NATIONAL ELECTRICITY BOARD

OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

FEASIBILITY REPORT

OCTOBER 1968

GOVERNMENT OF JAPAN

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FOREWORD

The Overseas Technical Cooperation Agency, executive organization of the Government of Japan for the technical cooperation, commissioned the Electric Power Development Company to undertake the pre-investment study of the Raub Hydro-Electric Development in accordance with the Memorandum of Understanding between the Government of Malaysia and the Government of Japan on Pre-investment Study of the Raub Hydro-Electric Development, February 1966.

The Electric Power Development Co., Ltd. conducted a detailed investigation and the preparation of the present report.

It is our sincere hope that this report will be of some use in the development work comprisiong a part of the economic development programme of the Government of Malaysia and also contribute to the goodwill and friendship as well as economic exchange of the two countries, the Federation of Malaysia and Japan.

October 1966

S. Shibusawa

Shin-ichi Shibusawa
Director General
Overseas Technical Cooperation Agency

ELECTRIC POWER DEVELOPMENT COMPANY, LTD.
1-1, MARUNOUCHI, CHIYODA-KU, TOKYO

CABLE ADDRESS:
ELECTPOWER TOKYO

Mr. Shinichi Shibusawa, President
Overseas Technical Cooperation Agency

Dear Sir:

Transmitted herewith is a report on the feasibility studies of the Rabu Hydroelectric Development Scheme in Malaysia which was undertaken by this firm on behalf of the Government of Japan in accordance with your instruction.

The Electric Power Development Company sent to Malaysia a team of engineers headed by Mr. Taisuke Yanai for a period of 90 days from March 1, 1966. The team conducted reconnaissance survey of the entire catchment area of the Raub Scheme, and based on this survey a preliminary report giving the fundamental plan of development of the scheme was submitted to the National Electricity Board. Following this work, topographical and geological surveys, hydrological investigations of river conditions and studies of power market were conducted, in addition to collecting data and other information necessary for preparing of cost estimates and planning of the scheme.

After the team returned to Japan, the Electric Power Development Company mobilized engineers in the fields of planning of hydroelectric power development, design of hydraulic structures, programming of supply and demand of electricity, and planning of power transmission lines. Under the direction of the Chief Enginee of the company, these engineers conducted studies of the scheme and prepared this report.

The Raub Hydroelectric Development Scheme consists of three power stations, one each on the Sia, Liang and Sempan Rivers which have a total catchment area of approximately 112.7 square miles. The scheme will develop a total output of 30,000 KW and produce 191,800,000 KWh annually. The output will be transmitted to supply the demands of Raub, Fraser's Hill and Kuala Lipis, and the remainder of the power will be transmitted to the Central Network and contribute to the rapidly developing industries of the western region of which Kuala Lumpur, the capital of Malaysia is the center.

For execution of this scheme, a construction period of approximately three years and a construction expenditure of approximately $M 45, 600, 000 will be required, but with the completion of the scheme a surplus benefit of approximately $M 3, 089, 000 annually can be anticipated.

In view of the growing demand for electricity, it is considered necessary to start operation of the power plants of the scheme at the earliest praticable date, therefore, the detailed designs and thereafter the construction of the power stations and transmission lines should be carried out as soon as possible.

We take this opportunity to express our sincere gratitude to the officials of the Economic Planning Board, the Ministry of Commerce and Industry, the National Electricity Board and the Embassy of Japan in Malaysia, as well as to all other people the team came into contact during the course of their stay in Malaysia for their generous assistance and cooperation.

Respectfully yours,

October 1966

M. Yoshikoshi

Moritsugu Yoshikoshi, Director
Foreign Activities Department
Electric Power Development Co., Ltd.

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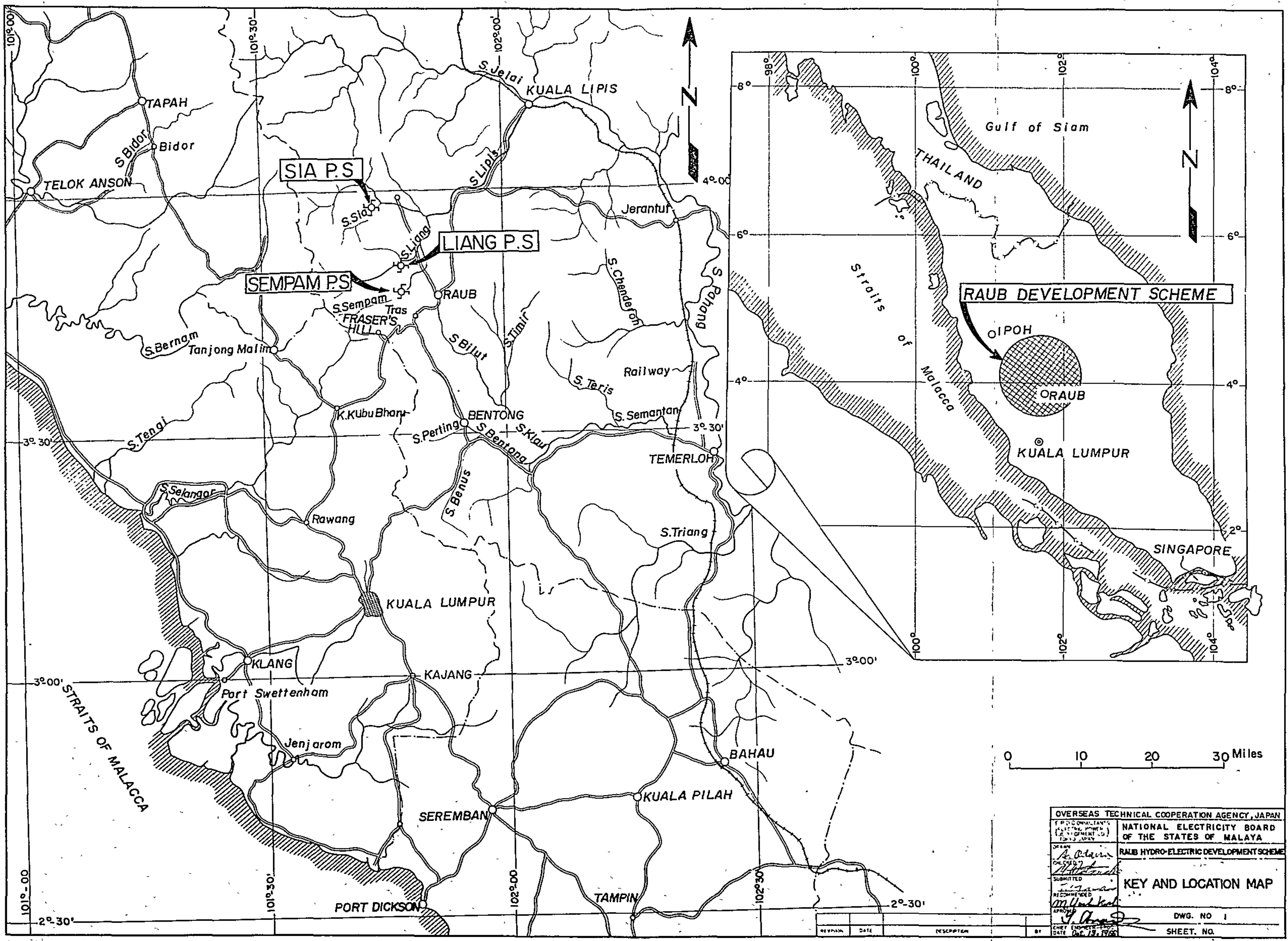
APPENDIX

DRAWING LIST



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

E.P.D.C. CONSULTANTS
(ELECTRIC POWER DEVELOPMENT CO.)
TOKYO, JAPAN

NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

KEY AND LOCATION MAP

DRAWN
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
CHIEF ENGINEER
DATE Oct. 19, 1966

DWG. NO 1
SHEET. NO.

REVISION	DATE	DESCRIPTION	BY

電源開発株式会社
日本国 東京

(A-3)

1. INTRODUCTION

1.1 HISTORY

1.1.1 Investigations

Malaysia, in recent years, is faced with the necessity of developing electric power resources to satisfy rapidly growing demand for electricity which is being created by the changing pattern of energy consumption, growth of population and marked industrial development. In order to satisfy the growing demand, the National Electricity Board (hereinafter called NEB), established by virtue of the Electricity Ordinance of 1949, is pursuing a long-term power development program in step with the Five-Years Plan.

The Raub Hydroelectric Development Scheme consists of a plan to develop the hydroelectric potentials of the Liang, Sia and Sempam Rivers near Raub in Pahang State. A reconnaissance survey of these hydroelectric resources was conducted under the Colombo Plan Technical Assistance from December 1959 to May 1960 and it was concluded that development of the Sia and Liang Rivers appeared to be economical. A survey of the Sempam River, however, was not carried out at that time.

Later, NEB made a study of the hydroelectric development on the Liang, Sia and Sempam Rivers, and in February 1965, it was decided that a feasibility study of proposed sites including observation of run-off of the three rivers should be carried out as soon as possible.

1.1.2 Circumstances Leading to the Present Survey

In February 1966, the Government of Malaysia requested the technical cooperation of the Government of Japan in connection with the development of hydroelectric potentials of rivers in the vicinity of Raub, Pahang State, and asked for an investigation team to be dispatched for the feasibility investigation. In compliance with this request, the Government of Japan decided to cooperate with the Government of Malaysia in its program of economic and technical development, and in February 1966, a memorandum of understanding was exchanged by the two Governments in regard to the present investigation.

In accordance with this memorandum of understanding the Government of Japan, through the Overseas Technical Cooperation Agency, its agency for implementing economic development and technical cooperation programs, delegated the Electric Power Development Company, Limited to conduct the investigation. The Electric Power Development Company accordingly organized an investigation team of seven engineers which was dispatched to Malaysia.

The investigation team visited Malaysia from March 1 to May 29, 1966 and upon consultation with the Malaysian Government regarding the method of investigation, was able to efficiently conduct field investigations and collect necessary data with the assistance and cooperation of the Malaysian Government.

After return of the investigation team to Japan, the Electric Power Development Company studied a development plan based on the data and information collected by the team and prepared this feasibility report.

1.2 PURPOSE AND SCOPE OF REPORT

1.2.1 Purpose

It is the desire of NEB to finance the costs of the project in the form of loans from an international financial institution. This report presents the investigations and studies of the technical and economic feasibility of the Raub Hydroelectric Development Scheme as a basis for NEB to negotiate the possibility of securing loans from an international financial institution.

1.2.2 Scope

The scope of the investigations and studies in this report is to establish an optimum and economical development plan for the water resources in the vicinity of Raub, and for the transmission of electricity produced therefrom to Kuala Lumpur on an 132 KV line to be planned by NEB and to the towns of Raub, Fraser's Hill and Kuala Lipis by local transmission lines.

Connecting transmission lines between the power stations included in the Scheme are also studied.

1.3 SURVEYS AND STUDIES

1.3.1 Field Investigations

From March 1 to May 29, 1966, surveying, run-off gauging, geological survey, and collecting of data necessary for planning of the scheme were carried out. An outline of the investigations conducted is given below.

a) From March 7 to March 22, reconnaissance was made of the catchment areas and a "Preliminary Report" was submitted to establish the general plan of the Scheme, and to indicate the location and number of drilling to be carried out by NEB.

b) From March 23 to May 29, discussions with NEB were carried out from time to time regarding the general plan of the Scheme and other engineering matters.

c) From March 22 to May 25, levelling was performed of the 9.0 miles from Kuala Lipis - Tras No.45 M.S. to the power plant and intake sites of the Sempam Project, the 14.3 miles from Raub - Batu Talam No.5 M.S. to the power plant, intake and Hijau intake sites of the Liang Project, and the 5.9 miles from

Raub - Batu Talam No. 14 M.S. to the power plant and intake sites of the Sia Project. (Total 29.2 miles) Bench marks were installed at power plant and intake sites.

d) From March 22 to May 25, topographical surveys were made of vicinities of diversion dam, surge tank and powerhouse sites. Profile levelling was carried out along the center lines of proposed penstook and tailrace sites.

e) Hydrologic data necessary for preparation of preliminary designs were made available by NEB. To check and confirm the rating curves of gauging stations, considerable observations were carried out at the gauging stations between March 22 and May 25.

f) From March 22 to May 25, a geological reconnaissance was carried out of the entire catchment areas, and to ascertain the geological conditions of diversion dam, surge tank and powerhouse sites, 2 test adits (50 yd) and 8 test pits (30 yd) were excavated.

g) In order to confirm the necessity of the power development under the Scheme, an investigation was made of the power demand growth and the actual condition of power usage.

Besides the above, hydrologic and meteorological data, information for estimation of construction costs and other information and data necessary for planning were collected.

In order to carry out the above field investigations, the Electric Power Development Company dispatched seven engineers: a chief, 2 civil engineers, 1 electrical engineer, 1 geologist and 2 survey specialists.

1.3.2 Work in Japan

From May 30, 1966 to October 31, 1966, studies of the scheme were conducted in the head office of Electric Power Development Company under the direction of the Chief Engineer mobilizing, engineers specialized in the fields of planning, design of hydraulic structures, power market analysis and power transmission on the basis of the data and information collected in the field. Detailed studies of the Scheme, studies of power market, hydrologic analyses, preliminary designs, calculation of quantities of work, construction cost estimation and economic evaluations were carried out in the preparation of this Report.

2. CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

As a result of the investigations and studies, the following conclusions are reached in regard to the Raub Hydroelectric Development Scheme:

a) Raub and Kuala Lipis are expected to develop into centers of economic activity in the central mountain zone with agriculture and forestry as the main industries and light industries such as lumber manufacturing, wood working and processing of agricultural products are promising.

The power demand of this district is 1,220 KW at present and the future growth rate of demand is estimated to be 8.5 percent annually. As a result, the maximum demand at the generating end at Raub, Kuala Lipis and Fraser's Hill in 1971, 1980 and 1990 are estimated to be 2,050 KW, 4,000 KW and 8,200 KW respectively. Against this growth, the supply capability of existing diesel generating facilities will become inadequate in 1971 and new power sources will have to be developed.

b) Should the hydroelectric potentials of the Liang, Sia and Sempam Rivers near Raub be developed, not only will the load of the Raub area be adequately carried, but by transmission of surplus power to Kuala Lumpur, there will be the benefit of saving fuel consumption of thermal power plants because of the considerably low cost of electricity of the Raub Scheme which is estimated to be 2.1 cts/unit at the transmitting end.

As alternatives for the Raub Scheme, the transmission of electricity from the Central System to the Raub area by constructing a 66 KV transmission line or the installation of a diesel power plant in the Raub area were studied. However the results of studies revealed that both alternatives are more expensive than the Raub Scheme.

c) The Raub Hydroelectric Development Scheme consists of three power stations, Liang, Sia and Sempam with a total output of 30,000 KW and annual energy production of 191,800,000 KWh. These stations will be a run-of-river type of development consisting of intakes, desilting basins, headrace of pressure tunnels, surge tanks, penstocks and powerhouses.

The power generated at the Liang and Sia Power Stations will be transmitted to the Sempam Power Station by 66 KV transmission lines, and combined with the output of Sempam Power Station, it will be transformed to 132 KV and 11 KV for transmission to the Kuala Lumpur and Raub regions respectively.

The general features of the power stations are given in the table which follows.

	Liang	Sia	Sempam	Total
Maximum discharge (cfs)	250	160	130	
Effective head (ft)	820	770	700	
Maximum output (KW)	15,000	8,500	6,500	30,000
Firm output (KW)	6,800	2,600	1,800	11,200
Annual energy production ($x10^6$KWh)	98.8	54.3	38.7	191.8

d) The estimated construction period for the Raub Hydroelectric Development Scheme is 36 months. If the power plants are to start operation at the end of 1970, the construction of access roads should be started from November 1967 and the main works from June 1968 upon completion of these roads.

e) The estimated construction cost of the Raub Hydroelectric Development Scheme is $M 45, 600, 000, not including transmission lines. Of this amount $M 25, 030, 000 is foreign currency while domestic currency requirements is $M 20, 570, 000. Included in the estimated construction cost is interest during construction which is $M 3, 100, 000 calculated at 5. 75 percent per annum for foreign currency and 6 percent for domestic currency.

The estimated construction cost for the connecting transmission lines is $M 1,450, 000, of which $M 870, 000 is in foreign currency and $M 580, 000 is in domestic currency.

f) The annual energy production of the Raub Hydroelectric Development Scheme will be 191, 800, 000 KWh at the generating end. The annual effective energy excluding losses in transmission will be 184, 000, 000 KWh and the cost per unit of effective energy during the life of the stations obtained from the annual costs ($M 3, 892, 000), uniformly distributed over the life of the stations, is 2. 11 cts /unit.

g) The uniformly distributed annual benefit in the 60-year life of the Raub hydroelectric power plants is estimated to be $M 6, 779, 000 This is based on alternatives of a diesel power plant for the local demand and steam power plant for the firm power to be transmitted to the Central Network. It was assumed that energy, other than the firm power, transmitted to the Central Network would contribute to save fuel consumption of existing steam power plants.

As the annual cost of the Raub Hydroelectric Development Scheme is $M 3, 892, 000, the excess benefit will be $M 2, 887, 000 and the cost-benefit ratio will be 1 to 1. 74

h) There should be no special problem in the design and construction of the Raub Hydroelectric Development Scheme as all structures and equipment are of conventional and proven types.

2.2 RECOMMENDATIONS

1) The Raub Hydroelectric Development Scheme is feasible both economically and technically.

2) The power from the Raub Hydroelectric Development Scheme will cost considerably less than the alternatives which were studied. This Scheme can replace diesel power generation in the Raub area and save fuel consumption of thermal power plants in the Central Network. As it is anticipated that all power can be consumed effectively upon the commencement of operation, it is recommended that the Scheme be constructed as soon as practically possible.

3) This Scheme will improve the social and economic conditions and raise the living standards of the population of the Raub region and of the western area of which Kuala Lumpur is the center, and thereby contribute greatly to the economic development of Malaysia.

3. MARKET SURVEY AND LOAD FORECAST

3.1 BACKGROUND

3.1.1 Existing Condition

Electricity generated from the Raub Scheme will be transmitted to Raub, Fraser's Hill and Kuala Lipis, and the remainder after supplying these towns will be transmitted by a 132 KV transmission line to the center of demand in Kuala Lumpur.

Raub is located in the central mountain area 75 miles to the northeast of Kuala Lumpur and it is connected by a highway passing via Bentong. The main economic activity of the Raub district is rubber cultivation, while in the past there had been some gold mining. In the area downstream of the project site, there is great activity in timbering. Raub, with a population of approximately 18,300 including suburbs, is the center of government, education and economy of the area.

Fraser's Hill is located at an elevation of 4,300 feet in the central mountain range 24 miles from Raub. This district is bestowed with beautiful natural scenery, and since 1919 it has developed as a resort town. The population is 940.

Kuala Lipis is located approximately 37 miles to the north northeast of Raub and is an important depot on the railroad running through the central mountains. The population including the vicinity is 10,300. The town is the center of government, education and economic activity of the Lipis district.

3.1.2 Pattern of Electric Power Industry

Raub, Fraser's Hill and Kuala Lipis are respectively supplied with electricity by independent and isolated power systems. The town of Raub and its vicinity are supplied from the existing Sempam Hydro-electric Power Station (1, 235 KW) by an 8 miles long 11 KV transmission line. This power station was built in 1918 so that the facilities are obsolete and unless overall improvements are made, the station cannot be expected to be serviceable for very long in the future. Other than the above, there are diesel power plants with a total capacity of 898 KW.

In Kuala Lipis and Fraser's Hill, there are diesel power plants of 652 KW and 300 KW respectively.

Electricity supply in all of the districts are being undertaken by NEB. NEB was established on September 1, 1949 pursuant to the Electricity Ordinance as the government agency in charge of supply of electricity in Malaya. It is headquartered in Kuala Lumpur from where financial control, maintenance and operation of power stations and transmission lines, sale of power, planning, control of major works are directed, and permits and approvals are issued to others engaged in electric power supply. Since the establishment of NEB in 1949, power supply facilities have been gradually increased, and in 1964 the installed capacity and energy production reached 487, 900 KW and 1, 851 GWh respectively. The generating capacity and energy production in 1964 are shown in Tables 3.1 and 3.2.

3.1.3 Present State of Supply and Demand

Power demands in Raub, Fraser's Hill and Kuala Lipis in 1964 are shown in Table 3.3. Power to be generated by the Raub Scheme will be transmitted to these districts and to the Central Region including Kuala Lumpur.

The major sources of power of the Central Region are the hydro power plants of the Cameron Highland and the thermal power plants at Connaught Bridge and Malacca. Power is supplied by the so-called Central Network consisting of two systems, the 132 KV transmission line between Cameron

Table - 3.1 Existing Power Plants

Year 1964

Area	Type of Prime Mover	N E B		Others		Total	
		Number of Power Stations	Installed Capacity (KW)	Number of Power Stations	Installed Capacity (KW)	Number of Power Stations	Installed Capacity (KW)
Northern	Diesel	6	19,640	64	11,336.16	70	30,976.16
	Steam	-	-	3	158,450	3	158,450
	Hydro	3	106,400	2	29,264	5	135,664
	Total	9	126,040	69	199,050.16	78	325,090.16
Central	Diesel	1	56	7	791	8	847
	Steam	1	80,000	-	-	1	80,000
	Hydro	1	2,288	-	-	1	2,288
	Total	3	82,344	7	791	10	83,135
Southern	Diesel	20	11,058	43	3,099.5	63	14,157.5
	Steam	2	50,000	-	-	2	50,000
	Hydro	-	-	-	-	-	-
	Total	22	61,058	43	3,099.5	65	64,157.5
Eastern	Diesel	26	14,262	2	42	28	14,304
	Steam	-	-	-	-	-	-
	Hydro	1	1,235	-	-	1	1,235
	Total	27	15,497	2	42	29	15,539
Grand Total	Diesel	53	45,016	116	15,268.66	169	60,284.66
	Steam	3	130,000	3	158,450	6	288,450
	Hydro	5	109,923	2	29,264	7	139,187
	Total	61	284,939	121	202,982.66	182	487,921.66

Table - 3.2 Gross Units Generated in The Fedration

Year 1964

Type of Prime Mover	Units Generated by Public Utilities		Units Generated by Mining Installations		Units Generated by Other Private Installations		Total Units Generated in The Federation	
	Millions	Percentage	Millions	Percentage	Millions	Percentage	Millions	Percentage
STEAM	*1,031.981	61.45	-	-	-	-	1,031.981	55.76
DIESEL	149.341	8.89	78.416	86.57	80.651	100.00	308.408	16.66
HYDRO	498.191	29.66	12.162	13.43	-	-	510.353	27.58
TOTAL	1,679.513	100.00	90.578	100.00	80.651	100.00	1,850.742	100.00

* 300,080 units purchased from Singapore for use in Johore Bahru not included.

