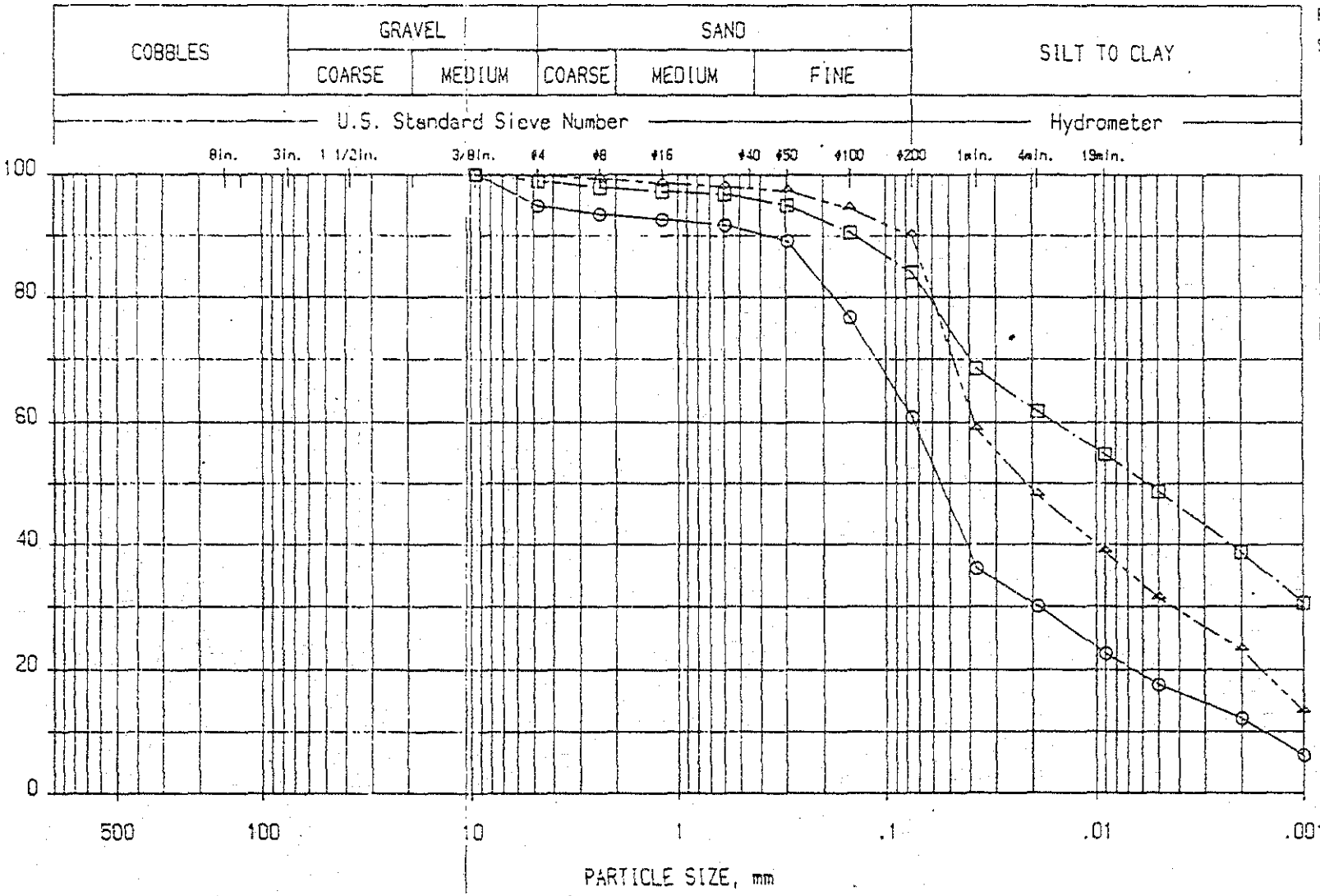
GRADATION TEST

Royal Irrigation Department
Reserch and Laboratory Division
Soil Engineering Branch

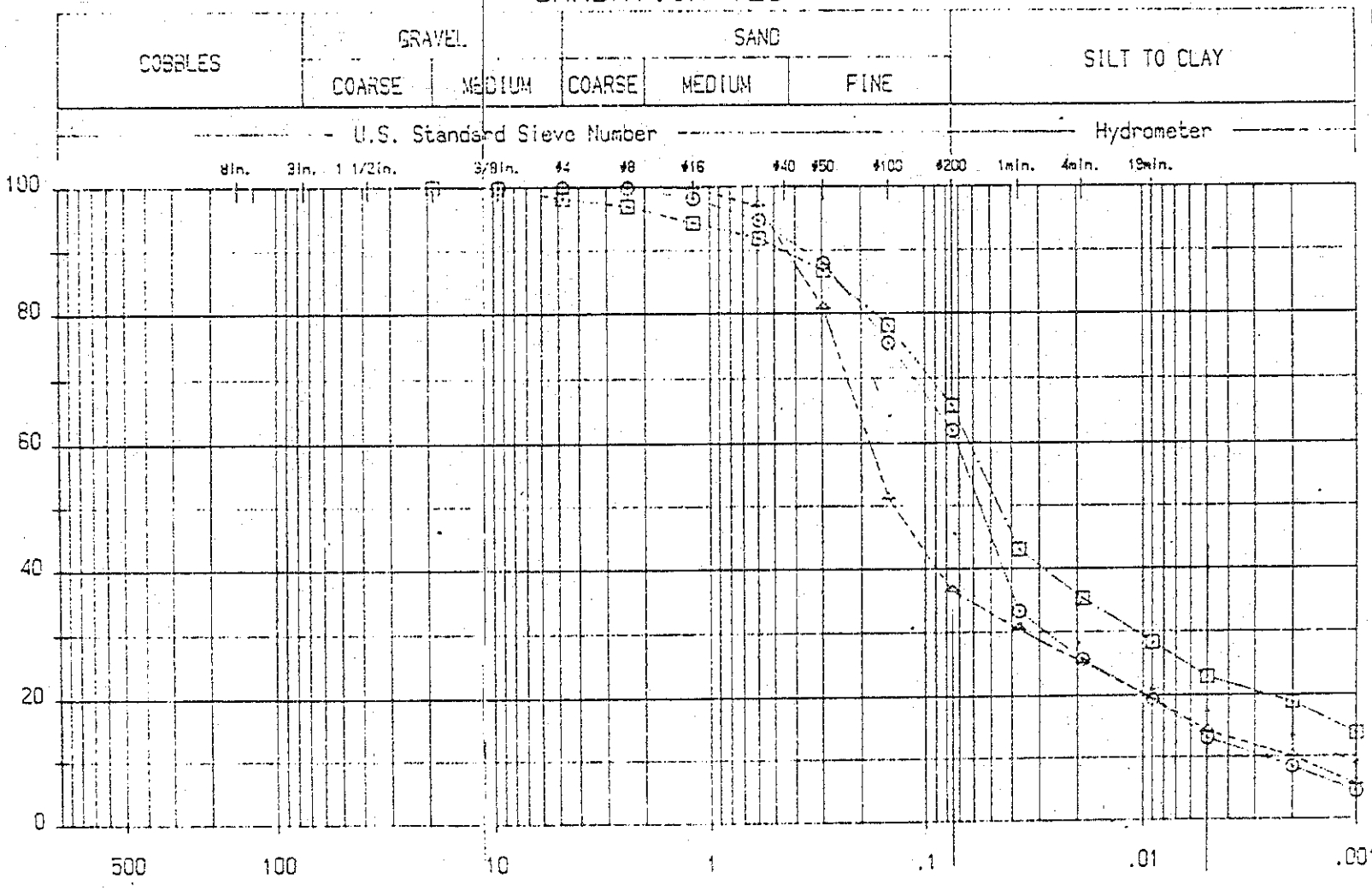


Project	DOM-YAI (2 nd.)
Memo	161/34
Checked by	PAIBOON
Date:	17/07/34

Sample No.		Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	Gs.	w_n, %	
⊙	1	D24-P1(2)	2.50 M.	30.30	17.00	13.30	CL	2.75	18.0	
⊡	2	D24-P2(1)		73.00	29.00	44.00	CH	2.69	26.2	
▽	3	D24-P3(1)		37.30	24.80	12.50	ML	2.73	26.3	

GRADATION TEST

Royal Irrigation Department
Research and Laboratory Division
Soil Engineering Branch



Project DOME-YAI (1st)
Memo 161/34
Checked by PAIBOON
Date: 10/07/34

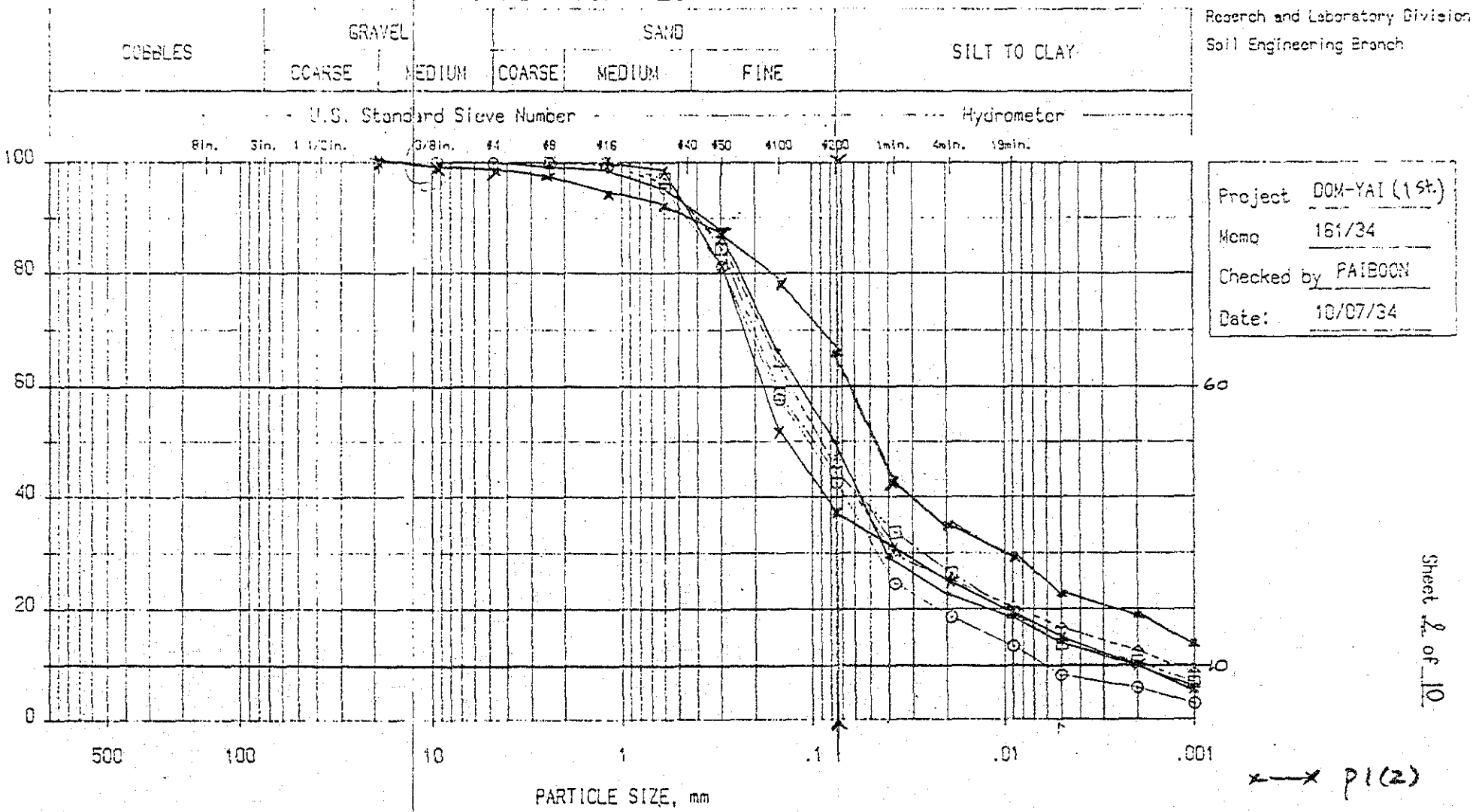
Dmax ≒ 10
Uc

Sheet 1 of 10

Sample No.	Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	Gs	Wn, %	Uc
⊙ 1	D-28; P1 (1)	1.00	32.50	18.50	14.00	CL	2.62	14.0	25.9
⊡ 2	D-28; P1 (2)	2.40	33.50	19.60	13.90	CL	2.73	15.1	~~710~~
⊿ 3	D-28; P2 (1)	1.50	----------	Non-Plastic	----------	SM	2.74	14.2	95.0

GRADATION TEST

Royal Irrigation Department
Research and Laboratory Division
Soil Engineering Branch



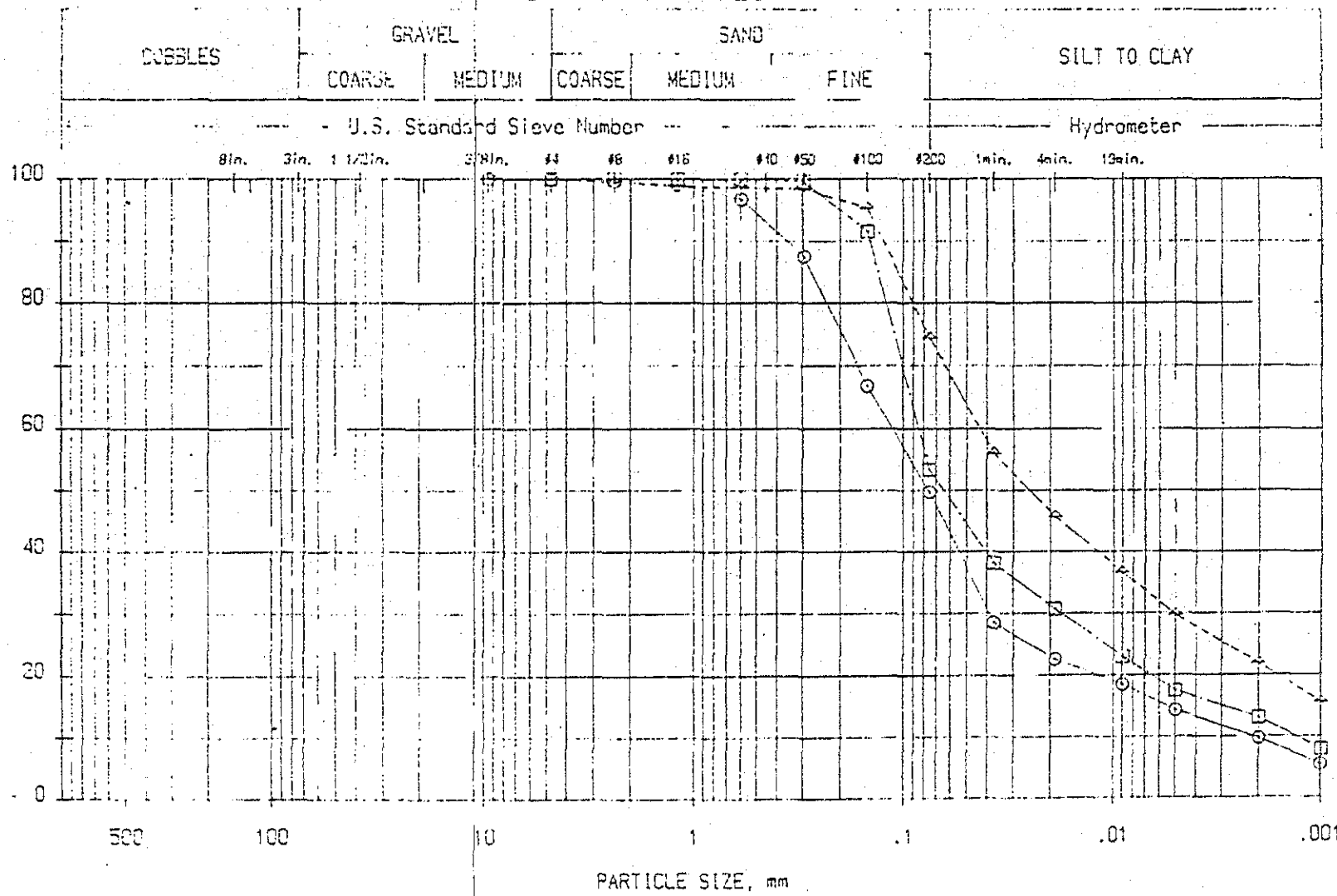
Project DOM-YAI (1st.)
Memo 161/34
Checked by PAIBOON
Date: 10/07/34

Sheet 4 of 10

Sample No.		Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	G_s	w_n,%	U_c
⊙	1	D-28; P2(2)	2.50	20.50	15.00	5.50	SM-SC	2.67	9.3	267
⊡	2	D-28; P3(1)	0.80	22.00	15.60	6.40	GM-GC	2.66	17.7	80.0
▲	3	D-28; P3(2)	1.80	24.60	16.10	8.50	SC	2.73	16.7	93.3

GRADATION TEST

Royal Irrigation Department
Research and Laboratory Division
Soil Engineering Branch



Project DOM-YAI (1st.)
Memo 161/34
Checked by PAIBOON
Date: 10/07/34

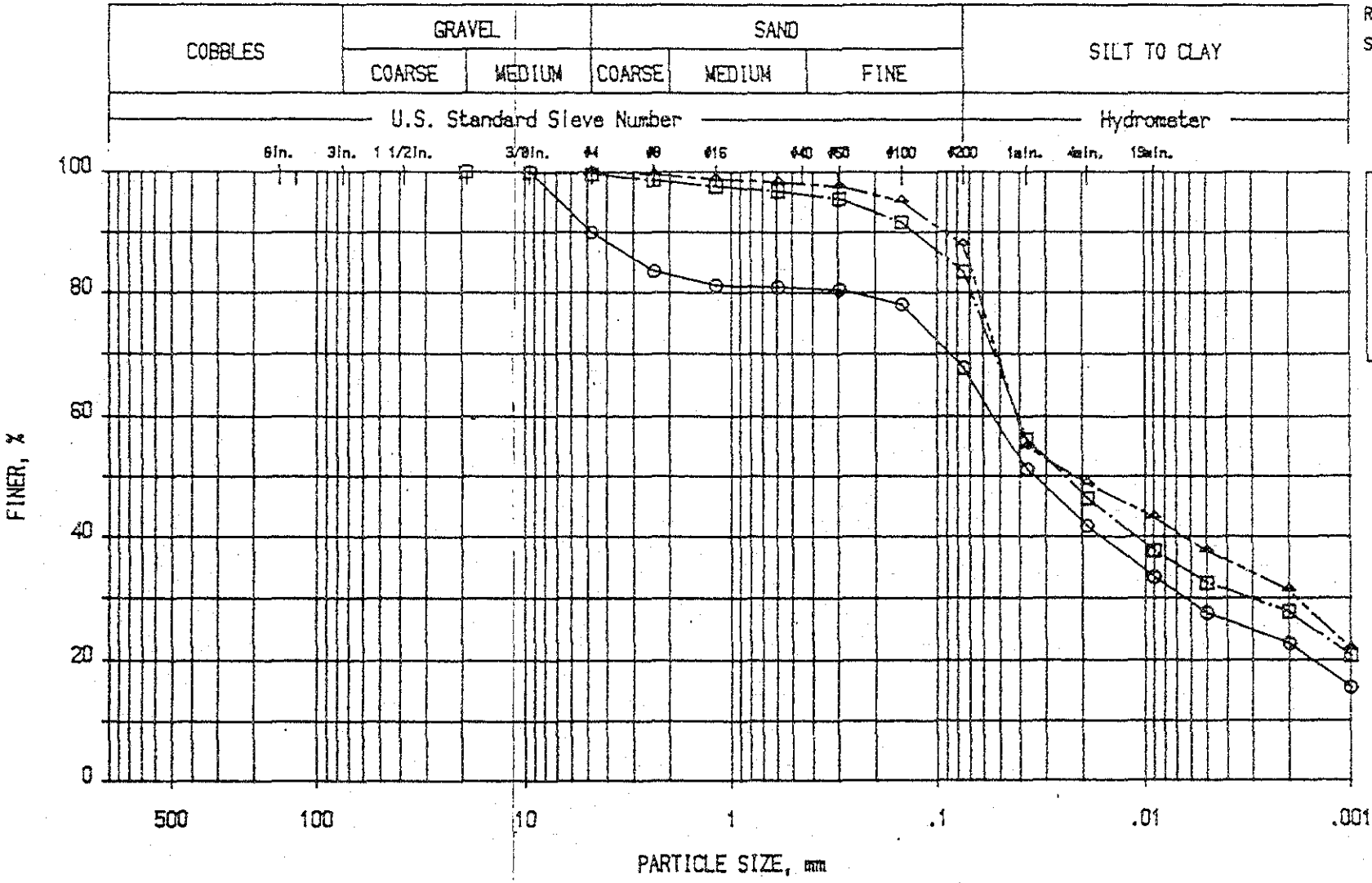
	Sample No.	Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	Gs	Wn; %	
⊙	1	D-28; P3(3)	2.70	24.80	15.50	9.30	SC	2.67	15.0	60.0
□	2	D-25; P-1	2.70	----------	Non-Plastic	----------	ML	2.69	14.4	
△	3	D-25; P-2.	[illegible]	23.30	15.70	7.60	CL	2.73	14.5	

D-26

Sheet 9 of 10

GRADATION TEST

Royal Irrigation Department
Research and Laboratory Division
Soil Engineering Branch

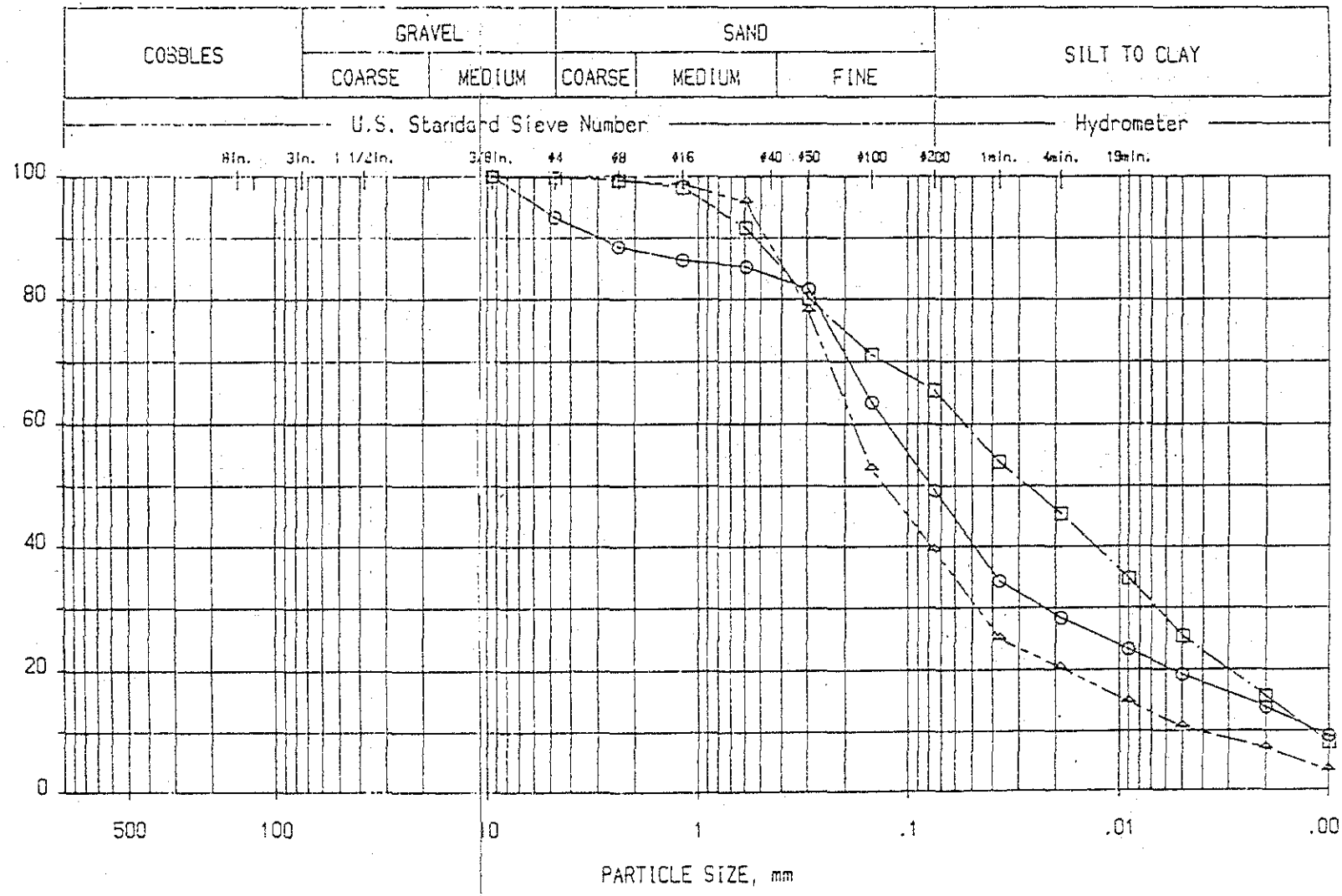


Project	DOM-YAI (1st.)
Memo	161/34
Checked by	PAIBOON
Date:	10/07/34

Sample No.		Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	G_s	W_n, %	
⊙	1	D-25 ; P-3	-	32.10	19.80	12.30	CL	2.74	15.7	
⊡	2	D-25 ; P-4(1)	-	52.00	31.70	20.30	MH	2.81	23.1	
▲	3	D-25 ; P-4(2)	-	47.20	25.10	22.10	CL	2.76	24.5	

GRADATION TEST

Royal Irrigation Department
Reserch and Laboratory Division
Soil Engineering Branch

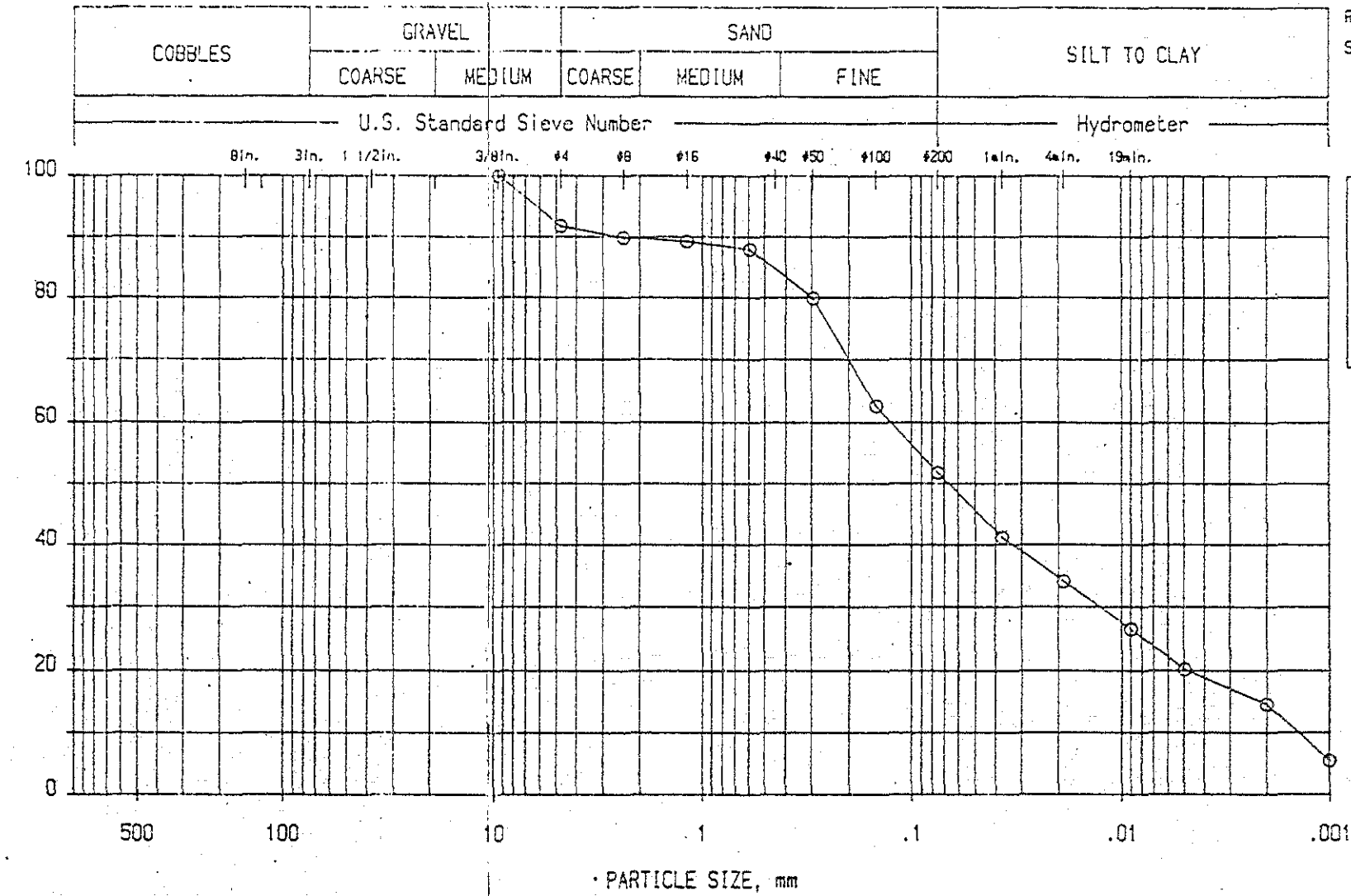


Project	DOM-YAI (2 nd)
Memo	161/34
Checked by	PAIBOON
Date:	17/07/34

Sample No.		Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	Gs	Wn, %	
○	1	D29-P2		35.10	19.60	15.50	SC	2.68	20.4	
□	2	J7-P1		32.20	19.20	13.00	CL	2.71	16.7	
△	3	J7-P2		----------	Non-Plastic	----------	SM	2.62	7.7	

GRADATION TEST

Royal Irrigation Department
Research and Laboratory Division
Soil Engineering Branch



Project	DOM-YAI (2 nd)
Memo	161/34
Checked by	PAIBOON
Date:	17/07/34

Sample No.	Boring No.	Depth (m.)	L.L.	P.L.	P.I.	CLASS	G_s	W_n, %	
⊙ 1	J7-P3		26.00	15.90	10.10	CL	2.70	14.8	

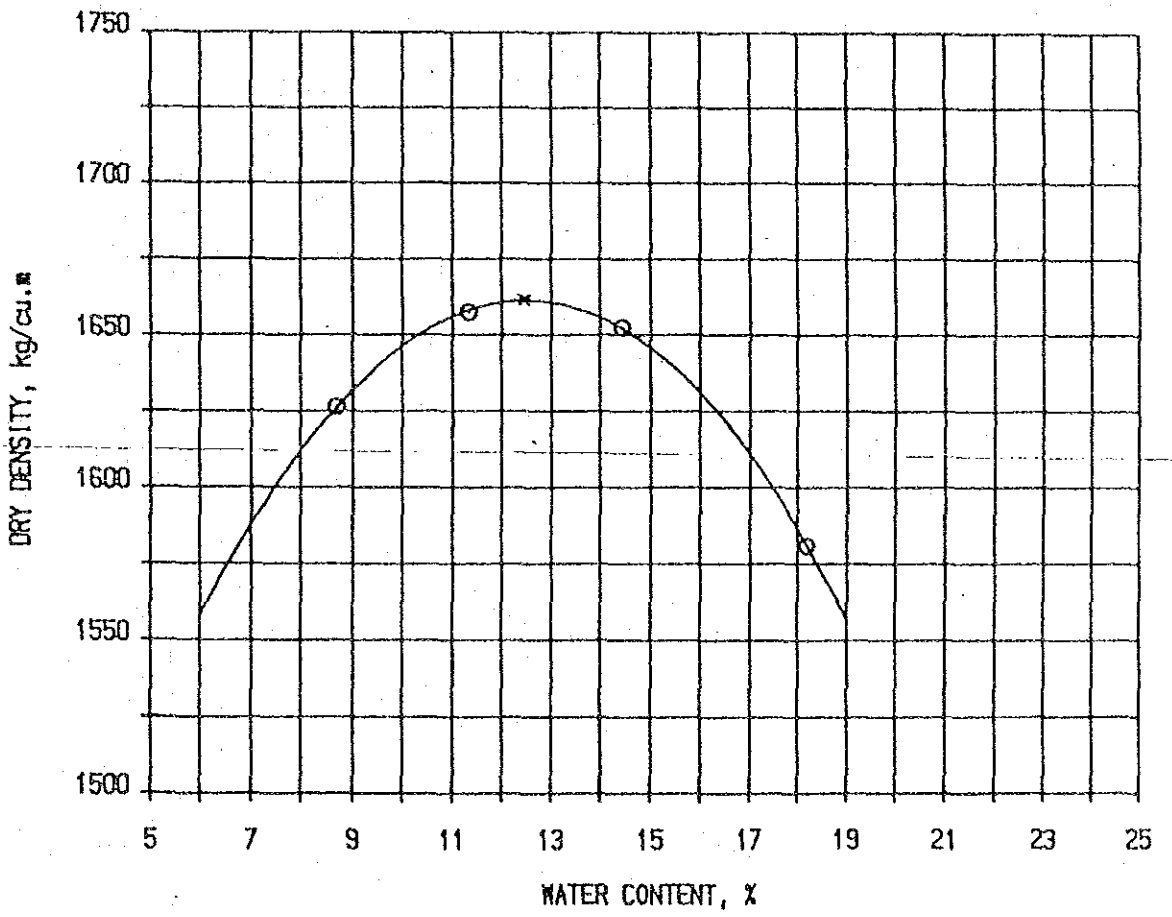
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DON-YAI (2 nd)	MEMO	161/34
LOCATION	D23		
BORING	P2	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	10/07/34
CHECKED BY	PAIBOON	DATE	11/07/34



