VEDDER SET-BACK DYKES
GEOTECHNICAL REPORT

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HILLIS CONSULTING SERVICES

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1. INTRODUCTION

This report presents the results of a site investigation carried out for the proposed set-back dykes along the Vedder River, Chilliwack, B. C., and gives design recommendations on the basis of the information obtained.

2. TOPOGRAPHY AND GEOLOGY OF THE SITE

Dykes are to be constructed along the Vedder River between approximately the location of the B. C. Hydro Railway bridge north of Yarrow and Webster Road approximately 3 km upstream of the bridge. The dykes are required on both sides of the river and are to be set back from the existing river bank by up to 350 m. The river falls about 16 m over this stretch and it flows from east to west. Along the proposed dyke alignment, the land is substantially level and consists mainly of arable and grazing farm land with a few forested areas. The B. C. Hydro railway and several roads cross the proposed alignment of the dykes. Floodboxes are to be provided at the location of five stream crossings.

A publication by the Geological Survey of Canada (Paper 57-5) shows this area to be underlain by post-glacial stream deposits "consisting of gravel and sand up to 50 ft or more thick", with a mixture of lacustrine and stream deposits to the north consisting of "stream deposited sand up to 25 ft thick overlying silt, clayey silt, silty clay and sand of lacustrine origin".

3. FIELD EXPLORATION

Eight exploratory holes were drilled by a truck-mounted rotary drill and 21 test pits were excavated by a backhoe at the positions shown on the site plan, Fig. 1. The depths of the drill holes and test pits, the descriptions of the soils encountered and other relevant data are given in Appendix A, "Logs of Drill Holes and Test Pits".

Disturbed soil samples were taken from the drill holes and test pits and undisturbed 3-1/2-in. dia Shelby tube soil samples were taken from the drill holes. Standard penetration tests were made in the drill holes to assess the density of the soil.

The ground levels at the drill holes and test pits given on the logs were taken from a longitudinal profile of the ground surface, Dwg No. 4805-17-102, supplied by the Water Investigations Branch.

The site work was carried out during the period 7 to 15 September 1978.

4. LABORATORY TESTING

The natural moisture contents, Atterberg Limits (liquid and plastic limits) and grain size distributions of four selected samples of silt were determined. Consolidation tests were carried out on three of the above samples. The results of these tests are given in Appendix B.

5. SOIL CONDITIONS

A simplified record of the soil types encountered in the drill holes and test pits is shown on a longitudinal profile of the proposed dyke, Fig. 2. Beneath the topsoil, a layer of soft, generally somewhat organic, sandy silt with layers of silty sand was usually encountered. Typically, this silt was found to extend to depths of from less than 1 m to about 4 m below the ground surface. The upper silt layer was not encountered at or upstream from Ford Road on the south bank, while at floodbox 3 it was exceptionally found to extend to 6.5 m depth. The silt rests upon loose to medium dense fine to medium sand overlying medium dense fine to coarse sand and gravel or directly on the sand and gravel. Generally, this sand and the sand and gravel were encountered throughout the entire depths of the drill holes, which terminated between 6 and 18 m depth below ground level. However, a layer of silt was encountered below the sand and gravel at a depth of 9.5 to 15.2 m depth in Drill Hole 8.

Groundwater was encountered at depths of from 0.5 to 2.6 m below ground level.

6. DYKE DESIGN

The average height of the proposed dykes is about 2.5 m and, according to information supplied by the Branch, it has been decided to make the crest 5 m wide. The riverside and landside slopes were tentatively fixed by the Branch at 1V:3H and 1V:2-1/2H respectively. Clean sand and gravel dredged from the Vedder River and presently stockpiled is to be used to construct the dykes. A report on this material was produced for the Branch by Crippen Consultants in June 1978 and reference should be made to this report for detailed material characteristics.

Prior to commencing fill placement, the dyke foundation should be stripped of all highly organic topsoil and other vegetation.

The proposed typical section through the dyke is shown on Fig. 3 and a discussion as to its development is given below.

The 1V:3H riverside slope proposed by the Branch is appropriate considering the proposed construction material and it is recommended that it be adopted.

Regarding the landside slope, since the proposed fill material is unusually clean for dyke construction (virtually zero fines content) steady state seepage, and thus a high phreatic surface, could be established within the dyke in a short period of time, certainly within the duration of the flood. This could result in a considerable amount of seepage through the dyke with water emerging quite high on the landside slope. The exact exit conditions for the seepage water will depend on the stratification which will occur during placement and on the natural variation in the properties of the fill material. It is believed prudent, therefore, to protect the dyke against possible erosion by emerging seepage water by flattening the landside slope from the previously assumed value of 1V:2-1/2H to about 1V:4H from the base up to 1 m below the crest. Above this, the 1V:2-1/2H slope may be adopted.

Regarding general fill specifications, the Vedder River sand and gravel may be placed without any processing in loose lift thicknesses of 250 mm. This will require the removal from the fill of only an insignificant amount of plus 200 mm material. Each lift should be thoroughly compacted by at least four coverages of a Dynapac C25 smooth drummed vibratory roller. During construction, the as-compacted density should be checked to determine if this compaction specification is yielding 95 per cent standard density, or more.

On the question of topsoiling, it is recommended that the landside slope not be topsoiled, but only hydro-seeded. This will ensure that the slope remains free-draining thus keeping the phreatic surface as low as possible.

Topsoiling and seeding of the riverside slope would, however, assist in stabilizing the surface of this slope and in reducing the seepage of water through the dyke.

In view of the relatively high permeability of the natural sand and gravel in the dyke foundation, it is possible that significant underseepage pressure could be transmitted to the landside toe. Where the upper silt layer is of insufficient thickness to counterbalance this pressure, it is possible that foundation piping problems could occur. Protection against boiling and piping may be achieved by constructing a gravel-filled drainage trench to intersect the underseepage or by loading the landside toe with a berm, as shown on Fig. 3.

A continuous trench would provide more positive protection against piping than a berm since a berm, although protecting the toe of the dyke and decreasing the hydraulic gradient somewhat, only moves the area of concern further inland. However, a trench may be more expensive to construct due to the possibility of collapse when the trench is excavated below the water table, as was noted in several test pits excavated during the site investigation, unless an automatic trencher capable of excavating and backfilling with gravel in one continuous operation could be obtained locally.

A trench or berm is only needed where the silt layer is less than about 2 m thick. However, the silt thickness varies considerably over relatively short distances and in order to reduce the protected length of dyke to a minimum further investigation will be required. Even with a reasonable amount of further investigation, however, some areas of thin silt cover may be missed, but the only alternative would be to install the trench or berm more or less along the entire length of the dykes, except upstream of Ford Road, where it is known that the foundation comprises mainly sand and gravel.

The above discussion notwithstanding, it should be noted that any piping problems are likely to be local in nature and that with sufficient inspection during a flood, which will last for only a short time, it should be possible to identify any problem areas and prevent boiling and possible piping by sand bagging or by dumping a layer of suitable filter material over the area of seepage.

Should the trench be adopted, the backfill material may be minus 19 mm Vedder River sand and gravel. If there are any problems with land purchase, the trench may be constructed 2 m within the dyke foundation area, rather than just outside as shown on Fig. 3.

Regarding stability of the dyke foundations during construction, no problems are anticipated providing the dyke is built up at a reasonable rate by constructing it in near-horizontal layers over a long stretch at a time. There will, however, be some settlement of the dyke due mainly to consolidation of the silt in the foundations. The amount of settlement will vary according to the thickness and compressibility of the foundation silt and it could be as much as 0.30 m. However, much of this settlement will occur during construction. Nevertheless, provision should be made for possible slight overbuilding of the dyke in some areas. In order to monitor the situation, some simple settlement plates should be installed at selected locations.

7. FLOODBOXES

Competent sand or sand and gravel is likely to be encountered at the foundation level of most of the floodboxes; hence bearing capacity and settlement are not likely to be problems. Exceptionally, Floodbox 3 will be founded on a layer of silt extending to a depth of approximately 4 m below the floodbox. It is recommended that at this location, the foundation be preloaded prior to constructing the floodbox. This may be achieved by installing a temporary Armco culvert, or similar, to pass the stream under the preload, which should be constructed to the height and approximate shape of the proposed dyke. After settlement is complete, which should be in a month or two, the preload would be excavated and the permanent floodbox constructed. This solution would appear to be more appropriate under the circumstances than diverting the stream during preloading.

Potential underseepage problems at the floodboxes during flood conditions should be controlled by providing a layer of granular filter material, minus 19 mm Vedder River sand and gravel, at the landside toe of the floodboxes and in the discharge channel invert and slopes in the vicinity of the floodbox outlet to prevent the erosion of fines. In addition, cutoff collars should be provided to increase the length of the seepage path along the outside of the floodboxes and the backfill material around the floodboxes should be minus 75 or 100 mm dirty sand and gravel.

8. OIL PIPELINE

Exploratory holes were drilled on both banks of the river within 15 m of the oil pipeline owned by Trans Mountain Pipe Line Co. Ltd. in order to determine the soil conditions and the settlement at these locations due to the loading imposed by the new dyke. The drill holes show that the surface layer of silt extends to about 4 m below the ground surface on the north bank and to about 3 m below the ground surface on the south bank. In addition, a layer of silt was encountered at 9.5 to 15 m below ground level on the south bank. Settlement calculations indicate that approximately 0.3 m and 0.2 m of settlement may occur beneath the pipeline at the centreline of the dyke on the south bank and north bank respectively and that less than 0.07 m of settlement may occur beneath the pipeline at the toes of the dyke. Thus, the differential settlement of the pipeline between the centre and toe of the new dyke may be about 0.25 m (10 in.). In view of this computed differential settlement, further calculations were made to determine the degree to which the rate of change of settlement along the pipeline could be reduced by locally flattening the side slopes of the dyke. The results of these calculations in the form of settlement profiles for the side slopes considered are shown on Fig. 4. It is understood that these profiles will be examined by Trans Mountain Pipe Line who will inform the Branch as to which profile they consider acceptable with respect to deformation of the pipe. It is recommended that once a decision is made on the side slopes, trial sections of the dyke be constructed to the selected slopes near the pipeline in order to confirm the validity of the settlement calculations. These trial sections of the dyke should be provided with instrumentation to measure the actual settlements. Prior to construction of the trial sections, additional holes will have to be drilled at the proposed locations in order to check that the soil conditions there are the same as those at the pipeline. The location and lengths of the trial embankments should be determined once the situation is discussed with

Trans Mountain and the side slopes have been decided upon. In the meantime, any dyke construction should be stopped 150 m short of the pipe.

