



**FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED REPLACEMENT OF THE REVELL RIVER BRIDGE
GWP 195-87-00
HIGHWAY 17, DISTRICT 61, THUNDER BAY**

**December 15, 1999
TG99135**

**Prepared For:
Cook Engineering
740 Syndicate Ave. S
Thunder Bay, Ontario P7E 1E9**

4 Copies	- Ministry of Transportation of Ontario, Thunder Bay
2 Copies	- Cook Engineering, Thunder Bay
1 Copy	- DST Consulting Engineers Inc., Thunder Bay



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1.0 INTRODUCTION

DST Consulting Engineers Inc. (DST) has been retained by Cook Engineering Co. to conduct a foundation investigation for the proposed replacement of the Revell River Bridge (Bridge No. 41S-70).

Authorization to proceed with this work was received from Cook Engineering Co. This work was carried out as part of the Total Project Management project for the Ministry of Transportation of Ontario (MTO) under GWP 195-87-00.

The purpose of the work is to conduct a site investigation of sufficient scope to verify design assumptions and to provide adequate subsurface descriptions to permit the contractor to plan construction of foundation elements and the immediate approach embankments. It is understood that the Ministry will be designing the foundation system for the replacement bridge.

2.0 SITE DESCRIPTION

The Revell River Bridge (No. 41S-70) is located along Highway 17, approximately 32 km west of Ignace, Ontario. The existing structure is a two-lane bridge deck support on a timber pile system. The bridge is approximately 18 m in length and crosses the river in an east-west direction. The general area north and south of the abutments is low laying wet area. A bedrock outcrop exists about 15 m to the southwest of the bridge. The site is located in a glaciofluvial out wash deposit.

3.0 INVESTIGATION PROCEDURES

Site work was carried out between September 7 and 16, 1999, utilizing a CME 750 drill rig equipped for geotechnical testing. Twelve boreholes were drilled to depths ranging between 5 m and 13.8 m. Borehole locations and stratigraphic sections are shown on the Borehole Location Plan, Enclosure 1.

Boreholes 1 to 4 and 9 to 11 were drilled to auger refusal at the abutment locations. The refusal material was confirmed in Boreholes 1, 2, 3 and 4 using diamond drilling techniques. Boreholes 5 to 8 were drilled to a depth of 5 m in the approach ramps.

Boreholes were advanced with hollow stem augers. Soil samples were obtained from the auger flights and from the split spoon sampler used for the standard penetration test (SPT). The SPT involves driving a 50-mm diameter thick-walled sampler into the soil under an energy of 63.5 kg weight falling through 760 mm. The number of blows required to drive the sampler 300 mm is known as the standard penetration blow count (N) which provides an indication of the relative density or consistency of the soil. Representative soil samples are obtained from within the sampler. Three-metre cores of the bedrock were obtained from Boreholes 1 to 4 utilizing a BTK core barrel.

Slotted PVC standpipes were installed in Boreholes 2 to 4 for monitoring of the groundwater level.

Ground surface elevations at the borehole locations were surveyed by DST and referenced to a

temporary benchmark on the bridge structure. The TPM was tied into the project survey by Cook Engineering. The elevation of DST's TPM was given as 429.035 m.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included natural moisture contents, gradation analyses and point load tests on the rock core. Laboratory test results are presented on the Borehole Logs where applicable, in the text of this report and Enclosures 14 and 15.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

Details of the subsurface conditions are given in the Borehole Logs, Enclosures 2 to 13 and are further discussed below.

The generalized stratigraphy of the site, based on the conditions at the borehole locations consists of asphalt or topsoil overlying fill which in turn is underlain with organics. Beneath the organics, sand exists overlying silt at some locations. Bedrock exists beneath the silt and/or sand. Bedrock was proven by diamond drilling techniques in Boreholes 1 to 4 inclusive.

4.2 Asphalt

Asphalt varying in thickness from 175 to 300 mm is present at the surface at all boreholes except Boreholes 1 and 6. Borehole 1 is located on the southwest bank of the river and Borehole 6 is located in the shoulder of the roadway.

4.3 Granular Fill

Granular fill is present beneath the asphalt or from surface in Boreholes 1 and 6. The fill thickness varies from 0.5 to 3.8 m. Within the granular fill, layers of cobbles and boulders or 'shot' rock exist near the base of the fill materials. Gradation analyses conducted on samples of the fill from Boreholes 1A at 0.3 m and Borehole 5 at 0.8 m are presented on Enclosure 15. The gradation results indicate this fill material is a sand with 5 to 20% gravel sizes and 10 to 25% fine content. The Standard Penetration Test values (N values of 4 blows/0.3 to 33 blows/0.3 m) indicate a loose to dense state.

4.4 Organics

Organics were encountered in all boreholes at the interface of the fill and underlying sand stratum. In Boreholes 3 to 6, distinct layers of peat are present. In the other boreholes, the organics are mixed or interbedded within the base of the fill or in the upper sand stratum. The moisture contents of these layers vary from 41% to greater than 100%. The thicknesses of the organics/peat vary from a few millimetres to 1.5 m.

The peat was classified in accordance with the Von Post classification system as follows:

- H = Humification, graded on a scale from 1 to 10 with 1 representing no decomposition and 10 representing complete decomposition.
- B = Water content, graded on a scale from 1 (dry) to 5 (very wet, $w > 2,000\%$)
- F = Fine fibre content, graded on a scale from 0 (nil) to 3 (high content), (coarse fibres are larger than 1 mm in diameter or width).
- W = Wood remnant content, graded on a scale from 0 (nil) to 3 (high content).
- N = Shrub remnant content, graded on a scale from 0 (nil) to 3 (high content).

The results of the Von Post classification have been reported on the Borehole Logs.

4.5 Sand

A sand layer exists beneath the fills and organics. The thickness of this deposit varies from a minimum of 2.9 m to a maximum of 6.6 m. The Standard Penetration Test results (5 blows/0.3 m to 25 blows/0.3 m) indicate a loose to compact condition. Gradation analysis (Enclosure 14)

conducted on samples from Borehole 2 at 3.8 m, Borehole 3 at 4.6 m, and Borehole 4 at 7.6 m indicate a fine to medium grained sand with 3 to 13% fines content. It was noted during drilling that occasional cobbles were encountered near the base of this deposit.

4.6 Silt

A silt deposit was encountered below the sand in Boreholes 1A and 3 only. The thickness of the deposit varied from 0.7 m to 2.2 m. The standard penetration test results indicated a compact condition (N values 14 to 19 blows/0.3 m).

4.7 Bedrock

In general, the bedrock consists of fine grained green/grey basalt. A quartz vein occurs in Rock Core #1 from Borehole 4 at a depth of 9.7 m to 9.95 m. A detailed geological description of the bedrock cores is presented on Enclosure 16.

In order to classify the bedrock with respect to strength, point load tests were conducted on selected core samples. The test results are tabulated below.

Borehole Number	Depth (m)	Strength Index I_s (MPa)	* Estimated Uniaxial Compressive Strength (MPa)
1	4.1	10.1	215
1	4.9	14.9	318
1	5.7	10.1	215
1	6.6	9.3	199

Borehole Number	Depth (m)	Strength Index I_s (MPa)	* Estimated Uniaxial Compressive Strength (MPa)
2	9.1	12.5	266
2	10.1	9.8	210
2	10.6	19.9	425
2	11.7	13.1	280
3	11.3	17.1	366
3	12.2	25.5	544
3	12.7	13.9	296
3	13.5	27.6	589
4	9.6	9.1	194
4	10.3	20.7	441
4	11.3	12.1	258
4	12.2	10.3	221

* Estimate based on published correlations.

From the above data, the bedrock strength can be classified as very to extremely strong.

The rock quality designation (RQD) is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths (greater than 100 mm) to the total length cored.

The RQD index is used to provide a classification for the rock quality according to the following limits.

RQD %	ROCK QUALITY
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Seven of the right cores have an RQD greater than 86% with an RQD of one core of 61%. From the above table, a rock quality from fair to excellent is indicated.

4.8 Groundwater Conditions

The groundwater levels were taken in open boreholes and in the open standpipes installed in Boreholes 2, 3 and 4 on September 13, 1999. At the time of the field program, it had rained for 5 days, the river level rose ± 0.3 m in this time. On September 13, the river was at elevation 426.5 m. The water level, as measured in each borehole is as follows:

Borehole No.	Surface Elevation (m)	Groundwater Elevation (m)	Remarks
1	426.6	426.3	On completion
1A	428.1	--	Dry Cave 1.5 m
2	428.1	426.4	Standpipe, Sept 13
3	428.2	426.6	Standpipe, Sept 13
4	428.1	426.5	Standpipe, Sept 13
5	428.1	426.3	On completion
6	428.1	426.4	On completion
7	428.1	426.3	On completion
8	428.0	426.1	On completion
9	428.1	426.1	On completion
10	428.2	426.2	On completion
11	428.1	426.2	On completion

5.0 DISCUSSIONS

5.1 General

The Ministry of Transportation of Ontario proposes to replace the existing bridge at the crossing of Highway 17 and Revell River (Bridge No. 41S-70). The replacement structure is understood to consist of single span structure with integral abutments. The soil conditions at the site are suitable for design of integral abutments. The only constraint may be the shallow bedrock located in the southwest corner of the site. The designer should confirm the pile lengths available for integral abutments are sufficient in this area.

The new structure will be constructed along the same alignment as the existing bridge. It is also understood that there will be a raise in bridge grade between 0.5 and 1.2 m. The construction will be staged to utilize half of the bridge for traffic, at each time.

The existing bridge consists of concrete over a longitudinal laminated timber deck approximately 18 m in length. The deck is supported at the concrete abutments and three timber bents supported on timber piles. The founding level or embedded length of the piles is not available.