Max. Dry Density 1661 kg/cu.m Optimum Water Content 12.5 %

Sheet 5 of 10

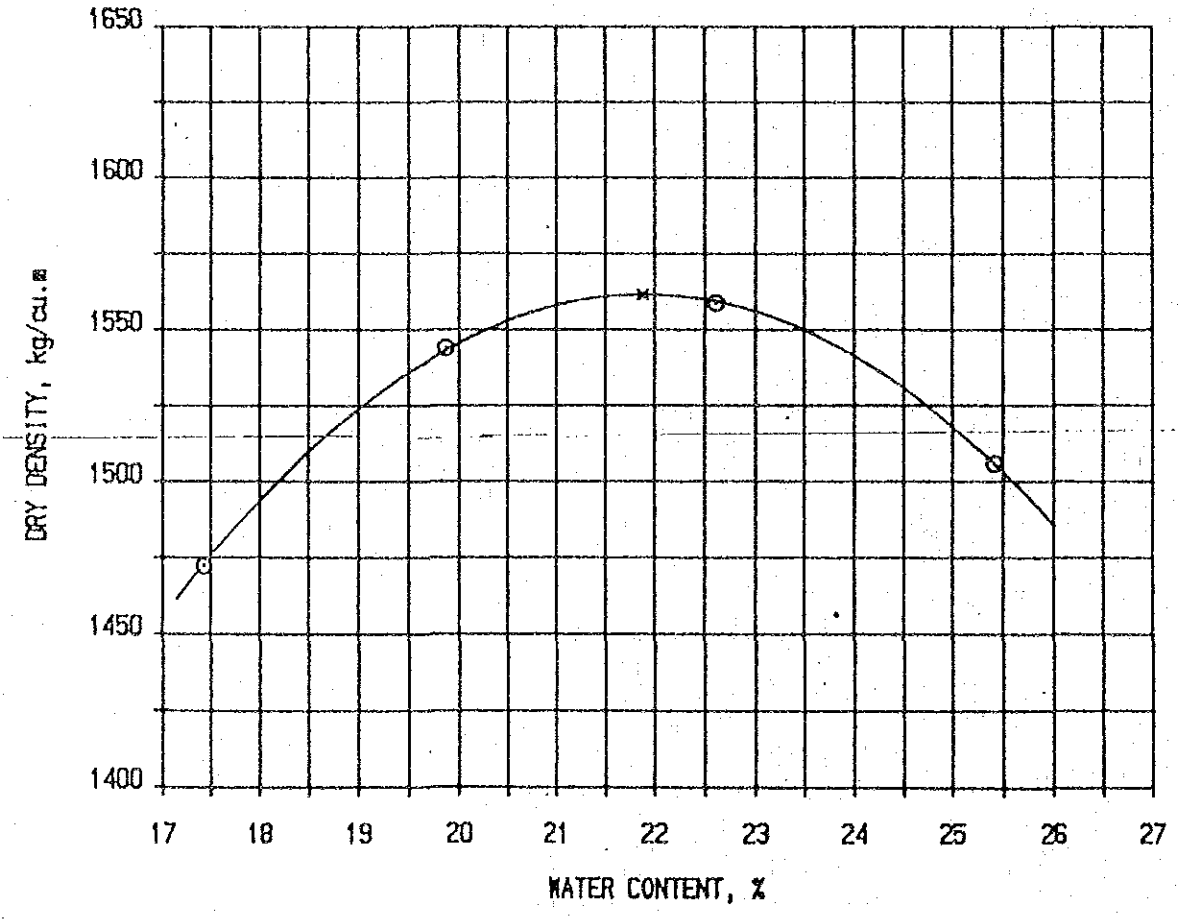
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DOM-YAI (2 nd)	MEMO	161/34
LOCATION	D24		
BORING	P2(1)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	10/07/34
CHECKED BY	PAIBOON	DATE	11/07/34



Max. Dry Density 1562 kg/cu.m Optimum Water Content 21.9 %

Sheet 6 of 10

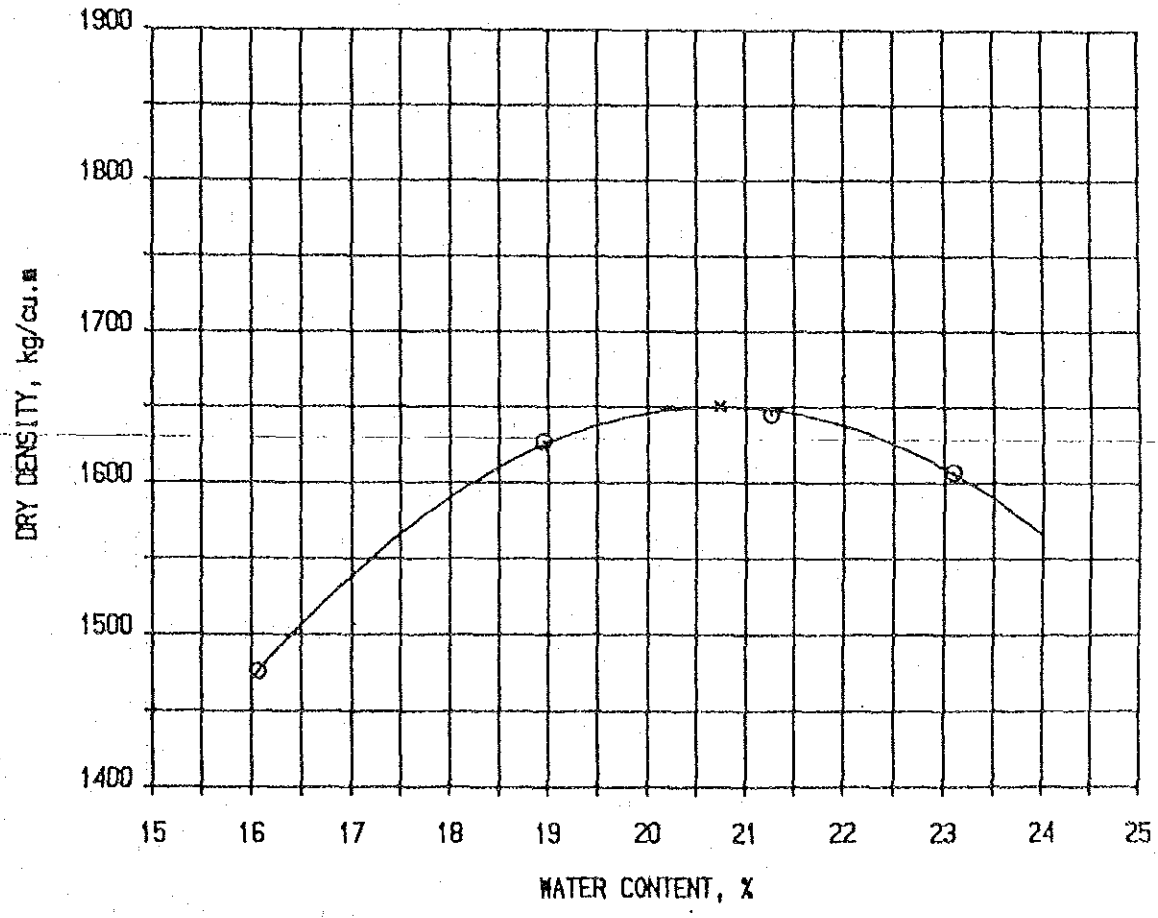
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DON-YAI (2 nd.)	MEMO	161/34
LOCATION	D24		
BORING	P3(1)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	10/07/34
CHECKED BY	PAIBOON	DATE	11/07/34



Max. Dry Density 1650 kg/cu.m Optimum Water Content 20.7 %

Sheet 7 of 10

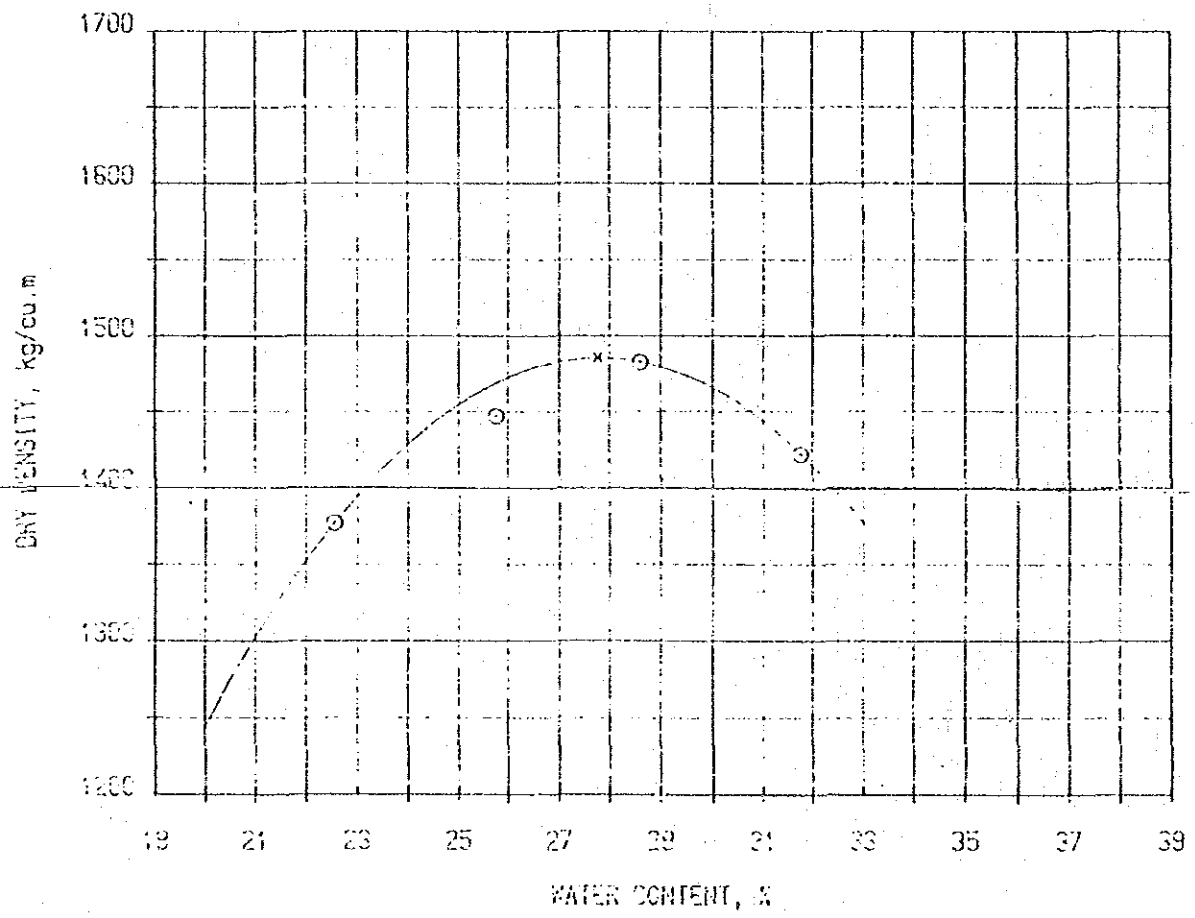
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DOME-YAI (1st.)	MEMO	161/34
LOCATION	D25		
BORING	P4(1)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	08/07/34
CHECKED BY	PAIBOON	DATE	08/07/34



Max. Dry Density 1485 kg/cu.m Optimum Water Content 27.8 %

Sheet 8 of 10

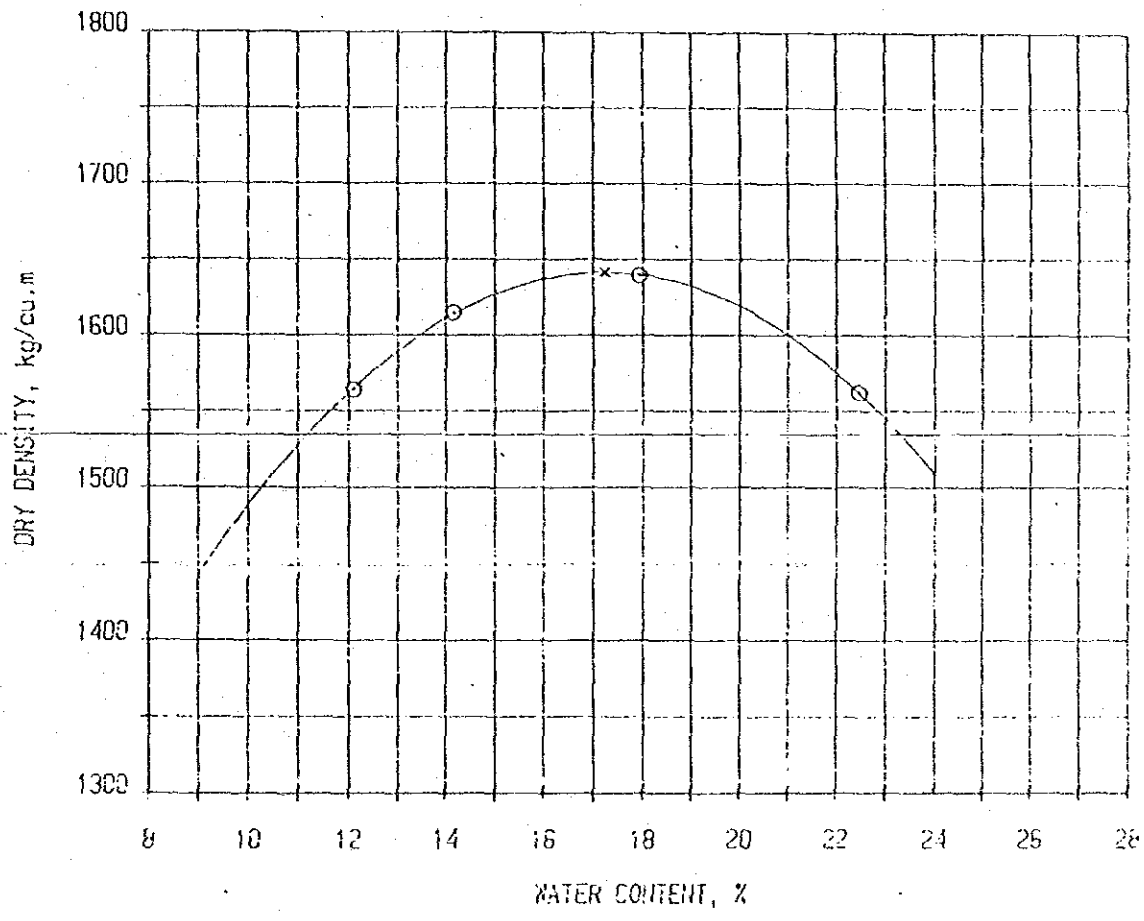
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DON_YAI (1 st.)	MEMO	161/34
LOCATION	D-25		
BORING	P4(2)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	05/07/34
CHECKED BY	PAIBOON	DATE	05/07/34



Max. Dry Density 1641 kg/cu.m Optimum Water Content 17.2 %

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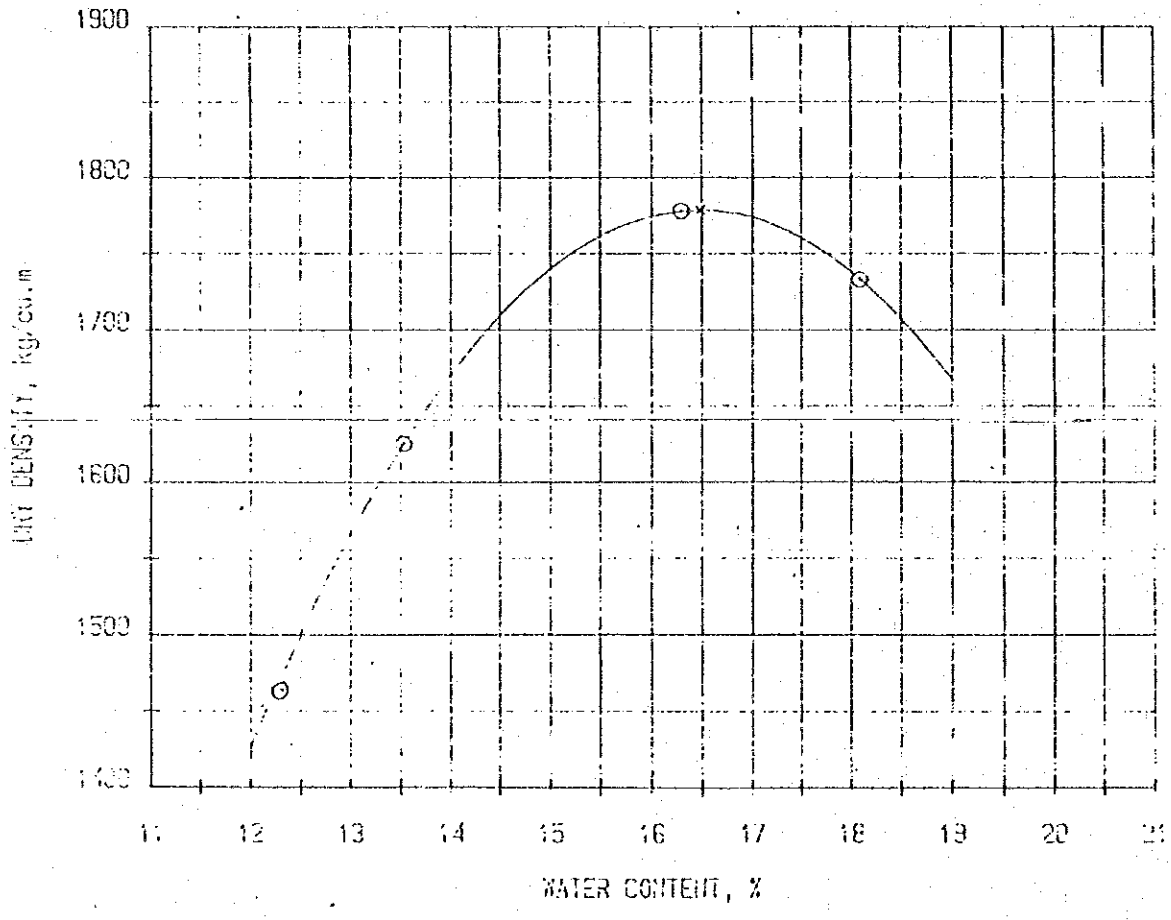
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DOME-YAI (1st.)	MEMO	161/34
LOCATION	D28		
BORING	P1(2)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	2.40
TESTED BY	KAMPONG	DATE	08/07/34
CHECKED BY	PAIBOON	DATE	08/07/34



Max. Dry Density 1778 kg/cu.m Optimum Water Content 16.5 %

Sheet 5 of 10

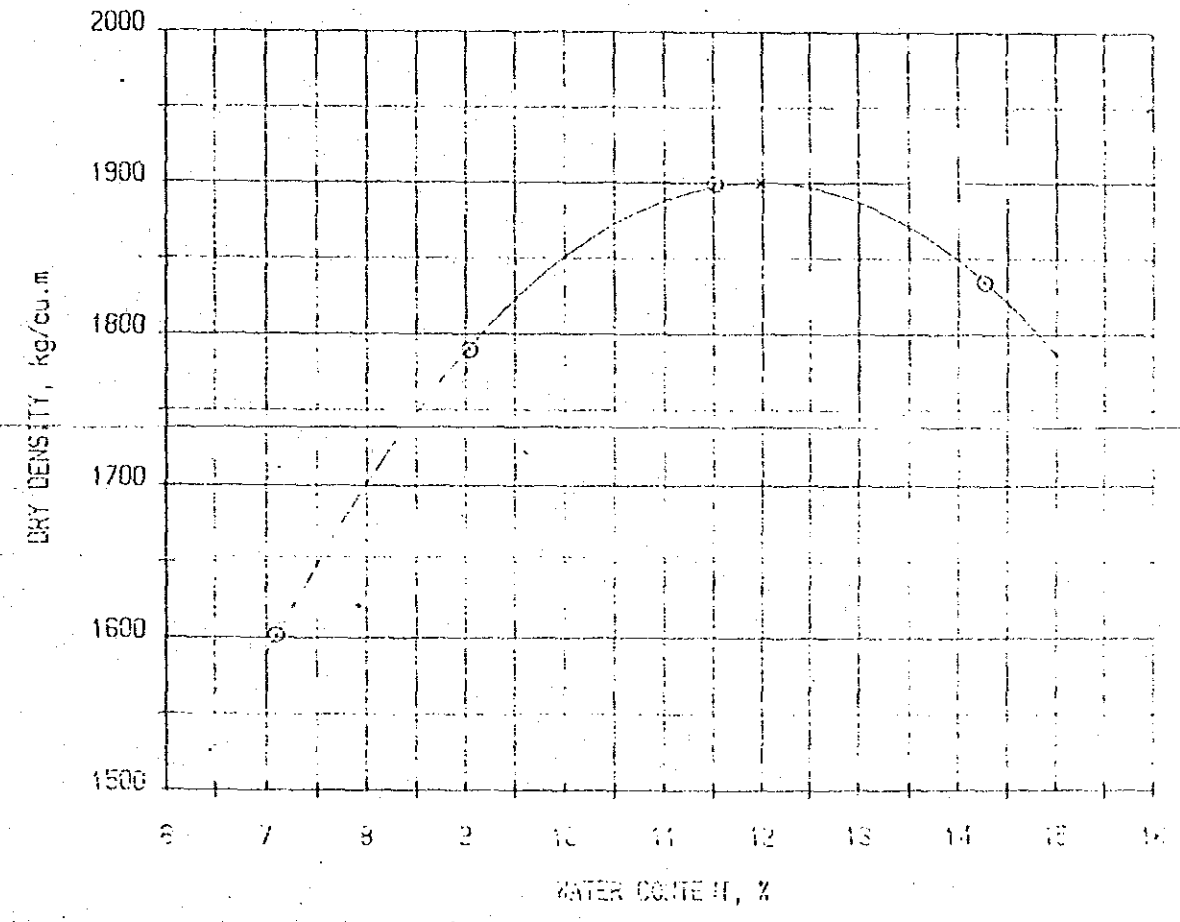
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DOME-YAI (1 st.)	MEMO	161 /34
LOCATION	D28		
BORING	P2(2)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	2.50
TESTED BY	KAMPONG	DATE	08/07/34
CHECKED BY	PAIBOON	DATE	08/07/34



Max. Dry Density 1930 kg/cu.m Optimum Water Content 12.0 %

Sheet 6 of 10

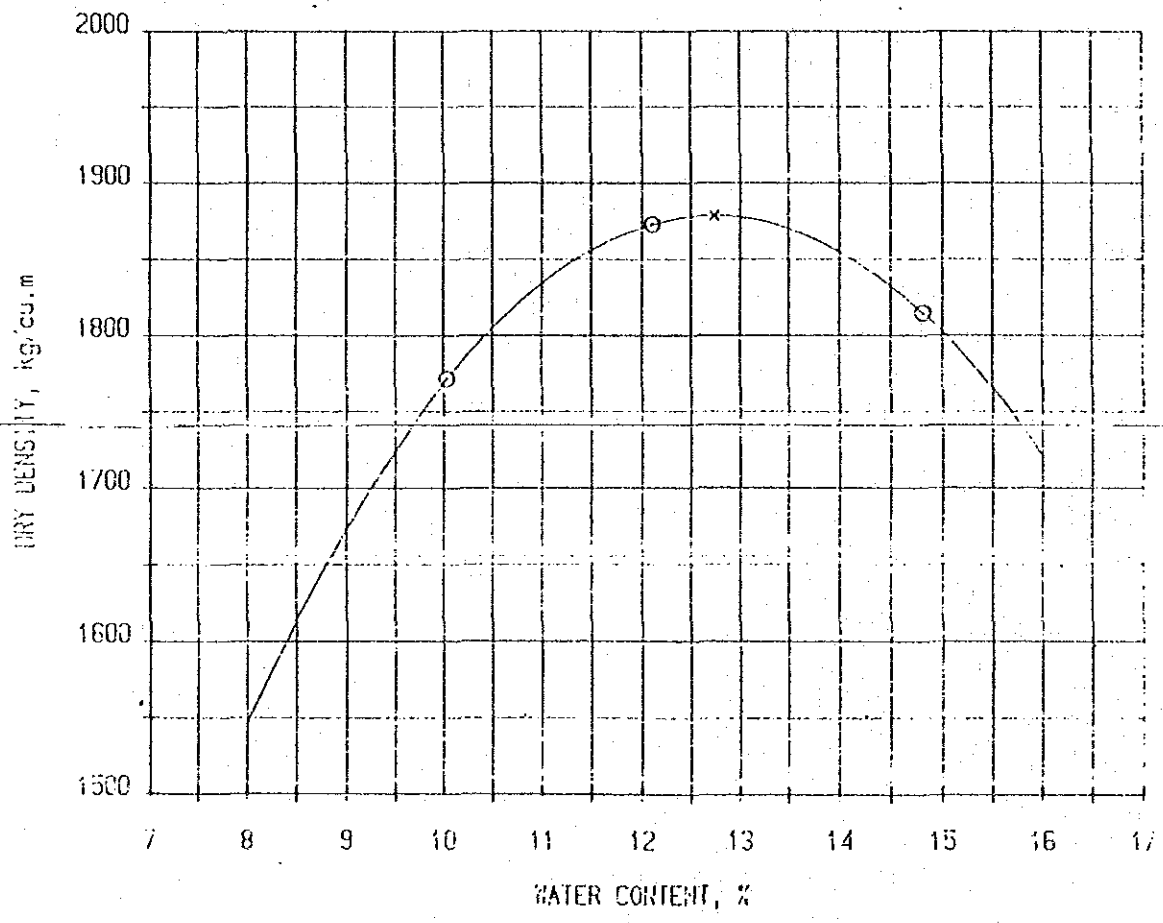
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DOME-YAI (1st.)	MEMO	161/34
LOCATION	D28		
BORING	P3(3)	TEST NO.	1
SOIL DESCRIPTION		DEPTH	2.70
TESTED BY	KAMPONG	DATE	08/07/34
CHECKED BY	PAIBOON	DATE	08/07/34



Max. Dry Density 1879 kg/cu.m Optimum Water Content 12.7 %

Sheet 7 of 10

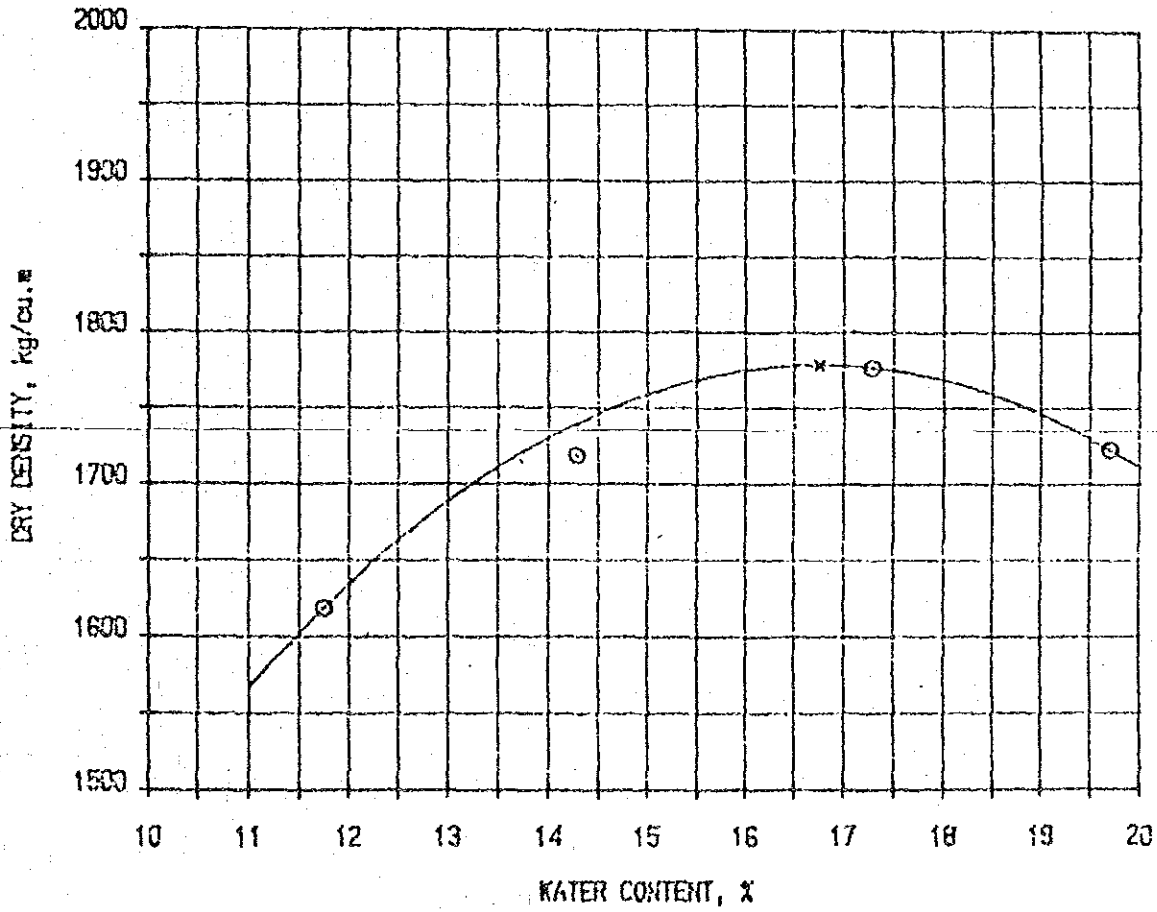
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DOM-YAI (2 nd)	MEMO	161/34
LOCATION	D29		
BORING	P2	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	10/07/34
CHECKED BY	PAIBOON	DATE	11/07/34



Max. Dry Density 1778 kg/cu.m Optimum Water Content 16.8 %

Sheet 8 of 10

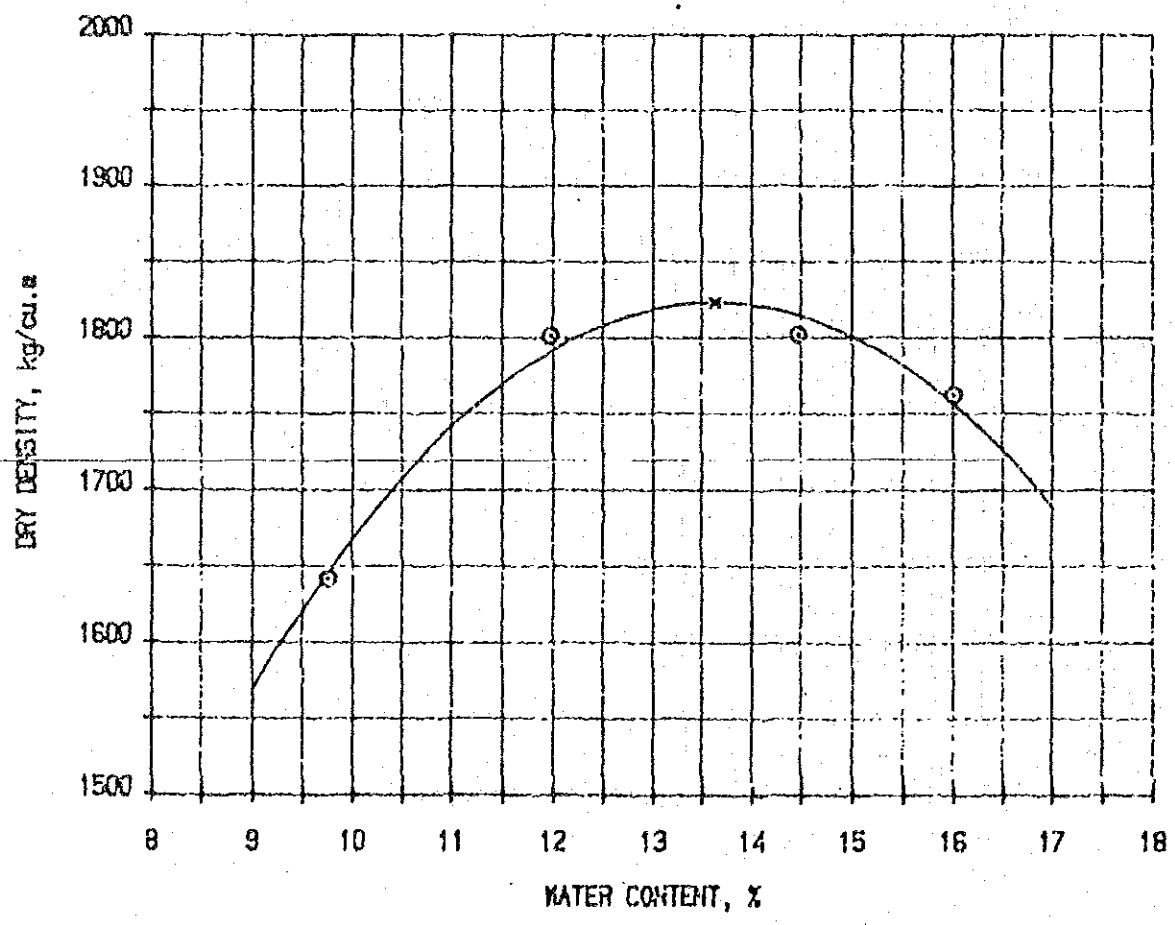
ROYAL IRRIGATION DEPARTMENT

RESEARCH AND LABORATORY DIVISION

SOIL ENGINEERING BRANCH

COMPACTION TEST

PROJECT	DON-YAI (2nd.)	MEMO	161/34
LOCATION	J7		
BORING	P3	TEST NO.	1
SOIL DESCRIPTION		DEPTH	
TESTED BY	KAMPONG	DATE	10/07/34
CHECKED BY	PAIBOON	DATE	11/07/34



Max. Dry Density 1823 kg/cu.m Optimum Water Content 13.6 %

Sheet 9 of 10

ROYAL IRRGATION DEPARTMENT
DIVISION OF RESEARCH AND LABORATORY

PERMEABILITY TEST RESULT

Project : DOME YAI RIVER BASIN (2nd)
Location UBON — MEMO 161/2534
Date 22/7/34
Checked PS

TEST NO.	SAMPLE NO.	DEPTH m	METHOD OF COMPACTED	INITIAL TEST				FINAL WATER CONTENT -/-	SOIL GROUP	VALUES OF PERMEABILITY K cm/sec
				DRY DENSITY t/m²	WATER CONTENT -/-	VOID RATIO	SATURATION -/-			
1.	D-23,P-2	-	95% γmax AT OMC+2%	1.578	14.0	0.698	53.8	17.0	SM	2.132×10^{-5}
2.	D-24,P-2(1)	-	"	1.484	23.2	0.813	76.8	25.0	CH	2.410×10^{-8}
3.	D-24,P-3(1)	-	"	1.568	22.3	0.741	82.2	24.7	ML	1.726×10^{-8}
4.	D-29,P-2	-	"	1.689	18.9	0.587	86.3	20.4	SC	2.960×10^{-8}
5.	J-7,P-3	-	"	1.732	15.7	0.559	75.8	17.4	CL	2.395×10^{-7}

