

G.I-30 SEPT. 1976

GEOCRES No. 314-68

DIST. 54 REGION

W.P. No. 65-98-00

CONT. No.

W. O. No.

STR. SITE No. 43-368

HWY. No. 94

LOCATION Lavase River Culvert

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FINAL



MERLEX ENGINEERING LTD.,
Consulting Geotechnical Engineers



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CONSULTING GEOTECHNICAL ENGINEERS

FOUNDATION MEMO REPORT

Lavase River - MTO Site No. 43-368
Highway 94

W.P. 65-98-00
East Ferris Township
M.T.O. District 54, Sudbury

Merlex Reference No. 98/07/98058-F

November 1998

Prepared for

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1.0 INTRODUCTION

The Work Project is located on Highway 94 from 1.5 km west of Highway 11 (at Callander Bay Road), easterly to Highway 17, a distance of some 9.3 km. Initially the rehabilitation work involved treatment of frost heaves, distressed areas and hot mix paving. However, it was discovered, after spring water levels receded, that the bottom of the single span 4.75m x 3.50m Structural Plate Pipe Arch (SPPA) at Station 16+211.34 had started to rust out at the low water line.

The RFP documents specified that the field investigation for this Foundation Memo Report was to be carried out using the same drilling equipment as was used in the geotechnical investigation. However, since field drilling equipment, more appropriate for a foundation investigation, was available locally (in-house), it was mobilized to the site. At the time of preparation of this report, two options of rehabilitation were being considered by the structural designer; relining or replacement. This Foundation Memo Report addresses the geotechnical aspects at this structure.

2.0 FOUNDATION INVESTIGATION

2.1 Site and Project Description

The site is located just on the western limit of the Village of Corbeil on Highway 94 at approximately Station 16+211. The Lavase River flows in a northerly direction at this crossing of Highway 94. The land south of the highway (upstream) is presently used for cattle grazing and the river channel flows around the toe of a series of small rolling hills. In this area the channel is some 1.5 m to 2.5 m wide with 0.5 to 1.0 m high banks. The existing banks are heavily vegetated with grasses and the occasional alder clump. North of the Highway, the river continues to meander slightly through a flat flood plan area which is grass covered. Some 100 to 150 m to the north, the land rises some 20 to 30 m and the hill is covered with mature coniferous tree growth. At this location the river commences flow in an easterly direction. North of the highway, the channel is some 2.5 to 3.5 m wide and again the banks are some

0.5± m high within some 150 m of the crossing. These banks are also heavily grass covered with small shrub and alder growth located some 10 to 20 m back from the banks.

The existing 4.75m structural plate pipe arch appears in good condition above the spring line. At an elevation of some 200 to 300 mm above the invert (low water level line) the bottom has rusted out at two locations, located some 1.5 and 4.0 m in from the south end of the culvert east side. In reviewing the condition of the culvert, along the low water line, it was observed that minor perforations (pinhole to some 10 mm diameter in size) were occasionally present. A concrete headwall, what appeared to be standard, had been constructed at both the south and north ends of the culvert. No signs of stream bed scour were observed at either the inlet or the discharge ends, however debris, consisting of 300 to 500 mm angular blast rock had built up inside the north end of the culvert and to a lesser extent in the south end. It is believed that the blast rock and sand fill debris had been washed down along the exterior edges of the culvert since the existing shoulders and rounding exhibit signs of gouging due to erosion. Erosion had also washed some granular fill from behind the cut off wall, at the sides, exposing rock fill. This debris had built up to the point where water was dammed some 450 mm± in depth on the north (discharge) end.

Based on preliminary field measurements, it appears that the existing pipe invert elevations are very similar to those on the 1970 Construction Contract Drawings of elevation 225.86 m and 226.16 m, left and right respectively.

2.2 Field Investigation

The field work for this investigation was carried out on July 23, August 13 and September 9, 1998 and consisted of nine sampled boreholes (Boreholes 100 to 108, inclusive) put down with a muskeg mounted CME auger drill and hand sampling equipment. Samples were obtained using a 50 mm O.D. split spoon driven by the standard penetration test method. Adjacent to Boreholes 100, 101, 102, 104, 106, 107 and

108, one or more dynamic cone tests were carried out to refusal depth. The field work was under the full time direction of a senior member of our engineering staff who was responsible for layout of the boreholes, retrieval and field classification plus overall drill supervision. The borehole locations and ground surface elevations were established by Osborne & Simpson, Ontario Land Surveyors. Groundwater levels at the borehole locations were recorded during and upon completion of the drilling program. No artesian pressures were encountered during borehole advance. Upon completion, all borings were backfilled to slightly above existing grade with native soil, and imported granular soil where necessary to ensure a safe condition. As noted above, no artesian conditions were encountered which would have required special sealing operations.

2.3 Subsurface Conditions

Detailed descriptions of the soils and groundwater conditions are presented on the enclosed individual Borehole Logs 100 to 108, inclusive. It should be noted that conditions are confirmed only at the test locations and could vary between and beyond these locations.

Organics

A surficial layer, some 50 to 75 mm thick, of silt and sandy organics intermixed with grass roots was encountered at Boreholes 100, 101 and 104. At the location of Borehole 106, the organics were intermixed with silty clay and extended to a depth of approximately 600 mm below existing grade. It is believed that this latter thickness of organic contaminated soil resulted from dredging operations carried out along a small drainage swale which parallels the west side of the embankment at this location.

Sands

The predominant natural soil encountered at this site consisted of medium and fine sands with varying silt and gravel content. The upper portion of the sands, within some 1.0 to 2.0 m of existing natural grade represents fluvial deposits and were generally finer in nature and had a generally higher silt content

than the lower sands. With depth the sands were generally in a compact state of relative density, based on the dynamic cone testing and "N" values. The relative density of this deposit, along with the gravel content, increased below depths of some 3.0 to 4.0 m to the compact to very dense range. Boreholes 103 and 105 were put down, by hand, in the river bottom to identify the presence of fine and medium sands to a depth of some 800 to 900 mm.

Silty Clay

At the location of Borehole 100 (north end of culvert, west river bank) a grey silty clay was penetrated between elevation 225.4 to 224.1. An atterberg limit test on this sample indicated a liquid limit of 43%, plastic limit of 20% with natural moisture content of 56%. In-situ vane testing indicated the shear strength ranged between 20 to 36 kPa indicating a soft to firm consistency. Based on the relationship between the liquid limit and natural moisture content, it is estimated that this clay deposit is normally or only slightly over-consolidated.

To delineate if this soft silty clay was present under the existing embankment, Boreholes 107 and 108 were advanced along with dynamic cone tests. The results indicated that at Borehole 108 granular soils were present below the elevation of the silty clay stratum encountered at Borehole 100. However, at Borehole 107, a dark grey silty clay containing pockets of fine and medium sand (up to 25 mm in size), was present at between elevation 226.1 to 225.6. Atterberg limit testing on this deposit indicate the following: liquid limit of 59%, plastic limit of 22.5% and natural moisture content of 39%. This deposit was underlain by granular soils of a compact to very dense relative density as indicated by the dynamic cone test results.

Granular Backfill

Borehole 102, and subsequently Boreholes 107 and 108, were advanced through the existing embankment east and west of the pipe arch. These borings indicated a sand backfill which generally met

the specification of a Granular "B" Type I gradation down to a depth of some 4.0 to 5.0 m below existing grade close to the culvert. However, the quality of the embankment fill decreased to a SSM type material containing cobbles and boulders further away from the culvert sides as apparent in Boreholes 107 and 108.

The relative density of the sand backfill, based on standard penetration test values and dynamic cone testing was in the compact to dense range.

Auger Refusal

Boreholes 100, 101, 102, 104, 106, 107 and 108 were all advanced to practical auger refusal. The dynamic cone test carried out adjacent to the borings met refusal at similar depths except at Borehole 106 and 108 where refusal was met on the cone at a shallower depth and was due to encountering a boulder in the overburden/backfill.

Where auger refusal was met at depth, it was probably due to the presence of bedrock and/or boulders overlying rock. Since this depth was beyond anticipated excavation depths, proving the presence of bedrock versus boulders using diamond drilling operations was considered beyond the terms of reference for this project.

Groundwater Conditions

Details of the groundwater conditions in the open boreholes are shown on the Borehole Logs. At the time of the field work, the river water level was at approximately elevation 226.31 on August 19, 1998 with water levels in the boreholes ranging between elevation 226.2 to 226.6. These water levels are directly related to the river level and will fluctuate seasonally.

3.0 FOUNDATION DESIGN

Discussions and Recommendations

It is understood that the 4.75m x 3.50m Structural Plate Pipe Arch culvert will either be relined or replaced. Presently, the preferred alternate is to reline, however if replaced, we understand a rigid concrete box culvert would probably be considered. The following comments are provided for use by the designer only.

3.1 General

The existing SPPA, above the spring line, appears to be in good condition, based on visual observations, with only a minor inward deflection of the plate around the center of the culvert, at a distance some two-thirds up from the invert, west side. No appreciable sag was observed along the pipe crown. The existing invert elevations, north (left) and south (right), are at approximately elevation 225.8 and 226.1 which is similar to the 1970 design elevation. As such, it would appear that the culvert has not undergone any appreciable total or differential settlement. In addition, a review of the existing approach embankments did not reveal any distortions associated with possible settlement or subsidence of the soils. Therefore, from a geotechnical point of view, this pipe arch would be considered a good candidate for relining.

3.2 Excavation

If the culvert is to be replaced, it will be necessary to carry out excavations in the dry season, for removal and installation of the new culvert. The native soils, below the existing embankment fill and bedding, are expected to be primarily sands with varying silt content and becoming coarser and gravelly with depth and possibly encountering cobble/boulder sizes. It is anticipated that a new culvert would be set at an invert elevation similar to the existing 226.0±. The river water level, at the time of this investigation was 226.31 (Aug. 19, 1998) however can rise to an estimated 2/3 to 3/4 of the culvert height based on

available preliminary hydrology information. Based on the above, it appears that an excavation to about 225.3 (i.e. some 1 m below the existing water level) will be required.

All excavations must be sloped or shored in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects.

✓ There are several different methods of controlling the stream flow during construction, such as coffer dam, sheet pile cut-off, diversion stream, etc., which are dependent upon the individual contractor's preference and availability of materials.

A sheet pile cut-off wall could be installed with pumping around the excavation to provide temporary dewatering during construction. The borehole results at the ends of the SPPA generally indicate sands of a compact density to between approximately elevation 223 to 224 and increasing in relative density to dense to very dense and coarser in gradation below this elevation with refusal at between elevation 222.5 and 220.6, Boreholes 101 and 104 south end of culvert. Similar conditions should be anticipated at the north end except a less favourable refusal elevation of some 223.3 at Borehole 106, however this refusal is believed to be due to a boulder. The depth of sheeting penetration required to prevent piping/heave is dependent upon the elevation to which the water is allowed to rise above the base of the excavation which in turn is dependent upon the pumping capacity available and season during which construction is undertaken.

