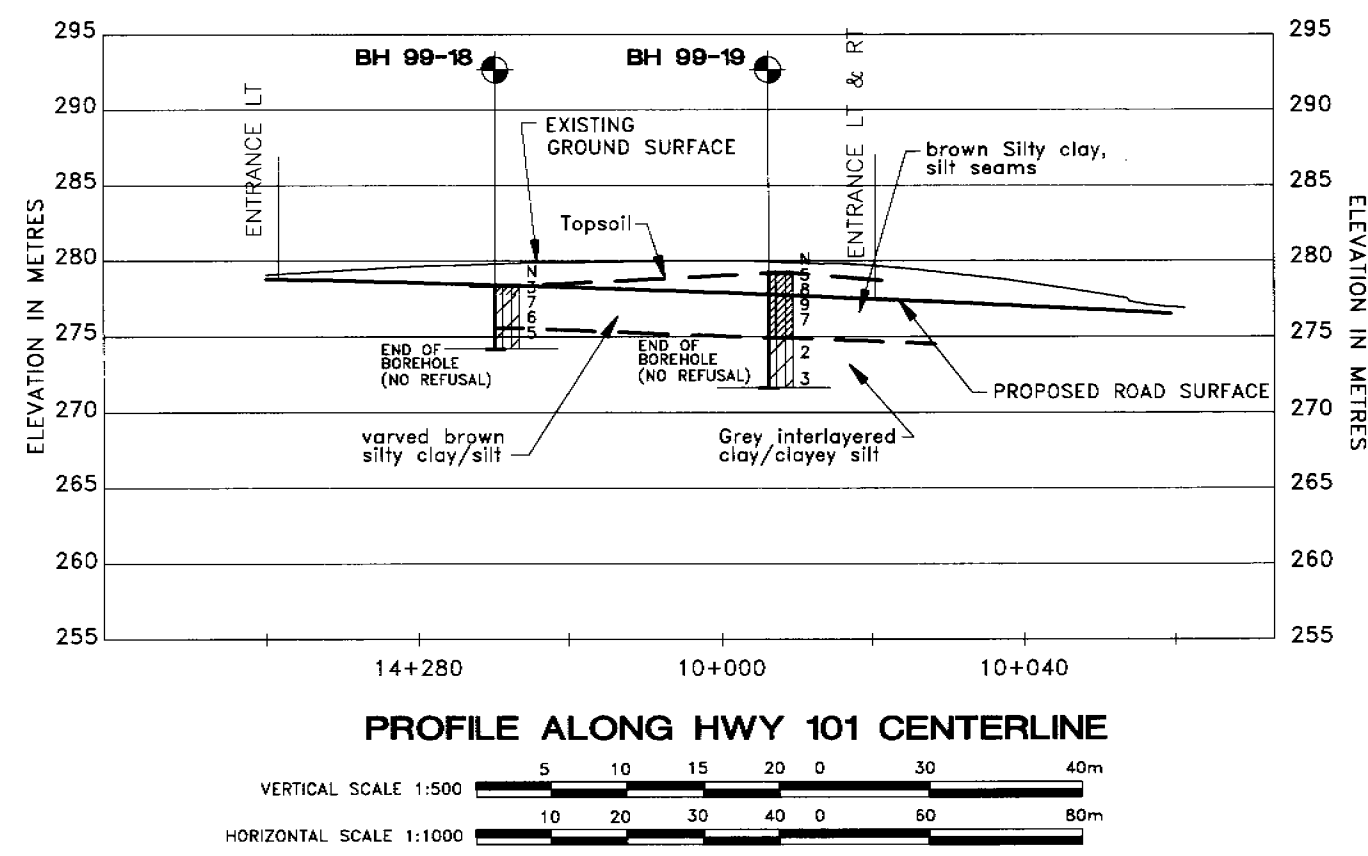
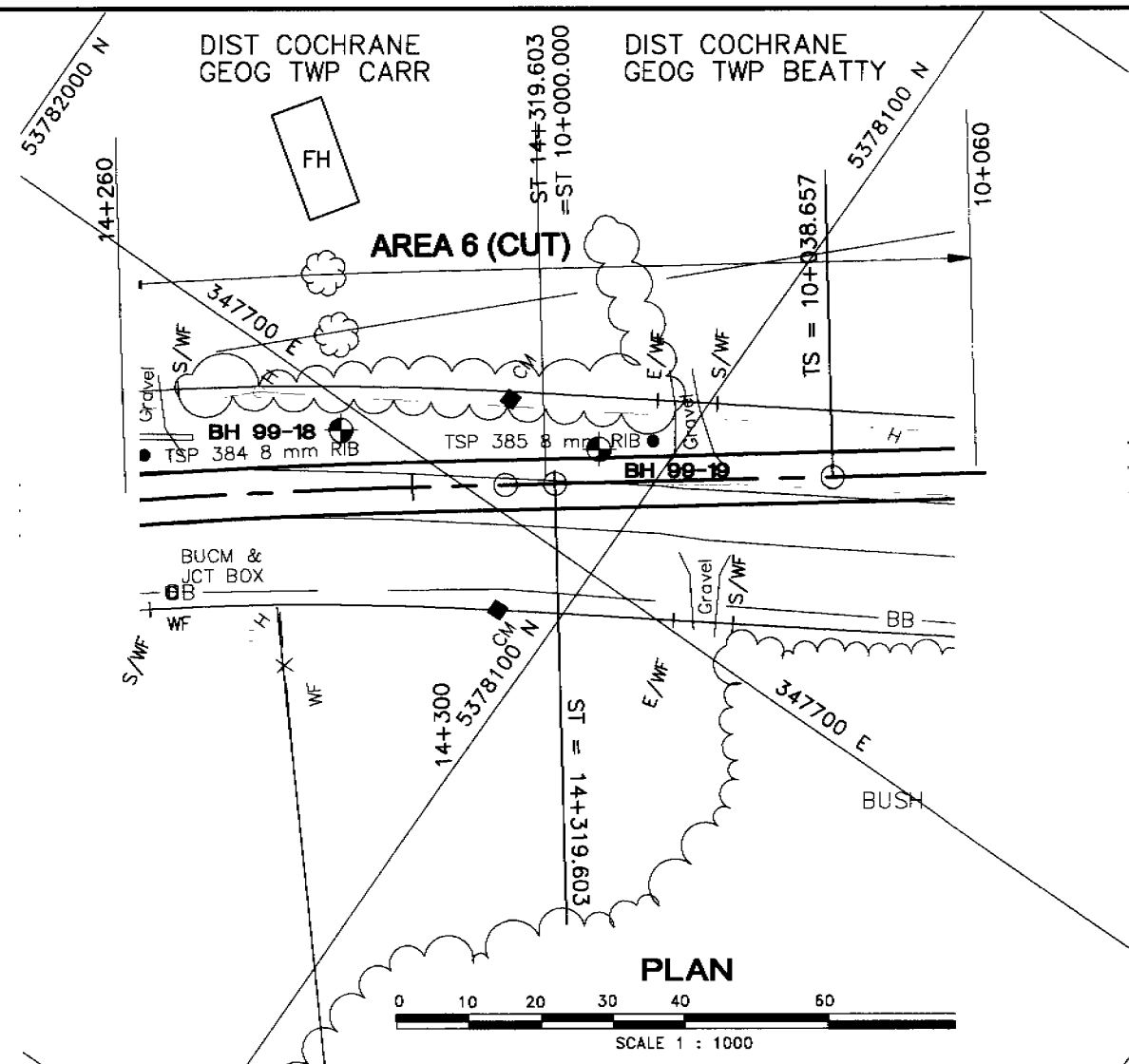
Geocres No.			
HWY 101	PROJECT NO.:	991-1145	DIST.
SUBM'D. DEB	CHKD. DCJ	DATE: 1999 07 07	SITE
DRAWN: JFC	CHKD. DEB	APPD.	FIGURE 5B



N1145F05.DWG



CONT No.
WP No. 258-96-00



CONT No.
WP No.

258-96-00

HIGHWAY 101
Sta. 14+260 to Sta. 10+060
BOREHOLE LOCATIONS & SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

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

STRATIGRAPHY LEGEND

- | | |
|------------------------------|--|
| FILL/TOPSOIL | SILT |
| SAND | VARVED/INTERLAYERED CLAYS AND SILTS |
| SILTY SAND/SANDY SILT | SILTY CLAY |
| SAND AND GRAVEL | CLAY |

- NOTES:**
- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
 - BOREHOLES 18 AND 19 DRY UPON COMPLETION OF DRILLING

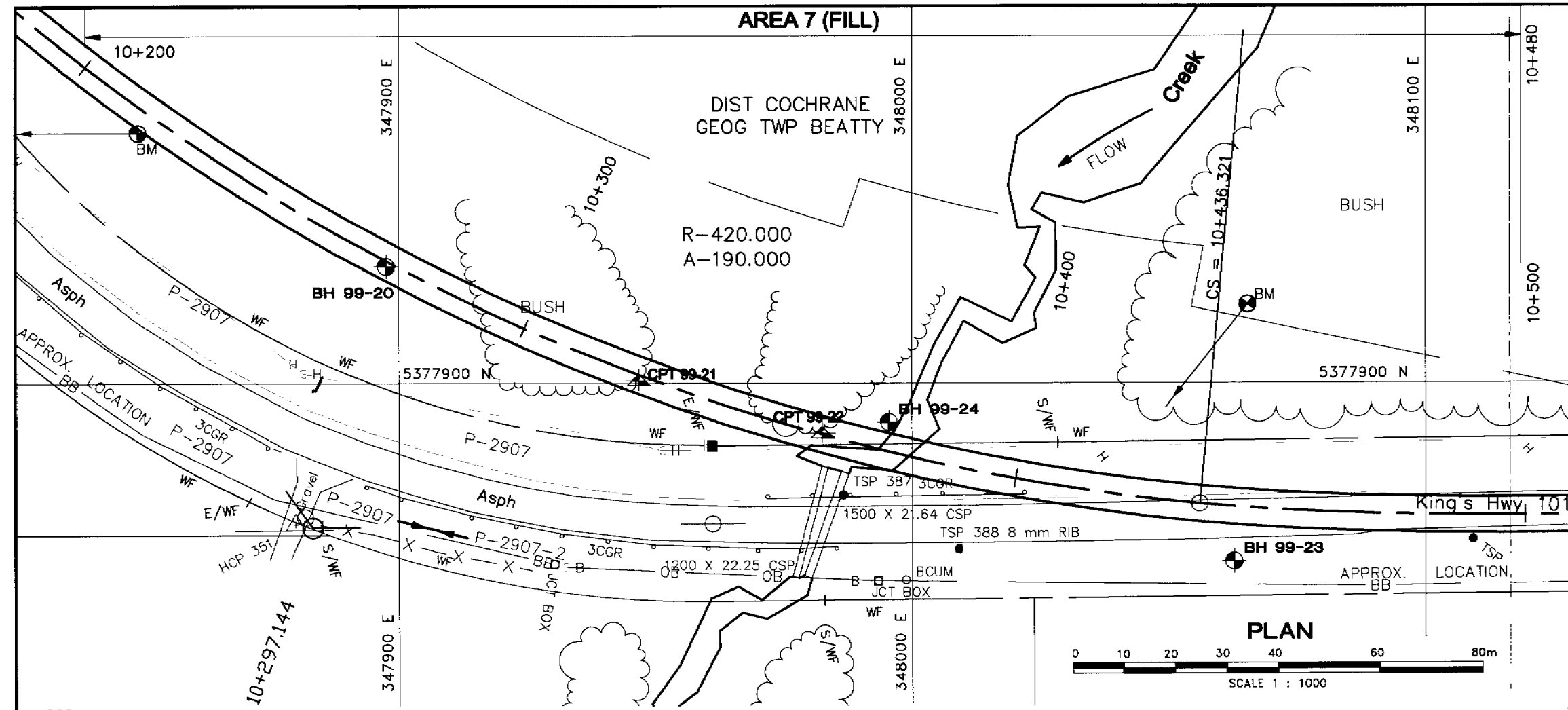
LEGEND			
	Borehole		
	CPT		
	Blows/0.3m (Std. Pen. Test, 475 j/blow)		
	WL in piezometer on July 23, 1999		
	WL in open borehole upon completion of drilling		
No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-18	278.49	5378139.8	347696.6
BH 99-19	279.32	5378109.0	347714.9

NOTES
 The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.			
HWY 101	PROJECT NO.:	991-1145	DIST.
SUBM'D. DEB	CHKD. DCJ	DATE: 1999 07 07	SITE
DRAWN: JFC	CHKD. DEB	APPD.	FIGURE B

N1145F09.DWG



CONT No.
WP No. 258-96-00

HIGHWAY 101
Sta. 10+200 to Sta. 10+480
BOREHOLE LOCATIONS & SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

SHEET

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

STRATIGRAPHY LEGEND

	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

- NOTES:**
- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
 - BOREHOLES 20 AND 23 DRY UPON COMPLETION OF DRILLING
 - STRATIGRAPHIES FOR CPT 99-21 AND CPT 99-22 INTERPRETED FROM CPT RESULTS.

LEGEND

	Borehole
	CPT
	Blows/0.3m (Std. Pen. Test, 475 j/blow)
	WL in piezometer on July 23, 1999
	WL in open borehole upon completion of drilling

No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-20	265.80	5377922.8	347897.5
BH 99-23	264.81	5377865.2	348062.6
BH 99-24	257.20	5377892.4	347995.5
CPT 99-21	263.26	5377900.5	347946.7
CPT 99-22	257.07	5377890.2	347982.4

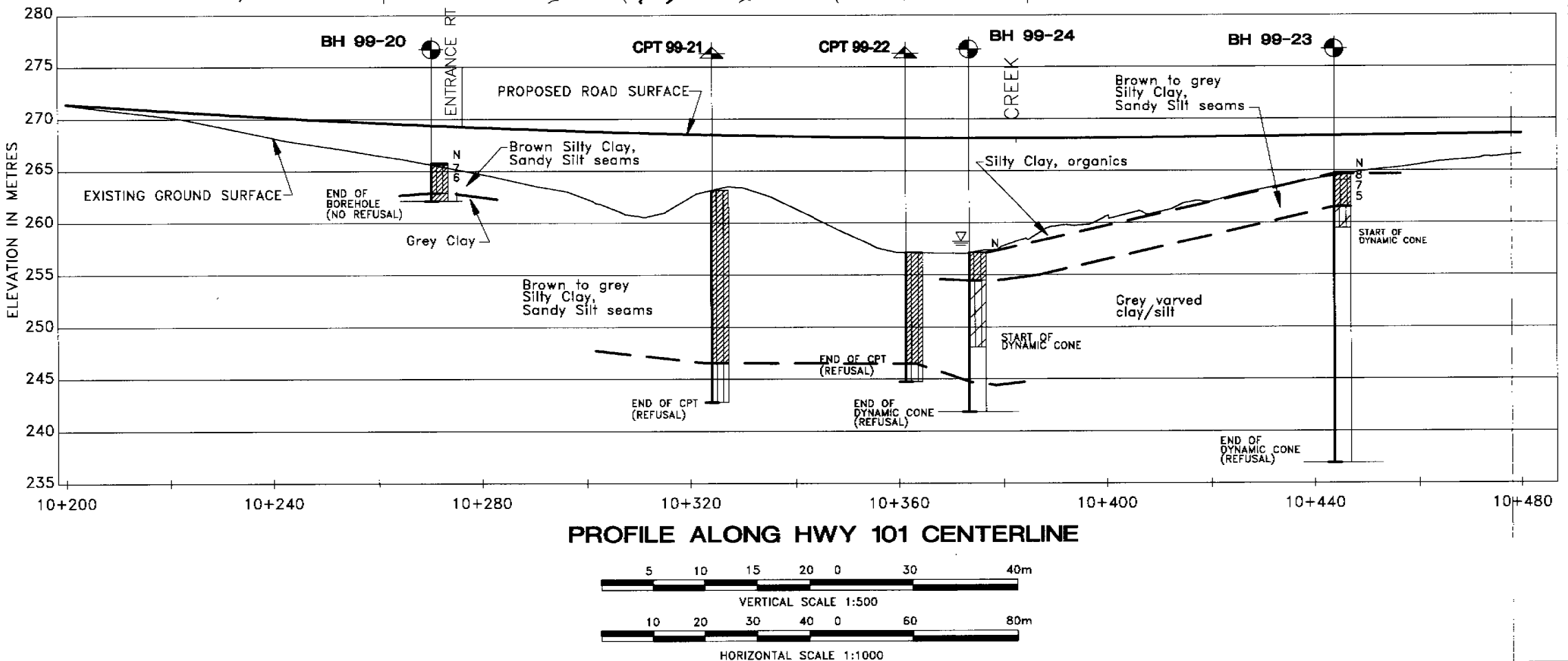
NOTES

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

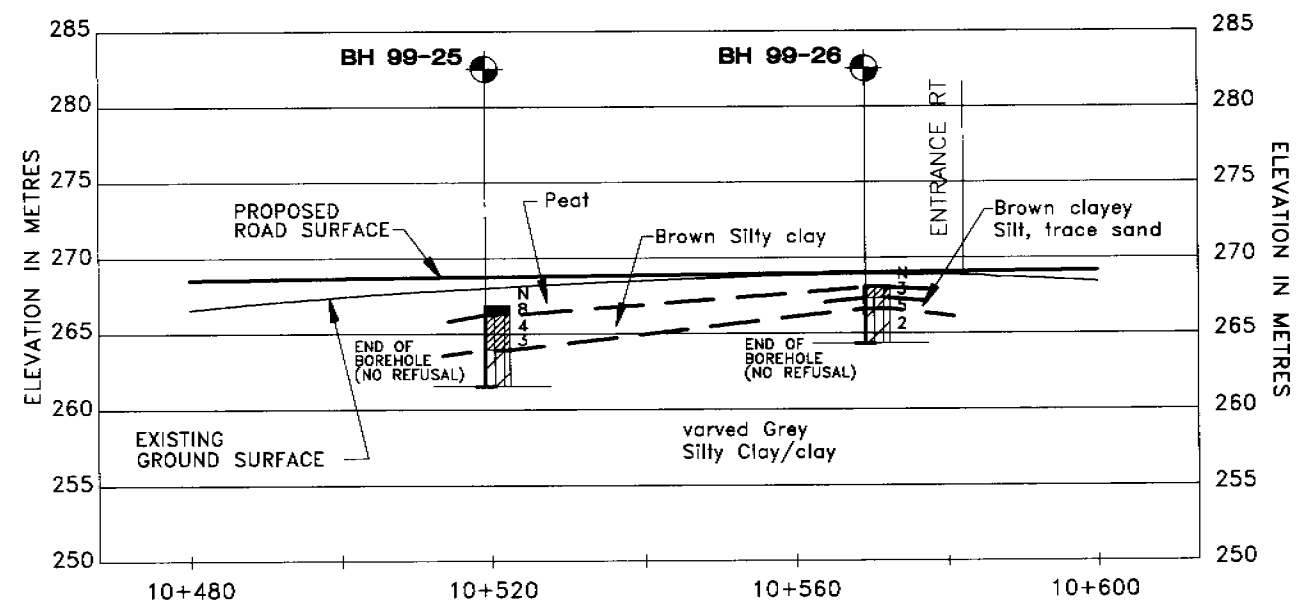
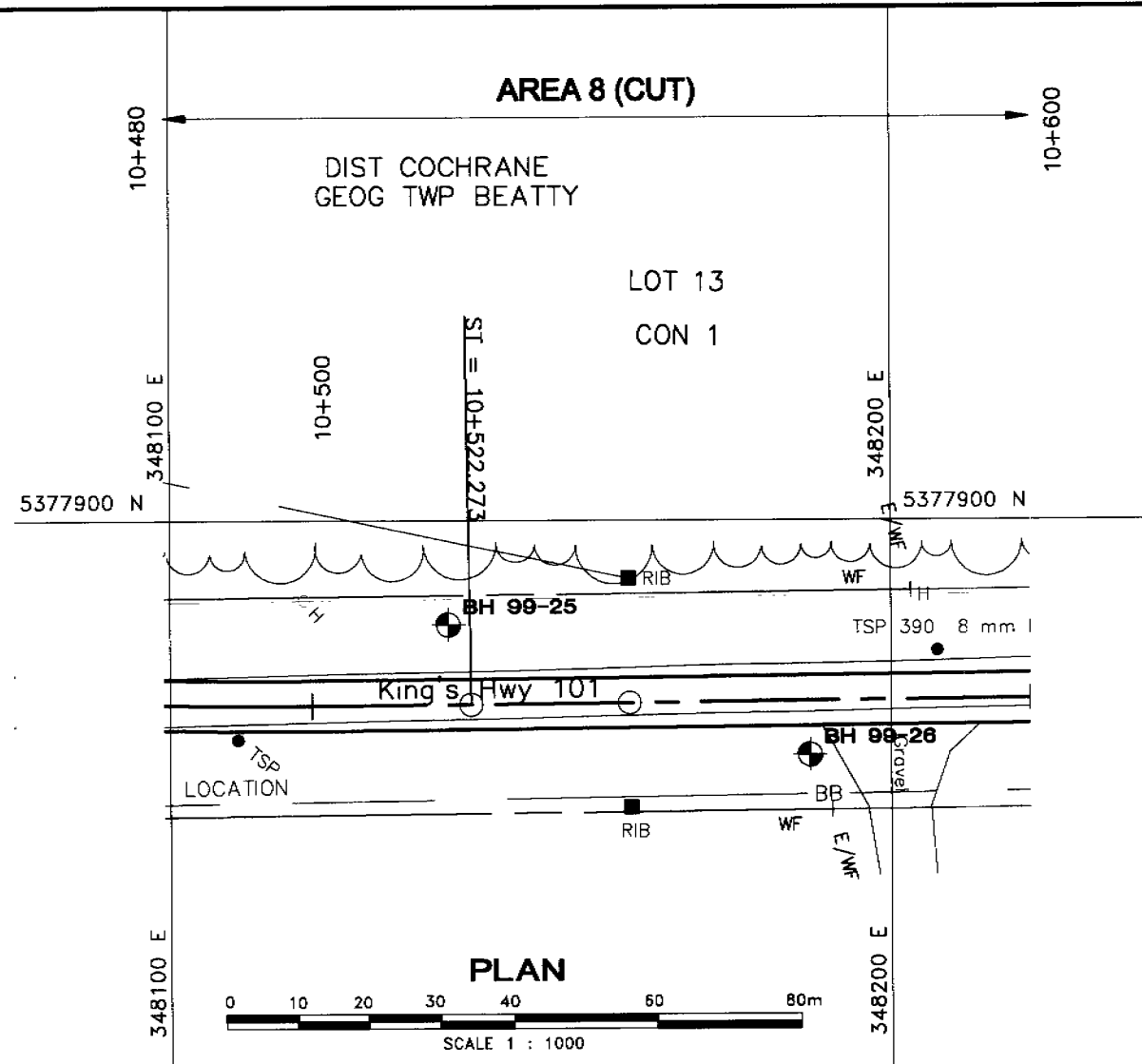
NO.	DATE	BY	REVISION

Geocres No.

HWY 101	PROJECT NO.: 991-1145	DIST.
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07
DRAWN: JFC	CHKD: DEB	APPD.
		FIGURE 9



N1145F10.DWG



CONT No.
WP No. 258-96-00

HIGHWAY 101
Sta. 10+480 to Sta. 10+600
BOREHOLE LOCATIONS & SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

STRATIGRAPHY LEGEND

	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

NOTES:

- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
- BOREHOLES 25 AND 26 DRY UPON COMPLETION OF DRILLING

LEGEND

	Borehole
	CPT
N	Blows/0.3m (Std. Pen. Test, 475 j/blow)
	WL in piezometer on July 23, 1999
	WL in open borehole upon completion of drilling

No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-25	266.88	5377885.5	348138.8
BH 99-26	268.15	5377867.3	348188.8

NOTES


The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION


Geocres No.

HWY 101	PROJECT NO.: 991-1145	DIST.
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07
DRAWN: JFC	CHKD: DEB	APPD.
		FIGURE 10

CONT No.
WP No. 258-96-00










SHEET

HIGHWAY 101
Sta. 11+560 to Sta. 11+880
BOREHOLE LOCATIONS & SOIL STRATA





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MISSISSAUGA, ONTARIO, CANADA

METRIC
DIMENSIONS ARE IN METRES
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UNLESS OTHERWISE SHOWN

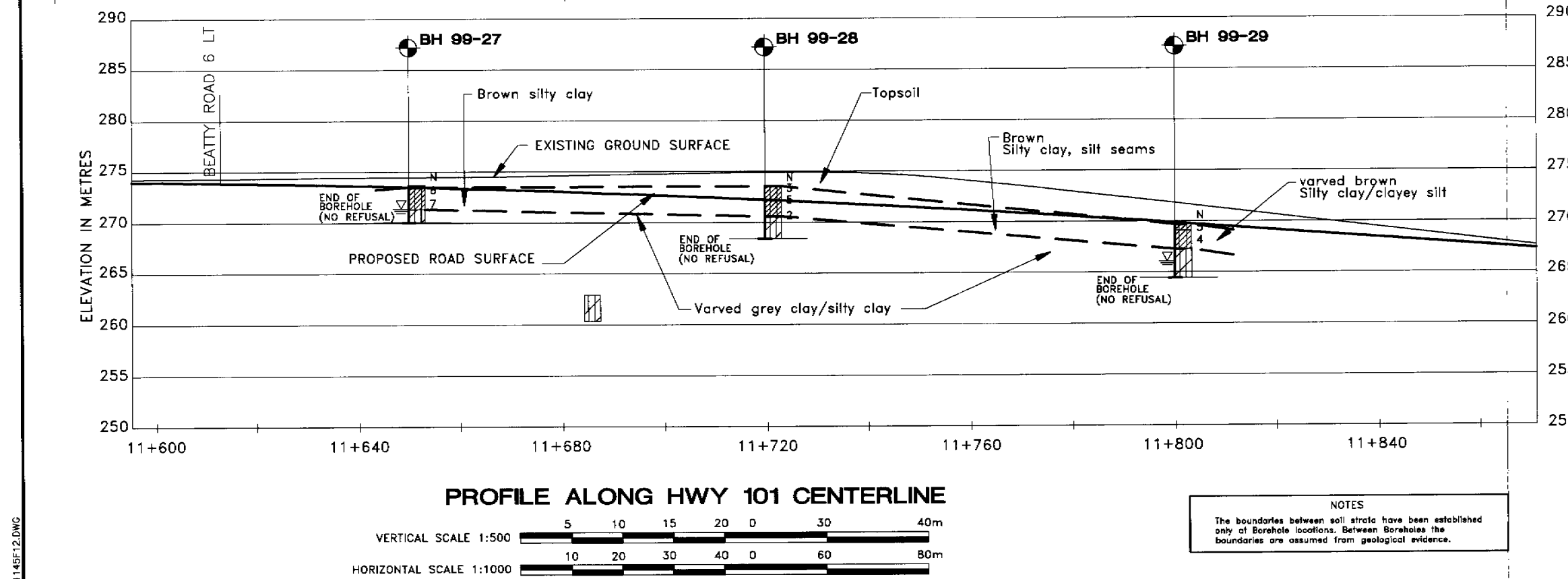
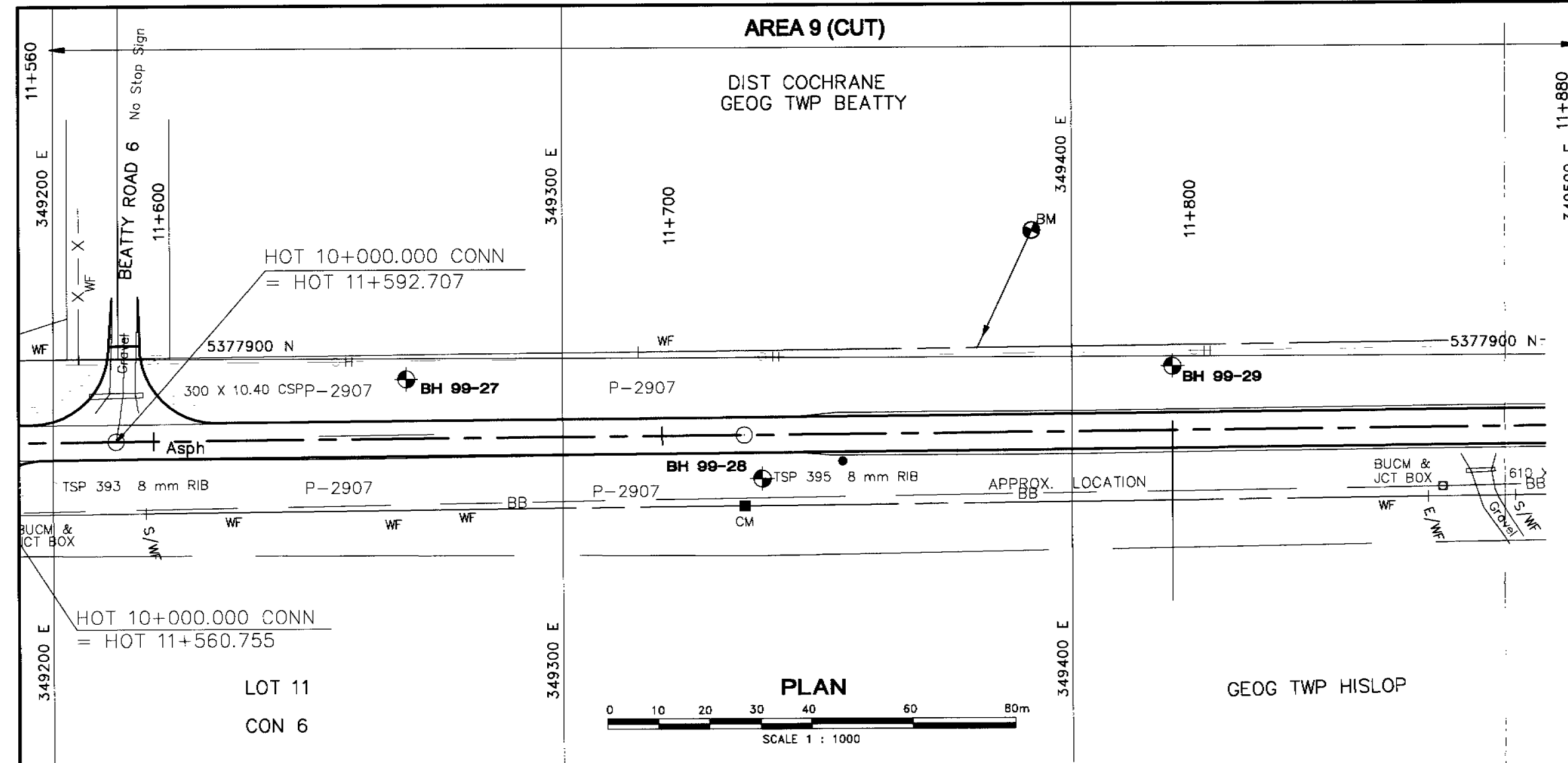
STRATIGRAPHY LEGEND