5.2 Structure Foundation

East Abutment

The bedrock at this location was proven at Boreholes 3 and 4 between elevations 417.1 m and 418.7 m. Auger refusal occurred in Boreholes 10 and 11 at elevations 417.0 m and 418.5 m respectively. The abutment may be supported on steel H-piles driven to bedrock. The following

axial capacity values are recommended for the design of the pile.

Pile Section	HP310 x 110	HP310 x 79
Factored Axial Capacity at ULS	1,600 kN	1,150 kN
Axial Capacity at SLS	1,150 kN	825 kN

West Abutment

It is recommended that the abutment at this location also be supported on steel H-piles driven to bedrock. The bedrock was proven at Boreholes 1A and 2 at elevations 422.5 m and 419.0 m. (Note that Borehole 1 is approximately 4.6 m south of the abutment.) Auger refusal was encountered in Boreholes 1A and 9 at elevations 421.3 m and 419.3 m, respectively. The recommended capacity for the east abutment may be used for the design of the piles.

General

All shot rock fill should be excavated prior to the start of pile driving.

Pile caps at the abutments should have a minimum of 2.8 m of earth cover to protect against frost penetration. If less soil cover is provided, then the equivalent synthetic insulation should be provided for frost protection.

The driving equipment should have the capacity to exert a driving energy of at least 37 kJ. The steel section should be adequate for sustained heavy driving.

Refusal is tentatively defined as 10 blows for 25 mm for 75 consecutive millimetres subject to the

discretion of the geotechnical engineer. A restrike check of the final refusal after at least 24 hours is recommended to confirm that capacity does not decrease with time. Approval of satisfactory refusal should also involve consideration of the pile tip elevation with respect to the borehole data and other adjacent piles.

Inspection and quality control should be in accordance with OHBDC 6-4.5.

Driving records should be kept for each pile. Information to be recorded should include but not necessarily be limited to: pile dimensions, hammer type, rated energy, ram weight, cap block weight and type, anvil weight, number of blows for each 0.3 m of penetration and final set. All pile driving equipment must be in good working order.

The piles should be equipped with a driving shoe in accordance with OPSD 3304.00. To ensure that rock points set into the bedrock, it is recommended that the driving energy at refusal be gradually increased to the maximum specified energy in accordance with Ontario Provincial Standard Specifications (OPSS) 903.07.02.05. Furthermore, where the bedrock is shallow, care should be taken in driving as not to over stress and damage the pile.

The elevation of the tops of driven piles should be measured immediately after driving. If uplift occurs in any piles during the driving of adjacent piles, the displaced piles should be re-driven to at least their previous final elevation and final set.

Piles should be spaced no closer than 2.5 times the pile diameter, measured centre-to-centre. Where piles are driven in groups, they should be driven from the centre outwards. In general, all piles in a group should be driven to approximately the same tip elevation.

Pile driving may result in significant vibrations which may affect the adjacent bridge structure. If this is a concern, continuous monitoring of vibrations induced in adjacent bridge structure is recommended in order to assess the potential for damage and the need for modification of driving procedures.

5.3 Lateral Earth Pressure

Earth pressures should be computed as per Section 6.7.4.5 of the Ontario Highway Bridge Design Code (OHBDC). Granular 'A' or 'B', Type 1 backfill should be in accordance with Ontario Provincial Specifications (OPSS 1010). Minimum granular backfill requirements for the abutments should be in accordance with OPSD 3501.000. The following parameters are recommended when calculating earth pressures.

	Granular 'A'	Granular 'B', Type 1
Angle of Internal Friction	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weights (kN/m ³)	$\gamma = 23$	$\gamma = 21$

5.4 Approach Embankments

The finished grade of Highway 17 may be 0.5 to 1.2 m higher than the existing grade. The raise in grade will induce settlements in the existing embankment. The total settlement is dependent on the height of grade raise. For a 0.5 m raise in grade, settlement between 25 and 50 mm may

occur. For a raise in grade in the order of 1.2 m, the settlements will double in magnitude. The majority of settlement should be completed within 2 months.

Slopes of embankments constructed with Granular 'B', Type 1 fill will be stable (factor of safety greater than 1.3) where construction at a slope of 2h:1v.

5.6 Scour Protection

The abutments should be provided with sufficient scour protection to ensure the piles are not exposed. Scour protection should be design in accordance with Section 1-9 of the OHBDC.

5.7 Construction Considerations

All excavations should be carried out in accordance with the Occupational Health and Safety Act of Ontario.

For staged construction, the excavation may be supported by soldier piles and timber lagging. The supporting system may be design assuming the following parameters. Given the shallow depths, a tie back or crib system may be required.

Angle of Internal Friction	$\phi = 30^{\circ}$
Unit Weights (kN/m ³)	$\gamma = 20$

6.0 LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

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Sr. Project Engineer

Reviewed by:



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President

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APPENDIX 'A'

LIMITATIONS OF REPORT

APPENDIX 'A'

LIMITATIONS OF REPORT

The conclusions and recommendations presented in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. It is recommended practice that DST Consulting Engineers be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

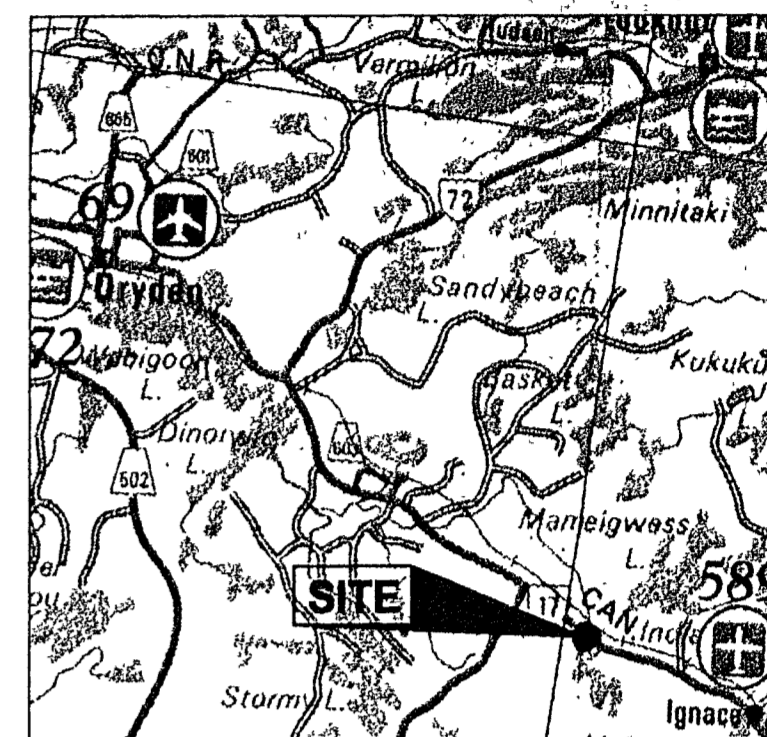
Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

D R A W I N G

REVEL RIVER BRIDGE

BOREHOLE LOCATIONS & SOIL STRATA



KEY PLAN

0 SCALE 100
KILOMETRES

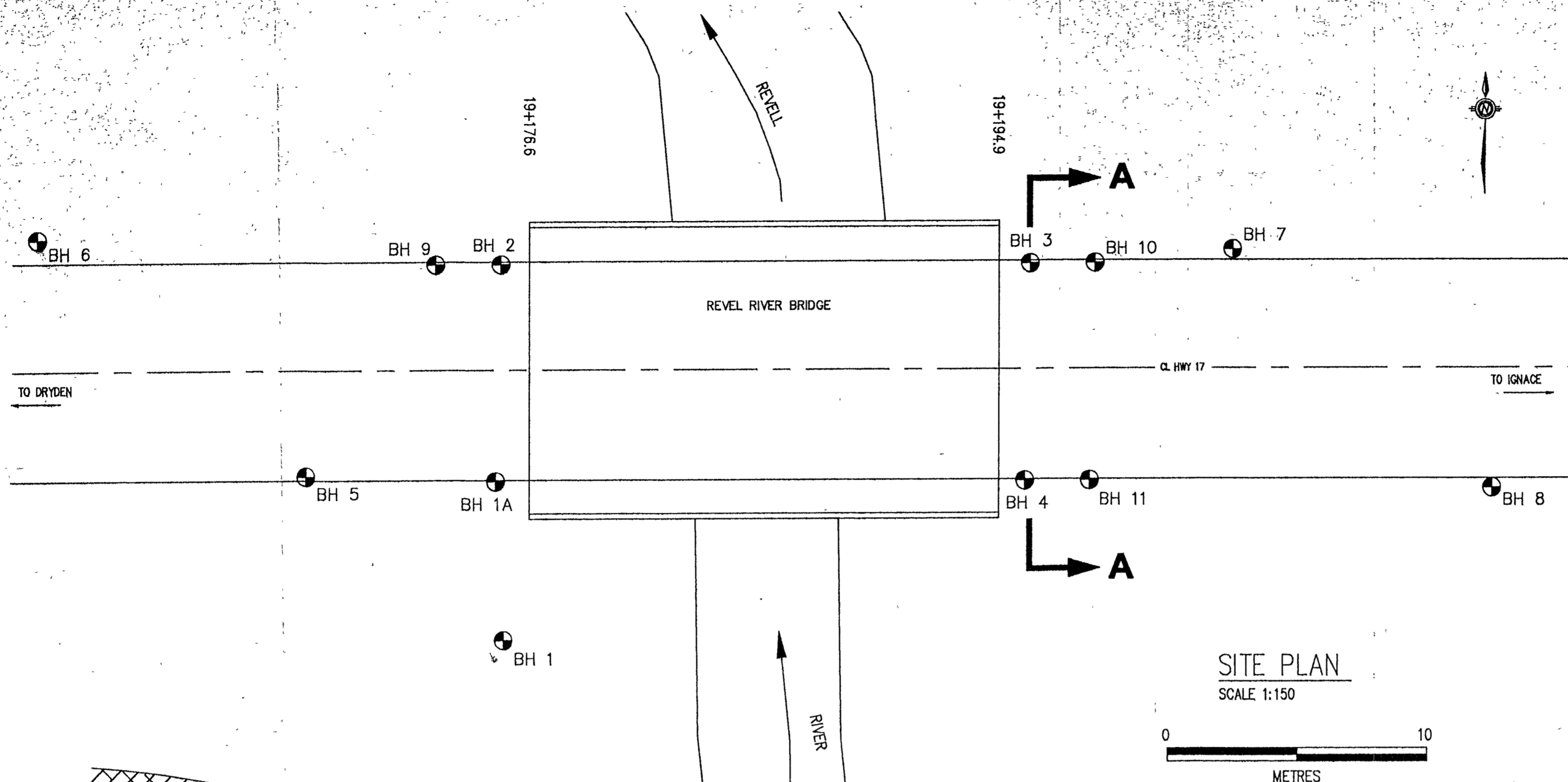
LEGEND

- Borehole
- 'N' Blows/0.3m (Std. Pen Test, 475 J/Blow)
- Water level at time of Investigation.