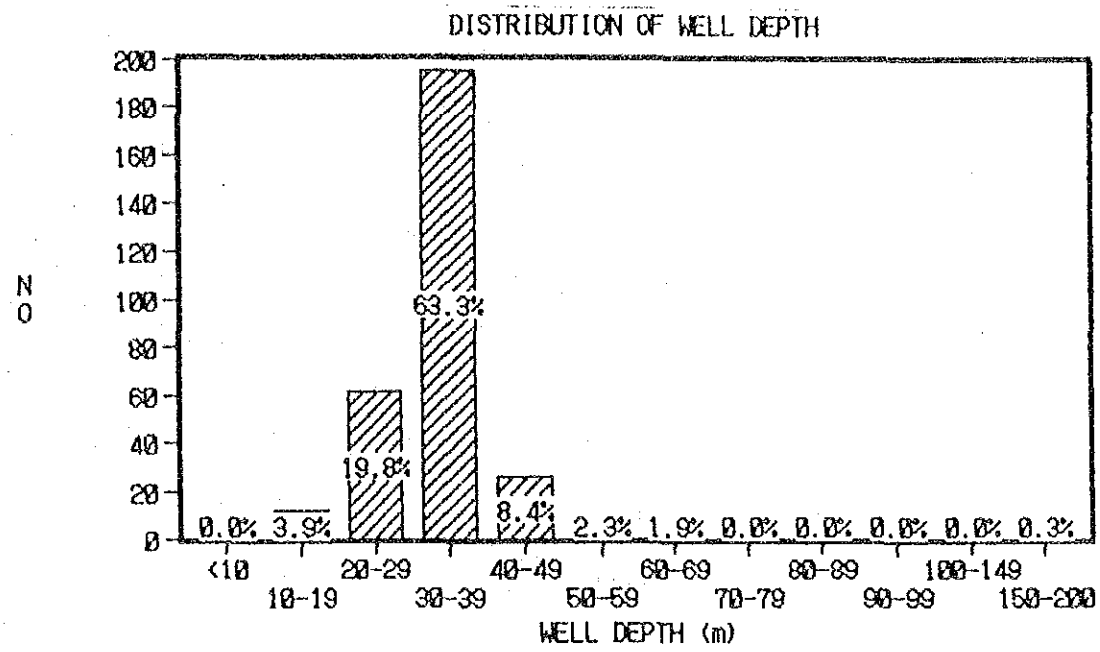
ROYAL IRRGATION DEPARTMENT
DIVISION OF RESEARCH AND LABORATORY

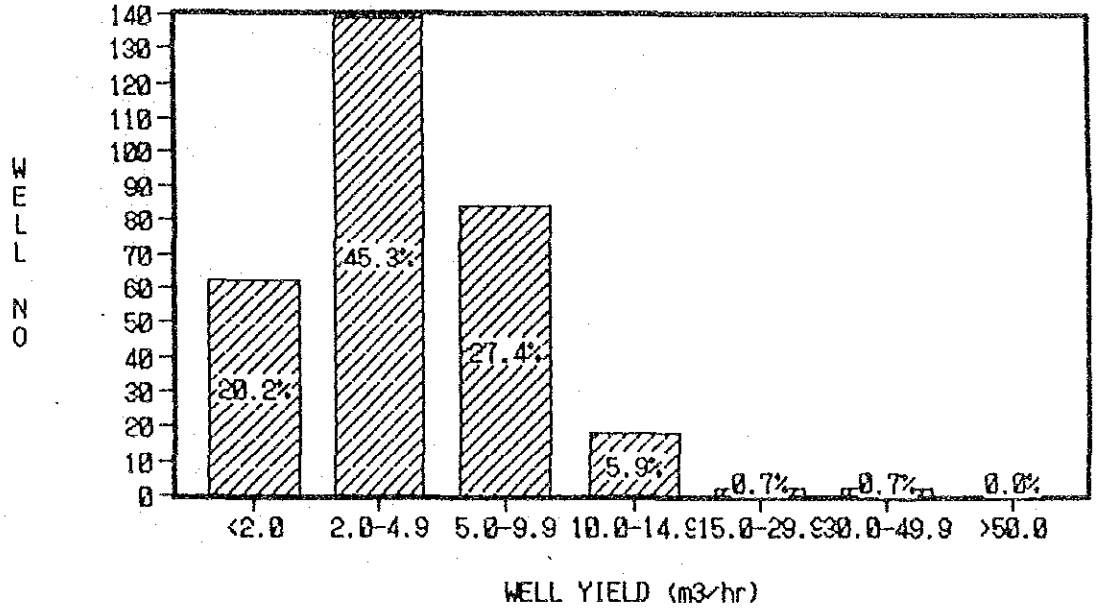
PERMEABILITY TEST RESULT

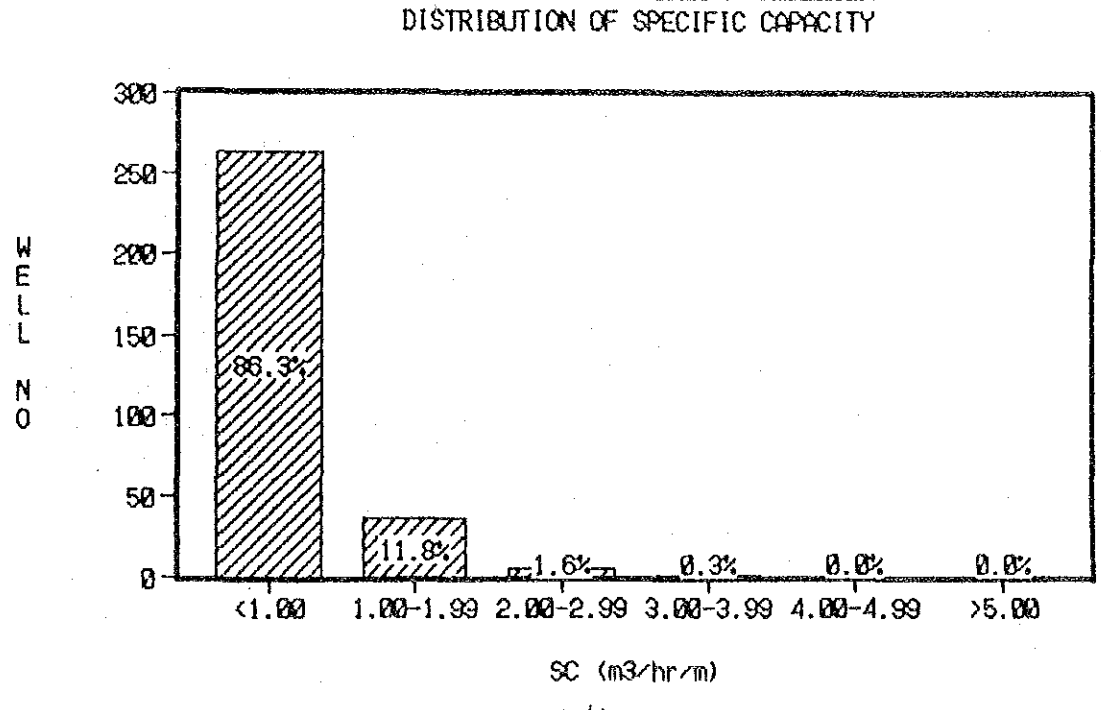
Project : DOME YAI RIVER BASIN (1 ST)
Location UBON
MEMO 161/2534
Date 22/7/2534
Checked PS

TEST NO.	SAMPLE NO.	DEPTH m	METHOD OF COMPACTED	INITIAL TEST				FINAL WATER CONTENT %	SOIL GROUP	VALUES OF PERMEABILITY K cm / sec
				DRY DENSITY t/m3	WATER CONTENT %	VOID RATIO	SATURATION %			
1.	D-28,P-1(2)	-	95%γmax ATOMC+2%	1.689	18.4	0.616	81.5	19.9	CL	5.784×10^{-8}
2.	D-28,P-2(2)	-	"	1.805	14.0	0.479	78.0	16.4	SM-SC	3.310×10^{-7}
3.	D-28,P-3(3)	-	"	1.785	14.5	0.496	78.1	16.7	SC	2.356×10^{-7}
4.	D-25,P-4(1)	-	"	1.411	29.7	0.991	84.2	30.8	MH	3.459×10^{-8}
5.	D-25.P-4(2)	-	"	1.559	19.7	0.770	70.6	21.4	CL	9.685×10^{-8}

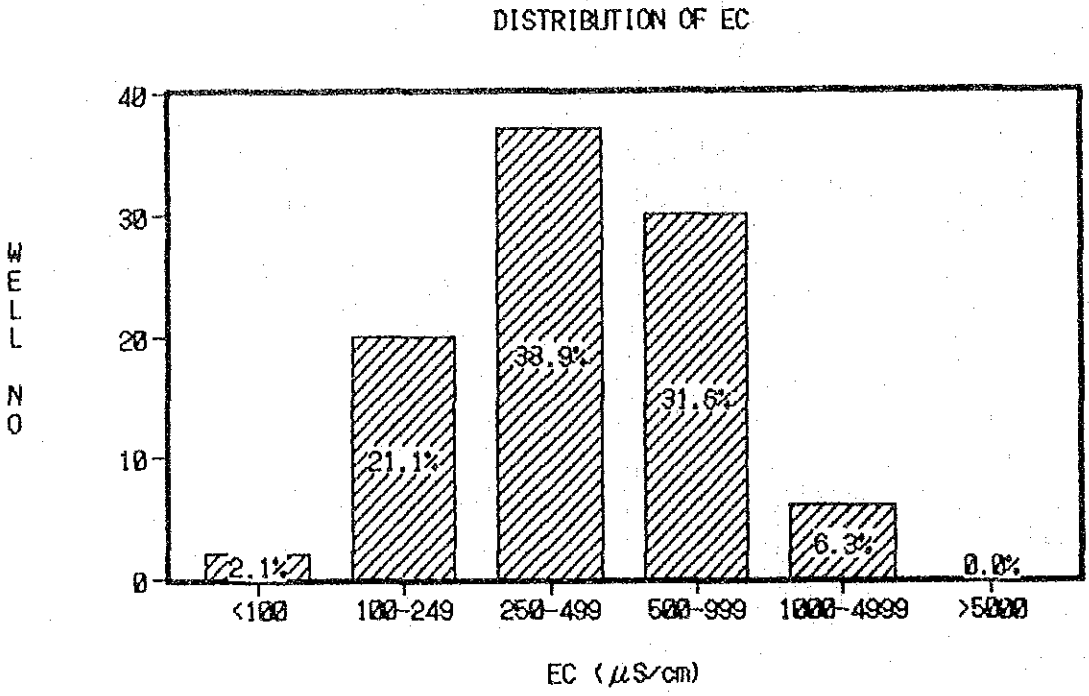
FIGURE D-1 DISTRIBUTION OF WELL DEPTH, YIELD & SPECIFIC CAPAITY







FIGURRE D-2 DISTRIBUTION OF EC & pH



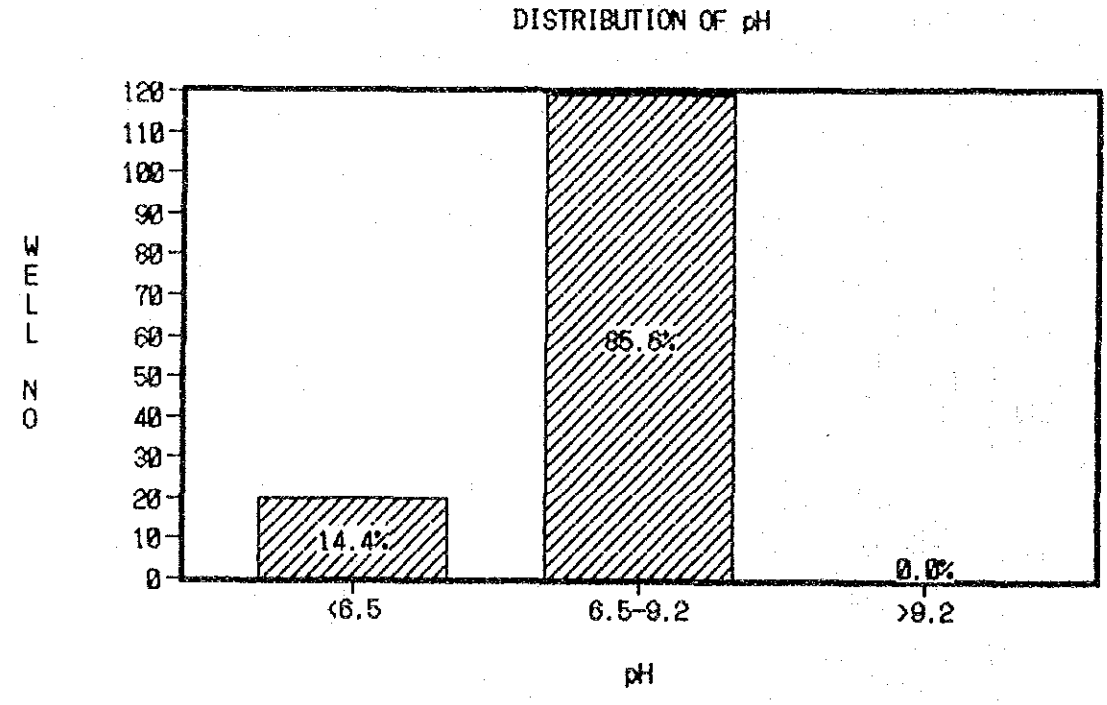
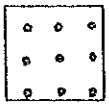


