REPORT

OF

ENGINEERING GEOLOGY FOR BAN CHAO NEN PROJECT

QUAE YAI RIVER

YOZO FUKUTAKE

COLOMBO PLAN EXPERT

ELECTRICITY GENERATING AUTHORITY OF THAILAND

JULY 1973

OVERSEAS TECHNICAL COOPERATION AGENCY

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An Address of Thanks

July 26, 1973

Mr. Kasame Chatikavanij
General Manager
Electricity Generating Authority
of Thailand
Rama VI Bridge, Nonthaburi
Thailand

Dear Sir,

I hold it to my privilege and honour to submit, upon termination of my assignment as a Colombo Plan expert from the Japanese Government, herewith to you a report covering the whole details and traces of engineering geological studies I made of your Ban Chao Nen Project (Quae Yai No. 1 Project).

As you may recall, it was on July 29, 1970, exactly three years ago that I took up my assignment with your Authority with an initial schedule of office period of two years. Later in July 1972 the schedule was extended for another one year until this date in view of manifold and time costing engineering studies indispensable to elucidate fundamental factors of the Project and on the basis of unanimous approval of Japanese Government officials who well realized significantly important roll the Project is to perform toward development of your esteemed country.

On the brim of leaving this estimable land after three years assignment for the Project I am slightly in a sentimental retrospection. I remember as if it were only yesterday that the first attack of the Project was first initiated in October 1966 by a joint investigation team under participation of Mr. Srid Aphaiphuminart, Director of Planning Department of your Authority, with his many engineers and three Japanese experts under Colombo Plan. Since then, however, a rather long spanning of nine years has already elapsed and many people, Thai nationals and Japanese inclusive, came and joined in a successive and cooperative effort to reveal concealed key elements of the Project under the light and thereby to attain a firm and clearcut concept of project figure, and now we have come successfully to a point where we can command the whole view of the Project, though only intellectual existence as yet but it will come to reality is several years after the commencement of construction in the next year.

On leaving my office with your Authority and submitting my report I sincerely extend my cordial appreciation to you for that you gave me a good chance to participate, though for a relatively short period, in this significant Project which stimulated and stirred up my professional interest as an engineering geologist and has provided me with lots of engineering experience. Besides, I extend from the core of my heart many many thanks to the collaborators I made intimate friends throughout my assignment for their humane and unsparing cooperation and assistance without which I would not be able to lay my report to you.

Included among such intimate collaborators are Mr. Srid Aphaiphuminart and his engineering staffs who never failed to wrap me in hearty sympathy and compassion with my assignment, Mr. Lek Kanchanaphol and his juniors who shared a pleasant and fatigueless condominium life with me at the same field site in a latter period of my assignment, and responsible staffs of Electric Power Development Co., Ltd., Tokyo, Japan who have been taking continual backing-up support to me.

It would be to my utmost pleasure if my report can fully evidence my achievement and such collaboration I received from many people.

I hope the construction of the Project be successfully implemented.

Sincerely yours,

Yozo Fukutake
Colombo Plan Expert
by Japanese Government

Part I

GEOLOGY

OF

RESERVOIR AND DAM

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I. The work during the term and the present situation of Ban Chao Nen project at Quae Yai river

The term as a colombo plan expert (Speciality engineering geology) in EGAT (Electricity Generating Authority of Thailand) was from July 29, 1970 to July 28, 1973. Ban Chao Nen project when I arrived at my post has already completed the feasibility report on March 1968 and was continued to collect data of civil engineering and geology by the co-operation of engineers of EGAT and colombo plan expert. At that time (July 1970), EGAT judged that Ban Chao Nen project was in time to start the detail design for civil work and made the contract about the job with the consultant. But, in the cause of the complication of the geology at the site, during progressing the detail design EGAT must still continue to gather the geologic data for the design of the civil work. For instance the following items about the geology of the dam foundation has been investigated at the time from the middle of 1970 to the middle of 1973.

* The permeability of the foundation and the confirmation of the ground water level at the dam site.
* The detail geologic analysis for the selection of the dam axis.
* The various grouting test for the improvement of the dam foundation.

The other hand, the geology of the reservoir area which seal the fate of this large scale project was feared concerning the leakage water from the reservoir by the reason of the wide distribution of limestone. But, as the reservoir area is vast and the accessibility in the area is very poor, any regular geological investigation of the reservoir area was not performed on the time of the beginning of 1970. EGAT started to solve the reservoir geological problems from the middle of 1970, because if the problem is not solved, the Ban Chano Nen project can not be started no more.

Taking into consideration of the vast investigation area and the difficult accessibility, the co-operated investigation team was organized by EGAT, EPDC (Electric Power Development Co.,) and colombo plan expert. The team performed two times field investigation during the period from 1971 to 1972 and also EGAT performed the exprolation drillings located in the reservoir area on the same period by EGAT direct work. According to the result of these detail investigations, it was concluded that the foundation of the reservoir has no fear to leak the impound water in the reservoir.

As described above, various geological investigations were conducted at the damsite and data required for the detail design of the civil work were completed. The detail designs were also completed on February 1973 and the specification of the civil work will be completed on August 1973, the preparations for the construction of Ban Chao Nen project are progressing steadily.

All investigated data collected were objectively studied by the IBC (International Board of Consultant) who were invited according to the recommendation of IBRD (International Bank of Reconstruction and Development) by EGAT and were composed of three enough experienced engineers concerning civil work, engineering geology and foundation treatment. The meeting with IBC was held two times on 1971 and 1972 at Bangkok.

The studies result by IBC was submitted to the government of Thailand through EGAT. The such biggest project in the Asian area shall be soon started after passing the steadily long investigation period.

II. Summary and Recommendation

I want to summarize my opinion and some points which must be attended or investigated during the construction as follows.

1. Ban Chao Nen reservoir has no fear of leakage after impound the water by the reasons of the described later on.

2. The construction of the proposed civil structures at the Ban Chao Nen site is possible. But according to the investigation results completed, the foundation rock, especially the left bank foundation rock is rather complecated, therefor the foundation treatment of the damsite must be conducted carefully and enoughly. The foundation treatment is a biggest key point of this project.

3. A judgment concerning a quantity of a investigation work wich must be performed before an actual construction work is difficult to decide simply because of many cases at various sites. The investigation works at Ban Chao Nen site have been done enoughly to start the actual construction work of the project. But the investigation work at the site which has the complicated geologic structure can make clear its structure within a certain limitation. Therefor after starting the construction work, the appropriate judgment in response to the excavated rock of the foundation under the close relation between civil engineer and experienced engineering geologist must be required, and the exact geologic data of the final foundation of the structures must be recorded and kept for the long period maintenance of them.

4. The behavior of the ground water at the exist boring holes located at the flat area of the both banks must be continuously observed during the construction and after the completion. Because the behavior of the ground water is important data for the maintenance of the reservoir. (See Fig. 12) The behavior of the ground water level at the left abutment site of the dam is compleccate, the other hand, the exact distribution of the ground water at the dam site is useful data for the foundation treatment and for the observation of the leakage at the abutment after the completion of the dam. Therefor, at the damsite also, some boring holes located at the site which has not any obstacle for the construction work must be drilled and must be used as an observation hole from the time before impounding the water in the reservoir.

5. The saddle site connecting the left abutment of the dam must be investigated at the parallel direction of the river (down and up-stream direction) and the elevation and the thickness of the impervious rock at this saddle must be confirmed at the early stage of the construction.

6. The ground water level at the right bank flat area located near the intake channel is recorded higher than 190 m. M.S.L in the rainy season and about 178 m. M.S.L in the dry season. During the rainy season a spring water is found at the location about 500 m. downstream from BC-8 (BRN-2) and the elevation about 170 m. M.S.L. The ground water level of EL. 178 m. in the dry season has been kept from 1969 to the present time, therefor we do not fear to leak the impounding water through the flat area, but after impounding the water to the full water level, we must give some attention to the place.

7. The impervious core material of the dam has been investigated at F and I area, enough quantity and suitable quality were already confirmed. But the transportation distance is rather far. The suitable material is only hopeful to find it at the slope of the mountain consisted of quartzite or sandstone in this project area. By the reason, the closer site than F and I is located at Ban Tap Tao and Lam Mong Lai area, but the quantity of the deposit may be smaller than F and I area.

8. Quarry site for the rock fill and the concrete aggregate is located at the left bank of 2 km. downstream from the dam. The rock at the site is impure limestone belonging to Kanchanaburi series. The quantity and the quality for the material of the rock fill or the coarse concrete aggregate are suitable according to the test result of the rock, but as a material for a fine aggregate, remaining percentage was not so good (percentage of loss 36.5 %) according to the test result. When the construction work shall be started, if the rock shall be not economical as a fine aggregate material, the calcareous sandstone which is directly neighboring on the impure limestone at the upstream side may has much possibility as a fine aggregate material because the abration test result of the calcareous sandstone is better than the impure limestone (Abrasion test : impure limestone 25% calc. sandstone 18.0% loss).

9. Other site which is desired to be farther investigated at the early stage of the construction work is the site between the end of the right bank dam abutment and the site of the proposed intake structure. The rock of the site was already confirmed to be good by the drilling and the adit, but no

water permeability test has been done. The additional water permeability test results at the site must be useful to do economical foundation treatment of the site.

10. Finally, as mentioned above, the left bank foundation treatment of the dam abutment must be difficult. Therefor I hope that the treatment shall be performed under the good and satisfying understanding among the owner, the engineer and the contractor.

III. Geology of Reservoir (See Figs. 1, 2)

The following report about the geology after reservoir is extracted from the report of Quae Yai No. 1 Project (Ban Chao Nen Project) Geological Investigations of Reservoir Area February 1972 by EPDC.

The investigation of the report were conducted by the co-operated team with three EGAT's engineers, one EPDC geologist and one colombo plan geologist. The details of the result are reported in the above mentioned report, therefor Purpose and Scope, Method of Investigations, Previous Investigation, Cores Borings at Flat Areas around Damsite and Conclusion are described hereinafter.

III-1 Introduction

Purpose and Scope

This report on the geological investigations of the reservoir area of the Quae Yai No. 1 Project, which was conducted in accordance with the recommendations in Report No. 1 of the International Board of Consultants, dated July 10, 1971, was performed for the purpose of evaluating the watertightness of the reservoir.

In the recommendations in the Board's report, geological mapping and boring are recommended as the method of investigations. This report is only on the geological mapping. Regarding the reservoir geology, all results obtained up to the present time, including those from the preliminary stage of the project investigations, have been analyzed, studied and incorporated into this report.
investigations, have been analyzed, studied and incorporated into this report.

The extent of this geological mapping includes not only all sites recommended by the Board for investigations at the meeting held on July 9, 1971 between the International Board of Consultants, the Electricity Generating Authority of Thailand and the Electric Power Development Company, but also a fair amount of supplementary investigations covering areas not included in the recommendations of the Board.

This geological mapping was carried out jointly by EGAT and EPDC over a period of approximately 70 days from November 1971 to January 1972. EGAT engineers participated in the study under the direction of Mr. Srid Aphaiphuminart, Director of Planning Department. Besides, participating in the field reconnaissance, EGAT conducted chemical analyses of surface and ground water samples collected in the field and also furnished necessary labor and equipment. On the other hand, EPDC, at the request of EGAT, dispatched a geologist to the field throughout the period of the investigations, while other geologists and civil engineers in the head office in Tokyo headed by

Mr. Takeji Yasuda, Consultant to the President, provided advice in connection with the investigations.

The geological mapping team headed by Colombo Plan Expert, Mr. Yozo Fukutake, consisted of the members listed below. The team collected information in the field and consulted with Mr. Srid and other EGAT engineers at the EGAT head office in connection with the results of the geological mapping.

The field team consisted of the following geologists and engineer:

EGAT	Mr. Dhanit Suvanasiri, Geologist Mr. Paitoon Pityachawan, Civil Engineer Mr. Annop Koavichagon, Mining Geologist
Colombo Plan Expert	Mr. Yozo Fukutake, Geologist
EPDC	Mr. Masahiro Shibata, Geologist

After discussions at the head office of EGAT, the geologic data collected in the field were sent to the head office of EPDC, Tokyo. EPDC studied and compiled these data, exchanging views with Mr. Y. Fukutake, and prepared this report.

Area Investigated and Methods

Area Investigated

The pertinent features of the proposed Quae Yai No. 1 Reservoir is indicated below.

Height of Ban Chao Nen Dam	140.0 m
Reservoir surface area at normal high water level	404.65 sq. km
Length of reservoir	110.0 km
Normal high water level	180.0 m
Available drawdown	12.0 m
Total storage capacity	17,200 million cu. m.
Effective storage capacity	4,350 million cu. m.

The area investigated for evaluation of the watertightness of the reservoir is indicated in Fig. 1. The sites investigated, in addition to the most important nine spots recommended by the Board at the aforementioned meeting at the head office of EGAT, included numerous sites additionally investigated which in some parts extended to as far as the neighboring Quae Noi River. For the area surrounding the dam site, and the right bank of middle stream area, in view of its importance, detailed reconnaissance were widely carried out. Moreover, aerial observations were made over a wide area by means of helicopter.

The distance covered during this period was as much as 300 km.

Method of Investigations

The field reconnaissance was performed using topographic maps (scale 1/50,000) covering the whole reservoir area and 1/5,000-scale maps in the vicinity of damsite, aerial photographs (scale, 1/50,000 and 1/25,000), and photogeologic maps (scale, 1/50,000) were utilized for reference data.

The geological mapping were not confined to the confirmation of geologic phenomena of the designated or selected sites, but also, in order to clarify rock types, stratigraphy and structures, the geologic conditions of the route were observed or measured in detail for preparation of geologic maps. Therefore, the reconnaissance was conducted on foot mainly, though jeeps, boats and helicopters were utilized in some cases to expedite and elaborate on the investigations. In carrying out the reconnaissance, attention was paid to the flow conditions of surface water and samples of water were taken at ten-odd places which were analyzed chemically.

For confirmation of calcareous rocks, diluted hydrochloric acid was dripped on samples in the field. As fossils were extremely rare in the strata comprising the reservoir and its surrounding area, the determination of geologic ages was difficult. Therefore, efforts were made to clarify stratigraphy and geologic structure through detailed observations of outcrops and measurements of beddings.

For rock types which were difficult to determine by visual observation or the determination of which were especially important, samples were sent to EPDC Tokyo to identify their characters by means of microscope and X-ray diffraction.

III-2 Previous Investigations

As limestone is widely distributed in the Quae Yai No. 1 Reservoir area and its vicinity, leakage from the reservoir due to karst phenomena has been feared and evaluation of the watertightness of the reservoir was a major item of study of the Quae Yai No. 1 Project from the very beginning of the project planning.

(1) In regard to geological investigations within the area of this vast reservoir, in 1968, EPDC recommended as the first step i) geological mapping of the damsite and the connecting table land on both banks, and ii) photogeological studies of the reservoir and its surrounding area.

(2) In accordance with these recommendations, EGAT, in cooperation with Colombo Plant Expert, Mr. Takao Toyoda, geologist, carried out geological reconnaissance of the damsite and its surrounding area as well as some boring investigations of the table land on the right bank. The reconnaissance revealed that there were no karst phenomena in the table land on both banks of the damsite and it was generally confirmed that the base of karstic limestone was far above the reservoir high water level (EL. 180 m). Thus, the anxiety of leakage at the damsite and surrounding area was considerably alleviated.

(3) In August 1969, at the suggestion of EPDC, EGAT engaged a group of experts to inspect the project site.

Dr. F. A. Nickell, a member of this group in his report concerning leakage from the reservoir made the following statement:

> "Reservoir seepage is related both to the geological character and structure of the enclosing rock formation in turn, reflected by configuration and level of the normal groundwater table. There should be established (by determination concerning elevation of any springs, levels of any wells and valid hydrological measurements (if any) about losses from the river in the reservoir area) whether the groundwater table is tributary and higher than the adjoining river. I consider that the inclined bedding in the reservoir area is favorable. It is tentatively concluded that seepage from the reservoir area will be normal and acceptable. It is recommended that geophoto studies be made to show the geological structure and nature of the rocks at two or more transverse sections across the reservoir area."

(4) In accordance with the recommendations of EPDC which included the opinion of Dr. F. A. Nickell, EGAT awarded a contract to Kokusai Aerial Survey Co., Ltd. (KASC) in August 1970 to carry out photogeological survey work of the reservoir area. This work consisted not only of geological interpretations of aerial photographs covering the the reservoir and surrounding area (surveyed area approximately 6,500 sq.km), but also reconnaissance by two geologists, and was performed during the period from August 1970 to January 1971. The report submitted by KASC is accompanied by 1/50,000 photogeologic

maps, photogeologic profiles of 4 locations, 12 text figures and 85 field photographs.

KASC has stated in conclusion as follows on the problem of leakage:

"It became clear that karstic Rat Buri limestone is distributed widely over the investigated area and also occupies a considerable wide portion of the proposed reservoir area.

The most important problem should be focused on the possible water leakage through these limestone formations near the reservoir though facts pointing for a great danger of water leakage are not found.

Although the geotectonical tendency of the NW-SE direction and the lineament system are remarkable the leaking possibility through these tectonic elements are considered to be smaller than that of limestone due to their long leaking path length. .....

Although the possibility of water leakage from upstream and midstream of the proposed reservoir area is not necessarily realistic, the chances are relatively higher in the adjacent area of the dam site."

(5) EPDC examined in detail and evaluated the results of the photogeological survey by KASC and submitted a report to EGAT in May 1971 in which EPDC's comments on further investigations are given. In the course of evaluating the report prepared by KASC, EPDC reinterpreted the aerial photographs and presented its opinion regarding rock types, geologic structure of the reservoir area and watertightness.

The opinion of EPDC in its report regarding the watertightness of Quae Yai No. 1 Reservoir is summarized as follows:

"The geological conditions as revealed by the (Photogeological) study indicate that the Rat Buri limestone, which is the questionable rock, is distributed over a much wider area than assumed, but the reservoir area suspectable to leakage through this rock has been confined to a limited area.

. There are important factors brough to light which deny the possibility of leakage from the huge reservoir to adjacent basins to the east and west.

These are:

i) the distribution of granite which would serve as a natural barrier against leakage to the east (though the continuity of granite distribution is questionable in the southern part),

ii) the distribution of undetermined formation which would serve as a natural barrier against leakage to the west (if it belongs to the pre-Rat Buri limestone),

iii) the small possibility of existence of long caves crossing the repeated folded structure which develops along the mountain range forming the divide between the Quae Yai and Quae Noi River basins,

iv) the existence of Tertiary formation which can be expected to be an impervious blanket in the middle stream of proposed reservoir, and

v) that karstic phenomena which can be directly related to leakage cannot be recognized in the reservoir area.

Although continuity of granite distribution and the filtration of the undetermined formation have not been clearly defined by this photogeological survey, it is anticipated that field reconnaissance will be able to give positive information on the effectiveness as a barrier of these geological units.

As the next stage of investigations, the field reconnaissance and the hydrogeological survey should be conducted in order to disclose the abovementioned unconfirmed geologic conditions by photogeological survey."

(6) In May 1971, around the time the aforementioned report of EPDC was submitted to EGAT, a geological reconnaissance of the reservoir area was conducted by EGAT over a period of approximately one month with a team consisting of geologists listed below which included an EPDC geologist who cooperated in the work.

Mr. Dhanit Suvanasiri, Geologist, EGAT

Mr. Annop Koavichagon, Mining Geologist, EGAT

Mr. Yozo Fukutake, Geologist, Colombo Plan Expert

Mr. Masahiro Shibata, Geologist, EPDC

This reconnaissance was carried out on the basis of photogeologic maps (scale, 1/50,000) prepared by KASC and EPDC. These maps were checked during the field survey to improve their accuracy, and as a result numerous facts were revealed which have enhanced evidence of the watertightness of the reservoir. The results of the field investigations are compiled in a report dated June 1971, prepared by EGAT with the cooperation of EPDC. Microscopy tests of rock samples collected during the field investigations were carried out by EPDC.

The reconnaissance covered an area from the upstream to downstream of the reservoir and the Central Mountain Range forming the divide with the Quae Noi basin. The results of this reconnaissance are concluded in the report as follows:

"Upstream Area

Rat Buri limestone is distributed below the high water surface level of the reservoir, EL. 180 m, but the basal rock under-lying the Rat Buri limestone and surrounding area is a distribution of either rocks belonging to the Kanchanaburi Series or granite .... On one hand, the depth of water in this part of the reservoir is less than 50 m so that hydrostatic pressure is low, ..., the water level gradient to other basin is small. As stated above, it is judged there is no danger of leakage from this area.

Middle Stream Area

.... this Tertiary deposit is an impervious stratum. Viewed further macroscopically, it is estimated that the Kanchanaburi Series is distributed underneath this Tertiary deposit, and moreover, since at the west margin there is the Central Mountain Range (the divide between the Quae Yai and Quae Noi basins) comprised of metamorphic rocks and distributions of slate and granite at the mountainous area at the east margin, it is judged there will be no risk of leakage in the east-west direction. However, in the upstream basin of the Huai Mae Lamun, Rat Buri limestone extends in the downstream direction parallel to the Quae Yai River, part of which is distributed within the reservoir (to below EL. 180 m) and if there should happen to be a large-scale cave in this Rat Buri limestone the possibility of leakage through this channel is conceivable. However, if there should be leakage this will be discharged into the Downstream Area described below.

Downstream Area

.... the right bank side below EL. 270 m - 300 m is comprised of the Kanchanaburi Series while above this elevation Rat Buri limestone covers the basal rock of the Kanchanaburi Series. There is development of karst topography in this Rat Buri limestone, but these karsts are all above the high water surface level (EL. 180 m) of the reservoir.

On the left bank side, the mountain (maximum height approximately 500 m) at the abutment of the dam consists entirely of alternations of quartzite, limy quartzite, shale and limestone belonging to the Kanchanaburi Series, and after so-called foundation treatment for the dam foundation, this will not be a formation that would contain a leakage path that would affect leakage of the reservoir.

However, behind the abutment (east side), there is a flat plain of EL. 200 m - 260 m spread out over a fairly wide area, the northern margin of this flat plain contacts the reservoir ....

This limestone (Rat Buri limestone) is distributed above EL. 250 m at the northern side and southeastern side of the flat plain and there were a few karst phenomena seen in the photogeological interpretation by EPDC ....
.... the basal rock of this plain consists of the Kanchanaburi Series which was covered by Rat Buri limestone from elevations of 200 to 250 m. However, this limestone was later washed away through erosion with only a part of it remaining as monadnock.
........, it may be judged there will be little possibility of leakage through this flat plain, ..."

(7) From the site inspection and examination into all geologic information accumulated over a period of several years from the start of geological investigations, the Board in its Report No. 1 (July, 1971) concluded and recommended as follows with respect to the watertightness of the reservoir.

"The watertightness of the reservoir in the upstream area and left and right midstream areas is nearly assured, and can be verified by moderately additional surface geological mapping. Additional geological investigation is necessary to permit evaluation of watertightness in both the left and right banks near the dam. Geological studies, consisting principally of surface mapping and drilling, should proceed with priority over further damsite investigation."

(8) In accordance with the above recommendations of the Board, geological studies were immediately started. Geological mapping was completed in January 1972 and the results are compiled in this report.

III-3 Core Borings at Flat Areas around Damsite (Fig. 12)

Based on the recommendations of IBC, EGAT carried out core borings at the flat areas on both banks of the damsite. The elevations of the ground water tables measured at these drill holes are given in Table 1.

Table 1 Elevation of ground water table in bore hole drilled in flat areas

Location	Hole No.	Elevation of top of hole (m)	Elevation of ground water table (m)
Left Bank	BLN-1	200.84	178.60
	BLN-2A	196.47	186.30
	BLN-4	240.02	209.00
	BLN-5A	231.12	200.90
Right Bank	BRN-1	201.35	177.43
	BRN-2 (BC-8)	199.60	181.39
	BRN-3	206.65	174.36

Note: Measured in June 30, 1972

As seen in the foregoing table, it was found that the elevation of the ground water table at the flat area of the left bank is 178 to 209 m and the water table is sloped gently towards the reservoir in the northwest direction. However, the ground water table near the left abutment of the dam is low and there is a significant difference between the elevation of the ground water table of the flat area and the damsite. On the other hand, there is also a flat area on the right bank, although of a smaller scale than on the left bank, and the elevation of the ground water table according to borings in this area is roughly 174 to 181 m. In view of the fact that the ground water table near the right abutment of the dam is fairly high, the ground water table on the right bank is more or less parallel with the topography. Therefore, it is considered that water collected at the flat area on the upstream of the right bank abutment of the dam will flow into the Quae Yai River. Further, according to examinations of these boring cores and results of permeability-tests, there have been no cavities discovered which could serve as passage-ways for water.

III-4 Conclusions

As the result of the geological mapping, based on the rock types prevailing in the area investigated and the geologic structure confirmed, the watertightness of the basal rock of the reservoir area has become more nearly assured, as summarized below:

(1) There is a distribution of pure limestone (so-called Rat Buri limestone) showing prominent karstic phenomena at the right bank of the reservoir, but the rock is distributed above the high water level of the reservoir (EL. 180 m).

(2) The formation underlying the pure limestone on the right bank of the reservoir is an alternation of impure shaly limestone, shale and calcareous sandstone (Formation B). Large-scale caves, sink holes or underground channels were not found. This fact leads to the conclusion that, lithologically, there is extremely small possibility of the existence of large-scale caves, sink holes or underground channels in this formation. In fact, no significant karstic phenomena were recognized through the geological mapping and according to the photogeological survey, in the area of distribution of this formation, information regarding karstic phenomena is exceedingly scarce. On the left bank of the reservoir, there are no outcrops of pure limestone and the abovementioned Formation B of considerable thickness is widely distributed.

(3) Under Formation B, there exists the oldest clastic rock (Formation A), mainly consisting of quartzite and slate. This formation is distributed SSE-NNW on the left bank extending from the vicinity of the damsite to the upstream area of the reservoir and even partially to the right bank side. Therefore, Formation A, B and granite which is intruded in Formation A will be an effective barrier against esatward leakage from the reservoir.

(4) The core of the Central Mountain Range which is the divide between the Quae Yai and and Quae Noi is comprised of metamorphic rocks, such as schist and gneiss and can be expected to be an effective barrier against westward leakage from the reservoir.

(5) The main stream and the major tributaries were reconnoitered, and in spite of the fact that it was in the dry season, almost all of the tributaries were continuous streams, and so-called interrupted streams, influent streams, underground streams and exposed underground streams were not recognized within the reservoir area. This is considered to be one evidence indicating the watertightness of the bedrock in the reservoir area.

(6) The geology of the table land on both wings of the damsite is comprised of Formation B which has no significant karstic phenomena as mentioned in (2). According to boring being performed at these table lands, the ground water levels are being found to be somewhat higher than the reservoir high water level. It is expected that negative information against leakage through these table lands may be confirmed with the boring works which are underway.

Judging from the geologic condition revealed by the recent field investigations, it is considered that the fear of leakage which had been entertained has been almost entirely eliminated.

IV Geology of Damsite (See Fig. 3 - 11)

IV-1 General Description

(1) Left Abutment

The left abutment below an elevation of roughly 100 m is covered with thin topsoil of 2 to 3 m deep. The topsoil at the higher elevations is extremely thin. At the foot of the slope there are also terrace deposits of thicknesses less than 10 m.

The bedrock at the left abutment may be broadly divided into two varieties. One is calcareous sandstone distributed in the vicinity of the dam axis in a range roughly from EL. 140 down to the river bed. The other is quartzite which is distributed above EL. 140 m in the vicinity of the dam axis. The boundary between the two is not clear because of the existence of topsoil, but can be pursued by exploratory adits and boring. As seen at exploratory adit TL-8 (EL. 115.25 m), the boundary is slightly sheared, crushed, and the rock is brittle.

The thickness of a stratum of calcareous sandstone is about 30 to 150 cm and there are occasional intercalations of thin layers of shaly limestone and quartzite. The character of rocks in fresh parts is hard, but where folding is severe, crushing and weathering are prominent and as a whole it has become brittle. Intercalated shale has become clay in most cases.

Quartzite distributed at places of high elevation is less crushed and weathered than the calcareous sandstone distributed at lower elevations and there are thin clay seam along bedding planes, but rock pieces are hard. However, development of cracking is prominent as a whole and brownish weathered surfaces along the cracks continue to fairly great depths. Therefore, the permeability of these parts at high elevations are estimated to be high. This portion of elevation between 90 and 100 m has been called Zone A.

Below elevation of 90 to 100 m there is a fairly large-scale weak zone called Zone B. The width at EL. 60 m is estimated to be approximately 130 m along the dam axis and is believed to continue in the upstream-downstream direction parallel to the river. There is outcropping of sound bedrock at the river bed, and in boring to a depth of apprxomately 100 m (BL-8), this weak zone has not been found. As seen in the two exploratory adits TL-5 (EL. 60.35 m) and TL-10 (EL. 72.82 m) excavated in this weak zone, there are fairly thick masses of hard rock existing in the weak zone in irregular forms. The continuity to the part underlying this weak zone is unconfirmed, but is probably of irregular form due to complex folding with the character gradually improving.

This weak zone is seen at a depth of 20 m from the portal of exploratory adit TL-5 (EL. 60.35 m). The condition being as follows (the distance of 20 m from the portal is comprised of a terrace deposit and the weathered surface portion of the bedrock): from this 20 m point to 90 m there are repetitions of slightly hard rock intercalated by thin sheared portions of 5 to 10 m thick and completely crushed weathered zones of 3 to 5 m thick. From 90 m to the facing of the adit (101.30 m) there is a continuation of a completely crushed weathered zone, although slightly hard quartzite can be seen at the bottom part of the facing. However, since a weak zone is seen at drill hole BL-9 (EL. 102.47 m), it is estimated that a similar condition to that between 20 m and 90 m exists over a fairly wide area deeper into the rock than the facing of the exploratory adit. Judging from the condition of this exploratory adit TL-5, despite the fact that there are portions of hard rock locally, this must be called a weak zone as a whole.

It is thought this weak zone was formed due to compounding of weathering action from the ground surface to the rock crushed by severe folding. Therefore, it is expected that the condition gradually becomes better at deeper parts in the rock.

There is no water seen in either of the test adits on the left bank. Clay is well-compacted even in the weak zone, while many of the cracks in comparatively hard rock in the weak zone are filled with clay seams. Grouting tests (L-group tests) were performed from the ground surface to evaluate the effect of foundation treatment by grouting against this weak zone. It was recognized from the results that cement grouting was effective as a method of treatment for the weak zone.

Besides this weak zone, the left abutment has small-scale faults at the boundary between calcareous sandstone and quartzite near an elevation of approximately 140 m and in these faults there are sheared zones of thicknesses of roughly 3 m to 5 m (Exploratory adit TL-8, EL. 115.25 m). But, there is wide distribution of hard bedrock above an elevation of 100 m. Even at parts of hard rock in the test adits, there are a number of noncontinous small-scale cavities filled with secondary lime or soil. Such cavities filled with secondary deposits are seen at the several test adits excavated at both banks, but all are located near the ground surface.