Temporary embankment excavations for installation of the concrete box culvert may be sloped at a minimum of 1 to 1 (horizontal to vertical) from the base of the excavation to ground surface or supported with sheeting. Flatter side slopes will be required in areas where local loose soil conditions are encountered, where local sumping of groundwater ingress occurs and to meet the details of OPSD 803.

3.3 Bedding

It will be essential to maintain a stable dry subgrade prior to placement of bedding for the concrete box culvert. To prevent fines migration into the bedding, it is recommended that a non-woven geotextile fabric be laid over the prepared subgrade. The Class II Non-Woven fabric shall have an F.O.S. between 85 to 170 μm .

The bedding material for the culvert should comprise of 450 mm of HL4 coarse aggregate placed and tamped to uniform density on top of the geotextile and conform to OPSS 422. To prevent fine migrations into the bedding, the geotextile should be wrapped up and over the top of bedding sides to a minimum of 1 m inside the outside edge of the box culvert.

3.4 Backfill

Backfill to the sides of the proposed culvert should comprise of an OPSS Granular "B" Type I material that is placed and compacted to a uniform density of 95% standard proctor dry density in accordance with OPSS 501. It is recommended that within a 600 mm distance to the edge of the culvert, a Granular "A" material be used for backfilling purposes to minimize the risk of large cobble size aggregate directly adjacent to the culvert wall. The backfill should be brought up equally on both sides of the culvert (maximum differential 400 mm) using lightweight compaction equipment (within 2 m of the sides) to avoid damage and to minimize the risk of unbalanced loading which could possibly result in tilting or lateral movement of the culvert. The backfill requirements of OPSS 422 apply.

3.5 Lateral Earth Pressure

Since free draining material such as OPSS Granular "B" Type I and Granular "A" will be used within the sides of the culvert, the following design parameters for the soil as given below should be used.

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of internal friction (ϕ unfactored)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2

Since the culvert walls are rigid, the "at rest" earth pressure coefficient of $K_0 = 0.5$ should be used.

3.6 Frost Protection

For frost protection purposes in assessing backfilling requirements as per OPSD 803, a value of 1.8 m should be used for this project.

3.7 Bearing Capacity

In reviewing the individual borehole logs, the predominant soil directly under the proposed culvert will generally be a compact sand within a depth of some 1.0 m of culvert followed by a compact to very dense sand with depth. As such, for a concrete box culvert, some 6 m wide by 25 m in length, we suggest a factored geotechnical resistance at Ultimate Limit State of 270 kPa be used and at Serviceability Limit State a geotechnical resistance of 150 kPa. The settlements should be within a total of 25 mm, provided the subgrade conditions are not excessively disturbed during construction, since the site has previously been loaded for some 30 years with the SPPA and embankment fill.

We understand that the relining option will involve placement of a 200 mm \pm thick reinforced concrete bottom inside the existing culvert. This additional new dead load (concrete liner) will not result in any appreciable total or differential settlement.

4.0 CLOSURE

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

MERLEX ENGINEERING LTD.



M. A. Merleau, P. Eng.
Principal



Report Distribution: Proctor & Redfern Ltd. (9 copies)
Merlex File 98058F (1 copy)



C. Mirza, P. Eng.



EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kn/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kn/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ²	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

W.P. 85-98-00

LOCATION N 5124357.637 E 319971.033

ORIGINATED BY JRB

DIST 54 HWY 94

BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test

COMPILED BY JRB

DATUM Geodetic

DATE 7.23.98 - 7.23.98

CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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						WATER CONTENT (%)		
227.2	Ground Surface														
227.0	Organics														
0.2	Sands														
	Brown (Grey below 1 m±) Fine and Medium layered Sands with varying Silt content (trace to silty) trace Coarse Sand/Fine Gravel content (Very Loose to Loose)		1	SS	1								1 72 (27)		
													9 73 (18)		
225.4			2	SS	WH										
1.8	Silty Clay														
	Grey Clay with Red Clay Varves and Frequent 10 mm thick Light Grey Clayey Silt Varves below 3 m± (Soft/Firm)		3	SS	WH										
224.1															
3.1	Silt		4	SS	8										
	Grey Fine Sandy Silt (Compact)														
222.9															
4.3	Gravel and Sands		5	SS	24								41 48 (11)		
	Grey Fine to Coarse Sands and Gravel trace Silt Occasional Cobbles (Compact to Very Dense)														
220.7			6	SS	82								6 83 (11)		
6.5	Auger Refusal End of Borehole														
Water Level Records															
Date		Ground Water Depth (Meters)													
7/23/98		0.96													

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE



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RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 65-98-00 LOCATION N 5124331.714 E 318969.242 ORIGINATED BY JRB
DIST 54 HWY 94 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test COMPILED BY JRB
DATUM Geodetic DATE 7.23.98 - 7.23.98 CHECKED BY MAM

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 + FIELD VANE ● QUICK TRIAXIAL X LAB VANE							
228.6	Ground Surface														
228.4	Organics Sands														
0.1	Grey Silty Fine Sands (Loose)														
225.9	Sands														
0.7	Grey Fine to Medium Sands trace Silt with Gravel (Compact/Dense)		1	SS	38										33 61 (6)
			2	SS	29										
			3	SS	33										36 57 (7)
			4	SS	44										
222.5	Auger Refusal End of Borehole														
4.1															
Water Level Records															
Date		Ground Water Depth (Meters)													
7/23/98		0.3													

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

MEL-MTO 98050F.GPJ MERLEX.GDT 11/1/98



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RECORD OF BOREHOLE No 102

1 OF 1

METRIC

W.P. 65-98-00 LOCATION N 5124343.236 E 319978.967 ORIGINATED BY JRB
DIST 54 HWY 94 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test COMPILED BY JRB
DATUM Geodetic DATE 7.23.98 - 7.23.98 CHECKED BY MAM

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 + FIELD VANE ● QUICK TRIAXIAL X LAB VANE							
230.4	Ground Surface														
230.1	Asphalt														
229.9	Crushed Granular		1	AUGER			230								
0.4	Sand Backfill														
	Brown Fine to Medium Sands trace to some Silt trace Gravel (Compact)		2	SS	26		229							Overt Elev. 229.72 13 84 (3)	
			3	SS	12		228							2 92 (6)	
			4	SS	25		227							2 87 (11)	
			5	SS	18		226							Invert Elev. 226.16 2 90 (8)	
225.4	Sands		6	SS	61		225								
5.0	Grey Fine to Medium Sands some Silt some Gravel (Very Dense)						224								
223.9	Auger Refusal		7	AUGER											
6.5	End of Borehole														
Water Level Records															
Date	Ground Water Depth (Meters)														
7/23/98															

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

MEL-MTO 980598.GPJ MERLEX.GDT 11/11/98

W.P.	65-98-00	LOCATION	N 5124859.365 E 318977.912	ORIGINATED BY	ELS
DIST	54	HWY	94	BOREHOLE TYPE	Split Spoon
DATUM	Geodetic	DATE	8.13.98 - 8.13.98	COMPILED BY	JRB
				CHECKED BY	MAM

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
226.3	Ground Surface																			
226.2	Water																			
0.1	Sands																			
	Brown Fine to Medium Sands trace Silt trace Gravel		1	SS	4												9 88 (3)			
225.6	(Loose)																			
0.8	End of Sampling																			

NOTE: Split Spoon sample in creek bed. Borehole caved in immediately upon spoon withdrawal.

+³, X³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE



1 OF 1

METRIC**LOCATION**

N 5124331.168 E 319981.852

ORIGINATED BY ELS

DIST 54

HWY 94

BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test

COMPILED BY JRB

DATUM Geodetic

DATE _____

8.13.98 - 8.13.98

CHECKED BY MAM

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MEL-MTO 98058F.GPJ MERLEX.GDT 11/17/88



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Consulting Geotechnical Engineers

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

W.P. 65-98-00 LOCATION N 5124336.661 E 319985.028 ORIGINATED BY ELS
DIST 54 HWY 94 BOREHOLE TYPE Split Spoon COMPILED BY JRB
DATUM Geodetic DATE 8.13.98 - 8.13.98 CHECKED BY MAM

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			T _N VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
226.3	Ground Surface															
226.1	Water															
0.3	Sands															
	Brown Fine and Medium Sands trace Silt some Gravel		1	SS	4											
225.4	(Loose)															
0.9	End of Sampling															
NOTE: Drive open sample in creek bed. Borehole caved in immediately upon spoon withdrawal.																

Date	Ground Water Depth (Meters)
8/13/98	0

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



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Consulting Geotechnical Engineers

RECORD OF BOREHOLE No 106

1 OF 1

METRIC

W.P. 85-98-00 LOCATION N 5124381.415 E 319886.757 ORIGINATED BY ELS
DIST 54 HWY 94 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test COMPILED BY JRB
DATUM Geodetic DATE 8.13.98 - 8.13.98 CHECKED BY MAM

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 + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
228.3	Ground Surface														
	Organics (Fill)														
	Black Silty Clay with Organics		1	AUGER											
227.7															
0.6	Sands														
	Brown to Grey Fine to Medium Sands some Silt some Gravel Occasional Cobbles and Boulders (Compact/Dense)		2	SS	21										
			3	SS	40										
			4	SS	36										
			5	SS	54										
			6	SS	40										
223.3															
5.0	Auger Refusal End of Borehole														
Water Level Records															
Date		Ground Water Depth (Meters)													
8/13/98		2.08													

+3, x3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MEL-MTO 98059F.GPJ MERLEX.GDT 11/17/98



