

GEOCRES No:
52H-8

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 110-87-01

DIST 19

HWY 17

STR SITE 48C-176

Little Ozone Creek Culvert

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FOUNDATION INVESTIGATION REPORT

FOR

Little Ozone Creek Culvert
W.P. 110-87-01; Site 48 C-176
Hwy. #17, District #19, Thunder Bay

INTRODUCTION

This report summarizes the foundation investigation for the proposed culvert replacement at Little Ozone Creek. The report applies to the structure, the structure approaches and the detour between STA. 13 + 460 and STA. 13 + 540, 20 m RT. and LT. of Hwy. 17 E.

SITE DESCRIPTION

The site is located at the Hwy. #17 crossing of Little Ozone Creek, approximately 15 km east of the junction of Hwy. #11 at Nipigon, Township of Patience, District of Thunder Bay.

Within the investigation limits (30 ± m on each side of the culvert), the natural ground surface varies from approximately 193 m to 190 m, sloping at 10 H:1V to the creek bed. Ozone Creek flows to the south through an existing culvert (4.3 m x 2.7 m SPCSPA with invert at Elev. 190 ± m) which has experienced considerable distress. The grade of Hwy. #17 at this location is 195 ± m.

INVESTIGATION PROCEDURES

The field work was conducted between 87 06 30 and 87 07 08 utilizing a continuous - flight auger machine equipped with 82 mm I. D. hollow-stem augers, B-casing and a B-core barrel.

The investigation consisted of;

- 4 sampled boreholes accompanied by dynamic cone penetration tests
- 4 sampled boreholes and
- 3 dynamic cone penetration tests

The borehole locations were selected to provide subsurface information within the existing Hwy. #17 embankment, beneath the culvert and near the proposed detour alignments.

Survey details of the borehole locations were provided by the Northwestern Region, Surveys and Plans Section.

A total of 112 samples were collected; 12 shelby tube samples, 95 split spoon samples, 1 chunk sample, and 4 rock cores. The shelby tube samples provided relatively undisturbed samples for detailed laboratory evaluation of representative zones of the cohesive overburden. The split spoon samples provided Standard Penetration Test values for assessment of the insitu state of compaction of the non-cohesive materials and for an indication of shear strength of the cohesive materials. The split spoon samples and chunk samples provided material for identification purposes. The rock cores provided details of the bedrock. The field work program also included 49 field vane tests to determine insitu shear strengths and sensitivity values of the cohesive material. Groundwater elevation measurements were attempted at each borehole. However stabilized levels were difficult to achieve because of the high plasticity of the overburden.

The laboratory testing consisted of:

- 22 grain size analyses and 23 water content/Atterberg Limit tests to identify the material
- 4 unconfined compression tests to determine shear strengths
- 4 unit weight tests
- 4 consolidation tests

Subsurface Conditions

Subsoil at the site consists of fill material composed mainly of silty sand overlying deposits of varved clay, silts and sands, all underlain by diorite and granodiorite bedrock. Surface layers of organic soil are also present at some locations. Depth to bedrock ranges from 8 to 16 m below the creek bed level (Elev. 190). Reference should be made to the Record of Borehole Sheets in the Appendix which illustrate the subsurface conditions, at the borehole locations. The boreholes are number BH #1 - #11. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Dwg. #1108701-A.

Detailed descriptions of the various deposits encountered are as follows:

Silty Sand to Gravelly Sand (Fill Material):

This material is the existing Hwy. #17 embankment fill. It was encountered in most borings and the max. depth is 9.1 m. The material consists of silty sand to sandy gravel containing traces of clay. 'N' values range from 3 to 63 blows per 0.3 m indicating a very loose to very dense state. In general, however, the deposit may be classified as compact. Figure 1, illustrates a typical grain-size envelope for the material. Natural moisture content was found to range from 5.6 to 21.5 percent with an average value of 10.5.

Silty Clay/Organic Silt:

This material ranges from silty clay at the surface to organic silt with depth. Occasional distinct organic zones can be observed throughout. Based on a single unconfined compression test and on a single 'N' value of 5, the undrained shear strength of this material is estimated to be 40 kPa \pm . Atterberg Limit tests yielded a Plastic Limit of 38% and a Liquid Limit of 46.5%. The natural moisture content was found to be 40%. Based on the foregoing the consistency of the deposit is assessed to be firm. Consolidation test results are shown on Figure 4C. These indicate the soil to be slightly over consolidated.

Varved Clay:

This is the major deposit at the site. The material consists of alternate layers of clay and silt. Thickness of these layers ranges from 3 to 20 mm. The deposit is generally located near the surface, although at some locations it is overlain by fill or organic silt. The thickness of the deposit varies from 2.8 m to 11.6 m, but is generally 6 m to 10 m thick. It appears that there has been some subexcavation or displacement of this material beneath the existing highway ambankment.

Properties of the material, as determined by field and laboratory tests, are summarized as follows:

<u>Atterberg Limits</u>	<u>Range</u>	<u>Average</u>	<u>Median</u>
- Natural Moisture Content (W)	31.8 - 52.8%	43.7%	37.8%
- Liquid Limit (w_L)	27.0 - 65.0%	40.8%	33.0%
- Plastic Limit (w_p)	15.5 - 21.0%	17.9%	18.0%

<u>Undrained Shear Strength (cu)</u>	<u>Range</u>
in-situ field vane (natural)	15 - 30 kPa
in-situ field vane (remoulded)	3 - 17 kPa
sensitivity (field vane results)	1 - 5
unconfined compression	4.6 - 12.5 kPa
unit weight (γ)	17.0 - 18.1 kN/m ³

Based on the results of the Standard Penetration Tests (N = 1 to 9), the field vane tests and the unconfined compression tests, consistency of the material is soft to firm but generally soft. The results of consolidation tests shown on Figures 4A, 4B, and 4D indicate that the material is in a slightly over consolidated condition.

Figure 2, illustrates a typical grain-size distribution envelope for this material. The wide envelope results from the varved nature of the deposit. The upper limit of the envelope represents a typical clay varve while the lower limit represents a typical silt varve.

Silt:

This deposit was encountered below the varved clay at all locations except BH #7. The material is classified as silt, however, it contains traces of fine sand and clay. The thickness of the deposit varies from 0 to 6.1 m but is typically 2 to 3 m. The natural moisture content ranges from 24 to 28 percent. Based on the results of the Standard Penetration Tests (N = 1 to 26), the material is very loose to compact. However, some sampling disturbance is suspected, and the in-situ state of the material is probably mainly compact. Figure 3, illustrates a typical grain-size distribution for this material.

Silty Sand:

This deposit was encountered immediately above the bedrock at all boreholes except BH #1. The thickness of the deposit at the borehole locations varies from 0 to 6.0 m but is typically 2 to 3 m. The material is classified as silty sand, however, it contains traces of clay and gravel. The natural moisture content ranges from 2 to 17 percent.

Based on the results of the Standard Penetration Tests (N = 3 to 100+), the material is very loose to very dense. However, some sampling disturbance is suspected, and the insitu state of the material is probably compact to very dense.

Bedrock

The bedrock consist of diorite and granodiorite. The surface is variable, with elevations ranging from 174.1 m to 181.8 m. Refer to Record of Bore-hole Sheets for specific elevations of the bedrock surface. Based on visual inspections and the recovery values of the core, the bedrock is un-weathered. The Geologists description of the core is provided in Table 1.

Groundwater

Due to the low permeability of the varved clay deposit, it was not possible to establish the exact groundwater elevation during the short period of the investigation, however, it can be assumed that the groundwater elevation coincides with the level of Little Ozone Creek (Elev. 190 to 191 m) or is slightly above this level.

DISCUSSION AND RECOMMENDATIONS

Existing Culvert

The existing culvert was constructed in the winter of 1960. It has been reported that it was founded on a 0.15 m pad of granular material, directly overlaying frozen clay. The culvert immediately experienced distress and required repair, strutting and replacement of backfill in February, 1960. It has also been reported that Hwy. 17 has experienced over 0.35 m of settlement in the vicinity of Little Ozone Creek and that a depression of the highway exists at the site.

Proposed Structure Replacement

It has been proposed to replace the existing culvert with either a concrete culvert or a steel culvert. It is our understanding that structure selection is still under consideration, and that one of the following culvert types will be selected:

- 1) flexible corrugated steel circular section (3.6 m Ø)
- 2) flexible corrugated steel arch section (4.2 m x 2.7 m)
- 3) concrete box (4.2 m x 3.0 m)
- 4) rigid frame open concrete (4.2 m x 3.0 m)

Foundation Alternatives

The main foundation problems at this site are bearing capacity, slope stability and settlement. These problems are caused by the extensive deposit of soft and compressible varved clay, and will affect the proposed structures and approaches of both the detour and Hwy. 17 alignment.

In our opinion, the detour can consist of a flexible corrugated steel conduit and normal-weight fill provided that the fill height is less than 3 m. Although settlements will occur, we believe that periodic maintenance will ensure adequate performance.

The Hwy. 17 alignment presents a more critical problem due to the required embankment height of up to 5 m and in view of the distress of the previous culvert. The 100% solution for the culvert foundation would be to support a concrete culvert on end-bearing piles driven to bedrock.

Alternatively, a flexible corrugated steel conduit or concrete box culvert could be founded on the varved clay provided that the bearing capacity of the clay is not exceeded. However, unless the existing loading is reduced, settlements would still occur and the culvert would have to be designed to accommodate these movements. The problems of settlement of the structure and slope stability and settlement of the approach embankments are related in that they could be eliminated or reduced if the load imposed by the backfill/embankment material could be reduced. This could be accomplished by constructing the backfill and immediate approach of a light-weight material such as blast furnace slag.

Bearing Capacity - Spread Footings

The following O.H.B.D.C. bearing capacity values are recommended for steel or concrete culverts founded on varved clay near the existing culvert invert (Elev. 190± m).

Factored Bearing Capacity at U.L.S. = 45 kPa

Bearing Capacity at S.L.S. Type II = 30 kPa

The raft foundation recommendation implemented for The Ministry of Transportation, Contract 85-209 (McKinnon Creek) was investigated. This design involved a box culvert "floating" over unfavourable foundation conditions. This concept usually refers to the removal of overburden and replacement with the structure so that the existing soil stresses are not exceeded. Although this approach may provide a structure that settles as a unit, the shear strength of the soil is the limit for loading. Consequently, the recommended bearing capacities cannot be exceeded.