(2) River Bed

Besides small-scale sand and gravel terrace deposits approximately 10 m deep at elevations below approximately 65 m at both banks, there are deposits of sand about 6 m deep at parts of the river banks. However, outcrops of sound quartzite are seen over wide areas of the river bed in the vicinity of the dam axis. Underlying this quartzite there is limestone intercalated with numerous thin layers of shale and calcareous sandstone. In most cases, the boundary between limestone and calcareous sandstone is not clear. In other words, there are parts with extremely high contents of calcium carbonate (limestone) and parts with low contents (calcareous sandstone) and the changes between these are gradual. Further, there are numerous shale beds intercalated in the limestone, while there are parts which are alternations of limestone and shale.

The bedrock at the river bed is generally fresh and sound. Although there are thin sheared zones existing, there is no large-scale weak zone as seen on the left bank. Cracks are rather numerous from the ground surface to around 50 m deep in the rock. Since the cracks are not filled with clay the permeability is high (20 - 100 Lugeons). The amount of cement grout injected in grouting tests (A-group tests) carried out at the river bed is large. However, cracks become fewer at greater depths and permeability is lower (2 - 20 Lugeons).

(3) Right Abutment

The types of rocks distributed are calcareous sandstone, quartzite, shale and limestone. These rocks cannot be divided broadly into two groups, i.e., calcareous sandstone and quartzite, which was possible for the left abutment. Calcareous sandstone is predominant in the bedrock as a whole with the other types of rock of various thicknesses intercalated in irregular form.

The foundation rock which is comprised of these rocks has been confirmed to be fresh and sound in general from test adits and boring holes, and the ground water level has been found at an elevation higher than the river water level. However, there are places of severe local folding as seen at exploratory adits TR-1 (EL. 147.0 m) and TR-5 (EL. 55.80 m) and boring hole BR-2 (EL. 122.4 m), and at parts where there have been local crushing, weathering has progressed slightly as seen at boring hole BR-9 (EL. 64.55 m).

Permeability tests of the bedrock were conducted at boring hole BR-10 (EL. 91.0 m) and BR-11 (EL. 143.0 m) located immediately upstream of the dam axis and BR-14A (EL. 187.8 m) near the power intake structure. At all of these holes the Lugeon values at parts deeper than 60 - 70 m from the ground surface are close to zero.

IV-2 Evaluation of Bedrock for Dam Foundation

There is a large scale weak zone from the lower part to the middle part of left abutment. Many cracks can be found in calcareous sandstone and quartzite which are located in the upper part of the abutment. Furthermore, the weathering in this zone reaches deep, therefore the permeability of bedrock of the left abutment is estimated to be high. In the preparation of the foundation for the dam, extremely fissured, weathered and soft portions on the surface of rock should be naturally removed and the weaker portions of the underlying weak zone should be excavated in order to improve the foundation condition.

Since the abovementioned weak zone contains fine particles, such as clay, some counter-measure should be considered in order to prevent the fine materials from being washed-out by percolation of water. Though may cracks are found of the bedrock in the river bed, it is hard and should have adequate bearing strength as a foundation of a rockfill dam. The bedrock of the right abutment, except for the partial weak zone which is found at EL. 70 m, EL 90 m and the deep part of boring BR-2, is also hard and strong with sufficient bearing strength to support the load of even a concrete gravity dam of the same height of structure proposed at the site.

The ground water table at the damsite has been confirmed through 3 broing holes on the left abutment and 5 holes on the right abutment including the spillway and forebay sites. According to these drill holes the ground water table at the left abutment is low and is roughly at about the same elevation as the river water level, while on the right abutment it is higher than the river water level and maintains a plane more or less in agreement with the topography of the slope.

The ground water table confirmed through boring holes at the damsite and appurtenant structure sites is indicated in Table 2.

Table 2 Elevation of ground water table in bore hole at dam site and vicinity

Location		Boring No.	Elevation of top of hole (m)	Elevation of ground water table (m)
Dam	Left abutment	L-13	84.46	53.18
		BL-9	102.47	52.79
		BL-10A	128.87	53.02
	Right abutment	BR-10	.00	61.28
		BR-11	143.00	65.19
		BR-13	182.67	127.66
Spillway		BS-8	176.49	117.21
Forebay		BR-14A	187.80	170.20

Note: (1) Measured on 30 June 1972.

(2) Water level of Quae Yai River on date of measurement was EL. 54.05 m at vicinity of A-group grouting tests.

(3) Grouting of Hole L-13 completed only for upper half.

At the left bank, grouting tests were carried out on the dam axis at an elevation of approximately 80 m (L-group test). Besides this test, permeability tests were carried out at boring holes BL-9 (EL. 102.47 m), BL-10 (EL. 149.41 m) and BL-10A (EL. 128.87 m). The results show values of 20 to 40 Lugeons (coefficient of permeability roughly 2.7 to 5.4×10^{-4} cm/sec.).

On the other hand, the coefficient of permeability from a test conducted in a vertical pit of 1.5 m depth excavated in exploratory adit TL-5 (EL. 60.35 m) was 1×10^{-4} cm/sec. This difference between the two is probably due to the difference in testing methods and the fact that cracks in the bedrock at exploratory adit TL-5 are almost all filled with clay, while the cracks in the drill holes are not filled with clay. As described above, the permeability of bedrock of the left abutment is slightly high.

After storage of water in the reservoir the foundation of the dam will be subject to hydrostatic pressure of a maximum of approximately 130 m and thorough caution will be required in treatment of the foundation rock. It will be noted that the effectiveness of cement grouting is recognized. As further tests, it will be necessary to carry out soil or clay grouting tests in order to be able to perform effective and economical foundation treatment.

According to permeability tests conducted in Hole A-4 (same hole as BL-8) which was drilled for grouting test, the permeability of the bedrock at river bed is 80 to 100 Lugeons down to 30 m from the ground surface, 20 to 47 Lugeons between 30 and 40 and 1 to 20 Lugeons between 45 to 98 m. The rock down to 40 to 50 m from the ground surface is fresh and hard, but cracks are not filled with material such as clay. There are numerous cracks, the permeability is high and injection amount of cement grout were large.

Therefore, this portion requires thorough consideration of injection methods as well as injection materials to treat the foundation by grouting.

The permeability of the right abutment was investigated at drill holes BR-10 (EL. 91.0 m), BR-11 (EL. 143.0 m), BR-14A (EL. 187.8 m) and BRN-1 (EL. 201.35 m), and the results are shown in the log of core boring. Except for localized leakage of water, the test results indicate an extremely watertight condition in general, the Lugeon value being under 5.

Although the permeability of the mountain mass between the forebay planned at the right bank and the dam abutment has not yet been tested, due consideration should be exercised in conducting grouting works. The ground water table from this mountain mass to the vicinity of the dam abutment is at a depth of 30 to 70 m from the ground surface and rock at this depth would be subjected to action of water infiltrated from the forebay or the reservoir and it may be necessary to construct drain holes behind the curtain grout considering the stability of the bedrock after impounding water in the reservoir.

IV-3 Geology of Left Bank Saddle

There is a saddle 200 m to 300 m wide at reservoir normal high water level (EL. 180 m) and approximately 500 m long continuing from the left abutment of the dam. The elevation of the top of this saddle is from 250 m to 270 m and is more than 50 m above the reservoir high water level, but both the upstream side (reservoir side) and the downstream side of the saddle are deeply eroded ravines.

Depending on the condition of the bedrock of this saddle, there would be a risk of stored water leaking downstream and detailed geological investigations were therefore made. The investigations were carried out through geological mapping of the entire saddle area including the ravines on both sides by three core broings (BLS-1, BLS-1A and BLS-2) drilled from an elevation of 185 m at the reservoir side of the saddle. Besides these investigations, observations were made in an exploratory adit (TL-6) which had been excavated several years ago.

According to the results of geological mapping, the slope of the saddle is covered by lateritized topsoil mixed with pebble which is 0.5 m to 3 m thick. But, at the top area there is a prominent scattering of blocks separated from the bedrock while the topsoil is thin. At the upstream ravine outcrops of rock can be seen more or less continuously from around an elevation of approximately 100 m to around an elevation of 380 m. The rock comprising the bedrock consists of bedded quartzite with thickness of unit bed from 20 cm to less than 100 cm from around an elevation of approximately 100 m to around 340 m, while thin beds of calcareous sandstone are intercalated here and there. Above EL. 340 m, the rock is mainly comprised of alternations of calcareous sandstone with thickness of bed from 10 cm to 30 cm and shale with thickness of bed of approximately 10 cm, intercalated occasionally with thin beds of quartzite. The rock character of outcrops at the bottom of the ravine is fresh, sound, compact and extremely good.

The ravine at the downstream side is covered with over-burden and has less outcrops of rock compared with the reservoir side, but at parts of higher elevation there is distribution of outcrops over a fairly wide area. Judging by the condition of outcrops the geologic feature of the reservoir side can be considered to continue to the downstream side with little change. Similar to the damsite, the geologic structure of the saddle is represented by folding. However, the strikes and dip of the outcrops do not change as prominently as at the damsite, mostly being strikes of N30^{o} to 50^{o}W and dips of 30^{o} to 50^{o}N or S. Considering by such data, it is estimated that folding and shearing at the saddle are not as violent as seen at the bottom portion of the left abutment of the damsite. Further, according to the results of geological mapping, there are no large-scale faults that may pass through the saddle.

Fresh, sound cores were generally recovered from the core borings made at the saddle. However, as seen at BLS-2, there are occasional places (sheared zones) of low core recovery and places where cracks have been weathered and filled with clay even in deeper parts. In spite of this, the results of permeability tests show values of only several Lugeons at the most, except for 30 m to 40 m from the ground surface. From this fact, it is considered that although the bedrock of the saddle has sheared zones and cracky zones as a result of being subjected to folding, these zones are on the whole tight and compact at deep portions.

On examination of the results of geological mapping, inspections of core borings and the test adit, and permeability tests, it is judged that the rock of this saddle is of relatively good quality and that leakage of water from the reservoir would be insignificant. However, the pressure of stored water would permanently continue to act on the bedrock in which there exist sheared zones, clay seams or cracks filled with weathered materials. In consideration of this fact, it is recommended that adequate foundation treatment to prevent wash-out of materials filled in sheared zones and cracks be planned.

IV-4 Geology of Appurtenant Structure Sites

Forebay

A forebay connecting to the power intake structure and spillway is planned at a location fairly distant from the right abutment of the dam. This area consists of calcareous sandstone and quartzite intercalated with thin layers of shale. In most cases there is a gradual transition between the two.

Investigations were made at exploratory adits TC-1 (EL. 186.76 m), TC-2 (EL. 200.85 m) and TC-3 (EL. 176.94 m) and drill holes BC-1 (EL. 160.80 m), BC-2 (EL. 187.90 m), BC-5 (EL. 215.53 m), BC-6 (EL. 206.54 m) and BR-14A (EL. 187.80 m). According to the results, the weathered rock at the surface portion is partially less than 10 m to 20 m from the tops of holes and core recovery is close to 100%. The rock thus is sound, and at exploratory adits TC-2 (EL. 200.85 m) and TC-3 (EL. 176.94 m) the bedding planes seen at the portals are roughly parallel to the slope of the mountain. Therefore, in the excavation of the forebay, sound engineering judgement to stabilize the slope on the western side taking into consideration the geologic condition should be necessary.

Permeability tests in this area were made at drill hole BR-14A (EL. 187.80 m). The results of the permeability tests show large values of 45 Lugeons or more down to 25 m from the top of the hole, but below this to a depth of 80 m (EL. 107 m), the rock is impermeable with values of 2 Lugeons or lower. The ground water table is roughly at EL. 170 m (June 1972).

Penstock and Spillway

These structures are located close to each other. This area has been investigated through the test adits and core borings indicated in Table 3.

Table 3 Exploratory adits and core borings

Exploratory adit		Core boring	
No.	Elevation (m)	No.	Elevation (m)
TS-1	79.52	BS-1	82.90
TS-2	147.13	BS-4	127.20
TS-3	167.19	BS-6	188.50
TS-4	171.78	BS-7	152.10
		BS-8	176.49
		BS-9	143.07
		BC-5	215.53
		BC-6	206.54

The geology of this area is comprised of calcareous sandstone irregularly intercalated with thin layers of shale and limestone. As a result of investigation, there is no cavity in exploratory adit TS-1 (EL. 79.52 m) at the powerhouse site described later. However, since layers of limestone are intercalated, it may be possible that dissolved cavities are uncovered during excavation, but it is unlikely that large-scale cavities which will be detrimental to the penstock and spillway structure foundations might exist.

The bedrock distributed at this site has adequate bearing strength for the penstock and spilway structure. Particularly, the bedrock at exploratory adits TS-3 (EL. 167.19 m) and TS-4 (EL. 171.78 m) at the spillway site is of good quality. Judging from data of the test adits and core borings, it may be probable that the foundation rock which is exposed after excavation will be of better quality than that seen at the test adits.

However, it is estimated that the bedding plane of the bedrock at the chute portion of the spillway is roughly parallel to the mountain slope, and precautions should be taken against stability of the slope. Since the face of the excavated slope of the bedrock at the penstock site will be extremely high in part, it is thought that adequate attention should be paid to the stability of this slope. Regarding geological structure, there is severe folding locally as seen in exploratory adit TS-2 (EL. 147.13 m) and it will be necessary to take measures to stabilize the slope based on engineering judgment taking into consideration the geologic condition during the excavation work.

It has been confirmed that the ground water table in this area as seen at drill hole BS-8 (EL. 176.49 m) is at an elevation of approximately 117 m (June 1972). The depth of the ground water table from the ground surface is in the range of 30 to 78 m at the right abutment of the dam and at drill hole BS-8, it is approximately 59 m from the ground surface. In general, the ground water table at the penstock and spillway area appears to be higher than in the vicinity of the dam abutment. However, as in the case of the dam abutment, there will be a new environment for infiltration of water from the forebay after storage of water and thorough consideration must be given to stability of the bedrock.

Powerhouse

The bedrock at the powerhouse site is chiefly calcareous sandstone in which there are intercalations of thin layers of shale and limestone. Investigations of this site have been made through exploratory adit TS-1 (EL. 79.52 m) and drill holes BS-2 (EL. 76.40 m), BS-3 (EL. 67.80 m) and BS-4 (EL. 127.20 m).

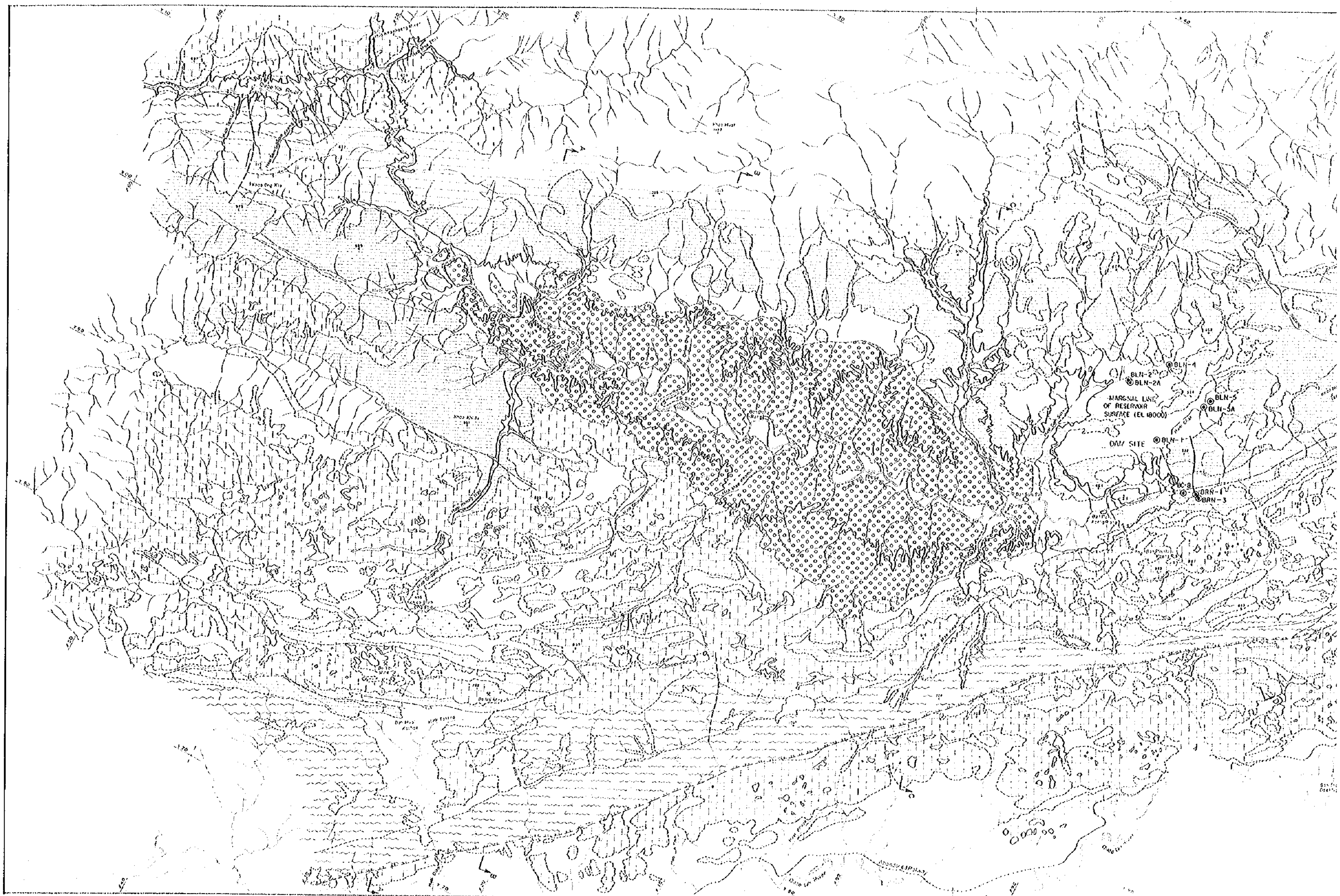
Exploratory adit TS-1 was excavated in limestone and there is a cave with maximum width of approximately 8 m which is filled with talus deposits at the ceiling. This cave is blocked at the floor of the test adit and since the location is at a depth of less than 10 m from the ground surface, it is though probably to be a localized dissolved cave formed by erosion of the thin limestone layer from the ground surface. Investigations of deeper parts through core borings have not uncovered other such caves. The bedrock at this site has adequate bearing strength as a foundation for the powerhouse, and the existence of large-scale caves such as to hinder construction of the powerhouse is not anticipate. However, since the excavation will be deep down to a maximum of 40 m vertically, thorough care should be exercised in stabilization of slopes. Since folding is generally severe in this vicinity, it will be necessary to carry out inspections of the conditions of the bedrock as excavation progresses and make engineering judgments for proper slope stablization from time to time.

IV-5 Conclusion

Since the decision was made by EGAT to proceed with the investigations for the development of the project in 1965, EGAT performed continuous geological investigation works based on the recommendations of IBC and EPDC and all recommendations made by them have been completed. Further, the opinions of experts engaged by EGAT have been fully respected and effective investigation works have been carried out.

During this time, experts dispatched by the Japanese Government have cooperated with EGAT and have offered appropriate advice from time to time. Meanwhile, based on the several field reconnaissances and on information from investigation works carried out by EGAT, EPDC has performed analyses and made overall judgment on the geological condition. As a result, the conditions of engineering geology of the reservoir and civil structure foundations with complex geological conditions have been ascertained, and the data and information are being utilized in the detail design work directing careful attention to the structures and their foundations.

However, the bedrock comprising the project area is calcareous clastic rock subjected to advanced weathering so that the rock character is considerably deteriorated added to which the geological structure - particularly folding - is complex. Therefore, it is expected that in foundation excavation and foundation treatment for civil structures, there will be many cases when civil engineering and engineering geology judgments will be required to be made in accordance with the geological phenomena uncovered.


BLN-4
BLN-2
BLN-2A
MARGINAL LINE OF RESERVOIR SURFACE (EL 180.00)
BLN-5
BLN-5A
DAM SITE
DC-8
BRN-3

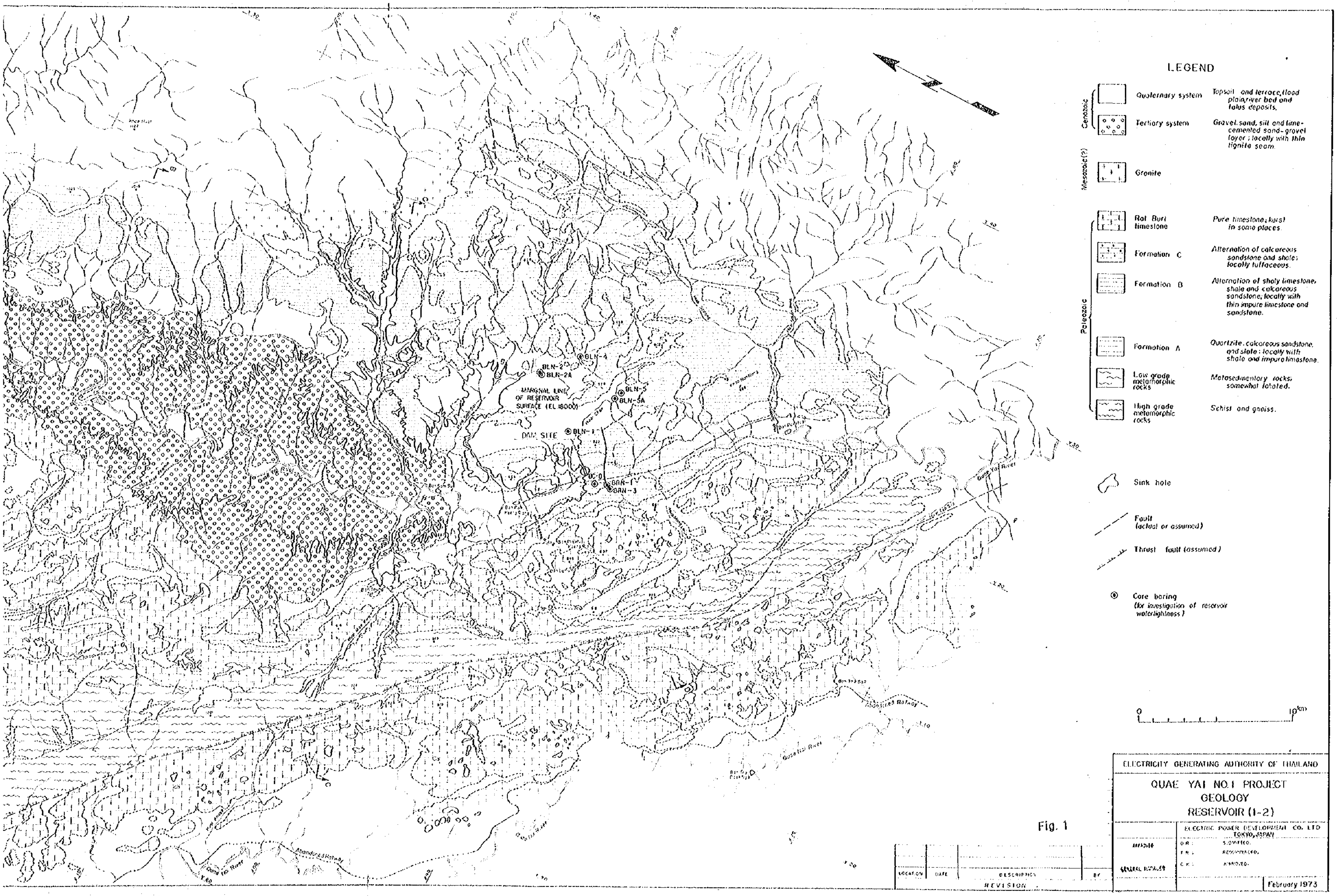
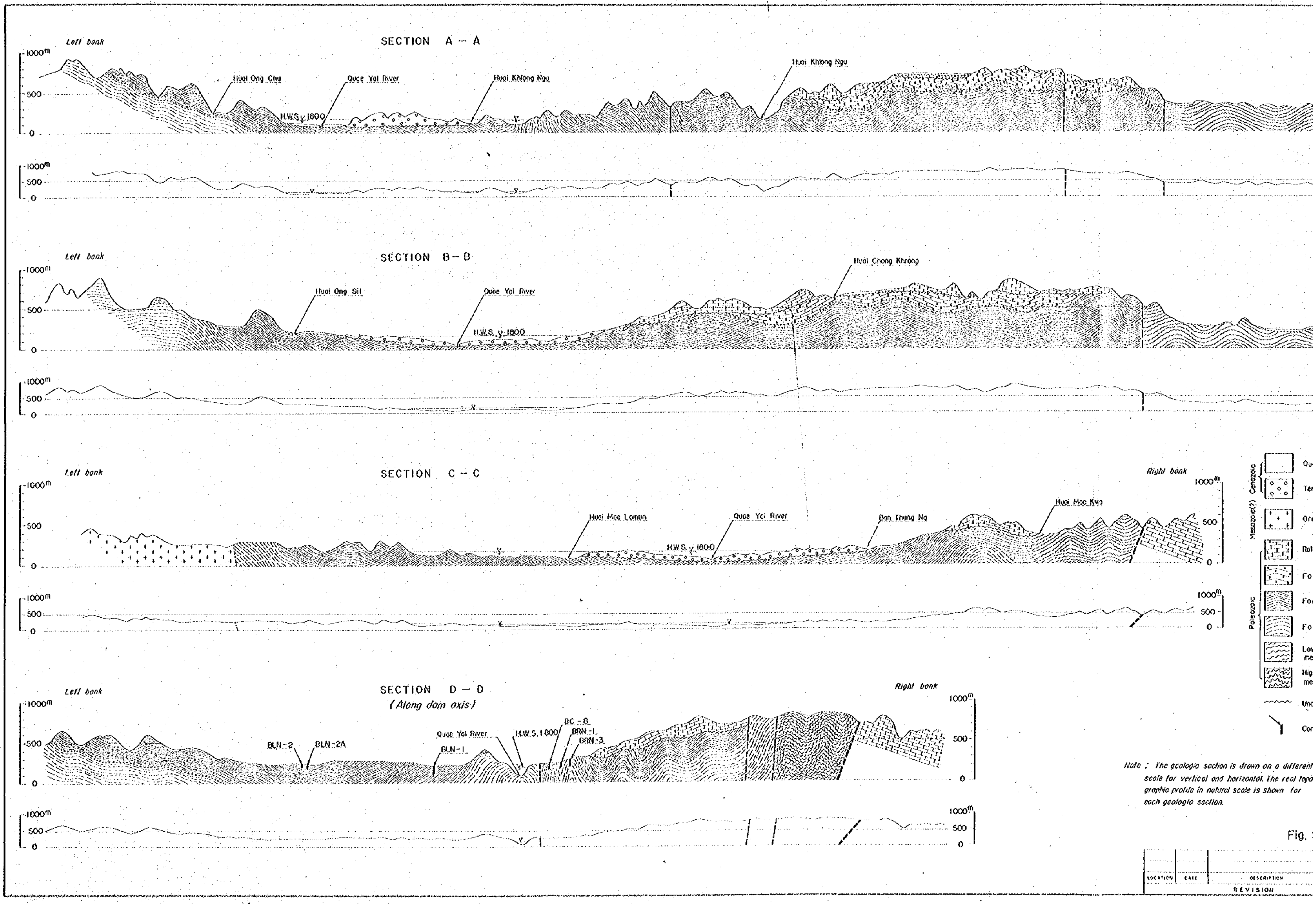
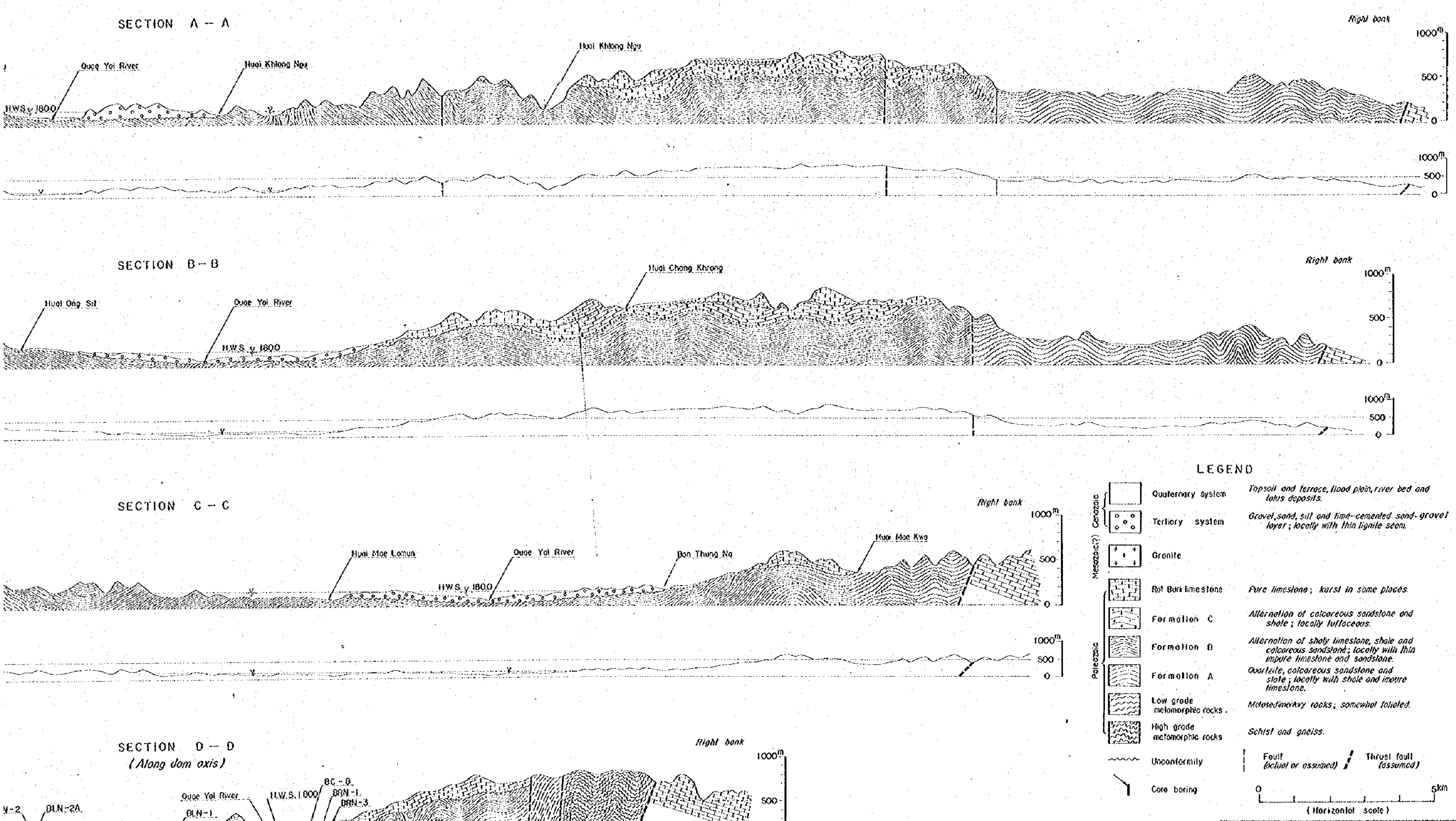

LEGEND
Cenozoic
Quaternary system
Topsoil and terrace, flood plain, river bed and talus deposits.
Tertiary system
Gravel, sand, silt and lime-cemented sand-gravel layer ; locally with thin lignite seam.
Mesozoic(?)
Granite
Paleozoic
Rat Buri limestone
Pure limestone; karst in some places.
Formation C
Alternation of calcareous sandstone and shale; locally tuffaceous.
Formation B
Alternation of shaly limestone, shale and calcareous sandstone; locally with thin impure limestone and sandstone.
Formation A
Quartzite, calcareous sandstone, and slate : locally with shale and impure limestone.
Low grade metamorphic rocks
Metasedimentary rocks; somewhat foliated.
High grade metamorphic rocks
Schist and gneiss.
Sink hole
Fault
(actual or assumed)
Thrust fault (assumed)
Core boring
(for investigation of reservoir watertightness)
0
10km
BLN-2
BLN-2A
BLN-4
BLN-5
BLN-5A
BLN-1
MARGINAL LINE OF RESERVOIR SURFACE (EL 180.00)
DAM SITE
BRN-1
BRN-3
ELECTRICITY GENERATING AUTHORITY OF THAILAND
QUAE YAI NO.1 PROJECT
GEOLOGY
RESERVOIR (1-2)
ELECTRIC POWER DEVELOPMENT CO. LTD
TOKYO, JAPAN
February 1973
LOCATION
DATE
DESCRIPTION
BY
REVISION

Fig. 1


SECTION A – A
Left bank
Huoi Ong Chu
Quoc Yoi River
Huoi Khlong Ngu
H.W.S. ▽ 1800
SECTION B – B
Left bank
Huoi Ong Sil
Quoc Yoi River
Huoi Chong Khrong
SECTION C – C
Left bank
Right bank
Huoi Moe Lomun
Quoc Yoi River
Don Thung Ng
Huoi Moe Kwa
SECTION D – D
(Along dam axis)
Left bank
Right bank
BLN-2
BLN-2A
BLN-1
Quoc Yoi River
H.W.S. 1800
BC-8
BRN-1
BRN-3
1000m
500
0
Cenozoic
Mesozoic(?)
Paleozoic
Note : The geologic section is drawn on a different scale for vertical and horizontal. The real topographic profile in natural scale is shown for each geologic section.
Fig.
LOCATION
DATE
DESCRIPTION
REVISION



Note: The geologic section is drawn on a different scale for vertical and horizontal. The real topographic profile in natural scale is shown for each geologic section.

