### The Kingdom of Thailand

## Electricity Generating Authority of Thailand

# UPPER QUAE YAI HYDROELECTRIC DEVELOPMENT PROJECT FEASIBILITY REPORT

Volume 3
(APPENDIX 2 and 3)

June 1980

Japan International Cooperation Agency



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APPENDIX 2

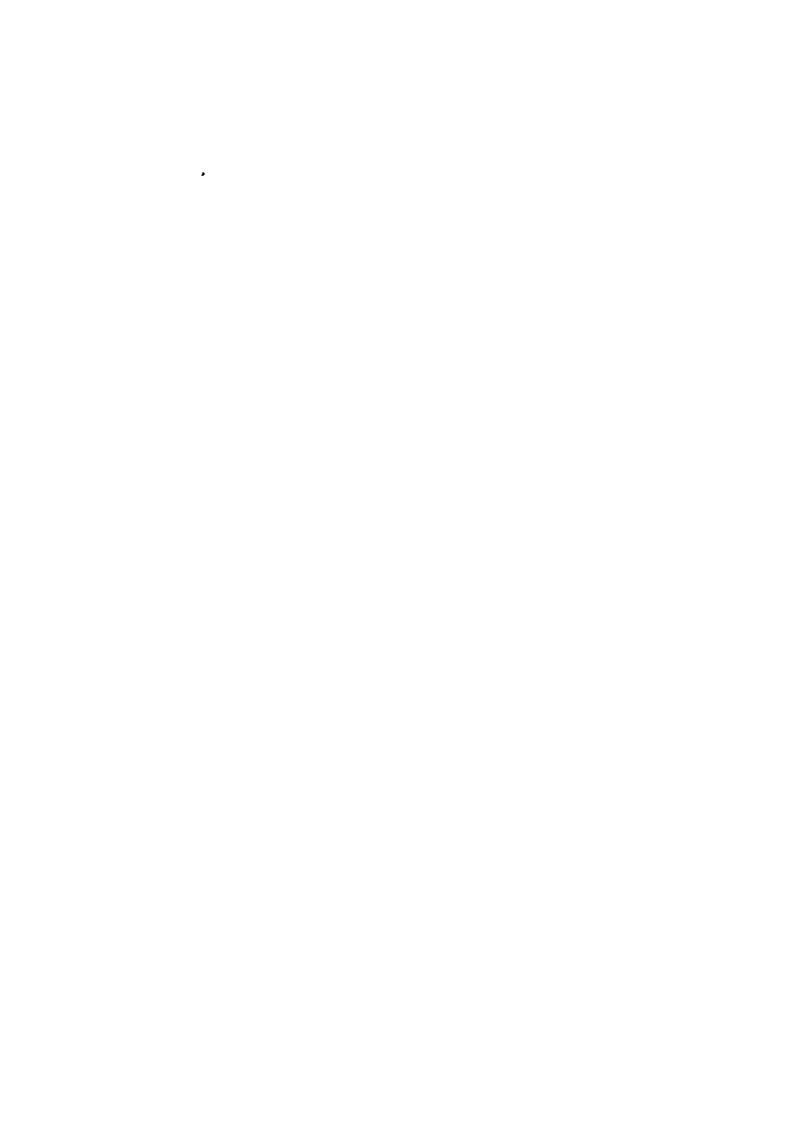
## CHAPTER 1 GEOLOGY

#### APPENDIX 2 GEOLOGY AND MATERIAL

#### CHAPTER 1 GEOLOGY

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#### RESERVOIR GEOLOGY

#### 1. Introduction

The Upper Quae Yai project is located at the upstream area of the Quae Yai River and the location of the proposed damsite is about 141 km from Srinagarind dam.

The main figures of the Nam Chon reservoir are as follows:

Height of Dam 185 m Normal High Water Level 370 m Catchment Area 4,908 km $^2$  Reservoir Surface Area at Normal High Water Level 137 km $^2$  Total Storage Capacity 5,975 x  $10^6$ m $^3$ 

As various karstic rocks are found in the reservoir area, the geological studies mentioned later have been done to ensure the reservoir watertightness.

The field geological investigation in the reservoir area was carried out by the cooperation team with EGAT geologists and the geologists dispatched by the Japanese Government.

All geologists participated in the investigation would express our thanks to Mr. Srid Aphaiphuminart, Director of Planning Department, EGAT and all other engineers of Planning Department, because people in the Department assisted us very much to execute the work smoothly.

Terms of Field Investigation and participated Geologists are as follows:

\* April - July, 1978 and December, 1978 - May, 1979.

\* Geologist dispatched by Japanese
Government

EGAT Geologist

Yozo Fukutake Peel Chitakarn

Mamoru Yamada Panpong Karnchanpan

#### 2. Conclusion

The reservoir watertightness is ensured for the following reasons.

- a) The formations comprising the backbones of the eastern and western watersheds consist of non-calcareous rocks. These rocks can serve as reliable barriers against leakage to other river basins.
- b) Formation D which is considered as a risky rock with respect to leakage is widely distributed in the northeast part of the catchment area. However, the width of the distribution gradually dwindles from the left bank (east side) of the damsite, and at a place on the left bank at an elevation of approximately 700 m, the distribution vanishes. Therefore, this Formation D as a whole is enclosed by Formation A, B and C of which the watertightness is ensured.
- c) Formation D distributed at other than the above location, especially Formation D distributed at the right bank of the damsite is at an elevation above high water surface level of 370 m. Furthermore, Formation D seen at the right bank approximately 5 km upstream of the damsite continues down below the reservoir water level, but the thickness is small, and the boundary between Formation D and the underlying Formation B is judged to be higher than the high water surface level as a result of geological investigations in the field.
- d) Swallets have not been found in strata other than Formation D, while running water is seen throughout the year at main gullies having formations other than Formation D as their basement rocks. This means that formations other than Formation D, even if calcareous, have sufficient resistance against karstic erosion, and that adequate watertightness is possessed as a whole.
- e) According to results of chemical analyses of rock samples taken from the various formations, as indicated in Table 1-4, there are fairly large differences in the CaCO3 and MgCO3 contents of samples from Formation D and other formations. These differences in contents indicate that compared

•

with Formation D, Formation A, B and C have stronger resistance against karstic erosion.

f) On comparisons of SiO<sub>2</sub> contents of rocks, the samples from Formation D have less than 1%, whereas samples from other formations have more than 5%. Other than SiO<sub>2</sub> content, according to microscopic observation of the rocks, a layer arrangement of SiO<sub>2</sub> mineral of thickness of several millimeters is seen in the calcareous sandstone of Formation B. And, according to results obtained from drillholes, karstic erosion has not progressed to deeper parts in Formation B at the left bank of the damsite. By this, it can be evaluated that the above-mentioned SiO<sub>2</sub> content and mineral arrangement possess strong resistance against karstic erosion.

#### 3. Method and Area Investigated

The reservoir area is very steep topography and covered by jungle. In addition to such hard conditions, poor accessibility and some security problems restricted the field investigations, accordingly photo geological investigation, topographical studies and geotectonic judgments were fully used as listed below. The field survey was carried out at the area where we could go in and for the area where could not go in, the downstream area where the formations at the upstream area of the reservoir are geotectonically continued has been investigated.

#### List of Method

- a) Photo-geological interpretation
  - About 5,000 km<sup>2</sup> whole catchment area including about 30 km downstream of proposed damsite.
  - Scale of Photo 1: 50,000, 1: 15,000 (partially)
- b) Summit level analysis
  - Same area as photo interpretation.
  - ~ 1: 50,000 scale map.
- c) Drainage pattern analysis
  - Same area and same scale map as summit level analysis.

- d) Field survey
  - From No. 9 site to 30 km downstream of the proposed damsite including from main river to El. about 900 m of both banks.
  - -1:5,000 scale maps enlarged from 1:50,000 maps.
- e) Chemical analysis of rock and water sample.
- 4. Data and Previous Investigation
  - a) Geological Map of Thailand 1:1,000,000 1969, by Department of Mineral Resources
  - b) Geological Map of Kanchanaburi Province. 1:250,000
    1971, by German Mission
  - c) Quae Yai No.1 Project, Geological Investigation of Reservoir Area.
     1972, by EPDC for EGAT
  - d) Geological Map, Sheet No. ND 47-7 and ND 47-3
     (East side of the project area) 1: 250,000
     1976, by Department of Mineral Resources
  - e) Photo-Geological Interpretation for Upper Quae Yai Project 1: 50,000 1978, by UNEX for EGAT
  - f) Restudy of photo-geological interpretation for the whole catchment area and some field investigation surround No. 5 and Nam Chon damsite were carried out on April August, 1978 by Expert dispatched from Japanese Government and EGAT's geologists See Preliminary Report Upper Quae Yai Project Report No. 846-2112, August 1978 and Geology of Damsite Area Upper Quae Yai Project Report No. 842-2116 December 1978.
  - g) Site inspection by IBC (International Board of Consultant) was carried out on January and on November 1979. The reports were submitted.

#### 5. Topography

The catchment area of the Upper Quae Yai project is 4,980 km<sup>2</sup> and it is defined by N.L. 16°30' at the upstream end and by N.L. 15°10' at the downstream end approximately. The East Longitude 98°55' is nearly the center line of the catchment area and its widest width is about 60 km.

Whole reservoir area is covered by the dense jungle and shows the steep topography, especially along the main river. The Quae Yai river in the reservoir area, though meandering partially, flows straightly from NNW to SSE direction in accordance with the prominent direction of the mountainous structures.

The mountain range of the eastern divide is generally higher than the western divide which borders to the Quae Yai river and the elevations of this mountains at the eastern and at the western divide are from about 1,200 m to about 2,000 m and from 1,000 m to about 1,800 m respectively. Besides, the average elevation of the mountainous area between both of the divides and the main river is about 700 - 1,000 m.

The remarkable karstic phenomena are seen at the eastern half of the catchment area.

The topography of the reservoir area is divided into two areas as follows:

- a) The area along main river
  - The topography along the main river excepting the area around the junction between the main river and the Mae Chan river is quite steep and the slope angle at both banks is generally 45° to 60° or steeper. Many rapids and many cliffs are formed in this area, accordingly, basing on the topographic map of 1:5,000 scale enlarged from 1:50,000, the width of the reservoir water surface at El. 370 m is more or less 420 m in average.
- b) The area along Mae Chan River
  - The river banks along the Mae Chan river including the main river of some certain km downstream from the junction with the main river become wide suddenly. The widest width of the reservoir surface is about 7 km basing on the same map of 1:5,000 scale. The topography in this area is hilly plain with gentle unduration and the river terrace topography is wall formed.

#### 6. Morphological Analysis based on Summit Level Map

A summit level map is a topographic map which reproduces the topography of a certain age - old topography - by subdividing a certain region into portions of equal area and connecting the points of highest elevation in the subdivisions. The aim is to make comparison studies of this old topography and the present topography to obtain information concerning resistance to erosion, geologic structure, upheaval, etc. of bedrock.

The summit level map having every 100 m contour lines made for the Upper Quae Yai Project area was obtained by subdividing into grids of  $1 \text{ km}^2$  on a 1/50,000 topographic map.

#### (1) Topographic Classification by Summit Level Map

The heights of elevations, the densities of contour lines spacings (degree of slope) and the directions of contour lines on the summit level map were considered and the project area was grouped into the following three topographic division (see Fig. 1-2).

Group I Area - Mountain body having watershed

Group II Area - Mainstream and major tributaries

Group III Area - Area between Group I and II

#### (2) Characteristics of Areas

Group I Area - Elevations from 900 to 1,800 m, contour line spacings not more than 1 cm, with NNW-SSE predominant direction.

Group II Area - Elevations from 300 to 800 m, contour line spacings generally not more than 1 cm, but 2 - 7 cm at parts. Contour lines predominant in NNW-SSE direction.

Group III Area - Elevations from 700 to 1,000 m, contour line spacings mostly around 2 cm and 3 to 7 cm. Areas of this claceification are so-called peneplain areas, and the greatest number of dolines in the Upper Quae Yai Project area is distributed in these areas. The distribution frequency is higher than 75% as indicated in Fig. 1-5.

#### (3) Considerations

- a) The foundation rocks which are widely distributed in Group III areas and underlain Formation D are severely folded, but this is not prominently shown in the summit level map. From this, it can be surmised that folding ended prior to the peneplanation of Group III areas.
- b) At the vicinity of the confluence of the Quae Yai and Mae Chan river where the width of the reservoir is greatest and along the Mae Chan river (Area F, see Fig. 1-2), it is estimated there is distribution of a Tertiary formation consisting of sand, gravel and silt. This formation is not seen in peneplain of Group III areas. This type of formation has been confirmed to be distributed inside the Srinagarind Reservoir area.
- c) The river topography along the mainstream from approximately 20 km upstream of the Nam Chon damsite to approximately 10 km downstream shows a gorge. In this area the difference in elevation between the present topography and the old topography is approximately 800 m. This indicates that this area in a certain geological was heaved up and then (until the present) subjected to severe down-cutting erosion.
- d) From the geologic conditions of b) and c), it is judged that as a whole the Mae Chan river basin is subsiding and the Nam Chon damsite surroundings are heaving up, and it is considered there is a strong connection between the previously-mentioned Tertiary deposit and this subsidence of the basement.

#### 7. Geology

#### (1) General Geologic Structure

The geologic structure in the catchment area of this Project is roughly divided into two tectonic provinces which is formed by the tectonic line consisted of the several faults group locating along the mountain range of the eastern divide and having the direction of NNE-SSW. The direction of folding and faults at both areas divided by this tectonic line is changed as follows:

- \* Their directions at the eastern side (along Huai Kha Khaeng) of this tectonic line show N-S or NNE-SSW.
- \* However, the directions at the western side (whole catchment area) of this tectonic line are changed to NW-SE.

#### (2) General Geology

The outline of the reservoir geology based on the general geologic sequence (Table 1-1) is explained hereinafter, however, as the river deposit, the talus deposit and the land slide in this area are not remarkable due to the steep topography, the expalnations for them are eliminated on this report.

#### (a) Metamorphic Rock

This rock distributes mainly at the mountain ranges of both divides and another distribution of this rock (semi schist) is found about 20 km downstream of the proposed damsite, in addition to them, some part of alternation of calcareous sandstone and shale belonging to Formation B, for instance, about 3 km upstream of the proposed damsite, is metamorphosed to schist.

Most of the metamorphic rocks confirmed at the field is estimated to be clastic sediment origin. They are mainly schist or phyllite, however, the grade of the metamorphism is variable in places. The metamorphism in this area is estimated so as to have close relation to intrusion of Granite taking its distribution into consideration and the origin rock of the schist is assumed to be mainly Formation A.

Judging from engineering geological point of view, this schist is quite available as a barrier to prevent the leakage water from the reservoir to another catchment area.

#### (b) Formation A

Formation A is estimated to be the oldest rocks in the Project area and its distribution is remarkably found along the east foot of the eastern divide, that is, along the major tectonic line mentioned in (1). Furthermore, this formation is continued from the eastern divide of Srinagarind reservoir which is located at the

downstream of this Project and is impounding now.

Formation A consists of mainly quartzite, locally sandstone, slate and schist. They are quite hard and have well watertightness as a foundation rock of a big reservoir as we have experienced at Srinagarind reservoir.

#### (c) Formation B

Formation B is covering Formation A in conformity and main distribution of this rock is found around the proposed damsite, at the west side mountainous area, along the main river near the junction with the Mae Chan river and along the eastern divide contacted with Formation A.

