














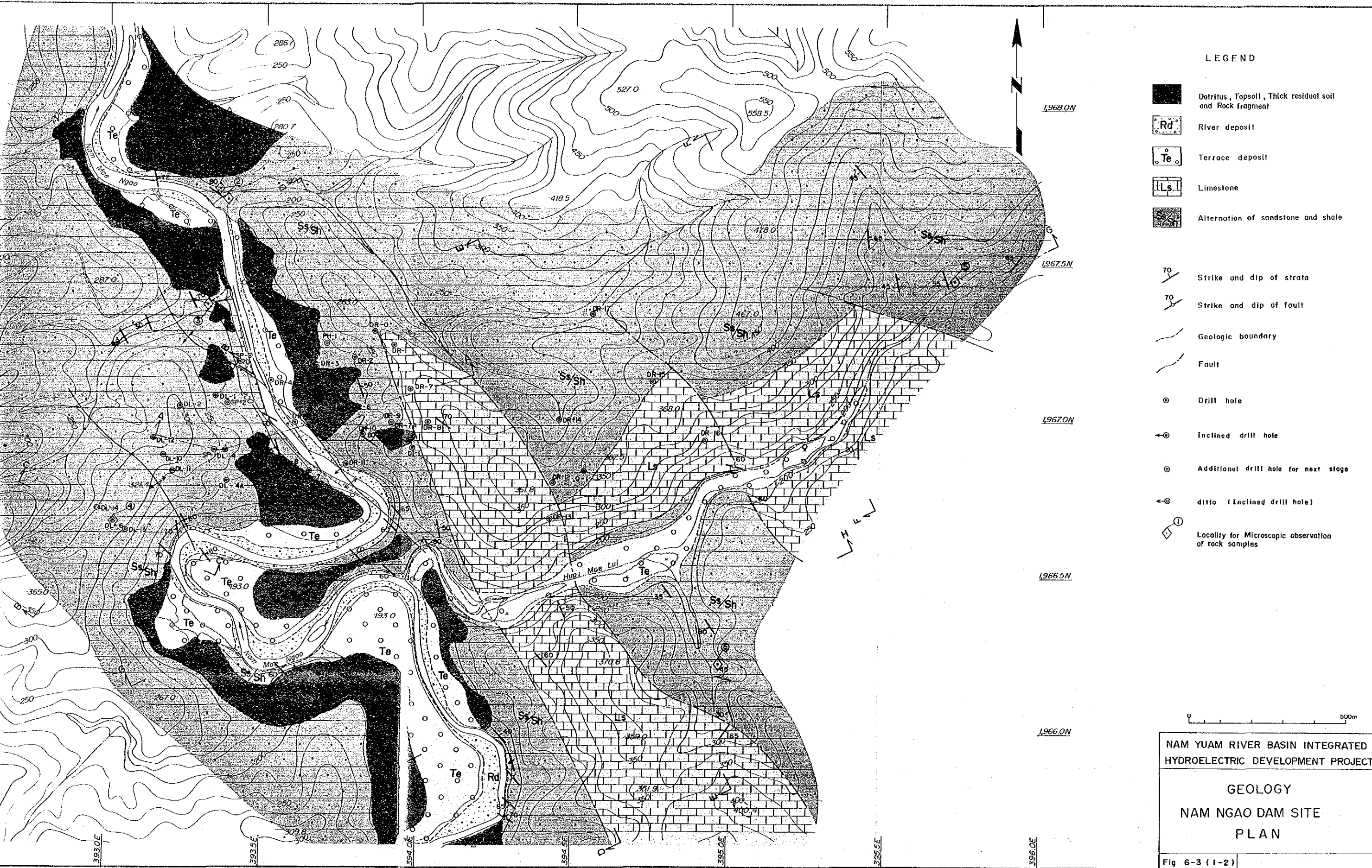
















LEGEN

-  Detritus, Top and Rock fra
-  River depos
-  Terrace de
-  Limestone
-  Alternation
-  Strike and
-  Strike and
-  Geologic b
-  Fault
-  Drill hole
-  Inclined dr
-  Additional
-  ditto (Inc
-  Locality for 1
-  of rock samp

NAM YUAM RIV  
HYDROELECTRIC  
GE  
NAM NGA  
P  
Fig 6-3 (1-2)



LEGEND

-  Debris, Topsoil, Thick residual soil and Rock fragment
-  River deposit
-  Terrace deposit
-  Limestone
-  Alternation of sandstone and shale
-  70° Strike and dip of strata
-  70° Strike and dip of fault
-  Geologic boundary
-  Fault
-  Drill hole
-  Inclined drill hole
-  Additional drill hole for next stage
-  ditto (Inclined drill hole)
-  Locality for Microscopic observation of rock samples

NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

GEOLOGY  
NAM NGAO DAM SITE  
PLAN
















Fig 6-3 (1-2)







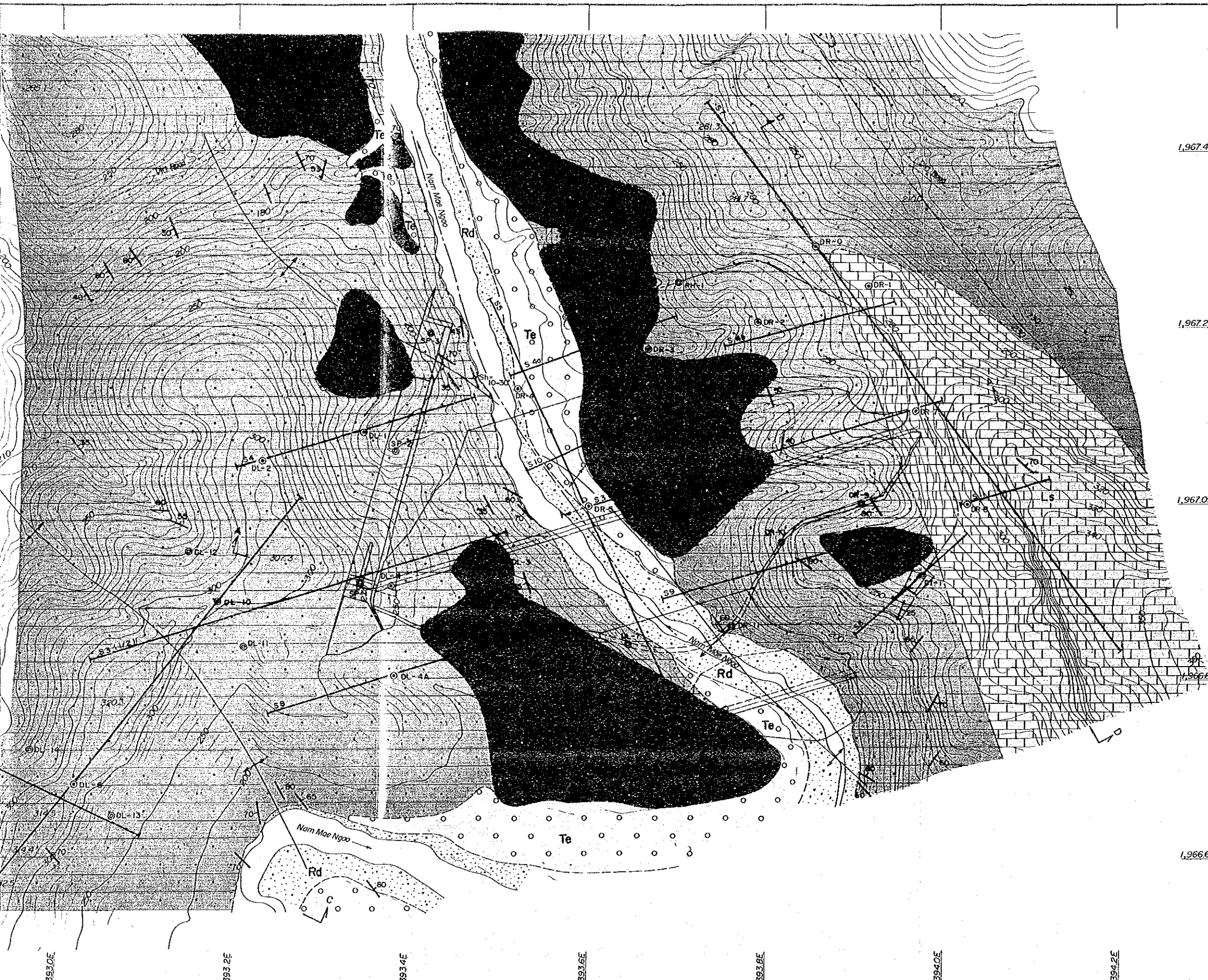
LEGEND

-  Detritus, Top and Rock fra
-  River depos
-  Terrace dep
-  Limestone
-  Alternation
-  Strike and
-  Geologic b
-  Fault
-  Axis of
-  Seismic P
-  Drill hole
-  Inclined dr
-  Additional
-  ditto (Inc
-  Adit for Furt
















NAM YVAM RIV  
HYDROELECTRIC

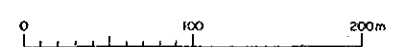
GI  
NAM NGAO  
F

Fig. 6-3 (2-2)



LEGEND

-  Detritus, Topsoil, Thick residual soil and Rock fragment
-  River deposit
-  Terrace deposit
-  Limestone
-  Alternation of sandstone and shale
-  70 Strike and dip of strata
-  Geologic boundary
-  Fault
-  Axis of Anticline
-  Seismic Prospecting line
-  Drill hole
-  Inclined drill hole
-  Additional drill hole for next stage
-  ditto (Inclined drill hole)
-  Adit for Further Investigation



NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

GEOLOGY  
NAM NGAO DAM SITE  
PLAN

Fig. 6-3 (2-2)





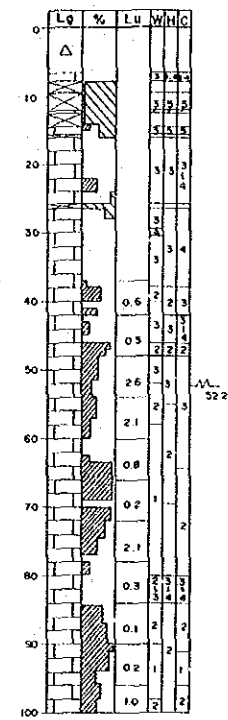
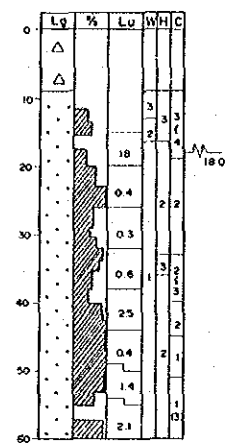
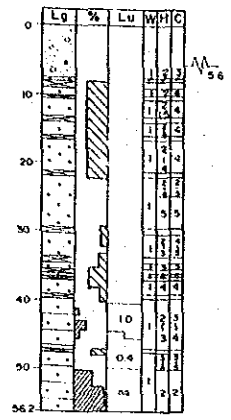
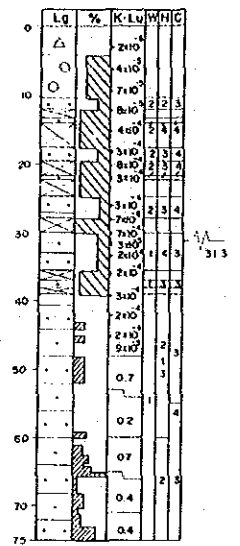
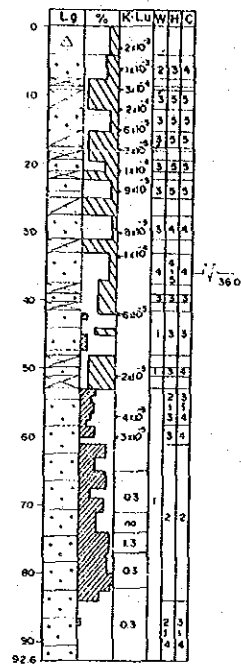
DL - 4  
EL. 254.45m  
L. 92.60m