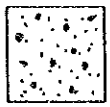
FIGURE D-3 TEST PIT LOG

Sand

Clay

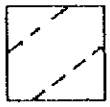


Gravel



Laterite

Sandy



Silty

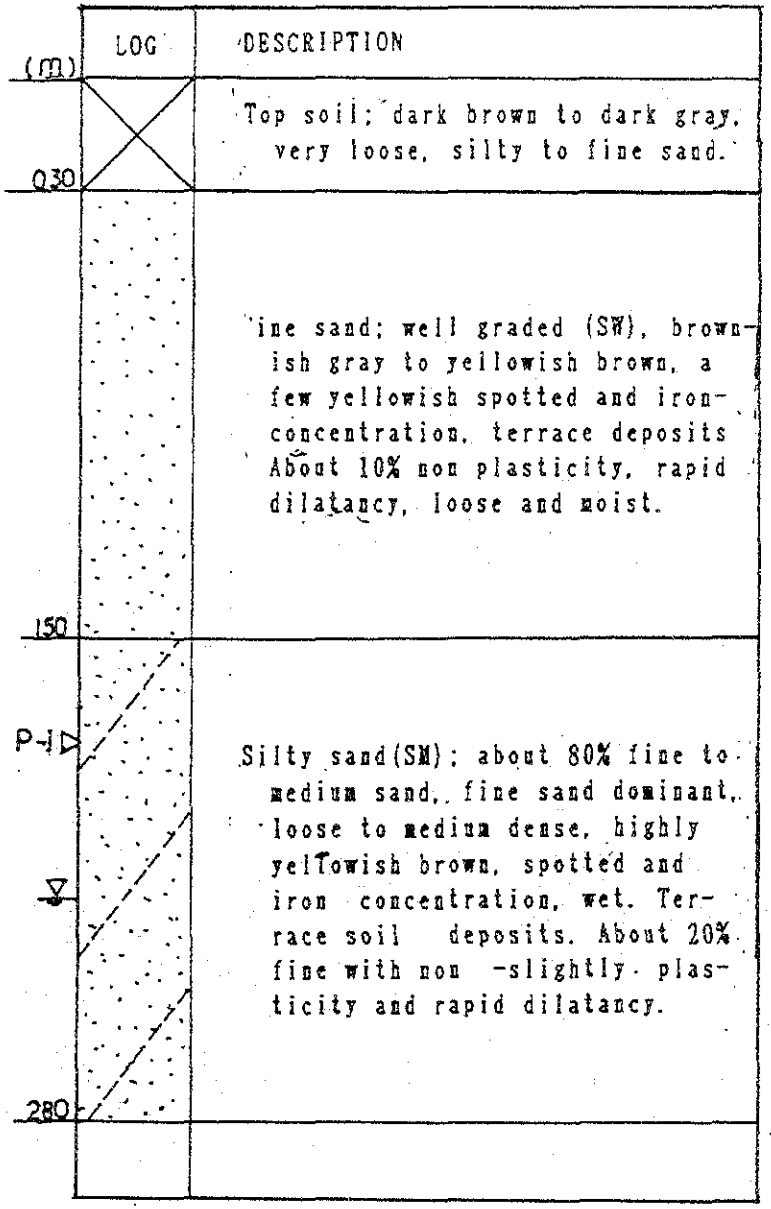
Clayey

Groundwater Table

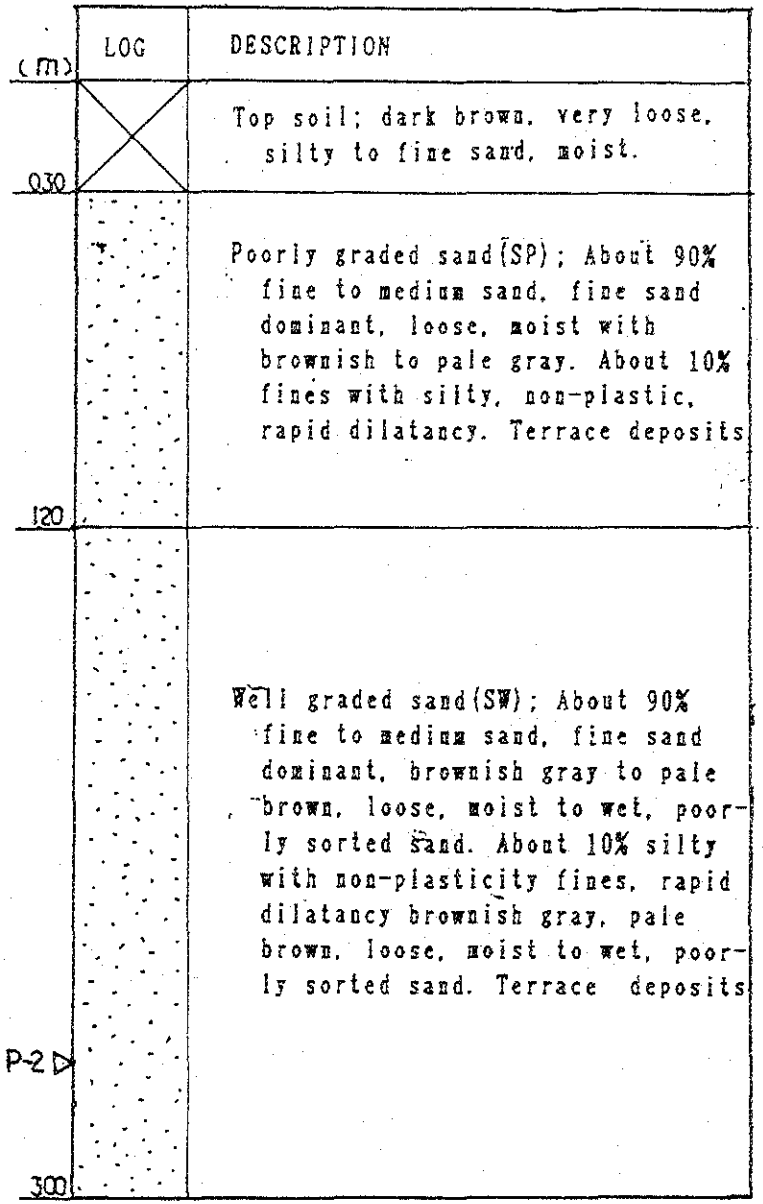
P-1 

Soil Sampling Point

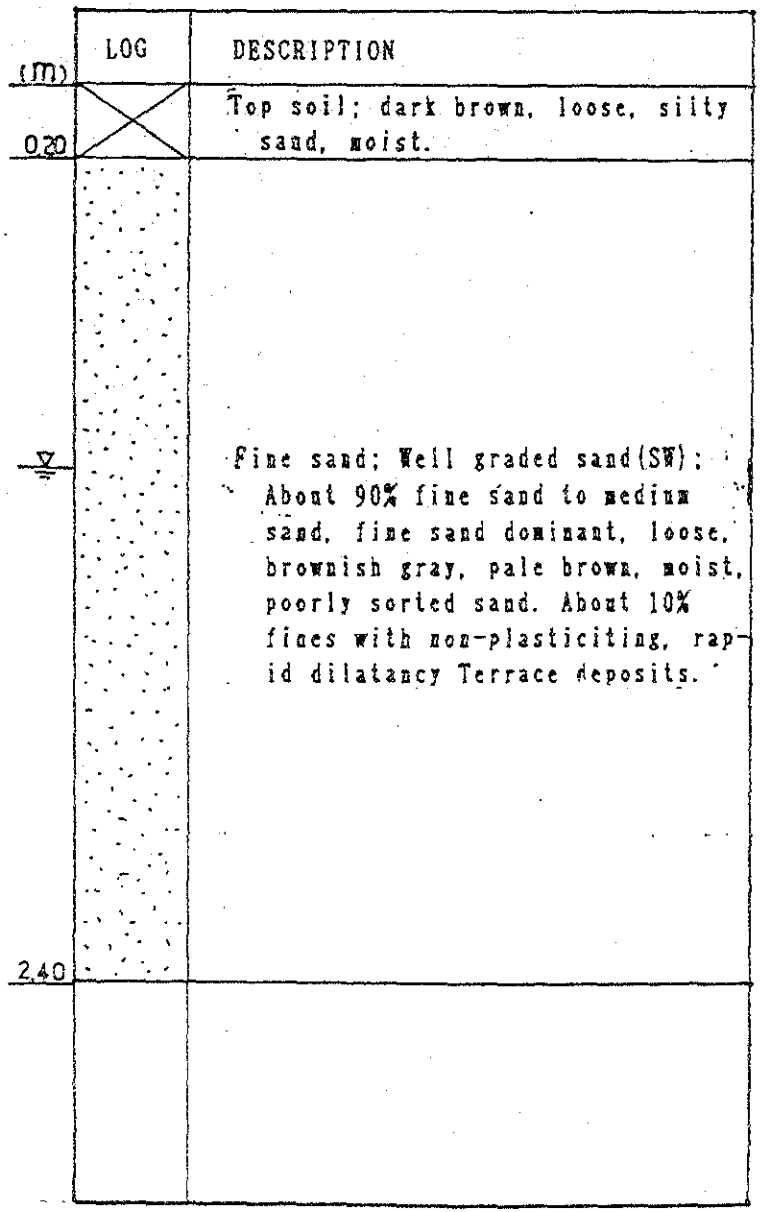
D-23 LAM DOM YAI
P-1



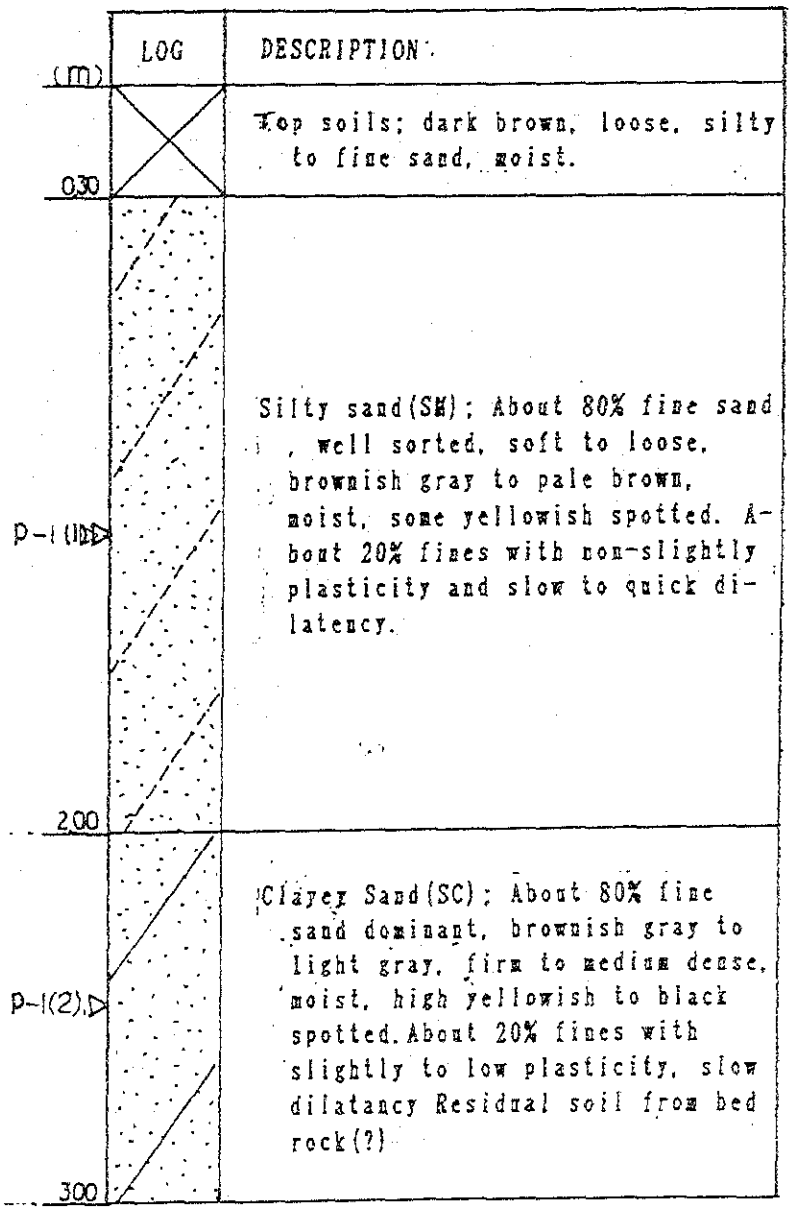
D-23 LAM DOM YAI
P-2



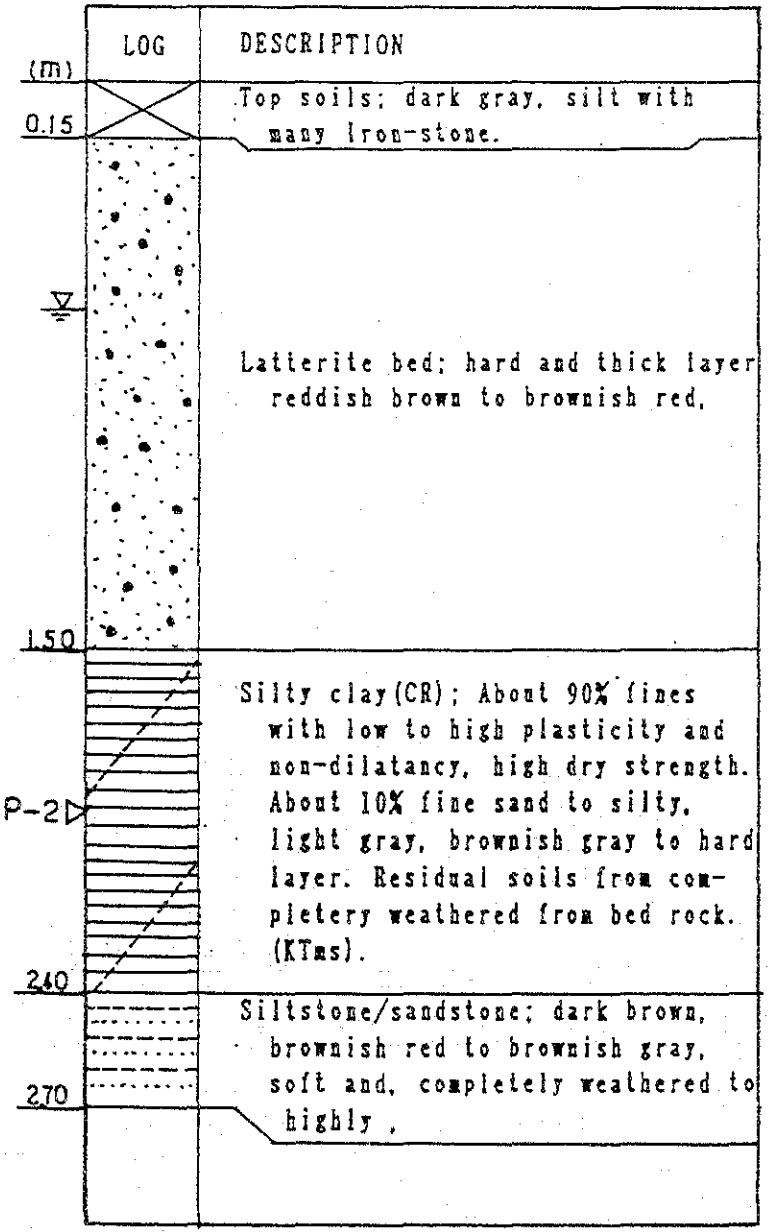
D-23 LAM DOM YAI
P-3



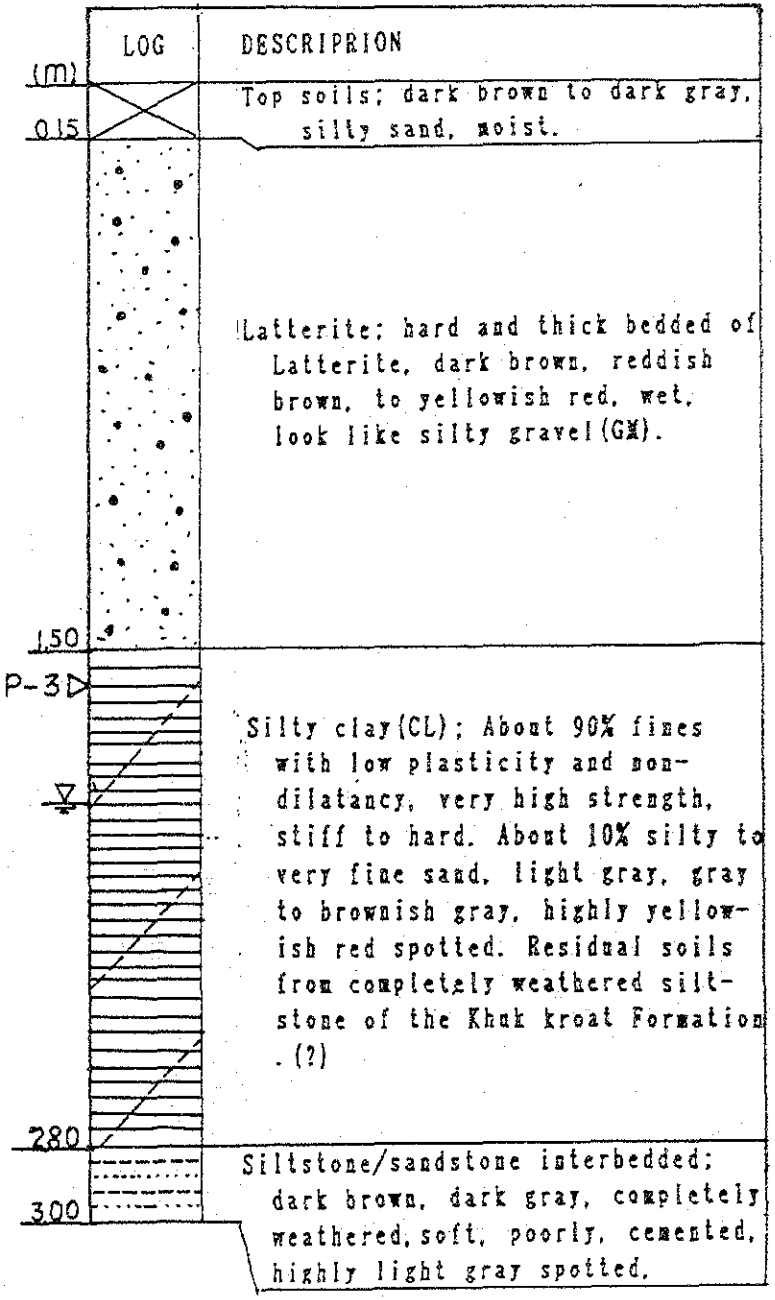
D-24 LAM SOM
P-1



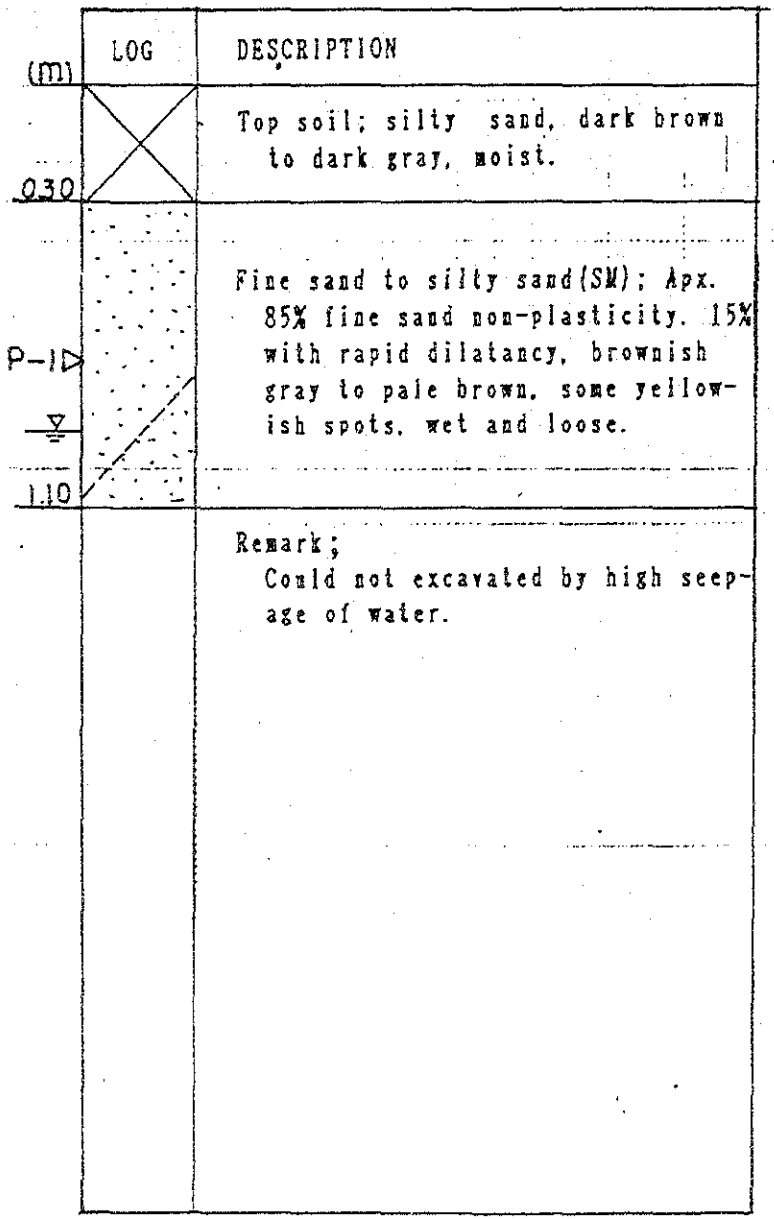
D-24 LAM SOM
P-2



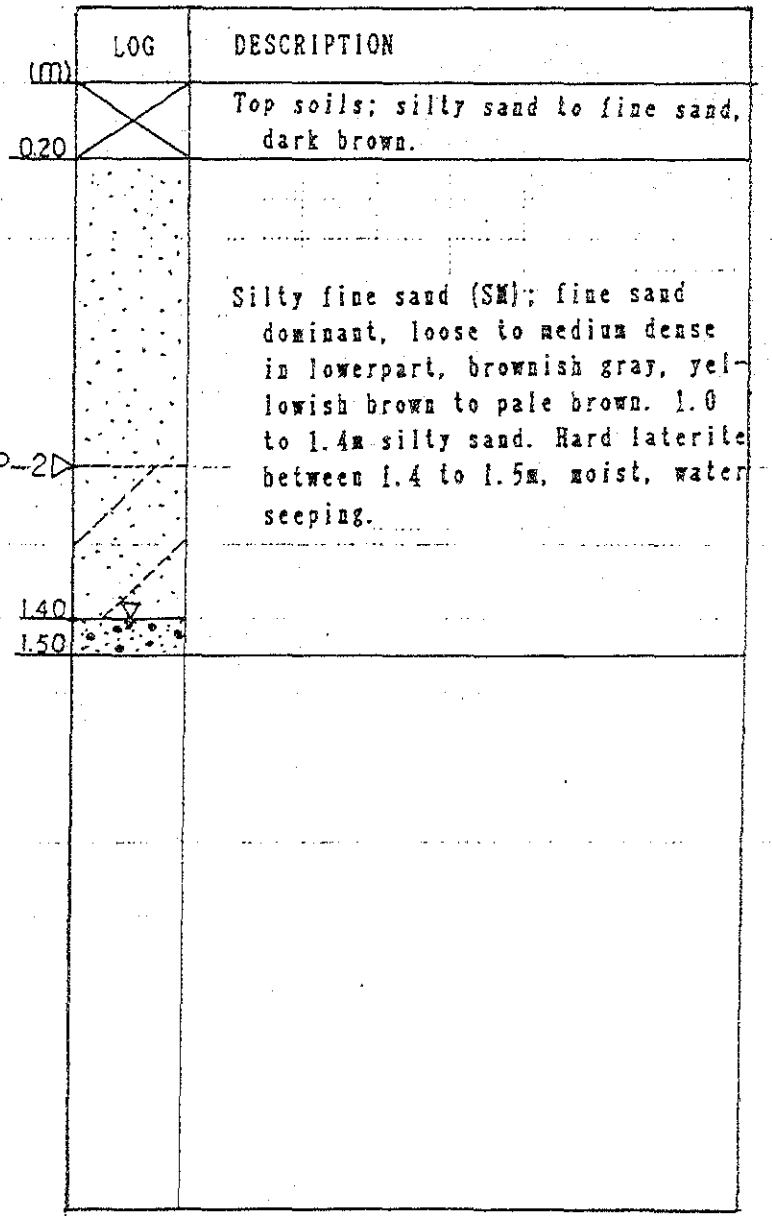
D-24 LAM SOM
P-3



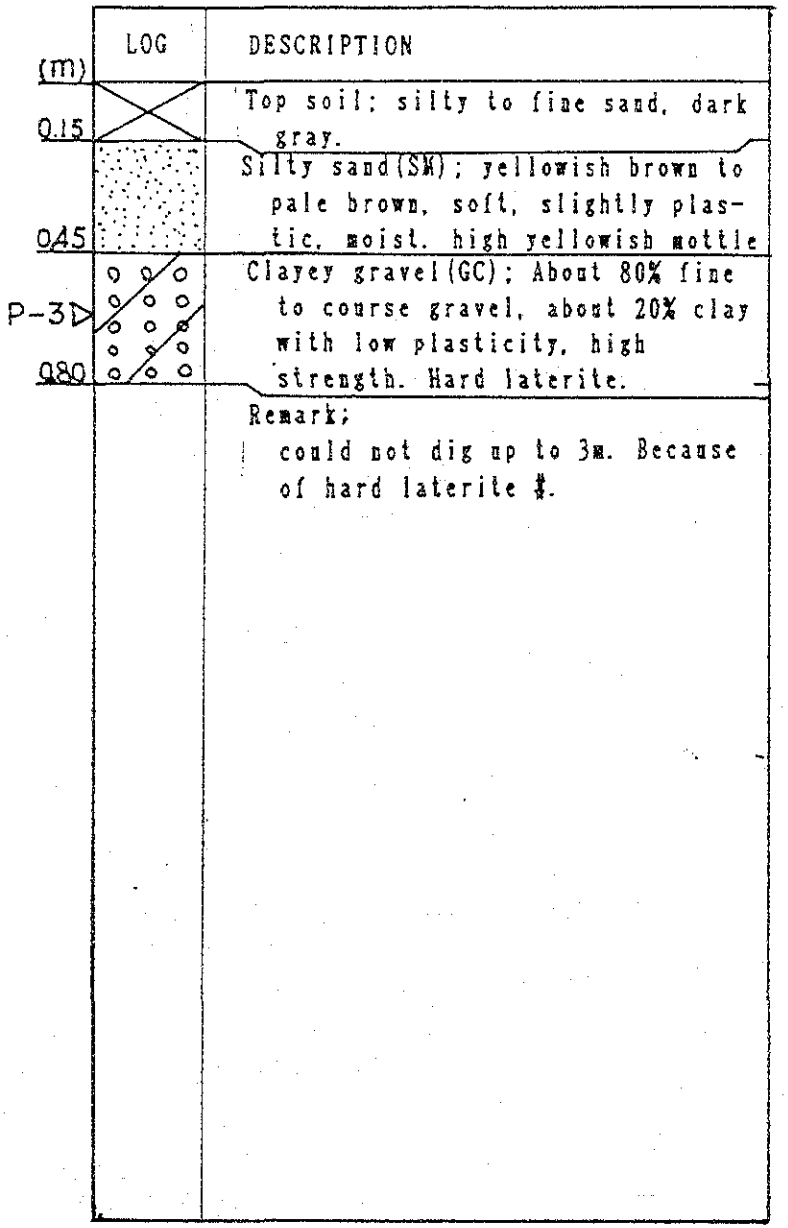
D-25 HUAI ARI
P-1



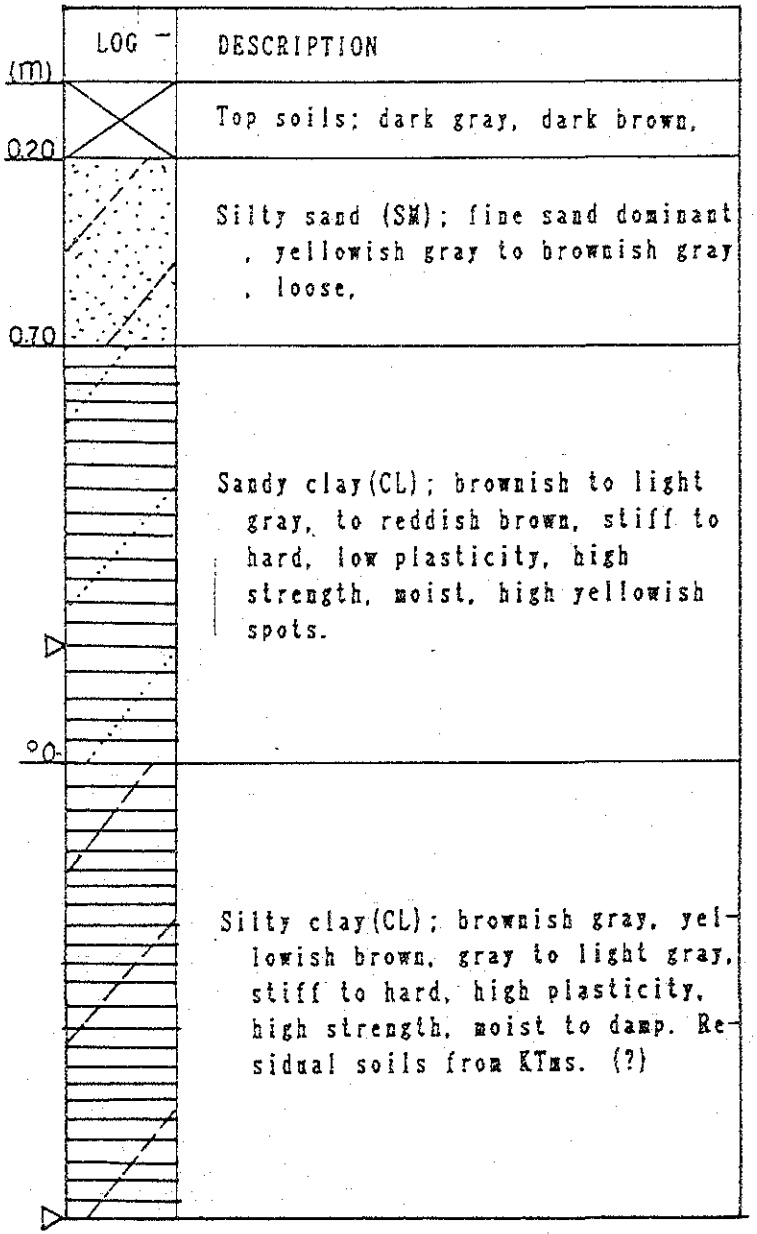
D-25 HUAI ARI
P-2



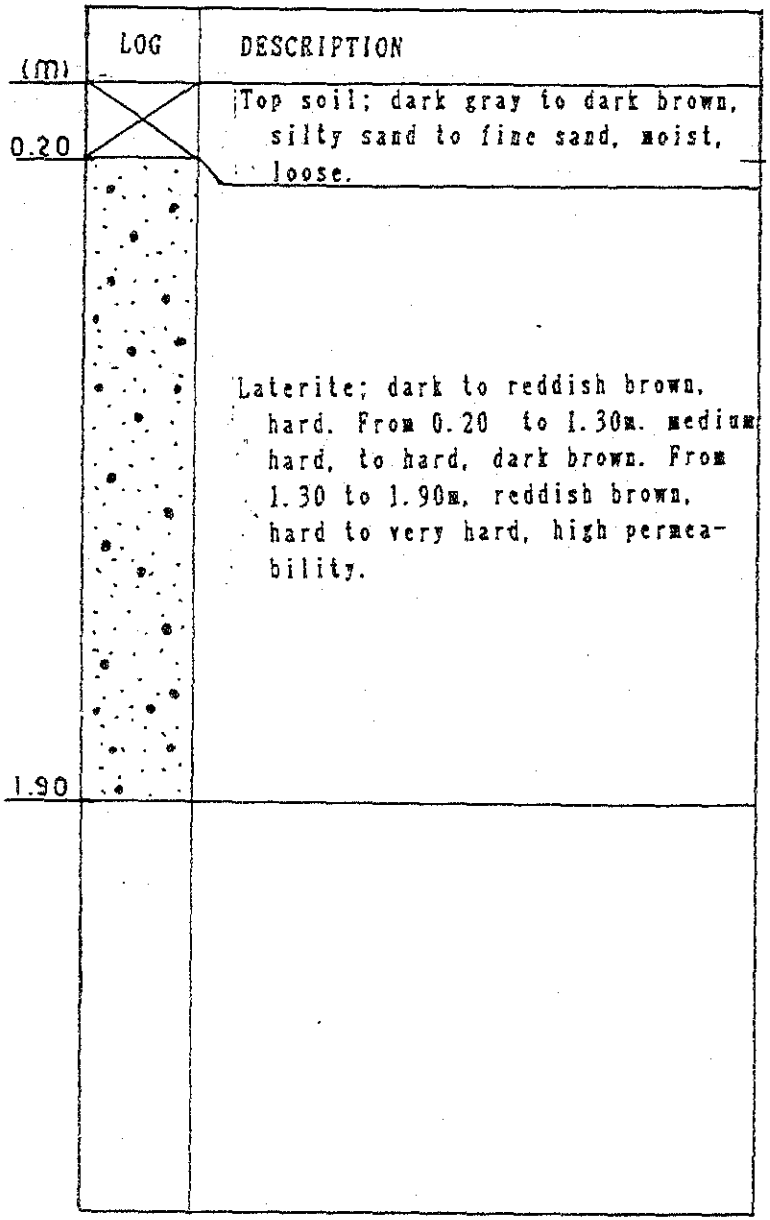
D-25 HUAI ARI
P-3



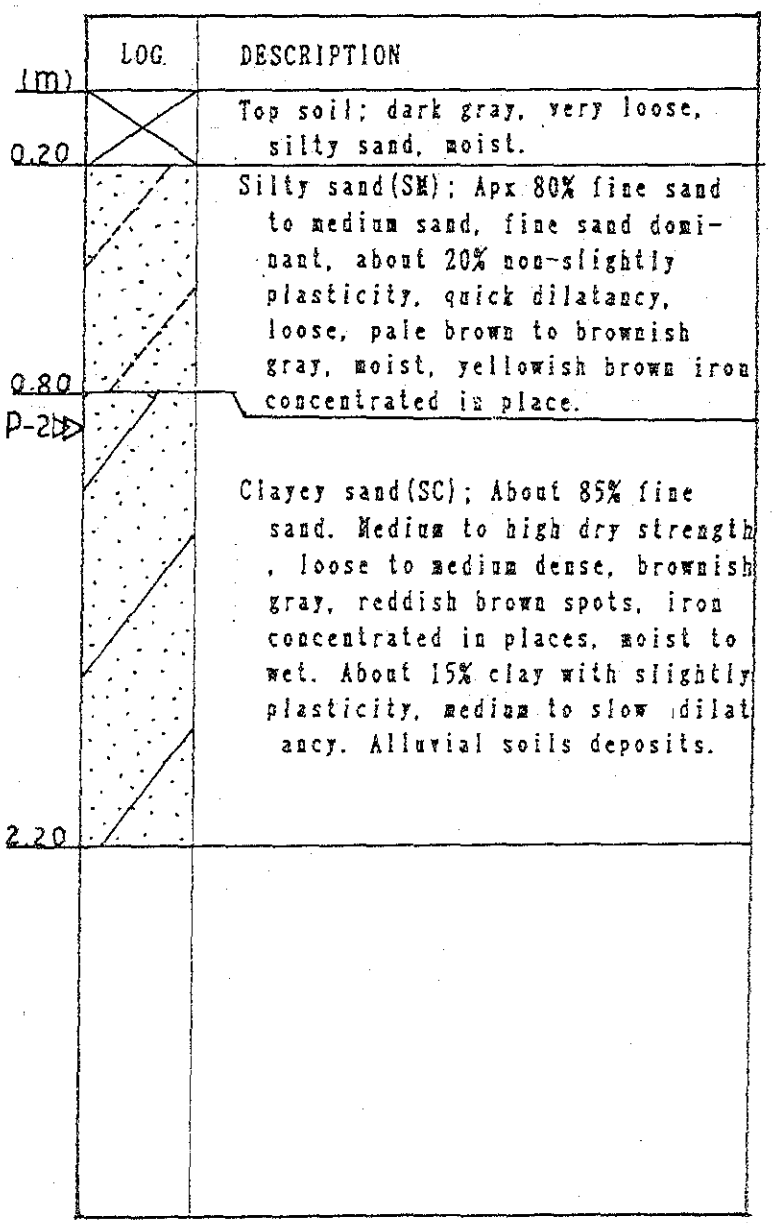
D-25 HUAI ARI
P-4



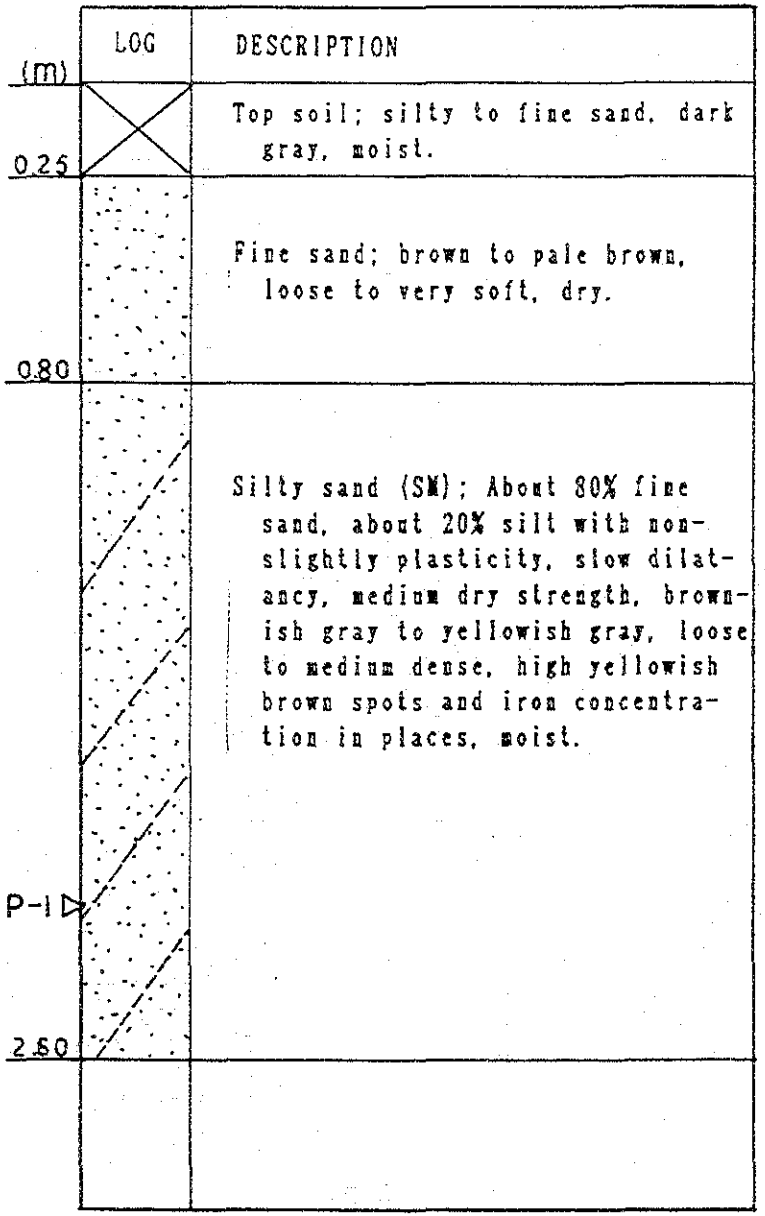
D-29 HUAI FANG DEANG
P-1



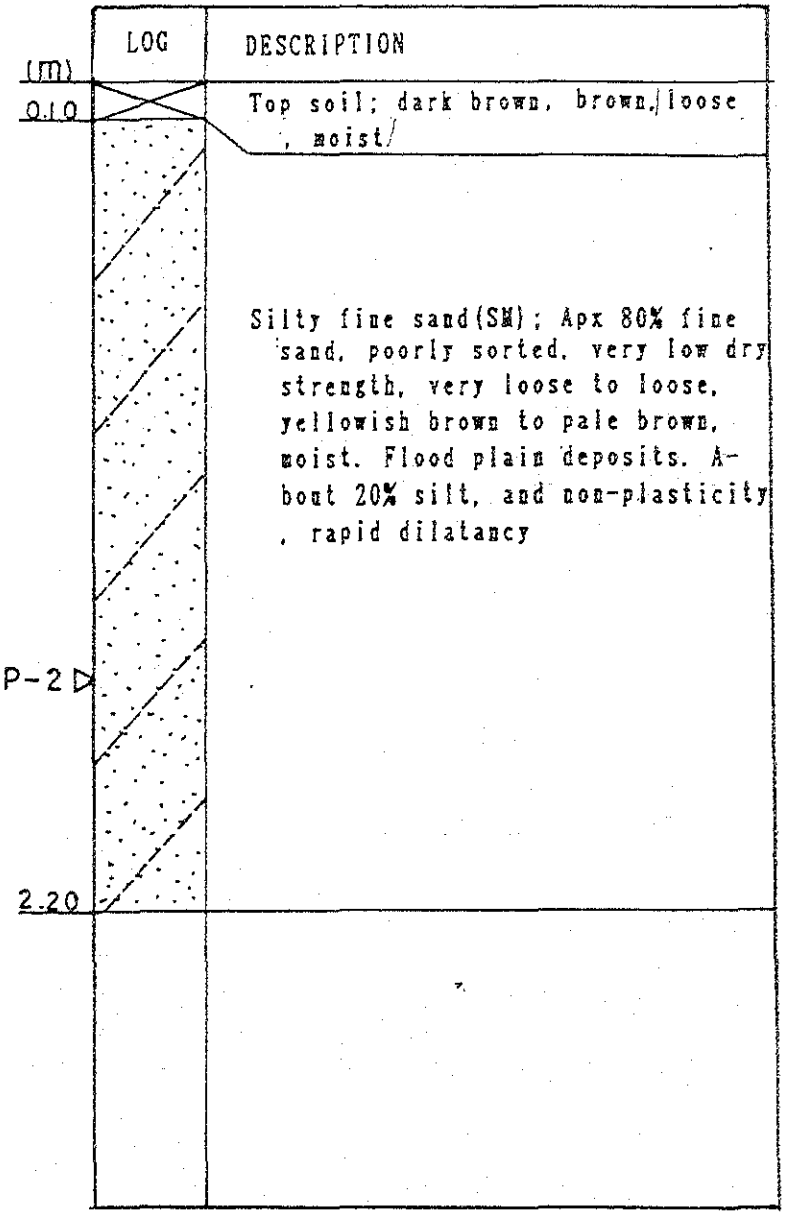
D-29 HUAI FANG DEANG
P-2



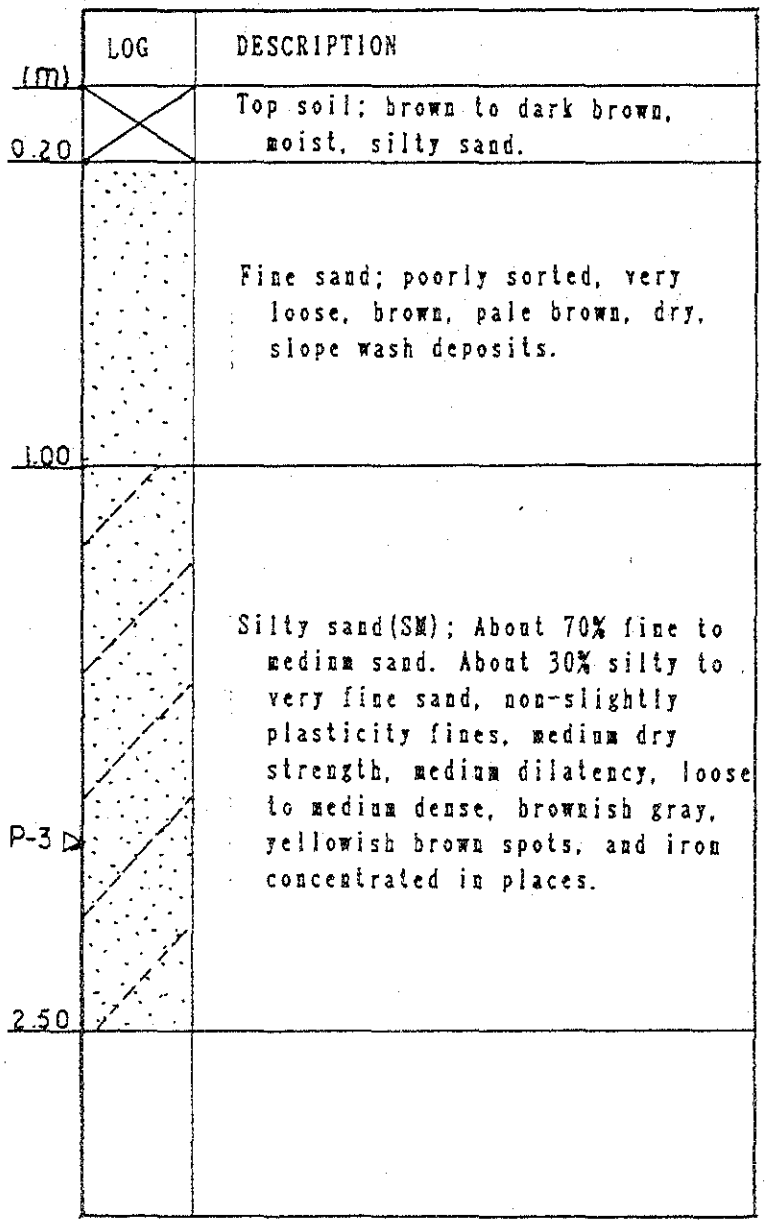
J-7 HUAI BON
P-1



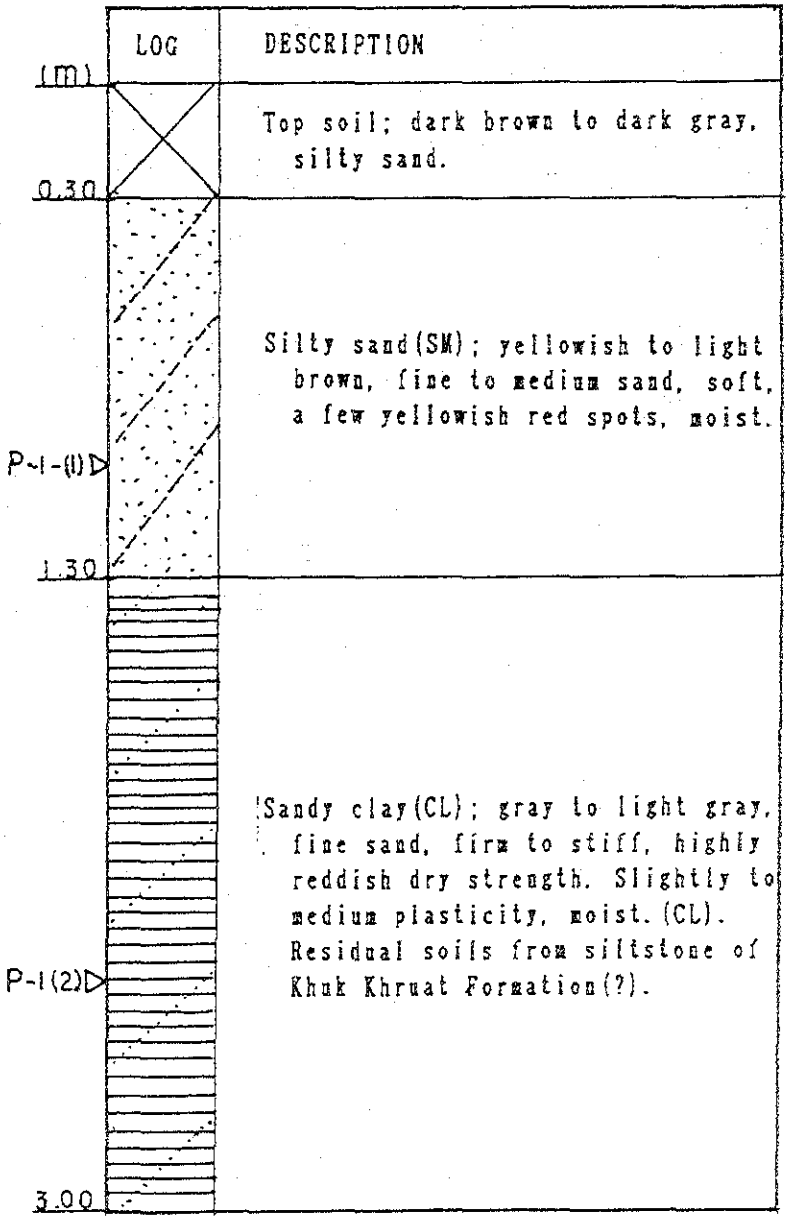
J-7 HUAI BON
P-2



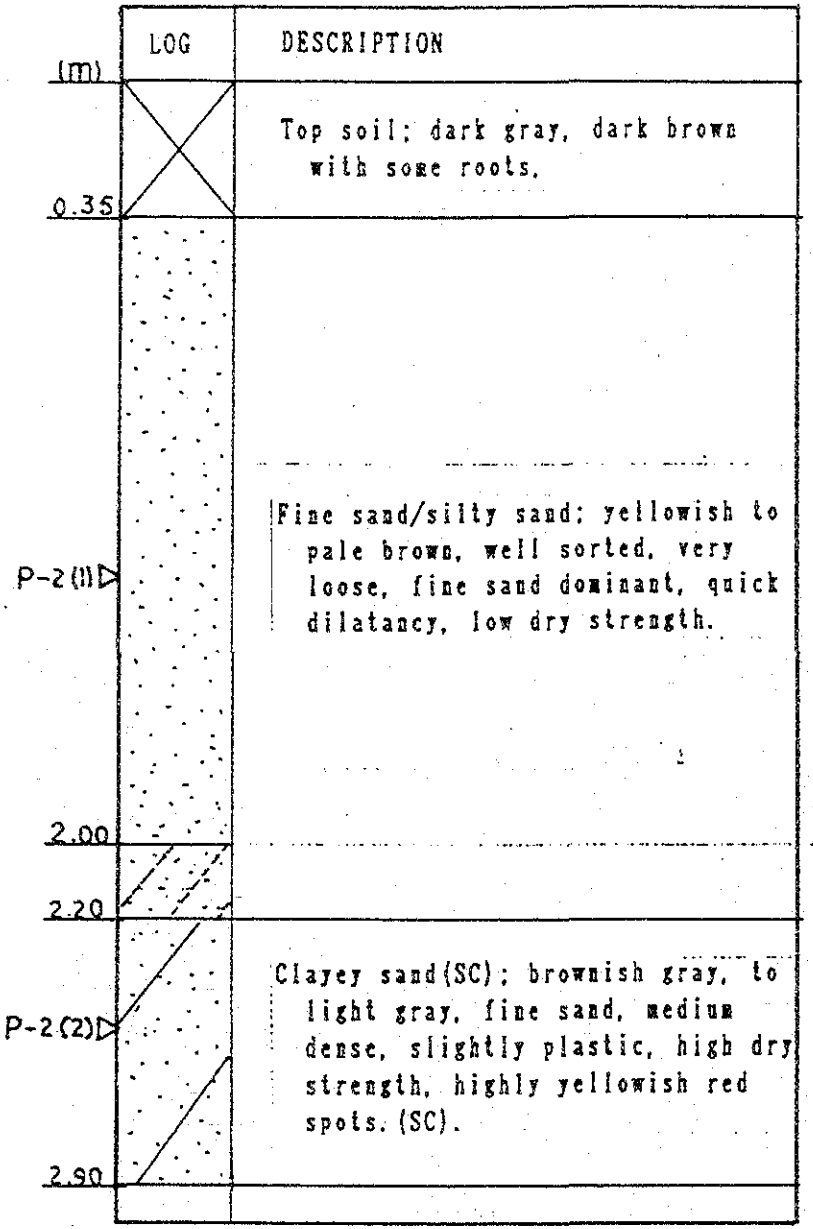
J-7 HUAI BON
P-3



D-28 LAM DOM YAI
P-1



D-28 LAM DOM YAI(CL)
P-2



D-28 LAM DOM YAI
P-3

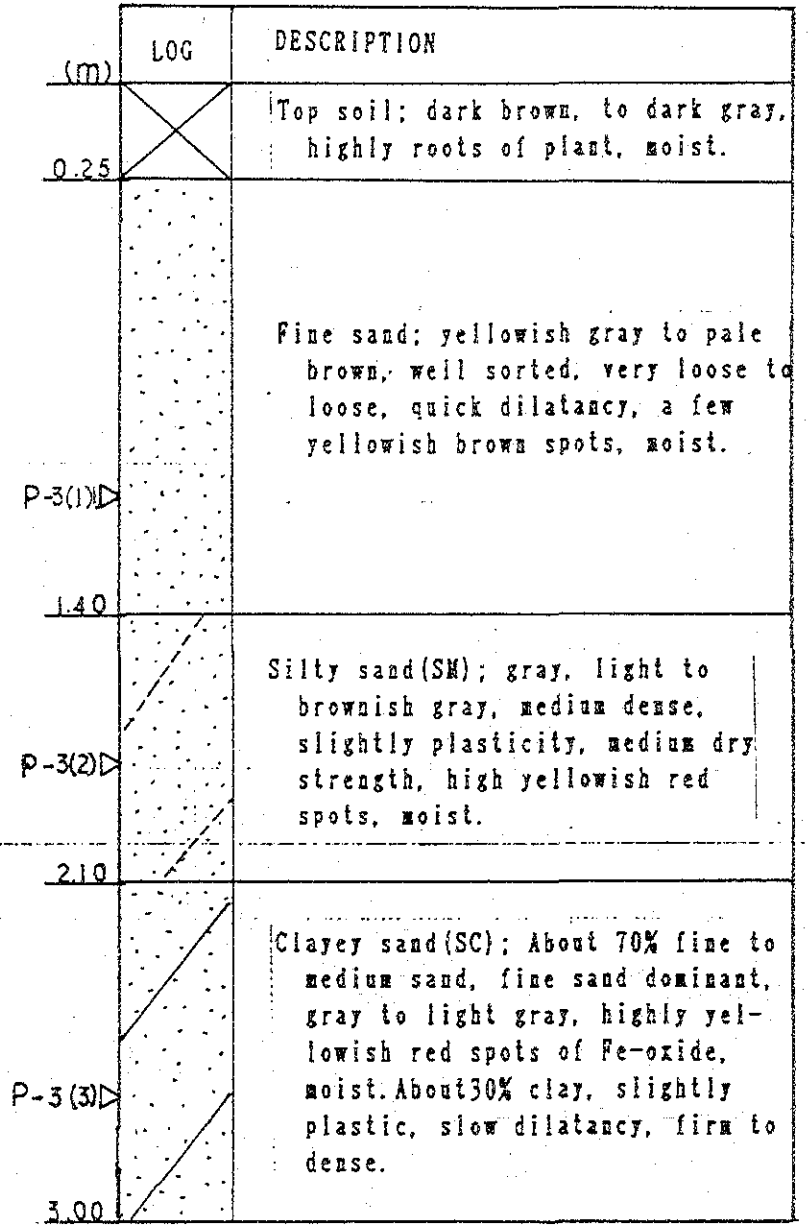
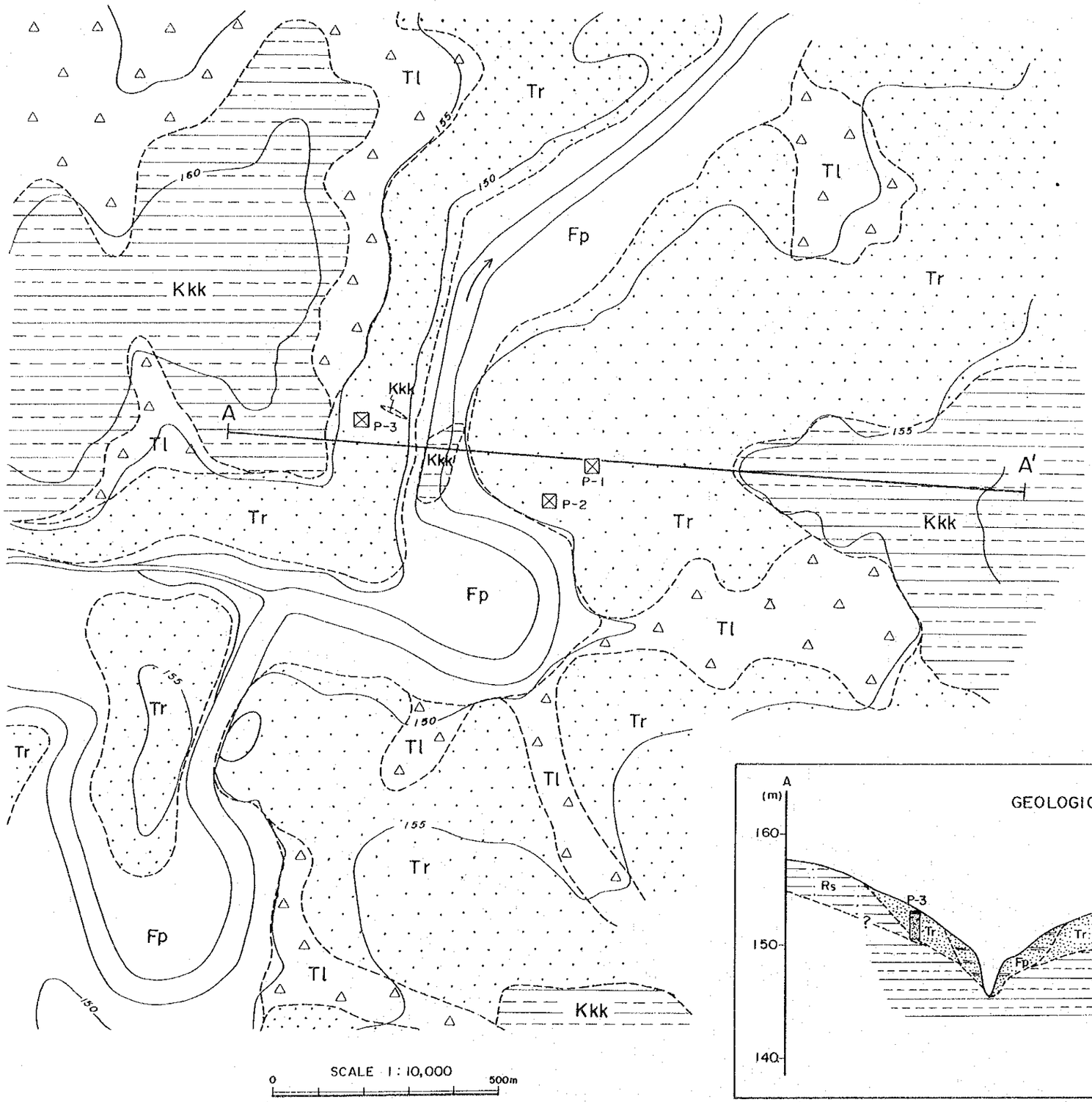


FIGURE D-4 GEOLOGICAL MAP (D-23, LAM DOM YAI (M))



LEGEND

Flood Plane Deposits	Fp	Sand,silt&clay
Talus Deposits	Tl	Sand,silt&clay
Terrace Dpeosits	Tr	Sand
Residual Soils	Rs	Sand & silt
Khok kruat Formation	Kkk	Siltstone & sandstone
	------	Geological boundary
	P-1	Test pit
	A — A'	Geological cross section line