Formation B is mainly consists of calcareous sandstone and alternation of calcareous sandstone and shale. The remarkable character of this rock around the proposed damsite is as follows:

Lower part: Fine alternation of calcareous sandstone and shale,

locally like schist

Middle part: Massive calcareous sandstone, but shows remarkable

banded structure

Upper part: Massive calcareous sandstone and less banded

structure than middle part

The chemical component of this rock collected at the damsite is as follows:

CaCO3, MgCO3 74%, SiO2 20%, Others

And, according to the microscopic observation, alternated pattern of  $\text{CaCO}_3$  and  $\text{SiO}_2$  is clearly seen with the thickness less than several mm.

As regarding the engineering geological judgement of this formation, the watertightness of this formation is ensured by the following data:

\* According to the photo-geological interpretation, few dolines of small scale are formed in this formation, at the eastern area of the proposed damsite, but their elevation is higher than 1,000 m. Excepting this area, no any doline is formed at this formation of the catchment area.

\* Two rock massess of this formation which will be submerged in the reservoir water have not any doline and even some small cavities are found on the outcrop at the proposed damsite, the cavities are only limited within several meters from the ground and no any karstic erosions are found in the deeper part basing on the results of the drill holes at the damsite.

#### (d) Formation C

Formation C is covering Formation B in conformity. The distribution of this rock is found at almost whole project area excepting the area of metamorphic rock and Formation A at both divides.

Formation C consists of sandstone, calcareous sandstone, shale, conglomerate, impure limestone, etc. The conglomerate of this formation is different from the conglomerate in Formation D mentioned later, because the gravels of this conglomerate (Formation C) consist of pebbles of quartzite, sandstone and slate.

Formation C is the basement rock of Formation D which is pure karstic limestone or dolomite estimated to be high permeable, accordingly this formation will be able to be used as a good barrier to prevent the leakage water through Formation D.

#### (e) Formation D

Basing on the previous investigation data, this limestone has been classified as Rat Buri limestone belongs to upper carboniferous-permian of paleozoic era, however, during our field investigation, we could not find the key fossile to clarify the geologic age of this limestone and furthermore, according to the latest information for this limestone, this limestone may not belong to the geologic age said before.

Therefore, the geologic age of this formation is not mentioned in this report and we use the name of Formation D for this rock temporarily in this report.

Formation D is covering Formation C and other older formations with

angular unconformity, this formation distributes widely in the whole project area and will be submerged under the reservoir water at some places of the reservoir area such the place along the main river from about 5 km upstream of the junction with the Mae Chan river to the reservoir end.

Formation D mainly consists of pure limestone, cataclastic dolomite and dolomitic limestone, but reddish brown conglomerate and dark gray hard limestone contained shell fossiles are also found at many places in the project area.

Formation D is characterized as karstic limestone and many doline are formed in this rock area, therefore if this limestone distributes continuously from the reservoir area to the downstream area or to the outside of the catchment area, there are possibilities to leak the reservoir water through the doline or other karstic topographies. However, this formation in the reservoir area is enclosed by the other watertight formations as mentioned in 2 (Conclusion of Reservoir Watertightness).

#### (f) Tertiary System

The distribution of tertiary deposit is observed at the place from 6 km down-stream of the junction between the Quae Yai and the Mae Chan river to about 11 km upstream along the Mae Chan river with about 5 km width. This formation is not confirmed in the firld, but the same drainage pattern and the same topographical conditions are confirmed on the tertiary deposit area in the Srinagarind Reservoir by the photo geological interpretation.

The deposit is estimated consists of semi-consolidated silt, sand and gravels having horizontal bedding plane.

#### (g) Granite

Basing on the existing data, the time of the intrusion of the granite in this area is estimated to be middle to late mesozoic. The biggest granite mass is found on the western foot of the west divide about 15 km west from the proposed damiste. And other small granite masses are found along the eastern divide.

As previously stated, the intrusion of granite has close relation to metamorphic rock and both of them are at the suitable locations to present the leakage

water to another basins.

#### 8. Running Water

Running water investigations were made during the dry season for the major tributaries in the stretch from approximately 12 km upstream of Nam Chon Dam past the damsite at approximately 25 km downstream.

The locations of running water, spring water and under flow streams are indicated in Table 1-2 and Fig. 1-3. In the investigation area, springing and under flow are seen at Huai Tong Thai located immediately downstream of the right bank of the damsite and at tributaries located downstream of Huai Tong Thai, while such phenomena are not seen at tributaries further upstream.

The characteristic phenomena in the present investigation are that the section of approximately 7 km between the sinking point at El. 425 m at Huai Tong Thai and the springing point at El. 100 m is an underflow section, that the water quantity at the springing site seems to be larger than the disappearing quantity, and that the spring points of the water sinking at Huai Du Hgae and Huai Pa Chi downstream of the abovementioned tributary have not been discovered, and when these phenomena are considered, as described in the Clause of Damsite Selection, No. 5 damsite is unsuitable because of the many unconfirmed factors from a geological standpoint.

For the area investigated, the states of running water at tributaries in the vicinity of Nam Chon Dam are as indicated below.

	Name or Location of Stream	Running Water	Geology
1)	Huai Phra (9 km upstream) (Left Bank of Reservoir)	Yes	Formation C
2)	Huai Yai (7 km upstream) (Right Bank)	Yes	Formation B & C
3)	Stream; 4 km upstream (Left Bank)	No in the dry season	Formation B

	Name of Location of Stream	Running Water	Geology
4)	Stream; 5 km downstream (Left Bank)	Yes small in January	Formation B
5)	Huai Tong Thai (600 m downstream) (Right Bank)	Yes in the Formation E El. 500 m) No in Rat Buri LS area	
6)	Huai Nam Chon (2 km downstream) (Left Bank)	Yes	Formation B & C
7)	Huai Dun Ngae (2.5 km downstream)	Yes at higher El. 600 m No at lower El. 600 m	Formation B Formation D
8)	Huai Pachi (Branch of Dun Gae)	No at lower El. 680 m	Formation D

Km shows the distance from the Nam Chon damsite.

#### 9. Chemical Analyses of Running Water

Chemical analyses were carried out on seven samples of river water and spring water taken from the vicinity of the damsite. The locations from which samples were collected and the results of the analyses are shown in Table 1-3 and Fig. 1-6. The following were disclosed as a result of these chemical analyses:

- a) On looking at the relation between the geology of the flow channel and the Ca<sup>++</sup>, Mg<sup>++</sup> and HCO<sub>3</sub><sup>-</sup> contents of the water samples, the sample from Locality No. 6 passing through Formation D contains the above-mentioned chemical components the mo-t, followed by Locality No. 9 (mainstream Formation B, C, D) and Locality No. 12 (Huai Phra Formation C). With Sample No. 12 as an exception, on the whole, samples from Formation B and C (Localities No. 5, 8, 10 and 11) do not have great differences in their contents of the above-mentioned components, and they are distinctly less than for the samples of Formation D.
- b) Regarding the two samples from Huai Tong Thai on making comparisons of the above components, a great difference between the sample (No. 8) from

Formation B and the sample (No. 6) infiltrated through Formation D was indicated.

c) With regard to pH, except for Sample No. 6, all samples indicated alkalinity with pH = 8.0 - 8.4, whereas No. 6 indicated pH = 7.63. On comparison of the two samples from the Huai Tong Thai, No. 8 and No. 6, the pH of the sinking Sample No. 8 of 8.18 is changed to pH = 7.63 of Sample No. 6 springing out. This phenomenon indicates that at present there are still resolution reactions of calcareous rocks going on at the under flow section in Formation D.

#### 10. Chemical Analysis of Rock

With the purpose of finding the carbonate mineral contents of rocks distributed in the Project area, quantitative analyses were made of rocks collected from the vicinity of the damsite. The samples analyzed were six from Formation D, three from Formation B, and one each from Formation C and A.

The components analyzed were CaO, MgO and  $SiO_2$ , with  $Al_2O_3$  also analyzed for a number of samples. The results of the analyses are indicated in Table 1-4.

The samples from Formation D consisted 93 to 99% (by weight) of the two minerals of CaCO3 and CaMg (CO3)2, with almost no other minerals contained, and especially, the content of SiO2 was less than 1%. Formation B consists of 74 to 90% CaCO3 and CaMg (CO3)2, and of the other minerals amounting to 26 - 10%, the quantity of SiO is 6 - 20%, a sudden increase compared with the samples from Formation D. According to field observations, Formation B consists of calcareous sandstone and sandy limestone of banded structure.

This banded structure of around several milimeters is due to the mineral arrangement of  $SiO_2$  and  $CaCO_3$ , and the stratified arrangement of quartz particles, compared with Formation D, may be judged to have considerable influence on resistance against karstic erosion. The difference in resistance is prominently shown in the degrees of development of dolunes and other karstic phenomena in the areas of Formation D and Formation B.

Appriximately 90% of Formation A consists of  $\mathrm{SiO}_2$  , and the content of calcium carbonate is zero.

Microphotographs of rocks representing the various formations have been attached as references.

#### DAMSITE SECTION

#### 1. Introduction

Before starting the feasibility study, twelve (12) alternative sites were planned as the damsite for the Upper Quae Yai Project and they were evaluated from geological and civil engineering viewpoints during the preliminary and the pre-feasibility stage. Finally, No. 6 site (Nam Chon site) and No. 9A site were selected as comparative damsites for this Project and the pre-feasibility report concluded that Nam Chon damsite is superior to No. 9A site.

During the study mentioned above, the full attentions from geological viewpoints were paid to the comparison between the Nam Chan and No. 5 sites, because No. 5 site where is located about 1 km downstream of the Nam Chon site has the similar topographic conditions with the Nam Chon site.

However, as the conclusions of the comparisons between both sites, the Nam Chon site which has less unknown geologic problems was judged to be superior to No. 5 site.

The unknown geologic problems at No. 5 site are as follows:

#### 2. Limestone Mass at Right Abutment of No. 5 Damsite

The large limestone mass continuing from the upstream area and extending to the downstream area bordering with a fault distributes at the right abutment of No. 5 site. Caves and corrosion open cracks were often found in this rock mass by the field survey.

The limestone mass, if selected as a damsite, has serious foundation problems for the permeability and, to verify karstic erosions in the limestone mass, the ground water in this rock mass must be confirmed by drillholes. However, according to the drilling data at the Nam Chon site (No. 6 site), no groundwater has been confirmed in the same limestone mass located at the upstream area.

Moreover, judging from the surface geological conditions around No. 5 damsite, there are large possibilities so that remarkable karstic erosions such as underground

channels may be formed in the limestone mass.

Accordingly, fairly quantities of investigation works shall be executed on this rock mass and also, as mentioned in the IBC Report No.1 dated Feb. 1979, a treatment to prevent leakage must be considered for the wide area faced to Huai Tong Thai.

#### 3. Underflow at Vicinity of Huai Tong Thai

Remarkable underflows are found along Huai Tong Thai and Huai Du Ngae, the submerging point (swallet) at Huai Tong Thai and at Huai Du Ngae are located at El. 420 m and El. 600 m respectively. The spring point of Huai Tong Thai has been confirmed at El. 200 m and the spring point was not found at Huai Du Ngae so far.

However, EGAT (Survey Division, Planning Department) carried out very useful test to survey underground channels by using Fluorescence on Feb. 9, 1980 and the following informations have been obtained.

- a) The submerging water at Huai Du Ngae and Huai Pa Chi are joining to the spring point at Huai Tong Thai.
- b) The linear distance between the submerging point at Huai Du Ngae and the spring point at Huai Tong Thai is about 5 km (shortest distance between two streams in about 2.5 km) and the travelling times of Fluorescence for about 5 km are 35 hours.
- c) According to the following discharge data, the discharge (B) at the spring point is 50% to 90% larger than the total quantity (P + D + T) of three submerging points.

Flow Measurement at Huai Pa Chi, Huai Du Ngae & Huai Tong Thai Period Jan. - Feb. 1980

Discharge - Litre/Sec.

Date	Huai Pa Chi	Huai Du Ngae	Upper Huai Tong Thai	Total	Lower Huai Tong Thai	Remarks
	(P)	(D)	(T)	P-D-T	(B) (Spring point)	
Jan. 24, 1950	\$5	9	167	261	401(-54%)	Current
Jan. 27, 1980	79	ชิ	155	272	407(-50%)	Meter:
Feb. 8, 1980	79	5	117	201	365(-53%)	Pigmy Type
Feb. 9, 1950	<b>±</b> 0	5	102	167	357(-90%)	
Feb. 10, 1950	79	6	111	196	369(−88 <sup>∞</sup> )	

#### 4. Estimation and Consideration for No. 5 Damsite

Judging from the above-mentioned data, the following estimation for the underground channels around Huai Tong Thai is obtained.

- a) Huai Du Ngae located at the downstream area of No. 5 damsite and Huai Tong Thai located in the reservoir of No. 5 dam are mutually connected with the underground channels.
- b) Judging from the travelling hours of Fluorescence, the gradient of the underground channels between both Huais is estimated to be very gentle and there are no any evidences that the elevation of the channels may be higher than the reservoir high water level of El. 370 m. Accordingly, a possibility to may leak the reservoir water through the underground channels can not be solved unless the route and the elevation of the channels are completly elucidated.
- c) Judging from the discharge at the spring point of Huai Tong Thai, the water is estimated so as to be gathered from many underground channels connecting to the upstream and the downstream areas.

In addition to the underground channels, the limestone mass at the right abutment of No. 5 site is also important subjects which should be made clear as mentioned previously.

Therefore, considering geological problems remained at No. 5 site, the Nam Chon damsite (No. 6 site) which can avoid such problems was judged to be superior to No. 5 site and selected as the damsite of which the geological investigation works for the feasibility study shall been commenced.