Providing only a simple running surface of gravel is provided, there should be no problem in having trucks cross the pipeline. However, this should be discussed with Trans Mountain and their permission obtained.

9. RAISING OF VEDDER CANAL DYKE

On the north side 1200 m of the Vedder Canal dyke has to be raised by up to about 2.4 m. The maximum increase in height occurs at Chainage 0+00 and from there west to Sumas Prairie Road the dyke can be raised by building on the landside using the dyke section shown on Fig. 3. Over this stretch, there is an existing cutoff drainage trench. This being the case, there is no need to construct a new drainage trench since the existing trench will continue to function in spite of the fact that it has been covered by fill. Any water coming from the trench will simply seep into the pervious overlying Vedder River sand and gravel fill and hence out to the toe.

From Sumas Prairie Road along Sinclair Road, there is no room to build up on the landside and along this stretch, to where the dyke swings off to the south, construction should be mainly on the riverside. However, it is recommended that in this section the existing landside slope be cut into and the excavated material used to construct a core of relatively impervious material above the existing dyke, that the landside slope be restored to its original line and grade using Vedder River sand and gravel, and that most of the new fill be placed on the riverside to a 1V:3H slope.

From where the existing dyke swings away from Sinclair Road to the end of the stretch of dyke to be raised, the required increase in height amounts to less than 0.5 m (less than the freeboard allowance) and this additional height can be obtained by slightly oversteepening the existing slopes providing a 3.6 m crest width is acceptable. If, however, it is desired to maintain the 5 m crest to the end of the new construction, fill will have to be placed on the riverside to a 1V:3H slope.

10. INTERSECTION OF NEW DYKE AND EXISTING RAILWAY EMBANKMENT

Both the north and south set-back dykes intersect the B. C. Hydro Railroad embankment. On the south side, the top of the new dyke is some 0.6 m below the top of the embankment, but on the north side, the railway embankment will have to be raised about 1.5 m.

At the intersections, it is recommended that:

a. The dyke crest be flared on both the landside and the riverside. This will have the effect of providing an increased width of new fill at the contact. It will also provide turning areas at appropriate locations. (Turning areas should also be provided elsewhere along the dykes.)

b. The dyke material on the riverside should include a blanket of dirty sand and gravel and this blanket should be continued along the railroad embankment for about 25 m from the intersection.

c. The material on the landside of the dyke should be normal Vedder River sand and gravel, but a blanket of this material to act as a filter should be placed along the railroad embankment for about 25 m from the intersection.

d. On the north side the railroad embankment should be raised using sand and gravel and only the minimum of ballast utilized. Technically, it would be best to remove the existing ballast in the vicinity of the intersection and to replace this with sand and gravel but this could present scheduling problems to the railroad.

It should be noted that although the above measures will protect the railroad embankment from failure at the dyke intersection and thus prevent flooding, the integrity of the railroad embankment itself has not been investigated.

It appears that the subsoil conditions are such that there will be little settlement of the dyke or railroad embankment at the intersections.

It is recommended that discussions be held with B. C. Hydro as soon as possible so that detailed plans showing the special measures required at the intersections can be prepared for their approval.

APPENDIX 'A'

LOGS OF DRILL HOLES AND TEST PITS

LOG OF DRILL HOLE

HOLE NO. 4

PROJECT: Vedder Dykes
LOCATION OF HOLE: –
–
ELEVATION: 17.5 m
CONTRACTOR: Keller
TYPE OF DRILL: Mayhew 1000
DATE OF DRILLING: Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- ⊕ UNCONFINED COMPRESSION
- + TORVANE

PENETRATION RESISTANCE

- ⊙ STANDARD N - VALUE

ATTERBERG LIMITS

P.L. ——×—— L.L.
MOISTURE CONTENT

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS (10, 20, 30, 40 kN/m²; 20, 40, 60, 80 BLOWS/FT. (0.3 m))	SAMPLE NO.	RECOVERY cm
	TOPSOIL	0.6				
GW	Dense to very dense silty fine to coarse SAND and GRAVEL, becoming less silty below 4.0 m depth				132⊙	
					131⊙	
		6.1				

LOG OF DRILL HOLE

HOLE NO. 7

PROJECT: Vedder Dykes
LOCATION OF HOLE: –
–
ELEVATION: 13.0 m
CONTRACTOR: Keller
TYPE OF DRILL: Mayhew 1000
DATE OF DRILLING: Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- UNCONFINED COMPRESSION
- TORVANE

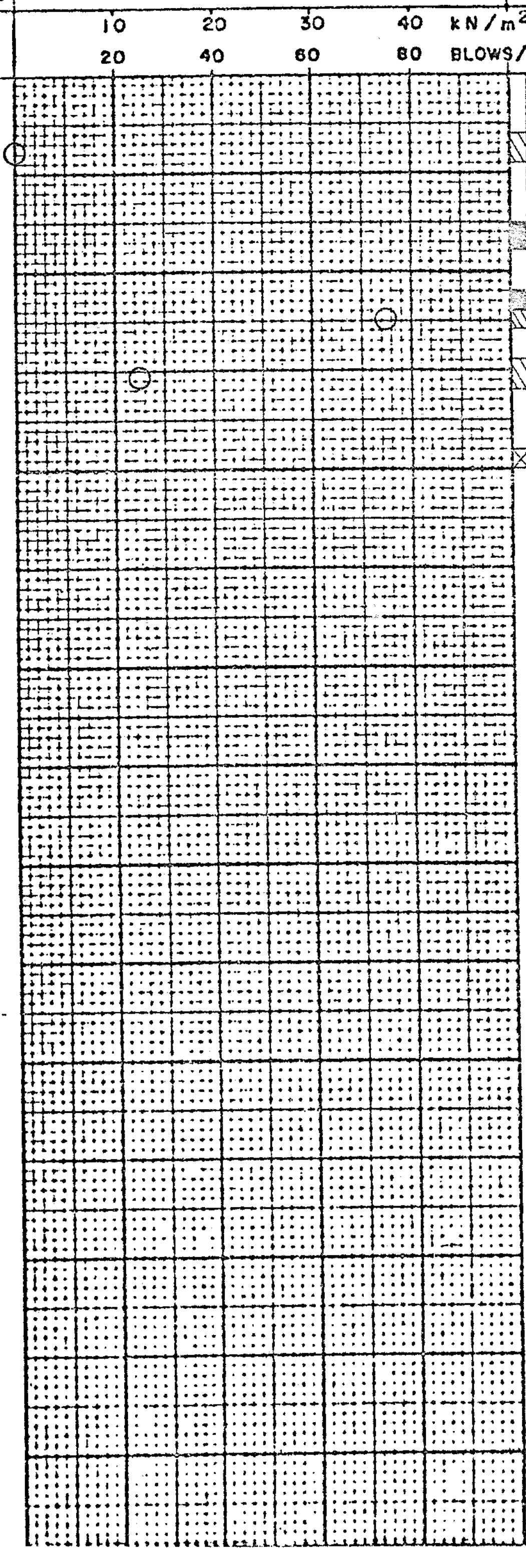
PENETRATION RESISTANCE

- STANDARD N-VALUE

ATTERBERG LIMITS

P.L. — MOISTURE CONTENT — L.L.

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS	SAMPLE NO.	RECOVERY cm
ML	Soft grey sandy SILT	2.1				
GW	SAND and GRAVEL	2.7				
SW	Clean fine to medium SAND	4.3				
ML	Grey SILT	4.7				
GW	Medium dense to very dense medium to coarse SAND and GRAVEL, slightly silty above 6.0 m depth. Layer of decomposed wood at 8.2 m depth	9.1				



HOLE NO. 8

LOG OF DRILL HOLE

PROJECT: Vedder Dykes
LOCATION OF HOLE: –
ELEVATION: 12.5
CONTRACTOR: Keller
TYPE OF DRILL: Mayhew 1000
DATE OF DRILLING: Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- UNCONFINED COMPRESSION
- TORVANE

PENETRATION RESISTANCE

- STANDARD N-VALUE

ATTERBERG LIMITS

P.L. — L.L.

MOISTURE CONTENT

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS (10 20 30 40 kN/m^2; 20 40 60 80 BLOWS/FT. (0.3 m))	SAMPLE NO.	RECOVERY cm
MH	Soft grey sandy SILT	2.9				
SW	Medium dense grey fine to medium SAND	4.3				
GW	Medium dense, becoming very dense, grey medium to coarse SAND and fine to medium GRAVEL	9.5				
MH	Soft grey SILT with occasional bands of grey silty fine sand. Bands of black decomposed wood approx 0.2 m thick at 9.7 m and 11.3 m depth	15.2				
GW	Dense to very dense medium to coarse SAND and fine to coarse GRAVEL	18.3				

LOG OF DRILL HOLE

HOLE NO. 9

PROJECT: Vedder Dykes
LOCATION OF HOLE: –
–
ELEVATION: 10.5 m
CONTRACTOR: Keller
TYPE OF DRILL: Mayhew 1000
DATE OF DRILLING: Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- UNCONFINED COMPRESSION
- TORVANE

PENETRATION RESISTANCE

- STANDARD N-VALUE

ATTERBERG LIMITS

P.L. — MOISTURE CONTENT — L.L.

