GEOCRES # 30M16-30

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Golder Associates

REPORT ON

FOUNDATION INVESTIGATION AND DESIGN PERMANENT CUT SECTION STATIONS 21+850 TO 22+250 HIGHWAY 401 WIDENING NORTHUMBERLAND COUNTY G.W.P. 274-96-00, AGREEMENT NO. 4005-A-000103 (A)

Submitted to:

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PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION

Golder Associates Ltd. has been retained by The Greer Galloway Group Inc. (Greer Galloway) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detailed foundation investigation and design services for the widening of Highway 401 between former Highway 2 and Highway 28 near Port Hope, Ontario. The foundations engineering component of the project includes a proposed retaining wall at Highway 28 to accommodate a new W-N/S Ramp, and a permanent cut section between Cranberry and Choate Roads along the median of Highway 401. This report addresses the permanent cut slope section.

The purpose of the foundation investigation is to determine the subsurface conditions along the deep cut section by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. The terms of reference for the scope of work are outlined in our Total Project Management proposal P01-1216, dated July 2000. The work has been carried out in accordance with our Quality Control Plan for Foundation Design Services, dated August 2, 2000.

A plan of the Highway 401 widening between Cranberry and Choate Roads was provided to us in digital format by Greer Galloway on October 25, 2000.

2.0 SITE DESCRIPTION

The permanent cut section is located in the median area of Highway 401 along the south side of the Westbound Lanes, between Cranberry Road (located at Station 21+131) and McKibbon Street / Choate Road (located at about Station 22+783) in the Town of Port Hope, in Northumberland County. The permanent cut slope will be approximately 450 m in length, extending from about Stations 21+800 to 22+250.

The topography of the area is dominated by the Ganaraska River valley, located to the east of the permanent cut section. The ground surface declines from west to east, toward the river valley; the ground surface in the median area along the proposed cut declines from about Elevation 142 m at Station 21+800 to Elevation 129 m at Station 22+250. The Westbound and Eastbound Lanes of Highway 401 have been constructed in cut in the vicinity of the proposed median cut; the Westbound Lanes have a significantly deeper cut than the eastbound lanes to afford appropriate uphill grades, with the grade rising from Elevations 124.5 m to 13.5 m between the east and west limits of the proposed cut section.

Within the project limits, the vegetation cover generally consists of grass, bushes, and small trees.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between October 10 and 13, 2000. At this time ten boreholes (Numbered 1 to 10) were advanced at approximately 50 m intervals along the proposed permanent cut section, in the median area along the south side of the Westbound Lanes of Highway 401.

The investigation was carried out using a bombardier-mounted CME-55 drill rig supplied and operated by Eastern Soil Investigation of Courtice, Ontario. The boreholes were extended to depths of between 5.9 m and 9.6 m below the existing ground surface, in order to extend at least 50 per cent of the cut depth below the proposed base of the cut. Samples of the overburden were obtained at 0.75 m to 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers, consisting of 200 mm long slotted tips threaded into 12 mm diameter rigid PVC tubing, were installed in three of the ten boreholes to permit monitoring of the groundwater levels at the site. All boreholes were backfilled with bentonite.

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 labelled containers and transported to our laboratory in Mississauga for further examination. Index and classification tests consisting of water content determinations, Atterberg Limits tests and grain size analyses were carried out on selected samples.

The borehole elevations and centre-line offsets were provided to us by Greer Galloway on October 17, 2000. The locations of the boreholes are shown on the attached Drawing 1.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

The site is located on the margin of the physiographic region known as the Iroquois Plain. The surficial soils within this region are comprised of sands, silts and clays deposited by glacial Lake Iroquois. To the north of the Port Hope area, these lacustrine deposits are interrupted by drumlins comprised of till soils, which stood as islands in glacial Lake Iroquois. (Reference: "The Physiography of Southern Ontario", 3rd Edition, Chapman and Putnam, 1984).

Limestone bedrock was encountered at about Elevation 90 m in the Ganaraska River valley, about 500 m east of the proposed cut section, in a 1957 subsurface investigation by E.M. Peto Associates Ltd. for the Ministry of Transportation. (Reference: "Report on Soil and Foundation Condition, Highway 401 – Ganaraska River Crossing, Hope Township Bridge 16, W.P. 757-56, GEOCRES No. 30M16-7).

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in Boreholes 1 to 10, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets and Figures 1 to 5 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.

In summary, the subsoils at the site consist of thin surficial layers of topsoil and silty clay to clayey silt, underlain by localized deposits of sand to silty sand atop a clayey silt till sheet. The till sheet is in turn underlain by a silty sand to sandy silt deposit. Bedrock was not encountered in the boreholes drilled during this investigation.

The locations and elevations of the borings, together with the interpreted stratigraphic profile along the permanent cut section, are shown on the attached Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

A surficial layer of topsoil between 100 mm and 200 mm thick was encountered in all of the boreholes.

4.2.2 Silty Clay / Clayey Silt

In all boreholes, a 300 mm to 600 mm thick layer of dark brown silty clay to clayey silt with sand containing trace quantities of rootlets was encountered below the topsoil. The measured Standard Penetration Test (SPT) 'N' values ranged from 4 to 17 blows per 0.3 m of penetration within this surficial deposit, indicating a firm to very stiff consistency.

4.2.3 Upper Sand to Silty Sand

Localized deposits of sand to silty sand were encountered beneath the topsoil and thin cohesive soil layer atop the clayey silt till sheet in two localized areas, as shown on Drawing 1. A grain size distribution test result for a representative sample of the sand, containing some silt, is shown on Figure 1.

In Boreholes 1 to 3, near the west end of the proposed cut section, the sand to silty sand deposit was about 5.5 m to 7 m in thickness; this deposit was not encountered in Boreholes 4 through 6, in the central portion of the cut section. In Boreholes 7 to 9, near the east end of the cut section, the surficial sand to silty sand deposit was 1 m to 2 m thick.

In both localized deposits, the measured SPT 'N' values range from about 30 to greater than 97 blows per 0.3 m of penetration, indicating a dense to very dense, but generally very dense, relative density. The deposits are generally dry to moist, with measured water contents between about 2 and 7 per cent; however, below 6 m to 7.5 m depth near the west end of the proposed cut section, in Boreholes 1 to 3, the sand to silty sand soils are wet.