Table - 3.3 General features of Local Power Stations

Local Power Stations	Type of Prime Mover	Installed Capacity (KW)	Max. Demand (KW)	Energy Demand (KWh)
Raub	Hydro	1,235	560	1,727
	Diesel	898	(Stand by)	460
	Total	2,133	560	2,187
Fraser's Hill	Diesel	300	254	804
Kuala Lipis	Diesel	652	410	1,622

Highland and Kuala Lumpur, and the 66 KV transmission line between Malacca and Kuala Lumpur. The demand in this region in 1964 was approximately 562 GWh. With the present hydro and thermal facilities, the capability is not adequate to cope with growing demands, and to meet the situation, NEB is presently constructing power plants at Prai (60 MW thermal), Woh (154 MW hydro) and Port Dickson (120 MW thermal). With the completion of a 132 KV transmission line between Prai and Woh in 1966, it will form the Western Network covering the west coast of the peninsula where most of the country's industries are concentrated.

3.2 LOAD FORECAST

The load forecast was studied based on data furnished by NEB. The forecast of local load will be studied chiefly, with a brief discussion of the load forecast for the Central Network.

3.2.1 Forecast of Local Load

a) Raub and Kuala Lipis Districts

These districts have developed as the centers of the central mountain zone with agriculture and forestry as the main industries. Development is looked forward to light industries, such as lumber manufacturing, wood working and processing of agricultural products.

According to NEB data the per capita consumption of electricity of entire Malaya in 1990's is estimated to be 860 KWh. For the Raub and Kuala Lipis districts, the per capita consumption in 1990's is estimated to be about 500 KWh, as power demand from mining industries cannot be anticipated.

Per capita consumption of electricity in these districts is 112 KWh at present. On the other hand, if the present annual growth rate of population in these districts which is 3 percent, is to continue, the rate of growth taking into consideration the increase of per capita consumption and of population, can be assumed to be 8.2 percent annually.

b) Fraser's Hill District

Fraser's Hill is expected to continue to expand as resort town, and, therefore, the demand is large in the commercial sector. The per capita consumption of electricity of the district was 637 KWh in 1963. The annual rate of growth of demand calculated from the load curves from 1958 through 1964 was 9.5 percent, which rate of growth is assumed to continue in the future.

3.2.2 Loss Percentages

The loss percentages in the NEB power systems based on actual figures for 1964 are shown in Table 3.4. The gross loss rate for 1963 was 15.1 percent. With the reorganization of the systems and rationalization, the losses in power stations and in transmission are showing a gradually decreasing trend. The gross loss rates are assumed as shown below, taking into consideration the distance of transmission and other factors.

Raub	12%
Kuala Lipis	16%
Fraser's Hill	16%

3.2.3 Load Factor

The relation between the load factor and maximum power demand of systems belonging to NEB in 1963 and 1964 are shown in Fig. 3.1. When the load of a system is 1,500 KW or greater, the load factor of the said system will be greater than 50 percent.

In consideration of the demand growth it is assumed that there will be a gradual increase of load factor in the next 30 years to 55 percent and 50 percent respectively from the 45 percent at Raub and Kuala Lipis, and the 36 percent at Fraser's Hill in 1964. The annual transition is indicated in Fig. 3.2.

3.2.4 Total Local Demand for the Area Including Raub, Kuala Lipis and Fraser's Hill

Taking into account the gross loss rate described in the preceding paragraph, the energy demands at the generating end of the respective districts were calculated and summarized. The KW demands were calculated from these energy demands taking into consideration the load factors. The results are shown in Table 3.5.

The growth rate of energy demand and maximum power demand are 8.5 and 7.6 percent respectively. These growth rates are considered to be reasonable in view of the actual results for 1956 through to 1964, the living standards of people and the present state of industrial development of this area.

3.2.5 Load Forecast for Western Network

According to the data furnished by NEB, the growth rate of energy demand for entire Malaya will be 7.2 percent up to 1969, 7.4 percent up to 1976 and 7.6 percent up to 1984, and the growth rate of maximum power demand will be 7.4 percent up to 1969, 7.9 percent up to 1976 and 8.0 percent up to 1984. The load factor is estimated to be approximately 66 percent.

The demands for entire Malaya have been divided into the demands for the Western Network and the other regions of the Federation, and are graphically depicted in Figs. 3.3 and 3.4.

Table - 3.4 Loss Percentage

Network & Power Station	Units generated (MWh)	Units Used				Loss Percentage (%)			
		in Stations	on Works	in Trans-mission	Total	in Stations	on Works	in Trans-mission	Total
Central Network	785, 190	31, 785	9, 128	73, 294	114, 207	4.0	1.2	9.3	14.5
Johore Bahru (Steam Station)	79, 270	5, 745	1, 265	5, 975	12, 985	7.3	1.6	7.5	16.4
Bulk Supplies	95, 949	3, 636	117	7, 732	11, 485	3.8	0.1	8.1	12.0
Diesel Station	110, 588	3, 192	1, 935	9, 919	15, 046	2.9	1.7	9.0	13.6
Total	1, 070, 996	44, 358	12, 446	96, 920	153, 724	4.1	1.2	9.1	14.4

Network & Power Station	Units generated (MWh)	Units Used				Loss Percentage (%)			
		in Stations	on Works	in Trans-mission	Total	in Stations	on Works	in Trans-mission	Total
Raub	2, 187	75	108	189	372	3.4	4.9	8.7	17.0
Kuala Lipis	1, 622	54	34	139	227	3.3	2.1	8.6	14.0
Total	3, 809	129	142	328	599	3.4	3.7	8.6	15.7

Fig.- 3.1. Correlation Between Load Factor and Maximum Demand in 1963, 1964

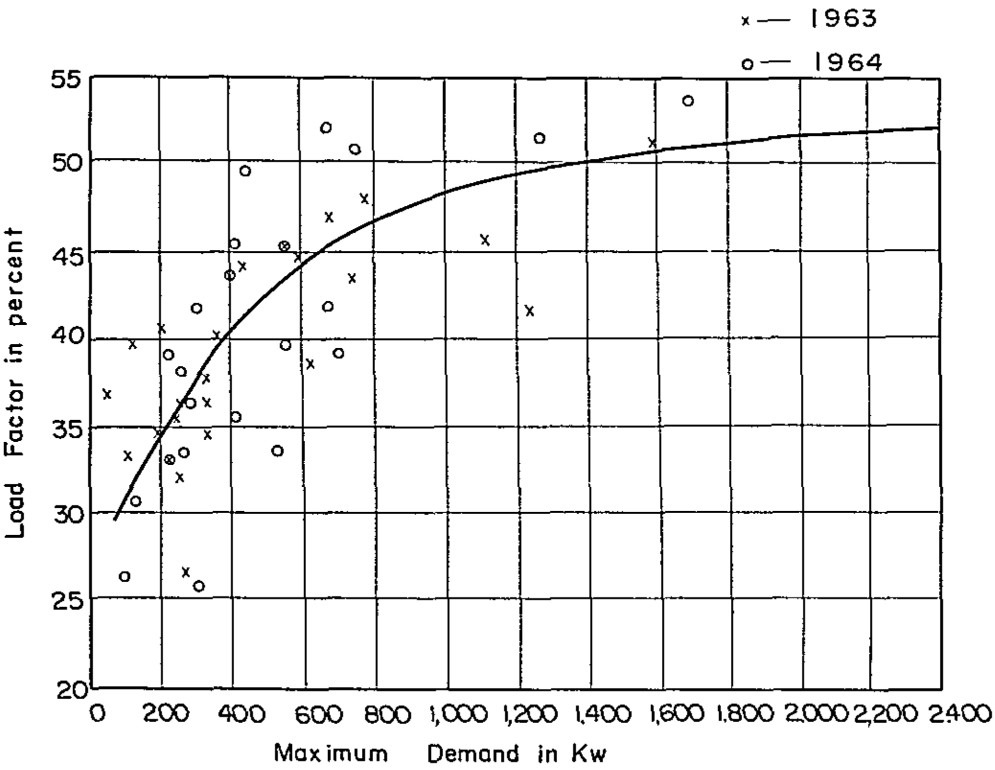


Fig-3.2 Assumed Load Factor in Future

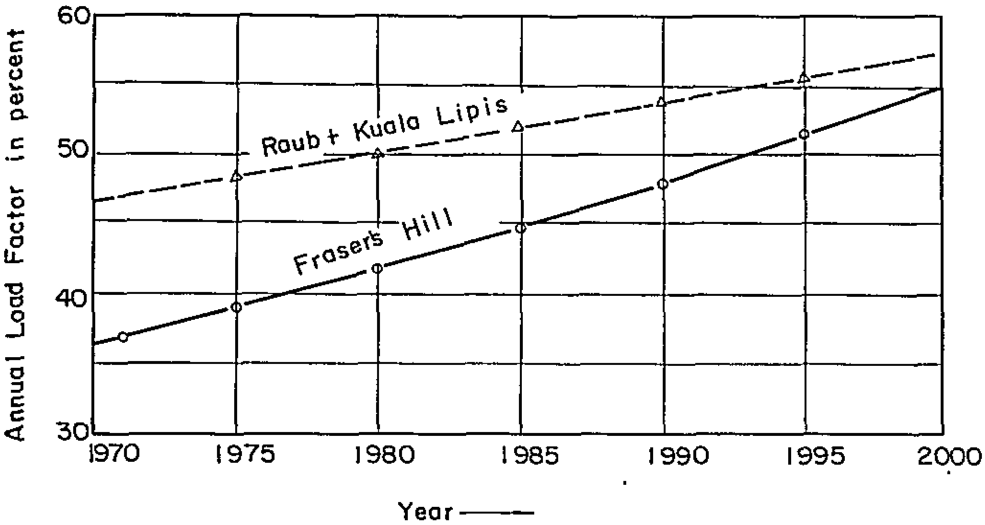


Table - 3.5 Load Forecast in Raub, Kuala Lipis and Fraser's Hill

Year	Total Demand at Consuming End (MWh)				Total Demand at Generating End (MWh)				Maximum Demand (KW)			
	Raub	Kuala Lipis	Fraser's Hill	Total	Raub	Kuala Lipis	Fraser's Hill	Total	Raub	Kuala Lipis	Fraser's Hill	Total
1963	1,800	1,300	500	3,600	2,000	1,600	600	4,200	520	410	210	1,140
1971	3,500	2,400	1,100	7,000	4,000	2,800	1,300	8,100	950	700	400	2,050
1972	3,800	2,600	1,200	7,600	4,300	3,100	1,400	8,800	1,020	750	430	2,200
1973	4,100	2,800	1,300	8,200	4,700	3,300	1,500	9,500	1,100	810	460	2,370
1974	4,400	3,000	1,400	8,800	5,000	3,600	1,700	10,300	1,190	860	500	2,550
1975	4,800	3,700	1,600	9,600	5,100	3,800	1,900	10,800	1,280	920	540	2,740
1976	5,200	3,500	1,700	10,400	6,000	4,100	2,000	12,100	1,380	980	590	2,950
1977	5,700	3,700	1,900	11,300	6,500	4,400	2,200	13,100	1,490	1,050	630	3,170
1978	6,200	4,000	2,000	12,200	7,100	4,800	2,400	14,300	1,610	1,120	680	3,410
1979	6,700	4,300	2,200	13,200	7,600	5,200	2,600	15,400	1,740	1,200	740	3,680
1980	7,300	4,700	2,400	14,400	8,300	5,600	2,900	16,800	1,880	1,280	790	3,950
1981	7,900	5,000	2,700	15,600	9,000	6,000	3,200	18,200	2,020	1,370	820	4,210
1982	8,600	5,400	2,900	16,900	9,800	6,400	3,500	19,700	2,180	1,470	930	4,580
1983	9,300	5,800	3,200	18,300	10,600	6,900	3,800	21,300	2,360	1,570	1,000	4,930
1984	10,200	6,300	3,500	20,000	11,500	7,500	4,200	23,200	2,540	1,680	1,080	5,300
1985	11,000	6,800	3,900	21,700	12,500	8,100	4,600	25,200	2,740	1,790	1,170	5,700
1986	12,000	7,300	4,200	23,500	13,600	8,700	5,000	27,300	2,960	1,920	1,260	6,140
1987	13,000	7,800	4,600	25,400	14,800	9,300	5,500	29,600	3,190	2,050	1,360	6,600
1988	14,100	8,500	5,100	27,700	16,000	10,100	6,000	32,100	3,450	2,190	1,470	7,110
1989	15,300	9,100	5,500	29,900	17,400	10,800	6,600	34,800	3,720	2,340	1,590	7,650
1990	16.700	9,800	6,100	32,600	18,900	11,700	7,200	37,800	4,010	2,500	1,720	8,230
1991	18,100	10,600	6,600	35,300	20,500	12,600	7,900	41,000	4,330	2,680	1,850	8,860
1992	19,000	11,400	7,300	38,300	22,300	13,500	8,700	44,500	4,670	2,860	2,000	9,530
1993	21,300	12,200	8,000	41,500	24,200	14,600	9,500	48,300	5,040	3,060	2,160	10,260
1994	23,200	13,200	8,700	45,100	26,300	15,700	10,400	52,400	5,440	3,270	2,340	11,050
1995	25,200	14,200	9,500	48,900	28,600	16,900	11,400	56,900	5,870	3,490	2,520	11,880
1996	27,300	15,300	10,500	53,100	31,000	18,200	12,500	61,700	6,330	3,740	2,730	12,800

Fig.-3.3. Energy Demand

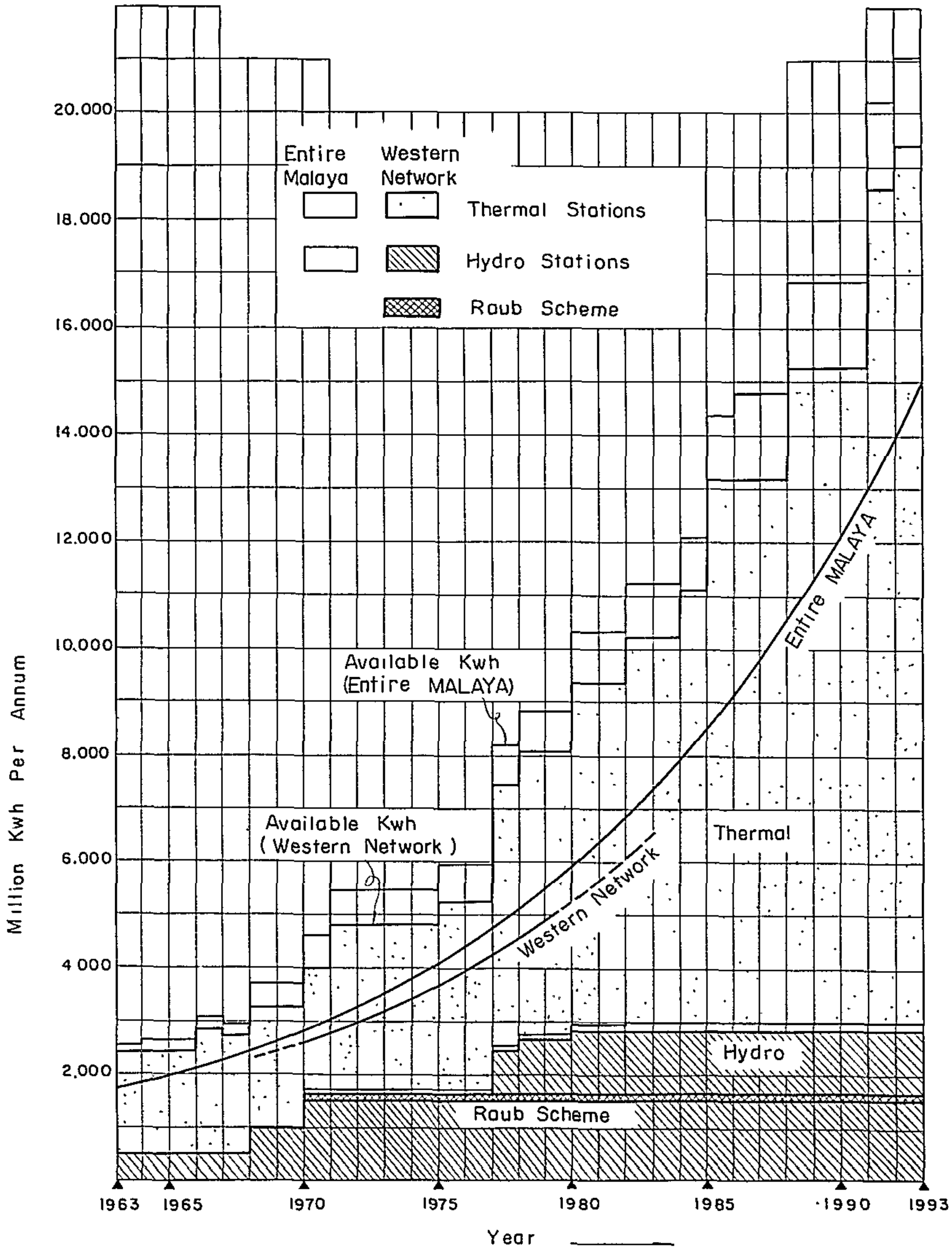
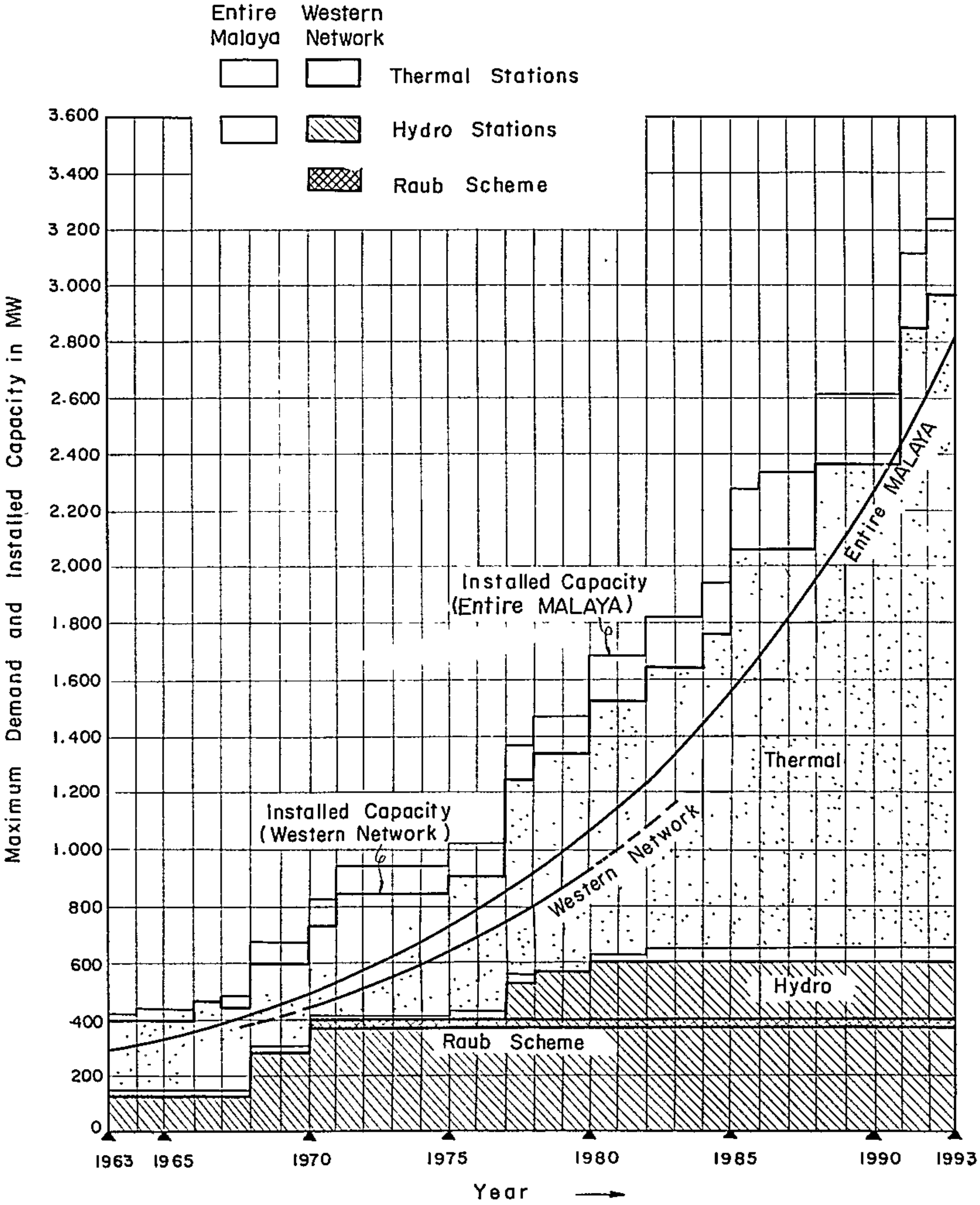


Fig.- 3.4 Maximum Power Demand



3.3 IMPLEMENTATION OF SCHEME

The existing generating capacity in Raub, Fraser's Hill and Kuala Lipis totalling 2,085 KW, consist of diesel plants and an obsolete hydroelectric plant. It will be noted in Table 3.5 that the demand, at generating end, of this district in 1971 will reach approximately 2,050 KW and it will become necessary to increase the diesel generating capacity or renovate the hydroelectric plant.

On the other hand, the demand around 1971 of the western region, with Kuala Lumpur as the center, will be met with completion of large capacity hydro and thermal power stations, but the weight of thermal generation will be great. The capacity of the Raub Scheme will be relatively small compared with the total capacity of the Western system and as described in Chapter 10, the cost of power of the Raub Hydro-electric Development Scheme will be considerably cheap compared with existing thermal power so that the surplus power after supplying local load can be fully used to save fuel consumption of steam plants in the NEB power system.

With the growth in local load, the power and energy which can be supplied to the Western Network will decrease yearly, and the firm power capability will be exhausted before the energy supply capability.