No.	Elevation	Station	Offset
1	428.615	19+175.6	10.2 Rt
1A	428.095	19+175.3	4.2 Rt
2	428.075	19+175.5	4.0 Lt
3	428.165	19+196.1	4.0 Lt
4	428.125	19+195.9	4.2 Rt
5	428.125	19+168.0	4.0 Rt
6	428.095	19+157.6	5.0 Lt
7	428.095	19+203.9	4.5 Lt
8	428.045	19+213.9	4.5 Rt
9	428.075	19+172.7	4.0 Lt
10	428.165	19+198.2	4.0 Lt
11	428.125	19+193.4	4.2 Rt

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

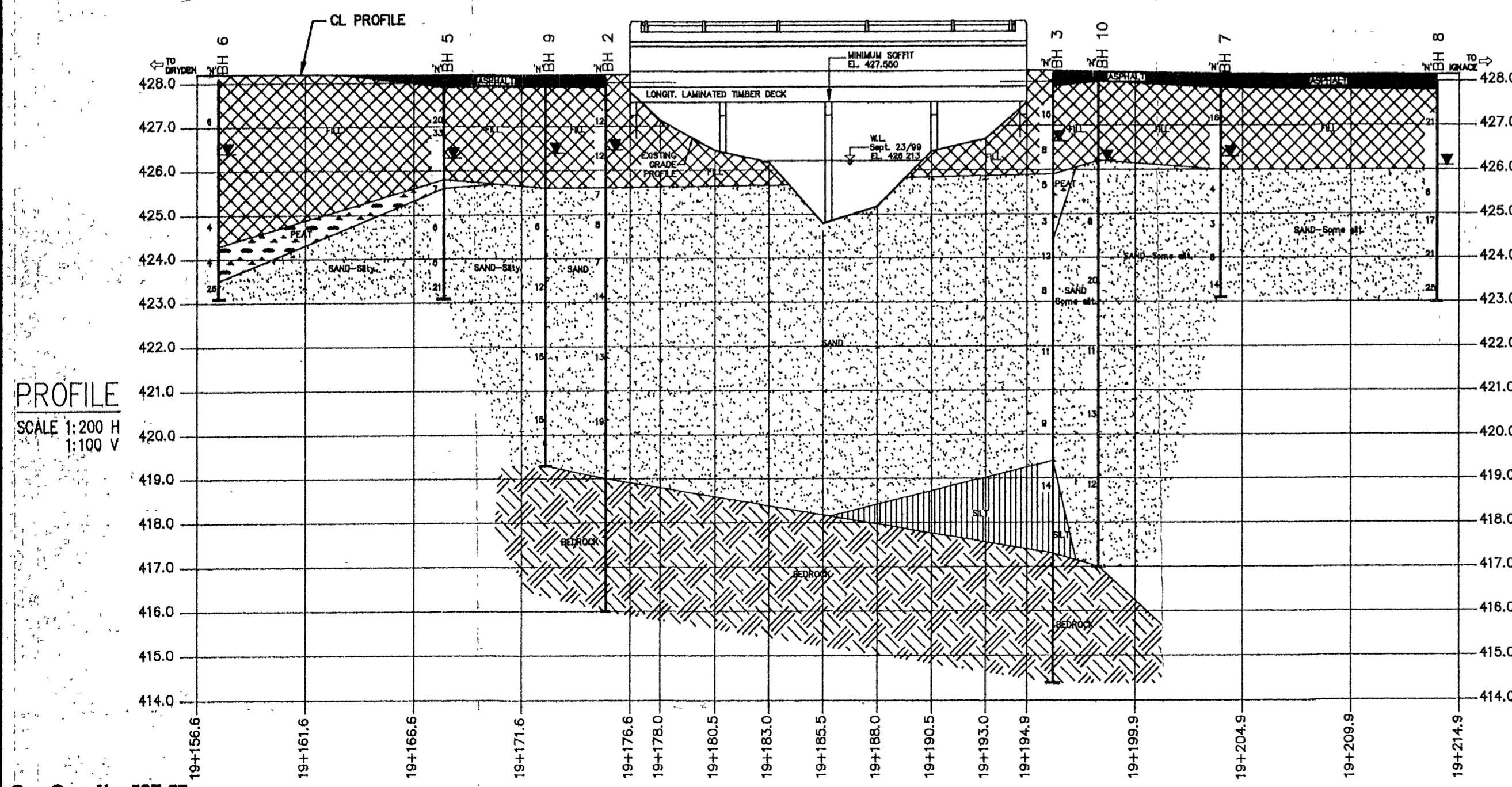
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SITE PLAN

SCALE 1:150

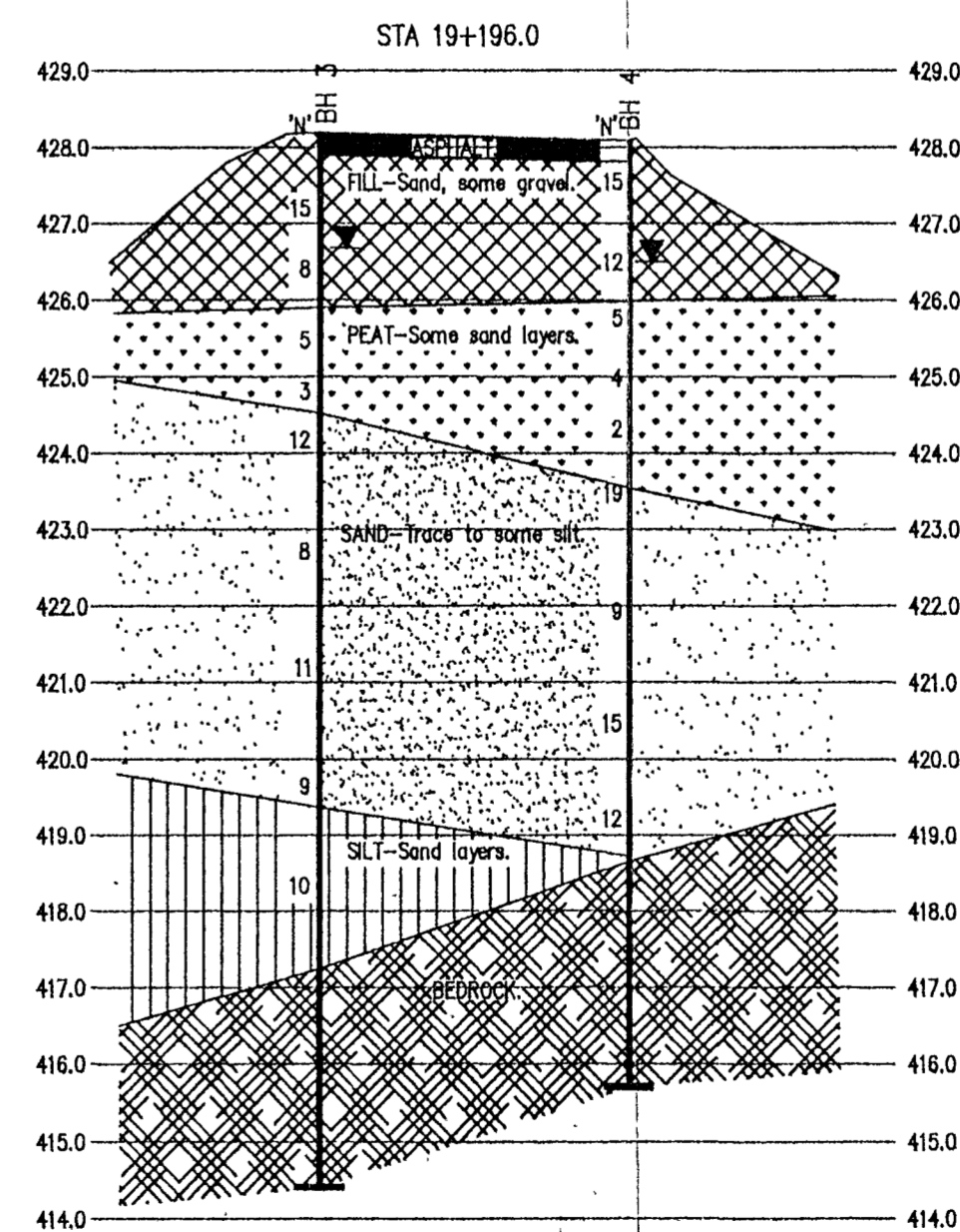
0 10
METRES



PROFILE

SCALE 1:200 H
1:100 V

Geo Cres No. 52F-27



SECTION A-A

SCALE 1:200 H
1:100 V

ENCLOSURES

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+175.6 10.2 Rt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
 DATUM Geodetic DATE 07.09.99 CHECKED BY R.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			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				
426.6							20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
0.0	50mm Topsoil. FILL - Sand & Gravel, silty, occ. cobble, brown.		1	AS								
425.9			2	SS	2							
0.8	SAND - Silty, layered peat, some rootlets, brown, loose to compact.											
	- interbedded sand/organics, grey.		3	SS	2							
	- silty, grey.		4	SS	12							
			5	SS	9							
422.5												
4.1	- cobbles. BEDROCK - Basalt.		1	RC								
			2	RC								
419.5												
7.1	End of Borehole @ 7.1m.											