Capacity - Piles

Concrete culverts could be founded on piles, equipped with reinforced tips and driven to bedrock.

The following O.H.B.D.C. capacities are recommended:

<u>File Type</u>	<u>Factored Capacity</u> <u>at U.L.S.</u>	<u>Capacity at</u> <u>S.L.S. Type II</u>
Timber Size 36	350 kN	250 kN
Steel HP 310 x 79	1150 kN	820 kN
Steel HP 310 x 110	1600 kN	1150 kN

Slope Stability

The safe height for embankments with 2H:1V slopes and constructed of normal-weight fill ($\gamma = 20.4 \text{ kN/m}^3$) is 3 m. The height of the existing embankment is up to 5 m and the stability is near the limit equilibrium condition. Consequently, the foundation soil has been overstressed resulting in distress to the existing culvert.

Alternatively, if a light-weight fill ($\gamma = 12.6 \text{ kN/m}^3$) is used, the safe height for embankments with 2H:1V slopes is 5 m.

The stability of embankments were evaluated using Bishop's total stress analysis and assuming soil properties that exist outside the limits of the existing Hwy 17 embankment.

The results of these analyses are illustrated in Figures 5 to 9. The safety factor of less than unity, for a 5 m embankment, illustrates that some of the original embankment loading was transferred to the culvert - a situation that may have contributed to the culvert distress. The analysis also illustrates, that due to the extensive thickness of the soft clay layer, berms are not an efficient solution to the stability problem. However, as illustrated in Figure 9, the use of light-weight fill does provide a solution.

Settlement

Consolidation characteristics of the compressible deposits are illustrated in Figure 4. Results of settlement analyses are summarized in Table 2. Some inconsistencies resulted from the varved nature of the clay, and due to the organic nature of sample 2 - 4.

Based on the consolidation characteristics of the varved clay, and assuming normal-weight fills, the following total settlements are predicted for original conditions (outside the Hwy. 17 embankment):

3 m embankment - 0.4 m

5 m embankment - 0.6 m

Since the Hwy. 17 alignment was constructed in 1960, much of the predicted total settlement will have already occurred under the existing highway. However, due to the low permeability and extensive thickness of the varved clay, it is expected that up to 25% of the predicted total settlement may still occur under the existing loading conditions. If light-weight fill is used, further settlements would be virtually eliminated.

If detour embankments are restricted to 3 m in height, up to 0.3 m of settlement may occur during the life of the proposed detour.

Light-weight Fill

National Slag Company, based in Hamilton, produces a product called open-graded pit run slag which has a compacted in-place unit weight of less than 12.6 kN/m^3 . In 1985-86 the F.O.B. material costs for a site 325 km from the plant was $\$28/\text{m}^3$. If this material is not locally available, the costs of this option may be prohibitive.

Compaction requirements for slag have not been formally specified. The normal practice is one or two passes with a light roller. Our past experience is that a thin blanket (0.3 m thick) of Granular 'A' facilitates forming of slopes and shoulders.

Another possibility is to use styrofoam as backfill/embankment material. This material has a unit weight of less than 1 kN/m^3 but requires approximately 1 m of roadbed cover. Its F.O.B. material costs at Kingston in 1985-86 was $\$85/\text{m}^3$.

The light-weight material backfill should extend from the bedding at 2H:1V slope to highway grade. A transition zone, extending approximately 20 m from the 2H:1V intersect, would minimize potential differential settlements. This transition zone should slope at 5H:1V.

Earth Pressure Calculations

Computation of earth pressures should be in accordance with Section 6.6.1.2 of the O.H.B.D.C.

For design purposes, the following physical properties can be assumed for Granular 'A' and Granular 'B' and light-weight fill.

<u>Material</u>	<u>ϕ</u>	<u>γ</u>
Granular 'A'	35°	22.0 kN/m^3
Granular 'B'	30°	21.2 kN/m^3
Open-graded Pit Run Slag	35°	12.6 kN/m^3

For culverts founded on end-bearing piles and any retaining/cut-off structures rigidly connected the at-rest condition will govern earth pressure design. For culverts founded on spread footings, the active condition will govern earth pressure design.

Dewatering

It is anticipated that dewatering can be achieved by normal stream diversion/oversize excavation and sump pumping techniques.

Frost Protection

The minimum earth cover required for frost protection is 2.2 m.

For piled foundations, reference is made to Section 6-8.3.4.3 of the O.H.B.D.C. The horizontal component of battered piles may be used for lateral resistance.

CONSTRUCTION CONSIDERATIONS

Culvert Inlet

A seal of cohesive material (CI-CH clay) with a minimum thickness of 0.6 m should be constructed at the culvert inlet. The seal should extend a minimum of 5 m on each side of the culvert inlet, and from the high water level down the embankment to the creek bed. The CI-CH material available at this site would be a suitable seal.

Erosion protection, in the form of rock protection (minimum blanket thickness = 0.6 m) should be placed to protect the embankment. It should extend from the high water level to the toe of the slope and 2 m along the creek bed. In a transverse direction, the erosion protection should extend a minimum of 5 m on each side of the culvert.

Culvert Outlet

The culvert outlet should be protected with rip-rap treatment as per OPSD 810.01 Type A.

Bedding

Bedding for culverts on spread footings should consist of Granular "A" or light-weight slag and extend a minimum of 2 m below the base of the culvert. Reference is made to OPSD - 802.01 and 802.02 for details for steel culverts.

Backfill

Backfill should consist of Granular "A", Granular "B" or light-weight fill. Reference is made to OPSD-803 standards for details.

Camber

Due to the underlying compressible cohesive material at this site, some continued settlements are anticipated for a culvert on spread footings. It is therefore recommended that culverts founded on spread footings should be constructed with a 0.3 m mid-span camber.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of P.M. Jolink, Engineering Student using equipment owned and operated by Dominion Soil Investigation Inc.

The report was written by Mr. Jolink and D. Dundas, Senior Foundations Engineering and reviewed by M. Devata, Chief Foundations Engineer (East).



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APPENDIX

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 (R Q D), 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						

DESCRIPTION OF ROCK CORE - WP 110-87-01

HOLE #	CORE DESCRIPTION	
	DEPTH (m)	DESCRIPTION
2	17.98-20.27	DIORITE, dark black, spotted white, pink; medium to coarse grained (up to 1 cm); slightly porphyritic.
1	9.35-12.34	GRANODIORITE, spotted pink, white, black; medium to very coarse grained (up to 2 cm); slightly foliated; porphyritic.

TABLE 1

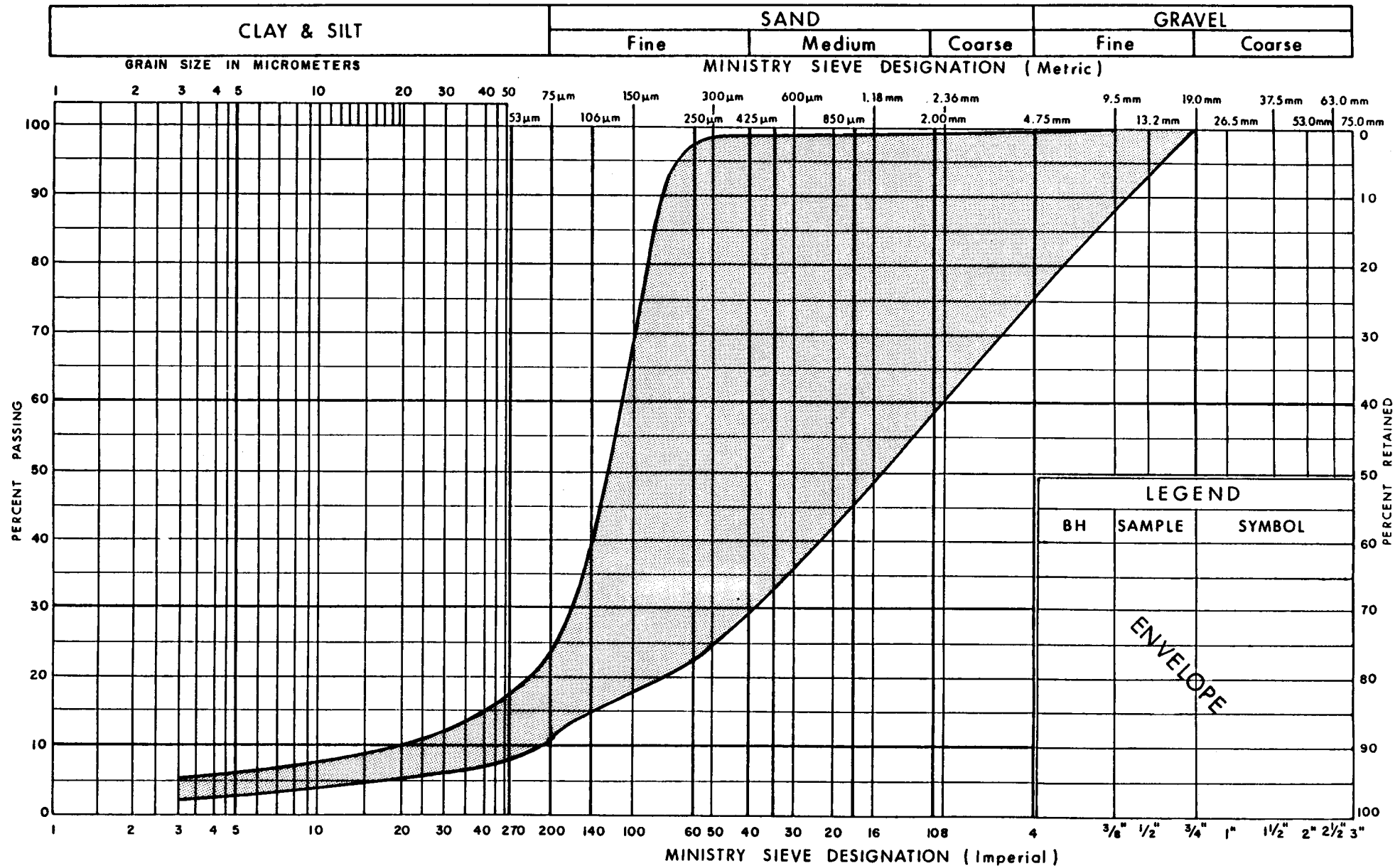
TABLE 2

SUMMARY OF SETTLEMENT ANALYSES

W. P. 110-87-01

Sample BH/Sample #	Elev. m	Po kPa	Pc Casagrande kPa	Pc Schmertmann kPa	Pc Calculation kPa	e _o	e	H
1 - 6	187	46	58	50	50	1.840	3 m = 0.23 5 m = 0.36	3 m = 0.6 m 5 m = 1.0 m
1 - 10	184	78	115	80	80	0.996	3 m = 0.09 5 m = 0.12	3 m = 0.4 m 5 m = 0.5 m
2 - 4	189	53	120	150	120	0.906	3 m = 0.02 5 m = 0.03	3 m = 0.1 m 5 m = 0.15 m
2 - 9	184	88	35	80	80	0.823	3 m = 0.07 5 m = 0.10	3 m = 0.3 m 5 m = 0.5 m

