

memorandum



To: Mr. J. McDougall, P.Eng.
Head, Geotechnical Section
Northern Region

Date: 1993 01 14

Att: Mr. H. Pattenden
Pavement and Design Evaluation Officer

From: Foundation Design Section
Room 315, Central Building
Downsview, Ontario

Re: Hidden Valley Road Realignment
Highway 60, From Highway 11 to Hidden Valley Road
W.P. 438-90-00
Northern Region
District 11, Huntsville

The attached report provides recommendations for the proposed realignment of Hidden Valley Road between Stations 10+180 and 10+325, to be located, along Highway 60, near the eastern limits of the Town of Huntsville, within the District of Muskoka.

Although, we believe that this report will be adequate for your purposes, should you have any questions regarding its content, please do not hesitate to contact this office.

John A. Blair

J. A. Blair, P.Eng.
Project Foundation Engineer

For

D.H. Dundas, P.Eng.
Sr. Foundation Engineer

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Geocres No 31E-114

FOUNDATION INVESTIGATION REPORT
For
Hidden Valley Road Realignment
(Stations 10+180 to 10+325)
Highway 60, From Highway 11 to Hidden Valley Road
W.P. 438-90-00
Northern Region
District 11, Huntsville

INTRODUCTION

At the request of the Northern Region Geotechnical Section, a foundation investigation was carried out at the above-captioned site for the proposed realignment of a section of Hidden Valley Road, near the eastern limits of the Town of Huntsville, within the District of Muskoka, Ontario.

This report contains the factual information, obtained from this investigation.

SITE DESCRIPTION

The site is located on the south side of Highway 60, to the northwest of Peninsula Lake, near the eastern limits of the Town of Huntsville, within part of Lots 30 and 31, Concession II, Chaffey Township, District of Muskoka.

Hidden Valley Road presently intersects Highway 60 at Station 18+300, approximately 1.9 km east of Muskoka Road 23 (ie. Canal Road). This two-lane asphalted road presently traverses a series of small hills and is flanked by wooded areas, on both sides. Some of the existing asphalt shows longitudinal and alligator cracking.

This investigation covers a portion of the area where Hidden Valley Road is to be realigned. The area of interest, which is located to the south of the existing road, is surficially covered by peat with numerous dead or dying, moss-covered trees and stumps. The water table is at or close to the ground surface and drainage is generally to the southwest; ie. towards Peninsula Lake.

PROCEDURES

The fieldwork for this project was carried out during the period between July 20 to 23, 1992 and consisted of 7 sampled boreholes (Boreholes 2, 5, 7 and 9 to 12), which were advanced to depths of 5.9 to 10.7 m, using continuous flight, solid or hollow stem augers driven by a bombardier-mounted drilling rig, equipped with standard soil sampling equipment.

Standard penetration tests were carried out at frequent intervals of depth in the boreholes (ie. intervals of 0.8 to 1.5 m) in order to obtain soil samples and to measure the penetration resistances (or 'N'-values) of the soil. 'N'-values represent the number of blows required to drive a standard split spoon sampler a distance of 0.3 m (1') using a 63.6 Kg (140 lb) hammer falling a distance of 0.76 m (30"). Such values were used to assess the consistency or compactness conditions of the various soil strata encountered.

Samples of relatively undisturbed soft, cohesive soils were also obtained by pushing thin walled steel tubes (ie. Shelby tubes) into the soil.

Dynamic cone penetration tests were carried out adjacent to each of the seven boreholes. Cone tests, often supplemented by auger probing with selective sampling, were also carried out at the remaining locations (Boreholes 1, 3, 4, 6 and 8).

The locations of the boreholes, cone tests and auger probings are shown on Drawing No. 4389000A.

Groundwater levels were measured in the open boreholes, immediately upon completion of sampling.

The boreholes were staked out in the field by a representative of this office. The locations and elevations of the boreholes were determined by the Northern Region Surveys and Plans Office, upon completion of the investigation.

The soil samples, were examined in the laboratory by visual and tactile methods. Moisture content, Atterberg Limits, Unit Weights and Grain Size Distribution tests were carried out on selected soil samples. A consolidation test was also conducted on a sample obtained from a cohesive layer. The results of the laboratory testing are shown on Figures 1 to 5 and the borehole logs at the back of this report.

SUBSURFACE CONDITIONS

The subsurface conditions at the boreholes generally consist of a layer of organic materials, up to 5.6 m thick, which is underlain by 2.0 to 3.7 m of clayey silt to slightly plastic silt.

At most locations, a layer of cohesionless sandy silt to sand is sandwiched between the clayey silt to slightly plastic silt layer and the bedrock surface. Probable bedrock was encountered in the boreholes and cone tests, at depths of 3.0 to 10.7 m.

The groundwater table was generally found to be at the surface) or to up to 0.3 m (ie. elevations of 332.4 to 332.6 m), beneath the ground surface.

Details of the subsurface information are shown on the borehole logs and Figures 1 to 5 at the back of this report. Brief descriptions of the individual strata and the groundwater conditions encountered in the boreholes are given below.

Granular Fill

Approximately 0.5 m of a brown, gravel fill was contacted at the ground surface in Borehole 1. This material covers the remains of a small dirt track or trail, which traverses a portion of the site.

Organic Material

A layer of dark brown to black organic material, from 0.9 to 5.6 m thick, was encountered beneath the gravel fill at Borehole 1 and at the surface in all but one of the remaining boreholes and probings. The organic material was found to be quite variable across the site. In several locations it was found to be quite fibrous, while at others it was found to contain finely disseminated root fibres and other organics, with occasional pieces of wood.