Therefore, the contribution that can be expected of the Raub Hydro-electric Scheme to the Western system is the savings in thermal operation costs within the system, mainly in fuel costs, rather than supplementing generating capacity.

4. GENERAL DESCRIPTION OF PROJECT

4.1 GENERAL DESCRIPTION OF PROJECT AREA

The Liang, Sia and Sempam Rivers originate from the central mountain range which is about 6,000 feet above sea level, flow eastward to the north of Raub and after merging become the Lipis River. The Lipis, fed by many tributaries on the way becomes the Pahang River and finally drains into the South China Sea.

The catchment areas of the Liang, Sia and Sempam Rivers are 58.3, 24.3 and 30.1 sq. miles respectively, totalling 112.7 sq. miles.

The annual precipitation in these catchment areas ranges from 100 to 110 inches. Variation of precipitation is relatively small throughout the year. Almost all of the catchment areas is granite with deep weathered strata and is covered with dense jungle so that the annual run-off is comparatively constant.

The gradients of these rivers range from 1/20 to 1/40 so that they are considerably rapid streams suited for hydroelectric power generation as a high head can be developed with a relatively short waterway.

Since some daily variation in run-off is observed, it would be advisable to construct a regulating reservoir. However, field surveys revealed that there is no suitable site for a reservoir in the area. This is due to the fact that the river gradient is steep, the foundation rock of the dam, especially at both abutments, is covered with overburden 200 to 250 feet deep and the amount of sediment carried by the river is extremely large, indicating that the cost of the dam is very expensive in comparison with the benefit to be expected by the construction thereof.

Therefore, the power station should be a run-of-river type plant without regulating pond.

4.2 SCHEME OF DEVELOPMENT

4.2.1 General

The Raub Scheme consists of three power stations, the Liang, Sia and Sempam Power Stations.

The Sia River is located quite a distance away from the Liang River and any development plan combining these two together will require an extremely long diversion tunnel, which is obviously uneconomical. Therefore, the development plan for the Sia River was made entirely independent of other rivers.

On the other hand, as the Liang River and the Sempam River appear to be connectable by a diversion tunnel, alternative plans for independent development of the Liang River and the Sempam River with a power station on each river, and for diversion of the Sempam River into the Liang River to construct one power station only were made after careful examination. A comparison between these two alternatives are shown in Table 4. 1. It will be noted that the plan to build a power station on each river is more advantageous than the alternative both technically and economically.

The sites of the intake structures and powerhouses were determined taking into account the topography of the sites and to use to the maximum and most efficiently the potentials of the river.

Table 4.1 Comparison of Alternative Schemes of Development

	Alternative-I	Alternative-II
	Liang and Sempam developed as two separate schemes	Sempam diverted to Liang, then developed as one scheme
Number of Power Stations	2	1
Installed Capacity (KW)	21,500	20,000
Firm Power (KW)	8,600	8,200
Energy (GWh)	137.5	122.5
Construction Cost (10^3\$M)	37,300	34,900
Generation	33,600	31,200
Transmission	3,700	3,700
Construction Cost per KWh		
Generating End (cts M)	24.2	25.5
Transmitting End (cts M)	27.1	28.5
Surplus Benefit B - C (10^3\$M)	1,910	1,560
Cost per KWh (cts M) with transmission	1.77	1.85

4.2.2 Liang Power Station

The Liang Power Station will draw water from a point about 1,000 feet downstream of the confluence of the Liang River and the Jerneh River which is around 1,440 feet above sea level and also from the Hijau River, one of the tributaries, and through a headrace 21,800 feet long it will generate a maximum of 15,000 KW. The maximum discharge will be 250 cfs. and the effective head will be 820 feet.

The headrace will be a pressure tunnel 21,800 feet long with an inside diameter of 8 ft. 0 in. The headrace tunnel from the Hijau will be a non-pressure tunnel 5,100 feet long with an inside diameter of 6 ft. 10 in.

The tunnels pass through a zone of granite covered with overburden 250 to 300 feet deep. Results of geological surveys indicate that the tunnels will pass through sound rock requiring little concrete lining. The tunnel routes were selected on the basis that they should run through this sound rock as much as possible, and the length of one tunnel be 6,000 feet with an appropriate number of adits.

The major portion of this tunnel route passes through hard rock and there appears to be no particular problem in excavation of this tunnel, since many adits can be easily made along the route, which will enable simultaneous excavation from several faces.

The geology of the proposed site of the head tank consists of a thick weathered layer and the foundation rock is at a great depth. Therefore, an economic comparison between a combination of a non-pressure type tunnel and a heak tank and a combination of a pressure type tunnel and a surge tank, including penstock lines, was conducted.

In case of a non-pressure type tunnel, it tends to result in a higher construction cost of the head tank. Namely, as a loss in bearing strength of the foundation can be foreseen due to possible leakage from the head tank in the future, the safety of the tank may be jeopardized unless the tank is located at a considerably deep place from the surface. In this case, it will also be indispensable to construct a spillway.

In case of a pressure tunnel, on the other hand, the surge tank can easily be constructed deep in the mountain by excavating access shafts and adits of relatively small diameter for construction purpose, and thus a safer structure can be made. A possible problem that may be anticipated in connection with the pressure tunnel, if any, will be about the safety of the rock surrounding it. However, the problem can be coped with by guniting, since the water pressure is expected to be relatively small and the route of the tunnel can be selected through fresh sound rock.

The results of comparison between the above two alternatives are shown in Table 4.2.

It will be seen that the development with a pressure tunnel and a surge tank is more economical, and is also advantageous from the view point of instantaneous start-up and shut-down in operation of the power station. It is the conclusion that a pressure type tunnel can be employed for the headrace tunnel.

Regarding the Hijau tunnel, it will be a non-pressure tunnel connected to the surge tank.

The power station will be built on the right bank of the river, and the water will be conducted through the penstock crossing the Liang River.

The powerhouse has been located on the right bank because adequate space is available for the power station and the outdoor switchyard, the tailrace can be built without difficulty due to the shape and condition of the river, and the works for the surge tank and penstock can be carried out independently.

The power station will be a semi-underground structure in consideration of the deep overburden and of gaining more head through a tailrace

Table 4.2 Comparison of Tunnel and Head (or Surge) Tank Type of Development

Power Stations	Liang		Sia		Sempam	
Tunnel Type	Non-pressure	Pressure	Non-pressure	Pressure	Non-pressure	Pressure
1) General Features						
Max. Discharge (cfs)	220		160		130	
Length (feet)	22,400	21,800	11,700	11,100	16,200	16,000
Gradient	1:800	-	1:800	-	1:1000	-
Diameter	7'-10"	8'-00"	7'-00"	6'-00"	7'-00"	6'-10"
2) Estimated Costs (x 10^3\$M)	6,870	6,618	4,240	3,816	4,340	4,114
3) Annual Costs (x 10^3\$M)	687	662	424	382	434	411
4) Annual Energy Loss (GWh)	3.32	1.94	1.27	1.13	1.21	1.10
5) Value of Annual Energy Loss (x 10^3\$M)	149	87	57	51	54	50
6) (3) + (5) (x 10^3\$M)	836	749	481	433	488	461

tunnel taking advantage of the steep river gradient.

The tailrace tunnel will be 380 feet long discharging water at around elevation 560 feet.

4.2.3 Sia Power Station

The Sia Power Station, drawing water from a point at an elevation of 1,440 feet by a headrace 11,000 feet in length, will generate a maximum of 8,500 KW. The maximum discharge will be 160 cfs. and the effective head will be 770 feet.

The headrace will be a pressure tunnel 11,100 feet in length with an inside diameter of 6 ft. 10 in.

The geological condition of the area through which the tunnel route runs is almost similar to that of the Liang Power Station. To take the route on the left bank will be the shortest distance in view of the topographical condition of the area. The tunnel route was selected after examination carried out on the same principles used in the case of the Liang Power Station.

In connection with the type of tunnel, comparative studies, as in the case of Liang Power Station, was made and the results are shown in Table 4.2, according to which a pressure tunnel and a surge tank will be employed.

The power station will be built on the left bank. It will be a semi-underground structure due to the deep overburden at the site.

The tailrace will be an open channel directly releasing the discharge into the natural river bed.

4.2.4 Sempam Power Station

The Sempam Power Station will generate a maximum of 6,500 KW taking water from the Sempam River through a headrace 16,000 feet long It will have a maximum discharge of 130 cfs. and an effective head of 700 feet.

The headrace will be a pressure tunnel 16,000 feet long with an inside diameter of 6 ft. 10 in.

The area through which the tunnel route runs is mainly granite covered with a thick overburden 250 to 300 feet deep. However, the downstream part of the tunnel is argillaceous rock. Concrete lining should be executed in the section where the tunnel passes through argillaceous rock. The tunnel route was selected on the same principle used for the Liang and Sia Power Stations.

The power station will be built on the left bank of the river. It will be a semi-underground structure in consideration of the deep overburden and of gaining more head through a tailrace tunnel taking advantage of the steep river gradient.

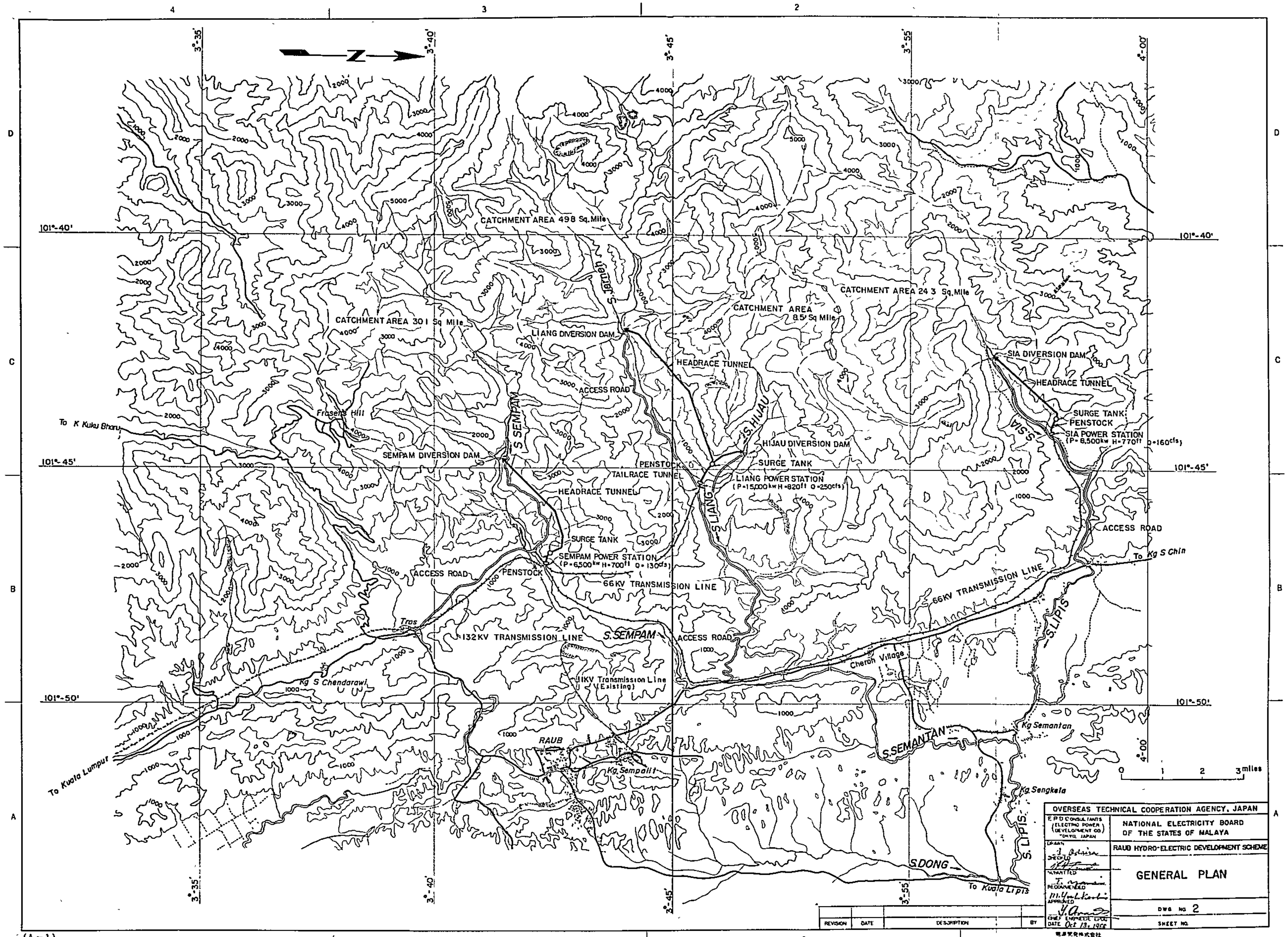
The tailrace tunnel will be 260 feet long discharging water at around elevation 695 feet.

4.2.5 Transmission System

With Sempam Power Station as a terminal station, connections will be made with the Sia and Liang Stations by one circuit each of 66 KV transmission lines taking independent separate routes. At the Sempam Station a 132/66 KV connecting transformer will be installed, and the electricity stepped-up to 132 KV will be transmitted to Segambut via Tras by a 1 circuit transmission line. (See Appendix-2 for comparison of routes)

The existing 11 KV transmission line will be utilized to transmit electricity to the town of Raub. This will be done at first by connecting the existing 11 KV transmission line with the Sempam Power Station and in the future by newly constructing an 11 KV transmission line parallel to the existing line, corresponding to growth of power demand in the town of Raub. Transmission to Fraser's Hill will be made also by the construction of another new 11 KV transmission line. The Sempam Power Station will be equipped with an 11/3.3 KV, 3,000 KVA connecting transformer, permitting outgoing of 1 circuit of 11 KV. The switchyard is so designed that in the future it will be possible to install additional transformers and outgoing facilities.

In consideration of future power demands in Kuala Lipis, the construction of a 66 KV transmission line of 1 circuit is recommended. Therefore, the switchyard of Sempam Power Station will be designed so that it will be possible to install outgoing facilities for an additional 1 circuit of 66 KV line. The transmission system is shown in Fig. 8.2.



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

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

NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

GENERAL PLAN

DRAWN I. Ashiira
CHECKED
SUBMITTED I.
RECOMMENDED M. Yoshikoshi
APPROVED Y. Ame
CHIEF ENGINEER EPDC
DATE Oct 13, 1958

DWG NO 2
SHEET NO.

電源開発株式会社
日本国 東京

5. HYDROLOGY

5.1 RUN-OFF GAUGING STATIONS AND METEOROLOGICAL STATIONS

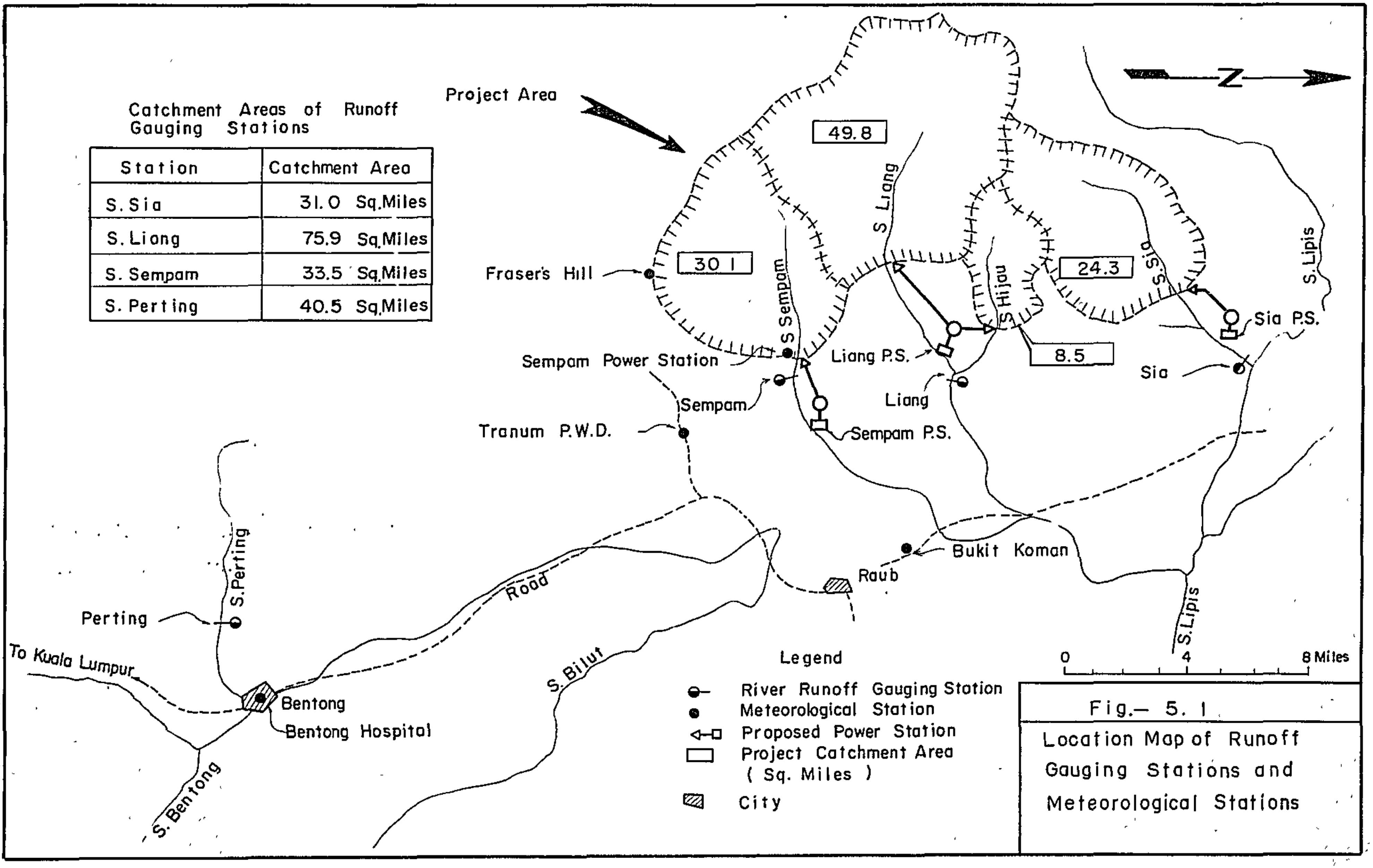
The locations of meteorological stations and run-off gauging stations in the catchment area and in areas surrounding the Raub Scheme are shown in Fig. 5.1, and the periods of observation of precipitation and run-off are shown in Table 5.1 and Table 5.2.

In the catchment area, there is a precipitation observation station at Fraser's Hill having records of over 30 years and in adjoining basins there are stations at the existing Sempam Power Station, Bukit Komas and Bentong Town.

The run-off gauging stations are located on the three rivers in the catchment area, namely, the Liang River, Sia River and Sempam River, and on the Perting River that flows near the vicinity of Bentong Town. At the gauging station on the Perting River, observation by an automatic water-level recorder has been conducted since July, 1961. On the other hand, many observations of run-off have been carried out and a rating curve as shown in Fig.5.2 is available. Based on the water-level data and the rating curve, the run-off at the gauging station on the Perting River has been estimated for the period between July, 1961 and May, 1966.

The water level observation by an automatic water-level recorder has been continued at the gauging stations on the Liang, Sia and Sempam; however, since they were established in 1965, the available data cover only a period of less than a year and a rating curve has not been prepared.

In the recent field investigation, the EPDC survey team conducted actual observations of the run-offs of the Liang, Sia and Sempam Rivers. From these observed data, the rating curves shown in Fig. 5.3 through Fig. 5.5 were obtained, and the run-off at these three gauging stations were calculated for a period of almost one year.