4.2.4 Clayey Silt Till

A deposit of clayey silt till was encountered in Boreholes 1 and 3 through 10, underlying the topsoil, silty clay to clayey silt and, where present, the localized sand to silty sand deposits. The top of the deposit undulates between Elevation 138 m and 129 m, generally declining toward the east. The till deposit is typically 4 m to 7 m in thickness, although it thins to about 1 m in thickness at the location of Borehole 3, is not present within the investigated depth at the location of Borehole 2, and was not fully penetrated at the location of Borehole 1.

The clayey silt till contains significant quantities of sand, and trace to some gravel. Representative grain size distribution test results for samples of this till are shown on Figure 2.

The measured SPT 'N' values ranged from 48 to greater than 100 blows per 0.3 m of penetration, and are generally greater than 100 blows per 0.3 m of penetration, indicating that this till has a hard consistency. Atterberg limits testing carried out on representative samples of the clayey silt till measured a liquid limit of 15 to 17 per cent and a plasticity index of between 6 and 7 per cent, indicating that the clayey silt is inorganic and of low plasticity. The results of the Atterberg limits testing are shown on the Records of Boreholes and on Figure 3. Measured water contents on selected samples of the clayey silt till ranged from about 6 to 11 per cent, typically at or below the plastic limit for the soil.

4.2.5 Lower Silty Sand to Sandy Silt

A deposit of silty sand to sandy silt was encountered below the clayey silt till sheet in Boreholes 3, 4, and 6 to 8. A grain size distribution test result for the sandy silt portion of the deposit is shown on Figure 4.

The top of the deposit generally declines eastward, from about Elevation 132.5 m at the location of Borehole 3 to about Elevation 125.5 m at the location of Borehole 8. This layer was not fully penetrated in any of the boreholes, and is at least 1 m to 2.5 m thick. These lower silty sand to sandy silt soils were generally wet.

The measured SPT 'N' values in this lower deposit ranged from 80 to greater than 100 blows per 0.3 m of penetration, indicating a very dense relative density.

4.3 Groundwater Conditions

The groundwater conditions in the open boreholes were recorded upon completion of each boring. Boreholes 2, 6, 9 and 10 were dry upon completion of drilling. In open Boreholes 3, 4, 7 and 8, water levels were measured between 5.6 m and 7.9 m depth on completion of drilling; the water levels in these boreholes were associated with the wet lower silty sand to sandy silt deposit.

Piezometers were installed in Boreholes 1, 5 and 9 to permit monitoring of the groundwater levels across the site. The piezometer in Borehole 1 was dry, while the piezometers in Boreholes 5 and 9 measured water levels at Elevations 130.3 m and 128.7 m, respectively, on October 23, 2000. The water levels are shown on the attached Record of Borehole sheets, and the water levels in the piezometers are shown on the attached Drawing 1.

It should be noted that groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

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PART B – FOUNDATION DESIGN REPORT

PERMANENT CUT SECTION
STATIONS 21+800 TO 22+250
HIGHWAY 401 WIDENING
NORTHUMBERLAND
G.W.P. 274-96-00, AGREEMENT NO. 4005-A-000103

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of proposed permanent cut section, 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 proposed widening of the Highway 401 Westbound Lanes involves a permanent cut slope within the median, which will shift the crest of the cut slope toward the north shoulder of the Eastbound Lanes. The cut slope section will be approximately 450 m long, extending between Stations 21+800 and 22+250. The height of the permanent cut slope will range between 4.5 m and 5.8 m. The existing cut slopes in this area are of similar height and have an inclination of about 1.8 horizontal to 1 vertical (1.8H:1V).

5.2 Permanent Cut Slopes

Based on the borehole information, the permanent cut will be formed predominantly in the very dense sand to sandy silt or the hard clayey silt till. It is noted that in the lower portion of the slope (below Elevation 129 m) to the east of Station 22+150, the base of the cut will be below the groundwater level.

It is understood that the existing slopes are generally formed at a gradient of 1.8 horizontal to 1 vertical (1.8H:1V) but are locally steepened to about 1.6H:1V; these slopes appear to have performed satisfactorily. The new permanent cut slopes should be formed at (2H:1V). The factor of safety for slopes formed at this gradient will be greater than 1.5. If space does not allow cut slopes at 2H:1V, consideration could be given to a low retaining wall to effect this slope.

5.3 Construction Considerations

All cut slopes should be inspected after the cut has been completed to check for evidence of water seepage which could affect surficial stability. It is recommended that remedial measures, such as a granular blanket, should be placed where seepage is present.

It is anticipated that a granular blanket treatment will be required east of Station 22+150, where the proposed cut will extend below the measured groundwater level; it is recommended that a Non-Standard Special Provision be incorporated into the Contract Documents for placement of a granular blanket in this area. The drainage blanket treatment should extend from Elevation 130 m to the toe of the cut slope, ensuring a positive drainage connection between the blanket and the ditch or subdrain at the slope toe. In order to provide an effective filter and drainage medium, the drainage blanket should be comprised of 600 mm of non-crushed, pit run source Granular "A" with less than 5 per cent passing the 200 sieve. Following placement of the drainage blanket, the cut slope surface should be covered with 250 mm of earth cover. A typical detail for the drainage blanket is shown on Figure 5.

Vegetation cover should be established on all slope faces to protect against surficial erosion, as per OPSS 572.

All excavation work should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and Regulations for Construction Projects (June 2000 edition).

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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
SS	Split-spoon
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 Cone Penetration Resistance; N_d:

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)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 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	c_u, s_u 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 (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 δ
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 001-1142

RECORD OF BOREHOLE No 1

1 OF 1 **METRIC**

W.P. 274-96-00 LOCATION Sta. 21+800, CL 4.92 ORIGINATED BY SP

DIST 41 HWY 401 BOREHOLE TYPE 114mm Solid Stem Augers COMPILED BY SP

DATUM Geodetic DATE Oct.12/00 CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.74	GROUND SURFACE										
140.89	Topsoil										
0.20	Silty Clay, some sand, trace roots		1	SS	7						
141.14	Firm										
0.60	Dark brown						141				
	Moist										
	Sand, fine to medium, some silt		2	SS	72						
	Very dense										
	Brown										
	Dry		3	SS	76		140		o		0 84 16 -
			4	SS	90/.28						
							139				
			5	SS	89/.23						
							138				
			6	SS	50/.10		137				
							136				
	Becoming moist sandy silt, trace gravel, trace clay at 6.1m depth.		7	SS	50/.08				o		
134.74							135				
7.00	Clayey Silt with sand										
	Hard										
	Brown										
	Moist										
133.94	(Till)		8	SS	50/.08		134		o		
7.80	END OF BOREHOLE										

Note:
1. Piezometer was dry on Oct.23, 2000.