	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

- NOTES:**
- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
 - BOREHOLE 28 DRY UPON COMPLETION OF DRILLING

LEGEND			
	Borehole		
	CPT		
N	Blows/0.3m (Std. Pen. Test, 475 j/blow)		
	WL in piezometer on July 23, 1999		
	WL in open borehole upon completion of drilling		
No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-27	273.71	5377896.0	349269.4
BH 99-28	273.60	5377876.3	349339.1
BH 99-29	269.77	5377898.1	349419.6

NO.	DATE	BY	REVISION
Geocres No.			
HWY 101	PROJECT NO.: 991-1145	DIST.	
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07	SITE
DRAWN: JFC	CHKD: DEB	APPD.	FIGURE 11



CONT No.
WP No. 258-96-00

HIGHWAY 101
Sta. 12+520 to Sta. 12+700
BOREHOLE LOCATIONS & SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

STRATIGRAPHY LEGEND

	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

NOTES:

- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
- BOREHOLE 31 DRY UPON COMPLETION OF DRILLING

LEGEND

	Borehole
	CPT
N	Blows/0.3m (Std. Pen. Test, 475 J/blow)
	WL in piezometer on July 23, 1999
	WL in open borehole upon completion of drilling

No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-30	265.50	5377888.4	350186.6
BH 99-31	267.49	5377910.6	350277.8

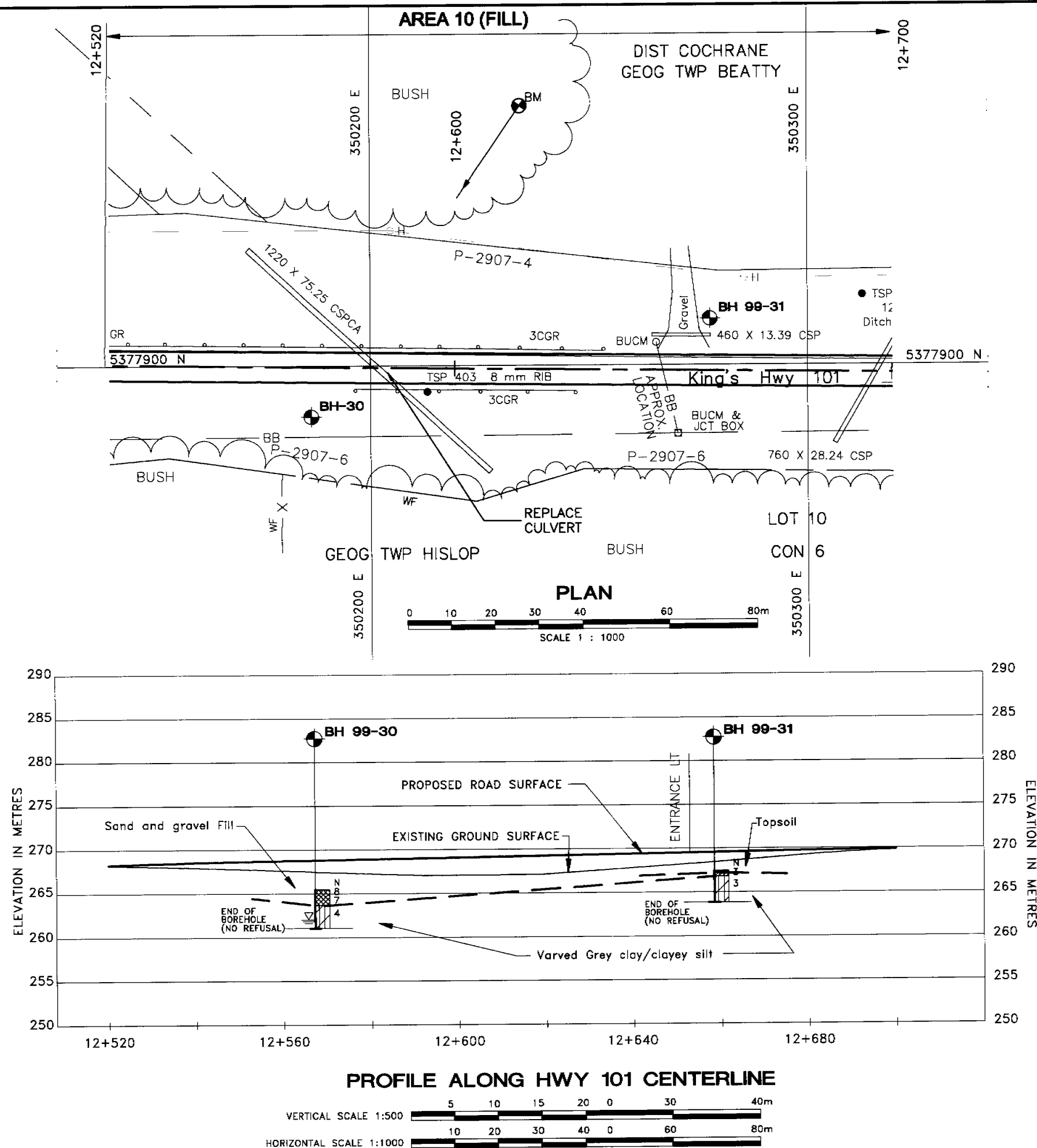
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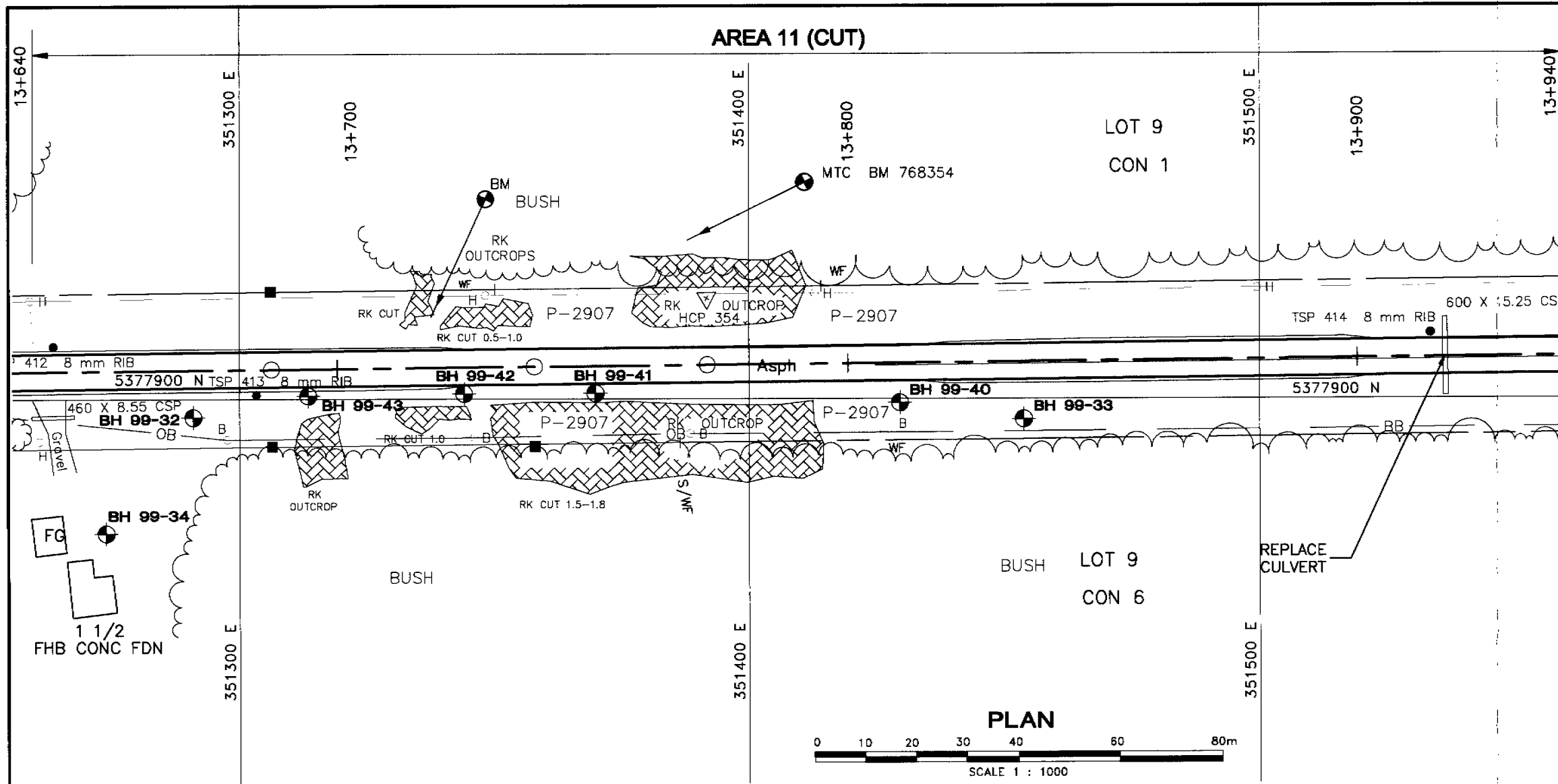
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.

HWY 101	PROJECT NO.: 991-1145	DIST.
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07
DRAWN: JFC	CHKD: DEB	APPD.
		FIGURE 12





CONT No.
WP No. 258-96-00

HIGHWAY 101
Sta. 13+640 to Sta. 13+940
BOREHOLE LOCATIONS & SOIL STRATA

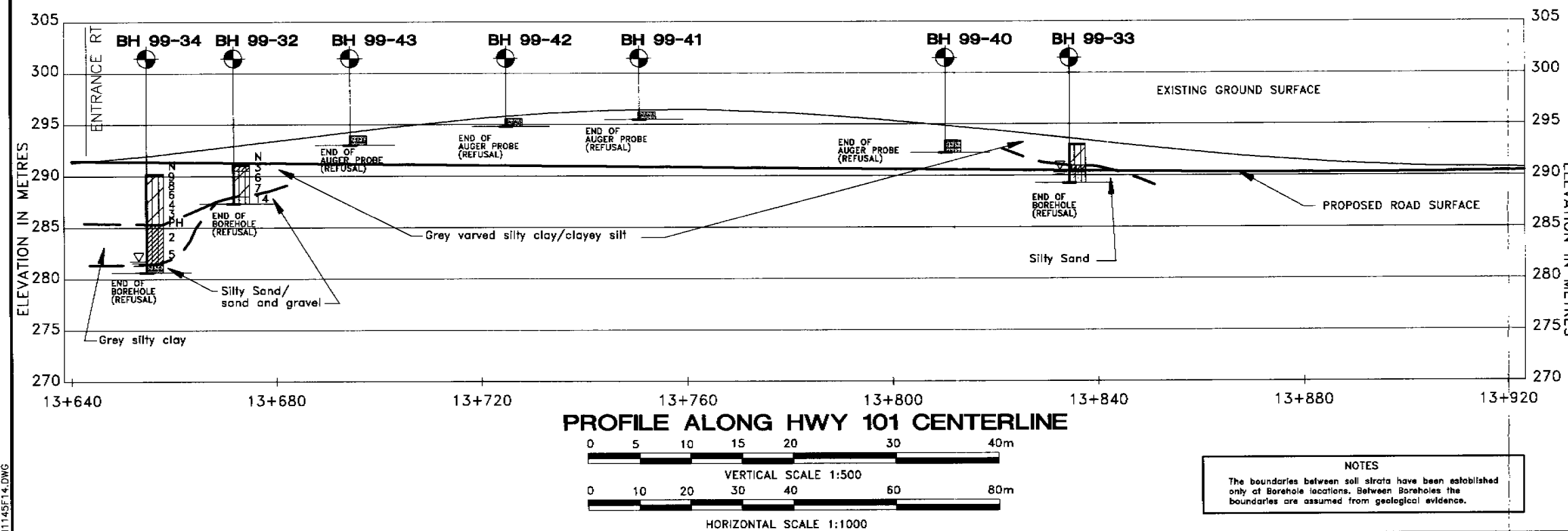
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

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

STRATIGRAPHY LEGEND

	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

- NOTES:**
- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
 - BOREHOLE 32 DRY UPON COMPLETION OF DRILLING



LEGEND			
	Borehole		
	CPT		
N	Blows/0.3m (Std. Pen. Test, 475 j/blow)		
	WL in piezometer on July 23, 1999		
	WL in open borehole upon completion of drilling		
No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
BH 99-32	291.13	5377896.4	351290.9
BH 99-33	293.07	5377896.0	351453.7
BH 99-34	290.24	5377873.6	351273.9
BH 99-40	293.44	5377899.2	351429.6
BH 99-41	296.24	5377901.1	351369.9
BH 99-42	295.57	5377901.0	351344.1
BH 99-43	293.93	5377900.6	351313.7

NO.	DATE	BY	REVISION
Geocres No.			
HWY 101	PROJECT NO.: 991-1145	DIST.	
SUBM'D. DEB	CHKD. DCJ	DATE: 1999 07 07	SITE
DRAWN: JFC	CHKD. DEB	APPD.	FIGURE 13

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

CONT No.
WP No. 258-96-00


SHEET

HIGHWAY 101
Sta. 14+460 to Sta. 14+880
BOREHOLE LOCATIONS & SOIL STRATA

**Golder Associates Ltd.**
MISSISSAUGA, ONTARIO, CANADA

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

STRATIGRAPHY LEGEND

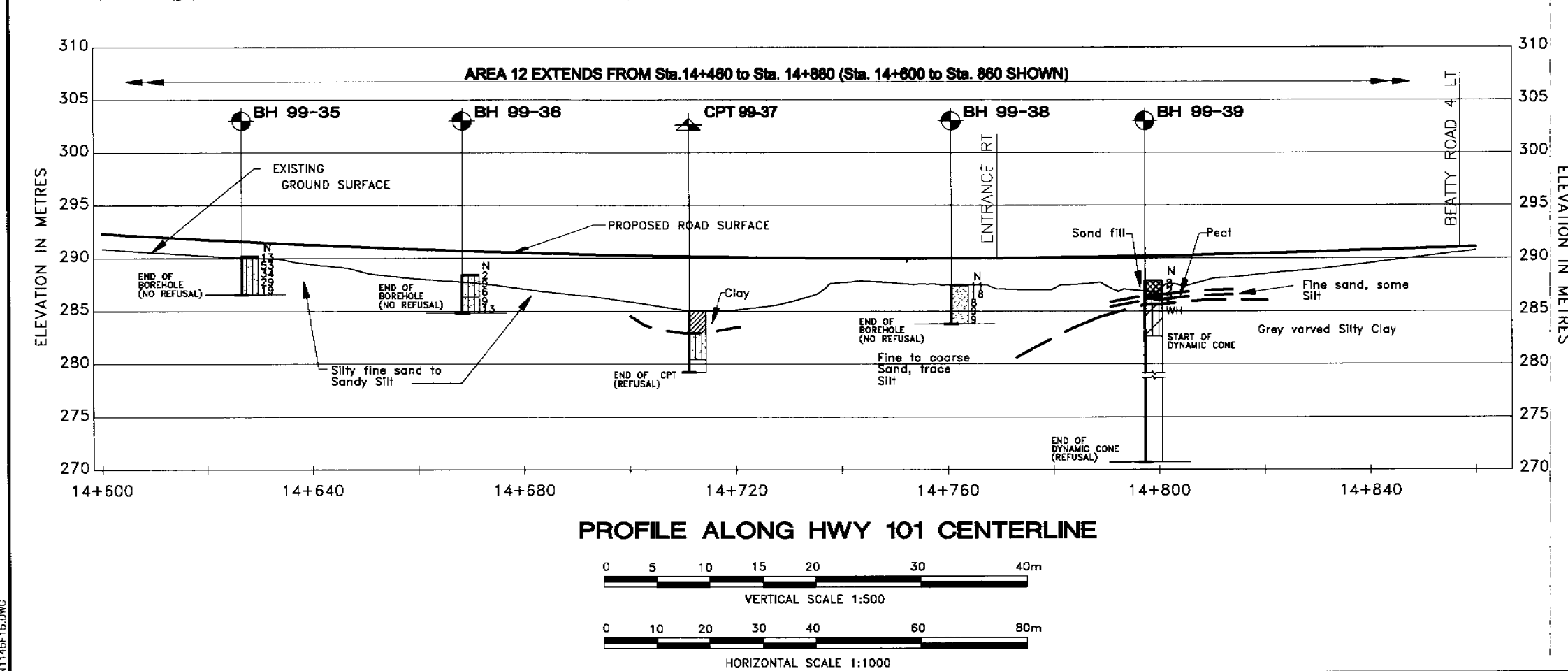
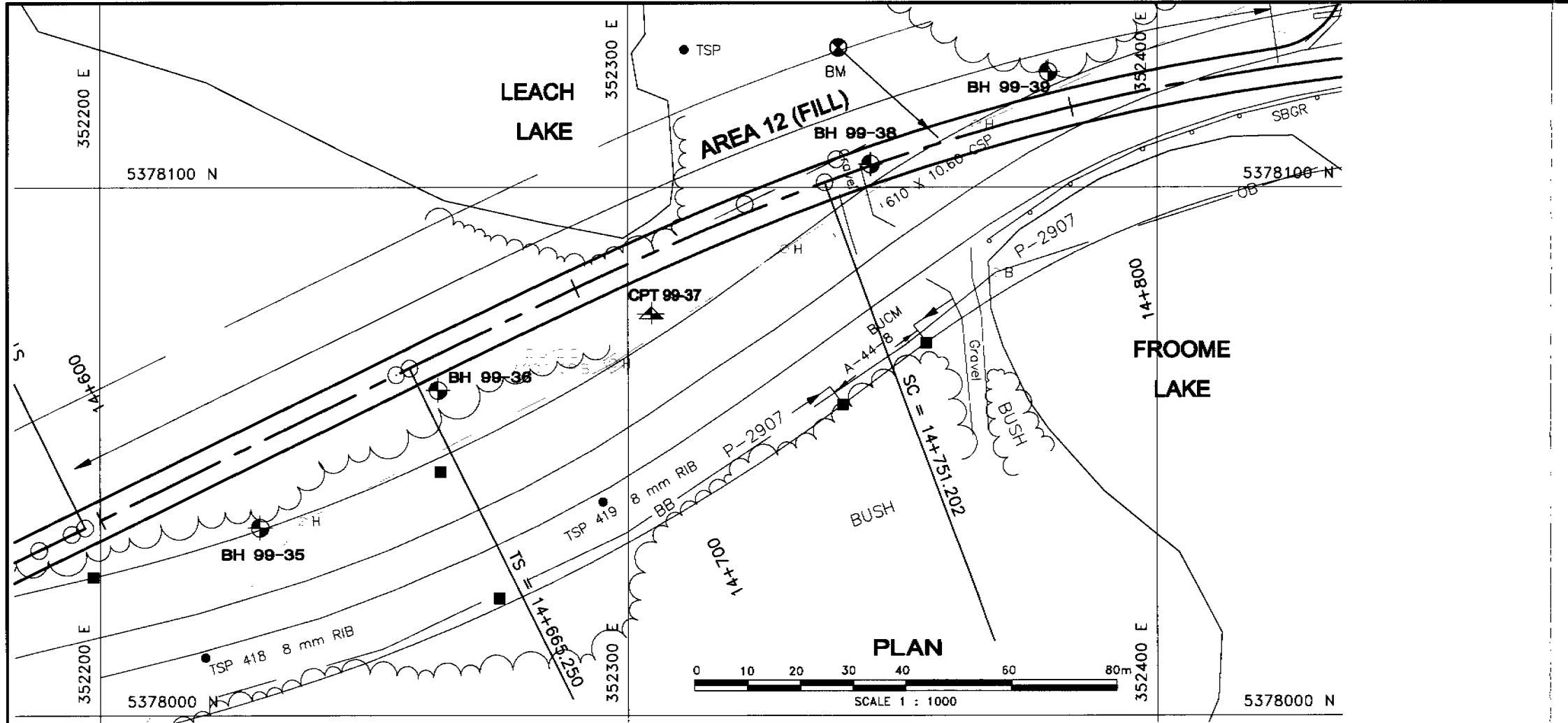
	FILL/TOPSOIL		SILT
	SAND		VARVED/INTERLAYERED CLAYS AND SILTS
	SILTY SAND/SANDY SILT		SILTY CLAY
	SAND AND GRAVEL		CLAY

- NOTES:**
- FOR DETAILED STRATIGRAPHY AT BOREHOLE LOCATIONS REFER TO RECORD OF BOREHOLE SHEETS.
 - BOREHOLES 35, 38 AND 39 DRY UPON COMPLETION OF DRILLING.
 - STRATIGRAPHY FOR CPT 99-37 INTERPRETED FROM CPT RESULTS.

LEGEND			
	Borehole		
	CPT		
N	Blows/0.3m (Std. Pen. Test, 475 j/blow)		
	WL in piezometer on July 23, 1999		
	WL in open borehole upon completion of drilling		
No.	ELEVATION	COORDINATES	
		NORTHING	EASTING
CPT 99-37	286.09	5378076.1	352304.4
BH 99-35	290.44	5378035.6	352230.4
BH 99-36	288.48	5378061.6	352264.2
BH 99-38	287.46	5378104.4	352345.9
BH 99-39	287.93	5378121.8	352379.4

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION
Geocres No.			
HWY 101	PROJECT NO.:	991-1145	DIST.
SUBM'D. DEB	CHKD: DCJ	DATE: 1999 07 07	SITE
DRAWN: JFC	CHKD. DEB	APPD.	FIGURE 14



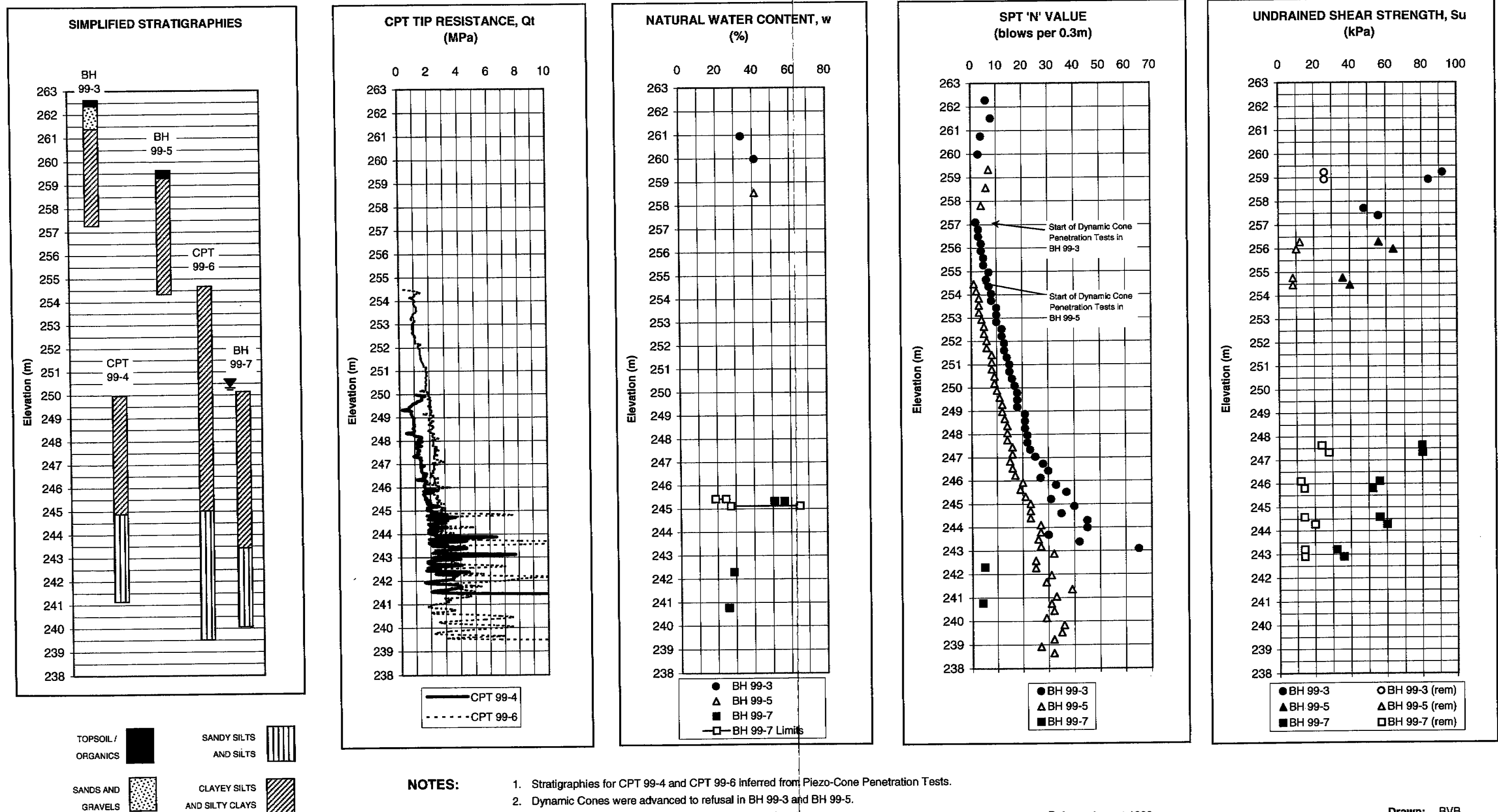
N1145F15.DWG

GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS (m)

BH 99-3	262.6
CPT 99-4	250.0
BH 99-5	259.6
CPT 99-6	254.6
BH 99-7	250.2

AREA 2 SUMMARY OF GEOTECHNICAL DATA HIGHWAY 101 (W.P. 258-96-00)

FIGURE 15



Water level in piezometer on July 23, 1999

Date: August 1999

Project: 991-1145

Golder Associates

Drawn: BVB

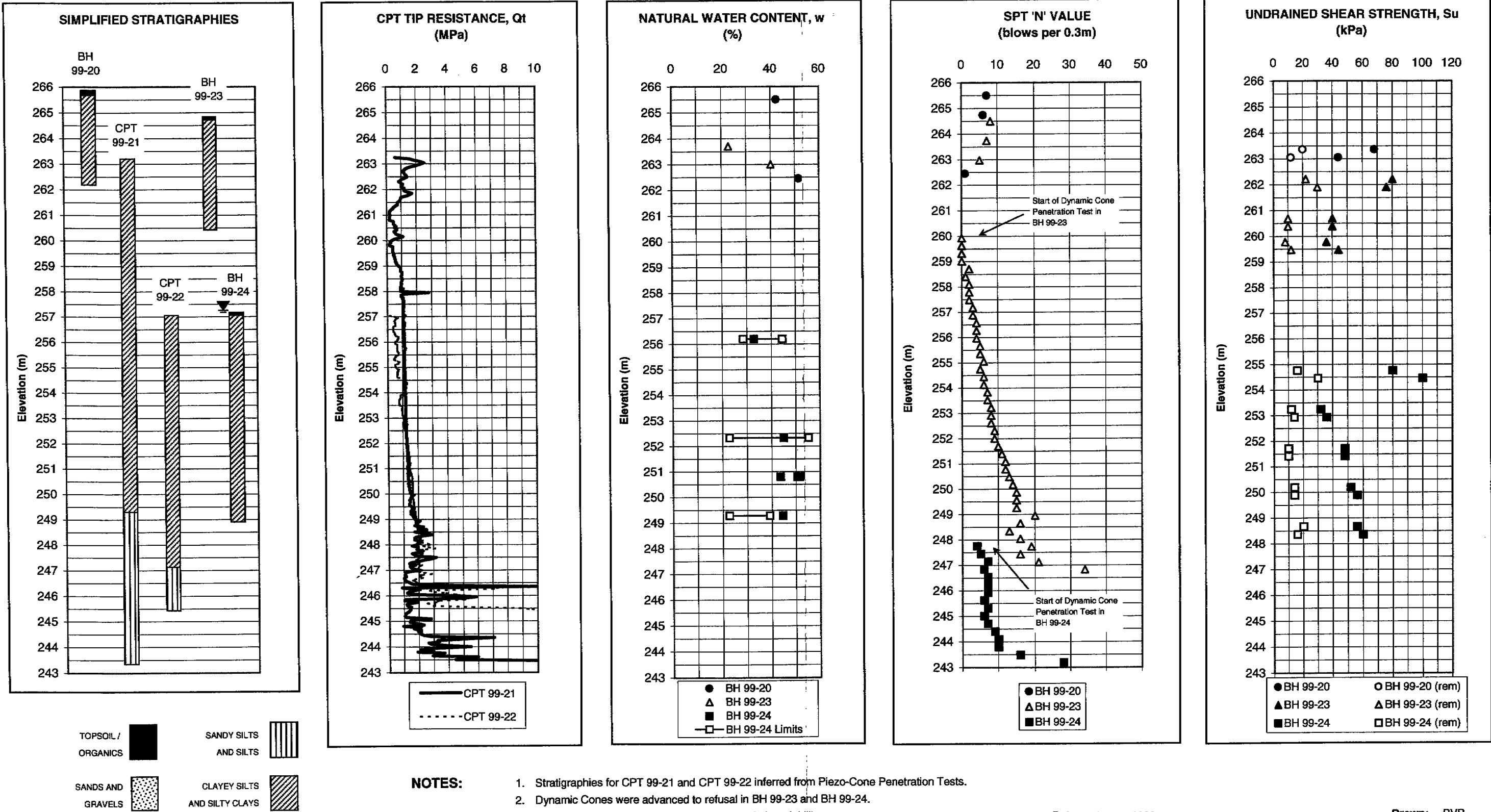
Checked: AJW

GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS (m)

