

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 42D-21
42D-15

DIST. 18 REGION

W.P. No. 195-87-01

CONT. No.

W. O. No.

STR. SITE No. 48E-46C

HWY. No. 17

LOCATION Hwy 17 & McKellar Creek

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



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CLAY - 7.8
SAND 12.6
18.6

FILE No. _____ DATE _____

REMARKS _____

SURVEYS - FAX 473-2167 (CRYSTAL)

MNR (DUNCAN MACKAY) 825-3205

FAX 825-9318

DOMINION SOILS INVESTIGATIONS

605 HEWITSON STREET

1



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FOUNDATION DESIGN SECTION

foundation investigation and design report

**ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION**

WP 195-87-01(C)
HWY 17

DIST 61
STR SITE 48E-46C

Highway 17 and McKellar Creek

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FOUNDATION INVESTIGATION REPORT
FOR
Hwy 17 and McKellar Creek
WP 195-87-01(C), Site No. 48E-46C
District 61, Thunder Bay
Northwestern Region

Introduction

This report summarizes the results of the Foundation Investigation carried out at the above site between 95 02 28 and 95 03 01. The investigation was conducted at the request of the Northwestern Planning and Design Section for a proposed replacement of the existing two cell timber culvert.

Soils investigations previously conducted during August 90 and April 91 along an alternative alignment indicated poor foundation conditions requiring large excavations. Due to high expenditures the project had been reassessed with this report addressing the alternative proposal of a new culvert being placed approximately 3 m west of the existing structure along the existing alignment. It is proposed to replace the timber box culvert with a new 3 m diameter CPCSP steel culvert. The replacement culvert is proposed to be constructed within the existing rock fills. As excavations within the native material undesirable it is planned to limit the construction of the culvert within the area of the existing rockfill embankment. Utilization of a retained earth system with gabion walls has been suggested and is reviewed in this report. In order to minimize the effect on traffic flow two detour options are proposed. The first consists of a Bailey bridge resting within the existing rock fills on a timber grillage system. The second is a 5 - 10 m high detour embankment constructed approximately 55 m north of the existing Hwy. 17 location.

Site Description

The site is located at McKellar Creek along Hwy. 17 approximately 34.5 km east of Terrace Bay in the Township of Walsh, District of Sault Ste. Marie. The existing culvert is a tie crib with little bracing with 2 m x 2 m boxes. The culvert has shown signs of distress as its ceiling is failing and its shape has been distorted. The existing embankment is approximately 6 m high with a gradient of 1.25:1. The area is undulating and heavily vegetated with trees. To the north of Hwy. 17 a swampy flood region exists. The creek is located in a valley with bedrock outcrops at its crests. According to the Geological Map S265 in Ontario Geological Survey Report GR 164, the site consists largely of deposits of varved or massive Clay and Silt and bare bedrock.

Investigation Procedures

The field investigation for this project was conducted between 95 02 28 and 95 03 01 and consisted of two samples boreholes accompanied by Dynamic Cone Penetration Tests. Boreholes are located at the toe on each side of the Highway embankment. Due to

access problems both boreholes had to be relocated slightly away from the exact culvert location.

A continuous flight track mounted drilling machine equipped with Hollow Stem Augers was used to auger the boreholes. A Bull Dozer was employed to help gain access to each location by clearing the way and winching the drilling unit in and out of the valley.

Standard Penetration Tests were conducted utilizing split spoon samplers at 1.5 intervals with additional samples taken near the surface. In-situ field vane tests were conducted with the cohesive deposits together with undisturbed thin wall samples taken for consolidation testing. Boreholes were terminated at depths of 21.6 m and 23.2 m with rock core samples of the bedrock surface obtained. Dynamic cone tests reached refusal at depths of 19.8 m and 20.1 m.

Groundwater levels were measured in open boreholes. All boreholes were backfilled upon completion of the fieldwork.

Surveying required to ascertain borehole locations and elevations were carried out by the Northwestern Regional Surveys and Plans Section.

The laboratory testing on selected soil samples consisted of the following:

- Grain Size Distribution
- Natural Moisture Content
- Atterberg limits
- Unit weight determination
- Consolidation Testing

Laboratory results are given in the following section of this report and are illustrated on the Record of Borehole Sheets in the appendix.

Subsurface Conditions

The subsurface stratigraphy confirmed the results of the previous investigations with it comprising of a 7.1 m thick Silty Clay to Clay overlying a 13 - 14.9 m thick Silty Sand. The overburden rested on bedrock which dipped down into the valley at depths of 20.1 - 22 m at the culvert location and appeared at each crest surfically. Approximately 0.76 m of organics was encountered at the surface.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 1958701-C in the attached appendix. The field and laboratory test results are plotted on the Record of Borehole sheets and in the appendix of this report. A brief description of the different soil types is given below.

Organics

Organic material was encountered as a sublayer at the surface within the Silty Clay. The thickness of the material was approximately 0.75 m.

Silty Clay to Clay

This cohesive deposit was encountered at the ground surface or below the organic layer to a depth of 7.1 m. Results of grain size distribution tests carried out on select samples are shown on Figure 1 in the appendix. The deposit comprised of 0 % gravel, 0 % sand, 20 - 25 % silt and 75 - 80 % Clay.

The results of the laboratory testing carried out on the soil samples are as follows:

<u>Property</u>	
Natural Moisture Content (%)	40, 48.5, 56.5
Liquid Limit (%)	50, 51, 58
Plastic Limit (%)	21, 22, 25
Unit Weight (kN/m ³)	16.6, 17.2, 17.4

From the plasticity chart (Figure 2) the layer can be classified as a Silty Clay to Clay of medium to high plasticity.

Three consolidation tests were carried out which indicated void ratios of 1.342, 1.323 and 1.483 and compression indices of 0.684, 0.558 and 0.811 respectively. The results indicated this material to be highly compressible and in a normally consolidated state. In-situ void ratio log pressure curves are provided in Figures 4 and 5 in the appendix.

Field vane tests carried out on this material indicate undrained shear strengths of 20 to 90 kPa with an average of 30 kPa estimated. Based on this information, the consistency of this material can be described as soft to stiff.

Silty Sand, Trace Clay

Underlying the above layer was a non-cohesive Silty Sand, Trace Clay which had a thickness of 13 - 14.9 metres. This material can be found throughout the valley with varying thicknesses. Results of grain size distribution tests carried out on select samples are shown on Figure 3 in the appendix. This deposit comprised of 0 - 3 % gravel, 78 % sand, 14 - 19 % silt and 3 - 5 % clay.