Table 1 - 1 General Geologic Sequence of Upper Quae Yai Project Area

Era	Stratigraphic Unit	Rock	Main Distribution	Characteristic
Cenozoic	Quaternary to Tertiary System	Gravel, Sand, Silt and Clay	Junction between Mae Chan & Quae Yai	Moderatly consolidated, horizontal bedding
Mesozoic	Intrusion Intrusion	Granite	at eastern & western divide	Medium to coarse biotite Granite
	Formation D	Massive pure LS (locally bedded), cataclastic	Many places, es- pecially eastern half	Remarkable karstic phe- nomena, folded
	Unconformit or	Dolomite, Dolomitic LS, near base often Red Conglomerate	of catchment area, except both divides	
	Formation C	Shale, Sandstone, calcareous Sandstone, Conglomerate and thin impure LS. locally alternation	Whole project area	Thick deposit, folded
Palaecozic	Formation B	Banded calcareous Sandstone, banded sandy LS. alternation of Sandstone & Shale and locally lenticular LS.	Along main river including proposed damsite and other many places	Massive, folded, par- tially strongly folded and rock like Schist locally
	Formation A	Quartzite, Sandstone, Slate and like Schist	Along eastern divide and continuously from Srinagarind reservoir area	Vary hard, thick deposit
	Metamorphic rocks	Schist and semi Schist	At both divides and about 20 km down- stream of damsite	Locally show gneissose structure

Table 1-2 Data of Running and Ground Water

Locality No.	Distribution of Water	$\frac{1}{2}$ Topographic Situation and Name of River	Elevation <u>2</u> / (m)	Geology	Date of Observation	Chemical Analysis	Remarks
<b>(</b> )	Running water	Downstream, left bank, Huai Ong Thang Yai	Lower than 230*	Formation B, C	DEC 1978		Much water
Other	Spring and running water	Huai Ong Thang Lek, tributary of Huai Ong Thang Yai	SP. P. 220 Lower than 220	" B	11 11		17
Other	Running water	Tributary of Huai Ong Thang Yai	Upper than 230	" A	11	ļ	A little water
<b>(2)</b>	Spring	About 20 km Downstream, right bank, stream of Quae Yai river	SP. P. 250	" В	JAN 1979		Too much considering $C.A.$
3	Spring and running water	Downstream, right bank, Huai Phru	SP. P. 340 Lower than 340	" В	11		Much water
Other	Running water	Downstream, left bank, Huai Thi Khong	Lower than 640	" C	T F		. A little water
<b>(4)</b>	Running water and swallet	Downstream, right bank, Huai Du Ngae	Upper than 600 SW. P. 600	" C	11		Can not find SP. P.
\$	Running water and swallet	Huai Pachi, tributary of Huai Du Ngae	Upper than 690 SW. P. 690	· " C " D	11	0	Much water Can not find SP. P.
<b>(6)</b>	Spring and running water	Downstream, right bank, Hui Tong Thai	SP. P. 200 Lower than 200	" D	11	0	More water than $\langle \overline{7} \rangle$ SW.P.
♦	Running water and swallet	ıı	Upper than 425 SW. P. 425	" C	11 11		Much water
<b>\\$</b>	Spring and running water	ti .	SP. P. 480 Lower than 480	" B " B	11	0	Much water
Other	Running water	Downstream, left bank, Huai Nam Chon	Lower than 300*	ıı B	11		A little water
(9)	11	Quae Yai river at Nam Chon Damsite		" B,C,D	APR 1979	0	
(1)	11	Upstream, right bank, Huai Yai	Upper than 250	" B,C	JAN 1979	0	Much water
<b>(1)</b>	11	11	Lower than 550*	" B,C	MAR 1979	0	11
12	11	Upstream, left bank, Huai Phra	Lower than 400*	" С	JAN 1979	0	11

Downstream & upstream show the location from the Nam Chon damsite.

Right bank & left bank show the location on the main river.

2/ SP. P. shows spring point.

\_l/

SW. P. shows swallet point.

3/ C.A. shows catchment area.

<sup>\*;</sup> No survey at more upstream than the elevation in the Table.

Table 1-3 Chemical Analysis of Water Samples in Reservoir Area

Locality No.		(\$c)	<b>\$</b>	<b>⊗</b>	\$	<b></b>	( <del>1</del> )	(12)
Date of sampling		JAN 1979	JAN 1979	JAN 1979	APR 1979	JAN 1979	MAR 1979	JAN 1979
Locality		Huai Pachi EL. 690 m	Huai Tong Thai EL. 200 m	Huai Tong Thai Nam Chon EL. 480 m damsite	Nam Chon damsite	Huai Yai EL. 280m	Huai Yai EL. 510m	Huai Phra EL. 290 m
ЪН		8.40	7,63	81.8	8.25	8.37	8,26	8.03
Carbonate (CO3 )	p.p.m e.p.m	4.8 16.00 x 10 <sup>-2</sup>	0	2.4 $8.00 \times 10^{-2}$	4.8 16.00 × 10 <sup>-2</sup>	7.2 24.00 x 10 <sup>-2</sup>	$4.8$ $16.00 \times 10^{-2}$	1.2 4.00 × 10-2
Bicarbonate (HCO3 <sup>-</sup> )	p.p.m e.p.m	83 1.36	361 5.92	146 2.39	222 3.64	137 2,25	146 2.39	181 2,97
Sulfate (SO <sub>4</sub> ")	p.p.m e.p.m	$0.75$ $1.56 \times 10^{-2}$	1.9 3.96 x 10 <sup>-2</sup>	1.7 3.54 x 10 <sup>-2</sup>	2.3 4.79 x 10 <sup>-2</sup>	2.3 4.79 x 10 <sup>-2</sup>	$0.9$ $1.87 \times 10^{-2}$	13.6 28.32 x 10 <sup>-2</sup>
Chloride (Cl <sup>-</sup> )	p.p.m e.p.m	2.0 5.64 x 10-2	3.0 8.46 x 10 <sup>-2</sup>	3.0 8.46 x 10-2	2.0 5.64 × 10-2	$3.0$ $8.46 \times 10^{-2}$	2.0 5.64 x 10 <sup>-2</sup>	3.0 8.46 × 10 <sup>-2</sup>
Calcium (Ca <sup>++</sup> )	m·d·a	20.82 1.04	66.47 3.32	42.45 2.12	40.04 2.00	33,64 1,68	38.44 1.92	32.04 1.60
Magnesium (Mg <sup>++</sup> )	p.p.m e.p.m	4.37 0.36	13.60 1.12	5.34 0.44	21.86	8.74	6.80 0.56	20,46
Hydroxyl radical (OH <sup>*</sup> )	p.p.m e.p.m	0	0	0	0	0	0 0	0

Table 1-4 Quantitative Analysis of Calcareous Rock

Locality			Result of analysis		1/ Result of norm calculation		2/ Result of norm calculation		1 4/
No.	Locality	Rock Name	Composition	% (wt)	Composition	% (wt)	Composition	% (wt)	П
<u></u>	Right bank near No. 8 site	Dolomitic limestone (Formation D)	CaO MgO SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	51.6 2.4 2.3 0.36 56.66	CaCO <sub>3</sub> MgCO <sub>3</sub> Total	92.0 4.5 ———————————————————————————————————	CaCO <sub>3</sub> CaMg(CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	87.2 9.3 2.3 0.36 99.16	1
2	Sink hole at left bank of Huai Tong Thai EL 470m	Calcitic dolomite (Formation D)	CaO MgO SlO <sub>2</sub> Total	35.1 17.2 0.2 52.5	CaCO3 MgCO3 ————	62.64 35.98  98.62	CaCO3 CaMg(CO3)2 SiO2 Total	19.93 78.69 0.2 98.64	2
<b>3</b>	Hight bank of Huai Tong Thai EL-250m	Dolomite (Formation D)	CaO MgO SIO <sub>2</sub> Total	32.3 19.7 0.1 51.6	CaCO3 MgCO3 Total	57.64 41.21 	CaCO <sub>3</sub> CaMg(CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Total	8.72 90.13 0.1 98.86	-
3	Right bank of Huai Tong Thai EL-430m	Dolomite (Formation D)	CaO MgO SiO <sub>2</sub> Total	30.9 21.1 0.2 52.2	CaCO <sub>3</sub> MgCO <sub>3</sub> Total	55,14 44,13 ————————————————————————————————————	CaCO <sub>3</sub> CaMg(CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Total	2.75 96.52 0.2 99.47	
(3)	Huai Du Ngae	Calcitic dolomite	CaO MgO SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub>	30.8 20.3 1.3 0.33	CaCO3 MgCO3	55.0 38.1 ————————————————————————————————————	CaCO <sub>3</sub> CaMg(CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	14.6 78.5 1.32 0.33	
<b>6</b>	EL.590m Left bank near No. 2 site	(Formation D)  Dolomite  (Formation D)	Total  CaO  MgO SiO2  Total	30,6 21,3 0,1 52.0	Total CaCO3 MgCO3 Total	54.61 44.55 ———————	CaCO <sub>3</sub> CaMg(CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Total	1,72 97,44 0,1 99,26	-
7	Huai Pachi EL_790m	Calcareous shale (Formation C)	CaO MgO SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	2.2 1.8 58.8 19.20	CaCO <sub>3</sub> MgCO <sub>3</sub> Total	3.9 3.4 			5
(B)	Left bank at Nam Chon damaite	Banded sandy limestone (Formation B)	CaO MgO SiO <sub>2</sub> Total	39,3 1.9 20.2 61,4	CaCO3 MgCO3 Total	70.13 3.97 ————————————————————————————————————	CaCO <sub>3</sub> CaMg(CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Total	65.42 8.68 94.3 94.3	7
9	Left bank near Nam Chon damaite	Banded sandy Umestone (Formation B)	CaO MgO SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	2,2 1,2 7,3 3,43 59,33	CaCOj MgCO3	84.6	CaCO3 CaMg(CO3)2 SiO2 3/ CaAl2Si2O8 Total	78.6 4.66 5.16 9.45	
9	Hual Tong Thai	Banded sandy limestons	CaO MgO SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	49.9 0.6 5.9 1.54	CaCC <sub>3</sub> MgCO <sub>3</sub>	89.1 1.13 ————————————————————————————————	CaCO <sub>5</sub> CaMg <sub>2</sub> CO <sub>3</sub> ) <sub>2</sub> SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> Total	87.9 2.33 5.9 1.54	
11)	Huzi Ong Thang Yai (downstream of Nam Chon damsite) EL. 250m	(Formation B)  Quartzite  (Formation A)	CaO MgO SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub>	0.0 0.6 89.1 4.44	1041	art a 64	1041	31.01	10

 $<sup>\</sup>underline{1}/$  All CaO are calculated as CaCO3 and all MgO are calculated as MgCO3.

#### Quantitative Analysis of Limestone at Khao Laem Damsite (Quae Not River)

Y	Rock Name	Result of analysis		Result of norm calculation		Result of norm calculation	
Locality		Composition	% (wt)	Composition	% (ut)	Composition	% (wt)
*15*11		CaO	54,2	CaCO <sub>3</sub>	96.72	CaCO3	94,24
Inside of gallery at	Limestone	MgO	1.0	MgCO <sub>3</sub>	2.09	CaMg(CO <sub>3</sub> ) <sub>2</sub>	4.57
right bank		SiO <sub>2</sub>	0.2		<del></del>	SIO <sub>2</sub>	0.2
	(Formation D)	Total	55.4	Total	18.80	Total	99.01

<sup>2/</sup> All MgO are calculated as CaMg(CO<sub>3</sub>)2 and remaining CaO are calculated as CaCO<sub>3</sub>.

<sup>3/</sup> Al<sub>2</sub>O<sub>3</sub> is calculated as CaAl<sub>2</sub>Si<sub>2</sub>O<sub>6</sub> (Anorthite) by way of example.

<sup>4/</sup> Locality No. for micrograph of rock sample.

Table 1-5 Micrograph of Typical Rock Sample

1/	①	(2)			(6)		<u>(%)</u>			(3)			
Remarks			Tiny fossil remains			Calcareous		Original rock is alternation of sandstone & shale	Non calcareous	Non calcareous	River gravel,		
Rock Name	Dolomitic limestone (Formation D)	Calcitic dolomite (Formation D)	Limestone (Formation D)	Calcareous sandstone (Formation C)	Calcareous shale (Formation C)	Conglomerate (Formation C)	Banded sandy limestone (Formation B)	Phyllite (Formation B)	Slate (Formation A)	Quartzite (Formation A)	Schist (Metamorphic rock)	Phyllite (Metamorphic rock)	Granite
Locality	Near No. 8 site, 7 km upstream from Nam Chon damsite, right bank	Sink hole at left bank of Huai Tong Thai EL. 470 m	Right bank between No. 7 & No. 8 site	16 km downstream from Nam Chon damsite, left bank of Quae Yai R.	Huai Pachi EL. 790 m	Huai Phra, 11 km upstream from Nam Chon damsite EL. 290 m	Left bank of Nam Chon damsite	Near No. 7 site, 4 km upstream from Nam Chon damsite, right bank	26 km downstream from Nam Chon damsite, right bank of Quae Yai R.	Huai Ong Thang Yai EL. 250 m 25 km downstream from Nam Chon damsite	Upstream of Huai Yai	22 km downstream from Nam Chon damsite, right bank of Quae Yai R.	29 km downstream from Nam Chon damsite, river bank of Quae Yai R.
Locality No.	F	[2]	E	4	[2]	9		<b>®</b>	6	01		12	13

1/ Number shows locality No. in Table-1-4

#### Micrograph and Petrographic Description of Rock (Plate 1 of 7)

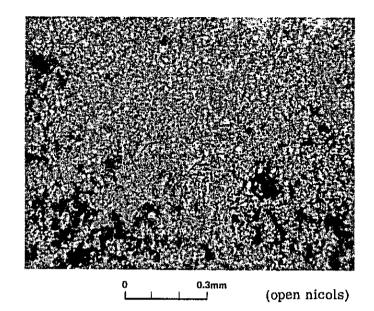
Locality: 1

Right bank of Quae Yai R. near No.8

site

Rock name:

Dolomitic limestone
Formation D



Petrographic description:

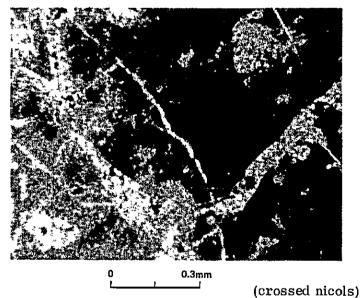
Light grey massive carbonate rock having white carbonate veins.

Locality: 2

Sink hole at left bank of Huai Tong Thai, EL. 470m

Rock name:

Calcitic dolomite
Formation D



Petrographic description:

Grey massive carbonate rock having white carbonate veins, a few bearing quartz.

# Micrograph and Petrographic Description of Rock (Plate 2 of 7)

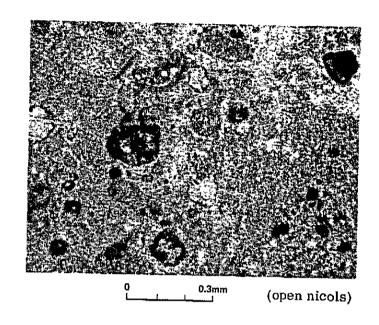
### Locality: 3

Between No. 7 and No. 8 site, right bank of Quae Yai R.

#### Rock name:

Limestone

Formation D



### Petrographic description:

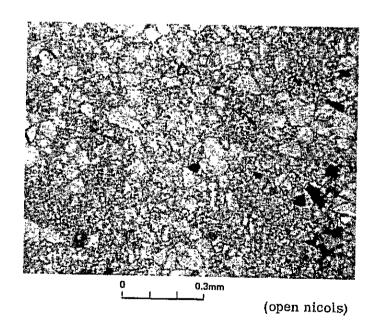
Grey massive carbonate rock with some white carbonate veins and tiny fossil remains. Carbonate  $\ggg$  quartz

### Locality: 4

16 Km down stream from Nam Chon dam site, left bank of Quae Yai R.

#### Rock name:

Calcareous sandstone
Formation C



### Petrographic description:

Light brown carbonate-quartz clastic sediment.

Calcite = quartz ≫ hematite and chlorite

# Micrograph and Petrographic Description of Rock (Plate 3 of 7)

Locality: 5

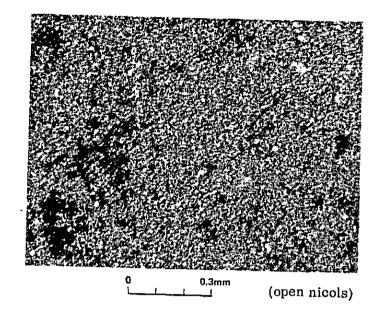
Huai Pachi, river bed

EL. 790m

Rock name:

Calcareous shale

Formation C



Petrographic description:

Dark grey calcareous shale mainly composed of fine-grained quartz, chlorite, sericite and graphite.

Foliation has the direction from upper right to lower left in microphoto.

