

GEOCRES No. 30M14-274

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HWY. No. 404

LOCATION CNR OVERPASS
BLOOMINGTON RD To
AURORA RD

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

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REPORT ON

**FOUNDATION INVESTIGATION AND DESIGN
- CNR OVERPASS
HIGHWAY 404 WIDENING
BLOOMINGTON ROAD TO AURORA ROAD
G.W.P. 433-98-00, SITE 37-700 / 1 AND 37-700 / 2
REGIONAL MUNICIPALITY OF YORK**

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January 2000

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**PART A – FIELD INVESTIGATION
CNR OVERPASS
HIGHWAY 404 WIDENING
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1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation at the site of the proposed widening of the twin overpass structures at Highway 404 and the CNR in the Region of York, Ontario. The project consists of the widening of Highway 404 from south of Bloomington Road to Aurora Road, and the widening of the twin overpass structures at Bloomington Road and the CNR tracks within the project limits. This report addresses the proposed widening of the twin CNR overhead structures at Highway 404 and their approaches within 20 m of the structures.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed additions to the bridge structures by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the foundation aspects of design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect the design of the proposed bridges and approach embankments.

The terms of reference for the scope of work are outlined in our proposal letter P91-1113, dated March 26, 1999. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, dated June 1999.

2.0 SITE DESCRIPTION

2.1 General

The site is located approximately 1.6 km north of the intersection of the Highway 404 and the Bloomington Road interchange, bordering the Towns of Aurora and Whitchurch-Stouffville, in the Regional Municipality of York. The Westview Golf Course is located to the west of the site.

The topography of the site area is generally undulating with low swampy areas. The ground surface generally slopes down to the south towards Lake Ontario, but varies locally from about Elevation 305 m to Elevation 316 m. Based on available existing site information, the CNR overpass was constructed with embankments up to 11 m in height. A review of existing contract documents and the provided plan indicates the approximate grade of Highway 404 south of the CNR tracks is at about Elevation 317.0 m and drops to about Elevation 311 m towards the north. The CNR track elevation at the site is at about Elevation 306.5 m.

Vegetation cover within the median consists of grass. The valley floor contains swamp areas; standing water was noted in several of these low areas at the time of site investigation.

2.2 Site History

On May 17, 1983, Pier "1S" of the southbound lane structure of the Highway 404 bridge over the CNR tracks failed as a result of horizontal movements of the pier footing. A post-failure investigation was subsequently carried out by MTO to determine the nature and cause of the failure. It was concluded that the movement was primarily the result of a shallow slope failure in the adjacent south approach fill, which was under construction at the time under Contract 82-74. The reconstruction for the failure was carried out under Contract 84-10. Detailed information pertaining to the failure can be found in the reference documents listed below.

In addition to the Pier "1S" failure and remediation program, an additional investigation at the site was carried out in August 1986 and reported in April 1987 by MTO which provided recommendations for repair of localized south approach embankment instabilities. The embankment instabilities occurred at the south approaches of both the northbound and southbound structures. The distressed areas consisted of uncontrolled surficial drainage channels, surficial

slope instabilities, and erosion and undermining at the toe of the rock protection in front of the abutments. Remedial measures, including counterfort drains and improved drainage channels, were implemented to correct the distressed locations. The details of the investigation carried out by MTO and the subsequent remediation program can be found in the reference documents.

The following table lists the relevant MTO reports for the existing structures at the site that have been referred to in this report:

Table 1 – Reference Documents

GEOCRES ID	REPORT	NUMBER OF BOREHOLES FOR INVESTIGATION
Original Foundation Report		
30M14-160	"Foundation Investigation Report for C.N.R. Overhead, 3.7 Miles North of Regional Road 14", W.P. 160-74-33, Highway 404, District 6, Site 37-700, Toronto, dated October 1978	30
Pier "1S" Failure Reports		
30M14-160	"Foundation Investigation Report for C.N.R. Overhead (Reconstruction of SBL Structure)", W.P. 160-74-56, Highway 404, District 6, Site 37-700, Toronto, dated December 1984	56
	"Failure of Pier "1S", CNR Overhead Structure", report on relevant events preceding the failure, Contract 82-74, Highway 404, dated July 1983	N/A
	"Report on Structure Failure, Highway 404 – CNR Overhead South of Vandorf Side Road", dated April 1985	N/A
South Approach Embankment Instabilities		
30M14-183	"Foundation Investigation Report for South Approach Embankment Instabilities", W.O. 86-11006, Highway 404, District 6, Site 37-700, Toronto, dated April 1987	4

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between August 17 and August 25, 1999. At this time, ten boreholes were put down at the site. Two boreholes, 99-5 and 99-10, were put down in the median at the base of the south and north embankments, respectively. Note Boreholes 99-1 to 99-4 were put down at the Bloomington Road crossing, Golder Associates Ltd. Report No. 991-8024A. Boreholes 99-6 and 99-11 were drilled in the median at the crest of the south and north approach embankments, respectively. The remaining six boreholes (99-7 to 99-9 and 99-12 to 99-14) were located in the lower areas of the south and north embankments.

The investigation was carried out using a track-mounted B-57 drill rig supplied and operated by Master Soil Investigation of North York. In the boreholes, samples of the overburden were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. The boreholes were extended to depths of between 6.7 m and 29.0 m below the existing ground surface. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers were installed in four boreholes to permit monitoring of the groundwater levels at the site.

The field work was supervised on a full-time basis by a member of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples. The results of the testing are shown on the attached Record of Borehole sheets and on Figures 1 to 7.

A plan view for the twin bridge structures at Highway 404 and the CNR was provided to us in digital format by J.D. Barnes Limited, professional land surveyors. J.D. Barnes Limited surveyed and staked in the field the Highway 404 median at 50 m chainage intervals within the project limits.

The boreholes were surveyed by J.D. Barnes Limited upon completion of the drilling operation. It is understood that the northing and easting co-ordinates of the borehole locations are given in UTM, and the borehole elevations are referenced to the Geodetic Datum. The co-ordinates of the boreholes are indicated on the Record of Borehole sheets and the locations of the boreholes are shown on Drawing 1.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

The site is located in the physiographic region known as the Oak Ridges Moraine, which was formed between two opposing movements of ice during the late Wisconsinan period of glaciation (Chapman and Putnam, "The Physiography of Southern Ontario", 3rd Edition, 1984). The topography of the Oak Ridges Moraine is hilly, with knob and basin relief that is typical for an end moraine. The subsoils for this region are generally comprised of sandy or gravelly materials, which are underlain by glacial till. Interbeds of fine sand, silt, and clay are also common. Bedrock is generally deep below the ground surface in this region; a previous investigation carried out by others in the region found the top of bedrock varied between 180 m to 240 m below the ground surface.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

The subsurface information obtained from the current investigation (Boreholes 99-5 to 99-14) was supplemented by the borehole information from the original foundation report and subsequent reports for the south abutment failure and south approach instabilities. The additional boreholes directly used for stratigraphy interpretation are provided in Appendix A.

In summary, the subsoils at the site are variable, but generally consist of surficial topsoil underlain by sand and / or clayey silt fill. The fills are about 5.3 m thick and 7.1 m thick at the south and north approach embankments, respectively. At the base of the embankments, the fills were found to be about 3.2 m to 6.1 m thick on the south side and about 0.6 m to 3.0 m thick on the north side. An organic silt deposit up to 1 m thick was encountered in two boreholes put down at the base of the south embankment and one borehole put down at the base of the north embankment. A deposit

of sand up to 7 m thick was generally encountered below the fills and / or organic silt. The sand is generally underlain by a deposit of clayey silt which varies in thickness from 1.5 m to 12 m. Occasional layers of silt and sand were noted within the clayey silt. At depth, a deposit of silt was encountered, which was found to be about 14 m thick on the south side and 4.5 m thick on the north side. The silt is underlain by silty sand glacial till which was encountered at about Elevation 281 m south of the CNR tracks and about Elevation 286 m north of the CNR tracks. The silty sand till was not fully penetrated in the current boreholes, but proved to a thickness of 3.4 m and 3.7 m.

Locations and elevations of the borings for the current and original investigations, together with the estimated stratigraphical profile and sections, are shown on the attached Drawings 1 to 3. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided in the following sections.

4.2.1 Topsoil

A surficial layer of topsoil was encountered at the location of all boreholes for this investigation, except in Borehole 99-8. The topsoil thickness varies between 50 mm and 100 mm in the boreholes.

4.2.2 Fills

Sand

Below the topsoil a 0.5 m to 3.8 m thick layer of sand fill was encountered. The sand fill contains trace to some silt and gravel. At the location of Borehole 99-8, the surficial fill layer is gravelly sand. Occasional organics were noted within the sand fill. Standard Penetration testing (SPT) carried out within the sand fill gave "N" values ranging from 4 blows to greater than 50 blows per 0.3 m of penetration, indicating a loose to very dense state of packing. The measured water contents for selected samples of the sand fill range from 3 percent to 12 percent.

A layer of sand fill was encountered underlying the gravelly sand fill in Borehole 99-8 and the clayey silt fill in Borehole 99-9. The fill has a very loose to compact state of packing. Standard Penetration testing carried out within this lower sand fill gave "N" values of 0 (i.e. the weight of

the hammer) to 24 blows per 0.3 m of penetration. The measured water content for selected samples of the sand fill range from about 3 percent to 16 percent.

This lower sand fill may be the granular material that was backfilled into a portion of the swamp excavation following the slope failure.

Clayey Silt

A layer of clayey silt fill up to about 3.9 m in thickness was encountered below the sand fill in all the boreholes, except Boreholes 99-8, 99-10 and 99-12. The clayey silt fill contains trace to some sand, trace gravel, and occasional organics. Grain size distribution curves for selected samples of the clayey silt fill are shown on Figure 1. Standard Penetration testing (SPT) carried out within the fill gave "N" values of between 6 blows to greater than 50 blows per 0.3 m of penetration, indicating a firm to hard consistency. Undrained shear strengths of 57 kPa and 48 kPa were measured in Boreholes 99-5 and 99-7, respectively. An undrained shear strength of greater than 100 kPa was also measured in a deeper section of this layer in Borehole 99-7.

Atterberg limits testing was carried out on selected samples of the clayey silt fill; the results are shown on the attached Plasticity Chart, see Figure 2. The following table summarizes the Atterberg limits test results carried out on the selected samples of the fill.

Table 2 - Results of Atterberg Limit Tests – Clayey Silt Fill

	<i>Liquid Limit (%)</i>	<i>Plastic Limit (%)</i>	<i>Plasticity Index (%)</i>
Range	18 to 32	12 to 18	6 to 14.5
Average	23.5	14	10

Based on the results of the Atterberg limits tests, the clayey silt fill is classified as low plasticity. The measured water contents on selected samples of the clayey silt fill range from 9 percent to 19 percent, and were generally near the plastic limit.

4.2.3 Organic Silt

A deposit of organic silt up to 1 m in thickness was encountered below the fill materials in Boreholes 99-7, 99-8, 99-10 and 99-13. The deposit contains decaying wood fragments at the location of Borehole 99-10. Standard Penetration testing carried out within the organic silt deposit at the location where wood fragments were encountered (Borehole 99-10) gave an "N" value of 16 blows per 0.3 m of penetration. The undrained shear strength, as determined by in-situ vane testing, was 23 kPa in Borehole 99-13. Based on the vane result, and given that the SPT "N" value was obtained in an area containing wood fragments which may have affected the "N" value, it is estimated that this deposit has a soft to firm consistency. The water content of a selected sample of the organic silt was measured at about 110 percent; this high natural water content is typical for soil that contains a large amount of organic material.

4.2.4 Sand

A deposit of sand with some silt to sand and silt was encountered underlying the organic silt in Boreholes 99-7, 99-8 and 99-13, and the fill in Boreholes 99-5, 99-6 and 99-12. At the location of Borehole 99-11 the sand deposit was found at greater depth, below the clayey silt deposit. The sand deposit was fully penetrated in Boreholes 99-5, 99-6 and 99-12 where the deposit was found to be up to 7 m in thickness. The sand / silt deposit contains traces of gravel and occasional thin (10 mm to 25 mm thick) seams of clayey silt. Grain size distribution curves for selected samples of this deposit are shown on Figure 3. Standard Penetration testing carried out within the sand deposit gave "N" values of between 3 blows to 36 blows per 0.3 m of penetration, which indicates a very loose to dense state of packing. The water contents measured on selected samples of the sand deposit range from 10 percent to 18 percent, and generally decrease with depth.

4.2.5 Clayey Silt

A deposit of clayey silt was encountered underlying the sand deposit in Boreholes 99-5, 99-6 and 99-12, and the fill / organic silt in Boreholes 99-9 to 99-11, and Borehole 99-14. The clayey silt contains trace to some sand, and traces of gravel. Occasional layers of silts and sands were noted within the clayey silt. At the location of Borehole 99-10, occasional wood fragments were noted within the clayey silt. Grain size distribution curves for selected samples of the clayey silt are shown on Figure 4. Boreholes 99-6, 99-9, 99-12 and 99-14 were terminated in this deposit.

The deposit varied in thickness from 1.5 m in Borehole 99-5 to 12 m in Borehole 99-10. Standard Penetration testing carried out within the deposit gave "N" values of between 6 blows to greater than 50 blows per 0.3 m of penetration, indicating a firm to hard consistency. In-situ undrained shear strength testing was also carried out within the clayey silt using vane test equipment. The results are summarized in the following table;

Table 3 - Results of In-Situ Undrained Shear Strength Testing – Clayey Silt

	<i>Undrained Strength (kPa)</i>
Range	23 to 77
Average	53

The above results indicate that, where the test could be carried out, the consistency of the clayey silt varied from firm to stiff.

The results of the Atterberg limits testing carried out on selected samples of the clayey silt deposit are summarized in the following table, and shown in Figure 5.

Table 4 - Results of Atterberg Limits Tests – Clayey Silt

	<i>Liquid Limit (%)</i>	<i>Plastic Limit (%)</i>	<i>Plasticity Index (%)</i>
Range	17 to 25	10 to 17	5 to 9
Average	22	14	8

Based on the results of the Atterberg limits tests, the clayey silt is classified as low plasticity. The measured water contents on selected samples of the clayey silt fill range from 10 percent to 27 percent.

4.2.6 Silt

In Boreholes 99-5 and 99-10 a deposit of silt was encountered underlying the clayey silt. Grain size distribution curves for selected samples of the silt are shown on Figure 6. The silt was fully penetrated in each borehole and was found to be 14 m and 4.5 m thick at the locations of

Boreholes 99-5 and 99-10, respectively. Standard Penetration testing carried out within the silt deposit gave "N" values of 8 blows to greater than 50 blows per 0.3 m of penetration, which indicates a loose to very dense state of packing. In general, the silt is compact to very dense. Some of the samples obtained from the silt deposit exhibited slight plastic characteristics in the field. However, an Atterberg limits test carried out on a selected sample gave a non-plastic result.

4.2.7 Silty Sand (Glacial Till)

Silty sand till was encountered underling the silt deposit in Boreholes 99-5 and 99-10. The silty sand till is comprised of trace to some gravel and clay as illustrated by the grain size distribution curves shown on Figure 7. The surface of the till was encountered at about Elevation 281.4 m south of the CNR tracks (Borehole 99-5) and about Elevation 286.4 m north of the CNR tracks (Borehole 99-10). The change in elevation of the surface of the till deposit from south to north is consistent with the borings put down as part of the original MTO investigation carried out at the site. Standard Penetration testing carried out within the deposit generally gave "N" values of greater than 100 blows per 0.3 m of penetration, which indicates a very dense state of packing. Occasional grinding of the augers observed during the drilling operation within this deposit indicates the presence of cobbles and boulders, which are typically found within glacial till deposits. The natural water contents for two selected samples of the silty sand till were measured at about 8 percent and 9 percent. The thickness of the deposit was not fully penetrated in the current or previous boreholes but proved to thicknesses of 3.4 m in Borehole 99-5 to about 12 m in Borehole 8.

4.3 Groundwater Conditions

Groundwater levels were noted in the open boreholes during and upon completion of the drilling operation; the noted levels are shown on the attached record of Borehole sheets. Piezometers were sealed in Boreholes 99-5, 99-6, 99-10 and 99-11 to permit the monitoring of the stabilized groundwater conditions at the site. Details of the piezometer installations and water level measurements are shown on the attached Record of Borehole sheets. A summary of the monitoring results are provided in the following table.

Table 5 - Summary of Groundwater Conditions


Borehole	August 31, 1999		September 14, 1999		October 19, 1999	
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
99-5	4.9	302.1	4.8	302.2	4.6	302.4
99-6	11.9	303.7	11.9	303.7	11.8	303.8
99-10	6.2	299.9	2.6	301.9	1.8	302.3
99-11	9.4	302.7	9.2	302.9	9.2	302.9

Groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

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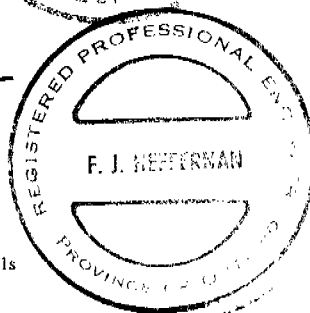
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5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of widening of the twin bridge structures at the CNR crossing based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

The works described in this report are associated with the proposed twin bridge widening and their approaches within 20 m of the structure. It is understood that the widened bridge structures will carry an additional lane in each direction of Highway 404 over the CNR tracks. It is further understood that the additional lanes will be constructed in the median area adjacent to the existing median lanes and that the proposed twin bridge widening will be placed adjacent to the existing bridge structures. It is assumed the additional lanes will be built to coincide with the existing Highway 404 grade which varies from about Elevation 311 m to Elevation 317 m across the site and the widening will be about 4 m in width. It is therefore anticipated that up to 3 m of fill material may be placed on the side of the existing embankments and in the median to provide the appropriate grade at the bridge structures.

5.2 Bridge Foundations

The available contract documents for the original twin bridge structures (Contract No. 82-74) and the subsequent reconstruction in the area of the south approach for the southbound lane structure (Contract 84-10) indicate the existing abutments and piers are supported on end bearing steel H-piles driven into the very dense glacial till.

The subsoils encountered in the boreholes put down at this site for the current investigation are not suitable for support of shallow spread footings; therefore, deep foundations are recommended for the support of the abutments and the piers. Consideration could be given to the use of steel H-piles

driven into the silty sand till deposit. The pile arrangement should be checked with the structural engineer to ensure that interference with the existing piles does not occur. The following table summarizes the approximate elevation of the top of the silty sand till deposit at the location of each foundation unit and the estimated pile tip elevations for piles driven about 2.0 m into the till.

Table 6 – Summary of Estimated Pile Tip Elevations

<i>Foundation Unit</i>	<i>Approximate Surface Elevation of Silty Sand Till (m)</i>	<i>Estimated Pile Tip Elevation (m)</i>
South Abutment SBL	281.0	279.0
Pier 'A'	279.5 – 282.0	277.5 – 280.0
Pier '1S'	280.0	278.0
Pier '2S'	277.5	275.5
Pier '3S'	285.0	283.0
Pier '4S'	288.0 – 289.0	286.0 – 287.0
North Abutment SBL	288.0 – 289.0	286.0 – 287.0
South Abutment NBL	281.0 – 282.0	279.0 – 280.0
Pier '1N'	281.0 – 282.0	279.0 – 280.0
Pier '2N'	282.0 – 283.0	280.0 – 281.0
Pier '2N'	285.0 – 286.0	283.0 – 284.0
North Abutment NBL	283.0 – 287.0	281.0 – 285.0

The above elevations may be assumed for estimating purposes.

Although not encountered during the current investigation, a layer of cobbles and boulders up to 1.5 m thick was found within the very dense glacial till deposit in some boreholes put down as part of the original investigation at the site.

5.2.1 Geotechnical Resistance

The factored geotechnical resistance at Ultimate Limit States (ULS) for piles driven to practical refusal within the glacial till at this site will be greater than the structural capacity of the piles. Since the piles will be driven into an unyielding deposit of very dense silty sand till, the geotechnical resistance at Serviceability Limit States (SLS) is not applicable.

For this site, therefore, the structural resistance of the piles will govern and the capacities will be determined by current MTO practices (Standard SS103-11). For example, HP 310 x 110 piles driven to refusal may be assumed to have a factored axial resistance at ULS of 2,000 kN.