Moisture contents, which were carried out on several samples of soil obtained from this layer, ranged from a low of 169 percent at Borehole 2 (ie. at the southern fringes of the swampy area) up to 1035 percent where the organic material was found to be the deepest. The moisture content of the samples tested averaged about 657 percent across the site. Such high moisture contents are indicative of very high initial void ratios and compressibilities.

'N'-values, ranged from 0 blows/0.3 m (ie. the split spoon and rods simply sank under their own self-weight) to 2 blows/0.3 m. Field vane tests gave shear strengths of only 6 to 16 (with an average of about 11) kPa. However, the shear strengths may be slightly higher in the root mat lying within about 1.0 m of the surface.

Silty Sand, With Gravel

A thin silty sand, with gravel deposit was encountered beneath the peat at a depth of 1.1 m (or an elevation of 331.5 m) at Borehole 1, and beneath a thin layer (0.3 m thick) of organic material (leaves, wood etc.) at Borehole 12.

A typical grain size distribution test shown on Figure 1, indicates 42 percent sand, 26 percent silt, 26 percent gravel and 6 percent clay-sized particles.

Moisture contents of 9 and 11 percent were measured in two samples and N-values ranged from 8 to 18 blows/0.3 m. This indicates that this deposit is generally loose to compact.

Clayey Silt to Slightly Plastic Silt

At depths of 2.1 to 5.6 m (or elevations of 327.0 to 331.8 m) most of the boreholes (all except Borehole 12, and possibly Borehole 1, at the north and south ends of the site) contacted a grey, clayey silt to slightly plastic silt layer from 2.0 to 3.7 m thick, beneath the organic materials (and the thin silty sand layer, encountered at Borehole 2).

Atterberg limits tests, which were carried out on several samples of soil obtained from this deposit, gave liquid limits and plasticity indices ranging from 20 to 31 (average of 28) and 20 to 24 (average of 22), respectively. Although, some of these soil samples appeared to be somewhat 'sticky', the Atterberg Limits test results, which are shown on Figure 2, indicate that the soils should be classified as CL to ML or clayey silt to silt. The 'stickiness' of the soil and the relatively high plastic limit may possibly be due to some finely disseminated organic material, since at least one of the samples tested was a borderline organic soil.

A grain size distribution test was carried out on a thin till-like pocket of the same deposit, which was encountered in Borehole 11. The results of this test, which are shown on Figure 3, indicate 41 percent silt, 37 percent sand, 18 percent gravel and 4 percent clay-sized particles.

Moisture contents, which were measured in several samples obtained from this deposit, ranged from 34 to 51 (average of 44) percent.

'N'-values, measured in these clayey soils, ranged from 0 to 14 blows/0.3 m and field vane tests gave measured shear strengths ranging from 5 to 52 kPa. These results indicate that the soils of this deposit are generally of soft to stiff consistency.

The results of a consolidation test are shown on Figure 4. These results indicate that the soil has a preconsolidation pressure of 17 kPa, which indicates that it can only be considered normally consolidated. Other results indicate an initial void ratio and compression index of 1.28 and 0.15, respectively.

Sand and Silt to Silty Sand and Gravel

A deposit of sand and silt to silty sand and gravel was encountered in Boreholes 5 to 7, 10 and 11 (and in some of the cone tests, at other locations), at depths of 2.9 to 7.8 m (or elevations of 324.8 to 329.8 m). This deposit extended to the maximum depth explored in these boreholes.

Grain size distribution tests, which were carried out on three samples obtained from this deposit (and shown on Figure 5), show 40 to 58 (average of 46) percent sand, 28 to 39 (average of 31) percent gravel, 12 to 27 (average of 19) percent silt and between 3 and 5 (average of 4) percent clay-sized particles.

Moisture contents, measured in samples obtained from this cohesionless deposit, generally ranged from 11 to 12 (average of 11) percent.

'N'-values measured, during Standard Penetration Testing, ranged from 7 to 19 blows/0.3 m, indicating generally compact conditions in these soils.

It should be noted that a sandy silt layer, about 1.2 m thick, was also found sandwiched between the organic materials and the underlying silty clay, in Borehole 1.

Bedrock

The probable bedrock surface was encountered in the boreholes and dynamic cone penetration tests, at depths of 3.0 to 10.7 m or elevations of 321.9 to 332.8 m.

Outcrops adjacent to the swamp and in the immediate area, indicate that the local bedrock is comprised of a hard, granitic gneiss.

Groundwater Conditions

The groundwater levels measured in the open boreholes, immediately upon completion of sampling, ranged from the ground surface to depths of 0.3 m or elevations of 332.4 to 332.6 m.

DISCUSSIONS AND RECOMMENDATIONS

General

The existing Hidden Valley Road, consists of a two-lane asphalt roadway, which begins about 1.9 km east of Muskoka Road 23 (ie. Canal Road) on the southeast side of Highway 60, at Station 18+315 (approximately). From this point, the existing roadway extends towards the east through undulating topography.

It is proposed to move the intersection of Hidden Valley Road and Highway 60, about 150 m to the southwest. A narrow two lane dirt road, presently exists at this location. The road extends from Highway 60, to the southeast a distance of about 65 m. Beyond this, the road begins to curve south towards several cottages.

It is proposed that the new two lane, asphalt Hidden Valley Road will follow the initial 65 +/- m portion of this existing road and then continue to the southeast over an old existing gravel track, towards a rather large rock ridge. The road will then begin to skirt the bottom edge of this ridge, partially following the gravel track, and, at the same time, curving towards the north. Between Stations 10+180 and 10+325, as the proposed road begins to curve away from the rock ridge, it will begin to traverse a rather extensive swamp. This investigation deals specifically with this area where it is being proposed to construct an embankment up to 2.0 m high.