Locality: 6

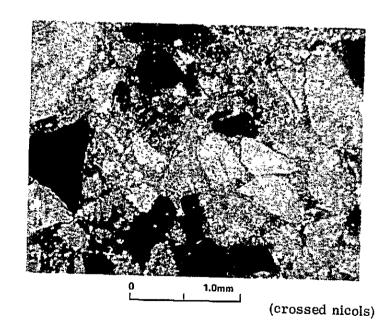
Huai Phra

EL. 290m

Rock name:

Conglomerate

Formation C



Petrographic description:

Light grey brecciated rock composed of compacted fragments of limestone, carbonate-quartz sandstone and calcareous shale.

#### Micrograph and Petrographic Description of Rock (Plate 4 of 7)

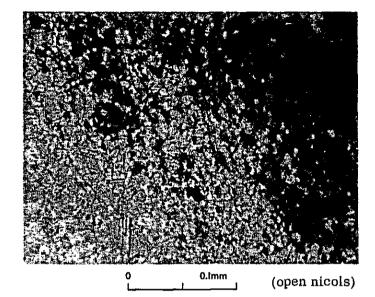
Locality: 7

Nam Chon dam site; left bank of Quae

Yai R.

Rock name:

Banded sandy limestone Formation B



Petrographic description:

Pale grey banded sandy limestone composed of coarse sandy limestone part ( $\oint = 70 \,\mu$ , calcite  $\gg$  quartz) and fine calcareous sandstone part ( $\oint = 20 \,\mu$ , calcite = quartz). Wholly altered at hydrothermal conditions with following results; recrystallization and equi-granulation of calcite, sericitization.

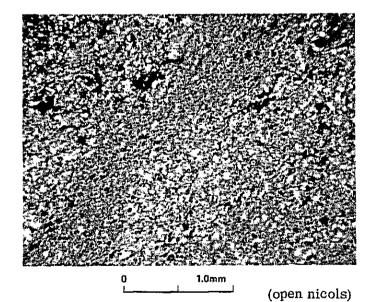
Locality: 8

Near No. 7 site, right bank of Quae Yai R.

Rock name:

Phyllite

Formation B



Petrographic description:

Original rock is alternation of sandstone and shale. Alternated phyllite composed of greenish grey slate (carbonate, chlorite, quartz >> graphite, sericite) and pinkish grey slate (carbonate >> quartz >> sericite, hematite). Foliation is observed from upper right to lower left in microphoto.

#### Micrograph and Petrographic Description of Rock (Plate 5 of 7)

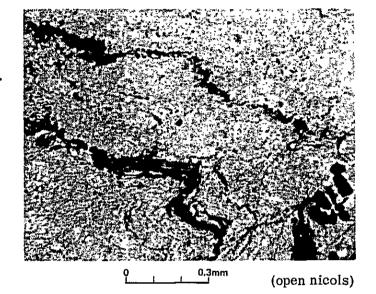
Locality: 9

26 Km downstream from Nam Chon dam site, river bank of Quae Yai R.

Rock name:

Slate

Formation A



Petrographic description:

Grey slate chiefly consisting of fine-grained quartz and sericite with small amounts of graphite, chlorite and plagioclase. No carbonate is observed.

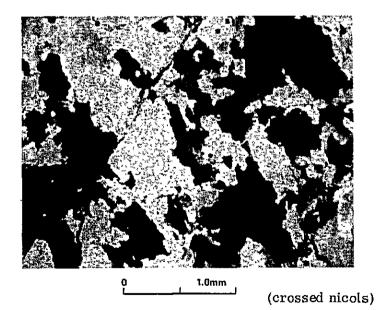
Locality: 10

Huai Ong Thang Yai EL. 250m

Rock name:

Quartzite

Formation A



Petrographic description:

Light grey hard siliceous rock. Chief constituting minerals are quartz >>> plagioclase > sericite, chlorite.

Foliation formed by recrystallization is clear; indicating a type of siliceous metamorphic rock.

#### Micrograph and Petrographic Description of Rock (Plate 6 of 7)

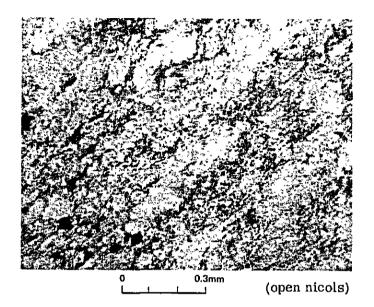
Locality: 11

Upstream of Huai Yai

Rock name:

Schist (River gravel)

Metamorphic rock



Petrographic description:

Greenish siliceous sediment having clear foliation (schistosity) and recrystal-lization texture.

Schistosity runs from upper right to lower left in microphto. Quartz  $\gg$  chlorite, sericite, plagioclase > apatite

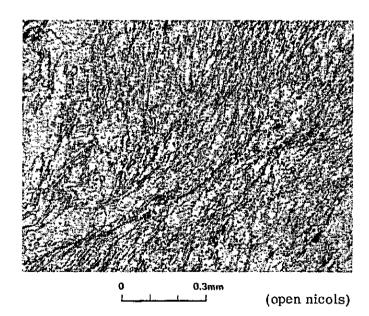
Locality: 12

22 Km downstream from Nam Chon dam site, right bank of Quae Yai R.

Rock name:

Phyllite

Metamorphic rock



Petrographic description:

Grass green phyllite composed of thin layers of calcareous band (carbonate, quartz >> chlorite, sericite) and siliceous band (quartz >> chlorite, sericite, plagioclase, actinolite >= graphite).

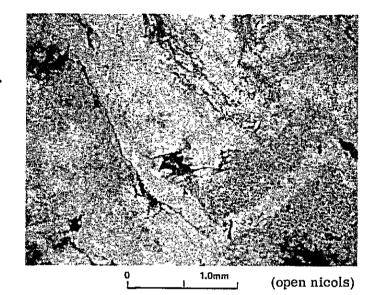
#### Micrograph and Petrographic Description of Rock (Plate 7 of 7)

Locality: 13

29 Km downstream from Nam Chon dam site, river bank of Quae Yai R.

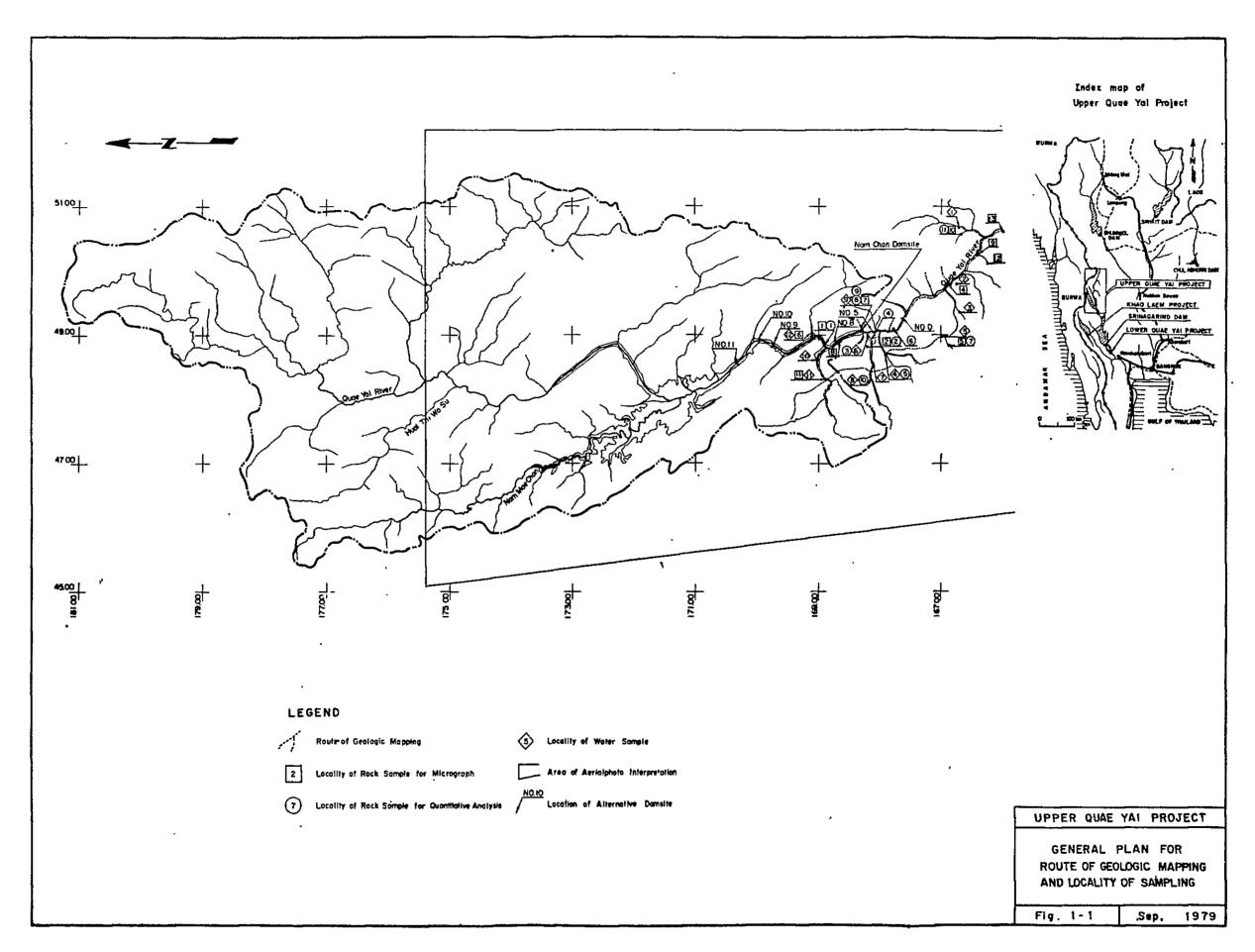
Rock name:

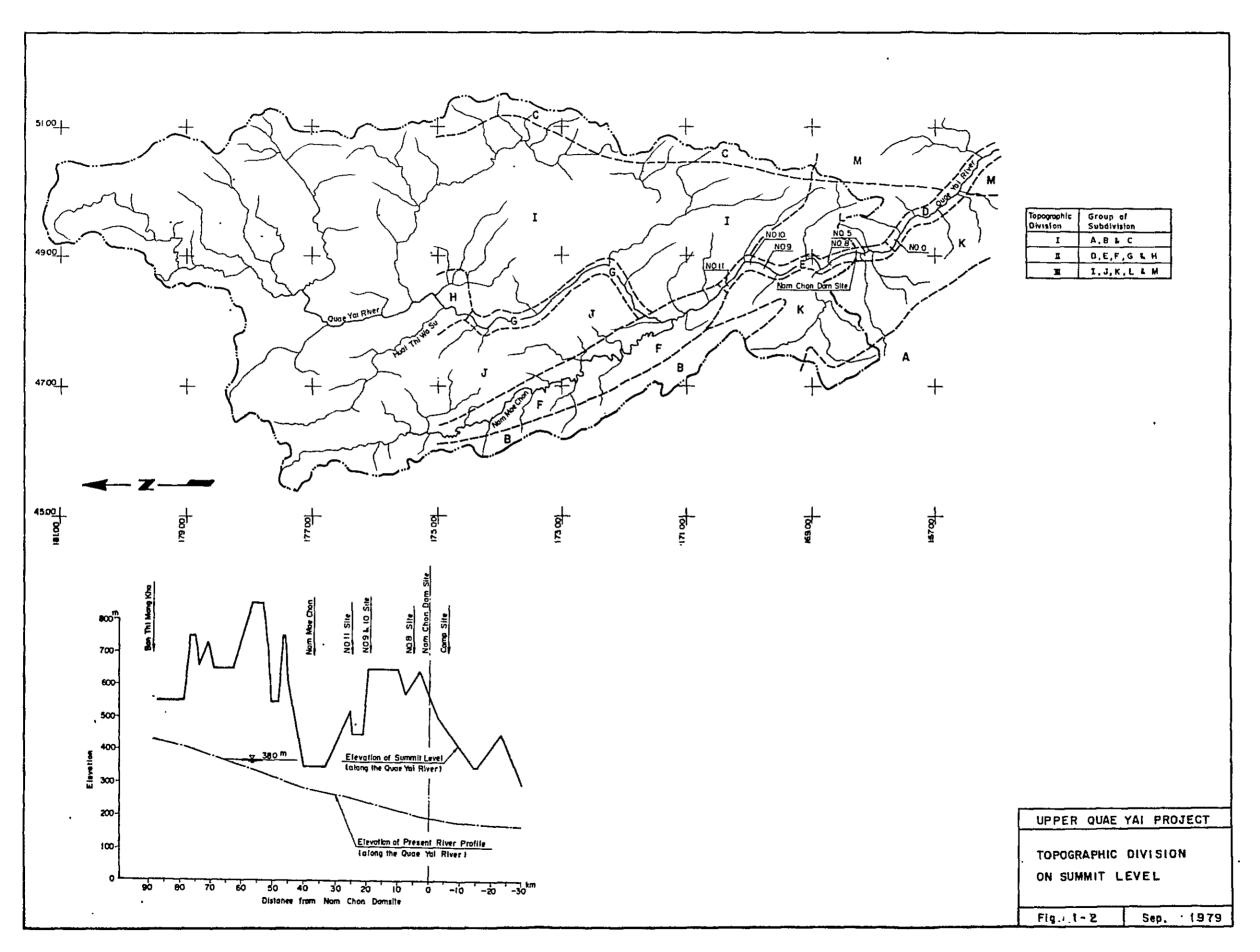
Biotite granite

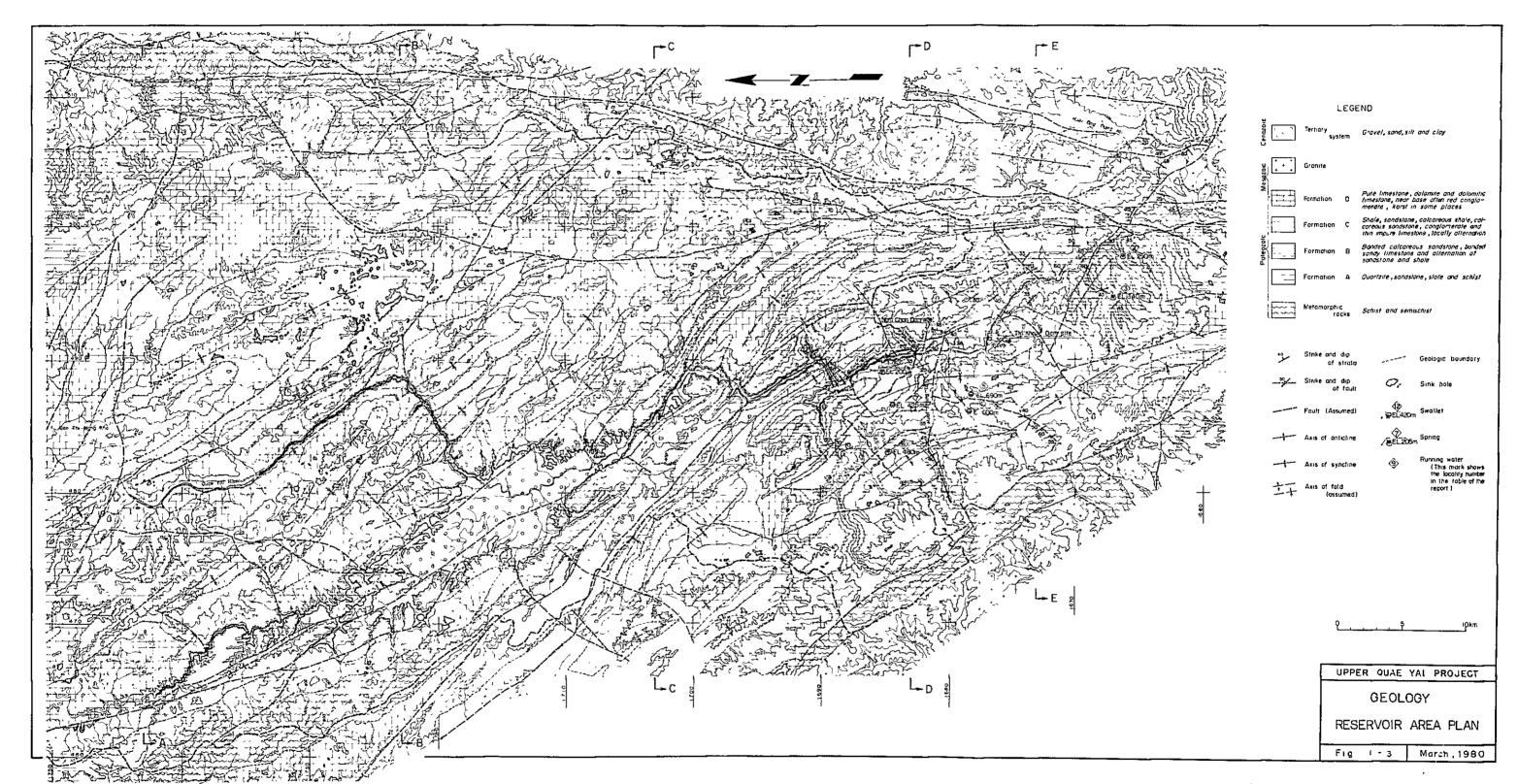


Petrographic description:

Brownish hydrothermally altered biotite granitic rock. Wholly sheared and altered at hydrothermal conditions with the following results; chloritization of biotite, sericitization of K-feldspar, albitization of plagioclase, deformation and recrystallization of quartz.