Standard Penetration tests had 'N' values ranging from 3 Blows/0.3 m to 42 Blows/0.3 m, indicating a very loose to dense state. Due to the presence of a high water level samples taken within this layer were susceptible to blow up conditions and could be disturbed. Thus blow counts may not be representative.

Bedrock

The overburden rests on a Meta-Volcanic and Schist Bedrock of the Superior Province. While bedrock was found to rest at 20.1 m and 22 m depths at the culvert location, within this valley its depth varies greatly. Bedrock outcrops can be seen nearby.

Rock core recoveries (CR) and rock quality designation (RQD) are provide below:

<u>BH No.</u>	<u>RC No.</u>	<u>Depth (m)</u>	<u>% CR</u>	<u>% RQD</u>
95-1	16	20.12 - 21.34	94	58
	17	21.34 - 21.64	100	100
95-2	15	22.05 - 23.42	94	41

Petrographer descriptions of both types of rock are provided in the appendix.

Groundwater

Groundwater levels obtained at the time of the investigation revealed that the groundwater table is generally at the elevation of the water in the creek. This corresponds to 1 - 2 m below the ground surface at the toe of the embankment, an elevation of approximately 190 metres.

It should be noted that groundwater levels are subject to seasonal fluctuations.

Discussion and Recommendations

The existing timber box culvert appears to be failing as the ceiling and floor struts are buckling under their load, with the entire structure sinking into the soft Silty Clay layer below. Embankment materials are collapsing into the culvert from the ceiling causing a visible bump on the highway surface at this location. In addition the north slope is failing causing guide rails to lose their alignment requiring numerous paving and patching at this location. As the design life of this structure has clearly been reached a replacement structure located adjacent to the existing one has been proposed. The foundation recommendations for this proposal is provided below.

Structural Foundations

The native Silty Clay layer sampled at the toe of the existing Hwy. 17 embankment was found to be highly compressible and unsuitable to support shallow foundation. It is believed however that the material beneath the highway has undergone considerable consolidation and settlement due to its load. In addition, the placement of the culvert will decrease the load on this layer. The construction of a 3 - 4 m diameter culvert placed on a minimum 300 mm granular base within the native material would therefore be feasible. Due to concerns of the probability of differential settlements between the culvert and its approaches deep foundation units in the form of H-Piles would not be recommended.

While bearing capacities would not be required for steel culverts of these dimensions the following is provided in case a concrete structure were to be utilized. Greater capacities can be recommended with the utilization of a Granular 'A' pad of varying thickness in order to distribute the load.

Culvert Shallow Foundations

Pad thickness	.3 m	1 m	2 m	3 m
Geotechnical Bearing Capacity at SLS (kPa)	85	110	150	185
Factored Geotechnical Capacity at ULS (kPa)	125	165	225	275

Excavation within the saturated Silty Clay may cause heaving in the bottom of the excavation due to swelling of the clay. Any loose material should be removed with a minimum thickness of 300 mm granular 'A' pad be placed to provide a suitable founding base. Excavations should be carried out to remove as much of the soft material as possible. The excavation for the bedding shall extend to a width of a minimum 1.5 m on either side of the culvert.

Scour protection at the culvert inlet and outlet shall be provided to protect the culvert foundation. The design of the scour protection shall be made in conjunction with applicable hydrological parameters. The culvert outlet should be protected with 0.6 m rock

protection as per OPSD 810.01 type 'A'. The treatment should extend for 15 m along the channel to prevent undercutting of the bed.

Due to the consolidated nature of the clay beneath the highway embankment settlements would be minimized, in the order of 50 - 100 mm. Assuming a flexible culvert design no camber would be necessary along its length. For the design of a rigid culvert a 300 mm mid-span camber would be required to provide for any future settlements. An articulated joint should be constructed at the camber location in this case.

The culvert pipe bed is to be carefully shaped to receive the lowest segment of pipe formed by the bottom radius.

Rock back fill should be limited to 5 - 10 cm sizes within 1 m of the culvert. The frost penetration depth at the site is 2.2 m. Adequate frost protection shall be provided for all structural units.

The backfill material should be machine compacted on both sides of the pipe simultaneously in equal lifts according with OPSS 501.08.02.

Embankment Design

With the excavation and placement of the culvert it was proposed to backfill and utilize gabion walls at the culvert face with a retaining earth system. It is our understanding that this was proposed in order to shorten the width of the embankment within the limits of the consolidated regions of the underlying Silty Clay and avoid excavation away from the existing geometry. While settlements and bearing capacity failures of the underlying soils are not a concern this office believes that the global stability in the form of a circular slip failure extending through the embankment materials and into the foundation soils could pose a threat to the entire structure. The Silty Clay material at the toe of the fill which forms the counter weight against deep seated failures would not have adequate shear strength. In consideration of the added costs and potential instability it is recommended that a conventional slope of 1.25H:1V be placed consisting of rockfill.

At the time of the writing of this report, a review of the geometry indicated that the excavations into the Silty Clay to Clay deposit beyond the existing rockfill are minimal, with no construction preparations required. However, if the culvert extends beyond the existing slope, requiring excavation into the nonconsolidated Silty Clay region it is recommended to preload these areas for a period of 6 to 9 months prior to excavation of the culvert. Fill material could be dumped along the existing slopes improving the shear strength of the subsoil. Once some consolidation has taken place the excavation for the culvert within this soft material will be enhanced.

Slopes in clays should be excavated in such a manner as to ensure stability at all stages. Heavy surface loads caused by construction equipment, or fill material, should not be

placed near the crest of the slope.

Temporary Diversion

BAILY BRIDGE OPTION

To facilitate the construction of the culvert while maintaining traffic, a Bailey bridge is proposed to span Hwy 17 during the construction period. The Bailey bridge can be supported on conventional timber crib abutments founded in the existing rockfill. The following bearing capacities are provided for the design of the Bailey bridge foundations.

Bailey Bridge Timber Crib Foundation

Factored Axial Capacity at ULS (kN)	375 KPa
Factored Axial Capacity at SLS (kN)	250 kPa

These values assume that the Bailey Foundations will have a minimum of a 5 m pad within the existing rockfill embankment above the native Silty Clay.