After the road passes over the swamp, it will then follow a straight line in a north-northeasterly direction, where it eventually intersects the existing Hidden Valley Road, approximately, 160 m to the east of Highway 60.

Foundation Preparation / Embankment Construction

Based on the information which we have obtained from this investigation, it appears that up to 5.6 m of organic material is underlain by other weak soils extending to depths as great as 10.7 m, beneath the swampy area. The excavation and replacement of the organic materials and some of the clayey materials as well as the possibility of 'floating' the roadway over the swamp are considered below.

Subexcavation and Displacement

If continual maintainance requirements are to be minimized, then the removal of the organic materials and partial removal of the underlying clayey silt to silt layer should be carried out using normal excavation methods. Displacement methods would then be used to partially remove any remaining soft soils.

Normal excavation methods should be used to excavate the organic materials and the clayey soils down to an elevation of 326.5 m or to the underlying cohesionless layer (ie. the sand and silt to silty sand and gravel layer) whichever is contacted first in the excavation. Such excavation should be carried out without dewatering.

For stability purposes, in cross section, the backslope of the excavation must be constructed at a minimum of 1:1 from a point vertically below the toe of the slope. However, along the profile, the backslope of the excavation may be constructed as steeply as possible providing the organic materials and clayey soils do not slump into the excavation. It should be noted that, in either case, slopes approaching 2H:1V may be required to prevent slumping.

As the excavation progresses it will be necessary to simultaneously backfill the excavation with rockfill. Therefore, along the profile, there should also be sufficient room at the base of the excavation to create a mud wave ahead of the rockfill to displace as much of the clayey soils as possible.

The excavated soils should be placed far enough away from the excavation edge in order to avoid slope failures and the resulting entrainment of organic material and clayey soils into the rockfill.

Above the original ground surface, the embankment should be constructed with side slopes of 2H:1V.

Even with this method there will be some clayey soils (and possibly some organic soils) left beneath the rockfill and entrained within it, which could result in settlements ranging in the order of 0.3 to 0.6 m.

In order to cause a portion of these post construction settlements to take place, the embankment should be overbuilt by about 1.0 m. The surcharge should remain in place for as long as possible, but preferably for at least 6 months, after which time, the embankment may be bladed off and the slopes flattened to their final grades.

'Floating the Road'

Stability analyses were also carried out to determine if the proposed roadway could be built over the existing swamp as originally proposed.

Based on the field vane tests, carried out within the peat, and the underlying clayey silt to plastic silt, it appears that, a rockfill embankment with 2H:1V side slopes and a 12 m wide mid-height berm, could be constructed over the swamp (by carefully leaving the stumps and root mat intact) and still obtain a reasonable safety factor. The use of lightweight fill was also considered, but it appears that the stability of the embankment will improve only slightly even with a 12 m wide midheight berm.

However, it should be noted, that moisture content tests indicate that the underlying organic material has very high compressibility characteristics and consolidation tests on the underlying clayey silt to plastic silt, indicate that, the soils at this site, are normally consolidated. The potential compressibility of the organic material, at this site, is very high (even higher than most of the organics that have been recently encountered at similar sites, in Muskoka). Total settlements of even a 1.8 m high embankment, placed over such soils are estimated to be very large (ie. about 1.5 m). This, means that a roadway, constructed, over such soils, would experience large initial settlements during the construction period, but more importantly, continual maintainance problems long after construction.

It may be feasible to cause a portion of the post construction settlements to take place. This may be achieved by overbuilding the embankment using an additional 1.0 m of compacted Granular 'A'. Once this initial construction has been completed, the settlement of the embankment should then be allowed to take place over a period of at least a year. During this time, the embankment should be occasionally monitored and the fill 'topped-up' whenever necessary. After a year, the embankment should be bladed off and the slopes flattened to their final grades.

It should be noted, however, that even if the embankment is overbuilt, in this manner, long term settlements will continue to occur and routine maintainance of the roadway will definately be required for many years. For this reason, floating the roadway over the swamp is not recommended.

Excavations

It is expected that, without extensive dewatering, slopes subexcavated in the clayey and organic soils, to depths of up to 6 m, will only be very temporarily stable, even at slopes of 2H:1V. Subexcavation and backfilling can be carried out under water, if necessary.

Fill Placement

Where rockfill must be placed below the groundwater table, the material may be end-dumped.

However, once the fill material is 0.3 m above the groundwater table, placement and compaction should be carried out according to OPSS standards and MTO practice.

MISCELLANEOUS

The field investigation was supervised by R. Freymond under the direction of J. Blair, Project Foundation Engineer, using equipment owned and operated by Atcost Soil Drilling Inc.