Embankment construction at the abutments will induce settlement of the fill and native layers. However, given the nature of the subsoils, predominately compact granular or very stiff low plasticity clayey silt, we anticipate that most of the settlement will occur during embankment construction and prior to pile driving at the abutments. Therefore, negative skin friction loads are not required as long as the embankment construction is completed prior to pile driving.

The piles should be equipped with reinforced tips to ensure penetration to and seating into the till as per current MTO practice (Standard OPSD 3301.00).

Set criteria are highly dependent on hammer type and selected pile. The pile driving for the existing structure was controlled in the field by the use of dynamic formula as per MTO Standard SS103-11, which is applicable for the proposed foundations. Alternatively, set criteria could be determined by wave equation analysis at the time of construction once the proposed hammer type is known. Examples of typical hammer and required sets can be provided on request. In addition, dynamic monitoring should be carried out on the first few piles driven to confirm the set requirements. The dynamic monitoring should be carried out by an experienced specialist under the direction of a geotechnical engineer.

5.2.2 Horizontal Resistance

The lateral loading could be resisted fully or partially by the use of battered piles. If vertical piles are used to resist the lateral loading, the horizontal reaction to the pile can be estimated using the following table and where:

k_h	= coefficient of horizontal subgrade reaction (MPa/m)
d	= pile width or diameter (m)
n_h	= constant of horizontal subgrade reaction (MPa/m)
z	= depth below native / fill interface (m)

Table 7 –Horizontal Subgrade Reaction

<i>Soil Type</i>	<i>k_h</i>	<i>n_h</i> (MPa/m)	<i>Note</i>
Sand Fill	n _h /d	2	k _h constant with depth
Clayey Silt Fill	n _h /d	3	k _h constant with depth
*Organic Silt	n _h /d	0.25	k _h constant with depth
Clayey Silt to Silt	n _h (z/d)	2	k _h increasing with depth

*Organic silt was encountered below the sand fill/clayey silt fill at some borehole locations.

Group action for lateral loading should be considered when the pile spacing in the direction of loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of lateral subgrade reaction in the direction of loading by a reduction factor R as follows:

Table 8 – Subgrade Reduction Factors

<i>Pile Spacing in Direction of Loading d = Pile Diameter</i>	<i>Subgrade Reaction Reduction Factor R</i>
8d	1.00
6d	0.70
4d	0.40
3d	0.25

5.2.3 Frost Protection

All footings should be provided with a minimum of 1.2 m of earth cover for frost protection purposes.

5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments and the retaining walls in accordance with OHBDC:

Select free-draining granular fill meeting the specifications of OPSS Granular A or Granular B but with less than 5 percent passing the 200 sieve should be used as backfill behind the walls. All

granular fill should be compacted in lifts of loose thickness not greater than 200 mm to 95 percent of the material's Standard Proctor maximum dry density.

Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.

The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the stem (Case I) or within the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the footing (Case II).

If the wall support allows lateral yielding of the stem (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (restrained structure), at-rest pressures should be assumed for geotechnical design.

A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with OHBDC Figure 6-7.4.3. Compaction equipment should be restricted as per OPSS 501.06.

For Case I, the pressures are based on the embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight (assuming compacted clean earth fill)	21 kN/m ³
Coefficients of lateral earth pressure:	
'active'	0.33
'at rest'	0.5

For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

Soil Unit Weight	Granular A 22 kN/m ³	Granular B 21 kN/m ³
Coefficients of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

It should be noted that the above design parameters assume level backfill and / or ground surface behind the wall. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00.

5.4 Excavations

Local excavation at the locations of the abutments and piers will be required to construct the pile caps. The following table summarizes the approximate elevation and depth of the existing foundation units and a design water level.

**Table 9 – Summary of Excavation Requirements
Abutment / Pier Pile Caps**

<i>Foundation Unit</i>	<i>Approximate Elevation of Existing Pile Cap (m)</i>	<i>Proposed Pile Cap Base Elevation (m)</i>	<i>Design Water Level Elevation (m)</i>	<i>Average Depth of Pile Cap (m)</i>
South Abutment SBL	311.8	311.8	304	varies up to 5
Pier 'A'	308.0	308.0	302	4
Pier '1S'	303.4	304.5	302	3
Pier '2S'	303.3	304.0	302	2
Pier '3S'	302.5	304.0	302	2
Pier '4S'	303.1	303.5	303	4
North Abutment SBL	307.7	307.7	303	varies up to 4
South Abutment NBL	310.0	310.0	304	varies up to 5
Pier '1N'	303.6	303.5	302	2
Pier '2N'	303.2	304.0	302	2
Pier '3N'	302.5	303.5	302	2
North Abutment NBL	306.8	306.8	303	varies up to 5

- NOTE:** (i) assumed pile cap thickness is 1.2 m.
(ii) the depth of excavation for the abutments represents the maximum required adjacent to the existing abutment.

The depths of excavation shown to reach the founding elevation of Piers 'A', '1S' and '4S' are greater than 2 m and is probably due to regrading and berm construction that was carried out after footing construction. We recommend that the proposed abutment footings are constructed at the same elevation as the existing footings but that the pier footings are constructed only 1.2 m below existing ground surface. However, this recommendation should be reviewed by the structural engineer to confirm that the pier pile caps do not have to be connected at the footing level. Note that if the pier caps have to be connected, temporary shoring will be required at several pier locations. The structural engineer should also check that the proposed piling scheme does not interfere with the existing piles.

Due to the presence of weak layers (loose fill and soft to firm organic silt) and the previous instability of the south embankment slopes, temporary cuts may be made with side slopes not steeper than 2 horizontal to 1 vertical (2H:1V) in the area of the south embankments. Temporary cuts in the area of the north embankments can be made with side slopes not steeper than 1.5 horizontal to 1 vertical (1.5H:1V). Conventional excavation equipment would be suitable for excavation of the subsoil.

All excavation side slopes should conform to the requirements of the latest edition of the Occupational Health & Safety Act.

The water level measured in the piezometers varied across the site from about Elevation 302 m to Elevation 304 m. The water level may be higher in wet periods of the year. The base of the pile cap excavations will likely be above the groundwater level, however, some water inflow into the excavations should be expected from perched water conditions. This inflow can be handled by conventional pumping from properly filtered sumps. The sumps should be maintained outside the pile cap area. Surface run-off should be directed away from the excavations at all time.

All pile cap excavations should be inspected by qualified geotechnical personnel prior to placing concrete to ensure that the base has been adequately cleaned and that the subsoil conditions as exposed at the founding level are consistent with the design assumptions. All loose material within the footprint of the pile caps and at the founding level should be removed and replaced with compacted granular.

5.4.1 Excavation Support

The excavations for the abutments will be carried out adjacent to the existing bridges' wing walls. These walls may require temporary support during excavation. The requirement for temporary support should be determined by the structural engineer.

Assuming that the new abutment pile caps for the bridges will be constructed at about the same founding elevation and have a similar geometry to the existing pile caps then the excavation adjacent to the wing wall will, even using 1 horizontal to 1 vertical (1H:1V) temporary cuts, expose a vertical face of embankment fill adjacent to the highway. This face therefore requires temporary support to prevent undermining of the highway. Temporary support to this face may be provided by a conventional soldier pile and lagging wall.

Roadway protection should be included in the tender documents as per current MTO end result specifications.

Rakers

Support of the exposed retaining walls can be achieved with the use of rakers. For design, allowable bearing pressures given in the following table may be assumed for raker footings founded on the compact to dense sand fill for the north abutment and the firm to very stiff clayey silt fill for the south abutment at about Elevation 310 m.

Table 10 – Raker Footing Bearing Pressures

<i>Footing Size (m)</i>	<i>ULS Factored Resistance (kPa)</i>		<i>SLS Resistance (kPa)</i>		<i>Maximum Settlement (mm)</i>
	<i>Clayey Silt (fill)</i>	<i>Sand (fill)</i>	<i>Clayey Silt (fill)</i>	<i>Sand (fill)</i>	
2 by 2	200	300	150	200	25
3 by 3	250	350	100	150	25

Note that the bearing pressures must be reduced to allow for the effect of load inclination.

A factored ultimate base friction factor of 0.55 may be used for the raker footings founded on competent fill materials at the assumed elevation. The design of the rakers should be checked using the rectangular pressure distribution as shown on Figure 8 using; $K = 0.5$ and $\gamma = 21 \text{ kN/m}^3$.

Soldier Pile and Lagging

Excavation carried out beyond the limits of the abutment walls can be achieved using a soldier pile and lagging support system. To prevent any disturbance to the existing foundations augered caissons with soldier piles should be considered. Auger holes would extend below the ground water level and should be cased to the required design depth to prevent loss of ground. The steel H-pile should be placed in the augered hole and the annular space should be concreted to the base of the future excavation. This will facilitate the installation of timber lagging to support the excavation above the base.

The design of the soldier pile and lagging wall should be based on the earth pressure distribution shown on Figure 9, assuming an average earth pressure coefficient (K) equal to 0.3 and unit weight of soil (γ) of 21 kN/m^3 . Soldier piles should extend to at least 3 m below the base of the excavation. A design ground water level at Elevation 304 m and a construction surcharge of 16 kPa should be assumed. Unfactored socket resistances, for sockets located above the design groundwater level in cohesionless soil, can be determined based on the following relationship:

$$R_p = 1.5 K_p \gamma H^2 D$$

Where: R_p = unfactored passive resistance of socket (kPa)
 K_p = coefficient of passive resistance
 γ = unit weight of soil (kN/m^3)
 H = embedded length of pile below base of excavation (m)
 D = diameter of pile (m)

A coefficient of passive resistance of 5.0, and a unit weight of soil of 20 kN/m^3 may be assumed for design. The resistance of the upper 1 m of the embedded length of the pile should be ignored. Note that, according to the OHBDC, a factor of 0.5 should be used to calculate the factored passive resistance at ULS.

The proposed shoring system should be reviewed by a geotechnical engineer prior to installation. Stability and design checks should be made for each stage of the excavation.

5.5 Approach Embankments

On May 17, 1983, Pier "1S" of the southbound lane structure of the Highway 404 bridge over the CNR tracks failed as a result of horizontal movements of the pier footing. A post-failure investigation was subsequently carried out by MTO to determine the nature and cause of the failure. It was concluded that the movement was primarily the result of a shallow slope failure in the adjacent south approach fill, which was under construction at the time under Contract 82-74. The reconstruction for the failure was carried out under Contract 84-10.

In addition to the Pier "1S" failure and remediation program, an additional investigation at the site was carried out in August 1986 and reported in April 1987 by MTO which provided recommendations for repair of localized south approach embankment instabilities. The embankment instabilities occurred at the south approaches of both the northbound and southbound structures. The distressed areas consisted of uncontrolled surficial drainage channels, surficial slope instabilities, and erosion and undermining at the toe of the rock protection in front of the abutments. Remedial measures, including counterfort drains and improved drainage channels, were implemented to correct the distressed locations.

In general, the proposed overpass structures will require up to 3 m additional fill on the slopes to raise the existing embankments, within the median area, up to the existing Highway 404 grade. As noted, a slope instability previously occurred at the south abutment. We understand that the failure was generally shallow and confined within the swamp backfill at the top of the south approach slope. The swamp backfill was classified as a very soft to firm clayey silt to silt. We understand that the majority of this backfill was removed and replaced with compacted granular material and an additional berm constructed to about Elevation 306 m.

The current site investigation encountered occasional zones of very loose sand fill (Boreholes 99-8 and 99-9) and thin layers of organic silt typically at the interface between the fill and native materials. No zones of very soft clayey silt fill was encountered.

Slope stability analyses were carried out on critical sections at the south and north approach embankments using the commercially available program SLOPE/W (version 4.0). The program has the capability of modelling drained or undrained strength parameters for 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 embankment geometry 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 the available field data. 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 for assumed additional embankment load configurations. The following is a summary of the results and recommendations for the south and north approach embankments to ensure stability in both the short-term and long-term.

5.5.1 South Approach Abutment

North Bound Lanes

The proposed abutment will be located on the west side of the existing embankment. This location, see Figure 10, is an area which experienced surficial erosion and was repaired in 1986 and is adjacent to the failed area of the South Bound Lanes abutment. The existing slope is currently at about 2H:1V.

The subsurface conditions at the abutment consist typically of a loose to compact sand fill underlain by a firm to very stiff clayey silt fill and a compact silt / sand deposit. A layer of organic silt was encountered in Boreholes 99-7 and 99-8 directly underlying the fill.

The approximate location of the NBL abutment is shown in Figure 10. The abutment construction will involve raising the crest 2.0 m to 2.5 m to about Elevation 317 m. An undrained slope stability analysis was carried at Section 1-1, see Figure 10, for the existing slope configuration. The parameters and analysis results are shown on Figure 11 and indicate the existing slope has a minimum factor of safety of about 1.3. The key analysis assumptions were as follows:

- Presence of semi-continuous weak layer of organic silty / clayey silt with an undrained shear strength of 25 kPa (measured strength in Borehole 99-13 for organic silt).
- Undrained shear strength of 50 kPa for clayey silt fill.

Both the above assumptions are considered to be conservative but given the history of instability at the site and highly variable fill quality are considered reasonable.

If additional material is added to the abutment the factor of safety falls below the minimum acceptable value of 1.3. For example, the addition of 2 m of fill will lower the factor of safety to about 1.2. Acceptable alternative abutment configurations are as follows:

A – Embankment Construction

Additional fill added to the slope for stability. An acceptable configuration is shown in Figure 12. The configuration consists of a 3H:1V lower slope to Elevation 310 m a 4 m wide berm and a 2H:1V upper slope to Elevation 317 m. This configuration would extend the slope toe out about 5 m. Also note that the abutment extension would be partially buried and any wing wall would be fully buried. Construction of such an embankment must be from the toe up. Existing drainage systems would have to be incorporated into the new embankment. General embankment construction procedures are given in Section 5.5.3.

Note: the capacity of existing piers '1S' and '1N' should be checked by the structural engineer for the additional fill loading.

B – Approach Slab

A structural approach slab could be constructed to avoid the addition of fill. The slab would have to be about 10 m in length and supported on the abutment and a piled wing wall. The wing wall would have a height of up to 2.0 m. The structural engineer should determine the support requirements for the slab (i.e. additional piled supports may be required).

C – Abutment Relocation

The above two solutions assume the proposed abutment is in line with the existing abutment. However, if the abutment was moved about 30 m south the amount of fill required would be minimal. This option would require increased spans and possibly an additional pier.

The alternatives presented are considered feasible, however, they should be evaluated with respect to cost and constructability prior to selection. The proposed grading plans should be evaluated by the geotechnical engineer to confirm stable slope conditions.

Sound Bound Lanes

The proposed abutment will be located on the east side of the existing abutment. This location, see Figure 10, is in the area where the slope failure occurred and as a result has already been graded to between about 3H:1V to 4H:1V.

The subsurface conditions at the abutment consist typically of a very loose to compact sand fill underlain by a firm to very stiff clayey silt fill and a compact sand / silt and very stiff to hard clayey silt. A layer of organic silt was encountered in Boreholes 99-7 and 99-8 directly underlying the fill.

The approximate location of the South Bound Lanes abutment is shown in Figure 10. The abutment construction will involve raising the crest 2.5 m to 3.0 m to about Elevation 317 m.

An undrained slope stability analysis was carried out at Section 2-2 for the existing slope configuration. The minimum factor of safety, for the existing condition, exceeds 2.0. Note the assumptions and rationale made for parameter selection are as described for the North Bound Lane. If the crest is raised by 2.5 m to 3.0 m the factor of safety falls to about 1.8 which is still considered acceptable. The results are summarized on Figure 13. Therefore, standard abutment and wing wall construction may be utilized at this location.

5.5.2 North Approach Abutment

The subsurface conditions at the north abutment consist typically of compact sand fill and stiff to very stiff clayey silt fill underlain by either firm to very stiff clayey silt or loose to compact silt and sand. A layer of organic silt was encountered in Borehole 99-13.

The abutment extension will likely require the addition of about 1 m of fill at the crest in the median area to about Elevation 313 m. A slope stability analysis was carried out on a cross-section of the proposed abutment. Conservative assumptions were made regarding the extent of the organic silt (continuous between Boreholes 99-11, 99-13 and 99-14) and overall undrained strength of the clayey silt (50 kPa), but the minimum factor of safety after adding 1 m of fill on the crest, remained in excess of 1.3 for an undrained analysis and in excess of 1.5 for an effective stress analysis. Note planar failure surfaces were also checked. The factors of safety for the embankment being raised to Elevation 313 m are acceptable.

Note the embankment slope should be maintained at 2H:1V and the geotechnical engineer should review the proposed grading scheme.

5.5.3 General Embankment Construction Procedures

Topsoil and fill materials containing organics, and/or organic silt should be stripped from below the footprint area of the fill embankments and all subgrade soils should be proof-rolled prior to fill placement. As noted, thin layers of organic silt were encountered in some boreholes at the interface between the fill and native materials. The stability analyses included the organic silt at the fill/native soil interface, and therefore no subsurface excavation is necessary since adequate factors of safety are provided.

Construction of the embankment above the prepared subgrade may be carried out using clean earth fill (in accordance with OPSS 212) or Select Subgrade Material (in accordance with OPSS 1010), depending on material availability. Benching into the existing slopes should be carried out in accordance with OPSD 208.010. 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


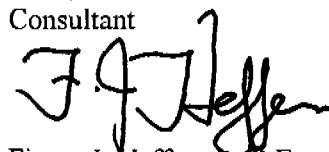
or base course should be compacted to 100 percent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical (2H:1V). Vegetation cover should be established on all slopes to protect embankment fill against surficial erosion.

The widening for an additional lane in each direction will alter the existing median width, however, it is believed that surface drainage will still be conveyed within the median ditch. To prevent localized erosion of the forward slopes due to surface run-off, proper drainage measures are warranted. The erosion channel constructed within the median along the south approach should be maintained or incorporated into the new approach, depending on the alternative adopted. Armoured drainage channels protected with rip-rap could be constructed along the north approach.

