

KOSTUCH ENGINEERING LIMITED

**FOUNDATION INVESTIGATION
AND
DESIGN REPORT**

**W.P. 82-91-00
PROPOSED BERM NOISE BARRIER
HIGHWAY 401 Sta. 22+315 TO 22+720
CORNWALL, ONTARIO**

**DISTRICT 41, KINGSTON
MINISTRY OF TRANSPORTATION ONTARIO**

PROJECT NO. ONO11284

FOUNDATION INVESTIGATION AND DESIGN REPORT

TO

KOSTUCH ENGINEERING LIMITED

ON

W.P. 82-91-00

**PROPOSED BERM NOISE BARRIER
HIGHWAY 401 Sta. 22+315 to 22+720, CORNWALL**

**DISTRICT 41, KINGSTON
MINISTRY OF TRANSPORTATION ONTARIO**

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FOUNDATION INVESTIGATION REPORT

For

Proposed Berm Noise Barrier

Cornwall, Ontario

W.P. 82-91-00

Highway 401 Sta. 22+315 to 22+720

District 41, Kingston

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out for the proposed berm noise barrier to be constructed along the north side of Highway 401, between Stations 22+315 and 22+720, in Cornwall, Ontario.

The work was carried out under Agreement No. 4005-A-000045 and in general accordance with our proposal dated March 30, 2000. Authorization to proceed was provided by Mr. J. Johnston, P.Eng., of Kostuch Engineering Limited (Kostuch).

This report contains a description of the investigation methodology and the factual information obtained from this investigation.

2.0 SITE DESCRIPTION AND GEOLOGY

The project site is located on Highway 401 within the municipal boundaries of Cornwall between Stations 22+315 and 22+720 on the north side of the west bound lanes. The site location is shown on the Key Plan portion of Drawing No. 11284-3 in Appendix 2.

This area is in the physiographic region identified by Chapman and Putnam (1984) as the Lancaster Flats where overburden generally consists of clay to very fine sand over glacial till over bedrock. Soils are generally thin with the exception of a few small areas of deep deposits.

Bedrock underlying the site generally consists of interbedded calcarenite and sublithographic to fine crystalline limestone and shale of the Bobcaygeon Formation.

Drainage in the immediate area is provided by ditches which direct water from west to east, to a centreline culvert at Station 22+750. Vegetation generally consists of short and long grasses. The site slopes downwards from west to east.

3.0 INVESTIGATION PROCEDURES

3.1 Field Program

The field work for this investigation was carried out in August 2000. The subsurface conditions were investigated through a borehole drilling program. A total of ten (10) boreholes, numbered 00-1 to 00-10, were advanced at select locations to a minimum depth of 6 m below the existing ground surface or auger refusal (actual borehole depths varied from 1.8 m to 8.2 m).

The boreholes were drilled using a CME 55 power auger drill suitably equipped for soil and bedrock sampling. Hollow stem auger equipment was used to advance the boreholes in the overburden. Subsoil samples were generally retrieved at 0.75 m intervals by a split spoon sampler in both cohesionless and cohesive soils in accordance with the Standard Penetration Test (ASTM D1586). The SPT carried out with the drilling equipment was performed using a standard 64 kg hammer with a 760 mm drop. Shear vane testing was carried out in cohesive deposits, where encountered, in order to estimate the undrained shear strength of the cohesive material. Undisturbed samples of the cohesive soils were acquired in thin walled tubes. Bedrock or boulders was inferred at numerous locations based on auger refusal.

The subsurface conditions are described in detail in the Borehole Records presented in Appendix 1. All soil and bedrock samples recovered were identified in the field, stored in moisture proof containers and were returned to our laboratory for detailed classification and testing.

Groundwater levels were recorded in the open boreholes throughout the duration of the investigation and in standpipes installed in Boreholes 00-1, 00-3, 00-5, 00-8 and 00-9. The standpipes were monitored on September 19, 2000. Prior to completing the investigation, the boreholes were backfilled using a cement-bentonite material.

Borehole locations were established in the field by Jacques Whitford personnel relative to the established chainage for the Highway 401 median. The offsets were measured from the centreline of the west bound lanes. The ground surface elevations at the borehole locations were referenced to an MTO Benchmark which is located on top of the southwest corner of the concrete culvert at approximately Station 22+720. It is understood that this benchmark has a Geodetic elevation of 58.814 m. The base plan drawings showing the roadway in plan with metric chainages were provided by Kostuch.



3.2 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content, Atterberg Limits and grain size distribution as well as consolidation properties. All soil samples will be stored for a period of twelve months after issuance of the final report. Unless otherwise directed, the stored samples will be disposed of after this period.

4.0 SUBSURFACE CONDITIONS

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix 1. An explanation of the symbols and terms used to describe the Borehole Records is also provided. A borehole location plan is shown on Drawing 11284-3 along with a Stratigraphic plot.

A detailed description of the subsurface conditions encountered in the boreholes is given below.

4.1 Topsoil

A layer of dark brown topsoil was encountered immediately beneath the surficial vegetation. The thickness of the topsoil layer varied from 200 mm to 370 mm at the borehole locations.

4.2 Clay

A deposit of clay was encountered in the eight boreholes located east of Sta. 22+363. Between Sta. 22+397 and Sta. 22+600, the clay was grey in colour and varied from 1.1 m to 1.8 m in thickness. East of Sta. 22+600, the thickness and depth of the clay deposit increased to a maximum of 7.0 m at the east end of the proposed berm alignment.

The deposit behaves as a cohesive soil. The consistency of the clay observed within the upper 2 m, varied from stiff to very stiff. Standard Penetration Test (SPT) N-values within the upper 2 m of the clay varied from 5 to 18. The moisture content of four samples tested varied from 37 % to 58 % with an average of 44 %. The results of an Atterberg Limits test carried out on a representative samples of this deposit indicated a liquid limit (w_L) of 66 % and a plastic limit (w_p) of 31 % (see the Plasticity Chart on Figure 1 in Appendix 1). The upper clay deposit at the site can therefore be classified as a clay of high plasticity (CH).

Where encountered, the clay deeper than 2 m below existing grade generally has a firm consistency. The natural moisture content of the 3 samples tested ranged from 65 % to 77 % with an average of 74 %. The SPT N-values ranged from 0 blows/0.3 m to 4 blows/0.3 m. Undrained shear strength, based on in-situ vane shear tests ranged from 26 kPa to 34 kPa with an average of 31 kPa for the five tests conducted. The sensitivity of the deposits was observed to range from 5 to 8.8 with an average of 6.3 which would indicate a medium sensitive clay. The results of Atterberg Limits testing carried out on two representative samples of the deeper clay deposit indicated a liquid limit (w_L) ranging from 70 % to 83 % and a plastic limit (w_P) between 26 % and 31 % (see the Plasticity Chart on Figure 1 in Appendix 1). The deeper clay deposit at the site can therefore be classified as a clay of high plasticity (CH).

Consolidation testing was carried out on two undisturbed samples of the clay. The results are plotted in Figures 2 and 3 in Appendix 1. Sample 4 from BH 00-9, which had a liquid limit of 70 % has a preconsolidation pressure of 45 kPa, a compression index of 0.80 and a recompression index of 0.04. Sample 6 from BH 00-9, which had a liquid limit of 83 % has a preconsolidation pressure of 62 kPa, a compression index of 0.44 and a recompression index of 0.03. The unit weight of these two samples was found to be 15.6 kN/m³ and 15.2 kN/m³ respectively.

4.3 Clayey Sand with Silt, some Gravel to Sandy Silt, some Gravel, Cobbles and Boulders (Till)

A glacial till deposit was encountered in all boreholes. It ranged from a clayey sand with silt and some gravel to a sandy silt, some gravel, cobbles and boulders. Generally, the till was more cohesive to the west.

The SPT tests carried out in this material revealed N-values ranging from 2 blows/0.3 m to over 50 blows/0.3 m where refusal of the split spoon sampler was reached. Generally, the deposit exhibited a stiff consistency where cohesive and compact where non-cohesive. The natural moisture content of twelve samples ranged from 6 % to 17 % with an average of 10 %. Four wash sieve and hydrometer, grain-size distribution analyses carried out on representative samples of this deposit indicated that it contained 0 % gravel, 47 % to 58 % sand, 25 % to 37 % silt and 16 % to 20 % clay sized particles, (see results in Appendix 1). Frequent cobbles and boulders were encountered in some locations.



4.4 Bedrock

Auger refusal on inferred bedrock or possible boulders occurred in five of the ten boreholes, at elevations ranging from 53.7 m at BH 00-1 to 58.2 at BH 00-6.

Borehole Location	Borehole	Inferred Bedrock Elevation (m)
Sta. 22+312	00-6	58.2
Sta. 22+363	00-10	refusal on boulders at 60.2
Sta 22+397	00-5	55.6
Sta. 22+500	00-3	57.4
Sta. 22+600	00-1	53.7

4.5 Groundwater

Five standpipes were installed during the drilling in August 2000. Groundwater levels were measured on September 19, 2000. At that time the groundwater level was found to range from an elevation of 58.4 m at BH 00-5 to elevation 60.0 m at BH 00-3.