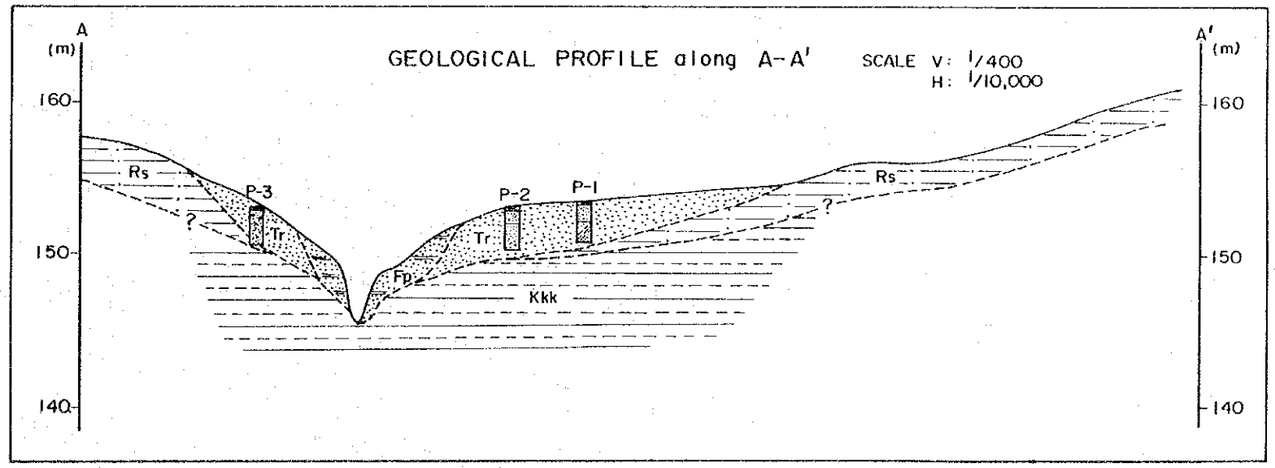
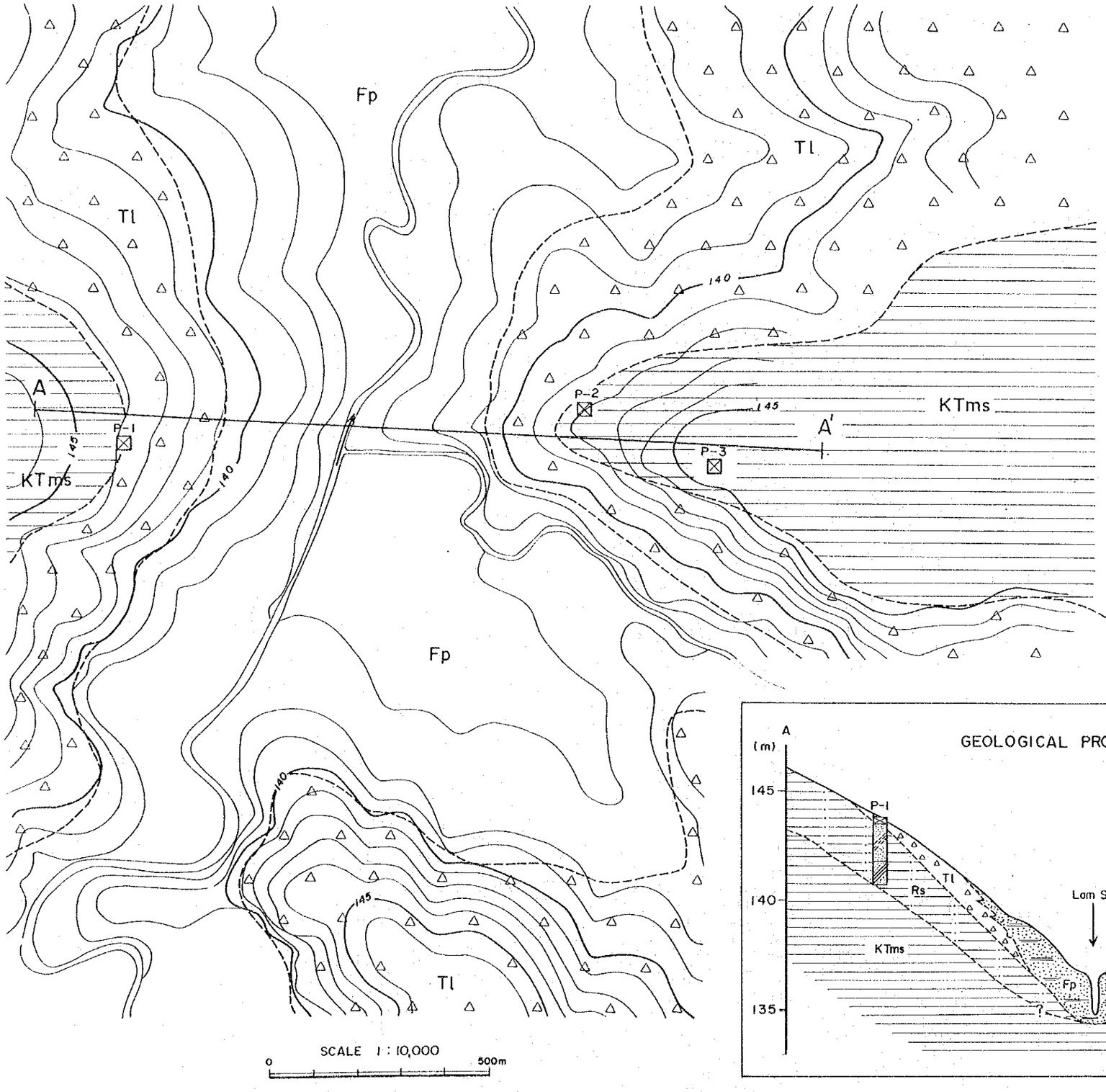
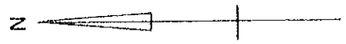


FIGURE **D-5** GEOLOGICAL MAP (D-24, LAM SOM)





LEGEND

Flood Plane Deposits	Fp	Sand, silt & clay
Talus Deposits	Tl	Sand, silt & clay
Residual Soils	Lt	Laterite
	Rs	Sand & silt
Khok Kruat Formation	Ktms	Siltstone & sandstone
	-------	Geological boundary
	P-1	Test pit
	A — A'	Geological cross section line

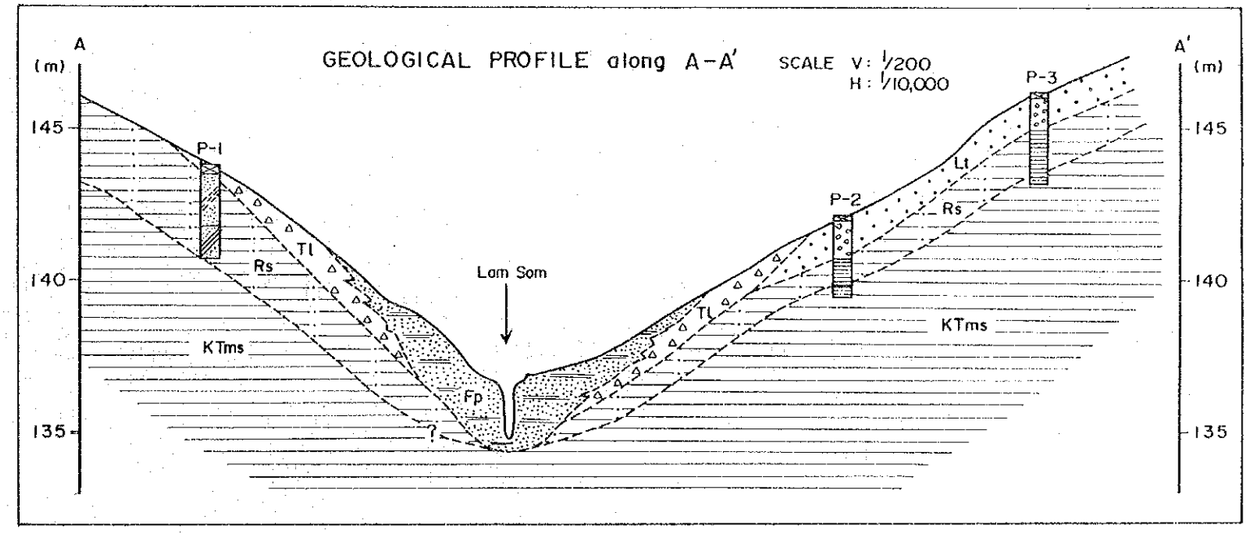
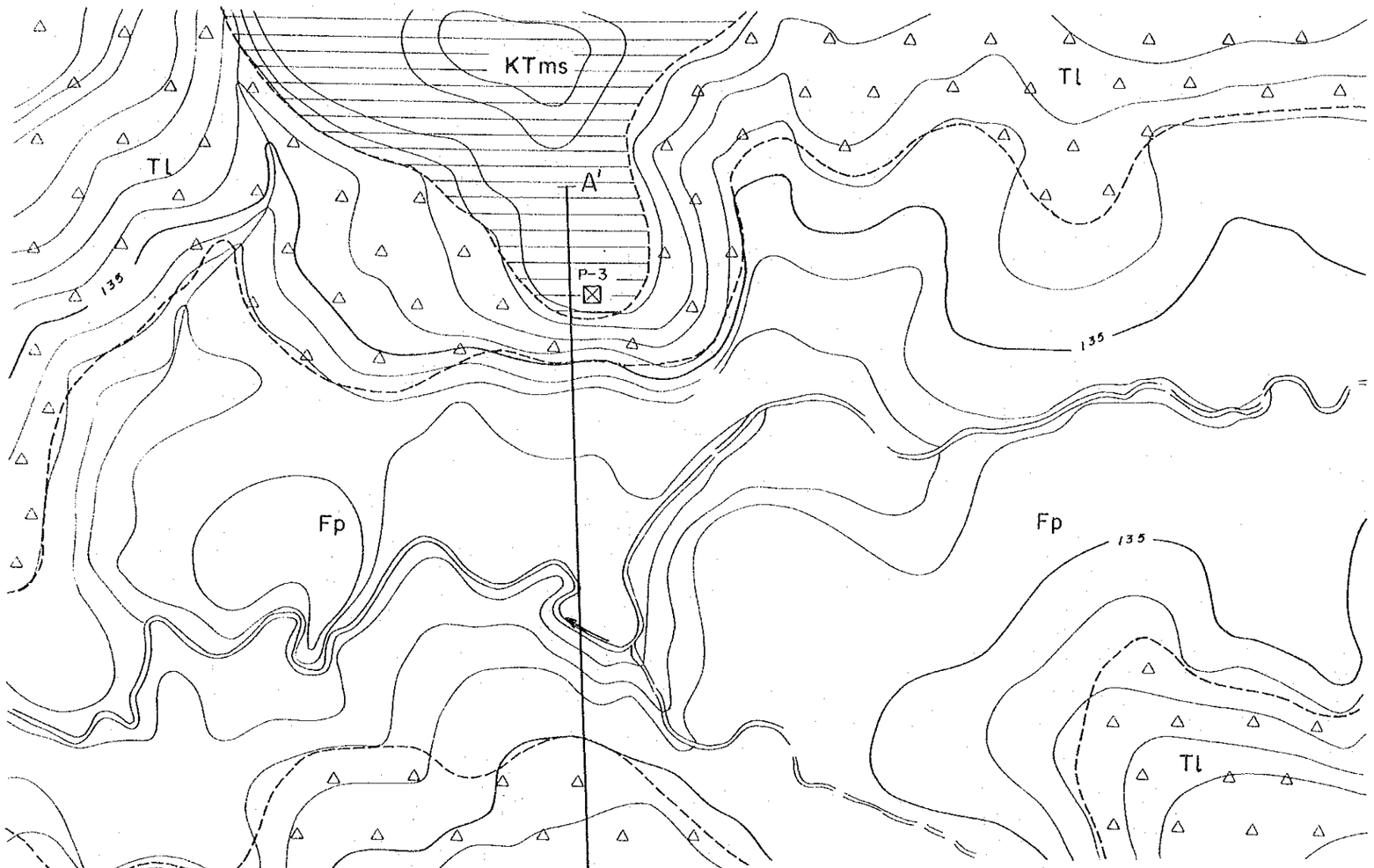
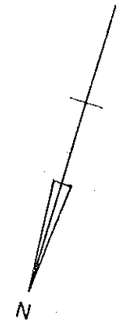


FIGURE **D-6** GEOLOGICAL MAP (D-25, HUAI ARI)





LEGEND

Flood Plane Deposits	Fp	Sand, silt & clay
Talus Deposits	Tl	Sand, silt & clay
Residual Soils	Lt	Laterite
	Rs	Residual soils
Maha-Sarakham Formation	Ktms	Siltstone & sandstone
	------	Geological boundary
	P-1	Test pit
	A — A'	Geological cross section line

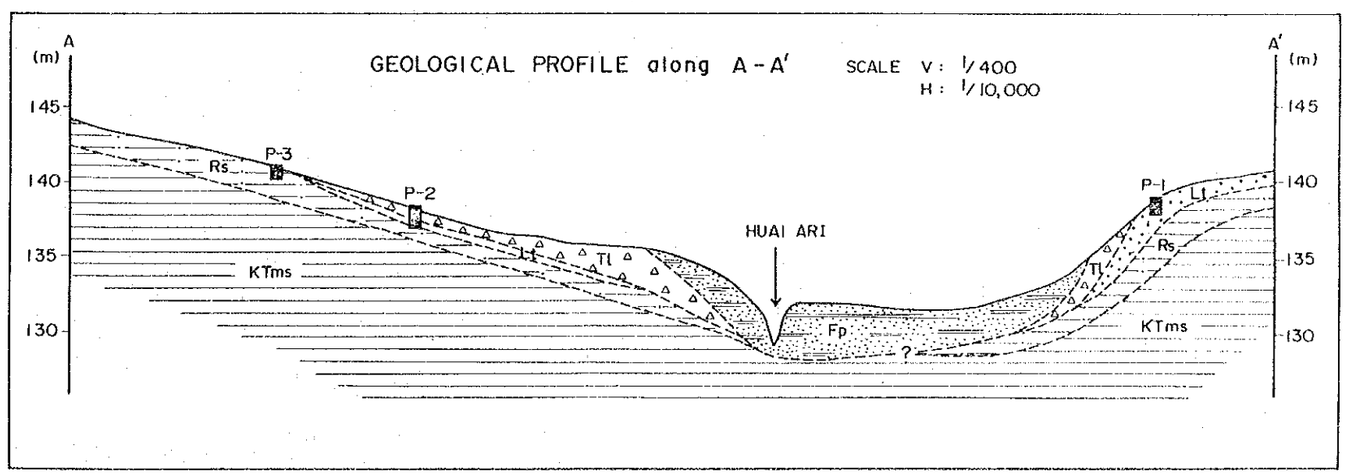
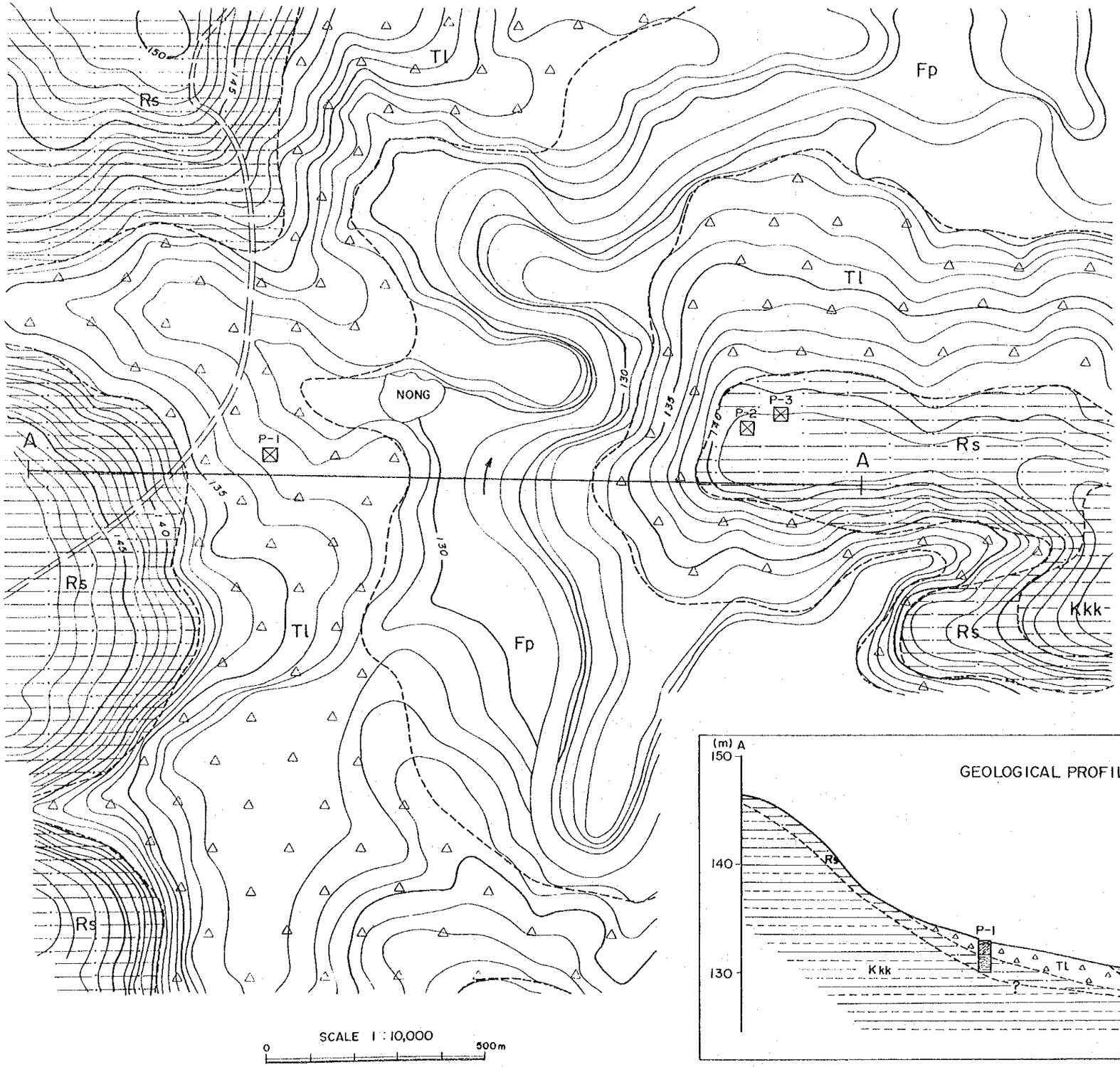


FIGURE D-7 GEOLOGICAL MAP (D-28, LAM YAI (L))



LEGEND

Flood Plane Deposits	Fp	Sand, silt & clay
Talus Deposits	Tl	Sand, silt & clay
Residual Soils	Lt	Laterite
	Rs	sand & silt
Khok Kruat Formation	Kkk	Siltstone & sandstone
	------	Geological boundary
	P-1 ⊠	Test pit
	A — A'	Geological cross section line

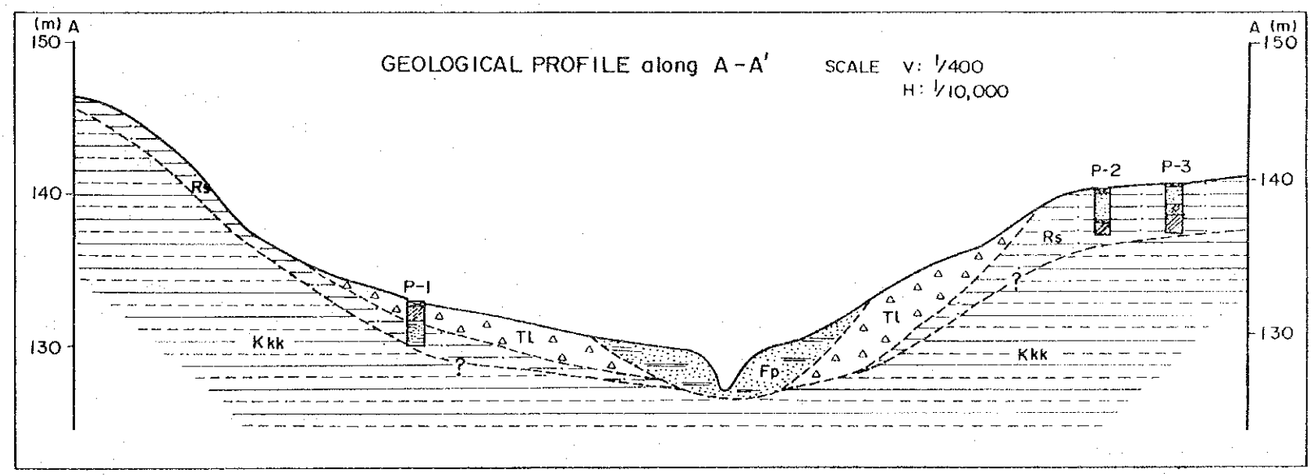
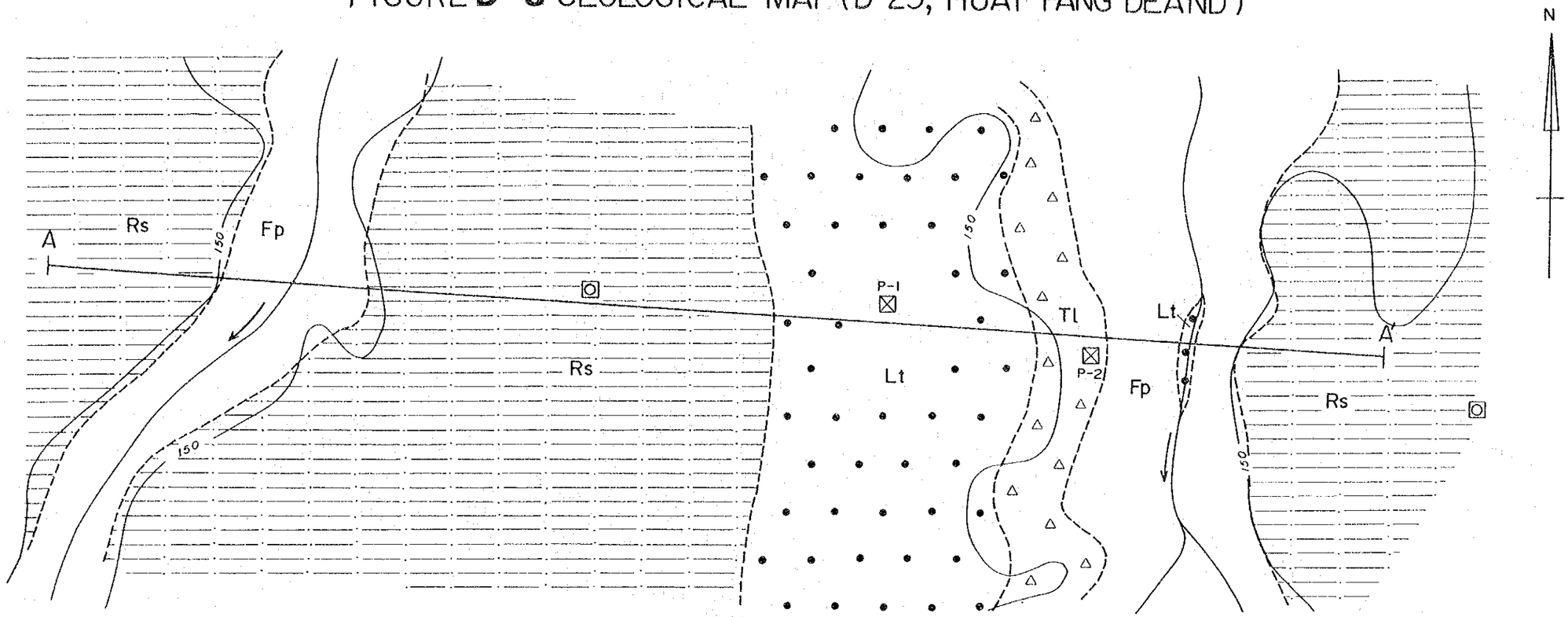
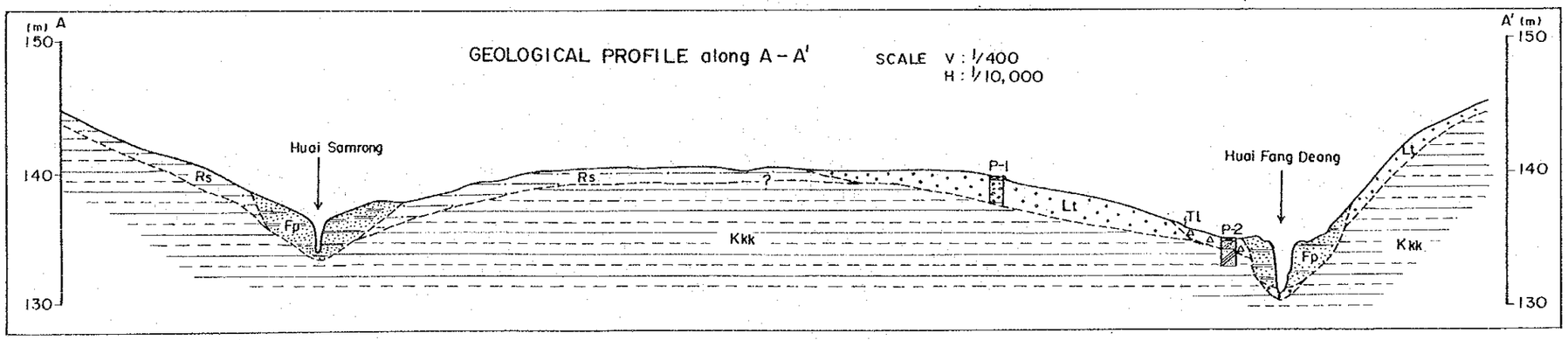


FIGURE D-8 GEOLOGICAL MAP (D-29, HUAI FANG DEAND)





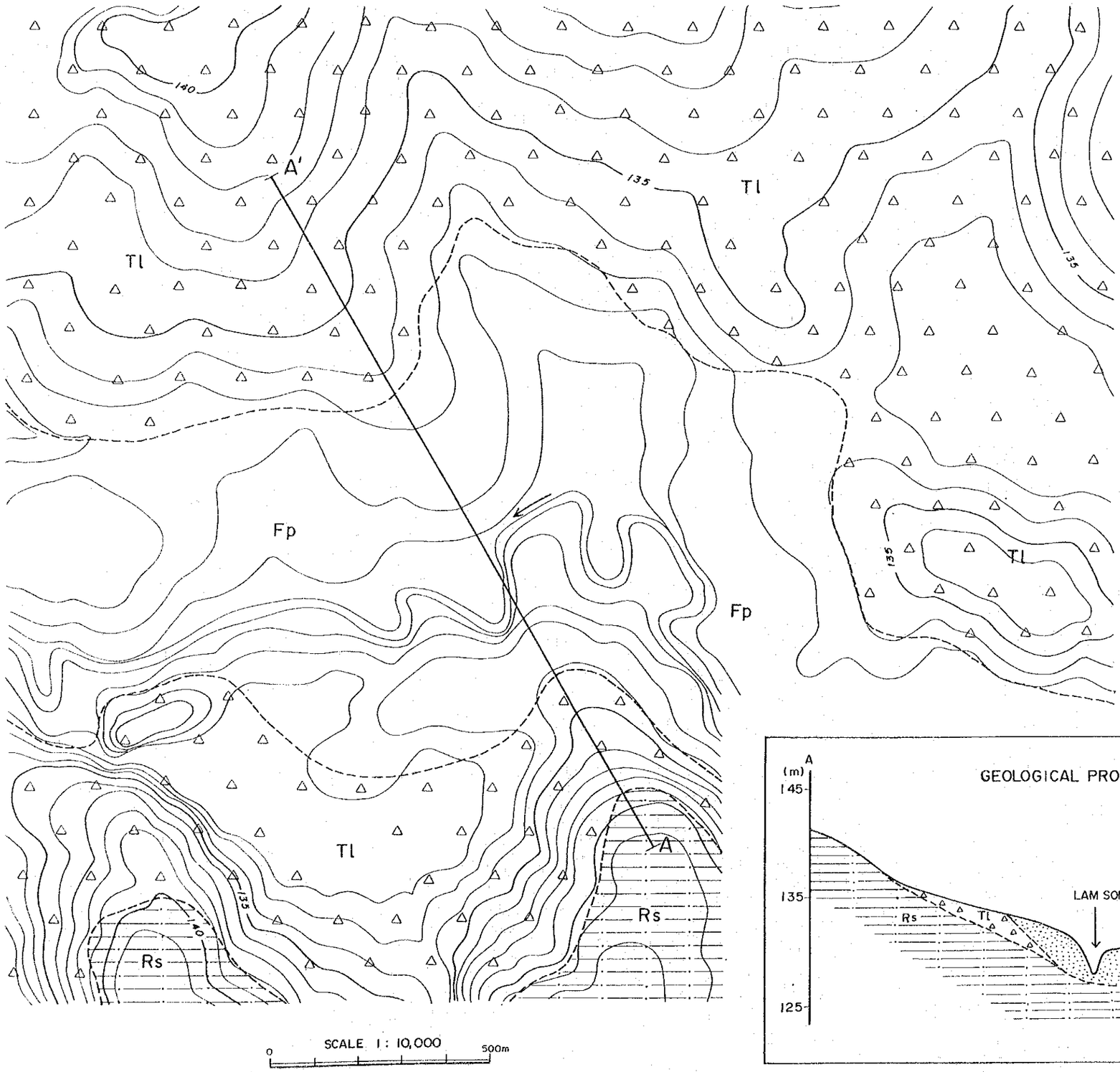
LEGEND

Flood Plane Deposits	Fp	Sand, silt & clay	Khok Kruat Formation	Kkk	Siltstone & sandstone
Talus Deposits	Tl	Sand, silt & clay		------	Geological boundary
Residual Soils	Lt	Laterite		P-1	Test pit
	Rs	Sand & silt			Dug well
				A — A'	Geological cross section line

SCALE 1 : 10,000

0 — 500m

FIGURE D-9 GEOLOGICAL MAP (J-I, LAM SOM)



LEGEND

Flood Plane Deposits	Fp	Sand, silt & clay
Talus Deposits	Tl	Sand, silt & clay
Residual Soils	Rs	sand & silt
	------	Geological boundary
	A — A	Geological cross section line

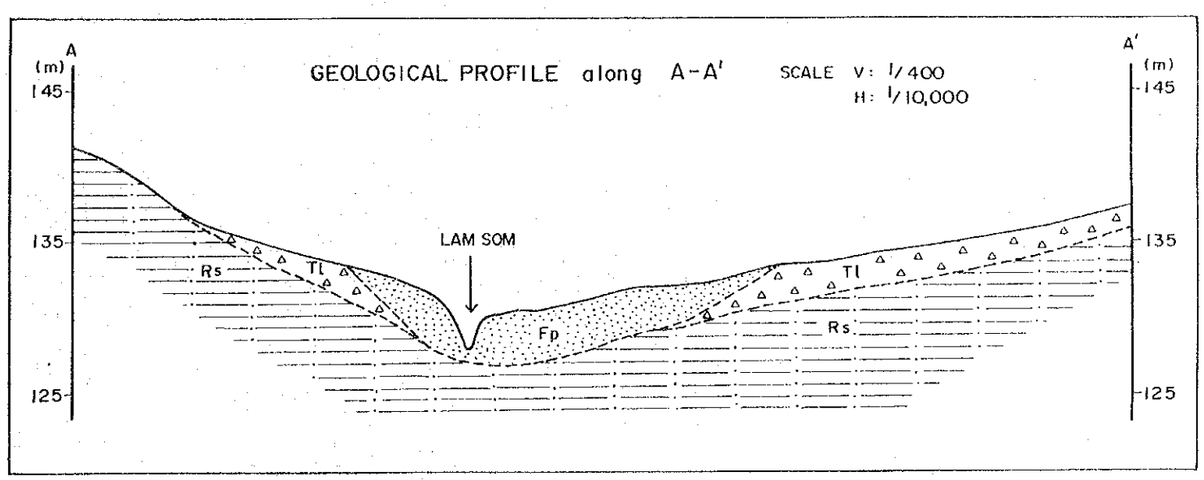
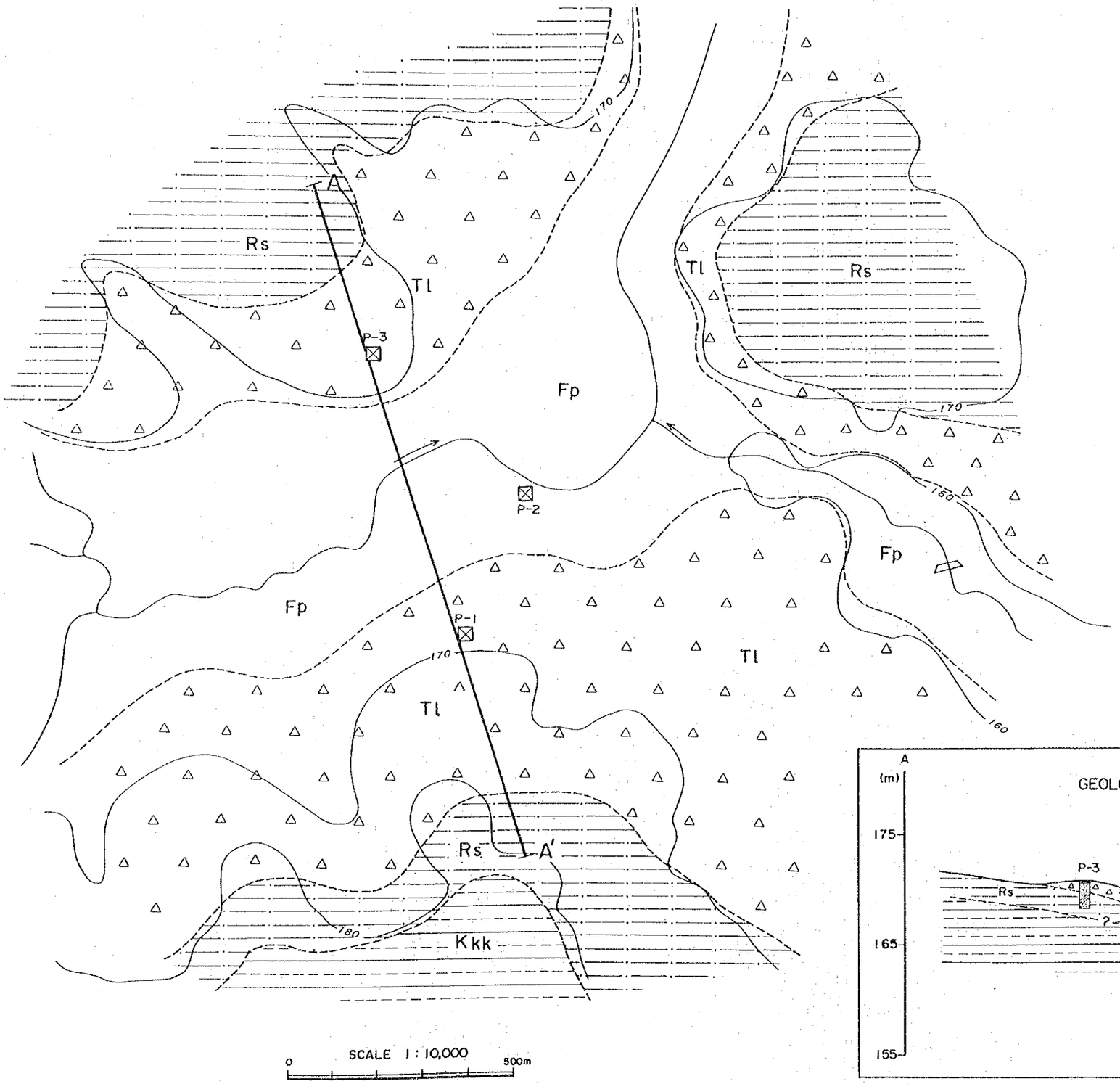
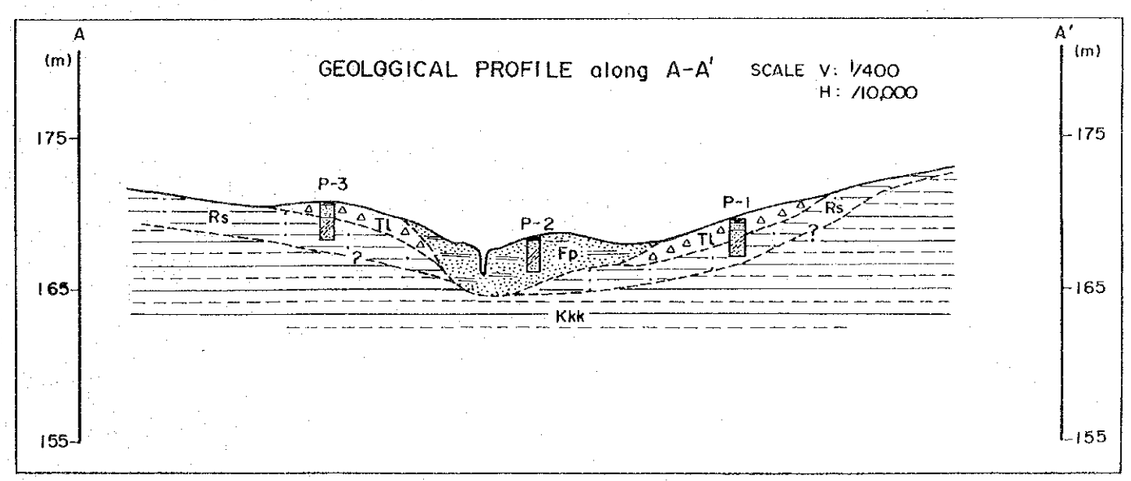


FIGURE D-10 GEOLOGICAL MAP (J-7, HUAI BON)



LEGEND

Flood Plane Deposits	Fp	Sand, silt & clay
Talus Deposits	Tl	Sand, silt & clay
Residual Soils	Rs	sand & silt
Khok kruat Formation	Kkk	Siltstone & sandstone
	------	Geological boundary
	P-1	Test pit
	A — A'	Geological cross section line



PART-II (FEASIBILITY STUDY)

CHAPTER IV. FIELD SURVEY

The dam axis was decided on the basis of the field survey under the consideration of following three factors, that is, i) the site with narrowest river width, ii) abutment in the highest elevation and iii) most favorable topography for the situation of spillway. Core drilling on the dam axis and survey for embankment material were performed by the Geological Investigation Branch of RID.