UNIFIED SOIL CLASSIFICATION SYSTEM



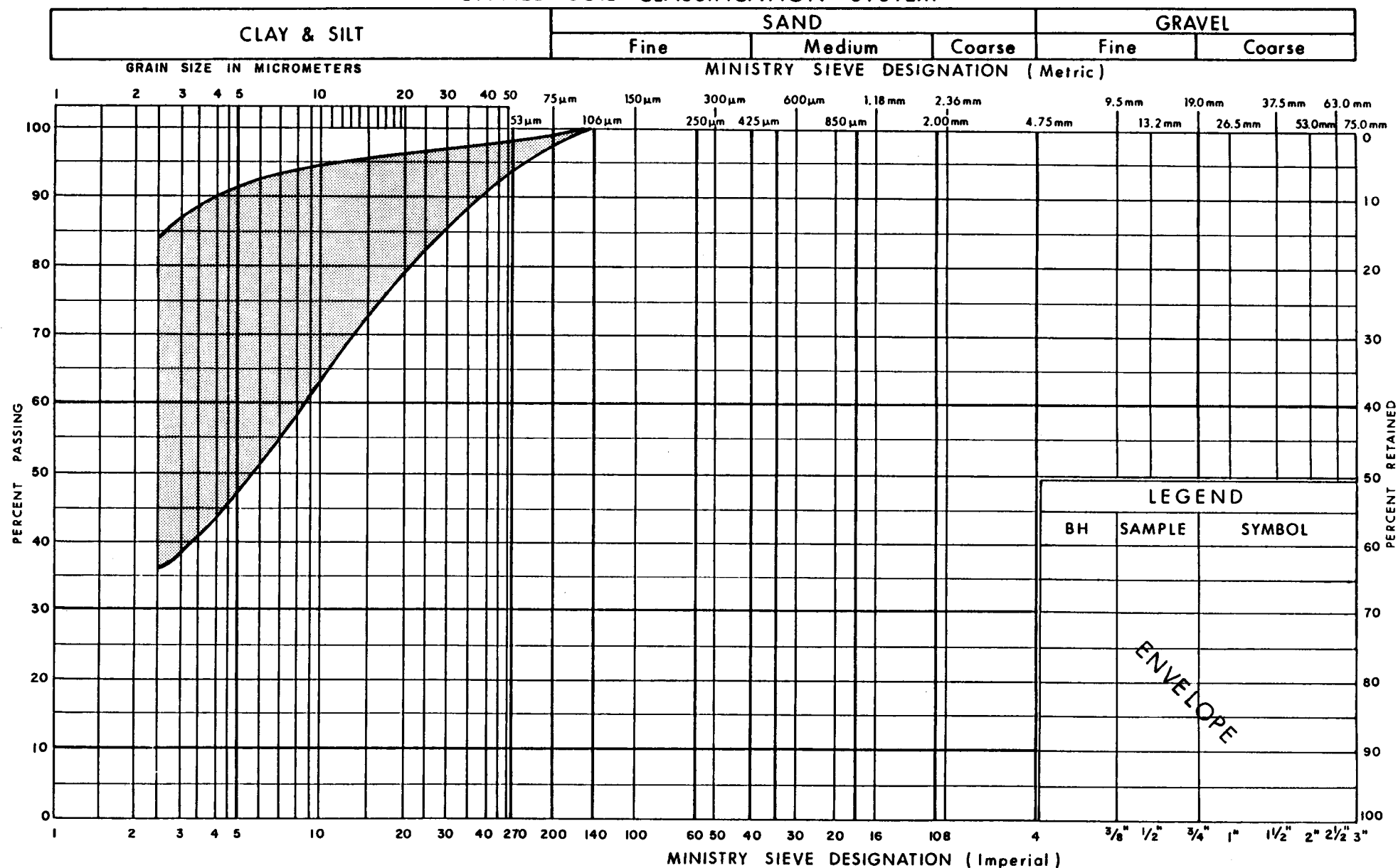
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILTY SAND TRACE/SOME GRAVEL, TRACE CLAY
(FILL MATERIAL)

FIG No 1

W P 110 - 87 - 01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION

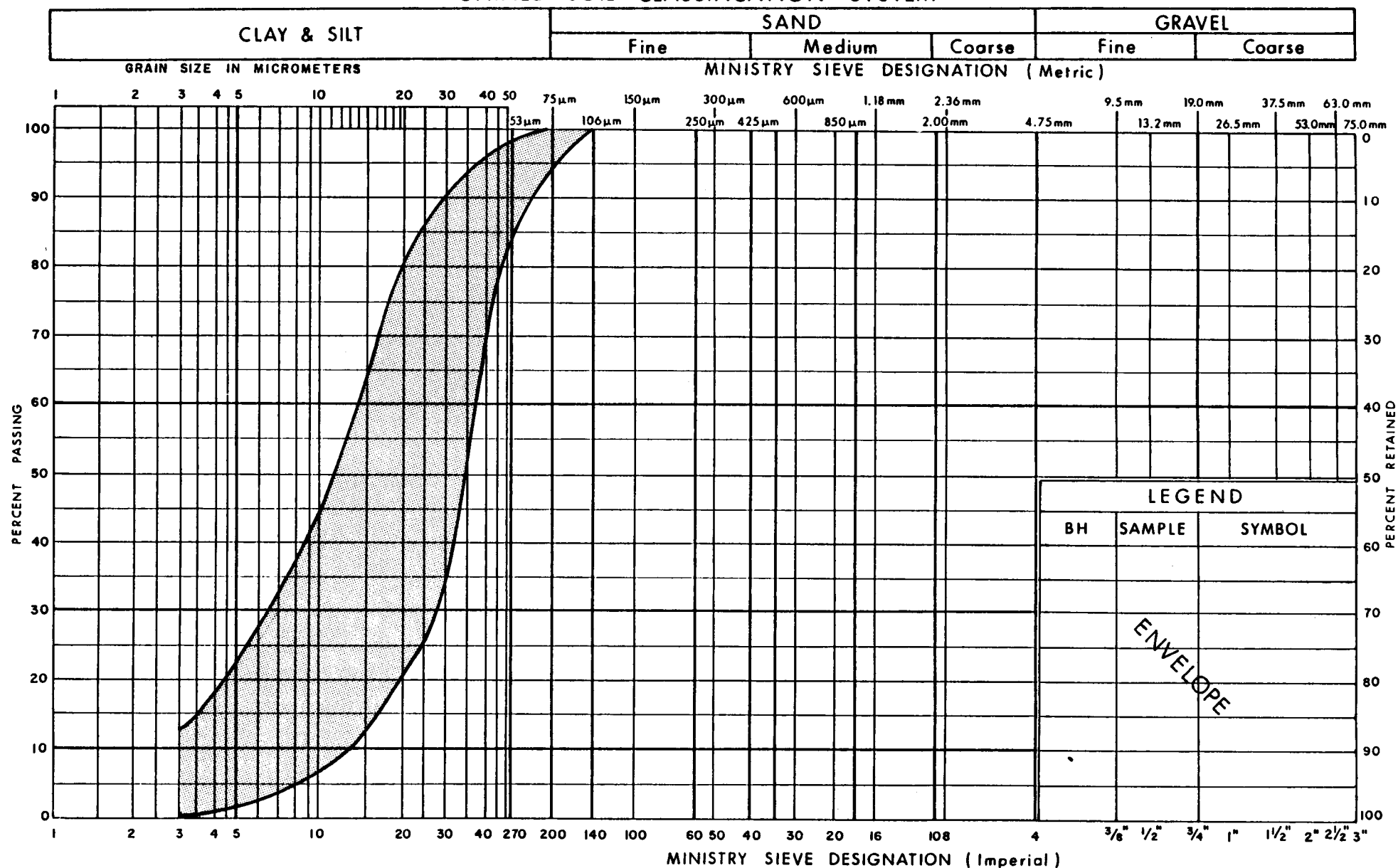
VARVED CLAY

ALTERNATING LAYERS (3 to 20mm thick) OF CLAY & SILT

FIG No 2

W P 110 - 87 - 01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

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Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILT TRACE / SOME CLAY, TRACE SAND