The report was written by J. Blair, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



John A. Blair

J. A. Blair, P.Eng.
Project Foundation Engineer

M. Devata

M. Devata, P.Eng.
Chief Foundation Engineer

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/0.3 m)	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_α	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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 826.93 E 333 034.16 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Auger Probe/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 23 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
332.7	Ground Surface													
0.0	Gravel													
332.2	Brown (Fill)													
0.5	Organic Material													
331.3	Dark Brown Soft													
1.4	End of Borehole (Sandy Silt at tip of Auger)													
	Probable Silty Sand to Sandy Silt													
329.7														
3.0	End of Cone Test (Probable Bedrock)													
	Note: • W.L. measured immediately upon completion of sampling													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 842.52 E 333 057.68 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Solid Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 20 CHECKED BY DD

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
332.6	Ground Surface												
0.0	Organic Material Brown Soft		1	SS	1								
331.5			2	SS	6								
1.1	Silty Sand With Gravel, Trace Clay Grey, Loose to Compact ('Till-Like')		3	SS	18								
330.5			4	SS	6								
2.1	Clayey Silt Grey Firm		5	SS	4								
328.0			6	SS	108**								
4.6	Weathered Biotite Gneiss With Sandy Silt Zones Black and Grey (Possible Rafted Bedrock Slab)				60**								
326.7													
5.9	End of Borehole (Probable Bedrock) Notes: • Water level measured immediately upon completion of Sampling ** The samples retained did not appear to be bedrock but possibly a portion of a weathered rafted slab of bedrock sitting on the bedrock surface.												

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 845.22 E 333 077.79 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Auger Probe/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 20 CHECKED BY DD

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	20 40 60			
332.6	Ground Surface													
0.0	Organic Material Dark Brown to Black Soft						332							
331.3														
1.2	End of Borehole						331							
	Probable Clayey Silt to Slightly Plastic Silt						330							
328.5							329							
4.1	End of Cone Test (Probable Bedrock)								120/15cm					

RECORD OF BOREHOLE No 4

1 of 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 849.5 E 333 075.22 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 23 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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								
332.8	Ground Surface												
0.0	Probable Organic Material												
329.7													
3.0	Probable Clayey Silt to Slightly Plastic Silt												
326.3													
6.4	Probable Sandy Silt to Gravelly Sand												
325.0													
7.0	End of Cone Test (Probable Bedrock)							120/13cm					

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 861.1 E 333 089.79 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Solid Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 21 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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								
332.7	Ground Surface												
0.0	Organic Material Dark Brown to Black Soft		1	SS	1								
			2	SS	1								
	Very Fibrous, Contains Wood Chips, Stems, Roots etc.		3	SS	1								
			4	SS	0**								
328.4													
4.3	Clayey Silt to Slightly Plastic Silt Grey Soft		5	SS	0**								
			5A	TW	PH								
326.1													
6.6	Gravelly Sand Brown Loose to Compact		6	SS	19								
			7	SS	51								
324.0													
8.7	End of Borehole (Probable Bedrock) Note: • W.L. immediately upon completion of sampling •• Split spoon and rods sank under their own self-weight.												

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 863.81 E 333 101.24 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Solid Stem Auger COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 23 CHECKED BY DD

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	W _P	W	W _L		
332.7	Ground Surface																
0.0	Organic Material																
	Black																
	Soft																
327.7																	
5.0	Slightly Plastic Silt																
	Grey																
	Soft																
325.5			1	TW	PH											17.6	
7.2	Sand and Silt																
	Brown																
	Loose to Compact																
323.1																	
9.6	End of Borehole (Probable Bedrock)																
	Note: * W.L. immediately upon completion of sampling																

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 874.94 E 333 102.92 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Hollow Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 23 CHECKED BY DD

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							w _p w w _L
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
							WATER CONTENT (%) 20 40 60								
332.6	Ground Surface														
0.0															
			1	SS	2										
			2	SS	1										
			3	SS	0**										
			4	SS	00*										
327.0															
5.6			5	TW	PH										
324.8			6	SS	7										
7.8															
			7	SS	11										
321.9															
10.7	End of Borehole (Probable Bedrock)														
	Note: • W.L. immediately upon completion of sampling ** Split spoon and rods sank under their own self-weight.														

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 867.57 E 333 112.39 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kR_c ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
332.6	Ground Surface										
0.0	Probable Organic Material										
326.5											
6.1	Probable Slightly Plastic Silt										
324.4											
8.2	Probable Sand and Silt										
322.8											
9.8	End of Cone Test (Probable Bedrock)										

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 890.75 E 333 113 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Hollow Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER + CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
332.6	Ground Surface													
0.0														
			1	SS	0 **									
			2	SS	1									
			3	SS	0 **									
			4	SS	0 **									
327.3														
5.3			5	SS	0 **									
			6	TW	PH									
			7	SS	12									
323.6														
9.0	End of Borehole (Probable Bedrock)													
	Note: • W.L. immediately upon completion of sampling ** Split spoon and rods sank under their own self-weight.													

RECORD OF BOREHOLE No 10

1 of 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 905.87 E 333 128.74 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Hollow Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
332.6	Ground Surface													
0.0	Organic Material Dark Brown to Black Soft		1	SS	0 **		332							
			2	SS	0 **		331							
			3	SS	0 **		330							
327.4	Slightly Plastic Silt Grey Soft		4	SS	0 **		329							
5.2			5	TW	PH		328							
325.4	Silty Sand and Gravel Grey Compact		6	SS	11		327							
7.2							326							
324.7							325							
7.9	End of Borehole (Probable Bedrock) Note: • W.L. immediately upon completion of sampling •• Split spoon and rods sank under their own self-weight													

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 927.36 E 333 124 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Solid Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
332.7	Ground Surface													
0.0	Organic Material Dark Brown to Black Soft													
331.8														
0.9	Sandy (Till-Like)		1	SS	7									4 37 41 18
	Clayey Silt to Slightly Plastic Silt Grey Firm to Stiff		2	SS	7									
397.1			3	SS	14									
329.4	Silty Sand, Some Gravel Grey, Dense		4	SS	50	/13cm								27 41 27 5
3.3	End of Borehole (Probable Bedrock)													
	Note: • W.L. measured immediately upon completion of sampling													