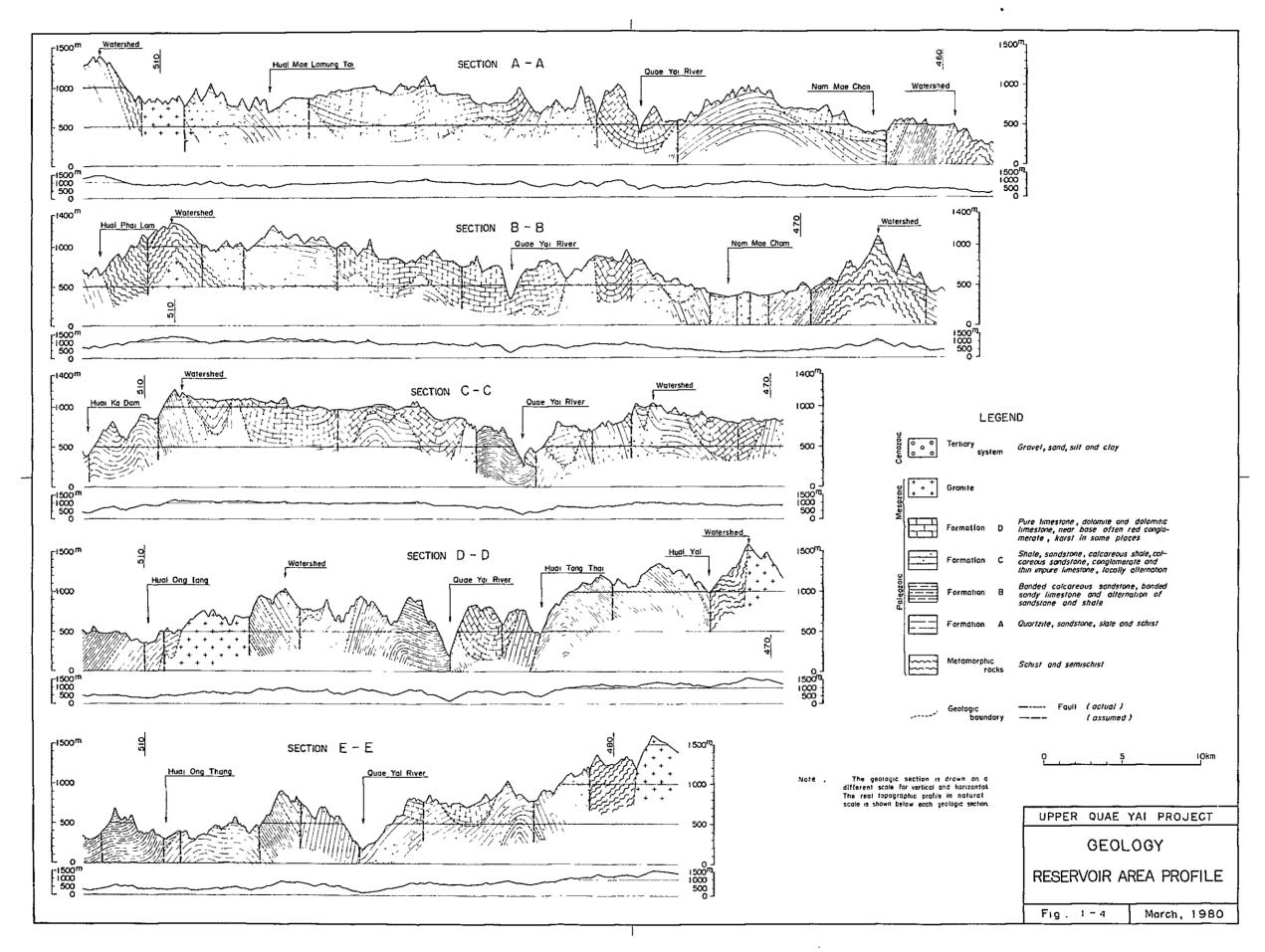
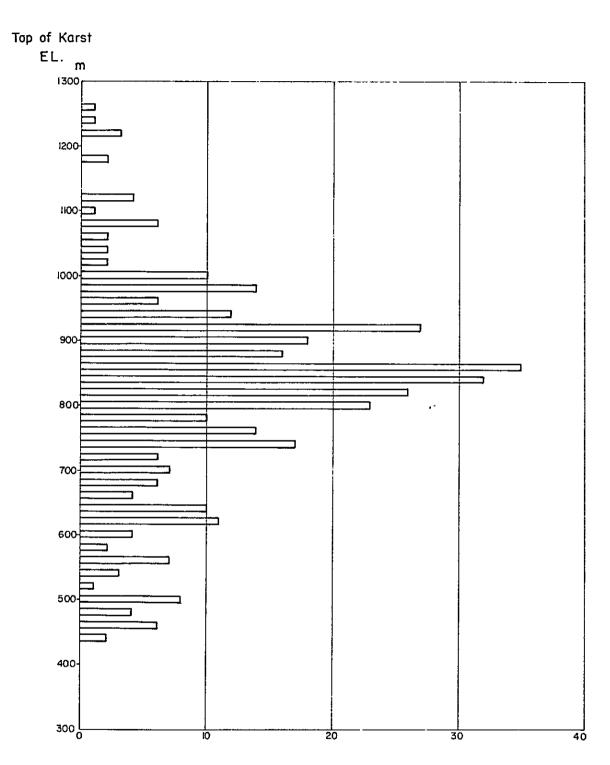