FIG No 3

W P 110-87-01

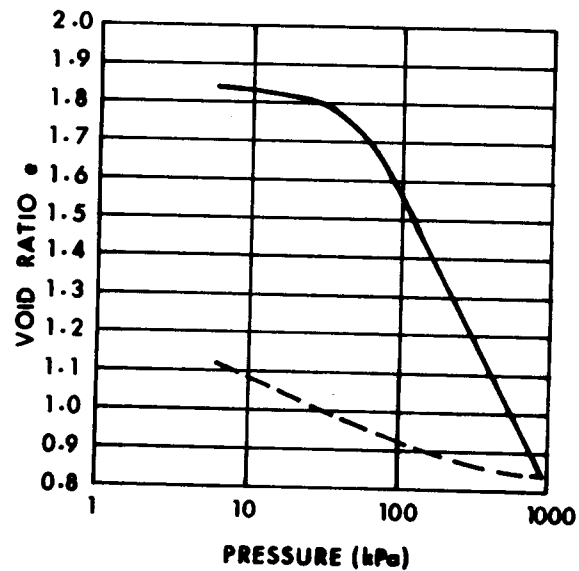


Fig 4 A

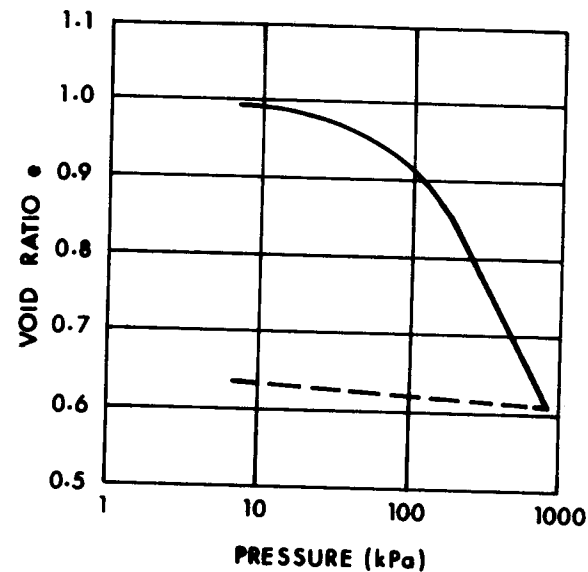


Fig 4 B

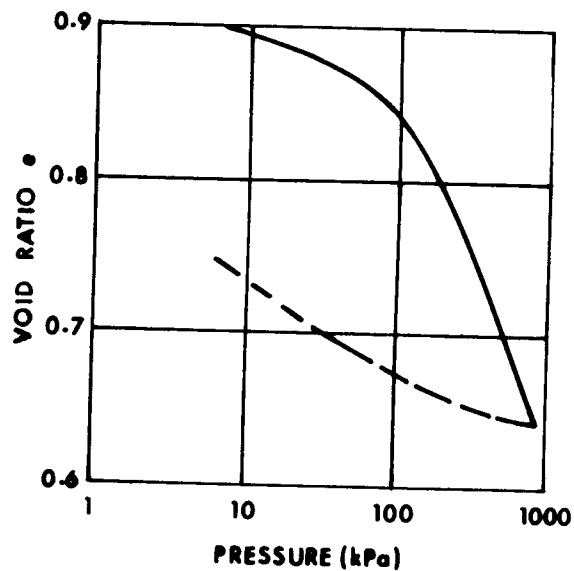


Fig 4 C

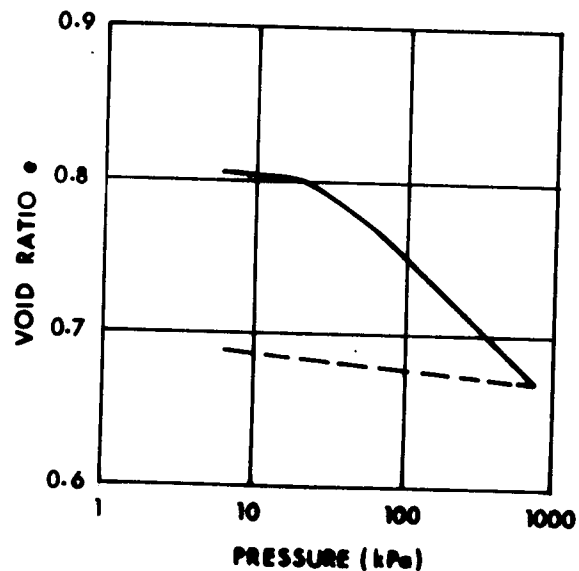
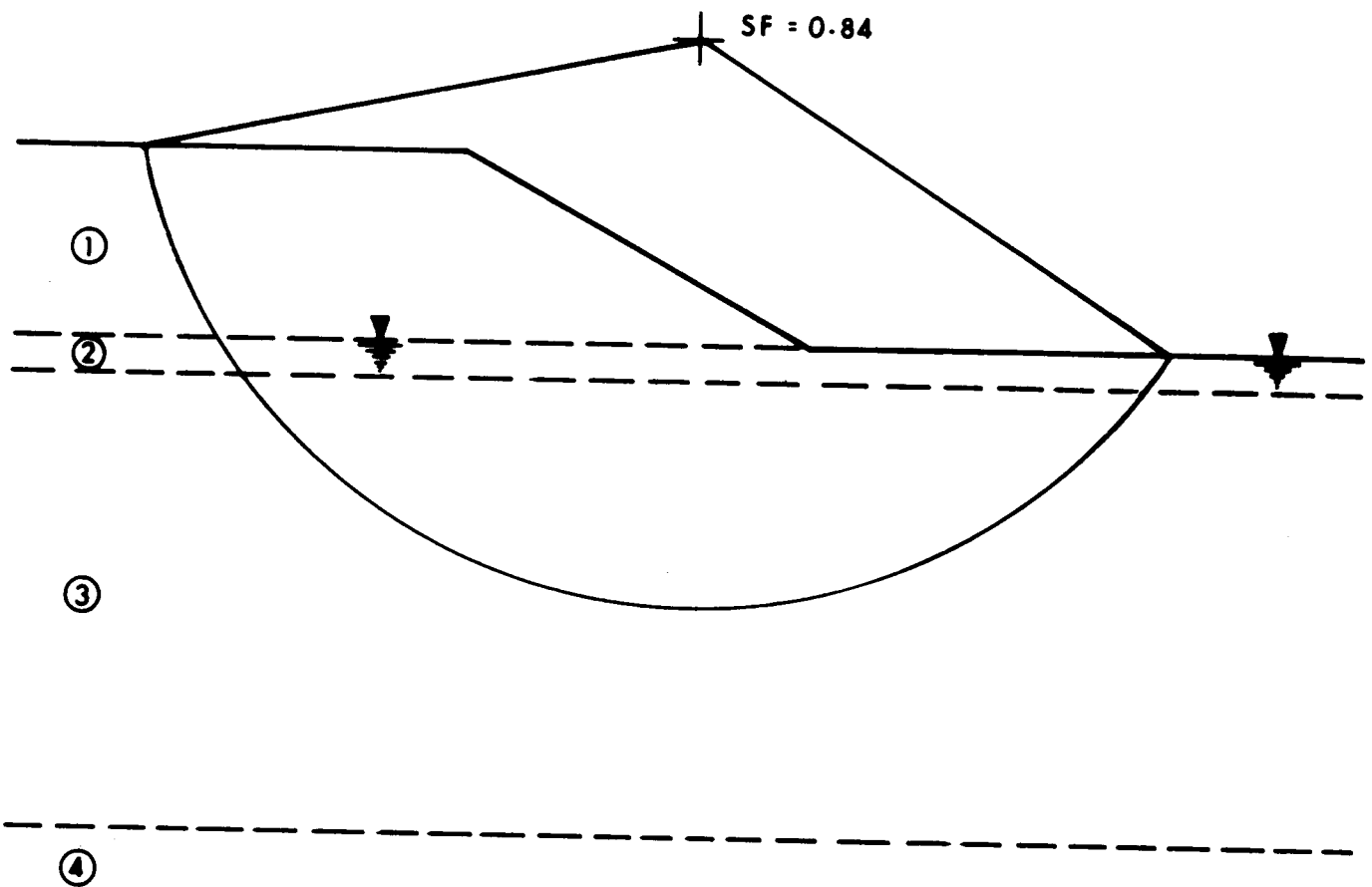


Fig 4 D

CONSOLIDATION CHARACTERISTICS

TOTAL STRESS ANALYSIS
5m EMBANKMENT
ORIGINAL CONDITION



SCALE 1:200

SOIL PARAMETERS

SOIL	C (kPa)	ϕ (°)	γ (kN/m ³)
①	0	30	20.4
②	0	28	18.9
③	16.8	0	16.5
④	0	28	17.5

Figure 5

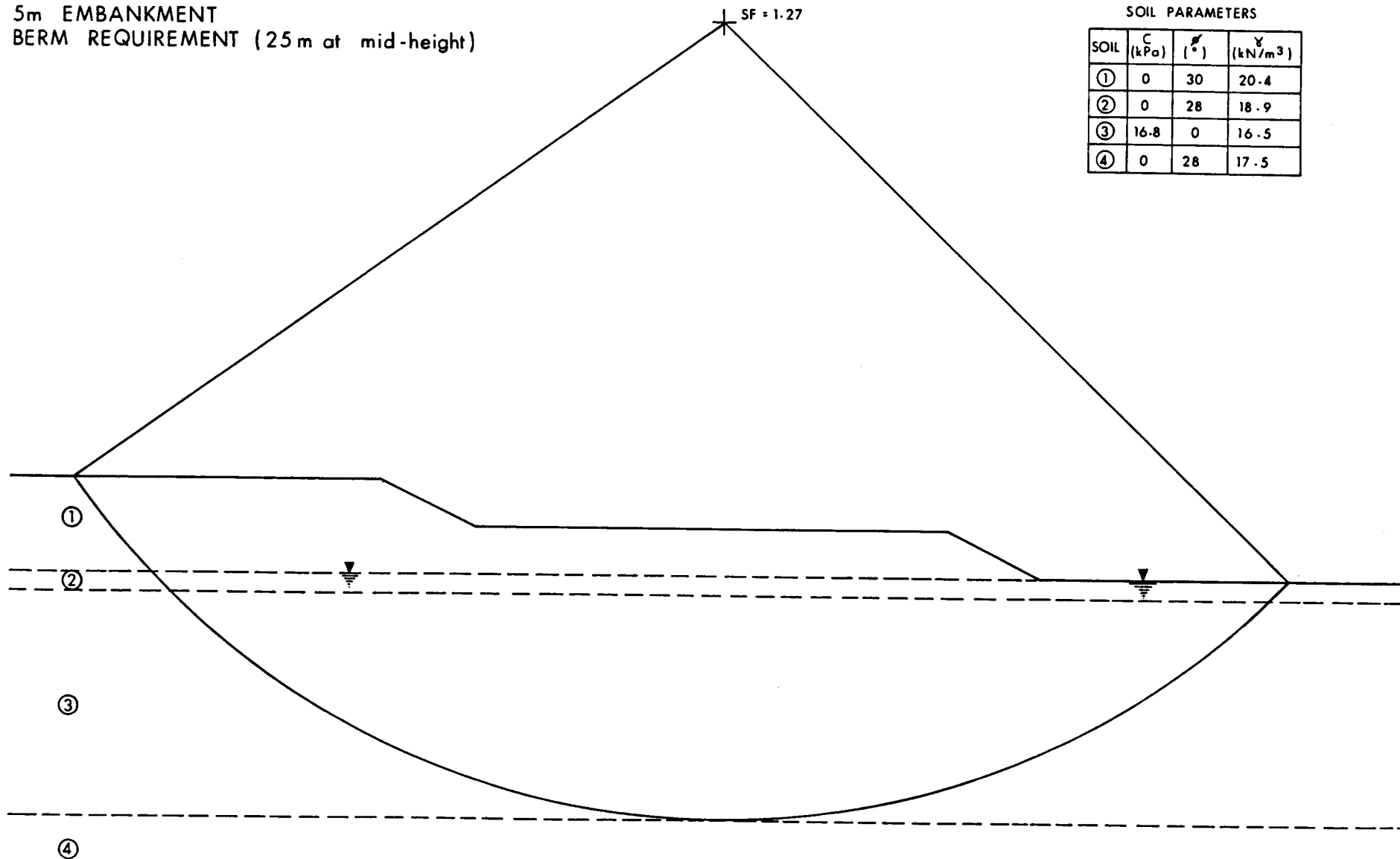
WP 110-87-01

TOTAL STRESS ANALYSIS
5m EMBANKMENT
BERM REQUIREMENT (25m at mid-height)