Artesian groundwater conditions were encountered at Boreholes 00-8 and 00-9. Groundwater was observed to flow slowly out of the top of those boreholes. Temporary standpipes indicated that the static water level was 270 mm and 100 mm, respectively, above existing ground surface. The standpipes were sealed after reading them on September 19, 2000.

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.0 CLOSURE

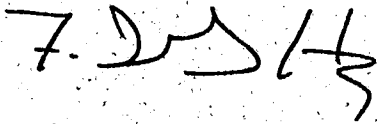
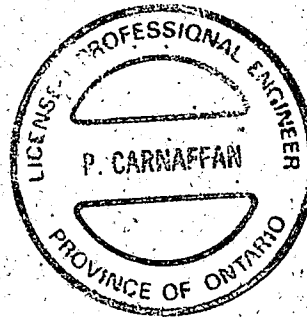
A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Yours very truly,

JACQUES, WHITFORD AND ASSOCIATES LIMITED



Paul Carnaffan, M.Eng., P.Eng.



Fred J. Griffiths, Ph.D., P.Eng.

Designated Principal MTO Foundation Contact



FOUNDATION DESIGN REPORT

For

Proposed Berm Noise Barrier

Cornwall, Ontario

W.P. 82-91-00

Highway 401 Sta. 22+315 to 22+720

District 41, Kingston

6.0 PROPOSED DEVELOPMENT

It is proposed to construct a berm to act as a partial noise barrier along the north side of Hwy 401, between Station 22+315 and 22+720. The berm is to be constructed primarily with excess material generated from the proposed removal of the Highway 401/CPR overhead structure and associated lowering of the highway approaches. The following berm geometry has been proposed by Kostuch:

Height:	4.0 m
Width of crest:	1.0 m
Width at base:	17.0 m
Foreslope:	2:1 (horizontal to vertical)
Backslope:	2:1 (horizontal to vertical)

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

7.1 Design Considerations

The primary design issues for the proposed noise barrier berm include the following:

- Stability of the berm, including internal stability of the berm and external stability both during construction and long term. The external stability was considered to be the most significant design consideration at the start of the investigation due to the possible presence of peat deposits and deposits of relatively weak and highly compressible clays in the area.
- Settlement of the berm is not a critical design issue as it does not present a safety hazard, however settlement of the berm needs to be considered to ensure that the berm after settlement is high enough to function as a partial noise barrier.
- The use of light weight fill materials have not been considered in detail since the noise barrier berm is intended to use excess material generated from the proposed removal of the Highway 401/CPR overhead structure and associated lowering of the highway approaches. In addition, the use of

advanced and costly techniques such as wick drains have not been discussed since the rate of settlement of the proposed berm is not a significant factor given the intended use.

7.2 Stability

The soil material that will be used to construct the proposed noise barrier berm ranges from silty sand trace gravel to sand some silt some gravel, based on foundation investigation boreholes drilled through the Hwy 401 approach fills for the Hwy 401/CPR overhead structure by Jacques Whitford in 1999. Internal stability of the berm, based on the proposed geometry, will be acceptable provided the berm material is placed in lifts and compacted to the degree recommended in Section 7.5 of this report.

External stability of the proposed berm was analyzed using slope stability software (SLOPE/W). The Bishop's Modified Method of analysis was used along with the berm geometry described in Section 6.0 of this report and the following soil parameters:

Soil Type	Unit Weight (kN/m ³)	Short Term		Long Term	
		undrained shear strength	friction	cohesion	friction
Berm Fill	20.0	-	32 °	-	32 °
Upper Clay	15.5	125 kPa	-	5 kPa	27°
Lower Clay	15.5	30 kPa		2 kPa	25°
Till	20.0	-	30 °	-	30 °

External stability was considered to be most critical at the east end of the proposed berm alignment where the thickness of the underlying clay is 7 m. External stability analysis was carried out based on the geological stratigraphy encountered in Borehole 00-9.

A factor of safety of slightly greater than 2.4 was achieved for external stability under short term conditions, which is deemed to be acceptable for this project.

The factor of safety under long term conditions was approximately 1.4, which is deemed acceptable for this project.

The stability under seismic loading conditions was assessed with a peak horizontal ground acceleration of 0.18 which corresponds to the recommended level for Montreal with a 10% probability of occurrence in 50 years. A factor of safety of greater than 1.3 was obtained, which is deemed to be acceptable for this project.



Copies of the SLOPE/W output for the configurations analyzed are presented in Appendix 3.

7.3 Potential for Localized Failure (Bearing Capacity)

Construction of berms can result in a rapid increase in the pore pressure within underlying clay layers. The potential for localized shear failure of the underlying relatively weak and compressible clay deposit was evaluated for this site. The analysis assumes that each stage of construction occurs over a span of approximately three weeks. Two stages of construction will be necessary to prevent localized shear failure from occurring between Stations 22+560 and 22+720. A construction break of three weeks is recommended once the berm reaches a height of 2.5 m above original grade in this location. The progress of excess pore pressure dissipation and settlement should be monitored with three piezometers and three settlement plates.

(1) conservative
or what?

7.4 Settlement

Settlement of the proposed berm will be greatest at the east end of the alignment which is underlain by the thickest layer of compressible clay. Settlement beneath the middle of the berm at Station 22+750 was estimated using the void ratio approach and the recompression and compression indices obtained from the consolidation testing. A total settlement in the order of 250 mm to 350 mm should be expected at the east end of the berm alignment.

Time
Rate

Total settlement along the length of the proposed berm should be expected to vary depending primarily on the thickness of the lower clay deposit.

Settlement within fill

7.5 Construction Recommendations

Construction Staging

Staging of the berm construction will be required between Stations 22+560 and 22+720 as described in ^{see comment (1)} above Section 7.3 above.

General Earthworks

The surficial vegetation and topsoil should be stripped from beneath the footprint of the berm prior to placing the berm fill. Fill placed for construction of the berm should be placed in lifts no greater than 300 mm thick and compacted to a minimum of 95 % Standard Proctor Maximum Dry Density (SPMDD).

Drainage will need to be established on both sides of the berm through swales and ditches. Should the seal of the standpipes installed in BH 00-8 and 00-9 be damaged during construction, the artesian flows observed during the investigation may be re-established. In this case the top of the standpipes should be excavated to a depth of 1.0 m in an area of at least 500 mm around the standpipe and the excavation backfilled with low strength concrete.

Erosion control in the form of seed and mulch should be established on the berms as quickly as possible.

8.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above conclusions.

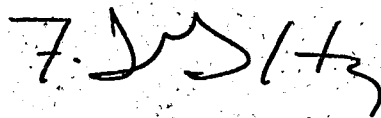
We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES, WHITFORD AND ASSOCIATES LIMITED



Paul Carnaffan, M.Eng., P.Eng.



Fred Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact



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APPENDIX 1

- Explanation of Terms Used in Report**
 - Borehole Records**
 - Plasticity Chart (Figure 1)**
 - Consolidation Test Results (Figures 2 and 3)**
- Grain Size Distribution Curves (Figures 4 through 7)**



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	-	mixture of soil and humus capable of supporting good vegetative growth
<i>Peat</i>	-	fibrous aggregate of visible and invisible fragments of decayed organic matter
<i>Till</i>	-	unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	-	any materials below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	-	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	-	having cracks, and hence a blocky structure
<i>Varved</i>	-	composed of regular alternating layers of silt and clay
<i>Stratified</i>	-	composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	-	> 75 mm
<i>Seam</i>	-	2 mm to 75 mm
<i>Parting</i>	-	< 2 mm
<i>Well Graded</i>	-	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
<i>Uniformly Graded</i>	-	predominantly of one grain size

Terminology describing soils on the basis of grain size and plasticity is based on the Unified Soil Classification System (USCS) (ASTM D-2488). The classification excludes particles larger than 76 mm (3 inches). This system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%

The standard terminology to describe cohesionless soils includes the compactness (formerly "relative density"), as determined by laboratory test or by the Standard Penetration Test 'N' - value.

Relative Density	'N' Value	Compactness %
<i>Very Loose</i>	< 4	< 15
<i>Loose</i>	4-10	15-35
<i>Compact</i>	10-30	35-65
<i>Dense</i>	30-50	65-85
<i>Very Dense</i>	> 50	> 85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength		'N' Value
	kips/sq. ft.	kPa	
<i>Very Soft</i>	< 0.25	< 12.5	< 2
<i>Soft</i>	0.25-0.5	12.5-25	2-4
<i>Firm</i>	0.5-1.0	25-50	4-8
<i>Stiff</i>	1.0-2.0	50-100	8-15
<i>Very Stiff</i>	2.0-4.0	100-200	15-30
<i>Hard</i>	> 4.0	> 200	> 30

ROCK DESCRIPTION

Rock Quality Designation (RQD)

The classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures.