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

x³, *³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 1

RECORD OF BOREHOLE No 1A

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+175.3 4.2 Rt ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 10.09.99 CHECKED BY R.C.

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						
428.1							20 40 60 80 100	20 40 60 80 100						
0.0 427.8	ASPHALT.													
0.3	FILL - Sand, some gravel, brown.		1	AS										Dry on Completion (25) Cave @ 1.5m.
			2	SS	9									
	- Shot Rock.		3	SS										SS on Shot Rock.
														Refusal in Shot Rock. Continued BH 1m East.
424.9	- sand & gravel, silty, brown.		4	SS	14									
3.2	SAND - Interbedded organics, brown, compact.													
	- grey.		5	SS	18									
422.0														
6.1	SILT - Sandy, grey.		6	SS	19									
421.3														
6.8	End of Borehole @ 6.8m. Auger Refusal.													

N MOT 99135 GPJ ON MOT GDT 15172199

ON MOT 99135 GPJ ON MOT GDT 15/12/99

×³, *³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 2

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+175.5 4.0 Lt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
 DATUM Geodetic DATE 08.09.99 CHECKED BY R.C.

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			20 40 60 80 100	20 40 60 80 100					
428.1	ASPHALT.						428							
429.9	FILL - Sand, some silt, gravel, brown, compact.		1	AS			427							Water level @ 1.65m on Sept 13/99.
0.2			2	SS	12		426							
	- trace gravel.		3	SS	12		425							Standpipe installed to 3.0m.
425.6	SAND - Trace silt, 2-10mm organic layers, brown, loose.		4	SS	7		424							0 92 (8)
2.5			5	SS	5		423							
			6	SS	7		422							
	- grey, compact.		7	SS	14		421							
							420							
	- silty.		8	SS	13		419							REC = 96% RQD = 91%
							418							
	- frequent cobbles.		9	SS	19		417							REC = 97% RQD = 86%
419.0	BEDROCK - Basalt.		1	RC			416							
9.1			2	RC										
416.0	End of Borehole @ 12.1m.													
12.1														

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

×³ *³ Numbers refer to
Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 3

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+196.1 4.0 LI ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
 DATUM Geodetic DATE 08.09.99 CHECKED BY R.C.

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						
428.2								20 40 60 80 100						
0.0	ASPHALT.						428							
427.9														
0.3	FILL - Sand, trace silt, gravel, brown, loose to compact.		1	AS										
			2	SS	15									
			3	SS	8									
425.9							426							
2.3	PEAT - Black (H9, B1, F0, R1, W0)		4	SS	5									
			5	SS	3		425							
424.4														
3.8	SAND - Trace silt, grey, loose to compact.		6	SS	12		424							
			7	SS	8		423							
			8	SS	11		422							
			9	SS	9		421							
	- silty.						420							
419.4							419							
8.8	SILT - Sand layers, grey, compact.		10	SS	14		418							
							417							
417.3	- cobbles. BEDROCK - Basalt.		1	RC			416							
			2	RC			415							
414.4														
13.8	End of Borehole @ 13.8m													

ON MOT 99135 GPJ ON MOT GDT 15/12/99

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

ENCLOSURE 4

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+195.9 4.2 Rt ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
DATUM Geodetic DATE 09.09.99 CHECKED BY R.C.

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						
428.1	ASPHALT.													
0.0 427.8														
0.3	FILL - Sand, some gravel, brown, compact.		1	AS										
			2	SS	15									
			3	SS	12									
426.0														
2.1	PEAT - Brown. (H3, B1, R2, W0)		4	SS	5									
	- interbedded sand layers.		5	SS	4									
			6	SS	2									
	- PEAT (H6, B1, F2, R1, W0)													
423.5	- interbedded sand layers.													
4.6	SAND - Trace silt, grey, loose to compact.		7	SS	19									
			8	SS	9									
	- some silt.													
			9	SS	15									
418.7			10	SS	12									
9.4	BEDROCK - Basalt.		1	RC										
			2	RC										
415.7														
12.4	End of Borehole @ 12.4m.													

ON MOT 99135 GPJ ON MOT GDT 15/12/99

✕ 3, ★ 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 5

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+168.0 4.0 Rt ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 10.09.99 CHECKED BY R.C.

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					
428.1	ASPHALT.						428							
428.0	FILL - Sand, some gravel, trace silt, brown, compact.		1	AS										
0.2			2	SS	20									
							427							
	- silty, trace gravel, grey, dense.		3	SS	33									
	- shot rock.						426							
425.8	PEAT - Brown.													
425.8	(H9, B1, F1, R0, W0)		4	SS	7									
2.5	SAND - Silty, occ. thin layer organics, brown, loose.						425							
	- trace organics.		5	SS	6									
							424							
	- 10mm layer wood.		6	SS	5									
			7	SS	21									
423.1	-silt layer													
5.0	End of Borehole @ 5.0m.													

ON_MOT 99135 GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+157.6 5.0 Lt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 10.09.99 CHECKED BY R.C.

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						
428.1 0.0	FILL - Sand, some gravel, brown, loose.		1	AS										Cobbles/boulders from 1.2m. Refusal @ 1.5m. Continued BH 1m West.
			2	SS	6									
	- cobbles/boulders.													
	- interbedded organics.													
424.3 3.8	PEAT - Trace sand, brown. (H6, B1, F1, R0, W1, N1)		3	SS	4									
423.5 4.6	SAND - Silty, grey, compact.	4	SS	4										
423.1 5.0	End of Borehole @ 5.0m.	5	SS	26										

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+203.9 4.5 Lt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 13.09.99 CHECKED BY R.C.

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								WATER CONTENT (%)
								○ UNCONFINED	× FIELD VANE	□ QUICK TRIAXIAL						
428.1								20	40	60	80	100				GR SA SI CL
427.8	ASPHALT.						428									
0.3	FILL - Sand, some gravel, brown, compact.		1	AS												
			2	SS	16											
							427									
	- frequent cobbles.		3	SS												
426.0							426									
2.1	SAND - Some silt, black/grey interbedded organic layers, grey, loose.		4	SS	4											
			5	SS	3		425									
424.3																
3.8	SAND - Trace silt, grey, loose to compact.		6	SS	8		424									
			7	SS	14											
423.1																
5.0	End of Borehole @ 5.0m.															

× 3, * 3. Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 8

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+213.9 4.5 RI ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 13.09.99 CHECKED BY R.C.

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								WATER CONTENT (%)	
								○ UNCONFINED	✕ FIELD VANE	□ QUICK TRIAXIAL							★ LAB VANE
								20	40	60							80
428.0															GR SA SI CL		
429.8	ASPHALT.																
0.2	FILL - Sand, some gravel, brown, compact.		1	AS			427										
			2	SS	21												
	- frequent cobbles.																
426.0							426										
2.0	SAND - Silty, interbedded organics, some silt layers, brown, loose.		3	SS	6												
425.0							425										
3.0	SAND - Trace silt, grey, compact.		4	SS	17												
							424										
			5	SS	21												
			6	SS	25												
423.0							423										
5.0	End of Borehole @ 5.0m.																

IN MOT 99135.GPJ ON MOT.GDT 13/7/99

ON MOT 99135 GPJ ON MOT.GDT 15/12/99

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

ENCLOSURE 9

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+172.7 4.0 Lt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 14.09.99 CHECKED BY R.C.

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	WATER CONTENT (%)					
428.1	ASPHALT						428							
420.9 0.2	FILL - Sand & Gravel, brown.						427							
	- sand/organics.		1	SS			426							SS on cobble.
	- frequent cobbles (possible shot rock fill).						425							
425.6 2.5	SAND - Several thin organic layers, grey, loose to compact.		2	SS	6		424							
							423							
			3	SS	12		422							
	- silty.		4	SS	15		421							
							420							
	- cobbles.		5	SS	15									
419.3 8.8	End of Borehole @ 8.8m. Auger Refusal.													

ON MOT 99135 GPJ ON MOT GDT 15/12/99

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+198.2 4.0 Lt. ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 14.09.99 CHECKED BY R.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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	W _p W W _L	10 20 30			
428.2	ASPHALT.													
428.0														
0.2	FILL - Sand & Gravel, brown.													
			1	SS										
426.2	- frequent cobbles.													
2.0	SAND - Interbedded organics, grey.													
			2	SS	8									
424.4														
3.8	SAND - Trace to some silt, trace gravel, grey, compact.													
			3	SS	20									
			4	SS	11									
			5	SS	13									
	- silt layers.		6	SS	12									
	- frequent cobbles.													
417.0														
11.2	End of Borehole @ 11.2m. Auger Refusal.													

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

x³ * 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 11

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+193.4 4.2 Rt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 14.09.99 CHECKED BY R.C.