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS (10 / 20 / 30 / 40 kN/m²; 20 / 40 / 60 / 80 BLOWS/FT. (0.3 m))	SAMPLE NO.	RECOVERY cm
	Fill (sand and gravel)	0.15				
ML	Firm brown sandy SILT	2.1				
GW	Dense medium to coarse SAND and fine to coarse GRAVEL	5.9				
	Drillhole cased to 5.2 m depth					

LOG OF DRILL HOLE

HOLE NO. 13

PROJECT: Vedder Dykes
LOCATION OF HOLE: –
–
ELEVATION: 10.0 m
CONTRACTOR: Keller
TYPE OF DRILL: Mayhew 1000
DATE OF DRILLING: Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- UNCONFINED COMPRESSION
- TORVANE

PENETRATION RESISTANCE

- STANDARD N - VALUE

ATTERBERG LIMITS

P.L. — L.L.
MOISTURE CONTENT

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS (10 20 30 40 kN/m²; 20 40 60 80 BLOWS/FT. (0.3 m))	SAMPLE NO.	RECOVERY cm
SP	Brown silty fine SAND	1.8				
ML	Soft grey SILT, occasionally very sandy	6.4				NO RECOVERY
GW	Medium dense fine to coarse SAND and fine to medium GRAVEL	9.1				

LOG OF DRILL HOLE

HOLE NO. 14

PROJECT Vedder Dykes
LOCATION OF HOLE –
–
ELEVATION 11.0 m
CONTRACTOR Keller
TYPE OF DRILL Mayhew 1000
DATE OF DRILLING Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- UNCONFINED COMPRESSION
- TORVANE

PENETRATION RESISTANCE

- STANDARD N-VALUE

ATTERBERG LIMITS

P.L. — MOISTURE CONTENT — L.L.

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS (10 20 30 40 kN/m²; 20 40 60 80 BLOWS/FT. (0.3 m))	SAMPLE NO.	RECOVERY cm
	TOPSOIL	0.15				
GW	Very dense fine to coarse SAND and fine to medium GRAVEL					
		6.1				

LOG OF DRILL HOLE

HOLE NO. 16

PROJECT: Vedder Dykes

LOCATION OF HOLE: –
–

ELEVATION: 13.0 m

CONTRACTOR: Keller

TYPE OF DRILL: Mayhew 1000

DATE OF DRILLING: Sept 78

LEGEND

- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH

- UNCONFINED COMPRESSION
- TORVANE

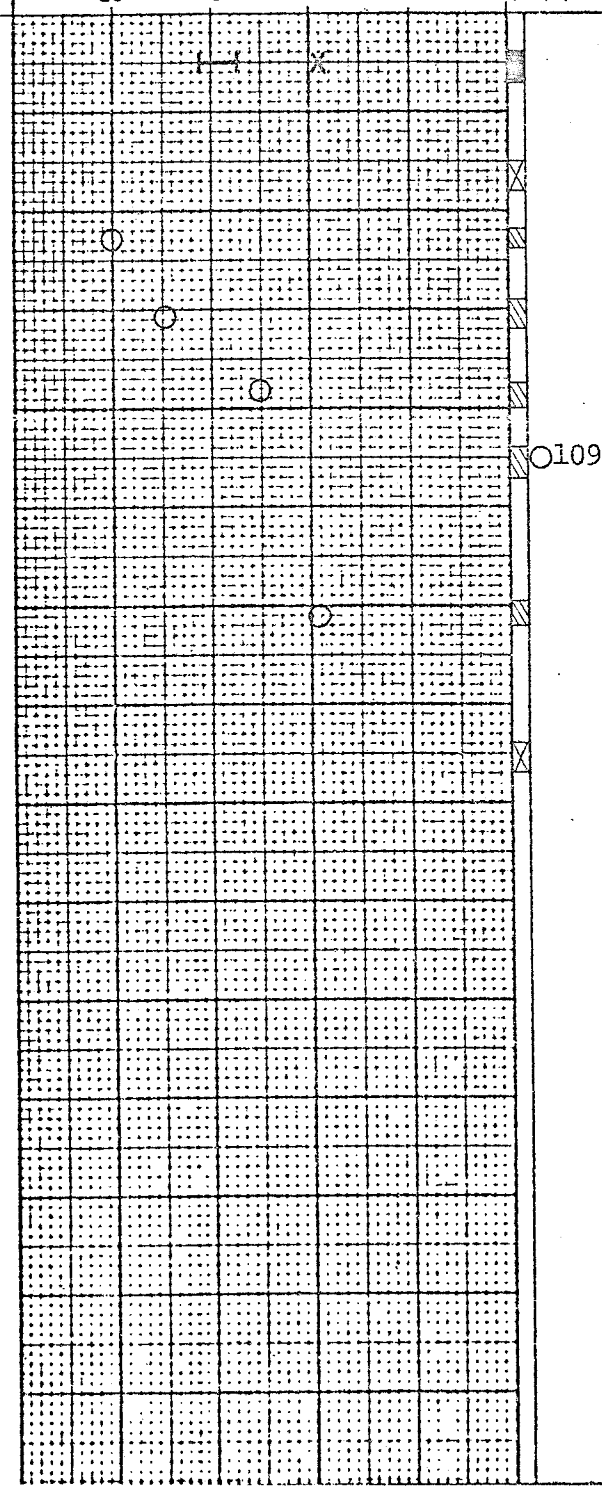
PENETRATION RESISTANCE

- STANDARD N - VALUE

ATTERBERG LIMITS

P.L. — L.L.

MOISTURE CONTENT

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS (10 20 30 40 kN/m²; 20 40 60 80 BLOWS/FT. (0.3 m))	SAMPLE NO.	RECOVERY cm
ML	Soft grey SILT with bands of silty fine SAND	4.0				
GW	Medium dense, becoming very dense, medium to coarse SAND and fine to medium GRAVEL	15.2				

HOLE NO. 18

LOG OF DRILL HOLE

PROJECT: Vedder Dykes
LOCATION OF HOLE: –
–
ELEVATION:
CONTRACTOR: Keller
TYPE OF DRILL: Mayhew 1000
DATE OF DRILLING: Sept 78

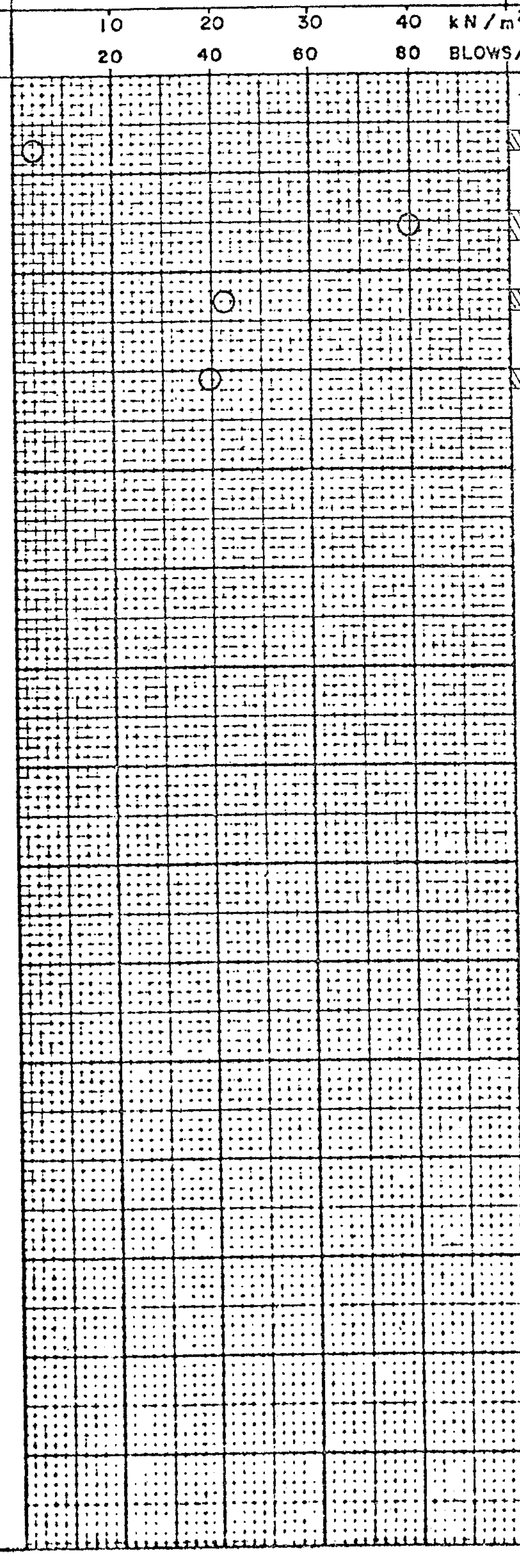
LEGEND
- SPLIT SPOON
- WASH SAMPLE
- SHELBY TUBE
- CORE SAMPLE

SHEAR STRENGTH
- UNCONFINED COMPRESSION
- TORVANE

PENETRATION RESISTANCE
- STANDARD N-VALUE

ATTERBERG LIMITS
P.L. — L.L.
MOISTURE CONTENT

SYMBOL	DESCRIPTION	DEPTH METRES	ELEV. METRES	TEST RESULTS	SAMPLE NO.	RECOVERY cm
GW	SAND and GRAVEL (prob fill)	0.6				
ML	Grey SILT	1.4				
SP	Loose brown fine SAND	2.7				
GW	Dense to very dense slightly silty fine to coarse SAND and fine to coarse GRAVEL	9.1				



LOGS OF TEST PITS

TP 1 Elevation 21.0 m

Depth		
0.0	0.07	TOPSOIL
0.07	0.17	Silty fine to medium SAND
0.17	0.28	Clean medium to coarse SAND
0.28	0.40	Silty fine SAND
0.40	2.24 (S)	Dense fine to coarse SAND and fine to coarse GRAVEL with occasional cobbles

Groundwater encountered at 2.24 depth

TP 2 Elevation 20.0 m

Depth		
0.0	0.90	Topsoil, silt, sand, gravel, numerous roots (probable fill)
0.90	2.44 (S)	Loose to medium dense slightly silty medium to coarse SAND with fine to coarse gravel and occasional cobbles

Groundwater encountered at 2.44 depth

TP 3 Elevation 20.0 m

Depth		
0.0	0.23	Topsoil and decayed wood fragments
0.23	2.44 (S)	Loose slightly silty fine to coarse SAND and fine to coarse GRAVEL with occasional cobbles

Groundwater was not encountered

TP 4 Elevation 17.5 m .