Catchment Areas of Runoff Gauging Stations

Station	Catchment Area
S. Sia	31.0 Sq.Miles
S. Liang	75.9 Sq.Miles
S. Sempam	33.5 Sq.Miles
S. Perting	40.5 Sq.Miles

Fig.— 5. 1

Location Map of Runoff Gauging Stations and Meteorological Stations

Table-5.1. River Runoff Data (Daily Record)

Station	River	Catchment Area	1961	1962	1963	1964	1965	1966
Sia	Sia	75.9 Sq.Miles					Sept. 15 ━	━ May 15
Liang	Liang	31.0 Sq.Miles					Sept. 1 ━	━ May 15
Sempam	Sempam	33 5 Sq.Miles					Sept. 28 ━	━ Apr. 25
Perting	Perting	40 5 Sq.Miles	July 27 ━	━	━	━	━	━ May 15

Table-5.2. Precipitation Data (Monthly Record)

Station	Elevation	'37	'38	'39	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66
Fraser's Hill (Station No. 75)	About 4.200ft	From 1921 ━	━	━	━						━	━	━	━	━	━	━	━		━	━	━	━	━	━	━	━	━	━	━	
Sempam Power Station	About 1.000ft																						Apr. ━	━	━	━	━	━	━	━	
Tranum P. W. D (Station No 19)	About 650ft	From 1924 ━	━	━	━	━						━	━	━	━		━	━	━	━	━	━	━	━	━	━	━	━	━	━	
Bentong Hospital (Station No. 63)	About 320ft	From 1901 ━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	
Bukit Koman (Station No. 87)	About 500ft												━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	

Fig.-5. 2. Rating Curve for S Perting at Perting Gauging Station

(C.A.= 40.5 Sq. Miles)

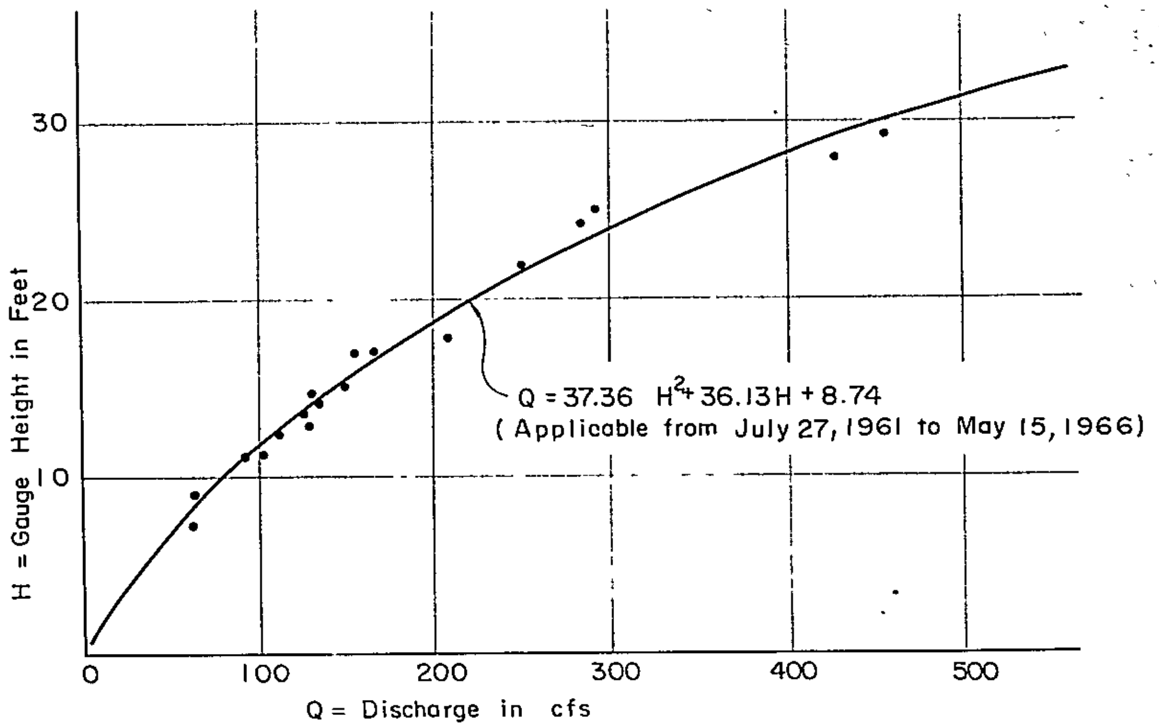


Fig.-5. 3. Rating Curve for S Liang at Liang Ganging Station

(C.A = 75 9 Sq. Miles)

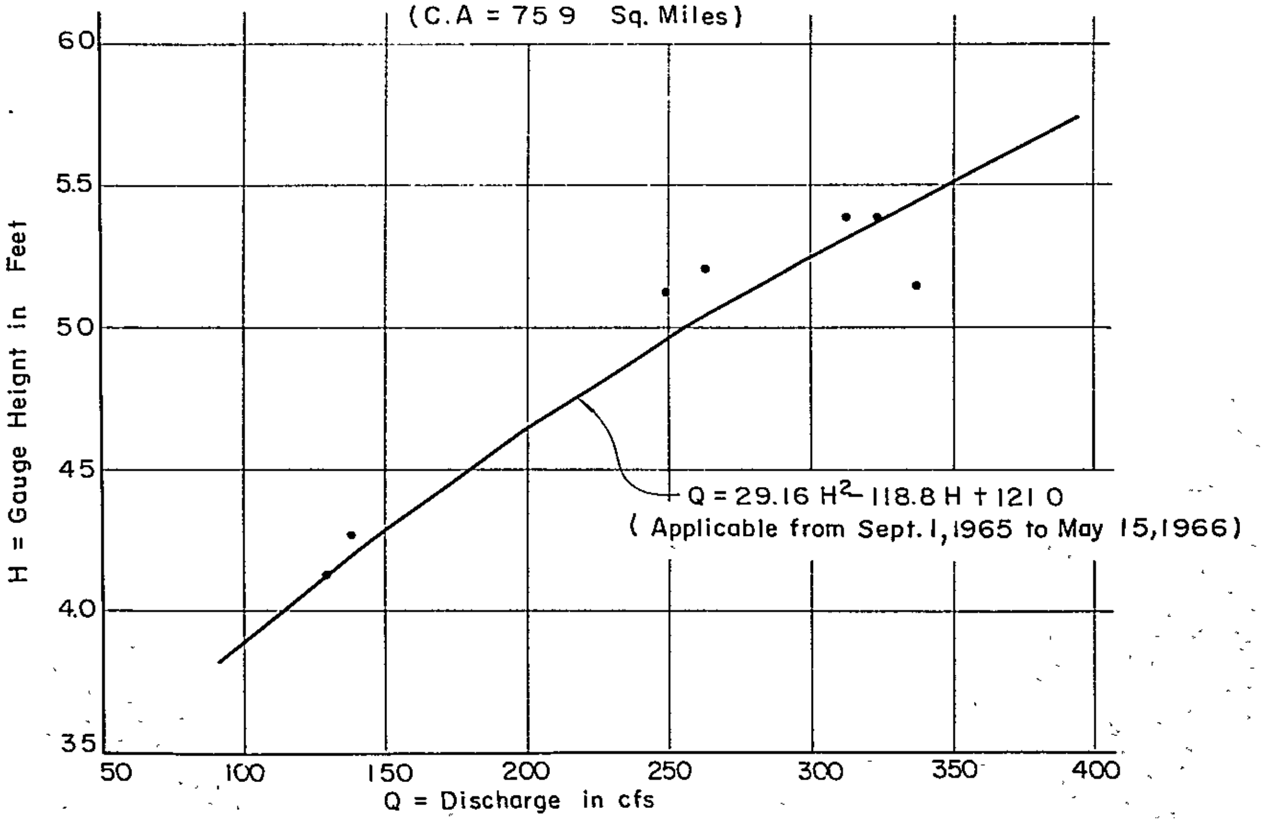


Fig.-5.4. Rating Curve for S. Sia at Sia Gauging Station

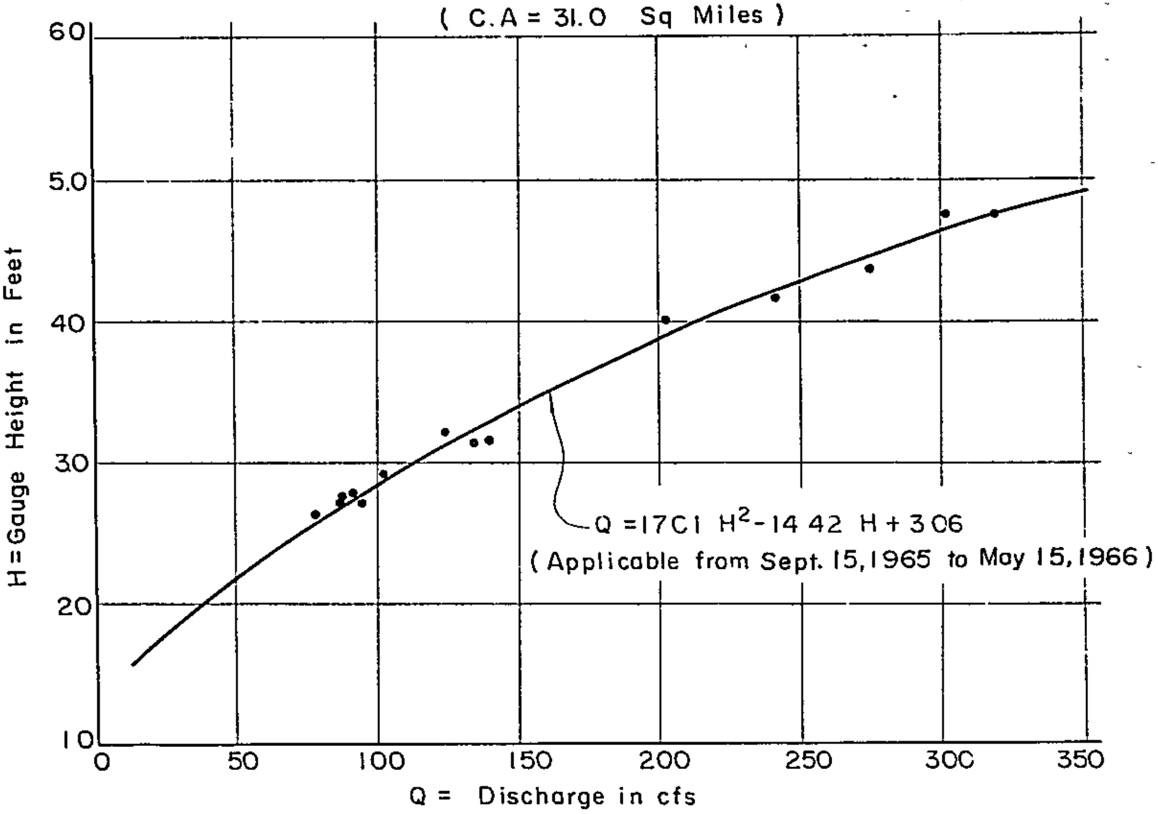
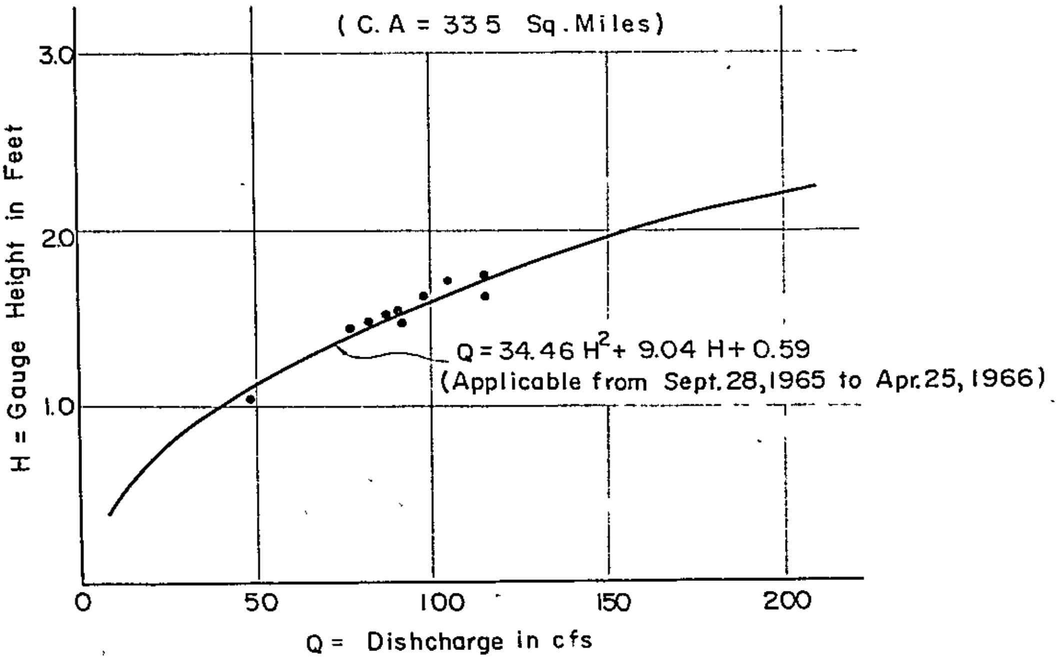


Fig.-5.5. Rating Curve for S. Sempam at Sempam Gauging Station



The river run-off of the Liang, Sia and Sempam Rivers can be estimated for 4 years by obtaining the correlation between the three rivers and the Perting River on the basis of the recent almost one year run-off record.

5.2 PRECIPITATION

The variation of annual precipitation is indicated in Fig.5.7. The average annual precipitation is 106 in. at Fraser's Hill for 44 years and 91 in. at Bentong Hospital for 63 years. The average of the recent 4 to 5 years for both stations is almost identical to that of the long period average. This means that the amount of energy production estimated on the basis of the hydrological data for the recnet 4 or 5 years can be regarded as the production during the life of the power stations. As shown in Fig. 5.6, Isohyetal Map of Annual Precipitation prepared by NEB, the project area has an annual precipitation of 100 to 110 in. which is of the same range as the Perting area. The monthly precipitation is greatest in the months of October through December followed by the months of March and April, and even in the other months the monthly precipitation is seldom below 5 in. (See Fig.5.8)

5.3 RIVER RUN-OFF

5.3.1 Method of Estimating Run-Off

The following formulas express the correlation between the specific run-off of the Perting River and the three rivers in the Raub catchment area for the period for which run-off data at the stations on the three rivers in the catchment area and for the same period on the Perting River are available, that is, from September 1965 to April or May 1966.

The measured values by NEB prior to the start of automatic gauging were also used to obtain these formulas.

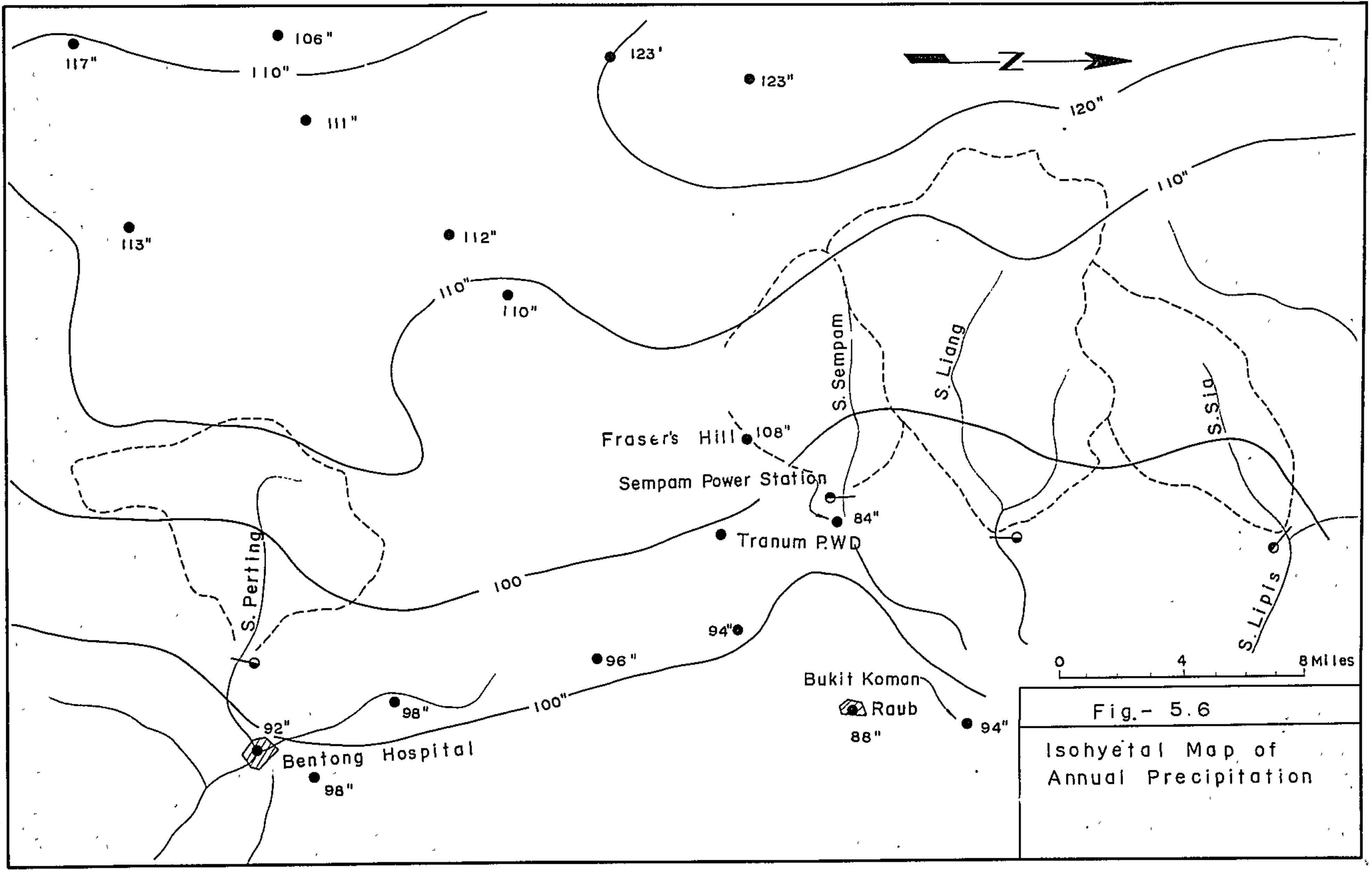


Fig.- 5.6

Isohyetal Map of Annual Precipitation

Fig. 5.7. Annual Precipitation

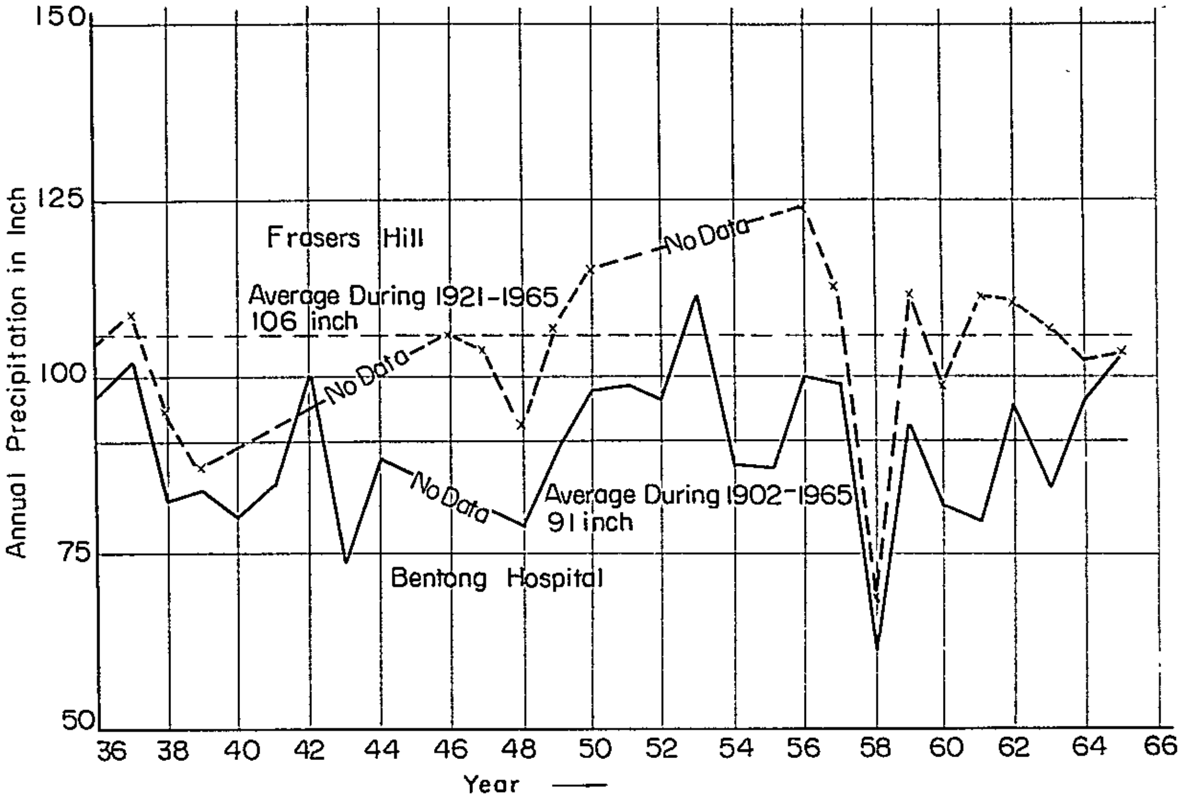
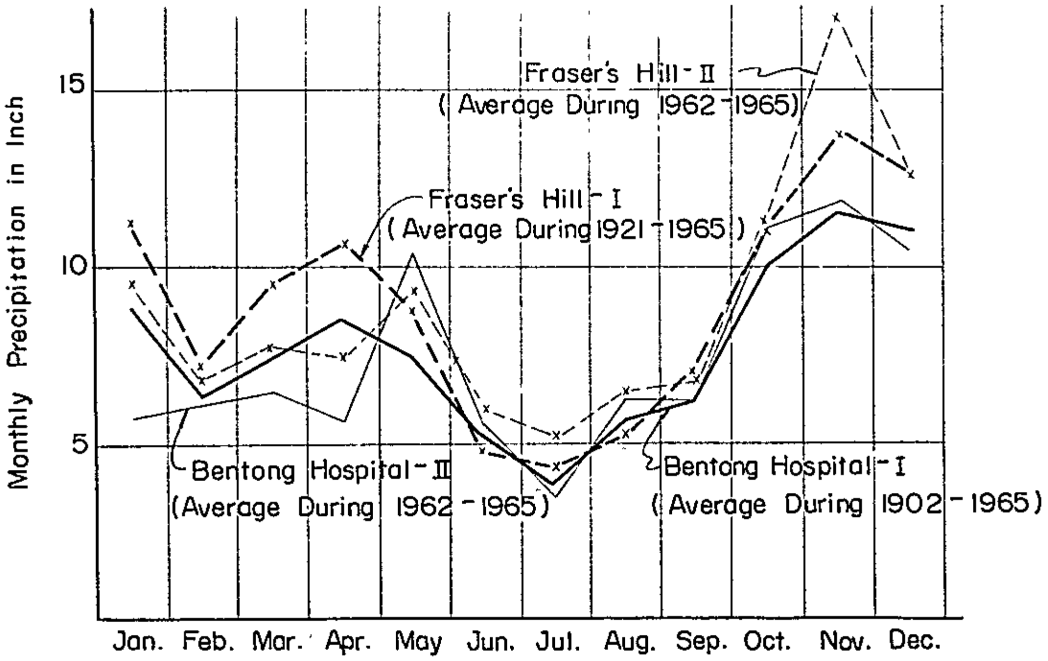


Fig. 5.8. Monthly Precipitation



$Ql = 0.60\ Qp + 0.80$ ....(5.1)

(See Fig. 5.9)

$Qi = 1.38\ Qp - 0.85$ ....(5.2)

(See Fig. 5.10)

$Qs = 0.85\ Qp - 0.52$ ....(5.3)

(See Fig. 5.11)

where

Ql: Specific run-off for Liang River in cfs per sq. mile
Qi: " " " Sia " "
Qs: " " " Sempam " "
Qp: " " " Perting " "

It will be seen in Fig. 5.9 through Fig. 5.11 that there are significant correlations between the Perting River and the three rivers. Therefore, by the use of these correlations, the specific run-offs of the three rivers in the catchment area can be obtained for the period of 4 years for which run-off data of the Perting River are available.

Flow-duration curves of the three rivers in the catchment area prepared from the calculated specific run-off of the Perting River are shown in Fig. 5.12.

As there is no great difference in the catchment area between the areas where the gauging stations exist and the proposed intake sites, the run-off at each proposed site is to be the value calculated by multiplying the specific run-off obtained from the above formulas by the respective catchment area of each proposed site.

5.3.2 Run-Off at Proposed Sites

The run-offs at each intake site on the Liang, Sia and Sempam River for 4 years from 1962 to 1965 obtained from the above mentioned calculation are tabulated in Table 5.3 through Table 5.5.