Fig. 2

LOCATION	DATE	DESCRIPTION	BY
REVISION			

ELECTRICITY GENERATING AUTHORITY OF THAILAND

BAN CHAO NEN PROJECT
GEOLOGY
RESERVOIR (2-2)

ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

APPROVED — DR.: SUBMITTED:
TR.: RECOMMENDED:
GENERAL MANAGER — CK.: APPROVED:

February 1973

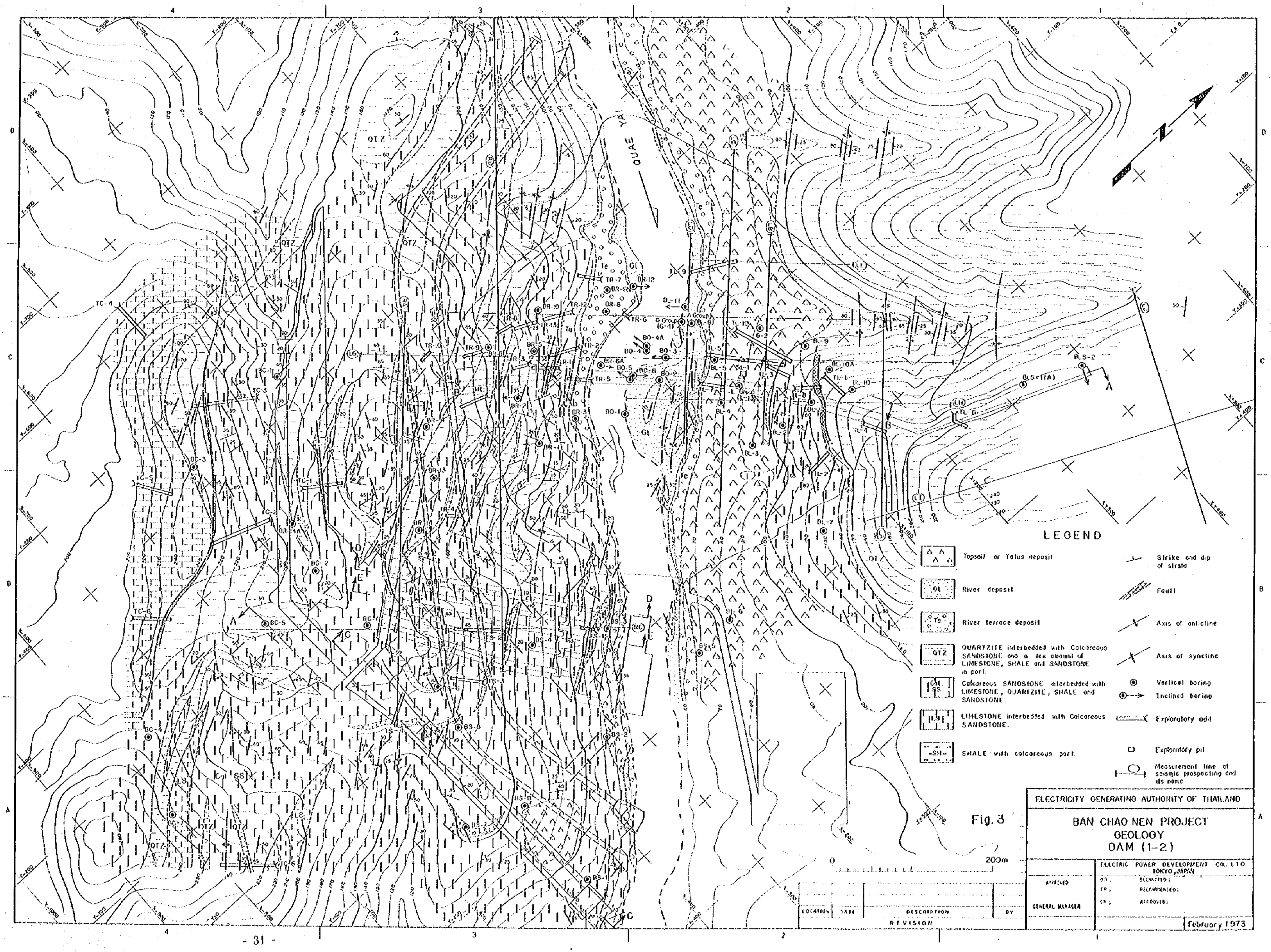
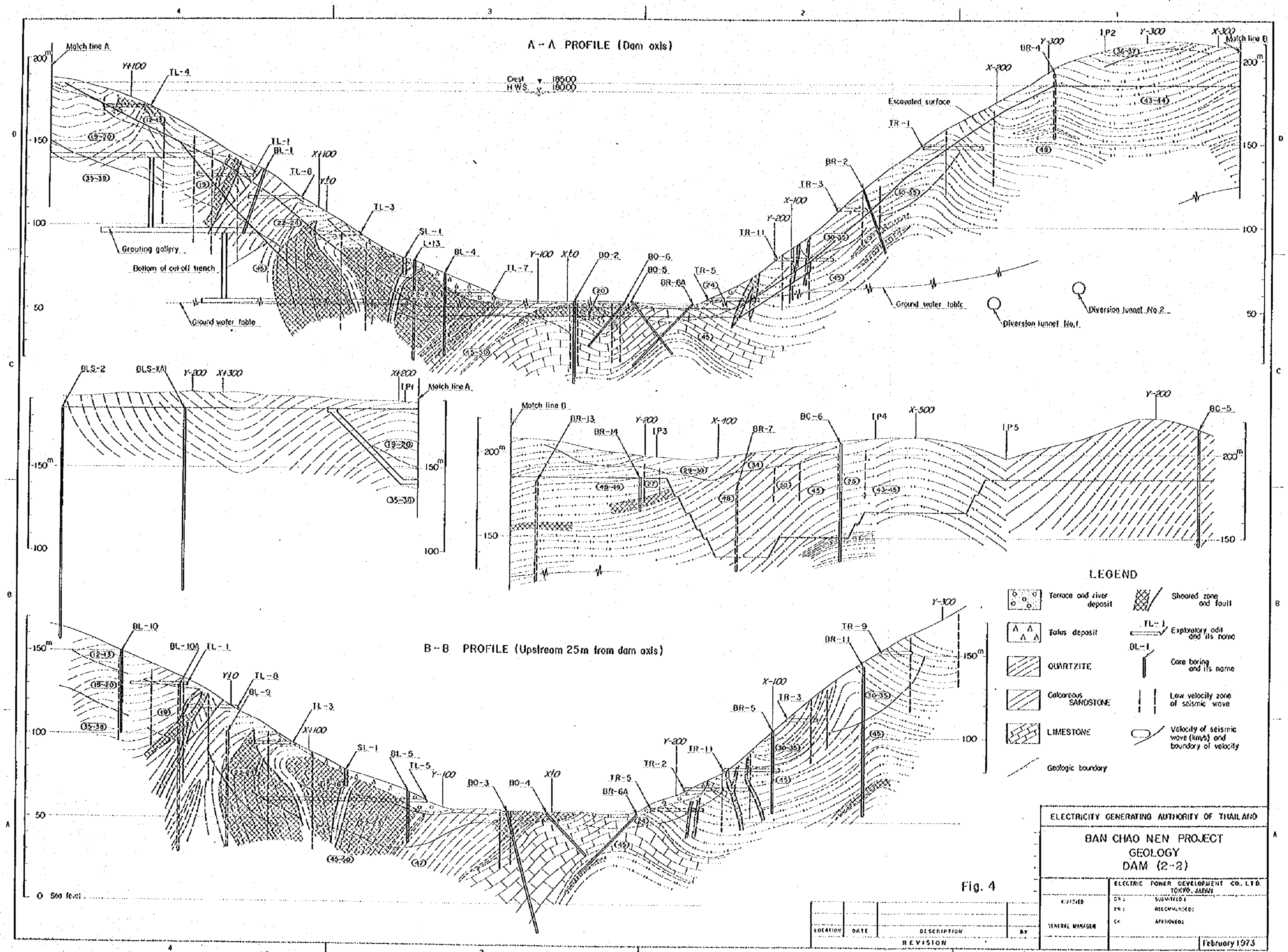
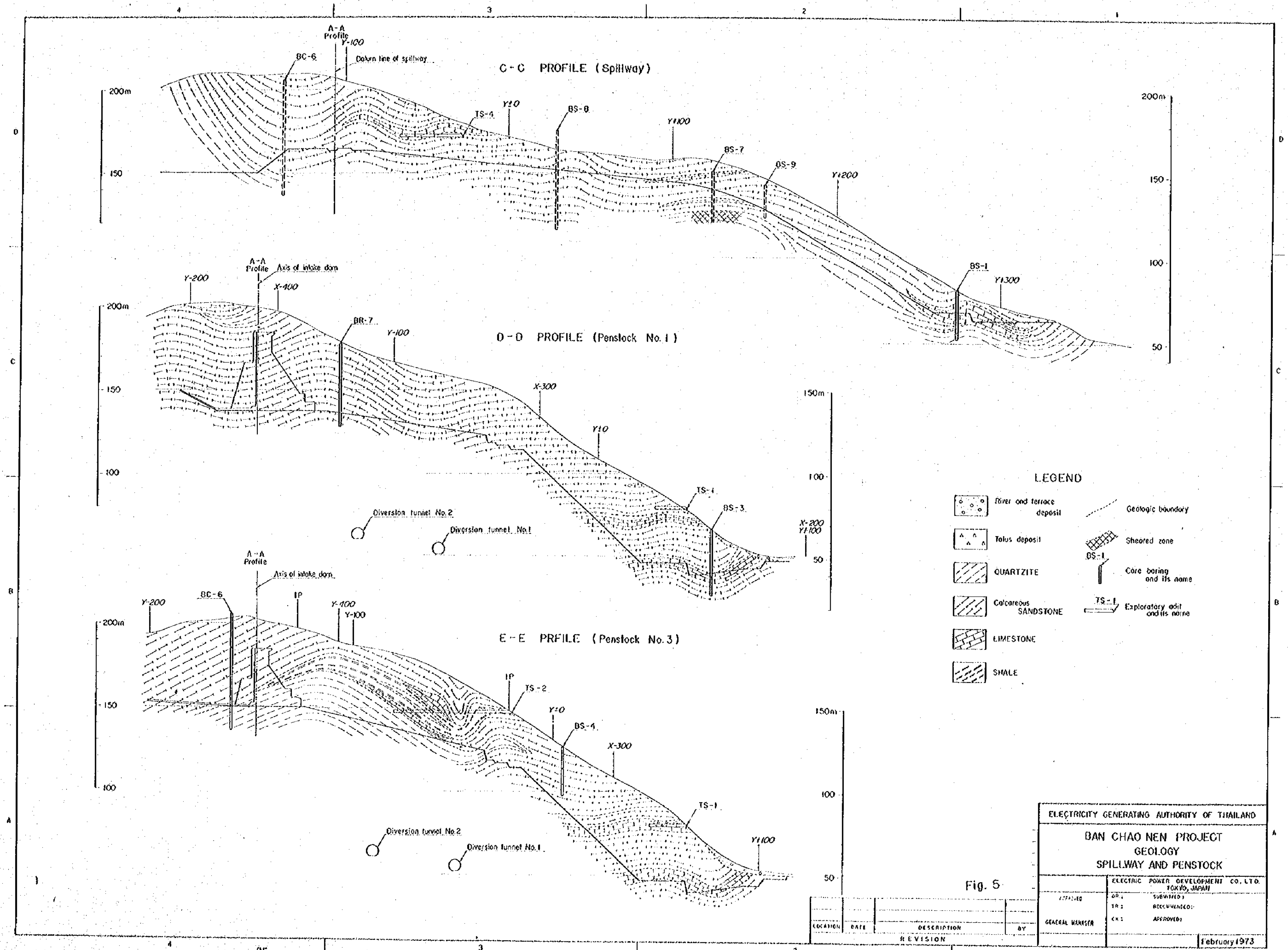

QUAE YAI
LEGEND
Topsoil or Talus deposit
River deposit
River terrace deposit
QUARTZITE interbedded with Calcareous SANDSTONE and a few amount of LIMESTONE, SHALE and SANDSTONE in part.
Calcareous SANDSTONE interbedded with LIMESTONE, QUARTZITE, SHALE and SANDSTONE.
LIMESTONE interbedded with Calcareous SANDSTONE.
SHALE with calcareous part.
Strike and dip of strata
Fault
Axis of anticline
Axis of syncline
Vertical boring
Inclined boring
Exploratory adit
Exploratory pit
Measurement line of seismic prospecting and its name
0
200m
LOCATION
DATE
DESCRIPTION
BY
REVISION
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
DAM (1-2)
ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO, JAPAN
GENERAL MANAGER
February 1973

Fig. 3


A - A PROFILE (Dam axis)
Crest 185.00
H.W.S. 180.00
Grouting gallery
Bottom of cut-off trench
Ground water table
Excavated surface
Diversion tunnel No.1
Diversion tunnel No.2
Match line A
Match line B
B - B PROFILE (Upstream 25m from dam axis)
LEGEND
Terrace and river deposit
Talus deposit
QUARTZITE
Calcareous SANDSTONE
LIMESTONE
Geologic boundary
Sheared zone and fault
Exploratory adit and its name
Core boring and its name
Low velocity zone of seismic wave
Velocity of seismic wave (km/s) and boundary of velocity
0 Sea level
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
DAM (2-2)
ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
LOCATION
DATE
DESCRIPTION
BY
REVISION
February 1973
Fig. 4


C - C PROFILE (Spillway)
A-A Profile
Y-100
BC-6
Datum line of spillway
Y±0
TS-4
BS-8
Y+100
BS-7
BS-9
Y+200
BS-1
Y+300
200m
150
100
50
D - D PROFILE (Penstock No. 1)
A-A Profile
Axis of intake dam
Y-200
X-400
BR-7
Y-100
X-300
Y±0
TS-1
BS-3
X-200
Y+100
Diversion tunnel No. 2
Diversion tunnel No. 1
E - E PRFILE (Penstock No. 3)
A-A Profile
Axis of intake dam
Y-200
BC-6
IP
Y-100
TS-2
Y±0
BS-4
X-300
TS-1
Y+100
LEGEND
River and terrace deposit
Talus deposit
QUARTZITE
Calcareous SANDSTONE
LIMESTONE
SHALE
Geologic boundary
Sheared zone
BS-1
Core boring and its name
TS-1
Exploratory adit and its name
Fig. 5
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
SPILLWAY AND PENSTOCK
ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO, JAPAN
SUBMITTED:
RECOMMENDED:
APPROVED:
GENERAL MANAGER
LOCATION
DATE
DESCRIPTION
BY
REVISION
February 1973

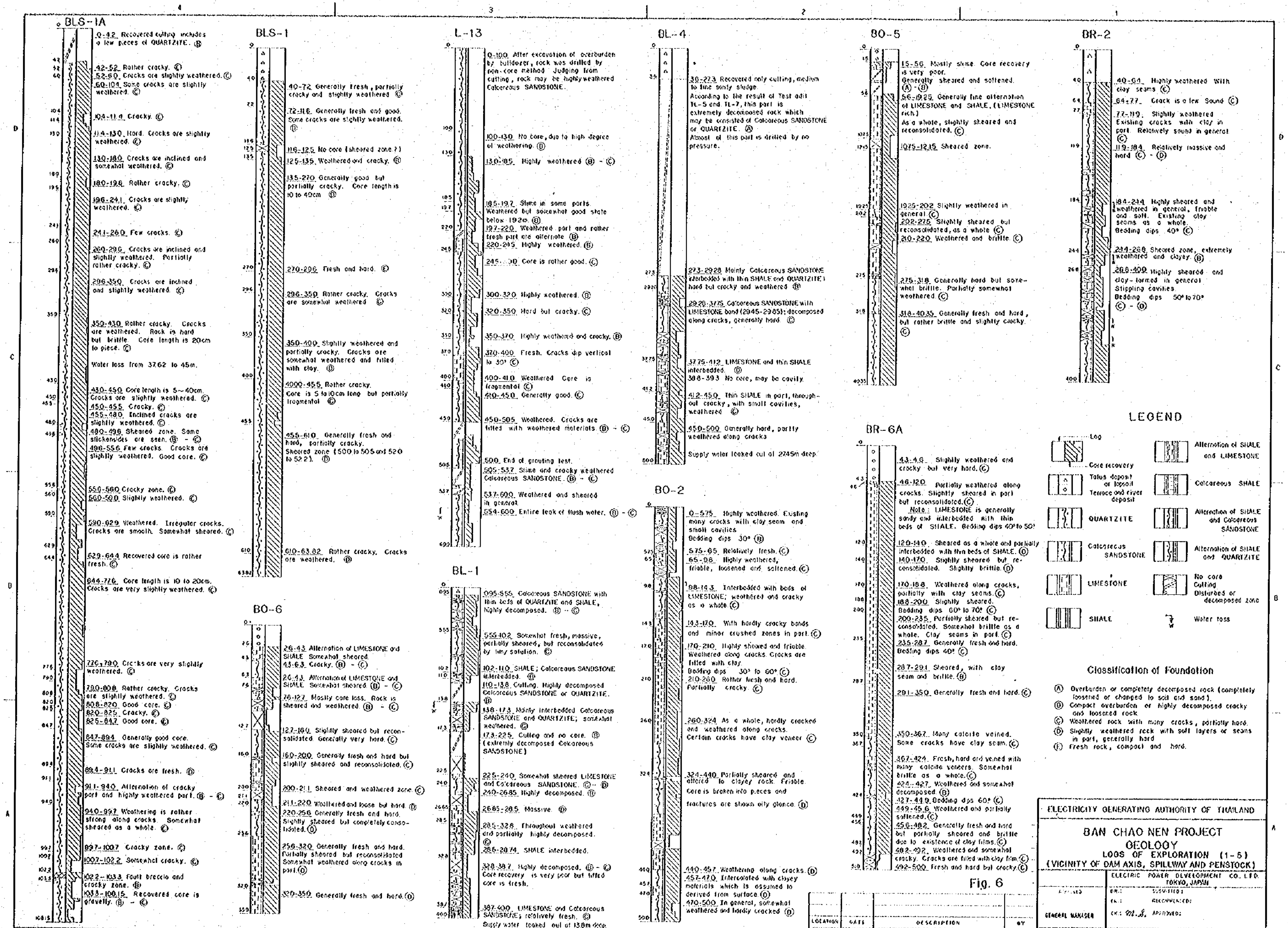

BLS-1A
0-42 Recovered cutting includes a few pieces of QUARTZITE. Ⓑ
42-52 Rather cracky. Ⓒ
52-60 Cracks are slightly weathered. Ⓒ
60-104 Some cracks are slightly weathered. Ⓒ
104-11.4 Cracky. Ⓒ
11.4-130 Hard. Cracks are slightly weathered. Ⓒ
130-180 Cracks are inclined and somewhat weathered. Ⓒ
180-19.6 Rather cracky. Ⓒ
19.6-24.1 Cracks are slightly weathered. Ⓒ
24.1-26.0 Few cracks. Ⓒ
26.0-29.6 Cracks are inclined and slightly weathered. Partially rather cracky. Ⓒ
29.6-35.0 Cracks are inclined and slightly weathered. Ⓒ
35.0-43.0 Rather cracky. Cracks are weathered. Rock is hard but brittle. Core length is 20cm to piece. Ⓒ
Water loss from 37.62 to 45m.
43.0-45.0 Core length is 5~40cm. Cracks are slightly weathered. Ⓒ
45.0-45.5 Cracky. Ⓒ
45.5-48.0 Inclined cracks are slightly weathered. Ⓒ
48.0-49.6 Sheared zone. Some slickensides are seen. Ⓑ - Ⓒ
49.6-55.6 Few cracks. Cracks are slightly weathered. Good core. Ⓒ
55.6-56.0 Cracky zone. Ⓒ
56.0-50.0 Slightly weathered. Ⓒ
59.0-62.9 Weathered. Irregular cracks. Cracks are smooth. Somewhat sheared. Ⓒ
62.9-64.4 Recovered core is rather fresh. Ⓒ
64.4-77.6 Core length is 10 to 20cm. Cracks are very slightly weathered. Ⓒ
77.6-79.0 Cracks are very slightly weathered. Ⓒ
79.0-80.8 Rather cracky. Cracks are slightly weathered. Ⓒ
80.8-82.0 Good core. Ⓒ
82.0-82.5 Cracky. Ⓒ
82.5-84.7 Good core. Ⓒ
84.7-89.4 Generally good core. Some cracks are slightly weathered. Ⓒ
89.4-91.1 Cracks are fresh. Ⓓ
91.1-94.0 Alternation of cracky part and highly weathered part. Ⓑ - Ⓒ
94.0-99.7 Weathering is rather strong along cracks. Somewhat sheared as a whole. Ⓒ
99.7-100.7 Cracky zone. Ⓒ
100.7-102.2 Somewhat cracky. Ⓒ
102.2-103.3 Fault breccia and cracky zone. Ⓑ
103.3-108.15 Recovered core is gravelly. Ⓑ - Ⓒ
BLS-1
40-72 Generally fresh, partially cracky and slightly weathered Ⓒ
72-116 Generally fresh and good. Some cracks are slightly weathered. Ⓓ
116-125 No core (sheared zone ?)
125-135 Weathered and cracky. Ⓑ
135-270 Generally good but partially cracky. Core length is 10 to 40cm Ⓓ
270-296 Fresh and hard. Ⓔ
296-350 Rather cracky. Cracks are somewhat weathered Ⓒ
350-400 Slightly weathered and partially cracky. Cracks are somewhat weathered and filled with clay. Ⓓ
4000-455 Rather cracky. Core is 5 to 10cm long but partially fragmental Ⓒ
455-610 Generally fresh and hard, partially cracky. Sheared zone (500 to 505 and 520 to 52.2). Ⓓ
610-63.82 Rather cracky. Cracks are weathered. Ⓓ
BO-6
26-43 Alternation of LIMESTONE and SHALE Somewhat sheared.
43-63 Cracky. Ⓑ - Ⓒ
26-43 Alternation of LIMESTONE and SHALE Somewhat sheared. Ⓑ - Ⓒ
76-127 Mostly core loss. Rock is sheared and weathered. Ⓑ - Ⓒ
127-160 Slightly sheared but reconsolidated. Generally very hard. Ⓒ
160-200 Generally fresh and hard but slightly sheared and reconsolidated. Ⓒ
200-211 Sheared and weathered zone. Ⓒ
211-220 Weathered and loose but hard. Ⓓ
220-256 Generally fresh and hard. Slightly sheared but completely consolidated. Ⓓ
256-320 Generally fresh and hard. Partially sheared but reconsolidated Somewhat weathered along cracks in part. Ⓓ
320-350 Generally fresh and hard. Ⓓ
L-13
0-100 After excavation of overburden by bulldozer, rock was drilled by non-core method. Judging from cutting, rock may be highly weathered Calcareous SANDSTONE.
100-130 No core, due to high degree of weathering. Ⓓ
130-185 Highly weathered Ⓑ - Ⓒ
185-197 Slime in some parts. Weathered but somewhat good state below 192m. Ⓑ
197-220 Weathered part and rather fresh part are alternate Ⓑ
220-245 Highly weathered. Ⓑ
245-.30 Core is rather good. Ⓒ
300-320 Highly weathered. Ⓑ
320-350 Hard but cracky. Ⓒ
350-370 Highly weathered and cracky. Ⓑ
370-400 Fresh. Cracks dip vertical to 30° Ⓒ
400-410 Weathered Core is fragmental Ⓒ
410-450 Generally good. Ⓒ
450-505 Weathered. Cracks are filled with weathered materials. Ⓑ - Ⓒ
500 End of grouting test.
505-537 Slime and cracky weathered Calcareous SANDSTONE. Ⓑ - Ⓒ
537-600 Weathered and sheared in general.
554-600 Entire leak of flush water. Ⓑ - Ⓒ
BL-1
095-555 Calcareous SANDSTONE with thin beds of QUARTZITE and SHALE, highly decomposed. Ⓑ - Ⓒ
555-102 Somewhat fresh, massive, partially sheared, but reconsolidated by limy solution. Ⓒ
102-110 SHALE; Calcareous SANDSTONE interbedded. Ⓑ
110-138 Cutting. Highly decomposed Calcareous SANDSTONE or QUARTZITE. Ⓑ
138-173 Mainly interbedded Calcareous SANDSTONE and QUARTZITE; somewhat weathered. Ⓒ
173-225 Cutting and no core. Ⓑ (extremely decomposed Calcareous SANDSTONE)
225-240 Somewhat sheared LIMESTONE and Calcareous SANDSTONE. Ⓒ - Ⓓ
240-2685 Highly decomposed. Ⓑ
2685-285 Massive. Ⓓ
285-328 Throughout weathered and partially highly decomposed. Ⓒ
286-2074 SHALE interbedded.
328-387 Highly decomposed. Ⓑ - Ⓒ Core recovery is very poor but lifted core is fresh.
387-400 LIMESTONE and Calcareous SANDSTONE; relatively fresh. Ⓒ
Supply water leaked out of 13.8m deep.
BL-4
36-273 Recovered only cutting, medium to fine sandy sludge. According to the result of Test adit TL-5 and TL-7, this part is extremely decomposed rock which may be consisted of Calcareous SANDSTONE or QUARTZITE. Ⓐ
Almost of this part is drilled by no pressure.
273-2928 Mainly Calcareous SANDSTONE interbedded with thin SHALE and QUARTZITE; hard but cracky and weathered Ⓑ
2920-3775 Calcareous SANDSTONE with LIMESTONE band (2945-2985); decomposed along cracks, generally hard. Ⓒ
3775-412 LIMESTONE and thin SHALE interbedded. Ⓓ
388-393 No core, may be cavity.
412-450 Thin SHALE in part, throughout cracky, with small cavities, weathered Ⓒ
450-500 Generally hard, partly weathered along cracks
Supply water leaked out of 2745m deep.
BO-2
0-575 Highly weathered. Existing many cracks with clay seam and small cavities. Bedding dips 30° Ⓑ
575-65 Relatively fresh. Ⓒ
65-98 Highly weathered, friable, loosened and softened. Ⓒ
98-143 Interbedded with beds of LIMESTONE; weathered and cracky as a whole. Ⓒ
143-170 With hardly cracky bands and minor crushed zones in part. Ⓒ
170-210 Highly sheared and friable. Weathered along cracks. Cracks are filled with clay. Bedding dips 30° to 60° Ⓒ
210-260 Rather fresh and hard. Partially cracky. Ⓒ
260-324 As a whole, hardly cracked and weathered along cracks. Certain cracks have clay veneer Ⓒ
324-440 Partially sheared and altered to clayey rock. Friable. Core is broken into pieces and fractures are shown oily glance. Ⓓ
440-457 Weathering along cracks. Ⓓ
457-470 Intercalated with clayey materials which is assumed to derived from surface. Ⓓ
470-500 In general, somewhat weathered and hardly cracked Ⓓ
BO-5
15-56 Mostly slime. Core recovery is very poor. Generally sheared and softened. Ⓐ - Ⓑ
56-1925 Generally fine alternation of LIMESTONE and SHALE. (LIMESTONE rich) As a whole, slightly sheared and reconsolidated. Ⓒ
1075-1215 Sheared zone.
1925-202 Slightly weathered in general Ⓒ
202-275 Slightly sheared but reconsolidated, as a whole Ⓒ
20-220 Weathered and brittle Ⓒ
275-318 Generally hard but somewhat brittle. Partially somewhat weathered Ⓒ
318-4035 Generally fresh and hard, but rather brittle and slightly cracky. Ⓒ
BR-2
40-64 Highly weathered with clay seams Ⓒ
64-77 Crack is a few. Sound Ⓒ
77-119 Slightly weathered Existing cracks with clay in part. Relatively sound in general Ⓒ
119-184 Relatively massive and hard Ⓒ - Ⓓ
184-244 Highly sheared and weathered in general, friable and soft. Existing clay seams as a whole. Bedding dips 40° Ⓒ
244-268 Sheared zone, extremely weathered and clayey. Ⓑ
268-400 Highly sheared and clay-formed in general Slipping cavities. Bedding dips 50° to 70° Ⓒ - Ⓑ
BR-6A
43-46 Slightly weathered and cracky but very hard. Ⓒ
46-120 Partially weathered along cracks. Slightly sheared in part but reconsolidated. Ⓒ
Note: LIMESTONE is generally sandy and interbedded with thin beds of SHALE. Bedding dips 40° to 50°
120-140 Sheared as a whole and partially interbedded with thin beds of SHALE. Ⓓ
140-170 Slightly sheared but reconsolidated. Slightly brittle. Ⓓ
170-188 Weathered along cracks, partially with clay seams. Ⓒ
188-200 Slightly sheared. Bedding dips 60° to 70° Ⓒ
200-235 Partially sheared but reconsolidated. Somewhat brittle as a whole. Clay seams in part. Ⓒ
235-287 Generally fresh and hard. Bedding dips 40° Ⓒ
287-291 Sheared, with clay seam and brittle. Ⓑ
291-350 Generally fresh and hard. Ⓒ
350-367 Many calcite veined. Some cracks have clay seam. Ⓒ
367-424 Fresh, hard and veined with many calcite veneers. Somewhat brittle as a whole. Ⓒ
424-427 Weathered and somewhat decomposed Ⓑ
427-449 Bedding dips 60° Ⓒ
449-45.6 Weathered and partially softened. Ⓒ
456-482 Generally fresh and hard but partially sheared and brittle due to existence of clay films. Ⓒ
482-492 Weathered and somewhat cracky. Cracks are filled with clay film Ⓒ
492-500 Fresh and hard but cracky Ⓒ
LEGEND
Log
Core recovery
Talus deposit or topsoil Terrace and river deposit
QUARTZITE
Calcareous SANDSTONE
LIMESTONE
SHALE
Alternation of SHALE and LIMESTONE
Calcareous SHALE
Alternation of SHALE and Calcareous SANDSTONE
Alternation of SHALE and QUARTZITE
No core Cutting Disturbed or decomposed zone
Water loss
Classification of Foundation
Ⓐ Overburden or completely decomposed rock (completely loosened or changed to soil and sand).
Ⓑ Compact overburden or highly decomposed cracky and loosened rock
Ⓒ Weathered rock with many cracks, partially hard.
Ⓓ Slightly weathered rock with soft layers or seams in part, generally hard
Ⓔ Fresh rock, compact and hard.
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
LOGS OF EXPLORATION (1-5)
(VICINITY OF DAM AXIS, SPILLWAY AND PENSTOCK)
ELECTRIC POWER DEVELOPMENT CO. LTD. TOKYO, JAPAN
GENERAL MANAGER
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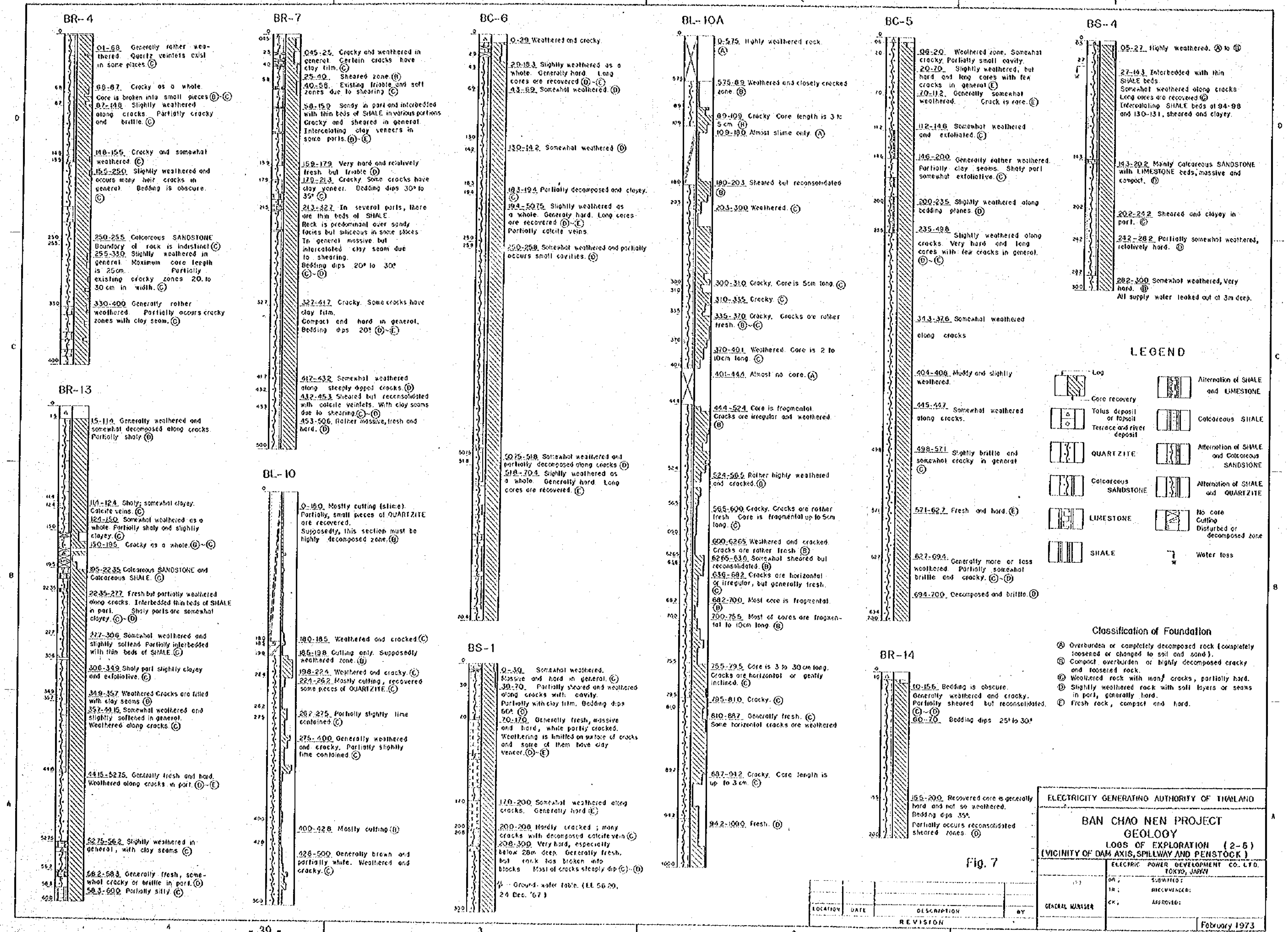
Fig. 6