$+^{3}$, $\times^{3}$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

1 OF 1 **METRIC**

PROJECT 001-1142 | W.P. 274-96-00 | DIST 41 HWY 401 | DATUM Geodetic

LOCATION Sta. 21+850, CL 4.91 | BOREHOLE TYPE 114mm Solid Stem Augers | DATE Oct.12/00

ORIGINATED BY SP | COMPILED BY SP | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.58	GROUND SURFACE										
140.08	Topsoil										
0.50	Clayey Silt, trace sand, trace roots Firm Dark brown Moist		1	SS	6		140				
	Sand, fine to medium Dense to very dense Brown Dry		2	SS	39				○		
			3	SS	74		139				
			4	SS	94/.28		138				
	Containing trace silt at 3.1m depth		5	SS	87				○		
							137				
			6	SS	50/.15		136				
							135				
			7	SS	94/.25						
							134				
	Becoming moist and containing some silt at 7.6m depth										
132.81			8	SS	90/.15		133		○		
7.77	END OF BOREHOLE										

Note:
1. Open borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

1 OF 1 **METRIC**

PROJECT 001-1142 | W.P. 274-96-00 | DIST 41 | HWY 401 | DATUM Geodetic

LOCATION Sta. 21+900, CL 6.05 | BOREHOLE TYPE 114mm Solid Stem Augers | DATE Oct.12/00

ORIGINATED BY SP | COMPILED BY SP | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
139.57	GROUND SURFACE										
0.00	Topsoil										
0.10	Silty Clay, some sand, trace roots Stiff Dark brown Moist		1	SS	8		139				
138.87											
0.70	Silty Sand, trace gravel, trace clay Very dense Brown Dry		2	SS	64						
138.17							138		o		
1.40	Sand, fine to medium, some silt Very dense Brown Dry		3	SS	97/.25						
			4	SS	58		137				
			5	SS	84						
							136				
			6	SS	50/.15		135				
133.47											
6.10	Clayey Silt with sand, trace gravel Hard Brown Dry to moist (Till)		7	SS	84/.23		134		o		
132.57							133				
7.00	Sandy Silt, trace clay Very dense Brown Moist to wet										
131.67			8	SS	70/.15		132		o		
7.90	END OF BOREHOLE Note: 1. Water level measured in open borehole at very bottom of hole, 7.9m depth (Elev.131.7m) on completion of drilling.										

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

RECORD OF BOREHOLE No 4

1 OF 1 **METRIC**

PROJECT 001-1142
W.P. 274-96-00
DIST 41 HWY 401
DATUM Geodetic

LOCATION Sta. 21+950, CL 5.46
BOREHOLE TYPE 114mm Solid Stem Augers
DATE Oct.12/00

ORIGINATED BY SP
COMPILED BY SP
CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.41	GROUND SURFACE						138				
0.00	Topsoil										
0.10	Clayey Silt, some sand, trace roots, oxidation stains		1	SS	9						
137.71	Stiff										
0.70	Dark brown Moist Clayey Silt with sand, trace gravel Hard Brown Dry (Till) Oxidation stains at 0.8m depth		2	SS	50/.08		137				
			3	SS	70/.15						
			4	SS	50/.13		136				
			5	SS	100/.13		135				
			6	SS	60/.10		134				
	A 0.2m thick layer of medium, brown sand at 6.1m depth. Becoming moist at 6.1m depth.		7	SS	93/.28		133				
131.31							132				
7.10	Sand, fine to medium, some silt Very dense Brown Wet		8	SS	80		131				
							130				
	Becoming sandy silt, trace clay at 9.1m depth.		9	SS	80/.28		129				1 24 71 4
128.81											
9.60	END OF BOREHOLE Note: 1. Water level measured in open borehole at 7.3m depth (Elev.131.1m) on completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

PROJECT 001-1142

RECORD OF BOREHOLE No 5

1 OF 1 **METRIC**

W.P. 274-96-00 LOCATION Sta. 22+000, CL 5.78 ORIGINATED BY SP

DIST 41 HWY 401 BOREHOLE TYPE 114mm Solid Stem Augers COMPILED BY SP

DATUM Geodetic DATE Oct.12/00 CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.80	GROUND SURFACE										
0.00	Topsoil										
0.10	Silty Clay with sand, tarce roots Stiff Dark brown Moist		1	SS	8						
136.10											
0.70	Clayey Silt with sand, trace gravel Hard Brown Dry to moist (Till)		2	SS	68		136				
			3	SS	60/.08		135				
			4	SS	50/.10						7 38 36 19
	Becoming silty clay, some sand, trace gravel at 3.1m depth.		5	SS	76		134				
			6	SS	73/.15		133				
			7	SS	70/.08		132				
	Becoming wet, grey and containing rock fragments at 7.6m depth						131				
129.00			8	SS	100/.15		130				
7.80	END OF BOREHOLE						129				

Note:
1. Water level measured in piezometer at 6.5m depth (Elev.130.3m) on Oct.23, 2000.

$+^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

1 OF 1 **METRIC**

PROJECT 001-1142
W.P. 274-96-00
DIST 41 HWY 401
DATUM Geodetic

LOCATION Sta. 22+050, CL 5.93
BOREHOLE TYPE 114mm Solid Stem Augers
DATE Oct.12/00

ORIGINATED BY SP
COMPILED BY SP
CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
135.24	GROUND SURFACE					
0.00	Topsoil					
0.10	Clayey Silt, some sand, trace roots, trace gravel Firm Dark brown Dry to moist		1	SS	4	
134.44						
0.80	Clayey Silt, with sand to some sand, trace gravel Hard Brown Dry to moist (Till)		2	SS	48	
			3	SS	50/.15	
			4	SS	76/.25	
			5	SS	50/.08	
			6	SS	100/.15	
129.74						
5.50	Silty Sand, trace gravel Very dense Brown Wet		7	SS	70/.15	
	Containing pocket of medium sand at 7.6m depth.					
127.47			8	SS	75/.15	
7.77	END OF BOREHOLE Note: 1. Open borehole dry upon completion of drilling.					