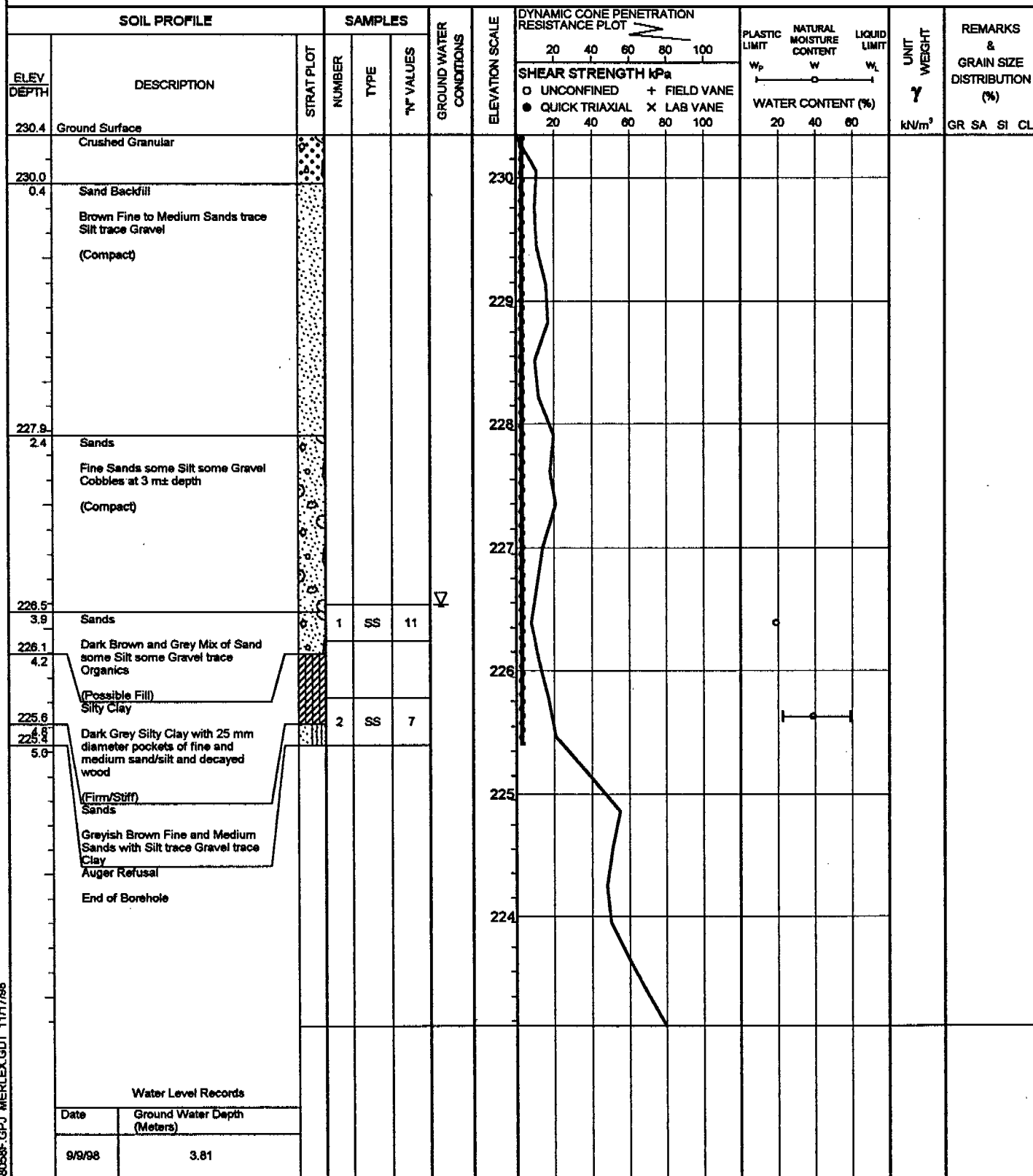
MERLEX ENGINEERING LTD.
Consulting Geotechnical Engineers

RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 65-98-00 LOCATION N 5124351.668 E 319983.252 ORIGINATED BY ELS
DIST 54 HWY 94 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test COMPILED BY JRB
DATUM Geodetic DATE 9.9.98 - 9.9.98 CHECKED BY MAM



MEL-MTO 980536.GPJ MERLEX.GDT 11/17/98

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



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RECORD OF BOREHOLE No 108

1 OF 1

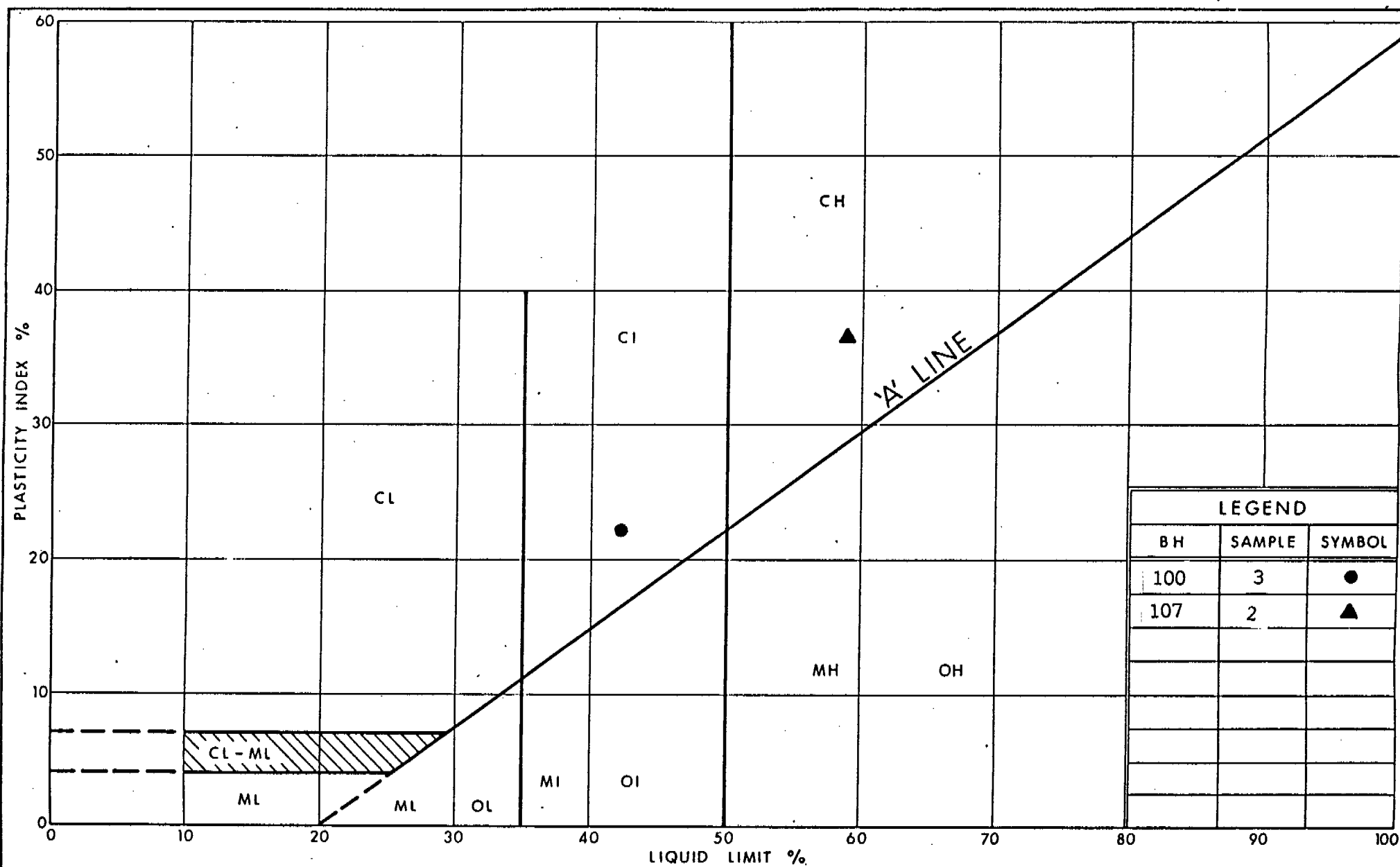
METRIC

W.P. 65-98-00 LOCATION N 5124348.987 E 319976.786 ORIGINATED BY ELS
DIST 54 HWY 94 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test COMPILED BY JRB
DATUM Geodetic DATE 9.9.98 - 9.9.98 CHECKED BY MAM

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 x LAB VANE	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								
230.4	Ground Surface												
	Crushed Granular												
230.0													
0.4	Sands												
	Brown Fine and Medium Sands some Gravel												
	(Compact)												
228.8													
1.5	Sand Backfill												
	Fine Sands with Silt trace Gravel												
	(Compact)												
225.9													
4.4	Sands												
	Grey Fine to Medium Sands some Gravel some Silt Occasional Cobbles		1	SS	30								
	(Compact to Very Dense)		2	SS	78								
			3	SS	25								
			4	SS	4								
			5	SS	24								
222.0													
8.4	End of Borehole												
	Water Level Records												
	Date												
	Ground Water Depth (Meters)												
	9/9/98												

+3, x3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MEL-MTO 98058F GPJ MERLEX GDT 11/17/98



Ministry of
Transportation
Ontario

PLASTICITY CHART

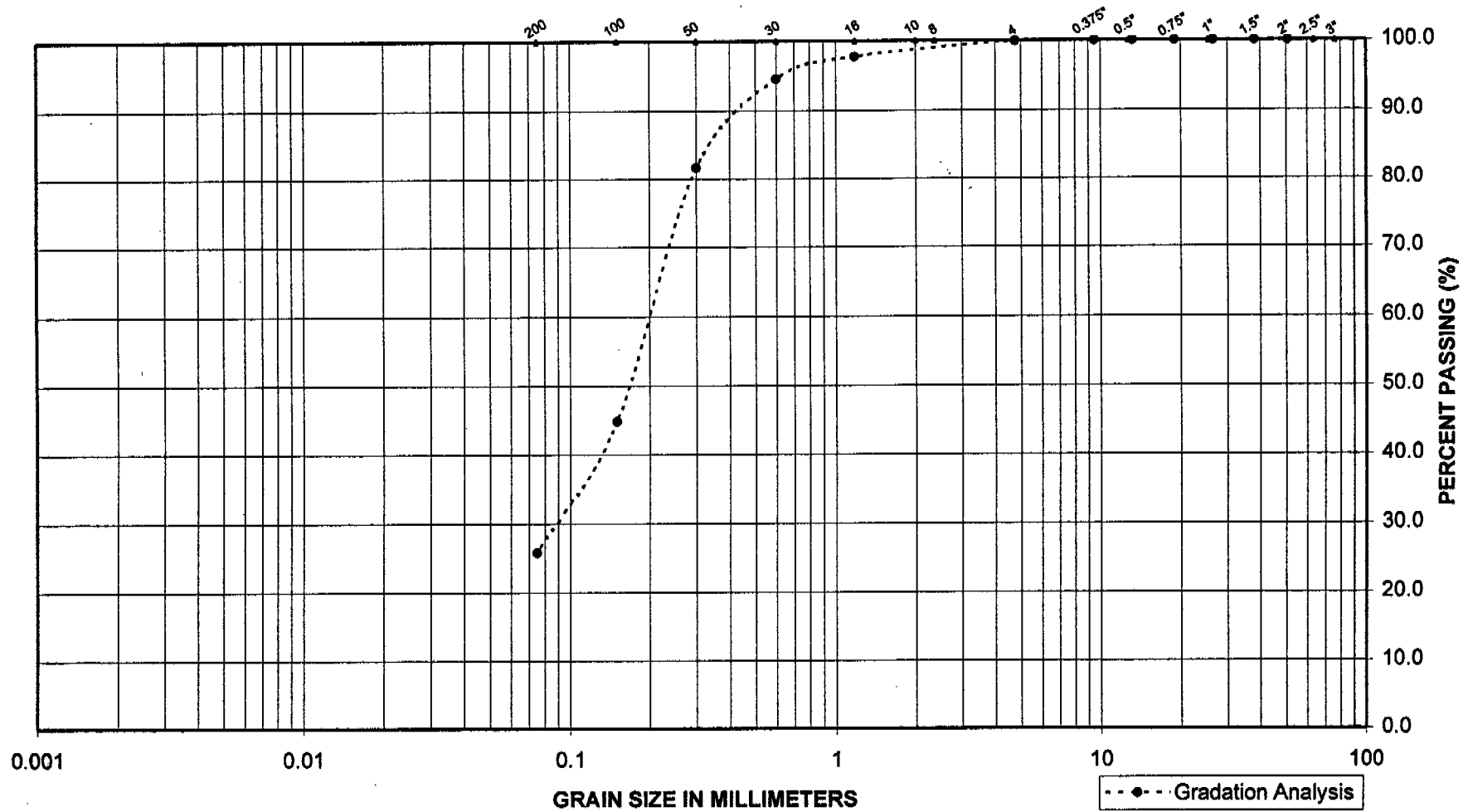
FIG No

W P 65-98-00



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 100
 SAMPLE NO.: 1
 DEPTH (m): 0.75 - 1.35