BH 99-20	265.8
CPT 99-21	263.3
CPT 99-22	257.1
BH 99-23	264.8
BH 99-24	257.2

AREA 7
SUMMARY OF GEOTECHNICAL DATA
HIGHWAY 101 (W.P. 258-96-00)

FIGURE 16



Date: August 1999

Project: 991-1145

Golder Associates

Drawn: BVB

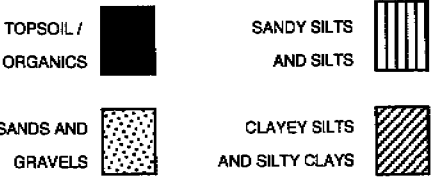
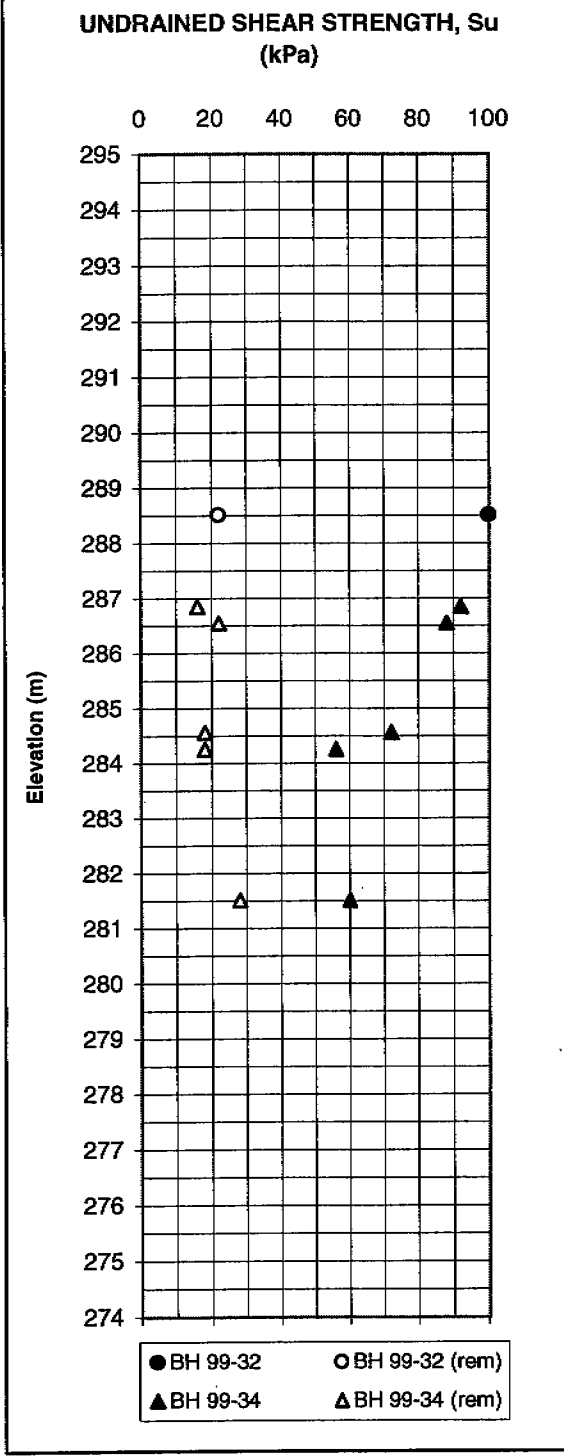
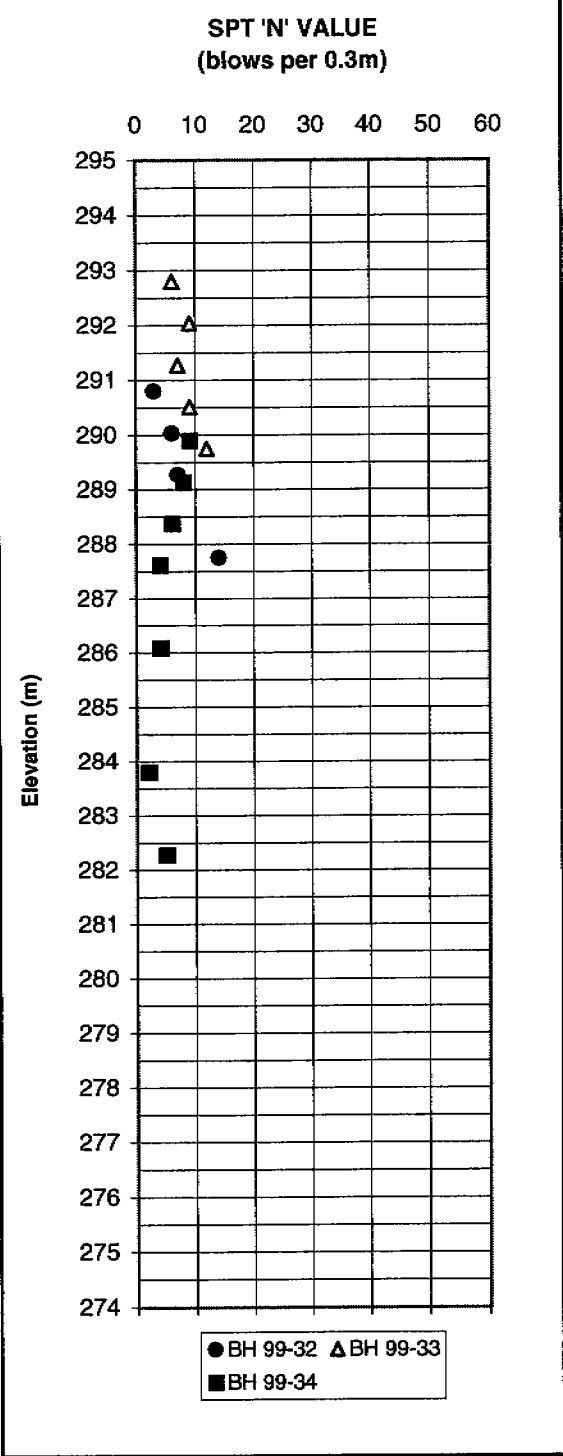
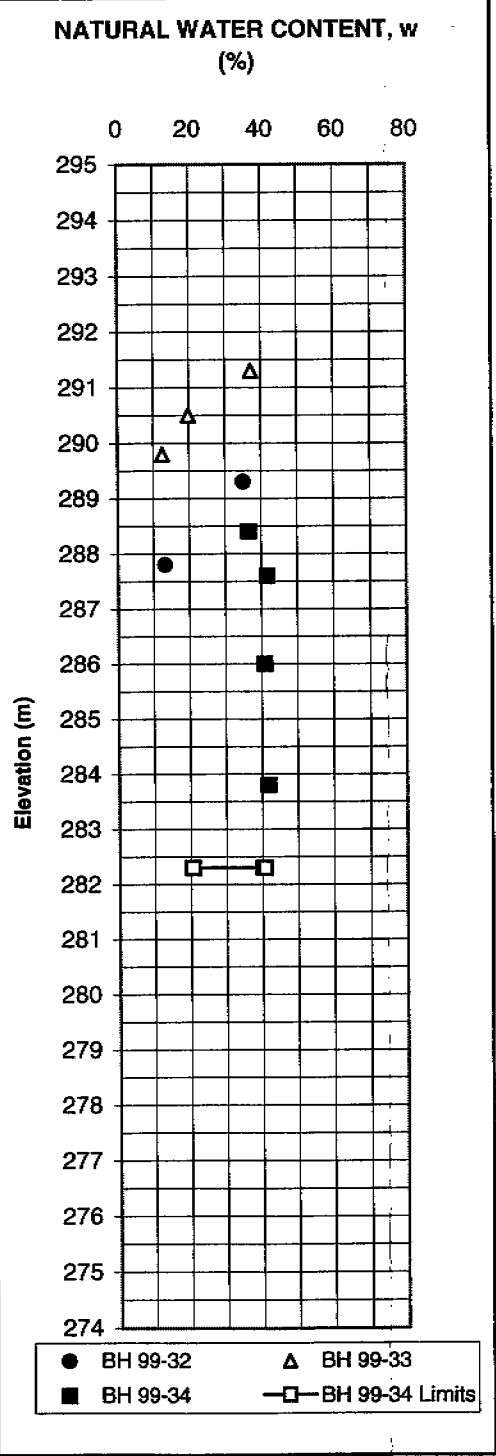
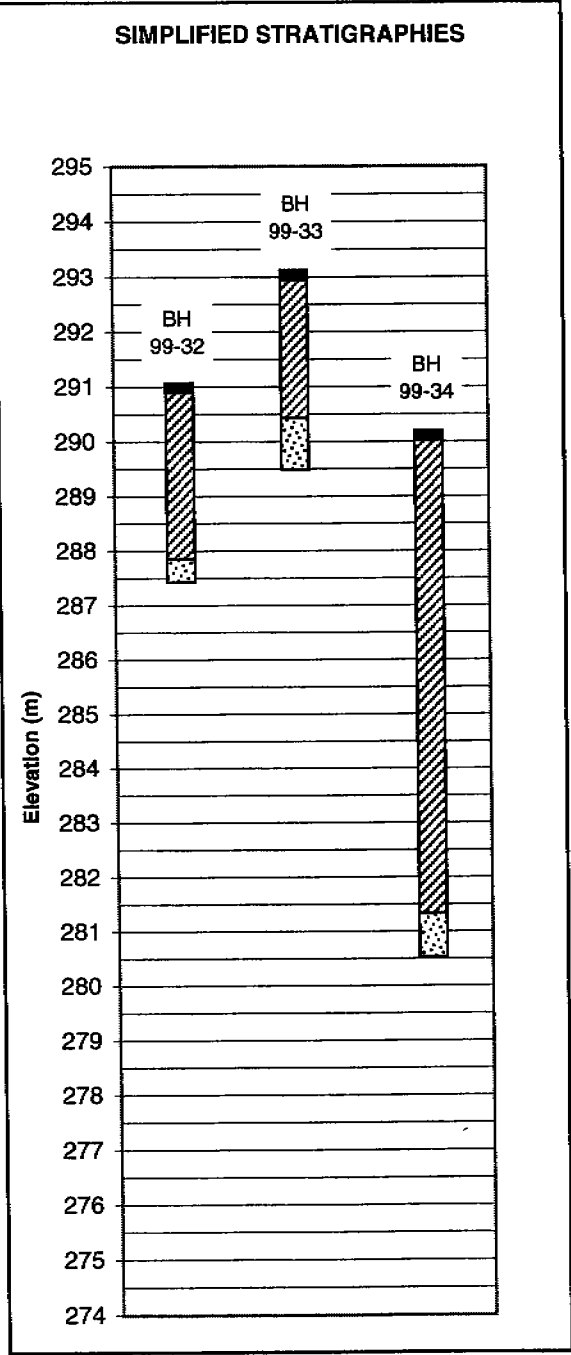
Checked: AJW

GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS (m)

BH 99-32	291.1	Auger Probes:	BH 99-40	293.4
BH 99-33	293.1	(see note)	BH 99-41	296.2
BH 99-34	290.2		BH 99-42	295.6
			BH 99-43	293.9

AREA 11
SUMMARY OF GEOTECHNICAL DATA
HIGHWAY 101 (W.P. 258-96-00)

FIGURE 17



- NOTES:
1. For Auger Probes 99-40 to 99-43, see Record of Borehole sheets.
 2. BH 99-32 was dry upon completion of drilling.

Water level in piezometer on July 23, 1999

Date: August 1999

Project: 991-1145

Golder Associates

Drawn: BVB

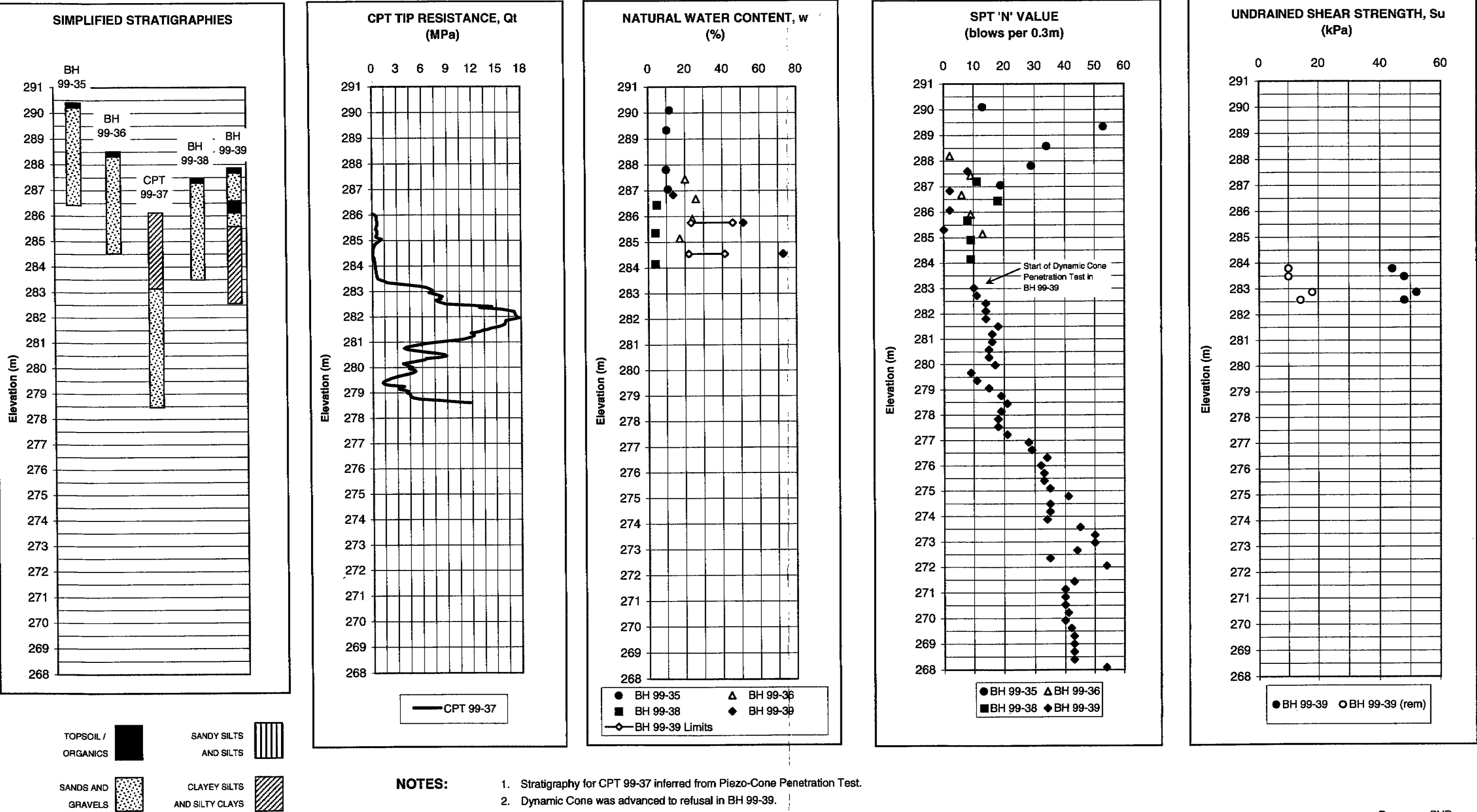
Checked: AJW

GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS (m)

BH 99-35	290.4
BH 99-36	288.5
CPT 99-37	286.1
BH 99-38	287.5
BH 99-39	287.9

AREA 12
SUMMARY OF GEOTECHNICAL DATA
HIGHWAY 101 (W.P. 258-96-00)

FIGURE 18



NOTES:

1. Stratigraphy for CPT 99-37 inferred from Piezo-Cone Penetration Test.
2. Dynamic Cone was advanced to refusal in BH 99-39.
3. BH 99-35, BH 99-38 and BH 99-39 were dry upon completion of drilling.
4. The piezometer in BH 99-36 was dry on July 23, 1999.