Nine holes on the dam axis and two holes on the service spillway were drilled during the period from November 1991 to January 1992. The result of the survey is shown in Figure D-11, Geological Map, Figure D-12, Geological Profile (A-A'), Figure D-13 Geological Profile (B-B') and Figure D-14 Lugeon Map.

36 auger holes and 18 test pits were conducted on the hilltop of the right bank and flood plane of the Lam Dom Yai. The description of auger holes and test pits are shown in Figure D-16, and the result of soil laboratory test is shown in Figure D-19 and Table D-4 to D-6.

CHAPTER V. GENERAL GEOLOGY

5. 1 TOPOGRAPHY

The selected dam-site is located in the halfway up of the Lam Dom Yai, which meanders back and forth near the dam site. The river has formed wide flood plane reaching about 600 m near the dam axis, and old river courses and natural levees are recognized from topographic maps and aero-photograph interpretation. Dammed lakes are present on the old river courses and back marshes, and the water of the lakes is utilizing for irrigation. The flood plane is heavily covered by fertile soil and widely cultivated. The area is mostly flat, that is, the gradient is about 1/600 and the elevation ranges in height from 130 to 133 m above the mean sea level (mamsl).

Rolling hills are present at the both sides of the flood plane, and they have gentle slopes and flat hilltops. The gradient of the slopes is 1/28 at the right abutment and 1/15 at the left abutment.

Talus and river terrace are present on a small scale at the feet of the rolling hills. It seems that a thin bed of terrace deposit is distributed on the hilltop of the right bank, because gravel excavated from a pond is observed near the service spillway.

6.2 Geology

As shown in Figure D-11 and D-12, the investigated area consists of bedrock, residual soil, terrace deposit, talus deposit and flood plane deposit.

No bedrock crops out in the area, and its lithological character is observable only from boring cores. The bedrock is a member of the Khok Kruat Formation (Kk) of Cretaceous age, and the general strike and dip is inferred to be N30°W to N40°E, 5° to 15°NW from existing data and the field reconnaissance so far made. The bedrock consists of fine to coarse grained sandstone, siltstone, thin beds of conglomerate and alternations of them. The bedrock underlies residual soil in rolling hill and flood plane deposit in flood plane.

Residual soil, which consists of weathering material of the bedrock, is distributed widely in rolling hills and overlies the bedrock. The soil composed of sand, silt and clay is less fertile, more sandy and less contributive to rice cultivation. The thickness is less than eight meters.

River terrace deposit, which is restricted in the distribution, consists of sand and gravel and is less than two meters thick.

Flood plane deposit, which has been transported by the Lam Dom Yai, is widely distributed along the recent river course. The deposit consists mostly of loose sandy soil and less 10 m thick.

Talus deposit overlies residual soil at the feet of rolling hill, and is presumably less than two meters thick. The deposit is formed mainly of loose sand, silt and clay.

10 bore holes were drilled on the dam axis, and Standard Penetration Test and Permeability Test were performed in each hole.

6. 1 Standard Penetration Test (SPT)

SPT was performed for unconsolidated deposit in each borehole using split-spoon sampler tube. N value is shown in Figure D-12.

Residual soil (Rs) consists of silty to clayey sand and silty clay including gravel. It ranges in thickness from three to seven meters, and ranges in N value from 4 to more than 50, but less than 10 within 5 meters deep.

Flood plane deposit (Fp) consists of very loose to dense sand and silty sand and 9.3 m thick in the middle of the flood plane. It ranges in N value from 2 to more than 50, but less than 20 in most points.

According to the criteria[1/], the ground whose N value is less than 20 is called "Soft Ground", and adequate foundation treatment is required to prevent sliding failure and remarkable deformation. N value of the two layers mentioned above is less than 20 in most depth, and adequate treatment such as elimination of soil by excavation is required. On the contrary, bedrock which underlies the two layers and consists of sandstone and siltstone, has sufficient bearing capacity for a fill type dam.

6. 2 Permeability Test

Permeability test for unconsolidated layer, such as residual soil and flood plane deposit, was performed on the basis of EARTH MANUAL DESIGNATION E-18, OPEN END METHOD, by United States Bureau of

1/ : Agricultural Land Improvement Project Planning and Design Criteria - Design Dam - ; Ministry of agriculture and Fisheries, Japan

Reclamation (USBR). The formula calculated coefficient of permeability (k) is as follows;

$$k = \frac{Q}{5.5rH}$$

k : Coefficient of permeability (cm/sec)
Q : Steady seepage flow into borehole (cm^3/sec)
r : Casing internal radius (Nx size = 3.81 cm)
H : Head of water (cm)

Lugeon test by single packer method was conducted for bedrock, and permeability (Lugeon value) was calculated by following formula;

$$Lu = \frac{10Q}{LH}$$

Lu : Permeability (Lugeon)
Q : total flow (liter/min)
L : Testing length (m)
H : Head of water (kg/cm^2)

When borehole diameter is 76 mm, the correlation between Lugeon value (Lu) and Coefficient of Permeability (k) is as follows;

$$1\ Lu = 1.16 \times 10^{-5}\ (cm/sec)$$

The result of the permeability test is shown in Figure D-14 LUGEON MAP. The map shows that coefficient of permeability of residual soil (Rs) is mostly less than 1×10^{-5} cm/sec which indicates impervious layer.

The permeability of flood plane deposit (Fp), however, ranges in k value from 1.5×10^{-2} to more than 1.0×10^{-5} cm/sec. The value indicates that the soil is pervious and will occur seepage flow. Particular attentions should be paid for the loose and permeable soil layer. According to the auger drilling, subsurface of the flood plane of the upper stream also consists mainly of sand and silty sand as shown in Figure 6-3, therefore, natural blanket for the dam foundation is not expected.

Bedrock consists of sandstone and siltstone intercalated by conglomerate, and has many open cracks. Therefore, the bedrock shows

high permeability, that is, ranging in Lugeon value from 0.5 to 216.7 as show in Figure D-14. Upper part of the rock is highly to moderately weathered, and belongs D to CL class in the rock classification (see CHAPTER VI. 6.4). Consolidation grouting will be required to consolidate the upper part, and curtain grouting to prevent seepage flow from the deeper part.

6. 3 Rock Quality Designation (RQD)

The bedrock is a member of the Khok Kruat formation (Kk) and consists of sandstone and siltstone intercalated by conglomerate. Drilling cores are completely to moderately weathered and easily broken by soft hammering. Some cores are dissolved by drilling water, specially thin siltstone bed in sandstone. The upper part of the rock has been changed to soil including angular gravel by extreme weathering.

Rock Quality Designation (RQD) shows condition of fissures besides core recovery, therefore, it is one of the indications of rock property as shown in following table;

RQD AND ROCK QUALITY

RQD (%)	Rock Quality
0 - 25	very poor
25 - 50	poor
50 - 75	fair
75 - 90	good
90 - 100	excellent

As shown in Table D-4, 1/3 of RQD is less than 50% that means poor rock condition, and they are mostly distributed within 10 m deep. Consolidation grouting will be required in this part.

Table D-5 shows that there is no special correlation between RQD and Lugeon value, and most Lugeon value is distributed between 0 to 120, and only 3 points are near 200. Permeability depends on the looseness of fissures of bedrock, and the permeability of CL class are generally higher than CM and CH class. However, as shown in Table D-5, the permeability of low RQD, that is CL class, is same with high RQD, because loosened fissures are filled by weathered

materials. In high RQD that means C_M or C_H class, the fissures are still fresh and opened, and have high permeability. Curtain grouting will be required in deep and pervious zone.

6.4 Rock Classification

Table D-6 shows the Rock classification by the observation of boring core by KIKUCHI et al. The result of the classification by boring core is shown in Figure D-11, and it reveals that boring cores are in the class of C and D.

CHAPTER VII. GEOLOGY OF SERVICE SPILLWAY

As shown in Figure D-13, the spillway axis consists of bedrock, residual soil, talus deposit and flood plane deposit. Assumed top of rock ranges in depth from 3 to 9.4 meters and coefficient of permeability is less than 1×10^{-5} cm/sec. The groundwater table ranges in depth 1.0 to 2.7 meters.

CHAPTER VIII. FOUNDATION TREATMENT

As mentioned in CHAPTER VI. DAMSITE GEOLOGY, the dam foundation is composed mostly of loose and pervious unconsolidated sediments and pervious bedrock.

The Soft Ground of the dam foundation ranges in depth from 6 to 8 meters in the flood plane deposits and 2 to 5 meters in the residual soils.

Typical foundation treatment methods considered for the soft ground are i) replacement, ii) rapid consolidation, iii) counter weight fill and iv) embankment control, and the applicability of each method will be examined in the dam design.

Foundation treatment for seepage flow will be required, and safety for the seepage failure is generally estimated by stability analysis. However, there is a high possibility of seepage failure in the case of that coefficient of permeability exceeds 1×10^{-4} cm/sec. When soil is composed of loose fine sand or silt and permeability is more than 1×10^{-4} cm/sec, soil particles are moved by seepage flow and finally seepage failure will occur in general. The residual soil has low permeability, but in flood plane deposit, the coefficient of permeability exceeds mostly 1.0×10^{-4} cm/sec. Foundation treatment is required for the high permeable zone of the deposit. Typical foundation treatment methods considered for pervious and unconsolidated layers are i) elimination and backfilling, ii) general pavement of pervious layer, iii) blanket and toe drain or iv) counter fill.

The permeability of the bedrock ranges in Lugeon value from 2.1 to 216.7, and their distributions are shown in Figure D-14 Lugeon Map. Typical foundation treatment methods to prevent seepage flow are i) elimination of high pervious zone, ii) grouting and iii) blanket method.

It seems that grouting is most suitable for the bedrock. Recommendable design of grouting is as follows:

- Curtain grouting
  - : Depth 1 = 10 m
  - : Pitch 2.0 m
  - : Line 2 lines (1.5 m in space)

CHAPTER IX. CONSTRUCTION MATERIALS

9. 1 Field Survey

9. 1. 1 Location of Borrow Area

It is considered that the borrow area for the embankment material should be located near the dam-site and to be easy to access even during the wet season. Residual soil on the right bank is inferred to be suitable for the material from the view point of geological features, observation of test pits and laboratory test according to the investigations so far made. The soil investigation including field reconnaissance, test pits and auger drilling were conducted for the hilltop at the right bank. The investigated area is shown in Figure D-15. The test pits and auger drilling were mainly located along the proposed service spillway and emergency spillway, in which big volume of cutting will be expected. Augerholes were also drilled on the flood plane for future references.

9. 1. 2 Soil Conditions of the Investigated Area

The investigated area consists of residual soils originated from bedrock composing mostly of sandstone and siltstone. As shown in Figure D-12, 13 and 16, the soil is three to five meters thick and consist of silty sand to silty clay. The soil along A-A' Line (service spillway) is mainly of silty clay (CL) and clayey silt (ML) and is suitable for core materials. The soil becomes gradually course to the northward, that is, B-B' Line; clayey sand (SC), C-C' Line; silty to clayey sand (SM-SC) and D-D' Line; silty sand (SM). The grounwater levels of each test pit and auger hole are 0.5 to 3.5 m deep, and some holes could not continue digging up to planned depth because of much water inflow.

The augerholes on the flood plane show that the soil nearby the recent river course consists mainly of sand and silty sand, and of fine materials on foot of hills. The fine materials will be suitable for core materials.

9. 2 Soil Laboratory Test

After the observation and description of the test pits and auger holes, soil sampling was conducted and selected 16 samples were delivered to the laboratory of RID. The numbers of delivered samples and test items are shown in Table D-7. The soil laboratory test was performed under the specification as shown in Table D-10. The test data were handed from RID to the Team at the end of January, 1992.

9. 3 Characteristics of Materials

9. 2. 1 Grading Curve

The samples taken from the test pits consist of silty to clayey and (SM-SC, SM and SC) and sandy to silty clay (CL-ML, CL and ML) as shown in Table D-8. The gradation curves of each sample are shown in Figure D-19, and the distribution of the grading is summarized in Figure D-18. The figure shows that maximum grain size is 20 mm and passing ratio of 0.074 mm (-200#) ranges in ratio from 28.0 to 82.5 percent. The soils are well graded and range in Uniformity Coefficient (UC) from 10 to 583. The figure also indicates that soils in the tested are consist of impermeable material and the dam of a homogeneous type or zone type with thick core as recommendable.

9. 3. 2 Water Contents and Plasticity

The samples range in Natural Water Contents (Wn) from 10.6 to 20.3 percent and almost Wn are lower than Plastic Limit (PL). The samples are in semi-solid state, and are on the wet side of the optimum water contents (Wopt) and on the dry side of W_{95} (water contents corresponding to 95 percent of dmax) with the exception of the sample from A-A' TP2. CL ranges in Plasticity Index (PI) from 8.4 to 22.0 percent, but other soils less than 10 percent which means that careful execution control of embankment is required. The soils range in rdmax from 1.7 to 2.0 cu.m.

9.3.3 Permeability

The permeability in the conditions of W_{95} is less than 1×10^{-7} cm/sec and the value is enough for impervious materials.

9.3.4 Deformation

Compression Index (Cc), which values is less than 0.15, indicates that the consolidation deformation of clayey materials is relatively small.

9.4 Conclusion

The summary of the soil test is shown in Table 6-1-1. The soil in the investigated area consists of silty and clayey sand, silt and clay, and well graded (UC 10 to 583). The ratio of 200# sieve passing is 20.0 to 82.5 percent, and the contents of gravel are zero to five percent. The soils range in Wn from 10.6 to 20.3 percent and are in semisolid state. Optimum water contents (Wopt) are 1 to 3 percent on the dry side of Wn, and γdmax ranges from 1.7 to 2.0 t/cu.m. Soils after cutting will be blocky from the view point of the condition mentioned above, therefore, it is required to use sheep's-foot roller on fill works to eliminate voids between blocks. Coefficient of permeability of $n \times 10^{-7}$ to 10^{-8} cm/sec indicates high protection for water seepage.

The data reveal that the soils in the investigated area are adequate impervious material for the dam embankment and have well construction conditions. However, the materials have the factors which must be considered in planning and constructing, that is; i) poor construction condition by the few contents of gravels (less 5 percent), ii) need to excavate drainage channels in the borrow area because of high water table, iii) need of careful execution control of water contents because of low PI and high contents of silt and clay, iv) need of careful design for potential of swelling after the impoundment because of high content of fine grained soils and v) selection of appropriate rolling compaction machine.

The residual soil is three to seven meters thick, but the thickness of appropriate for the embankment materials will be three meters in average.

The borrow area is suitable on the flat land setting B, C and D Line. The quantity of the materials is estimated as follows;

Area of B, C and D Line;

500 m × 500 m × 3.0 m = 750,000 cu.m

Cutting from Service Spillway (A Line);

600 m × 40 m × 4.0 m = 96,000 cu.m

Total (the quantity of natural ground);

= 846,000 cu.m

TABLE D-4 RQD vs. DEPTH

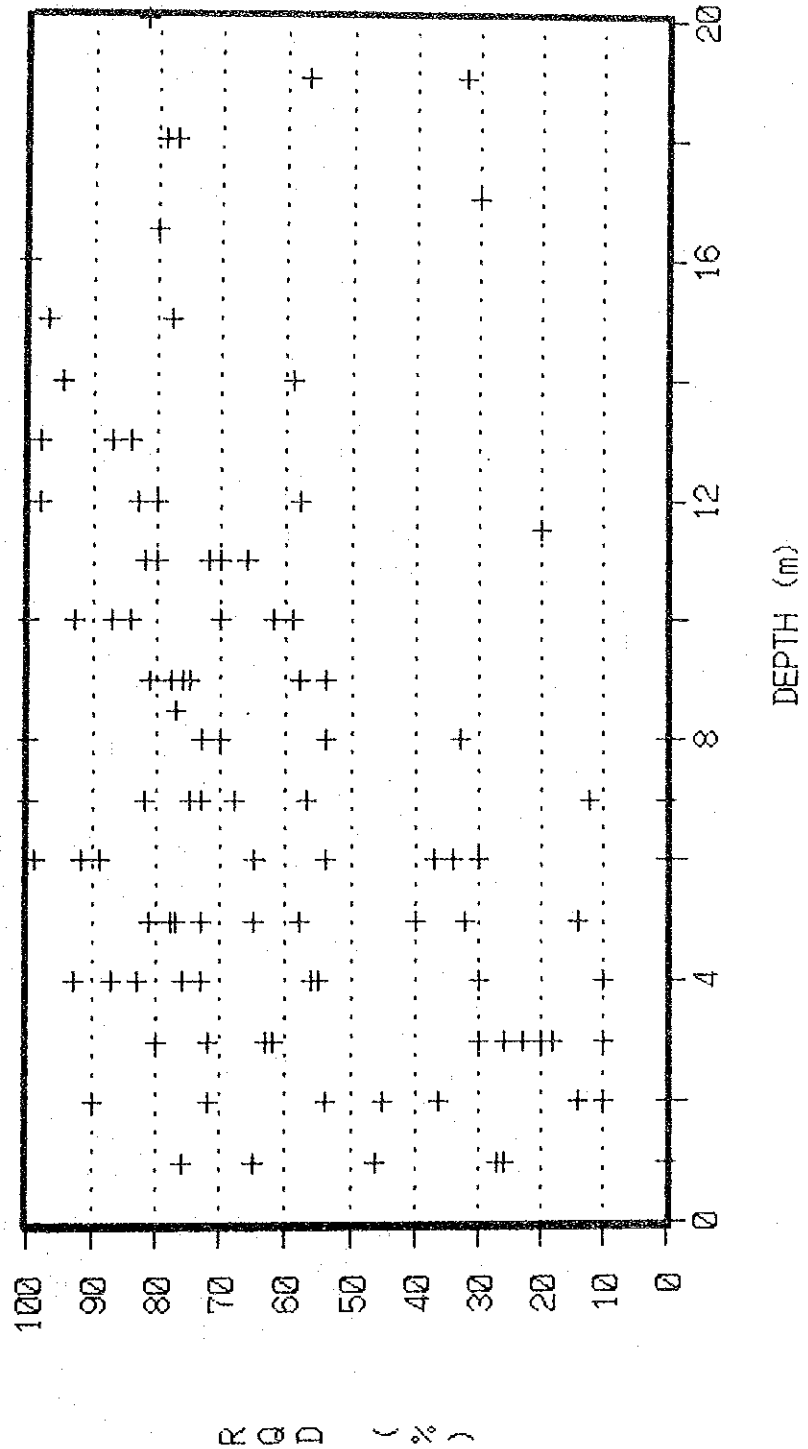


TABLE D-5 RQD vs. LUGEON

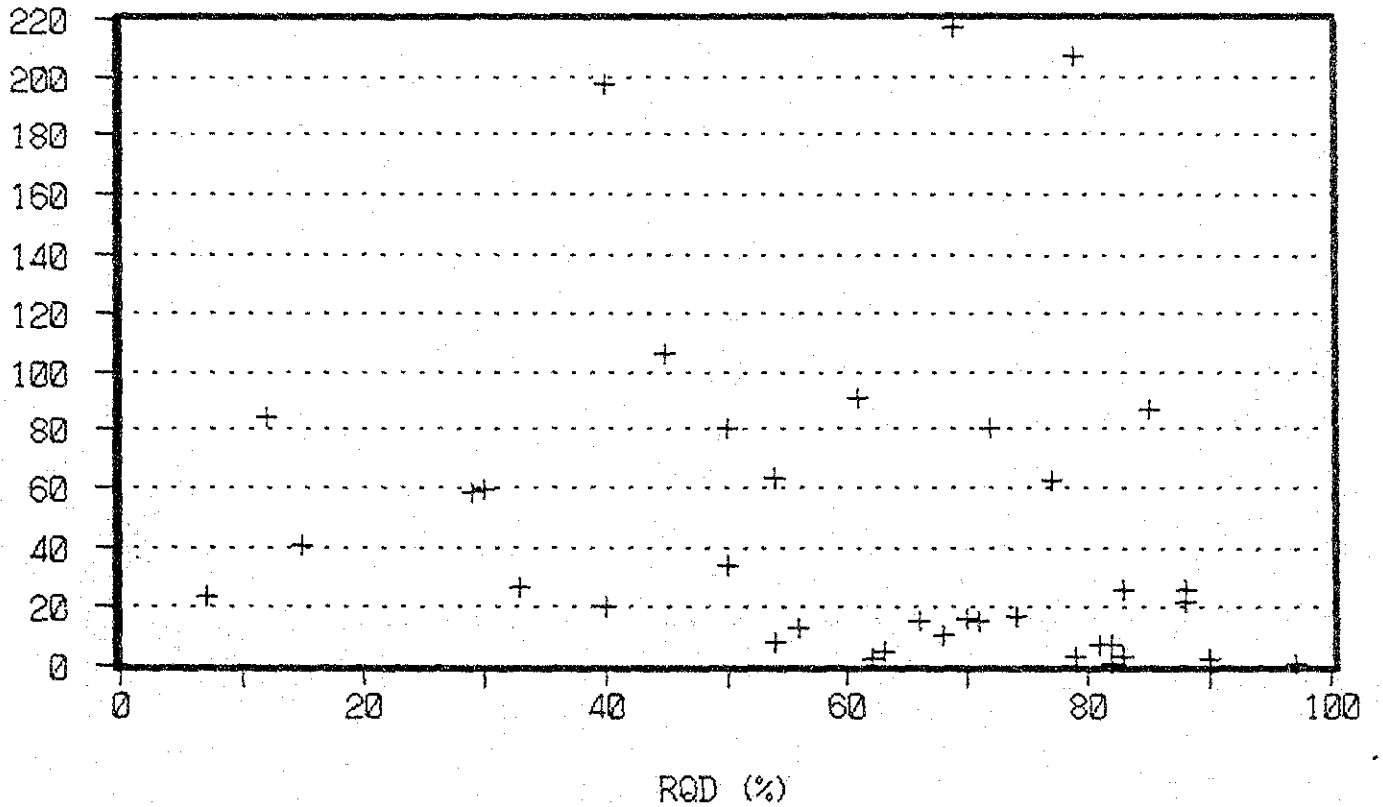


TABLE D-6 ROCK CLASSIFICATION BY BORING CORE OBSERVATION

Class	Condition of Core
A	- Core length is more than 100 cm, and core is extremely fresh and no fissures. Core recovery is excellent. - RQD is 80 to 100%
B	- Core length is mainly 40 to 50 cm, and core is fresh and the surface is glassy. Fissures are distributed on a small scale and closed. Recovery is excellent. - RQD is 80 to 100%
C_H	- Core length is mainly 10 to 30 cm and cilyndrically. Mostly fresh and the surface is mostly grassy. Fissures exist relatively on a large scale, and the planes have changed to brown by weathering. - Core recovery is good. - RQD is 60 to 100%.
C_M	- Consisting of short cylindrical core, and the length is around 10 cm. Slightly weathered and the surface is mostly rough. The plane of fissures has been contaminated by weathering, and the inside of core also been weathered. - Core recovery is mostly more than 80%. - RQD is 0 to 60%.
C_L	- Core is mainly composed of fragmentary rock and has been changed to brown to light brown by highly weathering. Core is generally highly weathered, and the surface is rough. Core is easy to break at the opening of core barrel, and partly changed to soil. - Core recovery is mostly less than 80%. - RQD is 0 to 20%.
D	- Core consists of sand, silt and clay. It is difficult to recognize the boundary between the core and overlying layer, but the core is relatively well consolidated. - Core recovery is generally very poor, even if double core tube is used. - RQD is 0 to 10%.

Correlation to "Degree of Weathering" by RID

1. = Fresh Rock ← A, B
2. = Slightly Weathered Rock ← $C_H \sim C_M$
3. = Moderately Weathered Rock ← $C_M \sim C_M$
4. = Highly Weathered Rock ← C_L
5. = Completely Weathered Rock ← D

TABLE D-7 NOS. OF SOIL LABORATORY TEST

NO	Physical Test					Mechanical Test			
	GS	Wn(%)	LL(%)	PL(%)	Grada-tion	Permeability Test	Compression Test Uncomfined	Compression Test Direct Shear	Consoli-dation
A-A' TP1	x	x	x	x	x				
A-A' TP2	x	x	x	x	x	x		x	x
A-A' TP3	x	x	x	x	x				
A-A' TP4	x	x	x	x	x				
C-C' TP1	x	x	x	x	x				
C-C' TP2	x	x	x	x	x	x		x	x
C-C' TP3	x	x	x	x	x				
C-C' TP4	x	x	x	x	x	x		x	x
C-C' TP4	x	x	x	x	x				
C-C' TP5	x	x	x	x	x	x		x	x
C-C' TP6	x	x	x	x	x				
C-C' TP7	x	x	x	x	x				
D-D' TP1	x	x	x	x	x	x		x	x
D-D' TP2	x	x	x	x	x				
D-D' TP3	x	x	x	x	x				
AL 9	x	x	x	x	x				
UAL9	x	x	x	x	x	x		x	x
D-DH3	x	x	x	x	x				
MUNR	x	x	x	x	x				
TOTAL	19	19	19	19	19	6		6	6

NOS. OF SOIL LABORATORY TEST
(Second Delivery)

NO	Physical Test					Permeability Test	Compression Test Uncomfined	Compression Test Direct Shear	Consoli-dation
	GS	Wn(%)	LL(%)	PL(%)	Grada-tion				
U-AL-9	x	x	x	x	x	x		x	x
D-DH3	x	x	x	x	x				
TOTAL	2	2	2	2	2	1		1	1

TABLE D-8 SUMMARY OF SOIL TEST (Physical)

Test Pit NO.	Unified Soil Classification	Grain Size Analysis				Specific Gravity (GS)	Atterberg Limit			Natural Moisture Content
		Gravel 4.76mm	Sand 0.074mm	Silt	Clay 0.005mm		Liquid Limit	Plastic Limit	Plasticity Index	
		(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)
A-A' TP1	CL	2.0	15.5	36.0	46.5	2.74	39.4	19.2	20.2	18.7
A-A' TP2	CL	3.0	15.5	36.0	45.5	2.78	39.4	19.2	20.2	12.1
A-A' TP3	CL	5.0	33.0	31.0	31.0	2.77	47.0	25.0	22.0	20.3
A-A' TP4	CL-ML	0.5	17.5	65.5	16.5	2.75	28.8	22.0	6.6	19.8
C-C' TP1	CL	0.0	47.5	40.0	12.5	2.74	24.6	15.0	9.6	11.5
C-C' TP2	SM-SC	0.0	61.5	21.0	17.5	2.65	18.6	13.1	5.5	11.3
C-C' TP3	SM-SC	0.0	64.5	22.5	13.0	2.68	17.7	13.1	4.6	10.6
C-C' TP4	SM-SC	0.0	58.0	27.0	15.0	2.61	19.4	12.4	7.0	12.9
C-C' TP5	SM-SC	0.5	59.5	24.5	15.5	2.73	18.8	12.8	6.0	11.5
C-C' TP6	SC	0.0	61.0	20.5	18.5	2.63	21.9	14.3	7.6	11.7
C-C' TP7	SC	0.0	53.0	28.0	19.0	2.72	26.1	16.3	9.8	12.8
C-C' TP8	CL	1.5	48.0	25.5	25.0	-	22.3	13.9	8.4	15.8
D-D' TP1	CL	4.0	45.0	28.5	22.5	2.76	38.9	19.5	19.4	17.7
D-D' TP2	SM-SC	0.2	62.8	15.0	22.0	2.68	19.1	13.0	6.1	10.6
D-D' TP3	SM	0.0	72.0	23.5	4.5	2.68	--Non Plastic--			5.8
AL9	SP-SC	0.0	88.5	11.5	0.0	2.61	--Non Plastic--			25.9
UAL9	CL-ML	0.0	10.0	90.0	-	2.72	24.6	18.6	6.0	21.2
D-DH3	SM	0.0	71.0	29.0	-	2.68	--Non plastic--			24.1
MUNR	SP	0.5	99.0	0.5	0.0	2.67	-	-	-	2.5

UAL9 : Undisturbed sample taken from the flood plane deposit
D-DH3: Sample taken from drilling core of DH-3
MUNR : Sample taken from a quarry of the Mun River

TABLE D-9 SUMMARY OF SOIL TEST (Mechanical)

	Direct Shear Test (CU)		Consolidation Test					Permeability Test
Opt. Water Content	Cohesion (Ccu)	Angle of Shear Resist.(ϕ cu)	Dry Density (initial)	Void Ratio (initial)	Degree of Saturation	Compression Index	Consolidation Yield Stress	k
(%)	(kgf/cm2)	(Degree)	(cm)	(e0)	(%)	(Cc)	(Pc, kgf/cm2)	(cm/sec)
17.1	0.28	19.61	1.64	0.70	84.44	0.19	1.8	1.87E-08
10.2	0.12	30.18	1.91	0.39	89.69	0.06	2.7	5.42E-08
10.0	0.19	32.04	1.91	0.37	87.42	0.07	1.9	4.90E-08
10.7	0.17	30.98	1.88	0.40	82.38	0.10	2.2	1.40E-07
15.4	0.23	28.25	1.71	0.61	82.03	0.15	1.7	7.52E-08
9.3	-	-	-	-	-	-	-	-
-	0.34	11.53	1.68	0.62	90.12	0.12	2.2	2.14E-07
-	-	-	-	-	-	-	-	4.02E-02

TABLE D-10 Specification of Soil Laboratory Test

(Mechanical Properties)

1) Compaction Test

(a) The test will be conducted based on the condition of natural water contents and not on a dry method.

2) Permeability Test

(a) The test will be conducted in the condition of two water contents as shown in the follwing figure: ρ_{dmax} (1) and ρ_{dmax} x 95% (2). In case of that w_n is extremely lower than w_1, the tests will be conducted with 92 or 93% of D value.

3) Compression Test

(a) Unconfined Test of Undisturbed Samples:

Dimension of test piece: 60mm x 120mm

(b) Direct Shear Test (UU and $\overline{CU}$)

-Principal stress(σ): 0.5, 1.0, 1.5, 2.0 kg/cm^2

-Speed of shear: standard (1%/min)

-Dimension of test piece: disturbed sample : 100mm x 40mm

: undisturbed sample: 60mm x 70mm

4) Consolidation Test

-Test piece of diturbed sample is conducted in the condition of ρ_{dmax} x 95% (point 2) as shown in following figure.

-Dimension of test piece: 60mm x 20mm

-Load: standard (0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4 kg/cm^2) for both undisturbed and disturbed samples.