The structure foundations shall be located a minimum 3.0 m beyond the crest of excavated slope. As the composition of the fill cannot be confirmed and consists of numerous boulders care must be taken when selecting a founding base. It is not unusual to get a fill with a hard crust over several metres of loose fill as a result of compacting only the last lift. Soils with very large volume changes should be eliminated.

As there are concerns with basal heave for the excavation down to the proposed culvert elevation due to a marginal safety factor, caution should be taken during construction. The geometry is acceptable provided that it is only of a temporary nature.

Settlements of the timber crib foundations are anticipated as a result of the further elastic compression within the fill. For the tabulated applied pressures, settlements in the order of magnitude of 50 mm can be anticipated, assuming a footing width of 4 m. It is recommended that the Bailey bridge be periodically monitored for the development of these settlements and the structure adjacent as required. Consolidation will also occur due to the additional weight, but this will occur over the long term.

EMBANKMENT FILL OPTION

A temporary detour embankment is proposed located approximately 55 m (centre-line to centre-line) north of the Hwy. 17. The height of the fill is estimated at approximately 8 m. As it will be located on compressible Silty Clay which will undergo consolidation, settlement in the order of 500 mm is anticipated. As this is only a temporary structure it is assumed such settlement would not be a concern and could be taken care of by regular maintenance.

As the location of the detour rests in the marshy soils all organics and unsuitable soils should be removed. Provision should be made to permit the creek to pass through the temporary embankment through a steel corrugated culvert. Care should be taken to provide erosion protection particularly if the construction period will be during spring thaw or heavy rain periods.

Slopes should be formed at 2H:1V gradient with a 1 to 2 m wide berm incorporated at midheight for fill heights of up to 9 metres.

Lateral Earth Pressure on Structure

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up. Design parameters of the soil are given below:

	<u>Rockfill</u>	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Internal Friction Angle(ϕ)	35°	35°	30°
Unit Weight (kN/m ³)	18.5	22.8	22.8
Coefficient of Active Earth Pressure (k_a)			
S.L.S.	0.27	0.27	0.33
U.L.S.	0.33	0.33	0.4
Coefficient of Earth Pressure at Rest (k_o)			
S.L.S.	0.43	0.43	0.5
U.L.S.	0.5	0.5	0.58

For a rigid and unyielding structure, the earth pressure coefficient at rest is to be used in computing lateral earth pressure.

Dewatering

The excavation of the culvert will be advanced below the water table level adjacent to the existing creek. It is recommended that a sump pumping discharge system be used to drain accumulated water within the excavation.

Channel Realignment

The realignment of McKellar Creek will necessitate excavation cuts in the order of 2 - 3 m within the Silty Clay deposit. The excavated slopes shall be no steeper than 2H:1V. The slopes shall be protected against scour in compliance with the hydrological specifications

Construction Considerations

In order to prevent settlement within the rockfill it is recommended that a layer of crushed stone placed on the rockfill, together with a geotextile underneath the subgrade material be placed. It has been found that settlement can be caused within the fill near the road surface and along its slopes due to the finer materials infiltrating the voids between the larger boulders. This is mitigated with the vibration caused by vehicular travel

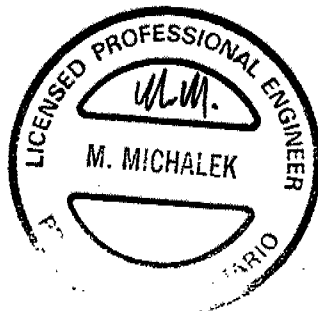
The construction of the proposed culvert will involve excavations to a depth 9 metres, 7 - 8 m within the existing rock fill and 2 m below the natural ground surface. Boulder obstruction are expected during the excavation process. Any temporary slopes during the construction period should be designed to be 1H:1V, with a 2 m bench at the elevation of the native material (approx. 191 m) and then having 2H:1V slopes within the 2 m excavation into the Silty Clay. Any excavations beyond the 2 m will require a temporary shoring scheme. A shoring system consisting of either sheet piles or soldier piles and timber lagging is recommended as specified by OPSS 538.

All soft or organic materials encountered beneath the culvert or fill embankments should be excavated and replaced with compact granular fill.

Miscellaneous

The field work for this investigation was carried out by M. Michalek, Jr. Foundation Engineer. The drilling equipment was owned and operated by Dominion Soil Investigations Ltd.

The report was prepared by M. Michalek, Jr. Foundation Engineer under the general supervision of T. C. Kim, Sr. Foundation Engineer. The report was reviewed and approved by T. C. Kim.



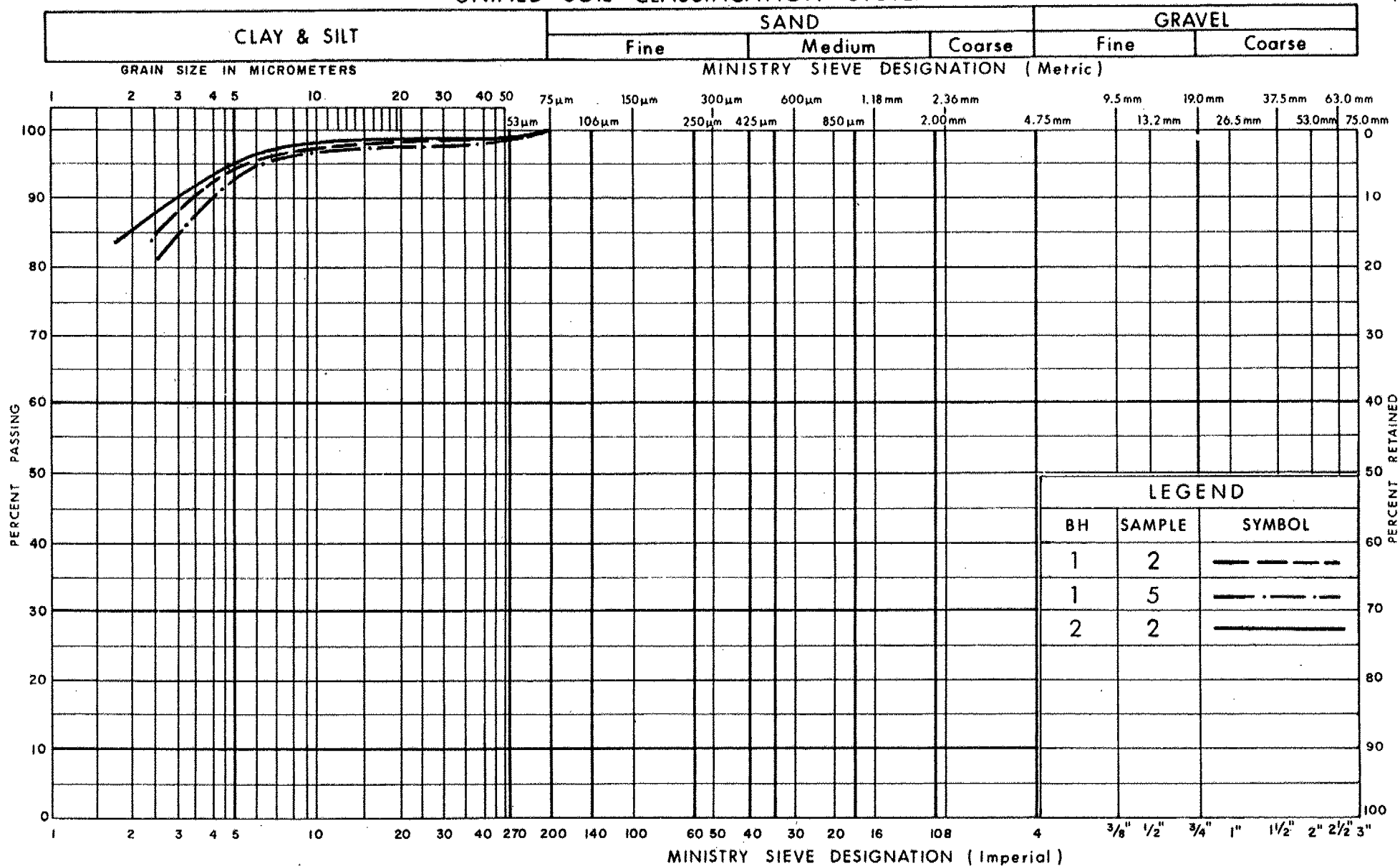
M. Michalek
M. Michalek
Jr. Foundation Engineer