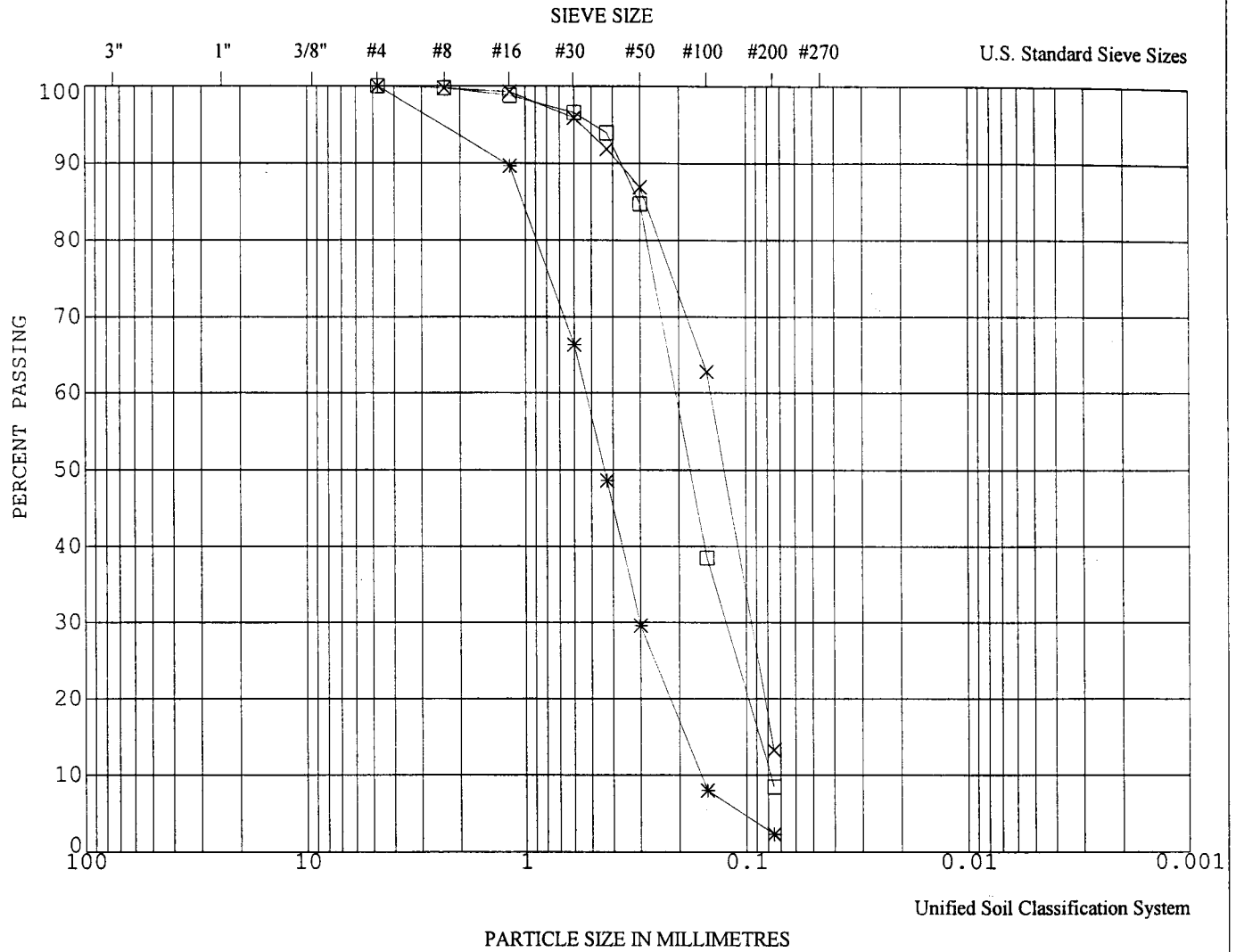
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W _p	W		
428.1	ASPHALT.					428							
427.8						427							
0.3	FILL - Sand, some gravel, brown, compact.					426							
			1	SS	23								
	- coarse fill.					425							
425.6						424							
2.5	SAND - interbedded organics, brown, loose.		2	SS	5								
						423							
423.8						422							
4.3	SAND - Trace silt, grey, loose to compact.		3	SS	18								
						421							
						420							
	- silty.		4	SS	9								
						419							
			5	SS	15								
			6	SS	14								
418.5													
9.6	End of Borehole @ 9.6m. Auger Refusal.												

ON MOT 99135 GPJ ON MOT GDT 15/12/99

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

ENCLOSURE 12

GRAINSIZE ANALYSIS



COB'L	GRAVEL		SAND			SILT & CLAY
	Coarse	Fine	Coarse	Medium	Fine	

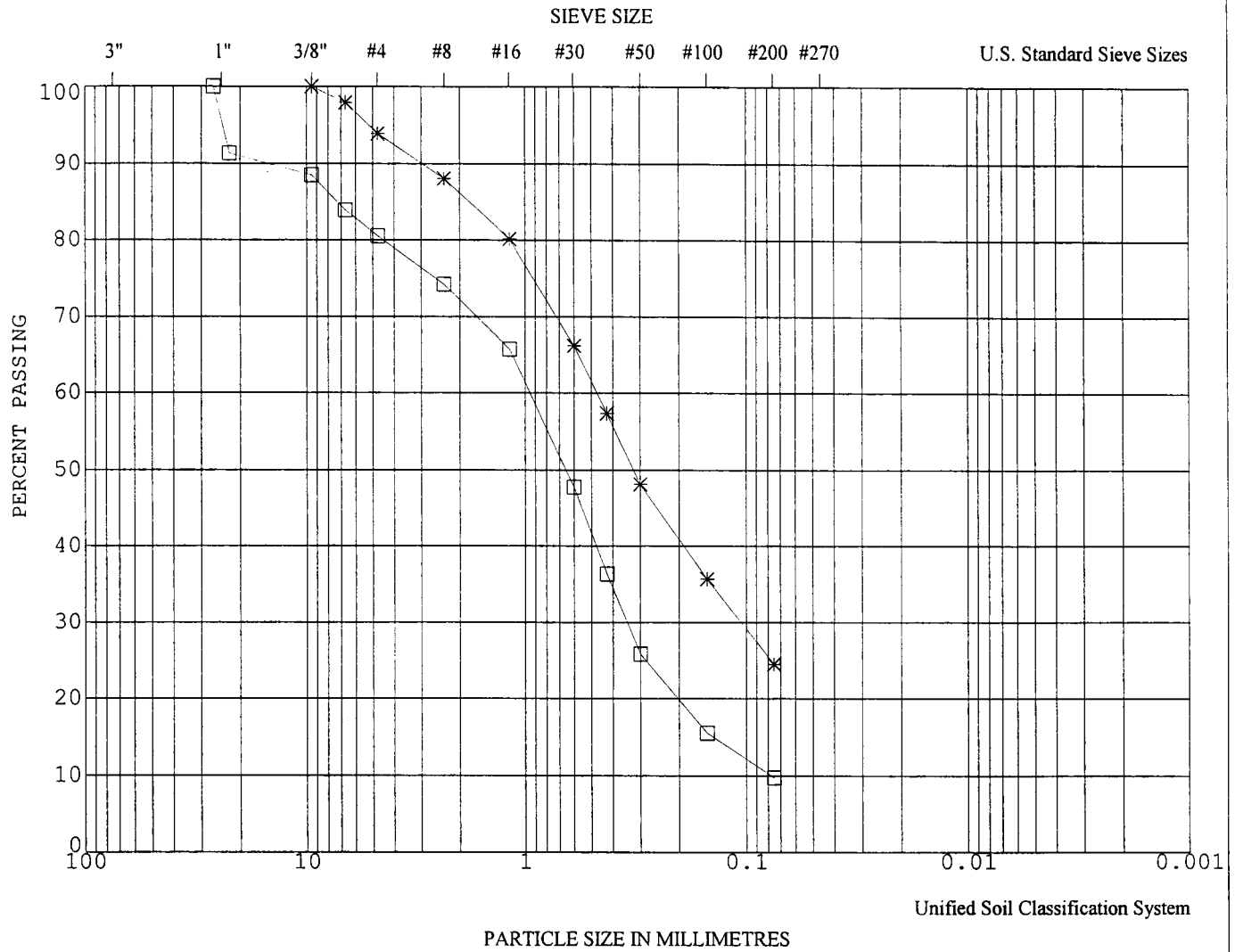
LEGEND:

- BOREHOLE 2 DEPTH 3.8
- * BOREHOLE 3 DEPTH 4.6
- × BOREHOLE 4 DEPTH 7.6

December 1999

Reference No.

GRAINSIZE ANALYSIS



COB'L	GRAVEL		SAND			SILT & CLAY
	Coarse	Fine	Coarse	Medium	Fine	

LEGEND:

- BOREHOLE 5 DEPTH 0.8
- * BOREHOLE 1A DEPTH 0.3

December 1999

Reference No.

GEOLOGICAL CORE DESCRIPTION

- Borehole #1** Basalt - Light greenish grey, fine grained, weakly to strongly foliated at 15° to core (15° dip), very hard, high strength, strongly silicified. Jointing occurs in two sets. One set is parallel to the foliation, slightly rough planar and tight. The second set is smooth - planar and cross-cuts foliation at 55°. Both sets are 1 - 2 mm in aperture and are filled with quartz-carbonate veinlets. Some random joints/veinlets also occur. Joint spacing is closely spaced to moderately spaced.
- Borehole #2** Basalt - fine grained, dark grey-green, weakly foliated at 15° to core (75° dip), moderately hard, high strength. Jointing occurs in two sets plus random orientation. One set is parallel to the foliation and consists of rough-planar, tight joints occupied by quartz veinlets, the second is smooth-planar and cross-cuts foliation at 55° to core (35° dip), and is moderately to widely spaced. Random, moderately to closely spaced, tight joints cut both sets, generally at 30° - 45° to core at random orientations.
- Borehole #3** Basalt - fine grained, dark green, slightly foliated at 10° - 15° to core (80° - 75° dip), moderately hard, high strength. Jointing occurs in one set plus random orientation. The one set of joints are smooth-planar, tight, unweathered, oriented at 60° - 75° to core (30° - 15° dip) and have a thin coating of carbonate. The other joints generally are rough-planar, tight, unweathered and occur 30° - 50° to core at random orientation. All joints are moderately to closely spaced.
- Borehole #4** Basalt - fine grained, dark green, slightly foliated at 15° - 20° to core (85° - 70° dip), moderately hard, high strength. Jointing consists of one set plus random orientations, the joint "set" occurs as rough-planar and smooth planar joints at 45° - 55° to core (35° - 45° dip), these joints are tight and the smooth-planar joints have thin coatings of calcite. The random joints occur at 30° - 55° to core (35° - 60° dip) at random orientations, in some cases intersecting each other. These joints are smooth-planar or rough-planar and may contain calcite coatings.