Depth		
0.0	0.60	TOPSOIL, numerous roots
0.06	1.98 (S)	Loose slightly silty fine to coarse SAND and fine to coarse GRAVEL with occasional cobbles. Some 75 mm

			thick layers of clean fine to medium gravel and a pocket approximately 0.6 m by 1 m of fine sand
1.98	2.13	(S)	Loose light brown (iron stained) very silty medium to coarse SAND and fine to coarse GRAVEL

Groundwater encountered at 1.98 depth

TP 5 Elevation 16.0 m

Depth			
0.0	0.15		TOPSOIL
0.15	1.37	(S)	Soft brown very sandy SILT and very silty fine SAND
1.37	1.82	(S)	Soft brown very sandy SILT with pockets of grey sandy silt
1.82	3.05		Soft grey sandy SILT with layers of fine sand, high organic content
3.05		(S)	Some fine to coarse GRAVEL recovered from 3.05 depth prior to collapse of test pit

Groundwater encountered at 1.82 depth

TP 6 Elevation 14.0 m

Depth		
0.0	0.18	TOPSOIL
0.18	1.37	Soft brown sandy SILT
1.37	2.13	Soft grey sandy SILT with pockets of fine to coarse sand

Groundwater encountered at 0.76 depth

TP 7 Elevation 13.0

Depth			
0.0	0.13		TOPSOIL
0.13	0.78	(S)	Soft brown organic slightly sandy SILT, numerous root fibres
0.78	1.12	(S)	Loose grey slightly silty, fine to medium SAND

1.12	1.42	(S)	Brown decayed wood and twigs with highly organic silt
1.42	1.82	(S)	Loose dark grey silty angular to sub rounded fine to coarse SAND and GRAVEL

Groundwater encountered at 1.42 depth

TP 8 Elevation 12.5 m

Depth

0.0	0.08		TOPSOIL
0.08	0.91	(S)	Loose to medium dense light grey silty fine SAND becoming reddish brown at 0.60 depth
0.91	2.43	(S)	Soft grey organic sandy SILT, decayed wood fragments at 1.52 depth

Groundwater encountered at 0.53 depth

TP 9 Elevation 10.5 m

Depth

0.0	0.15		TOPSOIL
0.15	0.96	(S)	Loose brown very silty fine SAND with numerous root fibres
0.96	1.34	(S)	Soft grey sandy SILT
1.34	1.42	(S)	Brown fibrous highly organic SILT
1.42	1.52		Soft light grey sandy SILT
1.52	2.13	(S)	Loose light grey angular to sub rounded fine to coarse SAND and GRAVEL

Groundwater encountered at 1.52 depth

TP 10 Elevation 10.0 m

Depth

0.0	0.13		TOPSOIL
0.13	0.91	(S)	Firm mottled brown and grey organic SILT, occasional pockets of grey fine sand

0.91	1.52 (S)	Very soft grey SILT
1.52	1.82 (S)	Fine to coarse SAND and fine to medium GRAVEL

Groundwater encountered at 0.91 m depth, on further excavation water flowed under pressure from the sand and gravel layer below 1.52 m depth, water level rose to 1.22 m depth below ground surface in 2 to 3 minutes.

TP 11 Elevation 9.5 m

Depth		
0.0	0.20	TOPSOIL
0.20	0.76 (S)	Medium dense dry light brown silty fine SAND, numerous root fibres
0.76	1.52 (S)	Loose to medium dense brown slightly silty fine to coarse SAND with some fine to coarse GRAVEL. Gravel content increases at 1.52 depth

Groundwater encountered at 1.52 depth

TP 12 Elevation 10.5 m

Depth		
0.0	0.08	TOPSOIL
0.08	0.45	Fine to coarse gravel with sand and silt (probable fill)
0.45	0.99	Soft to firm light brown sandy SILT
0.99	2.43 (S)	Silty medium to coarse SAND and fine to medium GRAVEL with occasional coarse gravel

Groundwater encountered at 1.06 depth

TP 13 Elevation 10.5 m

Depth		
0.0	0.075	TOPSOIL
0.075	2.44 (S)	Loose light brown mottled grey very silty fine SAND with very sandy silt and occasional root fibres for full depth. Layer of brown decayed vegetation 1 in. thick at 0.45 depth

2.44	2.74 (S)	Soft grey mottled brown sandy SILT

Groundwater encountered at 2.59 depth

TP 14 Elevation 11.0 m

Depth		
0.0	0.30	TOPSOIL
0.30	1.12 (S)	Loose brown fine to medium SAND, 50 mm thick layer of fine to coarse sand at 0.91 depth
1.12	1.82 (S)	Loose to medium dense fine to coarse SAND with occasional fine gravel

Groundwater was encountered at 1.52 depth

TP 15 Elevation 12.0 m

Depth		
0.0	0.15	TOPSOIL
0.15	1.22 (S)	Dark brown very silty fine SAND and soft to firm very sandy SILT. Decayed wood at 1.20 depth
1.22	1.82	Soft grey mottled brown sandy SILT

Groundwater encountered at 1.20 depth

TP 16 Elevation 13.0 m

Depth		
0.0	0.10	TOPSOIL
0.10	1.07	Very soft grey brown slightly sandy SILT, layer of decayed wood and twigs at 0.53 to 0.60 m
1.07	1.82	Grey very silty fine SAND
1.82	2.43 (S)	Very soft slightly sandy SILT

Groundwater encountered at 0.61 depth

TP 17 Elevation 15.5 m

Depth		
0.0	0.13	TOPSOIL

0.13	0.61 (S)	Firm to stiff brown slightly sandy SILT with numerous root fibres
0.61	1.37 (S)	Medium dense fine to coarse SAND with fine to medium gravel

Groundwater was encountered at 1.0 depth

TP 18 Elevation 17.0 m

Depth		
0.0	0.76	Silty SAND and GRAVEL (probable road fill material)
0.76	1.52	Firm brown mottled grey SILT with some pockets of grey and brown fine SAND. Some tree roots
1.52	1.82 (S)	Medium to coarse SAND and fine to medium GRAVEL

Groundwater was encountered at 1.52 depth

TP 19 Elevation 19.0 m

Depth		
0.0	0.10	TOPSOIL
0.10	0.76	Fine to coarse SAND with occasional fine GRAVEL (probable filled ground)
0.76	1.63	Soft light grey slightly sandy SILT

Groundwater was not encountered

TP 19A Elevation 18.5 m

Depth		
0.0	0.10	TOPSOIL
0.10	1.82 (S)	Loose medium to coarse SAND and fine to medium GRAVEL

Groundwater was encountered at 1.82 depth

TP 20 Elevation 21.0 m

Depth		
0.0	0.15	TOPSOIL

0.15	1.14 (S)	Dry light brown very silty fine SAND
1.14	3.05 (S)	Loose to medium dense medium to coarse SAND and fine GRAVEL with occasional medium to coarse gravel. Bands of light brown sandy silt from 1.82 to 1.98 (S) and from 2.13 to 2.28