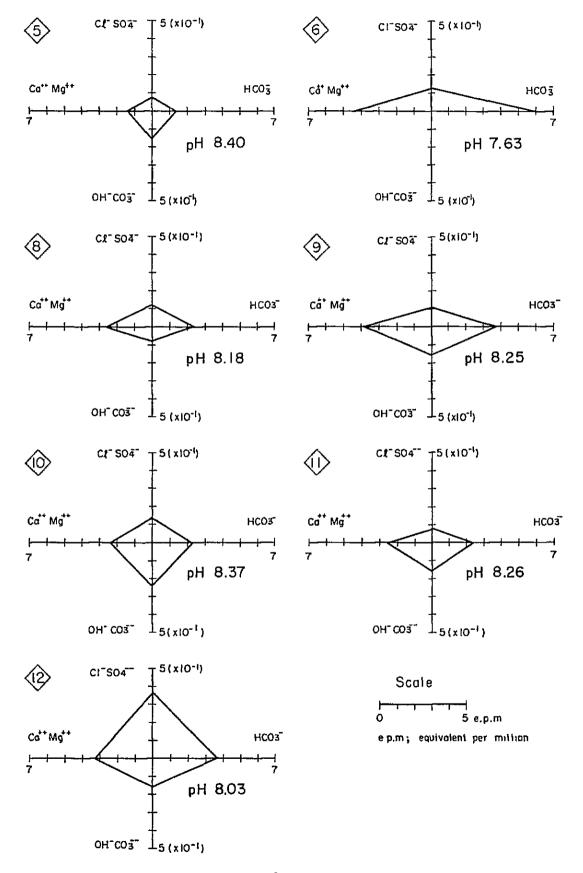


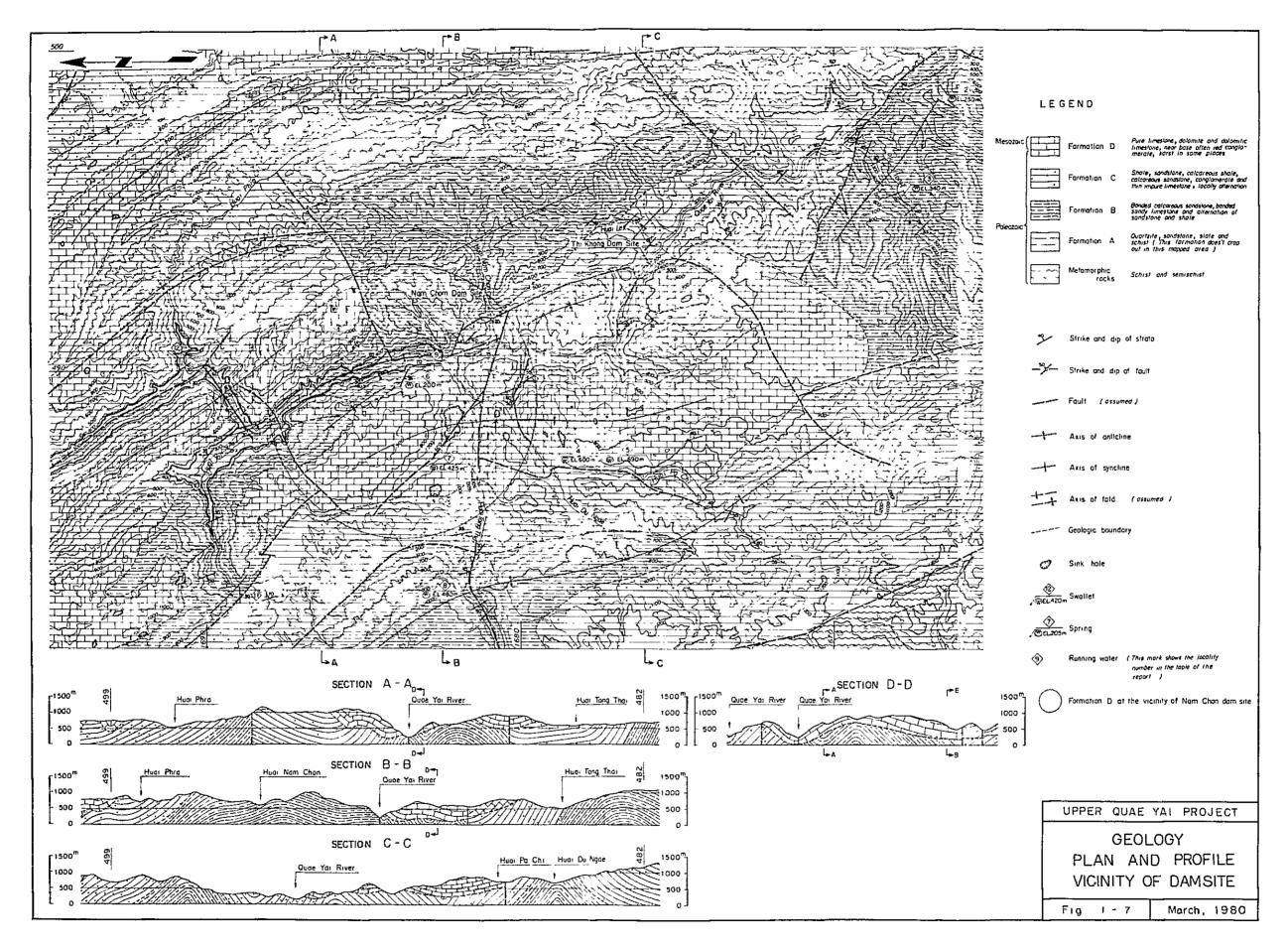
Fig. 1-5 Numbers of Sink Holes

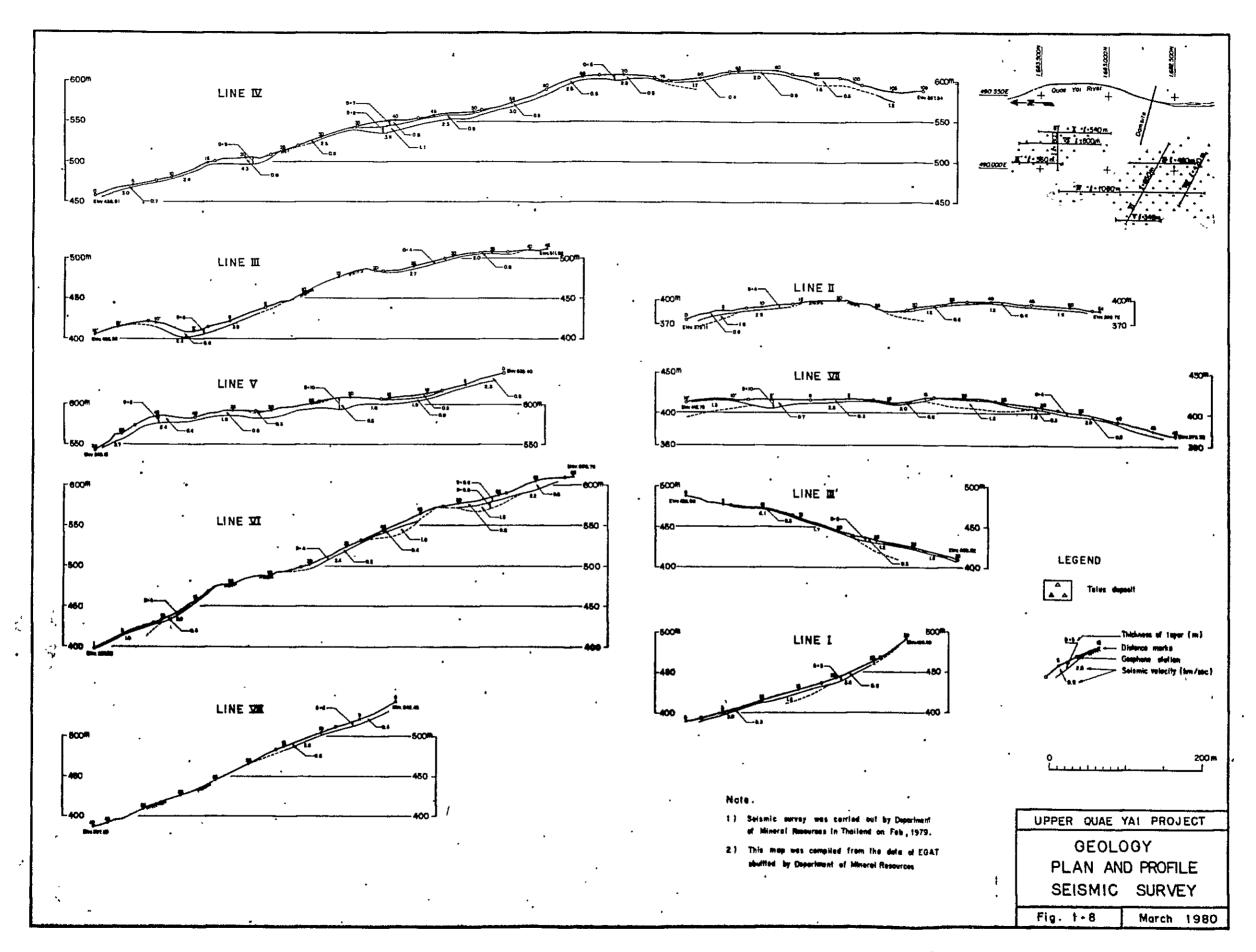


Numbers of Sink Holes in Catchment Area

Fig. 1 - 6. Chemical Character of Water Sample







LIST OF CORE BORING IN UPPER QUAE YAI PROJECT

Hole No.	Location	Elevation of top of hole(m)	Coordinate	Direction of hole	Length of hole (m)	Remarks
L - 1	Dam, Left Bank	391.8	1682575.6 N 490629.8 E	N85°E,45°	80.0	*
" - 2	11	336.1	1682570.5 N 490579.0 E	N85°E,60°	100.0	*
" - 3	<b>18</b>	293.9	1682565.6 N 490528.2 E	N85°E,70°	100.0	*
" - 4	**	201.2	1682564.6 N 490461.2 E	S85°W,60°	120.0	   * 
'' - 5	tt	279.7	1682613.1 N 490548.6 E	N85°E,60°	90.0	' *   *
" - 6	PT .	213.3	1682630.4 N 490481.0 E	N85°E,60°	60.0	*
R - 1	Dam, Right Bank	222.7	1682549.8 N 490391.1 E	N85°E, 70°	102.0	*
" - 2	†i	285.0	1682546.1 N 490323.9 E	Vertical	70.0	*
<sup>††</sup> - 3	ff	379.8	1682531.8 N 490207.4 E	**	100.0	*
" - 4	ft.	416.7	1682518.0 N 490127.2 E	17	50.0	*
" = 5	f†	256.7	1682618.1 N 490373.8 E	**	90.0	*
'' - G	11	338.1	1682615.0 N 490261.3 E	11	82.0	<b>*</b>
" - 7	31	476.7	1682662.7 N 490062.9 E	! !!	35.0	
" - 8	11	426.7	1682726.2 N 490139.7 E	tt	45.0	
P - 1	Penstock	403.2	1682330.6 N 490750.0 E	11	140.0	*
** - 2	ft	380.8	1682274.2 N 490653.3 E	11	180.0	*
" - 3	1 } ; 11	292.6	1682224.5 N 490563.8 E	N57°E, 60°	80.0	*

Hole No.	Location	Elevation of top of hole(m)	Coordinate	Direction of hole	Length of hole (m)	Remarks
S - 1	Spillway	376.1	1682417.5 N 490216.3 E	Vertical	40.0	
" - 2	11	316.3	1682 151.1 N 490 230.5 E	Ħ	46.0	
PH - 1	Powerhouse	200.7	1682206.4 N 490459.8 E	17	30.0	*
" - 2	11	223.9	1682135.7N 490500.9E	. 11	36.0	*
" - 3	11	211.4	1682149.0 N 490485.3 E	11	28.0	*
" - 4	17	242.8	1682023.5 N 490686.6 E	\$50°W,70°	50.0	
'' - 5	17	222.0	1682033.6 N 490576.2 E	N20°E,60°	40.0	
Q - 1	Quarry, Right Bank	No data	No data	Vertical	50.0	
11 - 2	71	11	Ff	† f	50.0	
" - 3	11	11	Ff	FI	50.0	
LL - 1	Thi Khong Site, Left Bank	189.0	11	a	35.0	*
'' - 2	ττ	216.0	Ħ	17	30.0	*
RR - 1	Thi Khong Site, Right Bank	187 0	11	11	30.2	*
" - 2	**	198.0	Ħ	f1	30.6	*
	To	otal			2069.8	

<sup>\*</sup> Permeability test hole

Un	per	Q١	iae Y	'a t		)JE(		.OC	HOLE N			4 1	
FOC			Dam 1		ulm			DE		O m	COMMENCED	/lay _ 14	_1979
ELE				3818		n		DE	PTH OF OVERBURDEN	<u>C</u> m	COMPLETED !	May - 25	- 1979
coc	RDII	VATE	1682	575 6N 4	190	629	8E	LĘ.	NGTH OF ROCK DRILLING 80	0 m	DRILLED BY .	_ ŁÓWI	
				ZONTAL		45	-		<del></del>	0 m	LOGGED BY	Y Fuki	itake
BEA	RINC	3 OF	ANGL	E HOLE	N E	5°6				<u> </u>		<del></del>	<del></del>
1.	<b>A</b> M€	ی	E E	TXO U	<u> </u>	œ.	ا ا		RVATION OF CORE	WATER	TABLE	_   _	ĕ
DEPTH	ROCK NAME	1.0	CORE RECOVERY	CEMENTA TION KIND OF BIT CASING	COLOR	WEATHER	HARD NESS	CORE	DESCRIPT ON	WATER	PRESSURE TEST	DEFTH	ELFVATION
	Š			2 + 20	8	₩E	Ŧ	85		LEAKA	SE OF DRILLING WATER		
Om			0 ↔ 100 ਆਮਾਤਰ ਵਿ		<b> </b>	<u> </u>	ļ. <u>.</u>			! <del>}</del>	Lugeon (e/min)	- on	3818 🖫
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8-71		XX				3			Shd zone with soft	]   ]		ʰ	
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			<u></u>	- RQD		1			ecomposed)				
				-							FIFCTRIC POWER I	evei and	ርኒም ረላ ፣ ተተ

Upper Quae Yai **PROJECT** HOLE No L - 1 (SHEET 2 OF 4 LOCATION Dam Left Abutment 80 O m DEPTH OF HOLE COMMENCED Moy\_ 14 \_ 1979 ELEVATION 381 8 0 0 m DEPTH OF OVERBURDEN COMPLETED May - 25 - 1979 COORDINATE 1682 575.6 N 490 629 8E LENGTH OF ROCK DRILLING 80 0 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL \_\_45 TOTAL LENGTH OF CORE 78 0 m LOGGED BY Y Fukutake BEARING OF ANGLE HOLE N85°E CORE RECOVERY 97 5 \_ 2 OBSERVATION OF CORE RECOVER WATER TABLE COLOR DESCRIPTION WATER PRESSURE TEST LEAKAGE OF DRILLING WATER LUGEON (P/min) 367.7 T 20m shd zane with Soft 1  $\sup_{P} \ell_y$ breccia. No. brn. material. than 2 =4.7 816 4 4 . 77 E-3 3 -5 No brn. cracks, but all 3 Cracks coated by white E-6 seam. 26.4 Core Loss. 269 -7 7es NO core. Fault zone. Εa 2 28.5 Shd zone with soft breccia. 30-- 20 Recemented Shd. 30n8. Generally good. 2 2 2 32.0  $\omega$ <u>-</u>2 Remarkable banded structure -3 and White Slams remarkable along band structure. 818 - 4 4 Shd and cracky generally, 3 - 5 5 3 37.0 Shd. generally, but 3 3 recemented. ı No brn cracks. 2 4 353.5 ▶ drillers note € 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain 1 (hard) ~ 5 (solt) I (fresh) ~ 5 (decomposed)

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**PROJECT** HOLE No L - 1 (SHEET 4 OF 4 ) Upper Quae Yai LOCATION Dom Left Abutment 800 m COMMENCED May - 14 - 1979 DEPTH OF HOLE COMPLETED May -25 - 1979 ELEVATION 381.8 m DEPTH OF OVERBURDEN 00 m DRILLED BY FONDISA COORDINATE 1682 5756N 490 6298E LENGTH OF ROCK DRILLING 80 0 m TOTAL LENGTH OF CORE ANGLE FROM HORIZONTAL 45 78 0 m LOGGED BY Y Fukutake 97.5 \_ 2, BEARING OF ANGLE HOLE N85°E CORE RECOVERY OBSERVATION OF CORE ELEVATION WATER TABLE DEPTH CORE WEATHER ING HARD WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER 0 - 100 LUGEON (Plmin) 3394 🗘 6 0m LenKage 3 3 2 2 63.0 77 - 3 Remarkable band structure. 5 Cracky. Generally good. but <u>-</u>8 brn cracks at 64.0 65.0, 65.6, 66.5, 68.4 68.9 , 69.1 , 73.1 , 77.0. EΒ Some of Cracks are SANDSTONE dissolved. 3 3 2 2 -2 - 5 0.7 g 80.0 325.2 ▶ driffer's note 4 1 (hard) - 5 (soft) 1 (fresk) ~ 5 (decomposed) - ROO

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Į.	POCK NAME	0		₹ Kp n	$\vdash$	14	1		ERVATION OF CORE	WATER	TABLE		z
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Upper Quae Yaı PROJECT	ног	E No L - 2	(SHEET 3 OF 5
LOCATION Dam Left Abutment	DEPTH OF HOLE		COMMENCED Apr _ 29 _ 1979
ELEVATION 336 I m	DEPTH OF OVERBURDEN		COMPLETED May - 7 - 1979
COORDINATE 1682 570.5N. 490 579 0E	LENGTH OF ROCK DRILLING		DRILLED BY FONDISA
ANGLE FROM HORIZONTAL 60 *	TOTAL LENGTH OF CORE	100 O m	LOGGED BY Y Fukutake
BEARING OF ANGLE HOLE N85°E	CORE RECOVERY	(000 a	<del>****</del> ********************************

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Upper Quae Yai

**PROJECT** 

HOLE No L-2 (SHEET 4 OF 5 ) LOCATION Dam Lett Abutment 100 0 m DEPTH OF HOLE COMMENCED APT \_ 29 \_ 1979 ELEVATION 336 I m DEPTH OF OVERBURDEN \_1 <u>O</u> m COMPLETED May - 7 - 1979 COORDINATE 1682 5705N. 490 579 0E LENGTH OF ROCK DRILLING 99 0 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL \_\_60 \* TOTAL LENGTH OF CORE 100 0 m LOGGED BY Y Fukutake BEARING OF ANGLE HOLE N85°E CORE RECOVERY 100 O % OBSERVATION OF CORE CORE RECOVERY WATER TABLE COLOR WEATHER ING HARD NESS WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER LUGEON 50(4min) 40 6 0m 293 7 T 60.0 Supply 4=7 NO Leakage 64.0 Completed recemented shd zone. No brn Cracks. 2 brn 2 2 3 reddish 70.0 Somewhat banded. Generally Shd With = 5.3-Chlorite material, but no brn. cracks. Cracky at 74.4~75.0. 3 3 3 1 95% 2 g -266.8 > drifter s note 4 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain 1 (hard) - 5 (soft) 1 (fresh) > 5 (decomposed)

DEPTH OF HOLE  LEVATION  3361 m  COORDINATE 1882 570 5H 495 57926  ANGLE FROM HORIZONTAL 60  ENGATION TOTAL LENGTH OF CORE BURBEN  PORT LENGTH OF MORE DRILLING 99.0 m  FOR ANGLE HOLE M92°C  CORE RECOVERY  TOTAL LENGTH OF CORE  100.0 m  LENGTH OF MORE CORE  100.0 m  SUBJECT M97 POND ISA  TOTAL LENGTH OF CORE  100.0 m  LOGGED BY Y FUNETGRE  COBSERVATION OF CORE  DESCRIPTION  CORRESS TO SH 495 195 195 195 195 195 195 195 195 195 1		Upp	er C	)uae	Yai	PRC				HOLE N		
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ANGLE FROM HORIZONTAL  BEARING OF ANGLE HOLE  LET SO BEACH STORE HOLE  LET SO BEACH STORE  LET SO BEACH ST					<del></del>		~	_	DE	PTH OF OVERBURDEN!		
BEARING OF ANGLE HOLE N839E CORE RECOVERY 1000.    1	COO	RDI	NATE !	682	570 5 N 49	<u>90 5</u>	790	E	LE	NGTH OF ROCK DRILLING 9	Om DRILLED BY FONDISA	
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Generally shd and cracky.  Most of cracks coated by chlorite material.  Strongly cracky gone at 92.3-92.5, 93.5-94.0  9 44.3-95.3, 96.0 ~ 97.3  3 1 98.5-98.7.  5 00.0 0 19.0 0 1	1-	-	XXIII							81,0		
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tight and the second of the se			1	<u></u>	- RQD		1 (	iresti)	5 (de	composed)		

**PROJECT** HOLE No L-3 (SHEET 1 OF 5 ) Upper Quae Yai COMMENCED May 9 \_ 1979 LOCATION Dom. Left Abutment DEPTH OF HOLE 100.0 m ELEVATION 2939 m COMPLETED May - 18 - 1979 DEPTH OF OVERBURDEN \_\_\_O\_O\_m COORDINATE 1682 565 6 N 490 528 2 E LENGTH OF ROCK DRILLING 100.0 m DRILLED BY FONDISA LOGGED BY Y Fukutake ANGLE FROM HORIZONTAL \_\_\_70 TOTAL LENGTH OF CORE 100 0 m BEARING OF ANGLE HOLE N85°E 100 0 % CORE RECOVERY OBSERVATION OF CORE PECOVERY SALER TABLE DEPTH CORE WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER LUGEON (4/min) om 293.9 T LeaKage wethd. as a whole and Supply some solution cavities are found. ٠, Solution at 5.4, 7.0 14.0 ~ 14.1. shd.at 12~13.0 (re-- 5 cemented ) 3 3 ı 8 3 brn- 7 -2 /5.2 Cracks brn, but generally 900d. brn. 3 2 2 20.0 p driffer a note 4 I (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain i (hard) - 5 (soft) 1 (fresh) ~ 5 [decomposed)

Upper Quae Yai PROJECT HOLE No L - 3 CHEET 2 UF 5 LOCATION Dam Left Abutment DEPTH OF HOLE 100 0 m COMMENCED May- 9 - 1979 ELEVATION 293 9 m DEPTH OF OVERBURDEN 0.0 m COMPLETED May - 18 - 1979 COORDINATE 1682 565 6N 490 528 2E LENGTH OF ROCK DRILLING 100 0 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL 70 TOTAL LENGTH OF CORE 100 0 m LOGGED BY Y Fukutoke BEARING OF ANGLE HOLE N85°E CORE RECOVERY 100.0 2 OBSERVATION OF CORE WATER TABLE - W-WATER PRESSURE TEST DESCRIPT ON LEAKAGE OF DRILLING WATER LUGEON 50(l/min) 40 20m 275./ T Leakage Good Core. Brn. cracks a few. -3 2 2 2 - 30 = 12.6 Supply 32.4 Fault breccia. Solution Cracks at 32.9. 33.85 Many brn. cracks with seam. Some cracks are dissolved 4 3 Ś 5 ' = 717 256.3 ▶ driller s note 4 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain 1 (fresh) 5 (decomposed)