* A quartz vein occurs from 9.7 m to 9.95 m at 25° to core (75° dip)

DT.

FEB. 27. 2001

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 2000-0247

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52F00-027

1.0 INTRODUCTION

DST Consulting Engineers Inc. (DST) has been retained by Cook Engineering Co. to conduct a foundation investigation for the proposed replacement of the Revell River Bridge (Bridge No. 41S-70).

Authorization to proceed with this work was received from Cook Engineering Co. This work was carried out as part of the Total Project Management project for the Ministry of Transportation of Ontario (MTO) under GWP 195-87-00.

The purpose of the work is to conduct a site investigation of sufficient scope to verify design assumptions and to provide adequate subsurface descriptions to permit the contractor to plan construction of foundation elements and the immediate approach embankments. It is understood that the Ministry will be designing the foundation system for the replacement bridge.

2.0 SITE DESCRIPTION

The Revell River Bridge (No. 41S-70) is located along Highway 17, approximately 32 km west of Ignace, Ontario. The existing structure is a two-lane bridge deck support on a timber pile system. The bridge is approximately 18 m in length and crosses the river in an east-west direction. The general area north and south of the abutments is low laying wet area. A bedrock outcrop exists about 15 m to the southwest of the bridge. The site is located in a glaciofluvial out wash deposit.

3.0 INVESTIGATION PROCEDURES

Site work was carried out between September 7 and 16, 1999, utilizing a CME 750 drill rig equipped for geotechnical testing. Twelve boreholes were drilled to depths ranging between 5 m and 13.8 m. Borehole locations and stratigraphic sections are shown on the Borehole Location Plan, Enclosure 1.

Boreholes 1 to 4 and 9 to 11 were drilled to auger refusal at the abutment locations. The refusal material was confirmed in Boreholes 1, 2, 3 and 4 using diamond drilling techniques. Boreholes 5 to 8 were drilled to a depth of 5 m in the approach ramps.

Boreholes were advanced with hollow stem augers. Soil samples were obtained from the auger flights and from the split spoon sampler used for the standard penetration test (SPT). The SPT involves driving a 50-mm diameter thick-walled sampler into the soil under an energy of 63.5 kg weight falling through 760 mm. The number of blows required to drive the sampler 300 mm is known as the standard penetration blow count (N) which provides an indication of the relative density or consistency of the soil. Representative soil samples are obtained from within the sampler. Three-metre cores of the bedrock were obtained from Boreholes 1 to 4 utilizing a BTK core barrel.

Slotted PVC standpipes were installed in Boreholes 2 to 4 for monitoring of the groundwater level.

Ground surface elevations at the borehole locations were surveyed by DST and referenced to a

temporary benchmark on the bridge structure. The TPM was tied into the project survey by Cook Engineering. The elevation of DST's TPM was given as 429.035 m.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included natural moisture contents, gradation analyses and point load tests on the rock core. Laboratory test results are presented on the Borehole Logs where applicable, in the text of this report and Enclosures 14 and 15.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

Details of the subsurface conditions are given in the Borehole Logs, Enclosures 2 to 13 and are further discussed below.

The generalized stratigraphy of the site, based on the conditions at the borehole locations consists of asphalt or topsoil overlying fill which in turn is underlain with organics. Beneath the organics, sand exists overlying silt at some locations. Bedrock exists beneath the silt and/or sand. Bedrock was proven by diamond drilling techniques in Boreholes 1 to 4 inclusive.

4.2 Asphalt

Asphalt varying in thickness from 175 to 300 mm is present at the surface at all boreholes except Boreholes 1 and 6. Borehole 1 is located on the southwest bank of the river and Borehole 6 is located in the shoulder of the roadway.

4.3 Granular Fill

Granular fill is present beneath the asphalt or from surface in Boreholes 1 and 6. The fill thickness varies from 0.5 to 3.8 m. Within the granular fill, layers of cobbles and boulders or 'shot' rock exist near the base of the fill materials. Gradation analyses conducted on samples of the fill from Boreholes 1A at 0.3 m and Borehole 5 at 0.8 m are presented on Enclosure 15. The gradation results indicate this fill material is a sand with 5 to 20% gravel sizes and 10 to 25% fine content. The Standard Penetration Test values (N values of 4 blows/0.3 to 33 blows/0.3 m) indicate a loose to dense state.

4.4 Organics

Organics were encountered in all boreholes at the interface of the fill and underlying sand stratum. In Boreholes 3 to 6, distinct layers of peat are present. In the other boreholes, the organics are mixed or interbedded within the base of the fill or in the upper sand stratum. The moisture contents of these layers vary from 41% to greater than 100%. The thicknesses of the organics/peat vary from a few millimetres to 1.5 m.

The peat was classified in accordance with the Von Post classification system as follows:

- H = Humification, graded on a scale from 1 to 10 with 1 representing no decomposition and 10 representing complete decomposition.
- B = Water content, graded on a scale from 1 (dry) to 5 (very wet, $w > 2,000\%$)
- F = Fine fibre content, graded on a scale from 0 (nil) to 3 (high content), (coarse fibres are larger than 1 mm in diameter or width).
- W = Wood remnant content, graded on a scale from 0 (nil) to 3 (high content).
- N = Shrub remnant content, graded on a scale from 0 (nil) to 3 (high content).

The results of the Von Post classification have been reported on the Borehole Logs.

4.5 Sand

A sand layer exists beneath the fills and organics. The thickness of this deposit varies from a minimum of 2.9 m to a maximum of 6.6 m. The Standard Penetration Test results (5 blows/0.3 m to 25 blows/0.3 m) indicate a loose to compact condition. Gradation analysis (Enclosure 14)

conducted on samples from Borehole 2 at 3.8 m, Borehole 3 at 4.6 m, and Borehole 4 at 7.6 m indicate a fine to medium grained sand with 3 to 13% fines content. It was noted during drilling that occasional cobbles were encountered near the base of this deposit.

4.6 Silt

A silt deposit was encountered below the sand in Boreholes 1A and 3 only. The thickness of the deposit varied from 0.7 m to 2.2 m. The standard penetration test results indicated a compact condition (N values 14 to 19 blows/0.3 m).

4.7 Bedrock

In general, the bedrock consists of fine grained green/grey basalt. A quartz vein occurs in Rock Core #1 from Borehole 4 at a depth of 9.7 m to 9.95 m. A detailed geological description of the bedrock cores is presented on Enclosure 16.

In order to classify the bedrock with respect to strength, point load tests were conducted on selected core samples. The test results are tabulated below.

Borehole Number	Depth (m)	Strength Index I_s (MPa)	* Estimated Uniaxial Compressive Strength (MPa)
1	4.1	10.1	215
1	4.9	14.9	318
1	5.7	10.1	215
1	6.6	9.3	199

Borehole Number	Depth (m)	Strength Index I_s (MPa)	* Estimated Uniaxial Compressive Strength (MPa)
2	9.1	12.5	266
2	10.1	9.8	210
2	10.6	19.9	425
2	11.7	13.1	280
3	11.3	17.1	366
3	12.2	25.5	544
3	12.7	13.9	296
3	13.5	27.6	589
4	9.6	9.1	194
4	10.3	20.7	441
4	11.3	12.1	258
4	12.2	10.3	221

* Estimate based on published correlations.

From the above data, the bedrock strength can be classified as very to extremely strong.

The rock quality designation (RQD) is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths (greater than 100 mm) to the total length cored.

The RQD index is used to provide a classification for the rock quality according to the following limits.

RQD %	ROCK QUALITY
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Seven of the right cores have an RQD greater than 86% with an RQD of one core of 61%. From the above table, a rock quality from fair to excellent is indicated.

4.8 Groundwater Conditions

The groundwater levels were taken in open boreholes and in the open standpipes installed in Boreholes 2, 3 and 4 on September 13, 1999. At the time of the field program, it had rained for 5 days, the river level rose ± 0.3 m in this time. On September 13, the river was at elevation 426.5 m. The water level, as measured in each borehole is as follows:

Borehole No.	Surface Elevation (m)	Groundwater Elevation (m)	Remarks
1	426.6	426.3	On completion
1A	428.1	--	Dry Cave 1.5 m
2	428.1	426.4	Standpipe, Sept 13
3	428.2	426.6	Standpipe, Sept 13
4	428.1	426.5	Standpipe, Sept 13
5	428.1	426.3	On completion
6	428.1	426.4	On completion
7	428.1	426.3	On completion
8	428.0	426.1	On completion
9	428.1	426.1	On completion
10	428.2	426.2	On completion
11	428.1	426.2	On completion

5.0 LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

Prepared by:

Reviewed by:

ORIGINAL SIGNED BY

ORIGINAL SIGNED BY

R.F. Crowley, P. Eng.
Sr. Project Engineer

Wayne Hurley, P. Eng.
Manager, Thunder Bay

RFC:dm

Vdm\MYFILES\TG-RPT\TE99135-FND-R

APPENDIX 'A'

LIMITATIONS OF REPORT

APPENDIX 'A'

LIMITATIONS OF REPORT

The conclusions and recommendations presented in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. It is recommended practice that DST Consulting Engineers be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

DRAWING

ENCLOSURES

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+175.6 10.2 Rt ORIGINATED BY H.F.
 DIST 81 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
 DATUM Geodetic DATE 07.09.98 CHECKED BY R.C.