RQD

ROCK QUALITY

90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

Terminology describing rock mass:

Spacing (mm)	Bedding, Laminations, Bands	Discontinuities
2000-6000	<i>Very Thick</i>	<i>Very Wide</i>
600-2000	<i>Thick</i>	<i>Wide</i>
200-600	<i>Medium</i>	<i>Moderate</i>
60-200	<i>Thin</i>	<i>Close</i>
20-60	<i>Very Thin</i>	<i>Very Close</i>
< 20	<i>Laminated</i>	<i>Extremely Close</i>
< 6	<i>Thinly Laminated</i>	

Strength Classification	Uniaxial Compressive Strength (MPa)
<i>Very Low</i>	1-25
<i>Low</i>	25-50
<i>Medium</i>	50-100
<i>High</i>	100-200
<i>Very High</i>	> 200

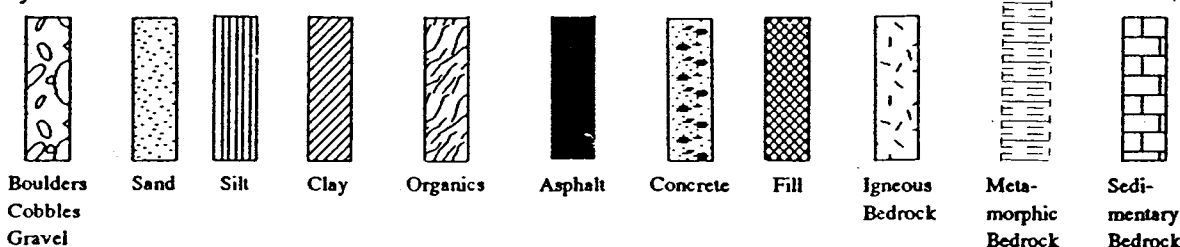
Terminology describing weathering:

<i>Slight</i>	-	Weathering limited to the surface of major discontinuities. Typically iron stained.
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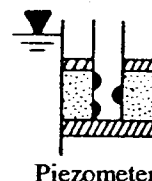
- Moderate* - Weathering extends throughout rock mass. Rock is not friable.
High - Weathering extends throughout rock mass. Rock is friable.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)	BS	Bulk sample
ST	Shelby tube or thin wall tube	WS	Wash sample
PS	Piston sample	HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits.

N - VALUE

Numbers in this column are the results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and 'N' values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75).

OTHER TESTS

S	Sieve analysis	H	Hydrometer analysis
G _s	Specific gravity of soil particles	γ	Unit weight
k	Permeability (cm/sec)	C	Consolidation
↓	Single packer permeability test; test interval from depth shown to bottom of borehole	CD	Consolidated drained triaxial
	Double packer permeability test; test interval as indicated	CU	Consolidated undrained triaxial with pore pressure measurements
○	Falling head permeability test using casing	UU	Unconsolidated undrained triaxial
▽	Falling head permeability test using well point or piezometer	DS	Direct shear
		Q _u	Unconfined compression
		I _p	Point Load Index (I _p on Borehole Record equals I _p (50); the index corrected to a reference diameter of 50 mm)



RECORD OF BOREHOLE No BH 00-1

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+600, 22.25 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY PC
DATUM Geodetic DATE 08.08.00 - 08.08.00 CHECKED BY FG

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 ○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
							20	40	60	80	100					
60.6	Tall grass & weeds															
0.0	Topsoil, dark brown		1	GS												
60.3																
0.3	Clay, some silt, occasional sand seams, very stiff, grey		2	SS	10											
			3	SS	5											
58.3																
2.3	Clay, some silt, occasional sand seams, firm, grey		4	SS	2											
57.5																
3.1	Clayey sand with silt, some gravel, stiff, grey (TILL)		5	SS	2											
			6	SS	7											
			7	SS	12											
			8	SS	33											
53.7																
6.9	Auger refusal on inferred bedrock or boulders Standpipe installed															

MT0 11284B GPJ ON MOT.GDT 21/02/01

RECORD OF BOREHOLE No BH 00-2

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+550, 20.45 m Lt of C/L ORIGINATED BY Bk
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY AC
DATUM Geodetic DATE 08.08.00 - 08.08.00 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
60.8	Tall grass & weeds													
0.0	Topsoil, dark brown													
60.5														
0.3	Clay, some silt, very stiff, grey													
			1	SS	9		60						66.54	
59.2														
1.5	Clayey sand with silt, some gravel, stiff, grey (TILL)		2	SS	4		59							
			3	SS	13									
57.9							58							
2.9	Clayey sand with silt, some gravel, stiff, grey (TILL)		4	SS	4									0 52 28 20
			5	SS	5		57							
			6	SS	4									
			7	SS	9		56							
			8	SS	21		55							
54.1														
6.7	End of Borehole													

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

RECORD OF BOREHOLE No BH 00-3

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+500, 20.65 m Lt of C/L ORIGINATED BY BK
 DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY PL
 DATUM Geodetic DATE 08.08.00 - 08.08.00 CHECKED BY FG

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						
61.2	Tall grass & weeds													
0.0	Topsoil, dark brown													
60.9														
0.3	Clay, some silt, occasional sand seams, very stiff, grey													
60.0			1	SS	12									
1.2	Sandy silt, some gravel, some clay, compact, brown (TILL)													
			2	SS	15									
			3	SS	30									
58.2														
3.1	Clayey sand with silt, some gravel, stiff, grey (TILL)													
			4	SS	10									
57.4														
3.8	Auger refusal on inferred bedrock or boulders Standpipe installed													

MT0 11284B.GPJ ON MOT.GDT 21/02/01

RECORD OF BOREHOLE No BH 00-4

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+450, 25.25 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY AC
DATUM Geodetic DATE 08.08.00 - 08.08.00 CHECKED BY FG

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 (%)
						20	40	60	80	100	20	40	60	80	100
61.3	Tall grass & weeds														
0.0	Topsoil, dark brown														
61.0															
0.3	Clay, some silt, very stiff, brownish grey														
60.2			1	SS	8										
1.1	Clayey sand with silt, some gravel, stiff, brown (TILL)		2	SS	15										
59.0															
2.3	Clayey sand with silt, some gravel, occasional cobbles, stiff, grey (TILL)		3	SS	8										
			4	SS	6										
			5	SS	5										
			6	SS	9										
			7	SS	11										
			8	SS	9										
54.6															
6.7	Gravelly sand and silt, occasional cobbles, very dense, grey (TILL)		9	SS	50+										
53.7															
7.6	End of Borehole														

MT0 112848.GPJ ON MOT.GDT 21/02/01

RECORD OF BOREHOLE No BH 00-5

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+397, 21.05 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY PC
DATUM Geodetic DATE 08.08.00 - 08.08.00 CHECKED BY FG

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						
61.6	Tall grass & weeds																
61.4	Topsoil, dark brown																
0.2	Clay, some silt, very stiff, greyish brown																
59.8			1	SS	17												
1.8	Sandy silt, some gravel, occasional cobbles, occasional boulders, compact, brown (TILL)		2	SS	50+												
			3	SS													
58.5																	
3.1	Sandy silt, some gravel, occasional cobbles, occasional boulders, compact, grey : TILL		4	SS	21												
			5	SS	18												
			6	SS	26												
			7	SS	40												
55.6																	
5.9	Auger refusal on inferred bedrock or boulders Standpipe installed																

MT0 11284B GPJ ON MOT GDT 21/02/01

RECORD OF BOREHOLE No BH 00-6

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+312, 28.65 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY AC
DATUM Geodetic DATE 11.08.00 - 11.08.00 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
62.5	Tall grass & weeds													
0.0	Topsoil, dark brown													
62.2														
0.3	Sandy silt, some gravel, trace clay, occasional cobbles, occasional boulders, dense to very dense, brown (TILL)		1	SS	50+		62							
			2	SS	34		61							
60.2														
2.3	Sandy silt, some gravel, frequent cobbles, frequent boulders, compact to dense, grey (TILL)		3	SS	20		60							
			4	SS	44		59							
			5	GS										
			6	SS	50+									
58.2														
4.2	Auger refusal on inferred bedrock or boulders													

+ 3, x 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 00-7

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+650, 26.85 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY PC
DATUM Geodetic DATE 11.08.00 - 11.08.00 CHECKED BY FG

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
61.8	Tall grass & weeds															
0.0	Topsoil, dark brown															
61.5																
0.3	Clay, some silt, very stiff to stiff, greyish brown															
			1	SS	17											
			2	SS	8											
			3	SS	3											
58.8																
3.1	Clay, some silt, firm, grey		4	SS	1											
57.8																
4.1	Sandy silt, some gravel, trace clay, frequent cobbles, frequent boulders, compact to dense, grey (TILL)		5	SS	13											
			6	SS	40											
55.1																
6.7	End of Borehole															

METRIC



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

RECORD OF BOREHOLE No BH 00-9

1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+750, 24.85 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY AC
DATUM Geodetic DATE 11.08.00 - 11.08.00 CHECKED BY FG