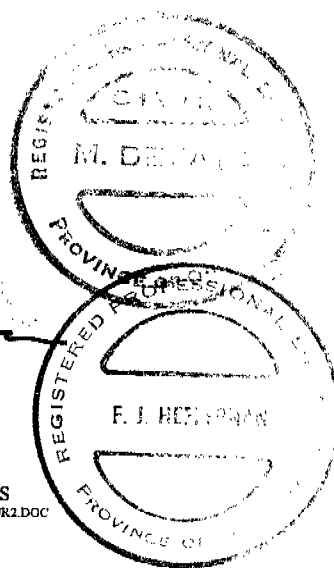
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LIST OF ABBREVIATIONS

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 x 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 $= \sigma'_p / \sigma'_{vo}$

(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

PROJECT 991-8024		RECORD OF BOREHOLE No 99-5		1 OF 3	METRIC
W.P. 433-98-00		LOCATION N 4872222.54; E 313157.57		ORIGINATED BY DKB	
DIST 6 HWY 404		BOREHOLE TYPE 108mm I.D. HOLLOW STEM AUGERS		COMPILED BY DKB	
DATUM GEODETIC		DATE 17.8.99		CHECKED BY AJW	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
306.98 0.00	Topsoil		1	50 DO	10									
	Sand, trace to some silt, trace gravel, occ. organics		2	50 DO	65/15									
305.71 1.27	Compact Brown Dry to moist		3	50 DO	20									
	Gravel piece noted in tip of split spoon sampler for sample 2 (Fill)		4	50 DO	6									
	Clayey Silt, some sand, trace gravel, occ. organics													
	Very stiff to stiff													
	Brown/grey													
	Moist (Fill)													
303.78 3.20	Sand and Silt to sand, some silt, trace gravel, occ. thin (5mm to 10mm thick) clayey silt seams		5	50 DO	24									
	Loose to compact		6	50 DO	20									
	Brown to grey													
	Moist to wet													
			7	50 DO	16									
			8	50 DO	9									
			9	50 DO	11									
296.77 10.21	Clayey Silt, trace to some sand, trace gravel		10	50 DO	28									
	Very stiff													
	Grey													
	Moist													
295.25 11.73	Silt, trace sand		11	50 DO	22									
	Loose to dense													
	Grey													
	Wet													
	Generally compact to dense		12	50 DO	29									

ON MOT 991-8024 GPJ ON MOT GDT 21/10/99

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>991-8024</u>		RECORD OF BOREHOLE No 99-5		2 OF 3	METRIC
W.P. <u>433-98-00</u>	LOCATION <u>N 4872222.54; E 313157.57</u>	ORIGINATED BY <u>DKB</u>			
DIST <u>6</u> HWY <u>404</u>	BOREHOLE TYPE <u>108mm I.D. HOLLOW STEM AUGERS</u>	COMPILED BY <u>DKB</u>			
DATUM <u>GEODETIC</u>	DATE <u>17.8.99</u>	CHECKED BY <u>AJW</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								\circ UNCONFINED \bullet QUICK TRIAXIAL	$+$ FIELD VANE \times REMOULDED						
							20 40 60 80 100	20 40 60 80 100	10 20 30						
	Silt, trace sand Loose to dense Grey Wet(continued)		13	50 DO	18										
							291								
			14	50 DO	24		290						0 2 98		
							289								
			15	50 DO	31		288								
							287						0 0 100		
	Generally compact to dense		16	50 DO	31		286								
							285								
			17	50 DO	8		284						0 3 97		
							283								
			18	50 DO	16		282								
							281								
			19	50 DO	45		280								
							279								
281.38															
25.60	Silty Sand, trace to some clay and gravel Very dense Grey Moist (Glacial Till)		20	50 DO	82										
			21	50 DO	100/10								15 42 31 12		
277.95			22	50 DO	100/08										
29.03	END OF BOREHOLE														

ON MOT 991-8024.GPJ ON MOT.GDT 21/10/99

Continued Next Page

+³ X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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ON MOT 991-8024.GPJ ON MOT.GDT 21/10/99

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

PROJECT 991-8024			RECORD OF BOREHOLE No 99-6			1 OF 2		METRIC															
W.P. 433-98-00			LOCATION N 4872151.99; E 313161.45			ORIGINATED BY DKB																	
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS			COMPILED BY DKB																	
DATUM GEODETIC			DATE 19.8.99			CHECKED BY AJW																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80	100	20	40	60	80	100	10
315.60	8.88	Topsoil Sand, some silt, trace gravel, occ. organics Loose to very dense Brown Moist (Fill)		1	50 DO	32																	
				2	50 DO	50																	
				3	50 DO	8																	
313.49	2.11	Clayey Silt, trace to some sand, trace gravel, occ. organics Firm to very stiff Brown Moist (Fill)		4	50 DO	21																	
				5	50 DO	28																	
				6	50 DO	17																	
				7	50 DO	6																	
310.27	5.33	Sand, some silt, trace gravel Compact Brown Moist		8	50 DO	24																	
309.58	6.02	Clayey Silt, some sand, trace gravel Very stiff to hard Brown to gray Moist		9	50 DO	25																	
		-Gravel piece noted in tip of split spoon sampler for sample 10.		10	50 DO	90																	
				11	50 DO	44																	
				12	50 DO	25																	
				13	50 DO	23																	
		-Silty Sand layer noted from 10.2 m depth to 11.7 m depth.		14	50 DO	36																	
301.28	14.32	END OF BOREHOLE																					

ON MOT 991-8024 GPJ ON MOT GDT 21/10/99

Continued Next Page

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

ON_MOT 991-8024.GPJ ON MOT.GDT 21/10/99




PROJECT 991-8024			RECORD OF BOREHOLE No 99-7			1 OF 1			METRIC														
W.P. 433-98-00			LOCATION N 4872202.11; E 313154.19			ORIGINATED BY DKB																	
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS			COMPILED BY DKB																	
DATUM GEODETIC			DATE 20.8.99			CHECKED BY AJW																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60						80	100	20	40	60	80	100	10
309.24 8.89	Topsoil Sand, some silt, some gravel, occ. organics Loose to compact Brown Moist (Fill)		1	50 DO	7																		
			2	50 DO	10																		
			3	50 DO	4																		
307.03 2.21	Clayey Silt, some sand, trace gravel, occ. organics Firm to hard Brown Moist (Fill)		4	50 DO	63																		
			5	50 DO	20																		
			6	50 DO	6																		
			7	50 DO	16																		
303.14	Organic Silt Sand, some silt, trace gravel Compact Grey Moist to wet		8	50 DO	26																		
6.25																							
301.02 8.22	END OF BOREHOLE Note: 1. Water level measured in open borehole at 7.9m depth (Elev. 301.3m) upon completion of drilling.		9	50 DO	12																		

ON MOT 991-8024.GPJ ON MOT.GDT 22/10/99

PROJECT 991-8024			RECORD OF BOREHOLE No 99-8				1 OF 1		METRIC								
W.P. 433-98-00			LOCATION N 4872210.31; E 313149.32				ORIGINATED BY DKB										
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS				COMPILED BY DKB										
DATUM GEODETIC			DATE 20.8.99				CHECKED BY AJW										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
306.86							20	40	60	80	100						
0.00	Gravelly Sand, trace silt Loose Brown Moist (Fill)		1	50 DO	7												
306.17	Sand, trace silt Very loose to compact Brown Moist to wet (Fill)		2	50 DO	24							o					
0.69			3	50 DO	12												
			4	50 DO	4												
			5	50 DO	WH								o				
302.52	Organic Silt Sand, some silt, trace gravel, occ. thin (5mm-25mm thick) clayey silt seams Very loose to compact Grey Wet		6	50 DO	22												
4.49			7	50 DO	20								o				
			8	50 DO	3												
298.64			9	50 DO	20								o				
8.22	END OF BOREHOLE Note: 1. Water level measured in open borehole at 2.7m depth (Elev. 304.2m) upon completion of drilling.																

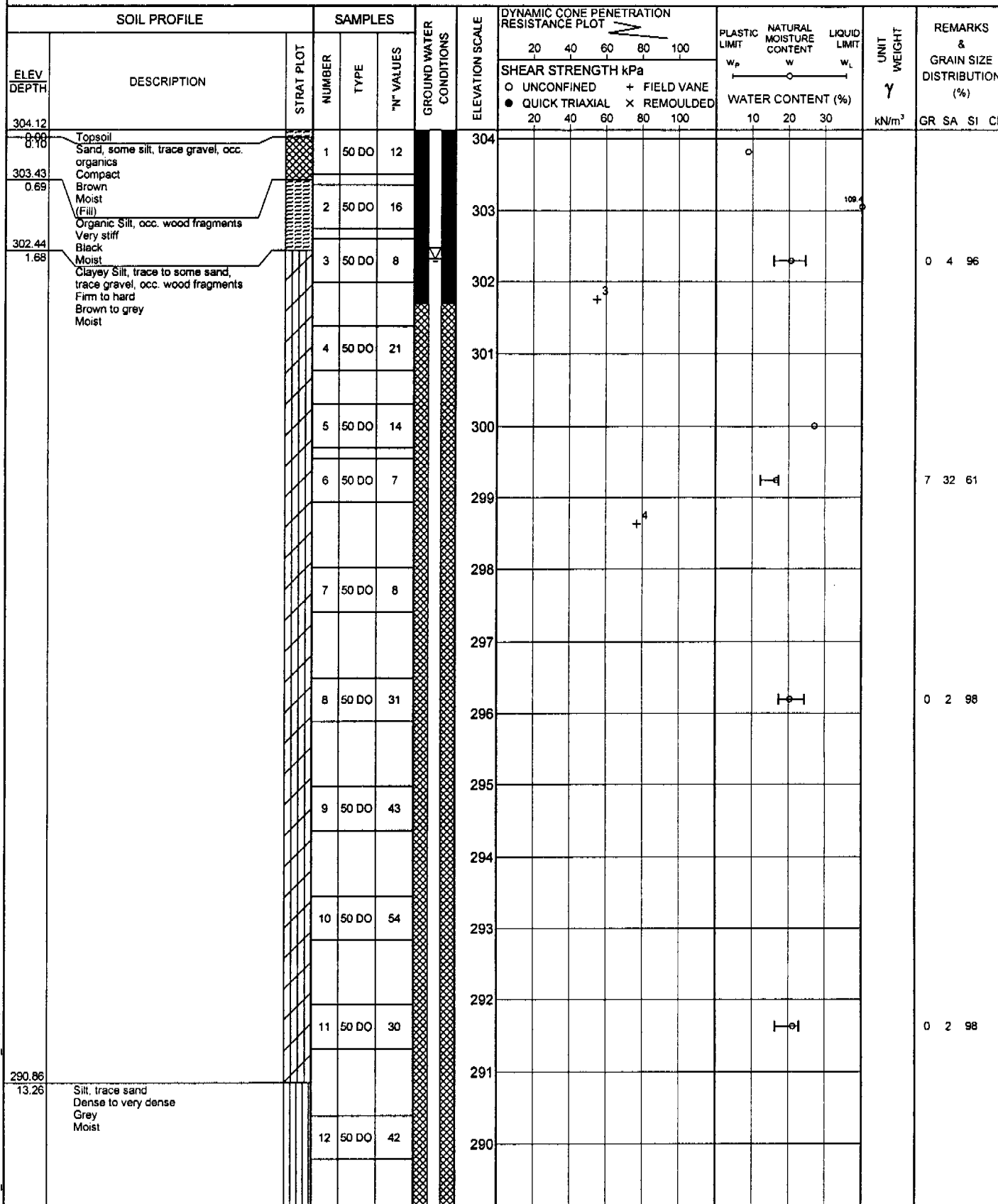
ON MOT 991-8024 GPJ ON MOT GDT 21/10/99

PROJECT <u>991-8024</u>		RECORD OF BOREHOLE No 99-9		1 OF 1 METRIC	
W.P. <u>433-98-00</u>		LOCATION <u>N 4872196.07; E 313148.17</u>		ORIGINATED BY <u>DKB</u>	
DIST <u>6</u> HWY <u>404</u>		BOREHOLE TYPE <u>114mm SOLID STEM AUGERS</u>		COMPILED BY <u>DKB</u>	
DATUM <u>GEODETIC</u>		DATE <u>20.8.99</u>		CHECKED BY <u>AJW</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20 40 60 80 100							w _p w w _L		
307.34																	
8.89	Topsoil		1	50 DO	11		307										
306.78	Sand, some silt, trace gravel, occ. organics		2	50 DO	51		306										
0.56	Compact Brown Moist (Fill)		3	50 DO	15		305										
305.89	Clayey Silt, some sand, occ. wood pieces/fragments		4	50 DO	5		304										
1.45	Very stiff Brown Moist (Fill)		5	50 DO	3		303										
	Sand, trace silt Loose to very loose Brown Moist to wet (Fill)		6	50 DO	WH		302										
302.08	Clayey Silt, some sand, trace gravel Hard Brown to grey Moist		7	50 DO	32		301								2 36 62		
300.64	END OF BOREHOLE																
6.70	Note: 1. Water level measured in open borehole at 2.7m depth (Elev. 304.6m) upon completion of drilling.																

ON MOT 991-8024 GPJ ON MOT.GDT 21/10/99

PROJECT <u>991-8024</u>		RECORD OF BOREHOLE No 99-10		1 OF 2	METRIC
W.P. <u>433-98-00</u>	LOCATION <u>N 4872309.54; E 313148.90</u>	ORIGINATED BY <u>DKB</u>			
DIST <u>6</u> HWY <u>404</u>	BOREHOLE TYPE <u>108mm I.D. HOLLOW STEM AUGERS</u>	COMPILED BY <u>DKB</u>			
DATUM <u>GEODETIC</u>	DATE <u>23.8.99</u>	CHECKED BY <u>AJW</u>			



ON MOT 991-8024.GPJ ON MOT.GOT 7/1/00

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

PROJECT 991-8024			RECORD OF BOREHOLE No 99-10				2 OF 2		METRIC						
W.P. 433-98-00			LOCATION N 4872309.54; E 313148.90				ORIGINATED BY DKB								
DIST 6 HWY 404			BOREHOLE TYPE 108mm I.D. HOLLOW STEM AUGERS				COMPILED BY DKB								
DATUM GEODETTIC			DATE 23.8.99				CHECKED BY AJW								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	10 20 30					
	Silt, trace sand Dense to very dense Grey Moist(continued)		13	50 DO	75		289								
							288								
			14	50 DO	60		287								
286.37 17.75	Silty Sand, trace to some clay and gravel Very dense Grey Moist (Glacial Till)		15	50 DO	110		286								
							285								
			16	50 DO	100/13		284								2 57 32 9
282.66 21.46	END OF BOREHOLE Note: 1. Water level measured in open borehole at 2.7m depth (Elev.301.4m) upon completion of drilling. 2. Water level measured in piezometer at 6.2m depth (Elev.297.9m) on August 31/99. 3. Water level measured in piezometer at 2.3m depth (Elev.301.9m) on September 14/99. 4. Water level measured in piezometer at 1.8m depth (Elev.302.3m) on October 19/99.		17	50 DO	100/13		283								

PROJECT 991-8024		RECORD OF BOREHOLE No 99-11		1 OF 2	METRIC
W.P. 433-98-00		LOCATION N 4872359.24; E 313144.25		ORIGINATED BY DKB	
DIST 6 HWY 404		BOREHOLE TYPE 114mm SOLID STEM AUGERS		COMPILED BY DKB	
DATUM GEODETIC		DATE 24.8.99		CHECKED BY AJW	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x REMOULDED						
312.07 0.00 0.10	Topsoil Sand, trace silt and gravel Compact to dense Brown Moist (Fill)		1	50 DO	15										
			2	50 DO	21										
			3	50 DO	40										
			4	50 DO	26										
			5	50 DO	16										
308.18 3.89	Clayey Silt, trace to some sand, trace gravel Very stiff to hard Brown Moist (Fill)		6	50 DO	32										
			7	50 DO	24										
			8	50 DO	18										
304.90 7.17	Clayey Silt, trace to some sand, trace gravel Very stiff to hard Brown Moist to wet		9	50 DO	25										
			10	50 DO	49										
			11	50 DO	23										
300.34 11.73	Sand, some silt, trace gravel Compact Gray Moist to wet		12	50 DO	20										
			13	50 DO	20										
297.74 14.33	END OF BOREHOLE														

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+³ X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON MOT 991-8024.GPJ ON MOT.GDT 21/10/99

ON_MOT 991-8024.GPJ ON_MOT.GDT 21/10/99

PROJECT 991-8024			RECORD OF BOREHOLE No 99-12			1 OF 1			METRIC													
W.P. 433-98-00			LOCATION N 4872329.24; E 313137.06			ORIGINATED BY DKB																
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS			COMPILED BY DKB																
DATUM GEODETIC			DATE 25.8.99			CHECKED BY AJW																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40	60	80	100
307.83 0.98 0.10	Topsoil Sand, trace to some silt, trace gravel, occ. organics Loose to dense Brown Moist (Fill)		1	50 DO	18																	
			2	50 DO	34																	
			3	50 DO	9																	
305.62 2.21	Sand, some Silt, trace gravel Loose to dense Grey Moist		4	50 DO	6																	
			5	50 DO	36																	
			6	50 DO	15																	
			7	50 DO	36																	
			8	50 DO	16																	
300.67 7.16	Clayey Silt, trace sand and gravel Very stiff Grey Moist																					
			9	50 DO	23																	
299.60 8.23	END OF BOREHOLE Note: 1. Open borehole dry upon completion of drilling.																					

ON MOT 991-8024 GPJ ON MOT GDT 21/10/99

ON_MOT 991-8024.GPJ ON_MOT.GDT 22/10/99

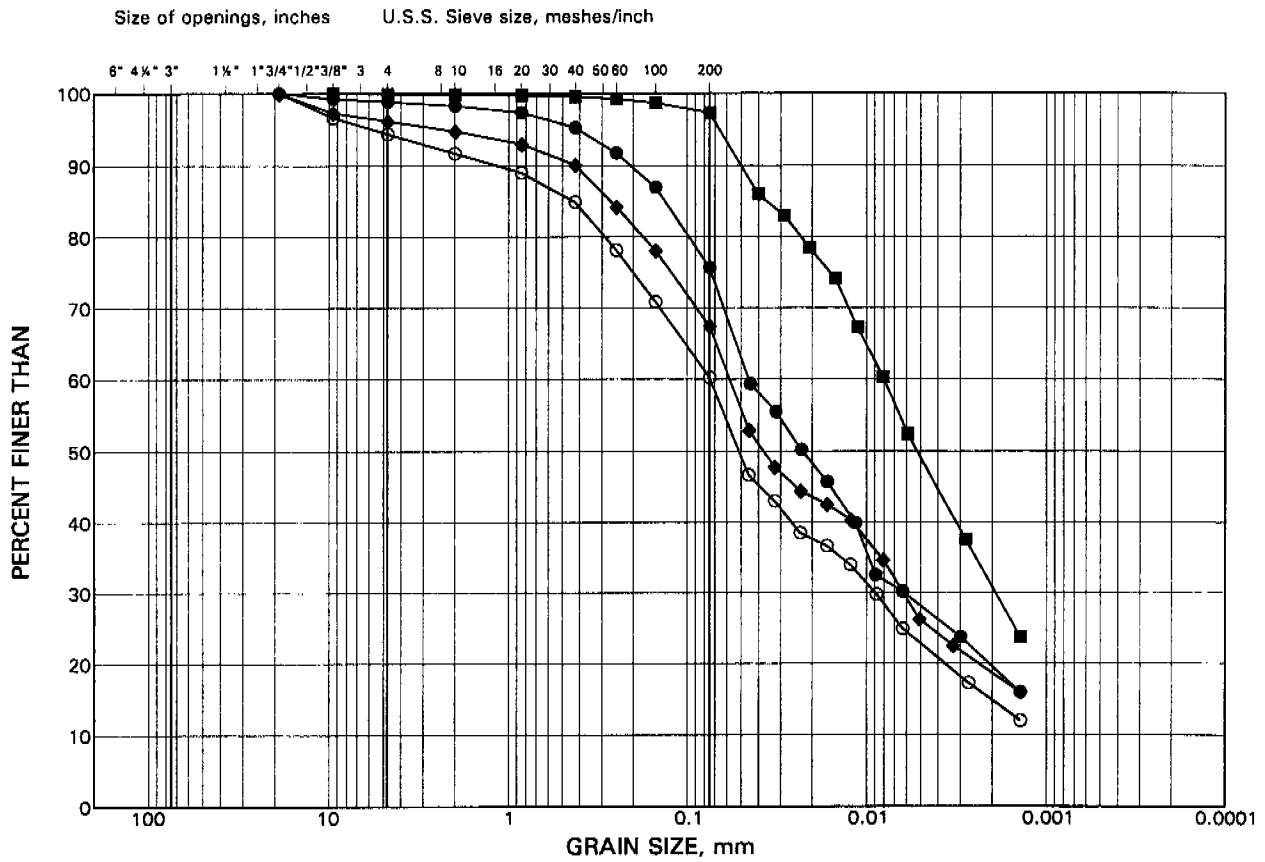
+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

PROJECT 991-8024			RECORD OF BOREHOLE No 99-14				1 OF 1		METRIC									
W.P. 433-98-00			LOCATION N 4872322.91; E 313157.25				ORIGINATED BY DKB											
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS				COMPILED BY DKB											
DATUM GEODETIC			DATE 25.8.99				CHECKED BY AJW											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60 80 100 WATER CONTENT (%)						
304.48	Topsoil		1	50 DO	11													
0.08	Sand, trace to some silt, trace gravel, occ. organics		2	50 DO	10													
303.79	Compact Brown Moist (Fill)		3	50 DO	16													
0.69	Clayey Silt, some sand, trace gravel		4	50 DO	20													
303.03	Stiff Brown Moist (Fill)		5	50 DO	6													
1.45	Clayey Silt, trace to some sand, trace gravel		6	50 DO	9													
	Firm to very stiff Grey Moist to wet Silty Sand layer noted at 2.4m to 2.9m depth.		7	50 DO	28													
297.77	END OF BOREHOLE																	
6.71	Note: 1. Water level measured in open borehole at 2.1m depth (Elev. 302.4m) upon completion of drilling.																	