BR-4
01-68 Generally rather weathered. Quartz veinlets exist in some places. (C)
68-87 Cracky as a whole. Core is broken into small pieces (B)-(C)
87-148 Slightly weathered along cracks. Partially cracky and brittle. (C)
148-155 Cracky and somewhat weathered. (C)
155-250 Slightly weathered and occurs many hair cracks in general. Bedding is obscure. (C)
250-255 Calcareous SANDSTONE Boundary of rock is indistinct (C)
255-330 Slightly weathered in general. Maximum core length is 25cm. Partially existing cracky zones 20 to 30 cm in width. (C)
330-400 Generally rather weathered. Partially occurs cracky zones with clay seam. (C)
BR-13
15-114 Generally weathered and somewhat decomposed along cracks. Partially shaly (B)
114-124 Shaly; somewhat clayey. Calcite veins. (C)
124-150 Somewhat weathered as a whole. Partially shaly and slightly clayey. (C)
150-195 Cracky as a whole. (B)-(C)
195-2235 Calcareous SANDSTONE and Calcareous SHALE. (C)
2235-277 Fresh but partially weathered along cracks. Interbedded thin beds of SHALE in part. Shaly parts are somewhat clayey. (C)-(D)
277-306 Somewhat weathered and slightly softend. Partially interbedded with thin beds of SHALE. (C)
306-349 Shaly part slightly clayey and exfoliative. (C)
349-357 Weathered Cracks are filled with clay seams (B)
357-4415 Somewhat weathered and slightly softened in general. Weathered along cracks. (C)
4415-5275 Generally fresh and hard. Weathered along cracks in part. (D)-(E)
5275-562 Slightly weathered in general, with clay seams (C)
562-583 Generally fresh, somewhat cracky or brittle in part. (D)
583-600 Partially silty (C)
BR-7
045-25 Cracky and weathered in general. Certain cracks have clay film. (C)
25-40 Sheared zone (B)
40-58 Existing friable and soft zones due to shearing (C)
58-159 Sandy in part and interbedded with thin beds of SHALE in various portions. Cracky and sheared in general. Intercalating clay veneers in some parts. (D)-(E)
159-179 Very hard and relatively fresh but friable (D)
179-213 Cracky. Some cracks have clay veneer. Bedding dips 30° to 35° (C)
213-327 In several parts, there are thin beds of SHALE. Rock is predominant over sandy facies but siliceous in some places. In general massive but intercalated clay seam due to shearing. Bedding dips 20° to 30° (C)-(D)
327-417 Cracky. Some cracks have clay film. Compact and hard in general. Bedding dips 20° (D)-(E)
417-432 Somewhat weathered along steeply dipped cracks. (D)
432-453 Sheared but reconsolidated with calcite veinlets. With clay seams due to shearing. (C)-(D)
453-506 Rather massive, fresh and hard. (D)
BL-10
0-180 Mostly cutting (slime). Partially, small pieces of QUARTZITE are recovered. Supposedly, this section must be highly decomposed zone. (B)
180-185 Weathered and cracked (C)
185-198 Cutting only. Supposedly weathered zone. (B)
198-224 Weathered and cracky. (C)
224-262 Mostly cutting, recovered some pieces of QUARTZITE. (C)
262-275 Partially slightly lime contained. (C)
275-400 Generally weathered and cracky. Partially slightly lime contained. (C)
400-428 Mostly cutting (B)
428-500 Generally brown and partially white. Weathered and cracky. (C)
BC-6
0-29 Weathered and cracky.
29-183 Slightly weathered as a whole. Generally hard. Long cores are recovered (D)-(E)
43-69 Somewhat weathered. (D)
130-142 Somewhat weathered (D)
183-194 Partially decomposed and clayey. (C)
194-5075 Slightly weathered as a whole. Generaly hard. Long cores are recovered (D)-(E) Partially calcite veins.
250-258 Somewhat weathered and partially occurs small cavities. (D)
5075-518 Somewhat weathered and partially decomposed along cracks (D)
518-704 Slightly weathered as a whole. Generally hard. Long cores are recovered. (E)
BS-1
0-30 Somewhat weathered. Massive and hard in general. (C)
30-70 Partially sheared and weathered along cracks with cavity. Partially with clay film. Bedding dips 60° (D)
70-170 Generally fresh, massive and hard, while partly cracked. Weathering is limited on surface of cracks and some of them have clay veneer. (D)-(E)
170-200 Somewhat weathered along cracks. Generally hard (E)
200-208 Hardly cracked; many cracks with decomposed calcite vein (C)
208-300 Very hard, especially below 28m deep. Generally fresh, but rock has broken into blocks. Most of cracks steeply dip (C)-(D)
Ground-water table. (EL 56.20, 24 Dec. '67)
BL-10A
0-575 Highly weathered rock. (A)
575-89 Weathered and closely cracked zone. (B)
89-109 Cracky. Core length is 3 to 5 cm (B)
109-180 Almost slime only (A)
180-203 Sheared but reconsolidated (B)
203-300 Weathered. (C)
300-310 Cracky. Core is 5cm long. (C)
310-335 Cracky. (C)
335-370 Cracky. Cracks are rather fresh. (B)-(C)
370-401 Weathered. Core is 2 to 10cm long. (C)
401-444 Almost no core. (A)
444-524 Core is fragmental. Cracks are irregular and weathered. (B)
524-565 Rather highly weathered and cracked. (B)
565-600 Cracky. Cracks are rather fresh. Core is fragmental up to 5cm long. (C)
600-6265 Weathered and cracked. Cracks are rather fresh (B)
6265-636 Somewhat sheared but reconsolidated. (B)
636-682 Cracks are horizontal or irregular, but generally fresh. (C)
682-700 Most core is fragmental. (B)
700-755 Most of cores are fragmental to 10cm long. (B)
755-795 Core is 3 to 30cm long. Cracks are horizontal or gently inclined. (C)
795-810 Cracky. (C)
810-887 Generally fresh. (C) Some horizontal cracks are weathered
887-942 Cracky. Core length is up to 3 cm. (C)
942-1000 Fresh. (D)
BC-5
06-20 Weathered zone. Somewhat cracky. Partially small cavity.
20-70 Slightly weathered, but hard and long cores with few cracks in general (E)
70-112 Generally somewhat weathered. Crack is rare. (E)
112-146 Somewhat weathered and exfoliated. (C)
146-200 Generally rather weathered. Partially clay seams. Shaly part somewhat exfoliative. (C)
200-235 Slightly weathered along bedding planes (D)
235-498 Slightly weathered along cracks. Very hard and long cores with few cracks in general. (D)-(E)
343-376 Somewhat weathered along cracks
404-406 Muddy and slightly weathered.
445-447 Somewhat weathered along cracks.
498-571 Slightly brittle and somewhat cracky in general (C)
571-627 Fresh and hard. (E)
627-694 Generally more or less weathered. Partially somewhat brittle and cracky. (C)-(D)
694-700 Decomposed and brittle. (B)
BS-4
05-27 Highly weathered. (A) to (B)
27-143 Interbedded with thin SHALE beds. Somewhat weathered along cracks. Long cores are recovered (C) Intercalating SHALE beds at 94-98 and 130-131, sheared and clayey.
143-202 Mainly Calcareous SANDSTONE with LIMESTONE beds, massive and compact. (D)
202-242 Sheared and clayey in part. (C)
242-282 Partially somewhat weathered, relatively hard. (D)
282-300 Somewhat weathered, Very hard. (D)
All supply water leaked out at 3m deep.
BR-14
10-156 Bedding is obscure. Generally weathered and cracky. Partially sheared but reconsolidated. (C)-(D)
60-70 Bedding dips 25° to 30°
155-200 Recovered core is generally hard and not so weathered. Bedding dips 35°. Partially occurs reconsolidated sheared zones. (D)
LEGEND
Log
Core recovery
Talus deposit or topsoil
Terrace and river deposit
QUARTZITE
Calcareous SANDSTONE
LIMESTONE
SHALE
Alternation of SHALE and LIMESTONE
Calcareous SHALE
Alternation of SHALE and Calcareous SANDSTONE
Alternation of SHALE and QUARTZITE
No core
Cutting
Disturbed or decomposed zone
Water loss
Classification of Foundation
(A) Overburden or completely decomposed rock (completely loosened or changed to soil and sand).
(B) Compact overburden or highly decomposed cracky and loosened rock.
(C) Weathered rock with many cracks, partially hard.
(D) Slightly weathered rock with soft layers or seams in part, generally hard.
(E) Fresh rock, compact and hard.
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GEOLOGY
LOGS OF EXPLORATION (2-5)
(VICINITY OF DAM AXIS, SPILLWAY AND PENSTOCK)
ELECTRIC POWER DEVELOPMENT CO. LTD. TOKYO, JAPAN
DR.:
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Fig. 7

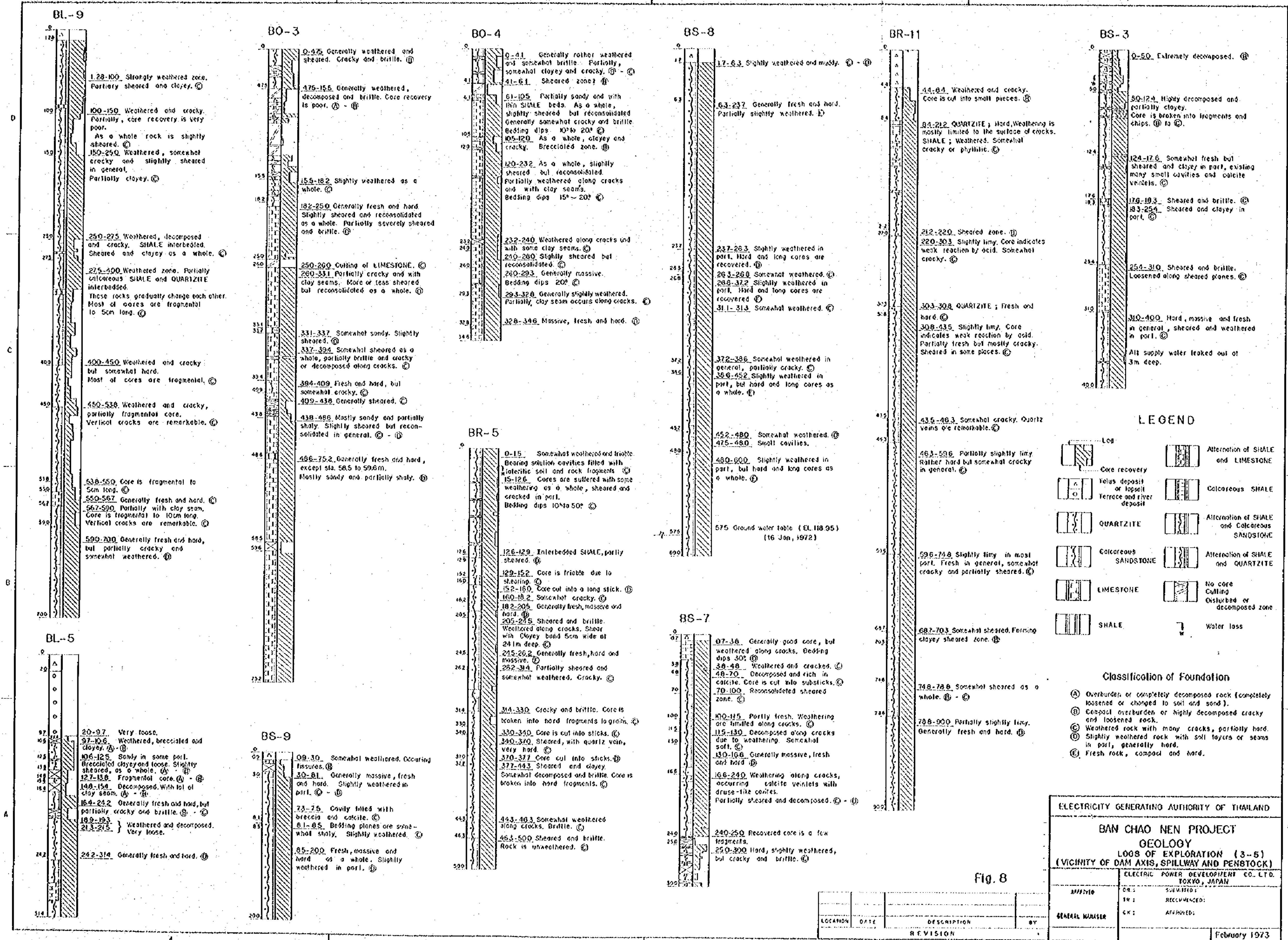
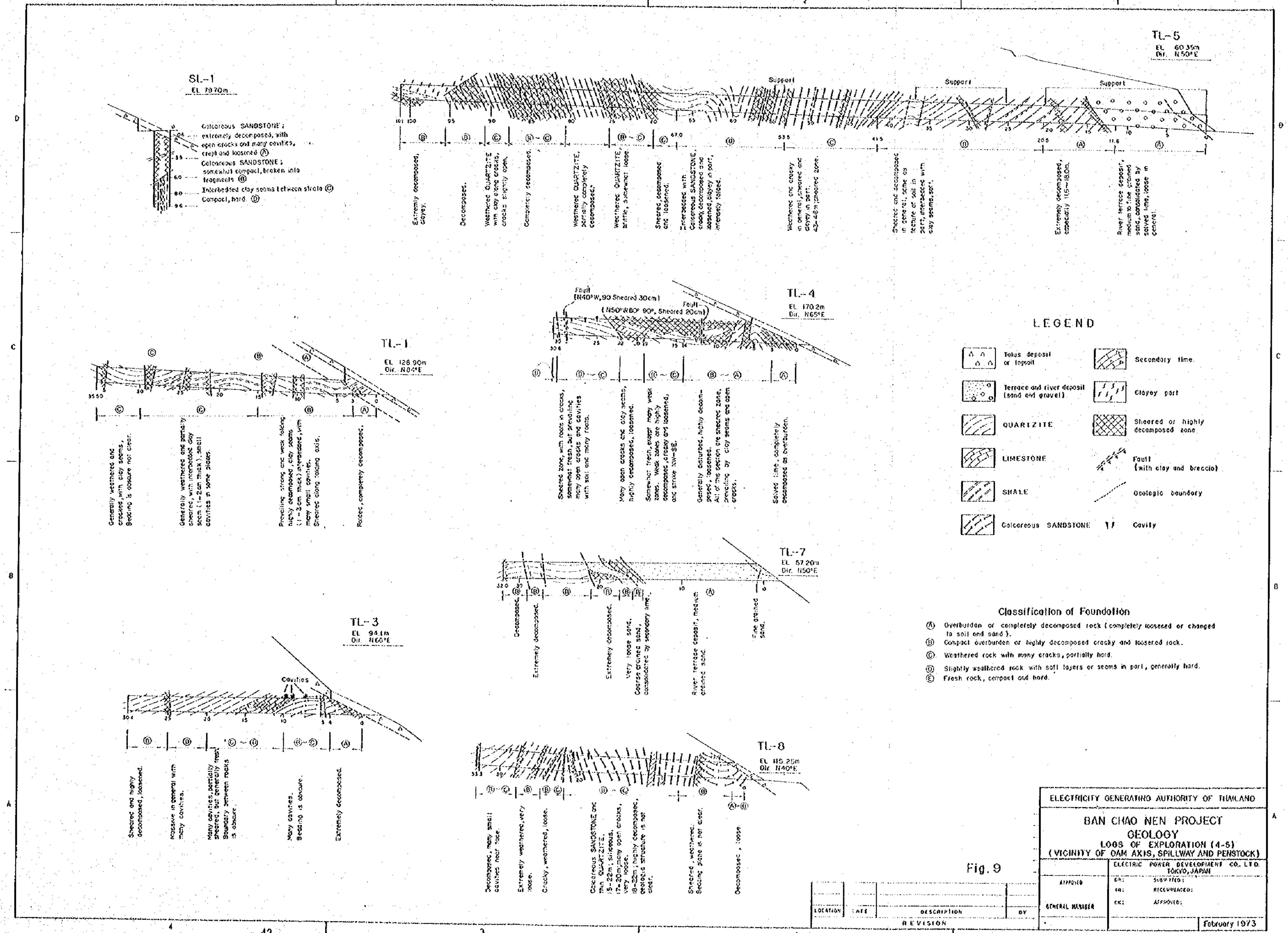
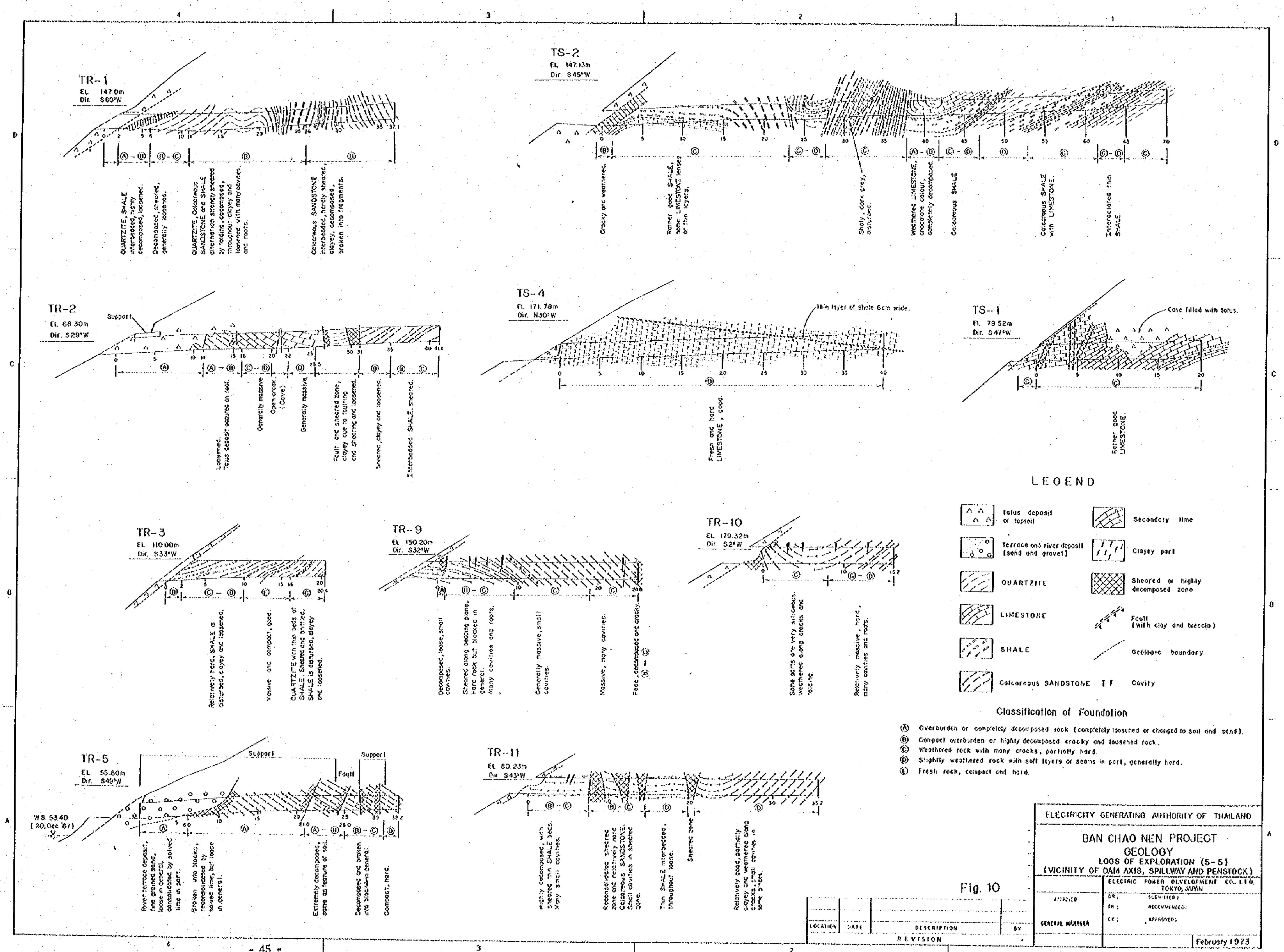

BL-9
1.28-100 Strongly weathered zone. Partially sheared and clayey. Ⓒ
100-150 Weathered and cracky. Partially, core recovery is very poor. As a whole rock is slightly sheared. Ⓒ
150-250 Weathered, somewhat cracky and slightly sheared in general. Partially clayey. Ⓒ
250-275 Weathered, decomposed and cracky. SHALE interbedded. Sheared and clayey as a whole. Ⓒ
275-400 Weathered zone. Partially calcareous SHALE and QUARTZITE interbedded. These rocks gradually change each other. Most of cores are fragmental to 5cm long. Ⓒ
400-450 Weathered and cracky but somewhat hard. Most of cores are fragmental. Ⓒ
450-538 Weathered and cracky, partially fragmental core. Vertical cracks are remarkable. Ⓒ
538-550 Core is fragmental to 5cm long. Ⓒ
550-567 Generally fresh and hard. Ⓒ
567-590 Partially with clay seam. Core is fragmental to 10cm long. Vertical cracks are remarkable. Ⓒ
590-700 Generally fresh and hard, but partially cracky and somewhat weathered. Ⓓ
BL-5
20-97 Very loose.
97-106 Weathered, brecciated and clayey. Ⓐ - Ⓑ
106-125 Sandy in some part. Brecciated clayey and loose. Slightly sheared, as a whole. Ⓐ - Ⓑ
127-138 Fragmental core. Ⓐ - Ⓑ
148-154 Decomposed. With lot of clay seam. Ⓐ - Ⓑ
164-242 Generally fresh and hard, but partially cracky and brittle. Ⓑ - Ⓒ
169-193, 213-215 Weathered and decomposed. Very loose.
242-314 Generally fresh and hard. Ⓓ
BO-3
0-475 Generally weathered and sheared. Cracky and brittle. Ⓑ
475-155 Generally weathered, decomposed and brittle. Core recovery is poor. Ⓐ - Ⓑ
155-182 Slightly weathered as a whole. Ⓒ
182-250 Generally fresh and hard. Slightly sheared and reconsolidated as a whole. Partially severely sheared and brittle. Ⓒ
250-260 Cutting of LIMESTONE. Ⓒ
260-331 Partially cracky and with clay seams. More or less sheared but reconsolidated as a whole. Ⓓ
331-337 Somewhat sandy. Slightly sheared. Ⓓ
337-394 Somewhat sheared as a whole, partially brittle and cracky or decomposed along cracks. Ⓒ
394-409 Fresh and hard, but somewhat cracky. Ⓒ
409-438 Generally sheared. Ⓒ
438-486 Mostly sandy and partially shaly. Slightly sheared but reconsolidated in general. Ⓒ - Ⓓ
486-752 Generally fresh and hard, except sta. 58.5 to 59.6m. Mostly sandy and partially shaly. Ⓓ
BS-9
0.9-3.0 Somewhat weathered. Occuring fissures. Ⓑ
3.0-8.1 Generally massive, fresh and hard. Slightly weathered in part. Ⓒ - Ⓓ
7.3-7.5 Cavity filled with breccia and calcite. Ⓒ
8.1-8.5 Bedding planes are somewhat shaly. Slightly weathered. Ⓒ
8.5-20.0 Fresh, massive and hard as a whole. Slightly weathered in part. Ⓓ
BO-4
0-4.1 Generally rather weathered and somewhat brittle. Partially, somewhat clayey and cracky. Ⓑ - Ⓒ
4.1-6.1 Sheared zone. Ⓑ
6.1-10.5 Partially sandy and with thin SHALE beds. As a whole, slightly sheared but reconsolidated. Generally somewhat cracky and brittle. Bedding dips 10° to 20° Ⓒ
10.5-12.0 As a whole, clayey and cracky. Brecciated zone. Ⓑ
12.0-23.2 As a whole, slightly sheared but reconsolidated. Partially weathered along cracks and with clay seams. Bedding dips 15° ~ 20° Ⓒ
23.2-24.0 Weathered along cracks and with some clay seams. Ⓒ
24.0-26.0 Slightly sheared but reconsolidated. Ⓒ
26.0-29.3 Generally massive. Bedding dips 20° Ⓓ
29.3-32.8 Generally slightly weathered. Partially clay seam occurs along cracks. Ⓒ
32.8-34.6 Massive, fresh and hard. Ⓓ
BR-5
0-1.5 Somewhat weathered and friable. Bearing solution cavities filled with lateritic soil and rock fragments. Ⓒ
1.5-12.6 Cores are suffered with some weathering as a whole, sheared and cracked in part. Bedding dips 10° to 50° Ⓒ
12.6-12.9 Interbedded SHALE, partly sheared. Ⓑ
12.9-15.2 Core is friable due to shearing. Ⓒ
15.2-16.0 Core cut into a long stick. Ⓓ
16.0-18.2 Somewhat cracky. Ⓒ
18.2-20.5 Generally fresh, massive and hard. Ⓓ
20.5-24.5 Sheared and brittle. Weathered along cracks. Shear with clayey band 5cm wide at 24.1m deep. Ⓒ
24.5-26.2 Generally fresh, hard and massive. Ⓓ
26.2-31.4 Partially sheared and somewhat weathered. Cracky. Ⓒ
31.4-33.0 Cracky and brittle. Core is broken into hard fragments to grains. Ⓒ
33.0-34.0 Core is cut into sticks. Ⓒ
34.0-37.0 Sheared, with quartz vein, very hard. Ⓒ
37.0-37.7 Core cut into sticks. Ⓓ
37.7-44.3 Sheared and clayey. Somewhat decomposed and brittle. Core is broken into hard fragments. Ⓒ
44.3-46.3 Somewhat weathered along cracks. Brittle. Ⓒ
46.3-50.0 Sheared and brittle. Rock is unweathered. Ⓒ
BS-8
1.7-6.3 Slightly weathered and muddy. Ⓒ - Ⓓ
6.3-23.7 Generally fresh and hard. Partially slightly weathered. Ⓓ
23.7-26.3 Slightly weathered in part. Hard and long cores are recovered. Ⓓ
26.3-26.8 Somewhat weathered. Ⓒ
26.8-37.2 Slightly weathered in part. Hard and long cores are recovered. Ⓓ
31.1-31.3 Somewhat weathered. Ⓒ
37.2-38.6 Somewhat weathered in general, partially cracky. Ⓒ
38.6-45.2 Slightly weathered in part, but hard and long cores as a whole. Ⓓ
45.2-48.0 Somewhat weathered. Ⓓ
47.5-48.0 Small cavities.
48.0-60.0 Slightly weathered in part, but hard and long cores as a whole. Ⓓ
57.5 Ground water table (EL 118.95) (16 Jan, 1972)
BS-7
0.7-3.8 Generally good core, but weathered along cracks. Bedding dips 30° Ⓓ
3.8-4.8 Weathered and cracked. Ⓒ
4.8-7.0 Decomposed and rich in calcite. Core is cut into substicks. Ⓒ
7.0-10.0 Reconsolidated sheared zone. Ⓒ
10.0-11.5 Partly fresh. Weathering are limited along cracks. Ⓒ
11.5-13.0 Decomposed along cracks due to weathering. Somewhat soft. Ⓒ
13.0-16.6 Generally massive, fresh and hard. Ⓓ
16.6-24.0 Weathering along cracks, occurring calcite veinlets with druse-like cavites. Partially sheared and decomposed. Ⓒ - Ⓓ
24.0-25.0 Recovered core is a few fragments.
25.0-30.0 Hard, slightly weathered, but cracky and brittle. Ⓒ
BR-11
4.4-8.4 Weathered and cracky. Core is cut into small pieces. Ⓑ
8.4-21.2 QUARTZITE ; Hard. Weathering is mostly limited to the surface of cracks. SHALE ; Weathered. Somewhat cracky or phyllitic. Ⓒ
21.2-22.0 Sheared zone. Ⓓ
22.0-30.3 Slightly limy. Core indicates weak reaction by acid. Somewhat cracky. Ⓒ
30.3-30.8 QUARTZITE ; Fresh and hard. Ⓒ
30.8-43.5 Slightly limy. Core indicates weak reaction by acid. Partially fresh but mostly cracky. Sheared in some places. Ⓒ
43.5-46.3 Somewhat cracky. Quartz veins are remarkable. Ⓒ
46.3-59.6 Partially slightly limy. Rather hard but somewhat cracky in general. Ⓒ
59.6-74.8 Slightly limy in most part. Fresh in general, somewhat cracky and partially sheared. Ⓒ
68.7-70.3 Somewhat sheared. Forming clayey sheared zone. Ⓑ
74.8-78.8 Somewhat sheared as a whole. Ⓑ - Ⓒ
78.8-90.0 Partially slightly limy. Generally fresh and hard. Ⓓ
BS-3
0-5.0 Extremely decomposed. Ⓑ
5.0-12.4 Highly decomposed and partially clayey. Core is broken into fragments and chips. Ⓑ to Ⓒ
12.4-17.6 Somewhat fresh but sheared and clayey in part, existing many small cavities and calcite veinlets. Ⓒ
17.6-18.3 Sheared and brittle. Ⓒ
18.3-25.4 Sheared and clayey in part. Ⓒ
25.4-31.0 Sheared and brittle. Loosened along sheared planes. Ⓒ
31.0-40.0 Hard, massive and fresh in general, sheared and weathered in part. Ⓒ
All supply water leaked out at 3m deep.
LEGEND
Log
Core recovery
Talus deposit or topsoil
Terrace and river deposit
QUARTZITE
Calcareous SANDSTONE
LIMESTONE
SHALE
Alternation of SHALE and LIMESTONE
Calcareous SHALE
Alternation of SHALE and Calcareous SANDSTONE
Alternation of SHALE and QUARTZITE
No core
Cutting
Disturbed or decomposed zone
Water loss
Classification of Foundation
Ⓐ Overburden or completely decomposed rock (completely loosened or changed to soil and sand).
Ⓑ Compact overburden or highly decomposed cracky and loosened rock.
Ⓒ Weathered rock with many cracks, partially hard.
Ⓓ Slightly weathered rock with soil layers or seams in part, generally hard.
Ⓔ Fresh rock, compact and hard.
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
LOGS OF EXPLORATION (3-5)
(VICINITY OF DAM AXIS, SPILLWAY AND PENSTOCK)
ELECTRIC POWER DEVELOPMENT CO. LTD. TOKYO, JAPAN
APPROVED
GENERAL MANAGER
SUBMITTED:
RECOMMENDED:
APPROVED:
LOCATION
DATE
DESCRIPTION
BY
REVISION
February 1973