GRAIN SIZE DISTRIBUTION

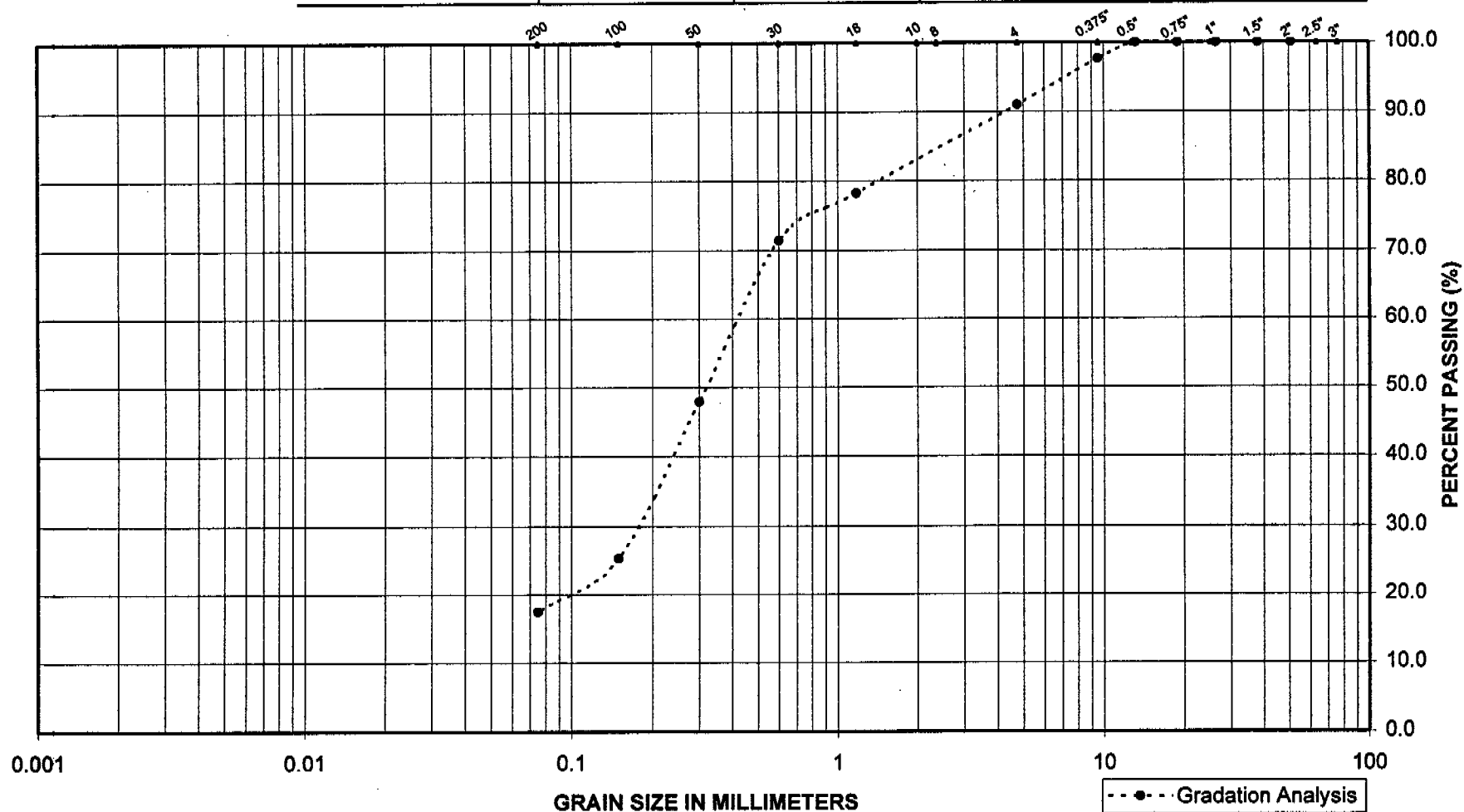
MERLEX ENGINEERING LTD.

W.P. 65-98-00



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 100
 SAMPLE NO.: 2A
 DEPTH (m): 1.5 - 1.7

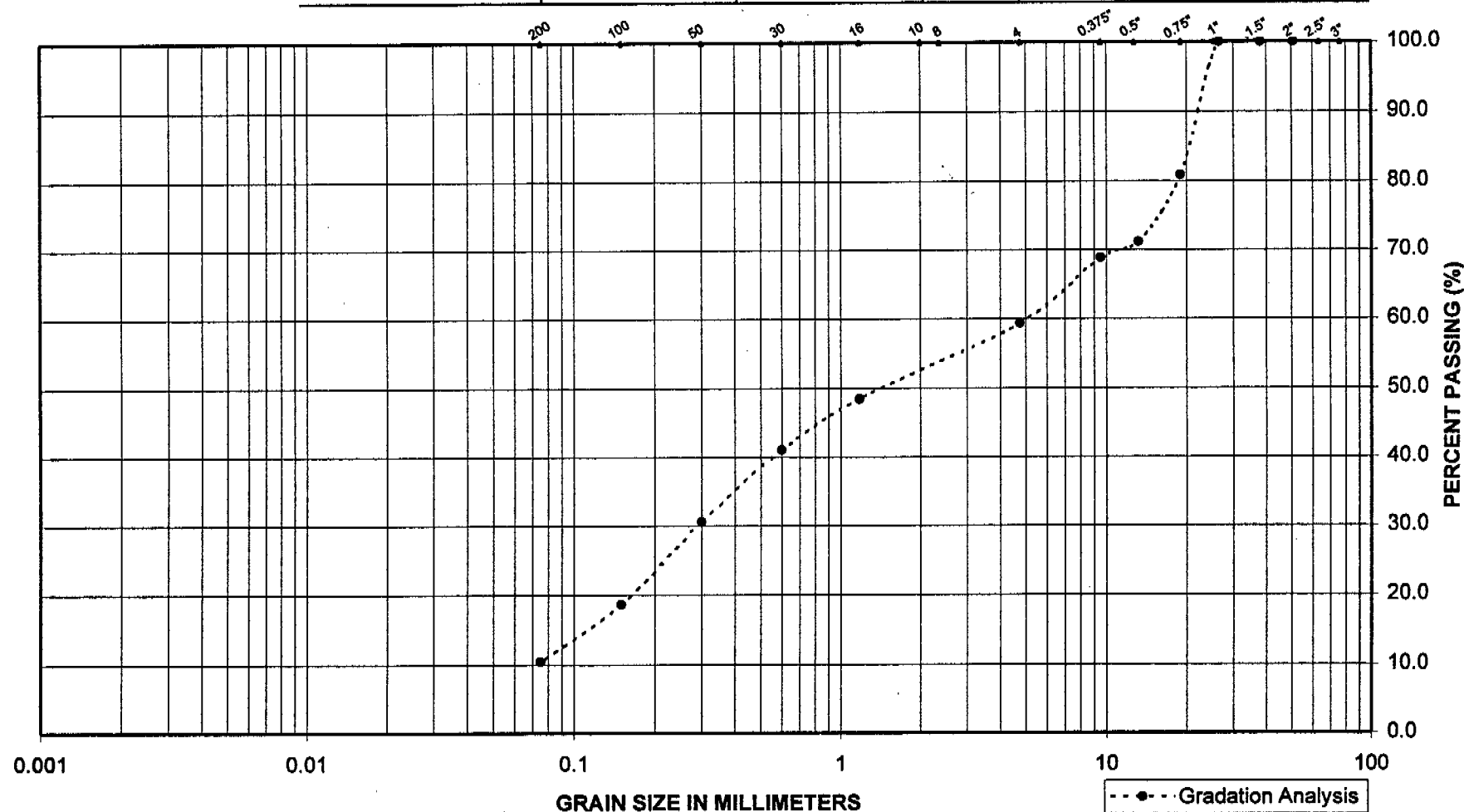
MERLEX ENGINEERING LTD.

W.P. 65-98-00



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



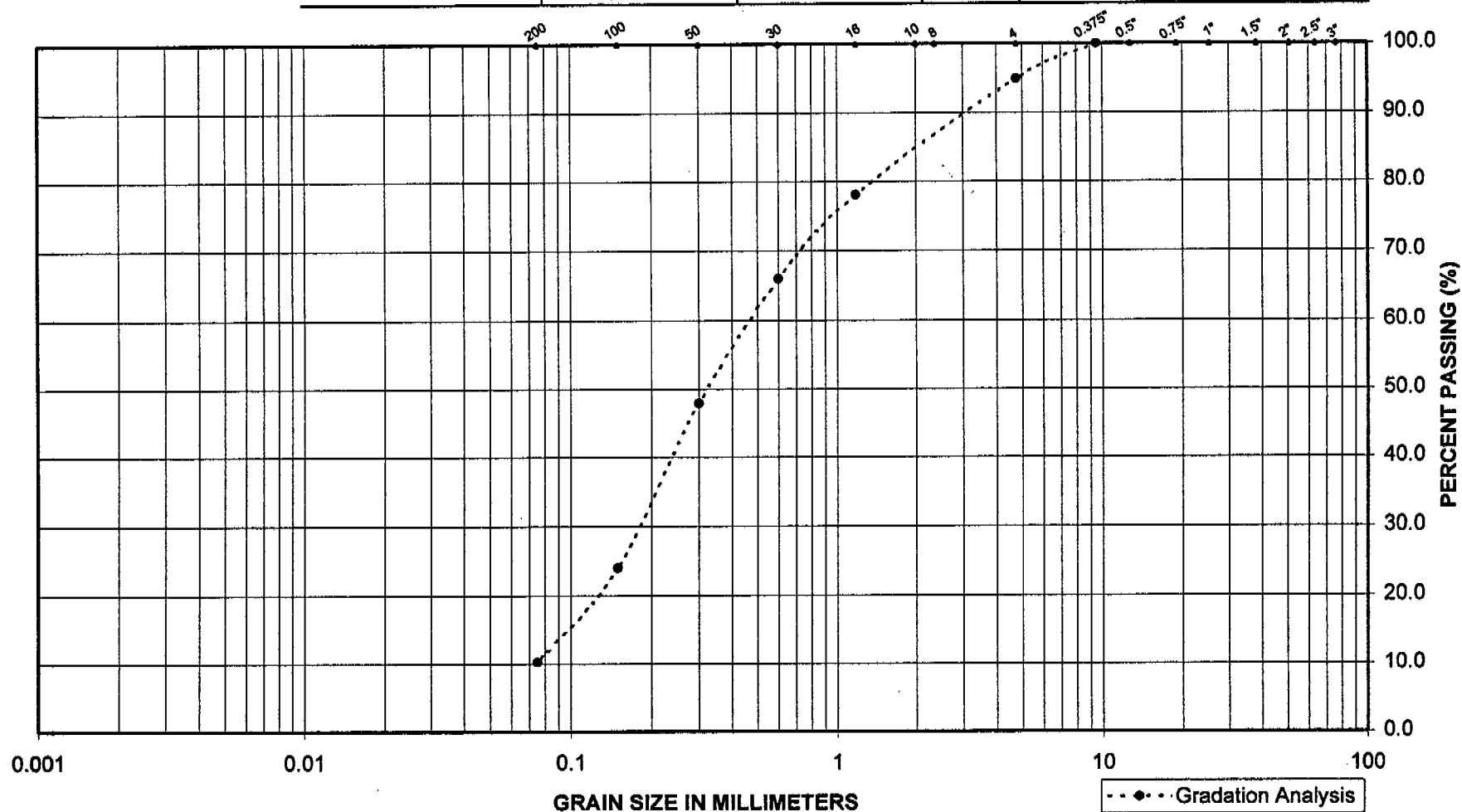
PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 100
 SAMPLE NO.: 5
 DEPTH (m): 4.6 - 5.2