OVERSIZE DRAWING(S)

GRAIN SIZE DISTRIBUTION Clayey Silt (Fill)

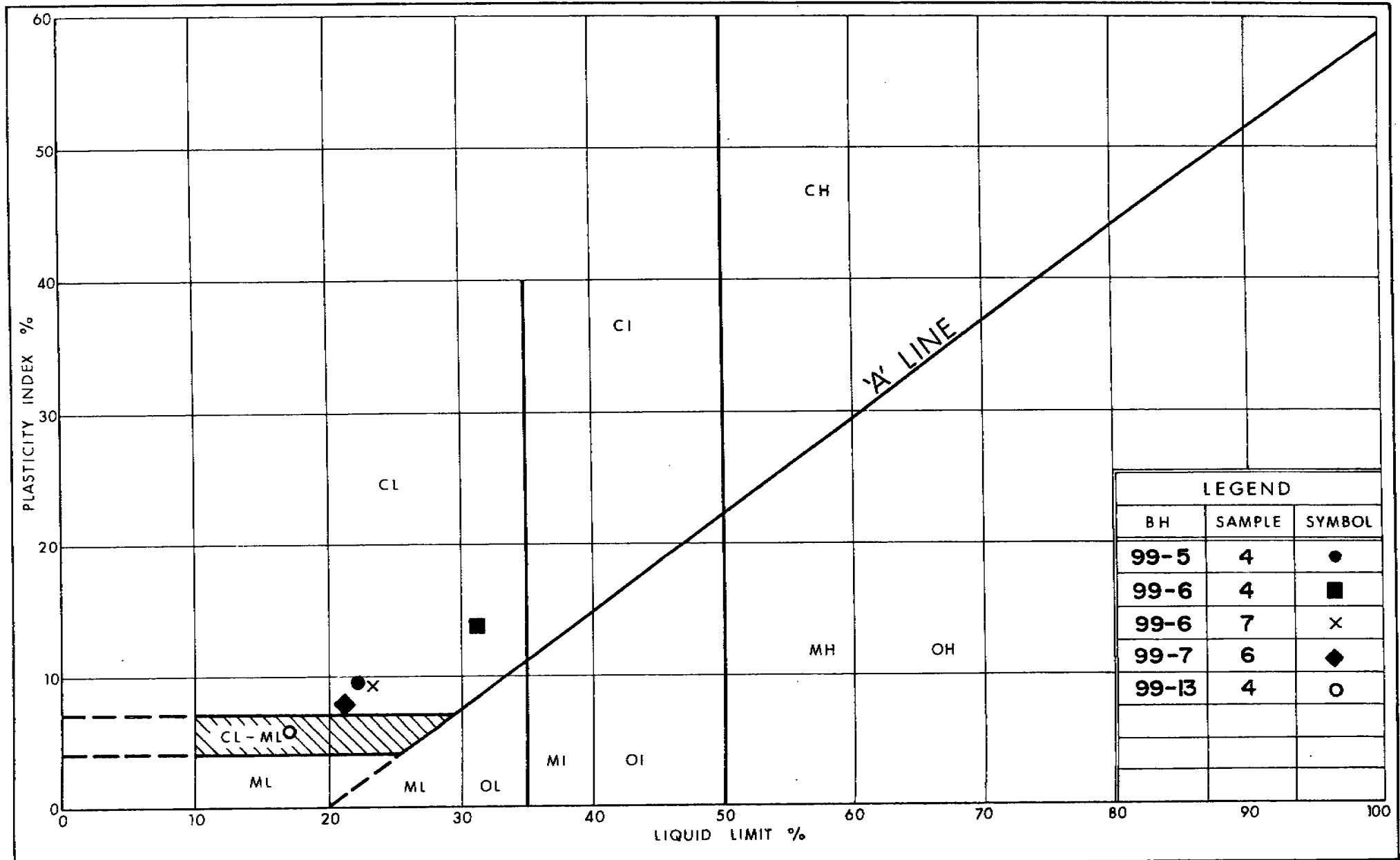
FIGURE 1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE ELEVATION(m)
●	99-5	4 304.1
■	99-6	4 312.7
◆	99-7	6 304.8
○	99-13	4 304.5



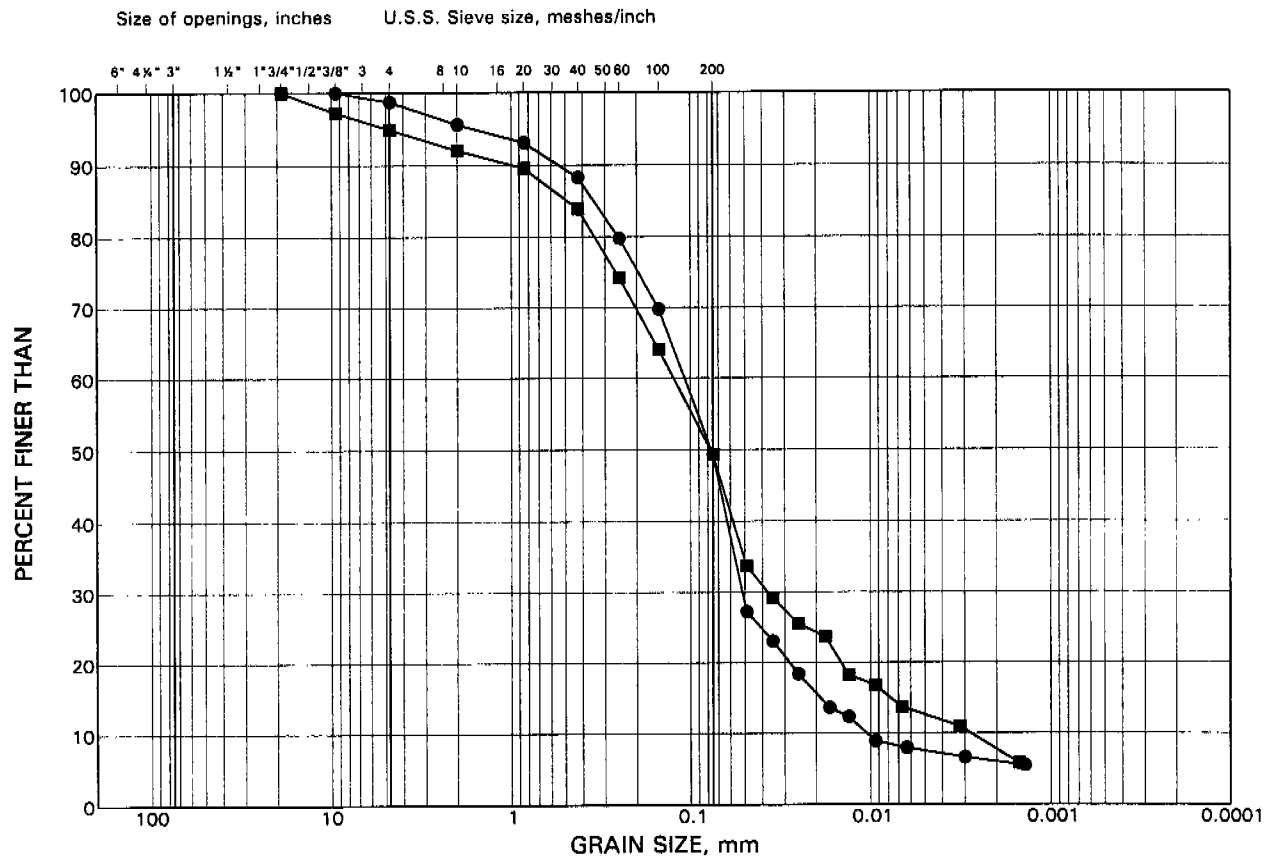
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PLASTICITY CHART CLAYEY SILT (FILL)

FIG No 2
W P 433-98-00

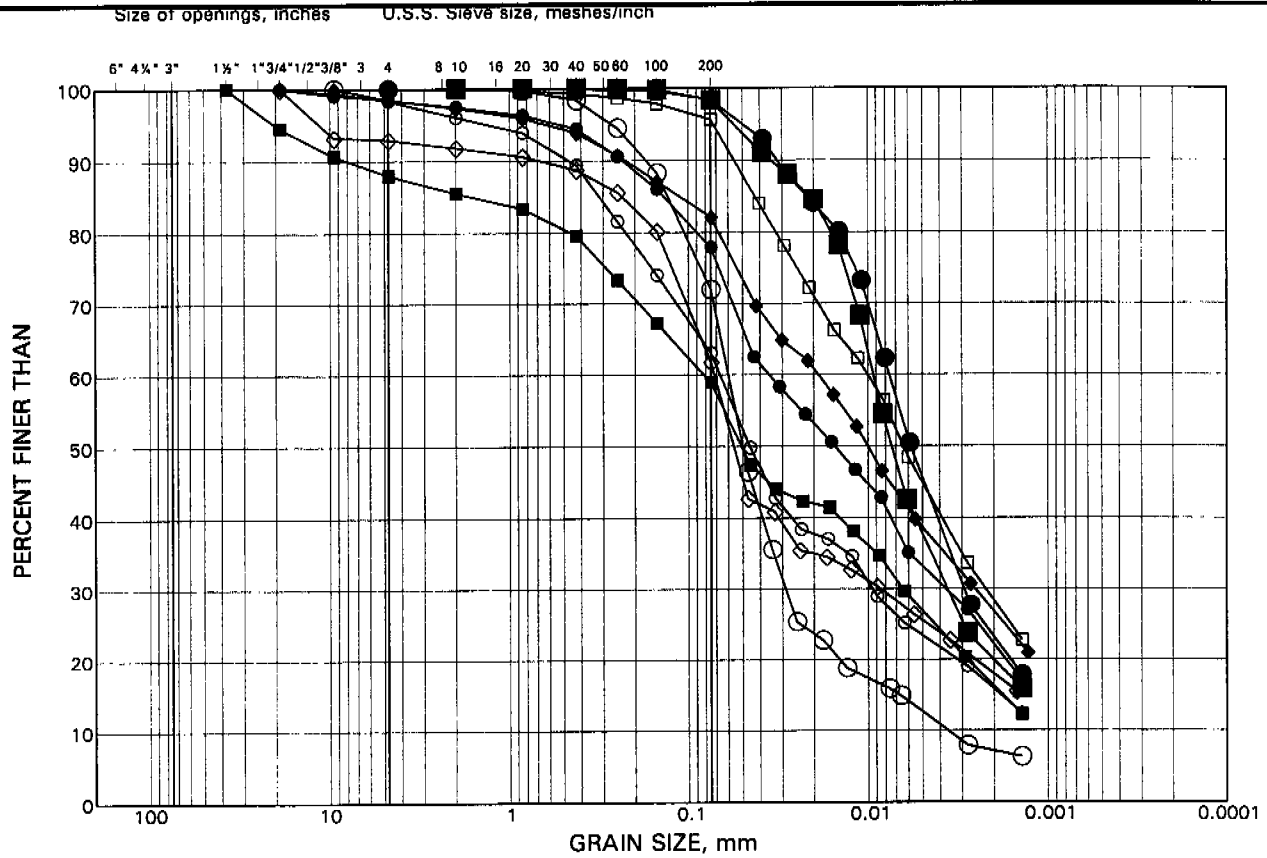
GRAIN SIZE DISTRIBUTION Sand and Silt

FIGURE 3



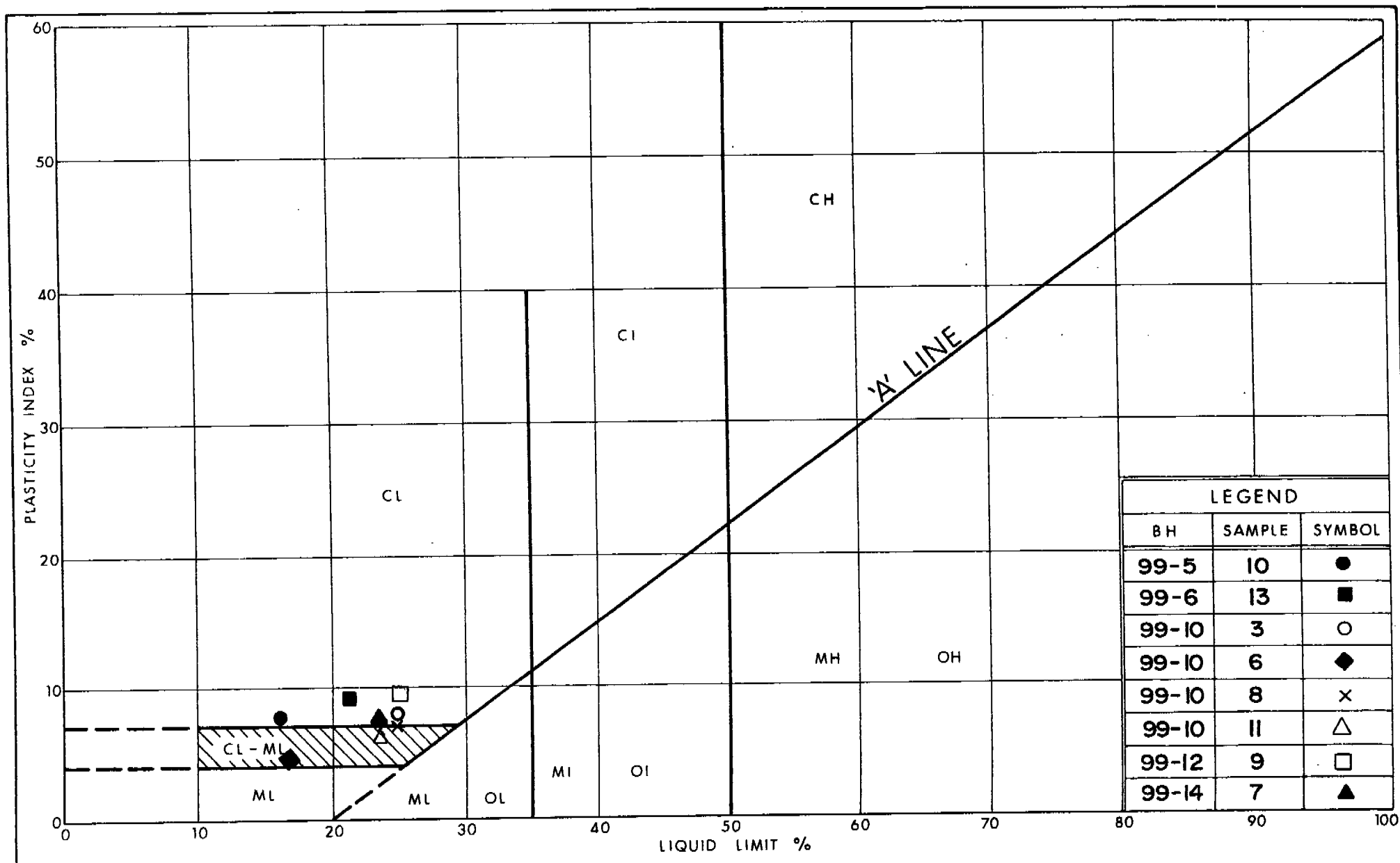
GRAIN SIZE DISTRIBUTION Clayey Silt

FIGURE 4



LEGEND

SYMBOL	BOREHOLE	SAMPLE ELEVATION(m)
●	99-5	10 295.7
■	99-6	9 308.9
◆	99-6	13 302.8
○	99-9	7 300.6
□	99-10	3 301.0
◇	99-10	6 298.9
●	99-10	8 295.9
■	99-10	11 291.3
○	99-14	5 300.8



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Ontario

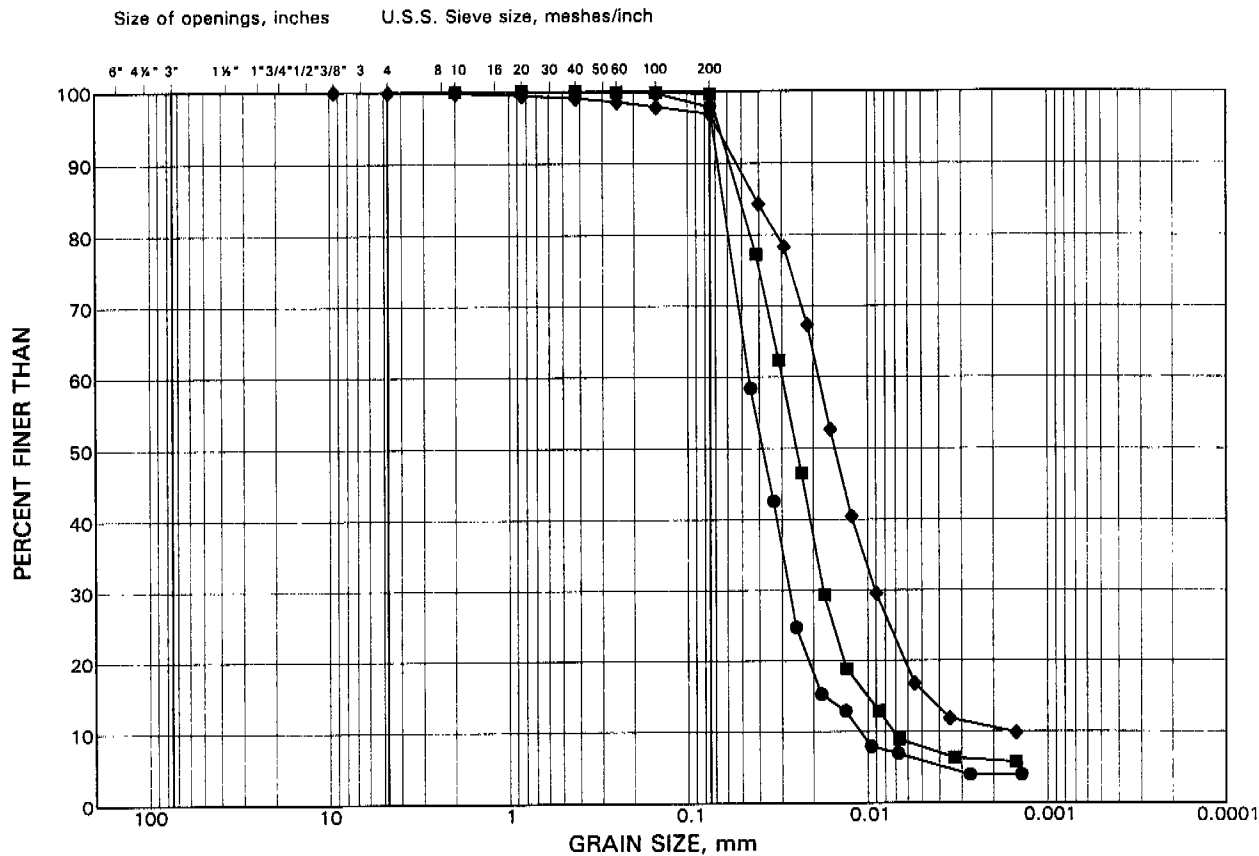
PLASTICITY CHART CLAYEY SILT

FIG No 5
W P 433-98-00

GRAIN SIZE DISTRIBUTION

Silt

FIGURE 6



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

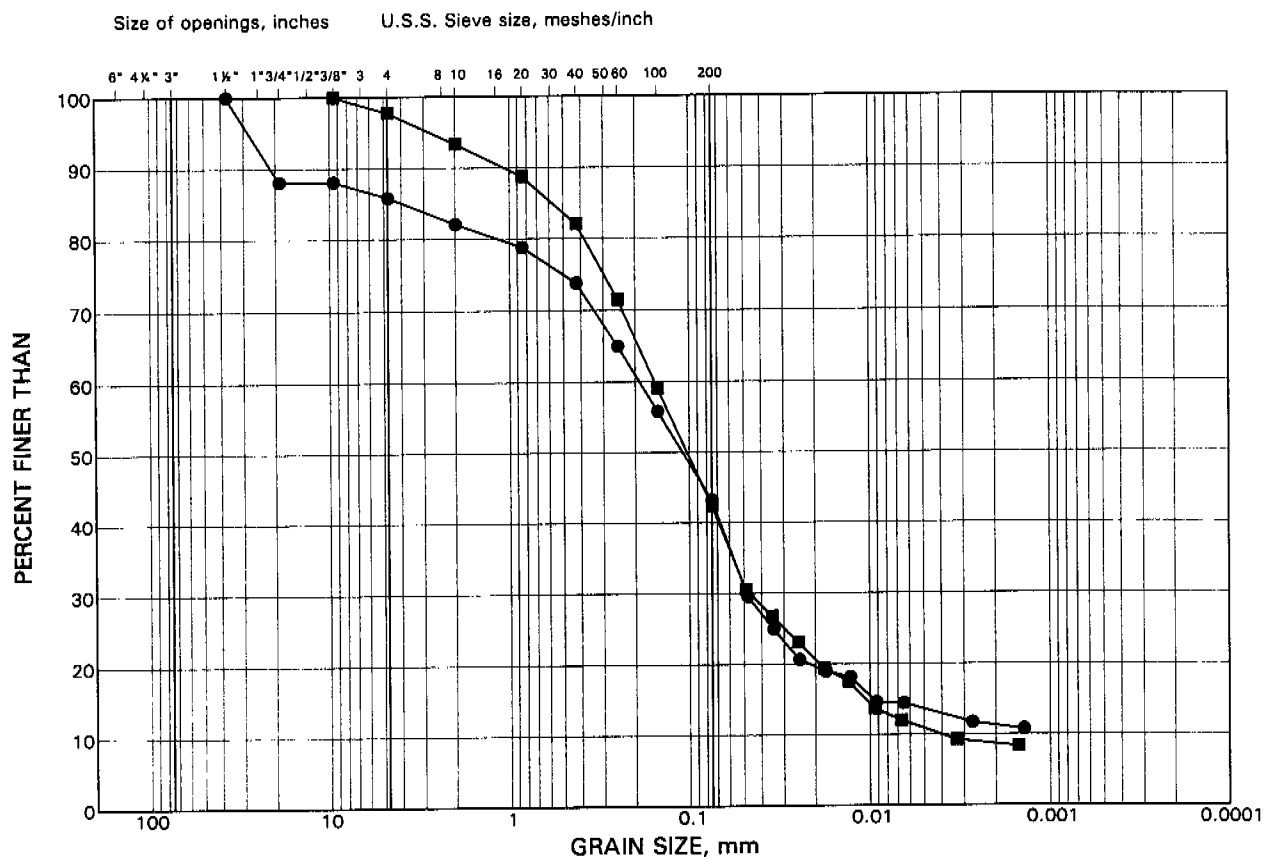
LEGEND

SYMBOL BOREHOLE SAMPLE ELEVATION(m)