Fig-5.9 Correlation Between Perting and Liang Specific Runoff

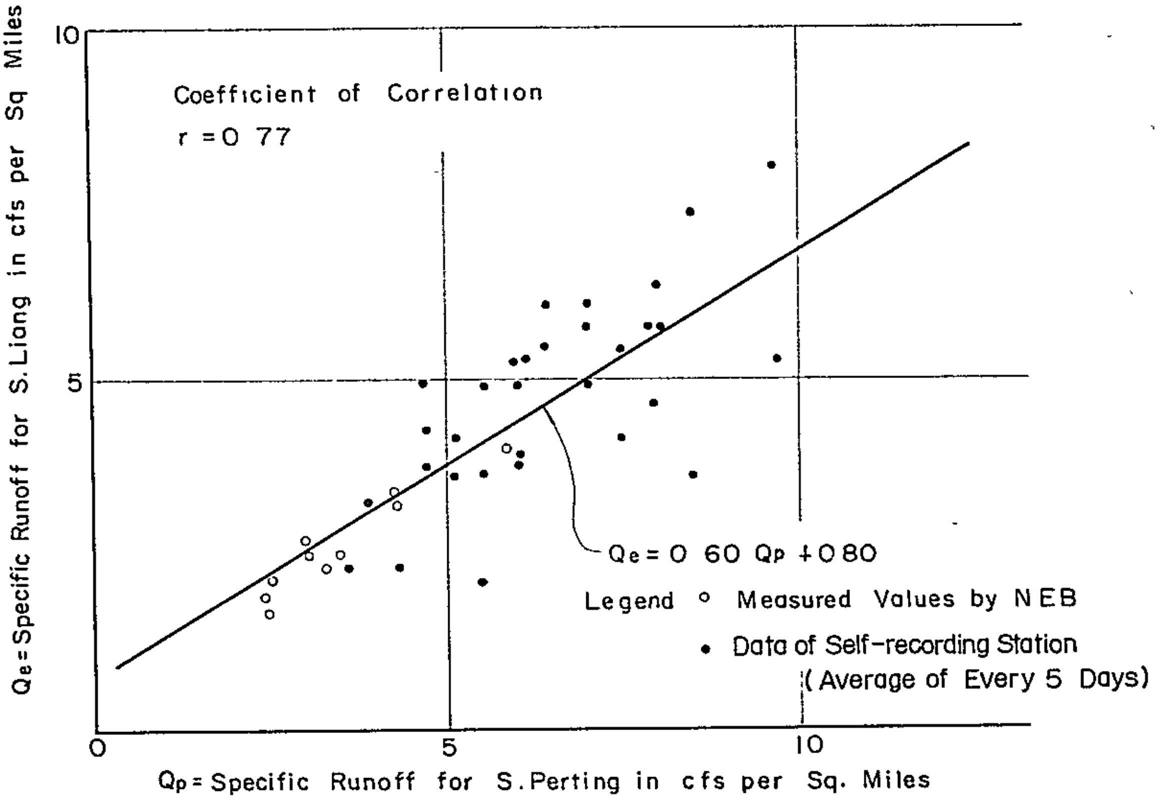


Fig.-5. 10. Correlation Between Perting and Sia Specific Runoff

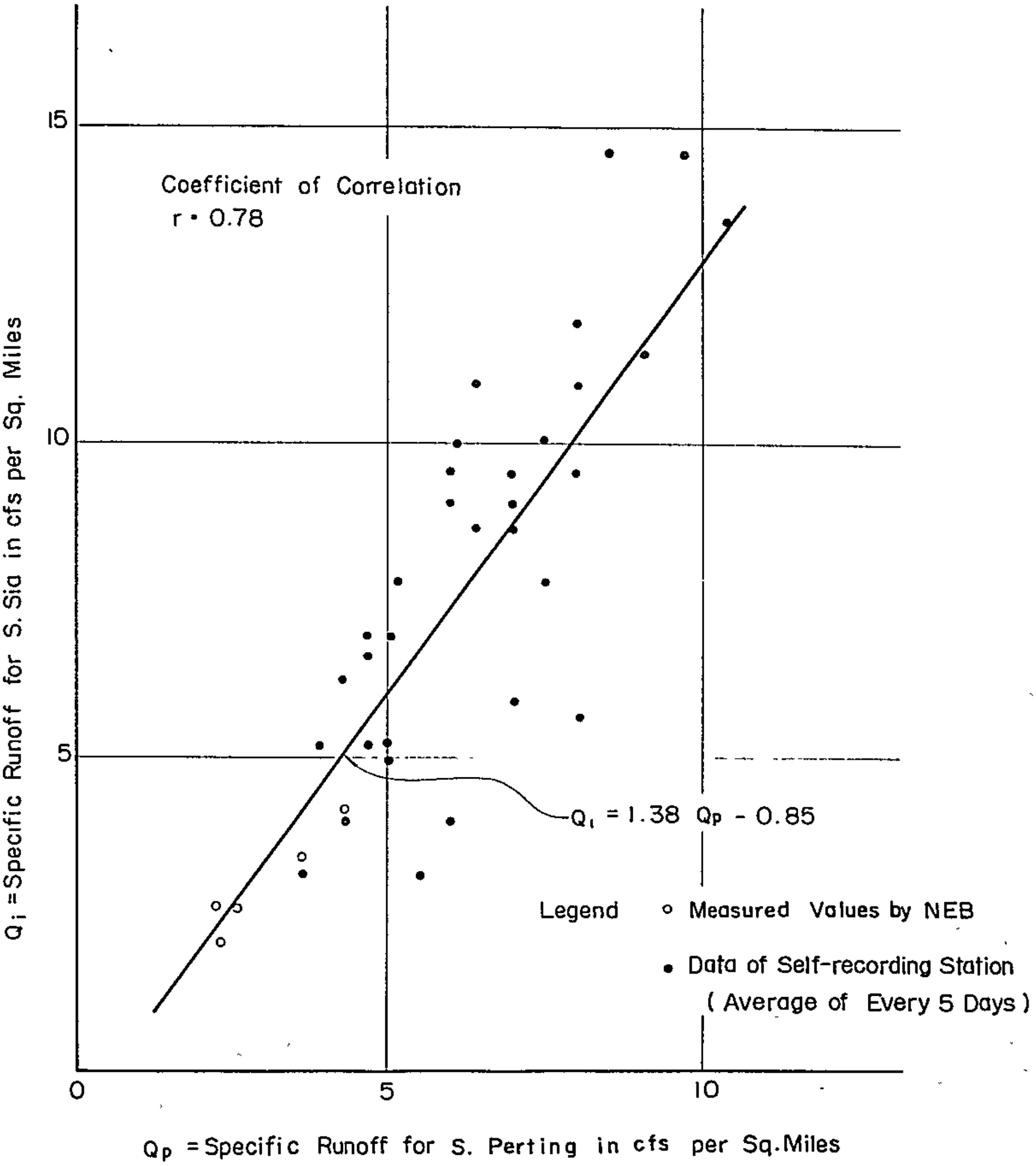


Fig.-5.11 Correlation Between Perting and Sempam Specific Runoff.

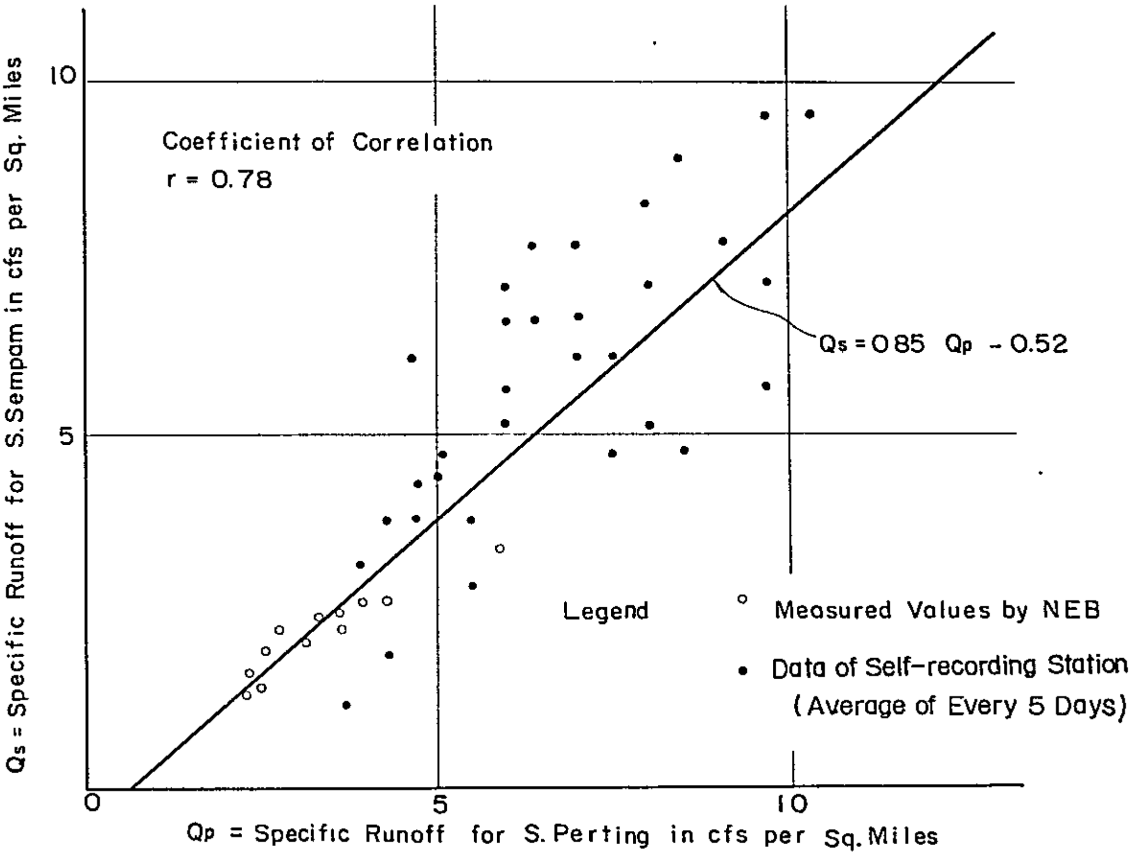


Fig.– 5.12 Flow Duration Curves

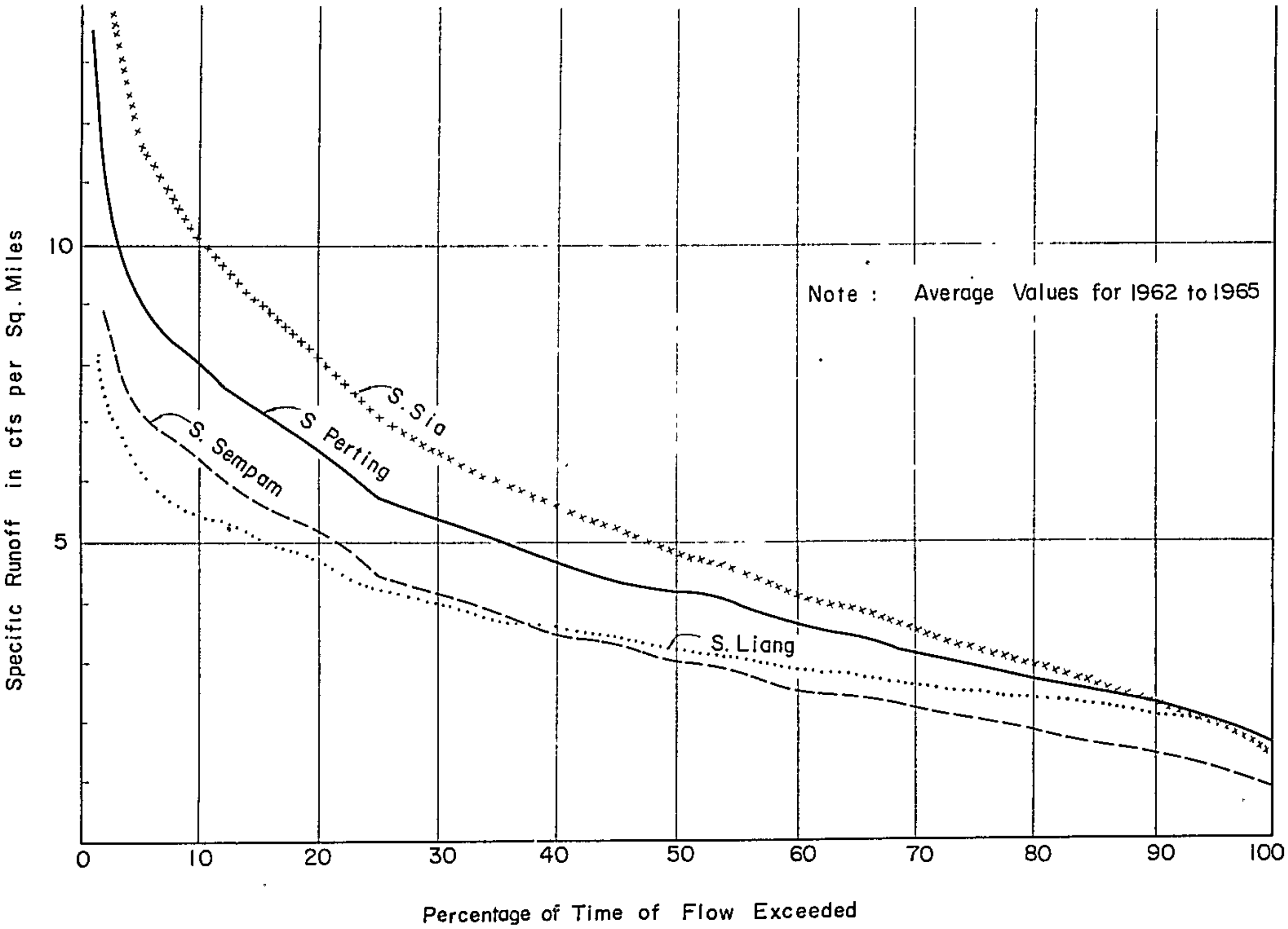


Table 5.3 Average Monthly Run-Off in Catchment Area (58.3 sq. miles) of Liang Power Station

Unit: cfs

Month	1962	1963	1964	1965	Average
January	316	222	253	166	239
February	193	231	241	154	205
March	228	231	223	138	205
April	272	158	287	174	223
May	254	209	245	212	230
June	171	144	182	132	157
July	138	138	185	109	143
August	171	185	149	134	160
September	170	159	163	168	165
October	238	207	175	285	226
November	287	345	225	333	297
December	274	284	263	412	308
Average Annual Run-off	226	209	216	202	213

Table 5.4 Average Monthly Run-off in Catchment Area (24.3 sq. miles) of Sia Power Station

Unit: cfs

Month	1962	1963	1964	1965	Average
January	238	148	177	94	164
February	119	156	165	82	131
March	153	156	148	67	131
April	195	86	210	102	148
May	178	135	170	137	155
June	99	73	109	61	85
July	67	67	112	39	71
August	99	112	77	63	88
September	97	87	91	96	93
October	163	133	103	208	151
November	210	265	150	253	220
December	197	208	187	330	230
Average Annual Run-off	151	135	141	128	139

Table 5.5 Average Monthly Run-off in Catchment Area (30.1 sq. miles) of Sempam Power Station

Unit: cfs

Month	1962	1963	1964	1965	Average
January	182	113	135	72	125
February	91	119	126	63	100
March	117	119	113	51	100
April	149	66	160	78	113
May	136	103	130	105	119
June	76	56	83	46	65
July	52	51	86	30	55
August	75	85	59	48	67
September	74	67	69	73	71
October	124	101	79	159	116
November	160	203	115	194	168
December	151	158	143	252	176
Average Annual Run-off	116	103	108	98	106

5.4 FLOOD FLOW

Since the available run-off data in the project area cover only a period of about 4 years, it is impossible to determine the design flood discharge from these data.

Therefore, the Rational Formula will be used to estimate the flood flow from the available precipitation data.

Rational Formula:

$$Qp \doteqdot 5930\ f.r.A. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.4)$$

where

Qp: Design flood discharge (cfs)
f : Coefficient of flood flow
r : Average intensity of precipitation within flood arrival time (inch/hour)
A : Catchment area (square miles)

The coefficient of flood flow, f, was set uniformly at 80 percent in consideration of vegetation, topography, size and other factors of the catchment area and also in consideration of the annual coefficient of run-off which is 50 to 80 percent.

The average intensity, r, of precipitation within flood arrival time was determined from the maximum daily precipitation by assuming the flood arrival time and distribution of hourly precipitation. The maximum daily precipitation adopted is 9.35 inches which is the maximum recorded in December 1926 at Fraser's Hill during the past 45 years. This maximum daily precipitation is considered to be equivalent to or greater than the probable daily precipitation in a 100-years probability. In addition, the average precipitation in the catchment area is assumed to be smaller than that at Fraser's Hill, as Fraser's Hill is located at a relatively high elevation in the catchment area. Therefore, the flood flow estimated from the above mentioned recorded maximum daily precipitation can be said to be on the safe side.

The flood arrival time was calculated by the Rziha Formula based on the gradients of the rivers.

Rziha Formula:

$$W = 44.8\,(H/L)^{0.6} \ldots\ldots\ldots\ldots\ldots\ldots (5.5)$$

where

W: Propagation speed of flood (miles/hour)

H: Head (miles)

L: Horizontal distance (miles)

The horizontal distance (L), propagation speed (W), and flood arrival time (T), to each project site are tabulated in Table 5.6.

Table 5.6 Horizontal Distance (L), Propagation Speed (W), Flood Arrival Time (T) to Each Site

Site	H (miles)	L (miles)	H/L	W (miles/hr)	T (hr)
Sempam					
Diversion Dam	1.8	12.4	1/18	7.9	1.6
Power Station	2.1	14.0	1/17	8.1	1.7
Liang					
Diversion Dam	2.1	16.0	1/20	7.5	2.1
Power Station	2.5	20.1	1/21	7.3	2.8
Hijau Diversion Dam	1.5	8.4	1/14	9.1	0.9
Sia					
Diversion Dam	1.6	11.5	1/9	7.9	1.5
Power Station	2.0	13.5	1/17	8.1	1.7

The distribution of hourly precipitation was calculated by Dr. Mononobe's Formula.

Dr. Mononobe's Formula:

$$rt = R24/24\,(24/T)^{2/3} \ldots\ldots\ldots\ldots\ldots\ldots (5.6)$$

where

r_t: Average intensity of precipitation within flood arrival time (inches/hour)

R24: Daily precipitation (inches)

T: Flood arrival time (hour)

The flood flow at each site of the projects calculated by the above formula is shown in Table 5.7.

Table 5.7 Design Flood Discharge at Each Site

	Sempam		Liang			Sia	
	D.D.	P.S.	D.D.	H.D.D.	P.S.	D.D.	P.S.
Catchment Area (sq. miles)	30.1	34.1	49.8	73.7	8.5	24.3	30.8
Design Flood Discharge (cfs)	37,000	40,000	50,000	63,000	15,000	32,000	37,000

Note: D.D. Diversion Dam Site

P.S. Power Station Site

H.D.D. Hijau River Diversion Dam Site

5.5 TEMPERATURE AND HUMIDITY

Although the annual variation of temperature is small, the daily variation is great, fluctuating about 20°F. According to recorded data in Raub, the maximum temperature is 95°F, while the minimum is 65°F. The relative humidity is remarkably high and reaches about 95 percent in the morning.

6. GEOLOGY

6.1 GEOLOGY OF PROJECT AREA

Most of the basin is a mountainous zone of 1, 000 to 6, 000 feet in elevation with a small part of the eastern margin comprised of a hilly zone with elevations from 500 to 1, 000 feet. The topography in general presents the appearance of being in the younger age of the mature stage.

The bedrock of the project area consists of Permocarboniferous schist and Triassic sedimentary rocks, through which granite and serpentine are intruded. The project area mainly consists of granite, being adjoined by sedimentary rocks in the eastern district. Schist and serpentine are distributed in the northeastern and eastern parts outside of the project area. (See Drawing No. 3)

Granite contains relatively large crystallized minerals and mostly has a porphyritic texture with aplitic texture in parts. Generally speaking, granite is susceptible to weathering and it is weathered to a residual soil to a considerably deep extent in the mountain zone. However, outcrops of fresh granite can be found at the river bed. The sedimentary rocks are mainly shale and alter to hornfels. Though it is generally hard and cemented, the outcrops have many cracks and are fairly weak.

The rivers in the area have little deposits of sand and gravel due to steep gradients, and deposits are mostly of boulders. Some small-scale river terraces can be found along the river.

6.2 GEOLOGY OF DAM SITE

6.2.1 Liang Dam

At the site of Liang Dam, 6 test pits: one pit 4 ft. 4 in. deep on the left bank, and 5 pits 7 ft. 9 in., 11 ft. 5 in., 2 ft. 0 in., and 14 ft. 10 in. respectively on the right.bank were excavated.

The width of the Liang River at the dam site is approximately 50 feet. There is a river terrace about 200 feet wide up to a height of 40 to 60 feet from the river bed on the left bank, and one about 500 feet wide up to a height of 50 to 60 feet from the river bed on the right bank. The bedrock of the dam site consists of granite and outcrops are exposed without any overlying deposit of sand and gravel along the river bed. The Lian Dam is planned to be 27 ft. high, and both abutments of the dam will be located on river terraces so that measures to prevent seepage of water through the river terrace deposits will be an important point in designing the structure.

On the left bank the river terrace deposits are assumed to be about 35 feet deep, consisting of soil, sand and gravel, with mixtures of boulders of granite with diameters less than 25 feet in the lower parts. The river terrace deposits on the right bank are assumed to be about 30 feet deep, mainly consisting of sand but containing some round pebbles of granite, quartzite, chert and slate less than 2 inches in diameter, and occasionally boulders of weathered granite with diameters up to 6 feet. These river terrace deposits are well compacted and are relatively impermeable. However, considerable permeation is expected at the contact plane of the terrace deposits and bedrock, where the ground-water level lies.

Granite is generally of porphyritic texture with large phenocrysts of feldspar; but melanocratic granite with high content of biotite is scattered spheruliticly near the dam axis. These, however, are in the form of a gradual transition. Granite outcrops at the river bed is fresh and sound. Although this granite has some large cracks at places, it is massive as a whole and is a good foundation rock for the dam. However, the bedrock covered with river terrace deposits, is assumed to be weathered, and the farther away from the river bank, weathering is more developed. That is, while fresh granite can be found immediately underneath the river terrace deposits at the river bank, at the foot of the mountain fresh granite is assumed to be found underneath weathered residual soil and weathered granite which underlie the river terrace deposits. The depth to reach the fresh granite is estimated to be about 45 feet at the maximum.