GRAIN SIZE DISTRIBUTION



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



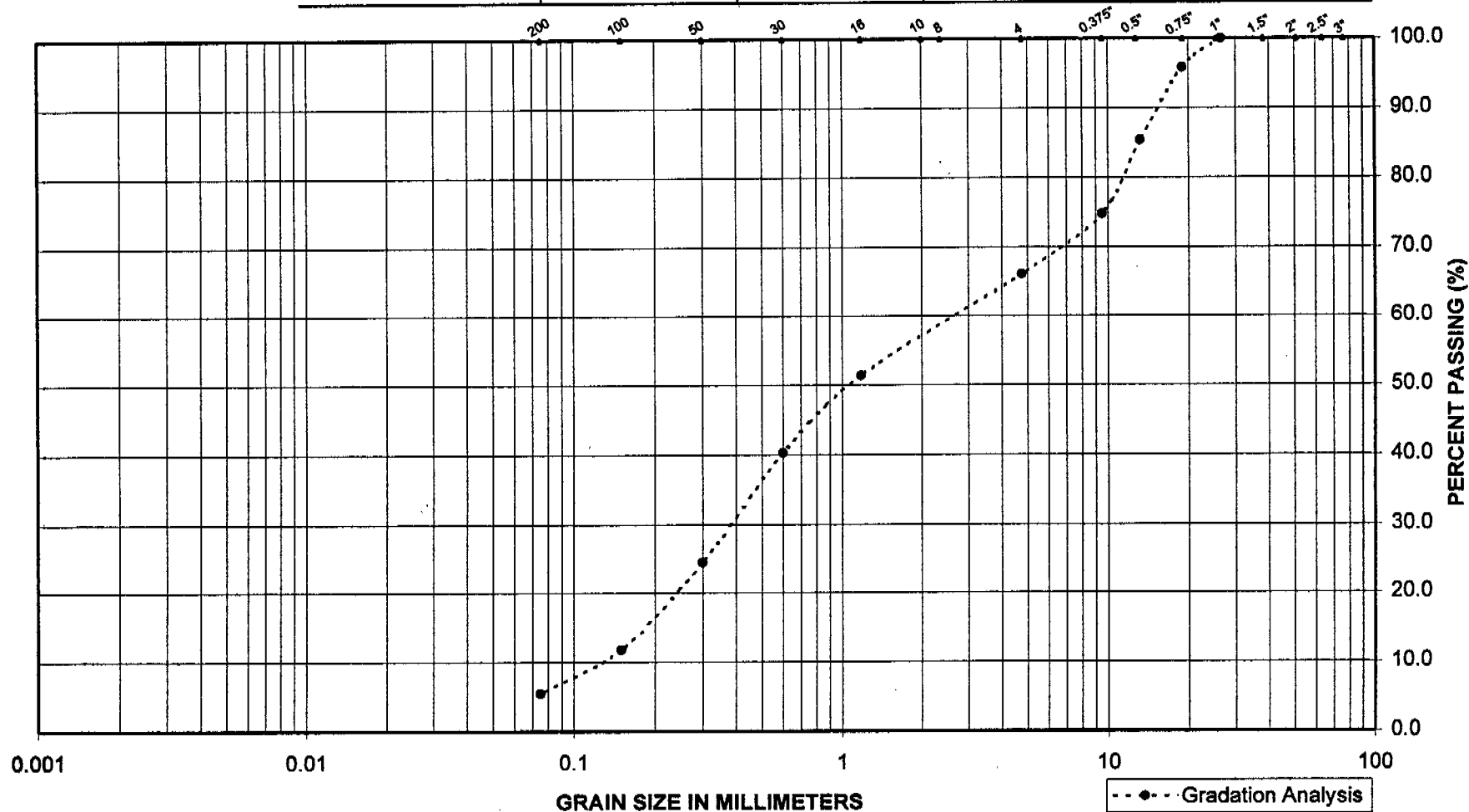
GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 100
 SAMPLE NO.: 6
 DEPTH (m): 6.1 - 6.7



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



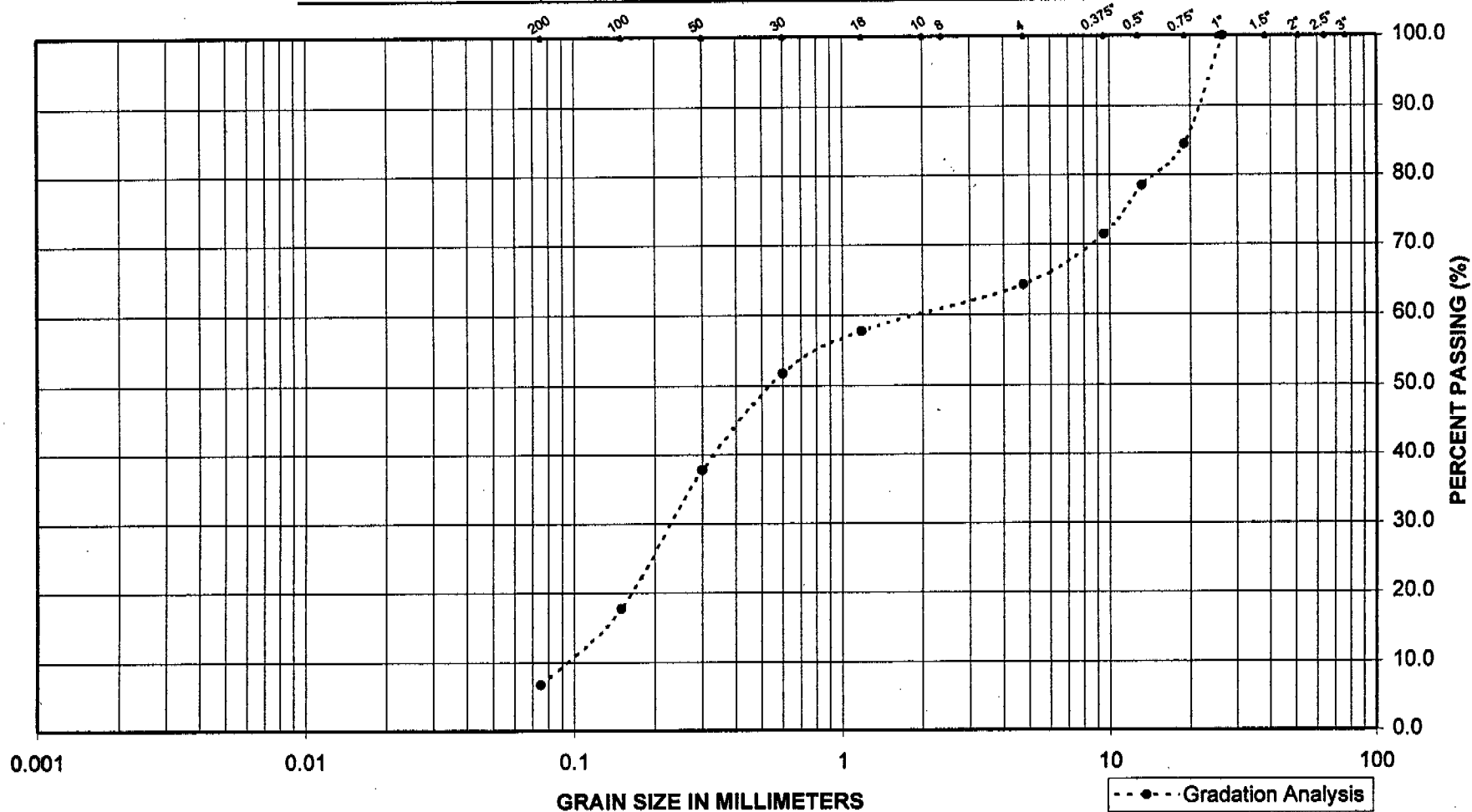
PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 101
 SAMPLE NO.: 1
 DEPTH (m): 0.75 - 1.2