●	99-5	14	289.6
■	99-5	16	286.6
◆	99-5	18	283.5

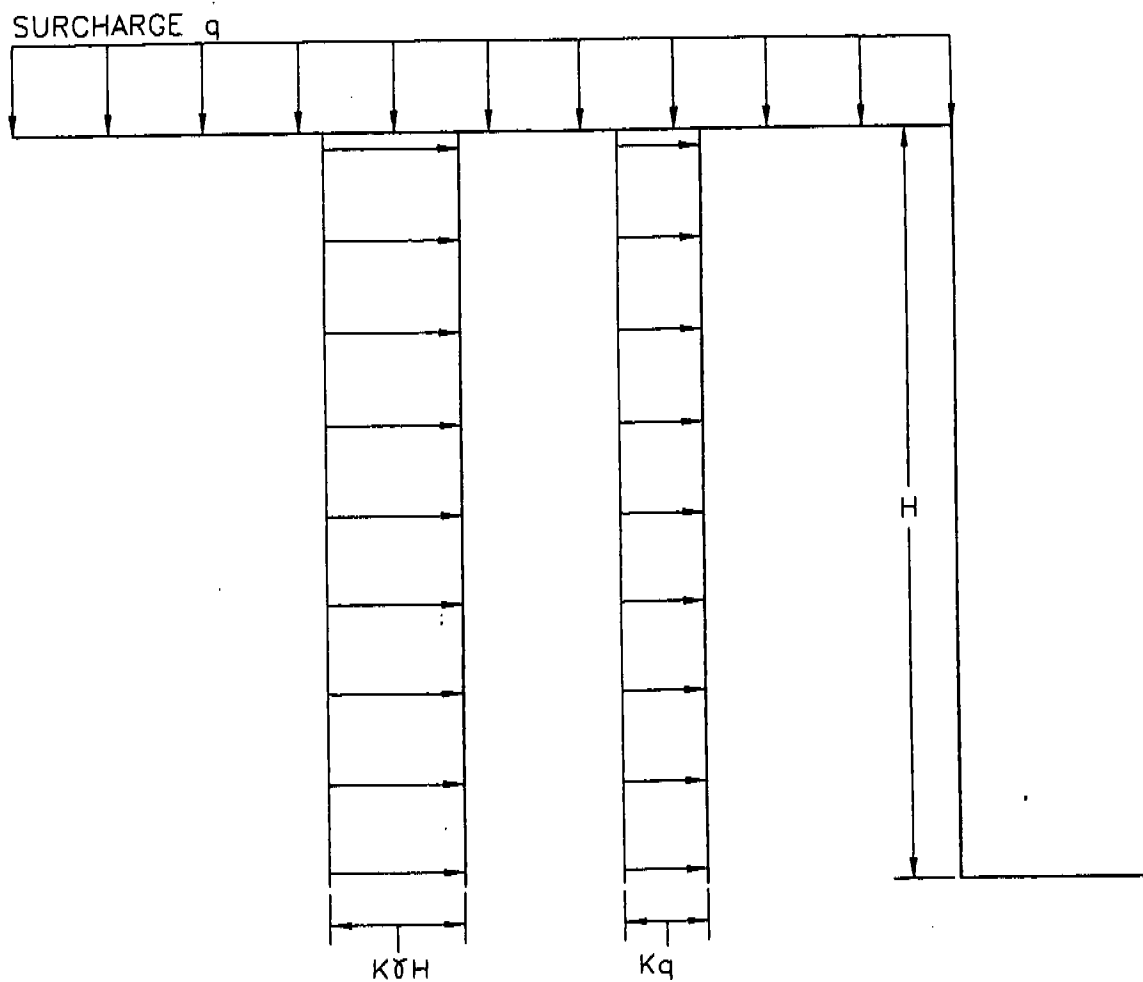
GRAIN SIZE DISTRIBUTION Silty Sand (Till)

FIGURE 7



DESIGN LATERAL EARTH PRESSURES FOR BRACED EXCAVATION

FIGURE 8



γ = UNIT WEIGHT OF SOIL

K = EARTH PRESSURE COEFFICIENT

Date OCTOBER, 1999

Project 991-8024B

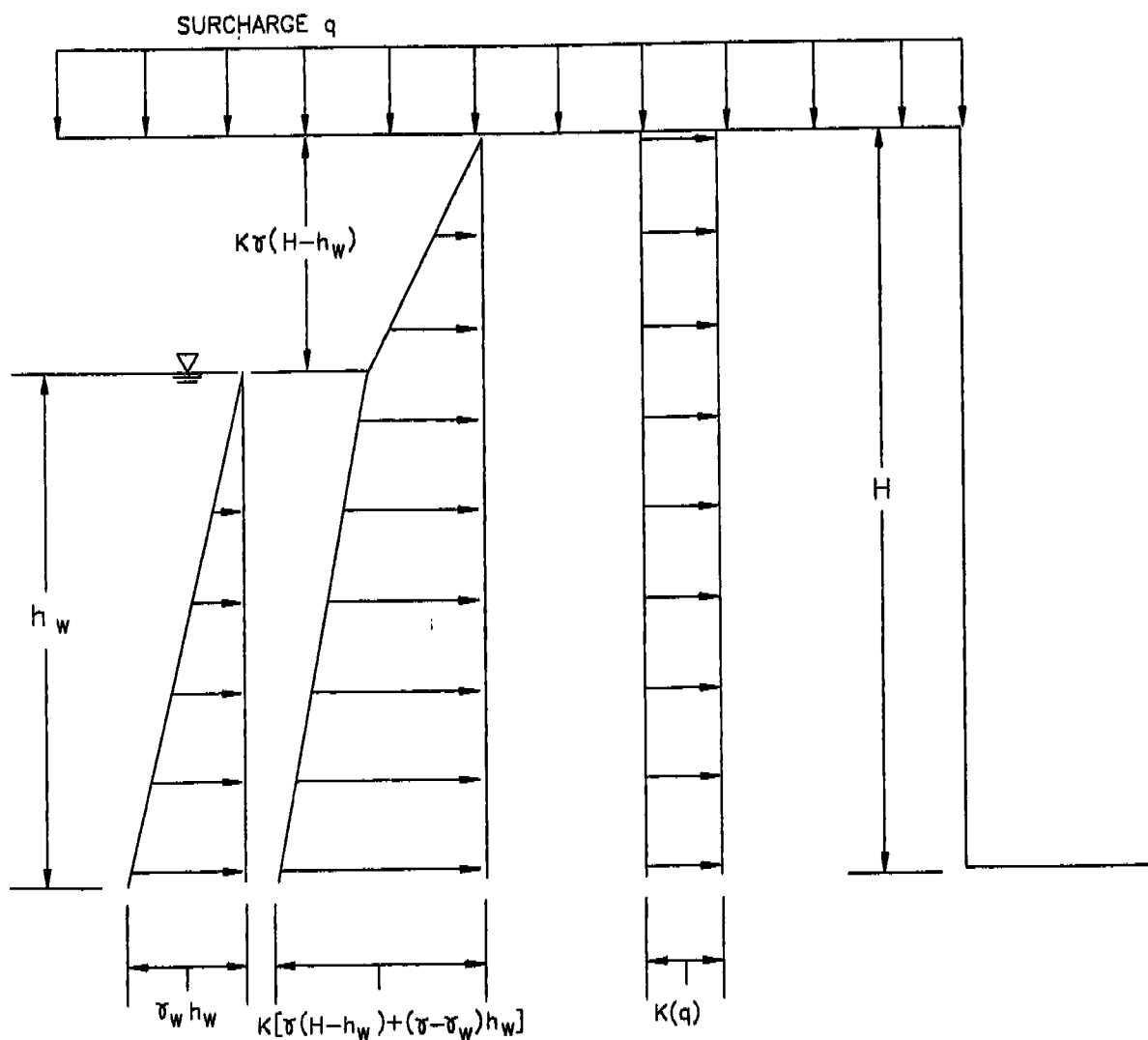
Golder Associates

Drawn R.J.

Chkd. D.K.B.

DESIGN LATERAL EARTH PRESSURES FOR BELOW GRADE PERMANENT WALLS AND TEMPORARY ANCHORED WALLS

FIGURE 9



γ = UNIT WEIGHT OF SOIL
 γ_w = UNIT WEIGHT OF WATER
 K = EARTH PRESSURE COEFFICIENT

File: C:\My Documents\Ron\Visio Files\Drawing Plate.vsd | Date: September 1999 | Drawn: R.J. | Checked:

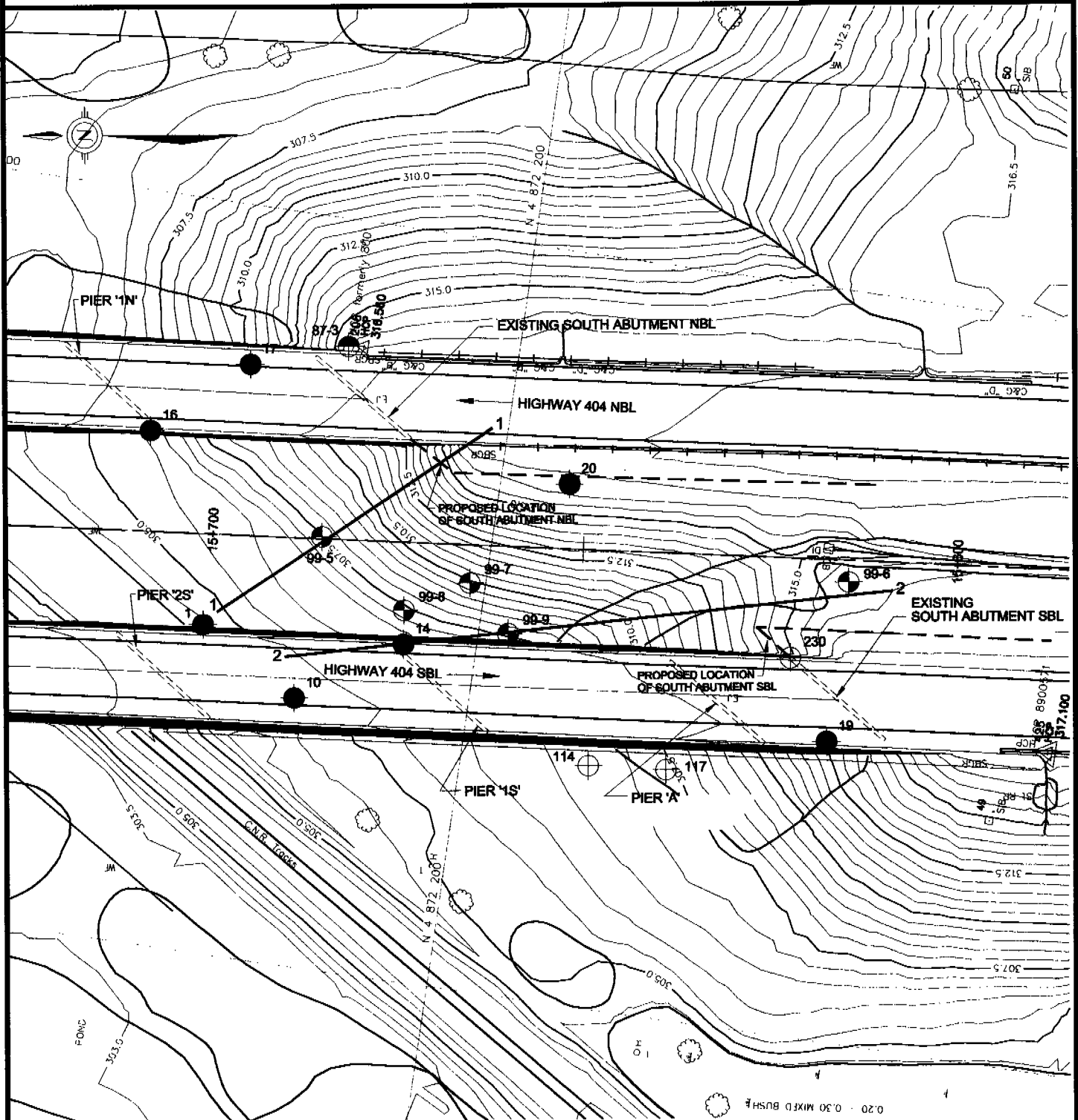
Date OCTOBER, 1999
 Project 991-8024B

Golder Associates

Drawn R.J.
 Chkd. D.K.B.

SOUTH ABUTMENT PROPOSED ABUTMENT LOCATIONS

FIGURE 10



0 10 20 30 40 50
METRES

SCALE 1:750

Golder Associates

Date OCTOBER 1999

Project 991-8024B

Drawn P.S.

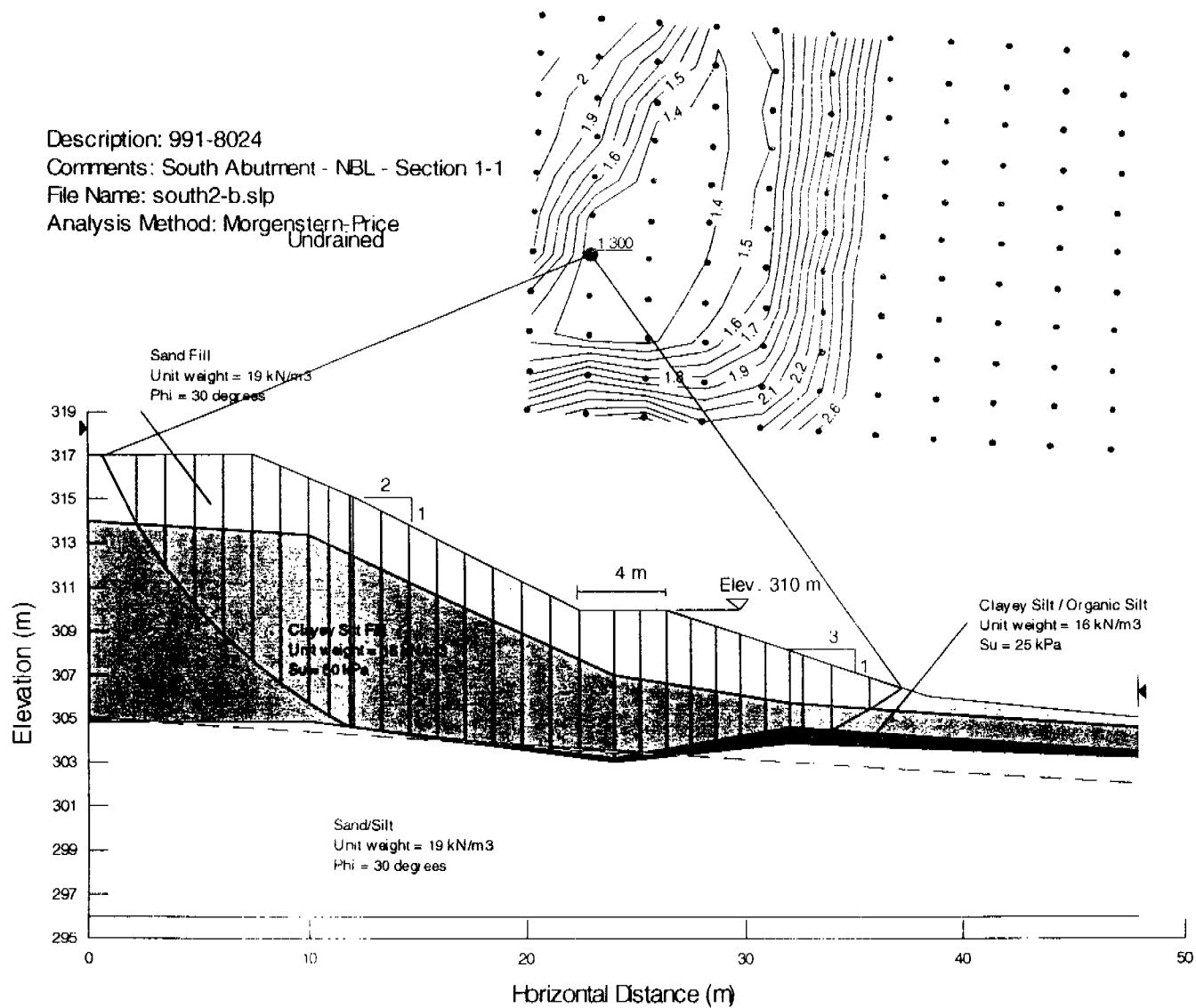
Chkd P.S.

Drawn AJW
Chkd. AJW



South Abutment - NBL - Proposed Slope Undrained Stability Analysis Summary

FIGURE 12



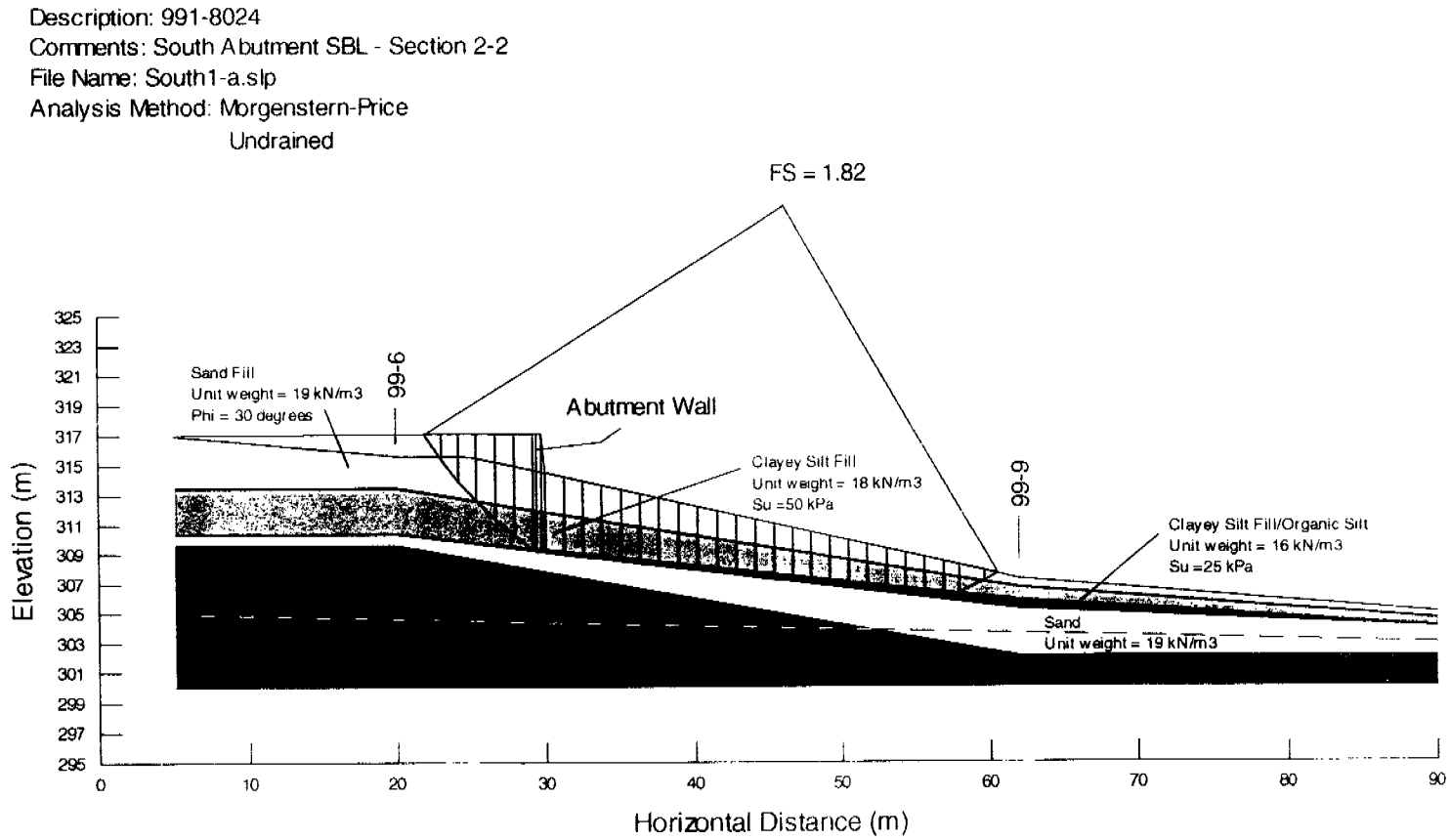
Date 21 October 1999
Project 991-8024

Golder Associates

Drawn A.J.W.
Checked A.J.W.