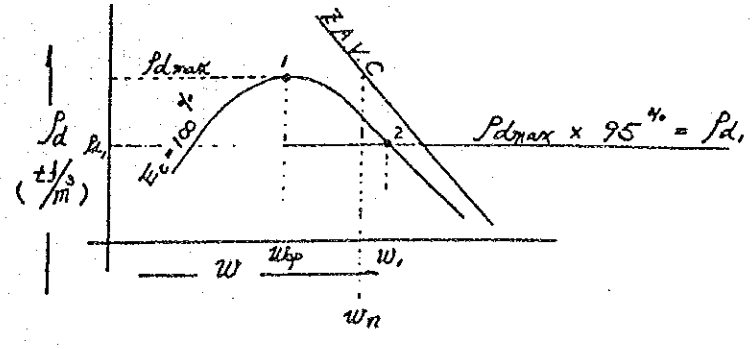


TABLE D-11 STRATIGRAPHY IN THE AREA

ERA	AGE	FORMATION	DESCRIPTION
CENOZOIC	QUATERNARY		Alluvial deposits; gravel, sand, silt, mud and lateritic soil
	TERTIARY	Basalt Flow	Olivine & nepheline basalt
MESOZOIC	CRETACEOUS	Maha-Sarakham Formation	Sandstone, siltstone & shale with rock salt, potash, gypsum & anhydrite. Brick red to purplish red.
			Unconformity
		Khok Kuruat Formation	Sandstone; brown to reddish brown partially micaceous. Shale & siltstone; pale brown, micaceous, with lime nodule conglomerate.
		Phu Phan Formation	Sandstone; white to pale orange, commonly pebbly, cross bedding with some shale & conglomerate.
	JURASSIC	Sao Khua Formation	Sandstone; reddish brown to gray, mostly micaceous. Siltstone, shale & conglomerate; purplish red to brick red.
		Pra Wihan Formation	Sandstone; with some reddish brown and gray shale. white to pink, massive, cross-bedded, pebble layering on the upper bed.

taken from 1) DMR, Geological Map of Thailand, 1/500,000, 1983
2) RID, Geological Investigation Reports in the area, 1983-1991

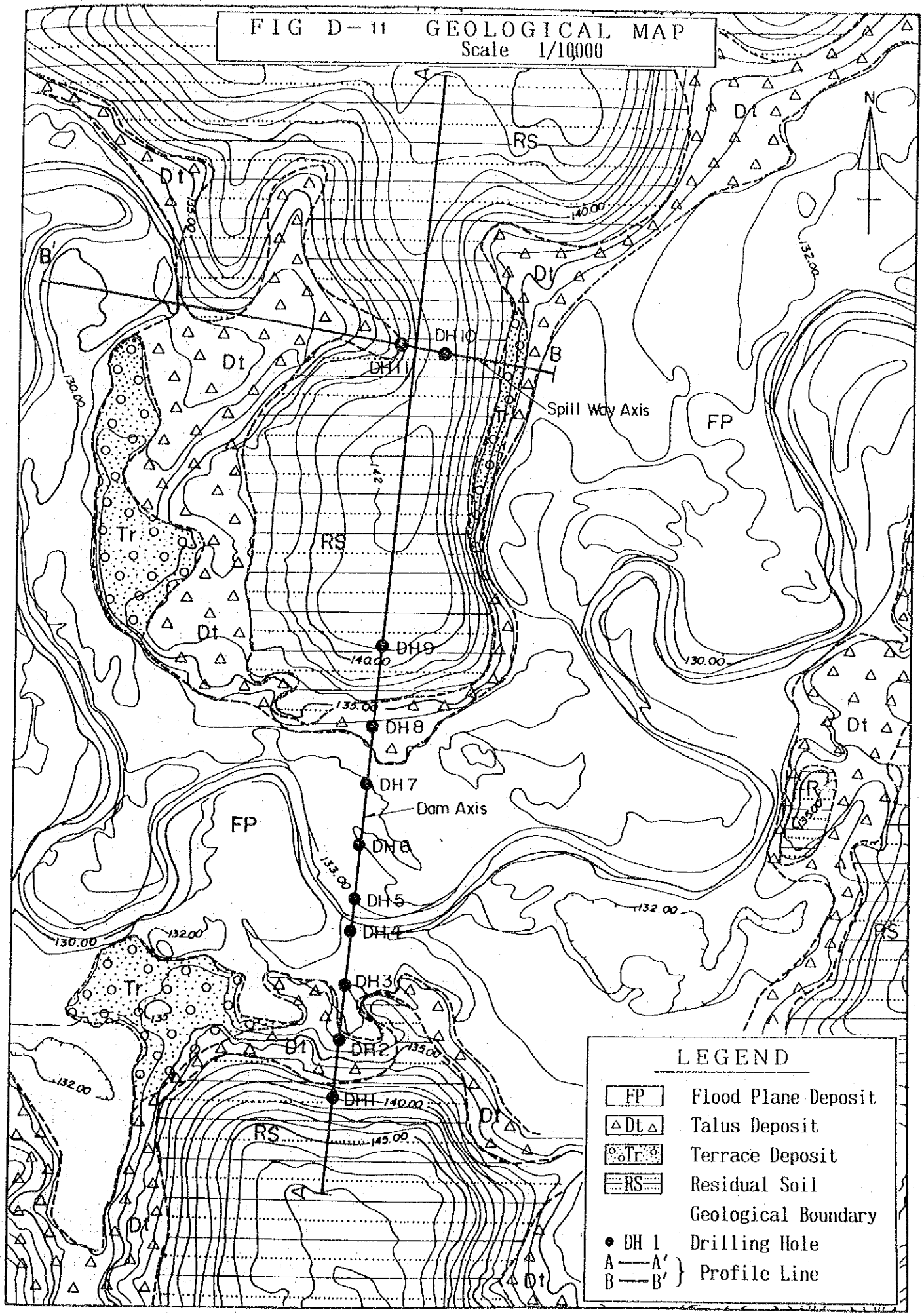
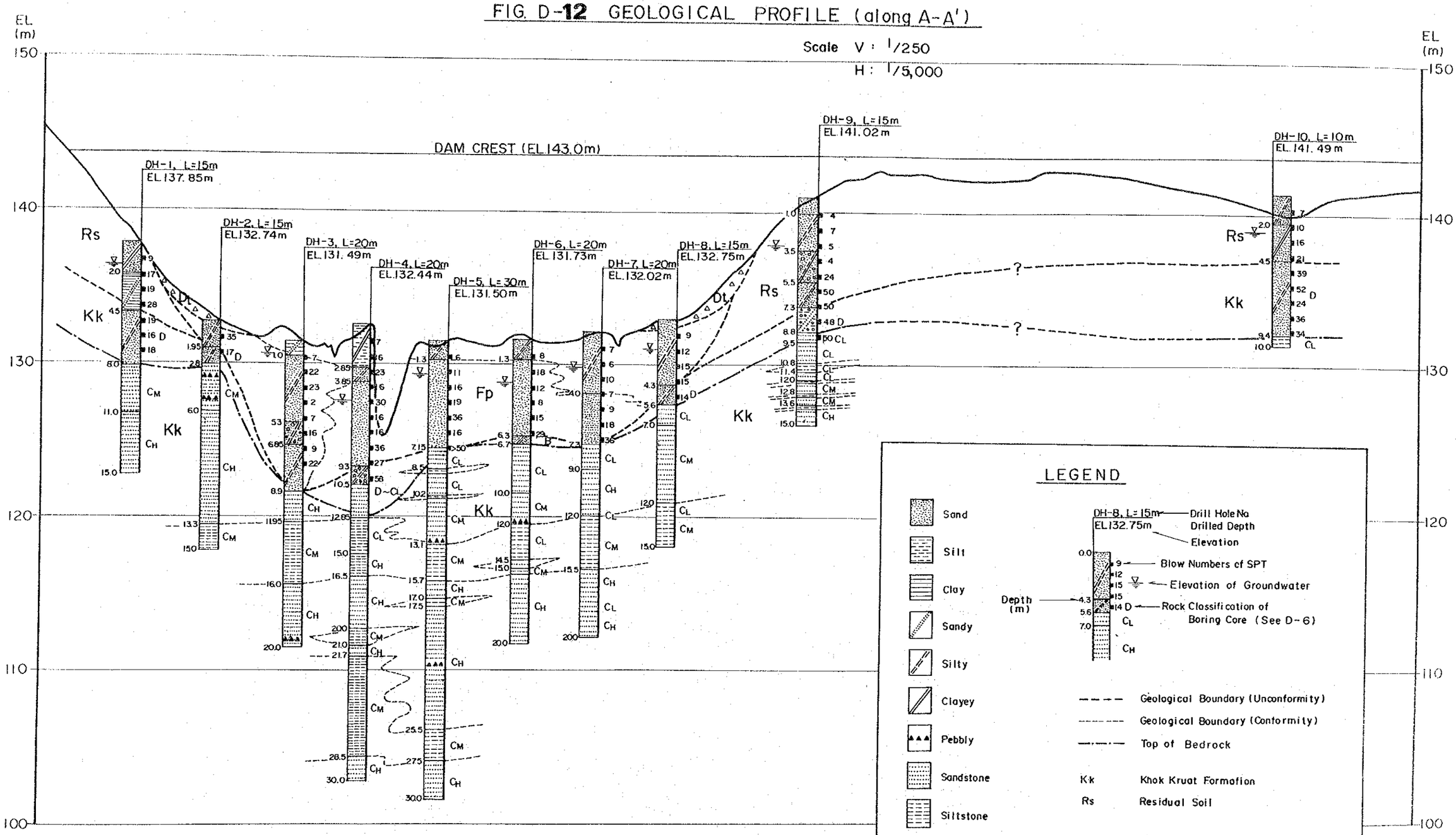


FIG D-11 GEOLOGICAL MAP
Scale 1/10000
N
RS
Dt
Tr
FP
DH 10
DH 11
DH 9
DH 8
DH 7
DH 6
DH 5
DH 4
DH 3
DH 2
DH 1
B
B'
Spill Way Axis
Dam Axis
140.00
135.00
130.00
132.00
133.00
145.00
LEGEND
FP Flood Plane Deposit
Dt Talus Deposit
Tr Terrace Deposit
RS Residual Soil
Geological Boundary
DH 1 Drilling Hole
A — A'
B — B' Profile Line

FIG. D-12 GEOLOGICAL PROFILE (along A-A')

Scale V : 1/250
H : 1/5,000



LEGEND

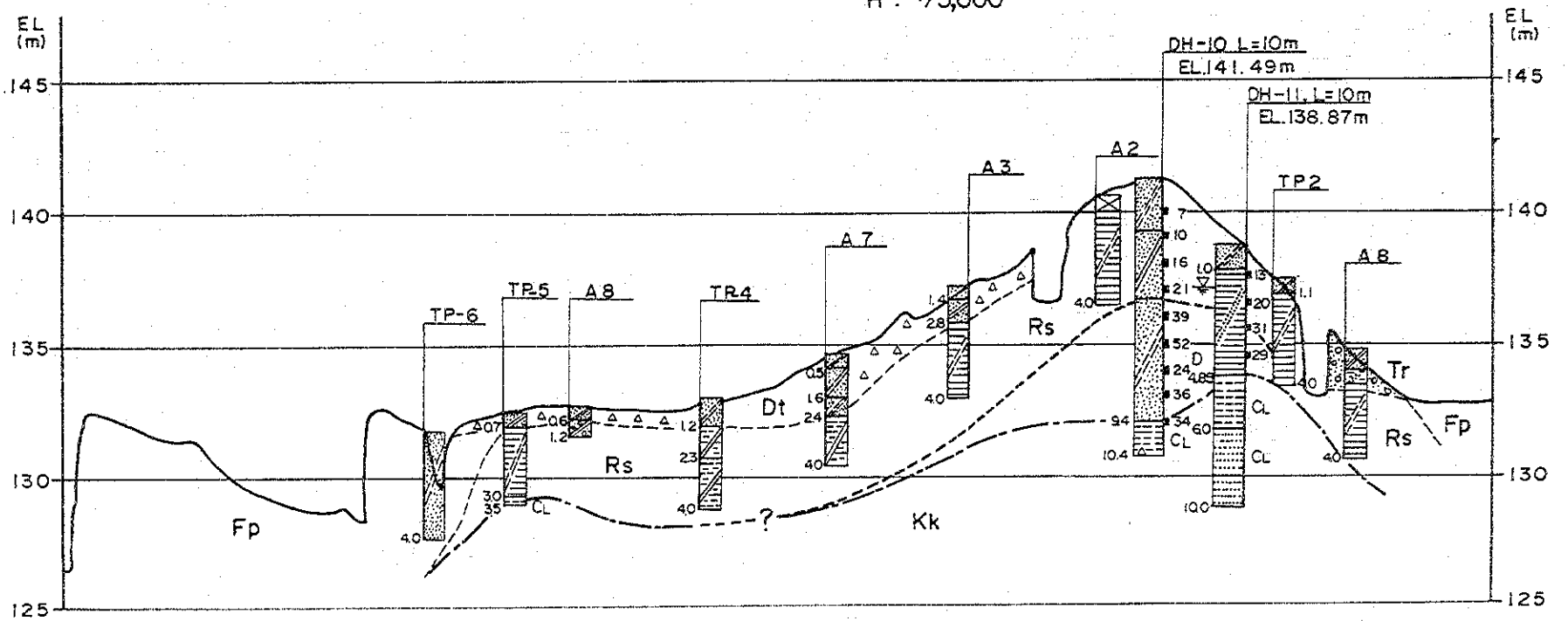
- Sand
- Silt
- Clay
- Sandy
- Silty
- Clayey
- Pebbly
- Sandstone
- Siltstone

- Geological Boundary (Unconformity)
- Geological Boundary (Conformity)
- Top of Bedrock

Kk	Khok Kruat Formation
Rs	Residual Soil
Fp	Flood Plane Deposit
Dt	Talus Deposit

FIG. D-13 GEOLOGICAL PROFILE (along B-B')

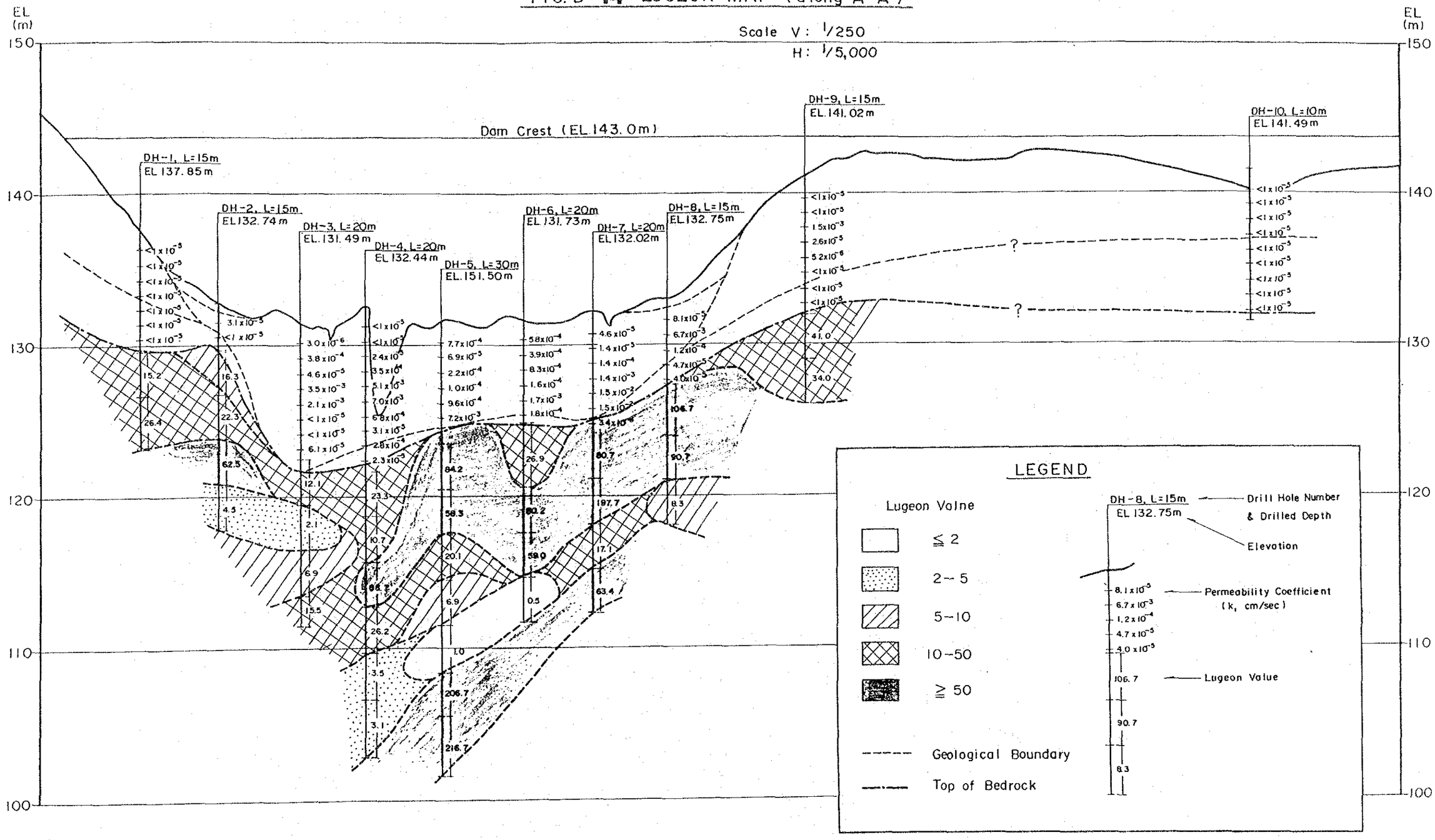
Scale V : 1/250
H : 1/5,000



LEGEND

- Sand
- Silt
- Clay
- Sandy
- Silty
- Clayey
- Pebbly
- Sandstone
- Siltstone
- DH-8, L=15m — Drill Hole No.
  EL 132.75m — Drilled Depth
  Elevation
- Blow Numbers of SPT
- Elevation of Groundwater
- Rock Classifation of Boring Core
- TP4 — Test Pit No.
- Geological Boundary (Unconformity)
- Geological Boundary (Conformity)
- Top of Bedrock
- Kk Khok Kruat Formation
- Rs Residual Soil
- Tr Terrace Deposit
- Fp Flood Plarre Deposit
- Dt Talus Deposit

FIG. D-14 LUGEON MAP (along A-A')



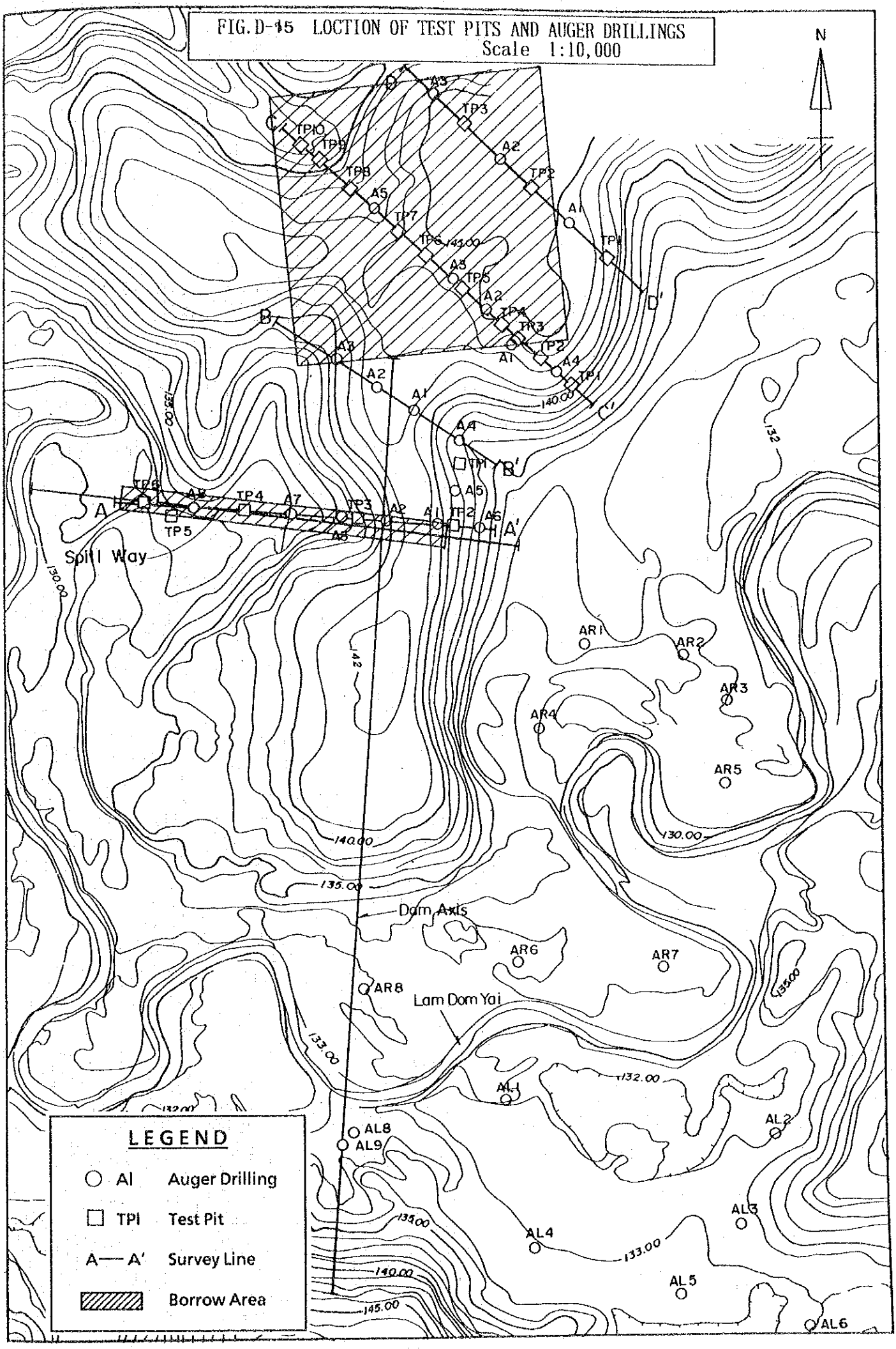
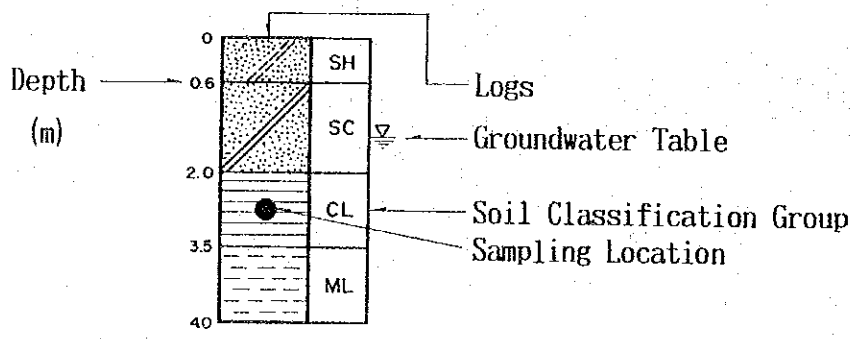


FIG. D-15 LOCTION OF TEST PITS AND AUGER DRILLINGS
Scale 1:10,000
N
Spill Way
Dam Axis
Lam Dom Yai
LEGEND
Al Auger Drilling
TPI Test Pit
A— A' Survey Line
Borrow Area

FIG. D-16 DESCRIPTIONS OF TEST PIT & AUGER DRILLING

LEGEND

A-A´ TP-2 ← Location (See FIG. D-5)



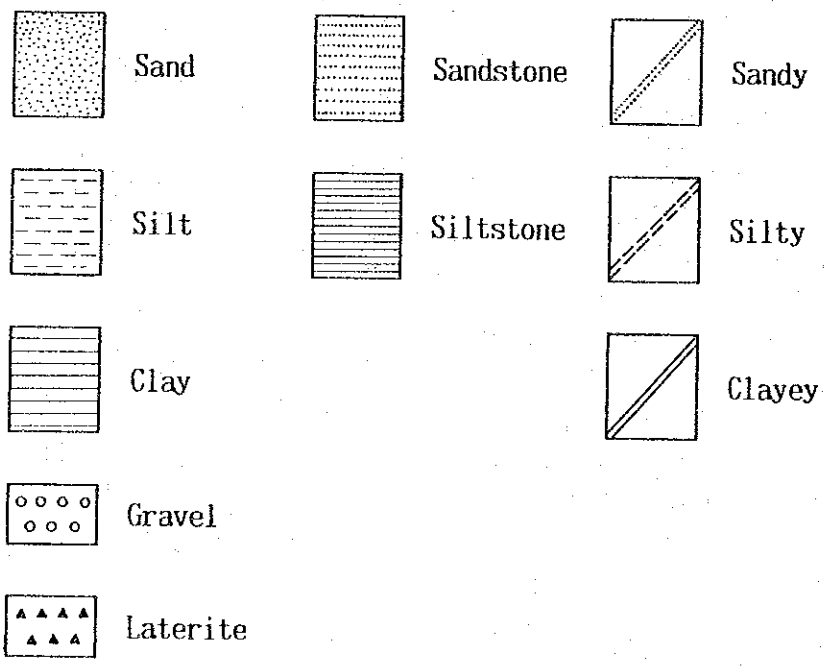


FIG D-16 (1)

A-A'

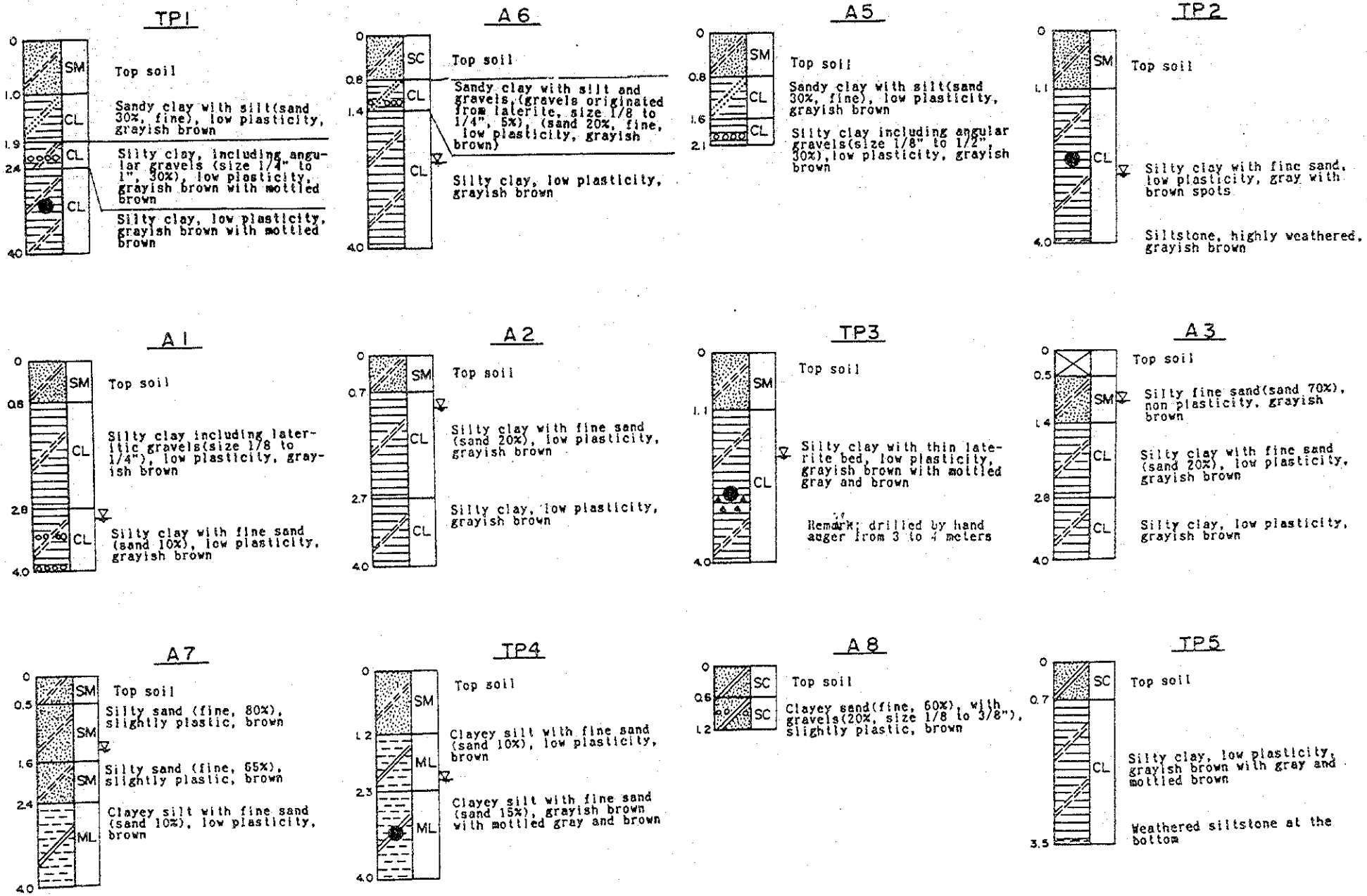
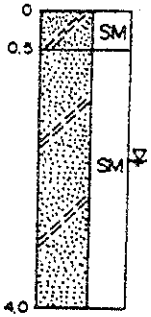

TP1
0
SM
Top soil
1.0
CL
Sandy clay with silt(sand 30%, fine), low plasticity, grayish brown
1.9
CL
Silty clay, including angular gravels (size 1/4" to 1", 30%), low plasticity, grayish brown with mottled brown
2.4
CL
Silty clay, low plasticity, grayish brown with mottled brown
4.0
A6
0
SC
Top soil
0.8
CL
Sandy clay with silt and gravels,(gravels originated from laterite, size 1/8 to 1/4", 5%), (sand 20%, fine, low plasticity, grayish brown)
1.4
CL
Silty clay, low plasticity, grayish brown
4.0
A5
0
SM
Top soil
0.8
CL
Sandy clay with silt(sand 30%, fine), low plasticity, grayish brown
1.6
CL
Silty clay including angular gravels(size 1/8" to 1/2", 30%),low plasticity, grayish brown
2.1
TP2
0
SM
Top soil
1.1
CL
Silty clay with fine sand, low plasticity, gray with brown spots
4.0
Siltstone, highly weathered, grayish brown
A1
0
SM
Top soil
0.8
CL
Silty clay including lateritic gravels(size 1/8 to 1/4"), low plasticity, grayish brown
2.8
CL
Silty clay with fine sand (sand 10%), low plasticity, grayish brown
4.0
A2
0
SM
Top soil
0.7
CL
Silty clay with fine sand (sand 20%), low plasticity, grayish brown
2.7
CL
Silty clay, low plasticity, grayish brown
4.0
TP3
0
SM
Top soil
1.1
CL
Silty clay with thin laterite bed, low plasticity, grayish brown with mottled gray and brown
4.0
Remark; drilled by hand auger from 3 to 4 meters
A3
0
Top soil
0.5
SM
Silty fine sand(sand 70%), non plasticity, grayish brown
1.4
CL
Silty clay with fine sand (sand 20%), low plasticity, grayish brown
2.8
CL
Silty clay, low plasticity, grayish brown
4.0
A7
0
SM
Top soil
0.5
SM
Silty sand (fine, 80%), slightly plastic, brown
1.6
SM
Silty sand (fine, 65%), slightly plastic, brown
2.4
ML
Clayey silt with fine sand (sand 10%), low plasticity, brown
4.0
TP4
0
SM
Top soil
1.2
ML
Clayey silt with fine sand (sand 10%), low plasticity, brown
2.3
ML
Clayey silt with fine sand (sand 15%), grayish brown with mottled gray and brown
4.0
A8
0
SC
Top soil
0.6
SC
Clayey sand(fine, 60%), with gravels(20%, size 1/8 to 3/8"), slightly plastic, brown
1.2
TP5
0
SC
Top soil
0.7
CL
Silty clay, low plasticity, grayish brown with gray and mottled brown
3.5
Weathered siltstone at the bottom

FIG D-16 (2)

A-A'

TP6

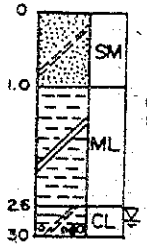


Top Soil

Silty sand(fine, 85%), non plasticity, brown

B-B'

A1

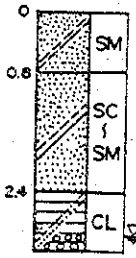


Top soil

Clayey silt with fine sand (sand 15%), low plasticity, grayish brown

Silty clay with fine sand (sand 15%), including weathered sandstone (size 1/2 to 1.5"), grayish brown

A2

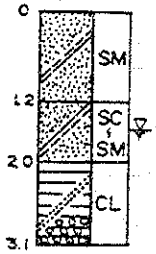


Top soil

Clayey to silty fine sand (sand 60%), slightly plastic, brown

Sandy clay(sand 30%, fine), including weathered sandstone(size 1/2 to 1.5"), grayish brown

A3

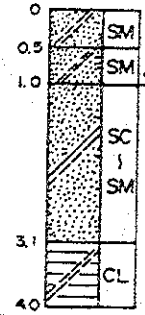


Top soil

Clayey to silty sand(sand 60%, fine), slightly plasticity, brown

Sandy clay(sand 30%, fine), including sub angular to sub rounded gravels(20%, size 1/4" to 3/8"), low plasticity, grayish brown

A4



Top soil

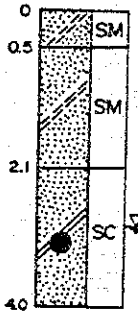
Silty fine sand (sand 70%), non plasticity, brown

Clayey to silty fine sand (sand 60%), medium plasticity, grayish brown

Silty clay with fine sand, low plasticity, grayish brown

C-C'

TP1



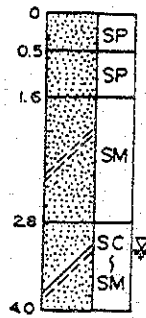
Top soil

Silty fine sand(65%), slightly plastic, brown

Clayey fine sand(50%), low plasticity, grayish brown with mottled gray and brown

Weathered siltstone at the bottom

A4



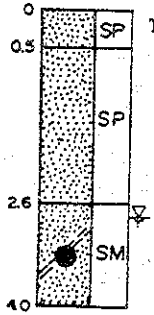
Top soil

Fine sand, poor grading, non plasticity, brown

Silty fine sand(70%), non plasticity, brown

Clayey to silty sand(fine, 60%), slightly plastic, brown with mottled white

TP2



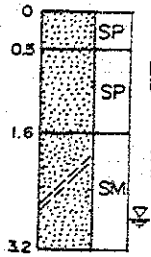
Top soil

Fine sand, poor grading, non plasticity, brown

Silty sand(fine, 70%), slightly plastic, brown

Weathered sandstone at the bottom

A1



Top soil

Fine sand, poor grading, brown

Silty fine sand(70%), slightly plastic, brown

FIG D-16 (3)

C-C'

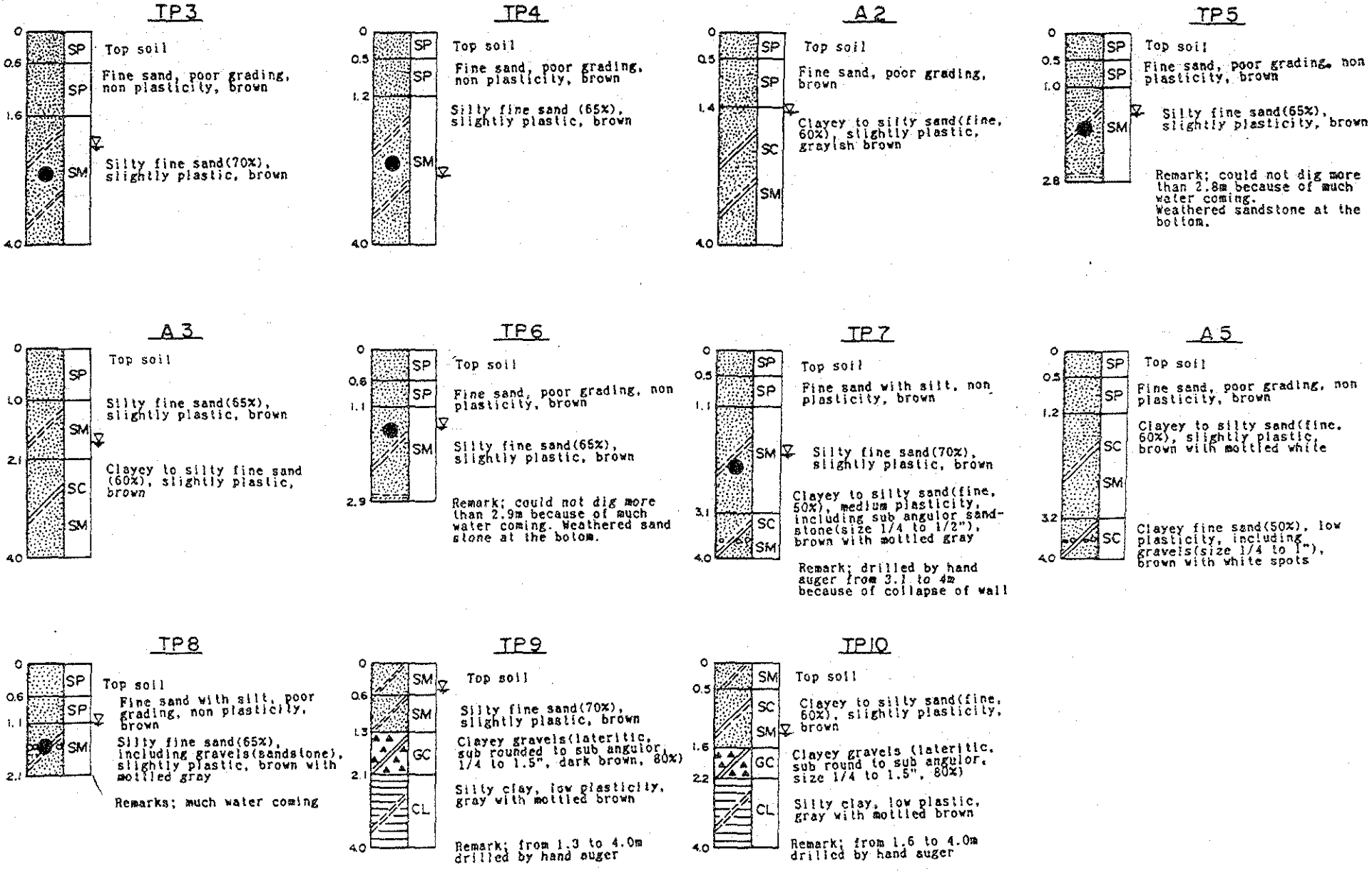
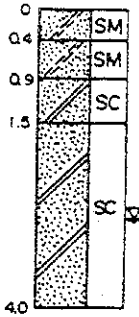