GRAIN SIZE DISTRIBUTION



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



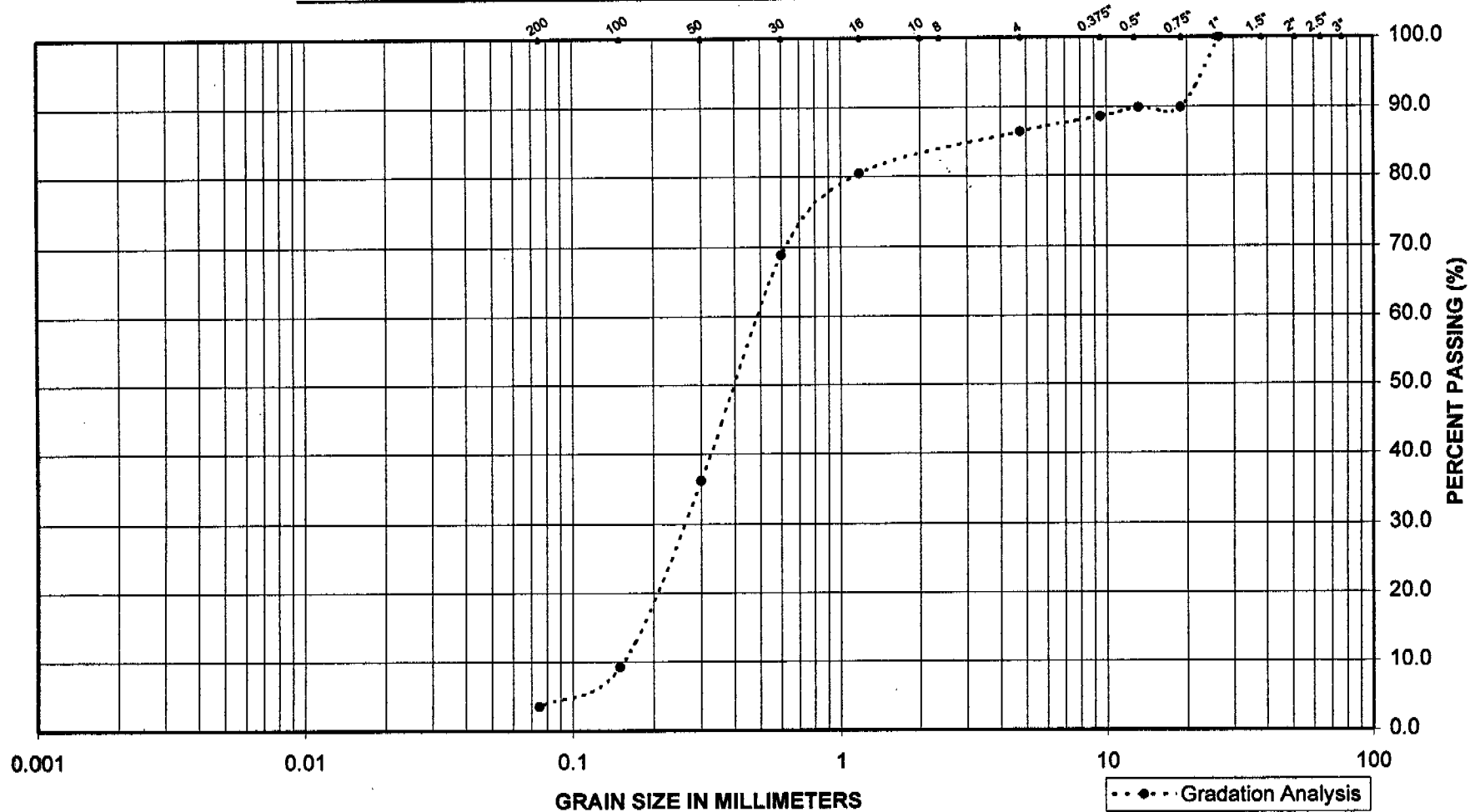
GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 101
 SAMPLE NO.: 3
 DEPTH (m): 2.3 - 2.4



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



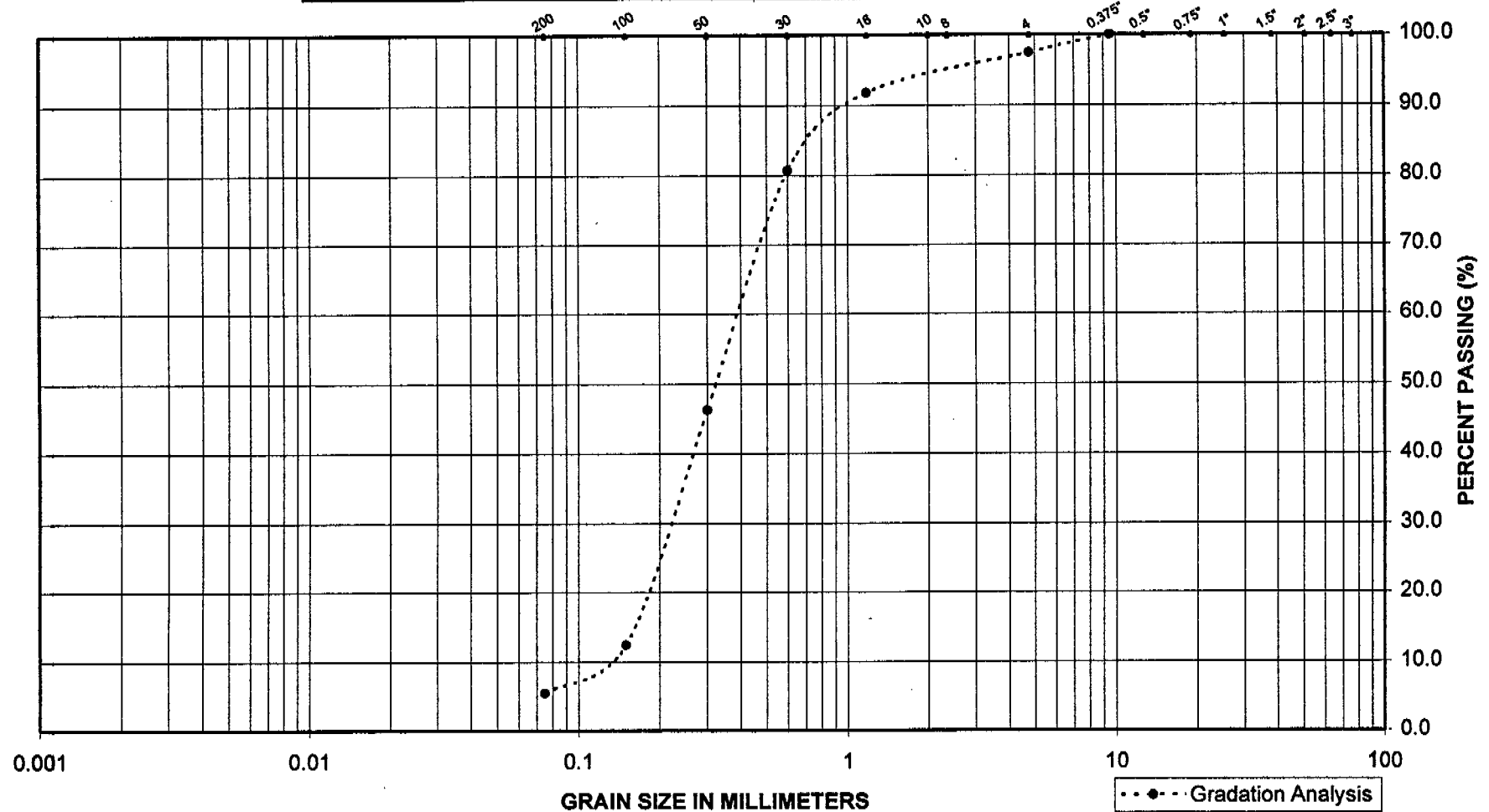
GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 102
 SAMPLE NO.: 2
 DEPTH (m): 0.75 - 1.2



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 102
 SAMPLE NO.: 3
 DEPTH (m): 1.5 - 2.1

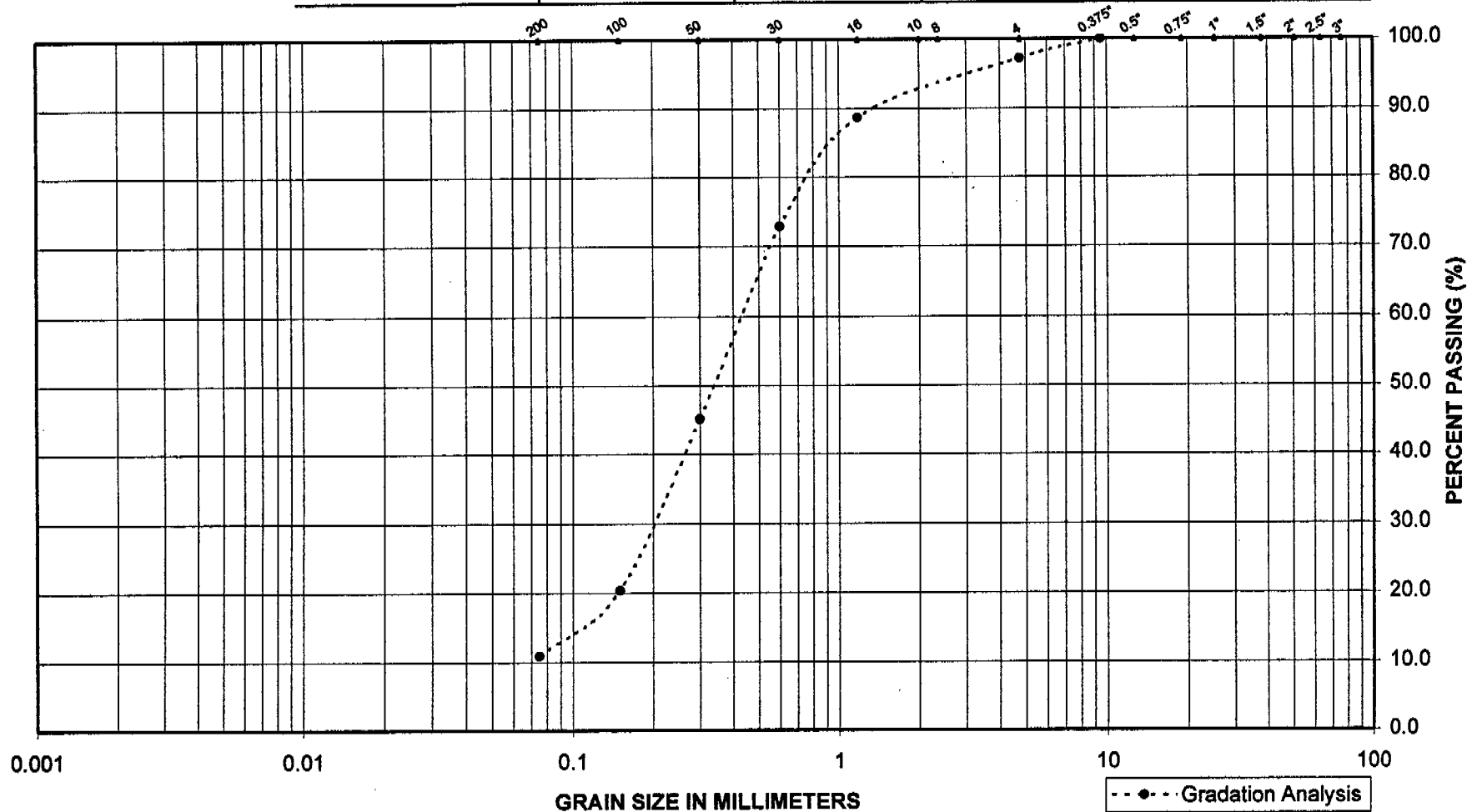
MERLEX ENGINEERING LTD.