HIJAU DAM

The width of the Hijau River at the dam site is about 50 feet. The bedrock of this site consists of granite, but it is covered with river deposits at the river bed and with river terrace deposits at both abutments, and no outcrop can be observed. The river deposits are comprised mostly of boulders of granite, through which the river water flows. The depth of the deposits is estimated to be about 20 feet.

The river terrace deposit on the left bank is assumed to be about 25 feet wide and about 10 feet deep and on the right bank it is estimated to be about 40 feet wide and about 20 feet deep, so that both are relatively small in size. These river terrace deposits on both banks are comprised mostly of boulders and are fairly loose. Both the river deposits and river terrace deposits are permeable.

6.2.2. Sia Dam

The width of the Sia River at the dam site is about 30 feet. The right bank rises from the river bed at a gradient of approximately 40°, while on the left bank there is a river terrace about 120 feet wide lying about 9 feet above the river bed and the mountain slope is about 30°.

The bedrock of this site consists of granite and an outcrop is found on the left bank about 50 feet downstream of the dam site. However, the vicinity of the dam site is covered with humus and river terrace deposits. The depth of humus is about 1 foot and below it there is clay, granitic soil and weathered granite. The depths to weathered granite on the slopes on both banks range from 15 to 30 feet. River terrace deposits of sand and gravel, is assumed to be about 25 feet deep, are distributed on the left bank. However, the permeability is low as the deposits contains a great amount of clay.

Granite is of porphyritic texture with phenocrysts of large feldspars having relatively little cracks. The depth to fresh bedrock is estimated to be about 20 feet at the left bank, about 15 feet at the right bank and about 20 feet at the river bed. Therefore, the dam can be constructed on sound bedrock without difficulty.

6.2.3 Sempam Dam

The Sempam River at the proposed dam site is about 50 feet wide and there is a sandbank in the river channel. On the left bank there is a river terrace about 80 feet wide approximately 30 feet above the river bed. The gradient of the left bank slope is approximately 25°, whereas the right bank slope rises immediately from the river bed at a gradient of 40° to 30°.

The bedrock of this site consists of granite, which is entirely exposed on the right bank, while on the left bank there are river terrace deposits at the river bank and overburden on the mountain slope. At the river bed there are deposition of sand and gravel and no outcrop of rock can be found. The river deposits consist of quartz sand and gravel about 20 feet deep.

The river terrace deposits are comprised of sand, gravel and boulders of granite and the depths of the deposits are assumed to be approximately 30 feet. These terraces are broader and become deeper towards the downstream direction.

The granite is sound, but has parallel joints with a strike of N20°E and a dip of 80°S at intervals of 0.5 to 3 feet. A slickenside with a strike and dip of N60°W, 60°N can be seen along the slope on the right bank. This slickenside is assumed to be the fault plane of a small scale fault, and as the parallel joints run parallel with the dam axis, the granite presents no particular problem as a foundation for a dam.

6.3 GEOLOGY OF WATERWAY ROUTE

6.3.1 Liang Waterway

Along the route of the waterway there are 11 gullies large and small, of which the largest is the one at the middle of the waterway route.

The bedrock of this route consists of granite, the major portion of which is porphyritic granite, partly with dykes of aplite. On the upstream part of the Liang River, there are some outcrops of porphyritic granite and aplite, but the vicinity of the tunnel route is covered with a thick layer of surface soil and no outcrops are observed. Judging from the condition of each gully, the depth to fresh rock ranges from 100 to 250 feet as shown in Drawing No.4.

Since this waterway will be at a depth of 300 to 750 feet from the surface, all of it runs through fresh rock except at the vicinity of the intake and the surge tank. Also judging from the geological conditions of the surrounding area it is thought there are no faults or sheared zones of any large scale.

6.3.2 Sia Waterway

Along the route of the waterway there are 6 gullies large and small of which the largest is the one closest to the surge tank.

The bedrock of this route is granite. Some outcrops can be seen at the river bed and banks of the Sia River, but the vicinity of the tunnel route is covered with a thick layer of surface soil and no outcrops are observed.

Judging from the condition of each gully, the depth to fresh rock ranges from 170 to 250 feet at the ridge and 80 to 250 feet at gullies as shown Drawing No.4.

Since this waterway will be at a depth of approximately 250 to 1,000 feet from the surface all of it runs through fresh rock except at the vicinity of the intake and the surge tank. Also judging from the geological condition of the surrounding area it is thought there are no faults of sheared zones of any large scale.

6.3.3 Sempam Waterway

Along the route of the waterway there are 7 gullies large and small, of which the largest is the one closest to the surge tank.

The bedrock of this route is granite for a distance of about 2.5 miles from the upstream end and argillaceous rock for a distance of about 0.5 mile on the downstream end. The granite is mainly porphyritic granite and there is a dyke of aplite at the middle section of the waterway route. Outcrops of these rocks are found at the river bed and banks of the Sempam River and the larger gullies. However, the vicinity of the tunnel route is covered with a thick layer of surface soil and no outcrops are observed. Judging from the condition of each gully, the depth to fresh rock ranges from 30 to 300 feet at the granite zone and about 100 feet at the argillaceous rock zone as shown in Drawing No.4.

Since this route will be at a depth of approximately 200 to 1,200 feet from the surface, all of it runs through fresh bedrock except at the intake site. However, in the argillaceous rock zone, even fresh rock will be susceptible to scaling-off.

6.4 GEOLOGY OF POWER STATION SITE

6.4.1 Liang Power Station

a) Surge Tank and Penstock

The ridge along which the penstock will be installed is on a gradient of about 25° between El. 1,400 feet and 570 feet. The penstock will cross the Liang River which is about 50 feet wide. For geological survey of the surge tank site, a test adit was excavated at El. 1,374 feet, the results of which are as follows:

Horizontal Distance	Description of Layer
0" to 3'0"	Black humus (Layer A)
3'0" to 15'4"	Yellowish clay mixed with quartz grains (Layer B)
15'4" to 27'8"	Reddish brown soil of decomposed granite (Layer C)
27'8" to 59'5"	Reddish brown granitic soil with white clay (kaoline) distributed in spots (Layer D)
59'5" to 74'7"	Completely weathered granite easily crushed by hand (Layer E)

The Layers (A), (B) and (C) have fairly high moisture content, but the water content decreases with depth so that in Layer (D) the soil can barely be compacted by the palm of the hand. Layer (E) has unweathered spheroidal granite cores caused by onion structure weathering. Each of these layers is fairly wellcompacted under natural condition.

The base rock of this site consists of granite and the geology of the upper layers is as observed in the test adit, and it is assumed that fresh rock will be about 80 feet deep below Layer (E). The bottom portion of Layer (E) is weathered granite with onion structure, and it is assumed that hard granite will not be reached at less than about 160 feet from the surface. Cracks are highly developed in the rock, and as the cracked surfaces must be assumed to be weathered, the total depth to reach fresh or only slightly weathered granite is estimated to be 230 to 250 feet.

Although fresh granite is preferable as a base for a surge tank, the weathered granite with onion structure is thought to have adequate bearing strength.

The base rock of the penstock is heavily weathered granite, same as at the site of the surge tank. However, the depth of weathering gradually decreases at lower elevations, and near the Liang River the depth to fresh granite is assumed to be about 20 feet. At the site where the penstock crosses the Liang River, the depth of the river deposit of sand and gravel is estimated to be about 25 feet. To obtain a base rock for the anchor blocks of the penstock, it is preferable to reach the weathered granite with onion structure, but Layer (B) will have sufficient bearing strength. However, rain may cause the excavated surfaces with moderate inclination to erode while landslides may occur at surfaces with steep inclination and, therefore, the excavated surfaces will require protective treatment.

b) Powerhouse

A test pit 11 ft. 11 in. deep was excavated at this site.

On the right bank of the Liang River where the site for the powerhouse is planned, there is a river terrace deposit of moderate slope 5 to 30 feet above the river bed. This deposit consists mainly of sand with occasional mixtures of granite boulders. The depth of this deposit is assumed to be 30 to 40 feet and the bedrock is assumed to be fresh granite or aplite, either of which is good as a foundation rock for the powerhouse.

According to a test pit excavated at a point about 80 feet from the bank of the Liang River, the ground water level is almost as high as the water level of the Liang River.

6.4.2 Sia Power Station

a) Surge Tank and Penstock

The average inclination of the ridge along which the penstock will be installed is about 10° between El. 1,400 feet and 1,200 feet, which is rather gentle, but it is about 25° between El. 1,200 feet and 630 feet.

For geological survey of the surge tank site a test pit was excavated at El. 1,323 feet, the results of which are as follows:

Vertical Depth	Description of Layer
0 to 8"	Black humus (Layer A)
8" to 3'4"	Yellowish clay mixed with quartz granis (Layer B)
3'4" to 8'6"	Reddish brown soil of decomposed granite (Layer C)
8'6" to 13'7"	Reddish brown granitic soil with white clay (kaoline) distributed in spots (Layer D)
13'7" to 21'3"	Completely weathered granite, easily crushed by hand (Layer E)

Layers (A), (B) and (C) have fairly high water content which decrease with depth so that at Layer (E) the soil is difficult to compact by the palm of the hand. Each of these layers is fairly well compacted under natural condition.

The base rock of these sites is granite and the geology of the surface layers is as observed in the abovementioned test pit. Layer (E) is assumed to be about 80 feet deep, the lower portion of which is weathered granite with onion structure. Hard granite will not be reached at less than about 150 feet from the surface. Cracks are highly developed in the rock and as the cracked surfaces must be assumed to be weathered, the depth to reach fresh or only sightly weathered granite is estimated to be 230 to 250 feet. Although fresh granite is preferable as a base for a surge tank, weathered granite with onion structure is thought to have adequate bearing strength.

The base rock of the penstock is heavily weathered granite, same as at the site of the surge tank. However, the depth of weathering gradually decreases at lower elevations, and around the powerhouse site the depth to fresh granite is assumed to be about 20 feet.

As base rock for anchor blocks of the penstock, weathered granite with onion structure is preferable, but Layer (B) will have sufficient bearing strength. However, rain may cause the excavated surfaces with moderate inclination to erode while landslides may occur at surfaces with steep inclination and, therefore, the excavated surfaces will require protective treatment.

b) Powerhouse

There is a river terrace deposit of sand, gravel and boulders on the left bank of the river at the proposed site of the powerhouse. This deposit is assumed to be about 20 feet deep. On the right bank there are outcrops of granite and, therefore, it is believed that the bedrock under the terrace deposit is granite which is an excellent foundation for the powerhouse.

6.4.3 Sempam Power Station

a) Surge Tank and Penstock

The average gradient of the ridge on which the penstock will be installed is about 30° between El. 1,400 feet and 715 feet.
For geological survey of the surge tank site, a test adit was excavated at El. 1,316 feet, the results of which are as follows:

Horizontal Distance	Description of Layer
0 to 3'6"	Black humus
3'6" to 46'0"	Reddish brown debris soil with high content of clay
46'0" to 77'0"	Black shale (hornfels)

The debris soil has a fairly high water content and the clay which constitute the major ingredient of the soil is weathered argillaceous rock with high viscosity. In addition, the debris soil contains a great deal of rubbles of sandy shale with diameters up to 1 inch and in rare cases rubbles of shaly sandstone or fine sandstone with diameters as great as 3 feet. According to polarization-microscopic observation, the shale alters to hornfels comprised of muscovite, quartz and plagioclase. This is a result of thermal metamorphism caused by intrusion of granite.
The surfaces of the bedding layer plane and cracks of shale observed in the test adit are stained by limonite to a reddish brown colour, and as the shale holds thin layers of clay in places, the rock is weak as a foundation although individual pieces of rock are fairly hard. The weathering of this shale is assumed to reach as deep as about 60 feet.

The surge tank should be constructed on fresh shale.

The base rock of the penstock line is weathered shale, the same as that observed at the surge tank site, and the depth of weathering decreases at lower elevations. Around the powerhouse the depth to fresh shale is estimated to be about 25 feet. However, the depth of debris soil is assumed to range from 10 to 20 feet without any remarkable variation.

The weathered shale will have sufficient bearing strength for the anchor blocks of the penstock.

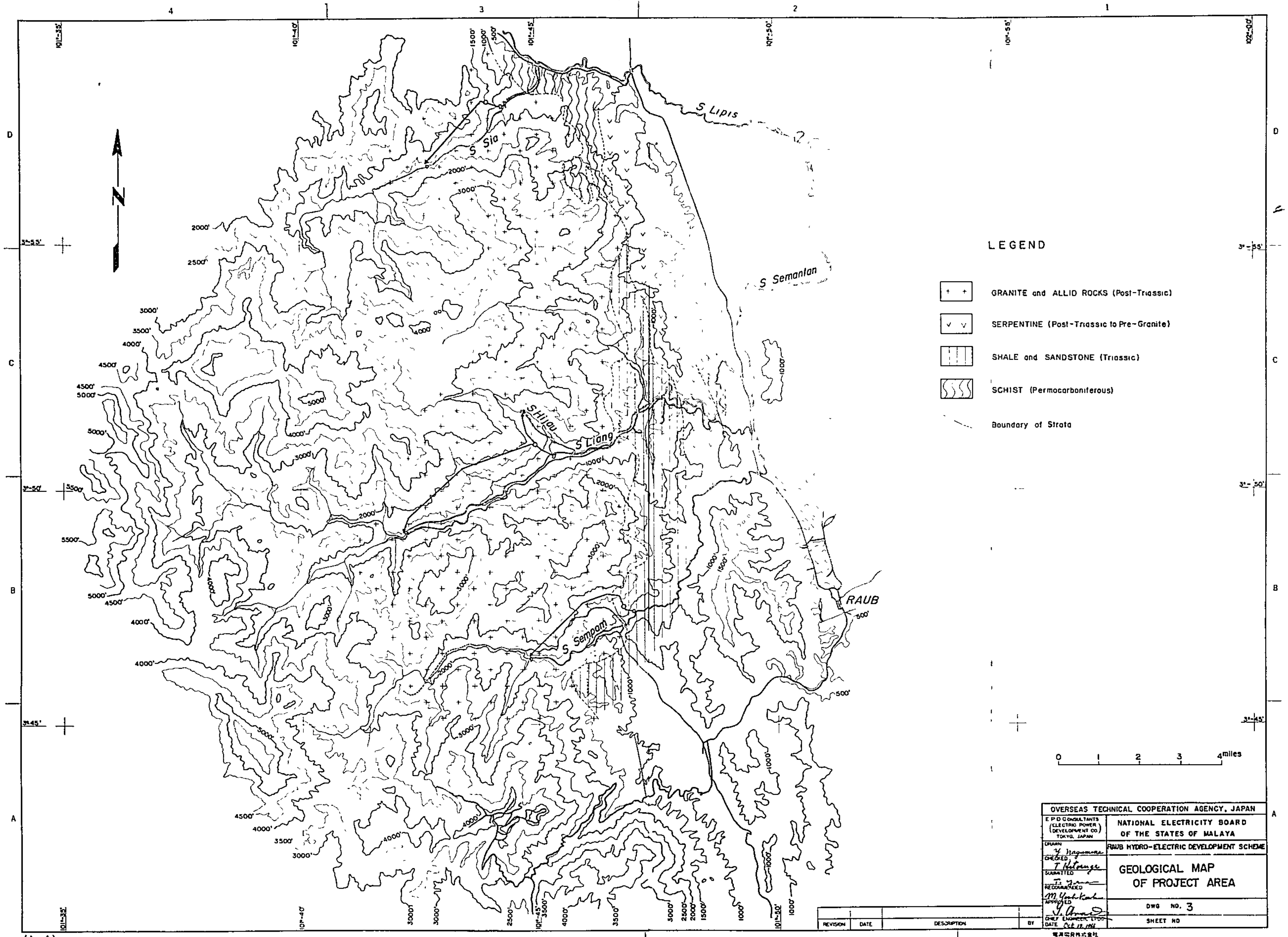
b) Powerhouse

Two test pits 8 ft. 11 in. and 10 ft. 6 in. deep were excavated for geological survey of this site.

The river deposits at this site range from 6 ft. 8 in. to 8 ft. 10 in. according to the results of the test pits. The river deposits contain clay, sand and gravel, and are fairly loose. The groundwater level is 0.5 ft. to 1 ft. above the bedrock.

The base rock is black shale or shaly sandstone, the upper portion of which is fairly heavily weathered. Especially the portion contacting the surface soil has turned into clay.

The powerhouse should be constructed on fresh shale which is assumed to be 20 to 25 feet below ground level.



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

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

NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

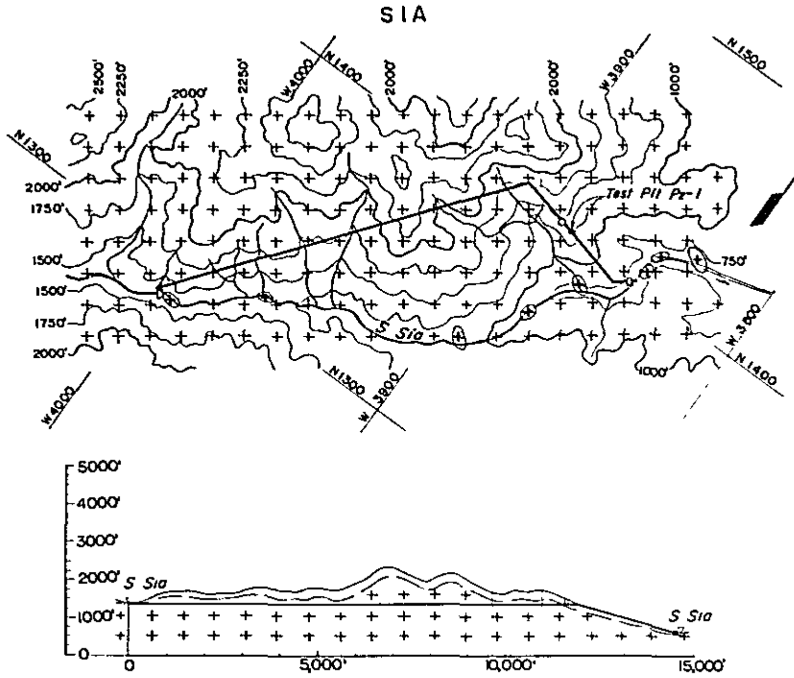
GEOLOGICAL MAP OF PROJECT AREA

DRAWN
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
CHIEF ENGINEER, EPDC
DATE Oct 17, 1964

DWG NO. 3
SHEET NO

REVISION	DATE	DESCRIPTION	BY

電源開発株式会社
日本国 東京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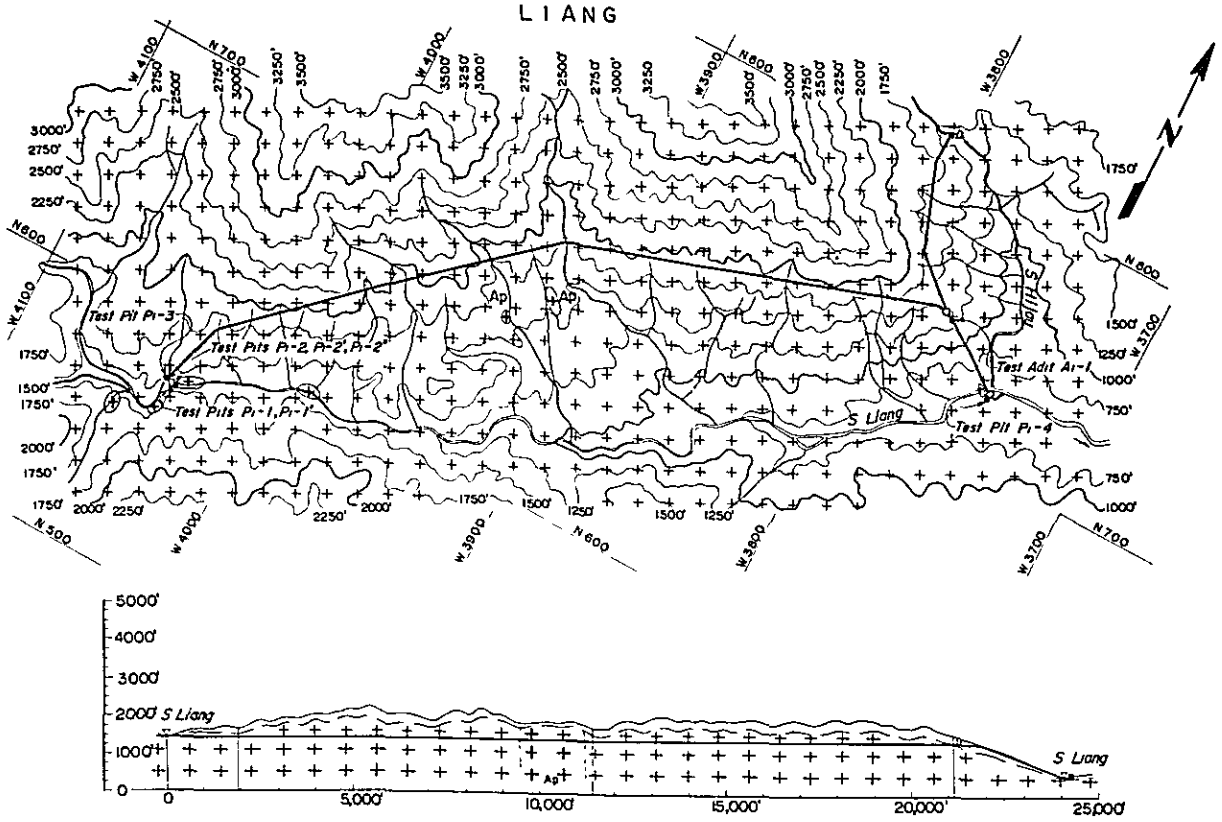
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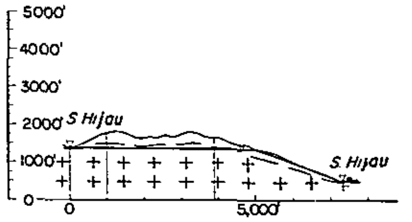
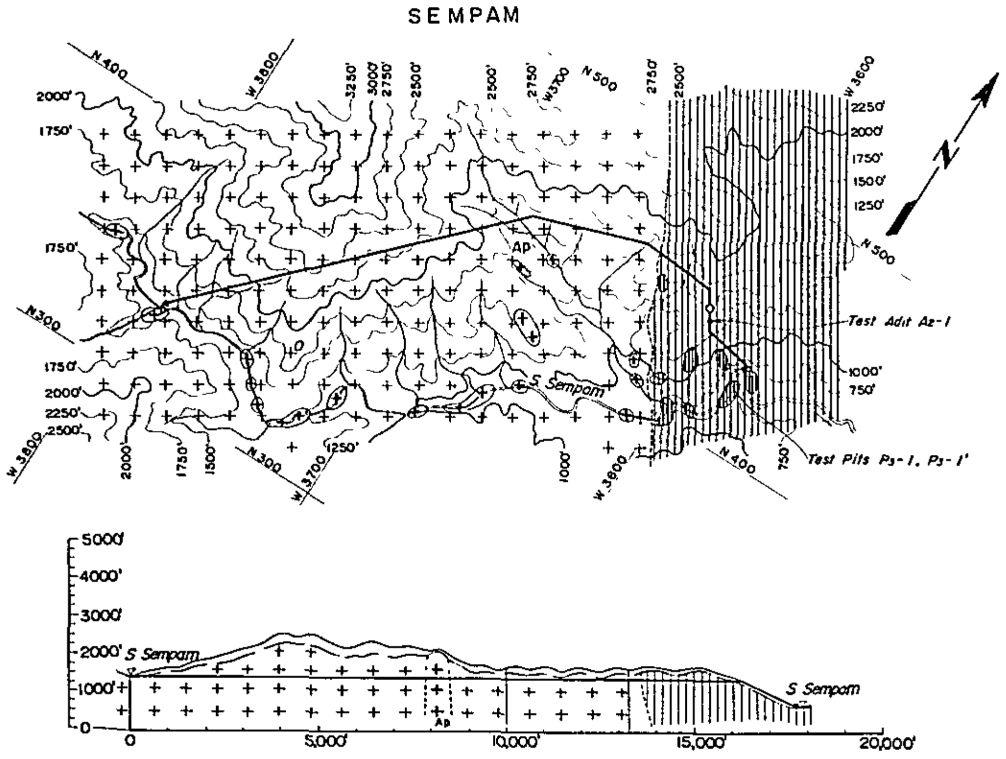
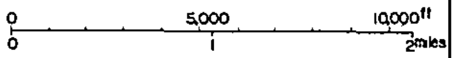