Date: August 1999

Project: 991-1145

Golder Associates

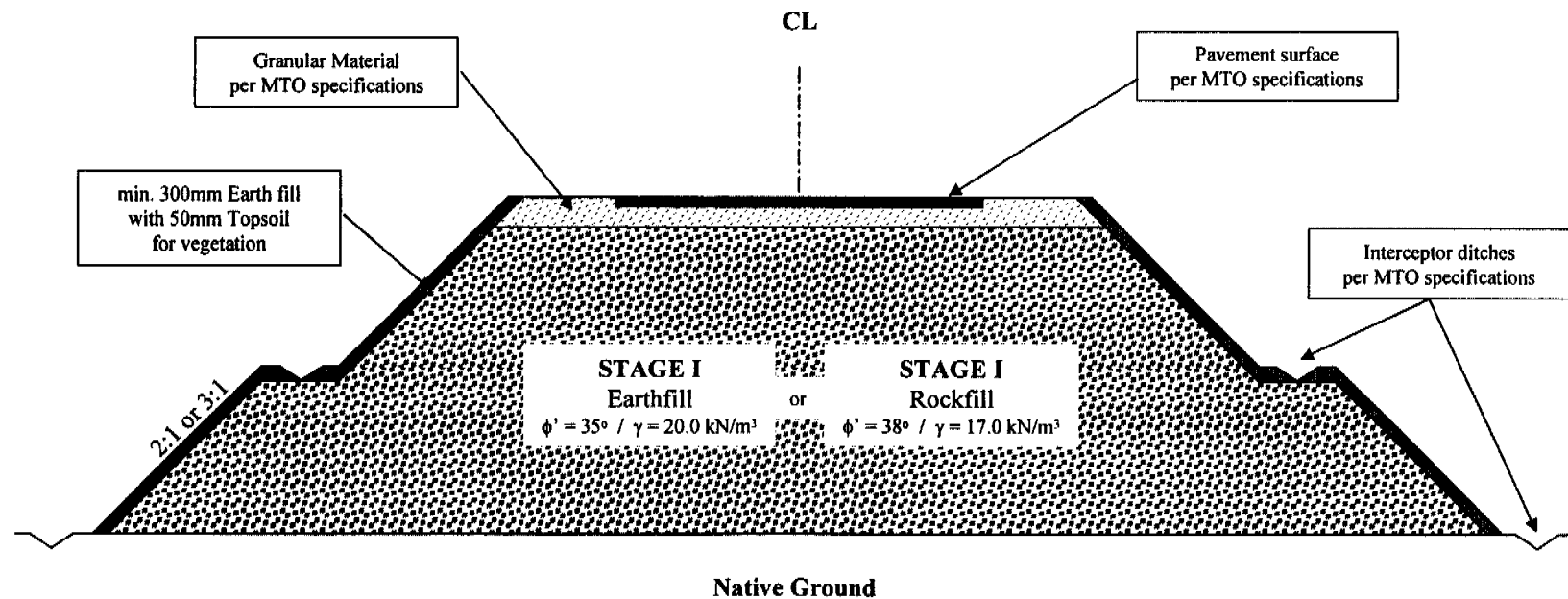
Drawn: BVB

Checked: AJW

Water level in piezometer on July 23, 1999

**OPTION I: Earthfill and Rockfill
Highway 101 (W.P. 258-96-00)**

Figure 19A



Date : Aug 1999

Drawn : BVB

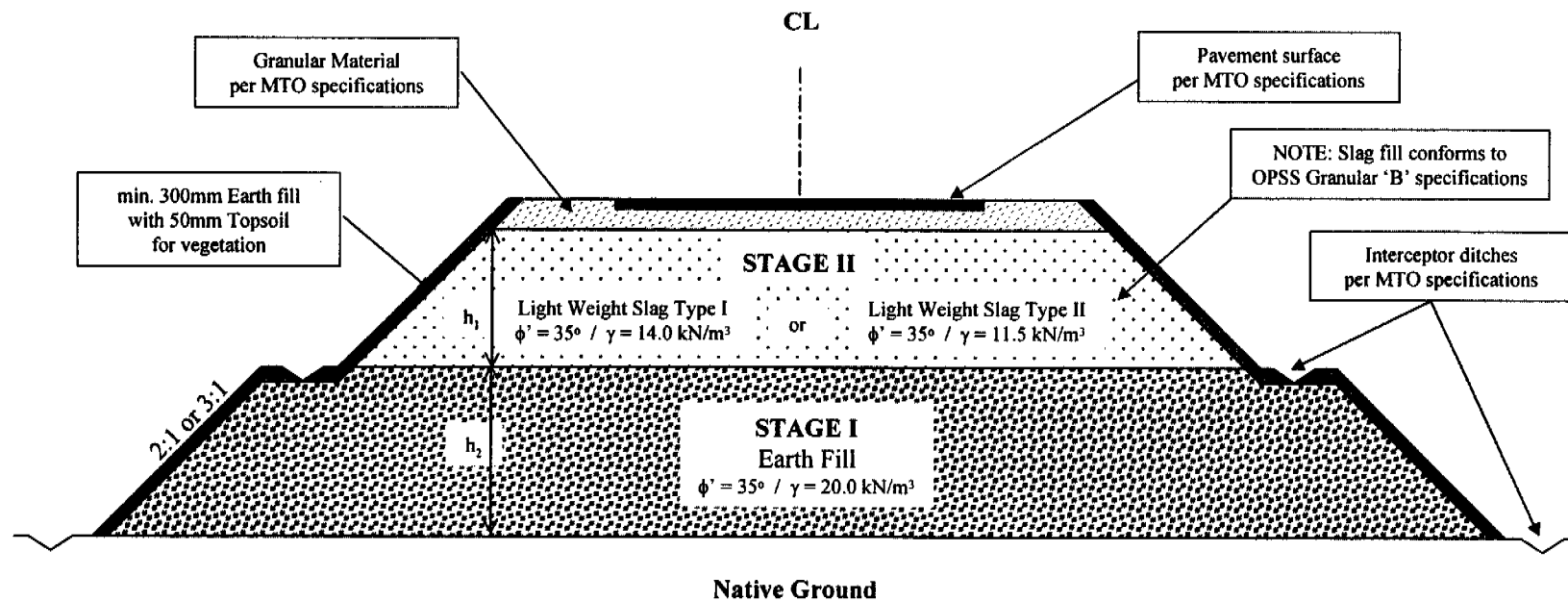
Project : 991-1145

Golder Associates

Checked : AJW

**OPTION 2: Composite Earthfill / Slag
Highway 101 (W.P. 258-96-00)**

Figure 19B



Date : Aug 1999

Project : 991-1145

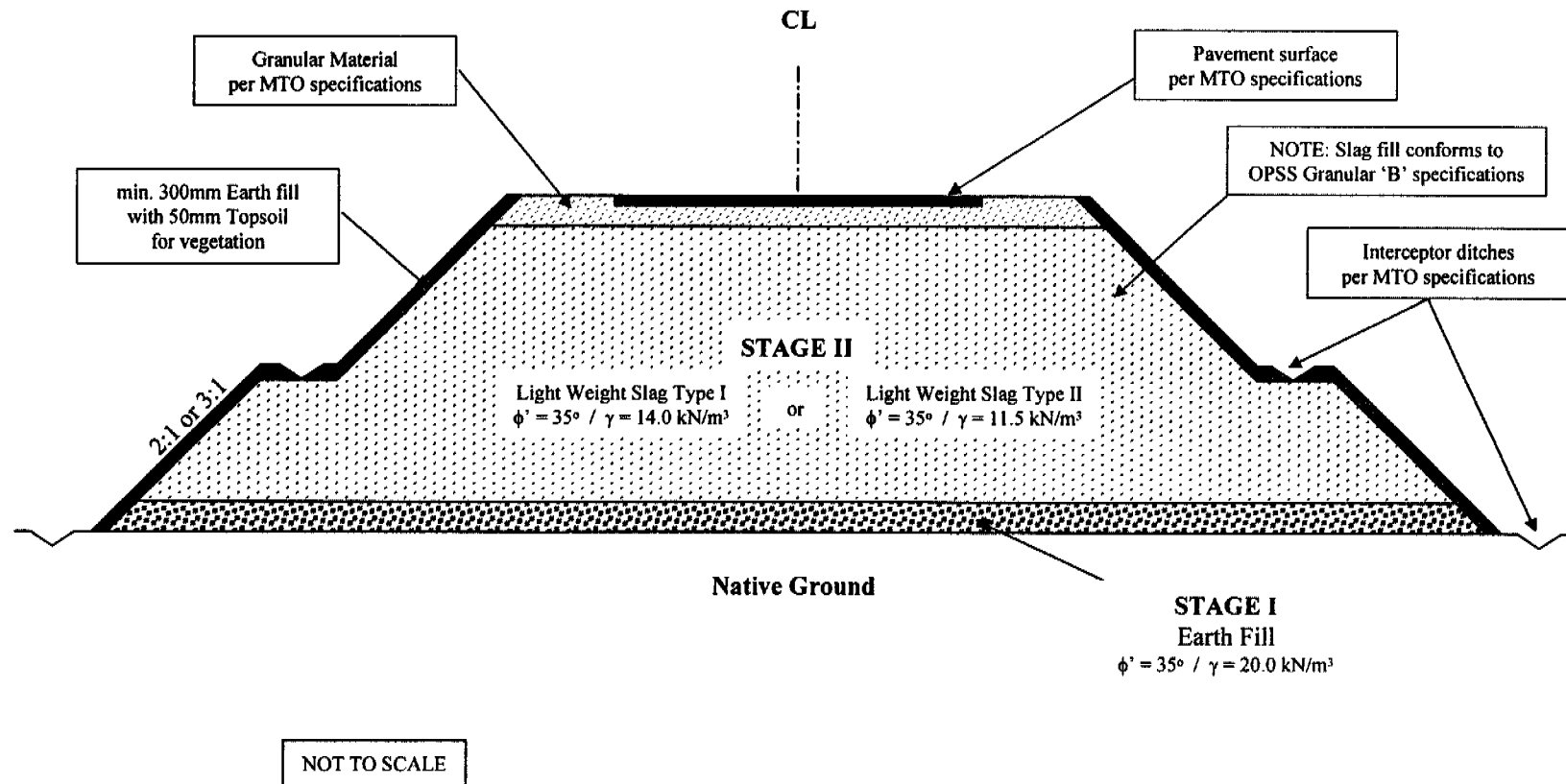
Golder Associates

Drawn : BVB

Checked : AJW

**OPTION 3: Light Weight Slag
Highway 101 (W.P. 258-96-00)**

Figure 19C



Date : Aug 1999

Project : 991-1145

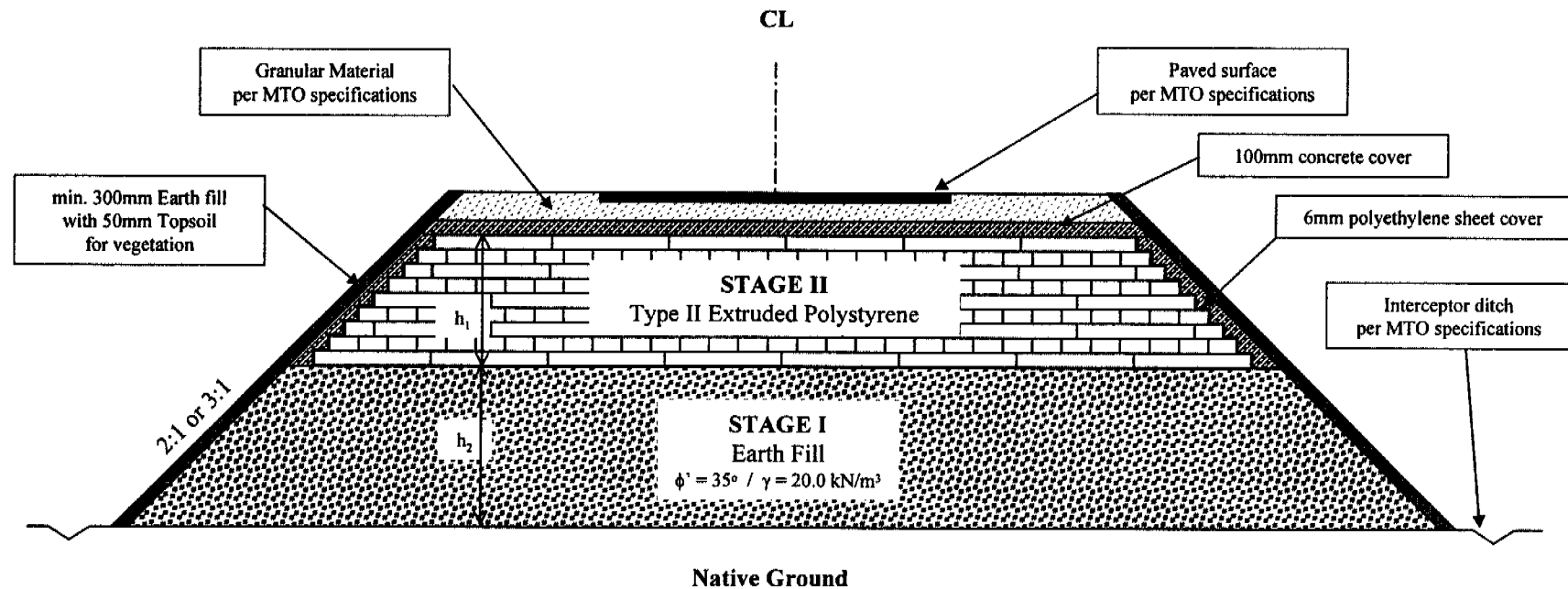
Golder Associates

Drawn : BVB

Checked : AJW

**OPTION 4: Composite Earthfill / Polystyrene
Highway 101 (W.P. 258-96-00)**

Figure 19D



NOT TO SCALE

Date : Aug 1999

Project : 991-1145

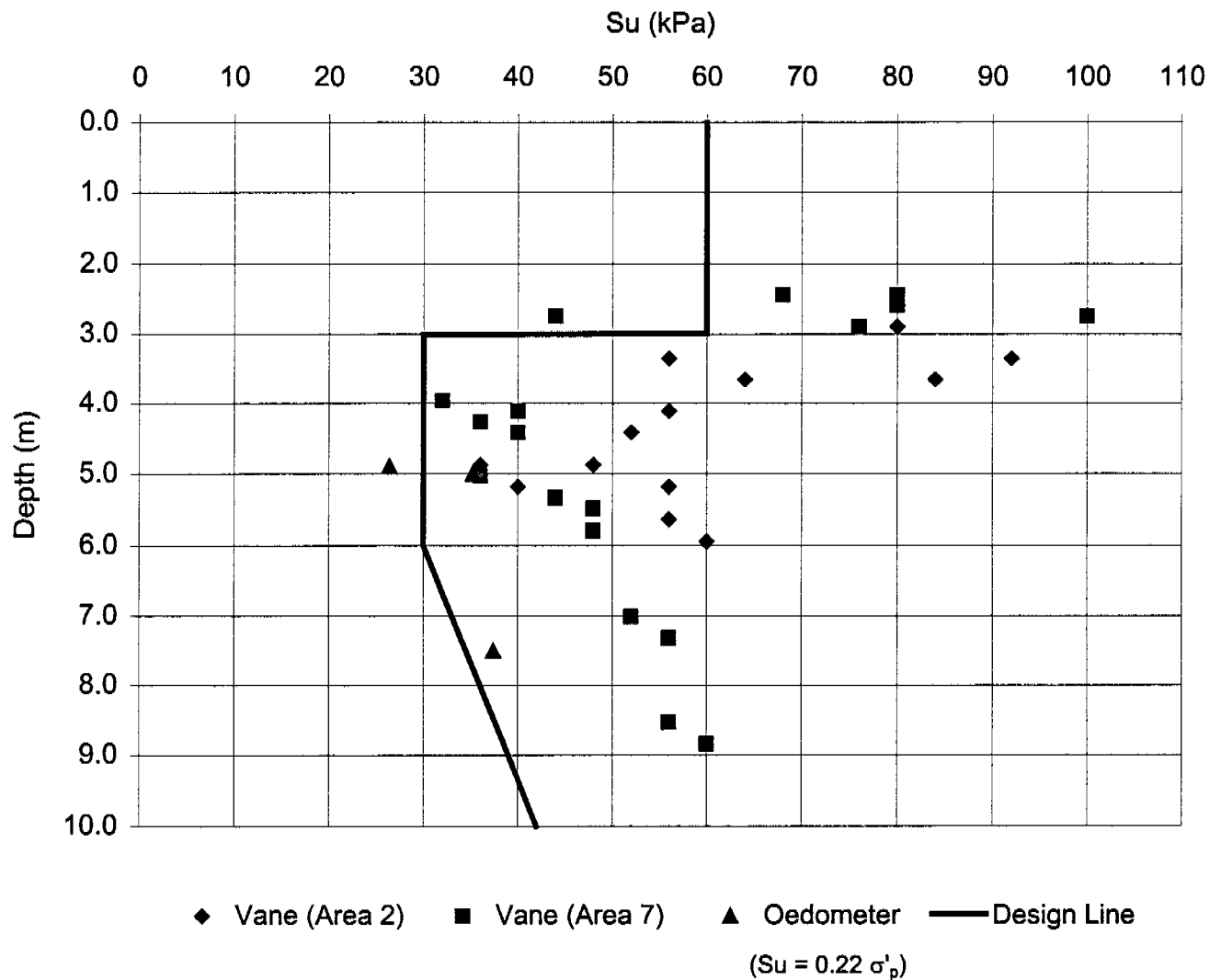
Golder Associates

Drawn : BVB

Checked : AJW

**Undrained Shear Strength Design Curve (Areas 2 & 7)
Highway 101 (W.P. 258-96-00)**

Figure 20



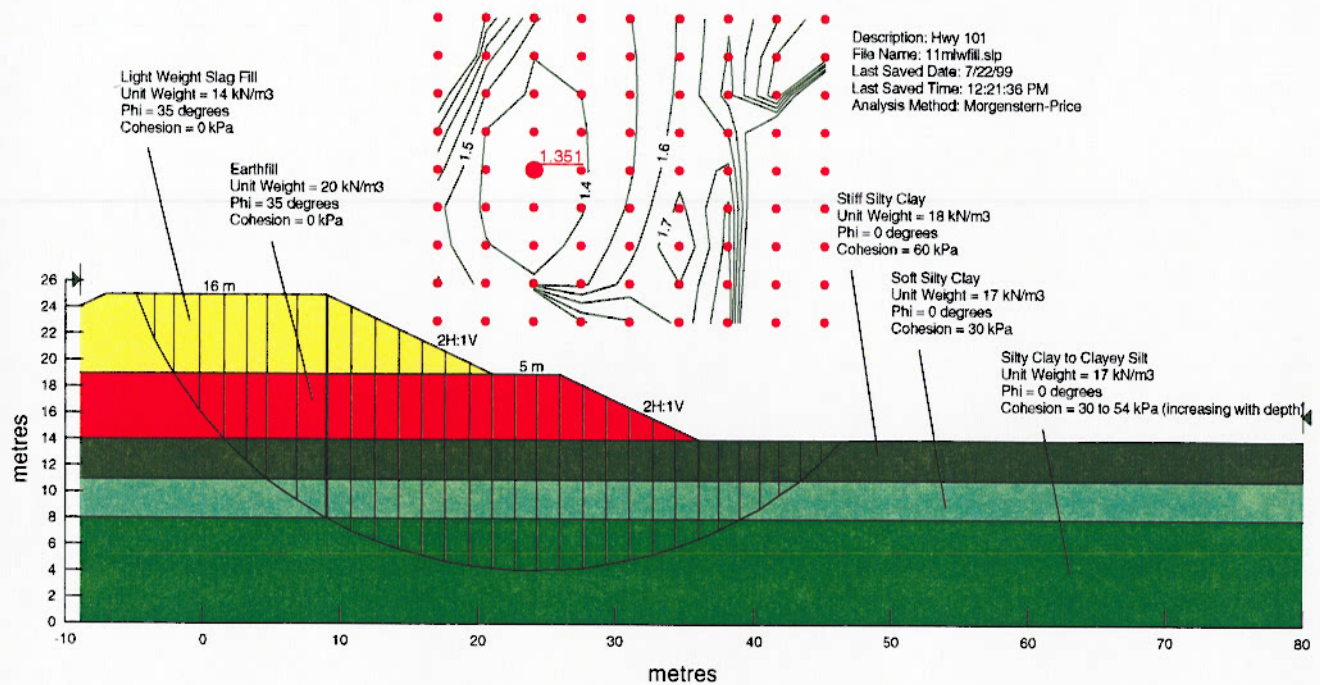
Date: August 1999
Project: 991-1145

Golder Associates

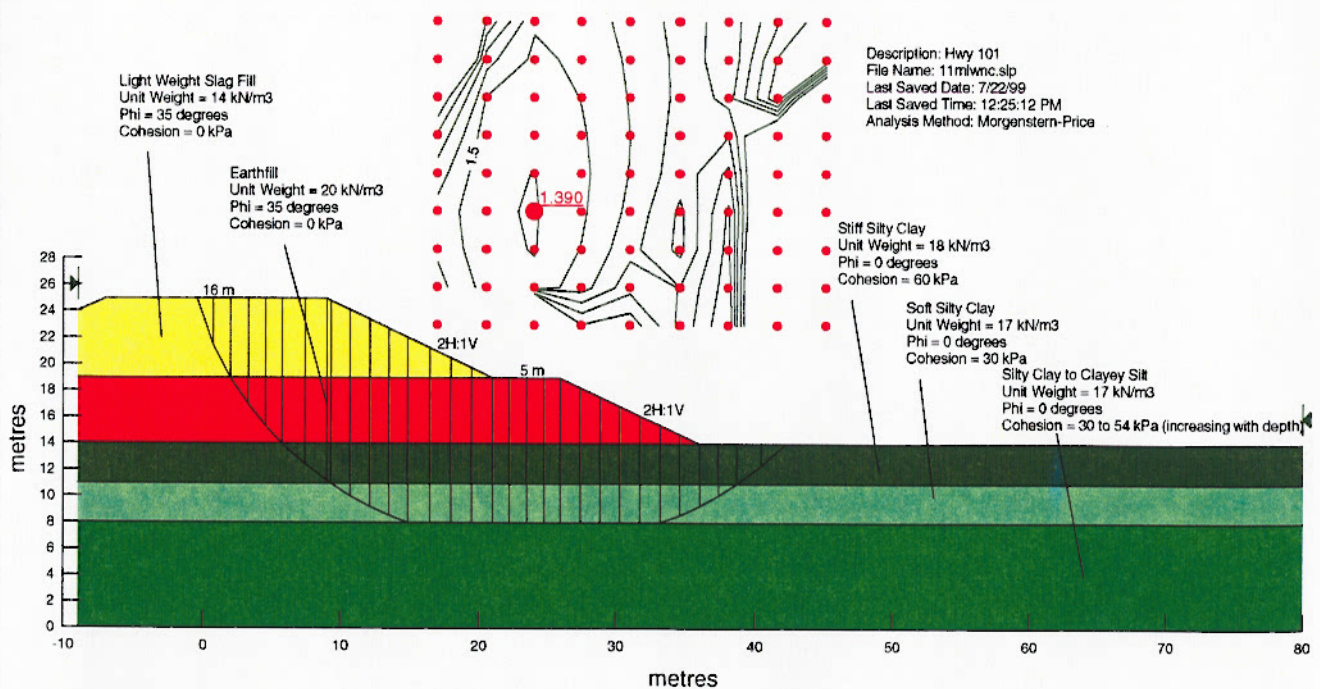
Drawn: DCJ
Checked: AJW

Slope Stability Analysis (Composite Slag, Areas 2 & 7) Highway 101 (W.P. 258-96-00)

Figure 22



Circular Trial Surface



Composite Trial Surface

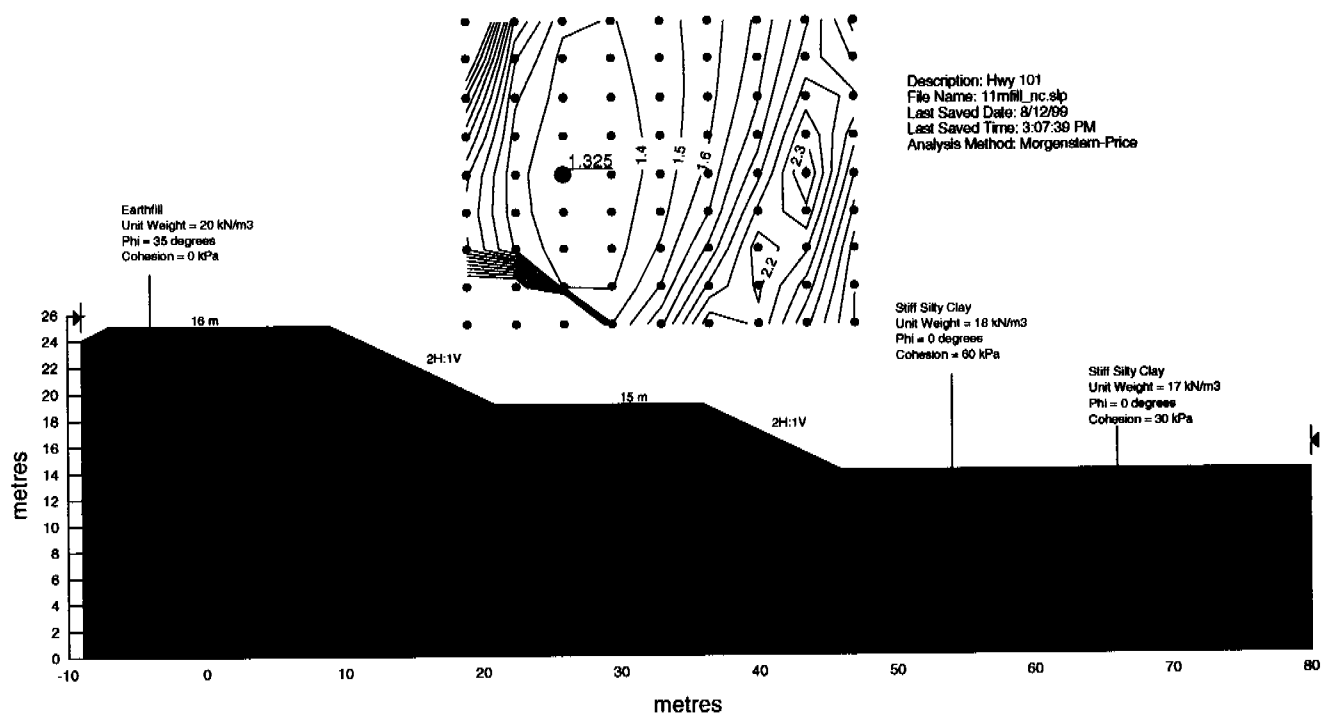
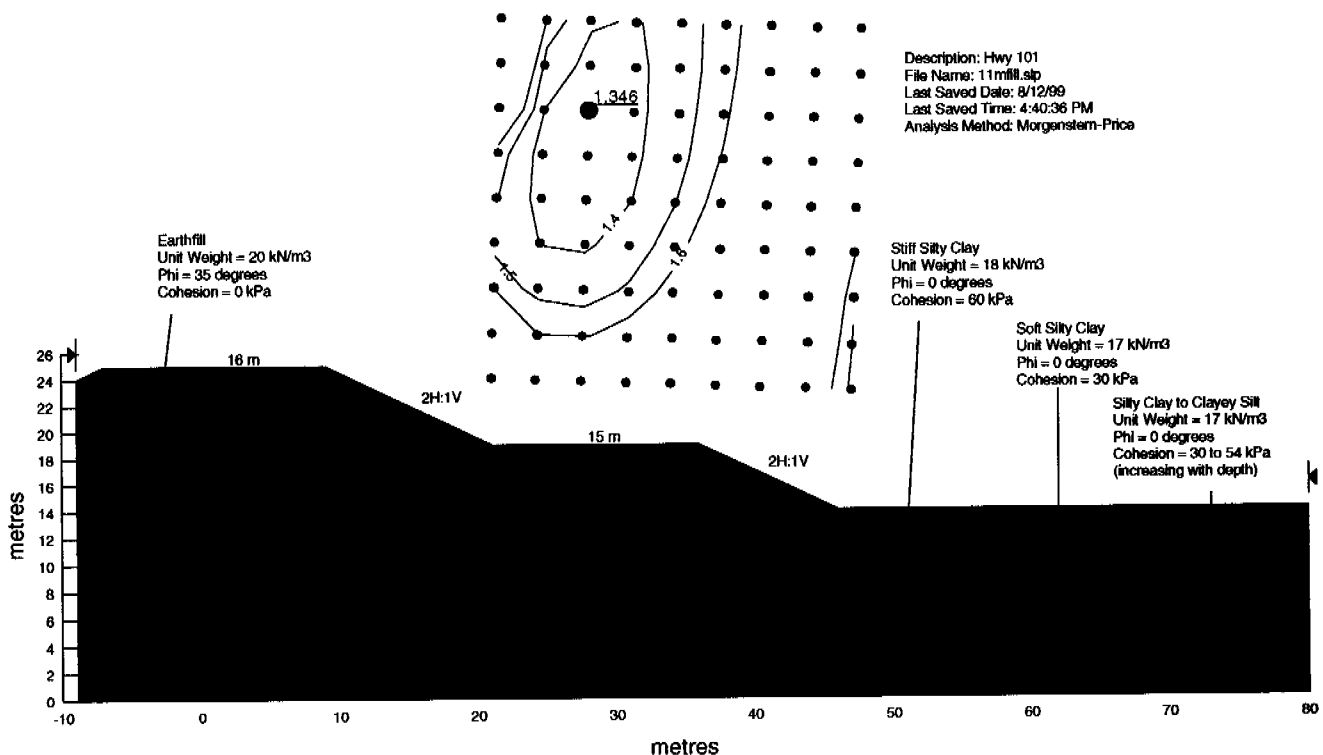
Date: August 1999
Project: 991-1145

Golder Associates

Drawn: DCJ
Checked: AJW

Slope Stability Analysis (Earthfill, Areas 2 & 7) **Highway 101 (W.P. 258-96-00)**

Figure 21



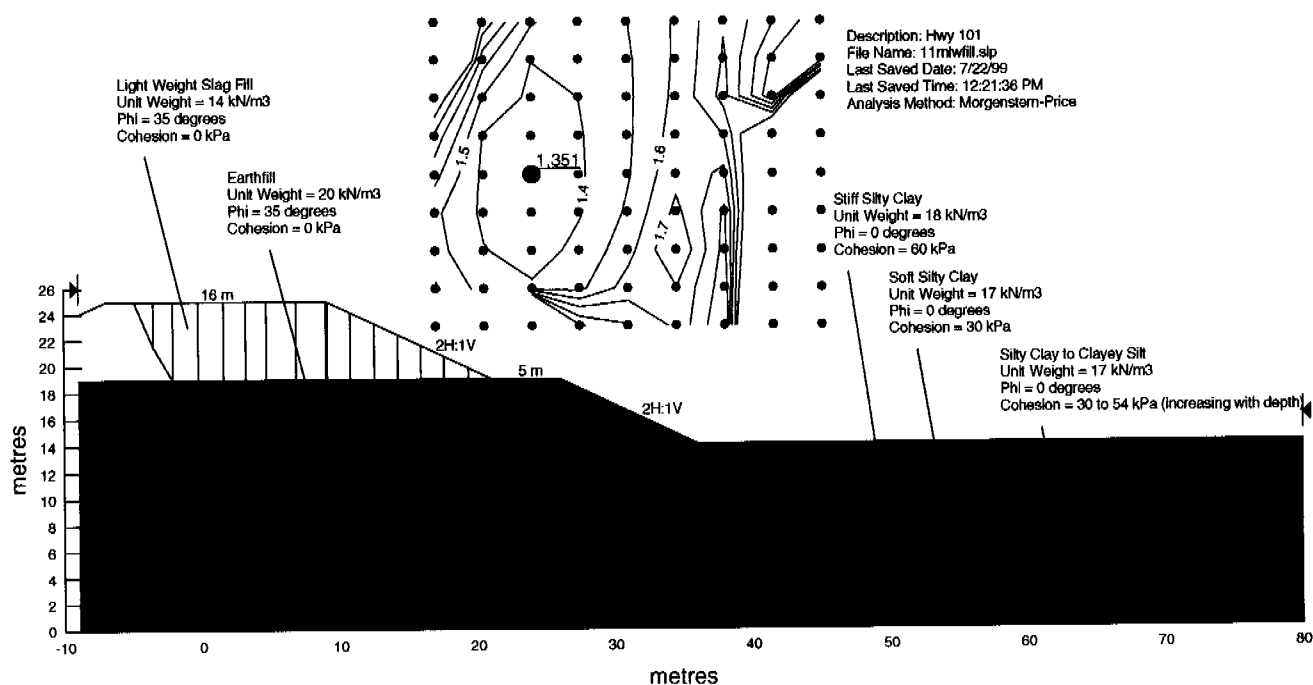
Date: August 1999
 Project: 991-1145

Golder Associates

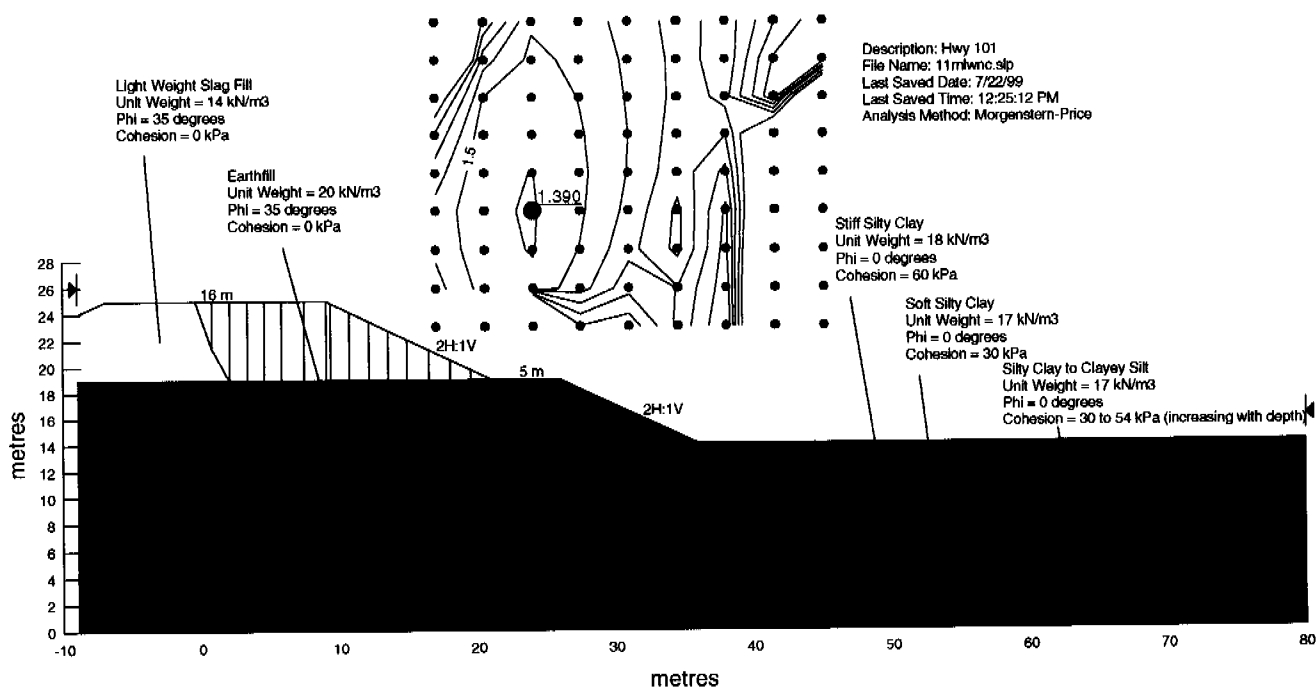
Drawn: DCJ
 Checked: AJW

Slope Stability Analysis (Composite Slag, Areas 2 & 7) **Highway 101 (W.P. 258-96-00)**

Figure 22



Circular Trial Surface



Composite Trial Surface

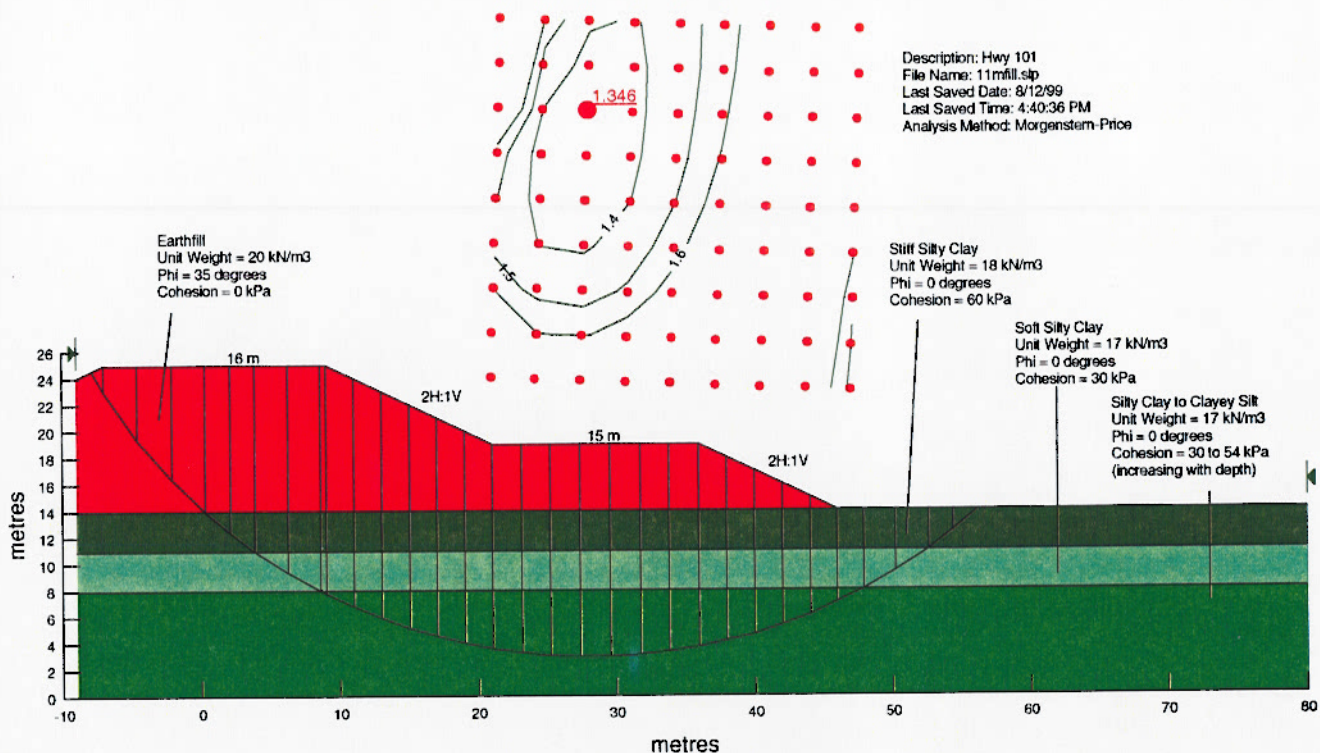
Date: August 1999
 Project: 991-1145

Golder Associates

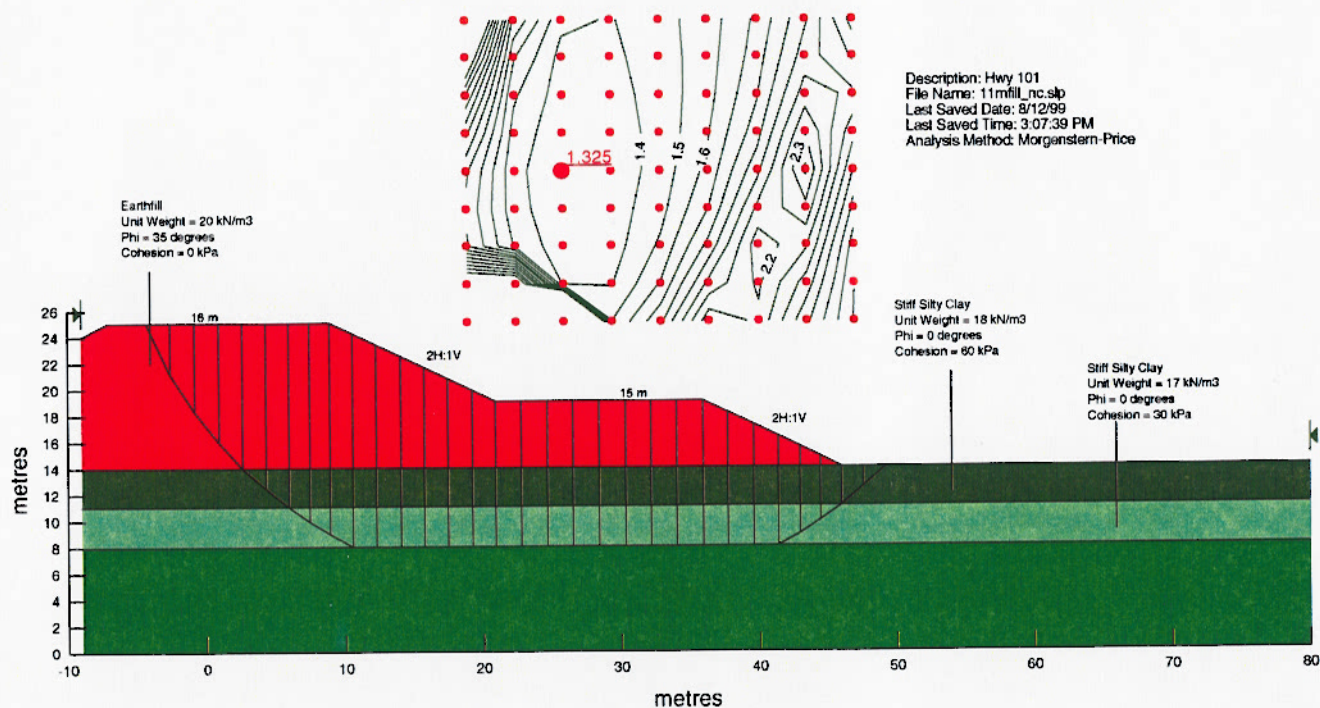
Drawn: DCJ
 Checked: AJW

Slope Stability Analysis (Earthfill, Areas 2 & 7) Highway 101 (W.P. 258-96-00)