DL - 3  
EL. 202.04m  
L. 75.0m

DR - 5  
EL. 166.11m  
L. 56.2m

DR - 6  
EL. 201.73m  
L. 60.0m

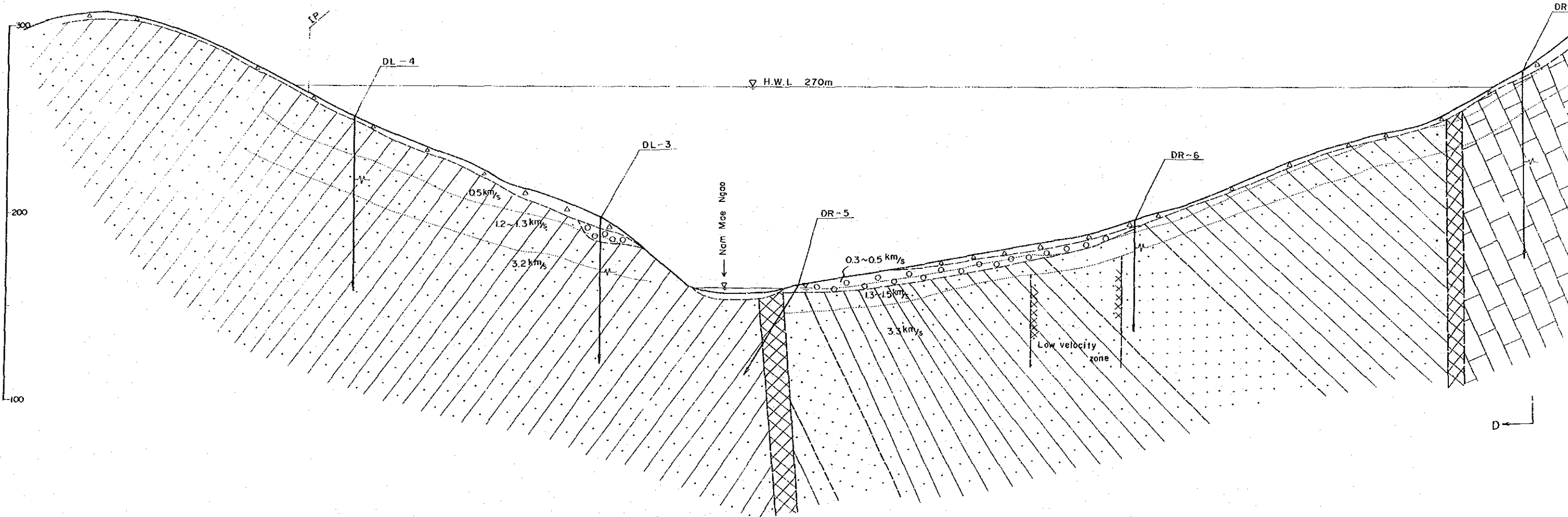
DR - 7  
EL. 279.97m  
L. 100.0m

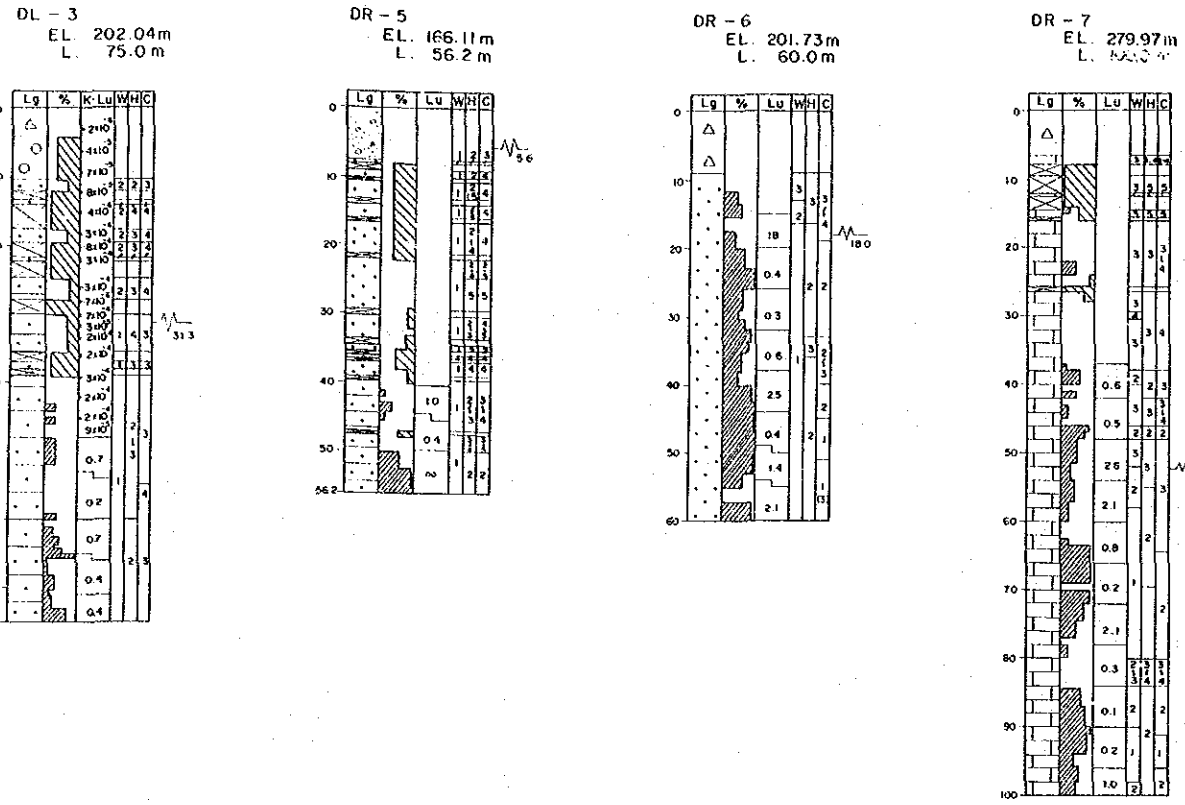


LEGEN

- (For Profile)
- Deiritus, Topsoil, Thick residuc soil and rock fragments
  - River deposit
  - Terrace deposit
  - Limestone
  - Sandstone
  - Alternation of sandstone and shale
  - Geologic boundary
  - Fault, Sheared zone
  - Seismic velocity and its boundary
  - Drill hole
  - Drill hole (projection)

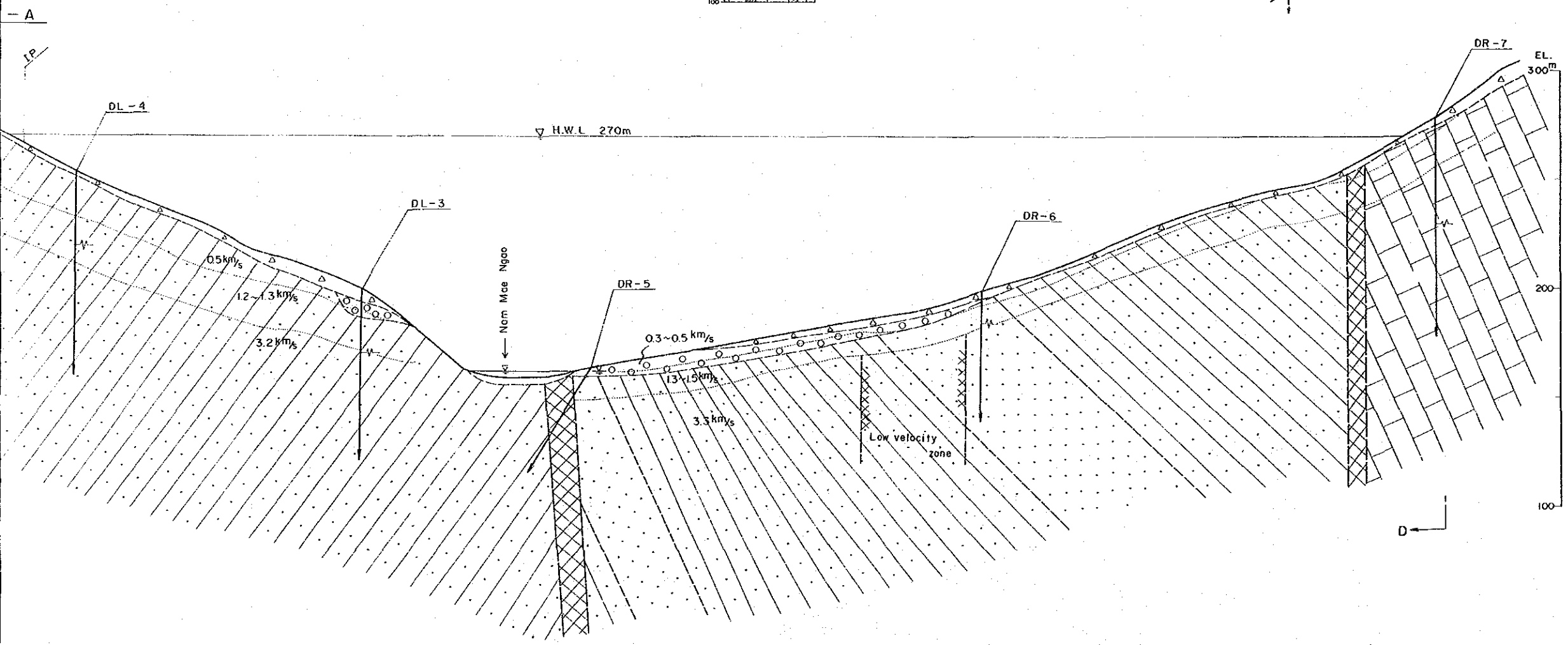
A - A





**LEGEND**

- (For Profile)
- Detritus, Topsoil, Thick residual soil and rock fragments
  - River deposit
  - Terrace deposit
  - Limestone
  - Sandstone
  - Alternation of sandstone and shale
  - Geologic boundary
  - Fault, Sheared zone
  - Seismic velocity and its boundary
  - Drill hole
  - Drill hole (projection)
- (For Core log)
- Geologic column
- Lugeon value or Permeability coefficient
- Core evaluation
- |    |   |    |   |   |   |
|----|---|----|---|---|---|
| Lg | % | Lu | W | H | C |
| 10 | 3 | 3  | 5 | 5 | 5 |
| 10 | 4 | 4  | 4 | 4 | 4 |
- No test  
Core loss (%)  
RQD (%)
- Groundwater table (measured on Feb.24.89)
- Detritus deposits
  - River deposit
  - Terrace deposit
  - Limestone
  - Sandstone
  - Alternation of sandstone and shale
  - Core loss
- W : Weathering  
1 : Fresh  
5 : Decomposed  
H : Hardness  
5 : Hard  
5 : Soft  
C : Core cutting  
1 : Stick  
5 : Grain



NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

**GEOLOGY**

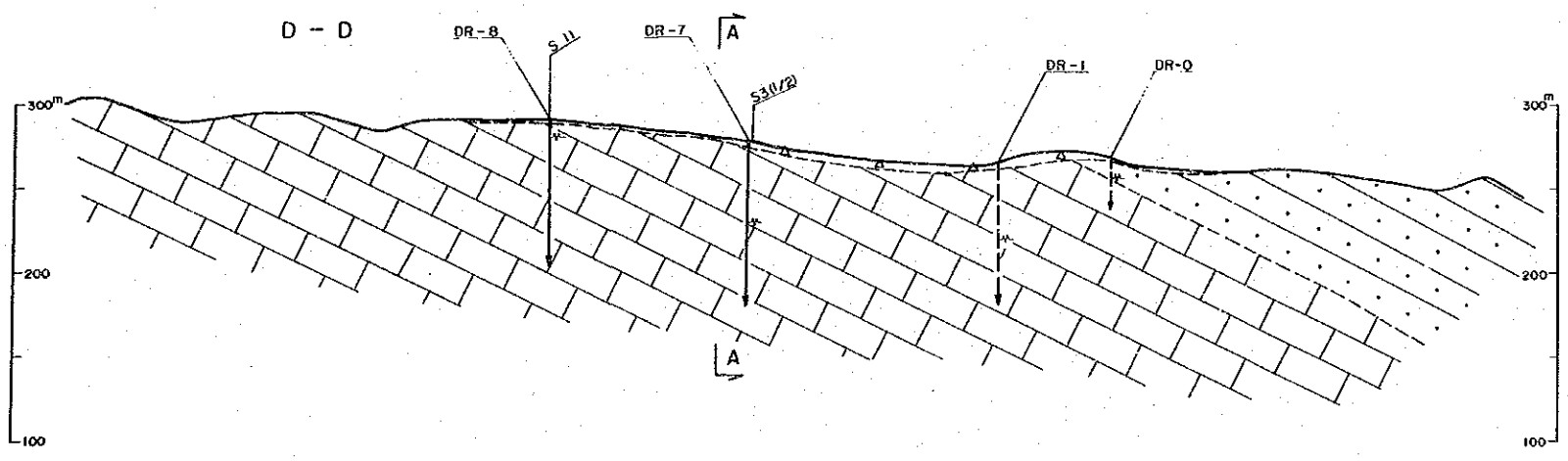
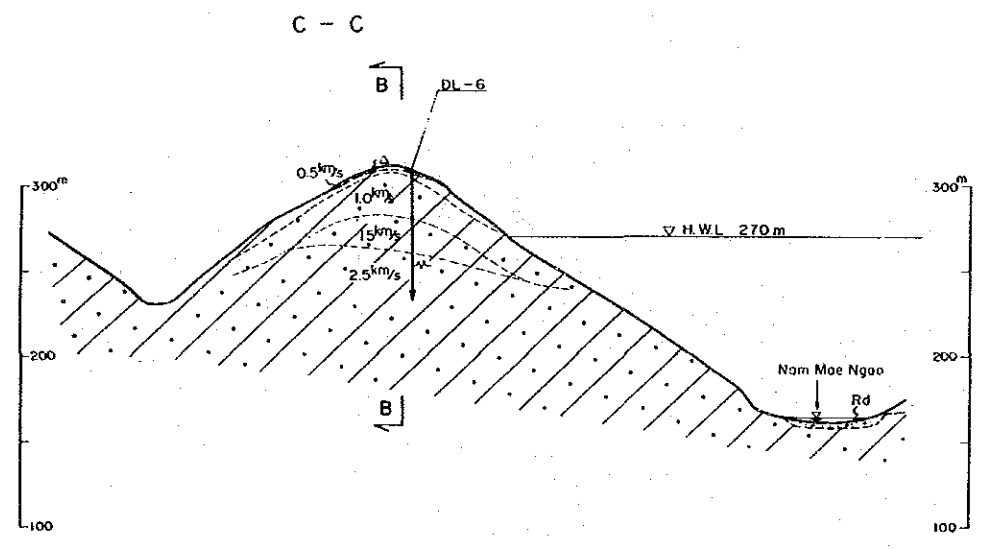
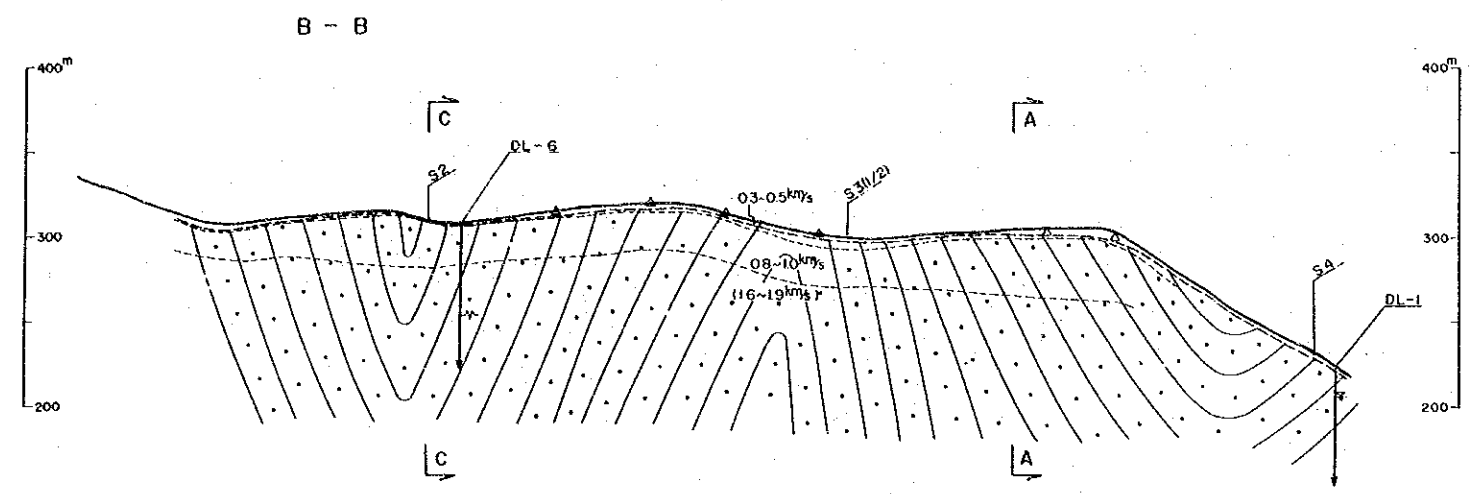
NAM NGAO DAM SITE