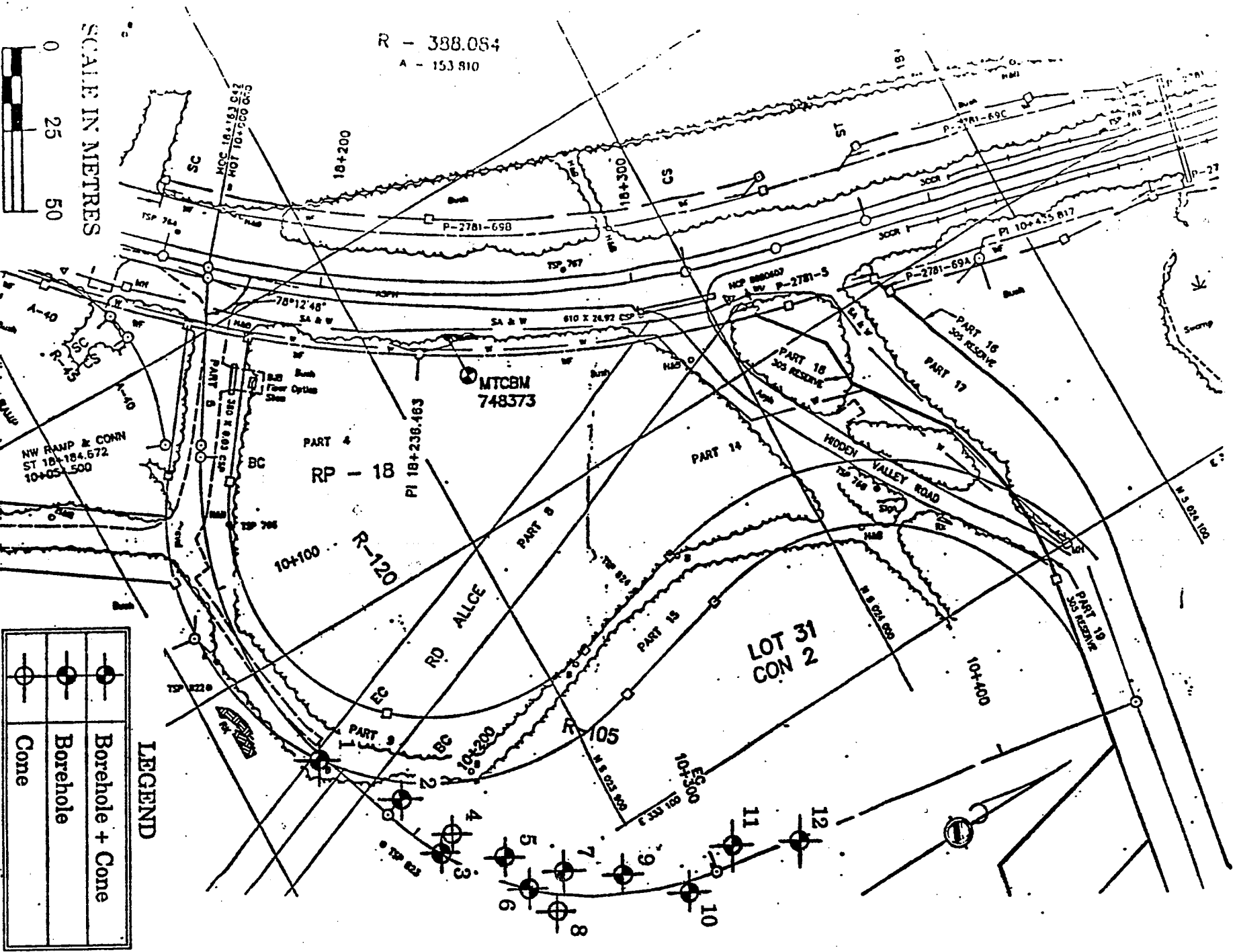
RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 438-90-00 LOCATION N 4 523 945.53 E 333 134.34 ORIGINATED BY RF
 DIST 11 HWY 60 BOREHOLE TYPE Solid Stem Auger/Cone Test COMPILED BY RF/JB
 DATUM Geodetic DATE 92 07 23 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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								
333.9	Ground Surface												
0.0	Wood, Leaves etc.		1	SS	8	DRY *							
332.8	Silty Sand, Some Gravel Yellowish Brown Loose to Dense		2	SS	46		333						
1.1	End of Borehole (Probable Bedrock)												
	Note: * W.L. measured immediately upon completion of sampling												