Groundwater was not encountered

(S) indicates sample taken

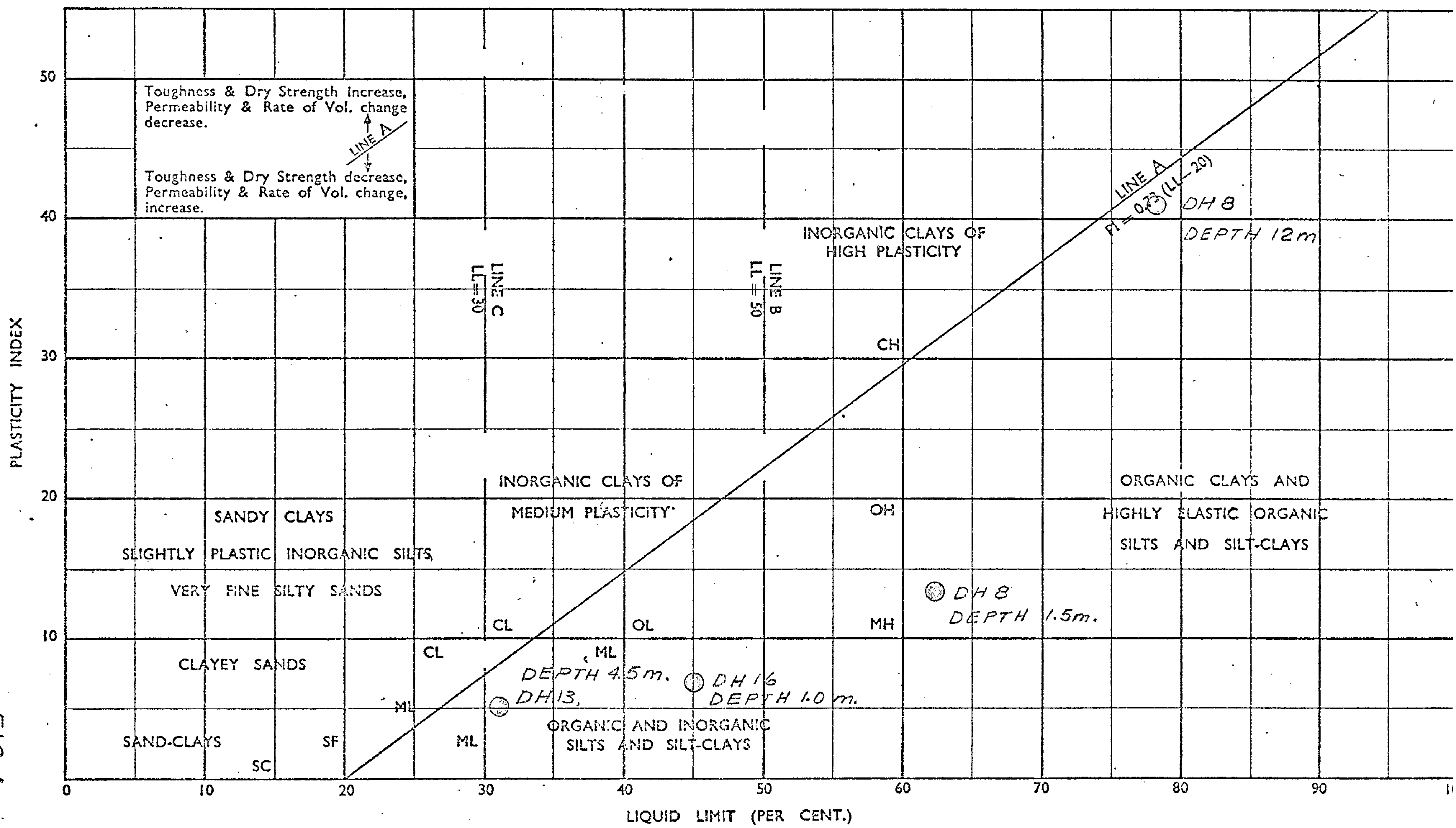
APPENDIX B

LABORATORY TESTING RESULTS

VEDDER SETBACK DYKES

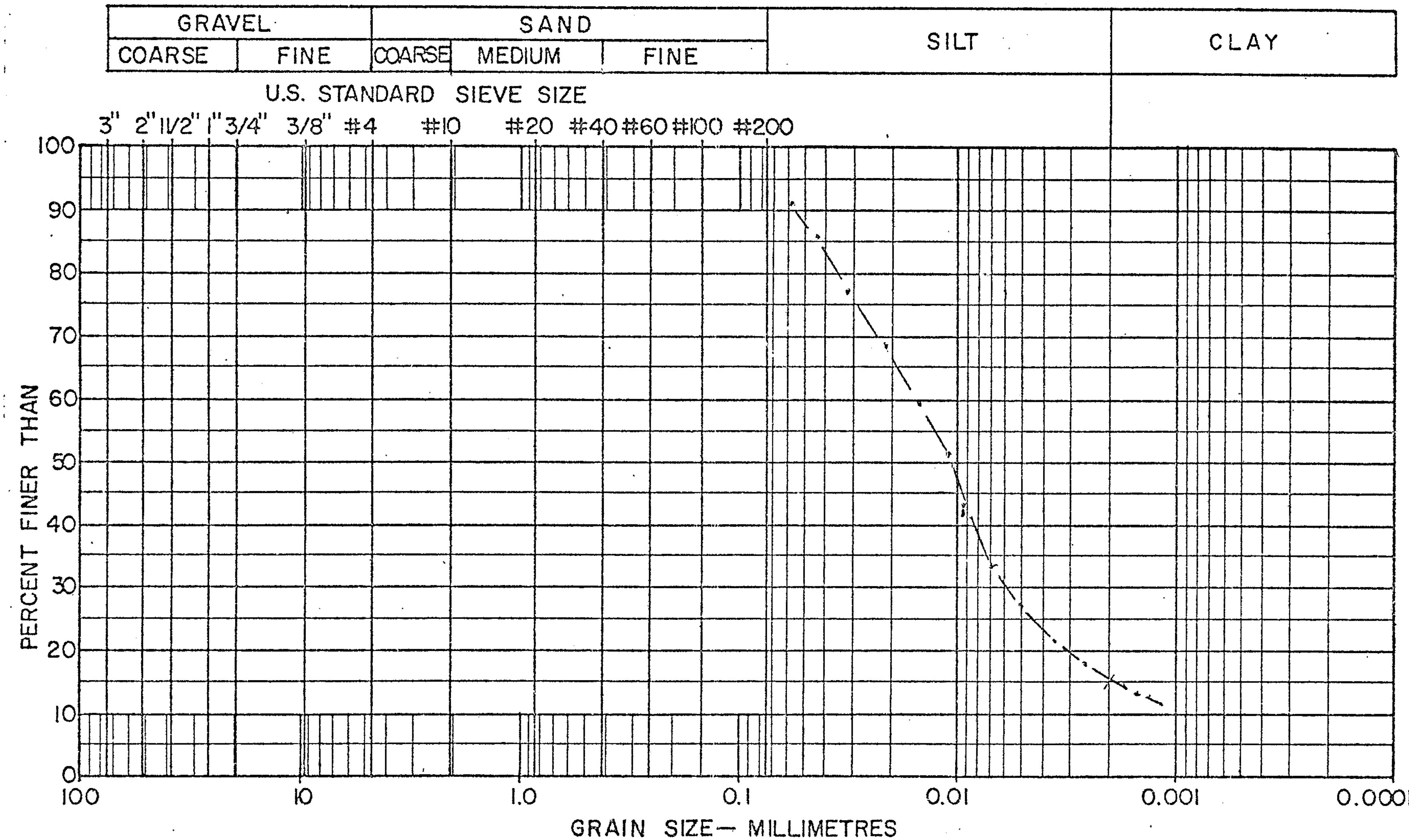
LABORATORY TESTING RESULTS

Drill Hole	Depth m	Natural Moisture Content %	Index Properties			Grain Size Dist.			Consolidation Data		
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Sand	Silt	Clay	Initial Void Ratio	Compression Index	Coefficient of Consolidation cm^2/sec
13	4.5	58	31	26	5	0	88	18	-	-	-
16	1.0	61	45	38	7	0	85	15	1.69	0.48	6.9×10^{-2}
8	1.5	55	63	49	14	0	85	15	1.53	0.43	5.8×10^{-2}
8	12	65	78	37	41	0	45	55	1.78	0.61	2.1×10^{-3}



Toughness & Dry Strength Increase, Permeability & Rate of Vol. change decrease.
LINE A
Toughness & Dry Strength decrease, Permeability & Rate of Vol. change, increase.
LINE C LL=30
LINE B LL=50
LINE A PI=0.73 (LL-20)
DH 8 DEPTH 12m
INORGANIC CLAYS OF HIGH PLASTICITY
CH
INORGANIC CLAYS OF MEDIUM PLASTICITY
OH
ORGANIC CLAYS AND HIGHLY ELASTIC ORGANIC SILTS AND SILT-CLAYS
SANDY CLAYS
SLIGHTLY PLASTIC INORGANIC SILTS
VERY FINE SILTY SANDS
DH 8 DEPTH 1.5m.
CL
OL
MH
CL
ML
CLAYEY SANDS
DEPTH 4.5m. DH 13,
DH 16 DEPTH 1.0 m.
ML
ORGANIC AND INORGANIC SILTS AND SILT-CLAYS
SAND-CLAYS
SF
ML
SC
PLASTICITY INDEX
LIQUID LIMIT (PER CENT.)