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
426.6 0.0	50mm Topsoil. FILL - Sand & Gravel, silty, occ. cobble, brown.		1	AS														
425.9 0.8	SAND - Silty, layered peat, some rootlets, brown, loose to compact.		2	SS	2													
	- interbedded sand/organics, grey.		3	SS	2													
	- silty, grey.		4	SS	12													
			5	SS	9													
422.5 4.1	- cobbles. BEDROCK - Basalt.		1	RC														
			2	RC														
419.5 7.1	End of Borehole @ 7.1m.																	

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 1A

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+175.3 4.2 RI ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 10.09.99 CHECKED BY R.C.

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		
428.1	ASPHALT.						428							Dry on Completion (25) Cave @ 1.5m.
0.0 427.8	FILL - Sand, some gravel, brown.		1	AS										
0.3			2	SS	9									
	- Shot Rock.		3	SS										
424.9	- sand & gravel, silty, brown.		4	SS	14		425							SS on Shot Rock. Refusal in Shot Rock. Continued BH 1m East.
3.2	SAND - Interbedded organics, brown, compact.													
	- grey.		5	SS	18		424							
422.0	SILT - Sandy, grey.		6	SS	19		422							
6.1														
421.3	End of Borehole @ 6.8m. Auger Refusal.													
6.8														

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+175.5 4.0 LI ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
DATUM Geodetic DATE 08.09.99 CHECKED BY R.C.

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	WATER CONTENT (%)					
428.1	ASPHALT.													
429.9	FILL - Sand, some silt, gravel, brown, compact.		1	AS										Water level @ 1.65m on Sept 13/99.
0.2			2	SS	12									
	- trace gravel.		3	SS	12									
425.6	SAND - Trace silt, 2-10mm organic layers, brown, loose.		4	SS	7									
2.5			5	SS	5									Standpipe installed to 3.0m.
			6	SS	7									0 92 (8)
	- grey, compact.		7	SS	14									
			8	SS	13									
	- silty.		9	SS	19									
	- frequent cobbles.													
419.0	BEDROCK - Basalt.		1	RC										REC = 98% RQD = 91%
9.1			2	RC										REC = 97% RQD = 88%
416.0	End of Borehole @ 12.1m.													
12.1														

ON MOT 98135.GPJ ON MOT GDI 15/12/99

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

ENCLOSURE

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+195.9 4.2 Rt ORIGINATED BY H.F.
DIST 81 HWY 17 BOREHOLE TYPE Hollow Stem Auger / BTK COMPILED BY R.V.
DATUM Geodetic DATE 09.09.99 CHECKED BY R.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED × FIELD VANE □ QUICK TRIAXIAL ★ LAB VANE 20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
428.1	ASPHALT.						428						Water level @ 1.6m on Sept 13/99. Standpipe installed to 3.0m. 0 87 (13) REC = 100% RQD = 85% REC = 100% RQD = 93%
427.8													
0.3	FILL - Sand, some gravel, brown, compact.		1	AS									
			2	SS	15								
			3	SS	12								
426.0													
2.1	PEAT - Brown. (H3, B1, R2, W0) - interbedded sand layers.		4	SS	5								
			5	SS	4								
			6	SS	2								
423.5													
4.6	SAND - Trace silt, grey, loose to compact.		7	SS	19								
			8	SS	9								
			9	SS	15								
			10	SS	12								
418.7	BEDROCK - Basalt.		1	RC									
9.4			2	RC									
415.7													
12.4	End of Borehole @ 12.4m.												

ON MOT 99135 GPJ ON MOT.GDT 15/12/99

× 3, ★ 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 5

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+168.0 4.0 Rt ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 10.09.99 CHECKED BY R.C.

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						
428.1								20 40 60 80 100	20 40 60 80 100	10 20 30				
429.9	ASPHALT.						428							
0.2	FILL - Sand, some gravel, trace silt, brown, compact.		1	AS										20 70 (10)
			2	SS	20		427							
	- silty, trace gravel, gray, dense.		3	SS	33		426							
	- shot rock.													
425.8														
428.8	PEAT - Brown. (H9, B1, F1, R0, W0)		4	SS	7		425							
2.5	SAND - Silty, occ. thin layer organics, brown, loose.													
	- trace organics.		5	SS	6		424							
	- 10mm layer wood.		6	SS	5									
			7	SS	21									
423.1	-silt layer													
5.0	End of Borehole @ 5.0m.													

ON MOT 99135.GPJ ON MOT GDT 15/12/99

× 3, * 3. Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 6

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+157.6 5.0 LI ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 10.09.99 CHECKED BY R.C.

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
428.1	FILL - Sand, some gravel, brown, loose. - cobbles/boulders. - interbedded organics.		1	AS			428												
0.0			2	SS	6		427												
								426											
			3	SS	4		425												
			4	SS	4		424												
424.3	PEAT - Trace sand, brown. (H6, B1, F1, R0, W1, N1)		4	SS	4														
423.5	SAND - Silty, grey, compact.		5	SS	26														
423.1																			
5.0	End of Borehole @ 5.0m.																		

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+203.9 4.5 LI ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 13.09.99 CHECKED BY R.C.

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					
428.1	ASPHALT.																
427.8	FILL - Sand, some gravel, brown, compact.		1	AS													
0.3			2	SS	16												
	- frequent cobbles.		3	SS													
426.0																	
2.1	SAND - Some silt, black/grey interbedded organic layers, grey, loose.		4	SS	4												
			5	SS	3												
424.3																	
3.8	SAND - Trace silt, grey, loose to compact.		6	SS	8												
			7	SS	14												
423.1																	
5.0	End of Borehole @ 5.0m.																

x 3, * 3. Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

ENCLOSURE 8

ON MOT 99135 GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+213.9 4.5 R1 ORIGINATED BY H.F.
DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
DATUM Geodetic DATE 13.09.99 CHECKED BY R.C.

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						
428.0	ASPHALT.																
429.8																	
0.2	FILL - Sand, some gravel, brown, compact.		1	AS													
			2	SS	21												
	- frequent cobbles.																
426.0																	
2.0	SAND - Silty, interbedded organics, some silt layers, brown, loose.		3	SS	6												
425.0																	
3.0	SAND - Trace silt, grey, compact.		4	SS	17												
			5	SS	21												
			6	SS	25												
423.0																	
5.0	End of Borehole @ 5.0m.																

ON MOT 98135 GPJ ON MOT GDT 15/12/99

x³, * 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE S

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+172.7 4.0 LI ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 14.09.99 CHECKED BY R.C.

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
428.1	ASPHALT.						428									
428.0	FILL - Sand & Gravel, brown.						427									
0.2			1	SS			426									
	- sand/organics.						425									
	- frequent cobbles (possible shot rock fill).						424									
425.6	SAND - Several thin organic layers, grey, loose to compact.		2	SS	6		423									
2.5							422									
	- silty.		3	SS	12		421									
							420									
	- cobbles.		4	SS	15											
			5	SS	15											
419.3	End of Borehole @ 8.8m. Auger Refusal.															
8.8																

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 285-98-00 LOCATION STATION 19+198.2 4.0 LI ORIGINATED BY H.F.
 DIST 61 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.V.
 DATUM Geodetic DATE 14.09.99 CHECKED BY R.C.

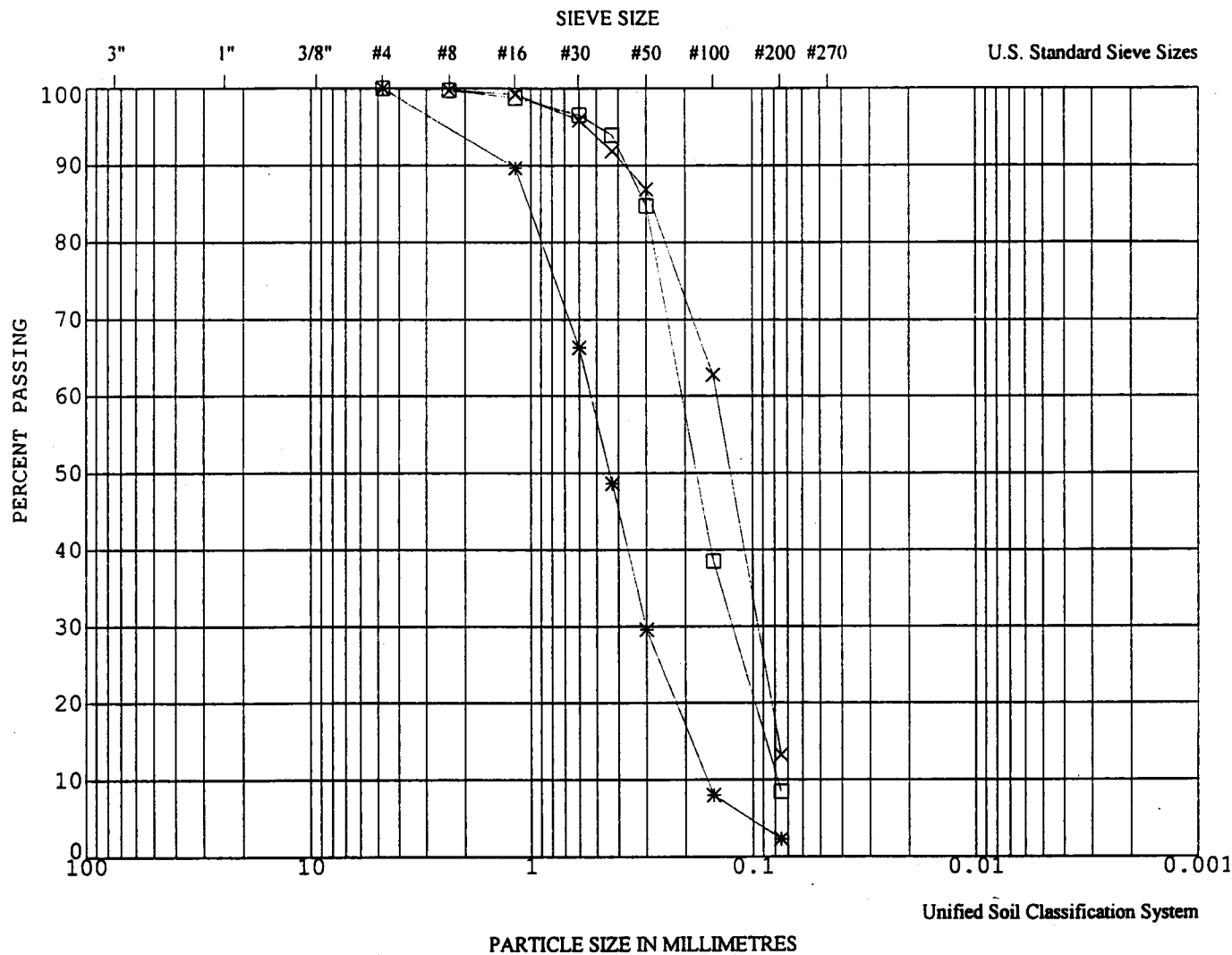
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100 ○ UNCONFINED x FIELD VANE □ QUICK TRIAXIAL * LAB VANE						
428.2	ASPHALT.						428							
428.0	FILL - Sand & Gravel, brown.						427							
0.2			1	SS										
426.2	- frequent cobbles.						426							
2.0	SAND - Interbedded organics, grey.		2	SS	8		425							
424.4							424							
3.8	SAND - Trace to some silt, trace gravel, grey, compact.		3	SS	20		423							
							422							
			4	SS	11		421							
							420							
			5	SS	13		419							
	- silt layers.		6	SS	12		418							
	- frequent cobbles.						417							
417.0	End of Borehole @ 11.2m. Auger Refusal.													