HOLE No L-3 (SHEET 3 OF 5 )

### GEOLOGIC LOG OF DRILL HOLE

Upper Quae Yal

**PROJECT** 

LOCATION Dam Left Abutment DEPTH OF HOLE 100 O m COMMENCED May - 9 - 1979 ELEVATION 293 9 m DEPTH OF OVERBURDEN <u>00</u> m COMPLETED May - 18 - 1979 COORDINATE 1682 565 6N 490 528 2E LENGTH OF ROCK DRILLING 100 0 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL \_\_\_70 ' TOTAL LENGTH OF CORE LOGGED BY Y Fukutake 100 0 m BEARING OF ANGLE HOLE N85°E CORE RECOVERY 100,0 3, OBSERVATION OF CORE CORE RECOVERY ELE VATION WATER TABLE DEPTH DESCRIPTION WATER PRESSURE TEST LEAKAGE OF DRILLING WATER LUGEON (Plmin) 40 4 0m 256.3 T 40.1 ĒΙ Shd. as a whole. SUPPLY Many thin Shd. 30ne 67= 77 NO Leakage With 1-5 cm. 4 Clay are found every - 3 10~30cm. 5 - 6 '= ¤7 48.0 2 3 Generally good, but all cracks wethd. and brn. 3 ı 4 > drifter s note 4 1 (stick) 2 (substick), 3 (piece), 4 (fragment), 5 grain 1 (hard) ~ 5 (soft) 1 (fresh) ~ 5 (decomposed)

Upper Quae Yaı

**PROJECT** 

HOLE No L - 3 SHEET 4 OF 5 LOCATION Dam Left Abutment DEPTH OF HOLE 1000 m COMMENCED May - 9 - 1979 ELEVATION \_\_\_<u>293\_9</u> m DEPTH OF OVERBURDEN \_ Q,Q m COMPLETED May - 18 - 1979 COORDINATE 1682 5656N 490 528 2 E LENGTH OF ROCK DRILLING 100 0 m DRILLED BY \_\_\_FONDISA\_\_ ANGLE FROM HORIZONTAL \_\_ 70 \* TOTAL LENGTH OF CORE 100 0 m LOGGED BY Y Fukutake BEARING OF ANGLE HOLE N85°E CORE RECOVERY 100 0 OBSERVATION OF CORE RECOVERY CEMENTA THON KIND DF BIT CASING WATER TABLE - W-ELEVATION DEPTH WATER PRESSURE TEST DESCRIPT ON LEAKAGE OF DRILLING WATER LUGEON 50(θ/m1π) 10 6 0m 237.5 T Generally good, but Supply all cracks wethd. and NO Leakage . 2 3 2 4 GL-63.5 65.0 - 5 shd.as a whole. - 6 Breccia every 10-30cm. <u>-</u>7 No brn. crachs, but 7 chloriti zation. - 8 3 ٠9 3 4 ~2 -3 74.0 Many cracks, but no brn. 918. 5 cracks. dark all cracks coated by Calcite film. 76.0 Generally good. Ġ gry.-dark gry. No brn cracks, but 2 3 some cracks coated by calcite film. 2/8.7 h driller's note 4 l (stick) 7 (substick) 3 (piece), 4 (fragment), 5 grain 1 (hard) 5 (soft) 1 (fresh) 5 (decomposed)

Ur	ner	Quae	Yaı			CT	_0	aic lug of Drill		-		
LOCAT			· · · · ·	utme			ne	HOLE N				<u> </u>
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COORD	INATE	1682	565 6N 4					NGTH OF ROCK DRILLING LOC	0 0 m	· · · · <del></del>		8 -1979
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BEARIN	G OF	ANGL	E HOLE	<u>N</u> :	85°	<u>E</u>			, 0 - 3 5 - 0	COGGED BY	Y Fuk	urake
¥.	T T		4_4				OBS	ERVATION OF CORE	<del></del>		<del></del>	
DEPTH POCK NAME	0 0	CORE	CEMENT. TION KIND OF BUT CASING	ä	H S	5.5	Ä S		WATER	, ,	DEPTH	Į į
□ Q	-	e G	E 5 E 2	COLOR	WEATHER	HARD	CUTTING	DESCRIPT ON	i .	PRESSURE TEST	불	ELEVATION
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nkurlushadantankurlushadantankurlushadankurlushadan Calcareous SANDSTONE.	$\mathbb{H}$			7					- 111		4 11 15	
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ı	linne	or (	Quae	Yaı	PRC				HOLE N					
LOC			Dam	Left Ab			<del></del> -	DE		O m COMMENCED Feb 13 - 1979				
ELE	ELEVATION 2012 m								DEPTH OF OVERBURDEN 3 0 m COMPLETED Mar - 23 - 1979					
COC	COORDINATE 1682 564 6N 490 461 2 E								NGTH OF ROCK DRILLING 117	0 m DRILLED BY FONDISA				
BEARING OF ANGLE HOLE \$85°W									TOTAL LENGTH OF CORE 1152 m LOGGED BY Y Fukutak					
BEA	RINC	OF	ANGL	E HOLE	<u>58</u>	5°W				2 ,				
	4ME	ی	. è	Ž Š p Š	<b>}</b>	102	,	<del>,                                     </del>	RVATION OF CORE	WATER TABLE 1/A = 2				
ОЕРТН	OCK NAME	ľ	CORE	CASING	COLOR	WEATHER	HARD	CUTTING	DESCRIPT ON	WATER TABLE V TO SEE THE SE				
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Оп			0 → 10€			L	<u> </u>			LUGEON 50(Pmin) 40 Om 201.2				
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1	Deposit	Δ			brn		İ		04-3.0 Sand with Sub angular gravel (max					
2 = 3	- 1				9				diameter 3cm)					
1 =	River	Δ												
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4		$\otimes$			Ī		İ		Fault clay with breccia					
4-		$\aleph\!$		į	brn.				Sized max. 10cm.	<u></u>				
=		$\otimes$			7					GY - 4.25				
5		$\bowtie$					Ì		5.25					
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°		$K\!$			nish				breccia.					
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"		$\bowtie$							Breccia. 71					
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		į		-		1	+	1	▶ driller s note ◀					
		- core loss					tick) 2 (substick) 3 (piece), 4 (fragment), 5 grain							
	<u></u>	- COIE IOSS - RQD		1 (hard) 5(soft) 1 (fresh) 5(decomposed)										
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LOC				Left Ab				DE	HOLE N	0 m			or (			
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Ē.,		74	ИШ					1	Cracky at 57.9~58.0.				
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60 -	-	<b>,</b> ← L'a		į	- 1	-	-			[ ]	1 11 1	E 60	149.2
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DEPTH OF HOLE   120 0 m		Unt	er	Onge	Yaı				.00	HOLE A				
DEPTH OF OVERBURDEN   3.0 m   COMPLETED   Mor. 23.1979   Photosophic   100 completed   100 c	Upper Quae Yai PROJECT HOLE No L - 4 (SHEET 4 OF 6 )  LOCATION Dam Left Abutment DEPTH OF HOLE 120 0 m COMMENCED Feb - 13 -													
COORDINATE 1692 566 EN 490 66125  BEARING OF ANGLE HOLE  SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5°W  COR RECOVERY  SB5. SB5. SB5. SB5. SB5. SB5. SB5. SB5.					<del></del>			_						
ANGLE FROM HORIZONTAL  BEARING OF ANGLE HOLE  \$2.50 \ \	COC	RDI	NATE	1682	564 6N 4	90				<del>-</del>				
BEARING OF ANGLE HOLE \$85.9W CORE RECOVERY \$6.0.5\$	ANG	LE.	FROM	/ HORI	ZONTAL		60	•						
Continue   Continue	BEA	RIN	G OF	ANGL	E HOLE	S 8	5°V	<u> </u>						
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		core loss			١.		itick), 2 (substick), 3 (piece), 4 (fragment), 5 gran - 5 (soft)	,				
	<u> </u>	— RQ0		1 (			- a (sort)					
		÷.										

Upper Quae Yai PROJECT HOLE No L = 5 (SHEET 1 OF 5 )  LOCATION Dam Left Abutment DEPTH OF HOLE 90 0 m COMMENCED APT = 24 - 1975												
LOC							<del></del> -	DE			1979	
ELE	VAT	ION		2	79	7 ,	<u>-</u> <u>n</u>	DE		Om COMPLETED May - 5 -		
COO	RDII	NATE	1 <u>682</u>	613 IN 49	90 5	48 E	E	LE	NGTH OF ROCK DRILLING 90			
				ZONTAL		60	_		=	Om LOGGED BY Y Fukuta		
BEA	RING	3 OF	ANGL	E HOLE	ΝĐ	5°E		CC	RE RECOVERY LOO	O_ ;		
	ME		2	1 - L				_	ERVATION OF CORE	WATER TABLE	z T	
DEPTH	POCK NAME	00	CORE	CEMENTA TION KIND OF BIT CASING	COLOR	Ξã	HARD	T Se	DESCRIPT ON	WATER PRESSURE TEST	ELEVATION	
^	POC		REC	음 조묘?	8	WEATHER	HAH	COTTIN	DESCRITT ON	LEAKAGE OF DRILLING WATER	E.E.	
Qm			0 - 100							LUGEON 50 (Vimin) 40 om 279	9.7	
		$\mathcal{H}$										
13		$ \sum$					١.	_	wethd.and many		- 1	
[ ]		$\cdot \square$			brn	4	3	5	cracKs.	Test Test		
2 3		H			Ì	İ						
4	ı	5				<del> </del>		<del> </del>	23 Cracks brn inclined Cracks remark 30	≥ Lephage 2		
3_=		$\cdot \square$	ЩШ						cracks remark. 30	3		
4	ļ	(-)	10 II	1	prn.							
4-		H							Good core in general,	Supply -4		
=		$\Sigma$	<b>/</b> }[]]]		reddish	3	2	3		Supely that		
5-4		$-\square$	<b>/</b> 44111		rea		-		but all cracks brn.			
4	İ	$\mathcal{H}$	$\mathcal{M}$							7// a		
6-3	- 1	3	11AIII		818					77		
4	l	$\cdot \square$	114		26						l	
7-	]	24	<b>##</b>	l					7.3		1	
3 - 3 - 4 - 2 - 2 - 2 - 3 - 3 - 3 - 3 - 3 - 3 - 3		$\mathcal{H}$		į		3-4	3	5	Cracky Jone (gravelly core)			
8-	i.	5	<del>У</del> #)			4	<u> </u>	5	all cracks brn 80	8		
=	SANDSTONE	$\cdot \square$	44 III									
9-4	15		#H									
=	0	$\mathcal{H}$	ШЩ						0 / / 0 / 0	6		
/0-릨	2	5			-				Banded Structure	0/e		
=	S	$\square$	***************************************						remarkable.	77	İ	
14		:	¥						all cracks wethd.andbrn	77		
🗐	ŀ	5	ЖШ			3	į	3	Some crachs dissolved			
2-7	2.5	5	<b>/</b>			1	2	1	and filled by soil.			
=	-eous	$\mathcal{A}$				2		4	Solution cracks at 8~			
	_	$\mathcal{H}$	<b>加IIII</b>	ŀ					10.0.	<del>                                      </del>		
]	Calca	51	7 <b>4</b>						Soil fill cracks at 14.7.		1	
📆	ġ	$\Sigma$	4m		gry.				Suie free Crucks at 14.1.		İ	
1.1		$\mathcal{L}$		İ	00						1	
37		$\mathcal{H}$	<b>4</b> 111111								-	
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20 =		·71	ШШ	<u></u>					20.0	2 0 26	2.4	
		E	KL R	-		1	1	1	▶ driller's note 4		-	
		V	171 R	core loss		1	1,,		ick), 2 (substick), 3 (piece), 4 (fragment), 5 grain 5 (soft)			
									composed)			

			PRO	JE	СТ			No L	- 5 (SHEET 2		
LOCATI		Left Abi						<u> </u>	COMMENCED		
COOPN	INATE 1 <u>682</u>		9 7 10 54		_		PTH OF OVERBURDEN( NGTH OF ROCK DRILLING <u>9(</u>	0 O w		FONI	
	FROM HOR			60	_			0 0 m	DRILLED BY	Y Fuk	
	G OF ANGL				_			00 %			
W W	2:	۷ ,,					ERVATION OF CORE	J			ž
DEPTH TOCK NAME	L O G CORE RECOVERY	CEMENTA TION KIND OF BIT CASING	COLDR	E E	ESS	ir IING	DESCRIPTION	1	R TABLE	ОЕРТН	ELEVATION
2   2	L C C	R X X X	ខ	WEATHER -ING	HARD MESS	CUTTING	DESCRIPTION	ı	AGE OF DRILLING WAT		ELE
20m	0 - 100								LUGEON 50(4min.	40 20m	262.4 🖫
infinding to the first of the form of the form of the first of the fir			918.	2	2	3 + 2	Banded Structure.  Some Cracks brn but  not so many.  Partially Shd.	2.6 = 12.0 = 12.	Lea Kage	որիավոտհումումում	
!	15-131111									40	245./
40 = core loss						(hard)	> driller a note 4 ctick): 2 (substick): 3 (pieca), 4 (fragment): 5 grain - 5 (soft) ecomposed)	ın	<del></del>	<u>, , , , , , , , , , , , , , , , , , , </u>	15.73

**PROJECT** HOLE No L-5 Upper Quae Yai (SHEET 3 OF 5 COMMENCED Apr \_ 24 \_ LOCATION Dom Left Abutment DEPTH OF HOLE 90 0 m COMPLETED May - 5 - 1979 2797 m DEPTH OF OVERBURDEN <u>00</u> m ELEVATION DRILLED BY FONDISA COORDINATE 1682 613 1N 490 548 6 E LENGTH OF ROCK DRILLING \_90 0 m ANGLE FROM HORIZONTAL \_\_60 \* TOTAL LENGTH OF CORE 90 0 m LOGGED BY Y Fukutake BEARING OF ANGLE HOLE N85°E 100 0 % CORE RECOVERY OBSERVATION OF CORE RECOVERY CEMENTA TION KIND OF BIT CASING WATER TABLE WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER LUGEON 50(2/mtn) 245.1 40° 40.0 Leakage 5hd. 3one with clay. 3 No brn. cracks. 5 Supply greenish 4 43.4 Generally good core. NO brn. cracks. Shd. at 49.5~50.0 51.0 , 55.7~564,57.5. 2 3 2 g 3 -50 -2 6.0 58.0 shd. 30ne with clay. 3 3 No brn. cracks. ▶ drifter a note 4 l (stick) 2 (substick) 3 (piece), 4 (fragment), 5 grain 1 (hard) - 5 (soft) 1 (fresh) ~ 5 (decomposed)

Upper Quae Yai PROJECT	но	LE No. L-	5 (SHEET 4	ne
LOCATION Dom Left Abutment	DEPTH OF HOLE	90 0 m		Apr _ 24 _ 1979
ELEVATION 279 7 m	DEPTH OF OVERBURDEN	0 0 m		May - 5 - 1979
COORDINATE 1682 613 1N 490 548 6E	LENGTH OF ROCK DRILLING		DRILLED BY	FONDISA
ANGLE FROM HORIZONTAL60 *	TOTAL LENGTH OF CORE	90 O m	LOGGED BY	Y. Fukutake
BEARING OF ANGLE HOLE N85°E	CORE RECOVERY	100.0	ESCOLD BI	i. i and ight
w	ORCEDIATION OF COL	<del></del>		