ELEVATION SCALE: 135, 134, 133, 132, 131, 130, 129, 128

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

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

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

1 OF 1 **METRIC**

PROJECT 001-1142 | W.P. 274-96-00 | DIST 41 | HWY 401 | DATUM Geodetic

LOCATION Sta. 22+100, CL 7.63 | BOREHOLE TYPE 114mm Solid Stem Augers | DATE Oct.13/00

ORIGINATED BY SP | COMPILED BY SP | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
134.08	GROUND SURFACE						134				
0.00	Topsoil										
0.15	Clayey Silt with sand, trace roots and grass		1	SS	8						
133.38	Stiff						133		o		
0.70	Dark brown Dry to moist Sand, fine to medium, trace silt		2	SS	33						
132.68	Dense										
1.40	Brown Dry Clayey Silt with sand, trace gravel		3	SS	50		132				
	Hard Brown Dry (Till)		4	SS	50/.15						
			5	SS	100/.15		131				
			6	SS	64/.15		130		o		
	Becoming moist at 6.1m depth		7	SS	100/.13		129				
127.08							128				
7.00	Silty Sand, trace gravel Very dense Brown Moist to wet		8	AS	94/.15		127				
							126				
	Becoming grey and containing rock fragments at 9.1m depth.		9	SS	87/.15		125		o		
124.68											
9.40	END OF BOREHOLE										

Note:
1. Water level measured in open borehole at 6.1m depth (Elev.128.0m) on completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

1 OF 1 **METRIC**

PROJECT 001-1142 | W.P. 274-96-00 | DIST 41 | HWY 401 | DATUM Geodetic

LOCATION Sta. 22+150, CL 4.86 | BOREHOLE TYPE 114mm Solid Stem Augers | DATE Oct.13/00

ORIGINATED BY SP | COMPILED BY SP | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
132.40	GROUND SURFACE					
0.00	Topsoil					
0.10	Clayey Silt with sand, trace roots Very stiff Dark brown Moist		1	SS	16	
131.70						
0.70	Sand, fine to medium, trace to some silt, trace gravel Very dense Brown Dry		2	SS	50/.15	
			3	SS	80/.08	
			4	SS	83/.15	
129.65						
2.75	Clayey Silt with sand, trace gravel Hard Grey Moist		5	SS	95/.15	
			6	SS	100/.15	
			7	SS	90/.15	
125.50						
6.90	Sandy Silt, trace clay Very dense Grey Moist to wet Containing trace gravel at 7.6m depth		8	SS	100/.08	
123.10			9	SS	100/.15	
9.30	END OF BOREHOLE Note: 1. Water level measured in open borehole at 5.6m depth (Elev.126.8m)on completion of drilling.					

ELEVATION SCALE: 132, 131, 130, 129, 128, 127, 126, 125, 124

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

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

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 9

1 OF 1 **METRIC**

PROJECT 001-1142
W.P. 274-96-00
DIST 41 HWY 401
DATUM Geodetic

LOCATION Sta. 22+200, CL 4.64
BOREHOLE TYPE 114mm Solid Stem Augers
DATE Oct.13/00

ORIGINATED BY SP
COMPILED BY SP
CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.18	GROUND SURFACE						130				
0.00	Topsoil										
0.10	Clayey Silt with sand, trace roots Stiff Dark brown to grey Moist to dry		1	SS	13						
129.48							129				
0.70	Sand, fine to emdium, trace to some silt, trace gravel, trace clay Very dense Grey Dry		2	SS	50/.15				○		
128.38			3	SS	100/.15		128				
1.80	Clayey Silt with sand, some gravel Hard Grey Dry (Till)		4	SS	100/.10						
			5	SS	100/.10		127		○ —		13 36 33 18
	Becoming dry to moist at 4.6m depth		6	SS	100/.13		126		○		
			7	SS	100/.13		125				
122.31	Becoming moist at 7.6m depth		8	SS	50/.10		124		○		
7.87	END OF BOREHOLE						123				

Note:
1. Open borehole dry upon completion of drilling.
2. Water level measured in piezometer at 1.54m depth (Elev.128.64m) on Oct.23, 2000.

$+^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT 001-1142.GPJ ON_MOT.GDT 26/10/00

PROJECT 001-1142

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 274-96-00 LOCATION Sta. 22+250, CL 5.55 ORIGINATED BY SP

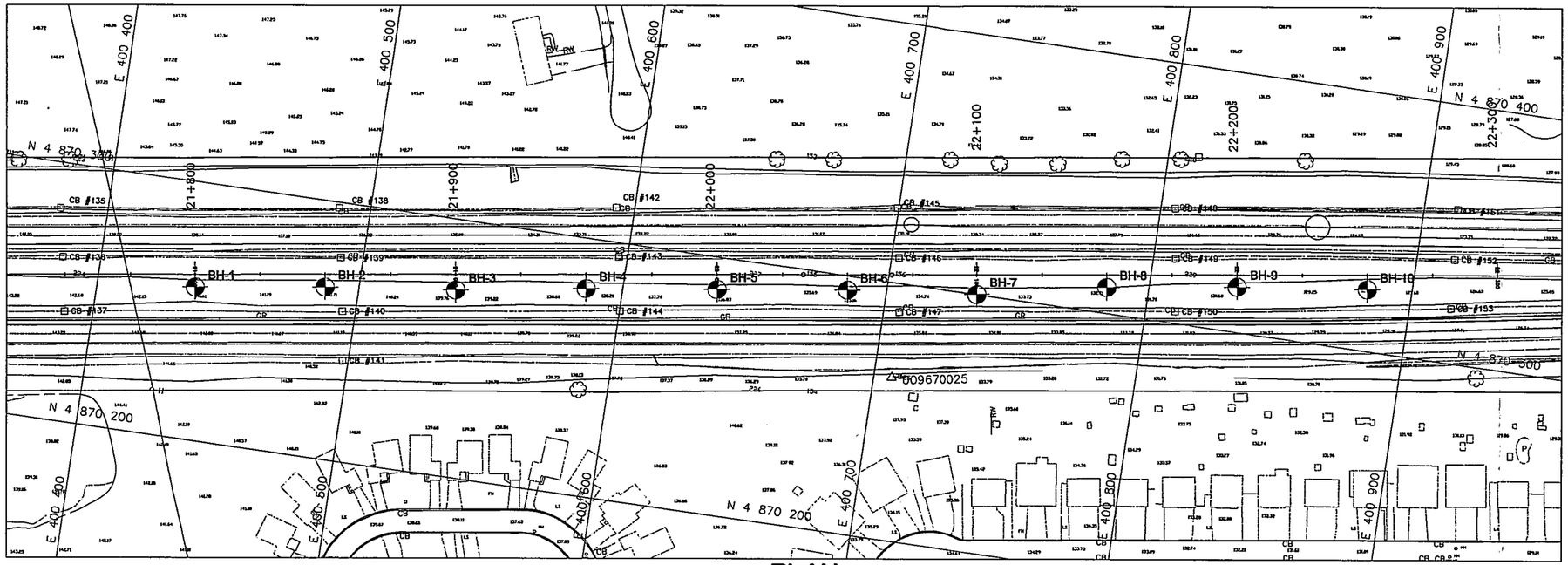
DIST 41 HWY 401 BOREHOLE TYPE 114mm Solid Stem Augers COMPILED BY SP