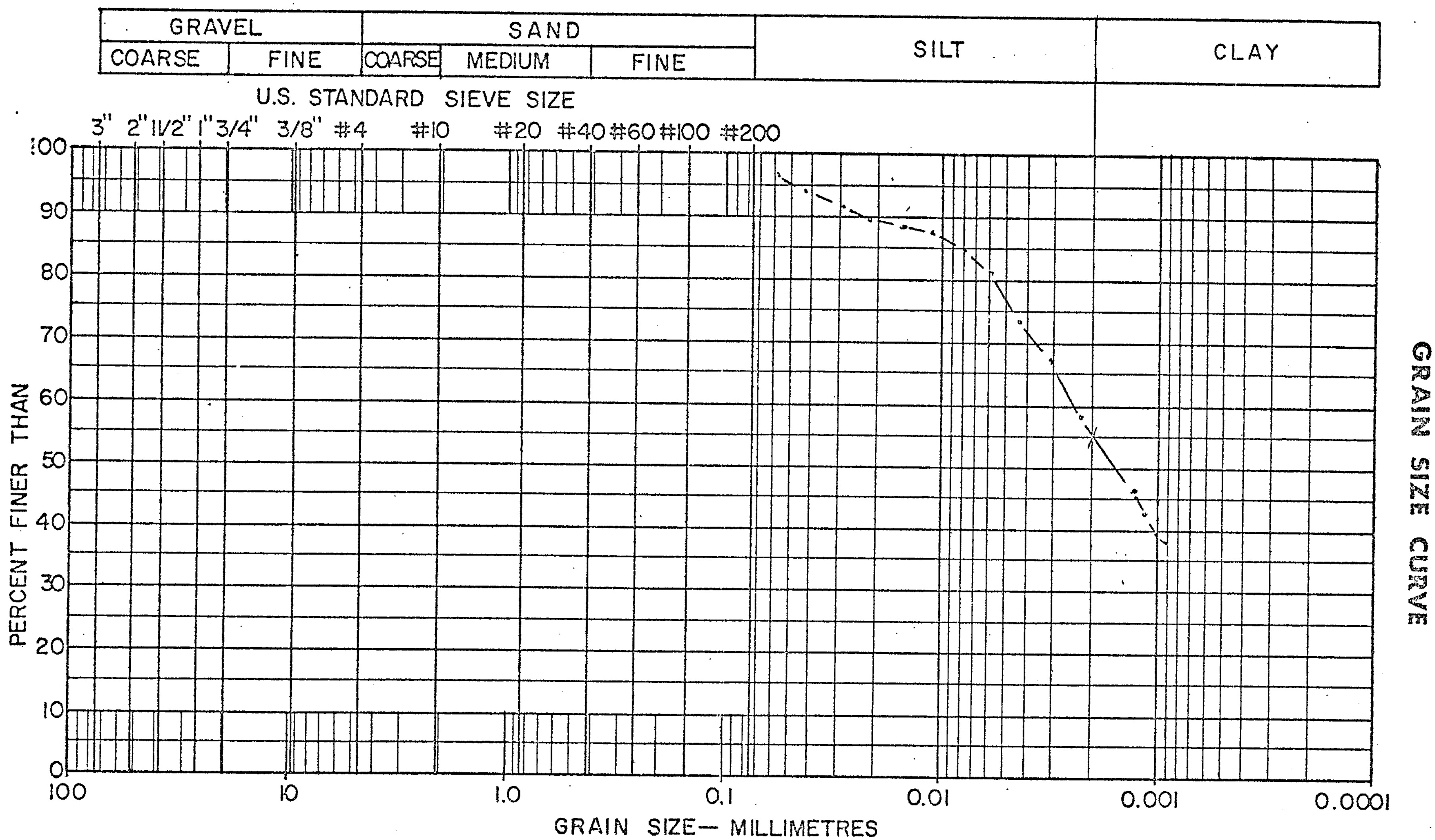
FIG. 1



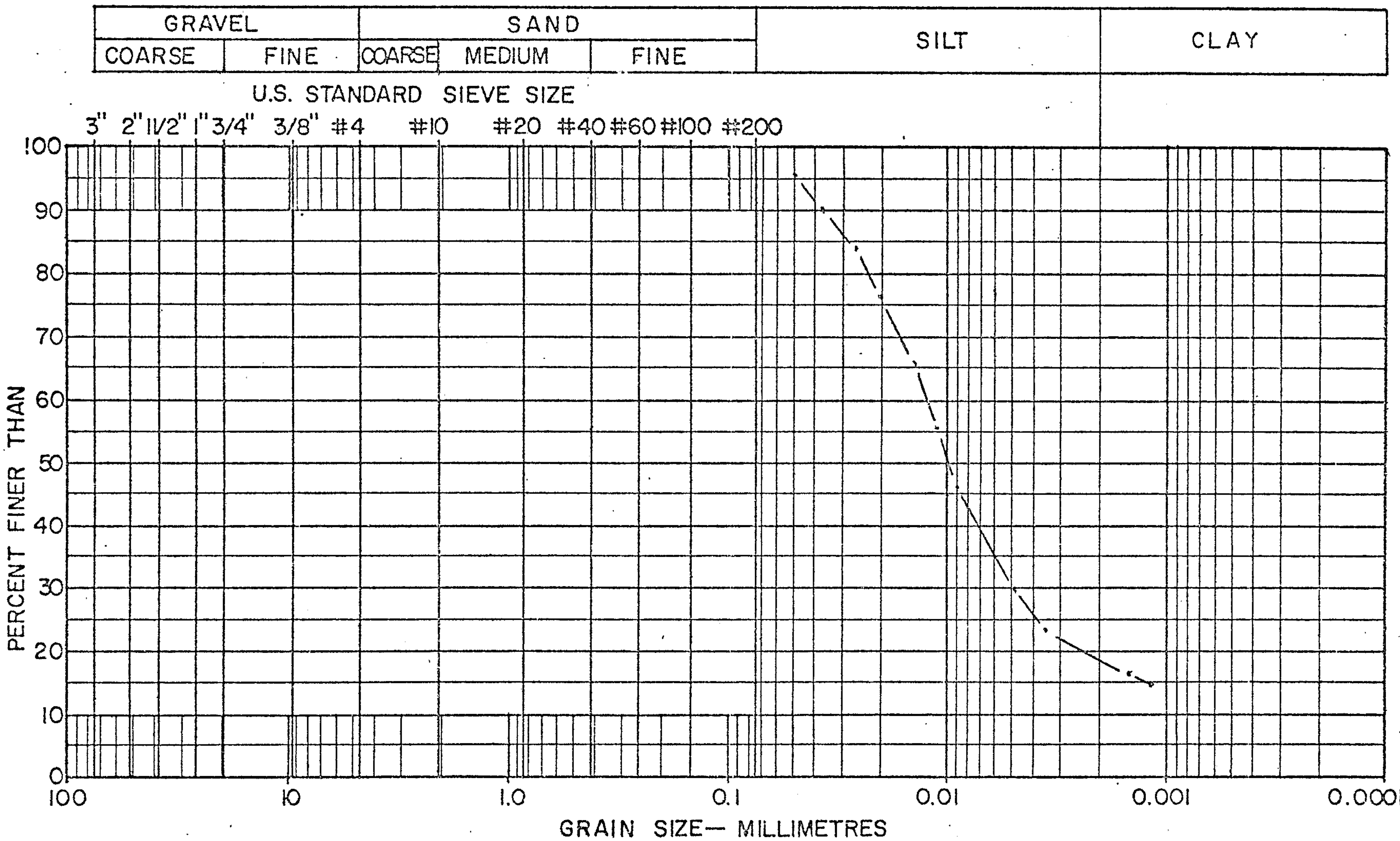
GRAIN SIZE CURVE

DH 8

DEPTH 1.5m

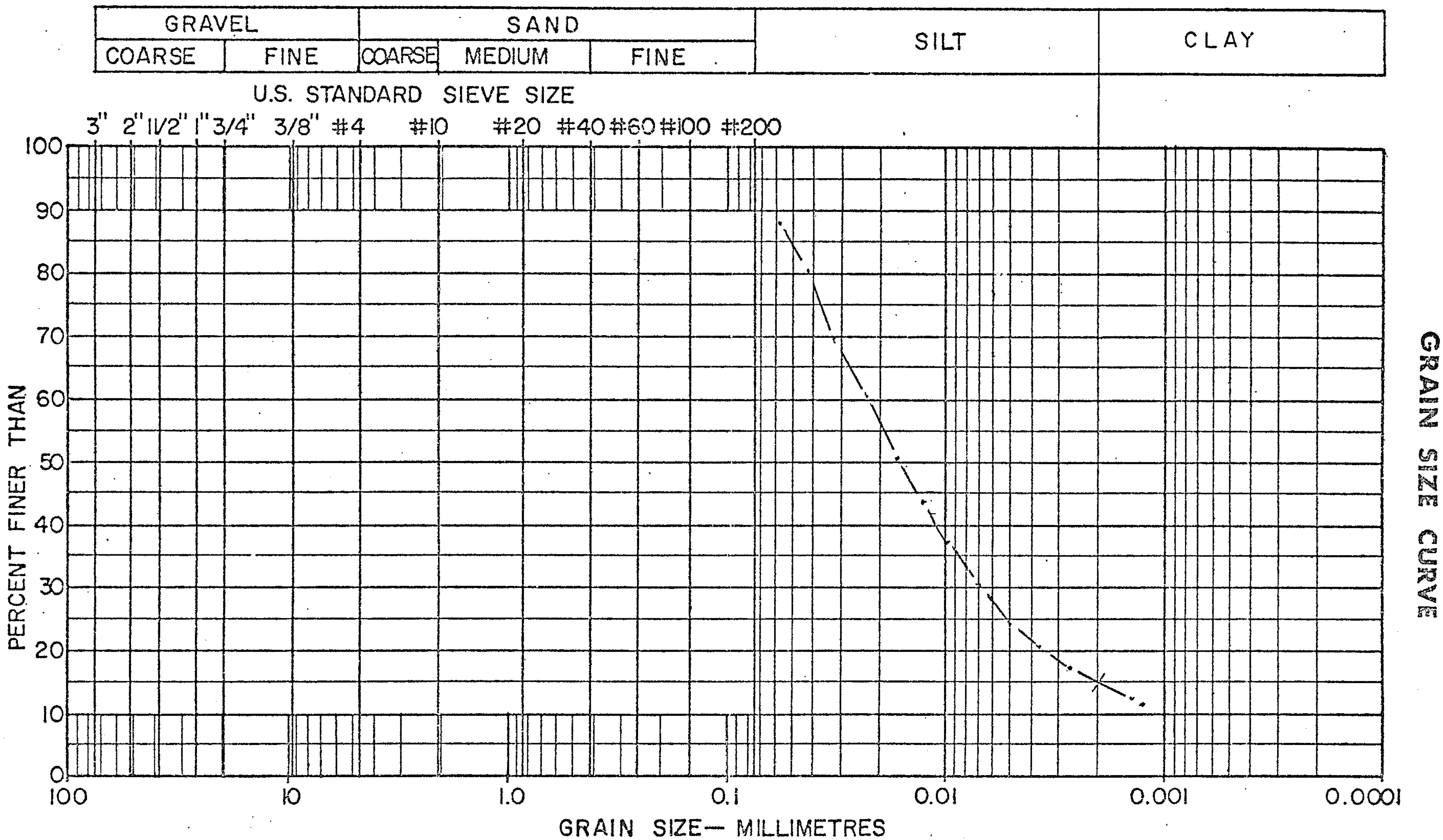


DH 8
DEPTH 12.0m

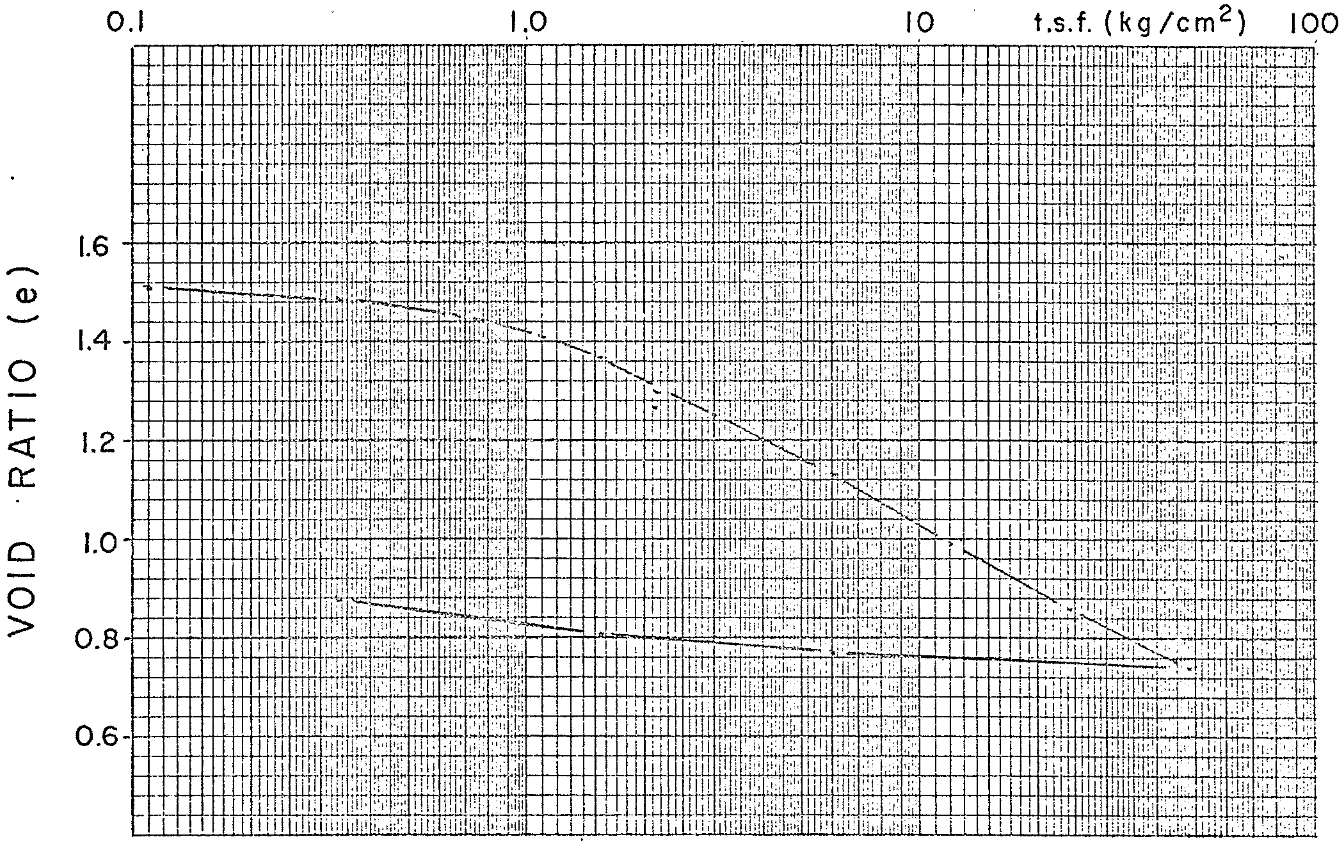


DH 13
DEPTH 4.5m

GRAIN SIZE CURVE

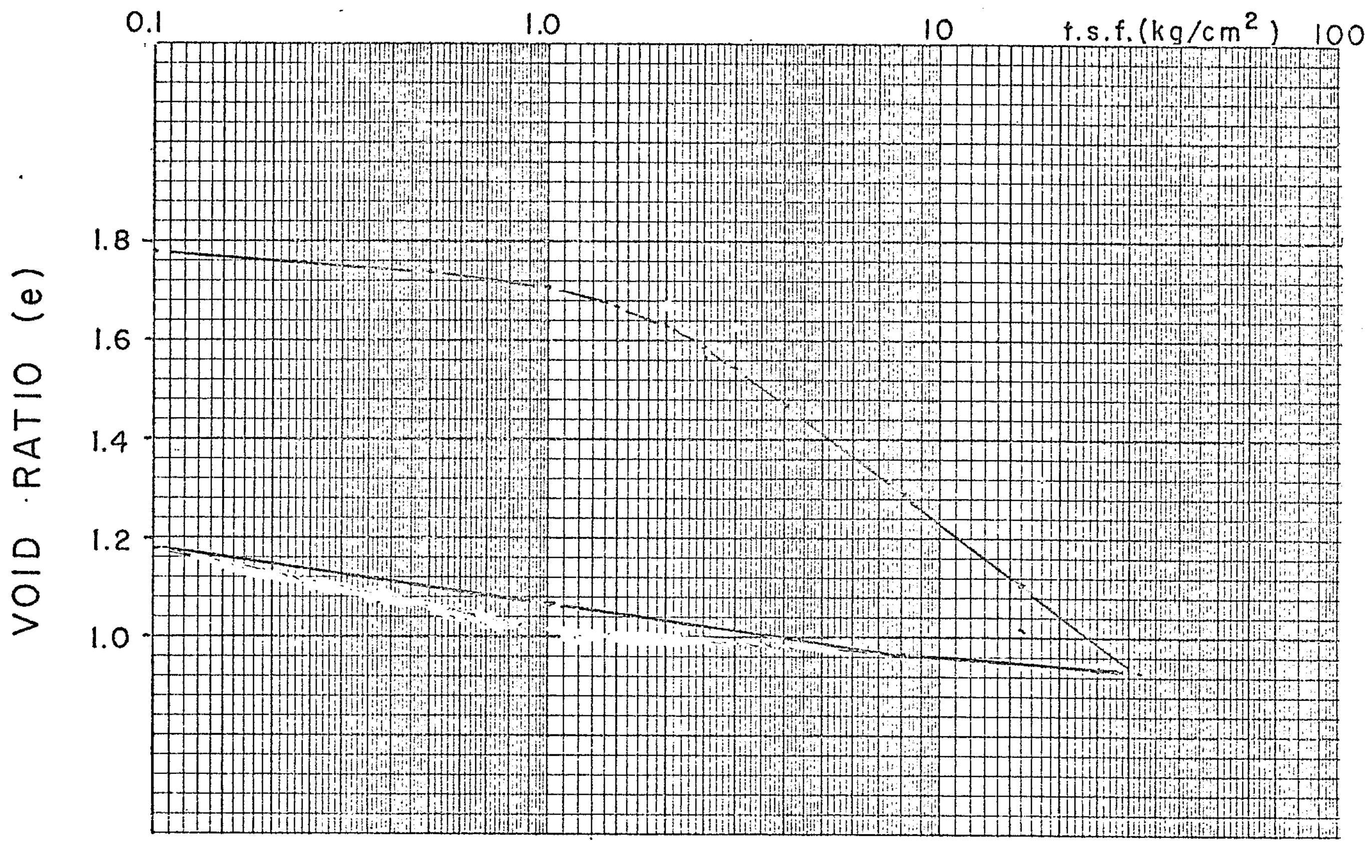


DH 16
DEPTH 1.0 m



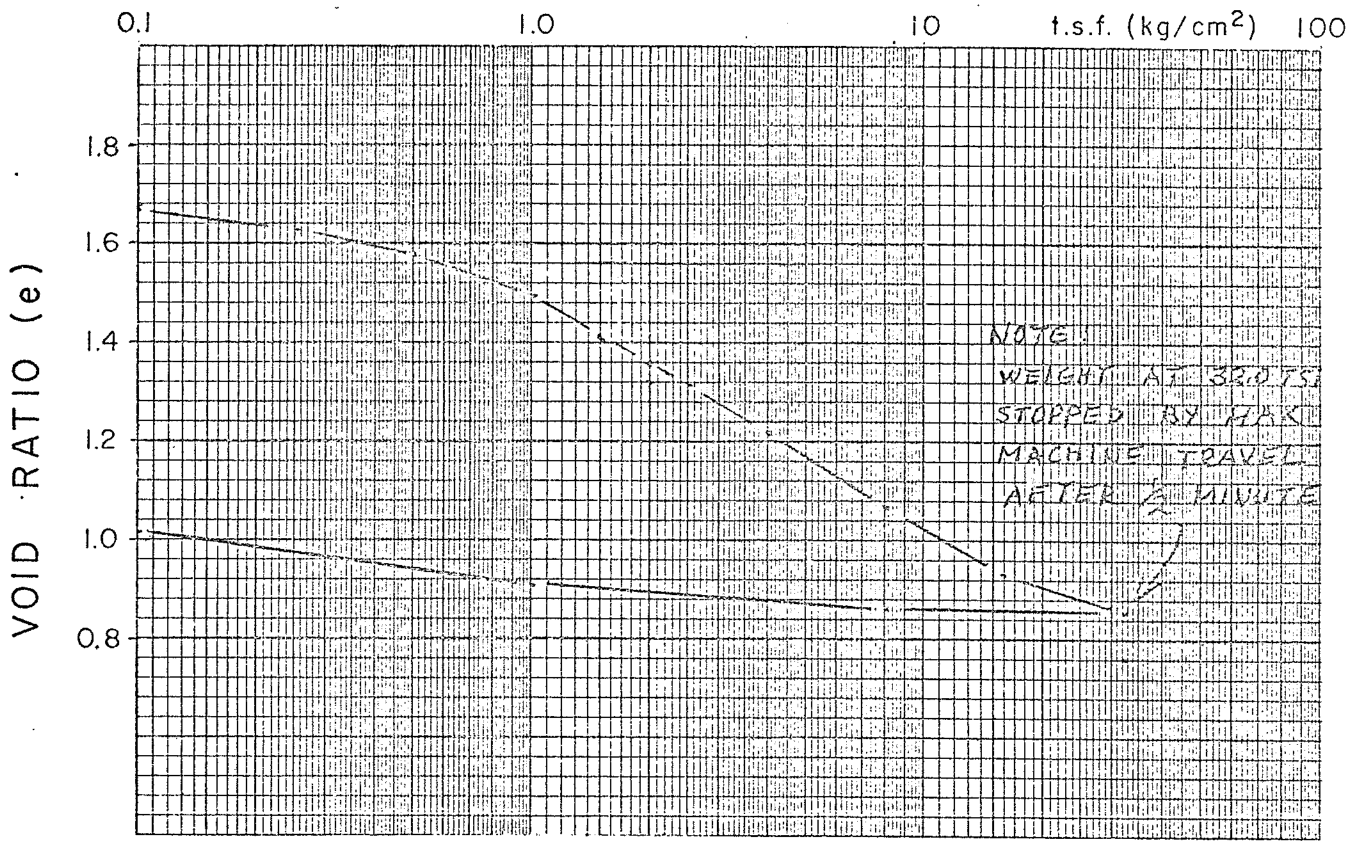
Drill hole 8
Depth 1.5m

Initial void ratio 1.53
Overburden pressure 0.17 kg/cm²
Compression index 0.43



Drill hole 8
Depth 12m

Initial void ratio 1.78
Overburden pressure 1.15 kg/cm^2
Compression index 0.61



Drill hole 16
Depth 1.0m

Initial void ratio 1.69
Overburden pressure 0.14 kg/cm^2
Compression index 0.48

LEGEND

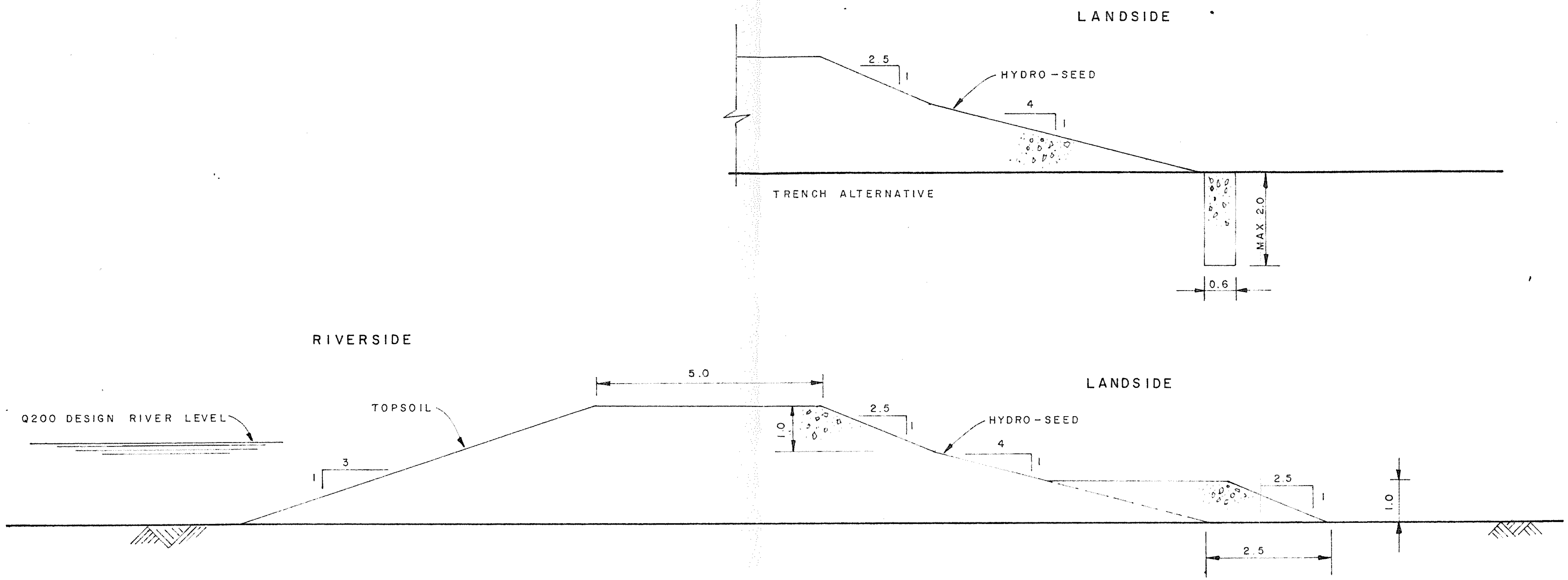