W.P. 65-98-00



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 102
 SAMPLE NO.: 5
 DEPTH (m): 3.0 - 3.5

GRAIN SIZE DISTRIBUTION

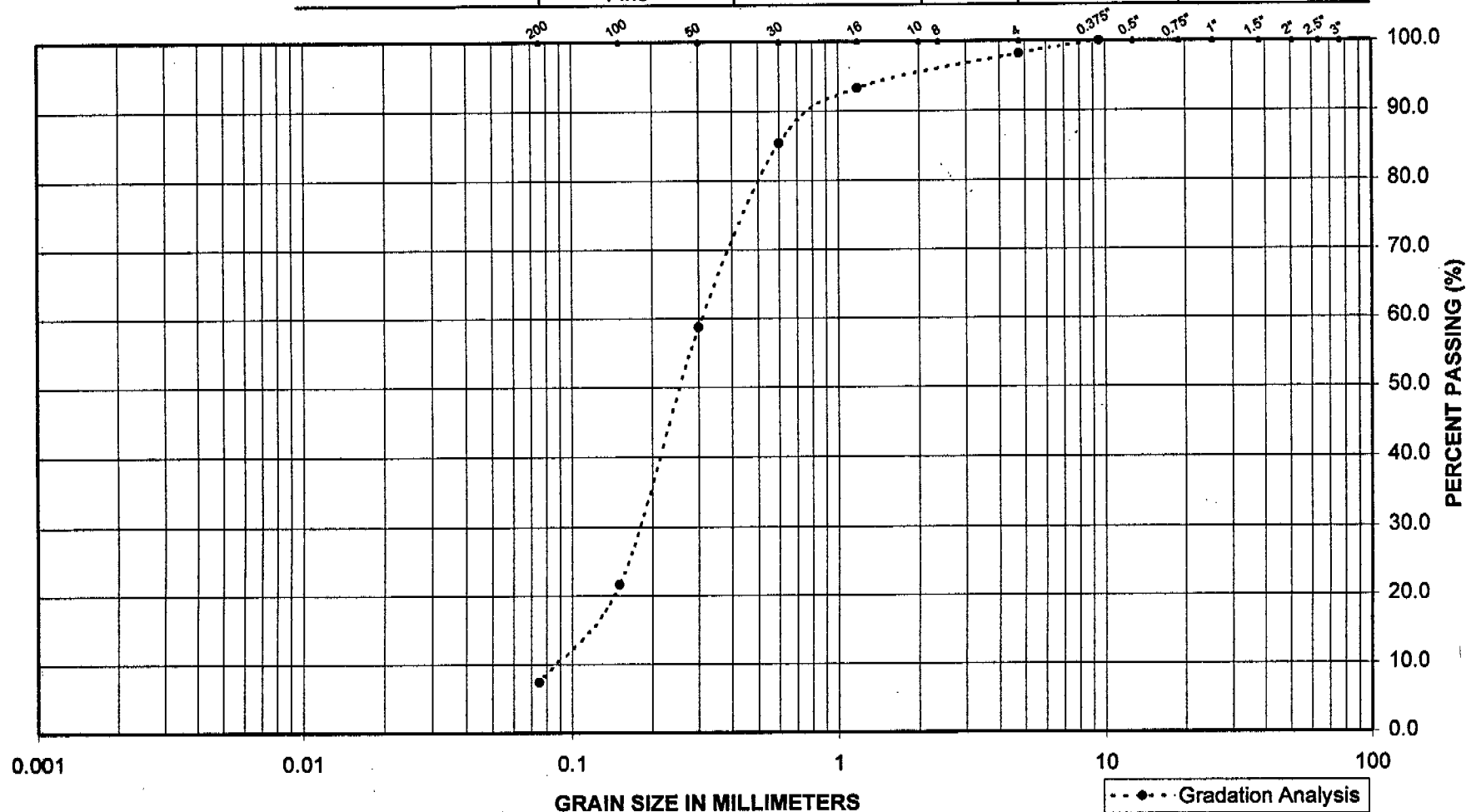
MERLEX ENGINEERING LTD.

W.P. 65-98-00



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



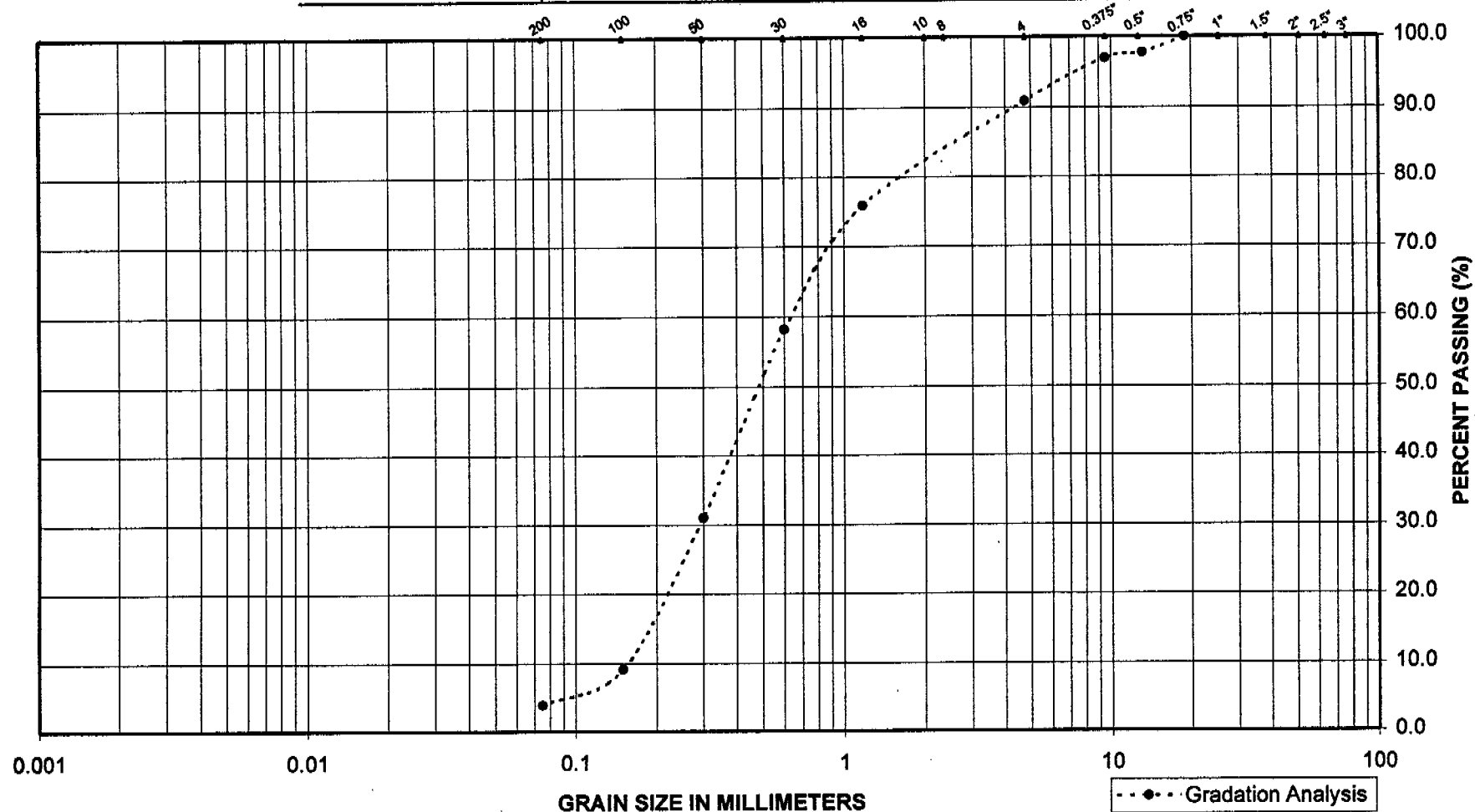
GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 102
 SAMPLE NO.: 6
 DEPTH (m): 4.6 - 5.2



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



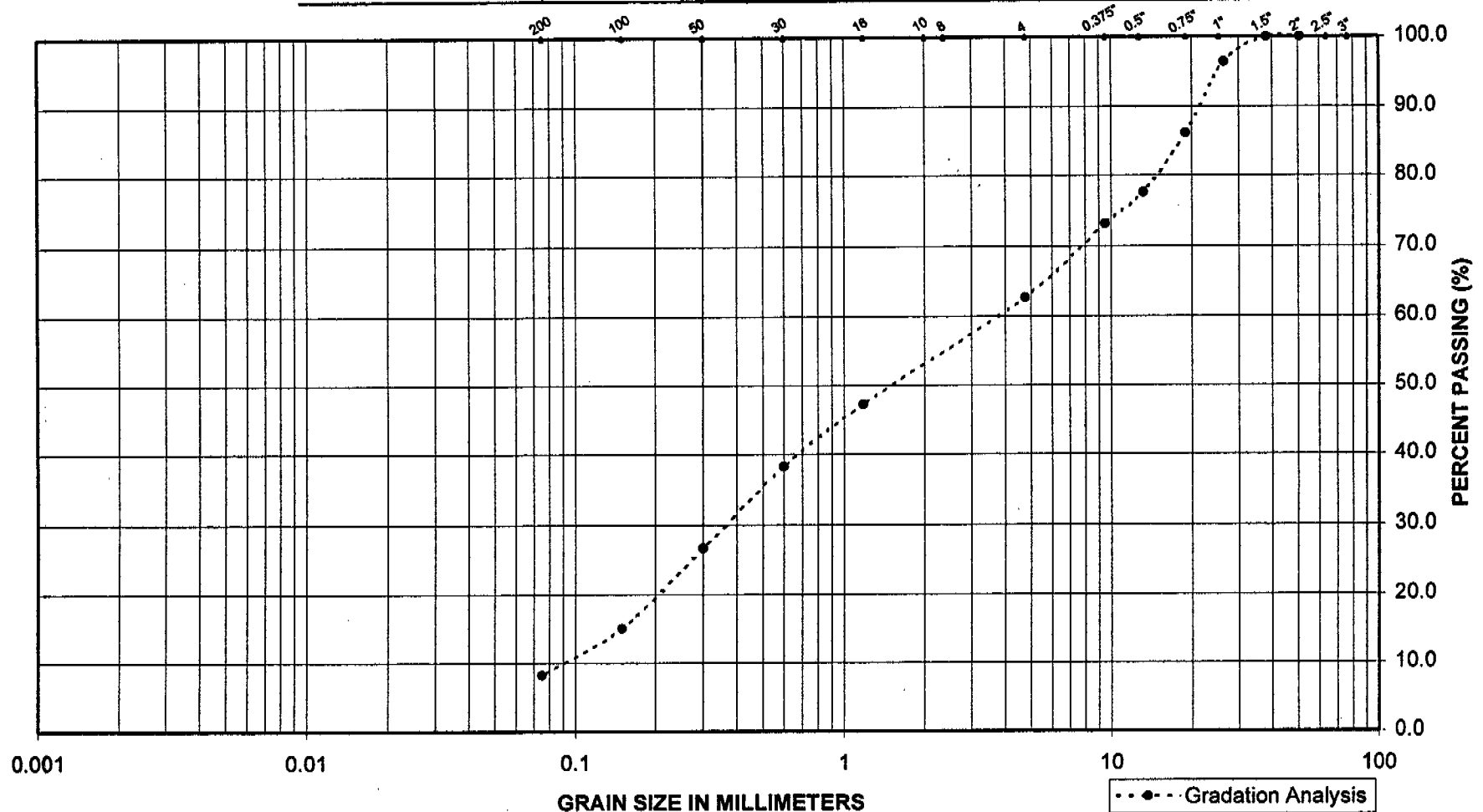
GRAIN SIZE DISTRIBUTION

PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 103
 SAMPLE NO.: 1
 DEPTH (m): 0.15 - 0.75