R - 388.054
A - 153.810

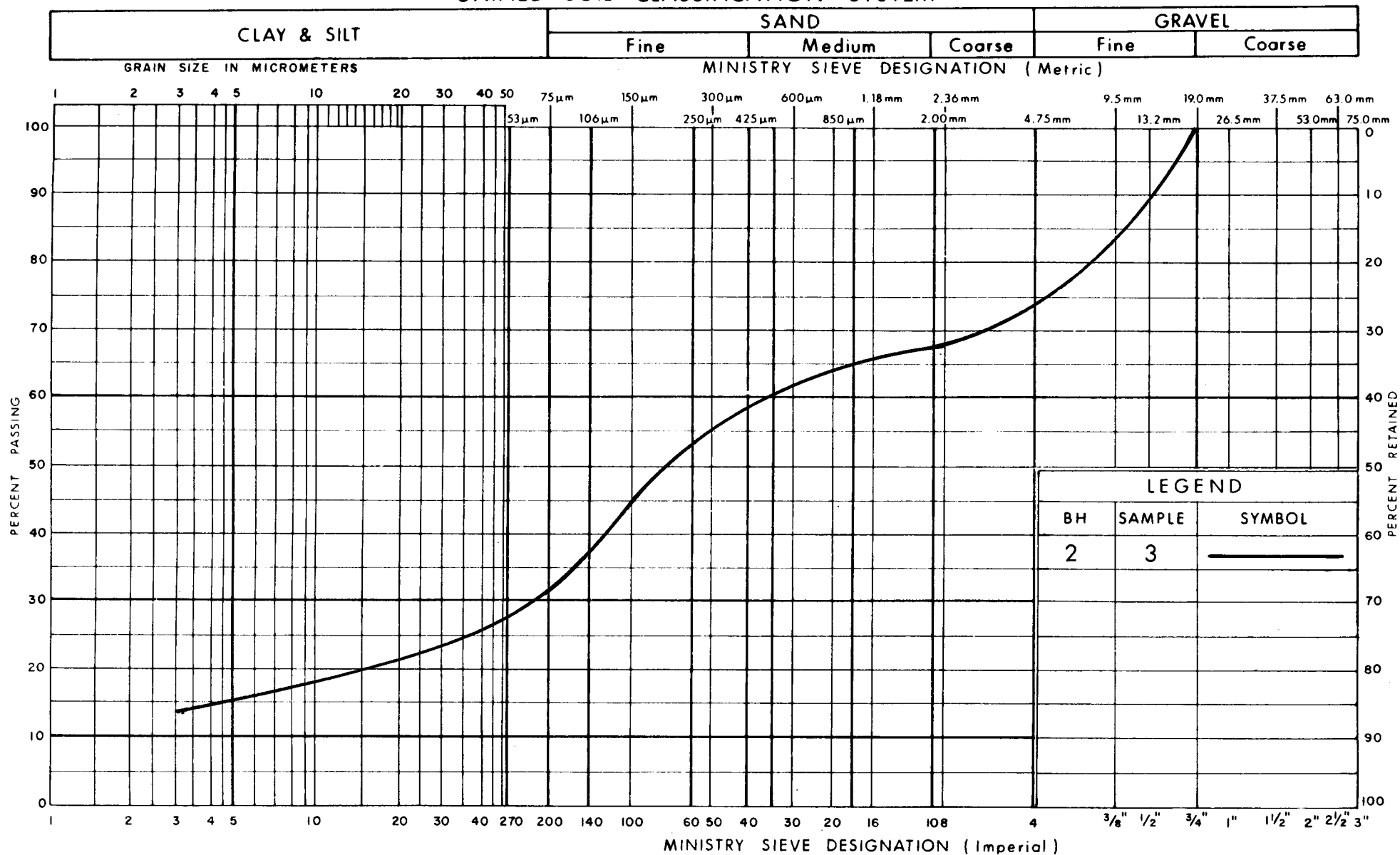
SCALE IN METRES



LEGEND

	Borehole + Cone
	Borehole
	Cone

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SILTY SAND WITH GRAVEL

FIG No 1

W P 438-90-00

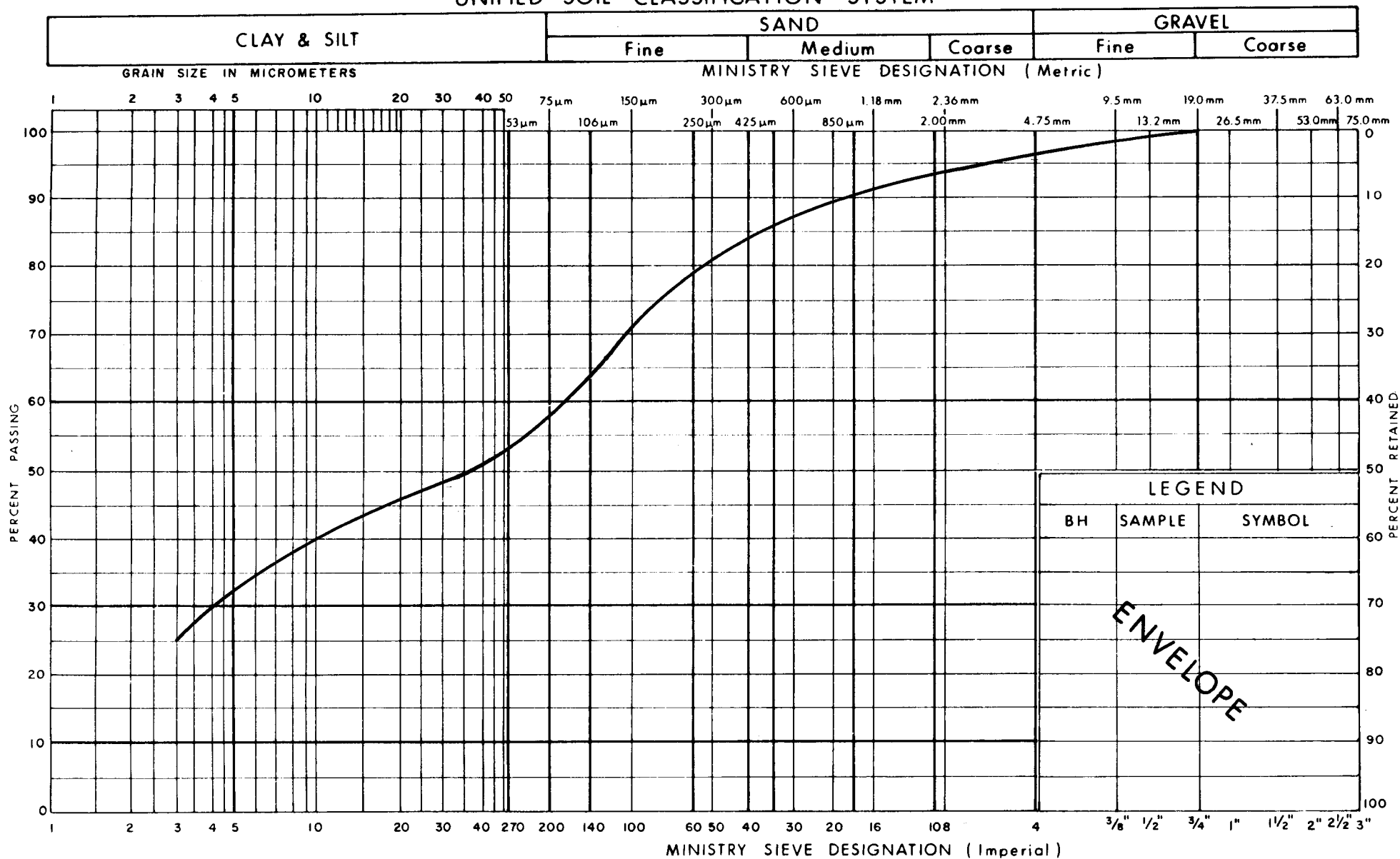