**PROFILE**

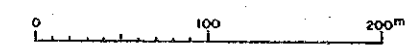
Fig. 6-4 (1-3)







- LEGEND**
- Detritus, Topsoil, Thick residual soil and Rock fragment
  - River deposit
  - Terrace deposit
  - Limestone
  - Alternation of sandstone and shale
  - Geologic boundary
  - Seismic velocity and its boundary
  - Drill hole
  - Groundwater table in drill hole
  - Drill hole (projection)



NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

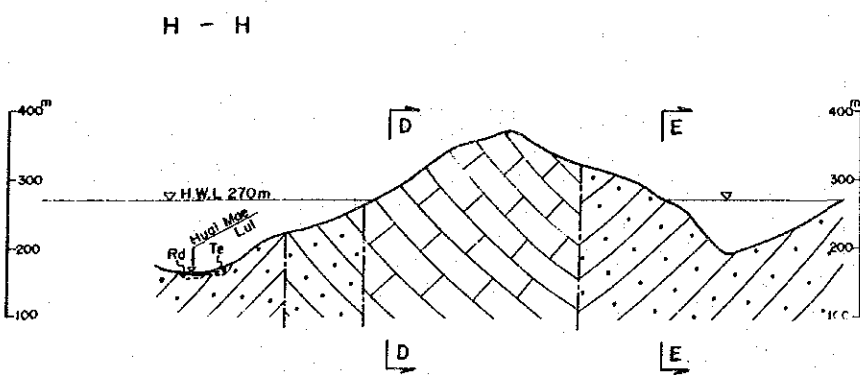
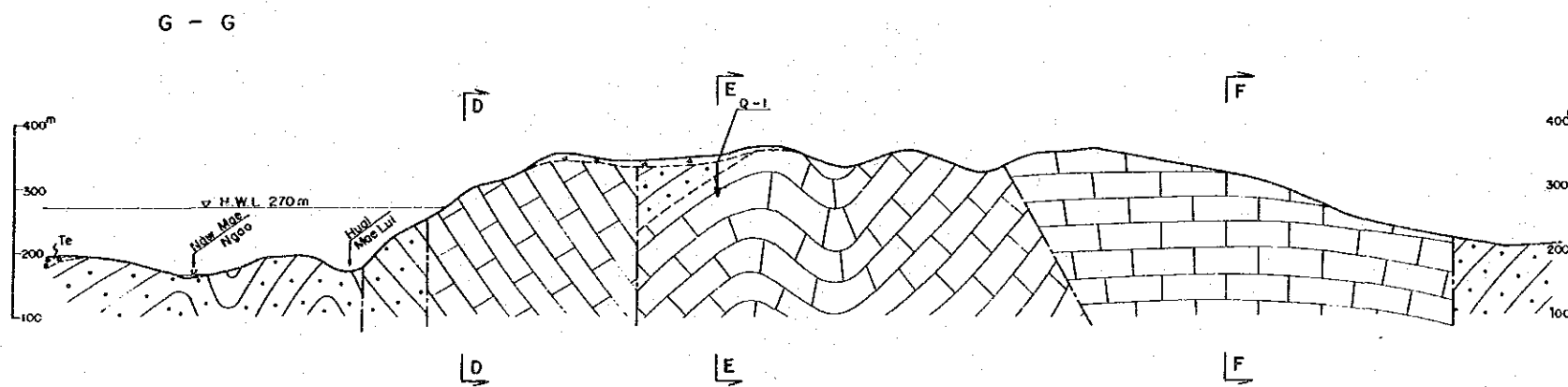
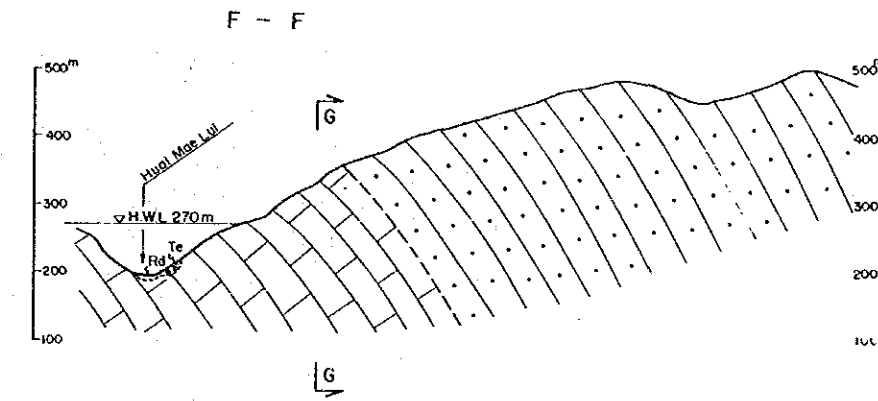
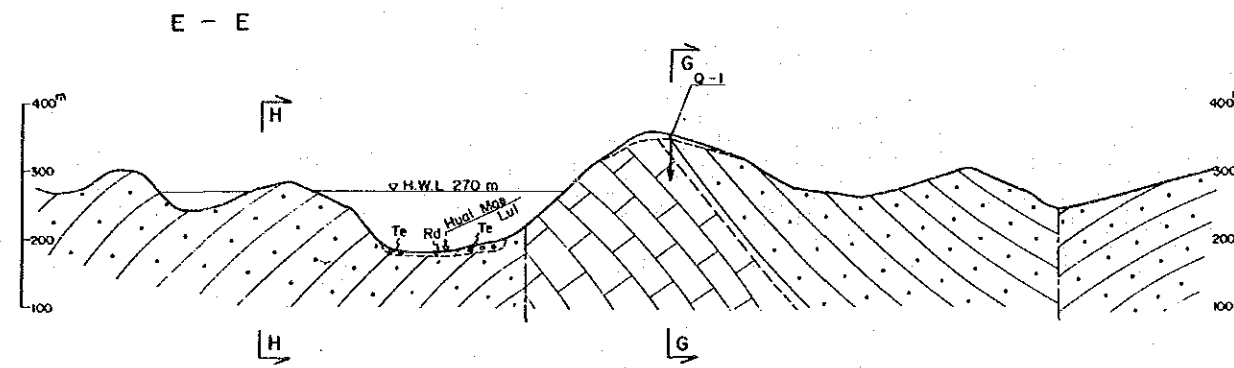
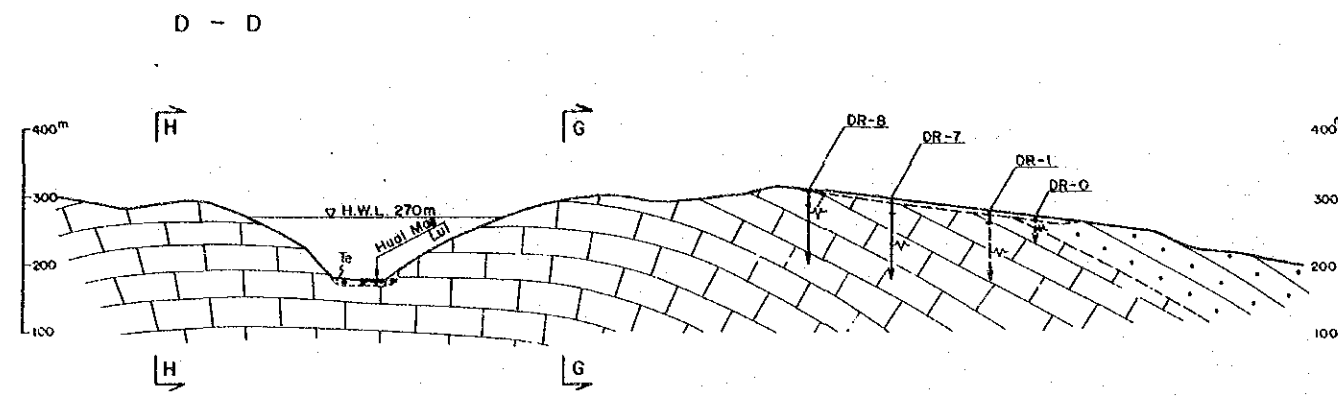
**GEOLOGY**

**NAM NGAO DAM SITE**

**PROFILE**

Fig 6-4 (2-3)





LEGEND

- |  |  |  |                                   |
|--|--|--|-----------------------------------|
|  | Detritus, Topsoil, Thick residual soil and Rock fragment |  | Geologic boundary                 |
|  | River deposit  |  | Fault                             |
|  | Terrace deposit  |  | Seismic velocity and its boundary |
|  | Limestone  |  | Drill hole                        |
|  | Alternation of sandstone and shale                       |  | Groundwater table in drill hole   |
|  |  |  | Drill hole (projection)           |



NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

GEOLOGY  
NAM NGAO DAM SITE  
PROFILE

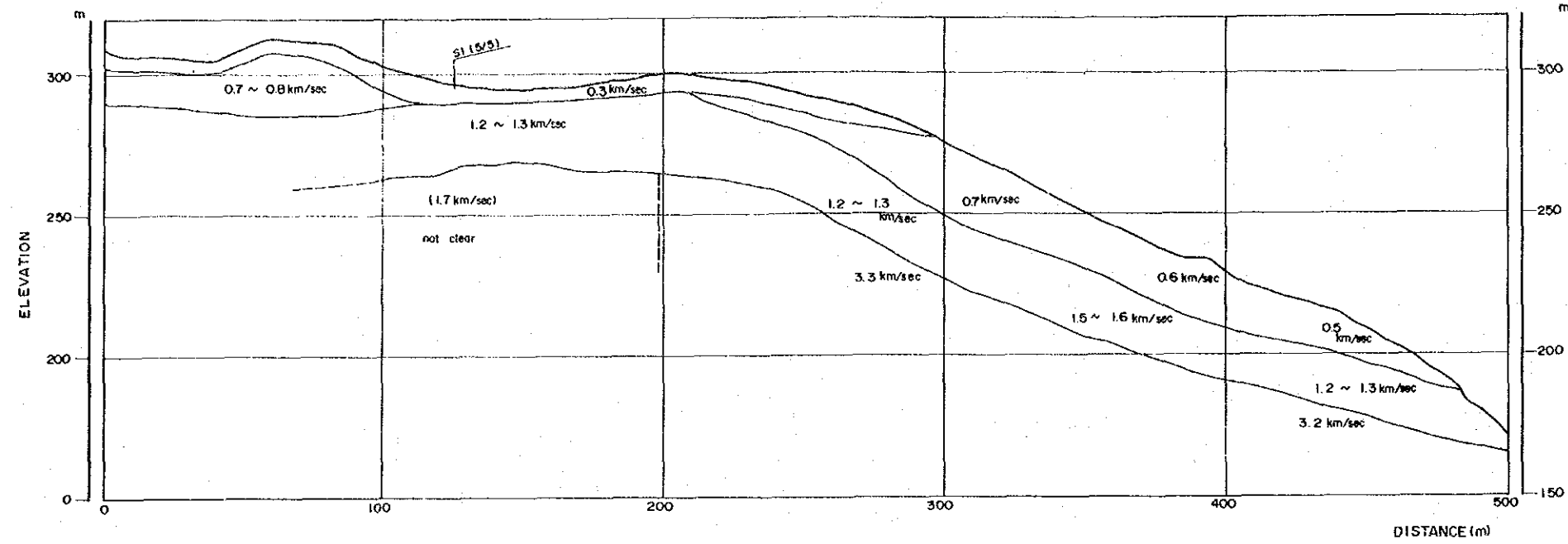
Fig 6-4 (3-3)