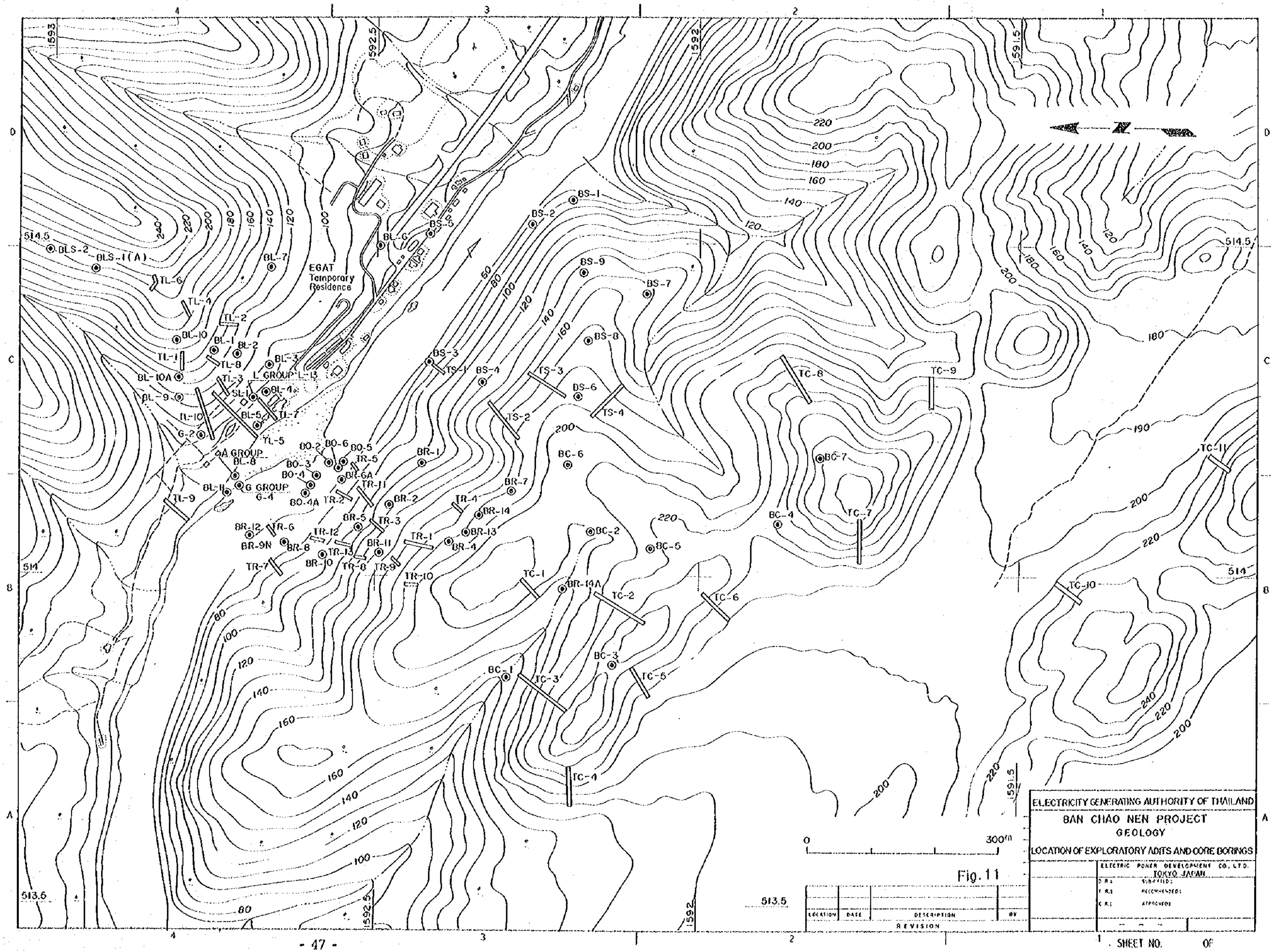
Fig. 8

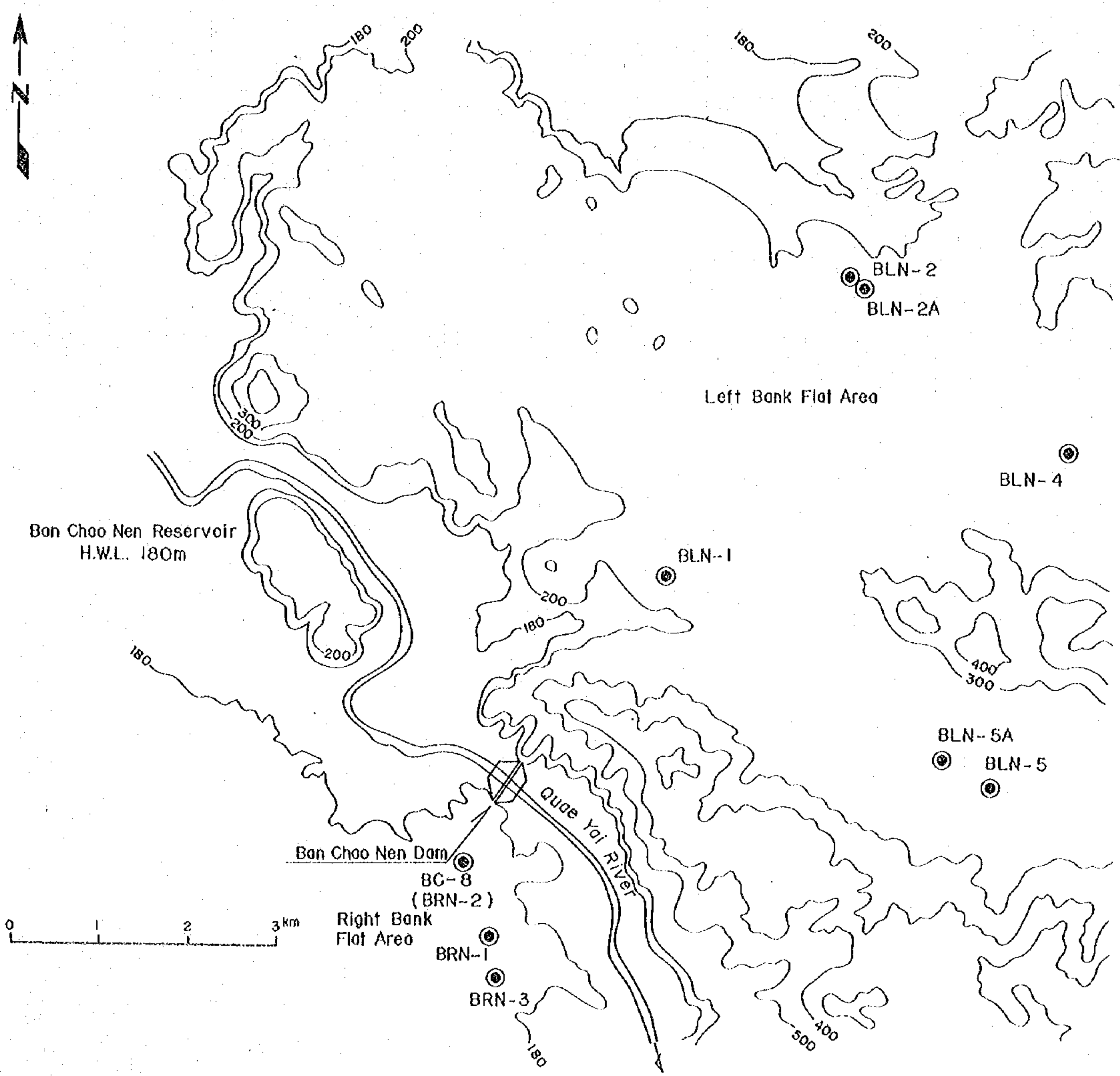


TL-5
EL 60.35m
Dir. N50°E
SL-1
EL 79.70m
Calcareous SANDSTONE; extremely decomposed, with open cracks and many cavities, crept and loosened (A)
Calcareous SANDSTONE; somewhat compact, broken into fragments (B)
Interbedded clay seams between strata (C)
Compact, hard (D)
TL-4
EL 170.2m
Dir. N65°E
TL-1
EL 126.90m
Dir. N04°E
TL-7
EL 57.20m
Dir. N50°E
TL-3
EL 94.1m
Dir. N66°E
TL-8
EL 115.25m
Dir. N40°E
LEGEND
Talus deposit or topsoil
Terrace and river deposit (sand and gravel)
QUARTZITE
LIMESTONE
SHALE
Calcareous SANDSTONE
Secondary lime
Clayey part
Sheared or highly decomposed zone
Fault (with clay and breccia)
Geologic boundary
Cavity
Classification of Foundation
(A) Overburden or completely decomposed rock (completely loosened or changed to soil and sand).
(B) Compact overburden or highly decomposed cracky and loosened rock.
(C) Weathered rock with many cracks, partially hard.
(D) Slightly weathered rock with soft layers or seams in part, generally hard.
(E) Fresh rock, compact and hard.
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
LOGS OF EXPLORATION (4-5)
(VICINITY OF DAM AXIS, SPILLWAY AND PENSTOCK)
ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
February 1973

Fig. 9


TR-1
EL 147.0m
Dir. S60°W
TS-2
EL 147.13m
Dir. S45°W
TR-2
EL 68.30m
Dir. S29°W
Support
TS-4
EL 171.78m
Dir. N30°W
Thin layer of shale 6cm wide.
TS-1
EL 79.52m
Dir. S47°W
Cave filled with talus.
TR-3
EL 110.00m
Dir. S33°W
TR-9
EL 150.20m
Dir. S32°W
TR-10
EL 179.32m
Dir. S2°W
TR-5
EL 55.80m
Dir. S49°W
WS 53.40
(20, Dec '67)
Support
Fault
TR-11
EL 80.23m
Dir. S43°W
LEGEND
Talus deposit or topsoil
Terrace and river deposit (sand and gravel)
QUARTZITE
LIMESTONE
SHALE
Calcareous SANDSTONE
Secondary lime
Clayey part
Sheared or highly decomposed zone
Fault (with clay and breccia)
Geologic boundary.
Cavity
Classification of Foundation
Ⓐ Overburden or completely decomposed rock (completely loosened or changed to soil and sand).
Ⓑ Compact overburden or highly decomposed cracky and loosened rock.
Ⓒ Weathered rock with many cracks, partially hard.
Ⓓ Slightly weathered rock with soft layers or seams in part, generally hard.
Ⓔ Fresh rock, compact and hard.
Fig. 10
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
LOGS OF EXPLORATION (5-5)
(VICINITY OF DAM AXIS, SPILLWAY AND PENSTOCK)
ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO, JAPAN
GENERAL MANAGER
DESCRIPTION
BY
REVISION
February 1973


ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
GEOLOGY
LOCATION OF EXPLORATORY ADITS AND CORE BORINGS
ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO JAPAN
Fig. 11
0
300m
EGAT
Temporary
Residence
L GROUP
A GROUP
G GROUP
LOCATION
DATE
DESCRIPTION
BY
REVISION
SHEET NO.
OF



Data of Ground Water
at Both Banks Flat Arras

NO. OF HOLE	EL. (M.S.L) TOP OF HOLE.	EL. (M.S.L) Ground Water.		Date
BLN-1 (Left)	200.^{84} m	A	180.^{25} m	Dec. 10'72
		B	178.^{46}	Aug. 30'72
〃 2	195.^{12}	A	187.^{47}	Dec. 10'72
		B	184.^{39}	June 20'73
〃 2A	196.^{47}	A	188.^{04}	Dec. 10'72
		B	186.^{05}	Aug. 30'72
〃 4	240.^{02}	A	210.^{79}	Nov. 30'72
		B	209.^{07}	Sep. 20'72
〃 5	235.^{26}	A	202.^{98}	Dec. 10'72
		B	200.^{30}	Sep. 20'72
〃 5A	231.^{12}	A	202.^{56}	Dec. 10'72
		B	200.^{47}	Sep. 20'72
BRN-1 (Right)	201.^{35}	A	189.^{38}	Sep. 20'72
		B	176.^{99}	Aug. 30'72
〃 -2 (BC-8)	199.^{60}	A	199.^{12}	Sep. 30'72
		B	180.^{62}	Aug. 30'72
〃 -3	206.^{65}	A	178.^{40}	Jan. 20'73
		B	173.^{96}	Sep. 20'72

NOTE;
A : Maximum water level during about 1 year
B : Minimum water level

Fig. 12

ELECTRICITY GENERATING AUTHORITY OF THAILAND

LOCATION MAP OF
DRILLING HOLE AT
BOTH BANKS FLAT AREAS

ELECTRIC POWER DEVELOPMENT CO., LTD. (E.P.D.Consultants) TOKYO JAPAN

LOCATION | DATE | DESCRIPTION | BY
REVISION

SHEET NO. OF

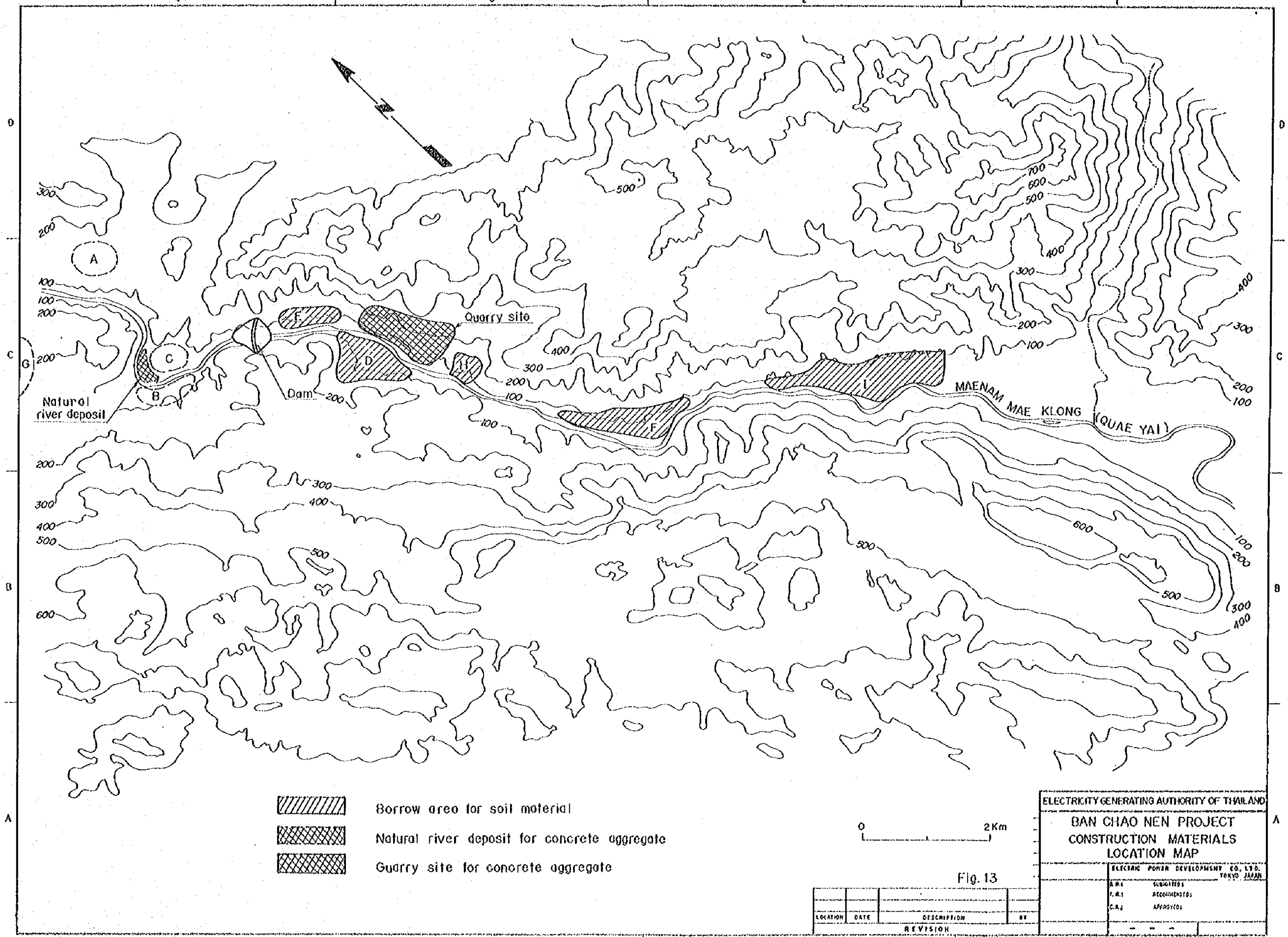

Quarry site
Dam
Natural river deposit
MAENAM MAE KLONG (QUAE YAI)
A
B
C
D
E
F
G
H
I
Borrow area for soil material
Natural river deposit for concrete aggregate
Quarry site for concrete aggregate
0
2Km
ELECTRICITY GENERATING AUTHORITY OF THAILAND
BAN CHAO NEN PROJECT
CONSTRUCTION MATERIALS LOCATION MAP
ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN
SUBMITTED
RECOMMENDED
APPROVED
LOCATION
DATE
DESCRIPTION
BY
REVISION
SHEET NO.
OF

Fig. 13

Part II

GROUTING TEST

OF

L AND A GROP

CONTENTS

LIST OF FIGURE

1) Location of L and A group site (See Fig. 1)

L-group is located on the proposed dam axis at the left bank and the elevation is about 84 m, A-group is located on about 100 m upstream from the dam axis at the left bank near river bottom and the elevation is about 57 m as shown on Fig. - 1.

2) Geological condition of test site

According to the geologic data of the site, the foundation of the dam is geologically divided into three zones named A - zone, B - zone and C - zone.

The rough description of each zone is as follows:

A - zone

A - zone is the area higher than EL. 90 m at the left bank and the whole area of the right bank. The rocks of A - zone are mainly limy quartzite and quartzite, they are fresh and hard but they have irregular cracks. Sheard zones are found at the remarkably folded part, but they are not predominant as in B - zone.

B - zone

B - zone is the area between EL. about 50 m and 90 m on the left bank and the zone is seemed to be dipped to the east (the mountain side) with a gentle angle. This zone is distributed paralel to the main river.

The rocks of B- zone are similar to the rocks of A - zone, but they appear to be somewhat sandy. The characteristic of B - zone are remarkable sheared zone, development of weathering and intercalation of clay caused by the folding. This phenomena can be found at adit TL - 5 and TL - 10.

C - zone

C - zone is identified as the rock of the river bed and this zone is composed of limy quartzite and impure limestone. The rocks are fresh and hard but they have cracks opened or filled by weathered material.

The L-group test site is located on B zone and judging from the core of the drill hole, the rock of the site is composed of weathered calcareous sandstone, weathered shale, weathere sandstone or quartzite and much clay caused by shearing and weathering. Therefor the core recovery of the hole is poor as shown as the attached data.

The A-group test site is belonging to C - zone. The rock at C - zone is fresh and hard, but there are many open cracks, therefor permeability and grout take of the test is rather high as shown on the attached data. The rock is consisted of calcareous sandstone, limestone, shale and sandstone or quartzite.

3) Purpose of grouting test

The purposes of the grouting test are as follows:

(1) Permeability and behavior of B and C zone by water test

(2) Whether the foundation of B zone is groutable or not

(3) How much cement are required and what spaces are most effective to perform the foundation treatment of this dam.

4) Length and pattern of test hole

The length of each hole is shown on Table - 1, 2 and the pattern is shown on Fig. - 2.

5) Test

5.1 Test stage and procedure of test

L - group

Upper 10 m portion of the hole from ground surface is not grouted, except for treatment to prevent collapse of drill holes and consolidation work, because almost all of this part will be too weak to inject grout under pressure.

Deeper than 10 m from the surface usually the length of a stage is 5 m and after 5 m length is drilled the hole is cleaned by water. The water permeability test and grouting follow after this cleaning. When during the drilling, the drainage water leaks perfectly, the drilling will be stopped and then grout will be injected immediately.

The same procedure as above is repeated again and again until the bottom of each hole.

A - group

Excepting sand deposit at the site, 5 m stage grouting was conducted. The space of the primary holes is 3 m and the secondary holes is 1.5 m, the test hole is located at the center of the test area. Other procedure is almost same with L - group.

5.2 Packer

The packer used at the site is a mechanical packer os screw type as shown on Fig. - 3.

5.3 Pressure

The pressure of permeability test is adjusted according to the geologic condition, coaverage of rock and height of dam proposed to be built. The standard pressure for the permeability test and the grouting is shown on the Table - 3.

The pressure for the grouting is decided by the result of the water permeability test.

5.4 Water permeability test (1) and (2)

The water test is conducted in two times. The first test is done before grouting and the second test is done after grouting. The former is named as water test (1) and the latter is water test (2).

The both water test for each test stage is conducted in two or three times by using the same pressure range and the quantity of leakage water is measured by minute during 5 to 10 minutes (or more) for each pressure.

The test stage for water test (1) is 5 m as described on Chapter 5 - 1, but the one for water test (2) is varied from 5 to 30 m, because this test is conducted after finished drilling and grouting of the whole length of the hole.

The pressure used for the test is described on Chapter 5 - 3 and the pressure for water test (2) is usually used the same pressure with water test (1).

5.5 Calculation of Lugeon value

After finished the water permeability test, all data for each test stage are arranged on the figure.

Lugeon value is calculated from the figure, but if a yield point is found on the figure, the Lugeon's value is calculated from the data before the yield point.

Usually Lugeon value should be calculated under 10 kg/cm^2 of a pressure, but the test at L - group site cannot be conducted by a high pressure because of the geologic condition of the foundation is very weak and the core recovery is very poor.

5.6 Grouting

The grouting pressure which is governed by the water test (1) and the depth of the grout stage is according to the standard given in the attached Table - 3.

The cement water ratio is used from 1:10 to 1:1 and is tried to use a various ratio at the beginning time of the test, but after getting the foundation condition of the test site the ratio is generally used one or two baches of 1:10 at the starting of the grouting and it is changed from 1:5 to 1:1.

The injection of the milk is generally continued until the injection is completely finished, but when the quantity of the injected cement is required vastly, the setting of the milk is consciously and deliberatly conducted by the control of the grouting pressure. The rough standard for setting milk, in case the milk of 1:1 is vastly required, is 10 sacks (500 kg) per one meter.

Table-1

L - group.

Hole No.	Ø	Depth	E.L.	Direction	Remarks
L - 1	AX	30^{m}	85^{m}.44	Vertical	Primary 0-10^{m} not injected
L - 3	"	30	84.10	"	" stage length ...5^{m}
L - 9	"	30	84.71	"	"
L - 12	"	30	84.70	"	Secondary
L - 2	"	30	84.23	"	"
L - 10	"	30	85.14	"	"
L - 11	"	25	84.29	"	"
L - 13	AX	60	84.46	Vertical	Check 50-60^{m} not injected only for geological investigation

Total 8 holes 265^{m}

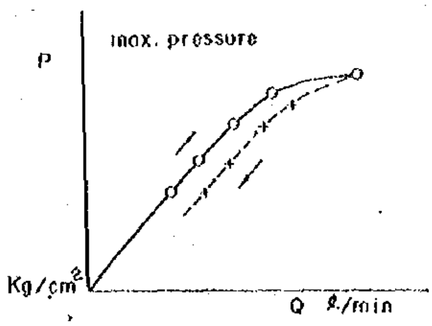
Table-2

A - group .

Hole No.	Ø	Depth	E.L.	Direction	Remarks
A - 1	AX	30^{m}	57^{m}.03	Vertical	Primary 0-10 m not injected
A - 2	"	30	57.40	"	" stage length ... 5^{m}
A - 3	"	45	56.87	"	"
A - 4	"	100	57.62	"	" This hole is identified as BL-8
A - 6	"	45	56.9	"	Secondary
A - 7	"	45	57.2	"	"
A - 8	"	45	57.5	"	"
A - 9	"	45	57.3	"	"
A - 5	AX	45	57.3	Vertical	Check

Total 9 holes 430^{m}

	Pressure for Permeability			Pressure for Grouting		
Stage	P_1	P_2	P_3	P_1'	P_2'	P_3'
	→ Safety ← Condition	→ Good ← Condition	→ Best ← Condition			
5-10m	0.5 kg/cm² ⇄ 1.0	⇄ 1.5 ⇄ 2.0 step by step	3.0	2.0 kg/cm²	3.0	5.0
10-15	0.75 ⇄ 1.5	⇄ 2.5 ⇄ 3.0 -----------	4.0	3.0	4.0	7.0
15-20	1.0 ⇄ 2.0 ⇄ 2.5	⇄ 3.0 ⇄ 3.5 ⇄ 4.0 -----------	6.0	4.0	6.0	9.0
20-25	1.25 ⇄ 2.0 ⇄ 2.5	⇄ 3.5 ⇄ 4.5 ⇄ 5.0 -----------	8.0	5.0	8.0	11.0
25-30	1.5 2.5 3.0	4.0 5.0 6.0 -----------	10.0	6.0	10.0	13.0
30-35	2.0 3.0 4.0	5.0 6.0 7.0 -----------	12.0	7.0	12.0	15.0
35-40	2.5 3.5 5.0	6.0 7.0 8.0 -----------	14.0	8.0	14.0	17.0
40-45	2.75 4.0 5.5	7.0 8.0 9.0 -----------	16.0	9.0	16.0	20.0
45-50	3.0 4.5 6.0	7.5 9.0 10.0 -----------	18.0	10.0	18.0	25.0



All water test will be measured by minute during 5-10 minutes (especially more) for each pressure.
Max. grouting pressure will be decided by the result of water permeability test by Engineer.

P_1 : Safety pressure
P_1+Pg = weight of covered rock static head

Table 7.