T.C. Kim
T.C. Kim, P. Eng.
Sr. Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

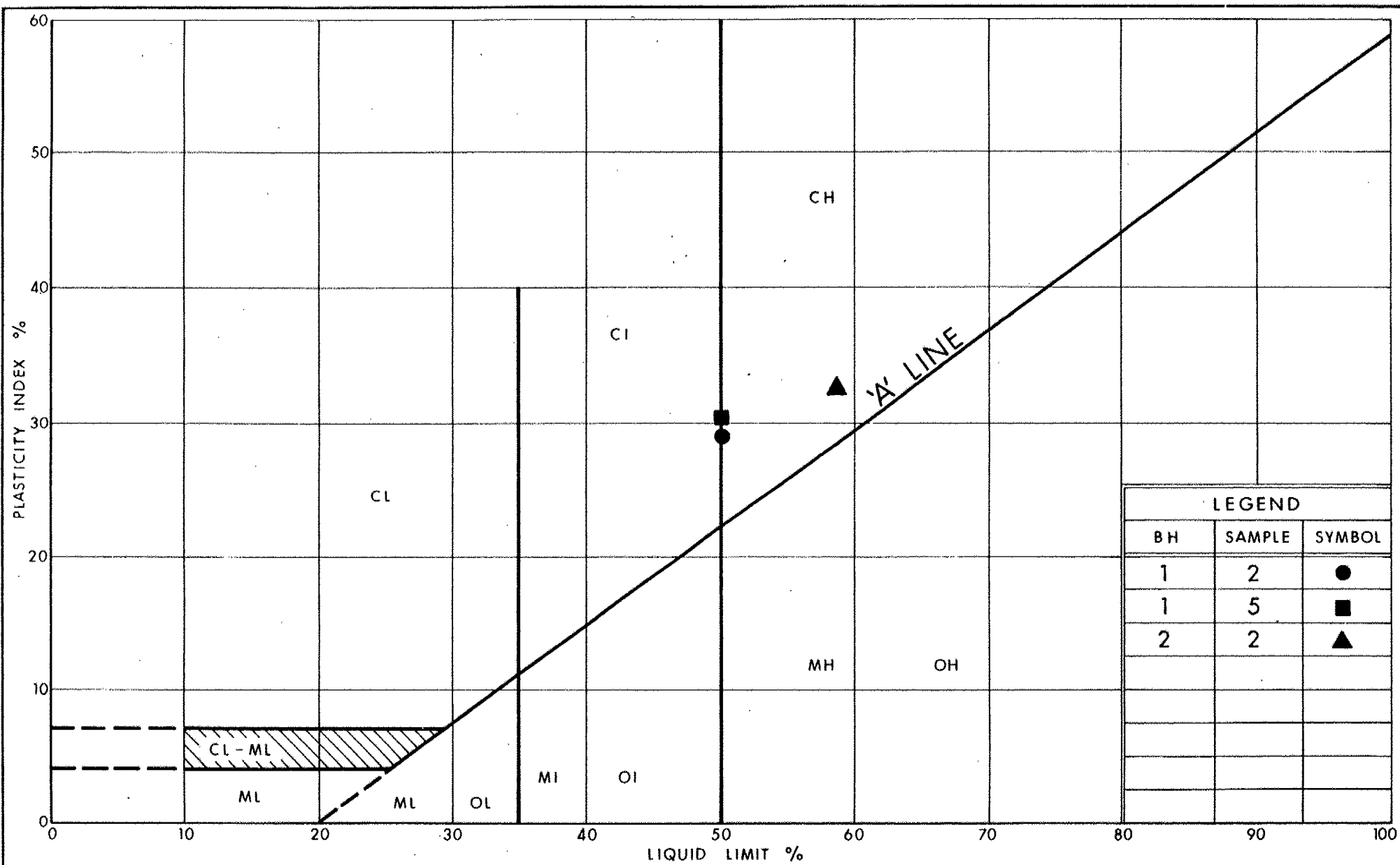


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GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY

FIG No 1

W P 195 -87-01(C)