PLASTICITY CHART

CLAYEY SILT TO SLIGHTLY PLASTIC SILT

W P 438-90-00

UNIFIED SOIL CLASSIFICATION SYSTEM



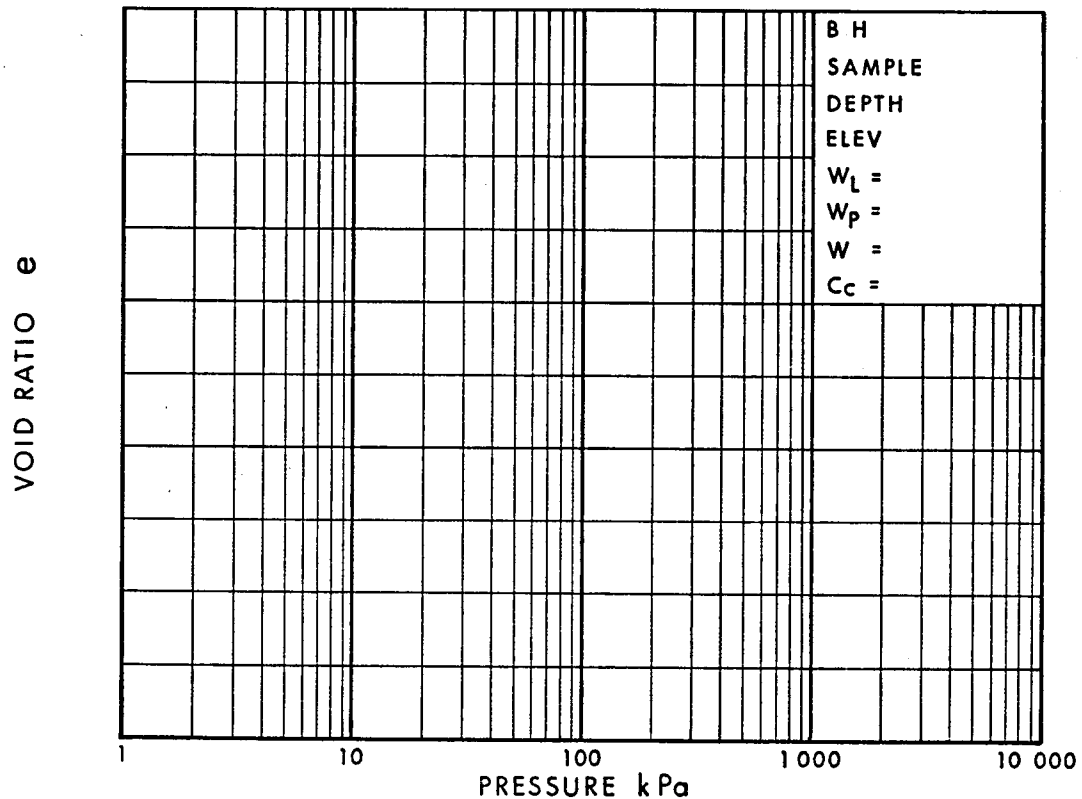
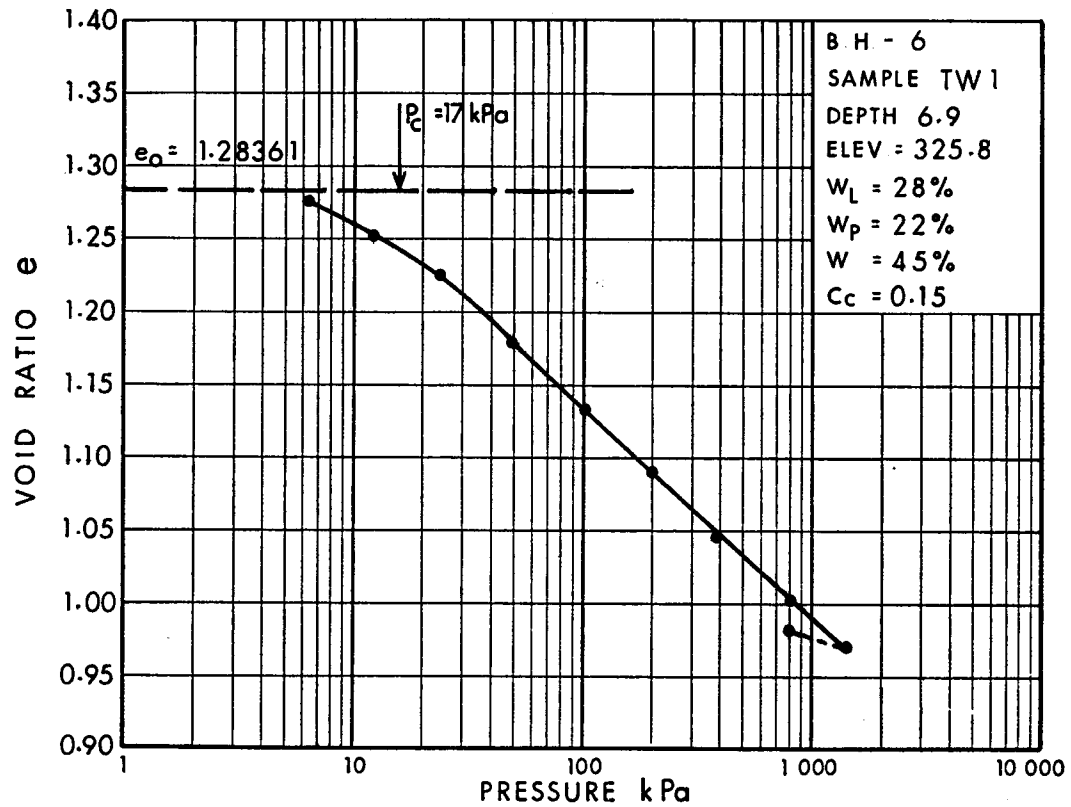
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SLIGHTLY PLASTIC SILT
 ('TILL LIKE')