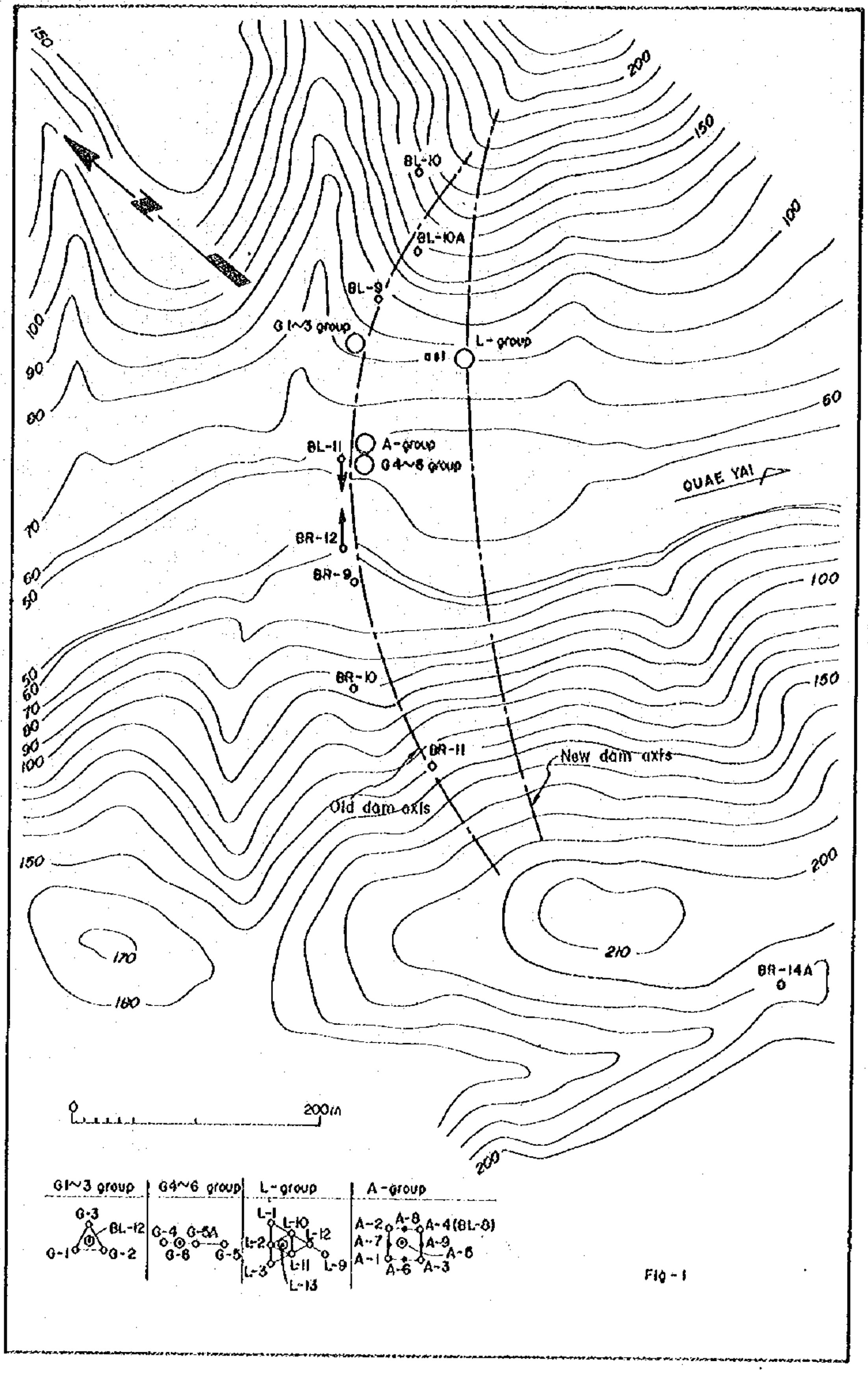
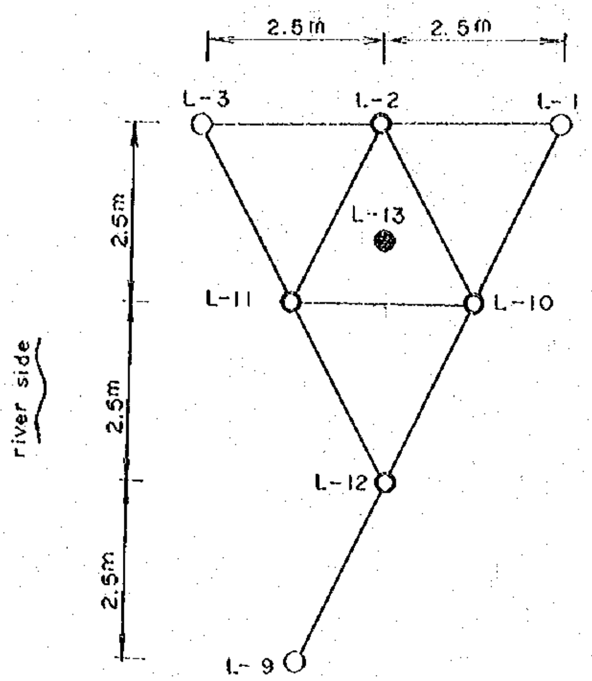

BL-10
BL-10A
BL-9
G 1~3 group
L - group
A - group
G 4~6 group
BL-11
BR-12
BR-9
BR-10
BR-11
BR-14A
QUAE YAI
New dam axis
Old dam axis
200m
G1~3 group
G4~6 group
L - group
A - group
G-3
BL-12
G-1
G-2
G-4
G-6A
G-6
G-5
L-1
L-10
L-12
L-2
L-3
L-11
L-13
L-9
A-2
A-8
A-4 (BL-8)
A-7
A-9
A-1
A-6
A-3
A-5

FIG - I

L-group Plan



Hole dia. Ax

Depth 30 m

(L-13...60m, L-3...2.5m)

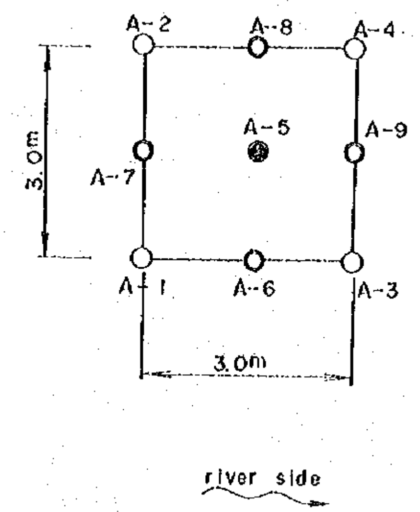
Direction ... Vertical

○ Primary holes

◎ Secondary holes

● Test hole

A-group Plan



Hole dia. Ax

Depth 30m 45m

(A-4 ... 100m)

Direction ... Vertical

○ Primary holes

◎ Secondary holes

● Test hole

Fig. 2

Mechanical Packer

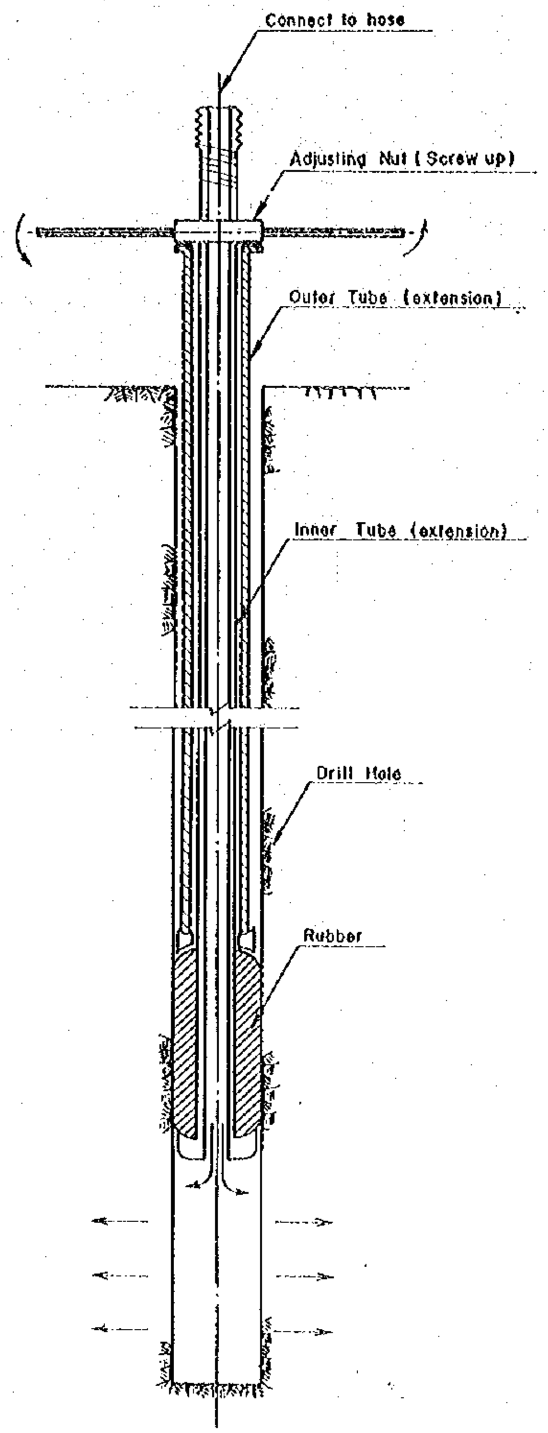


Fig - 3

(1) Basic Data of Group L on Water Test and Grouting

Abbreviation in Table

1.	Water Test (1)	Water Test before Grouting
2.	Water Test (2)	Water Test after Grouting
3.	Q.L.W. (ℓ/min./stage)	Quantity of Leakage Water
4.	C/W	Cement Water Ratio
5.	I.M. (ℓ)	Injected Milk
6.	I.R. (ℓ/min.)	Injected Rate per Minute
7.	I.C. (kg)	Injected Cement
8.	I.S. (kg)	Injected Sand
9.	Pa (m)	Location of Packer

Note:

1 Pressure for water test (1) and (2) shows Hp (gauge pressure) and Hg (head above ground water).

2 Pressure for grouting shows Hp (gauge pressure) only.

3 (o) in the line of I.R. shows no injection of milk under the indicated pressure.

4 ( ) in the line of I.C. shows the quantity of injected cement with unit of Sack.

RESULT OF L – GROUP

GROUP	HOLE NO	TOTAL Length(m)	WATER TEST (1) LUGEON 10–15 m	15–20 m	20–25 m	25–30 m	INJECTED CEMENT (SACK) 10–15 m	15–20 m	20–25 m	25–30 m	10–30 m	Sack/m	WATER TEST (2) 10–15 m	15–20 m	20–25 m	25–30 m	REMARK
1st GROUP	L–1	30	31	51	110–51	46	14	17	51	188	270	13.5	0	0	0	0–7	
	L–3	30	49	38	17	39	24	142	94	73	333	16.6	0	0	0^2	–	
	L–9	30	54	31	36	20	34	178	80	51	353	17.6	0	0*	0*	0*	*Water Test Conducted from 15to30m
	TOTAL INJECTED CEMENT FOR 1st GROUP 956 SACKS (15.9 S/M)																
2nd GROUP	L–12	30	23	25	5	1	2	6	4	10	22	1.1	0	0*	0*	0*	
	L–2	30	*–1 60	*–2 36	*–3 26	23	*–1 6	*–2 15	*–3 10	29	59	3.0	–	0*	0*	0*	*–1 Stage 9–15 m
	L–10	30	30	35	20	44	3	10	21	14	48	2.4	0	0*	0*	0*	*–2 Stage 14.5–20m
	L–11	25	24	35	20		2	12	7	–	*–5 21	1.4	–	–	–	–	*–3 Stage 18.5–25m
	TOTAL INJECTED CEMENT FOR 2nd GROUP 151 SACKS (2.0 S/M)																*–4 Stage 13–17.6m
3rd HOLE (CHECK HOLE)	L–13	50	40	27	2	2	8	4	5	7	24	1.2	*–6 4	*–7 1.5–2.0			*5 Stage 10–25 m
	(G. TOTAL)	255															*–6 Stage 10–50m
			(30–35 m)	(35–40 m)	(40–45 m)	(45–50 m)	(30–35 m)	(35–40 m)	(40–45 m)	(45–50 m)	(30–50 m)						*–7
			35	33	20	18	22	33	10	74	139	7.0					30–50 m

TOTAL INJECTED CEMENT FOR CHECK HOLE (10 – 30 M) 24 SACKS (1.2 S/M) }
(30 – 50 M) 139 SACKS (7.0 S/M) } (10 – 50 M) 163 S (4.1 S/M)

TOTAL INJECTED CEMENT FOR L – GROUP 1,270 SACKS

INJECTED CEMENT PER M FOR L – GROUP 7.3 SACKS

EL. 85.4m Depth of Hole 30m
EL. of Ground Water No.

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-1	10-15 Pa=10m	28 Sep. '70	4.25	65	31	30 Sep. '70	1:10	1-4	1,000	53	95		2 Oct. '70	10-15 Pa-10m	4	0.5-0.9	0	
							1:8	4-5	1,000	50	120							
							1:6	5	1,000	50	160							
							1:5	5	1,000	50	190							
							1:4	5	710	16(0.5)	149							
						Total C.					714(14)							
	15-20 Pa=15m	5 Oct. '70	4.25	108	51	10 Oct. '70	1:10	0	800	57	76							
							1:5	0	400	50	76							
							1:3	0-2	400	50	120							
							1:2	2	400	50	172							
							1:1	2-8	530	15(0)	403							
						Total C.					847(17)							
	20-21.30 Pa=15m	16 Oct. '70	3.25	49	110	16 Oct. '70	1:10	0	200	66	19							
			4.50	56			1:5	1-2.5	200	50	38							
			6.00	85			1:3	4	200	50	60							
			3.25	63			1:2	4	200	50	86							
							1:1	4-8	1,650	24(0)	1,254							
						Total C.					1,457(29)							
	21.30-25 Pa=16m	19 Oct. '70	3.50	70	51	20 Oct. '70	1:10	0	200	100	19							
			4.25	80			1:5	0	200	67	38							
			3.50	71			1:3	0-1	200	50	60							
							1:2	2-2.5	200	50	86							
							1:1	3-11	1,200	19(0)	912							
						Total C.					1,115(22)							
	25-30 1st Pa=15.5m	23 Oct. '70	3.75	87	46	23 Oct. '70	1:10	0	200	67	19		25 Oct. '70	24-30 Pa=24	4.25	43	25	
			3.55	84			1:5	0	200	50	38				5.75	73		
			3.25	79			1:3	0	200	40	60				5.95	76		
							1:2	0	200	50	86				4.25	57		
							1:1	0-6	3,470	33(0)	2,637				5.95	72		
						Total C.					2,840(57)				4.25	57		
	25-30 2nd Pa=15m					25 Oct. '70	1:10	0	200	100	19		27 Oct. '70	15-30 Pa=15m	3.25	8	6-10	
							1:5	1	200	50	38				3.75	20		
							1:3	2	200	50	60				4.25	40		
							1:2	3	1,000	50	430				3.75	35		
							1:1	3-2-5	3,420	32(0)	2,599				3.25	28		
						Total C.					3,146(63)				4.25	47		
															3.25	34		
															4.25	49		
															3.25	36	continue	

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm^2	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm^2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-1													27 Oct. '70	15-30	4.25	50	6-10	
														Pa=15m	4.75	60		
															4.25	23		
															5.25	72		
															4.25	59		
															5.25	76		
															4.25	62		
	15-30					27 Oct. '70	1:10	0	400	100-67	38		28 Oct. '70	15-30	3.25	0.16	0-3	
	Pa=15m						1: 5	2-3	200	67	38			Pa=15m	3.75	0.42		
							1: 3	3-4	200	67	60				4.25	0.52		
							1: 2	3-4	400	50-67	172				4.75	24		
							1: 1	3-6	3,250	28(0)	2,470				4.25	20		
						Total C.					2,778(56)				2.75	1		
															3.25	5		
	15-30					29 Oct. '70	1:10	2-3	200	50	19				3.75	13		
	Pa=15m						1: 5	3-4	400	67	76				4.25	21		
							1: 3	4	600	46	180		1 Nov. '70	25-30	4.25	0	0-7	
							1: 2	4-10	150	3(0)	64		(13.43-15.31)	Pa=24.5m	4.75	0.3		
						Total C.					339(7)				5.25	0.5		
	20-30					1 Nov. '70	1:10	5-7	1,200	16	114				5.75	0.8		
	Pa=20m					(19.26-22.56)	1: 5	7-6	600	12	114				6.25	0.8		
							1: 3	6	120	1(0)	36				6.75	22		
															5.75	18		
						Total C.					264(5)				4.75	12		
															4.25	9		
														20-30	4.25	5		
						Grand Total of Cement			13,500kg (270 sacks)					Pa=20m	4.75	11		
													2 Nov. '70	15-30	3.75	0.04	0	
						Injected Cement per m			675kg/m (13.5s/m)					Pa=15m	4.75	0.04		
															5.25	0.02		
														5-30	3.50	0.02		
														Pa=5m	4.25	0.02		
															5.25	0.06		

EL. 84.1m Depth of Hole 30m
EL. of Ground Water No.

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm^2	Grouting I. M. ℓ	Grouting I. R. ℓ/min.	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-3	10-15 Pa=10m (hydraulic packer)	13 Aug. '70	3.25	80	49	13 - 23 Aug. '70	1:10	1-5	480		46		25 Aug. '70	10-15 Pa=10m (hydraulic packer)	4.25	0.06	≒ 0	
						Milk was grouted by 3 times	1: 8	5	1,400		168							
							1: 6	5	920		147							
							1: 5	5	400		76							
							1: 4	5	600		138							
							1: 3	5	520		156							
							1: 2	5	200		860							
							1: 1	5	500		380							
						Total C.					1,197(24)							
	15-20 1st Pa=5m (hydraulic packer)	27 Aug. '70	5.75	107	33	28 Aug. '70	1:10	1-4	5,000	36	475		31 Aug. '70	15-20 Pa=5m (hydraulic packer)	6.75	114	34	
							1: 8	4-5	8,000	25	960							
							1: 6	8	1,000	6	160							
							1: 5	8	30	0.3(0)	6							
						Total C.					1,601(32)							
	15-20 2nd Pa=5m (hydraulic packer)					31 Aug. '70	1:10	0-2	3,000	56	285		3 Sep. '70	15-20 Pa=5m (hydraulic packer)	5.75	26	9	
						Cement was used up, grouting was stopped	1: 8	2-3	2,000	50	240							
							1: 6	3-4	1,000	50	160							
							1: 5	4	1,000	48	190							
							1: 4	5	1,000	43	230							
							1: 3	5-6	2,200	42	660							
						Total C.					1,765(35)							
						2 Sep. '70	1:10	4-5	1,000	53	95							
							1: 8	5	1,000	43	120							
							1: 6	5-6	1,000	43	160							
							1: 5	7	1,000	48	190							
							1: 4	7	1,000	40	210							
							1: 3	7	1,000	36	300							
							1: 2	8	1,000	29	430							
							1: 1	8	65	1	49							
						Total C.					1,549(31)							
	15-20 3rd Pa=5m (hydraulic packer)					5 Sep. '70	1:10	2-5	1,000	42	95		17 Sep. '70	15-20 ?a=13m	6.75	12	4	
							1: 8	6	1,000	40	120							
							1: 6	6-7	1,000	40	160							
							1: 5	7	1,000	37	190							
							1: 4	7-8	1,000	33	210							
							1: 3	8	1,000	33	300							
							1: 2	8	1,000	33	430							
							1: 1	8	70	1.7(0)	53							
						Total C.					1,558(31)							

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm^2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm^2	Grouting I. M. ℓ	Grouting I. R. ℓ/min.	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm^2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-3	15-20 4th Pa=13m					16 Sep. '70	1:10	8	1, 200	39	114		23 Sep. '70	15-20 Pa=15m	6. 75	0	0	
							1: 8	10-8	1, 400	27	168							
							1: 6	10	1, 200	29	192							
							1: 5	10	1, 000	16(0)	190							
						Total C.					664(13)							
						Total Cement of stage 15 to 20m					7, 137(42)							
	20-25 1st Pa=20m	25 Sep. '70	7. 25	62	17	26 Sep. '70	1:10	2-4	1, 000	53	95		28 Sep. '70	20-25 Pa=20m	7. 25	49	14	
							1: 8	4	1, 000	48	120							
							1: 6	4-5	1, 000	45	160							
							1: 5	5-6	1, 000	45	190							
							1: 4	6-7	1, 200	44	252							
							1: 3	7-10	2, 000	37	600							
							1: 2	10	2, 000	28	860							
							1: 1	10	270	8(0)	205							
						Total C.					2, 482(50)							
	20-25 2nd Pa=20m					28 Sep. '70	1:10	3-5	1, 000	50	95		30 Sep. '70	20-25 Pa=20m	7. 25	12	7	
							1: 8	5-6	1, 000	50	120							
							1: 6	6	1, 000	48	160							
							1: 5	7	1, 000	45	190							
							1: 3	7-8	1, 000	40	300							
							1: 2	8-10	2, 000	37	860							
						Total C.					1, 725(35)							
	20-25 3rd Pa=20m					1 Oct. '70	1:10	5	1, 000	45	95		4 Oct. '70	20-25 Pa=20m	7. 25	0. 64	0. 2	
							1: 8	5	200	40	24							
							1: 6	5	200	40	32							
							1: 5	5	200	40	38							
							1: 4	5	200	40	42							
							1: 3	5-10	800	9(0)	240							
						Total C.					471(9)							
						Total Cement of stage 20 to 25m					4, 678(94)							
	25-30 Pa=25m	11 Oct. '70	4. 25	80	38	11 Oct. '70	1:10	0	200	67	19		After grouting from 25 to 30m. Packer trouble accured, water test for last stage could not be performed.					
			5. 25	93	35		1: 5	0	200	50	38							
			5. 75	97	34		1: 3	0	200	50	60							
			5. 25	93	35		1: 2	0	200	200	86							
			4. 25	82	39		1: 1	1-6	4, 510	36(0)	3, 428							
						Total C.					3, 631(73)							

Ground Total of Injected Cement 16, 643kg (333 sacks)
Injected Cement per m 832kg (16.6 sacks)

EL. 84.7m. Depth of Hole 30m
EL. of Ground Water No.

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm2	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-9	10-15 1st Pa=10m	22 Sep. '70	2.75	74	54	23 Sep. '70	1:10	1-2	1,200	57	114		26 Sep. '70	10-15 Pa=10m	4.25	46	22	
							1: 8	2	1,200	50	144							
							1: 6	2-3	1,200	52	192							
							1: 5	3-4	1,200	48	228							
							1: 4	4-5	1,200	16(0)	252							
						Total C.					930(19)							
	10-15 2nd Pa=10m					27 Sep. '70	1:10	2	1,000	53	95		29 Sep. '70	10-15 Pa=10m	4.25	0	0	
							1: 8	2-3	1,000	50	120							
							1: 6	2-3	1,000	50	160							
							1: 5	2-3	1,000	45	190							
							1: 4	4-5	785	6(0)	181							
						Total C.					746(15)							
						Total Cement of stage 10 to 15m					1,676(34)							
	15-20 Pa=15m	1 Oct. '70	5.75	88	31	3 Oct. '70	1:10	1-3	1,000	53	95		5 Oct. '70	15-17.5 Pa=15m	5.5	0	0	
						The pressure reduced so grouting was stopped to check.	1: 8	3-4	1,000	48	120							
							1: 6	3-4	1,000	48	160			17.5-20 Pa=17.5m	3.75	110	117	
							1: 5	3-4	1,000	48	190							
							1: 4	3-4	1,000	50	210							
							1: 3	3-4	1,000	45	300							
							1: 2	3-4	1,000	45	430							
							1: 1	3-7	4,100	49	3,116							
							*1: 1	7-4-3	2,300	31	1,748							
							*1: 1	3-0	200	17	152							
						Total C.					6,521(130)							
	17.5-20 Pa=15m					10 Oct. '70	1:10	0	800	57	76							
							1: 5	0	800	50	152							
							1: 3	0	800	50	240							
							1: 2	0	800	50	344							
							1: 1	0-8	2,080	16(0)	1,581							
						Total C.					2,393(48)							
	20-21.5 Pa=15m	15 Oct. '70	2.55	94	74	16 Oct. '70	1:10	0	200	50	19							
							1: 5	0	200	40	38							
							1: 3	0	200	40	60							
							1: 2	0	200	40	86							
							1: 1	0-5	2,370	18(0)	1,801							
						Total C.					2,004(40)							
	20-25 Pa=15.7m	19 Oct. '70	3.5	66	38	19 Oct. '70	1:10	0	200	100	19							
			4.75	86	36		1: 5	0	200	67	38							
			3.5	76	43		1: 3	0	200	50	60							

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ /min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-9	20-25						1: 2	0-1	200	50	86							
							1: 1	1-8	2, 350	26(0)	1, 786							
						Total C.					1, 989(40)							
	25-30 Pa=15.5m	22 Oct. '70	4. 25	31	20	22 Oct. '70	1:10	0	200	50	19		25 Oct. '70 (11.03-11.51)	15-30 Pa=15.5m	3. 75	0. 4		
			5. 75	50			1: 5	2-3	200	50	38				5. 25	1. 4		
			6. 25	60			1: 3	3. 5	200	50	60				*6. 25	30		
							1: 2	4	200	50	86				4. 25	12		
							1: 1	4-10	3, 000	29(0)	2, 280				3. 75	7. 5		
						Total C.					2, 483(50)							
	15-30 Pa=15.5m					25 Oct. '70 (15.34-15.10)	1:10	4	200	100	19		27 Oct. '70	15-30 Pa=15m	3. 75	0	0	
							1: 5	4-5	800	50	152				4. 25	0		
							1: 3	5	600	43	180				4. 75	0		
							1: 2	5-6	490	8(0)	210				5. 25	0		
						Total C.					561(11)				5. 75	0. 20		
															5. 25	0. 04		
															4. 75	0. 02		
															4. 25	0		

Grand Total of Injected Cement 17, 627 kg (353 Sacks)
Injected Cement per m. 881 kg (17.6 Sacks)

*The pressure of gauge increase up to 4 kg/cm² and drop to 3 kg/cm².

EL. 84.7m Depth of Hole 30m
EL. of Ground Water No.

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) Kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Note
L-12	10-15 Pa=10m	21 Oct. '70	2 2.75 4.25	15 23 46	23	21 Oct. '70	1:10 1: 5 1: 5	3 4 5	200 200 111	67 22 2(0)	19 38 21		2 Nov. '70	5-30 Pa=5m	2 3.75 4.75	0.18 0.24 0.9	0	
						Total C.					78(2)							
	15-20 Pa=14.5m	24 Oct. '70	2.75 3.75 4.75 5.75 4.75 3.75 2.75	28 44 56 67 62 49 36	25	24 Oct. '70	1:10 1: 5 1: 3 1: 2	0 0 1-3 4-6	200 400 200 370	67 21 25 5(0)	19 76 60 159		2 Nov. '70	15-30 Pa=15m	3.75 4.25 4.75 5.25 6.75 7.25 8.25	0 0.08 0.10 0.12 0.32 0.34 0.48	0	
						Total C.					314(6)							
	20-24.4 Pa=15m	26 Oct. '70	3.47 4.22 4.72 5.22 6.22 6.72 7.22 7.72 6.22 5.22 4.22 3.47	9 10 14 18 29 38 45 50 55 42 31 23	5	26 Oct. '70	1:10 1: 5 1: 5 1: 5 Generater is out of order, so Injection stop.	0-4 4-5 5-6 6	400 400 200 150	67 36 20 30	38 76 38 29							
						Total C.					181(4)							
	24.4-30 Pa=15m	31 Oct. '70	4.22 5.22 5.72 6.72 7.72 5.72 6.72	0.5 2 4 11 32 17 27	1	31 Oct. '70 Milk leaks to L-1	1:10 1:10 1: 5 1: 3	5 5-6 6 6	1,000 200 600 1,000	40 33 40 40	95 19 114 300							
						Total C.					528(10)							

Grand Total of Injected Cement 1101 kg (22 Sacks)
Injected Cement per m. 55 kg (1.1 Sack)

EL. 84.2m Depth of Hole 30m
EL. of Ground Water No.

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-2	8-15 Pa=8m	4 Nov. '70	1.9	28	60	4 Nov. '70	1:10	1	200	40	19							
			1.9	52			1: 5	2	200	50	38							
			2.65	80			1: 3	2	200	40	60							
							1: 2	3-5	460	8(0)	198							
						Total C.					315(6)							
	14.50-20 Pa=14.5m	5-6. Nov.'70	2.7	58	36	6 Nov. '70	1:10	1	200	67	19		11 Nov. '70 (9.12 to 10.58)	15-30 Pa=15m	3.75	0.6	2	
			3.2	67			1: 5	2-4	400	57	76				4.75	1		
			2.7	56			1: 3	5-7	1,200	25	360				5.25	2		
			2.2	45			1: 2	7	400	25	172				5.75	3		
							1: 1	7	160	3(0)	122				6.25	4		
						Total C.					749(15)				7.25	16		
															6.25	12		
	18.50-25 Pa=18.5m	7 Nov. '70	3.4	59	26	7 Nov. '70	1:10	0	400	80	38				5.25	8		
			4.2	64			1: 5	1-3	800	53	152				3.75	3		
			4.6	71			1: 3	3-4	600	50	180				5.25	7		
			5.6	79			1: 2	4-8	245	3(0)	105				6.25	11		
			6.1	80											3.75	3		
			5.6	78														
			4.2	65														
			3.4	58														
						Total C.					475(10)							
	25-30 Pa=15m	9 Nov. '70	4.0	40	23	9 Nov. '70	1:10	0-1	400	80	38							
			5.25	56			1: 5	1-2	400	57	76							
			5.75	62			1: 3	2-5	800	50	240							
			6.75	77			1: 2	4-8	1,000	50	430							
			5.75	63			1: 1	8-10	130	4(0)	99							
			5.25	60														
			4.0	45														
			5.25	55														
			5.75	65														
			6.75	86														
			5.75	77														
			5.25	70														
			4.0	57														
						Total C.					883(18)							
	15-30 Pa=15m					11 Nov. '70 (11.28 to 14.17)	1:10	0-6	800	27	76							
							1: 5	6	600	13	136							
							1: 2	6	200	11	86							
							1:1.5	6	200	13	110							
							1: 1	6-10	130	2(0)	99							
						Total C.					507(10)							

Hole No.	Test Stage m	Water Test (1)				Grouting							Water Test (2)					Note
		Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	
L-2						15 Nov. '70	1:10	3	600	11	57		15 Nov. '70	15-30	3.75	0.08	0	
							1: 5	3	11	0	2			Pa=15m	4.75	0.5		
						Total C.					59(1)				5.25	2		
															4.75	0.9		
															3.75	0.3		
															4.75	1.1		
				Grand Total of Injected Cement 2,988 kg (60 Sacks)									17 Nov. '70	15-30	2.75	0	0	
				Injected Cement per m. 149 kg/m (3.0s/m)											3.75	0		
															5.25	0.1		
															6.25	0.4		

EL. 55.1m   Depth of Hole 30m
EL. of Ground Water   No.