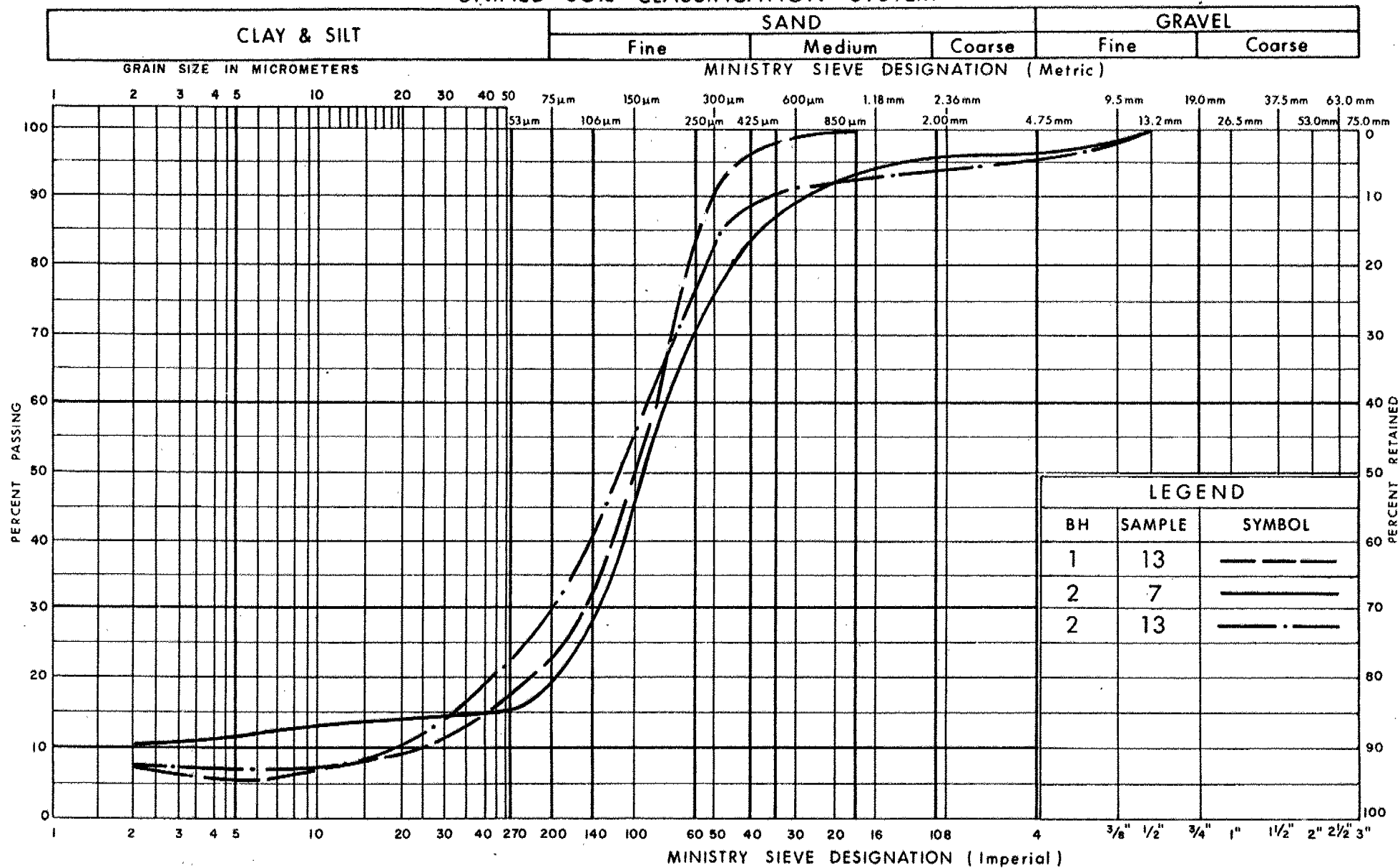
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PLASTICITY CHART SILTY CLAY, TRACE SAND

FIG No 2

W P 195-87-01 (C)

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE CLAY

FIG No 3

W P 195 -87 -01(C)