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
58.4	Tall grass & weeds													
0.0	Topsoil, dark brown													
58.1	Clay, some silt, very stiff, greyish brown													
0.3														
			1	SS	18									
				2	SS	9								
56.1	Clay, some silt, firm, grey													
2.3														
		3	SS	4										
		4	ST											
			5	ST										
			6	ST										
			7	ST										
51.4	Silty sand with clay, some gravel, frequent cobbles, frequent boulders, compact, grey (TILL)													
7.0														
			8	SS	13									
50.2	End of Borehole Artesian groundwater conditions encountered. Groundwater rose to 100 mm above ground surface on September 19, 2000													
8.2														

MT0 11284B GPJ ON MOT GDT 21/02/01

RECORD OF BOREHOLE No BH 00-10

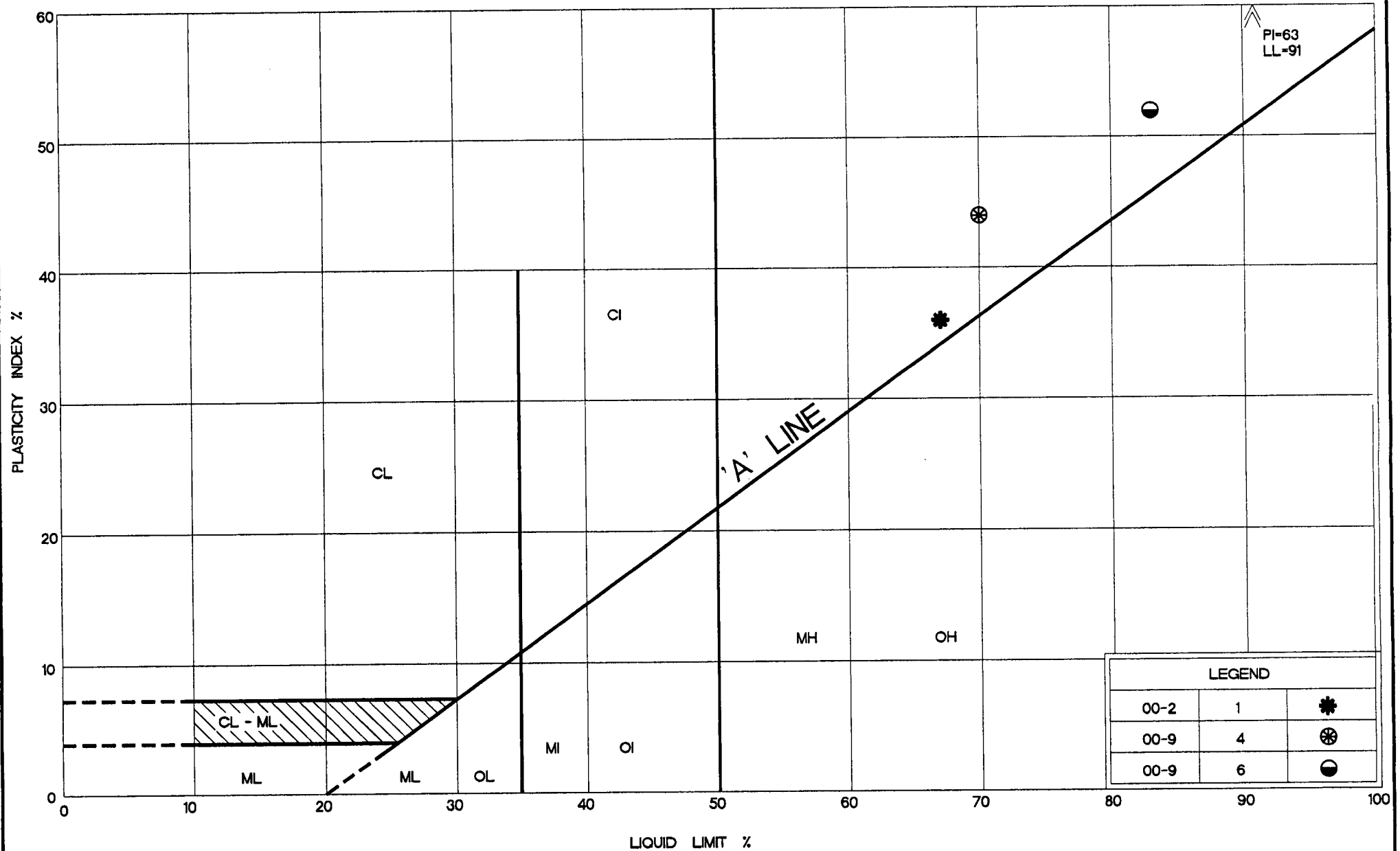
1 OF 1

METRIC

W.P. 82-91-00 LOCATION Highway 401 WBL, Cornwall Berm, Sta. 22+363, 23.15 m Lt of C/L ORIGINATED BY BK
DIST 41 HWY 401 BOREHOLE TYPE Hollow stem augers, split spoons COMPILED BY PC
DATUM Geodetic DATE 11.08.00 - 11.08.00 CHECKED BY FG

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						
62.0	Tall grass & weeds																
0.0	Topsoil, dark brown																
61.7																	
0.2	Silty sand, some gravel, frequent cobbles, frequent boulders, very dense, brown (TILL)		1	SS	50+												
60.2			2	SS	50+												
1.8	Auger refusal on boulders																

MT0 112848 GPJ ON MOT GDT 21/02/01



Ministry
of
Transportation
Ontario

PLASTICITY CHART CLAY OF HIGH PLASTICITY

FIG No 1

W P 82-91-00



**Jacques
Whitford**

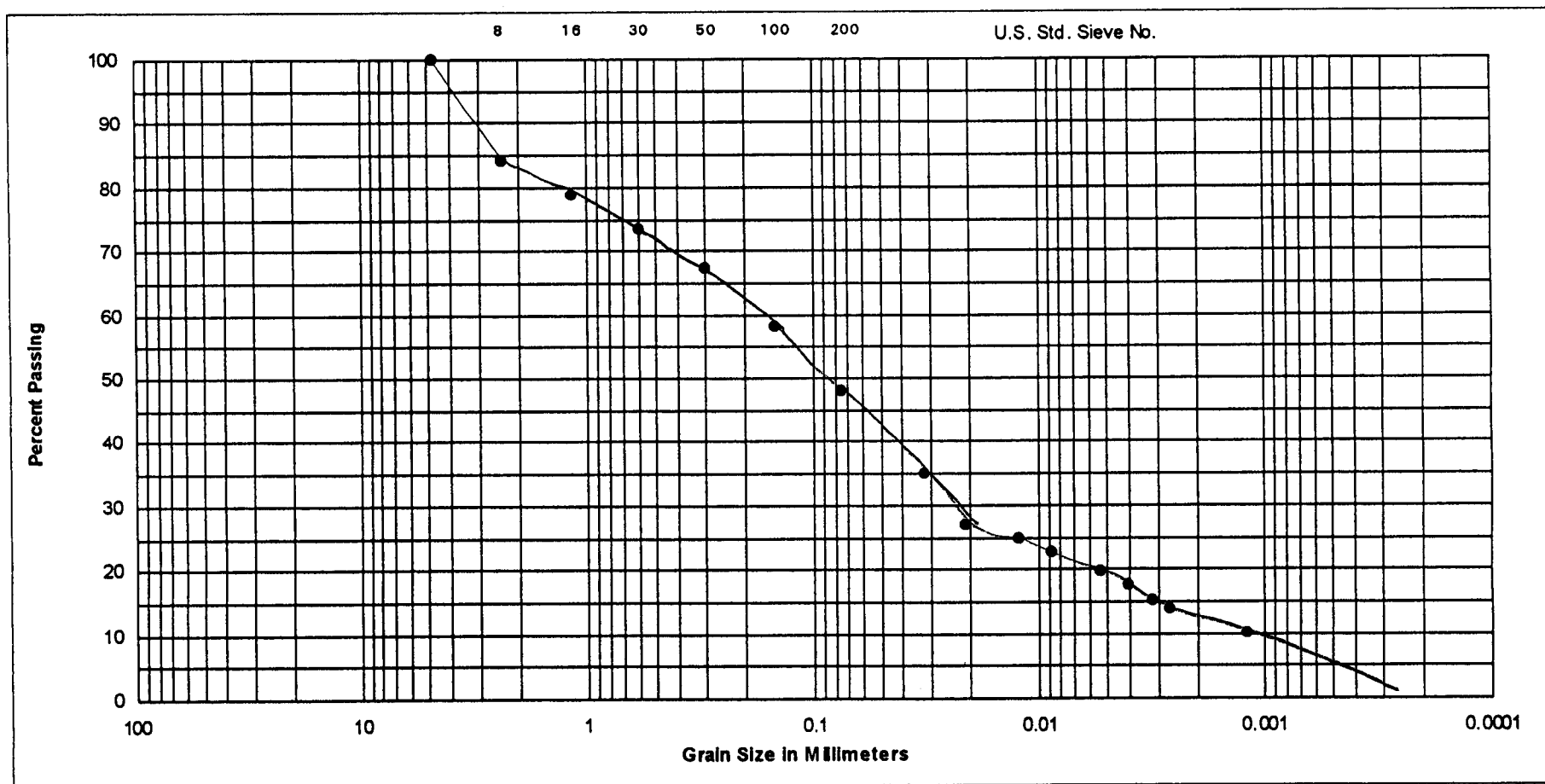
2781 Lancaster Rd. Tel: 613 738-0708
Ottawa, Ontario K1B 1A7 Fax: 613 738-0721