ON MOT 99135 GPJ ON MOT GDT 15/12/99

RECORD OF BOREHOLE No 11										1 OF 1		METRIC			
W.P. 285-98-00		LOCATION STATION 19+193.4 4.2 RI		ORIGINATED BY H.F.											
DIST 81 HWY 17		BOREHOLE TYPE Hollow Stem Auger		COMPILED BY R.V.											
DATUM Geodetic		DATE 14.09.99		CHECKED BY R.C.											
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 ○ UNCONFINED × FIELD VANE □ QUICK TRIAXIAL * LAB VANE							
428.1	ASPHALT.						428								
427.8							427								
0.3	FILL - Sand, some gravel, brown, compact.		1	SS	23		426								
425.6	- coarse fill.						425								
2.5	SAND - Interbedded organics, brown, loose.		2	SS	5		424								
423.8							423								
4.3	SAND - Trace silt, grey, loose to compact.		3	SS	18		422								
							421								
			4	SS	9		420								
	- silty.						419								
			5	SS	15										
418.5			6	SS	14										
9.6	End of Borehole @ 9.6m. Auger Refusal.														

ON MOT 99135.GPJ ON MOT.GDT 15/12/99

GRAINSIZE ANALYSIS



COB'L	GRAVEL		SAND			SILT & CLAY
	Coarse	Fine	Coarse	Medium	Fine	

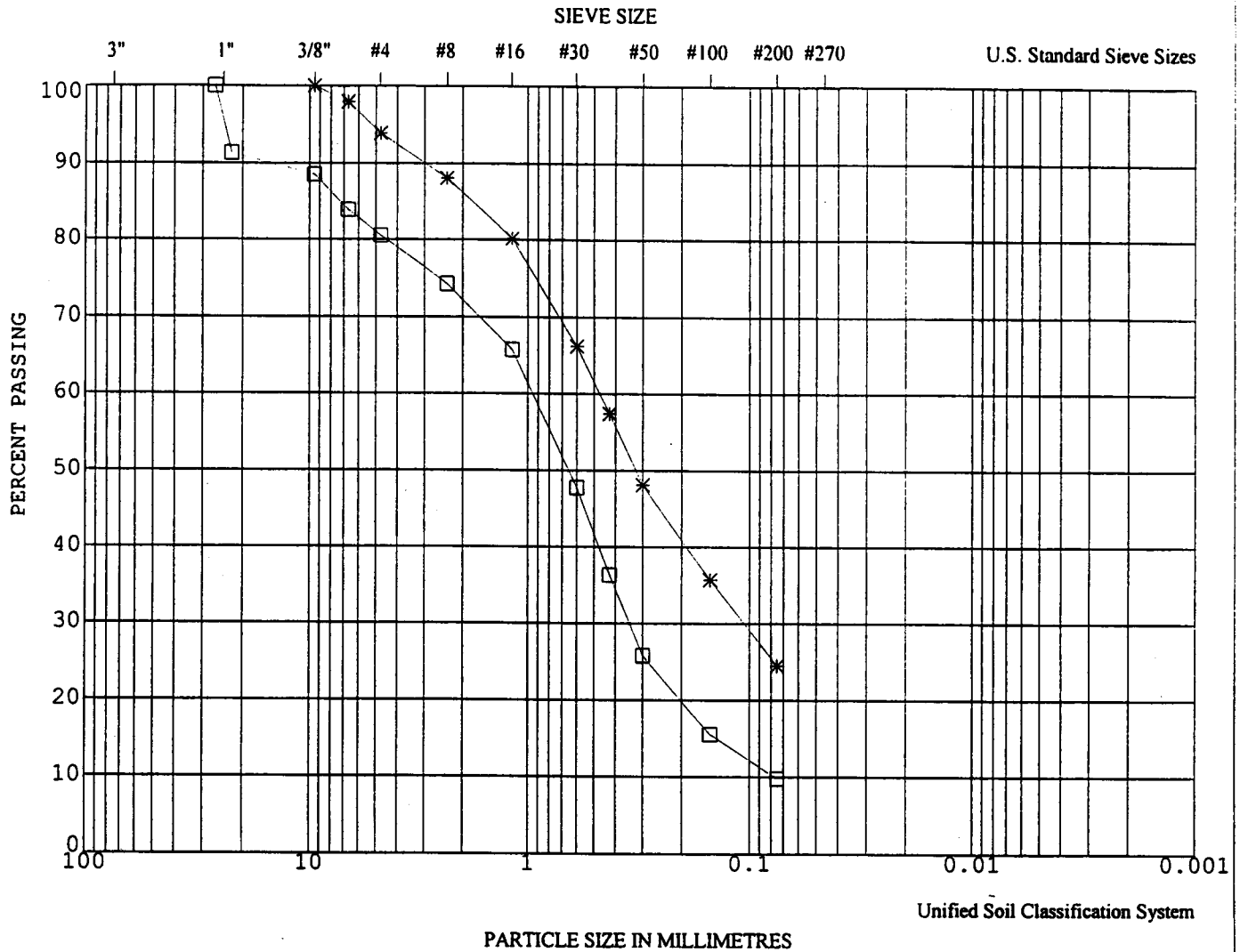
LEGEND:

- BOREHOLE 2 DEPTH 3.8
- * BOREHOLE 3 DEPTH 4.6
- × BOREHOLE 4 DEPTH 7.6

December 1999

Reference No.

GRAINSIZE ANALYSIS



COB'L	GRAVEL		SAND			SILT & CLAY
	Coarse	Fine	Coarse	Medium	Fine	

LEGEND:

- BOREHOLE 5 DEPTH 0.8
- * BOREHOLE 1A DEPTH 0.3

December 1999

Reference No.

GEOLOGICAL CORE DESCRIPTION

- Borehole #1** Basalt - Light greenish grey, fine grained, weakly to strongly foliated at 15° to core (15° dip), very hard, high strength, strongly silicified. Jointing occurs in two sets. One set is parallel to the foliation, slightly rough planar and tight. The second set is smooth - planar and cross-cuts foliation at 55°. Both sets are 1 - 2 mm in aperture and are filled with quartz-carbonate veinlets. Some random joints/veinlets also occur. Joint spacing is closely spaced to moderately spaced.
- Borehole #2** Basalt - fine grained, dark grey-green, weakly foliated at 15° to core (75° dip), moderately hard, high strength. Jointing occurs in two sets plus random orientation. One set is parallel to the foliation and consists of rough-planar, tight joints occupied by quartz veinlets, the second is smooth-planar and cross-cuts foliation at 55° to core (35° dip), and is moderately to widely spaced. Random, moderately to closely spaced, tight joints cut both sets, generally at 30° - 45° to core at random orientations.
- Borehole #3** Basalt - fine grained, dark green, slightly foliated at 10° - 15° to core (80° - 75° dip), moderately hard, high strength. Jointing occurs in one set plus random orientation. The one set of joints are smooth-planar, tight, unweathered, oriented at 60° - 75° to core (30° - 15° dip) and have a thin coating of carbonate. The other joints generally are rough-planar, tight, unweathered and occur 30° - 50° to core at random orientation. All joints are moderately to closely spaced.
- Borehole #4** Basalt - fine grained, dark green, slightly foliated at 15° - 20° to core (85° - 70° dip), moderately hard, high strength. Jointing consists of one set plus random orientations, the joint "set" occurs as rough-planar and smooth planar joints at 45° - 55° to core (35° - 45° dip), these joints are tight and the smooth-planar joints have thin coatings of calcite. The random joints occur at 30° - 55° to core (35° - 60° dip) at random orientations, in some cases intersecting each other. These joints are smooth-planar or rough-planar and may contain calcite coatings.

* A quartz vein occurs from 9.7 m to 9.95 m at 25° to core (75° dip)