South Abutment - SBL- Proposed Abutment Undrained Stability Analysis Summary

FIGURE 13



Date 21 October 1999
Project 991-8024

Golden Associates

Drawn ALW
Chkd ALW

January 2000

991-8024B

APPENDIX A

EXISTING BOREHOLE LOGS

W.P. 160-74-33 BOREHOLES 1, 3, 4, 8, 9, 10, 14, 16, 17, 19, 20, 21, 22 AND 23

W.P. 160-74-56 BOREHOLES 114, 117 AND 230

W.P. 86-11006 BOREHOLE 3 (87-3)

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

W P 160-74-33 LOCATION Coords. N 15,958,028, E 1,027,174 ORIGINATED BY M.M.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY M.M.
DATUM Geodetic DATE March 9, 1978 CHECKED BY J.T.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
996.2	Ground Surface																
0.0	Organic Silt, Some Sand Loose		1	TW	PM												
990.2			2	SS	4												9 27 48 16
6.0			3	SS	5												
			4	SS	8												2 36 44 18
			5	SS	8												3 24 57 16
			6	SS	20												
			7	SS	27												
			8	SS	26												0 1 79 20
			9	SS	45												
			10	SS	37												
			11	SS	55												0 10 74 16
			12	SS	47												
			13	SS	50												11 10 73 6
			14	SS	56												
919.2			15	SS	60/4"												
77.0	Heterogeneous Mixture, Clayey Silt, Sand and Gravel (Glacial Till) Hard		16	SS	138												4 37 43 16
894.7			17	SS	150/2"												
101.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

W P 150-74-33

LOCATION Coords. N 15,985,146 E 1,027,455

DIST 6 HWY 404

BOREHOLE TYPE Hollow Stem Augers and Cone Test

ORIGINATED BY M.M.

DATUM Geodetic

DATE March 7 & 8, 1978

COMPILED BY M.M.

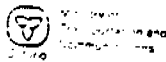
CHECKED BY J.L.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80					
998.6	Ground Surface															
0.0	Silt, Some Sand Loose to Compact					No Water Level Established										
992.6			1	SS	11											
6.0	Clayey Silt to Silt of Slight Plasticity Soft		2	SS	1											0 26 68 6
			3	Tw	PM											0 2 69 29
			4	Tw	PH											
974.6			5	SS	8											
24.0	Sand, Some Silt Some Gravel Loose to Compact		6	SS	6											27 44 24 5
			7	SS	10											7 69 (24)
959.6			8	SS	18											20 75 (5)
39.0	Clayey Silt to Silt of Slight Plasticity		9	SS	41											0 7 81 12
	Silt Very Stiff to Hard		10	SS	18											
			11	SS	22											
			12	SS	67											
			13	SS	41											
925.6			14	SS	60/5"											
73.0	Heterogeneous Mixture Clayey Silt, Sand and Gravel Hard Glacial Till		15	SS	145											
907.1			16	SS	100/3"											
91.5	End of Borehole Note: Water Level Not Established															

*3, *5: Numbers refer to
Sensitivity

20
15 *5 (%) STRAIN AT FAILURE
10



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

W P 160-74-33

LOCATION Coords. N 15,995,250; E 1,027,475

DIST 6 HWY 404

BOREHOLE TYPE Hollow Stem Augers and Cone Test

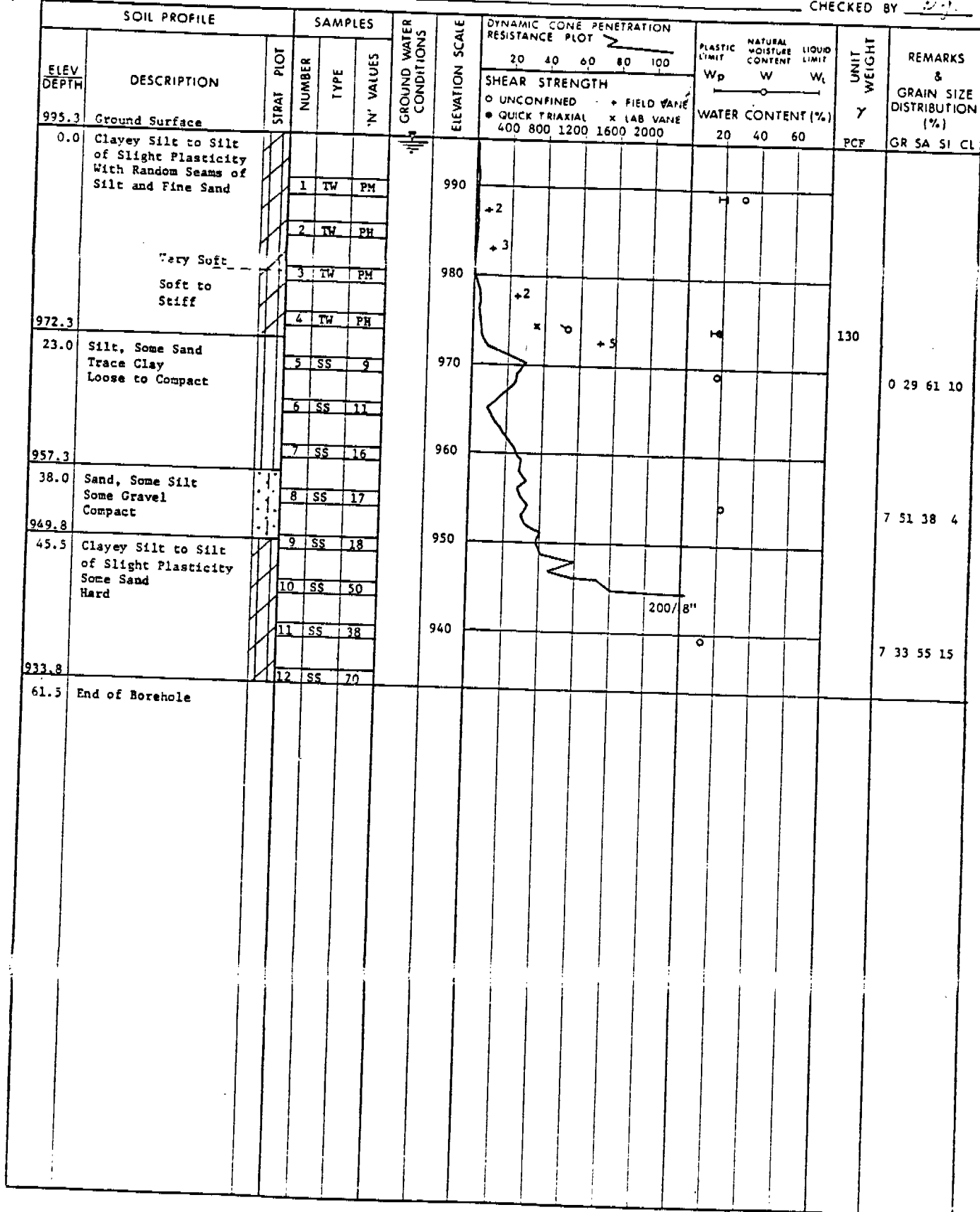
ORIGINATED BY P.L.

DATUM Geodetic

DATE March 8, 1978

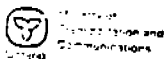
COMPILED BY M.M.

CHECKED BY



+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

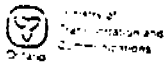
RECORD OF BOREHOLE No 8

W P 160-74-33 LOCATION Coords. N 15,985,148; E 1,027,313 ORIGINATED BY O.J.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY
DATUM Geodetic DATE March 7, 1978 CHECKED BY V.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
994.7	Ground Surface																
0.0	Organic Silt Very Soft to Soft																
	Organic Clay Very Soft		1	SS	PH		990										Om 17% W 148%
984.0																	
10.0	Clayey Silt to Silt of Slight Plasticity Very Soft Stiff to Hard		2	SS	0/18"		980										
			3	SS	1/18"												
			4	SS	10												
	Some Sand		5	SS	9		970										14 23 50 13
			6	SS	9												
			7	SS	18		960										
			8	SS	25												
			9	SS	55		950										2 23 61 14
			10	SS	28												0 1 80 19
	Sand, Some Silt, Compact		11	SS	55		940										10 42 34 14
936.7																	
58.0	Heterogeneous Mixture, Clayey Silt Cobbles Sand and Gravel Hard (Glacial Till)		12	SS	145		930										9 50 31 10
			13	SS	100/2"												
			14	SS	100/3"		920										
			15	SS	100/4"		910										14 44 32 10
908.2			16	SS	100/8"		900										
96.5	End of Borehole																

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 9

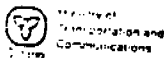
W P 160-74-33 LOCATION Coords. N 15,985,385; E 1,027,464 ORIGINATED BY O.J.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY O.J.
DATUM Geodetic DATE March 10 & 13, 1978 CHECKED BY J.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
995.4	Ground Surface																
0.0	Organic Silt Very Soft		1	TM	PM		990	+5									W 116% Om
	Organic Clay Very Soft		2	SS	1			+2									13%
								+6									W 147% Om 10%
979.4			3	SS	2		980	+12									
16.0	Sand, Some Silt Some Gravel Compact		4	SS	14												17 74 (9)
968.4			5	SS	20		970										1 54 35 10
27.0	Clayey Silt to Silt of Slight Plasticity Very Stiff		6	SS	19												
961.4			7	SS	20		960										50 31 17 2
34.0	Sandy Gravel		8	SS	43		950										8 17 50 25
956.4	Compact		9	SS	43												
39.0	Clayey Silt to Silt of Slight Plasticity Some Sand Hard		10	SS	17		940										11 18 61 10
			11	SS	55												18 40 28 14
935.4			12	SS	130		930										
60.0	Heterogeneous Mixture Clayey Silt Sand and Gravel (Glacial Till) Hard		13	SS	72												
			14	SS	100/4"		920										13 46 30 11
							910										
203.9			15	SS	100/2"												
91.5	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15
10

5 (% STRAIN AT FAILURE



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 10

W P 160-74-33

LOCATION Coords. N 15,984,984; E 1,027,348

ORIGINATED BY B.L.

DIST 6

HWY 404

BOREHOLE TYPE

Hollow Stem Augers and Cone Test

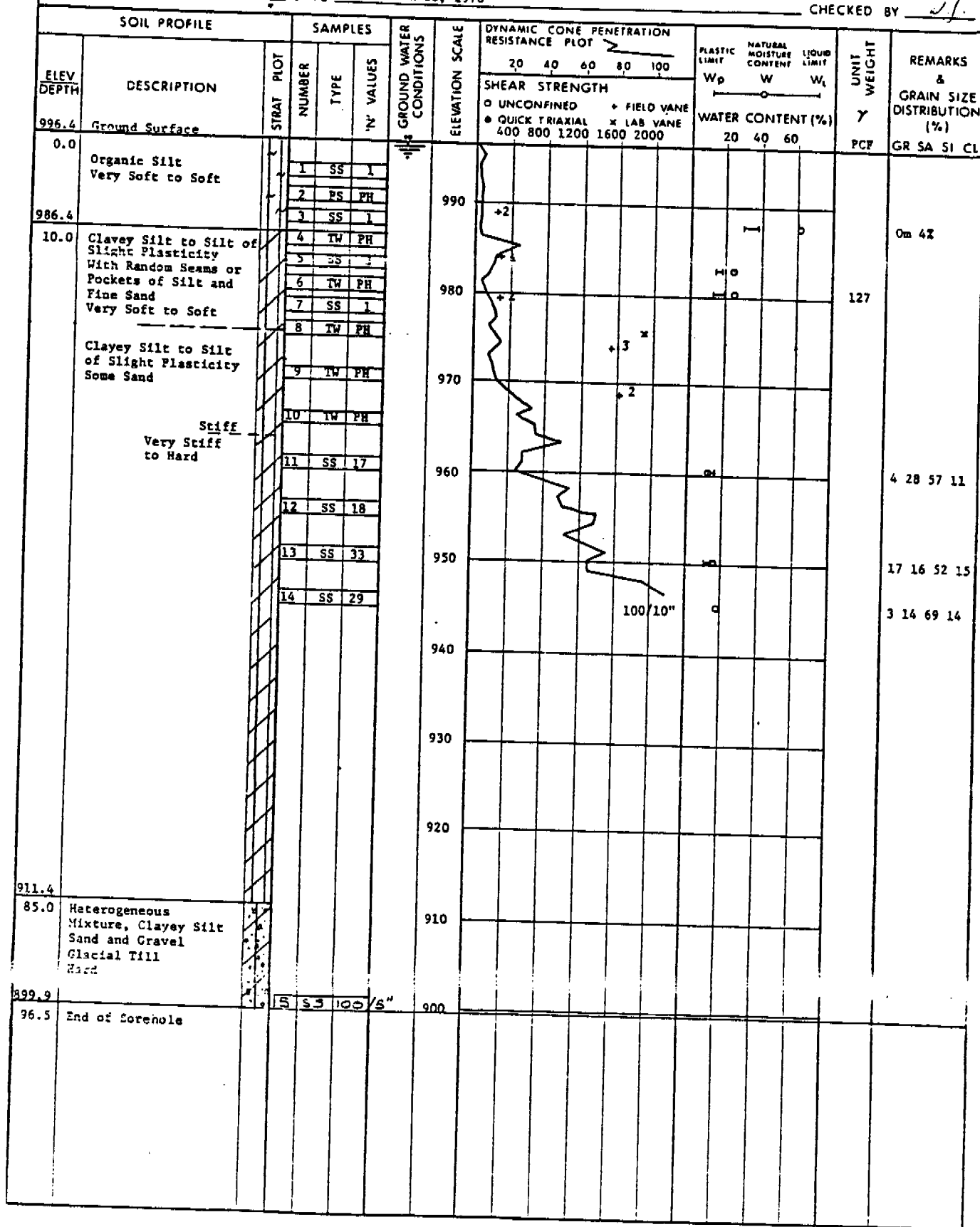
COMPILED BY M.M.

DATUM Geodetic

DATE

March 13, 1978

CHECKED BY J.

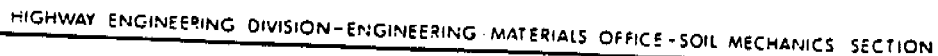
+3, x⁵: Numbers refer to
Sensitivity20
15 ϕ S (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14

W/P 160-74-33 LOCATION Coords. N 15,984,940; E 1,027,378
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers
 DATUM Geodetic DATE May 24, 1978
 ORIGINATED BY D.C.
 COMPILED BY M.M.
 CHECKED BY L.J.

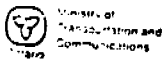
OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20 40 60 80 100										WATER CONTENT (%)	20 40 60
								SHEAR STRENGTH											
996.4	Ground Surface																		
0.0	Sand With Silt		1	SS	2														
	Loose		2	SS	11														
			3	SS	4														
	Soft Clayey Silt		4	SS	5														
			5	SS	4														
			6	SS	5														
977.4																			
19.0	Clayey Silt to Silt of Slight Plasticity Some Sand Very Stiff		7	SS	7														
968.4			8	SS	8														
28.0	Silt Compact to Dense		9	TW	PH														
			10	SS	14														
			11	SS	25														
			12	SS	18														
			13	SS	36														
			14	SS	38														
919.4																			
77.0	Heterogeneous Mixture Clayey Silt, Sand and Gravel Hard Glacial Till		15	SS	150/5"														
			16	SS	150/4"														
904.9																			
			17	SS	117/6"														
91.5	End of Borehole																		



W P 160-74-33 LOCATION Coords. N 15,985,063; E 1,027,455 ORIGINATED BY D.C.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY M.M.
DATUM Geodetic DATE May 31 & June 1, 1978 CHECKED BY 2/1

+3, x5: Numbers refer to Sensitivity



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

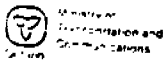
RECORD OF BOREHOLE No 17

W P 160-74-33 LOCATION Coords. N 15,985,024; E 1,027,490 ORIGINATED BY DC.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers 0-55, Washboring With Casing 55-80, Wash Ahead 80-95 COMPILED BY J.J.
DATUM Geodetic DATE June 1, 1978 and June 2, 1978 CHECKED BY W.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1000.3	Ground Surface																
998.3	Organic Silt With Sand Very Soft		1	SS	5		1000										
2.6	Sand, Some Silt		2	SS	13												
	Compact		3	SS	17												
990.3			4	SS	26												
			5	SS	43												
10.0	Clayey Silt to Silt of Slight Plasticity Some Sand With Pockets of Sand and Gravel up to 1 Ft. Thick Every 4 Feet		6	SS	21		990										
			7	SS	17												
			8	SS	23		980										
	Very Stiff		9	SS	34												
971.9																	
29.0	Silt		10	SS	14		970										
	Compact to Dense																
			11	SS	18		950										
							940										
							930										
923.3																	
77.0	Heterogeneous Mixture, Clayey Silt Sand and Gravel (Glacial Till)		12	SS	100/1"		920										
	Hard		13	SS	93/6"												
			14	SS	110/2"		910										
903.8			15	SS	110/4"												
96.5	End of Borehole																

*3, *5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 19

W.P. 160-74-33 LOCATION Coords. N 15,984,750; E 1,027,362
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers 0-60, Washboring With Casing 60-107
DATUM Geodetic DATE June 6, 1978
ORIGINATED BY D.C.
COMPILED BY J.J.
CHECKED BY R.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1009.4	Ground Surface																
0.0	Sand, Some Gravel		1	SS	4												
	Dense		2	SS	39												30 56 (14)
998.4							1000										
11.0	Clayey Silt to Silt of Slight Plasticity		3	SS	37												
	Some Sand		4	SS	34												
987.4	Hard		5	SS	34		990										1 32 51 16
22.0	Silt, Some Sand		6	SS	PH												
	Compact		7	SS	10												
981.4																	
28.0	Clayey Silt to Silt of Slight Plasticity		8	SS	40		980										0 37 59 4
	Some Sand		9	SS	PH												
	Hard																
							970										
							960										
							950										
							940										
932.4																	
77.0	Heterogeneous Mixture, Clayey Silt, Sand and Gravel		10	SS	149		930										
	Silt		12	SS	182												
	Hard																
	Glacial Till		13	SS	94/6"		920										
			14	SS	100/5"												
							910										8 47 34 11
902.9			15	SS	100/4"												
106.5	End of Borehole																

*3, *5: Numbers refer to Sensitivity

20
15 *5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

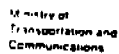
HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 20