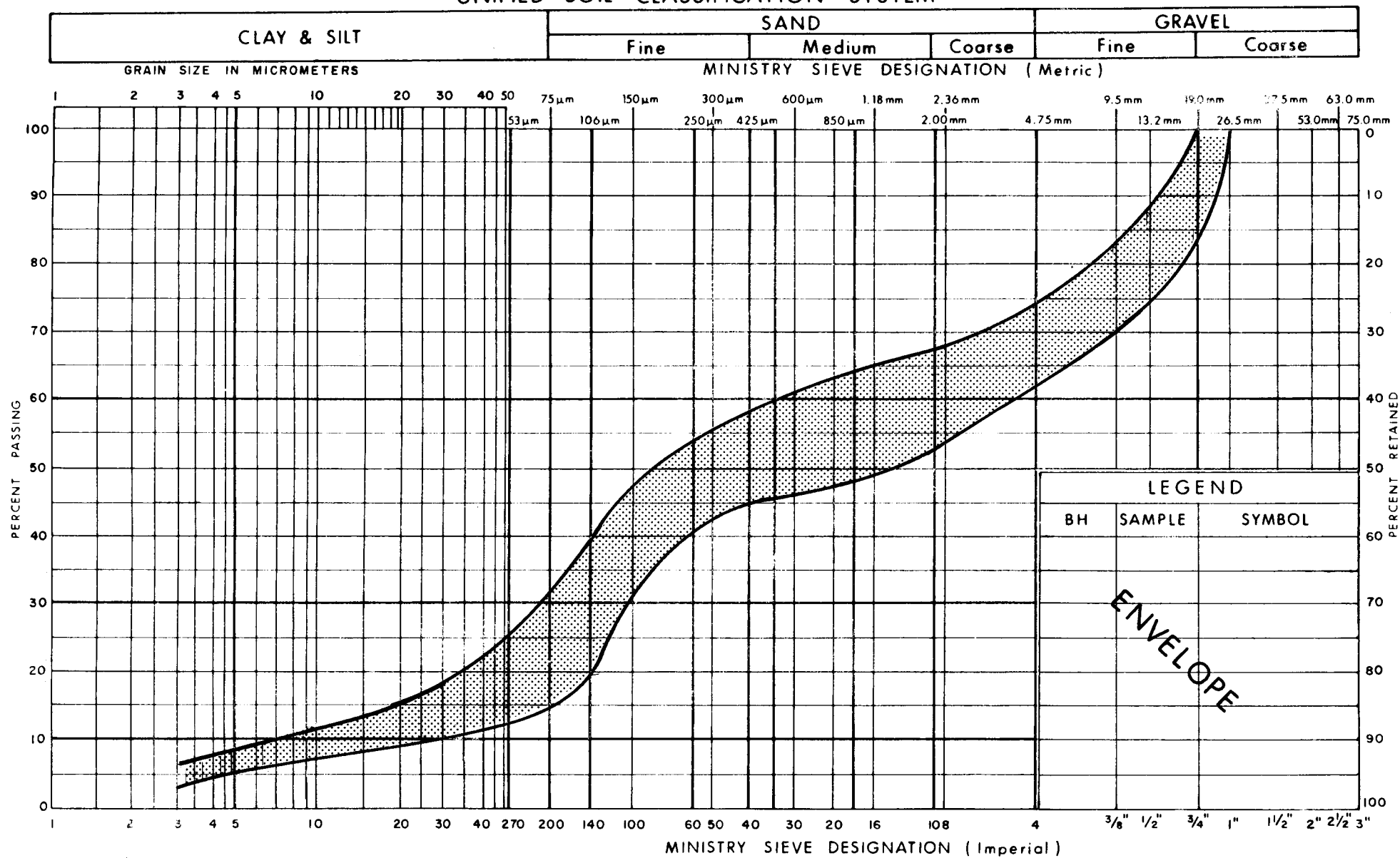
FIG No 3

W P 438 -90 - 00

VOID RATIO - PRESSURE CURVES



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND & SILT TO SILTY SAND & GRAVEL

FIG No 5

W P 438-90-00