Hydrometer Analysis

Client : Ministry of Transportation, Ontario
Project : Highway 401 Cornwall
Material Type : Soils/Aggregate : Inorganic Silty Clay
Proposed Use : Fill/Granulars : Clay
Supplier :
Source : BH2- SS4
Sampled From : Borehole 2 Sample 4
Sampled By : Dean Flanagan
Tested By : Herby Pierre

Project No. : 11284
Test Method : ASTM D422
Sample No.: 1542

Date Sampled : 24-Aug-2000
Date Tested : 06-Sep-2000





**Jacques
Whitford**

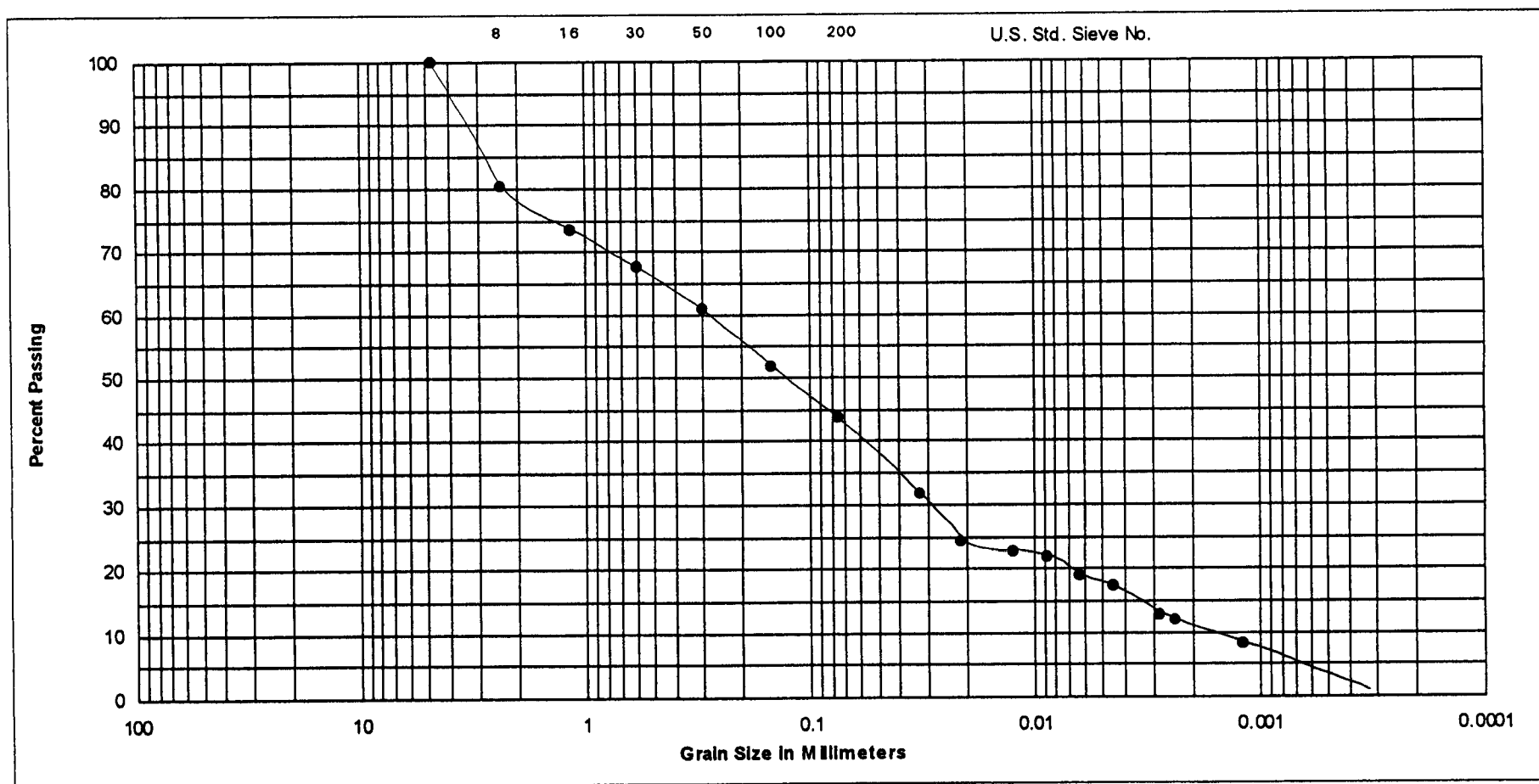
2781 Lancaster Rd. Tel: 613 738-0708
Ottawa, Ontario K1B 1A7 Fax: 613 738-0721

Hydrometer Analysis

Client : **Ministry of Transportation, Ontario**
Project : **Highway 401 Cornwall**
Material Type : **Soils/Aggregate : Inorganic Silty Clay**
Proposed Use : **Fill/Granulars : Clay**
Supplier :
Source : **BH4 - SS4**
Sampled From : **Borehole 4 Sample 4**
Sampled By : **Dean Flanagan**
Tested By : **Herby Pierre**

Project No. : **11284**
Test Method : **ASTM D422**
Sample No.: **1543**

Date Sampled : **06-Sep-2000**
Date Tested : **06-Sep-2000**





**Jacques
Whitford**

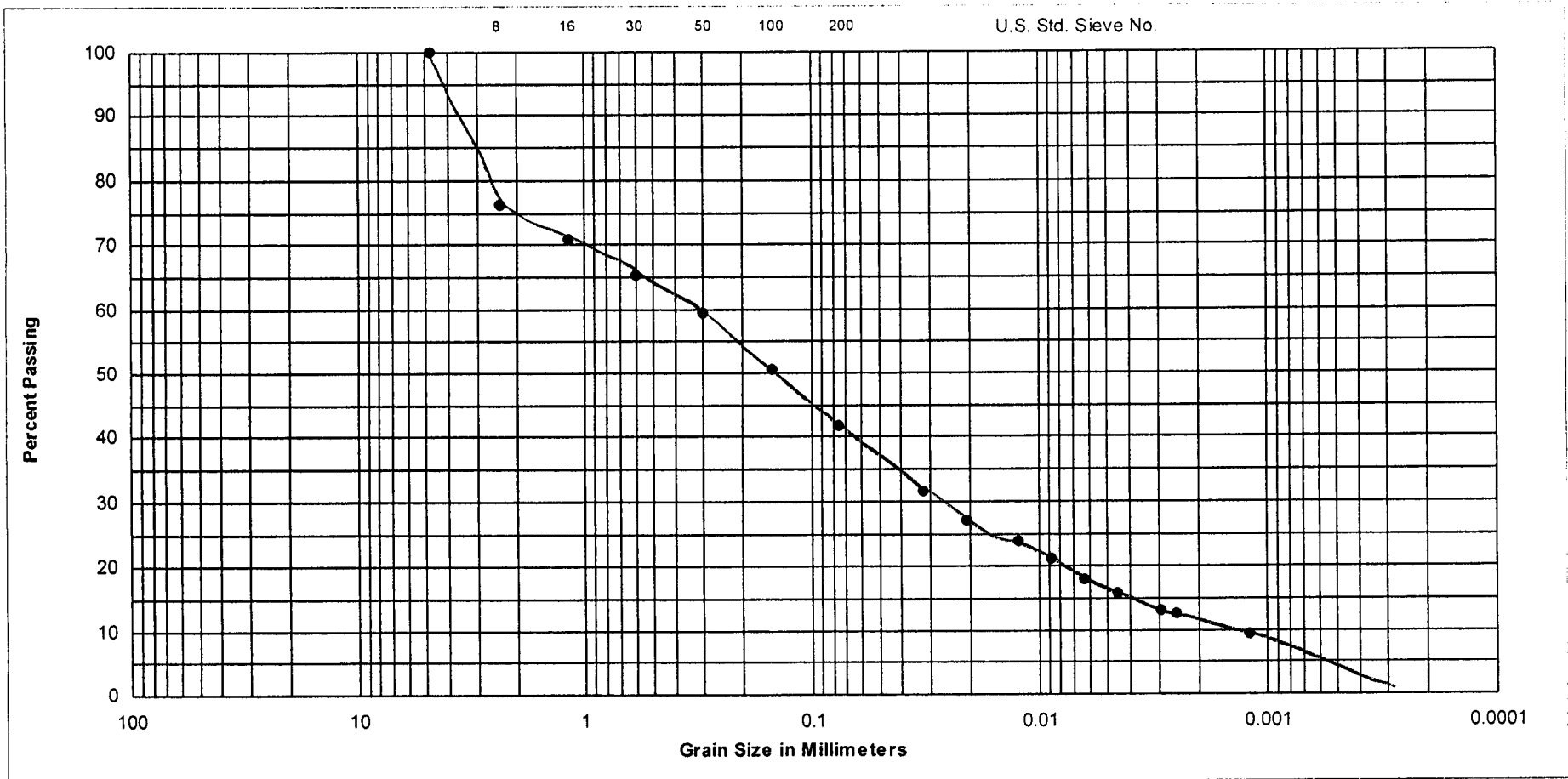
2781 Lancaster Rd. Tel: 613 738-0708
Ottawa, Ontario K1B 1A7 Fax: 613 738-0721