VOID RATIO - PRESSURE CURVES

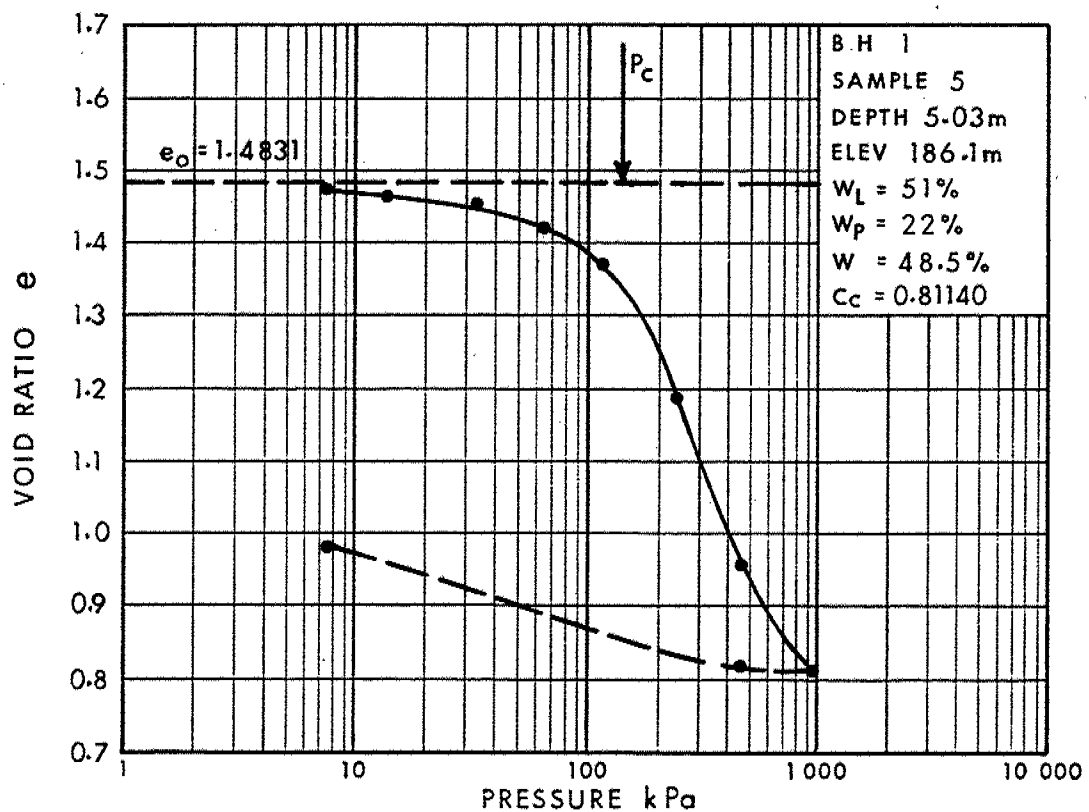
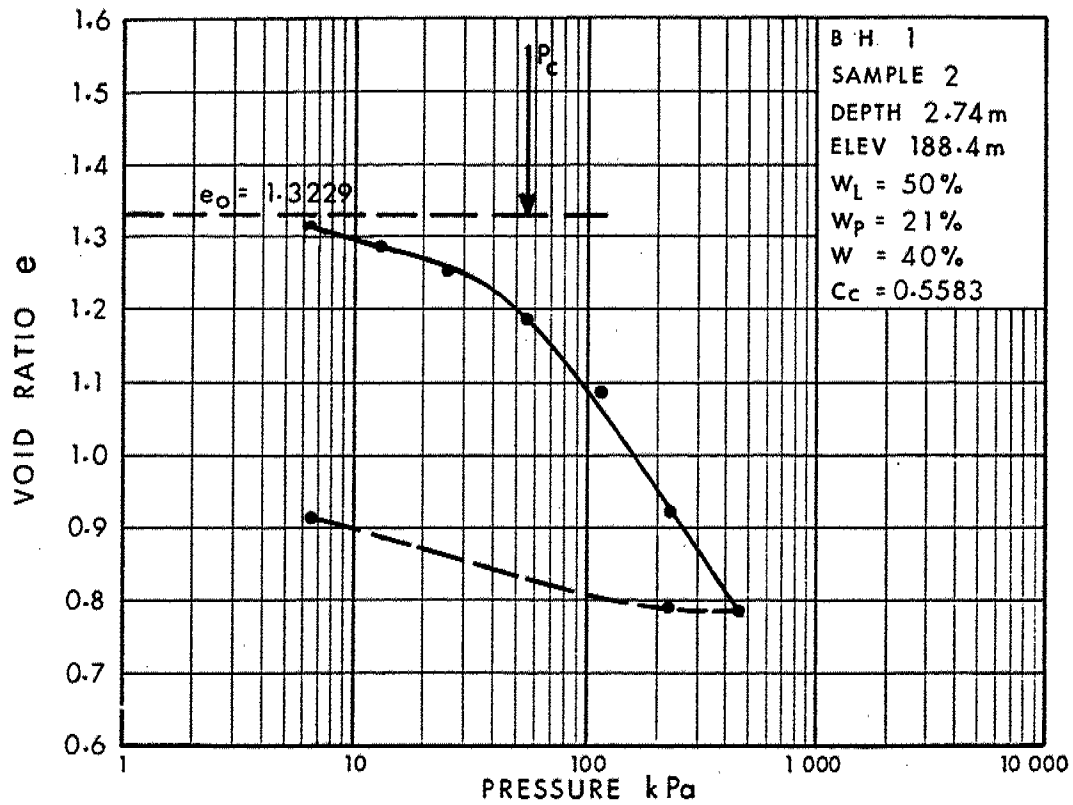


Fig 4

W P 195-87-01(C)

VOID RATIO - PRESSURE CURVES

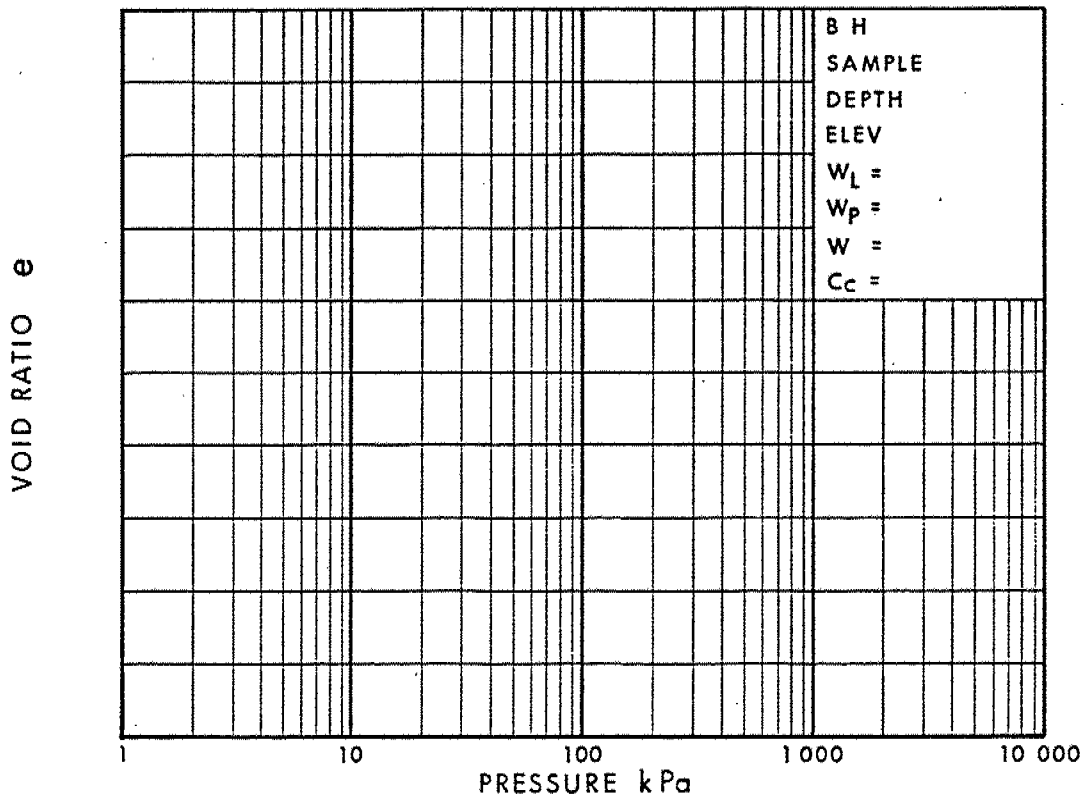
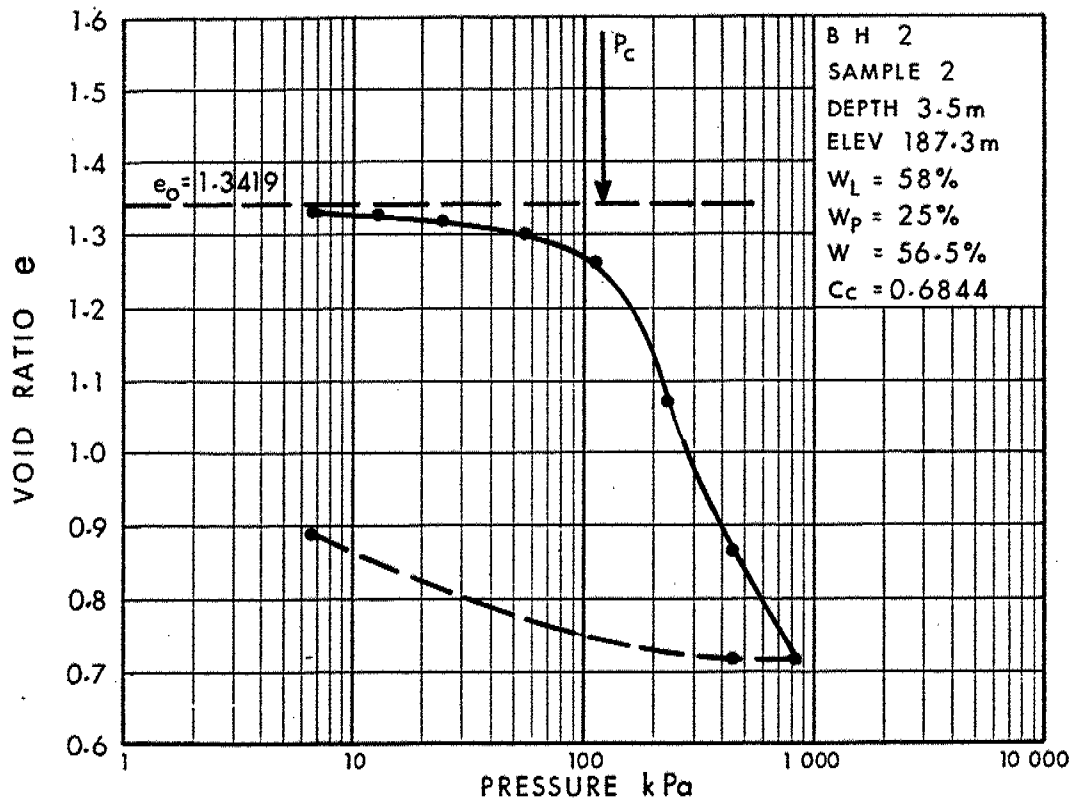