DATUM Geodetic DATE Oct.10/00 CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
128.10	GROUND SURFACE										
0.00	Topsoil						128				
0.10	Silty Clay, trace sand, trace roots Very stiff Dark brown		1	SS	17						
127.40	Moist to dry										
0.70	Silty Clay, trace to some sand, trace gravel Hard Brown Dry (Till)		2	SS	90/.23		127		○		
			3	SS	92		126				
	Becoming grey at 2.3m depth.		4	SS	50/.10				○		
			5	SS	50/.13		125				
			6	SS	50/.15		124				
							123				
122.20			7	SS	50/.10				○		
5.90	END OF BOREHOLE Note: 1. Open borehole dry upon completion of drilling.										

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

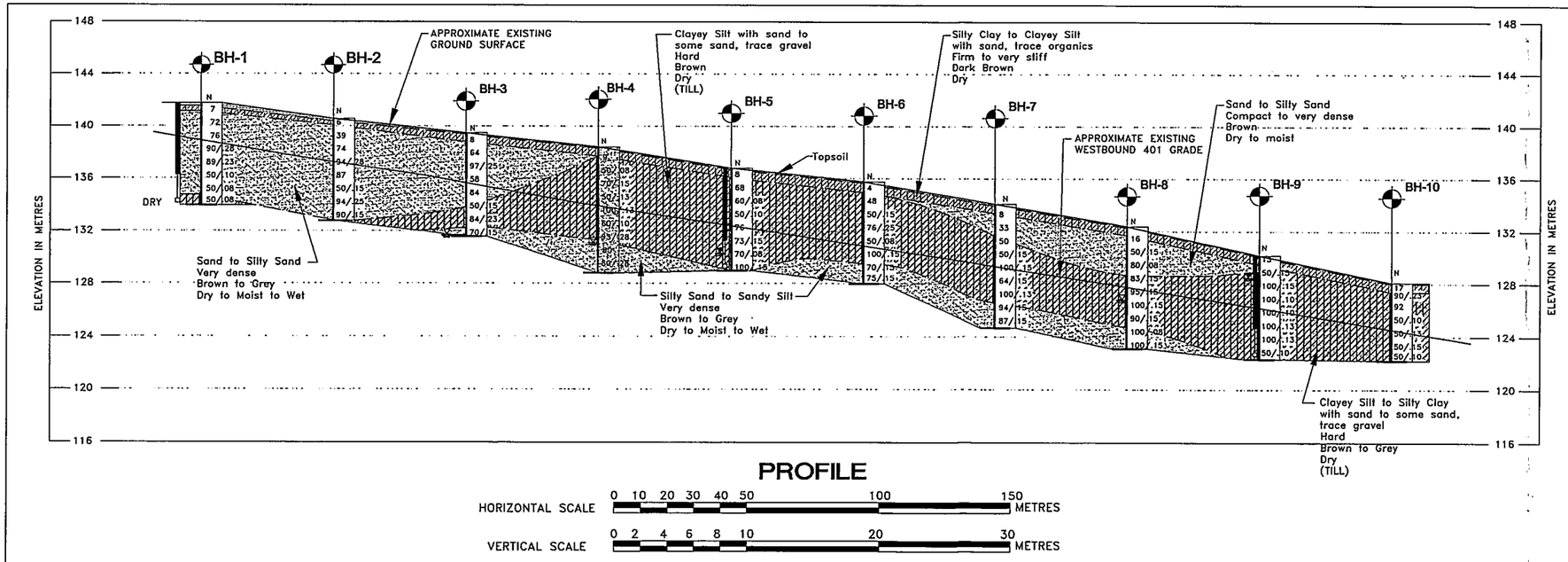
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

0 10 20 30 40 50 100 150 METRES

SCALE



PROFILE

HORIZONTAL SCALE 0 10 20 30 40 50 100 150 METRES

VERTICAL SCALE 0 2 4 6 8 10 20 30 METRES

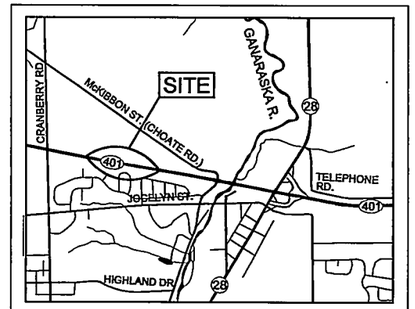
DIST No. 41	HWY 401
CONT No.	
GWP No.	274-96-00

SHEET

HIGHWAY 401
STATION 21+800 TO 22+250
PERMANENT CUT SECTION
BOREHOLE LOCATIONS & SOIL STRATA

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

LEGEND

- Borehole – Current Golder Associates Ltd. Investigation
- Seal
- Piezometer
- N Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer on October 23, 2000
- WL upon completion of drilling

No.	ELEVATION	LOCATION NORTHING	LOCATION EASTING
BH-1	141.74	4870259.336	400437.589
BH-2	140.58	4870266.582	400487.061
BH-3	139.57	4870272.689	400536.7
BH-4	138.41	4870280.509	400586.088
BH-5	136.80	4870287.428	400635.608
BH-6	135.24	4870294.516	400685.104
BH-7	134.08	4870300.069	400734.823
BH-8	132.40	4870310.046	400783.896
BH-9	130.18	4870317.499	400833.338
BH-10	128.10	4870323.835	400882.943

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

REFERENCE
This drawing was created from digital files "GOLD-BHBASE.dwg" dated October 25, 2000 provided by The Greer Galloway Group Inc.

NO.	DATE	BY	REVISION
1	00/10/27	ASP	REVIEW

Geocres No.