Hydrometer Analysis

Client : **Ministry of Transportation, Ontario**
Project : **Highway 401 Cornwall**
Material Type : **Soils/Aggregate : Inorganic Silty Clay**
Proposed Use : **Fill/Granulars : Clay**
Supplier :
Source : **BH6 - SS2**
Sampled From : **Borehole 6 Sample 2**
Sampled By : **Dean Flanagan**
Tested By : **Herby Pierre**

Project No. : **11284**
Test Method : **ASTM D422**
Sample No.: **1544**

Date Sampled : **24-Aug-2000**
Date Tested : **06-Sep-2000**





**Jacques
Whitford**

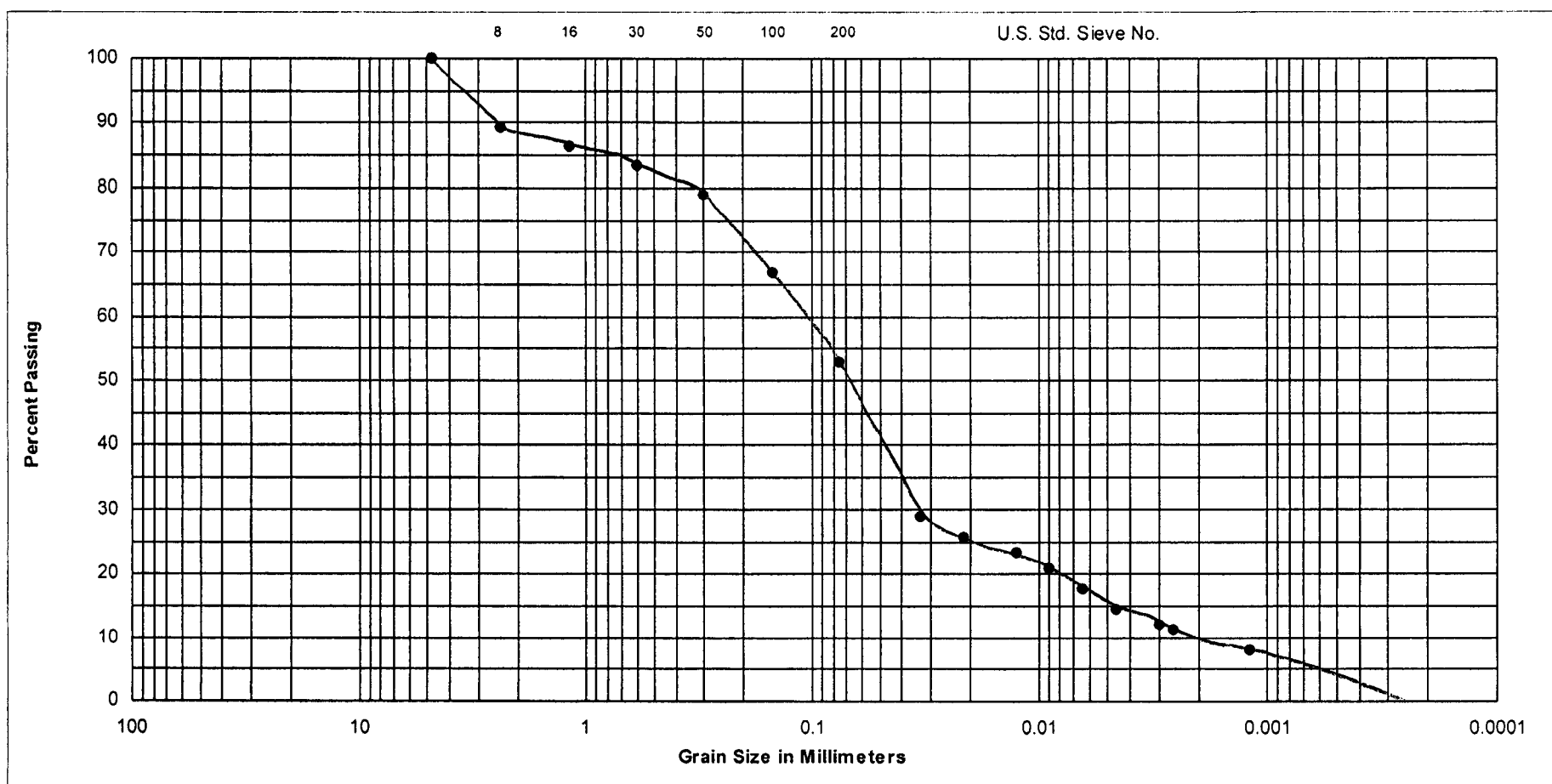
2781 Lancaster Rd. Tel: 613 738-0708
Ottawa, Ontario K1B 1A7 Fax: 613 738-0721

Hydrometer Analysis

Client : **Ministry of Transportation, Ontario**
Project : **Highway 401 Cornwall**
Material Type : **Soils/Aggregate : Inorganic Silty Clay**
Proposed Use : **Fill/Granulars : Clay**
Supplier :
Source : **BH9- SS8**
Sampled From : **Borehole 9 - Sample 8**
Sampled By : **Dean Flanagan**
Tested By : **Herby Pierre**

Project No. : **11284**
Test Method : **ASTM D422**
Sample No.: **1545**

Date Sampled : **24-Aug-2000**
Date Tested : **06-Sep-2000**



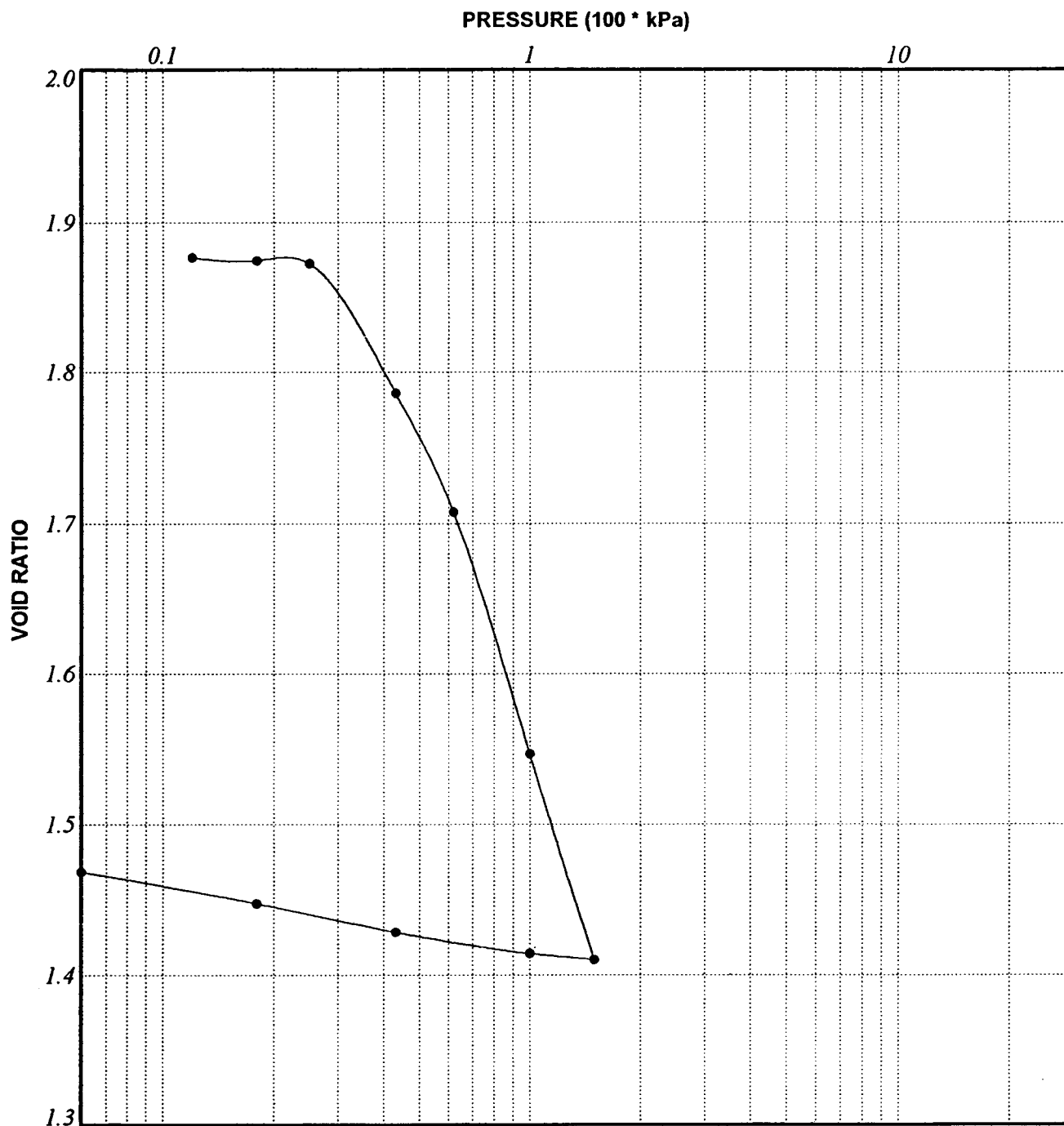


Les laboratoires
outaouais inc.