SF = 1.27

SOIL PARAMETERS

SOIL	C (kPa)	ϕ ($^{\circ}$)	γ (kN/m ³)
①	0	30	20.4
②	0	28	18.9
③	16.8	0	16.5
④	0	28	17.5



SCALE 1:300

Figure 6

TOTAL STRESS ANALYSIS
 4m EMBANKMENT
 BERM REQUIREMENT (12.5m at mid-height)

SOIL PARAMETERS

SOIL	C (kPa)	(°)	(kN/m ³)
①	0	30	20.4
②	0	28	18.9
③	16.8	0	16.5
④	0	28	17.5

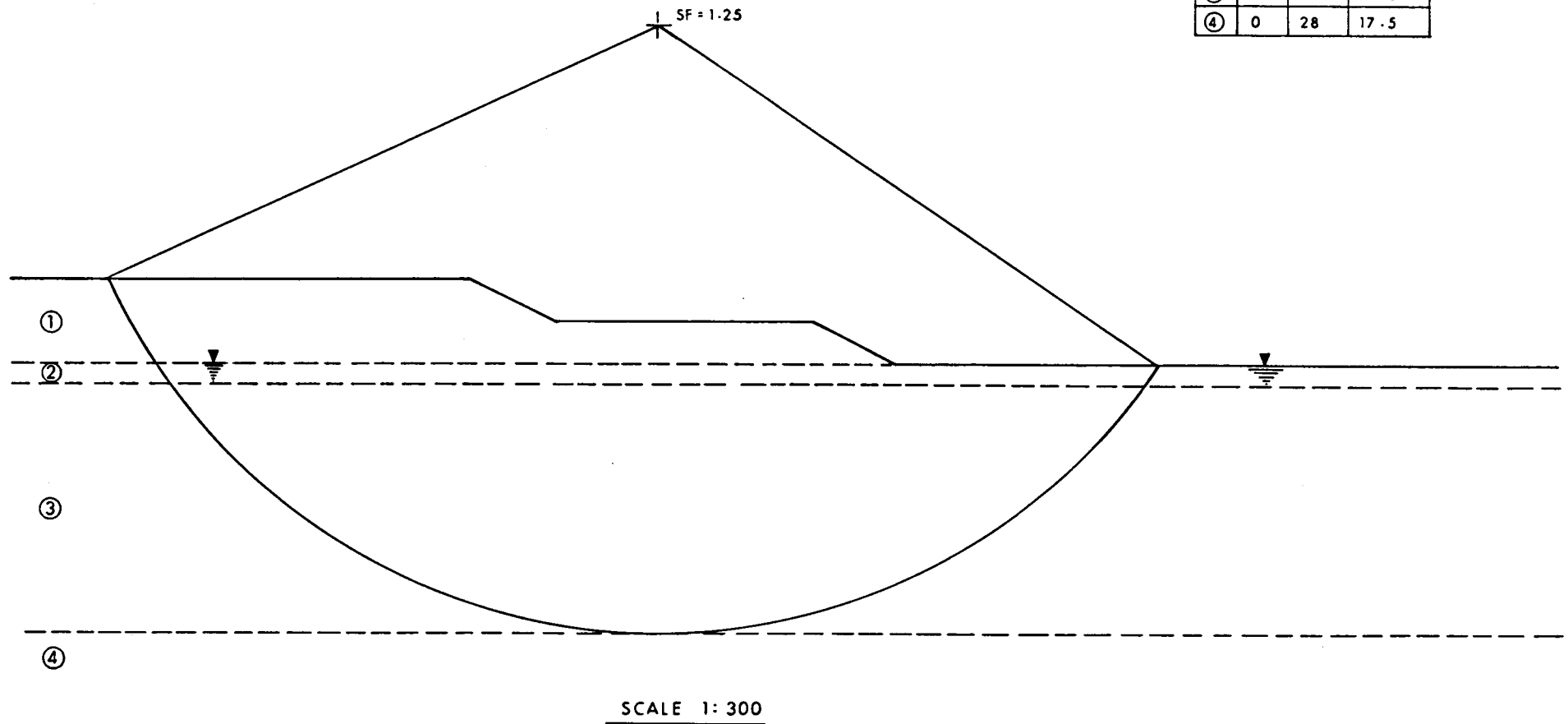
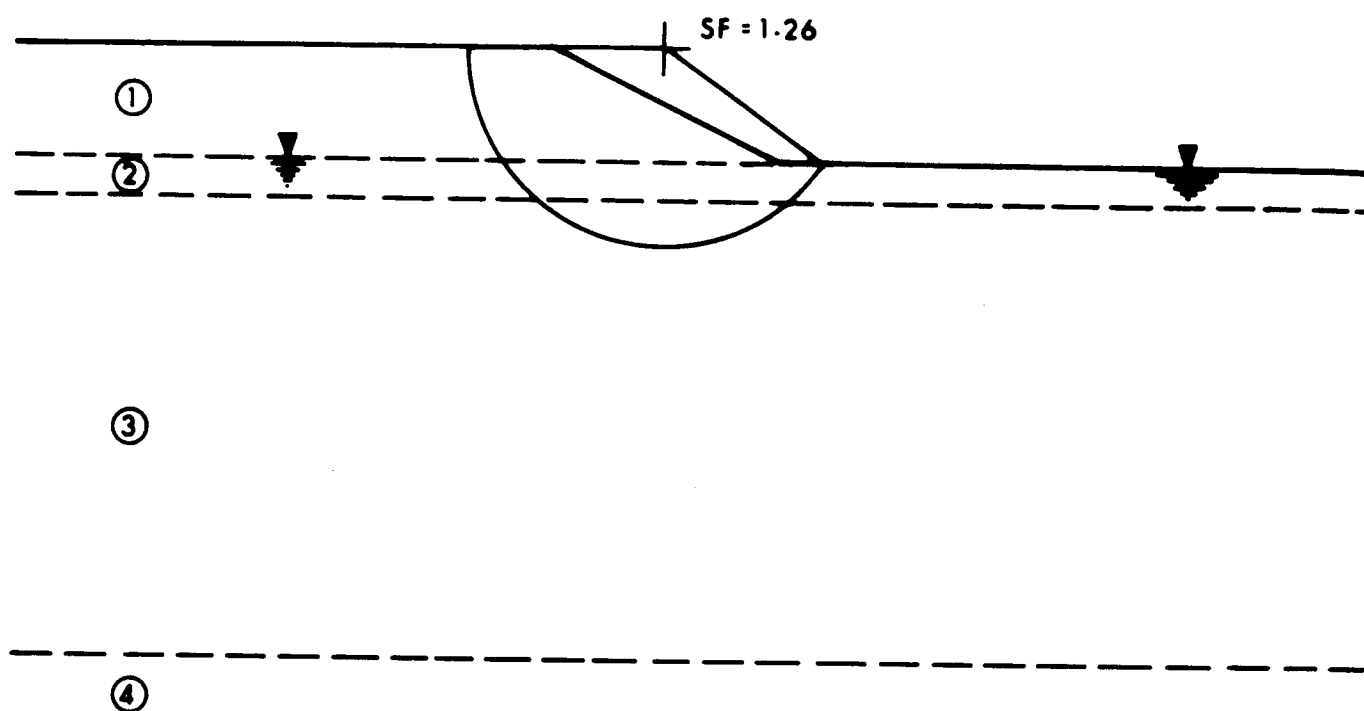


Figure 7

TOTAL STRESS ANALYSIS
 3m EMBANKMENT
 BERM REQUIREMENT (0.0m)