Figure 21



Circular Trial Surface



Composite Trial Surface

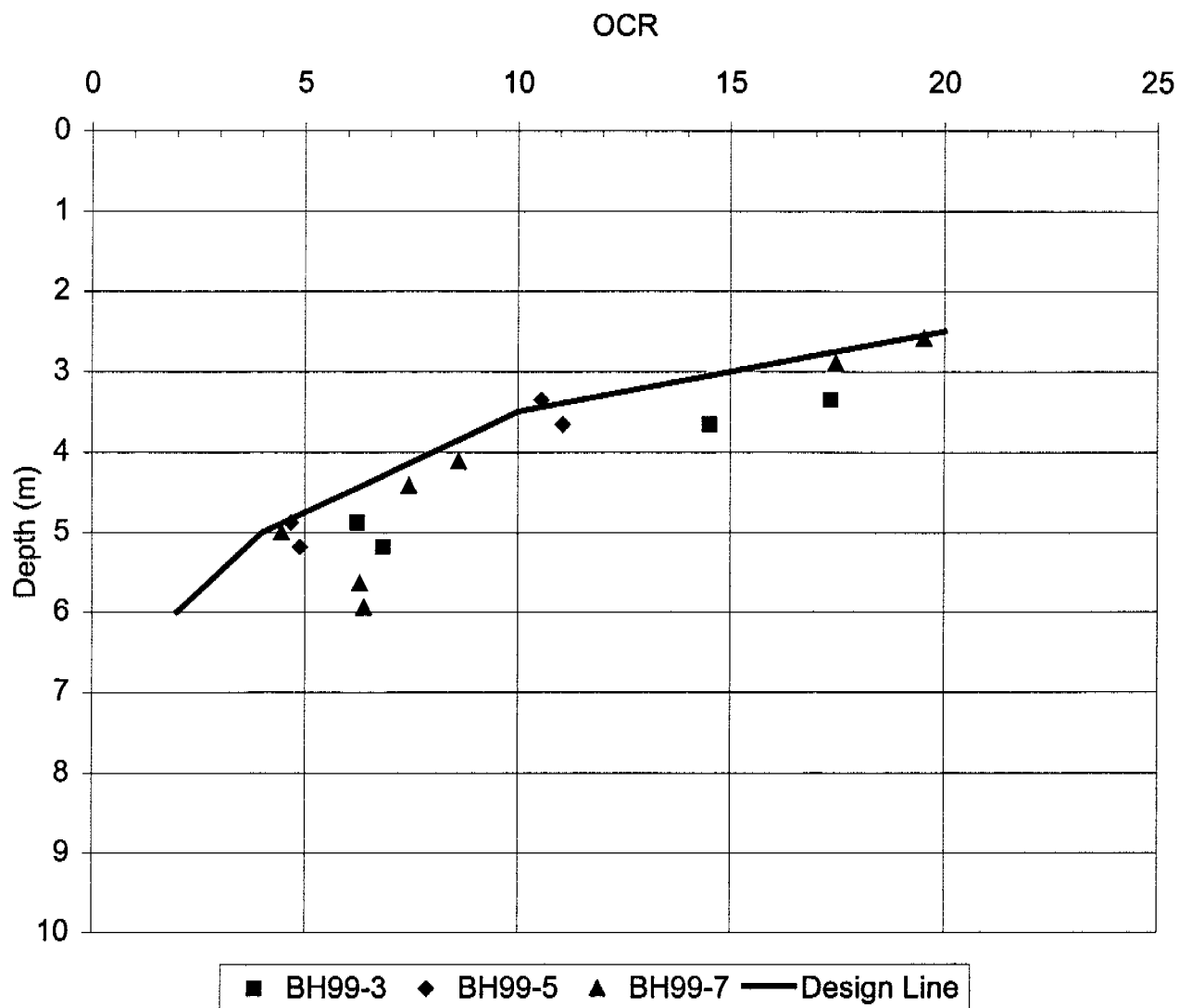
Date: August 1999
Project: 991-1145

Golder Associates

Drawn: DCJ
Checked: AJW

OCR versus Depth (Area 2)
Highway 101 (W.P. 258-96-00)

Figure 23



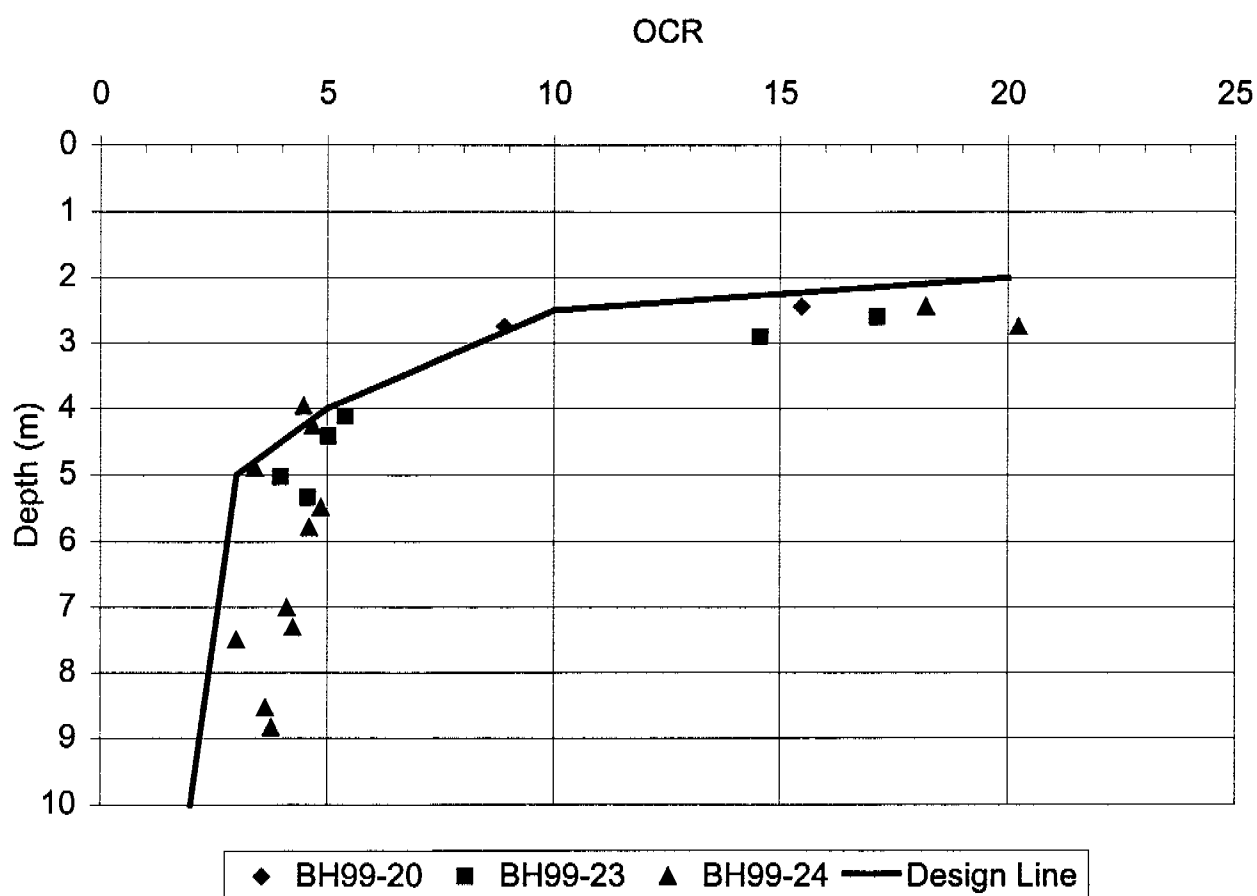
Date: August 1999
Project: 991-1145

Golder Associates

Drawn: AJW
Checked: DEB

OCR versus Depth (Area 7)
Highway 101 (W.P. 258-96-00)

Figure 24



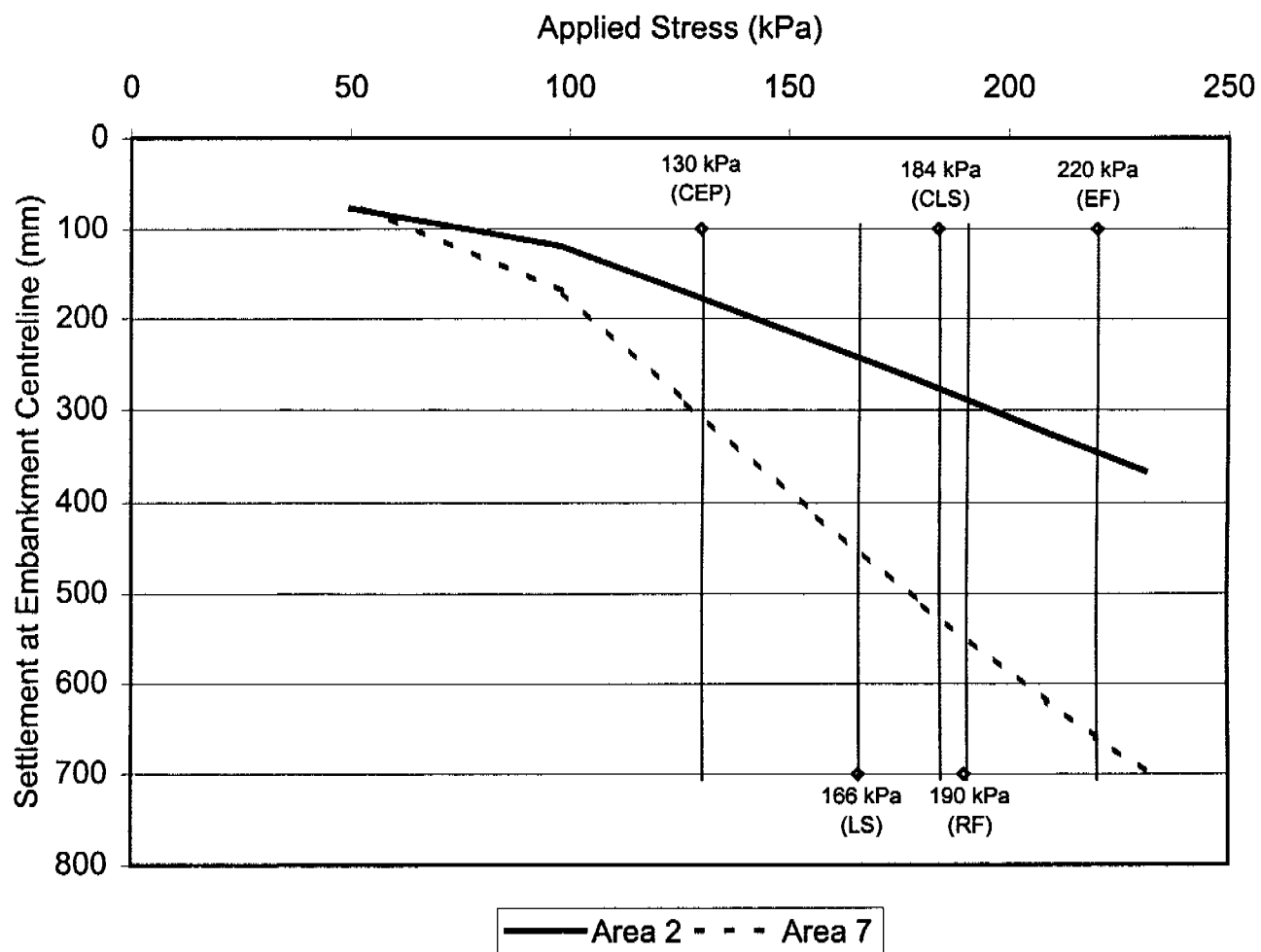
Date: August 1999
Project: 991-1145

Golder Associates

Drawn: AJW
Checked: DEB

**Settlement versus Applied Stress (Areas 2 and 7)
Highway 101 (W.P. 258-96-00)**

Figure 25



NOTES: EF = Earthfill
 RF = Rockfill
 CLS = Composite Lightweight Slag
 LS = Lightweight Slag
 CEP = Composite Extruded Polystyrene
 (Applied stress values are for an 11 m high embankment)

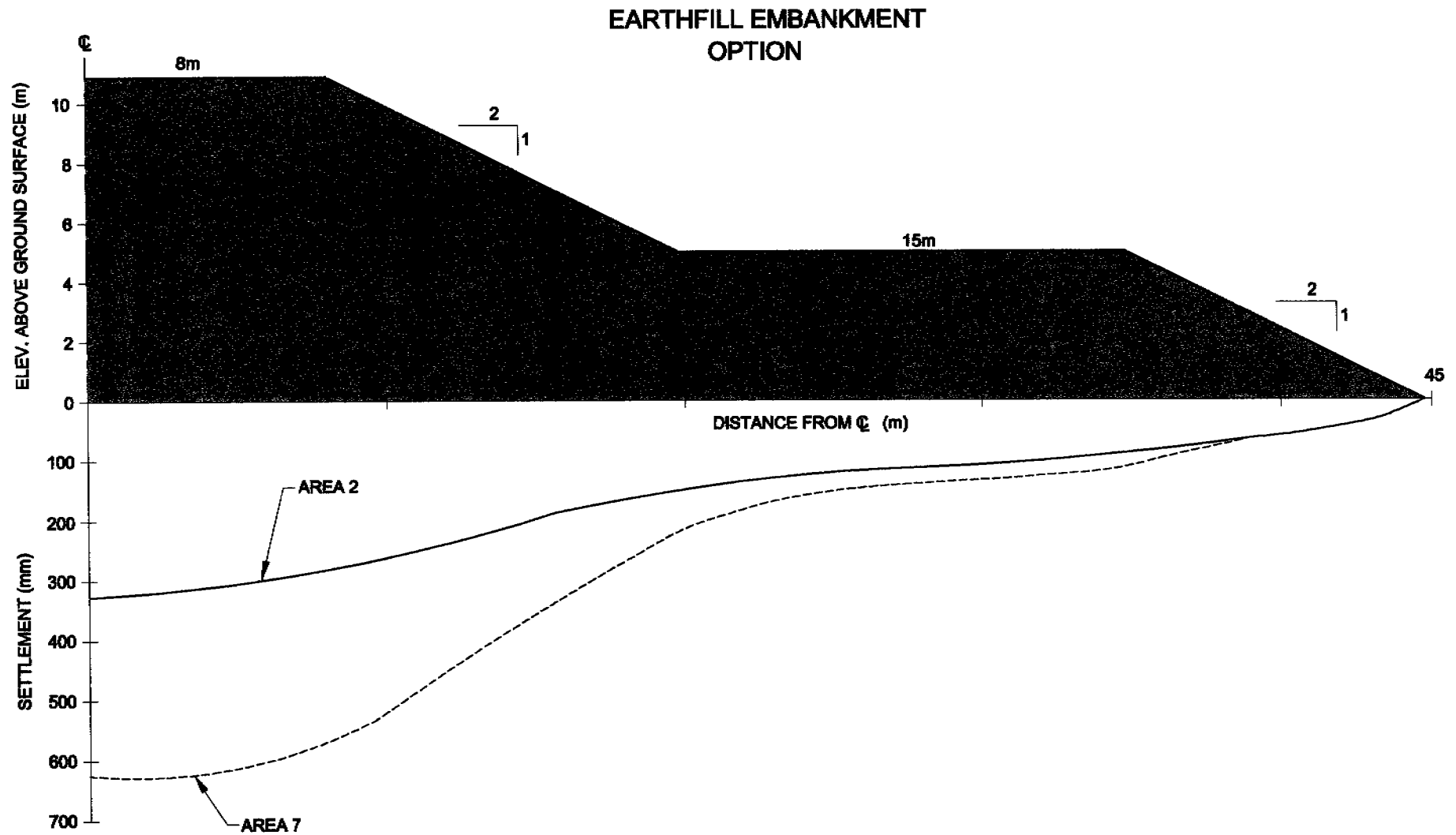
Date: August 1999
 Project: 991-1145

Golder Associates

Drawn: AJW
 Checked: DEB

SETTLEMENT PROFILES
AREAS 2 & 7
HIGHWAY 101 (W.P. 258-96-00)

FIGURE 26



Date AUGUST...1999..

Project .991...1145...

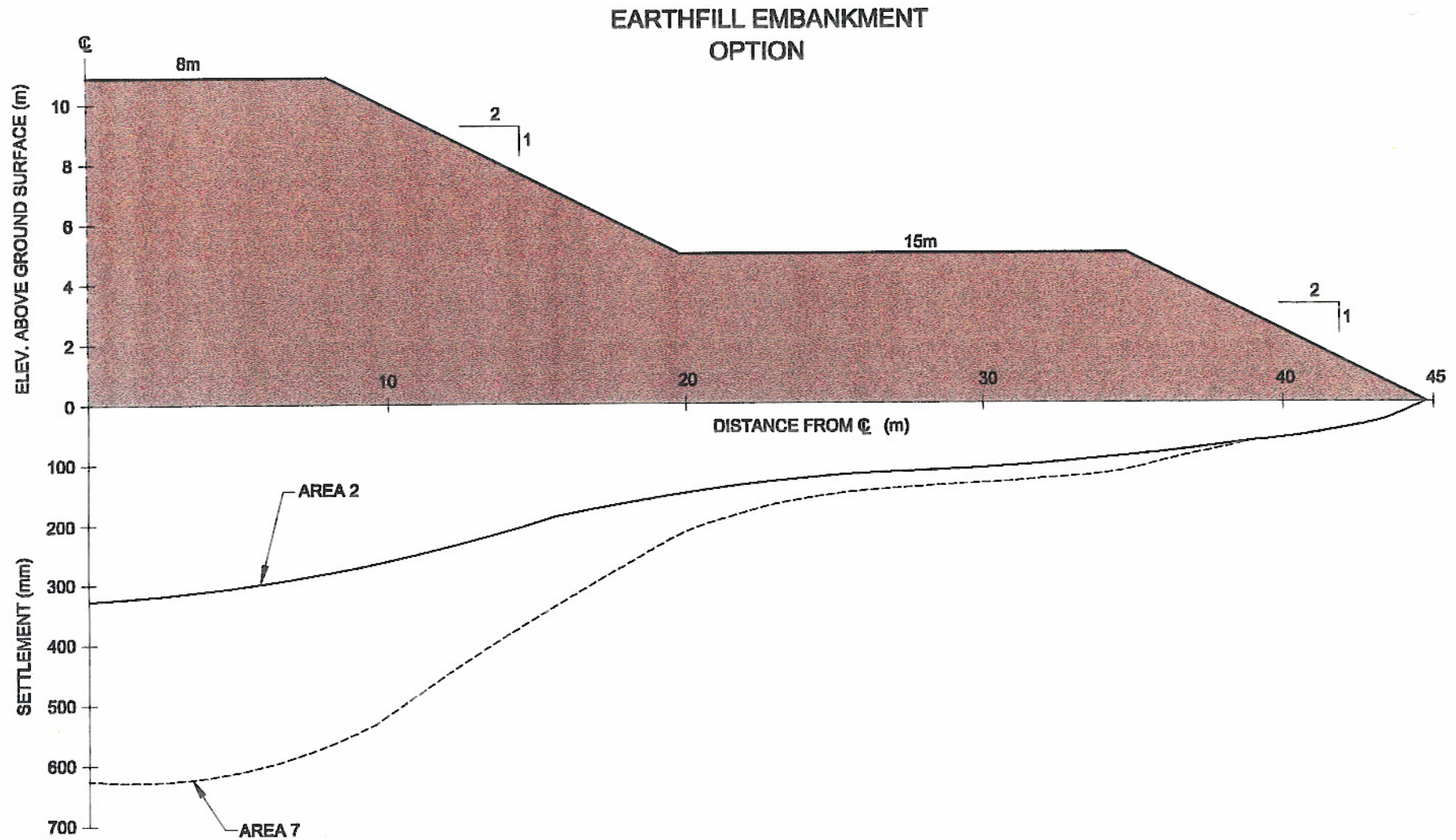
Golder Associates

Drawn ...JEC.....

Chkd ...AJW.....

SETTLEMENT PROFILES
AREAS 2 & 7
HIGHWAY 101 (W.P. 258-96-00)

FIGURE 26



Date AUGUST...1999..

Project .991-.1145...

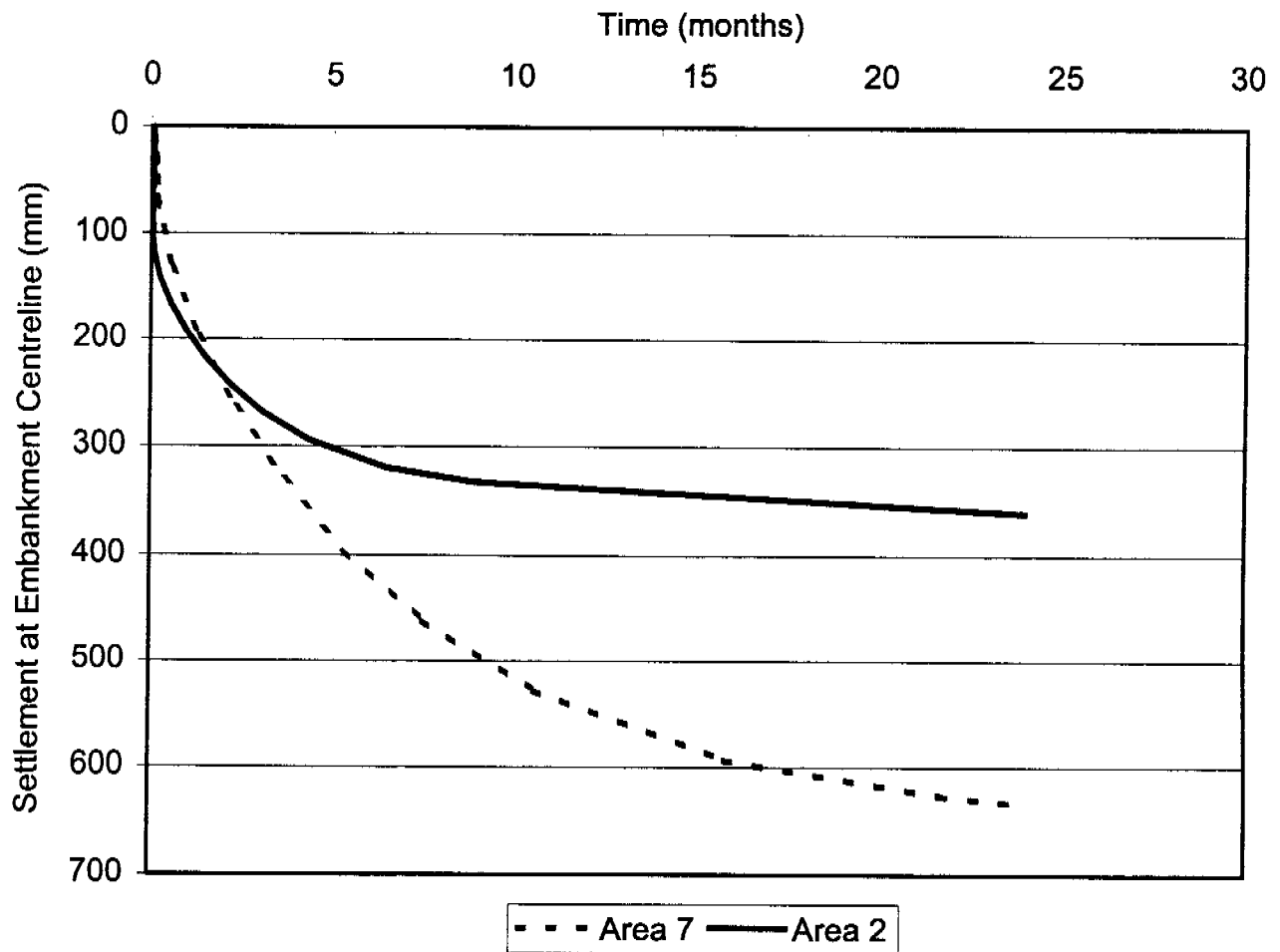
Golder Associates

Drawn ...JFC.....

Chkd ...AJW.....

**Settlement versus Time (Areas 2 and 7)
Highway 101 (W.P. 258-96-00)**

Figure 27



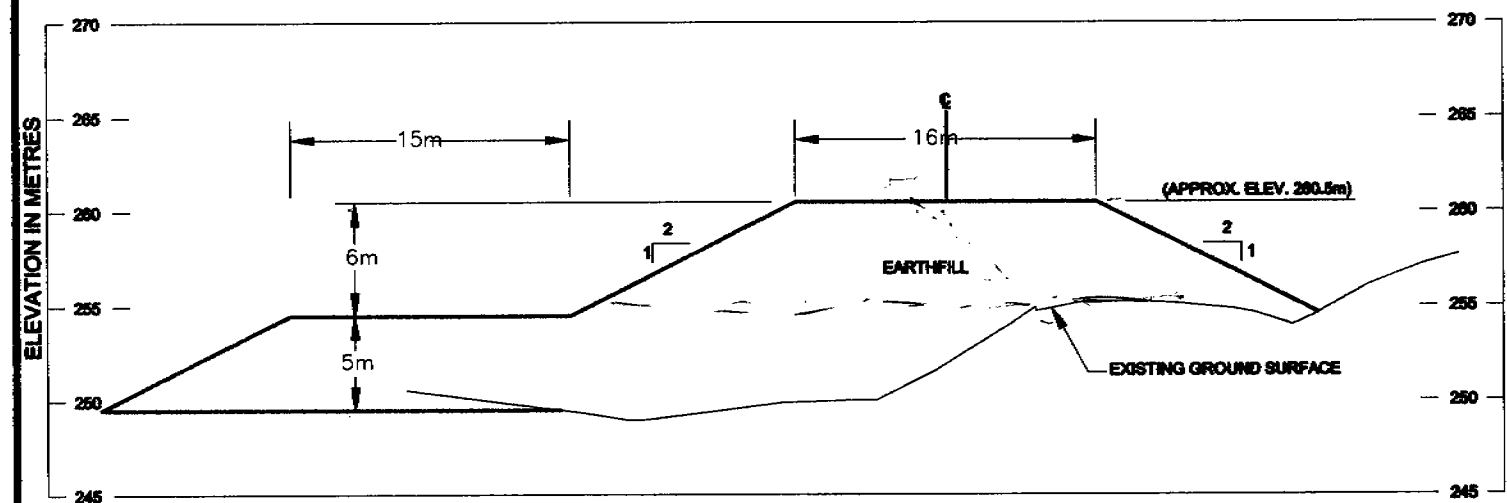
Date: August 1999
Project: 991-1145

Golder Associates

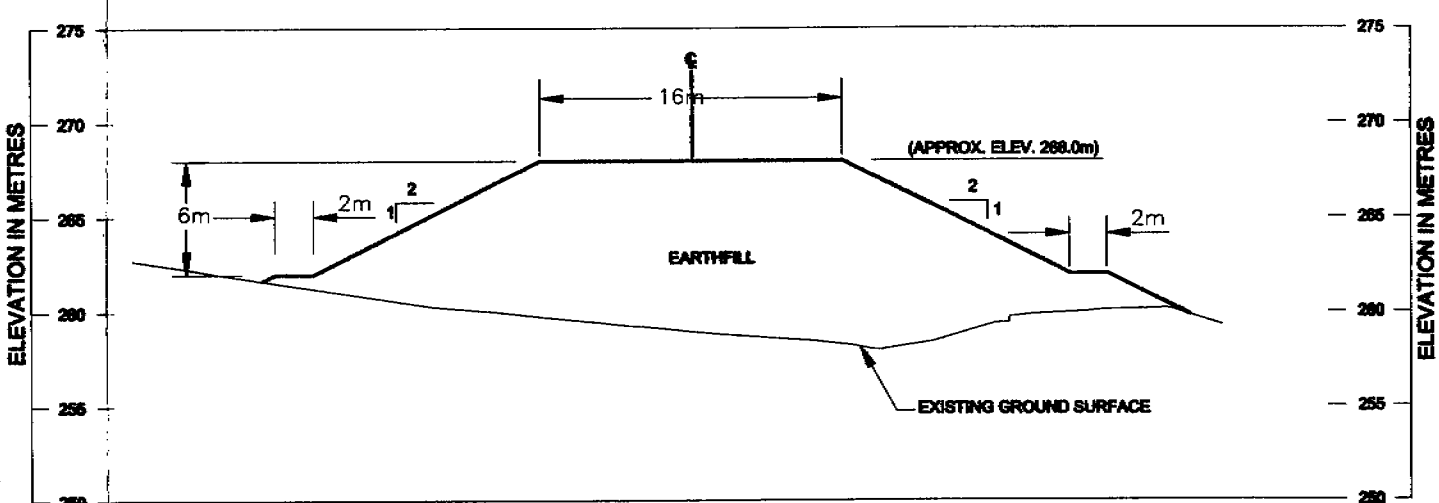
Drawn: AJW
Checked: DEB

TYPICAL EARTHFILL CROSS-SECTIONS (AREAS 2 & 7) HIGHWAY 101 (W.P. 258-96-00)