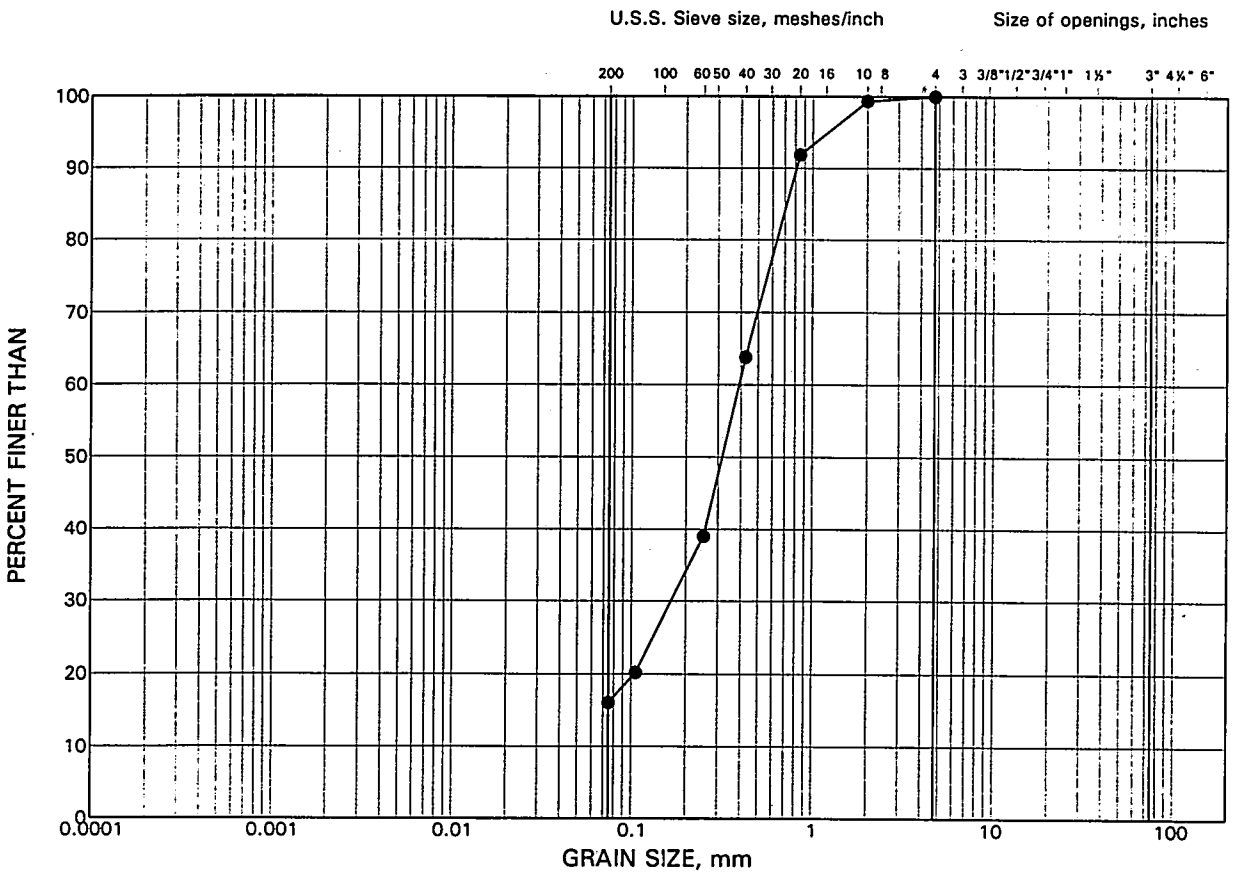
HWY 401	PROJECT NO.: 001-1142		DIST. 41
SUBM'D. SP	CHKD: LCC	DATE: 2000 10 27	SITE
DRAWN: JFC/PS	CHKD. ASP	APPD. LCC	DWG. 1

O1142B01.DWG

1" = 1" imp. (1:4,000MS)

GRAIN SIZE DISTRIBUTION
UPPER SAND TO SILTY SAND

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	1	3	139.7

Project 001-1142B

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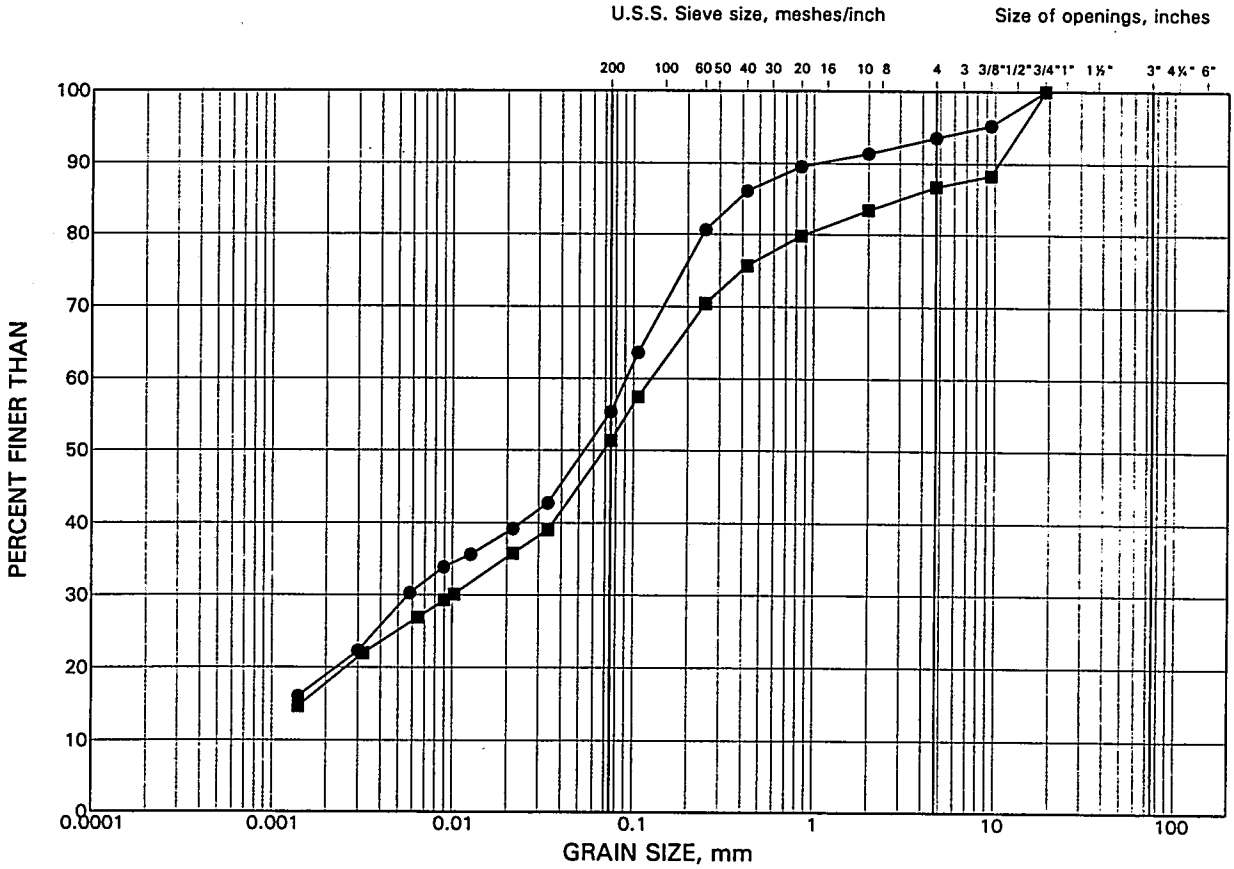
GRAIN SIZE DISTRIBUTION
CLAYEY SILT (TILL)