TP3
0
0.6
1.6
4.0
SP
SP
SM
Top soil
Fine sand, poor grading, non plasticity, brown
Silty fine sand(70%), slightly plastic, brown
TP4
0
0.5
1.2
4.0
SP
SP
SM
Top soil
Fine sand, poor grading, non plasticity, brown
Silty fine sand (65%), slightly plastic, brown
A2
0
0.5
1.4
4.0
SP
SP
SC
SM
Top soil
Fine sand, poor grading, brown
Clayey to silty sand(fine, 60%), slightly plastic, grayish brown
TP5
0
0.5
1.0
2.8
SP
SP
SM
Top soil
Fine sand, poor grading, non plasticity, brown
Silty fine sand(65%), slightly plasticity, brown
Remark; could not dig more than 2.8m because of much water coming. Weathered sandstone at the bottom.
A3
0
1.0
2.1
4.0
SP
SM
SC
SM
Top soil
Silty fine sand(65%), slightly plastic, brown
Clayey to silty fine sand (60%), slightly plastic, brown
TP6
0
0.6
1.1
2.9
SP
SP
SM
Top soil
Fine sand, poor grading, non plasticity, brown
Silty fine sand(65%), slightly plastic, brown
Remark; could not dig more than 2.9m because of much water coming. Weathered sand stone at the botom.
TP7
0
0.5
1.1
3.1
4.0
SP
SP
SM
SC
SM
Top soil
Fine sand with silt, non plasticity, brown
Silty fine sand(70%), slightly plastic, brown
Clayey to silty sand(fine, 50%), medium plasticity, including sub angular sand-stone(size 1/4 to 1/2"), brown with mottled gray
Remark; drilled by hand auger from 3.1 to 4m because of collapse of wall
A5
0
0.5
1.2
3.2
4.0
SP
SP
SC
SM
SC
Top soil
Fine sand, poor grading, non plasticity, brown
Clayey to silty sand(fine, 60%), slightly plastic, brown with mottled white
Clayey fine sand(50%), low plasticity, including gravels(size 1/4 to 1"), brown with white spots
TP8
0
0.6
1.1
2.1
SP
SP
SM
Top soil
Fine sand with silt, poor grading, non plasticity, brown
Silty fine sand(65%), including gravels(sandstone), slightly plastic, brown with mottled gray
Remarks; much water coming
TP9
0
0.6
1.3
2.1
4.0
SM
SM
GC
CL
Top soil
Silty fine sand(70%), slightly plastic, brown
Clayey gravels(lateritic, sub rounded to sub angular, 1/4 to 1.5", dark brown, 80%)
Silty clay, low plasticity, gray with mottled brown
Remark; from 1.3 to 4.0m drilled by hand auger
TP10
0
0.5
1.6
2.2
4.0
SM
SC
SM
GC
CL
Top soil
Clayey to silty sand(fine, 60%), slightly plasticity, brown
Clayey gravels (lateritic, sub round to sub angular, size 1/4 to 1.5", 80%)
Silty clay, low plastic, gray with mottled brown
Remark; from 1.6 to 4.0m drilled by hand auger

FIG D-16 (4)

D-D'

TP1



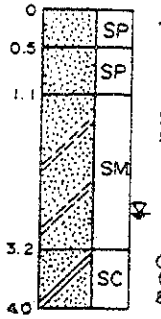
Top soil

Silty fine sand(80%), non plasticity, brown

Clayey fine sand(60%), slighlly plastic, brown

Clayey fine sand(55%), medium plasticity, gray with mottled brown

A1



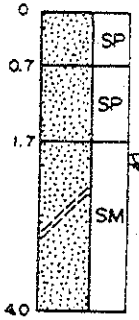
Top soil

Fine sand, poor grading, slighlly plastic, brown

Silty fine sand(65%), slighlly plastic, brown

Clayey fine sand with silt (sand 50%), medium plasticity, gray with mottled brown

TP2

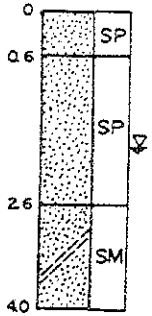


Top soil

Fine sand(70%), poor grading, slighlly plastic, gray with mottled brown

Silty fine sand(70%), slighlly plastic, gray with brown spots

A2

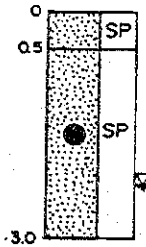


Top soil

Silty fine sand(70%), poor grading, non plasticity, brown

Silty fine sand(70%), slighlly plastic, brown

TP3

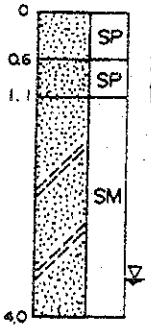


Top soil

Fine sand with silt, poor grading, non plasticity, brown

Remark; could not dig more than 3m because of much water coming

A3



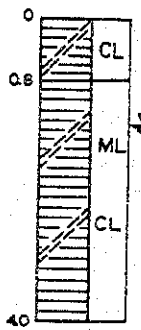
Top soil

Fine sand with silt, poor grading, non plasticity, brown

Silty fine sand(70%), slighlly plastic, brown with mottled gray

Flood Plane

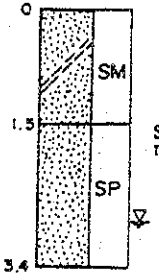
AR1



Clayey silt to silty clay with fine sand (sand 10%), low plastic, brown

Silty clay with fine sand (sand 10%), low plastic, brown

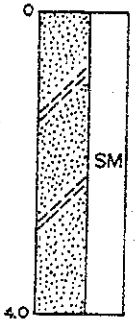
AR2



Silty fine sand(75%), non plastic, brown

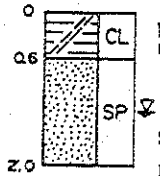
Sand with silt, poor grading, non plastic, brown

AR3



Silty fine sand with clay (sand 60%), non plastic, brown

AR4



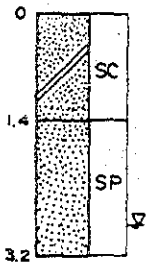
Fine sand with silt(sand 95%), non plasticity, brown

Silty clay with fine sand (sand 10%), low plasticity, brown

FIG D-16 (5)

Flood Plane

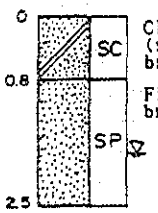
AR 5



Clayey fine sand with silt (sand 50%), low plastic, brown

Fine sand, poor grading, brown

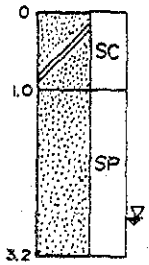
AR 6



Clayey fine sand with silt (sand 50%), low plasticity, brown

Fine sand, poor grading, brown

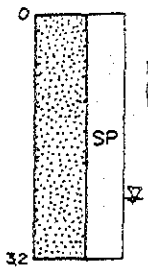
AR 7



Clayey fine sand with silt (sand 50%), low plasticity, brown

Fine sand, poor grading, brown

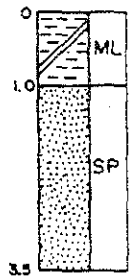
AR 8



Fine sand with silt, poor graded, non plasticity, brown

Remark; much water coming

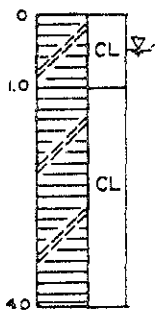
AL 1



Clayey silt with fine sand (sand 10%), low plasticity, brown

Fine sand with silt, poor grading, non plasticity, brown

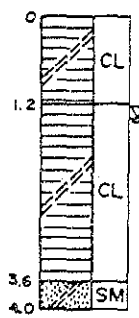
AL 2



Silty clay with fine sand (sand 10%), low plasticity, brown

Silty clay, low plasticity, grayish red

AL 3

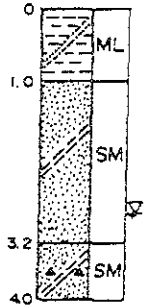


Silty clay with fine sand (sand 10%), low plasticity, grayish brown

Silty clay, low plasticity, grayish red

Silty fine sand(70%), non plasticity, grayish brown

AL 4

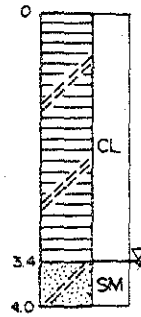


Sandy silt with clay, medium plasticity, brown

Silty fine sand with clay (sand 60%), medium plasticity, grayish brown

Silty fine sand including lateritic gravels(sand 65%), non plasticity, gray to brown

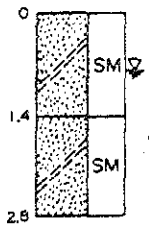
AL 5



Silty clay with fine sand (sand 10%), low plasticity, brown

Silty fine sand(70%), non plasticity, brown

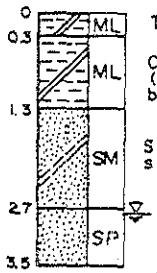
AL 6



Silty fine sand,(sand 65%), low plasticity, grayish brown

Silty fine sand with clay (sand 65%), low plasticity, grayish brown

AL 7



Top soil

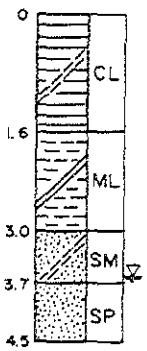
Clayey silt with fine sand (sand 30%), low plasticity, brown

Silty fine sand(65%), slightly plastic, brown

Fine sand with silt, poor grading, non plasticity, brown

Remark; much water coming

AL 8



Silty clay with fine sand (sand 10%), low plasticity, gray

Clayey silt with fine sand (sand 20%), low plasticity, brownish gray

Silty fine sand(70%), slightly plastic, brownish gray

Fine sand with silt, poor grading, non plasticity, dark gray

FIG. D-17 DRILLING LOG

Geotechnics Division

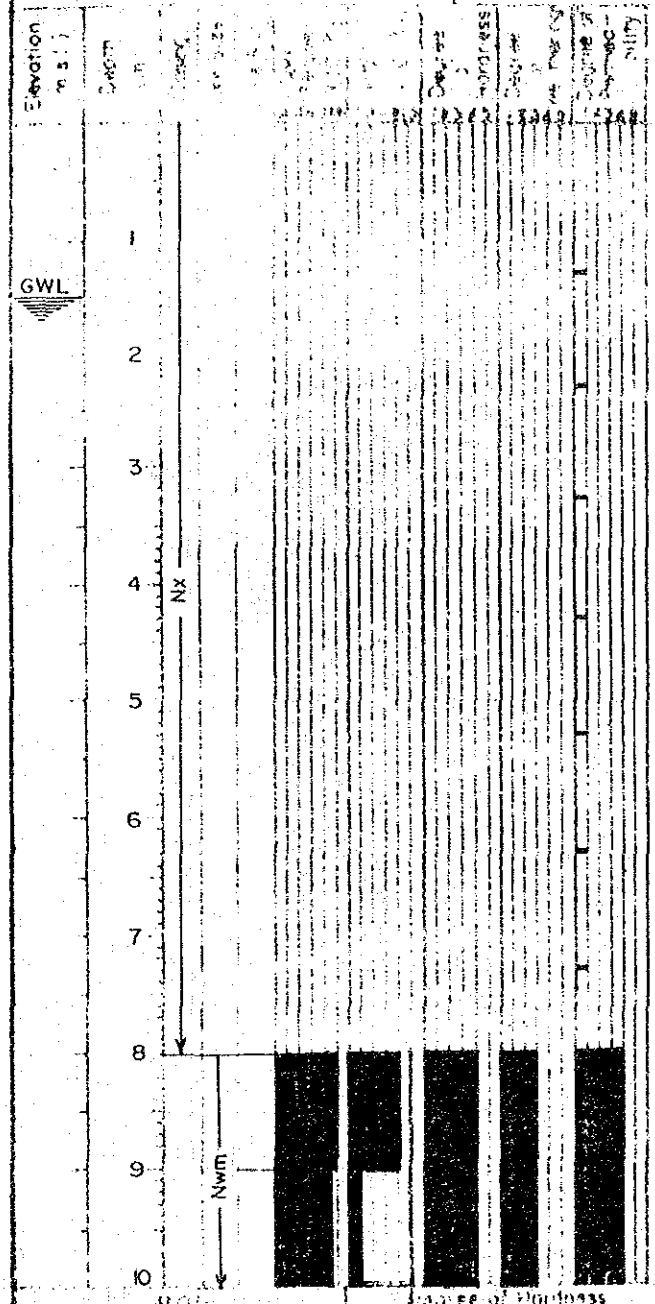
Royal Irrigation Department

GEOLOGIC LOG OF DRILL HOLE

Project Lam Dom Yai (D28)
Changwat Ubonratchathani
Site ℄ Dam
Location Left abutment
Elevation +137.85

Logged by V. Nipong
Logged Date 14/12/34
Drilling Method Rotary
Drilling Started 11/12/34
Drilling Finished 12/12/34

Hole No. DH.1
Total Depth 15.00 m.
Angle From Vertical 0°
Bearing of Angle Hole
Elevation of Groundwater +136.35



Description	Remark
0.00 - 2.00 m. SC Clayey sand; App.70% coarse-fine sand, subround to round, 30% low plasticity fines, yellowish brown to brown, medium dense, moist.	
2.00 - 4.50 m. CL Sandy clay; App.15% fine sand, 85% medium plasticity fines, gray, firm, moist, residual soil.	
4.50 - 8.00 m. SM Silty sand; App.85% fine sand, 15% slightly plasticity fines, reddish purple, dense, moist, completely weathered of sand stone.	
8.00 - 11.00 m. Sandstone moderately weathered, purple to gray, fine grained, fair sorted, well cemented, hard rock, bedding dip 3°, fractures	

RQD
0 - 25% = Very Poor Rock
25 - 50% = Poor Rock
50 - 75% = Fair Rock
75 - 90% = Good Rock
90 - 100% = Very Good Rock

Degree of Hardness
1 = Very Soft Rock
2 = Soft Rock
3 = Moderate Hard Rock
4 = Hard Rock
5 = Very Hard Rock

Degree of Weathering
1 = Fresh rock
2 = Slightly Weathered Rock
3 = Moderately Weathered Rock
4 = Highly Weathered Rock
5 = Completely Weathered Rock

Degree of Permeability
1 = < 1 Lugeon or < 10^{-5} cm/Sec
2 = 1 - 5 " $10^{-5} - 5 \times 10^{-5}$ "
3 = 5 - 10 " $5 \times 10^{-5} - 10^{-4}$ "
4 = 10 - 50 " $10^{-4} - 5 \times 10^{-4}$ "
5 = > 50 " > 5×10^{-4} "

Sheet 1 of 2

Geotechnics Division

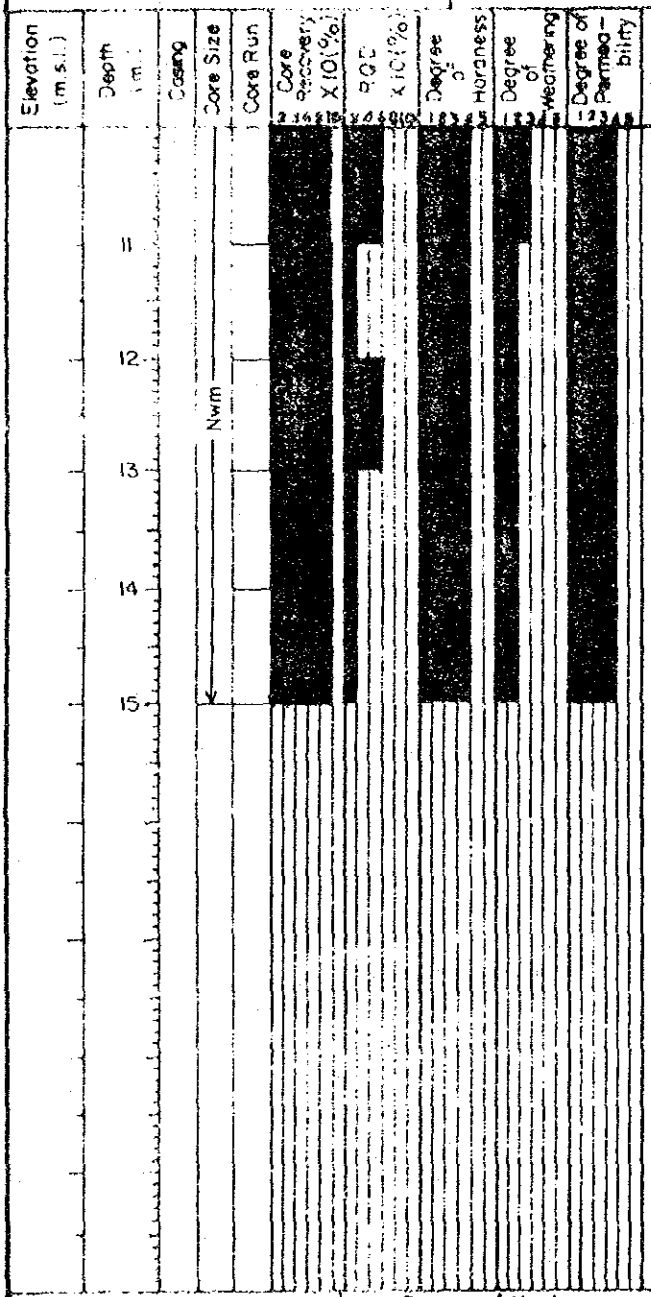
Royal Irrigation Department

GEOLOGIC LOG OF DRILL HOLE

Project Lam Dom Yai (D 28)
Changwat Ubonratchathani
Site ℄ Dom
Location Left abutment
Elevation + 137.85

Logged By V. Nipong
Logged Date 14/12/34
Drilling Method Rotary
Drilling Started 11/12/34
Drilling Finished 12/12/34

Hole No. DH. 1
Total Depth 15.00 m.
Angle From Vertical 0°
Bearing of Angle Hole
Elevation of Groundwater + 136.35



Description

dip about 2°-3° and 45°, pebbly sandstone intercalated at 10.20-10.90m.

11.00 - 15.00 m.
Sandstone
slightly weathered, gray, fine grained, well sorted and cemented, hard rock, bedding not clear, fractures dip 90° and clean surface, jointed to slightly jointed core, maximum core length 85 cm.

Remark

RQD	Degree of Hardness	Degree of Weathering	Degree of Permeability
< 25% = Very Poor Rock	1 = Very Soft Rock	1 = Fresh rock	1 = < 1 Lugeon or < 10^{-5} cm/Sec
25 - 50% = Poor Rock	2 = Soft Rock	2 = Slightly Weathered Rock	2 = 1 - 5 " 10^{-5} - 5×10^{-5} "
50 - 75% = Fair Rock	3 = Medium Hard Rock	3 = Moderately Weathered Rock	3 = 5 - 10 " 5×10^{-5} - 10^{-4} "
75 - 90% = Good Rock	4 = Hard Rock	4 = Highly Weathered Rock	4 = 10 - 50 " 10^{-4} - 5×10^{-4} "
90 - 100% = Very Good Rock	5 = Very Hard Rock	5 = Completely Weathered Rock	5 = > 50 " > 5×10^{-4} "

Sheet 2 of 2

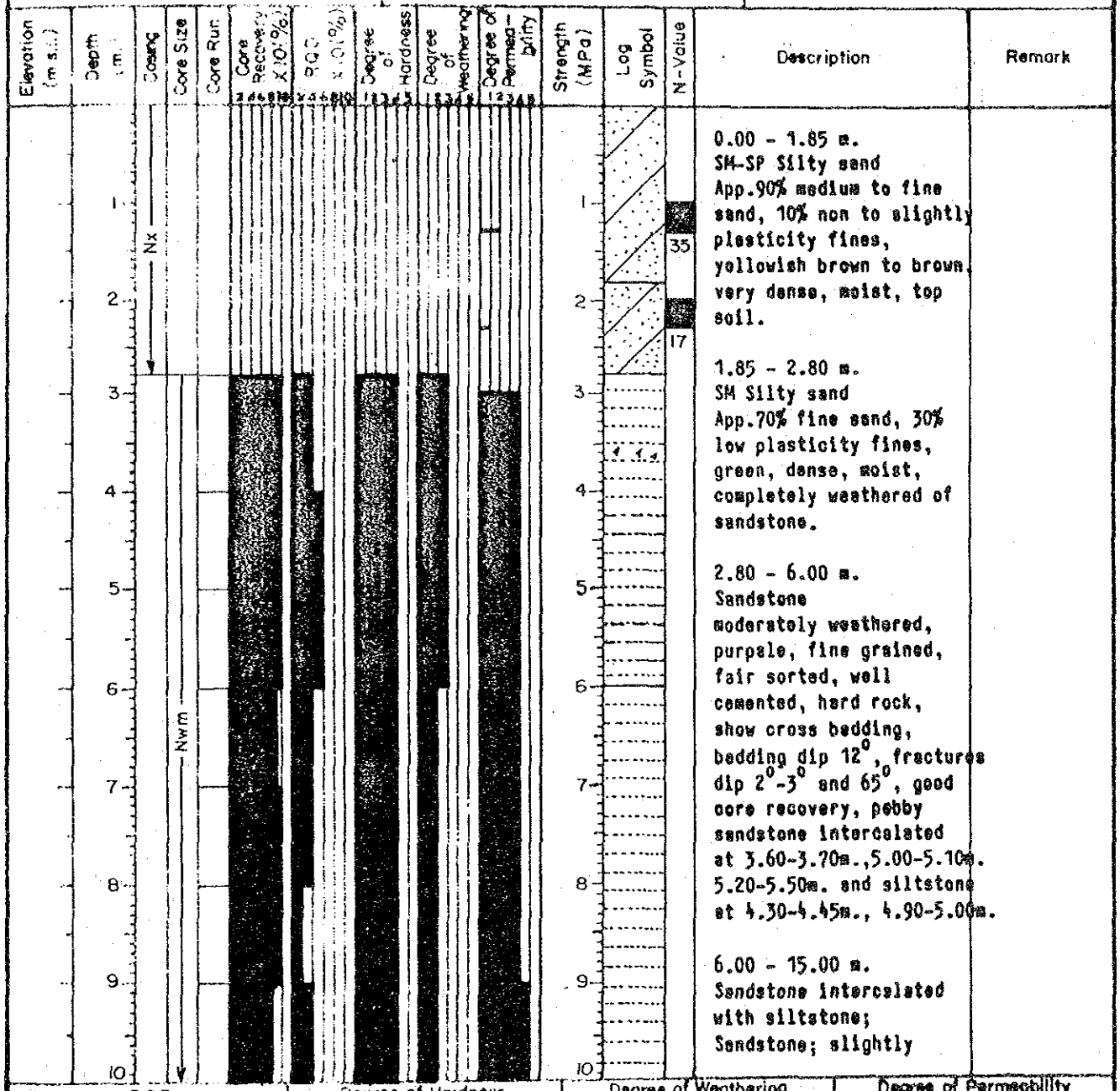
พิมพ์ ที่กรมโรงพิมพ์ กรมชลประทาน (ม.612-ม.ก.2533-4,000.).

Geotechnics Division

Royal Irrigation Deparment

GEOLOGIC LOG OF DRILL HOLE

Project Lam Dom Yai (D28)	Logged By V. Nipong	Hole No. D.H. 2
Changwat Ubonratchathani	Logged Date 12/12/34	Total Depth 15.00 m.
Site ℄ Dam	Drilling Method Rotary	Angle From Vertical 0°
Location Left obutment	Drilling Started 7/12/34	Bearing of Angle Hole —
Elevation + 132.74	Drilling Finished 10/12/34	Elevation of Groundwater



RQD	Degree of Hardness	Degree of Weathering	Degree of Permeability
< 25% = Very Poor Rock	1 = Very Soft Rock	1 = Fresh rock	1 = < 1 Lugeon or < 10^{-5} cm/Sec
25 - 50% = Poor Rock	2 = Soft Rock	2 = Slightly Weathered Rock	2 = 1 - 5 " 10^{-5} - 5×10^{-5} "
50 - 75% = Fair Rock	3 = Medium Hard Rock	3 = Moderately Weathered Rock	3 = 5 - 10 " 5×10^{-5} - 10^{-4} "
75 - 90% = Good Rock	4 = Hard Rock	4 = Highly Weathered Rock	4 = 10 - 50 " 10^{-4} - 5×10^{-4} "
90 - 100% = Very Good Rock	5 = Very Hard Rock	5 = Completely Weathered Rock	5 = > 50 " > 5×10^{-4} "

Sheet 1 of 2

พิมพ์ ที่กองโรงพิมพ์ กรมชลประทาน (บ.612-พ.ก.2533-4,000.)

Geotechnics Division

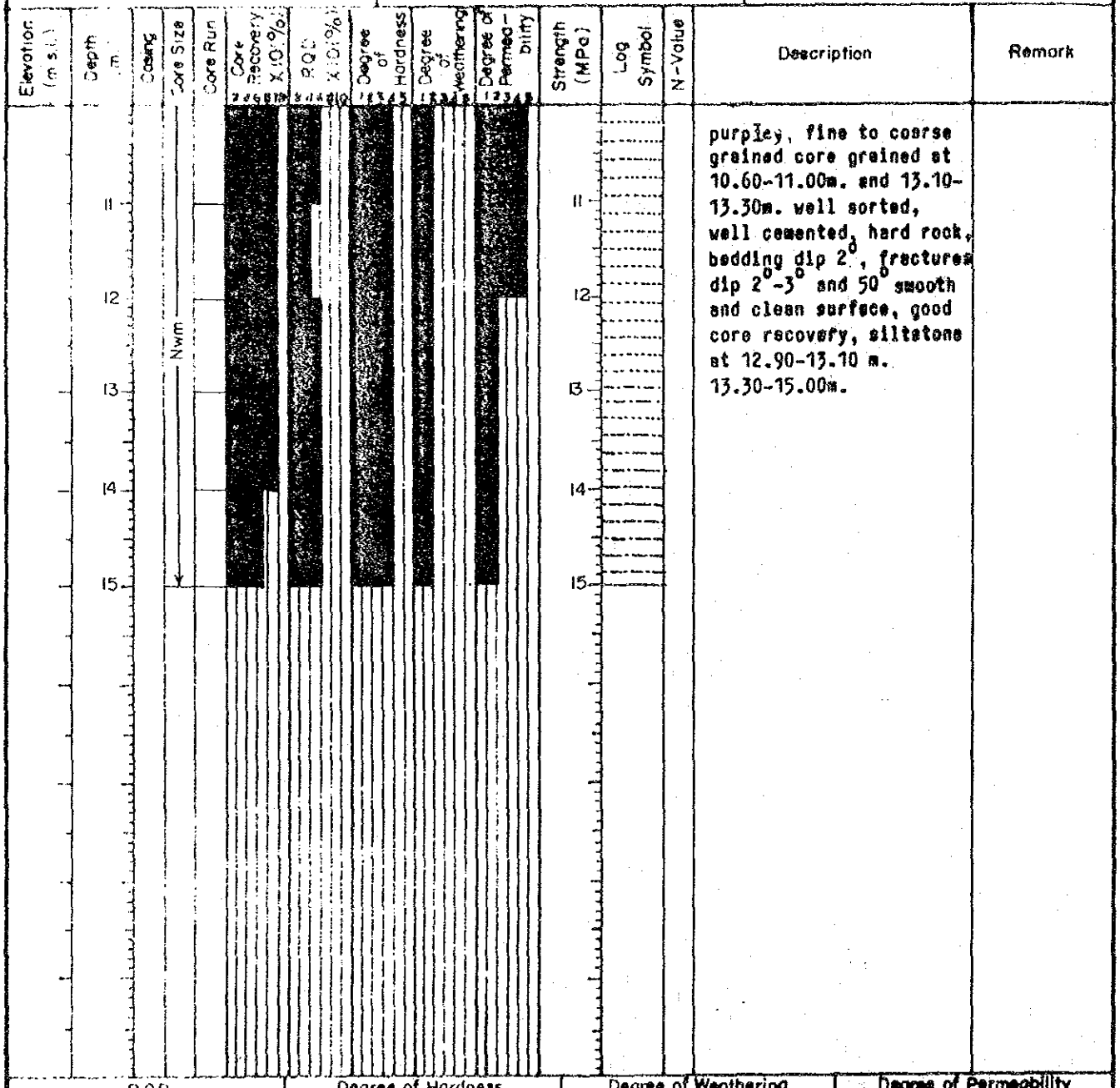
Royal Irrigation Department

GEOLOGIC LOG OF DRILL HOLE

Project Lam Dom Yai (028)
Changwat Ubonratchathani
Site ℄ Dam
Location Left abutment
Elevation + 132.74

Logged By V. Nipong
Logged Date 12/12/34
Drilling Method Rotary
Drilling Started 7/12/34
Drilling Finished 10/12/34

Hole No. DH. 2
Total Depth 15.00 m.
Angle From Vertical 0°
Bearing of Angle Hole
Elevation of Groundwater



RQD	Degree of Hardness	Degree of Weathering	Degree of Permeability
< 25% = Very Poor Rock	1 = Very Soft Rock	1 = Fresh rock	1 = < 1 Lugeon or < 10^{-5} cm/Sec
25 - 50% = Poor Rock	2 = Soft Rock	2 = Slightly Weathered Rock	2 = 1 - 5 " 10^{-5} - 5×10^{-5} "
50 - 75% = Fair Rock	3 = Medium Hard Rock	3 = Moderately Weathered Rock	3 = 5 - 10 " 5×10^{-5} - 10^{-4} "
75 - 90% = Good Rock	4 = Hard Rock	4 = Highly Weathered Rock	4 = 10 - 50 " 10^{-4} - 5×10^{-4} "
90 - 100% = Very Good Rock	5 = Very Hard Rock	5 = Completely Weathered Rock	5 = > 50 " > 5×10^{-4} "

Sheet 2 of 2

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Geotechnics Division

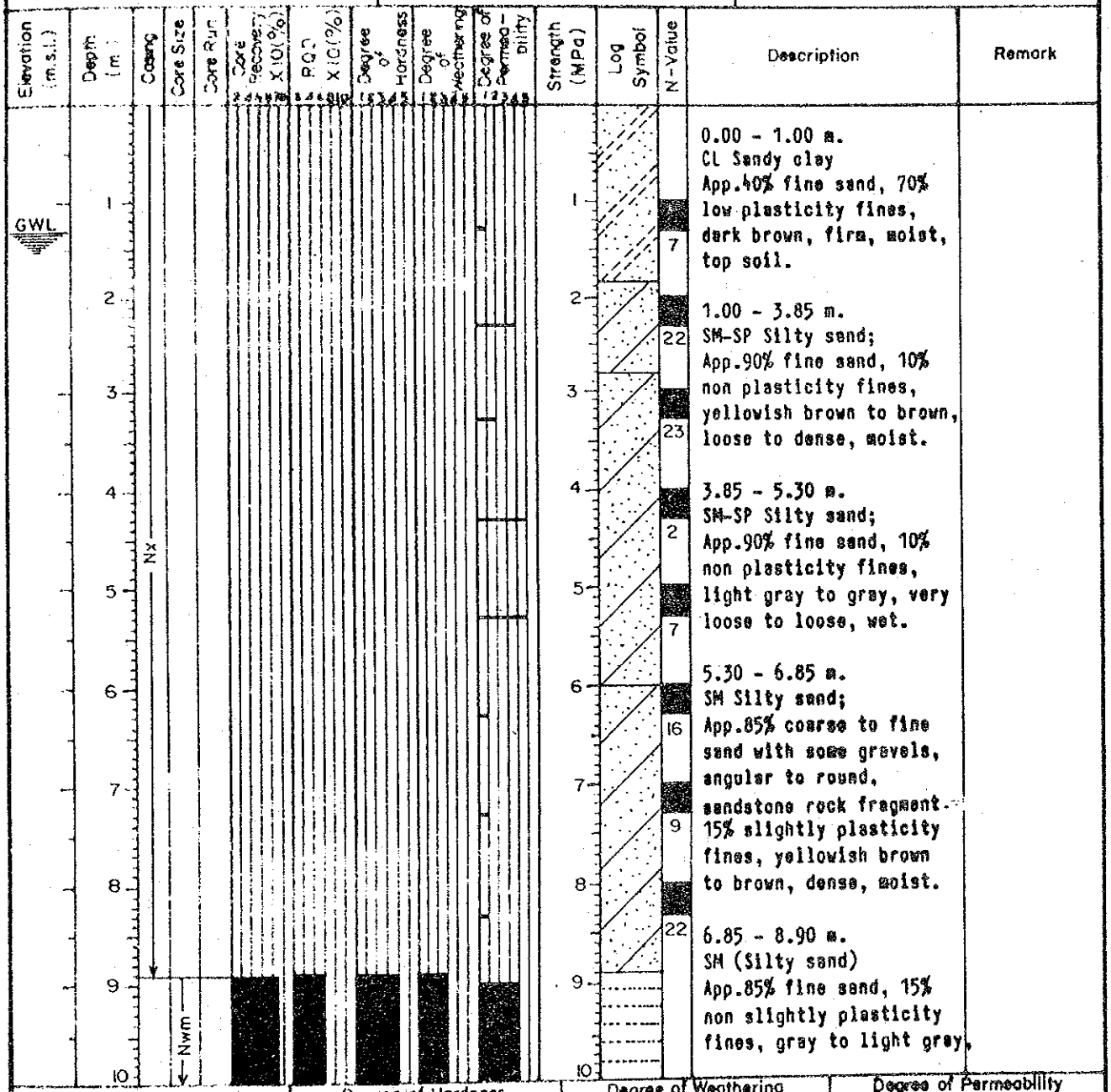
Royal Irrigation Department

GEOLOGIC LOG OF DRILL HOLE

Project Lam Dom Yai (D 28)
Changwat Ubonratchathani
Site ℄ Dam
Location Left bank
Elevation + 131.89

Logged By V. Nipong
Logged Date 28/11/34
Drilling Method Rotary
Drilling Started 23/11/34
Drilling Finished 27/11/34

Hole No. DH-3
Total Depth 20.00 m.
Angle From Vertical 0°
Bearing of Angle Hole
Elevation of Groundwater +130.59



RQD	Degree of Hardness	Degree of Weathering	Degree of Permeability
< 25 % = Very Poor Rock	1 = Very Soft Rock	1 = Fresh rock	1 = < 1 Lugeon or < 10^{-5} cm/Sec
25 - 50 % = Poor Rock	2 = Soft Rock	2 = Slightly Weathered Rock	2 = 1 - 5 " 10^{-5} - 5×10^{-5} "
50 - 75 % = Fair Rock	3 = Medium Hard Rock	3 = Moderately Weathered Rock	3 = 5 - 10 " 5×10^{-5} - 10^{-4} "
75 - 90 % = Good Rock	4 = Hard Rock	4 = Highly Weathered Rock	4 = 10 - 50 " 10^{-4} - 5×10^{-4} "
90 - 100 % = Very Good Rock	5 = Very Hard Rock	5 = Completely Weathered Rock	5 = > 50 " > 5×10^{-4} "

Sheet 1 of 2

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