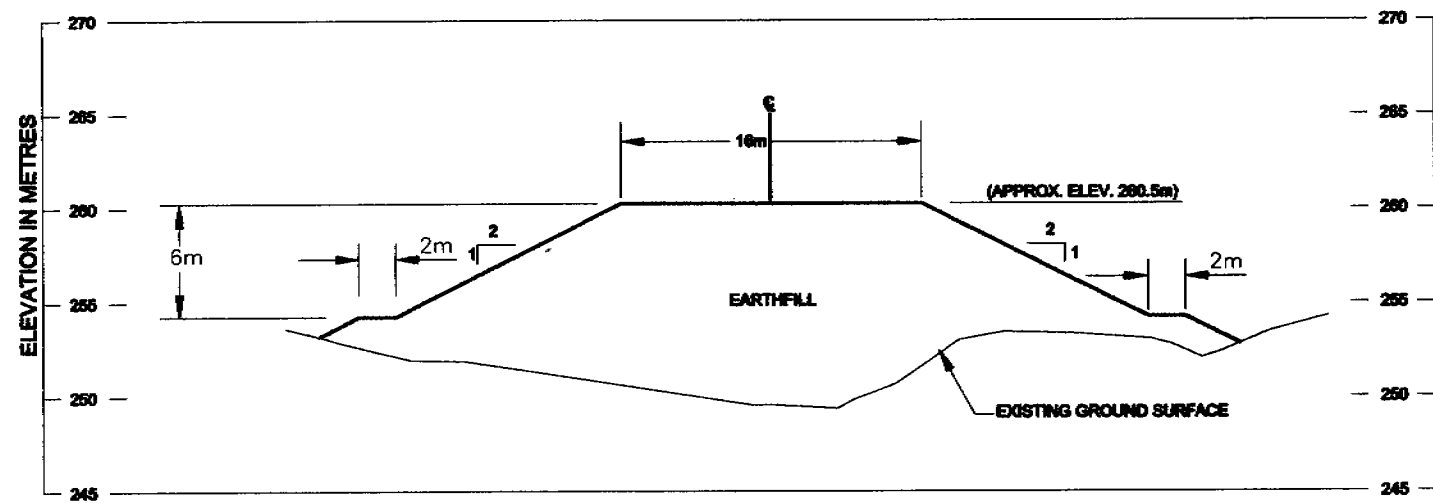
FIGURE 28



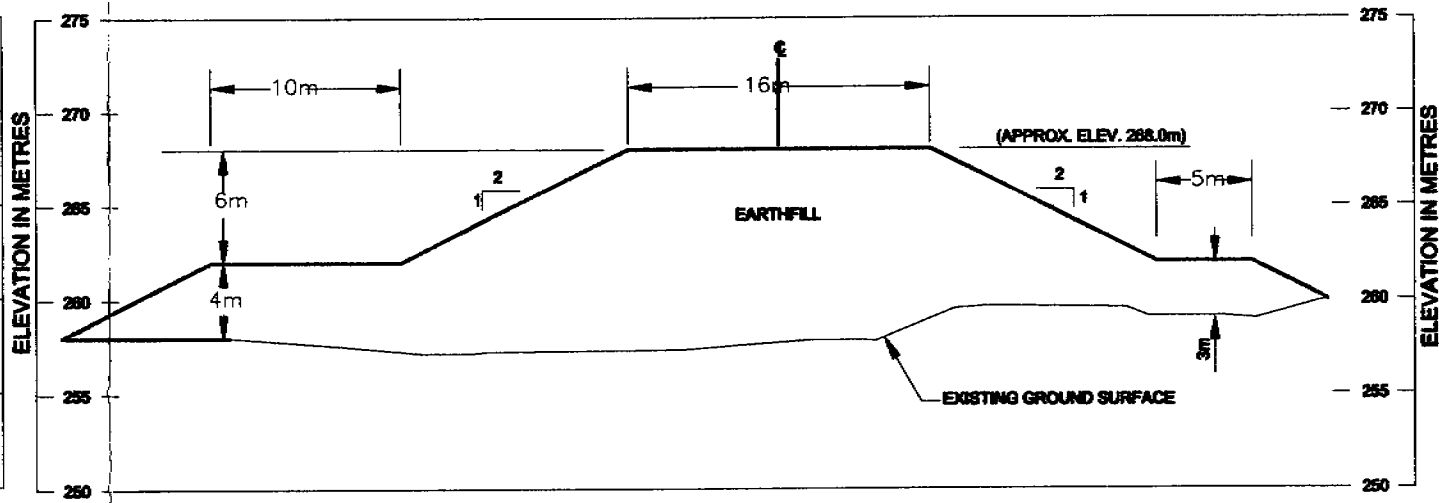
AREA 2 (STATION 13+000)
SCALE 1:400



AREA 7 (STATION 10+350)
SCALE 1:400



AREA 2 (STATION 13+025)
SCALE 1:400



AREA 7 (STATION 10+375)
SCALE 1:400

Date AUGUST, 1999

Project 991-1145

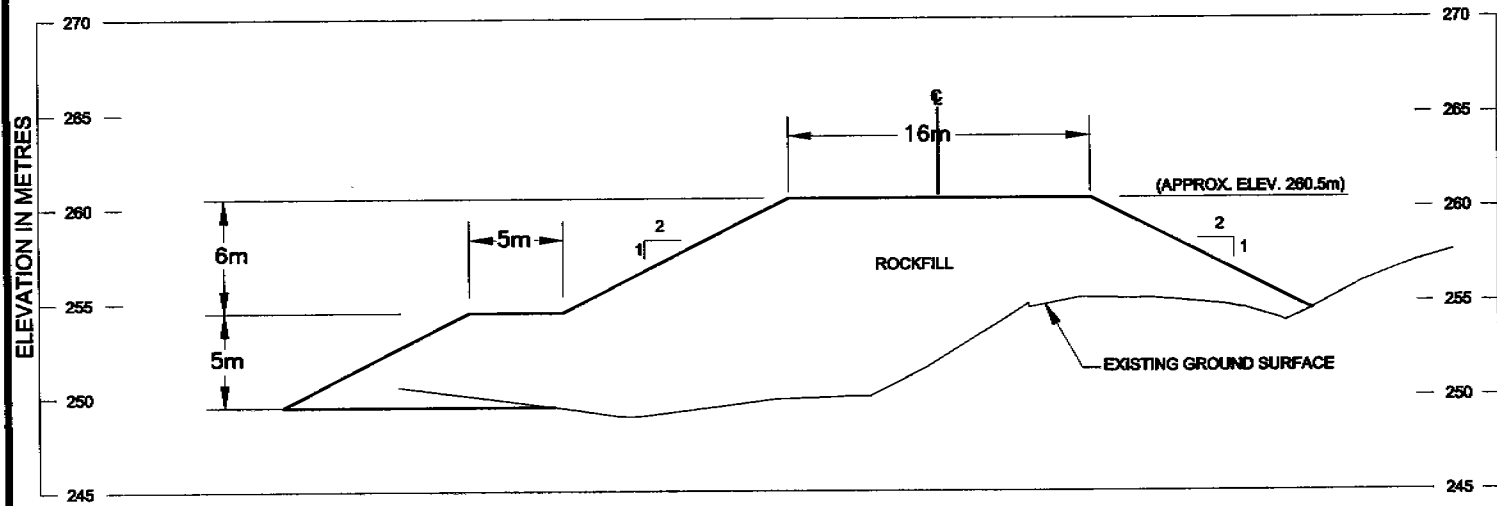
Golder Associates

Drawn JFC

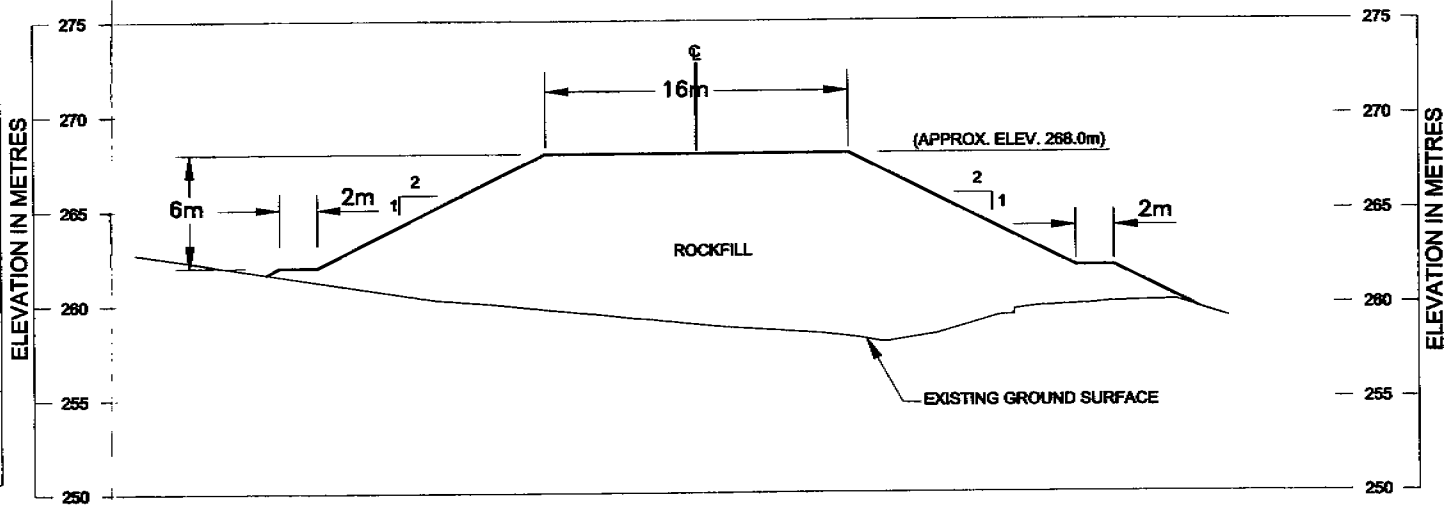
Chkd DCJ

TYPICAL ROCKFILL CROSS-SECTIONS (AREAS 2 & 7) HIGHWAY 101 (W.P. 258-96-00)

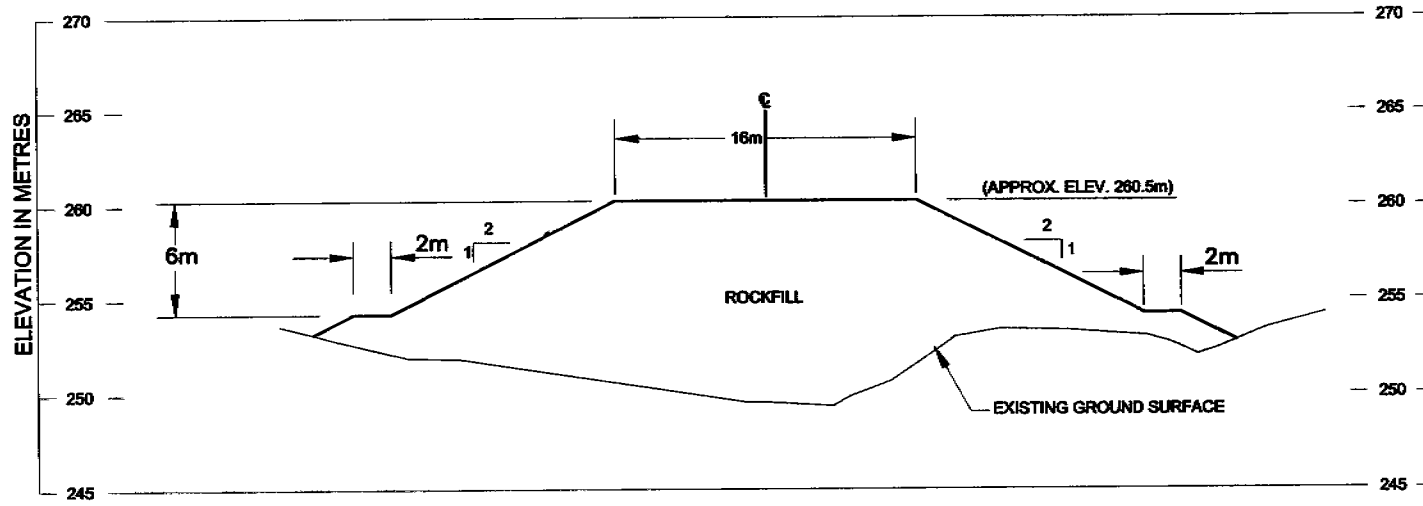
FIGURE 29



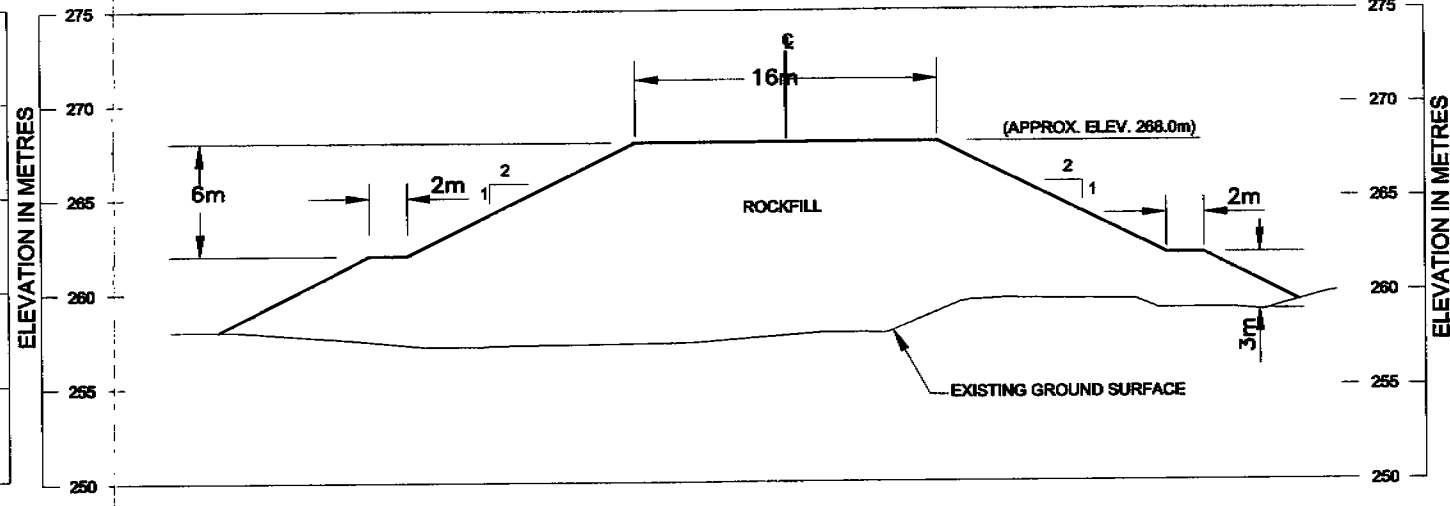
AREA 2 (STATION 13+000)
SCALE 1:400



AREA 7 (STATION 10+350)
SCALE 1:400



AREA 2 (STATION 13+025)
SCALE 1:400



AREA 7 (STATION 10+375)
SCALE 1:400

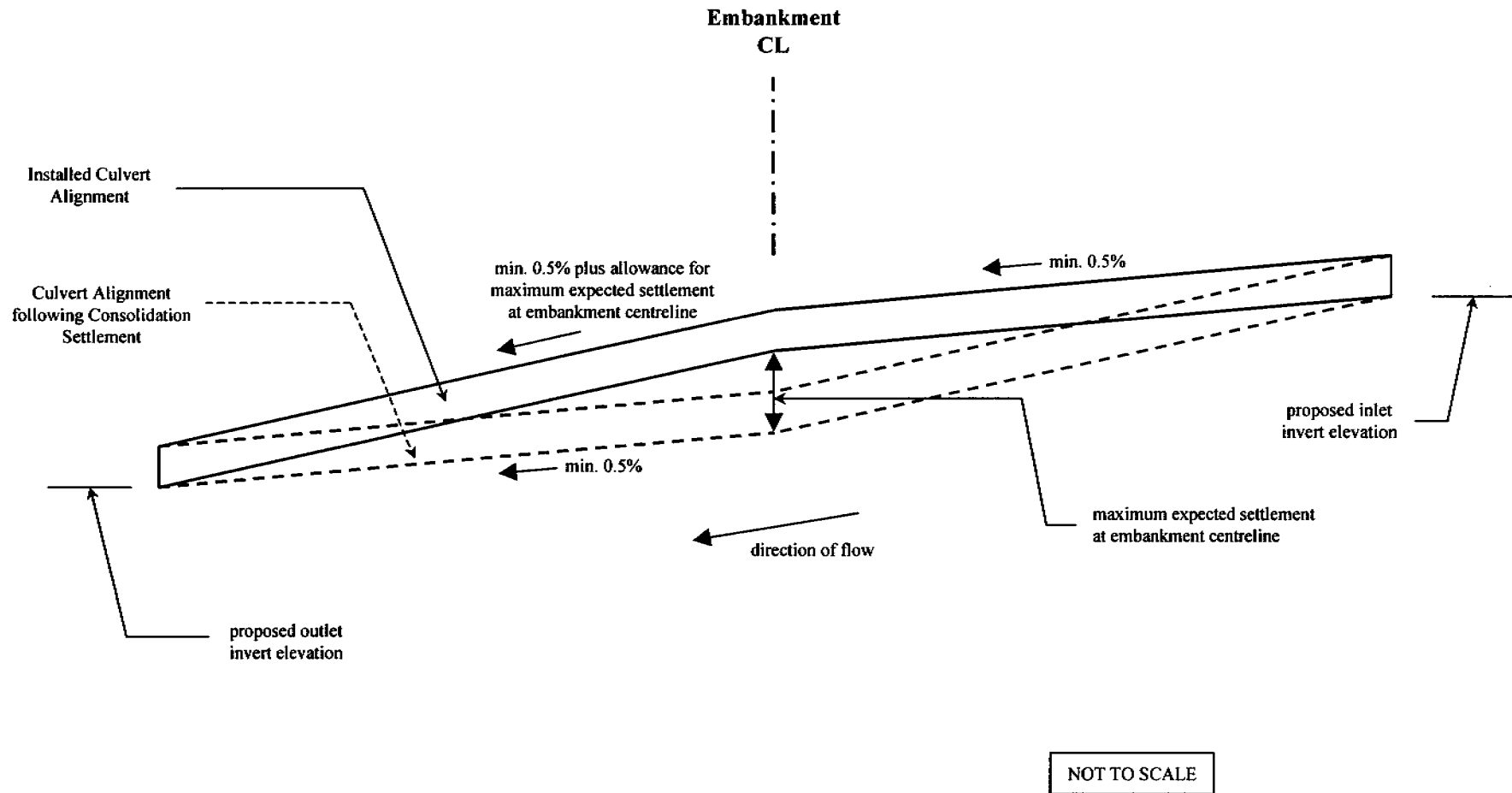
Date AUGUST, 1999.....
Project 991-1145.....

Golder Associates

Drawn JFC.....
Chkd DCJ.....

**Culvert Installation Schematic
Highway 101 (W.P. 258-96-00)**

Figure 30



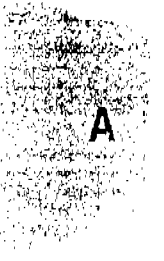
Date : Aug 1999

Project : 991-1145

Golder Associates

Drawn : BVB

Checked : AJW



APPENDIX A

LABORATORY TEST DATA

August 1999

991-1145

TABLE A1**SPECIFIC GRAVITY TEST RESULTS**

PROJECT NUMBER		991-1145
PROJECT NAME		MTO / Highway 101 / Matheson
DATE TESTED		July, 1999
Borehole No.	Sample No.	Specific Gravity Meas.
99-7	4	2.69
99-24	4	2.70
99-24	6	2.70
99-39	5	2.68

Note: Test carried out using distilled water.

TABLE A2

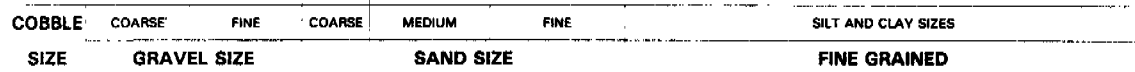
TOTAL ORGANIC CARBON CONTENT (TOC)

PROJECT NUMBER		991-1145						
PROJECT NAME		MTO / Highway 101 / Matheson						
DATE TESTED		July, 1999						
Borehole No.	Sample No.	Soil Passing 600µm	Grain Size Distribution				TOC (<600µm soil)	TOC* (whole soil)
		(%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	(%)	(%)
24	1	100.0					1.58	1.58
24	1 Repeat	100.0					1.71	1.71

Notes:

1. Samples dried at 110 degree centigrade prior to testing.
 2. Test performed on minus 600 micron soil fraction, using the method of Walkley and Black (Walkley, 1946). TOC is expressed as a percentage of the dry weight of the sample.
 3. Grain size distribution of sand, silt and clay based on Unified Soil Classification.
- * Corrected TOC for whole (ie. unfractionated) soil assuming negligible organic carbon content associated with the plus 600 micron soil.

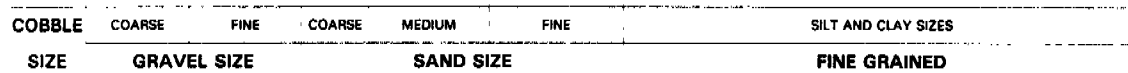
FIGURE A1



SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
--------	----------	--------	----------

●	99-2	7	6.1-6.71
■	99-7	4	4.57-5.18
◆	99-12	3	1.52-2.13
○	99-19	2	0.76-1.37
□	99-24	4	4.57-5.18
◇	99-28	3	2.29-2.90
●	99-31	2	0.76-1.37

FIGURE A2



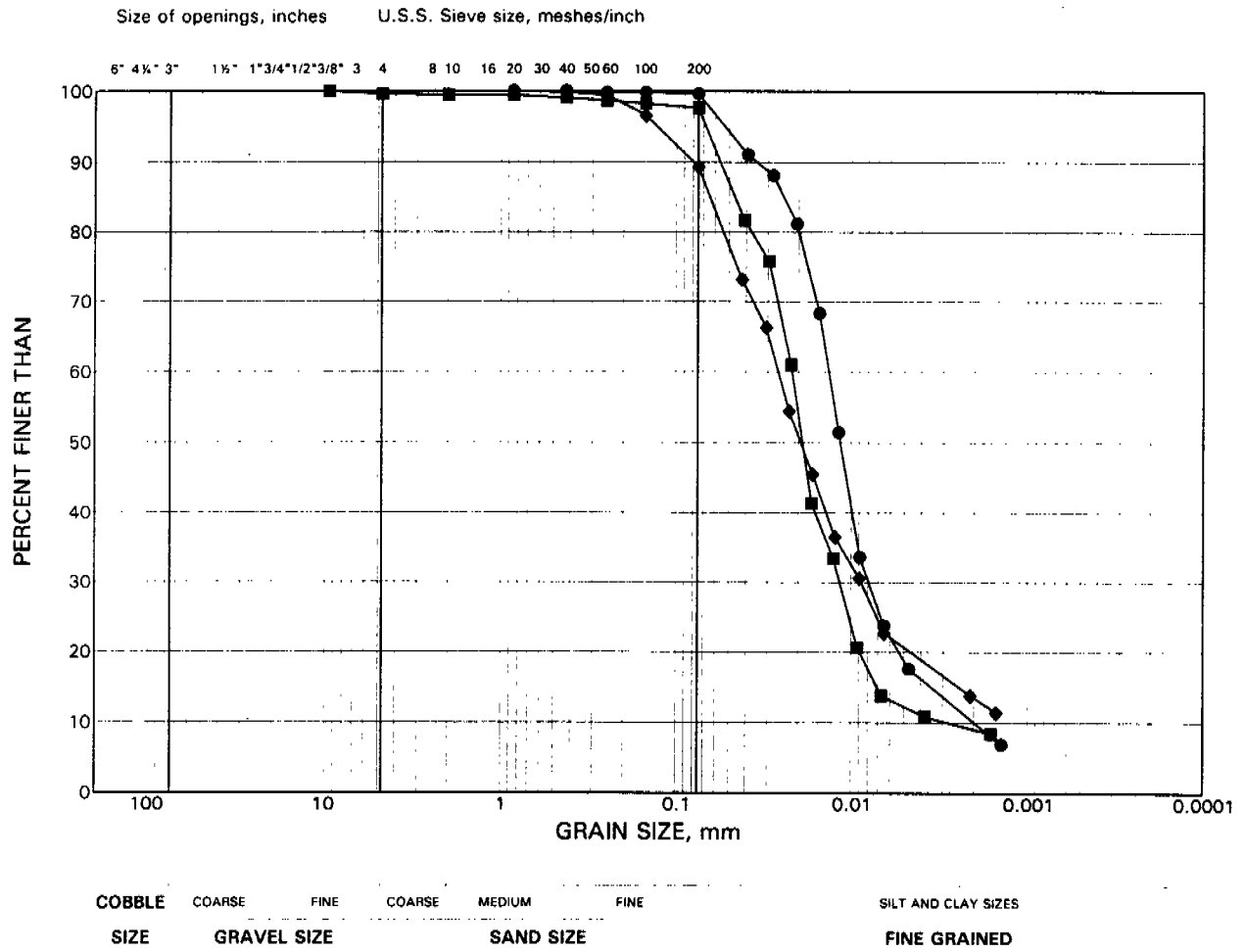
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
--------	----------	--------	----------

●	99-10	2	0.76-1.37
■	99-16	3	1.52-2.13
◆	99-24	6	7.62-8.23
○	99-26	3	1.52-2.13
□	99-34	8	7.62-8.23
◇	99-39	4	2.29-2.90
●	99-39	5	3.05-3.66

GRAIN SIZE DISTRIBUTION

SILT, trace sand, trace clay

FIGURE A3



LEGEND

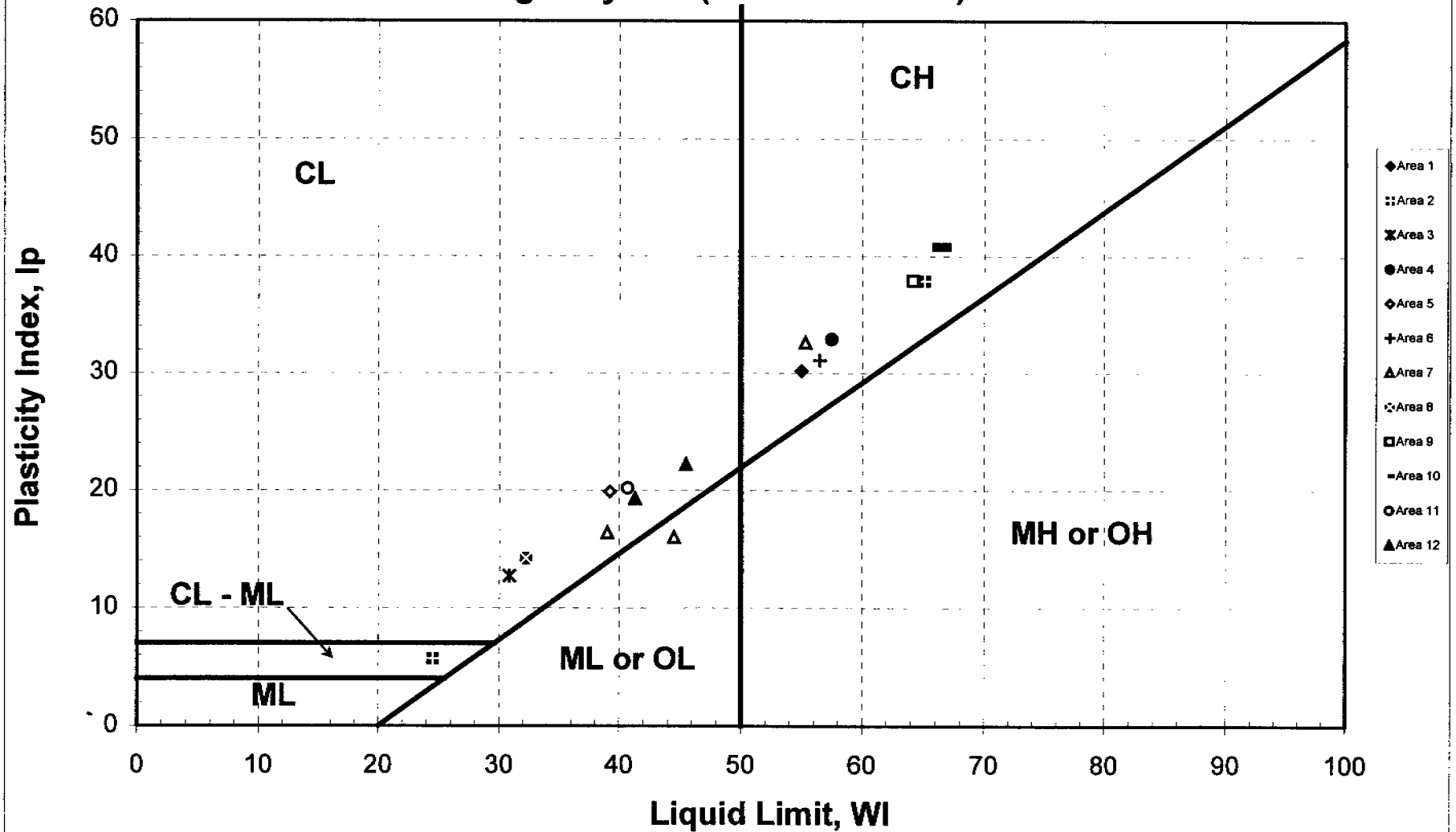
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	99-7	4	4.57-5.18
■	99-7	7	9.14-9.75
◆	99-36	3	1.52-2.13

FIGURE A4



SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	99-32	4	3.05-3.66
■	99-36	4	2.29-2.90
◆	99-35	4	2.29-2.90

Figure A5
Summary of Atterberg Limits
Highway 101 (W.P. 258-96-00)

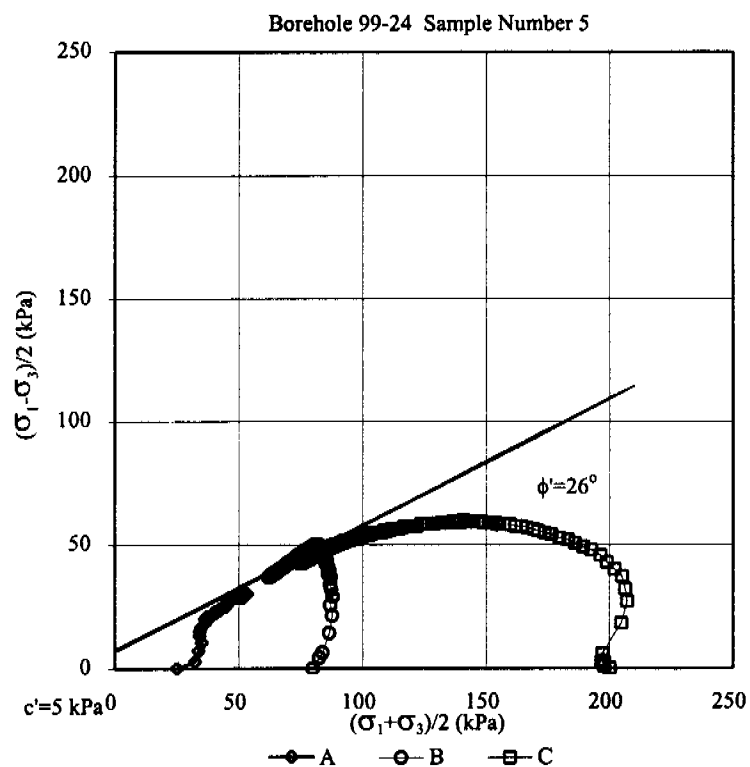
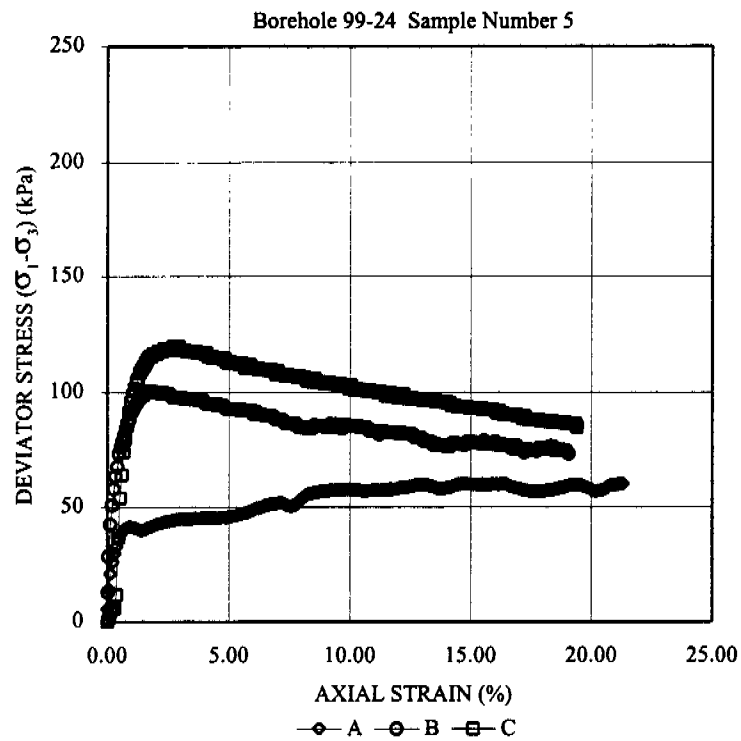


**CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 1 OF 3**

FIGURE A6

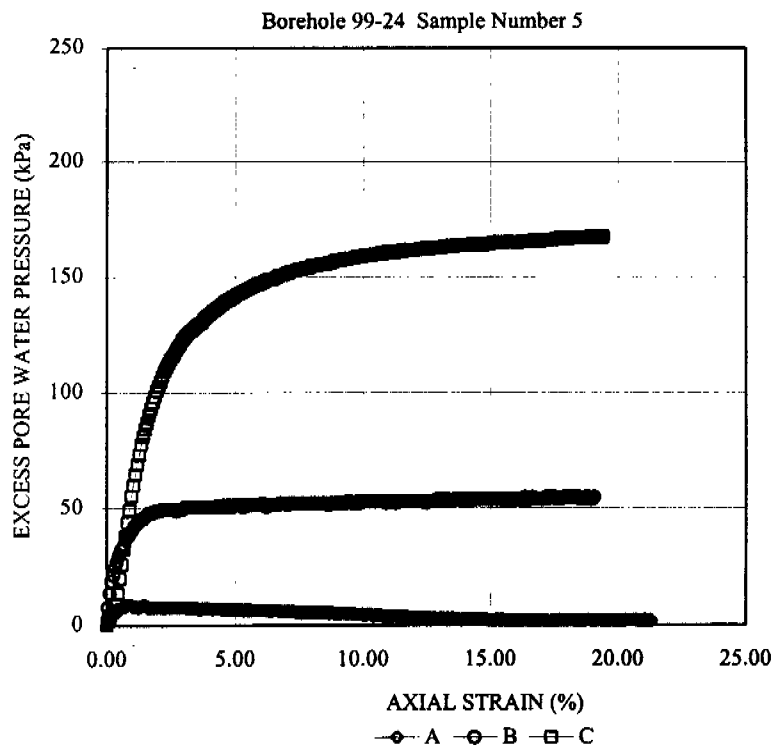
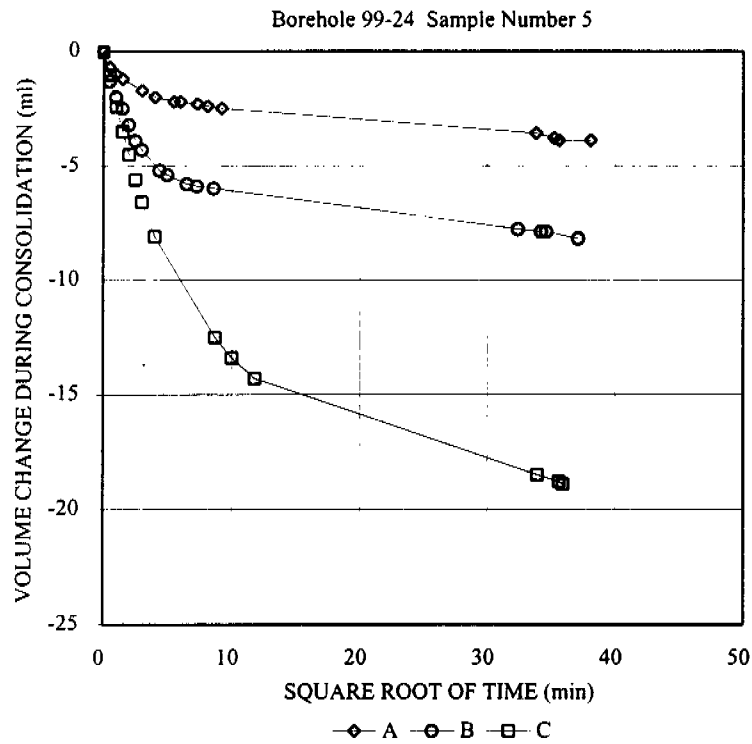
TEST STAGE	A	B	C
BOREHOLE NUMBER	99-24	99-24	99-24
SAMPLE NUMBER	5	5	5
SPECIMEN DIAMETER, cm	4.97	4.98	4.99
SPECIMEN HEIGHT, cm	10.19	10.17	10.16
WATER CONTENT BEFORE CONSOLIDATION, %	50.5	43.6	51.5
CELL PRESSURE, σ_3 , kPa	230.0	285.0	335.0
BACK PRESSURE, kPa	205.0	205.0	135.0
PORE PRESSURE PARAMETER "B"	0.98	0.96	0.97
CONSOLIDATION PRESSURE, σ_c , kPa	25.0	80.0	200.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	2.0	4.1	9.7
WATER CONTENT AFTER CONSOLIDATION, %	48.9	40.2	43.2
AVERAGE RATE OF STRAIN, %/hr	1.0	1.0	1.0
TIME TO FAILURE, DAYS	2	2	2
WATER CONTENT AFTER TEST, %	48.9	40.7	43.3
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$, kPa	41.4	100.4	119.7
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ MAXIMUM, %	0.9	1.7	2.7
MAX EFFECTIVE PRINCIPAL STRESS			
RATIO, (σ_1 / σ_3) MAXIMUM	3.6	4.1	2.6
DEVIATOR STRESS AT (σ_1 / σ_3) MAXIMUM, kPa	41.4	100.4	119.4
AXIAL STRAIN AT (σ_1 / σ_3) MAXIMUM, %	0.9	1.7	2.9
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 - \sigma_3)$ MAXIMUM	0.21	0.48	0.99
PORE PRESSURE PARAMETER, Af, AT (σ_1 / σ_3) MAXIMUM	0.21	0.48	1.03
NATURAL WATER CONTENT, %	47.3	48.2	48.5
DRY DENSITY, Mg/m ³	1.19	1.23	1.17
FILTER DRAINS USED, y/n	y	y	y
TEST NOTES:			
CHANGED RATE OF STRAIN, %/hr	-	-	-
AXIAL STRAIN WHERE RATE OF STRAIN WAS CHANGED, %	-	-	-
FAILURE PLANE NUMBER	1	-	-
ANGLE OF FAILURE, DEGREES	50	-	-
DATE:	July, 1999		
PROJECT NUMBER	991-1145		

Golder Associates



CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 3 OF 3

FIGURE A8



OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	991-1145	Sample Number	4
Borehole Number	99-7	Sample Depth, m	5.00

TEST CONDITIONS

Test Type	Quick / Standard	Load Duration, hr	(0.2 - 22)
Oedometer Number	7		
Date Started	99-07-06		
Date Completed	99-07-08		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	16.47
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	10.55
Area, cm ²	31.52	Specific Gravity, measured	2.69
Volume, cm ³	60.17	Solids Height, cm	0.764
Water Content, %	56.08	Volume of Solids, cm ³	24.07
Wet Mass, g	101.08	Volume of Voids, cm ³	36.10
Dry Mass, g	64.76	Degree of Saturation, %	100.6

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	1.909	1.499	1.909				
9.75	1.904	1.493	1.907	11	7.01E-02	2.47E-04	1.70E-06
19.40	1.899	1.487	1.902	15	5.11E-02	2.82E-04	1.41E-06
38.81	1.892	1.477	1.896	37	2.06E-02	1.92E-04	3.87E-07
77.62	1.881	1.462	1.886	19	3.97E-02	1.57E-04	6.09E-07
155.23	1.839	1.408	1.860	72	1.02E-02	2.81E-04	2.80E-07
310.46	1.634	1.140	1.737	902	7.09E-04	6.90E-04	4.79E-08
620.93	1.509	0.976	1.572	1051	4.98E-04	2.12E-04	1.03E-08
1241.86	1.394	0.825	1.451	401	1.11E-03	9.71E-05	1.06E-08
2483.71	1.300	0.702	1.347	170	2.26E-03	3.95E-05	8.76E-09
1241.86	1.337	0.750	1.318				
310.46	1.363	0.784	1.350				
38.81	1.387	0.816	1.375				
9.75	1.419	0.857	1.403				

Notes:

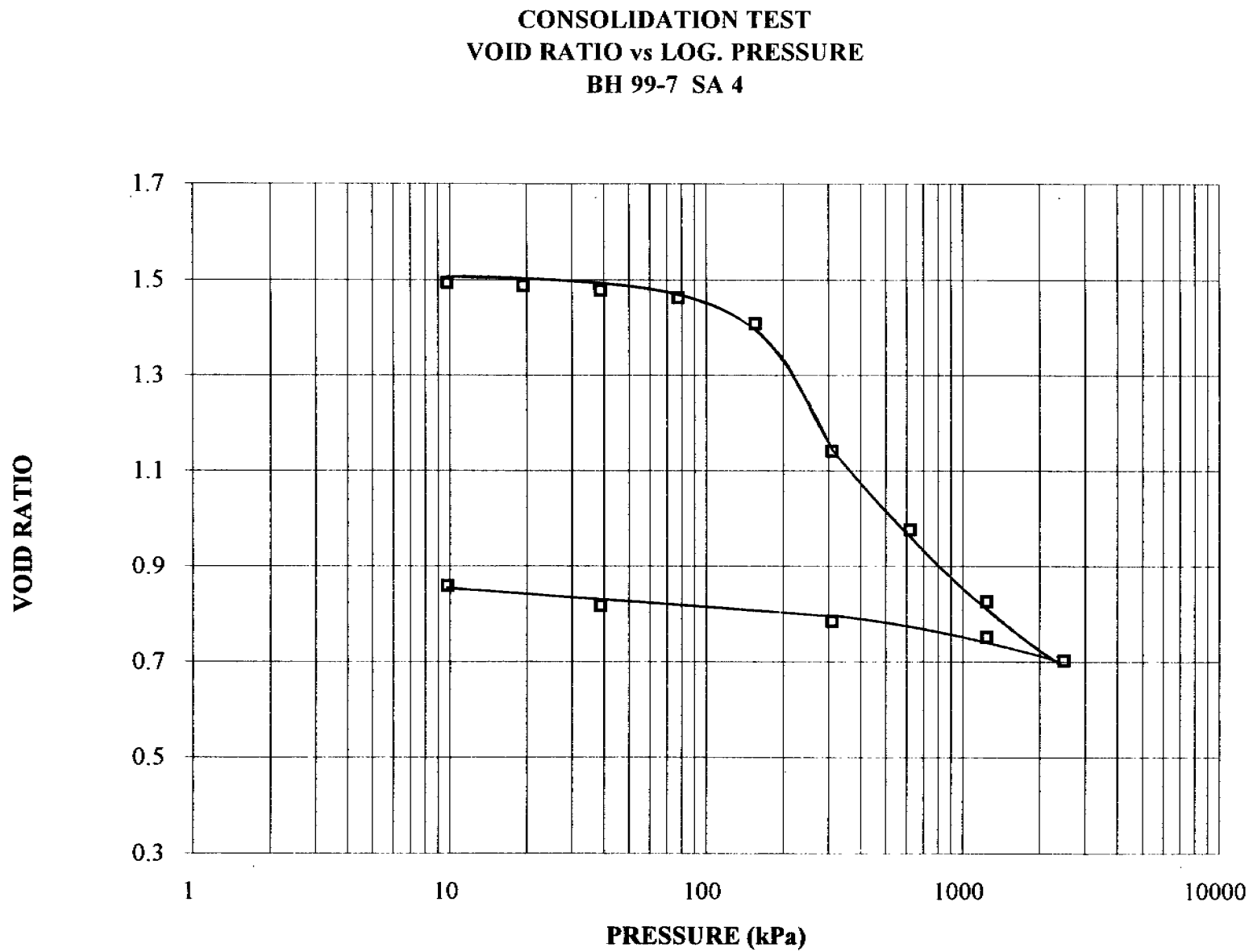
k calculated using cv based on t₉₀ values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.42	Unit Weight, kN/m ³	19.06
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	18.92
Area, cm ²	31.52	Specific Gravity, assumed	2.70
Volume, cm ³	44.71	Solids Height, cm	0.761
Water Content, %	34.2	Volume of Solids, cm ³	23.99
Wet Mass, g	86.91	Volume of Voids, cm ³	20.73
Dry Mass, g	64.76		

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

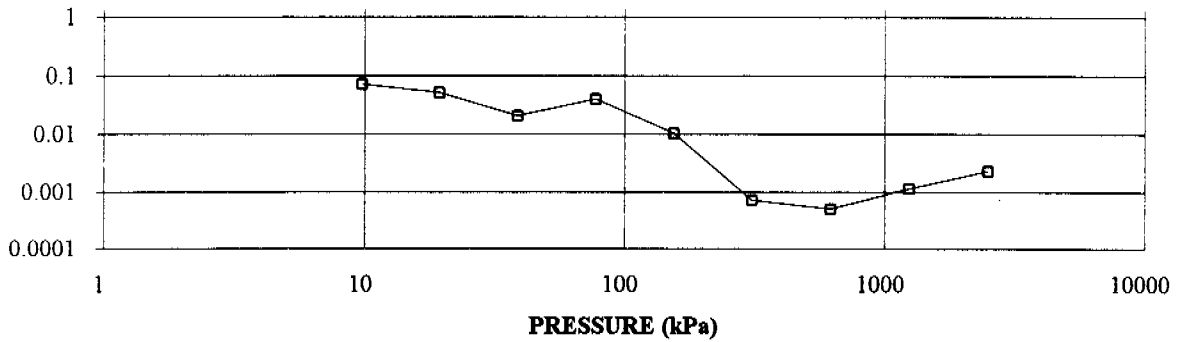
FIGURE A9



OEDOMETER CONSOLIDATION SUMMARY

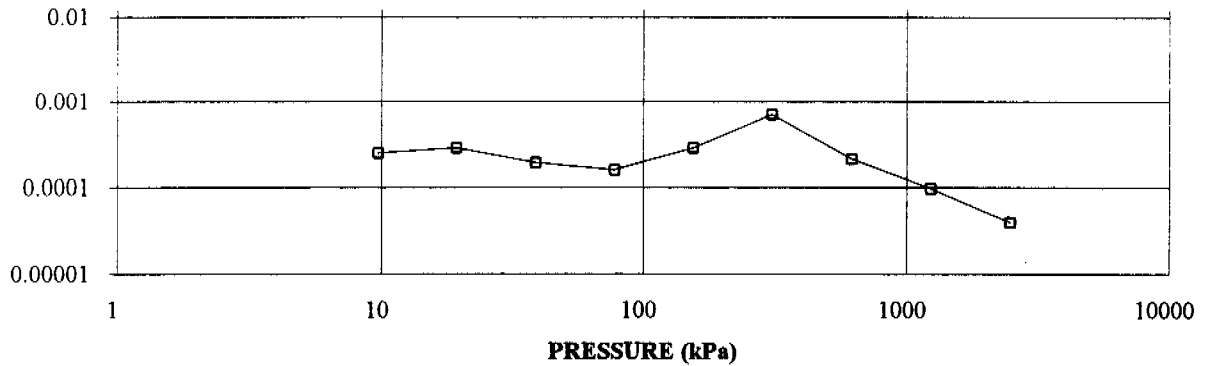
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
LOG. c_v cm^2/s vs LOG. PRESSURE (kPa)
BH 99-7 SA 4



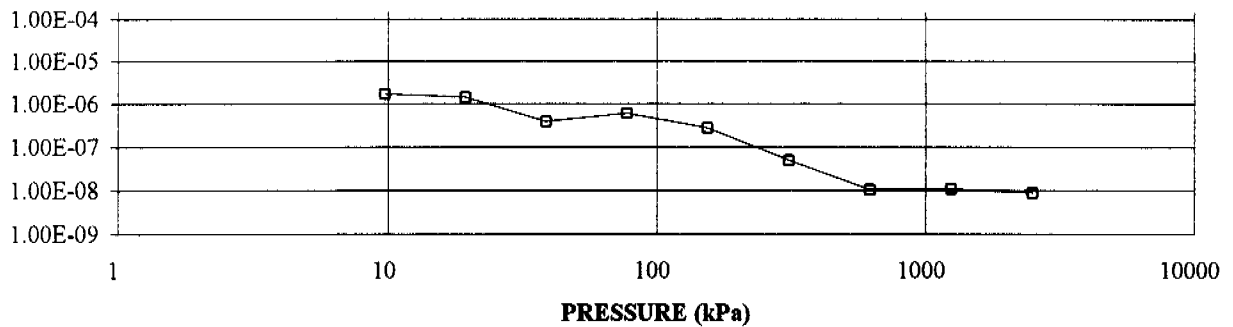
VOLUME
COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
LOG. m_v , m^2/kN vs LOG. PRESSURE (kPa)
BH 99-7 SA 4



HYDRAULIC
CONDUCTIVITY, cm/s

CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs LOG. PRESSURE
BH 99-7 SA 4



OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	991-1145	Sample Number	4
Borehole Number	99-24	Sample Depth, m	4.87

TEST CONDITIONS

Test Type	Quick / Standard	Load Duration, hr	(0.4 - 22)
Oedometer Number	6		
Date Started	99-07-06		
Date Completed	99-07-08		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	17.46
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	12.03
Area, cm ²	31.62	Specific Gravity, measured	2.70
Volume, cm ³	60.23	Solids Height, cm	0.866
Water Content, %	45.09	Volume of Solids, cm ³	27.37
Wet Mass, g	107.22	Volume of Voids, cm ³	32.86
Dry Mass, g	73.9	Degree of Saturation, %	101.4

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	1.905	1.201	1.905				
9.63	1.885	1.178	1.895	36	2.11E-02	1.09E-03	2.26E-06
19.34	1.858	1.147	1.872	548	1.36E-03	1.45E-03	1.93E-07
38.69	1.818	1.100	1.838	638	1.12E-03	1.09E-03	1.19E-07
77.37	1.764	1.038	1.791	419	1.62E-03	7.29E-04	1.16E-07
154.74	1.685	0.947	1.725	1215	5.19E-04	5.36E-04	2.73E-08
309.49	1.601	0.850	1.643	1131	5.06E-04	2.86E-04	1.42E-08
618.97	1.531	0.769	1.566	585	8.89E-04	1.18E-04	1.03E-08
1237.94	1.451	0.676	1.491	357	1.32E-03	6.81E-05	8.81E-09
2475.89	1.380	0.595	1.416	258	1.65E-03	3.00E-05	4.84E-09
1237.94	1.393	0.609	1.387				
309.49	1.416	0.636	1.405				
38.69	1.449	0.674	1.433				
9.63	1.476	0.705	1.462				

Notes:

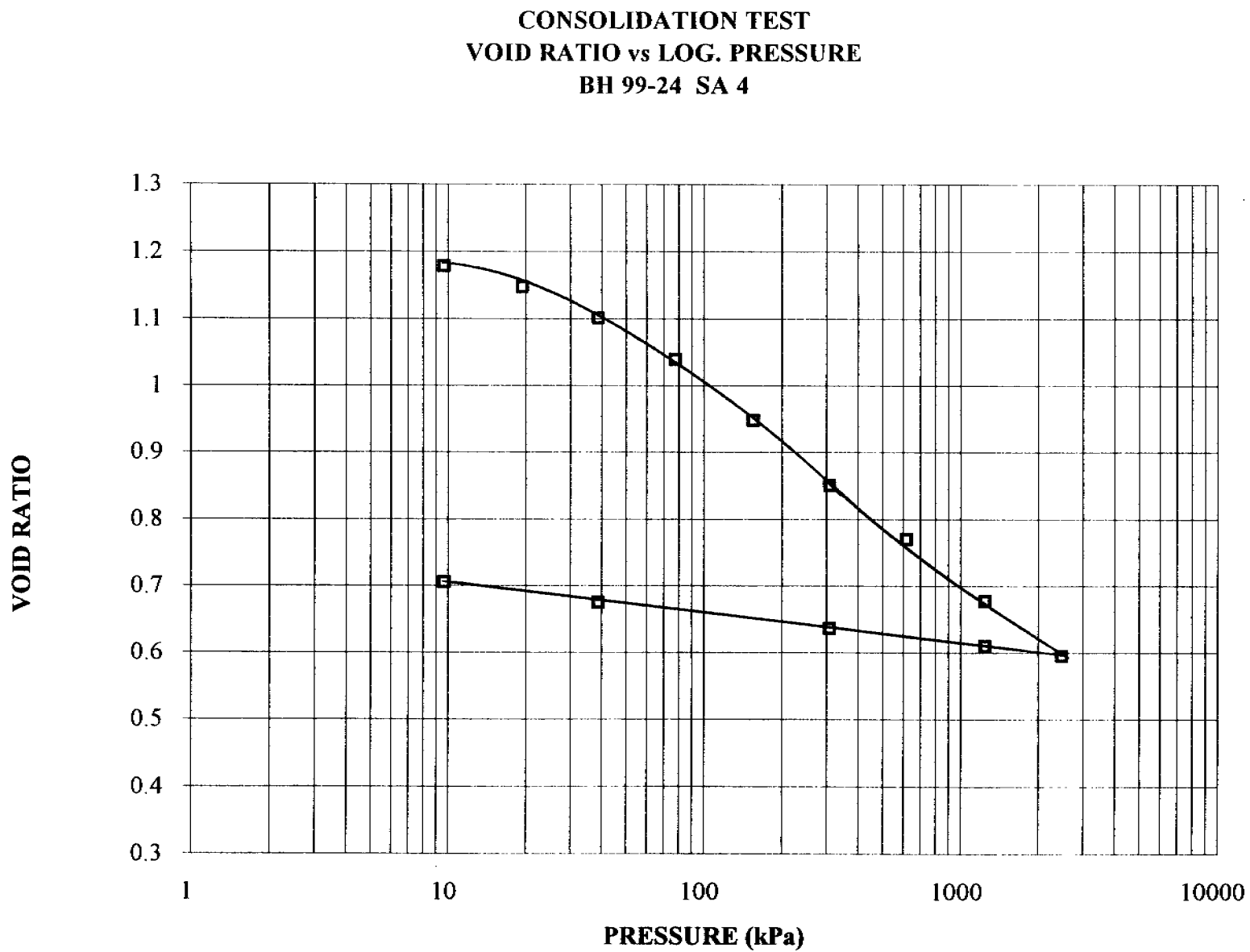
k calculated using cv based on t₉₀ values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.48	Unit Weight, kN/m ³	19.86
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	19.69
Area, cm ²	31.62	Specific Gravity, assumed	2.70
Volume, cm ³	46.67	Solids Height, cm	0.866
Water Content, %	27.9	Volume of Solids, cm ³	27.37
Wet Mass, g	94.53	Volume of Voids, cm ³	19.30
Dry Mass, g	73.9		

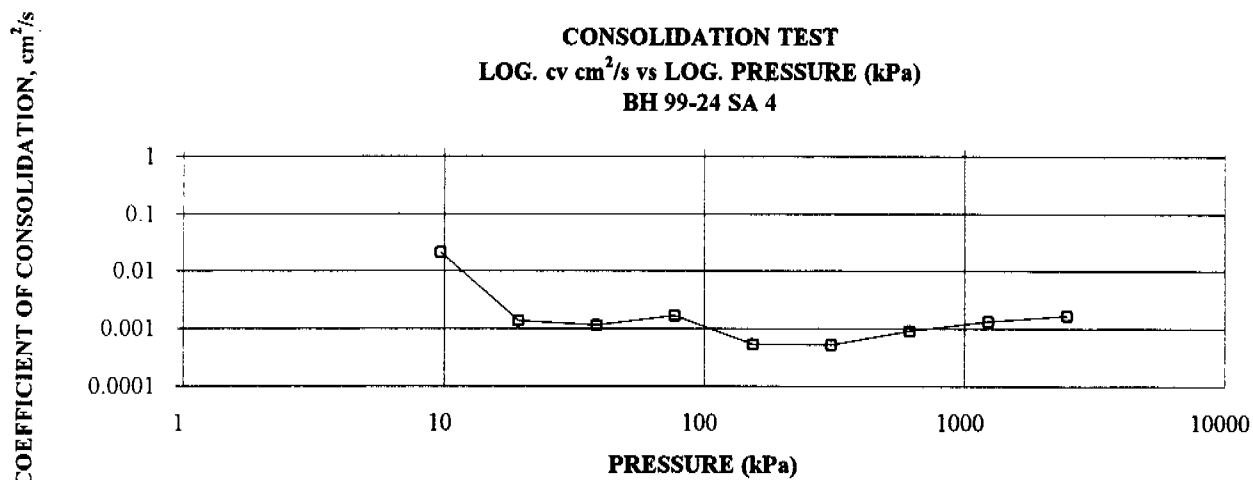
CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE A10

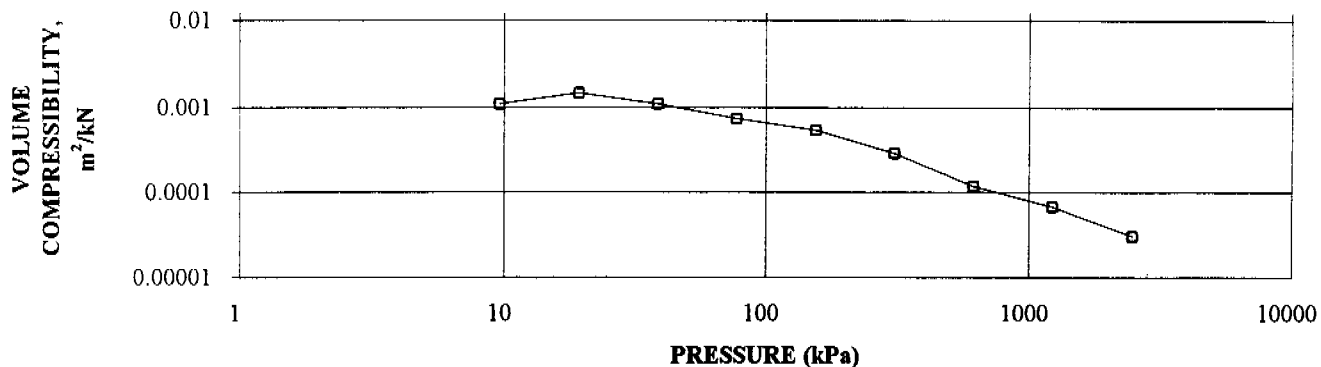


OEDOMETER CONSOLIDATION SUMMARY

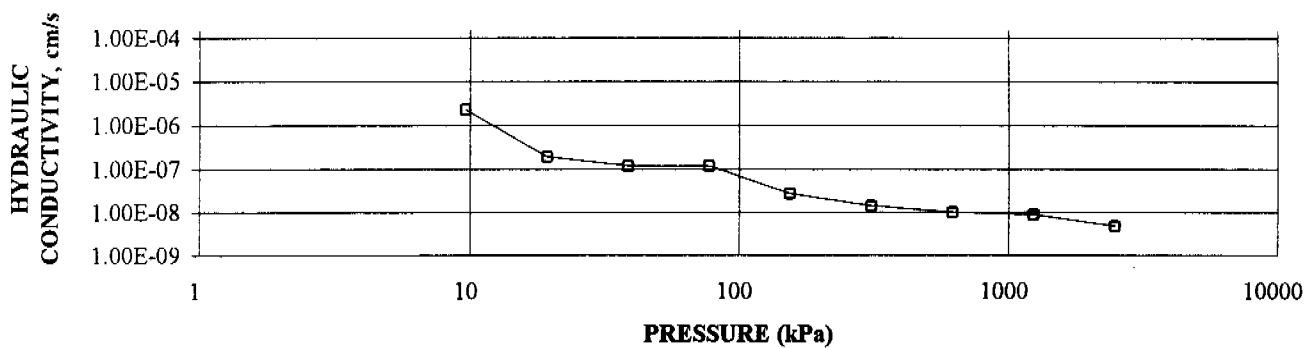
CONSOLIDATION TEST
LOG. c_v cm^2/s vs LOG. PRESSURE (kPa)
BH 99-24 SA 4



CONSOLIDATION TEST
LOG. m_v , m^2/kN vs LOG. PRESSURE (kPa)
BH 99-24 SA 4



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs LOG. PRESSURE
BH 99-24 SA 4



OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	991-1145	Sample Number	6
Borehole Number	99-24	Sample Depth, m	7.54