SEMPAM

LEGEND

☐	Overburden
+ +	GRANITE and ALLID ROCKS (Ap Aplite)
▥	SHALE and SHALY SANDSTONE (Hornfels)
⊕ ⦶	Outcropes of Rocks
- - - -	Boundary of Rocks
—	Surface of Fresh or Slightly Weathered Rock



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

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

NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

DRAWN Y. Miyamura
CHECKED T. Hitonaga
SUBMITTED
RECOMMENDED M. Yoshioka
APPROVED
CHIEF ENGINEER, EPDC
DATE Oct. 12 1966

GEOLOGICAL MAP HEADRACE TUNNELS OF SIA, LIANG AND SEMPAM

DWG NO. 4

SHEET NO

REVISION	DATE	DESCRIPTION	BY

電源開発株式会社
日本国 東京

(A-1)

7. ENERGY PRODUCTION

7.1 BASIC CONDITIONS

This Chapter is devoted to the determination of the maximum discharge and to the calculation of the generating capacity and energy production of the 3 power stations in the Raub Scheme. The basic condition that were considered are as follows:

a) The energy produced is to be supplied to take care of local loads, and the surplus is to be sent to the Central Network for the purpose of saving fuel of thermal power plants.

b) The benefit and cost of several cases of maximum discharge assumed were calculated to obtain the discharge which will create the maximum excess of benefit over cost, and also, the assessment standard adopted by NEB was employed to find the minimum energy cost in order to determine the most economic and optimum size of each power station.

c) The benefit is expressed in terms of the sum of the costs per KW and KWh of an equivalent diesel plant for that part of the output to supply local demands and of an equivalent steam plant for that part of the output to be transmitted to the Central Network.

d) Rating curves at the vicinities of intake and tailrace were obtained in order to determine the intake and tail water levels for a given amount of discharge. The effective head was calculated by subtracting the head loss calculated for each structure from the gross head.

e) The output and energy production are calculated daily based on the run-off records of four years from January 1962 to December 1965.

f) The dependable run-off is the 360 days run-off taken from an average duration curve of the four years.

g) The number of units of electrical equipment is determined after economic analysis and comparison, taking the costs of maintenance and operation into consideration.

7.2 MAXIMUM DISCHARGE

In order to determine the maximum discharge for the most economical installed capacity, the three cases of maximum discharge for each of the three power stations, namely, about 20, 30 and 40 percent of time of duration curve were studied. (See Fig. 7.1, 7.2 and 7.3)

The maximum discharge, installed capacity, energy production and approximate construction cost, etc. for each power station are shown in Table 7.1

Table 7.1 Basic Data for Determination of Maximum Discharge

Power station	Qmax	Pmax	Pfirm	Ph	Construction Cost		
					Generation	Transmission & Substation	Total
	(cfs)	(KW)	(KW)	(MWh)	(1,000$M)	(1,000$M)	(1,000$M)
Liang	275	17,400	6,800	103,000	23,100	2,250	25,350
	250	15,000	6,800	98,800	20,300	2,250	22,550
	210	12,500	6,800	95,000	19,500	2,250	21,750
Sia	200	10,600	2,600	57,800	13,300	1,270	14,570
	160	8,500	2,600	54,300	12,000	1,270	13,270
	135	7,200	2,600	49,700	11,100	1,270	12,370

	155	7,700	1,800	40,900	14,600	970	15,570
Sempam	130	6,500	1,800	38,700	13,300	970	14,270
	105	5,200	1,800	36,400	12,700	970	13,670

Legend: Qmax: Maximum Discharge
Pmax: Installed Capacity
Pfirm: Firm Output
Ph: Annual Energy Production at Generating End

The excess of benefit (B) over annual cost (C) calculated in accordance with the basic conditions for the three cases of maximum discharge of each station are graphically depicted in the top graphs in Fig. 7.4 to Fig. 7.6.

The energy cost which is the cost per KWh subtracting the benefit of KW in accordance with the assessment method, is shwn in the lower graphs in Fig. 7.4 to Fig. 7.6.

According to these graphs, the maximum economy is attained in case of the maximum discharges shown in Table 7.2 which follows. Therefore, these maximum discharges will be employed in the scheme.

Table 7.2 Maximum Discharge Used for Scheme

Power Station	Maximum Discharge
Liang	250 cfs
Sia	160 "
Sempam	130 "

The average monthly available discharges of the four years calculated using the above determined maximum discharges are shown in Table 7.3 to Table 7.5. The relation between these values and the inflow described in Chapter 5 are graphically shown in Fig. 7.7 to Fig. 7.9.

Fig-7.1 Duration Curve for Determination of Available Discharge of Liang P.S

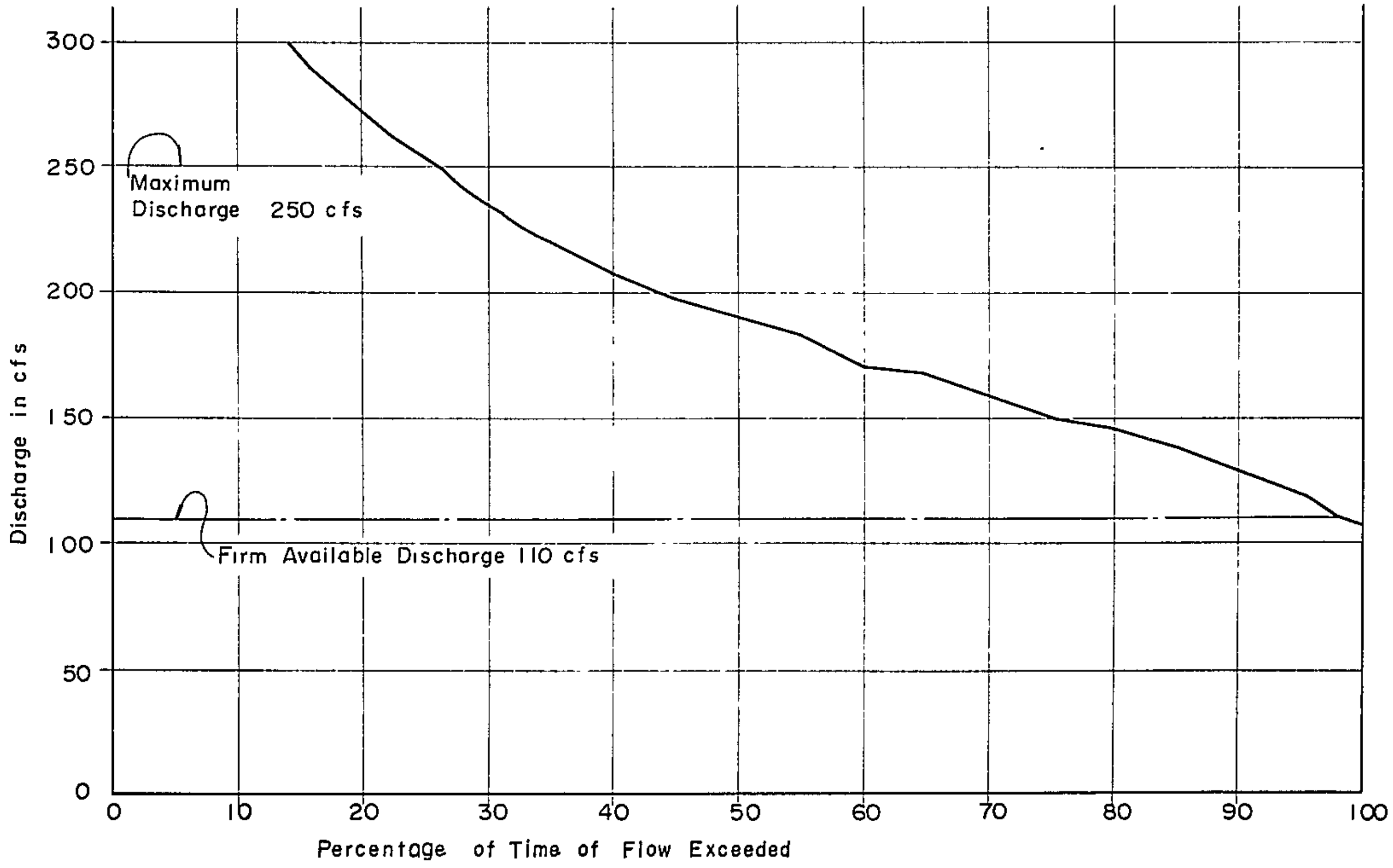


Fig.-7. 2. Duration Curve for Determination of Available Discharge of Sia P.S.

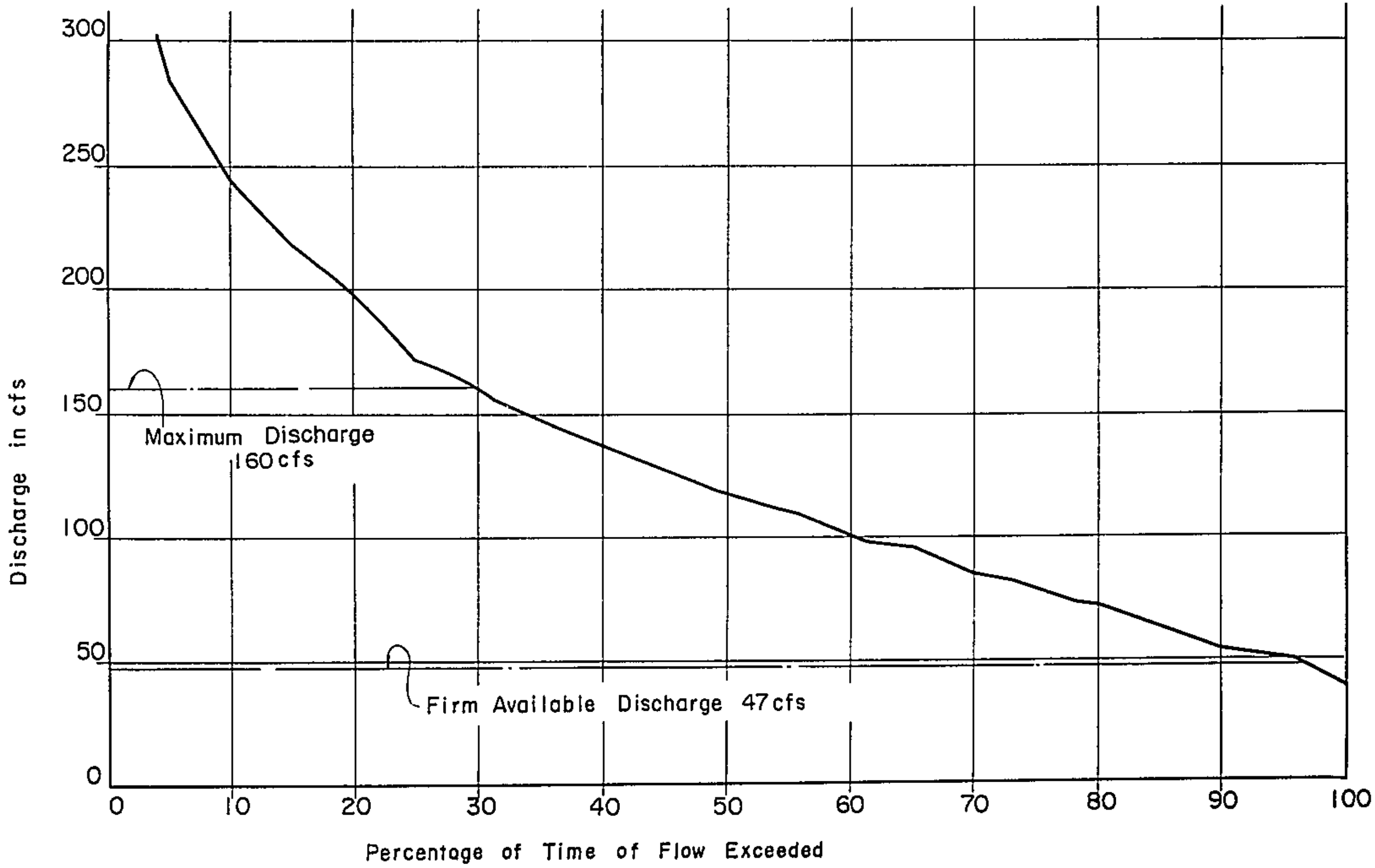


Fig.- 7. 3. Duration Curve for Determination of Available Discharge of Sempam P.S.

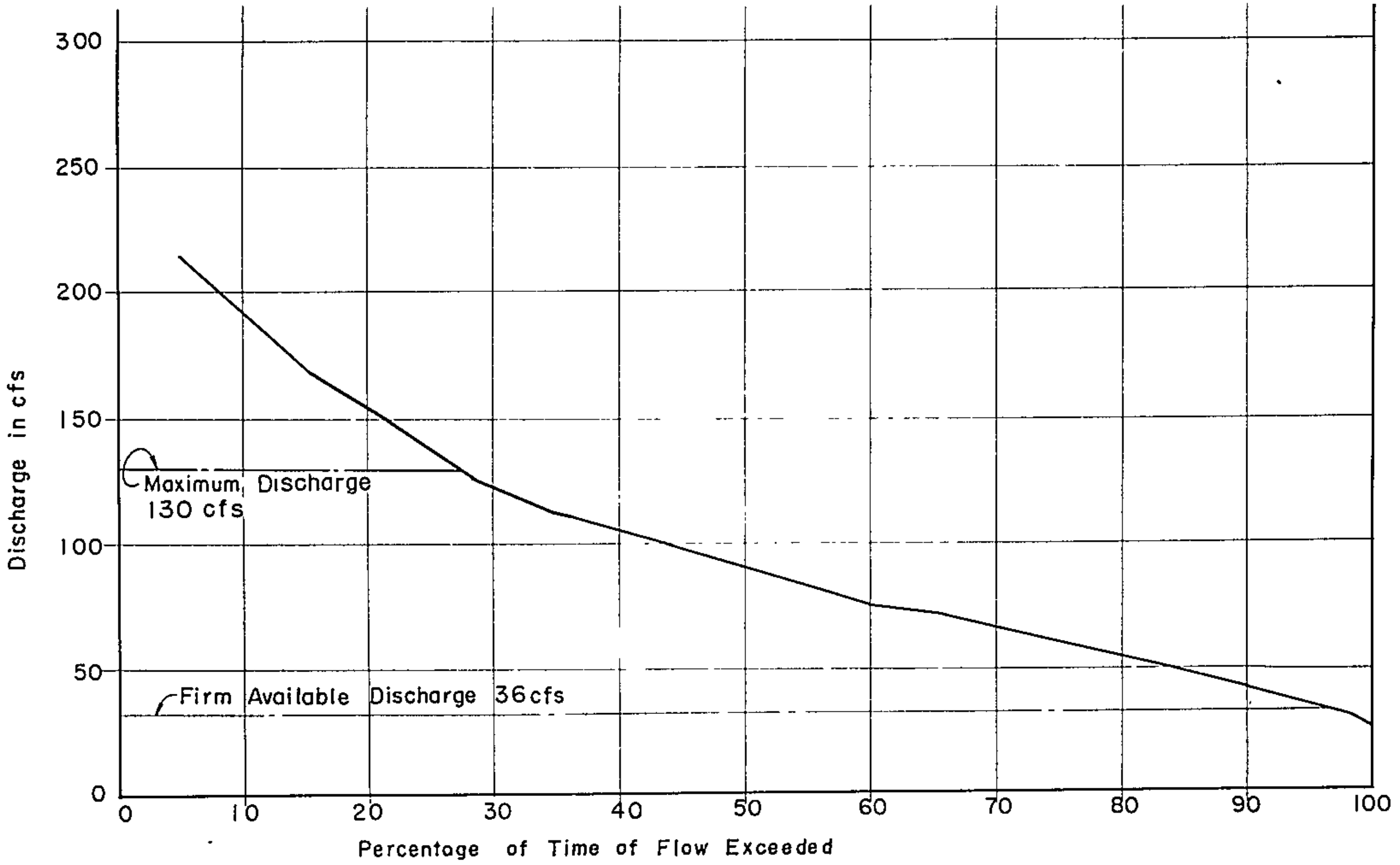


Fig.- 7. 4. Excess Benefit and Cost Per Kwh for Liang Power Station.