Fig 5

W P 195-87-01(C)

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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	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 95-1 1 OF 1 METRIC

W.P. 195-87-01(C) LOCATION Sta. 14+700.8 e/s 19 m RT. of Centreline Hwy. 17 ORIGINATED BY M.M.
 DIST 61 HWY 17 BOREHOLE TYPE H.S. Auger, Rock Coring COMPILED BY M.M.
 DATUM Geodetic DATE 1995 02 28 CHECKED BY T.K.

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 W _L	WATER CONTENT (%) 25 50 75		
191.1	Ground Surface												
0.0	Organics												
	Silty Clay to Clay Soft to Firm		1	SS	5							17.4	0 0 25 75
			2	TW	PH								
			3	SS	1								
			4	SS	1								
			5	TW	PH							17.2	0 0 24 76
			6	TW	PH								
184.0													
7.1	Silty Sand Trace Clay Very Loose to Very Dense		7	SS	3								
			8	SS	3								
			9	SS	17								
			10	SS	10								
			11	SS	13								
			12	SS	8								
			13	SS	7								0 78 19 3
			14	SS	6								
171.0			15	SS	120								
20.1	Bedrock Schist		16	RC	REC 100%								ROD 80%
169.5			17	RC	REC 100%	100%							ROD 100%
21.6	End of Borehole 'N' values within the Silty Sand deposit may be questionable due to blow up and disturbance during sampling.												

RECORD OF BOREHOLE No 95-2 1 OF 1 METRIC

W.P. 195-87-01(C) LOCATION Sta.14+702.3 o/s 24.8m Lt. of Centreline Hwy. 17 ORIGINATED BY M.M.
 DIST 61 HWY 17 BOREHOLE TYPE H.S. Auger, Rock Coring COMPILED BY M.M.
 DATUM Geodetic DATE 1995 03 01 CHECKED BY T.K.

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
190.8	Ground Surface													
0.0	Organics Silty Clay to Clay Soft to Stiff		1	SS	2		190							
			2	TW	PM		188						16.6	0 0 20 80
			3	SS	2		186							
			4	TW	PM		184							
183.7			5	SS	5		182							
7.1	Silty Sand Trace Clay Very Loose to Dense		6	SS	36		180							3 78 14 5
			7	SS	5		178							
			8	SS	13		176							
			9	SS	7		174							
			10	SS	8		172							
			11	SS	5		170							
			12	SS	12									
			13	SS	23									
168.8	Rock Fragments		14	SS	42									
22.0	Bedrock Meta-Volcanic		15	RC	REC 100%		168							RQD 43%
167.6														
23.2	End of Borehole 'N' values within the Silty Sand deposit may be question- able due to blow up and disturbance during sampling.													

ROCK CORE DESCRIPTION

WP 195-87-01 (C)

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
95-1	16	20.12-21.34	94	58	20.12-21.64	META-VOLCANIC (with calcite-pyrite veins), greyish black to greenish black; fine grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, dipping, undulating to planar, smooth.
	17	21.34-21.64	100	100		
95-2	15	22.05-23.42	94	41	22.05-23.42	SCHIST (micaceous), dark greenish grey to yellowish grey to light grey; fine grained; medium strong; unweathered to slightly weathered; fractures moderate to extremely close spaced, near vertical to dipping, undulating to planar, smooth.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%
 Logged by: DAW, Soils and Aggregates Section