		1 0	ANG	TE HOLE		821		cc	DRE RECOVERY IC	00.0	D_ 4;				
_	MA	ļ. <u>.</u>		1 × - 1	. L				ERVATION OF CORE	Т					
DEPTH	ROCK NAME	100	CORE	CEMENTA TION KIND OF BIT CASING	8	WEATHER	HARD.	, <u>9</u>		$\dashv$	WATER	TABLE	·	Ξ,	ELFVATION
5	ĺŠ	-	טַ ט	A FES	COLOR	ΙĘΞ	E z	CUTTING	DESCRIPTION		WATER	PRESSURE TEST	ł	ОЕРТН	, A
	<del> </del>	<u> </u>		ļ <u> </u>	ļ.,	<u> </u>	Ĩ	[°3	<u>                                      </u>	- 1	LEAKA	SE OF DRILLING W	ATER	<b>ن</b>	E.E.
60m	<b>L</b>		0 →100							<u>`</u>		LUGEON SOL Umi	$\overline{}$	£ ∩m	227.7 ₽
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[ '-	1	XXI	8		greenish gru	3	3	1	No brn. Cracks.	]	12.1		1 E	1	1
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4-	1	$\mathbb{K}$	1		1				Generally good core,		11	Japon	1		
1 4	]	H							•			NO Leaf	,,LE	4	
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70-3		.5H	40HIII	}	-+	-			70,0	j	4.8		سائس	اهج	J
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5-3	١.	ነ#	1411111		63	١١	ı		or nearly vertical.	1	<b> </b>		Ē.	. [	1
8	•	ЯΙ			greenish		İ	-		1	62	] [ ] [	E-5	'	
E. 1	1.	H	141111	l'	00			- 1		1	77	1 1 1 1	F	- 1	- 1
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"]	.'	<b>-777</b>			20		2	4	Rock is hard, but		<del>                                      </del>	<del>╎╶╏╸┨═╏</del> ┈	<del>                                     </del>		
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9-=	1.	)   <del>  </del>	HIII		اند	3			78.5				<b>E</b>		
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		1/1	[3]		ī	1	+		> driller # note ◀	•		<del>- 1 - 1 - 1</del>	<u> </u>	012	U.4
		1	以		- [		- 1,	(stick	) 2 (substick) 3 (piece), 4 (fragment), 5 grain						
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		Ł	RC	<b>X</b> 0	,				posed)						
				•											

-: <del></del>		-
Upper Quae Yaı PROJECT	HOLE No L	-5 (SHEET 5 OF 5 )
LOCATION Dom Left Abutment	DEPTH OF HOLE 900 m	COMMENCED APT - 24 _ 1979
ELEVATION 279 7 m	DEPTH OF OVERBURDENOO_m	COMPLETED May 5 - 1979
COORDINATE 1682 613 I N 490 5486 E	LENGTH OF ROCK DRILLING _90.0 m	DRILLED BY FONDISA
ANGLE FROM HORIZONTAL 60	TOTAL LENGTH OF CORE 90 0 m	LOGGED BY Y Fukutake
BEARING OF ANGLE HOLE N85°E	CORE RECOVERY 1000 _ 26	
F A KE	OBSERVATION OF CORE	R TABLEAA 7 Q
DEPTH CORE CORE CORE CORE CORE CORE CORE RECOVERY CEMENTA KIND BIT NO RING REATHER ING NO RESTHER	DESCRIPTION WATE	R TABLE

				$\equiv$				RVATION OF CORE	<u> </u>			
DEPTH ROCK NAME	9	ERY	CEMENTA TION KIND OF BIT CASING		œ			ERVATION OF CORE	WATER TABLE		1 3	ELFVATION
OEPTH CX NAM	L 0 G	CORE RECOVERY	ASIP TASE	COLOR	WEATHER ING	RD.	CORE	DESCRIPTION	WATER PRESS	JRE TEST	DEРТН	¥.
2 8			£ × BO	ŭ	WE.	ž	ប់ភូ			RILLING WATER		
8 om		0 →100							LUC	50(4/min)	80m	210.4
ndunkudunkudunkudunkulunkudunkunkudunkun Calcareous SANDSTONE.		000		dark gry.	3	3 - 4	4 - 5	NO brn.cracks, but Shd. as a whole. Most of cracks coated by calcite or chlorite material.	(u=3.2 \( \tau = 3.9	Supply NO leakag	મામોકામીકામીકામીકામીકામીકા જ	210.4 🕏
o dunilum dunilum	£							90.0	- <del>- 1</del> 29		90	201.8
4 Պատհամատկամատկամատկանակարևակարկարկարկարկար					•			> driHers note ◀			ումարևահակակավորիակակակակակակակակակակակակակակակակակակակ	
	ļ						1 (1	itick) 2(substick) 3(piece) 4(fragment) 5 grain				
		~~ <u>~</u> ↓	- core fass					- 5 (soft)				
		L	- RQO		1 (	itesh)	~ 5(d	ecomposed)				

Upper Quae Yai **PROJECT** HOLE No. L - 6 (SHEET 1 OF 3 ) LOCATION Dam Left Abutment DEPTH OF HOLE 60 0 m COMMENCED Mar \_ 26 \_ 1979 **ELEVATION** 2133 m COMPLETED AP - 7 - 1979 DEPTH OF OVERBURDEN 14 0 m COORDINATE 1682 6304N 490 481 0E LENGTH OF ROCK DRILLING 46 0 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL TOTAL LENGTH OF CORE 60 0 m LOGGED BY Y Fukutoke BEARING OF ANGLE HOLE N85°E **CORE RECOVERY** 100 O % OBSERVATION OF CORE RECOVERY WATER TABLE CORE MEATHER ING HARD NESS CORE DEPTH WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER LUGEON 50(/min) om 2/3.3 T F-2 wo kaakage 612 reddish Contain boulders. 7.0 - B Contain gravels brn. from river. Yellowish 14.0 Banded Structure. Strongly Wethd.and 4 3 4 Cracky. brn ı 1 1 Ã. 4 5 5 196.0 ▶ driller s nota 4 f (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain f (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

	Upper Quae Yai PROJECT HOLE No L-6 (SHEET 2 OF 3 )  LOCATION Dom Left Abutment DEPTH OF HOLE 600 m COMMENCED Mar = 26 - 1979												
_								DE					
ELE	VATI	ON		21	3 3	л	1			1 0 m	COMPLETED A	\pr	7 - 1979
coo	RDIN	NATE	1 <u>682 6</u>	30 4N 49	34	101	Ξ	LE	NGTH OF ROCK DRILLING 46		DRILLED BY _	FON	DISA
				ZONTAL			-	то	TAL LENGTH OF CORE _60	0 0 m	LOGGED BY	Y Fu	kuta ke
BEA	RINC	G OF	ANGL	E HOLE	NE	5°E	_	CO	RE RECOVERY 100	0 0 °			
	WE		È	۷. پ				,	RVATION OF CORE	WATER	TABLE - 10		š
DEPTH	OCK NAME	0 0 1	CORE	CEMENT TION KIND OF BIT CASING	COLOR	盖	ESS	₹E LING	DESCRIPTION	1	PRESSURE TEST	DE PTH	ELFVATION
5	Ω	-	2 2	CEME KIND BAT CASI	ទី	WEATHER	HARD	CORE	DESCRIPTION	ł	GE OF DRILLING WATER	Δ	33
200			0 - 100			_		_			LUGEON 50(4/min)	40 20m	196.0 T
بسلسنا					·				Banded Structure. Strongly wethd.and			արուրակուրայում Հ	
2-		X,				4	3	4	Cracky.	24.0		5	
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7-		H								19.4		E-7	
1	30	$\Box$					ĺ		Banded structure.	100		8	
8 4	70 NE	1	<b>XXX</b>	<u> </u> 			İ		Good Core, no brn.	77		E 8	<b> </b>
1	S 7	;							cracks			Ē,	
9411	07	$\Box$	/	[								E-9	
30-	SAND	$\mathcal{H}$							shd. at 293~29.6		_ <del>                                    </del>	_ <u>_</u>	1
1,1	5	$\mathcal{H}$	<u> </u>			_	٦		<i>30.3 ~ 30.6</i> .			Ę.	
;		H	]			2	3	3		1 11	Leakage	որիակակականությ	1
2111	uS	<u>;</u> ]	<b>X</b>			3	2	"				F	
2-3	Pcareous	$\mathcal{H}$	21111			ľ	-			4	│ │└┤ <del>╸</del> ┡┓│	₽2	
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903		_Z_  	71 N 10 N	и <u></u>		4	+	<u> </u>	► driller≤ note €			r - T V	
		,						1 (1	tick), 2 (substick), 3 (piece), 4 (fragment), 5 grain	ń			
		'	ነ 'ጣ ላር	_ tare loss		1			5 (soft)				
			L	- ROD		1 (	lresh)	- 5(4	compesed}				

**PROJECT** 

Upper Quae Yaı HOLE NO L-6 (SHEET 3 OF 3 ) LOCATION Dam Left Abutment DEPTH OF HOLE 60 0 m COMMENCED Mar \_ 26\_1979 ELEVATION 2133 m DEPTH OF OVERBURDEN 140 m COMPLETED APR - 7-1979 COORDINATE 1682 630 4N 490 481 0 E LENGTH OF ROCK DRILLING 46 0 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL \_\_60 \* TOTAL LENGTH OF CORE 600 m LOGGED BY Y Fukutake BEARING OF ANGLE HOLE N85°E 100 0 2 CORE RECOVERY OBSERVATION OF CORE RECOVERY DEPTH DESCRIPTION WATER PRESSURE TEST LEAKAGE OF DRILLING WATER **4** 0n LUGEON 50(Ψmiπ) 40 **4** 0m /78.7 🖫 Banded structure. Good Care, nobrn. 3 . 2 CracKs. 3 1 Supple 2 46.0 SANDSTONE 2 4 3 - 8 Banded Structure. Cracky Zone, but Ē-9 2 no brn. cracks. 4 1 3 Cracks Coated by Calcite film. -3 LeaKage 6 g 60.0 dollers note 4 I (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain I (hard) - 5 (soft) 1 (fresh) ~ 5 (decomposed)

_ ប	pper	Quae	Yaı	PF		ECT		HOLE 1		_		
LOCAT	TION	Dom	Right A						20 m	COMMENCED A		_
ELEVA		~	222			m			53_m	COMPLETED A		
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BEARI	NG OF	ANGL	E HOLE	N	859	<u>'E</u>		ORE RECOVERY 96				uiuke .
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DEPTH POCK NAME	007	CORE	CEMENTA TION KIND OF BIT CASING	3	HER	ا و	2 2		WATER	7 -	-   =	ELEVATION
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11	.51				- 1		ľ	Disolv. at 19.1.			-9	
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	M	N			1	1		▶ driller's note 4		<u> </u>	2016	
	M	12.3				'	f (stic	k) 2(substick) 3(piece) 4(fragment) 5 grain				
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	,	RC	90		1 (1)	esfi)	5 (deco	mposed}				

(SHEET 2 OF 6

#### GEOLOGIC LOG OF DRILL HOLE

Upper Quae Yai

**PROJECT** 

HOLE No R - t

COMMENCED Mar. - 25 - 1979 LOCATION Dam Right Abutment DEPTH OF HOLE 102 0 m COMPLETED Apr - 4 - 1979 ELEVATION 222 <u>7 m</u> DEPTH OF OVERBURDEN 5.3 m DRILLED BY FONDISA COORDINATE 1682 549.8N 490 391 1E LENGTH OF ROCK DRILLING 96.7 m TOTAL LENGTH OF CORE 98 64 m LOGGED BY Y Fukutake BEARING OF ANGLE HOLE N85°E CORE RECOVERY 967 % OBSERVATION OF CORE ELEVATION WATER TABLE WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER LUGEON 50 (P/min) 40 203.9 20.4 Many C. along schistosity c wethd. and coated by seam. Clength. gravel to 5cm. Remark. Solution at 20.7 ~21.0 (vert.). Breccia at 21.65-22.25 818 and 25.2-25.8. Some what shd. YGL-28.0 brn. c at 34.5 and 35-35.4. 3 2 Other C. coated by white seam or blk. graphite. gry. 30 Cracky 30ne at 34.3~35.25 and 35.4~35.6. greenish -2 Ş White Leakage 36.0 Shd. generally. No brn. C., but all C. = 5.5 Coated by white seam. Breccia at 39.5. 3 185.1 5 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain 1 (hard) ~ 5 (solt) 1 (fresh) ~ 5 (decomposed)

	IJa	ner	Oug	e Yai			CT		AIC LOG OF DRILL				
roc	CATI		_						HULE BTH OS HOLE	No R-	- 1 (SHEET 3 OF		
	LOCATION Dam Right Abutment ELEVATION 222.7 m						_	DEPTH OF HOLE 102 0					
	COORDINATE   682 549 8N 490 391 1							DEPTH OF OVERBURDEN					
				IZONTAL							DRILLED BY _		DISA
											LOGGED BY	Y Fu	kutoke
	BEARING OF ANGLE HOLE N85°E CORE RECOVERY 96 7 .  OBSERVATION OF CORE												
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Upper Quae Yaı **PROJECT** HOLE No R - 1 (SHEET 4 OF 6 ) LOCATION Dam Right Abutment DEPTH OF HOLE 1020 m COMMENCED Mar \_ 25\_ 1979 **ELEVATION** 222 7 m DEPTH OF OVERBURDEN \_ 5 3 m COMPLETED API - 4-1979 COORDINATE 1682 549 8 N 490 391 LE LENGTH OF ROCK DRILLING 96 7 m DRILLED BY FONDISA ANGLE FROM HORIZONTAL \_ 70 ° TOTAL LENGTH OF CORE LOGGED BY Y Fukutake 98 64m BEARING OF ANGLE HOLE N85°E CORE RECOVERY 967 OBSERVATION OF CORE RECOVERY WATER TABLE ELEVATION COLOR WEATHER ING HARD NESS WATER PRESSURE TEST DESCRIPTION LEAKAGE OF DRILLING WATER 601 LUGEON 50(4/min) 40 60m /66.3 ₽ shd. gone Ę١ No brn color. 2u = 3.0 Every 20-30cm interbedded ł breccia. 818 - 3 Wfite - 8 Generally good core. Partially shd. at 68.2, 69.0, 72-73.0,76.1. - 8 Cracky Jone at 66.4~ 67.2. white gry 2 2 3 -2 828 - 5 76.4 Ś Shd.3one. all cores brecciated and all gravelly cores B Coated by clay (white). 764-80.0 clear breccia. ₱ dzifler's note 4 I (stick) 2 (substick) 3 (piece), 4 (fragment), 5 grain 1 (hard) ~ 5 (soft) 1 (fresh) - 5 (decomposed)

Up	Upper Quae Yaı PROJECT					HOLE NO R - 1 (SHEET 5 OF 6 )						
	OCATION Dom. Right Abutment					DEPTH OF HOLE 102 0 m			COMMENCED Mar - 25 - 1979			
	ELEVATION <u>222 7 m</u> COORDINATE 1 <u>682 549 8N, 490 391 I</u> E						PTH OF OVERBURDEN5					
						LENGTH OF ROCK DRILLING 967 m						
			ZONTAL		<u>70</u> 5°E			<u>64</u> m	LOGGED BY	Y Fuku	take	
CREENATION OF CODE												
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