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Note
L-10	9.50-15 Pa=9.5m	6 Nov. '70	2	28	30	6 Nov. '70	1:10	1-3	400	80	38		17 Nov. '70	5-30 Pa=5m	2.0	0	0	
			2.75	42			1: 5	3-6	605	10(0)	115				3.25	0		
			3.75	56											4.75	0.52		
			2.75	45											5.75	1.0		
			2	33														
											153(3)							
	13-17.6 Pa=13m	7 Nov. '70	2.53	55	35	7 Nov. '70	1: 4	2-4	700	58	110							
			3.53	67			1: 5	4	400	57	76							
			4	70			1: 3	4-8	335	6(0)	100							
			4.53	76														
			5	81														
			4	69														
			3.53	59														
			2.53	42														
											286(6)							
	15-20 Pa=15m	8 Nov. '70	2.75	13	9	8 Nov. '70	1:10	6-8	1,000	34	95		16 Nov. '70	15-30m Pa=15m	2.25	0	0	
			3.75	15			1: 5	8	400	33	76				2.95	0.02		
			4.75	20			1: 3	8	70	1(0)	21				5.25	0.22		
			5.75	25											6.25	0.42		
			7.25	35											7.25	3		
			7.75	38											6.25	2		
			7.25	34											5.25	0.84		
			5.75	27											3.75	0.08		
			4.75	22														
			3.75	16														
			2.75	12														
						Total C.					192(4)							
	20-25 Pa=15m	10 Nov. '70	3.5		20	10 Nov. '70	1:10	0-4	400	80	38							
			4.25	26			1: 5	4	400	50	76							
			4.75	34			1: 3	5-6	1,000	50	300							
			5.75	47			1: 2	7-8	1,400	50	602							
			6.75	60			1: 1	8	60	3(0)	46							
			7.25	67														
			7.5	70														
			6.75	66														
			5.75	56														
			4.75	47														
			3.5	35														
			4.75	46														

Hole No.	Test Stage m	Water Test (1)				Grouting							Water Test (2)					Note
		Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	
L-10	20-25	10 Nov. '70	5.75 7.25 3.25	54 67 33														
											1,062(21)							
	25-30 Pa=15m	14 Nov. '70	3.0 3.75	84 83	44	14 Nov. '70	1:10 1: 5 1: 3 1: 2 1: 1	0 1 2 2 2-10	200 200 200 200 680	100 67 67 50 17(0)	19 38 60 86 517							
						Total C.					720(14)							

Grand Total of Injected Cement 2,414 kg (48 Sacks)
Injected Cement per m. 80 kg/m (1.6 s/m)

EL. 84.2m Depth of Hole 30m
EL. of Ground Water No.

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting L.M. ℓ	Grouting I.R. ℓ/min	Grouting I.C. kg	Grouting L.S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon	Note
L-11	10-15 Pa=10m	22 Nov. '70	2	21		22 Nov. '70	1:10	2	200	100	19							
			2.75	34			1:10	3-5	200	40	19							
			4.25	53	24		1:10	5-6	350	6(0)	33							
			2.75	35														
			2	24														
						Total C.					71(2)							
	15-20 Pa=12.5m	24 Nov. '70	2.75	42		24 Nov. '70	1:10	0-2	1,000	59	95		During the injection from 20 to 25 m. the packer was stucked in the hole and the injection could not be continued up to 30m.					
			3.25	51			1:5	2-2.5	600	55	114							
			3.75	60			1:3	3-5	800	50	240							
			4.25	67			1:2	5-8	405	6(0)	174							
			4.75	82														
			3.75	65	35													
			3.25	57														
			2.75	49														
			3.75	63														
			2.75	48														
						Total C.					623(12)							
	20-25 Pa=15.5m	27 Nov. '70	3.5	41		27 Nov. '70	1:10	0	400	57	38							
			4.25	41			1:5	1-2	200	29	38							
			5.25	46			1:3	3-4	200	29	60							
			6.25	53	20		1:2	4-5	200	29	86							
			7.25	72			1:1	6-8	200	29	152							
			5.25	50														
			3.5	33														
											374(7)							

Grand Total of Injected Cement 1,068 kg (21 Sacks)
Injected Cement per m. 43 kg (0.9 Sack)

EL. 34.6m Depth of Hole 50m
EL. of Ground Water 53.09m
(Feb. 14, 1971)

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Note
L-13	10-15 Pa=7.5m	23 Nov. '70	2	39	40	23 Nov. '70	1:10	0-2	1,000	71	95		21 Jan. '71	10-50 Pa=10m	2.5	40	4	
			2.75	55			1: 5	3-5	1,400	50	266				3	48		
			4.25	85			1: 3	5-6	170	6(0)	51				3.5	56		
			2.75	59											4	64		
			2	43											4.5	72		
															3.5	56		
															3	48		
															2.5	40		
						Total C.					412(8)							
	15-20 Pa=14.5m	29 Nov. '70	2.75	36	27	29 Nov. '70	1:10	0	200	50	19		20 Jan. '70	15-50 Pa=15m	3.3	48	4	
			3.75	50			1: 5	1-2.5	200	50	38				3.8	54		
			4.75	67			1: 3	3-4	200	40	60				4.3	63		
			5.25	77			1: 2	5-8	140	4(0)	60				4.8	74		
			3.75	53											4.3	62		
			2.75	36											3.8	53		
						Total C.					177(4)				3.3	45		
	20-25 Pa=14.5m	2 Dec. '70	3.75	2	2	2 Dec. '70	1:10	0-6	400	40	38							
			4.75	3		Milk leaks to L-2 and L-9 during injection of 1:5 under the pressure 6 kg/cm²	1:10	6-3-6	1,600	26	152							
			5.75	5			*1: 5	6-3-6	400	12	76							
			6.75	9														
			7.75	27														
			6.75	19														
			5.75	10														
			4.75	6														
			3.75	4														
			4.75	5														
			5.75	8														
											266(5)							
	25-30 Pa=20m	6 Dec. '70	4.25	0.88	2	6 Dec. '70	1:10	3.5-6	600	75	57							
			5.25	5		* The pressure drop Milk leaks to L-9 hole during injection of 1:10	1:10	6	1,000	23	95							
			5.75	8			*1:10	6-4	200	9	19							
			6.75	11			*1: 5	6-4	200	11	38							
			7.75	16			1: 1	4-8	200	50	152							
			8.75	27														
			9.75	46														
			10.75	72														
			9.75	54														
			8.75	39														
			7.75	43														
			6.75	24														
			5.75	14														
			5.25	11														
			4.25	7														
						Total C.					361(7)							

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Note
L-13	30-35	10 Dec. '70	4.5	79	35	10 Dec. '70	1:10	0	200	100	19		20 Jan. '70	30-50	3.5	36		
	Pa=25m						1:5	0	200	50	38			Pa=30m	4	39		
							1:3	0	600	46	180				4.5	44		
							1:2	0	400	44	172				5	50		
							1:1	0	600	43	456				5.5	56		
							1:1	2	200	40	152				6	65		
							1:1	2-10	100	3(0)	76				5.5	55	5	
						Total C.					1,093(22)				5	50		
	35-40	21 Dec. '70	3.5	52		21 Dec. '70	1:10	0	800	80	76				4.5	44		
	Pa=20m		4	62			1:5	0	200	100	38				4	40		
			4.5	69			1:1	0-4	1,400	70	1,064				5	49		
			4	59	33		*1:1	5-6-4	200	67	152				6	65		
			3.5	52			1:1	2-3	400	57	304							
	Water level in the hole 31.10m from top of hole		4	59														
						Total C.					1,634(33)							
	40-45	28 Dec. '70	4.5	45			1:10	1	200		19							
	Pa=30m		6	59			1:5	1	200		38							
			7.5	74	20		1:3	1	200		60							
			6	59			1:2	1	200		86							
	Water level in the hole 31.10m from top of hole.		4.5	47			1:1	2.5	400		304							
						Total C.					507(10)							
	45-50	13 Jan. '71	3	34		14 Jan. '71	1:10	1	200		19							
	Pa=30m		5	42			1:5	2	200		38							
			6	49			1:3	2	200		60							
			7	60			1:2	2	400		172							
			7.5	64			1:1	*3-6-3	400		304							
			7	62			1:1	*3-4	1,000		760							
			6	55			1:1	*4-2-13	190		144							
			5	49														
			4	43	18													
			5	50														
			6	58														
			7	52		* The pressure decrease artificially for setting milk.												
			7.5	67														
			7	63														
			6	56														
	Water level in the hole 31.10m from top of hole.		5	52														
			4	46														
						Total C.					1,497(30)							

Hole No.	Test Stage m	Water Test (1)				Grouting							Water Test (2)					Note
		Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Date	C/W	Pressure kg/cm2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Date	Test Stage m	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	
L-13	30-50 Pa=30m					22 Jan. '70	1:10	0	200	70	19		26 Jan. '71	30-50 Pa=30m	4	6		
							1:10	1.5	200	70	19				5	10		
							1:10	2	200	50	19				6	21		
							1:5	2.5	200	50	38				7	32		
							1:5	3	200	50	38				7.5	49		
							1:5	3	200	70	38				7	43		
							1:1	4	1,600	40	1,216				6	32		
							1:1	5	1,200	29	912				5	23		
											2,147(43)				4	16	1.5-2.0	
															5	20		
															6	33		
															7	42		
															7.5	50		
															7	42		
															6	34		
															5	26		
															4	19		

Grand Total of Injected Cement 8,094 kg (162 Sacks)
Injected Cement per m. 162 kg (3 Sacks)

(2) Basic Data of Group A on Water Test and Grouting

Group-A Grout Test

Water Test (1) Before grout
(2) After grout

Hole No.	Total Length	Water Test (1) (Lugeon) 10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	Inject Cement, (Sacks) 10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	Sack/m	Water Test (2) (Lugeon) 10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m
A-1	30m	25	110	110	50				10	50	1 Re-grout 45	55				8.05 s/m (402.5 kg/m)			65L (Before re-grout) 8L (After re-grout)				
										Total injected Cement 8,049.5 kg, Sand 585 kg													
A-2	45	130	45	100	100	95	51	9	49	9	52 Re-grout 49 Re-grout 12 Re-grout 78 + 24	51	49	53	1	12.2 s/m (610 kg/m)			17L			0L	
										Total injected Cement 21,354 kg, Sand 1,847 kg													
A-3	30	23	36	60	65				10	22	55	53				7.0 s/m (353 kg/m)			25L				
										Total injected cement 7,056 kg, Sand 0 kg													
A-4	98	93	100	90	80	45	46	20	66	54	26 Re-grout 15	34	37		1				2L				
		45-50 15	50-55 3 5.5	55-60 (10)	60-65 | 65-70 15 | 8 (1)	70-75 | 75-80 2 | 5 2	80-86	86-98 20	45-60 10	60-70 8	70-86 2	86-98 no test			10-45m 45-86 10-86	6.7 s/m 0.5 3.3 (167 kg/m)	10-15	15-30 4-5 16-17	30-35 0				
										Total injected Cement 12,677 kg, Sand 0 kg													
A-6	45	15	26	50	7	10	3	7	13	18	53			10		2.7 s/m (134 kg/m)	0.4	0	no test			0	
										Total injected Cement 4,682 kg, Sand 250 kg													
A-7	45	41	45	40	41	72	16	3	25	25	31 Re-grout 9	53 Re-grout 7	37	11	1	5.7 s/m (284 kg/m)	0	0	12	19	0.7	0.5	
										Total injected Cement 9,931 kg, Sand 827 kg													
A-8	45	21	15	45	34,	4	7	3	18	50 Re-grout 3		55			13	4.0 s/m (198 kg/m)	3	2	no test (connect)			no test	
										Total injected Cement 6,956 kg, Sand 270 kg													
A-9	45	24	36	36	no test connect	7	6	3	16	connect from A-6				14		0.3 s/m (42 kg/m)	0	0	0	20	0	0	0
										Total injected Cement 1,905 kg, Sand 0 kg													
A-5	45	After grout A-1-4 6	5	3	2	24	14																
		After grout A-6-9 1	1	25	25	4	2	1															

EL. 57.03 Depth of Hole 30m
EL. of Ground Water 52.98m
(Feb. 14, 1971)

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. l/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm2	I. M. l	I. R. l/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm2	Q. L. W. l/min/stage	Lugeon
A-1	8.5-15 Pa=8.5m	3 Dec. '70	1.25	21	25	3 Dec. '70	1:10	1-4	200	100	19						
			1.9	25			1:10	4	200	50	19						
			2.9	33			1: 5	4	600	38	114						
			3.4	41			1: 3	4	600	38	180						
			4.4	45			1: 2	4-3	200	33	86						
			3.4	34			1: 2	3	210	4(0)	90.5						
			1.9	24													
			1.25	14													
						Total C.					508(10)						
	15-20 Pa=15m	8 Dec. '70	1	67	110	9 Dec. '70	1: 1	1	800	80	608		14 Dec. '70	20-25 Pa=15m	1.65	62	65-86
							1: 1	1-1.5	600	75	456				2.15	69	
							1:0.8	1	400	80	356						
							1:0.8	1.5	600	86	534						
							1:0.8	2	600	60(0)	534						
						Total C.					2,488(50)discontinue						
	20-25 Pa=15m	11 Dec. '70	1.25	75	125	13 Dec. '70	1:10	1	200	100	19		16 Dec. '70 before re-grouting 18 Dec. '70	20-25 Pa=20m	1.65	55	65
			1.4	77	110		1: 1	1-8	50	2(0)	38				2.15	69	
						Total C.					57(1) some trouble				0.9	32	
	20-25 Pa=15m					18 Dec. '70 (After reboring) Re-grouting	1: 5	1	200	100	38						
							1: 3	1	200	100	60						
							1: 2	1	200	100	86	sand					
							1: 1	1	600	75	456	60					
							1: 1	2-2.5-1	400	57	304	60					
							1: 1	1	800	89	608	190					
							1:0.8	1-6-1.5	800	20	712	200					
						Total C.					2,264(45) discontinue	510					
	25-30 Pa=20m	22 Dec. '70	1.9	52	50	23 Dec. '70	1: 8	0	200	100	24		11 Jan. '71	15-30 Pa=15m	1.4	6	
			2.9	69			1: 5	0	200	100	38				2.4	16	
			3.4	77			1: 2	0	200	100	86				3.4	36-40	
			2.9	67			1: 1	0	600	67	456				2.4	31	
			1.9	50			1: 1	0	600	46	456	15			1.4	19	
			2.9	67			1: 1	0	800	47	608				2.4	31	
							1: 1	0	600	50	456	15			3.4	41-43	8 (15m stage)
							1: 1	0	600	55	456	30					
							1: 1	0	200	-	152	15					
						Total C.					2,732(55) discontinue	75					

Ground Total of Injected Cement 6,049.5 kg (161 Sacks), Sand 585 kg
Injected Cement per m (10-30m) 402.5 kg (8.05 Sacks).

EL. 57.40 Depth of Hole 45m
EL. of Ground Water 52.98m
(Feb. 14, 1971)

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q.L.W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm2	Grouting I.M. ℓ	Grouting I.R. ℓ/min	Grouting I.C. kg	Grouting I.S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm2	Water Test (2) Q.L.W. ℓ/min/stage	Water Test (2) Lugeon
A-2	10-15 Pa=10m	25 Nov. '70	0.9	67	130	25 Nov. '70	1:2	1	200	33	86						
			1.4	87		can not stop	1:1	1-1.5	800	73	608						
			0.9	73		completely.	1:0.8	1.5	2,000		1,730						
						Total C.					2,474(49) discontinue						
	15-20 Pa=15m	30 Nov. '70	1.4	48	45	30 Nov. '70	1:10	1-2	400	57	38		5 Dec. '70 (After re-grout)4, Dec.	20-25 Pa=14.5m	1.4	58	86
			2.4	60			1:5	2-3	200	67	38				1.65	70	
			3.4	75			1:3	3	200	67	60						
			2.4	59			1:2	3-4	200	21	86						
			1.4	38			1:1	4-5	320		244						
						Total C.					466(9)						
	20-25 Pa=14.5m	2 Dec. '70	1.65	80	100	2 Dec. '70	1:10	0	200	100	19		24 Dec. '70	20-45 Pa=20m	3.15	36	5
			1.9	90			1:5	0	200	67	38				4.4	57	
			1.65	80			1:3	0	200	67	60						
							1:2	0	200	40	86						
							1:1	0	2,000	56	1,560		24 Dec. '70	30-45 Pa=30m	3.15	3.5	0.62
							1:0.8		1,000	50	890				4.4	4.5	
						Total C.					2,613(52) discontinue				5.9	4.8	
	20-25 Pa=14.5m	Re-grout				4 Dec. '70	1:10	1	200	100	19						
						Pressure decrease for setting milk	1:5	1	200	100	38						
							1:3	1	200	100	60			20-30	3.15	32	20-24
							1:2	1	200	100	86				4.4	52	
							1:1	1.5-2	1,200	30	912						
							1:1	2-0*	600	23	456	81					
							1:0.8	0	1,000	32	890	135					
						Total C.					2,461(49) discontinue	216					
	20-25 Pa=14.5m	Re-grout				5 Dec. '70	1:1	0	200	50	152	57					
							1:1	2-6	200	11	152	67					
							1:0.8	6-7	300	11(0)	267	71					
						Total C.					571(12)	195					
	25-30 Pa=20m	9 Dec. '70	1.4	70	100	9 Dec. '70	1:1	1	1,000	83	760	135					
							1:0.8	1	400	50	356						
							1:0.8	1-3	400	31	356						
							1:0.8	3-5	400	31	356						
							1:0.8	5-6	800	42	712						
						Total C.					2,540(51) discontinue	135					
	30-35 Pa=20m	13 Dec. '70	1.9	85	95	13 Dec. '70	1:2	1	300	100	129		24 Dec. '70	30-45 Pa=30m	3.15	3.5	0.6
			0.9	45			1:1	1	1,400	100	1,064				4.4	4.5	
							1:0.8	1	1,400	100	1,246				5.9	4.8	
						Total C.					2,439(49) discontinue						

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm2	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-2	35-40 Pa=30m	17 Dec. '70	0.9	34	51	18 Dec. '70 Pa=21m	1: 3	0	200	100	60						
			1.9	56			1: 2	0	200	100	86						
			2.9	71			1: 1	0	400	80	304						
			1.9	56			1: 1	1	200	33	152	10					
			0.9	34			1: 1	0	800	62	608	130					
							1: 1	0.5-1	600	75	534	120					
							1: 1	1	1,000	71	890						
						Total C.					2,634(53) discontinue	260					
	40-45 Pa=30m	23 Dec. '70	3.15	26	9	23 Dec. '70	1:10	1	200	50	19						
			4.4	27			1: 8	2	200	67	24						
			5.9	29			1: 8	2-4	140	3.5(0)	17						
			7.4	33													
			8.4	37													
			9.4	39													
			8.4	33													
			7.4	30													
			5.9	23													
			4.4	19													
			3.15	15													
			4.4	18													
			5.9	23													
						Total C.					60(1)						
	15-45 */ Pa-15m	Re-grout				24 Dec. '70	1: 8	1	200	100	24		11 Jan. '71	15-30 Pa=15m	1.4	27	17
		*/ Result of W. T. may be 20-30m				*The pressure decrease suddenly from 4 to 1 kg/cm2, after that, pressure not increase.	1: 5	2-3	200	15	38				2.4	58	
							1: 3	4	400	31	120				2.9	74	
							1: 2	4	200	67	86				2.4	64	
							1: 1	4-6	1,000	77	760				1.4	42	
							1: 1	4	1,400	88	1,064	189			2.4	65	
							1: 1	4	400	100	304	72			2.9	76	
							1: 1	4	400	80	304	108			1.4	43	
							1: 1	1*	400	80	304	108			2.4	66	
							1: 1	1	400	44	304	144		30-45 Pa=30m	1.4	0	≒ 0
							1: 1	1	800	38	608	360			2.4	0.6	
						Total C.					3,916(78)	981			3.4	0.5	
															4.4	0.4	
															5.4	0.4	
															6.4	0.7	
															7.4	1.8	
															5.4	0.3	
															3.4	0.2	

Hole No.	Test Stage m	Water Test (1)				Grouting							Water Test (2)
		Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Date	C/W	Pressure kg/cm2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	
A-2	9-45m */ Pa=9m	Re-grout */ may be 20-30m				10 Apr. '71	1: 2 1: 1 1: 1	3	800 1,000 100	100 66 66(0)	344 760 76	 40 20	During grouting, it also connect to A-6 & A-9
						Total C.					1,180(24)	60	

Sand 1,847 kg
Grand Total of Injected Cement 21,354 kg (427 Sacks)
Injected Cement per m. (10-45m) 610 kg (12.2 Sacks)

EL. 56.87m Depth of Hole 30m
EL. of Ground Water 52.98m
(Feb. 14, 1971)

Hole No.	Test Stage m	Water Test (1)				Grouting							Water Test (2)				
		Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-3	10-15	17 Dec. '70	1.15	16		20 Dec. '70	1:10	2	400	44	38						
	Pa=10m		1.9	24			1:5	2	600	26	114						
			2.9	30			1:3	2	200	20	60						
			3.4	36			1:2	2-2.5	200	22	86						
			4.4	45	23		1:1	2.5-3	290	4(0)	221						
			3.4	38													
			2.9	33													
			1.9	24													
			1.15	16													
						Total C.					519(10)	.					
	15-20	18 Dec. '70	1.4	27		18 Dec. '70	1:10	2	200	100	19						
	Pa=15m		2.4	43			1:5	2	200	67	38						
			3.4	57			1:3	2	200	67	60						
			3.65	62	36	Cement used up.	1:2	2	200	67	86						
			3.4	57			1:1	2	600	50	456						
			2.4	45			1:1	2	600	50	456	15					
			1.4	29													
						Total C.					1,115(22) discontinue	15					
	20-25	27 Dec. '70	1.4	46		12 Jan. '71	1:5	0	200	100	38		17 Jan. '71	20-30	0.9	21	
	Pa=20m		1.65	50	60	Pa=15m	1:2	0	400	100	172			Pa=20m	1.4	33	
			2.4	70			1:1	0	1,000	67	760				1.9	46	
			1.65	51			1:0.8		2,000	67	1,780				2.4	60	
															1.9	49	
						Total C.					2,750(55) discontinue				1.4	38	
	25-30	15 Jan. '71	1.4	49		15 Jan. '71	1:5	1	200	100	38				0.9	25	25
	Pa=20m		2.4	78			1:3	1	200	100	60				1.4	37	
	*After 4 minutes, water connect to A-2 hole.		1.4	53	65		1:2	1	200	100	86				1.9	49	
			2.4	79			1:1	1	1,200	67	912				2.4	61	
			2.9	97*			1:1	1-0.5	200	100	152				1.9	49	
							1:0.8	0.5-1	1,600	100-50	1,424				1.4	38	
						Total C.					2,672(53) discontinue						

Grand Total of Injected Cement 7,056 kg (141 Sacks)
Injected Cement per m. (10-30m) 353 kg (7.0 Sacks)

During reboring, some equipments were droped in the hole. Drilling of this hole stoped.

EL. 57.62m Depth of Hole 45m
EL. of Ground Water 52.98m
(Feb. 14, 1971)

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2)* Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-4	10-15 Pa=10m	11 Nov. '70	1.65	77	93	11 Nov. '70	1:10	0	200	100	19		26 Jan. '71	10-85 Pa=10m	1.4	35	4-5
						can not stop.	1: 5	0	200	67	38				1.9	52	
							1: 3	0	200	67	60				2.4	62	
							1: 2	0	200	67	86				2.9	76	
							1: 1	0	3,600	50	2,736				2.4	64	
							1:0.8	0	400		356				1.9	53	
															1.4	39	
						Total C.					3,295(66)	discontinue					
	15-20 Pa=14.2m	12 Nov. '70	1.4	65	100	12 Nov. '70	1:10	0	200		19		*/ Leakage quantity from 30 to 85m is very small, so, quantity from 15 to 85m must be leaked in stage of 15 to 30m				
			2.15	94		can not stop.	1: 5	0	200		38						
			1.4	66			1: 3	0	200		60						
							1: 2	0	200		86						
							1: 1	0	2,600		1,976						
							1:0.8		600		504						
						Total C.					2,713(54)	discontinue					
	20-25 Pa=14.2m	14 Nov. '70	1.65	75	90	14 Nov. '70	1: 5	0	200	100	19						
			2.15	97		can not stop.	1: 3	0	200	100	38		26 Jan. '71	15-85 Pa=15m	1.4	31	
			1.65	78			1: 2	0	200	67	60				2.4	57	
							1: 1	0	400	133	304				2.9	69	* 16-17
							1:0.8	0	1,000	167	890				3.4	83	
						Total C.					1,311(26)	discontinue			2.9	73	
	25-30 Pa=14.2m	16 Nov. '70	1.9	77	80	16 Nov. '70	1: 1	0	600	75	456				2.4	63	
						can not stop	1:0.8	0	1,400	61	1,246				1.4	37	
						Total C.					1,702(34)	discontinue					
	30-35 Pa=14.2m	18 Nov. '70	2.4	53	45								26 Jan. '71	30-85 Pa=30m	3.4	0.8	≈0
			3.4	73											4.9	1.2	
			4.4	89											6.4	1.7	
			3.4	72											7.9	2.2	
			2.4	56											9.4	3.0	
	30-40 Pa=14.2m	21 Nov. '70	1.9	87	46	21 Nov. '70	1: 1	0	1,600	107	1,216				7.9	2.6	
							1: 1	4-6	200	50	152				6.4	1.4	
							1: 1	4-6	600		456				4.9	0.8	
															3.4	0.4	
						Total C.					1,824(37)	discontinue			4.9	0.8	
	40-45 Pa=14.2m	27 Nov. '70	1.9	13	20	28 Nov. '70	1:10	0-2	200	67	19				6.4	1.2	
			3.4	22			1: 5	3-4	200	67	38				7.9	1.9	
			5.9	57			1: 3	4-7	20	0.7(0)	6				9.4	2.6	
			7.4	75											7.9	1.9	
			3.4	45											6.4	1.3	
			1.9	26											4.9	0.7	
						Total C.					63(1)						

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-4	40-45 Pa=14.2m	30 Nov. '70 (After grout)	1.4	1	2	15-45m re-grout											
			2.4	1		1 Dec. '70	1:10	0-9	200	20	19		26 Jan. '71	30-85 Pa=30m	3.4	0.4	
			3.4	2		Re-grout	1:10	9-10	200	40	19						
			4.4	3		*Pressure drop gradually.	1:10	10-3*	200	200	19						
			5.4	4			1: 5	3-7	200	67	38						
			6.4	7			1: 3	7	200	100	60						
			3.4	5			1: 2	7-8	200	50	86						
			1.4	2			1: 1	8-10	690	10(0)	525						
						Total C.					766(15)						
	45-50 Pa=14.5m	3 Dec. '70	3.4	12	15												
			4.9	26													
			6.4	45													
			5.4	39													
			3.4	25													
			1.4	10													
			3.4	24													
			4.9	29													
			3.4	23													
	45-55 Pa=25m	4 Dec. '70	3.4	11	3												
			4.9	14													
			6.4	15													
			7.9	18													
			9.4	21													
			10.4	29													
			7.9	21													
			4.9	15													
			2.4	9													
	45-60 Pa=25m	5 Dec. '70	3.4	37	5.5	17 Dec. '70	1:10	0-3	200	25	19						
			4.9	48			1: 5	3-5	200	33	38						
			6.4	51			1: 5	5-10	800	38	152						
			9.4	78			1: 3	8-10	200	29	60						
			6.4	46			1: 2	8-10	200	25	86						
			4.9	37			1: 1	8-10	160	5(0)	122						
			3.4	28													
			1.4	15													
						Total C.					477(10)						
	60-65 Pa=25m	19 Dec. '70	3.4	36													
			4.9	43													
			6.4	50													
			7.9	57													

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm2	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-4	60-65 Pa=25m	19 Dec. '70	9.4	63													
			10.4	71													
			9.4	64													
			7.9	57	15												
			6.4	47													
			4.9	38													
			3.4	31													
	60-70 Pa=25m	20 Dec. '70	3.4	41		20 Dec. '70 Pa=25m	1: 5	5	200	50	38						
			4.9	49			1: 3	6	200	40	60						
			6.4	54			1: 2	6	200	40	86						
			7.9	63			1: 1	6	200	20	152						
			9.4	72	8		1: 1	7-10	100	2.5(0)	76						
			7.9	56													
			6.4	49													
			4.9	41													
			3.4	32													
				.		Total C.					412(8)						
	70-75 Pa=30m	22 Dec. '70	3.4	6													
			4.9	7													
			6.4	7													
			7.9	9													
			9.4	10													
			10.4	11													
			9.4	9	2												
			7.9	8													
			6.4	6													
			4.9	5													
			3.4	3													
			4.9	4													
			6.4	6													
	70-80 Pa=20m	23 Dec. '70	3.4	20													
			4.9	25	5												
			6.4	30													
		Pressure rise up & drops to 3kg/cm2	7.9	35													
			9.4*	-													
			3.4	.76													
	70-86 Pa=30m	22 Jan. '71	3.4	15		22 Jan. '71 Pa=30m	1:10	5-6	200	29	19						
			6.4	22			1: 5	5-6	200	20	38						
			7.9	28			1: 5	6-9	200	14	38						

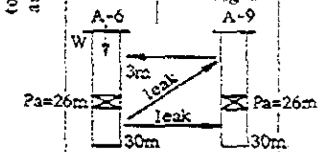
Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm2	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm2	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-4	70-86 Pa=30m	22 Jan. '71	9.4	36		26 Jan. '71	1: 5	1	100	0	19						
			7.9	30													
			6.4	25													
			4.9	20													
			3.4	15	2												
			4.9	20													
			6.4	25													
			7.9	31													
			9.4	41													
			7.9	33													
			6.4	28													
			4.9	23													
			3.4	18													
						Total C.					114(2)						
	86-98 Pa=50m	28 Feb. '71	1.4	60		Grand Total of Injected Cement 12,677 kg (253 Sacks)											
			2.4	78		Injected Cement per m (10-45m) 334 kg/m (6.7 Sacks/m)											
			3.4	92		Injected Cement per m (45-86m) 24 kg/m (0.5 Sacks/m)											
			4.2	101		Injected Cement per m (10-86m) 167 kg/m (3.3 Sacks/m)											
			3.4	91													
			2.4	78													
			1.4	60	20												
			2.4	77													
			3.4	92													
			4.2	100													
			3.4	91													
			2.4	77													
			1.4	60													

EL. 56.9 Depth of Hole 45m
EL. of Ground Water

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon
A-6	6-10 Pa=6m	19 Mar. '71	0.9	12	27	20 Mar. '71	1:10	1.5-5	200	30-0	19		16 May, '71	6-10 Pa=6m	1.4	0.5	λ
			1.4	18											2.4	1.0	
			1.9	23											3.4	1.7	
			2.4	27											2.4	0.9	
			2.9	31											1.4	0.4	
			3.4	35													
			2.9	29													
			2.4	25													
			1.9	22													
			1.4	18													
			0.9	13													
			1.4	17													
			1.9	21													
			2.4	25													
			2.9	30													
			3.4	33													
			2.9	29													
			3.4	33													
			2.9	29													
			2.4	26													
			1.9	22													
			1.4	17													
			0.9	13													
						Total C.					19(0.4)						
	10-15 Pa=10m	24 Mar. '71	0.9	8	15	25 Mar. '71	1:10	1-1.25	200	33	19		16 May. '71	10-20 Pa=10m	1.4	0	0.4
			1.4	13			1:10	3	200	16	19				2.4	0.5	
			1.9	16			1: 5	3	200	16	38				3.4	1.2	
			2.4	19			1: 5	3	400	22	76				2.4	0.7	
			2.9	23			1: 3	3	200	50	60				1.4	0.36	
			-	-			1: 3	*2.5	200	40	60						
			3.4	25			1: 2	*2	200	40	86						
			2.9	22			1: 2	*2	200	33	86						
			1.9	15			1: 1	2-3.5	200	40	152						
			0.9	8			1: 1	3.5-5	100	40-0	76						
			1.9	15													
			2.9	21													
			3.4	25													
			2.4	18													
			1.4	12													
			0.9	8													
						Total C.					672(13)						