W P 160-74-33 LOCATION Coords. N 15,984,878; E 1,027,458
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers 0-50, Washboring With Casing 50-80, Wash Ahead 80-91.5
DATUM Geodetic DATE June 8, 1978
ORIGINATED BY D.C.
COMPILED BY J.J.
CHECKED BY J.T.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1003.3	Ground Surface																
1000.0	Organic Silt		1	SS	6		1000										
995.3	Clayey Silt to Silt of Slight Plasticity Some Sand, Very Stiff		2	SS	22								OH				5 40 41 14
990.3	Sand, Some Silt Compact		3	SS	20												
980.0	Some Sand and Gravel		4	SS	39		990										
	Silt Dense		5	SS	45												
	Clayey Silt to Silt of Slight Plasticity Hard Some Sand and Gravel		6	SS	51		980										0 1 95 4
			7	SS	47												
							970										
							960										
							950										
							940										
							930										
925.3																	
920.0	Heterogeneous Mixture, Clayey Silt Sand and Gravel Hard Glacial Till		8	SS	147/	10"	920										
			9	SS	114/	6"											
911.8			10	SS	112/	6"							OH				
91.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 21

W P 160-74-33 LOCATION Coords. N 15,985,514; E 1,027,440 ORIGINATED BY D.C.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY J.J.
DATUM Geodetic DATE June 9, 1978 CHECKED BY W.T.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										WATER CONTENT (%)		
								SHEAR STRENGTH										20 40 60		
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
1003.3	Ground Surface		1	SS	3		1000									GR SA SI CL				
0.0	Trace Organics - Sand, Some Silt Loose		2	SS	5												Om 4%			
996.3	Some Sand Clayey Silt to Silt of Slight Plasticity Very Stiff to Hard		3	SS	27												2 67 25 6			
7.0			4	SS	18												0 19 66 15			
			5	TU	PW															
			6	SS	24															
			7	SS	24															
			8	SS	38															
			9	SS	36															
			10	SS	24															
			11	SS	30															
928.3	Heterogeneous Mixture, Clayey Silt Sand and Gravel Hard		12	SS	126/ 6"											0 2 80 18				
75.0			13	SS	100/ 5"											7 43 38 12				
916.8			14	SS	100/ 4"															
86.5	End of Borehole																			

x^3, x^5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22

W P 160-74-33 LOCATION Coords. N 15,985,386; E 1,027,415 ORIGINATED BY D.C.
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers (0-65 ft.) and Washboring COMPILED BY M.M.
 DATUM Geodetic DATE June 12-14, 1978 (65 ft.) CHECKED BY W.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20	40	60	80	100		
996.0	Ground Surface							SHEAR STRENGTH						
								O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE 400 800 1200 1600 2000						
992.0	Organic Silt Soft		1	SS	5									GR SA SI CL
2.0	Sand, Some Silt Some Gravel Loose to Compact		2	SS	15		990							8 78 (14)
			3	SS	6									
			4	SS	17									
			5	SS	17									
			6	SS	9									
979.0			7	SS	11		980							2 12 72 14
17.0	Clayey Silt to Silt of Slight Plasticity Very Stiff		8	SS	10		970							
			9	SS	15									
			10	SS	24		960							
			11	SS	113		950							
943.0			12	SS	88		940							
53.0	Heterogeneous Mixture, Clayey Silt Sand and Gravel Glacial Till Hard		13	SS	120/ 5"									
			14	SS	100/ 3 1/2"		930							
			15	SS	100/ 6"									
919.5			16	SS	114/ 6"		920							
76.5	End of Borehole													

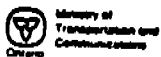
HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 23

W P 160-74-33 LOCATION Coords. N 15,985,302; E 1,027,300 ORIGINATED BY D.C.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY M.M.
DATUM Geodetic DATE June 14-15, 1978 CHECKED BY E.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
996.2	Ground Surface		1	SS	6												
994.2	Organic Silt		2	SS	16												GR SA SI CL
2.0	Sand, Some Silt		3	SS	20		990										Om 22
990.2	Compact		4	SS	24												
6.0	Clayey Silt to Silt of Slight Plasticity Very Stiff to Hard		5	SS	27												2 21 41 36
			6	SS	31		980										
			7	SS	28												
			8	SS	37		970										0 2 77 21
			9	SS	22												
			10	SS	71		960										
			11	SS	104												
948.2			12	SS	100/ 5"		950										10 43 32 15
48.0	Silt Very Dense		13	SS	106/ 6"		940										
941.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		14	SS	100/ 5"		930										
55.0	Hard Glacial Till																
926.7																	
71.5	End of Borehole																

SOIL PROFILE ALONG LINE OF BORING



Ministry of
Transportation and
Communications
Ontario

RECORD OF BOREHOLE No 114

IMPERIAL

W P 160-74-56 LOCATION Co-ords. N 15 984 852; E 1 027 337
DIST 6 HWY 406 BOREHOLE TYPE Washbore
DATUM Geodetic DATE 83 06 13-14
ORIGINATED BY AHT
COMPILED BY RM
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1005.4	Ground Surface																
0.0	Fill Clayey Silt to Silt of Slight Plasticity some sand, trace gravel Soft to Firm		1	SS	2												8 30 48 14
			2	SS	2												12 32 47 9
			3	SS	2												
			4	SS	2												
			5	SS	4												
			6	SS	6												
			7	SS	4												
991.6			8	SS	14												1 29 56 14
13.8	Sand, some silt Loose to Compact		9	SS	10												
			10	SS	11												
			11	SS	6												
			12	SS	12												
982.4			13	SS	24												
23.0	Clayey Silt to Silt of Slight Plasticity some sand with seams of sand and silt Stiff to Very Stiff		14	SS	19												
			15	SS	23												
			16	SS	22												
			17	SS	18												
			18	SS	9												
			19	SS	12												
965.4			20	SS	23												
40.0			21	SS	37												
	Silt trace of clay		22	SS	35												
			23	SS	42												
			24	SS	27												
			25	SS	33												
			26	SS	19												
	Compact to Dense		27	SS	6												
			28	SS	31												
919.4			29	SS	54												
86.0	Heterogeneous Mixture Clayey Silt, sand and gravel (Glacial Till) Hard		30	SS	154												
913.9																	
91.5	End of Borehole																
	* Note: Groundwater Level Not Established																

RECORD OF BOREHOLE No 117

IMPERIAL

W P 160-74-56 LOCATION Co-ords. N 15 984 818; E 1 027 340 ORIGINATED BY RM
DIST 6 HWY 404 BOREHOLE TYPE Washboring COMPILED BY RM
DATUM Geodetic DATE 83 06 23-24 CHECKED BY GP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)					
1013.5	Ground Surface													GR SA SI CL
0.0	Fill		1	SS	3									
	Clayey Silt		2	SS	3									
	some sand		3	SS	4									
	Soft to Stiff		4	SS	12									
			5	SS	10									
			6	SS	11									
			7	SS	8									
997.4			8	SS	54									
16.1	organic silt		9	SS	9									
	Clayey Silt to Silt of		10	SS	17									
	Slight Plasticity		11	SS	11									
	some sand		12	SS	12									
990.5	Stiff to Very Stiff		13	SS	11									
23.0	Sand, some silt		14	SS	31									
987.5	Compact		15	SS	26									
26.0	Silt, some sand		16	SS	21									
	Compact		17	SS	27									
			18	SS	14									
			19	SS	20									
979.0			20	SS	13									
34.5	Clayey Silt, some		21	SS	17									
975.0	sand Very Stiff													
38.5			22	SS	22									
			23	SS	32									
			24	SS	33									
	Silt		25	SS	24									
	trace clay		26	SS	28									
			27	SS	41									
			28	SS	31									
	Compact to		29	SS	38									
	Dense		30	SS	26									
			31	SS	22									
			32	SS	42									
917.5			33	SS	73									
96.0	Heterogenous Mixture													
912.6	Clayey Silt Sand and													
	Gravel (Glacial Till) Hard													
100.9	End of Borehole													
	* Note													
	Groundwater Level													
	Not Established													

IMPERIAL

W P 160-74-56

LOCATION Co-ords. N 15 984, 771; E 1 027 396

ORIGINATED BY LP

DIST 6

HWY 404

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY LP

DATUM _____ **Geodetic**

DATE 83 12 14, 15 & 16

CHECKED BY GE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	400 800 1200 1600 2000						10 20 30
								SHEAR STRENGTH P.S.F.		WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
1034.1 0.0	Ground Elevation														
	Fill		1	SS	3	*	1030							1 27 55 17	
	Clayey Silt to Silt of Slight Plasticity some sand Very Stiff		2	SS	9		1020								
			3	SS	13										
			4	SS	11										
1011.1 23.0			5	SS	14		1010							0 14 60 26	
	Clayey Silt to Silt of Slight Plasticity Some Sand Very Stiff to Hard		6	SS	39		1000							2 33 50 15	
			7	SS	45										
			8	SS	38										
989.1 45.0	Silt some sand Dense		9	SS	41		990							0 25 72 3	
983.1 51.0			10	SS	36										
	Clayey Silt to Silt of Slight Plasticity Very Stiff to Hard		11	SS	43		980								
			12	TU	PH		970								
			13	SS	80		960							0 1 94 5	
			14	SS	11		950								
			15	SS	18		940								
927.1 107.0	Silt Very Dense		16	SS	130/8"		930							0 2 92 6	
923.1 111.0	Heterogeneous mixture Clayey Silt, Sand and Gravel		17	SS	152/9"		920							10 46 33 11	
914.1	Hard		18	SS	160/4"										

* Note: Groundwater Level not established

♦², ♦³ : Numbers refer to Sensitivity

15 \pm 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

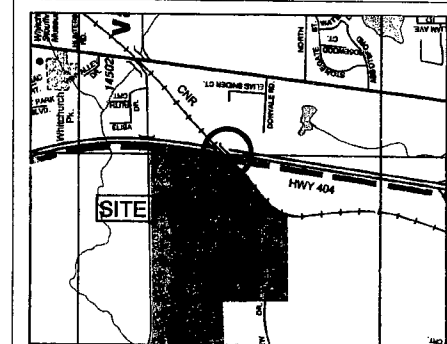
RECORD OF BOREHOLE No 3

METRIC

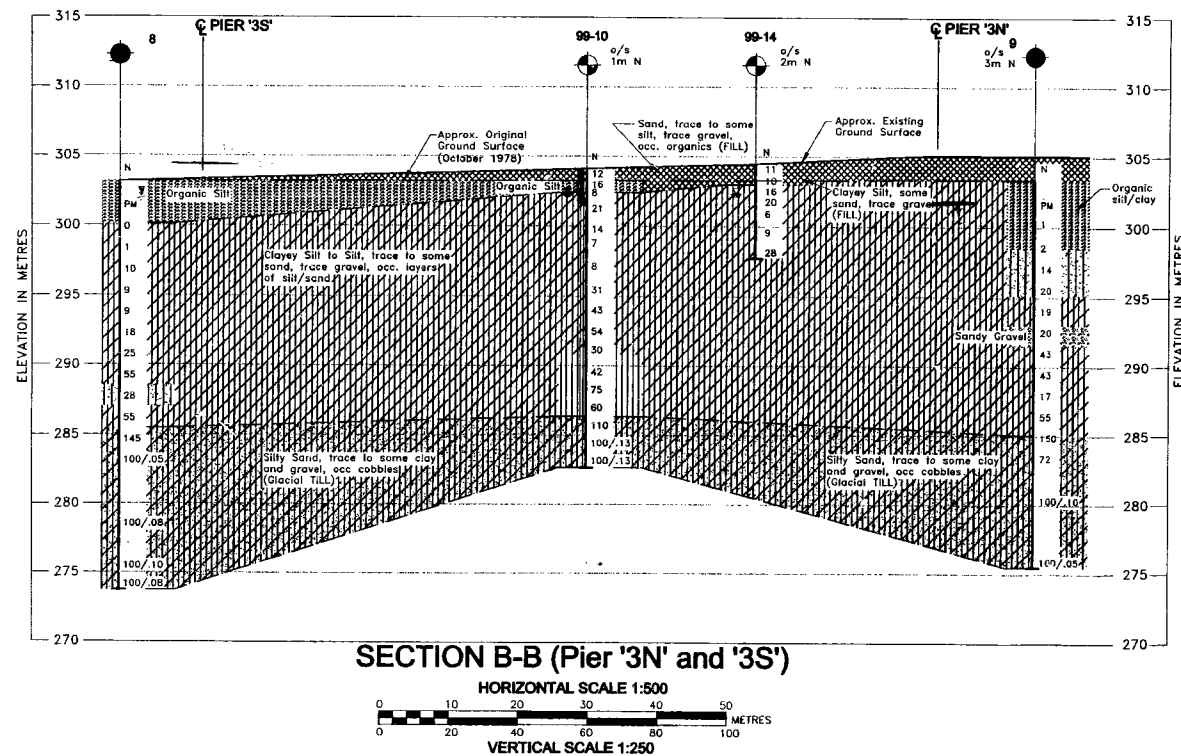
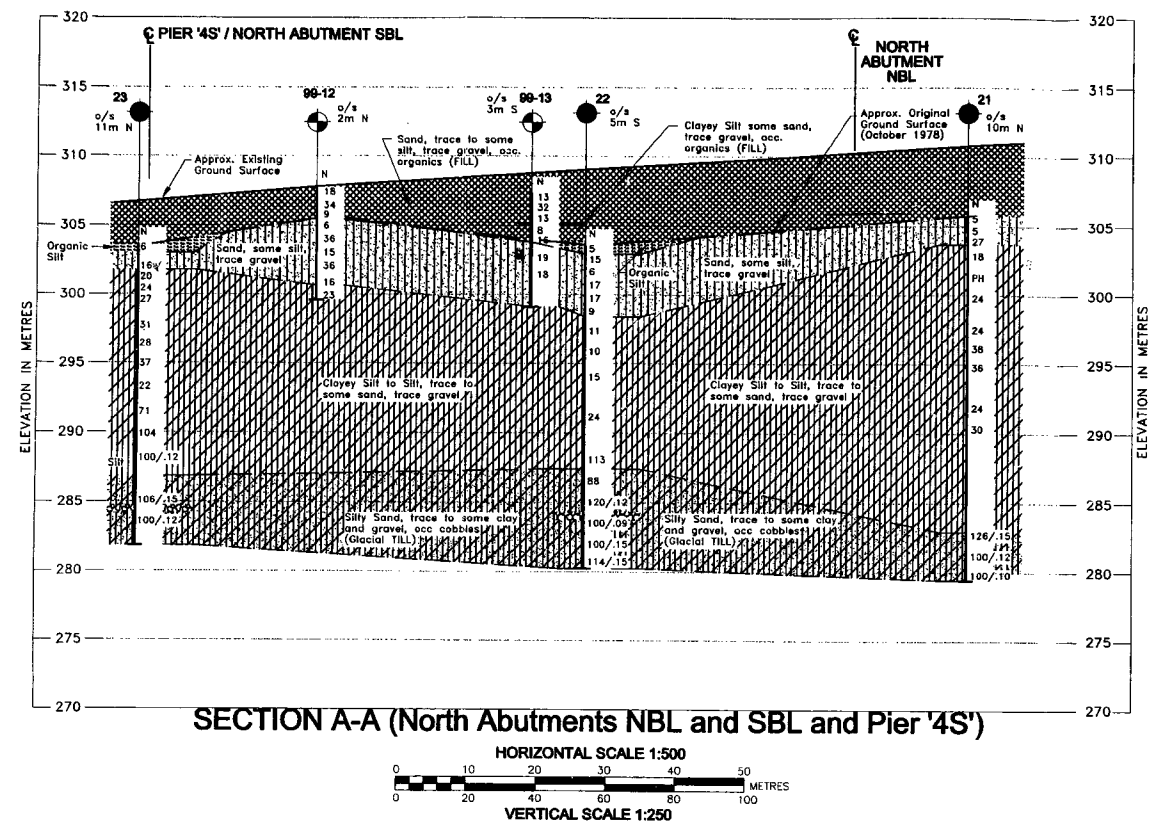
WO 86-11006 LOCATION Sta. 31 + 825.0, O/S 27.7 m Rt of C/L Hwy. 404 ORIGINATED BY JD
DIST 6 HWY 404 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 86 08 20 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION [%]
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	○ UNCONFINED ● QUICK TRIAXIAL					
316.1	Ground Surface													
0.0	Silty Sand *						316							
315.3	(Fill)													
0.8	Cobbles and Gravel (Lightweight Fill)		1	SS	30		314							89 10 (1)
313.4	Compact to Dense													
2.7			2	SS	50									1 22 72 5
	Silt (ML to CL-ML) some sand trace/some clay trace gravel Occasional silty clay (CL) zones Very Stiff to Hard (Fill)		3	SS	23		312							
			4	SS	28		310							1 24 60 15
			5	SS	27		308							
			6	SS	23		306							5 12 55 28
304.8			7	SS	36									
11.3	Silt (ML) to Sandy Silt with organics		8	SS	44		304							
301.9	Silt (ML to CL-ML) ** (Lacustrine)		9	SS	24		302							
14.2	End of Borehole													
	* trace gravel trace clay compact													
	** some sand trace/some clay trace gravel Occasional silty clay (CL) zones Very Stiff to Hard													

OFFICE REPORT ON SOIL EXPLORATION



KEY PLAN



- LEGEND**
- Borehole - Current Golder Associates investigation (99-5 to 99-14)
 - ⊕ Borehole - Previous MTO investigation Geocres No. 30M14-160 Dated December 1984
 - Borehole - Previous MTO investigation Geocres No. 30M14-160 Dated October, 1978
 - Seal
 - Piezometer
 - N Blows/0.3m (Std. Pen. Test, 475 j/blow)
 - WL in piezometer on October 19, 1999
 - WL during drilling

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
99-10	304.12	4872309.54	313148.90
99-12	307.83	4872329.24	313137.06
99-13	307.36	4872343.35	313152.01
99-14	304.48	4872322.91	313157.25
8	303.18	4872273.11	313125.00
9	303.40	4872345.35	313171.03
21	305.81	4872384.67	313163.71
22	303.58	4872345.65	313156.09
23	303.64	4872320.05	313121.04

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

2	00 01 07	AJW	FINAL
1	99 10 20	AJW	ISSUED FOR REVIEW
NO.	DATE	BY	REVISION
Geocres No.			
HWY. No.	404	PROJECT NO.	991-8024B
SUBM'D.	DKB	CHKD.	AJW
DRAWN:	PS/JFC	CHKD.	AJW
		DATE:	1999 09 24
		APPD.	
		DWG.	2