PRESSURE-VOID RATIO CURVE

(ASTM D-2435-90)

CLIENT: Jacques Whitford Limited
PROJECT: Consolidation tests
SITE: Highway 401
O/FILE: D-00325A



BOREHOLE: BH-00-9

SAMPLE No: TW-4

DEPTH (m): 3.25

ELEVATION (m):

SOIL DESCRIPTION: Gray silty clay

γ Total (kg/m³): 1591

P_0 (kPa):

C_r : 0.04

W_{ini} (%): 75

P_c (kPa): 45

C_c : 0.80

e_0 : 1.97

LL (%): 70

IP: 44

Approved by: Maxime Babin

GRA 017 (95-05); LLOCONSA

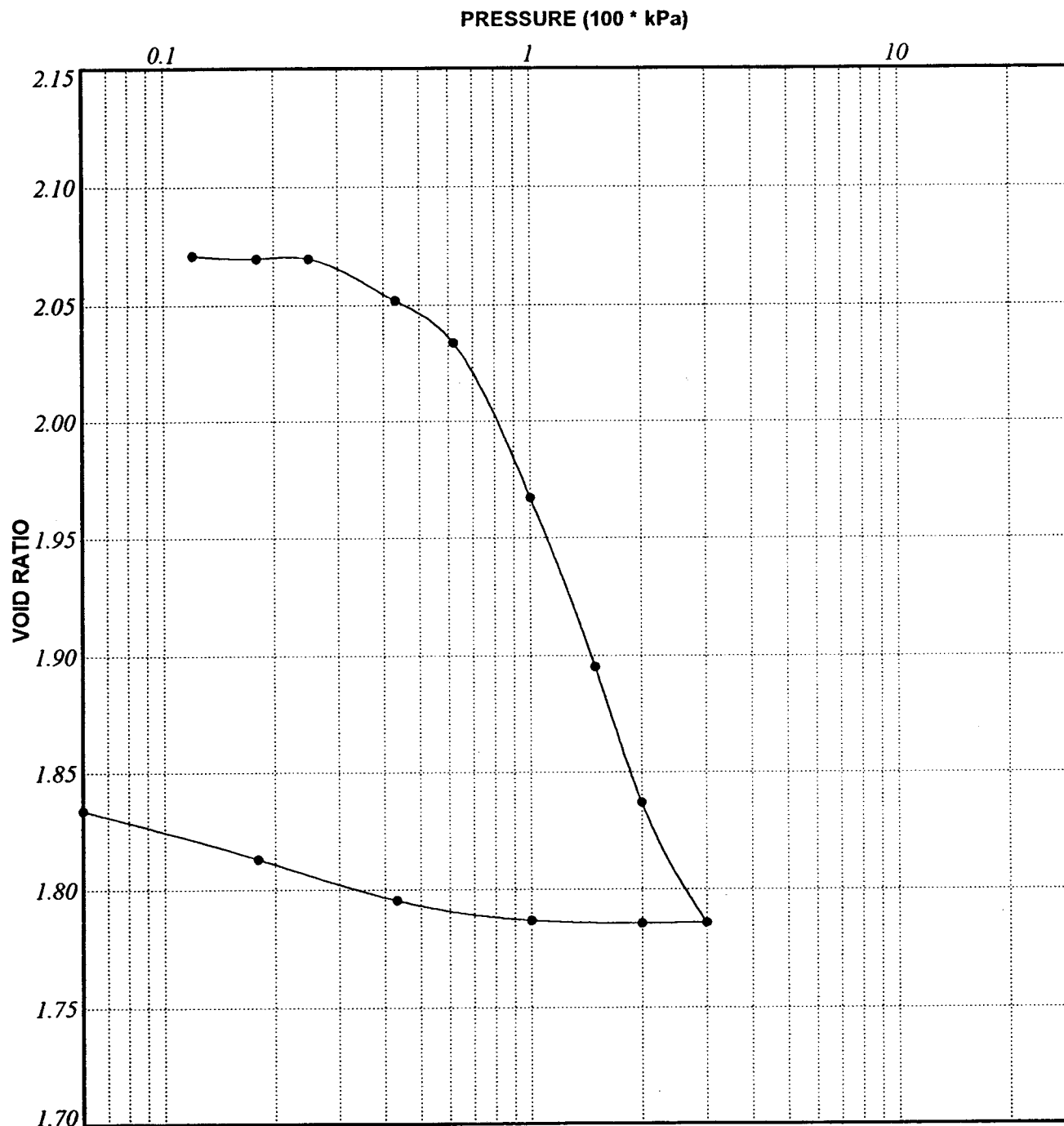


Les laboratoires
outaouais inc.

PRESSURE-VOID RATIO CURVE

(ASTM D-2435-90)

CLIENT: Jacques Whitford Limited
PROJECT: Consolidation tests
SITE: Highway 401
O/FILE: D-00325A



BOREHOLE: BH-00-9

SAMPLE No: TW-6

DEPTH (m): 5.26

ELEVATION (m):

SOIL DESCRIPTION: Gray silty clay

γ Total (kg/m³): 1547

P_0 (kPa):