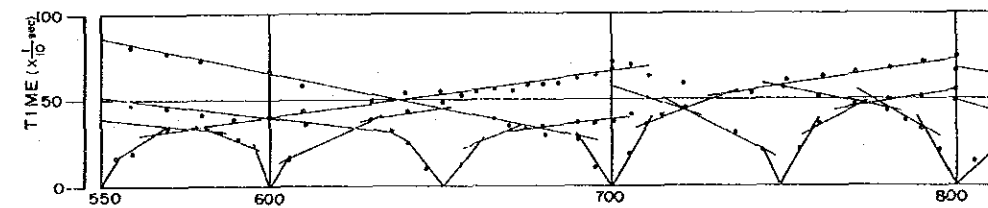
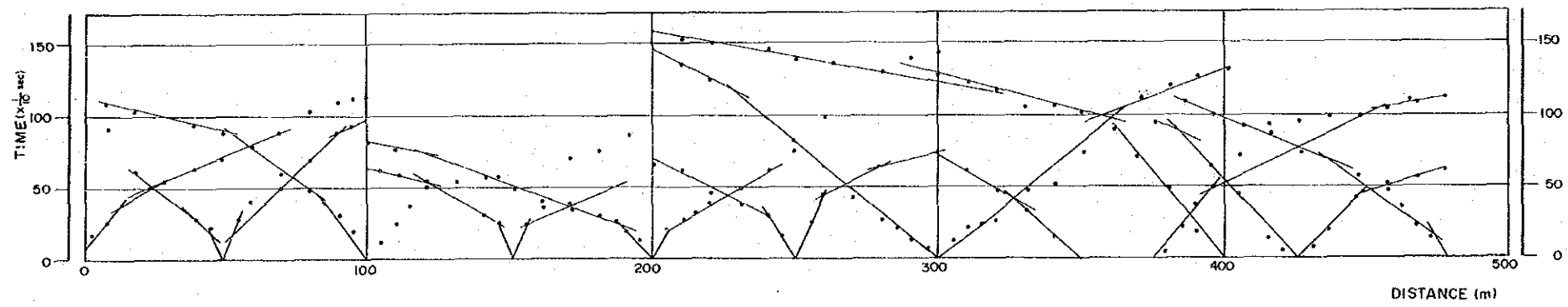
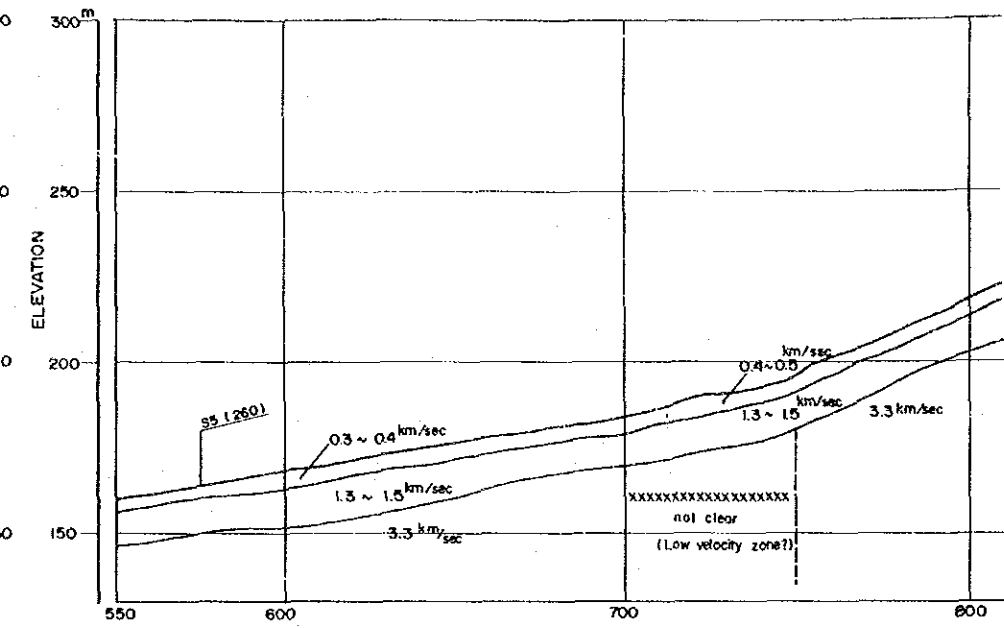


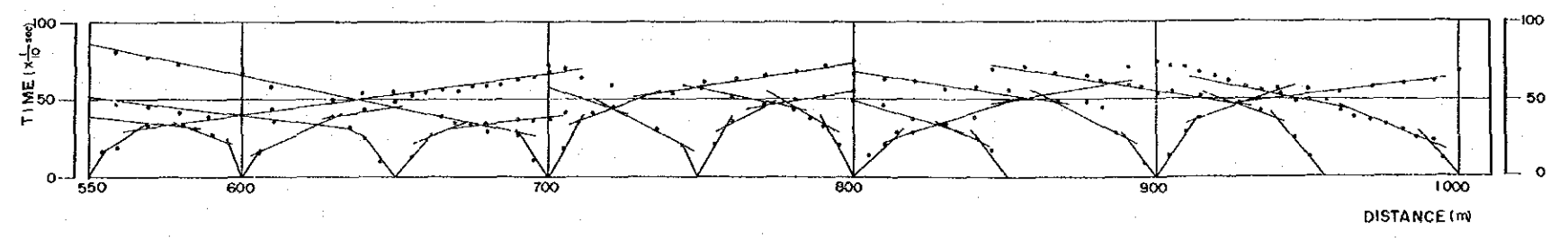
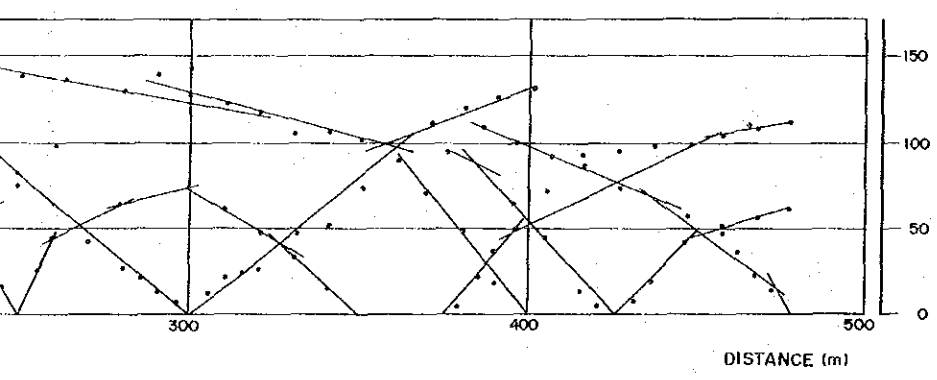
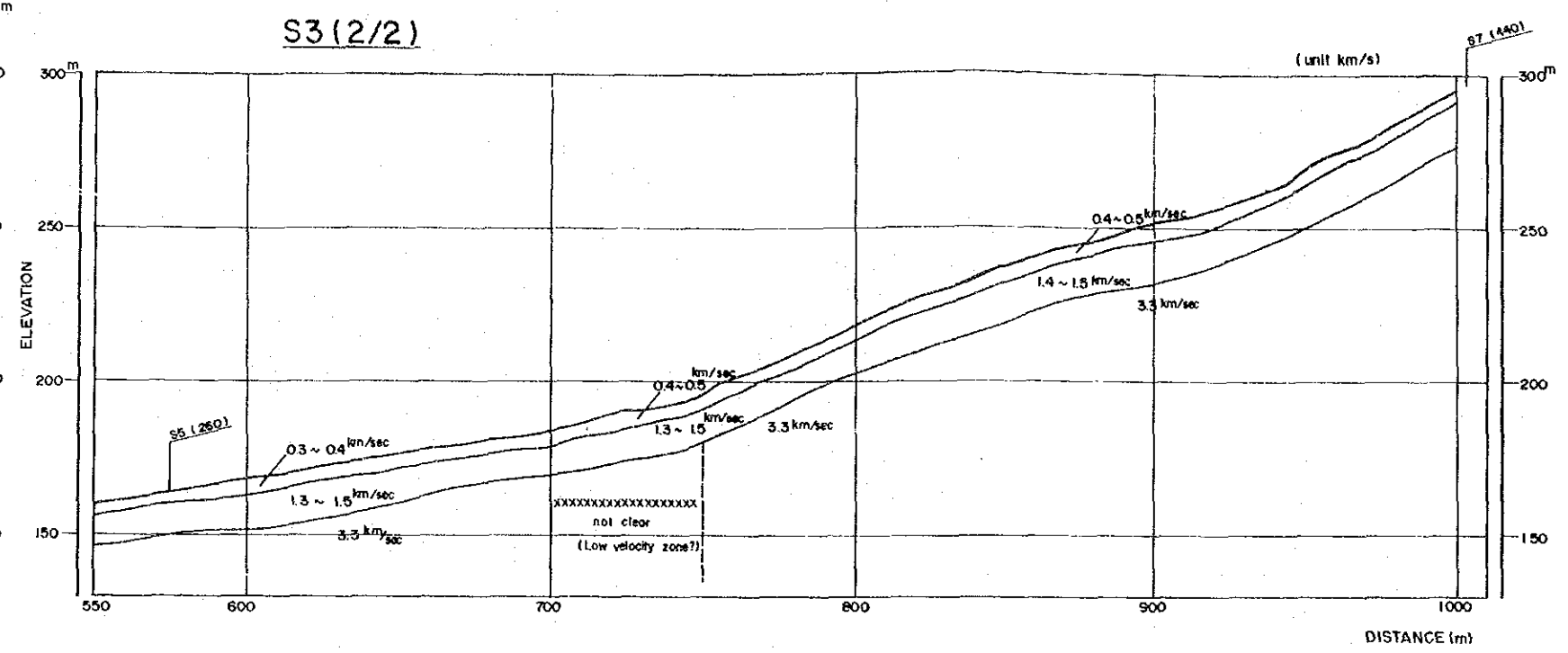
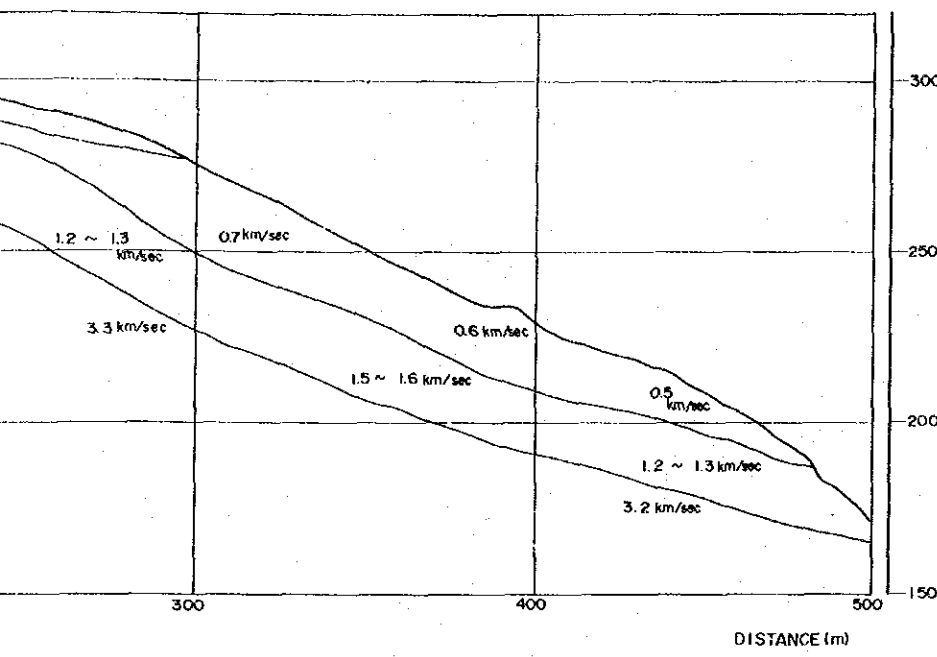
S3 (1/2)

(UNIT ) km /sec



S3 (2/2)