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

DIST 6 HWY 404
WP No. 433-98-00

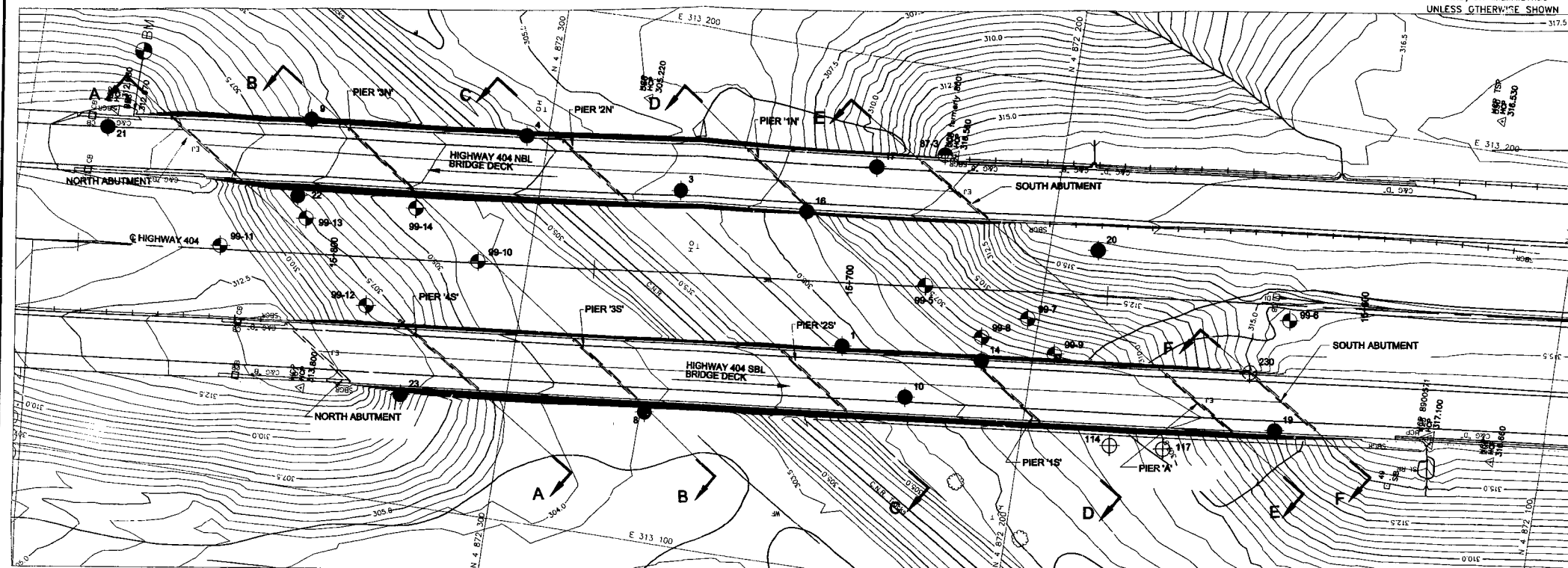


**HIGHWAY 404
CANADIAN NATIONAL RAILWAY
BOREHOLE LOCATIONS & SOIL STRATA**

SHEET

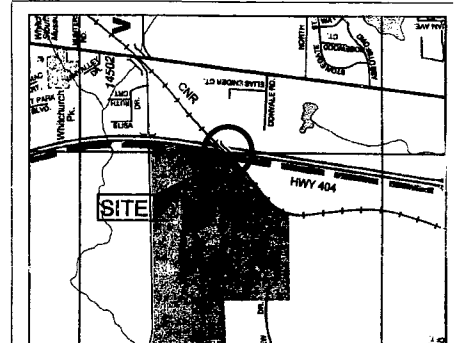


Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

SCALE 1:500
0 10 20 30 40 50 METRES



KEY PLAN

LEGEND

- Borehole - Current Golder Associates investigation (99-5 to 99-14)
- Borehole - Previous MTO investigation Dated April 1987
- ⊕ Borehole - Previous MTO investigation Geocres No. 30M14-160 Dated December 1984
- Borehole - Previous MTO investigation Geocres No. 30M14-160 Dated October, 1978
- Seal
- Piezometer
- N Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer on October 19, 1999
- WL during drilling

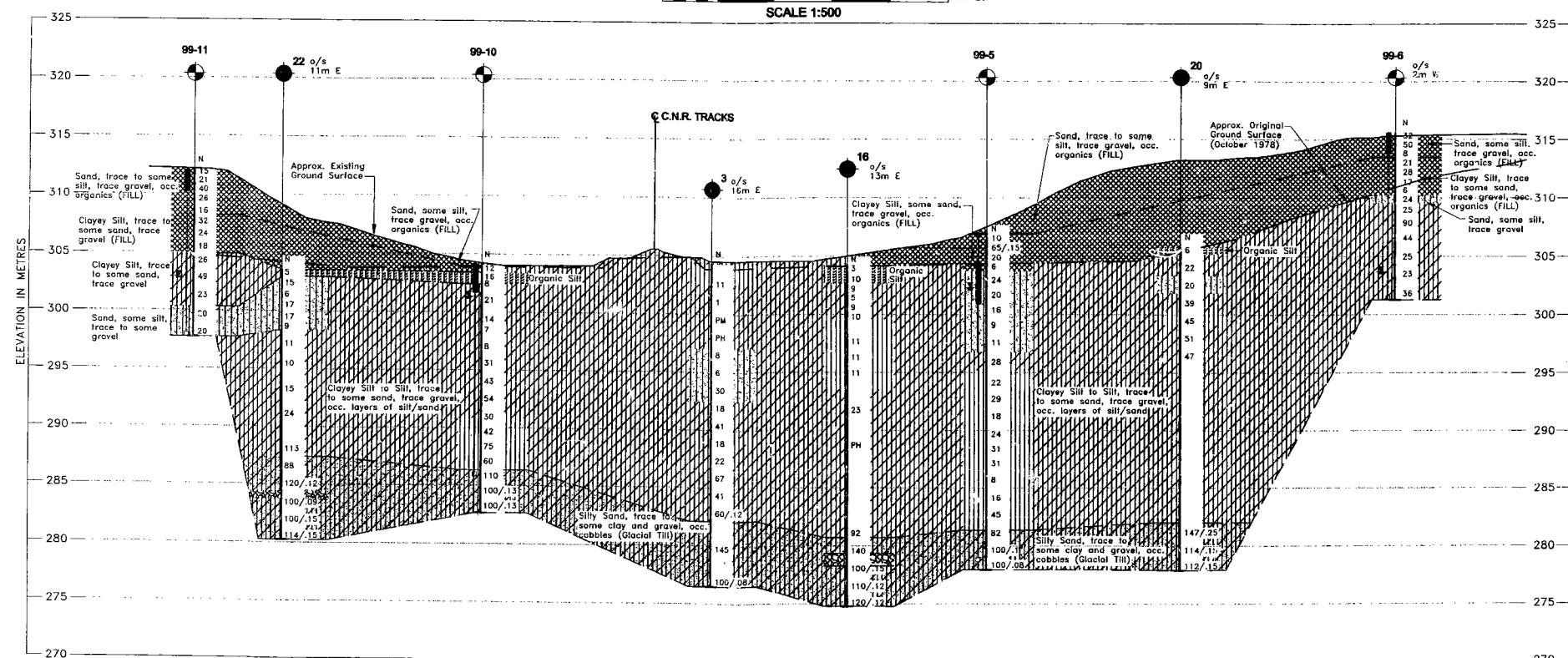
LOCATION			
No.	ELEVATION	NORTHING	EASTING
99-5	306.98	4872222.54	313157.5
99-6	315.60	4872151.99	313161.4
99-7	309.24	4872202.11	313154.15
99-8	306.86	4872210.31	313149.31
99-9	307.34	4872196.07	313148.17
99-10	304.12	4872309.54	313148.90
99-11	312.07	4872359.24	313144.25
99-12	307.83	4872529.24	313137.06
99-13	307.36	4872343.35	313152.01
99-14	304.48	4872322.91	313157.25
87-5	315.10		
230	315.19	4872158.20	313150.30
114	306.45	4872182.89	313132.31
117	308.91	4872172.53	313133.23
1	303.64	4872236.58	313143.60
3	304.37	4872272.50	313168.28
4	303.37	4872304.20	313174.38
8	303.18	4872273.11	313125.00
9	303.40	4872345.35	313171.03
10	303.70	4872223.11	313135.60
14	303.70	4872209.71	313144.81
16	304.19	4872247.20	313168.26
17	308.91	4872235.32	313178.95
19	307.67	4872151.80	313139.94
20	305.81	4872190.81	313169.20
21	305.81	4872384.67	313163.71
22	303.58	4872345.65	313156.09
23	303.64	4872320.05	313121.04

NOTES

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

2	00 01 07	AJW	FINAL
1	99 10 20	AJW	ISSUED FOR REVIEW
NO.	DATE	BY	REVISION

Geocres No.			
HWY. No.	404	PROJECT NO.:	991-80248
SUBM'D. DKB	CHKD: AJW	DATE:	1999 09 24
DRAWN: PS/JFC	CHKD: AJW	APPD.	DWG. 1



PROFILE HWY 404

HORIZONTAL SCALE 1:500

VERTICAL SCALE 1:250

0 10 20 30 40 50 METRES
0 10 20 30 40 50 60 70 80 90 100

Note:

- Pier and abutment locations shown on plan are approximate
- Co-ordinates not available for Borehole 87-3

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

DIST 6 HWY 404
WP No. 433-98-00

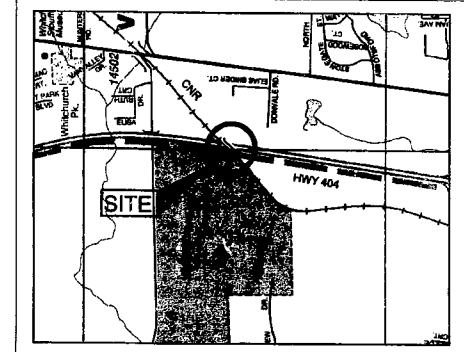


HIGHWAY 404
CANADIAN NATIONAL RAILWAY
SECTIONS C-C AND F-F

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

LEGEND

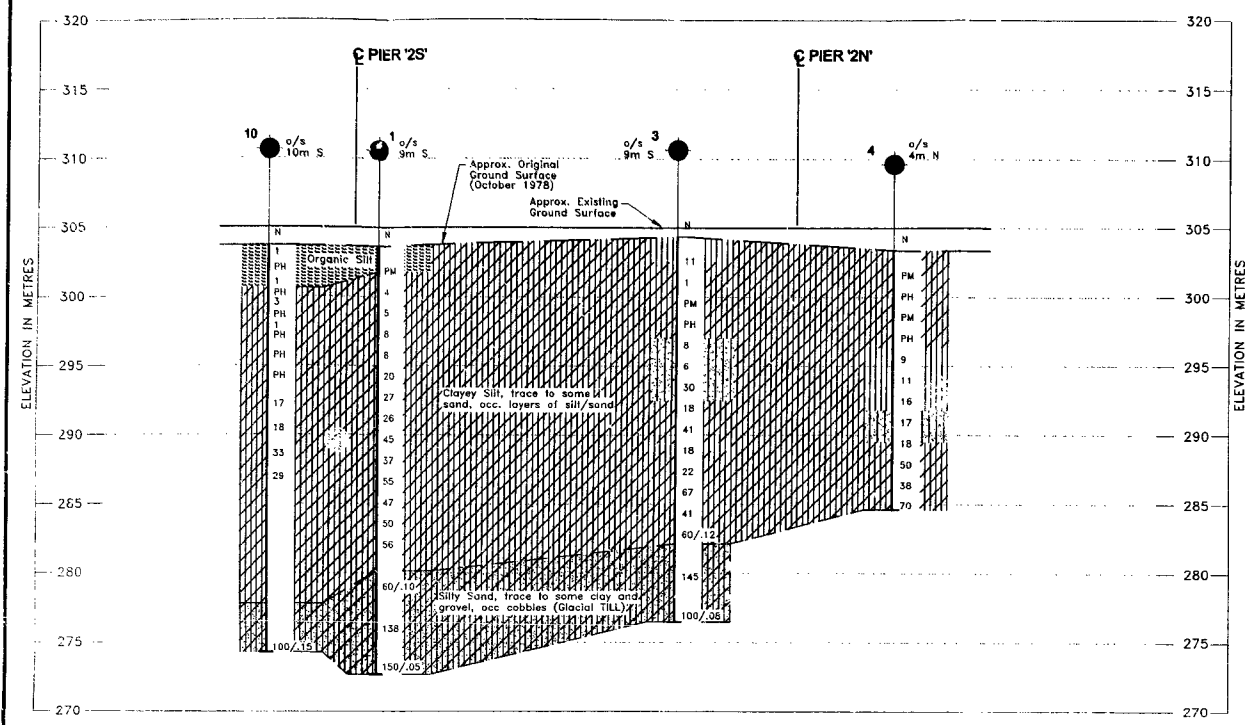
- Borehole - Current Golder Associates investigation (99-5 to 99-14)
- Borehole - Previous MTO investigation Dated April 1997
- Borehole - Previous MTO investigation Geocres No. 30M14-160 Dated December 1984
- Borehole - Previous MTO investigation Geocres No. 30M14-160 Dated October, 1978
- Seal
- Piezometer
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer on October 19, 1999
- WL during drilling

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
99-5	306.98	4872222.54	313157.57
99-6	315.60	4872151.99	313161.45
99-7	309.24	4872202.11	313154.19
99-8	306.86	4872210.31	313149.32
99-9	307.54	4872196.07	313148.17
87-3	316.10		
230	315.19	4872158.20	313150.30
114	306.45	4872182.89	313132.31
117	308.91	4872172.53	313133.23
1	303.64	4864006.93	313143.60
3	304.37	4872272.50	313168.28
4	303.37	4872304.20	313174.38
10	303.70	4872223.11	313155.60
14	303.70	4872209.71	313144.81
16	304.19	4872247.20	313168.28
17	308.91	4872235.32	313178.95
19	307.67	4872151.80	313139.94
20	305.81	4872190.81	313169.20

NOTES

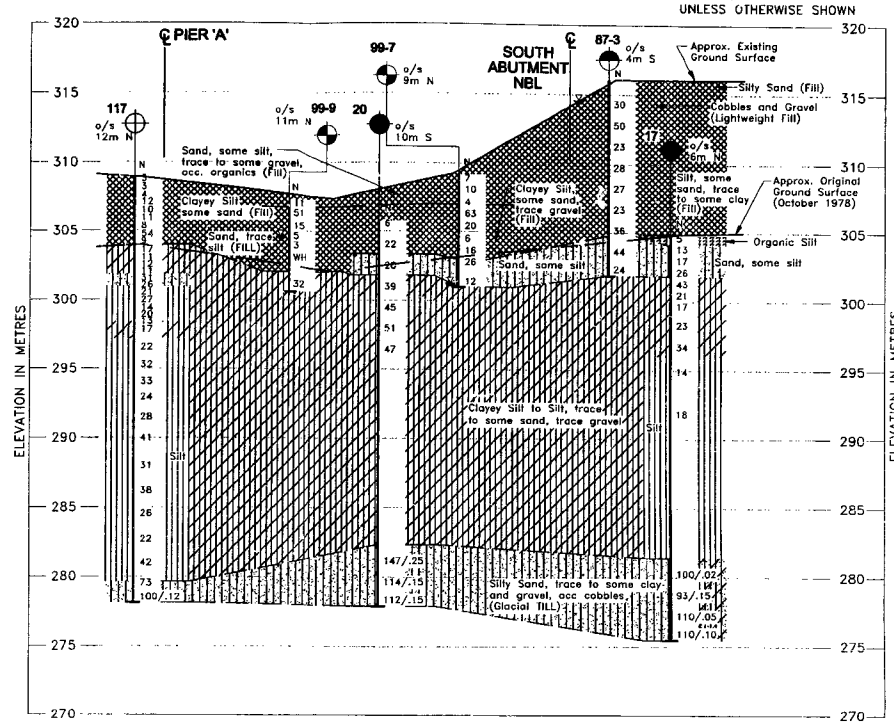
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2	00 01 07	AJW	FINAL
1	99 10 20	AJW	ISSUED FOR REVIEW
NO.	DATE	BY	REVISION
Geocres No.			
HWY. No.	404	PROJECT NO.:	991-8024B
SUBM'D.	DKB	CHKD:	AJW
DRAWN:	PS/JFC	CHKD:	AJW
		DATE:	1999 09 24
		APPD.	
		DWG.	3



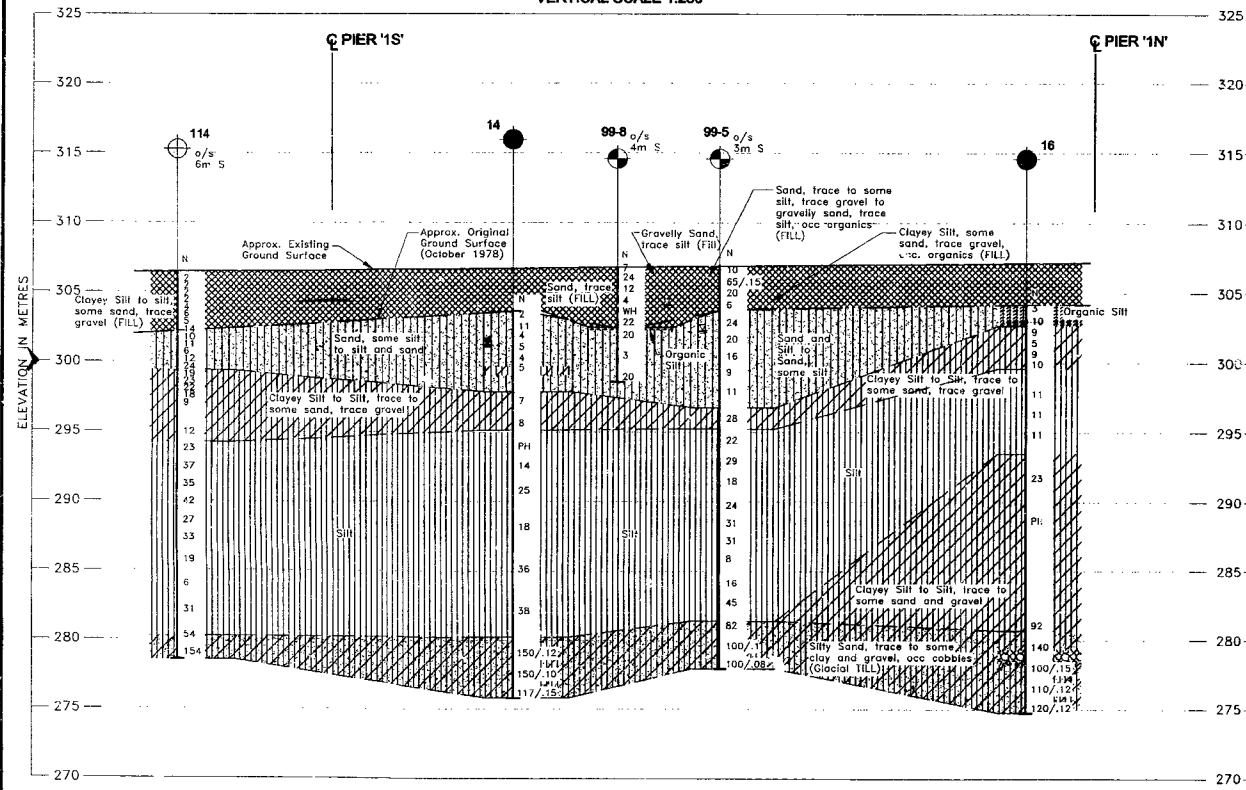
SECTION C-C (Pier '2N' and '2S')

HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:250



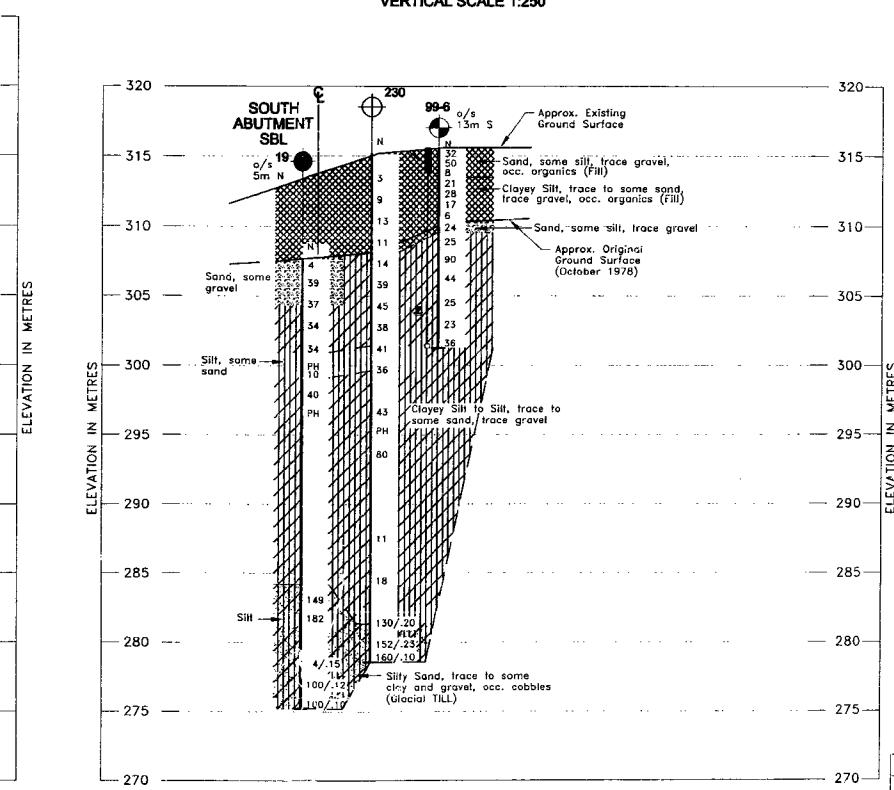
SECTION E-E (South Abutment NBL and Pier 'A')

HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:250



SECTION D-D (Pier '1N' and '1S')

HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:250



SECTION F-F (South Abutment SBL)

HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:250