SCALE 1:200

SOIL PARAMETERS

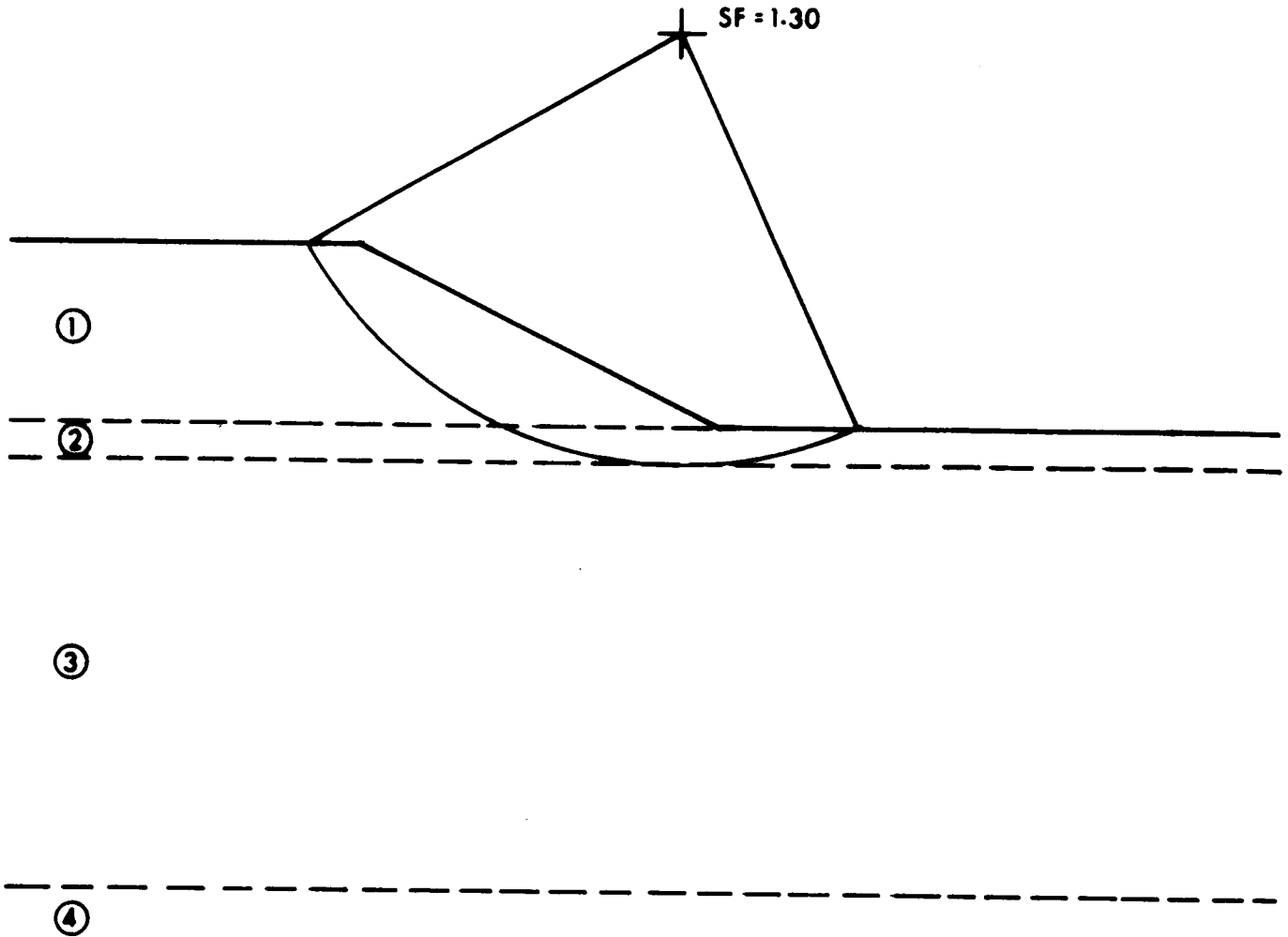
SOIL	C (kPa)	ϕ (°)	γ (kN/m ³)
①	0	30	20.4
②	0	28	18.9
③	16.8	0	16.5
④	0	28	17.5

Figure 8

TOTAL STRESS ANALYSIS

5m EMBANKMENT

LIGHTWEIGHT FILL SOLUTION ($\gamma < 12.6 \text{ kN/m}^3$)



SCALE 1: 200

SOIL PARAMETERS

SOIL	C (kPa)	ϕ (°)	γ (kN/m ³)
1	0	30	12.6
2	0	28	18.9
3	16.8	0	16.5
4	0	28	17.5

Figure 9

WP 110-87-01



RECORD OF BOREHOLE No 1

METRIC

W P 110-87-01 LOCATION STA. 13 + 502.3; O/S 16.5 m RT & HWY 17 ORIGINATED BY MJ
DIST 20 HWY 17 BOREHOLE TYPE Cone Test, H.S. Augers, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87-06-30 to 87-07-01 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT 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	WATER CONTENT (%)				
191.1	Ground Surface					**	190						22 17 (61)	
0.0	Silty Sand Some Gravel Trace Clay Loose to Compact (Fill)		1	SS	12									
189.1			2	SS	8									
2.0			3	SS	9									
	Varved Clay		4	SS	5									
	Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML)		5	SS	2		188						16.9	0 0 44 56 ***
			6	TW	PH									
			7	TW	PH									
			8	TW	PH									
	Soft to Firm (Lacustrine)		9	CS										
183.3			10	TW	PH		184						18.1	0 0 65 35 ***
7.8	Silt Trace/Some Clay Trace Sand		11	SS	9									0 0 89 11
181.8			12	SS	1		182							0 3 96 1
9.3	Bedrock Granodiorite Unweathered		13	RC	rec 97%			180						
178.8			14	RC	rec 100%									
12.3	End of Borehole													
	* Loose (Lacustrine)													
	** Stabilized ground- water Elevation not Established													
	*** Refer to Figure 4 for consolidation test results.													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC

W P 110-87-01

LOCATION STA. 13 + 482.9 ; O/S 16.9 m LT C HWY 17

ORIGINATED BY MJ

DIST 19 HWY 17

BOREHOLE TYPE Cone Test; H.S. Augers, B-Core

COMPILED BY MJ

DATUM Geodetic

DATE 87 07 01

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	60	80	100					
192.3	Ground Surface																
0.0	Silty Sand Trace/some Gravel Trace Clay Compact (Fill)		1	SS	24		192										
190.2			2	SS	23		190										6 69 20 5
2.1	Silty Clay (CL to CI) to Organic Silt (OI) Some Sand Occ. Organic Zones Firm; (Lacustrine)		3	TW	PH		188									16.6	*** 0.14 64 22
188.3			4	TW	PH		186										
4.0	Varved Clay Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML) Very Soft to Soft (Lacustrine)		5	TW	PH		184									17.4	*** 0 0 65 35
			6	TW	PM		182										
			7	TW	PM		180										
			8	TW	PM		178										
			9	TW	PH		176										
182.9			10	TW	PH		174										
9.4	Silt Trace/some Clay Trace Sand Loose to Compact (Lacustrine)		11	SS	8												0 2 91 7
			12	SS	8												
			13	SS	6												
176.8			14	SS	11												
15.5	Silty Sand Trace/some Gravel Trace Clay Compact (Lacustrine)		15	SS	22												
174.3			16	RC	rec 99%												
18.0	Bedrock Unweathered Diorite		17	RC	58%												
172.0																	
20.3	END OF BOREHOLE																
	*** Refer to Fig. 4 for consolidation test results.																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 3

METRIC

W P 110-87-01 LOCATION STA. 13 + 508.2; O/S 4.5 m LT Q HWY 17
DIST 19 HWY 17 BOREHOLE TYPE Cone Test. H.S. Augers
DATUM Geodetic DATE 87 07 03 to 87 07 06
ORIGINATED BY MJ
COMPILED BY MJ
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				
194.6	Ground Surface															
0.0	Silty Sand					*	194									
	Trace/some gravel		1	SS	68		192									
	Trace Clay															
	Compact to Very Dense (Fill)		2	SS	15											
			3	SS	21											
	Occasional Organic zones.		4	SS	19											
188.5	Occasional Boulders		5	SS	7											
6.1	Varved Clay		6	SS	3		188									
	Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML) Soft to Firm (Lacustrine)		7	SS	2		186									
			8	SS	3											
183.0			9	SS	3		184									
11.6	Silt															
	Trace/Some Clay		10	SS	13		182									
181.2	Trace Sand **															
13.4	Silty Sand		11	SS	3		180									
	Trace/Some Gravel															
	Trace Clay: Very loose: (Lacustrine)															
179.4																
15.2	Refusal to Auger															
	Probable Bedrock															
	END OF BOREHOLE															
	* Stabilized groundwater elevation not established.															
	** Compact (Lacustrine)															

+³, x⁵: Numbers refer to Sensitivity
20
15 + 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 110-87-01 LOCATION STA. 13 + 485.1; O/S 4.4 m RT Q HWY 17 ORIGINATED BY MJ
DIST 19 HWY 17 BOREHOLE TYPE Cone Test, H.S. Augers COMPILED BY MJ
DATUM Geodetic DATE 87 07 06 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
194.8	Ground Surface													
0.0	Silty Sand					**								
	Some Gravel													
	Trace Clay		1	SS	63									
	Very Loose		2	SS	18									
	to		3	SS	34									
	Very Dense		4	SS	15									
	(Fill)		5	SS	3									
	Occasional Organic		6	SS	19									
	Zones.		7	SS	13									
	Occasional Cobbles		8	SS	17									
185.7														
9.1	Varved Clay		9	SS	6									
	* Soft		10	SS	3									
	to Firm													
182.9	(Lacustrine)													
11.9	Silt		11	SS	15									
	Trace/Some Clay		12	SS	15									
	Trace Sand													
	Very loose													
	to													
	Very Dense		13	SS	1									
	(Lacustrine)													
178.3														
16.5	Silty Sand		14	SS	114									
	Trace/Some Gravel													
	Trace Clay, dense													
176.5	(Lacustrine)													
18.3	Refusal to Auger													
	Probable Bedrock													
	END OF BOREHOLE													
	*Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML)													
	** Stabilized Groundwater elevation not established.													