C_r : 0.03

W_{ini} (%): 77

P_c (kPa): 62

C_c : 0.44

e_0 : 2.09

LL (%): 83

IP: 52

Approved by: Maxime Babin

GRA 017 (95-05), LLOCONSA

APPENDIX 2

- Key Plan

- Borehole Location Plan and Stratagraphic Drawings

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

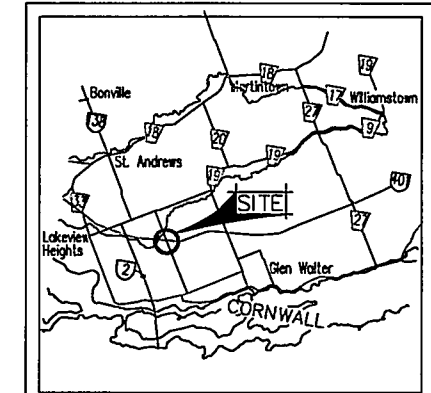
CONT No
WP No 82-91-00

NOISE BARRIER BERM
STA 22+315 TO STA 22+720
BORE HOLE LOCATIONS & SOIL STRATA

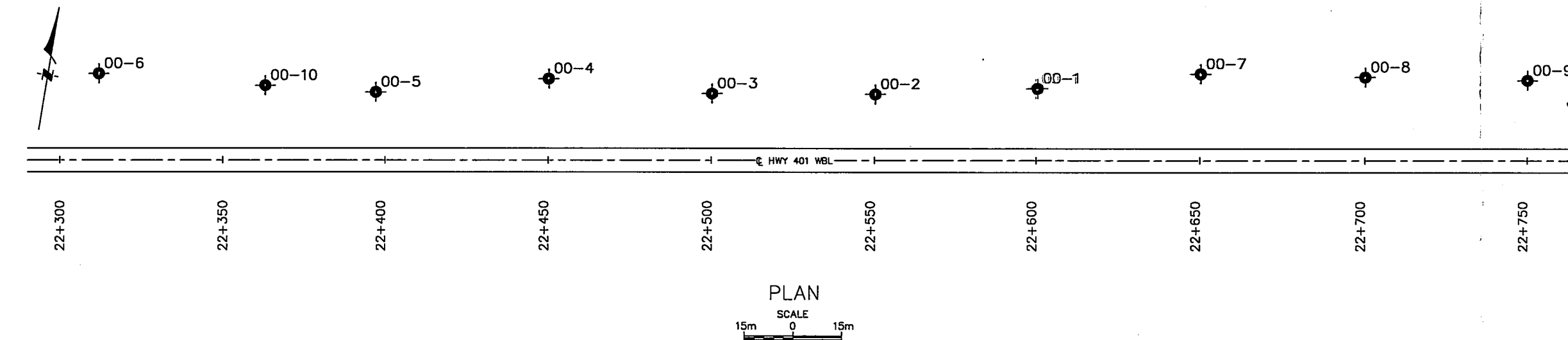


SHEET
1

JACQUES, WHITFORD & ASSOCIATES LIMITED

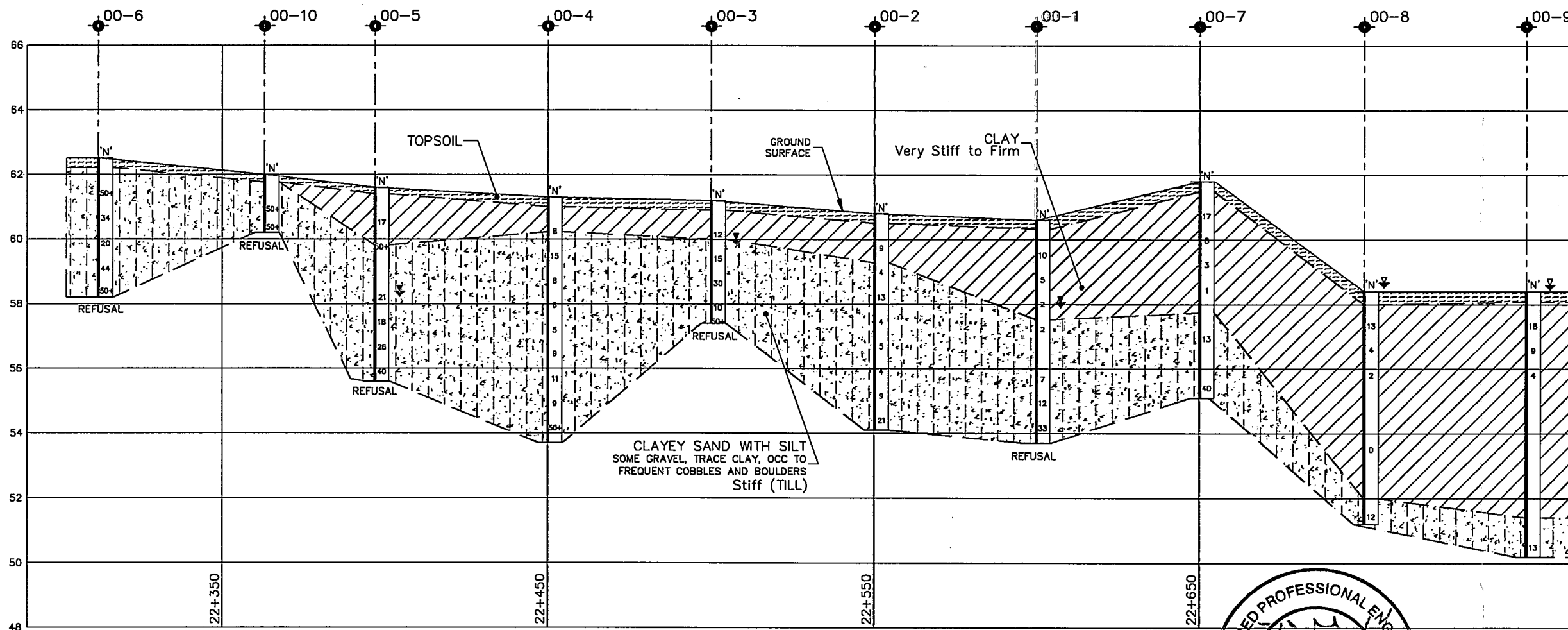


KEY PLAN
SCALE
5km 0 5 10km



PLAN

SCALE
15m 0 15m



PROFILE ALONG NORTH SIDE OF HWY 401 WBL

SCALE
15m 0 15m HOR
1m 0 1m VERT

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Probe Hole
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- WL at time of investigation Aug 8, 2000
- WL on Sept 19, 2000

BORE HOLES

No	ELEVATION	STATION	OFFSET FROM C OF WBL
00-1	60.6	22+600	22.25
00-2	60.8	22+550	20.45
00-3	61.2	22+500	20.65
00-4	61.3	22+450	25.25
00-5	61.6	22+397	21.05
00-6	62.5	22+312	28.65
00-7	61.8	22+650	26.85
00-8	58.4	22+700	25.85
00-9	58.4	22+750	24.85
00-10	62.0	22+363	23.15

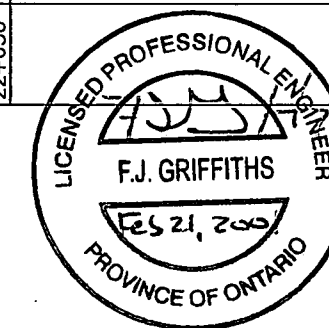
NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

Rev.	DATE	BY	DESCRIPTION
1			

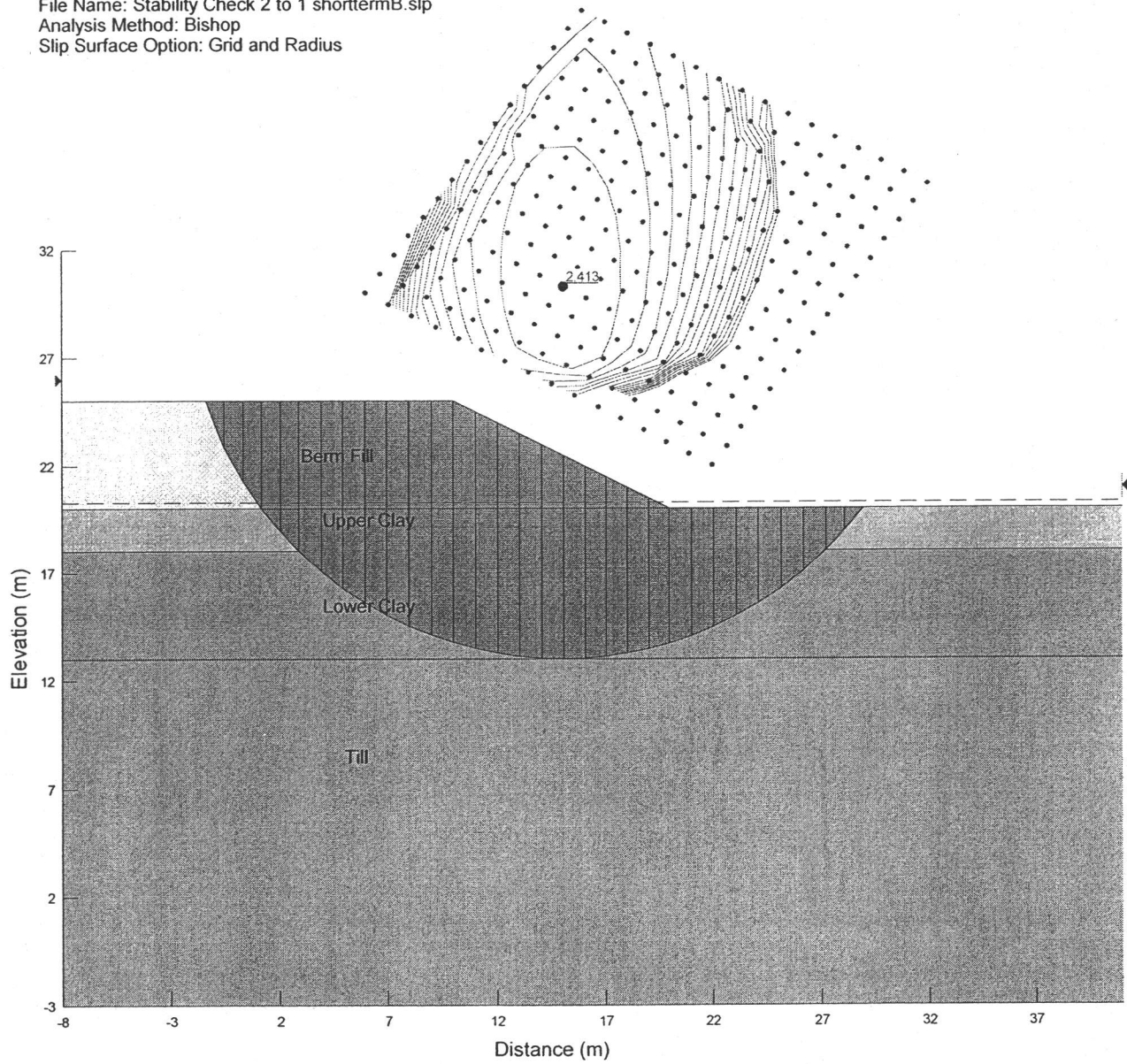
GEOCRE No			
HWY No 401	DATE 2001-02-21		DIST 41
SUBM'D FG	CHECKED	DATE 2001-02-21	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 11284-3



APPENDIX 3

- Slope Stability Analysis

Description: JWA File No. 11284 - Hwy 401 Noise Barrier Berm
 Comments: 5 m high berm with 2:1 side slope
 File Name: Stability Check 2 to 1 shorttermB.slp
 Analysis Method: Bishop
 Slip Surface Option: Grid and Radius



Slip Surface Option: Grid and Radius



Description: JWA File No. 11284 - Hwy 401 Noise Barrier Berm
Comments: 5 m high berm with 2:1 side slope
File Name: Stability Check 2 to 1 seismicB.slp
Analysis Method: Bishop
Slip Surface Option: Grid and Radius