NAM YUAM RIVERBASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

GEOLOGY

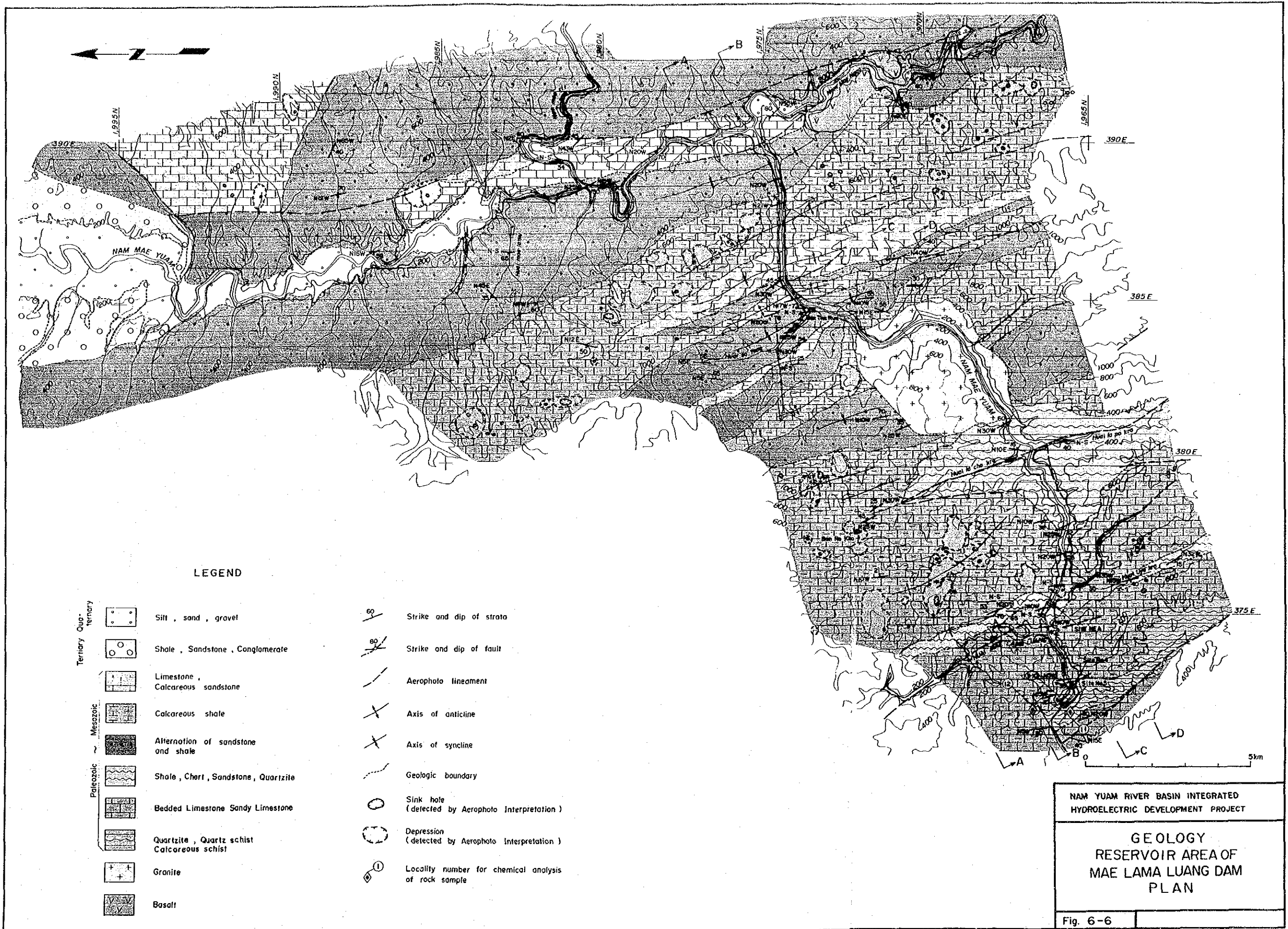
SEISMIC PROFILE and TIME DISTANCE CURVE

S3(1/2), S3(2/2) lines

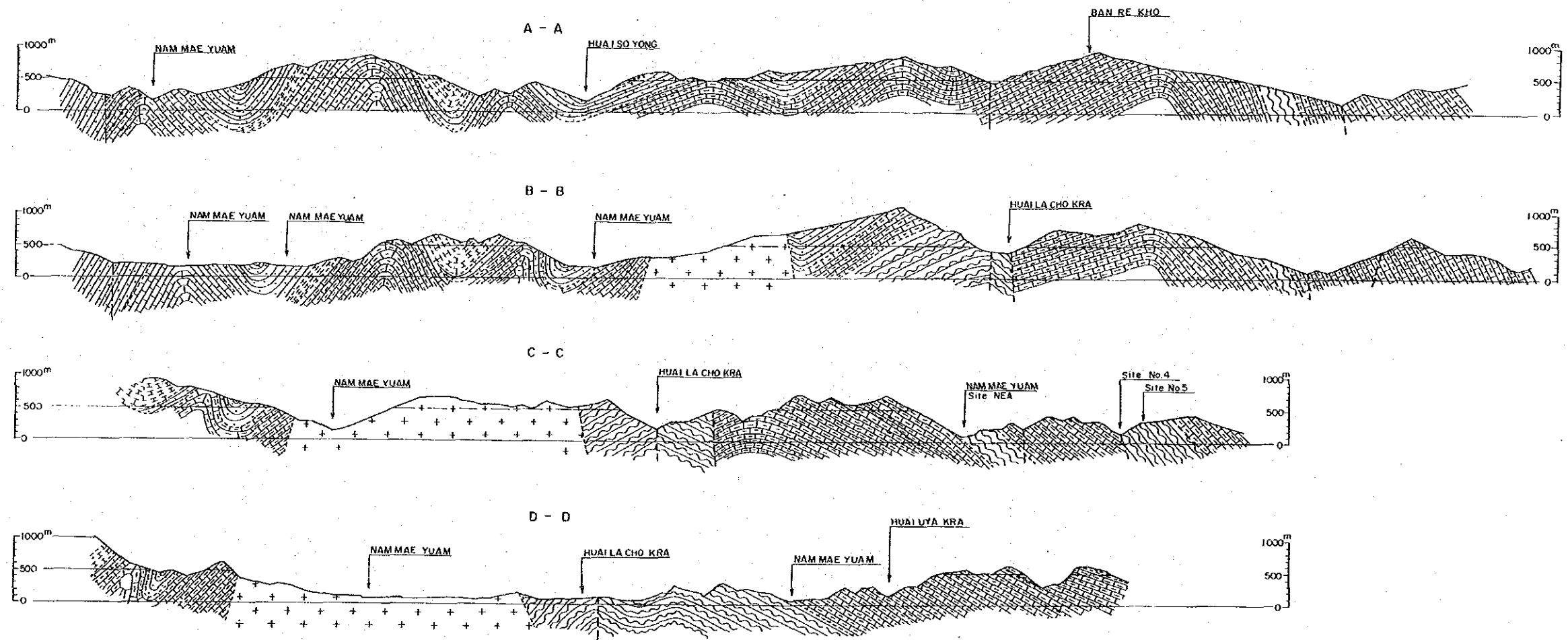
Fig. 6 - 5











**LEGEND**

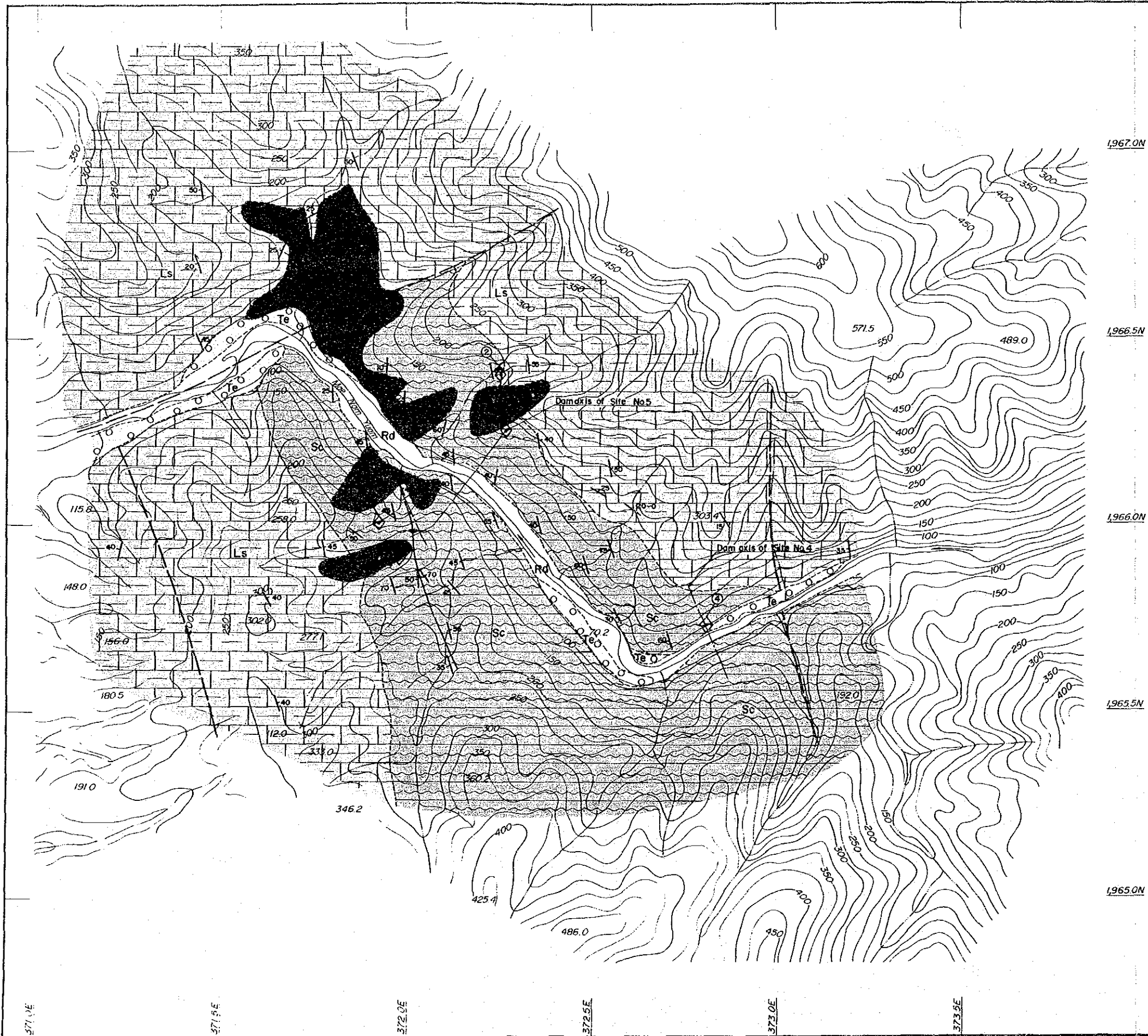
- |                      |  |  |  |                     |
|----------------------|--|--|--|---------------------|
| Paleozoic ~ Mesozoic |  | Limestone                                  |  | Granite             |
|                      |  | Calcareous sandstone                       |  | Fault               |
|                      |  | Calcareous shale                           |  | Aerophoto lineament |
|                      |  | Alternation of sandstone and shale         |  | Geologic boundary   |
|                      |  | Shale Chert, Sandstone Quartzite           |  |                     |
|                      |  | Bedded Limestone Sandy Limestone           |  |                     |
|                      |  | Quartzite, Quartz Schist Calcareous Schist |  |                     |



NAM YUAM RIVER BASIN INTEGRATED HYDROELECTRIC DEVELOPMENT PROJECT	
GEOLOGY	
RESERVOIR AREA OF MAE LAMA LUANG DAM	
PROFILE	
Fig 6 - 7	







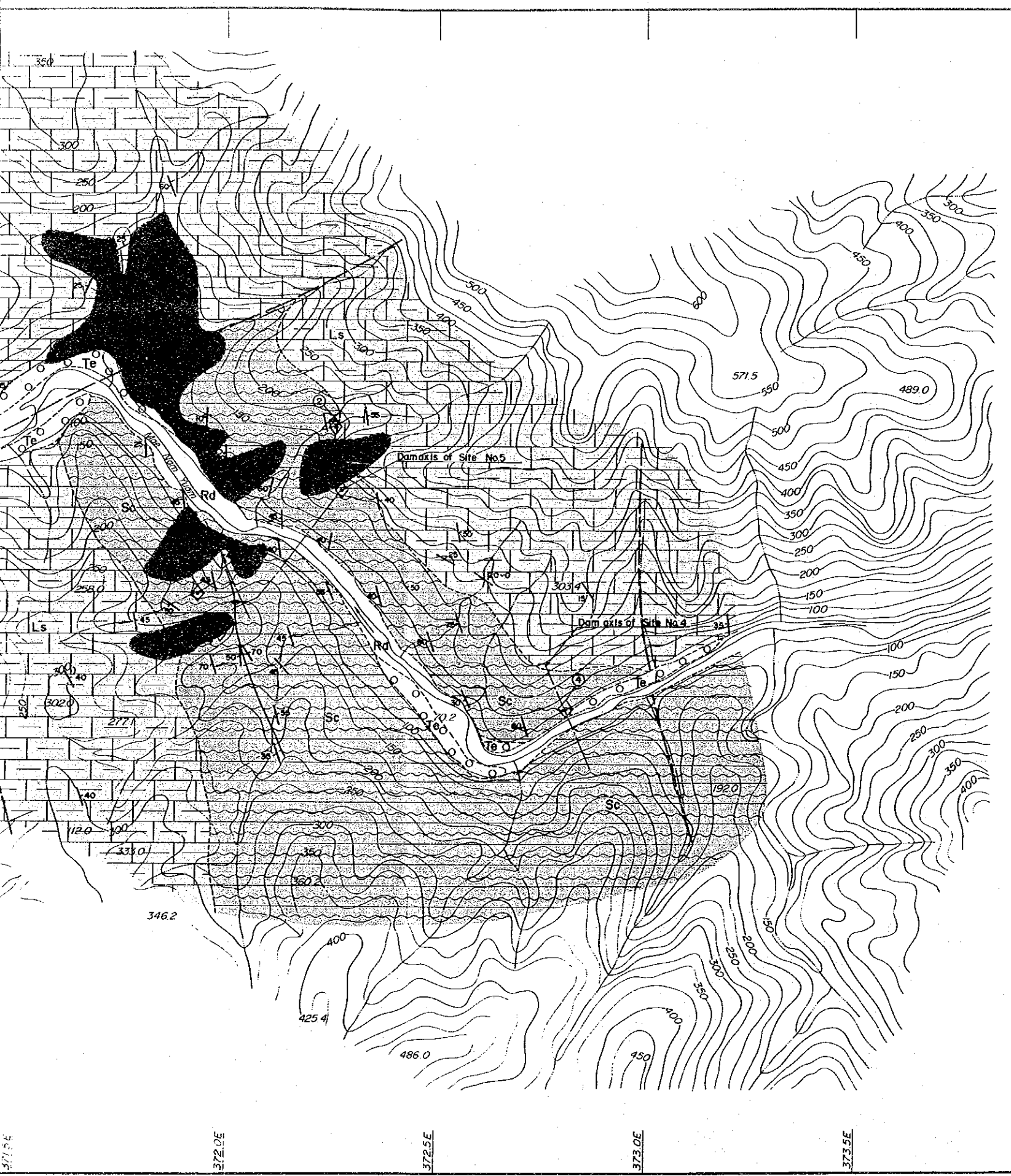
LEGENI

- Detritus, Tops and rock fra
- Rd River deposit
- Te Terrace deposi
- Ls Limestone
- Sc Quartzite, Qua and Sandy Li
- 60 Strike and dip
- Geologic bound
- Aerophoto line
- Axis of Antic
- ① Locality for h of rock samp

NAM YUAN  
HYDROELE

MAE L

Fig 6-8 (1)



**LEGEND**

- Detritus, Topsoil, Thick residual soil and rock fragments
- Rd River deposit
- Te Terrace deposit
- Ls Limestone
- Sc Quartzite, Quartz Schist, Calcareous Schist and Sandy Limestone
- 60° Strike and dip of strata
- Geologic boundary
- Aerophoto lineament
- Axis of Anticline
- ① Locality for Microscopic observation of rock samples