- BANKLINE DYKES REVETTED WITH ROCK RIP-RAP.
- NATURAL BANKS OF RIVER.
- RIGHT OF WAY 30 m WIDE FOR SETBACK DYKES.
- RIGHT OF WAY 10 m WIDE FOR ACCESS ROADS.
- □ TEST PIT
- ⊞ TEST PIT AND DRILLHOLE

AMENDED BY HILLIS CONSULTING SERVICES LTD. 9 NOVEMBER 1978 TO SHOW LOCATION OF TEST PITS AND DRILLHOLES.

BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT ENVIRONMENTAL AND ENGINEERING SERVICES WATER INVESTIGATIONS BRANCH CANADA – BRITISH COLUMBIA FRASER RIVER FLOOD CONTROL YEAR AGREEMENT	DESIGNED [signature]	SURVEYED
	DRAWN A.R.T.	DATE
VEDDER RIVER - PHASE III CADASTRAL SURVEY	CHECKED	FILE NO. 0281550-817A
	SCALE 1:10,000	DATE AUG 15, 1977
	DWG NO 4805-17-103	SHEET 3 OF 6 SHEETS

FIG. 1

Figure 2 contained in envelope at back of report.



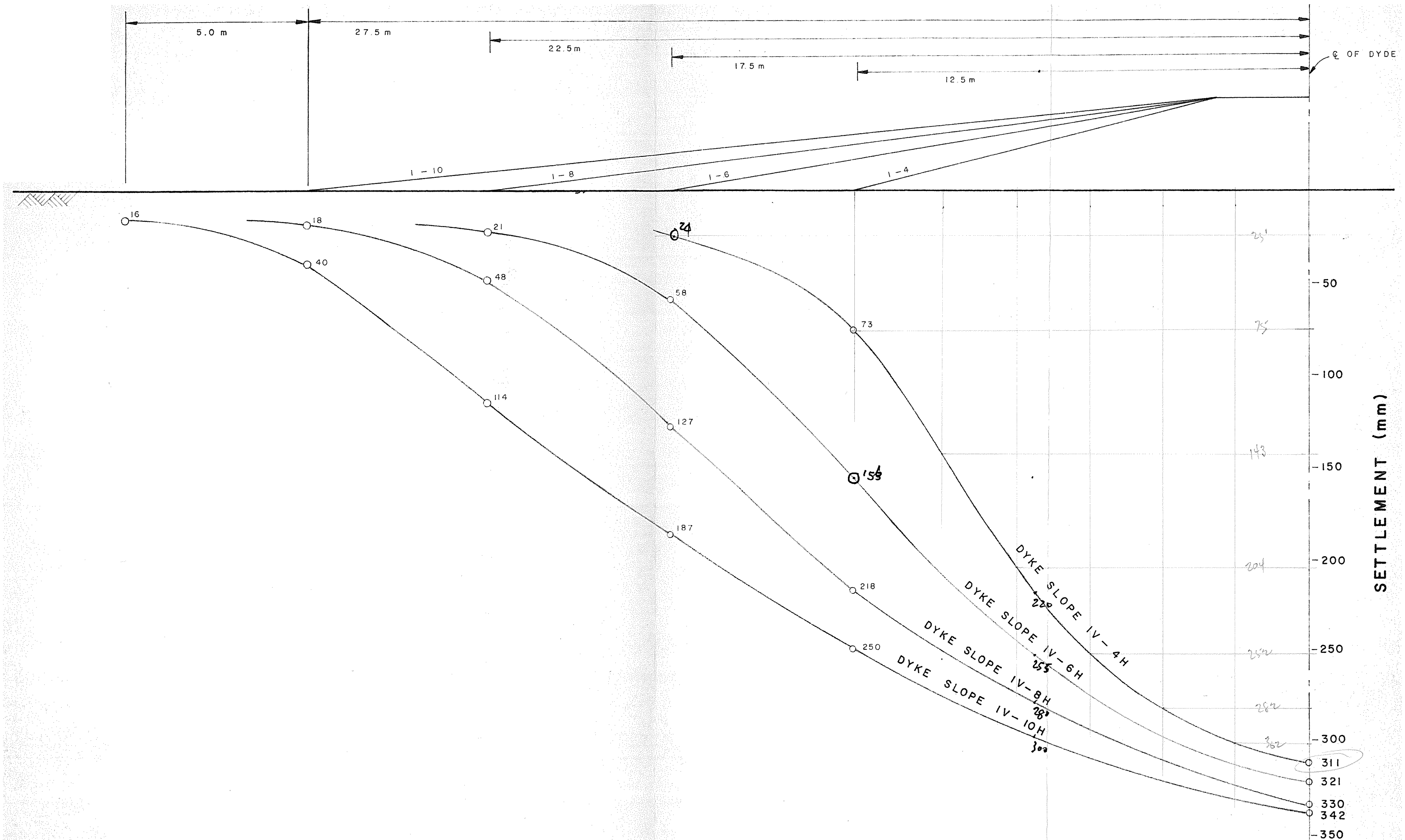
TYPICAL SECTION

SCALE 1:100

0 1 2 3 4 5

VEDDER RIVER
PHASE III

FIG. 3



SETTLEMENT PROFILE OF OIL PIPELINE VS SIDE SLOPE OF DYKE

FIG. 4

NO.	BY	REVISIONS	DATE

RECOMMENDED .... CHIEF, PROJECTS DIV.

DATE ....

APPROVED .... CHIEF ENGINEER

DATE ....

BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL AND ENGINEERING SERVICES
WATER INVESTIGATIONS BRANCH
CANADA — BRITISH COLUMBIA
FRASER RIVER FLOOD CONTROL 1968 AGREEMENT

VEDDER RIVER
PHASE III
FLOOD AND DYKE PROFILES

DESIGNED W. Caufield	SURVEYED
DRAWN A.R.T.	DATE
CHECKED	FILE NO. 0281550-B17A
SCALE AS SHOWN	DATE AUG 15, 1977
DWG. NO. 4805-17-102	SHEET 2 OF 6 SHEETS

FIG. 2