+³, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

METRIC

W P 110-87-01 LOCATION STA. 13 + 472.7; O/S 20.0 m RT & HWY 17
DIST 19 HWY 17 BOREHOLE TYPE H.S. Augers
DATUM Geodetic DATE 87 07 06

ORIGINATED BY MJ
COMPILED BY MJ
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					
193.0	Ground Surface																GR SA SI CL
0.0	Silty Sand Some Gravel/Tr. Clay Loose (Fill)		1	SS	4	*	192										
191.2			2	SS	2		190										
1.8	Varved Clay		3	SS	1		190										
	Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML)		4	SS	1		188										0 0 18 82
			5	SS	1		188										
	Very Soft		6	SS	1		186										0 0 41 59
	to		7	SS	1		186										
	Soft		8	SS	4		184										
	(Lacustrine)		9	SS	3		184										
182.9			10	SS	9		182										
10.1	Silt Trace/Some Clay Trace Sand Loose (Lacustrine)		11	SS	10		180										
180.5			12	SS	15		178										
12.5	Silty Sand Some Gravel Trace Clay Compact to Very Dense (Lacustrine)		13	SS	75/13cm												
177.4																	
15.5	Refusal to Auger Probable Bedrock END OF BOREHOLE * Stabilized Ground- water elevation not established.																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

METRIC

W P 110-87-01 LOCATION STA. 13 + 528.6; O/S 18.5 m RT Q HWY 17 ORIGINATED BY MJ
 DIST 19 HWY 17 BOREHOLE TYPE H.S. Augers COMPILED BY MJ
 DATUM Geodetic DATE 87 07 07 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
192.4	Ground Surface												
0.0	Silty Sand												
191.2	** (Fill)		1	SS	21								
1.2	Varved Clay		2	SS	4								
	Alternating Layers (3 to 20 mm thick)		3	SS	3								
	of Clay (CI to CH)		4	SS	2								
	and Silt (ML)		5	SS	1								
	Verv Soft		6	SS	1								
	to		7	SS	1								
	Soft		8	SS	1								
	(Lacustrine)		9	SS	5								
182.3			10	SS	4								
10.1	Silt												
	Trace/Some Clay		11	SS	14								
	Trace Sand												
	Compact												
179.9	(Lacustrine)		12	SS	26								
12.5	Silty Sand												
	Some Gravel												
	Trace Clay		13	SS	27								
	Compact to												
	Verv Dense												
177.2	(Lacustrine)		14	SS	50/5 cm								
15.2	Refusal to Auger Probable Bedrock END OF BOREHOLE												
	* Stabilized groundwater elevation not established.												
	** Some Gravel Trace Clay Compact												

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7

METRIC

W P 110-87-01 LOCATION STA. 13 + 534.4; O/S 21.7 m LT C HWY 17 ORIGINATED BY MJ
DIST 19 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MJ
DATUM Geodetic DATE 87 07 07 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
193.2	Ground Surface													
0.0	Silty Clay (CL to CI) to Organic Silt (OI)		1	SS	5	**	192							GR SA SI CL
191.7	*		2	SS	4		190							0 2 69 29
1.5	Varved Clay		3	SS	2		188							0 0 37 63
	Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML)		4	SS	2		186							
	Very Soft to Firm		5	SS	2		184							
	(Lacustrine)		6	SS	2		182							
			7	SS	1		180							
			8	SS	2		178							
			9	SS	2		176							
			10	SS	2									
			11	SS	6									
180.1			12	SS	5									
13.1	Silty Sand		13	SS	16									
	Trace Clay		14	SS	25									
	Trace Gravel		15	SS	30									
	Compact to Dense		16	SS	37									
174.1	(Lacustrine)													
19.1	Refused to Auger Probable Bedrock END OF BOREHOLE													
	* Some Sand Occ. Organic Zones Firm (Lacustrine)													
	** Stabilized groundwater elevation not established.													


+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8

METRIC

W P 110-87-01 LOCATION STA. 13 + 462.5; O/S 21.3 m Lc Q HWY 17 ORIGINATED BY MJ
 DIST 19 HWY 17 BOREHOLE TYPE H.S. Augers COMPILED BY NJ
 DATUM Geodetic DATE 87 07 08 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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	10 20 30 40 50					
191.2	Ground Surface													
0.0	Varved Clay		1	SS	3	**	190							
	Alternating Layers		2	SS	2									
	(3 to 20 mm thick)		3	SS	1									
	of Clay (CI to CH)		4	SS	1									
	and Silt (ML)		5	SS	1									
	Very Soft		6	SS	1									
	to		7	SS	2									
	Firm		8	SS	2									
	(Lacustrine)													
182.7	Silt		9	SS	2									
8.5	Trace/Some Clay		10	SS	9									
	Trace Sand		11	SS	16									
	Loose to Compact													
	(Lacustrine)		12	SS	15									
178.1	Silty Sand													
13.1	* Compact		13	SS	17									
176.6														
14.6	Refusal to Auger													
	Probable Bedrock													
	END OF BOREHOLE													
	* Trace/Some Gravel													
	Trace Clay													
	Compact													
	(Lacustrine)													
	** Stabilized groundwater elevation not established.													

+3, x5: Numbers refer to Sensitivity
 20
 15 5 (%) STRAIN AT FAILURE
 10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 9

METRIC

W P 110-87-01

LOCATION STA 13 + 469.8; O/S 13.5 m RT @ HWY 17

ORIGINATED BY MJ

DIST 19

HWY 17

BOREHOLE TYPE Cone Penetration Test

COMPILED BY MJ

DATUM Geodetic

DATE 87 07 06

CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
193.1	Ground Surface											
0.0	Probable Silty Sand *											
192.2												
0.9	Probable Varved Clay											
	Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML) (Lacustrine)											
181.8												
11.3	Probable Silt Trace/some clay Trace Sand (Lacustrine)											
177.9												
15.2	Probable Silty Sand Some Gravel, Tr. Clay (Lacustrine)											
176.3												
16.8	End of Cone Test											
	Probable Bedrock											
	* Some Gravel Trace Clay (Fill)											

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 10

METRIC

W P 110-87-01 LOCATION STA 13 + 536.5; O/S 13.2 m RT Q HWY 17 ORIGINATED BY MJ
DIST 19 HWY 17 BOREHOLE TYPE Cone Penetration Test COMPILED BY MJ
DATUM Geodetic DATE 87 07 07 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
192.6	Ground Surface											
0.0	Probable Silty Sand *											
191.7												
0.9	Probable Varved Clay											
	Alternating Layers (3 to 20 mm thick) of Clay (CI to CH) and Silt (ML) (Lacustrine)											
181.3												
11.3	Probable Silt Trace/Some Clay Trace Sand (Lacustrine)											
176.1												
16.5	Probable Silty Sand Some Gravel/Tr.Clay (Lacustrine)											
174.3												
18.3	End of Cone Test											
	Probable Bedrock * Some Gravel Trace Clay (Fill)											

+³, x⁵: Numbers refer to Sensitivity
20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 11

METRIC

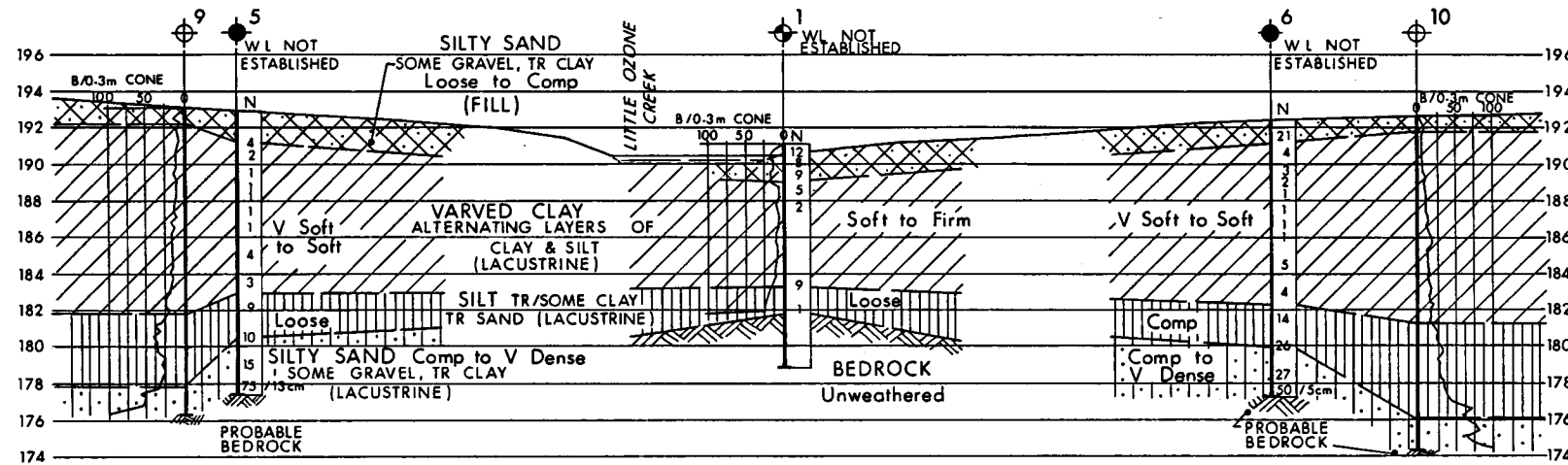
W P 110-87-01 LOCATION STA 13 + 471.2; O/S 13.8 m LT Q HWY 17 ORIGINATED BY MJ
DIST 19 HWY 17 BOREHOLE TYPE Cone Penetration Test COMPILED BY MJ
DATUM Geodetic DATE 87-07-02 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 10 20 30 40 50	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
192.6 0.0	Ground Surface										
188.0 4.6	Probable Silty Sand Trace/Some Gravel Trace Clay (Fill)										
182.2 10.4	Probable Varved Clay Alternating Layers (3 to 20 mm thick of Clay (CI to CH) and Silt (ML) (Lacustrine)										
176.4 16.2	Probable Silt Trace/Some Clay Trace Sand (Lacustrine)										
175.2 17.4	Probable Silty Sand *										
	End of Cone Test Probable Bedrock * Trace/Some Gravel Trace Clay (Lacustrine)										