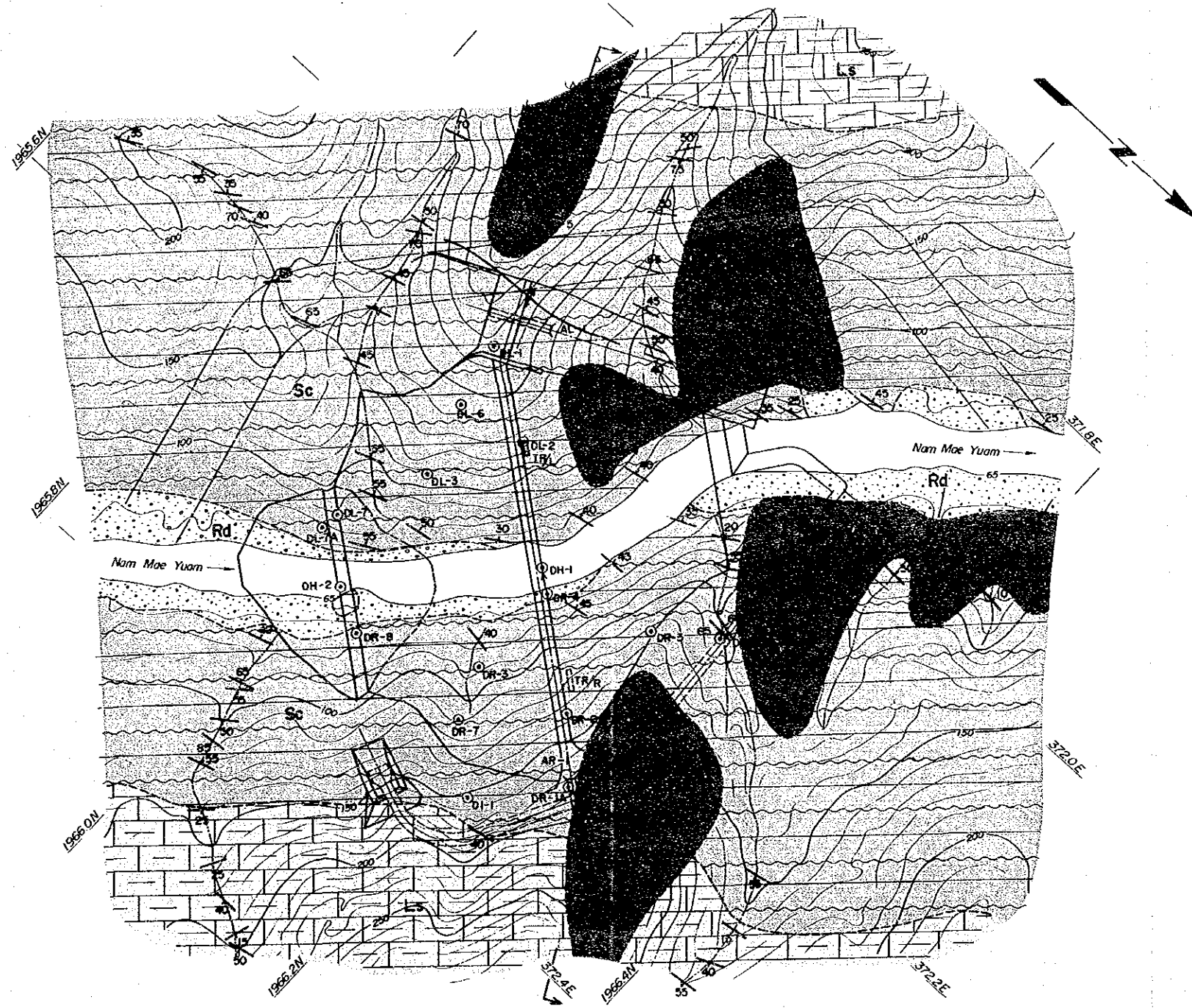


NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT












**GEOLOGY  
MAE LAMA LUANG DAM SITE  
PLAN**

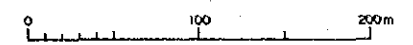
Fig. 6-8 (1-2)





**LEGEND**

-  Detritus, Topsoil, Thick residual soil and rock fragments
-  River deposit
-  Limestone
-  Quartzite, Quartz Schist, Calcareous Schist and Sandy Limestone
-  Strike and dip of strata
-  Geologic boundary
-  Axis of Anticline
-  Axis of Syncline
-  Drill hole (Vertical)
-  Inclined drill hole
-  Adit for Further Investigation



NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

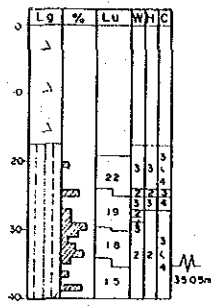
**GEOLOGY**  
MAE LAMA LUANG DAM SITE  
PLAN

Fig. 6 - 8(2-2)

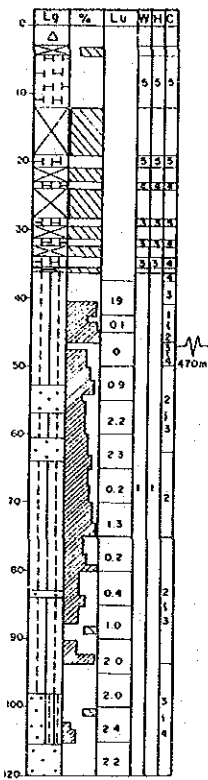




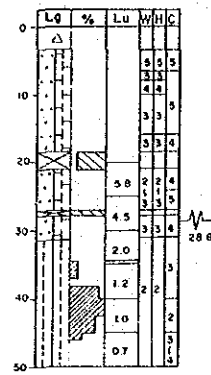
DL - 5  
EL. 201.93m  
L. 40.00m



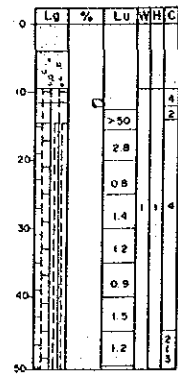
DL - 1  
EL. 166.49m  
L. 110.00m



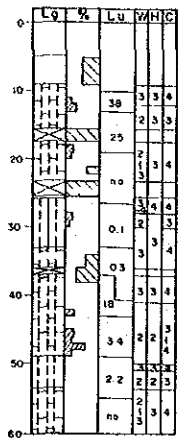
DL - 2  
EL. 126.76m  
L. 50.00m



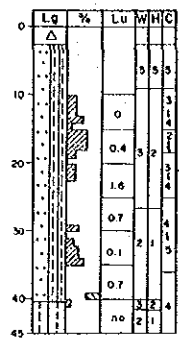
DH - 1  
EL. 61.93m  
L. 50.60m



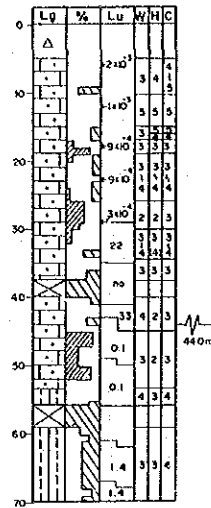
DR - 4  
EL. 65.88m  
L. 60.00m



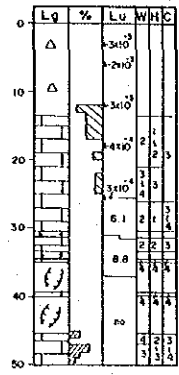
DR - 2  
EL. 133.36m  
L. 45.00m



DR - 1A  
EL. 174.27m  
L. 70.00m

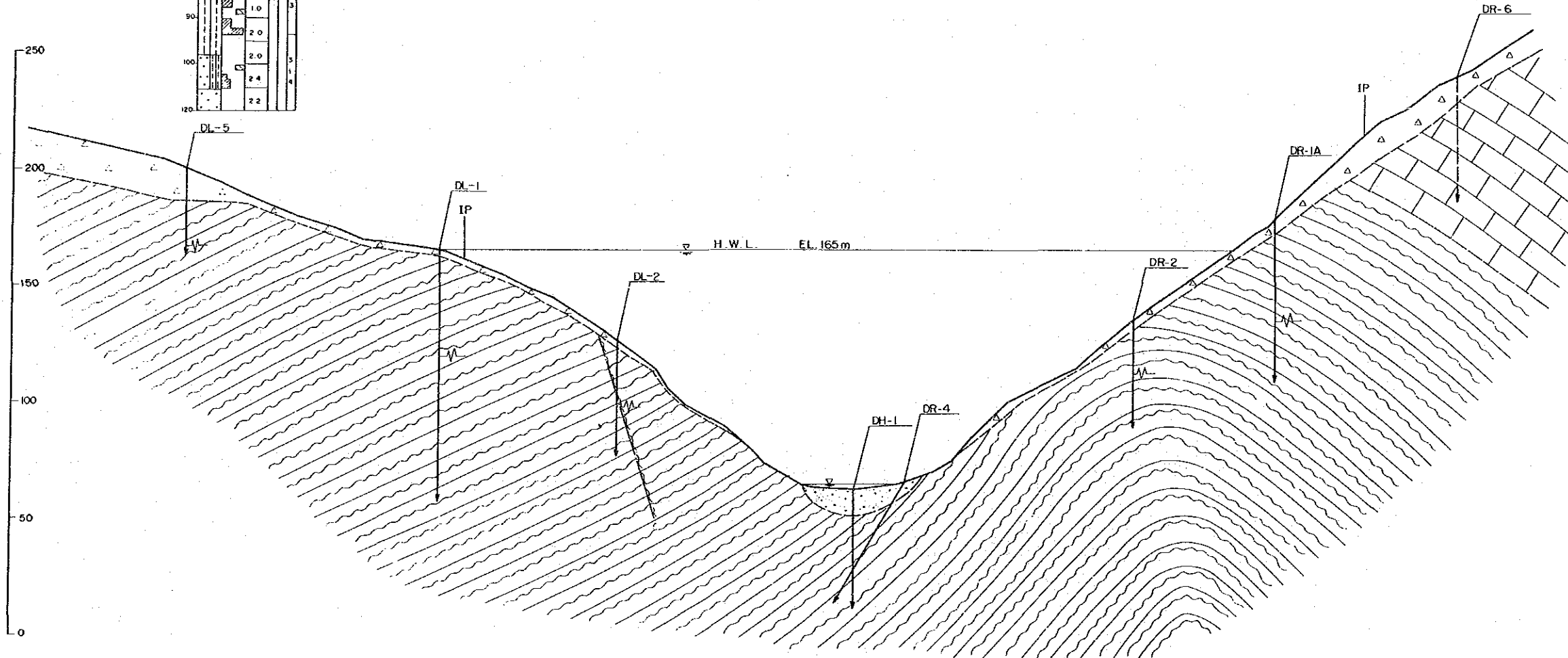


DR - 6  
EL. 236.59m  
L. 50.00m

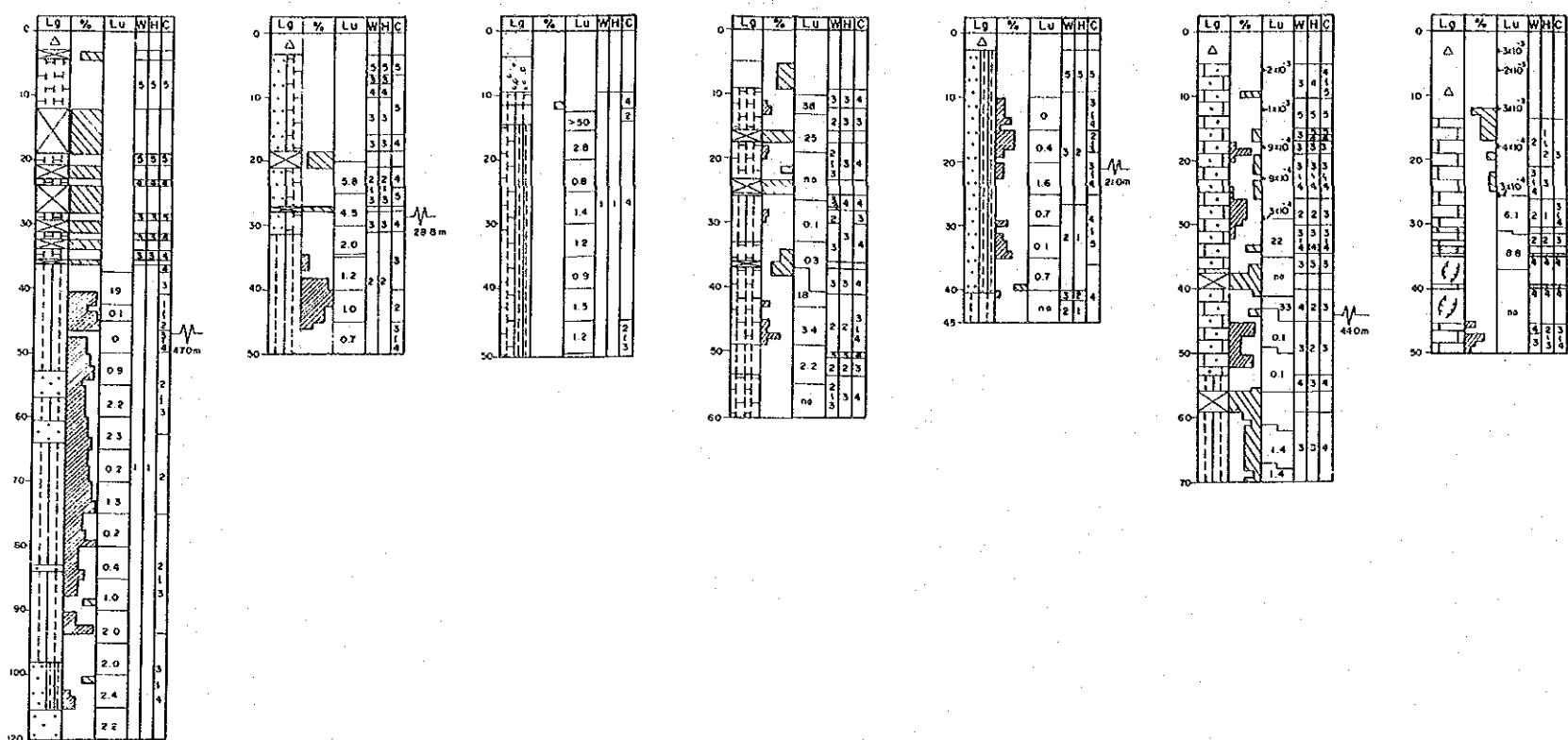


LEGEND

- (For Profile)
- Detritus, Topsoil, Thick residual soil and rock fragments
  - River deposit
  - Limestone
  - Quartzite, Quartz schist, Calcareous schist and Sandy limestone
  - Geologic boundary
  - Fault (Assumed)
  - Drill hole
  - Drill hole (projection)
- (For Core log)
- Geologic column
- Lugeon value
- Core evaluation
- W : A
- 1 : F
- 5 : C
- H : F
- 1 : F
- 5 : S
- C : C
- 1 : C
- 5 : C
- No test
- Core loss (%)
- RQD (%)
- Groundwater table (measured on Feb. 21, '89)
- Detritus deposits
  - River deposit
  - Limestone
  - Sandy limestone
  - Sandstone
  - Quartzite, Quartz schist
  - Calcareous schist
  - Cavity
  - Core loss