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	5	4	134.0
■	9	5	127.1

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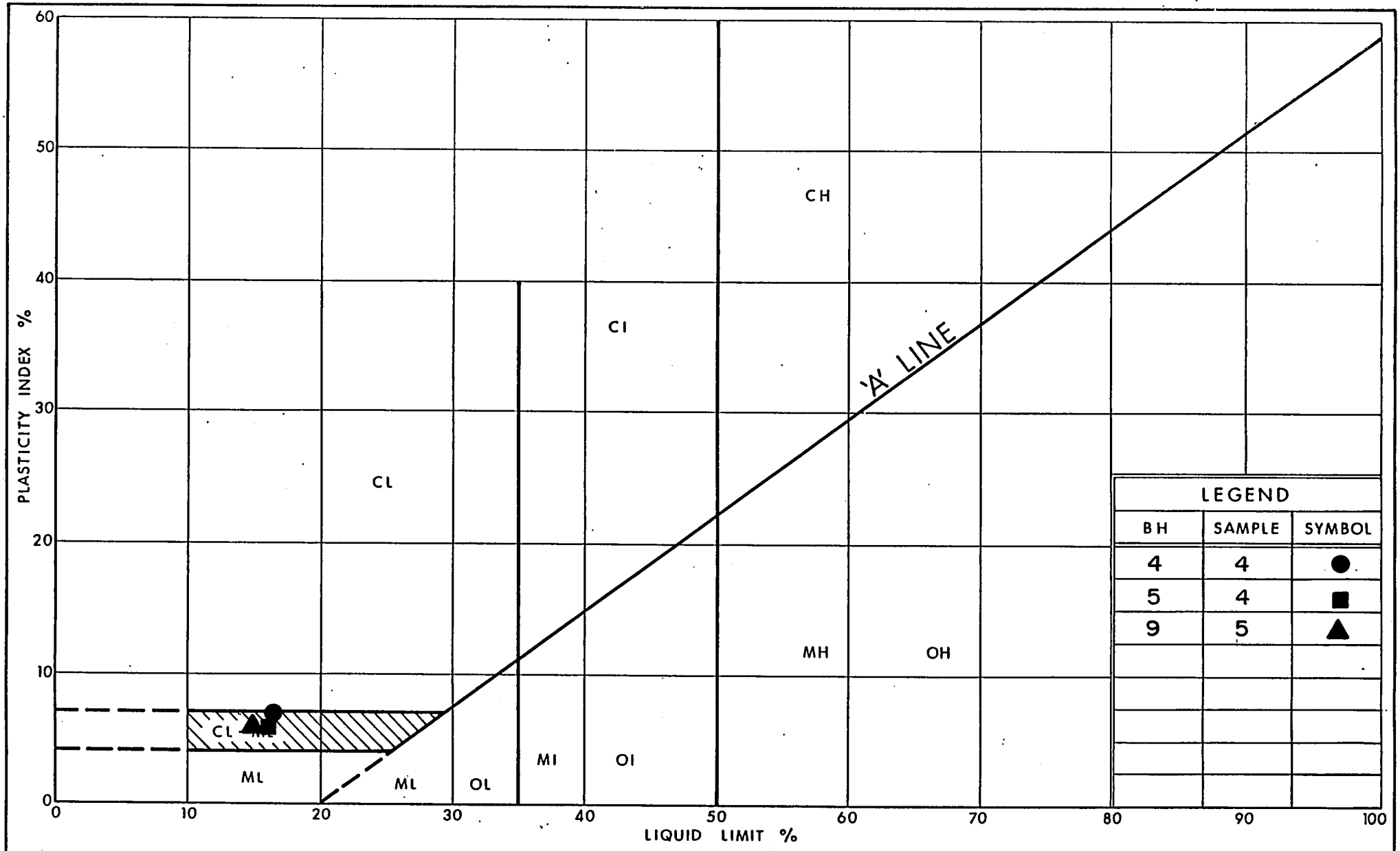