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

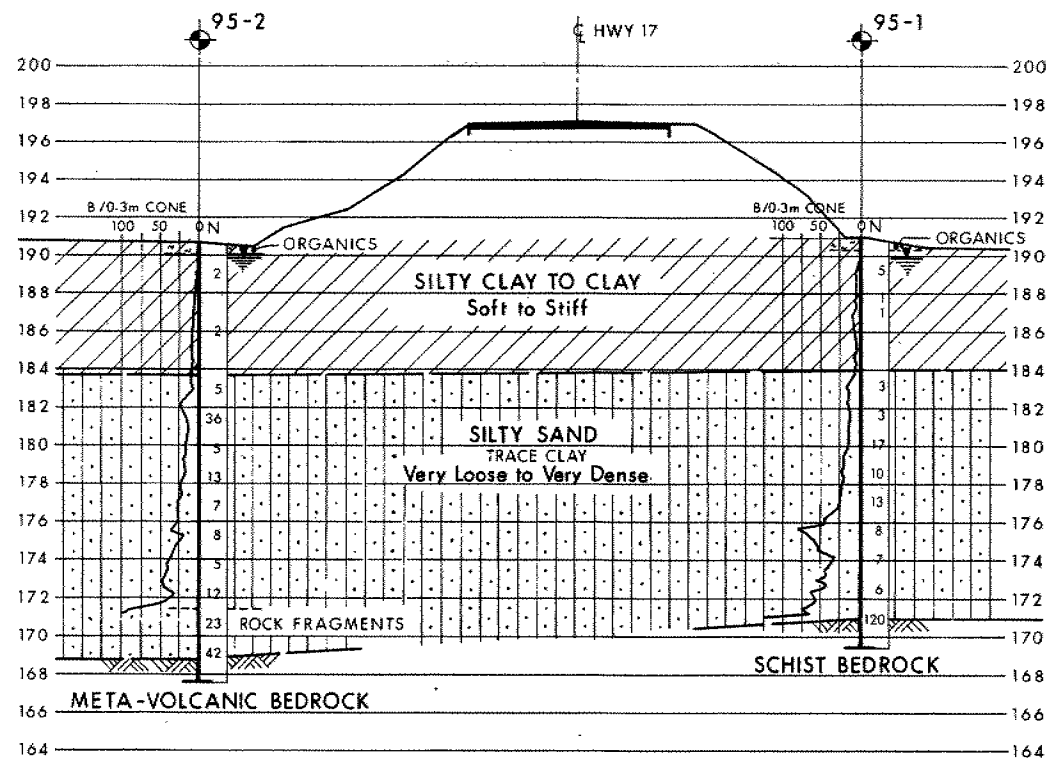
CONT No
WP No 195-87-01(C)

McKELLAR CREEK

BORE HOLE LOCATIONS & SOIL STRATA

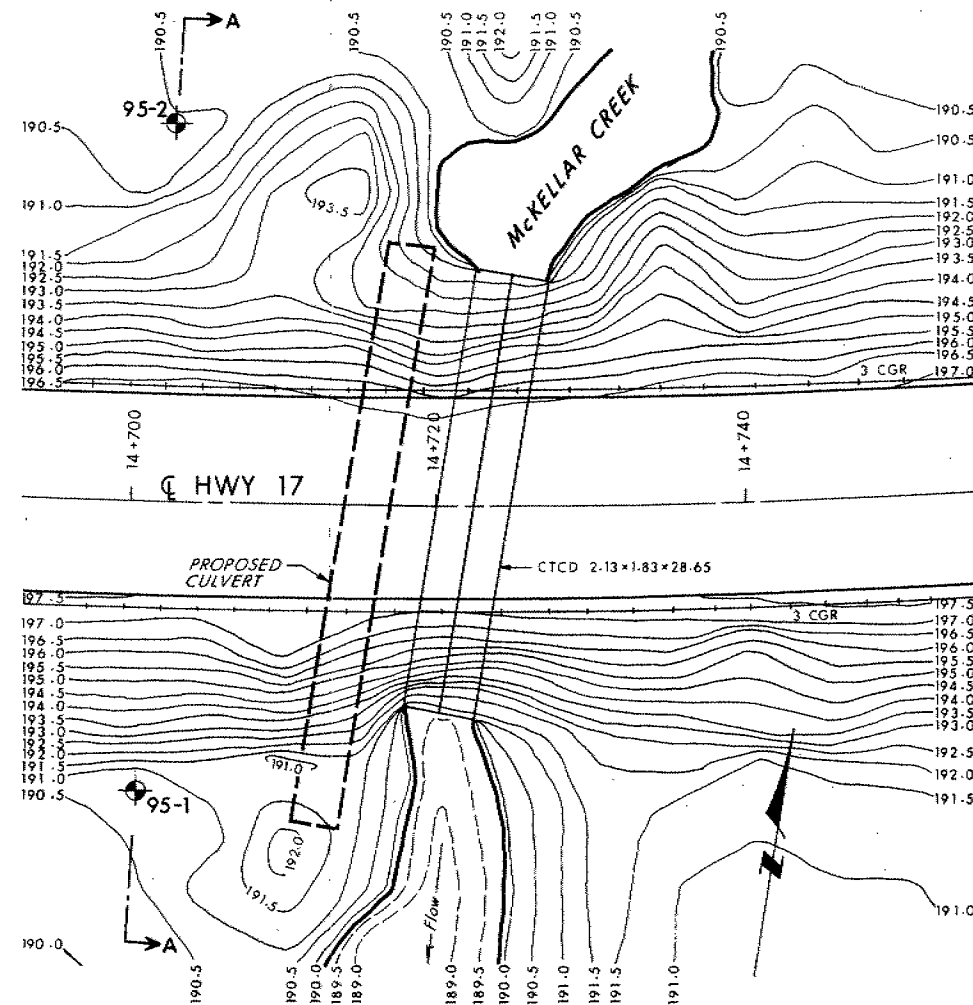


SHEET



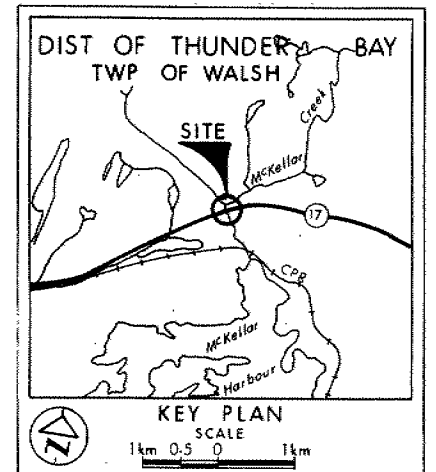
SECTION A-A

SCALE
5m 0 5m Hor
4m 0 4m Vert



PLAN

SCALE
5m 0 5m



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1995 02 and 03

No	ELEVATION	STATION	OFFSET
95-1	191.1	14+700.8	19.0m RT
95-2	190.8	14+702.3	24.8m LT

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen Cond



REF No E-668-17

REV.	DATE	BY	DESCRIPTION
1			

Geocres No 42D-21

HWY No 17	CHECKED	DATE 1995 12 06	DIST 61
SUBMIT MM	CHECKED	SITE 48E-46C	
DRAWN DT	CHECKED	APPROVED	DWG 1958701(C)-A