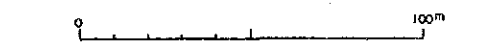
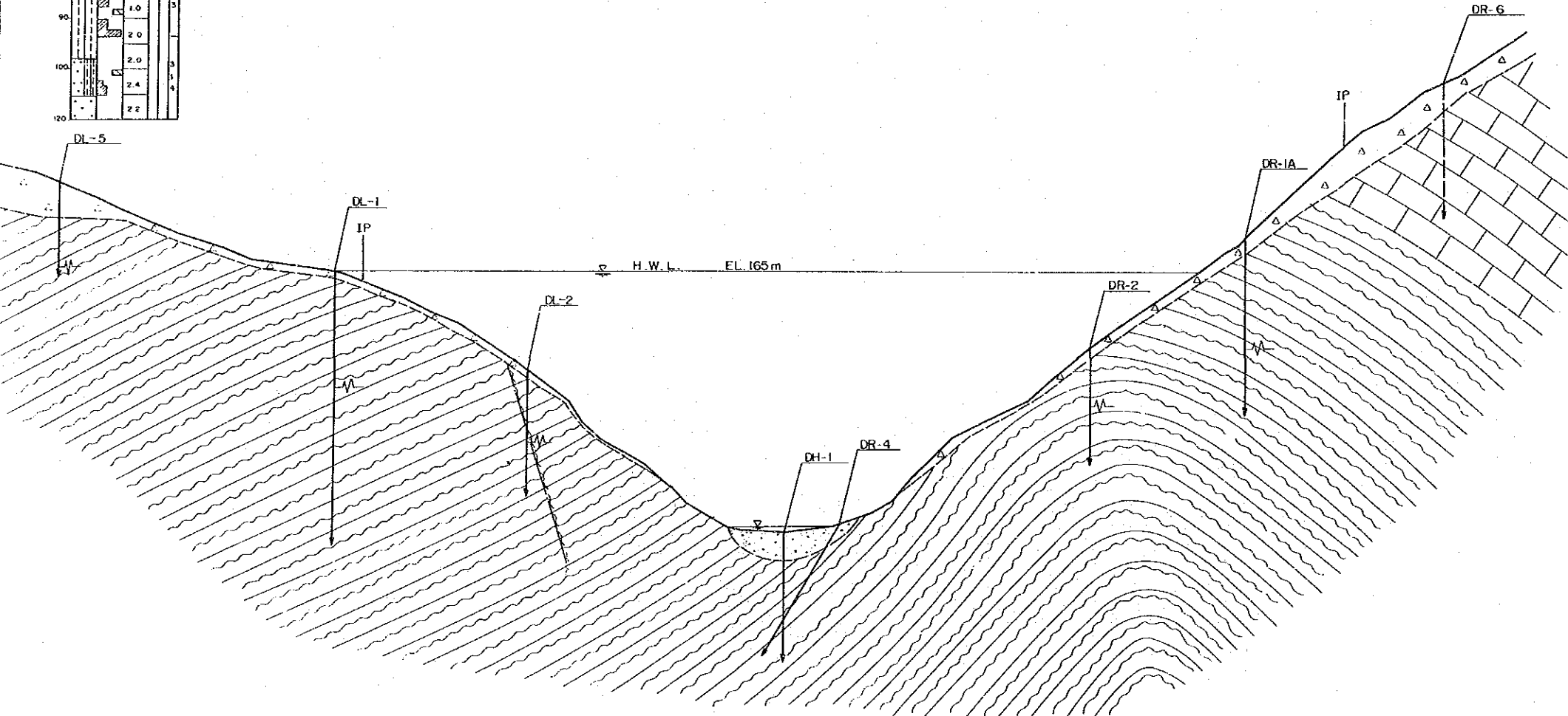


DL - 1 EL. 166.49m L. 110.00m  
 DL - 2 EL. 126.76m L. 500.00m  
 DH - 1 EL. 61.93m L. 50.60m  
 DR - 4 EL. 65.88m L. 60.00m  
 DR - 2 EL. 133.36m L. 45.00m  
 DR - 1A EL. 174.27m L. 70.00m  
 DR - 6 EL. 236.59m L. 50.00m



**LEGEND**

- (For Profile)
- Detritus, Topsoil, Thick residual soil and rock fragments
  - River deposit
  - Limestone
  - Quartzite, Quartz schist, Calcareous schist and Sandy limestone
  - Geologic boundary
  - Fault (Assumed)
  - Drill hole
  - Drill hole (projection)
- (For Core log)
- Geologic column
- Lugeon value or Permeability coefficient
- Core evaluation
- W : Weathering  
 1 : Fresh  
 5 : Decomposed
- H : Hardness  
 1 : Hard  
 5 : Soft
- C : Core cutting  
 1 : Stick  
 5 : Groin
- No test  
 Core loss (%)
- RQD (%)
- Groundwater table (measured on Feb. 21, '89)
- Detritus deposits
  - River deposit
  - Limestone
  - Sandy limestone
  - Sandstone
  - Quartzite, Quartz schist
  - Calcareous schist
  - Cavity
  - Core loss



NAM YUAM RIVER BASIN INTEGRATED  
 HYDROELECTRIC DEVELOPMENT PROJECT

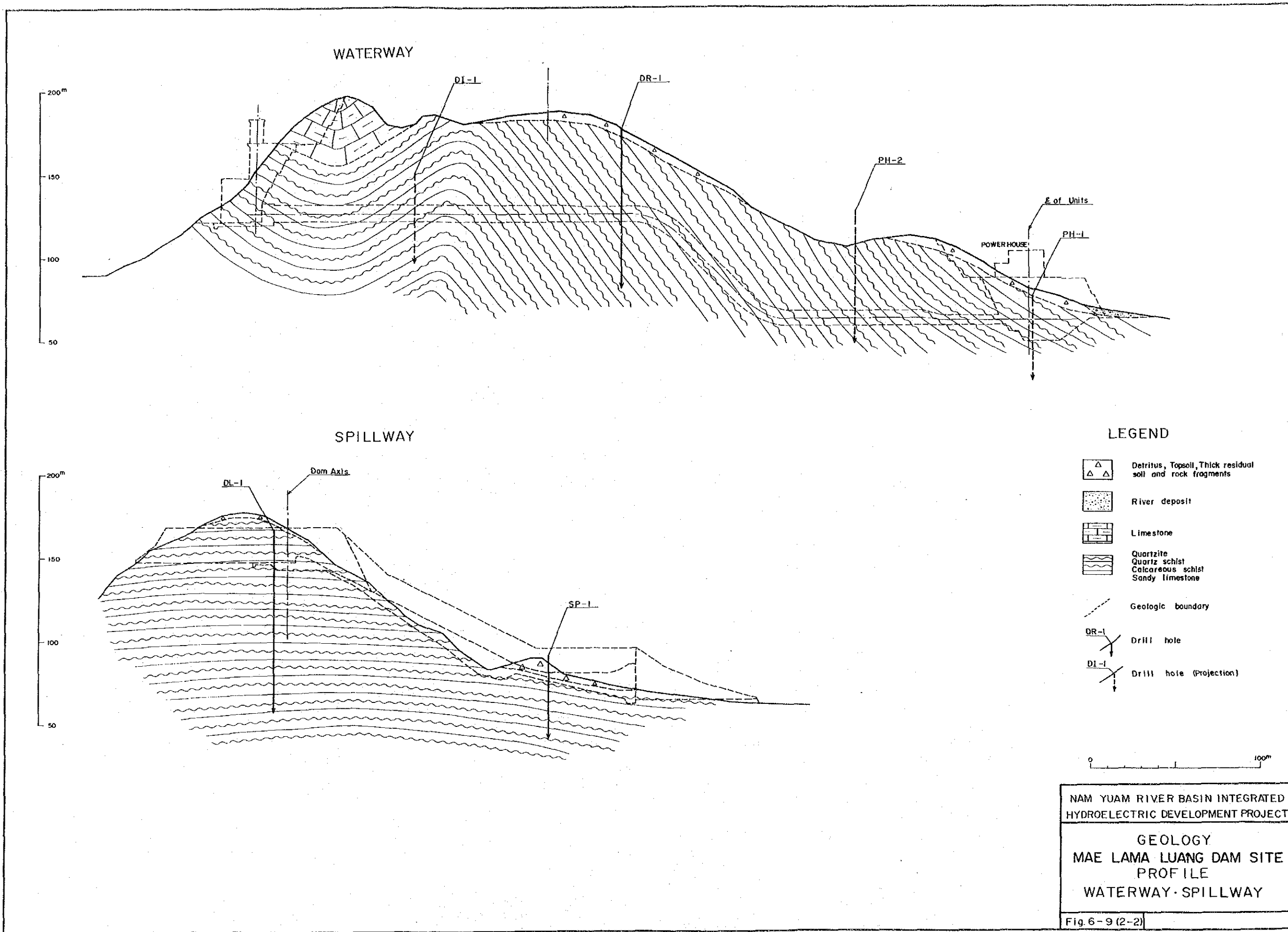
**GEOLOGY**

MAE LAMA LUANG DAM SITE

PROFILE

Fig. 6-9 (1-2)





NAM YUAM RIVER BASIN INTEGRATED  
HYDROELECTRIC DEVELOPMENT PROJECT

GEOLOGY  
MAE LAMA LUANG DAM SITE  
PROFILE  
WATERWAY · SPILLWAY

Fig. 6-9 (2-2)



## 6.4 Construction Materials

### 6.4.1 Nam Ngao Dam

Dam type of the Nam Ngao dam is a rockfill type dam with a concrete facing.

#### (1) Rock Material and Concrete Aggregate

##### - Rock Material

As shown in Fig. 6-10, the ridge on the right bank along the Mae Lui stream upstream of the dam site was selected as a possible quarry site. The geology of the site consists of limestone and alternation of sandstone and shale. The limestone is fresh, hard and massive, and solution cavities are recognized in some parts of the limestone. The alternation of sandstone and shale is slightly weathered.

According to the surface geological survey, it has been revealed that the deposit in the surface layers is thin. This suggests that they are appropriate for use as rock material or concrete aggregate.

##### - Concrete Aggregate

The river deposits used for the transition zone of the dam mentioned in item (2) below can be used for the concrete aggregate. Artificial aggregate from the limestone also can be used for the concrete aggregate.

As for the fine aggregate, it is worth to study the utilization of river deposits distributed in the junction of the Ngao and Yuam rivers.

#### (2) Transition Materials (Filter Materials)

It is conceivable that the fine-particle rock materials obtainable from the aforesaid mountain and the excavation muck to be obtained from the dam and other structures can be utilized as the transition material.



Furthermore, in view of the geology and properties of the soil distributed in the vicinity, the geology that can be considered to be usable as the transition material is the deposits on the bed of the existing river. In this survey, 17 vertical shafts 1.2 to 2.0 m deep were excavated between the location 0.2 km upstream of the dam site and the dam site No. 3 to check the deposits on the bed of the existing river. In addition, 7 vertical shafts 2.7 to 4.8 m deep were excavated between the Mae Lui stream and the dam site No. 3 to check the terrace deposits. The results of the geological tests conducted on the samples taken from these vertical shafts are shown in Table 6-10 and Fig. 6-12.

The results indicate that the river bed deposits have a little better particle size distribution and accordingly are regarded as being usable as the transition material.

However, it appears that the quantity of the reserves of the river bed deposits is small. Because of the fine particle size, the terrace deposits are unsuitable for use as the transition material but are usable as part of the impervious core material.

### (3) Impervious Core Materials

The rockfill dam with concrete facing was selected for the Nam Ngao dam. However, since there is a possibility to adopt the rockfill dam with a clay core in the definite design stage, the impervious core material was also investigated.

Impervious core materials have been investigated at areas A, B, C and D, which are located on the left bank 0.2 km upstream, 0.7 km downstream and on the right bank, 0.1 km, 1 km downstream of the dam site, respectively. The locations of these areas are shown in Fig. 6-10.

The investigation was made in areas A, B and D by digging eighteen test pits of 2 m to 7 m in depth, and in area C by excavating three trenches of 2 m to 7 m in length. The results of the surface geological investigation revealed that materials

distributed in these areas are detritus deposits and residual soil derived from sandstone and shale.

The material test comprising physical tests and mechanical tests have been carried out on samples collected from pits in every area. Collection and testing of samples were carried out by EGAT. The quantity of test pits, trenches and auger drillings are shown in table below.

<u>Item</u>	<u>Quantity</u>				<u>Total</u>
	<u>Area A</u>	<u>Area B</u>	<u>Area C</u>	<u>Area D</u>	
Test pit	7	7	-	4	18
Road cut trench	-	-	3	-	3
Auger drilling	5	5	7	27	44

- Items of Test and Quantity

Items and quantity of tests conducted on the samples obtained from pits dug in the borrow areas A, B, C and D are shown in the table below:

<u>Test Items</u>	<u>Number of Samples</u>				<u>Total</u>
	<u>Area A</u>	<u>Area B</u>	<u>Area C</u>	<u>Area D</u>	
Natural Water Content	11	11	4	5	31
Specific Gravity	11	11	4	5	31
Atterberg Limits	11	11	4	5	31
Gradation	11	11	4	5	31
Compaction	10	11	4	1	26
Permeability	2	2	1	1	6
Tri-axial Compression	2	2	1	1	6

- Test Results

The results of the various tests, conducted on samples collected from every pit, are shown in Table 6-9 and Fig. 6-12.