UNIFIED SOIL CLASSIFICATION SYSTEM

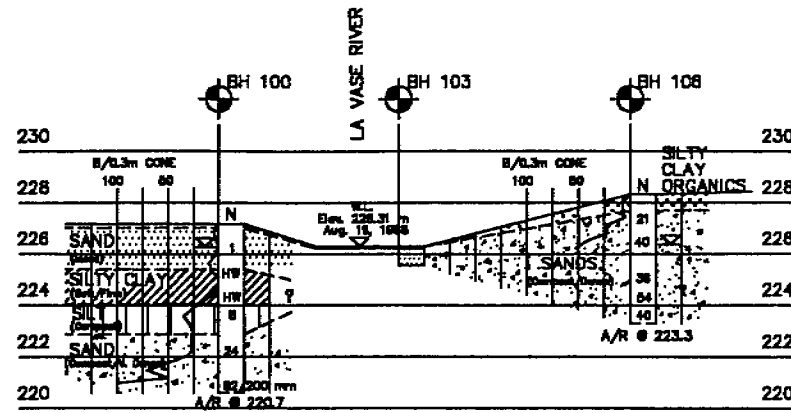
CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



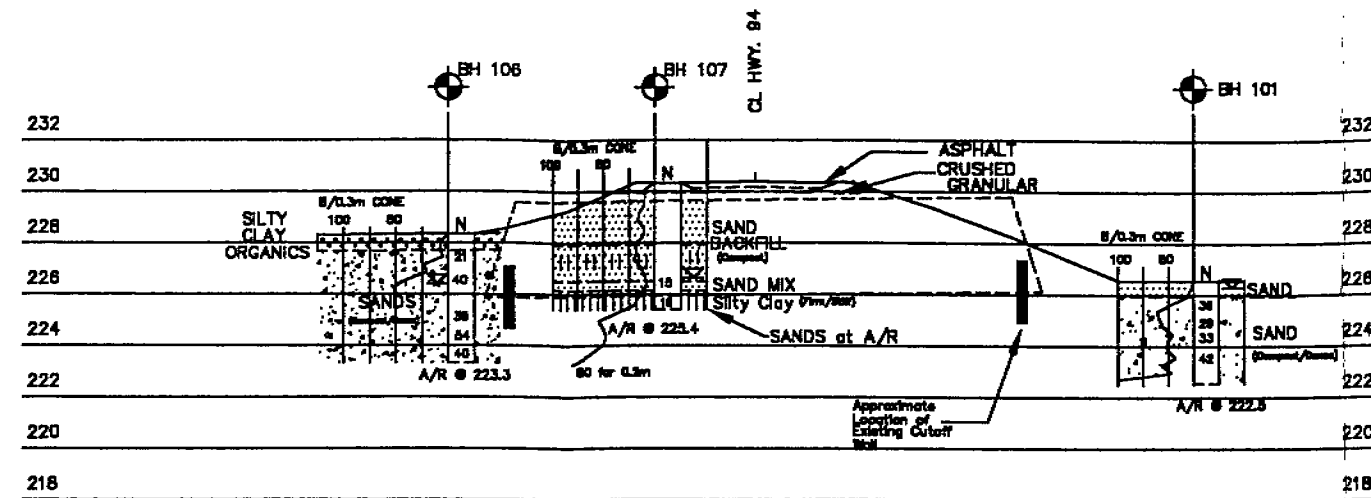
PROJECT: Hwy 94
 LOCATION: Lavase River
 BOREHOLE NO.: 104
 SAMPLE NO.: 6
 DEPTH (m): 5.6 - 6.1

GRAIN SIZE DISTRIBUTION

SECTION A - A



EAST PROFILE



CONT NO.
W.P. NO. 65-98-00

HWY 94
FOUNDATION INVESTIGATION
BOREHOLE LOCATIONS
AND SOIL STRATA

SHEET

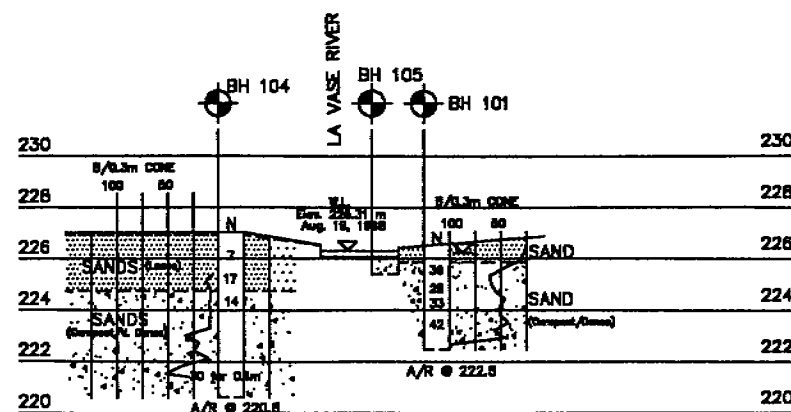


LEGEND

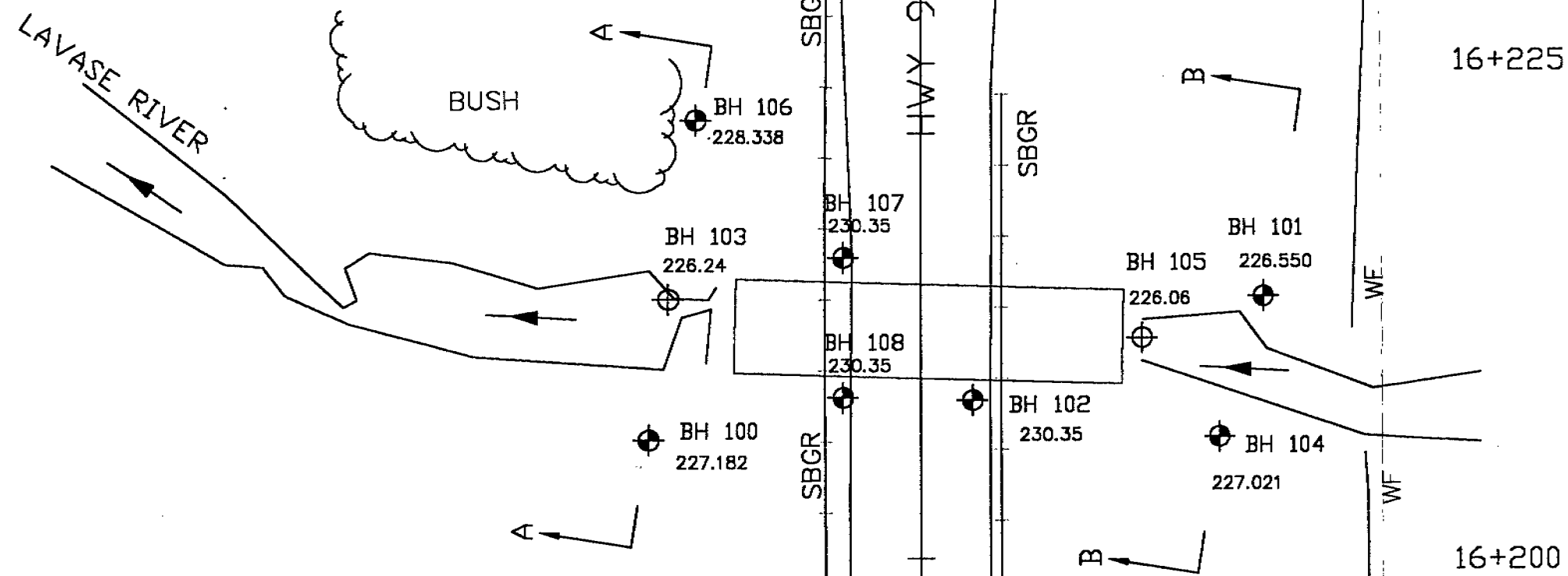
- Borehole and Dynamic Cone Penetration Test
- Borehole
- N Blows/0.3 m
- Water Level at Time of Investigation
- A/R Auger Refusal at Elevation

No.	Elev.	Co-ordinates	
		North	East
100	227.182	5124357.637	319971.033
101	226.350	5124331.714	319989.242
102	230.350	5124343.236	319978.967
103	226.24	5124359.365	319977.912
104	227.021	5124331.168	319981.852
105	226.06	5124336.661	319983.028
106	228.338	5124361.415	319986.757
107	230.350	5124331.668	319983.252
108	230.350	5124348.987	319976.786

SECTION B - B



PLAN

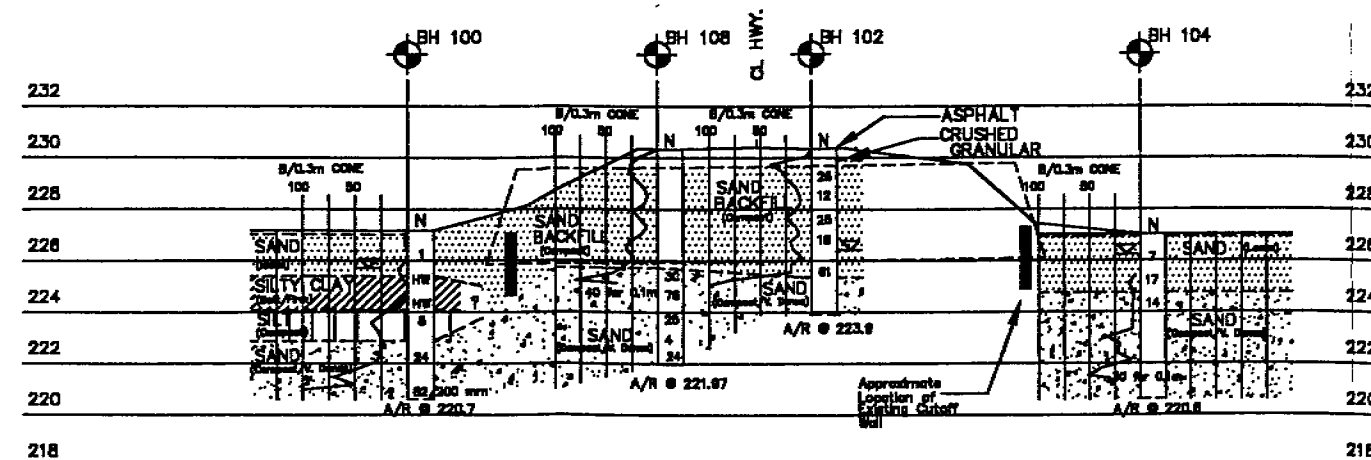


SCALE



NOTE 1:
The boundaries between soil strata have been established at the borehole locations only. The boundaries between boreholes are assumed based on borehole data.

WEST PROFILE



MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

PROJECT: HWY. 94, Culvert Investigation

REFERENCE NO: 98058F

DATE: Nov. 11, 1998

DRAWN BY: JRB

CHECKED BY: MAM