Ministry of Transportation
Ontario

PLASTICITY CHART

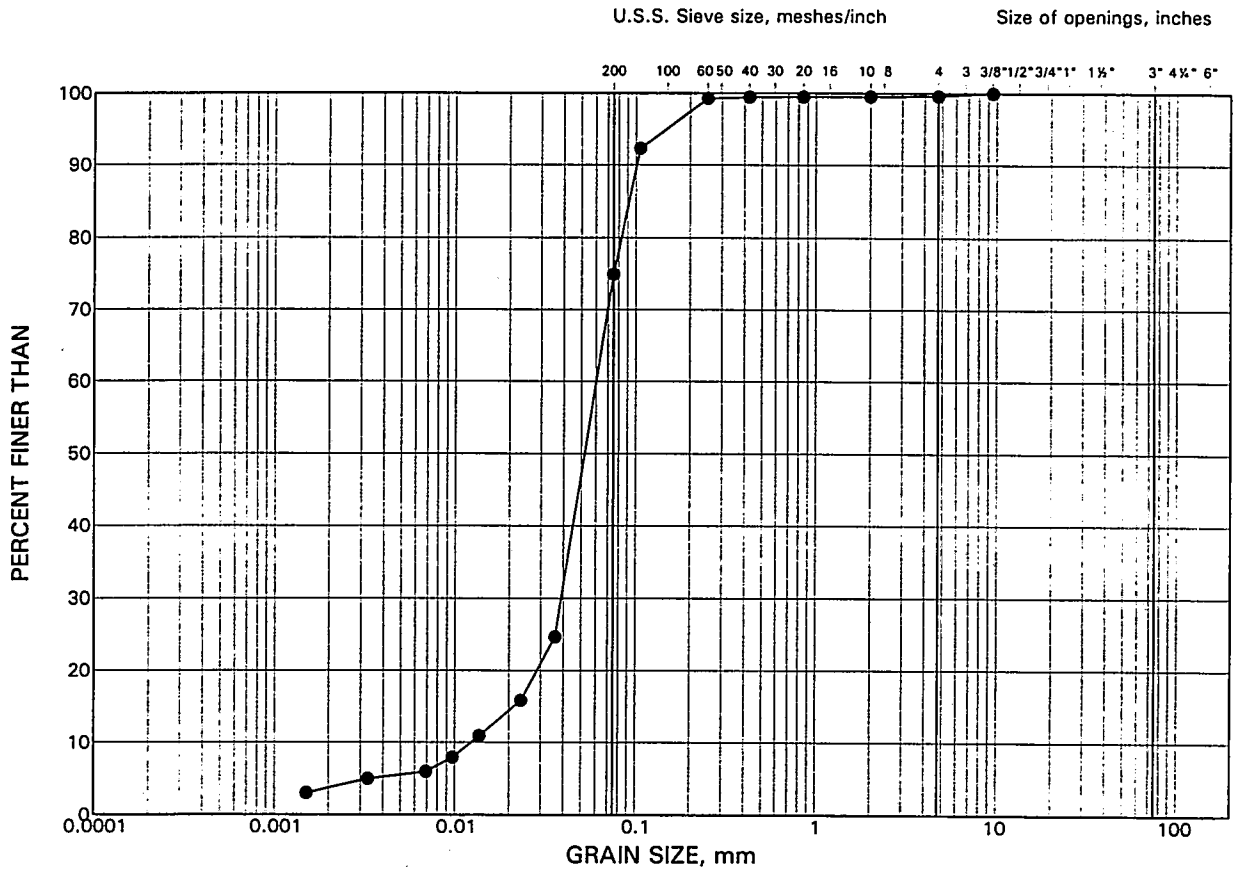
UPPER CLAYEY SILT (TILL)

FIG No 3

W P 274 – 96 – 00

GRAIN SIZE DISTRIBUTION
LOWER SILTY SAND TO SANDY SILT

FIGURE 4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	4	9	128.8

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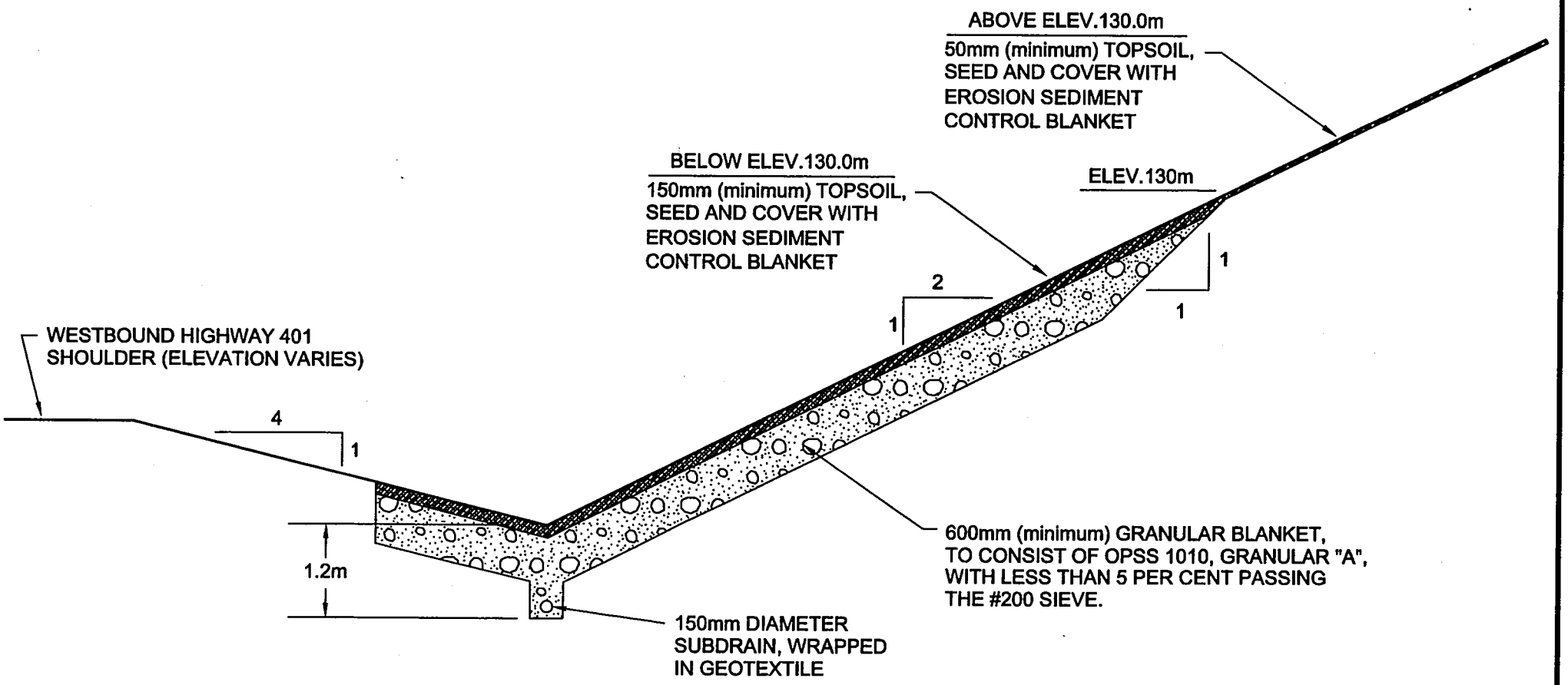
p1142005.dwg

TYPICAL SECTION
DRAINAGE BLANKET PROTECTION FOR PERMANENT CUT SLOPE
STATIONS 22 + 150 TO 22 + 250

FIGURE 5



Date NOVEMBER 2000

Project 001-1142

Golder Associates

Drawn MHW

Chkd KCC