The results of the auger drillings are attached in Appendix.

o According to the gradation analysis, the gradation of materials distributed in areas A, B, C and D ranges from 39% to 99% of the total particles passing through a sieve of 4.76 mm mesh and from 17% to 65% of the total particle passing through sieve of 0.074 mm. Therefore, it is recognized that finer grains are dominant for impervious core material. The liquid limit (LL) of all samples is between 29% and 59%, the majority of which show a value of 40% or so. The plasticity index (PI) is about 10% to 20%. Such materials are classified as between silty sand (SM) and silt (MH • ML) by the Unified Soils Classification System.

o The results of the compaction and permeability test indicate that the maximum dry density of the above-mentioned materials is within 1.535 to 1.926 t/m<sup>3</sup> (for materials passing the 19.0 mm sieve). The coefficient of permeability is within  $1.2 \times 10^{-7}$  to  $2.8 \times 10^{-8}$  cm/sec.

- Observations

o The fine grain soil at each borrow area for impervious core material "A, B, C and D" has a sufficiently low permeability to serve as core material.

o Borrow area A and C are located adjacent to the dam. Assuming that the location of A and C would be the foundation of the dam, the fine grain soil distributed in the dam area has to be excavated and removed anyway. Therefore, it would be economical to use this soil as the impervious core material. However, it will be necessary to study possible adjustment of the construction programme, need for a temporary stock pile, etc. On the other hand, borrow area B and D are located far away from the dam and adjustment of the construction program will not be required.

o Impervious core materials in general have a higher imperviousness in terms of the permeability coefficient when the

soil contains more fine particles. However, taking into account the settling due to consolidation, strength, workability, etc., it is preferable to use coarser soils within the limit of permissible imperviousness. Therefore, it is desirable to mix the materials in order to improve the workability and imperviousness.

#### 6.4.2 Mae Lama Luang Dam

Dam type of the Mae Lama Luang dam is a rockfill type dam with a clay core.

##### (1) Impervious Core Materials

The area investigated for impervious core materials are Area A, on the right bank about 0.7 km downstream of the dam site, Area B, on the left bank about 1.3 km downstream of the dam site, Area C, on the right bank about 2.0 km downstream of the dam site, and the slope on the left bank of the dam. The locations of these areas are shown in Fig. 6-11.

In the investigation, 19 pits of 2 m to 7 m deep were dug in these areas. As a result of surface geological survey, the materials distributed in these areas were found to be detritus deposit derived from limestone and schist. The number of pits dug in the areas are shown below.

Item	Quantity				Total
	Area A	Area B	Area C	Left Bank of the Dam	
Test pit	7	5	3	4	19
Trench	1	-	-	1	2
Auger drilling	15	47	-	-	62

- Test Items and Quantity

Items and quantity of tests conducted on the samples from pits are shown in tables below:

<u>Test Items</u>	<u>Number of Samples</u>				<u>Total</u>
	<u>Area A</u>	<u>Area B</u>	<u>Area C</u>	<u>Left Bank</u>	
Natural Water Content	13	6	8	12	39
Specific Gravity	13	6	8	12	39
Atterberg Limits	13	6	8	12	39
Gradation	13	6	8	12	39
Compaction	13	6	8	10	37
Permeability	3	1	1	1	6
Tri-axial Compression	1	1	0	0	2

- Test Results

The result of tests conducted on samples taken from the pits are shown in Table 6-11 and Fig. 6-13.

o According to the gradation analysis, the gradation of materials ranges from 40% to 90% of the total particles passing through a sieve of 4.76 mm mesh and from 30% to 65% of the total particle passing through sieve of 0.074 mm. Therefore, it is recognized that finer grains are dominant for core material. The liquid limit (LL) of all samples is between 25% and 40%. The plasticity index (PI) is about 3% to 10%. However, PI of a few samples indicate non plasticity (NP). Such materials are classified as between clayey silt (CM) and silt (ML) by the Unified Soils Classification System.

o The results of the compaction and permeability test indicate that the maximum dry density of the above mentioned

materials is within 1.520 to 1.920 t/m<sup>3</sup> (for materials passing the 19.0 mm sieve). The coefficient of permeability is within  $8.9 \times 10^{-7}$  to  $1.5 \times 10^{-7}$  cm/sec.

- o The results of the triaxial compression test is that under the effective normal stress conditions, the cohesion was 0 - 3.0 kgf/cm<sup>2</sup> and the angle of internal friction was 31.5° - 35°.

#### - Observations

The soil in borrow areas have a sufficiently low permeability as impervious core material. However, the plasticity index of 3 - 10 shows a very low value, and the particle size is fine. Therefore there is a anxiety concerning resistance against piping. It is considered favorable to try to increase strength and improve construction workability by mixing the fine grain soil distributed in the borrow area with other coarse grain material.

From the viewpoint of the material reserves, borrow area "B" and "C" are much wider, and the workability of the material would be better than at borrow area "A".

#### (2) Filter Material

As a quarry site for filter material (See Fig. 6-12), the river bed near Sop Moei village of the junction of the Yuam river and the Moei river, about 7 km downstream at the dam site, was selected. The river bed deposit is distributed in a slightly wide range along meandering Yuam river in the area.

According to the surface geological survey, the material is a deposit that consists of a gravel containing much round gravel of 5 cm - 10 cm in diameter and a little large sized gravel.

At this location, 35 pits were dug and the test on gradation and maximum dry density by using samples taken from the pits were conducted. The depths of the pits are 0.45 m - 3.10 m. Table 6-12 shows the summary of the results of the test.

The samples which were collected from this site should be assessed for permeability and strength by laboratory testing. Judging from the survey and test results, the material can serve as filter material.

(3) Rock Material and Concrete Aggregate

Quarry sites of "A" and "B" as seen in Fig. 6-11 have been selected. For these sites, rock samples taken from the outcrops have been tested for specific gravity, water absorption, Los Angeles test, etc., so far. Table 6-13 shows the results of these tests conducted.

- Quarry Site "A"

Quarry site "A" is located 1.5 km downstream of the dam site on the right bank and forms a ridge extending in a NW-SE direction between elevations of 500 - 600 m at the top. In the surrounding area, a fresh and hard limestone is distributed on the ridge.

- Quarry Site "B"

Site "B" is located 1.0 km upstream of the dam site on the right bank. The elevation of the top of the ridge is between 500 - 600 m and is the same elevation as site "A". The ridge extends in a ENE-NSW direction along the Yuam river. The slope facing the river forms steep cliff. The geology of the ridge consists of sandy limestone distributed on the upstream side, quartzite and quartz schist on downstream side. The outcrops at the site cannot be observed and the properties of the rock have not yet been confirmed. However, it is considered that a hard and massive rock would be distributed, considering the properties and topography of the same horizon on the downstream side.

From observation at the site and the results of rock test in the laboratory, the rock distributed at both sites "A" and "B" is considered appropriate for rock material and concrete aggregate. The material reserves are considered ample to satisfy the dam volume of about 2,700,000 m<sup>3</sup>.



Further, as for the concrete aggregate, there is a possibility to utilize the sand and gravel in the river bed described in the "Filter Material" as well as artificial concrete aggregate.



Table 6-9 Results of Soil Tests (Nam Ngao Dam Site)

I/	Sample No.	Depth (m)	Classificati of Soi by Unified System	Specific Cravity	Natural Water Content (%)	Atterberg Limits		Gradation Analysis							Compaction & Permeability				Triaxial Compression Strength			
						LL (%)	PI (%)	-19.0 (%)	-4.76 (%)	-2.0 (%)	-0.42 (%)	-0.074 (%)	-0.01 rmeabi (%)	-0.002 (%)	Maximu Dry Densit (t/m <sup>3</sup> )	Optimum Water Content (%)	Coeffi- cient of Permea- bility (cm/sec)	Molded Water Content (%)	Total Stress		Effective Stress	
																			C (Kgf/cm <sup>2</sup> )	(deg)	C (Kgf/cm <sup>2</sup> )	(deg)
A	VG-2	0.3-5.9	ML	2.52	11.21	37.75	12.47	100.0	98.46	95.40	8	52.13	39.98	30.15	1.787	15.4	-	-				
	NG-4	0.5-4.1	MH	2.73	19.96	54.10	19.45	74.77	61.25	57.63	54.79	50.29	38.75	25.15	1.580	23.2	-	-				
	NG-6	0.5-66.5	SM	2.63	22.11	30.81	6.58	100.0	99.89	98.96	89.34	47.98	34.15	22.23	1.757	17.0	-	-				
	NG-8	0.4-2.7	MH	2.74	14.27	53.70	22.68	100.0	91.51	81.46	74.08	64.78	52.50	40.00	1.675	21.0	-	-				
	NG-10	0.5-2.2	GM	2.75	4.37	54.20	22.79	86.54	68.65	62.23	58.56	50.38	39.98	30.00	1.654	21.2	-	-				
	NG-12	0.4-1.8	SM	2.71	15.65	41.61	13.67	100.0	74.51	65.42	61.10	45.31	34.10	22.50	1.722	17.8	-	-				
	"	1.8-6.3	ML	2.68	12.04	27.04	3.51	100.0	96.73	93.73	89.61	52.80	36.00	18.17	1.710	17.2	-	-				
	"	0.4-6.3	SM	2.70	3.82	34.75	9.63	97.57	83.62	77.49	71.98	47.70	37.10	22.75	-	-	-	-				
	NG-14	0.6-3.6	SM	2.67	1.45	29.00	4.60	96.98	78.32	68.44	57.78	41.06	27.50	17.52	1.775	17.0	-	-				
	NG-2, 4, 6, 8	-	SM	2.70	13.75	47.70	17.76	84.04	66.12	59.19	49.47	35.85	16.25	18.85	1.790	15.4	2.8x10 <sup>-6</sup>	17.8	0.2	12.2		
NG-10, 12, 14.	-	GM	2.70	6.63	30.50	7.15	71.68	53.97	48.99	45.85	31.12	22.30	13.50	1.775	15.6	1.2x10 <sup>-7</sup>	18.1	0.3	13.9			
B	NG-1	0.3-1.8	SM	2.69	10.88	45.18	15.27	90.62	66.83	45.96	34.40	28.87	24.15	20.00	1.775	17.6	-	-				
	NG-3	0.5-4.9	ML	2.67	18.78	45.10	16.43	100.0	98.19	95.30	87.87	62.63	49.20	37.60	1.686	18.3	-	-				
	NG-5	0.5-4.5	SM	2.68	15.89	33.30	6.66	100.0	94.08	88.74	44.16	44.16	32.50	20.00	1.765	16.5	-	-				
	NG-7	0.4-0.9	GM	2.74	18.39	51.40	21.31	82.23	60.73	50.63	34.76	34.76	28.00	22.35	1.770	16.5	-	-				
	"	2.9-3.8	CC	2.71	11.16	39.80	15.25	74.31	54.58	48.93	33.19	33.19	24.15	15.96	1.806	15.1	-	-				
	"	0.4-3.8	GM	2.72	14.78	42.60	15.33	84.53	59.24	50.14	30.21	30.21	21.90	15.16	1.786	15.2	-	-				
	NG-9	0.4-3.3	MH	2.72	16.23	54.65	25.19	98.64	85.18	76.51	59.70	59.70	48.85	37.65	1.613	22.3	-	-				
	NG-11	0.5-3.1	GM	2.69	11.46	50.45	22.32	70.13	39.53	27.35	17.82	17.82	15.00	11.75	1.757	16.4	-	-				
	NG-13	0.4-2.3	MH	2.69	19.81	59.00	21.33	95.83	68.71	60.00	54.10	54.10	47.00	38.10	1.535	26.5	-	-				
	NG-1, 3, 5, 7	-	SM	2.69	7.74	44.30	15.47	87.61	73.83	66.72	37.12	37.12	27.75	20.90	1.793	16.3	3.1x10 <sup>-6</sup>	17.7	0.1	13.2		
NG-9, 11, 13	-	MH	2.71	17.98	57.70	25.52	91.44	72.26	62.63	50.28	50.28	43.75	35.00	1.680	19.6	3.1x10 <sup>-6</sup>	20.6	0.2	13.9			
C	NG-16	0.5-7.0	GC-GM	2.72	1.7	32.80	9.59	78.0	51.8	41.5	30.6	20.4	14.9	9.5	1.926	12.6	-	-				
	NG-18	0.5-3.5	GC-GM	2.73	4.0	38.60	13.53	60.2	41.3	35.7	30.1	21.0	17.5	13.5	1.788	17.0	-	-				
	NG-20	0.4-1.6	MH	2.73	13.4	52.10	20.77	100.0	98.6	96.5	53.9	76.5	64.7	52.7	1.576	23.0	-	-				
	NG-16, 18, 20	-	GM	2.68	-	35.50	10.56	81.5	59.2	53.8	47.4	37.2	29.3	22.2	1.845	16.0	5.0x10 <sup>-6</sup>	17.6	0.3	12.2		
D	NG-21	0.2-3.8	ML	2.71	11.4	33.60	8.83	100.0	97.5	93.2	85.3	65.1	50.3	26.4								
	NG-22	0.2-2.2	ML	2.74	12.4	38.60	9.50	96.7	83.7	76.2	61.5	56.1	45.1	32.6								
	NG-24	0.2-2.4	CL	2.71	10.2	37.80	13.15	100.0	88.7	84.7	78.9	52.9	43.5	32.6								
	NG-25	0.2-3.3	MH	2.73	15.4	55.40	21.54	96.6	88.7	85.8	82.8	65.1	55.7	44.1								
	NG-21, 22, 24, 25	-	ML	2.74	9.9	40.80	14.58	100.0	86.5	81.9	76.0	58.2	48.7	36.7	1.684	18.4	4.8x10 <sup>-7</sup>	20.7	0.2	15.1		

Remarks: 1/The name of Borrow Area.