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon
A-6	15-20 Pa=15m	1 Apr. '71	1.4	21		2 Apr. '71	1:10	2-3	200	25	19		16 May, '71	15-20 Pa=15m	1.4		
			1.9	26			1:10	3	200	18	19				⟆	0	
			2.4	32			1:5	3.5	400	25	76				4.4		
			2.9	37		*Connect to A-7, set packer at 9m of A-7.	1:3	3.5	200	33	60				5.4	0.16	
			2.4	30			*1:3	3.5	200	13	60				6.4	0.2	≒ 0
			1.9	25	26		1:3	2.5	200	25	60				4.4	0	
			1.4	19			1:2	2.5	400	31	172						
			1.9	22			1:1	2.5	200	33	152						
			2.4	27			1:1	2.5	200	40	152						
			2.9	35			1:1	2.5-4-6	150	40(0)	114						
						Total C.					384(18)						
	20-25 Pa=20m	8 Apr. '71	1.4	37		17 Apr. '71 stage 15-30 Pa=15m	1:10	3	200	100	19						
			1.9	50			1:5	3	200	67	38						
		*Connect to A-7 and A-2	2.4	59			1:3	3	200	100	60						
			*2.9	69	50		1:2	3	200	100	86		The stage from 20m to 30m is not done the water test, because this stage connect to another holes. Accordingly, this stage is plugged by cement milk.				
			2.4	59			1:1	3	400	100	304						
			1.9	49			1:1	2(Reg)	200	80	152	10					
			1.4	37			1:1	2-3(Reg)	200	57	152	20					
	26-30 *Pa=26m	17 Apr. '71	1.4	0.8			1:1	3	200	67	152	20					
			2.4	7			1:1	3	200	100	152	20					
	Packer can not set at 25m	*Water connect to A-9 as shown as Fig-1	3.4	11			1:1	3	200	67	152	20					
			4.4	14	7		1:1	3	200	67	152	20					
			5.4	19			1:1	3	200	67	152	20					
			6.4	24			1:1	3	200	67	152	20					
			*8.4	-			1:1	3	200	100	152	20					
							1:1	3	200	100	152	20					
							1:1	3	200	100	152	20					
							1:1	3	200	67	152	20					
							1:1	3	200	100	152	20					
							1:1	3	200	67	152						
						Total C.					2,635(53) discontinue	250					
	30-35 Pa=30m	24 Apr. '71	2.4	12		10 May, '71 stage 30-45 Pa=30m	1:10	5-8	400	13	38						
			3.4	17			1:5	8	400	16	76						
			4.4	23			1:3	8-10	400	13	120						
		Water connect to - A-9	5.4	29		During grout the 2nd batch, the milk connect to A-8, 30-35m plug by packer 30m	1:2	8-10	400	13	172						
			6.4	33	10		1:1.5	8-10	150	8(0)	90						
			4.4	25			Total C.				496(10)						
			2.4	13			Grand Total of Injected Cement				4,682 kg (94 Sacks)						
			4.4	25			Injected Cement per m (10-45m)				134 kg (2.7 Sacks)						
								Sand			250 kg						

Fig-1



Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-6	30-35 Pa=30m	24 Apr. '71	6.4	32	10								12 May, '71	30-45 Pa=30m	2.4	0.1	≈ 0
			4.4	25											3.4	0.2	
			2.4	14											4.4	0.36	
	35-40 Pa=35m	29 Apr. '71	4.9	2.3	3										5.4	0.4	
	During test 6 kg/cm² some water leak up at A-4		3.9	3											6.4	0.44	
			5.4	4.2											7.4	0.5	
			6.4	4.8											8.4	0.7	
			7.4	6.9											6.4	0.4	
			8.4	9.1											4.4	0.3	
			9.4	11											2.4	0.04	
			10.4	14													
			8.4	11													
			6.4	7.9													
			5.4	6.4													
			3.9	4.5													
			2.9	3.1													
	40-45 Pa=40m	1 May, '71	3.15	13	7												
			4.4	15													
			5.9	17.5													
			7.4	26.5													
			8.4	29.5													
			5.9	20.5													
			3.15	13													
			5.9	20.5													
			8.4	29													
			5.9	20.5													
			3.15	13													
	35-45 Pa=35m	1 May, '71	2.9	22	4.5												
			3.9	23													
			5.4	26													
			6.4	29													
			3.9	19													
			2.9	15													
			3.9	19													
			6.4	26													
			7.4	30													
			6.4	29													
			3.9	19													
			2.9	15													

EL. 57.2　　Depth of Hole 45m
EL. of Ground Water

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm^2	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	C/W	Pressure kg/cm^2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m.	Pressure (Hg+Hp) kg/cm^2	Q. L. W. ℓ/min/stage	Lugeon
A-7	6-15	12 Feb. '71	0.9	52		17 Feb. '71	1: 3	0.5	200	67	60		16 Apr. '71	10-15	1.4	0	
	Pa=6m		1.4	68		Pa=6m	1: 2	0.5	200	67	86			Pa=10m	3.4	0.25	
		Water connect to A-5	1.9	76			1: 1	1	200	67	152			Q_{10-15}	4.4	1.04	
		Packer set at 6m in A-5	2.4	88			1: 1	1	200	50	152	10		=Q_{10-20}	3.4	0.7	
		too.	1.9	76			1: 1	1.5	200	50	152	20		-Q_{15-20}	2.4	0.36	
			1.4	64			1: 1	2	200	50	152	20			1.4	0.14	
			0.9	49	41		1: 1	2	200	25	152	20			2.4	0.35	≒ 0
			1.4	64			1: 1	2.5	200	22	152	20			3.4	0.6	
			1.9	76			1: 1	3	200	25	152	20			4.4	1.1	
			2.4	87			1: 1	3-4	50	2(0)	38	5			3.4	0.6	
			1.9	75											2.4	0.4	
			1.4	64											1.4	0.15	
			0.9	49													
						Total C.					1,248(25)	115					
	15-20	23 Feb. '71	1.4	56		23 Feb. '71	1:10	0	200	100	19		16 Apr. '71	15-20	1.4	0	
	Pa=15m		1.9	67			1: 5	1	200	100	38			Pa=15m	2.4	0.1	
			2.4	69			1: 2	1	200	100	86				3.4	0.1	
			2.9	77			1: 1	1	200	67	152				4.4	0.15	
			3.4	84			1: 1	1	200	50	152				5.4	0.2	≒ 0
			3.9	92			1: 1	1.5	200	50	152				6.4	0.5	
			4.4	99	45		1: 1	1.5	200	50	152				4.4	0.1	
			3.9	92			1: 1	1.5	200	67	152	10			2.4	0	
			3.4	85			1: 1	1.5	200	67	152	20					
			2.9	78			1: 1	2-4	200	40	152	20					
			2.4	70			1: 1	4	50	1(0)	38	5					
			1.4	52													
			2.4	70													
						Total C.					1,245(25)	55					
	20-25	27 Feb. '71	1.65	52		27 Feb. '71	1: 3	1	200	100	60		12 Apr. '71	20-24	1.65	1.0	
	Pa=20m		2.4	62			1: 2	1.5	200	100	86			Pa=20m	2.4	2.5	
			2.9	71	40		1: 1	1.5	400	100	304	30			2.9	2.5	3
			3.9	86			*-1 1: 1	1.5-2.0	200	33	152	20	This stage is grauted		3.9	5.5	
			4.9	98		*-1	1: 1	2	200	67	152	20	again on 15, Apr.		4.9	12.0	
		Water connect				milk connect to	1: 1	2-1.5	200	67	152	20			5.4	14.0	
		to A-2.				A-3.	1: 1	1.5	600	100	456	60			8.4	41.0 →	12
							1: 1	2	200	40	152	20			5.4	24.0	
							1: 1	2-5	50	2(0)	38	5			3.9	17.5	
						Total C.					1,552(31)	175			2.9	12.0	

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm2	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon
A-7	25-30 Pa=23.5m	8 Mar. '71	*-1		41	8 Mar. '71	1:10	2	200	22	19		8 Apr. '71	25-30 Pa=25m	1.4	3	19
		connect to A-2 and A-3	1.4	36		can not stop.	1:5	2-1-2	200	50	38		*under 3 kg/cm2 of gauge pressure water connect to A-2 so this stage is grouted again on 10, Apr.	Q_{25-30}	2.4	13	
			2.4	52			1:3	2-4	200	33	60			$=Q_{25-45}$	*3.4	32 →	
			2.9	61			1:2	4-2	200	33	86			$-Q_{30-45}$	2.4	21	
			3.4	70			1:1	3.5	200	100	152				1.4	7	
			2.9	62			1:1	2	200	67	152	10					
			2.4	54			1:1	2	200	100	152	20		$Q_{30-45}=0$			
			1.4	36			1:1	3	200	100	152	20					
			2.4	54			1:1	3-5-2	200	50	152	20					
			2.9	63			1:1	2-3	200	67	152	20					
			3.4	70			1:1	3	400	67	304	40					
			2.9	62			1:1	3	200	50	152	20					
			2.4	54			1:1	3	200	100	152	20					
			1.4	37			1:1	2	200	67	152	20					
							1:1	2	200	100	152	20					
							1:1	2	200	67	152	20					
							1:1	2	600	67	456	60					
						Total C.					2,635(53) discontinue	290					
	30-35 Pa=29.5m	19 Mar. '71	1.4	74	72	20 Mar. '71 Pa=29.5m	1:3	1	200	100	60		7 Apr. '71	30-35 Pa=30m	2.4	0	0.7
			1.9	85			1:2	1	200	100	86			Q_{30-35}	3.4	0.2	
			2.4	95			1:1	1	600	100	456	30		$=Q_{30-45}$	4.4	0.06	
			2.8	101			1:1	1	800	80	608	80		$-Q_{35-45}$	5.4	0.6	
			2.4	94			1:1	1-1.5	400	67	304	40			6.4	1.2	
			1.9	84			1:1	1.5-2	400	50	304	40			7.4	1.8	
			1.4	73			1:1	2-8	20	1(0)	15	2			8.4	3.0	
			1.9	85											6.4	1.9	
			2.4	94											4.4	1.1	
			2.8	100											2.4	0.5	
			2.4	94											4.4	1.3	
			1.9	84											6.4	1.6	
			1.4	73											8.4	3.0	
															5.4	1.7	
															3.4	1.0	
															1.4	0	
						Total C.					1,833(37)	192					
	35-40 Pa=35m	25 Mar. '71	2.9	17		27 Mar. '71 Pa=35m	1:10	3	200	50	19		7 Apr. '71	35-44.5 Pa=35m	1.4	0	
			3.9	33			1:5	3	200	50	38				2.4	0.36	
			4.9	39			1:3	3.5	200	40	60				3.4	0.52	
			5.9	45			1:2	3.5	200	40	86				4.4	0.74	
			6.4	52			1:1	3.5	200	28	152				5.4	0.8	
			4.9	42			1:1	3.5-4.5	200	15	152				6.4	1.1	
			3.9	37			1:1	5-8	70	2(0)	54				7.4	1.2	

Hole No.	Test Stage m	Water Test (1)				Grouting							Water Test (2)				
		Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-7	35-40 Pa=35m	25 Mar. '71	2.9	30										35-44.5 Pa=35m	8.4	1.5	
			3.9	36											6.4	1.4	
			4.9	41											4.4	0.7	
			6.4	51	15-16										2.4	0.2	
			4.9	42											3.4	0.5	
			3.9	37											5.4	0.8	0.5
			2.9	30											7.4	1.3	
						Total C.					561(11)				9.4	1.9	
															10.4	4.3	
	40-45 Pa=40m	4 Apr. '71	2.4	9		4 Apr. '71	1:10	1-10	300	5 to 0	28				7.4	3.0	
			3.4	10											5.4	2.0	
			4.4	11											3.4	1.0	
			5.4	11.5	3										2.4	0.4	
			6.4	11.5													
			7.4	12.0													
			8.4	12.0													
						Total C.					28(0.5)						
	25-30 Pa=25m	Re-grout				10 Apr. '71	1: 2	3	400	44	172						
							1: 1	3	200	40	152						
							1: 1	4-8	50	5(0)	38						
						Total C.					362(7)						
	20-24 Pa=20m	12 Apr. '71 (After grout 10 Apr. '71)	1.65	1		15 Apr. '71	1:10	5-7	1,000	14	95						
			2.4	3			1: 5	7-8	400	27	76						
			2.9	3			1: 3	7-8	400	18	120						
			3.9	6			1: 2	7-8	200	13	86						
			4.9	12	5-10		1:1.5	7-8	150	6(0)	90						
			5.4	14		Total C.					467(9)						
			8.4	42													
			5.4	23		Grand Total of Injected Cement 9,931 kg (199 Sacks)											
			3.9	18		Injected Cement per m (10-45m) 284 kg (5.7 Sacks)											
			2.9	13		Sand 827 kg											

EL 57.5 Depth of Hole 45m
EL of Ground Water

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-8	5-10 Pa=5m	24 Apr. '71	1.4	8	40	26 Apr. '71	1: 1	2-4	200	25	152		18 May, '71	6-10 Pa=6m	1.4	0	0
			1.9	13		Stage 5-15	1: 3	4-5-4	600	30	180				1.9	0	
			2.4	22		Pa=6m	1: 2	4	400	50	172				2.4	0	
			2.9	32			1: 1	3(Reg)	400	40	304				2.9	0	
			3.4	64.5			1: 1	3-6	100	40-0	76				3.4	0	
			2.9	58											4.4	0	
			2.4	51		Total C.					884(18)						
			1.9	37													
			1.4	26													
			0.9	15													
			1.4	30													
			1.9	42													
			2.4	53													
			2.9	61													
			2.4	51													
			1.9	38													
			1.4	27													
			0.9	15													
	10-15 Pa=10m	25 Apr. '71	1.4	16	21	17 May, '71	1:10	3-4	200	28	19		16 May, '71	10-20m Pa=10m	1.4	0.7	≒ 3
			1.9	21		Stage 10-20	1: 5	4	400	14	76		Water connect to A-6 under 4.4 kg/cm²		2.4	2	
			2.4	26		Pa=20m	1: 3	4	200	14	60				3.4	6	
			2.9	31			1: 2	4	50	14(0)	23				4.4	14	
			2.4	26		(Re-grout) After WT 16, May '71									3.4	4	
			1.9	20											2.4	1	
			1.4	14		This injection was done as a second grouting									1.4	0	
			1.9	21													
			2.4	26													
			2.9	31													
			1.9	21													
			1.4	16													
	16-20 Pa=16m	28 Apr. '71	1.4	12	15								16 May, '71	15-20 Pa=15m	1.4	0	≒ 2
			2.4	16											2.4	0.4	
			2.9	18											3.4	1	
			3.4	21											4.4	2	
			3.9	36											5.4	4	
			3.4	33											4.4	3	
			2.4	25		Total C.					168(3)				3.4	3	
			1.4	19											2.4	0.6	
															1.4	0.2	

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-8	20-25.7	29 Apr. '71	1.4	14		30 Arp. '71	1:5	3	400	125	76						
	Pa=20m		1.9	27		Stage 13-	1:1	3	400	133	304						
			2.4	43		25.7	1:1	3	400	80	304						
			2.9	55		Pa=13m	1:1	3-4	400	80	304						
			2.4	51			1:1	3	400	80	304						
			1.9	43			1:1	3-4	400	100	304						
			1.4	34	45	Cannot stop,	1:1	4-5	400	100	304						
			1.9	42		cement is	1:1	5	400	100	304						
			2.4	51		used up.	1:1	5	400	80	304						
			2.9	61													
			2.4	54													
			1.9	44													
			1.4	44													
						Total C.					2,508(50) discontinue						
	25-30	3 May, '71	1.3	35		10 May, '71	1:3	2-3	400	57	120						
	Pa=25m		1.4	25		Stage 24-30	1:2	3	400	66	172						
			0.9	11			1:1	3	400	66	304						
			1.4	26			1:1	3	400	66	304	40					
			1.9	34	34	Cannot stop	1:1	3	400	57	304	40					
			2.4	42		A-9.	1:1	3 400	66400	66	304	40					
			1.9	33			1:1	3	400	30	304	30					
			1.4	25			1:1	3	400	66	304	40					
			0.9	12			1:1	3	800	57	608	80					
						Total C.					2,724(55)	270					
	30-35	5 May, '71	1.4	3													
	Pa=30m		2.4	7		no inject											
			3.4	7		connect from other hole											
			4.4	10													
			5.4	11													
			6.4	13													
			7.4	15													
			8.4	18	4												
			10.4	23													
			8.4	18													
			6.4	13													
			4.4	9													
			2.4	4													
			1.4	1.3													

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-8	35-40 Pa=35m	13 May, '71	2.4	6	7	15 May, '71	1:10	4	400	80	38						
			3.4	8		Stage=	1: 5	4	400	80	76						
			4.4	11		35-45	1: 3	4	400	66	120						
			5.4	13		Pa=35m	1: 2	4-5	400	66	172						
			6.4	15			1: 1	5-12	350	66(0)	266						
			7.4	19													
			8.4	21													
			10.4	33													
			8.4	28													
			6.4	21													
			4.4	15													
			2.4	8													
			3.4	12													
			5.4	18													
			7.4	23													
			10.4	34													
			7.4	27													
			5.4	20													
			3.4	14													
			1.4	4													
	40-45 Pa=40m	14 May, '71	2.4	11	3												
			3.4	13													
			4.4	13													
			5.4	14													
			6.4	15													
			7.4	16													
			8.4	16													
			9.4	17													
			10.4	17													
			8.4	16													
			6.4	9													
			4.4	6													
			2.4	2													
						Total C.					672(13)						

Grand Total of Injected Cement 6,956 kg (139 Sacks)
Injected Cement per m (10-45m) 198 kg (40 Sacks)
Sand 270 kg

EL. 57.3 Depth of Hole 45m
EL. of Ground Water

Hole No.	Test Stage m	Water Test (1) Date	Water Test (1) Pressure (Hg+Hp) kg/cm²	Water Test (1) Q. L. W. ℓ/min/stage	Water Test (1) Lugeon	Grouting Date	Grouting C/W	Grouting Pressure kg/cm²	Grouting I. M. ℓ	Grouting I. R. ℓ/min	Grouting I. C. kg	Grouting I. S. kg	Water Test (2) Date	Water Test (2) Test Stage m	Water Test (2) Pressure (Hg+Hp) kg/cm²	Water Test (2) Q. L. W. ℓ/min/stage	Water Test (2) Lugeon
A-9	6-10	19 Mar. '71	0.9	3		20 Mar. '71	1:10	1-2	200	11	19		16 May, '71	6-25	1.4	0.16	
	Pa=6m		1.4	9			1: 5	2-2.5	200	22	38			Pa=6m	2.4	0.24	
			1.9	12			1: 5	2.5	400	20	76				3.4	0.48	≑ 0
			2.4	16			1: 3	2.5	200	10	60				2.4	0.24	
			2.9	19			1: 3	2.5	200	16	60				1.4	0.12	
			2.4	16			1: 2	2.5	200	16	86						
			1.9	13			1: 2	2.5	200	10	86						
			1.4	10			1: 2	2.5-3	20	0	8						
			0.9	7	14												
			1.4	11									16 May, '71	10-25	1.4	0	
			1.9	13										Pa=10m	2.4	0.08	
			2.4	17											3.4	0.14	
			2.9	21											4.4	0.28	≑ 0
			2.4	16											3.4	0.14	
			1.9	14											2.4	0.1	
			1.4	10											1.4	0	
			0.9	7													
						Total C.					433(8)						
	10-15	23 Mar. '71	1.4	16		24 Mar. '71	1:10	0	200	100	19		16 May, '71	15-25	1.4	0	
	Pa=10m		1.9	21			1: 8	1	200	100	24			Pa=15m	to		
			2.4	27			1: 5	1	200	66	38				5.4	0	
			2.9	35			1: 5	1.5	200	28	38				6.4	0.16	≑ 0
			3.4	40			1: 5	2-3	200	33	38				4.4	0	
			2.9	34			1: 5	3	200	40	38				to		
			2.4	29			1: 5	3	400	50	76				2.4	0	
			1.9	24			1: 3	3	200	33	60						
			1.4	19	24		1: 3	3	200	40	60		16 May, '71	20-25	1.4	0	
			1.9	25			1: 2	3	200	40	86			Pa=20m	to		≑ 0
			2.4	30			1: 2	3	200	25	86				8.4	0	
			2.9	35			1: 1	4	200	28	152						
			3.4	40			1: 1	4-6	100	5-0	76		* Packer and water meter is checked				
			2.9	34									and confirmed to be good.				
			2.4	29													
			1.9	24													
			1.4	19													
						Total C.					791(16)						
	15-20	1 Apr. '71	1.4	33													
	Pa=15m		1.9	39													
			2.4	44													

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-9	15-20	1 Apr. '71	2.9	52	36	17 Apr. '71	1:10										
	Pa=15m	connect	3.4	59		Stage 15-30											
		to A-6	2.9	52		Pa=15m											
			2.4	45			Any grouting milk can not be injected at the stage of 15-30m of A-9. Because this stage must be injected from A-6.										
			1.9	38													
			1.4	28													
	19.5-25 Pa=19.5m	8 Arp. '71	1.4	28													
	Under 1 kg/cm² of gauge pressure water leak to A-6, the test is stopped.																
	25-30	During water test at A-6 (25-30m), water connect to A-9. 50, water test from 25m to 30m is stopped at A-9. (See Fig-1 in A-6)											12 May. '71 *	24-45	1.9	16	≒ 20
														Pa=24m	2.9	33	
														Q_{24-30}	3.4	42	
														$=Q_{24-45}$	2.9	34	
														$-Q_{30-45}$	1.9	21	
														$Q_{30-45} \fallingdotseq 0$			
														Q_{24-30}	$\fallingdotseq Q_{24-45}$		
	30-35	21 Apr. '71	2.4	8	7	26 Apr. '71	1:10	3	200	100	19		3 May. '71	30-45	2.4	0.1	0
	Pa=30m		3.4	10		Stage 30-45	1:10	3	600	33-25	57			Pa=30m	3.4	0.2	
			4.4	14		Pa=30m	1: 5	4	400	25-20	76			Q_{30-35}	4.4	0.2	
			5.4	20			1: 5	5	400	28-25	76			$=Q_{30-45}$	5.4	0.2	
			6.4	25		Connect	1: 3	5-3	400	25-22	120			$-Q_{35-45}$	6.4	0.3	
			7.4	27		to A-6	1: 2	3	200	25	86				7.4	0.6	
			6.4	22			1: 1	3	200	20	162			$Q_{35-45} \fallingdotseq 0$	6.4	0.3	
			5.4	19			1: 1	3-8	125	20-0	95				4.4	0.2	
			4.4	15											2.4	0.1	
			3.4	12													
			2.4	8		Total C.					681(14)						
			3.4	11													
			4.4	15									* Water connect to A-6 and A-8. Accordingly, after finish the water test, the stage from 24m to the bottom of the hole is plugged by cement milk.				
			5.4	19													
			6.4	23													
			7.4	26													
			6.4	23													
			5.4	19													
			4.4	14													
			3.4	11													
			2.4	7													

Hole No.	Test Stage m	Water Test (1) Date	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon	Grouting Date	C/W	Pressure kg/cm²	I. M. ℓ	I. R. ℓ/min	I. C. kg	I. S. kg	Water Test (2) Date	Test Stage m	Pressure (Hg+Hp) kg/cm²	Q. L. W. ℓ/min/stage	Lugeon
A-9	35-40 Pa=35m	24 Apr. '71	1.4	7	6								3 May. '71	35-45 Pa=35m	2.9	0.1	0
			2.4	11											3.9	0.4	
			3.4	15										Q_{35-40}	5.4	0.1	
			4.4	17										$=Q_{35-45}$	6.4	0.2	
			5.4	21										$-Q_{40-45}$	7.4	0.3	
			6.4	22											8.4	0.2	
			7.4	24											9.4	0.3	
			6.4	21											10.4	0.4	
			5.4	18											8.4	0.3	
			4.4	15											6.4	0.2	
			3.4	13											3.9	0.1	
			2.4	10													
			4.4	15													
			6.4	20													
			8.4	24													
			6.4	20													
			4.4	15													
			2.4	9													
	40-45 Pa=40m	26 Apr. '71	2.4	11	3								1 May. '71	40-45 Pa=40m	2.9	0.0	0
			3.4	13											3.9	0.0	
			4.4	13											5.4	0.1	
			5.4	13											6.4	0.5	
			6.4	14											7.4	0.6	
			7.4	15											8.4	0.8	
			8.4	14											10.4	0.7	
			6.4	12											8.4	0.5	
			4.4	10											6.4	0.3	
			2.4	5											3.9	0.04	

Grand Total of Injected Cement 1,905 kg (38 Sacks) 5-10m 433 kg (9S)
10-45 1,472 (29S)

Injected Cement per m (10-45m) 42 kg (0.8 Sacks)

Water Test (After A-1-4 grout)

Hole No.	Stage	Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	
A-5	10-45m	15 Feb. '71	0.9	66	(6)	Packer method
	Pa=10m		1.4	80		
			1.9	92		
	Q_{10-15}		2.4	103		
	$=Q_{10-45}$		2.9	112		
	$-Q_{15-45}$		3.2	(9) 119		
			2.9	111		
			2.4	101		
			1.9	91		
			1.4	80		
			0.9	65		
			1.4	80		
			1.9	92		
			2.4	102		
			1.4	74		
	15-45m	14 Feb. '71	1.4	71	(5)	
	Pa=15m		2.4	98		
			2.9	106		
	Q_{15-20}		3.4	114		
	$=Q_{15-45}$		3.6	117		
	$-Q_{20-45}$		3.4	(9) 113		
			2.9	104		
			2.4	96		
			1.4	74		
			2.4	96		
			2.9	105		
			3.4	113		
			2.9	105		
			2.4	96		
	20-45m	14 Feb. '71	1.4	68	(3)	
	Pa=20m		2.4	90		
	Q_{20-25}		3.4	(5) 107		
	$=Q_{20-45}$		2.4	89		
	$-Q_{25-45}$		1.9	79		
			1.4	66		

Water Test (After A-6-9 grout)

Hole No.	Stage	Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon	
A-5	10-15m	18 May, '71	1.15	0		Stage method
	Pa=10m		1.9	0		
			2.9	1.2		
			3.4	1.3		
			3.9	2		
			4.4	2.3		
			3.9	1.9		
			2.9	1.3		
			1.15	0		
	15-20	20 May, '71	1.4	0		
	Pa=15m		2.4	0.5		
			3.4	0.8		
			4.4	1.4		
			5.4	1.9		
			6.4	2.9		
			5.4	2.0		
			3.4	0.7		
			1.4	0		
			2.4	0.1		
			4.4	1.5		
			6.4	2.8		
			*6.9			
			6.4	18.5		
			4.4	13.3		
			2.4	7.5		
			1.4	4.4		
			3.4	9.8		
			5.4	15.6		
			6.4	19.3		
			5.4	17.6		
			3.4	10.3		
			1.4	4.9		
	20-25m	21 May, '71	1.4	5		
	Pa=20m		2.4	16		
			3.4	30		
			4.4	46		
			5.4	65		
			5.9	75		
			4.4	59		

* When regular pressure to 6.5kg/cm², pressure drop down to 4.5kg/cm²

Hole No.	Water Test (After A-1-4 grout)				
	Stage	Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon
A-5	20-45m		3.4	102	
			2.9	93	
			2.4	86	
			1.4	63	
	25-45	14 Feb. '71	1.4	63	2
	Pa=23.5m		2.4	86	
			3.4	104	
	Q_{25-30}			(4)	
	$=Q_{25-45}$		3.65	107	
	$-Q_{30-45}$		3.4	103	
			2.9	94	
			2.4	86	
			1.4	63	
			2.4	86	
			2.9	95	
			3.4	102	
			2.9	93	
			2.4	86	
			1.4	63	
	30-45	13 Feb. '71	1.4	62	24
	Pa=29.5m		1.9	74	
			2.4	83	
	Q_{30-35}		2.9	91	
	$=Q_{30-45}$		3.4	99	
	$-Q_{35-45}$		3.65	103	
				(41)	
			3.4	99	
			2.9	91	
			2.4	83	
			1.4	61	
			2.4	83	
			3.4	99	
			3.65	103	
			2.4	83	
			1.4	61	
	35-45		1.4	25	
	Pa=35.5m		2.4	40	
			2.9	52	
			3.4	58	
			4.4	70	
			4.9	78	

Water Test (After A-6-9 grout)				
Stage	Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon
20-25m		3.4	46	
		1.4	18	
		2.4	33	
		4.4	60	
		5.6	72	
		4.4	60	
		2.4	34	
		1.4	18	
		3.4	52	
		5.6	75	
		3.4	52	
		1.4	18	
25-30m	22 May, '71	1.9	12	
Pa=25m		2.9	22	
		3.4	29	
		4.9	52	
		6.4	72	
		4.9	60	
		3.4	41	
		1.9	22	
		3.4	44	
		4.9	61	
		6.4	75	
		4.9	61	
		3.4	42	
		1.9	22	
30-35m	23 May, '71	2.4	5	
Pa=30m		3.4	7	
		4.4	8	
		5.4	10	
		6.4	12	
		7.4	14	
		8.4	17	
		9.4	19	
		10.4	22	
			18	
		6.4	14	
		4.4	10	
		2.4	7	

Hole No.	Water Test (After A-1-4 grout)						Water Test (After A-6-9 grout)				
	Stage	Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon		Stage	Date	Pressure (Hg+Hp) kg/cm2	Q. L. W. ℓ/min/stage	Lugeon
A-5	35-45m		5.4	83			30-35m		6.4	14	
			5.9	86					8.4	18	
			6.4	91					10.4	22	
			6.9	98					8.4	18	
			6.4	93					6.4	14	
			5.9	88					4.4	10	
			5.4	84	14				2.4	7	
			4.4	72			35-40m Pa=35m	24 May, '71	2.9	1	
			5.4	82					5.4	2	
			6.4	91					6.4	3	
			4.4	74					8.4	5	
			2.4	49					10.4	7	
			1.4	34					12.4	11	
									10.4	9	
									8.4	7	
									6.4	5	
									2.9	1	
									6.4	5	
									8.4	7	
									10.4	9	
									12.4	13	
									10.4	9	
									8.4	7	
									6.4	5	
									2.9	1	
							40-45m Pa=40m	25 May, '71	3.4	1	
									5.4	2	
									7.4	3	
									9.4	4	
									11.4	6	
									13.4	8	
									15.4	12	
									11.4	6	
									7.4	4	
									3.4	1	