TEST CONDITIONS

Test Type	Quick / Standard	Load Duration, hr	(0.2 - 22)
Oedometer Number	7		
Date Started	99-07-06		
Date Completed	99-07-08		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	16.85
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	11.13
Area, cm ²	31.55	Specific Gravity, measured	2.70
Volume, cm ³	60.10	Solids Height, cm	0.801
Water Content, %	51.42	Volume of Solids, cm ³	25.26
Wet Mass, g	103.25	Volume of Voids, cm ³	34.85
Dry Mass, g	68.19	Degree of Saturation, %	100.6

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	1.905	1.380	1.905				
9.52	1.891	1.363	1.898	9	8.49E-02	7.50E-04	6.24E-06
19.39	1.880	1.348	1.886	30	2.51E-02	6.17E-04	1.52E-06
38.77	1.864	1.329	1.872	62	1.20E-02	4.22E-04	4.96E-07
77.54	1.844	1.304	1.854	127	5.74E-03	2.68E-04	1.51E-07
155.09	1.791	1.238	1.818	234	2.99E-03	3.59E-04	1.05E-07
310.17	1.654	1.067	1.723	3127	2.01E-04	4.64E-04	9.15E-09
620.34	1.552	0.939	1.603	1855	2.94E-04	1.73E-04	4.97E-09
1240.68	1.447	0.808	1.500	759	6.28E-04	8.89E-05	5.47E-09
2481.36	1.358	0.696	1.403	145	2.88E-03	3.80E-05	1.07E-08
1240.68	1.372	0.713	1.365				
310.17	1.397	0.745	1.384				
38.77	1.423	0.778	1.410				
9.52	1.447	0.808	1.435				

Notes:

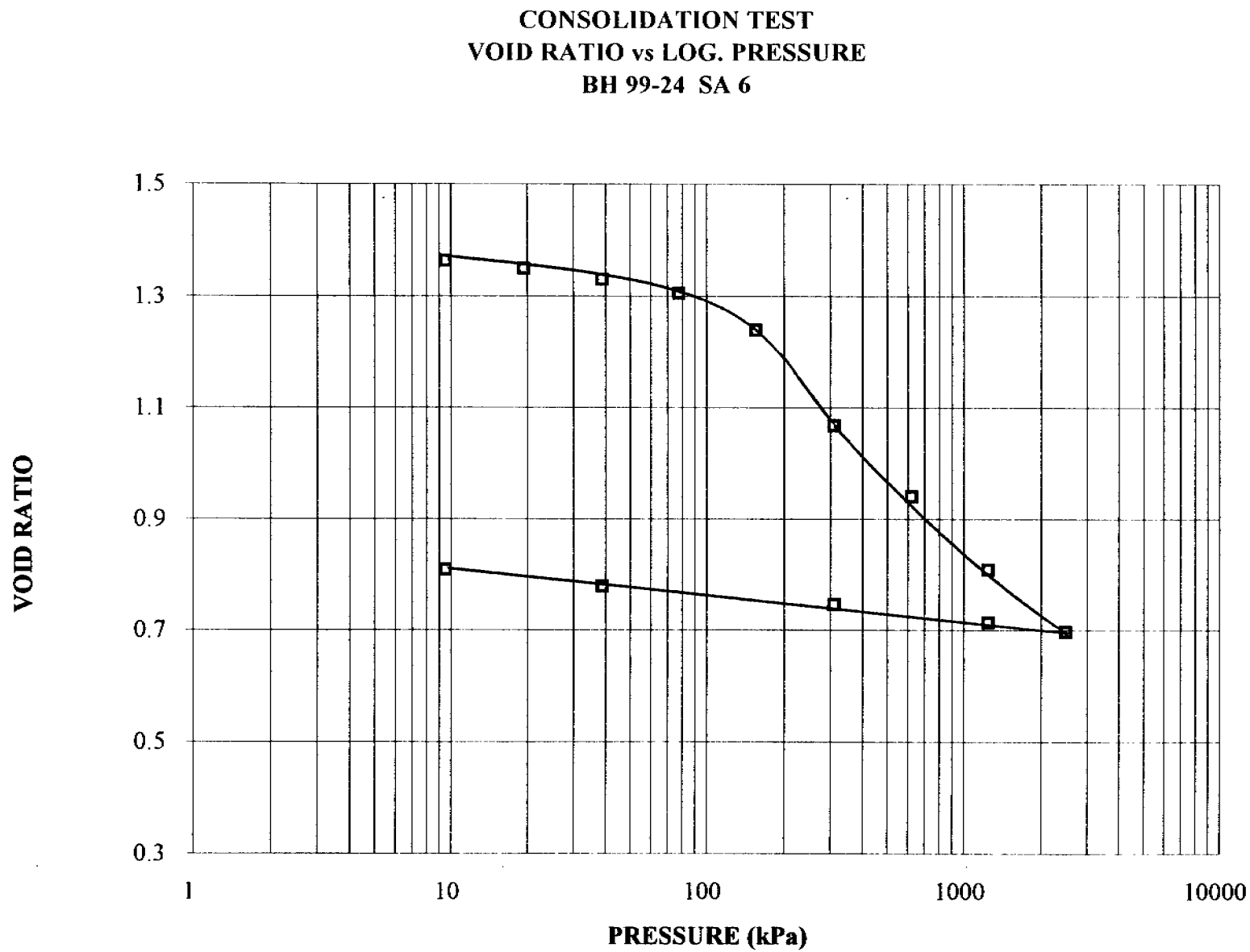
k calculated using cv based on t₉₀ values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.44	Unit Weight, kN/m ³	19.54
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	19.38
Area, cm ²	31.55	Specific Gravity, assumed	2.70
Volume, cm ³	45.27	Solids Height, cm	0.801
Water Content, %	32.3	Volume of Solids, cm ³	25.26
Wet Mass, g	90.2	Volume of Voids, cm ³	20.02
Dry Mass, g	68.19		

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE A11



OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	991-1145	Sample Number	6
Borehole Number	99-24	Sample Depth, m	8.1

TEST CONDITIONS

Test Type	Quick	Load Duration, hr	(0.15 -0.6)
Oedometer Number	7		
Date Started	99-07-19		
Date Completed	99-07-19		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	17.42
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	12.05
Area, cm ²	31.55	Specific Gravity, measured	2.70
Volume, cm ³	60.10	Solids Height, cm	0.867
Water Content, %	44.50	Volume of Solids, cm ³	27.36
Wet Mass, g	106.74	Volume of Voids, cm ³	32.75
Dry Mass, g	73.86	Degree of Saturation, %	100.4

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	1.905	1.197	1.905				
9.69	1.899	1.190	1.902	6	1.28E-01	3.20E-04	4.00E-06
19.39	1.894	1.184	1.897	13	5.87E-02	2.76E-04	1.59E-06
38.77	1.886	1.175	1.890	13	5.82E-02	2.22E-04	1.27E-06
77.54	1.871	1.158	1.879	19	3.94E-02	1.96E-04	7.58E-07
155.09	1.844	1.127	1.858	38	1.93E-02	1.82E-04	3.44E-07
310.17	1.792	1.067	1.818	18	3.89E-02	1.77E-04	6.77E-07
620.34	1.714	0.977	1.753	113	5.77E-03	1.32E-04	7.44E-08
1240.68	1.624	0.873	1.669	307	1.92E-03	7.62E-05	1.44E-08
2481.36	1.542	0.779	1.583	185	2.87E-03	3.46E-05	9.74E-09
1240.68	1.549	0.786	1.545				
310.17	1.555	0.794	1.552				
9.69	1.609	0.855	1.582				

Notes:

k calculated using cv based on t₉₀ values.

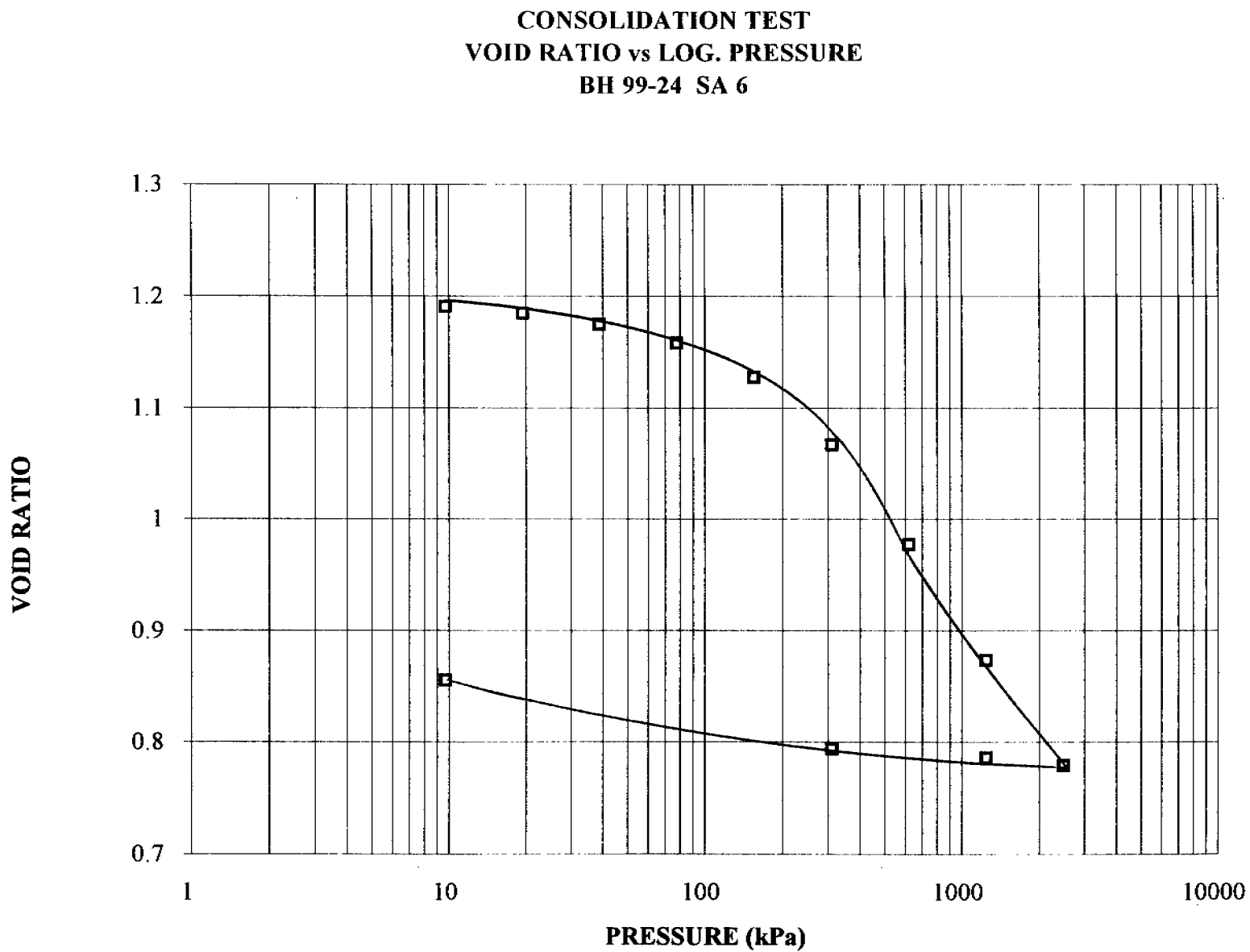
Test carried out on vertically trimmed sample.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.61	Unit Weight, kN/m ³	19.08
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	18.92
Area, cm ²	31.55	Specific Gravity, measured	2.70
Volume, cm ³	50.76	Solids Height, cm	0.867
Water Content, %	33.8	Volume of Solids, cm ³	27.36
Wet Mass, g	98.79	Volume of Voids, cm ³	23.41
Dry Mass, g	73.86		

CONSOLIDATION TEST
VOID RATIO vs. LOG PRESSURE

FIGURE A12



OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	991-1145	Sample Number	5
Borehole Number	99-39	Sample Depth, m	3.34

TEST CONDITIONS

Test Type	Quick / Standard	Load Duration, hr	(0.1 - 22)
Oedometer Number	5		
Date Started	99-07-06		
Date Completed	99-07-07		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	15.50
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	9.03
Area, cm ²	31.50	Specific Gravity, measured	2.68
Volume, cm ³	60.16	Solids Height, cm	0.656
Water Content, %	71.70	Volume of Solids, cm ³	20.67
Wet Mass, g	95.12	Volume of Voids, cm ³	39.49
Dry Mass, g	55.4	Degree of Saturation, %	100.6

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	1.910	1.910				
9.67	1.880	1.865	1.895	2	3.81E-01	1.61E-03	6.02E-05
19.42	1.863	1.838	1.871	86	8.63E-03	9.51E-04	8.04E-07
38.83	1.838	1.801	1.850	132	5.50E-03	6.63E-04	3.57E-07
77.67	1.763	1.686	1.800	194	3.54E-03	1.01E-03	3.52E-07
155.33	1.643	1.504	1.703	2602	2.36E-04	8.06E-04	1.87E-08
310.66	1.455	1.218	1.549	2535	2.01E-04	6.33E-04	1.24E-08
621.32	1.317	1.007	1.386	1622	2.51E-04	2.33E-04	5.73E-09
1242.64	1.211	0.845	1.264	743	4.56E-04	9.00E-05	4.02E-09
2485.28	1.114	0.698	1.163	650	4.41E-04	4.05E-05	1.75E-09
1242.64	1.125	0.715	1.120				
310.66	1.161	0.769	1.143				
38.83	1.203	0.833	1.182				
9.66	1.224	0.865	1.214				

Notes:

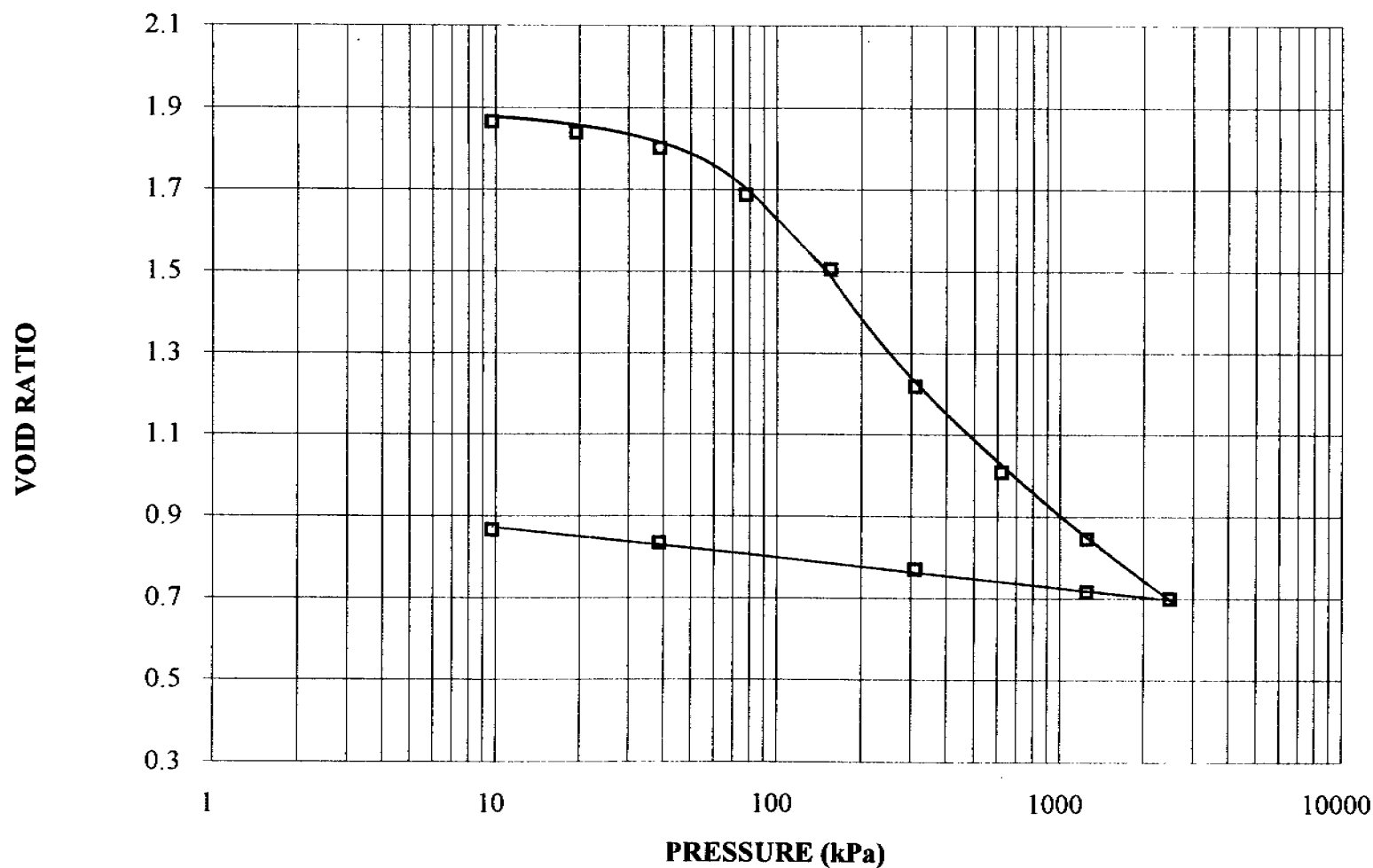
k calculated using cv based on t₉₀ values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.22	Unit Weight, kN/m ³	19.23
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	19.11
Area, cm ²	31.50	Specific Gravity, assumed	2.70
Volume, cm ³	38.56	Solids Height, cm	0.651
Water Content, %	36.5	Volume of Solids, cm ³	20.52
Wet Mass, g	75.61	Volume of Voids, cm ³	18.04
Dry Mass, g	55.4		

CONSOLIDATION TEST
VOID RATIO VS. LOG. PRESSURE

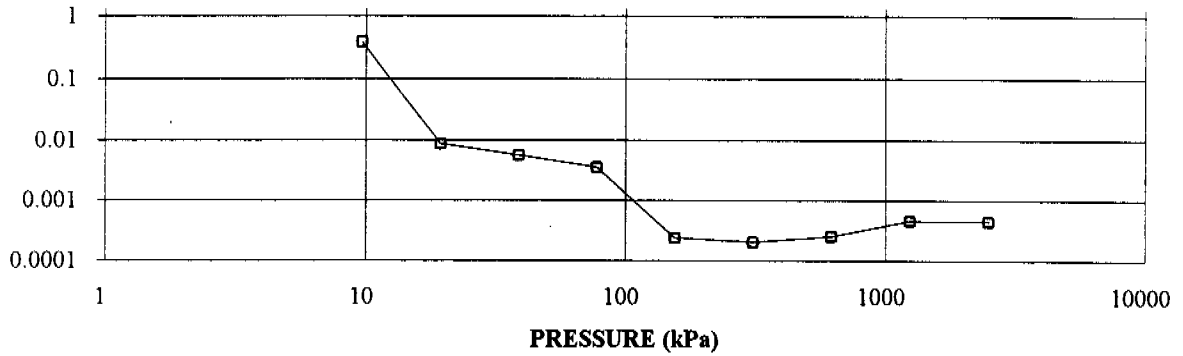
FIGURE A13



OEDOMETER CONSOLIDATION SUMMARY

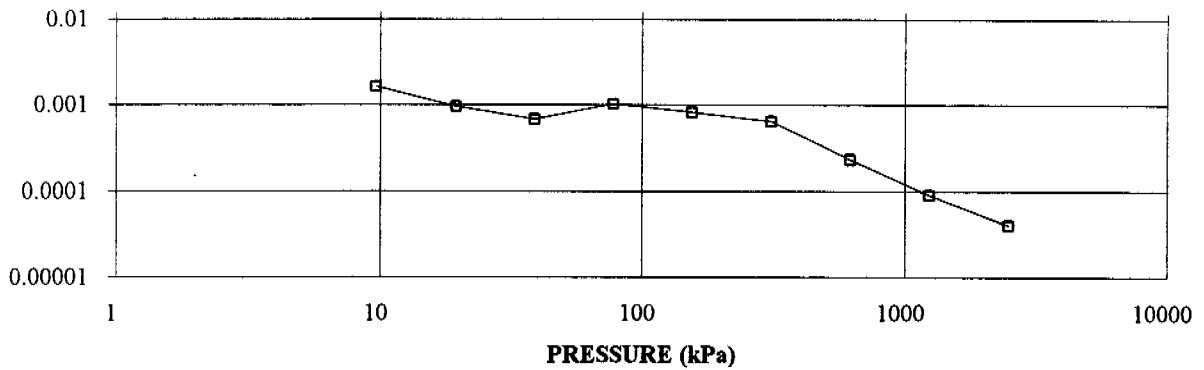
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
LOG. cv cm^2/s vs LOG. PRESSURE (kPa)
BH 99-39 SA 5



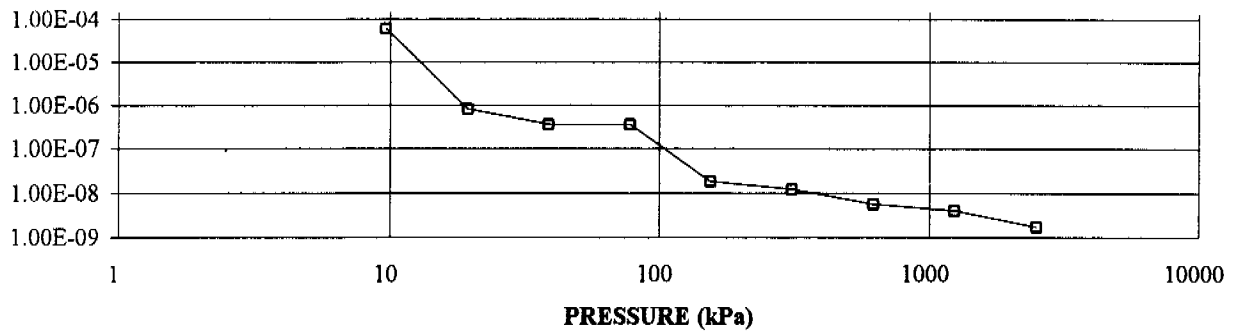
VOLUME
COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
LOG. mv , m^2/kN vs LOG. PRESSURE (kPa)
BH 99-39 SA 5



HYDRAULIC
CONDUCTIVITY, cm/s

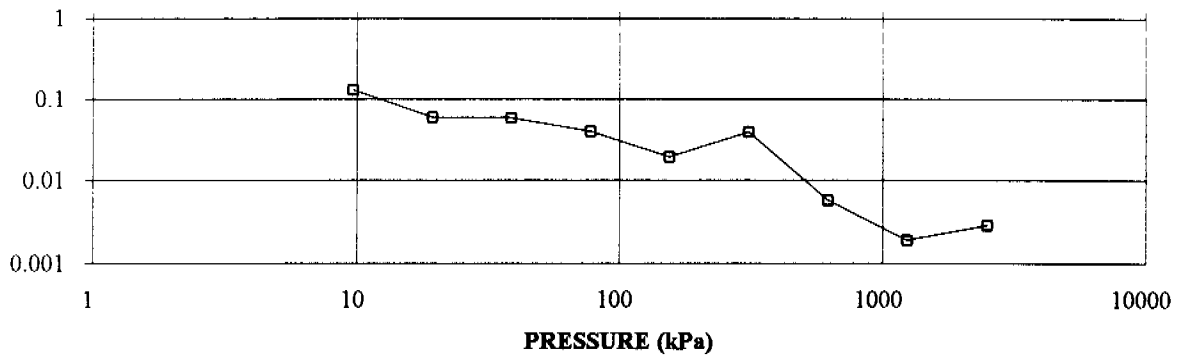
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs LOG. PRESSURE
BH 99-39 SA 5



OEDOMETER CONSOLIDATION SUMMARY

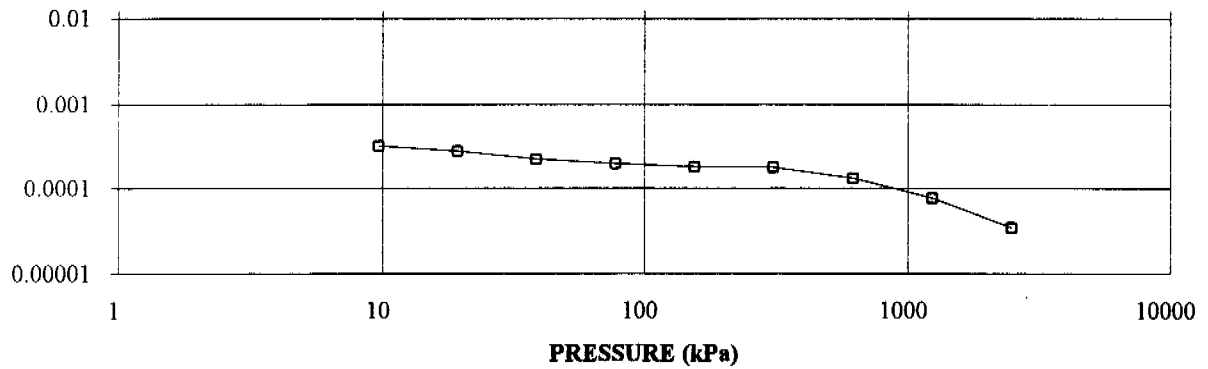
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
LOG. c_v cm^2/s vs LOG. PRESSURE (kPa)
BH 99-24 SA 6



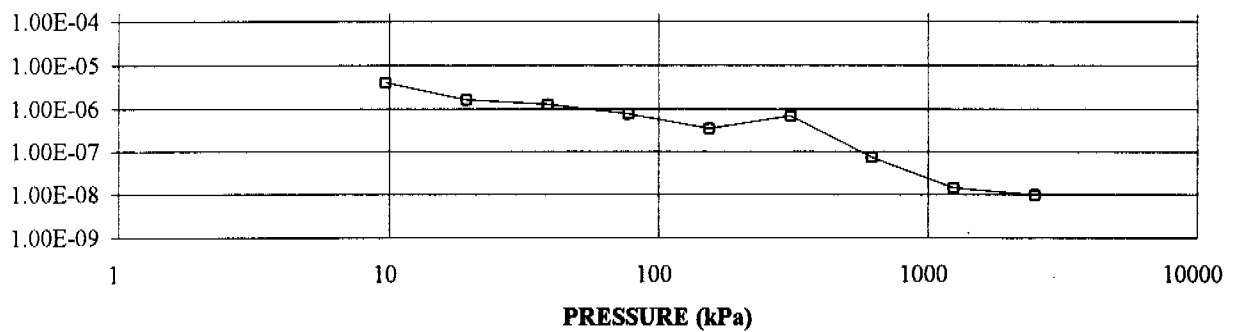
VOLUME
COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
LOG. m_v , m^2/kN vs LOG. PRESSURE (kPa)
BH 99-24 SA 6



HYDRAULIC
CONDUCTIVITY, cm/s

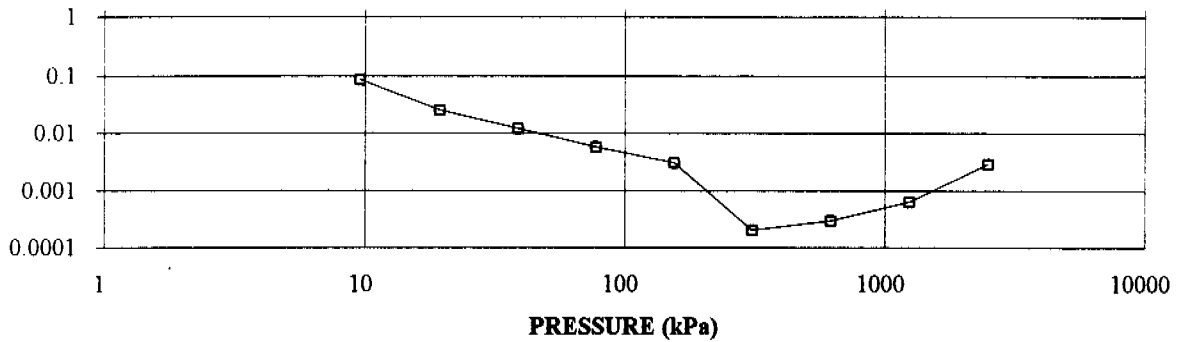
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs LOG. PRESSURE
BH 99-24 SA 6



OEDOMETER CONSOLIDATION SUMMARY

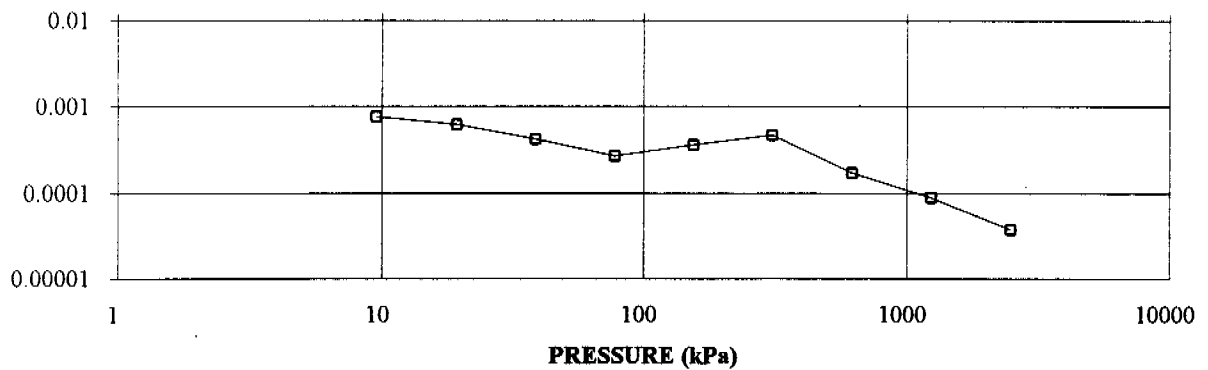
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
LOG. c_v cm^2/s vs LOG. PRESSURE (kPa)
BH 99-24 SA 6



VOLUME
COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
LOG. m_v , m^2/kN vs LOG. PRESSURE (kPa)
BH 99-24 SA 6



HYDRAULIC
CONDUCTIVITY, cm/s

CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs LOG. PRESSURE
BH 99-24 SA 6