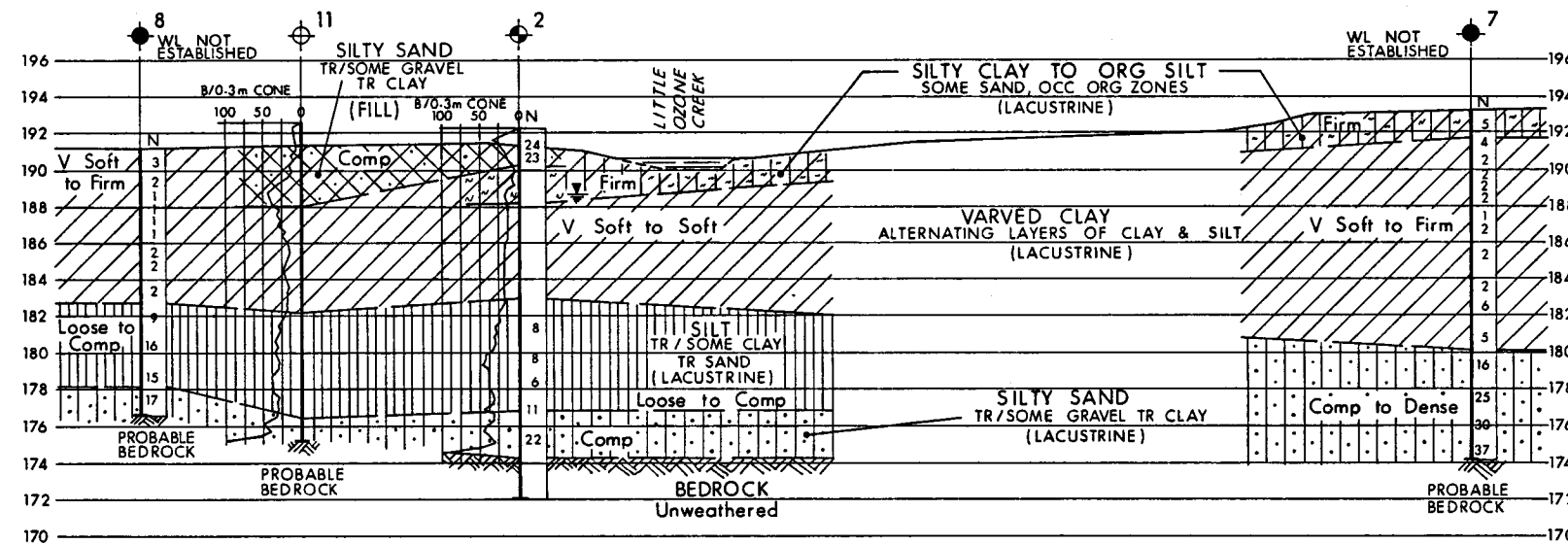
+3, x5 : Numbers refer to
Sensitivity

20
15 x 5 (%) STRAIN AT FAILURE
10

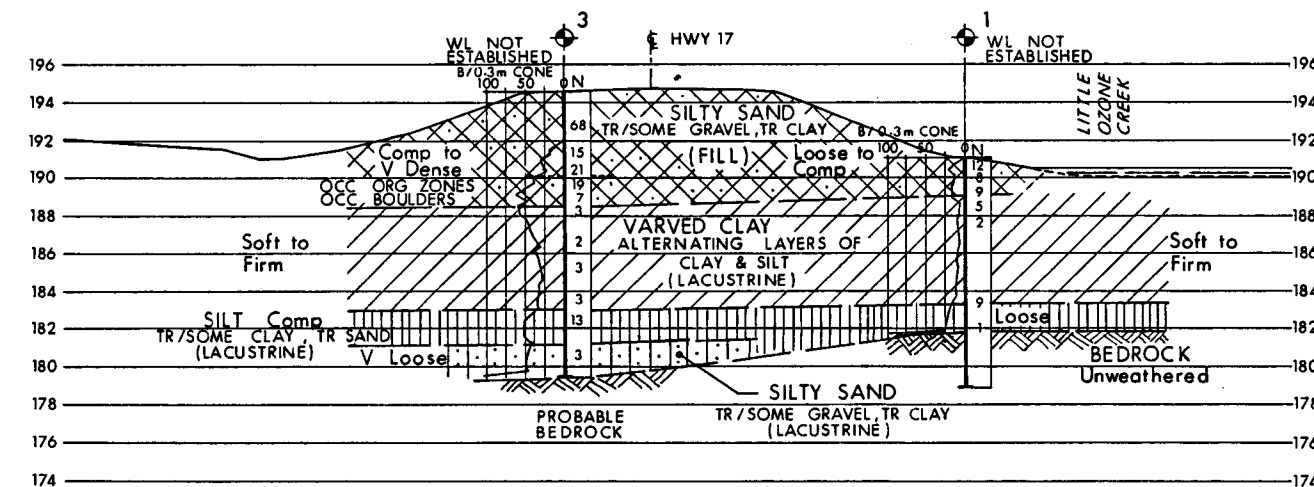
OFFICE REPORT ON SOIL EXPLORATION



D-D

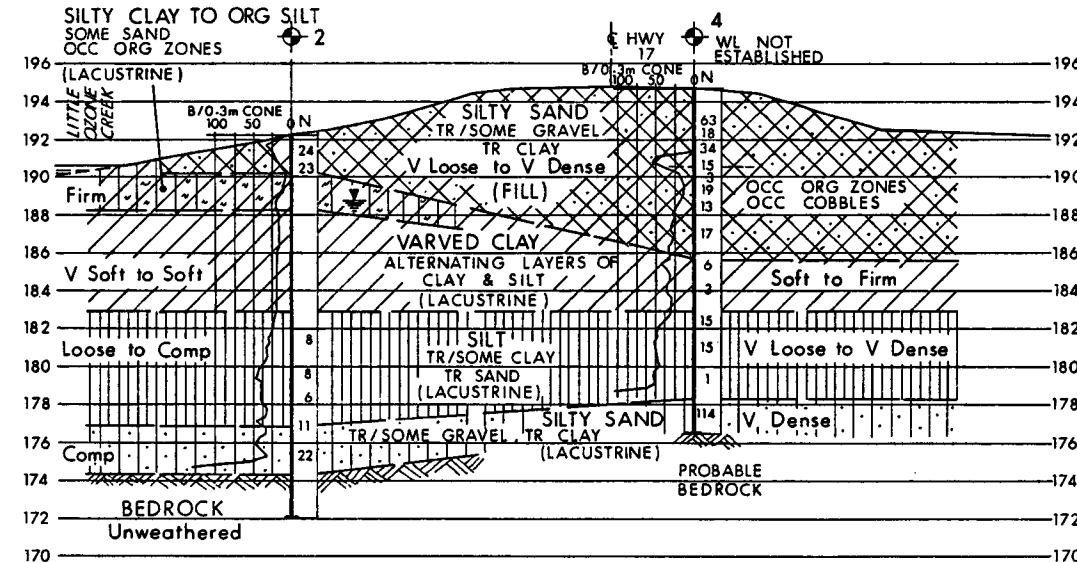


C-C

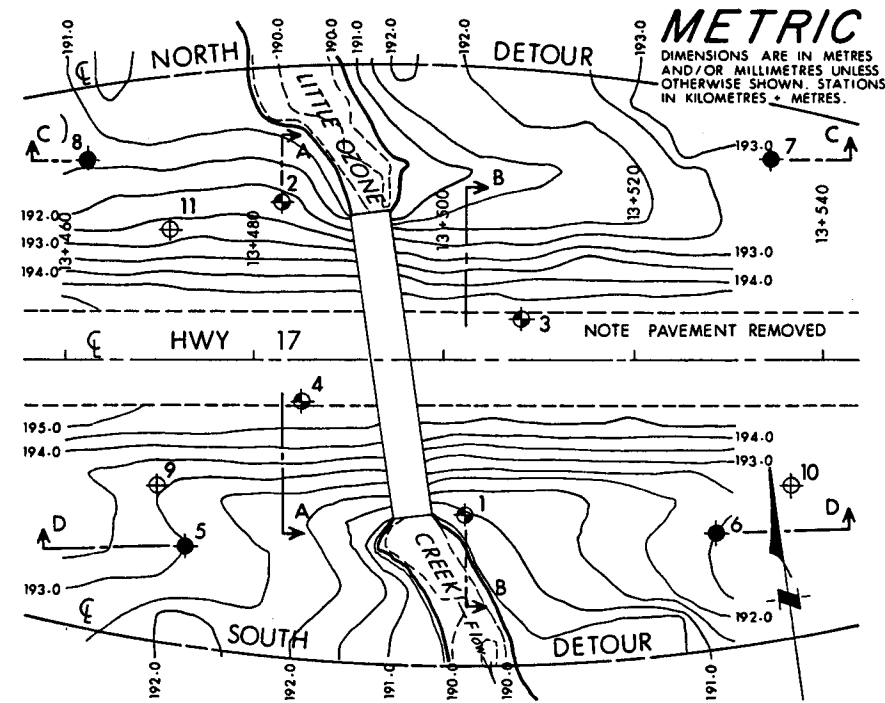


B-B

SECTIONS
SCALE
4m 2 0 2 4m

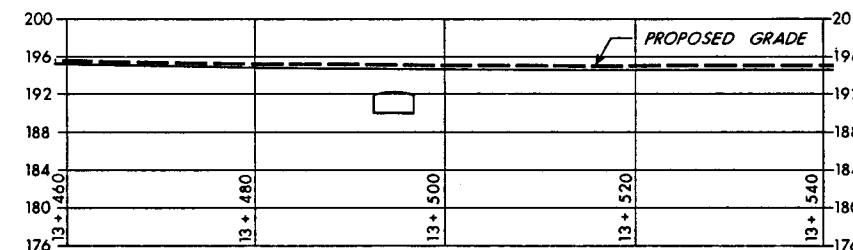


A-A



PLAN

SCALE
8m 4 0 8m



PROFILE HWY 17

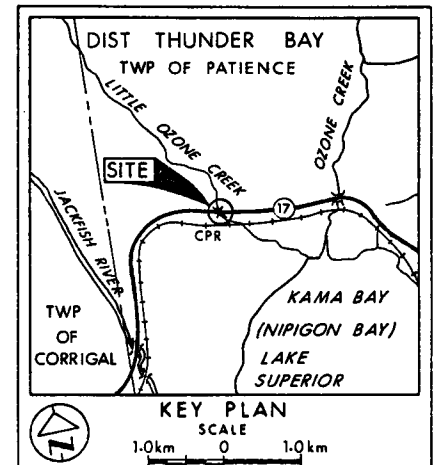
SCALE
8m 4 0 8m

CONT No
WP No 110-87-01

LITTLE OZONE CREEK
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



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 87 07

No	ELEVATION	STATION	OFFSET
1	191.1	13+502.3	16.5m Rt
2	192.3	13+482.9	16.9m Lt
3	194.6	13+508.2	4.5m Lt
4	194.8	13+485.1	4.4m Rt
5	193.0	13+472.7	20.0m Rt
6	192.4	13+528.6	18.5m Rt
7	193.2	13+534.4	21.7m Lt
8	191.2	13+462.5	21.3m Lt
9	193.1	13+469.8	13.5m Rt
10	192.6	13+536.5	13.2m Rt
11	192.6	13+471.2	13.8m 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 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
Geocres No	52H-8		
HWY No	17		
SUBNO	DD	CHECKED	DATE 87 09 16
DRAWN	DT	CHECKED	APPROVED
			SITE 48C-176
			DWG 1108701-A

REF No E-8084-1, 87 07