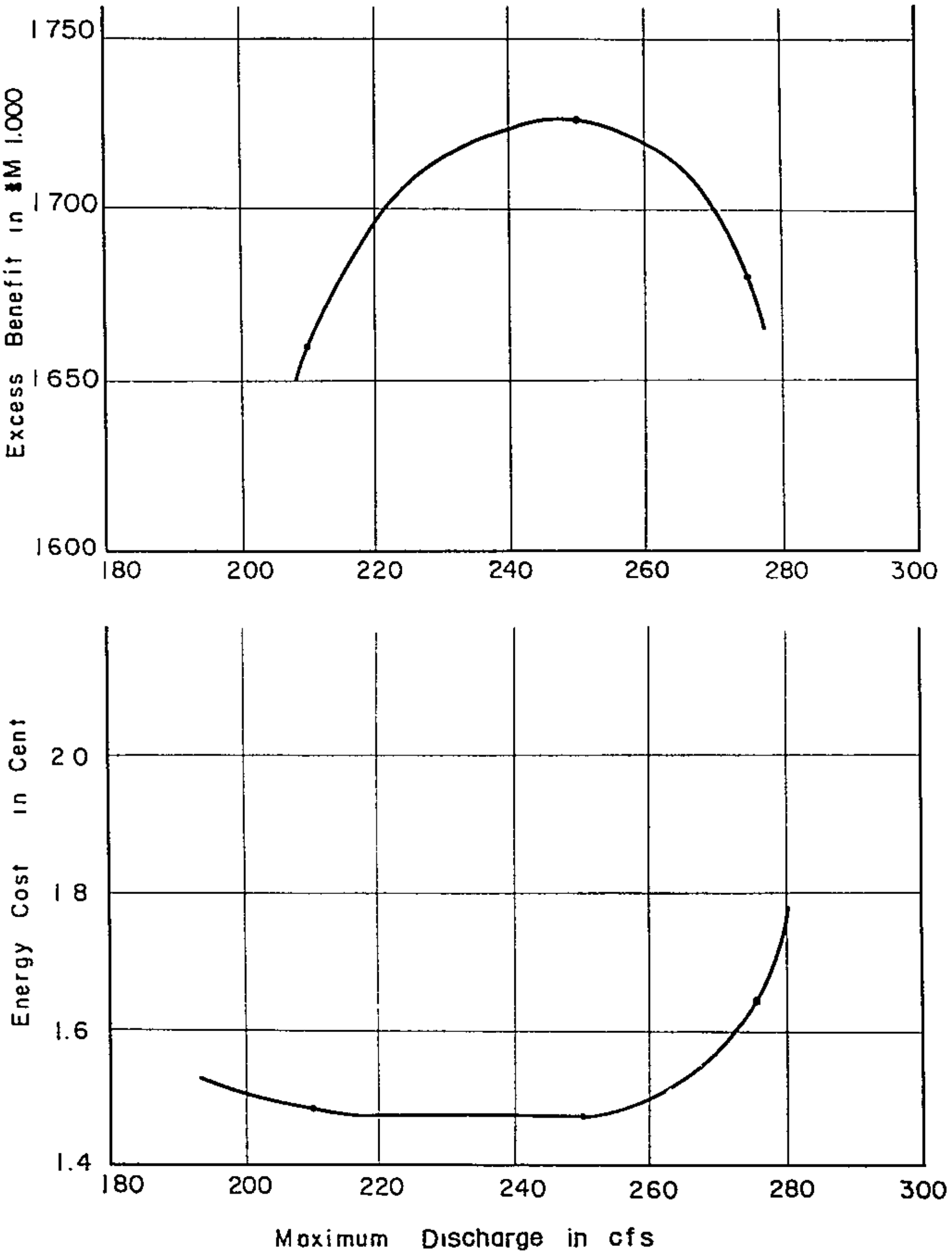


Fig.-7.5. Excess Benefit and Cost Per Kwh for Sia Power Station

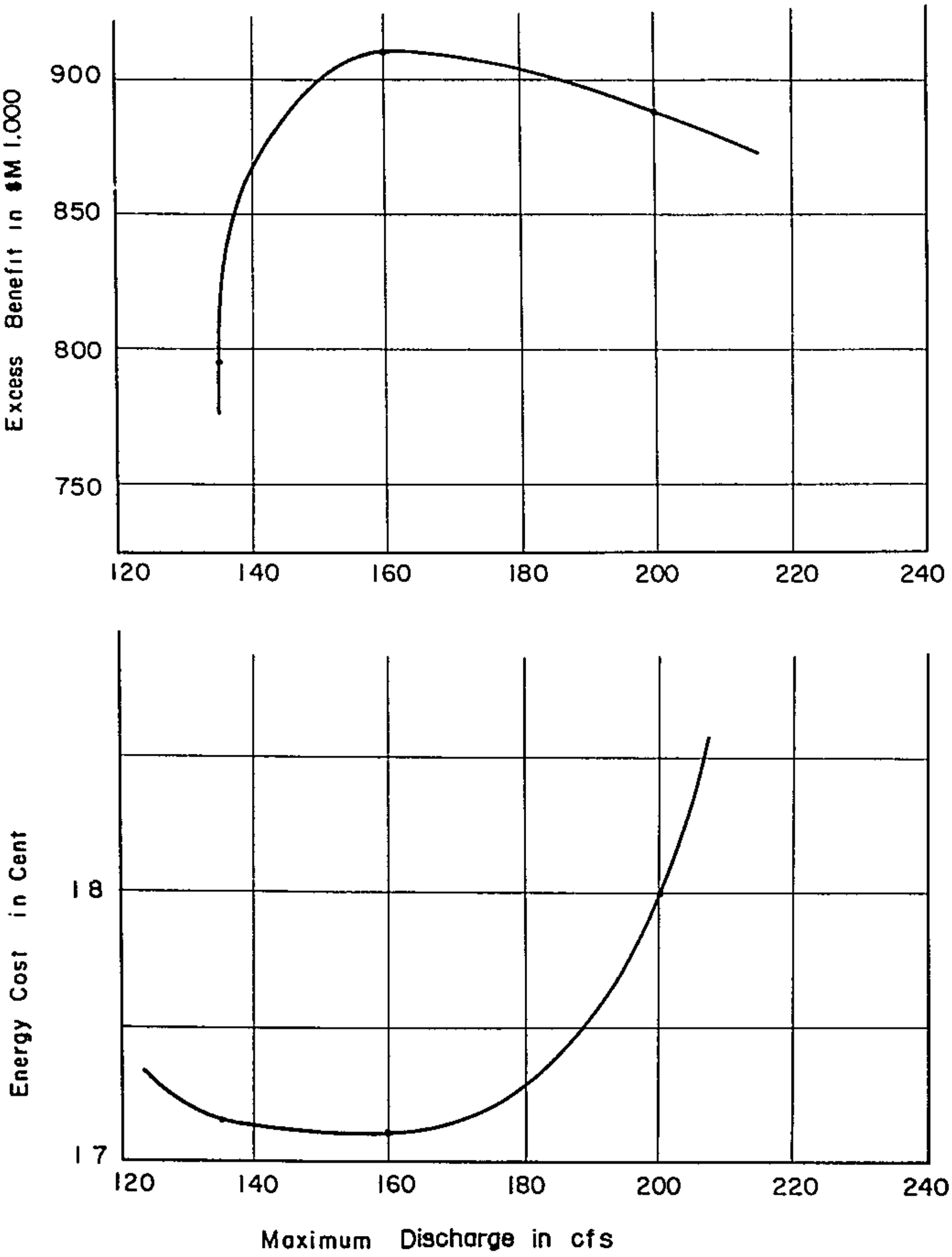


Fig.- 7. 6. Excess Benefit and Cost Per Kwh for Sempam Power Station.

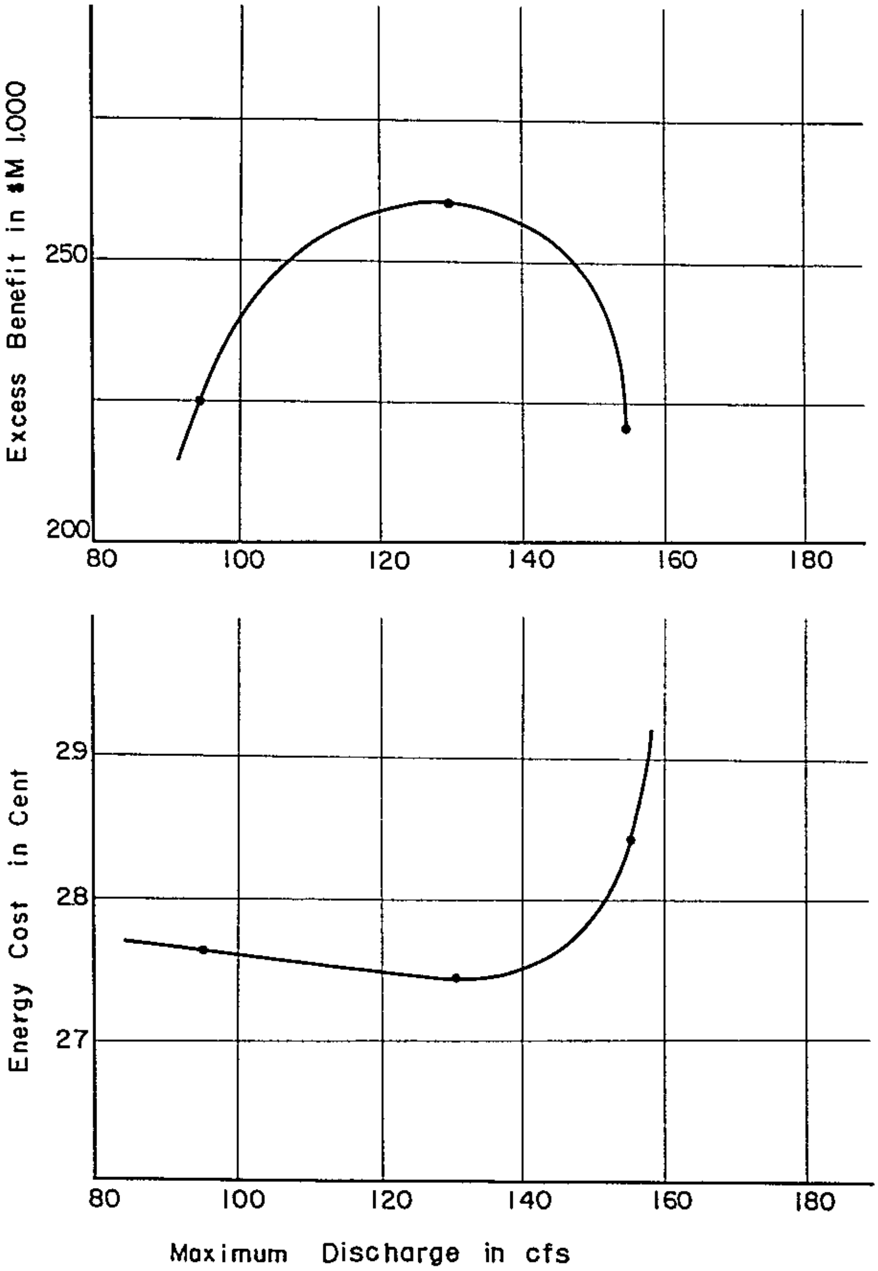


Table 7.3 Average Monthly Available Discharge at Liang Power Station

Unit: cfs

Month	1962	1963	1964	1965	Average
January	244	213	223	166	211
February	192	218	225	154	199
March	209	219	214	138	195
April	237	158	234	174	201
May	226	190	219	204	210
June	170	144	180	132	156
July	138	138	182	109	142
August	164	160	148	130	151
September	169	159	163	168	165
October	216	201	172	227	204
November	239	250	210	243	235
December	243	244	234	250	242
Average Annual	204	191	200	175	193

Table 7.4 Average Monthly Available Discharge at Sia Power Station

Unit: cfs

Month	1962	1963	1964	1965	Average
January	158	135	142	94	132
February	118	139	146	82	123
March	129	140	137	67	118
April	153	86	148	102	122
May	144	114	140	127	131
June	97	73	106	61	84
July	67	67	108	39	70
August	90	85	76	59	78
September	95	87	91	95	92
October	137	125	97	143	125
November	154	160	132	156	150
December	157	158	149	160	156
Average Annual	125	114	123	99	115

Table 7.5 Average Monthly Available Discharge at Sempam Power Station

Unit: cfs

Month	1962	1963	1964	1965	Average
January	127	106	112	72	104
February	91	109	114	63	95
March	102	110	106	51	93
April	121	66	119	78	96
May	114	89	110	99	103
June	74	56	81	46	65
July	52	51	83	30	54
August	70	66	59	45	60
September	74	67	69	73	71
October	108	97	76	114	99
November	123	130	103	125	120
December	126	126	119	130	123
Average Annual	99	89	96	77	90

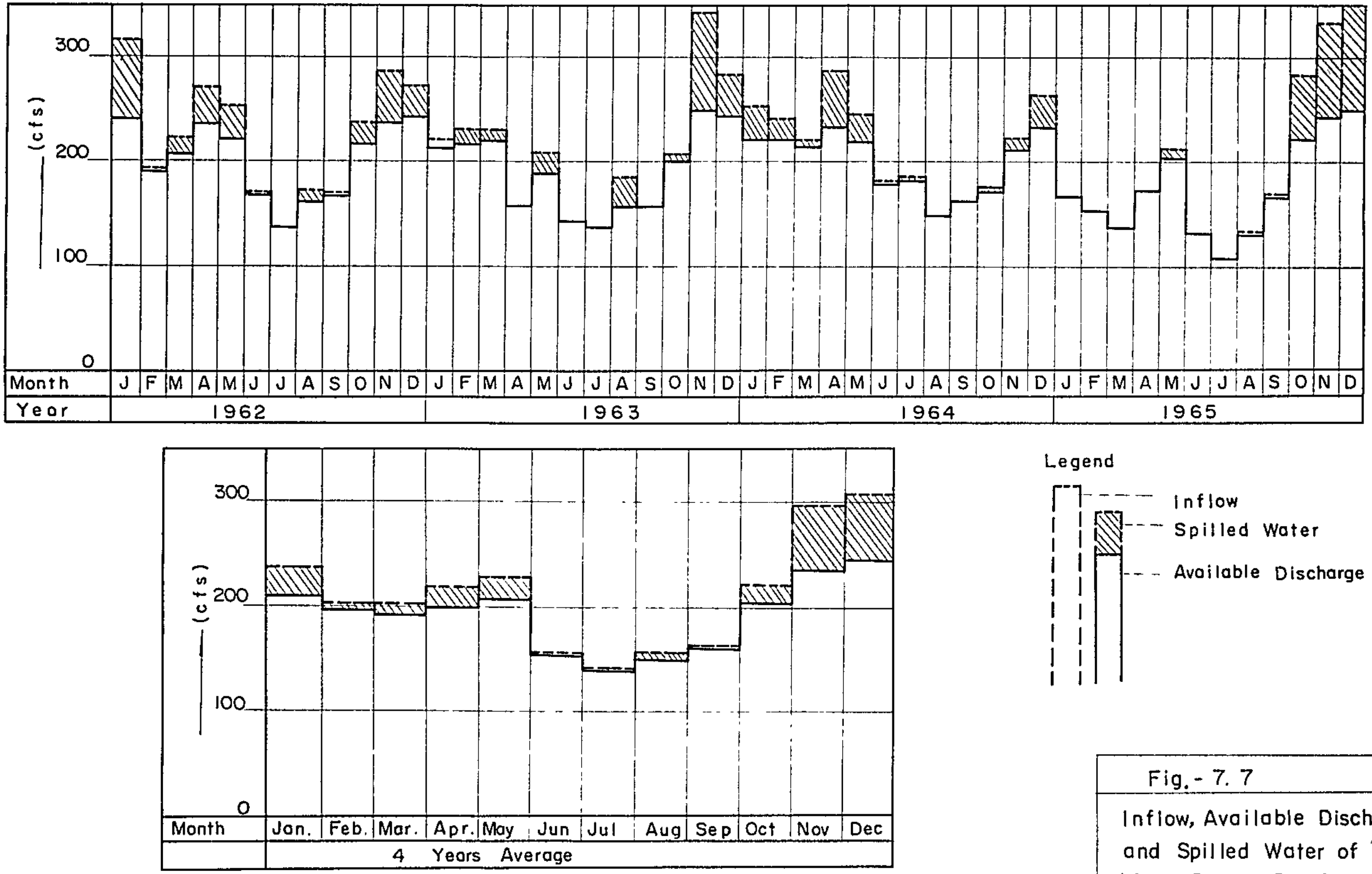


Fig.- 7. 7

Inflow, Available Discharge and Spilled Water of Liang Power Station

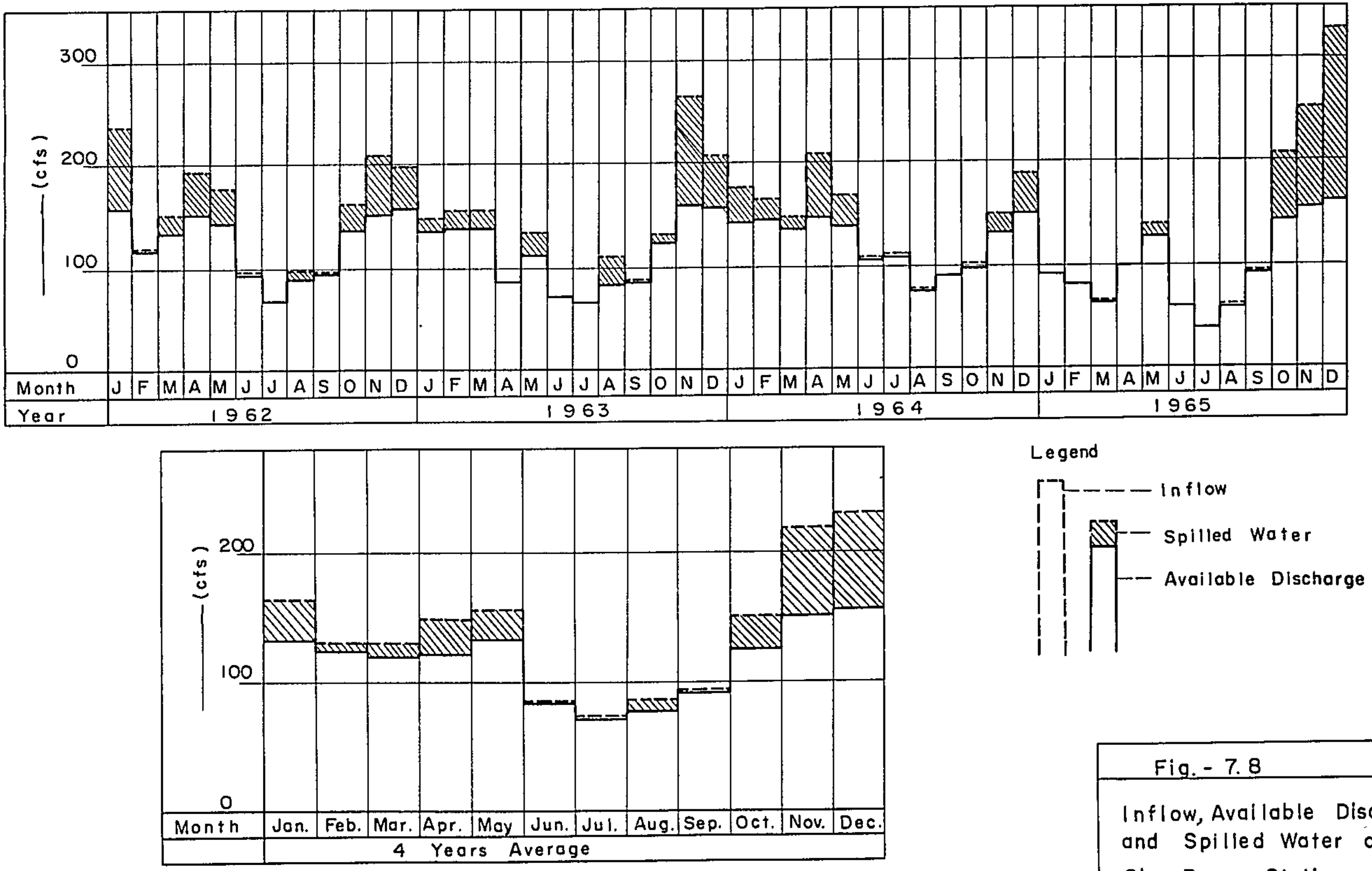


Fig. - 7.8

Inflow, Available Discharg
and Spilled Water of
Sia Power Station

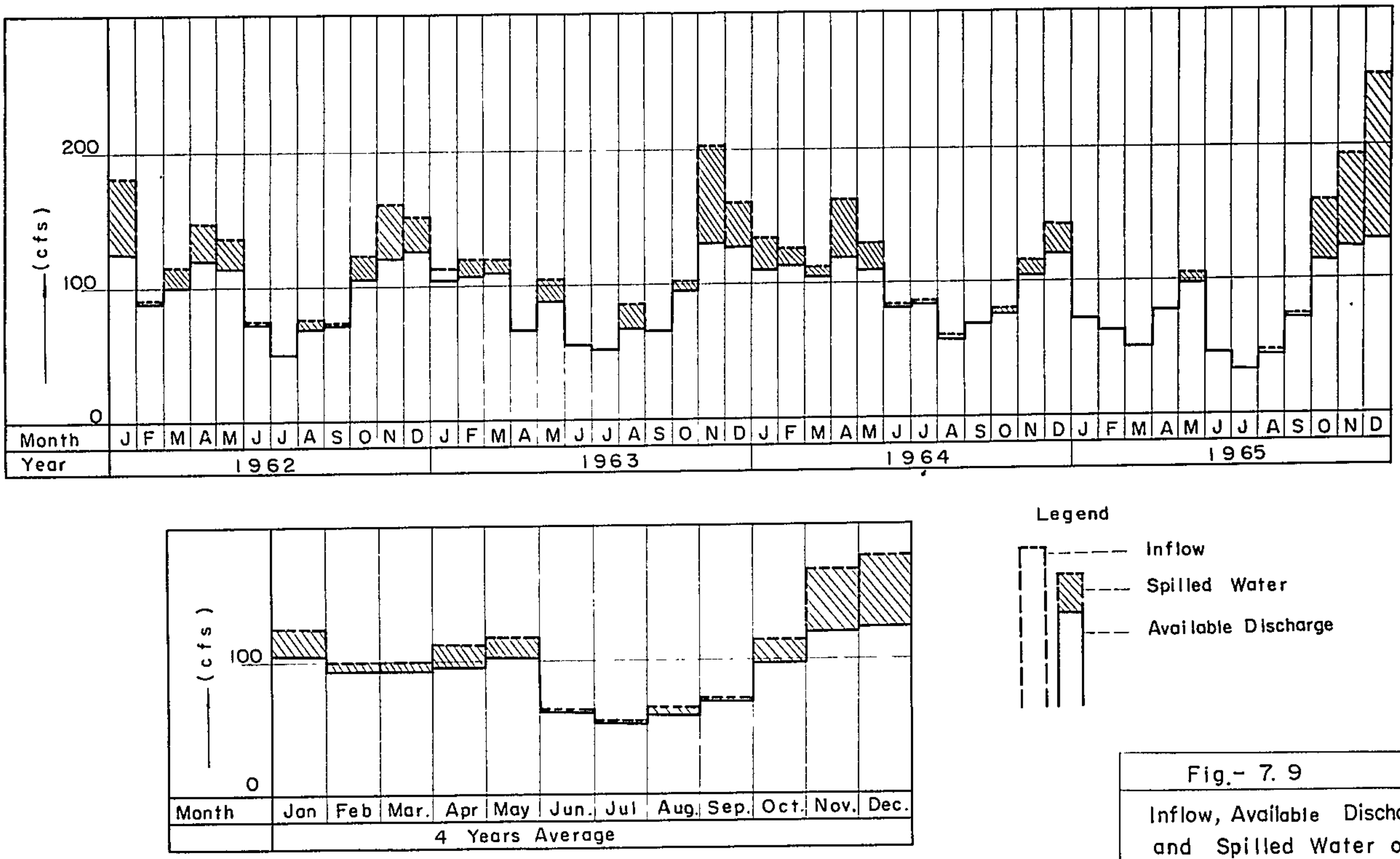


Fig.- 7. 9

Inflow, Available Discharge and Spilled Water of Sempam Power Station

7.3 INSTALLED CAPACITY AND FIRM OUTPUT

The installed capacity and firm output calculated using the maximum discharges determined in 7.2 and taking the effective head and efficiency into consideration are shown in Table 7. 6.

Table 7. 6 Installed Capacity and Firm Output

	Unit	Power Station		
		Liang	Sia	Sempam
Intake Water Level	feet	1, 440	1, 440	1, 450
Tail Water Level	"	560	605	695
Gross Head	"	880	835	755
Effective Head				
For Max. Discharge	"	820	770	700
For Firm Discharge	"	869	829	748
Efficiency				
For Max. Discharge	%	84	81	81
For Firm Discharge	%	84	77	79
Discharge				
Max.	cfs	250	160	130
Firm	"	110	47	36
Installed Capacity	KW	15, 000	8, 500	6, 500
Firm Output	KW	6, 800	2, 600	1, 800

7.4 NUMBER OF UNITS OF ELECTRICAL EQUIPMENT

It is anticipated that the capacity of the Central Network at the end of 1970, when the Raub Scheme is scheduled to be completed, will reach about 700, 000 KW. The Raub Scheme will have a weight of less than 1/20 of the network capacity, and therefore, it is possible to plan a one-unit development for each power station. Furthermore, the ratio between the firm discharge and maximum discharge is 44 percent at Liang, 30 percent at Sia and 28 percent at Sempam Station, so the one-unit development deserves full consideration.

If two units are installed in each station, the efficiency may be increased when available discharge is small and effective utilization of river run-off is possible at times of inspection of either unit. Therefore, the two-unit development is also worthy of consideration. However, a three-unit development will not produce substantial increase in the above merits, and besides, each unit will be too small, so that it is out of consideration.

The types of turbines suitable for the output and head of each power station are the Francis-type and Pelton-type turbines.

The Pelton-type turbine is more advantageous with respect to its efficiency under various loads and the ratio of water pressure rise can be controlled within 15 percent. However, the size of a unit is large and, therefore, it will entail a higher cost of construction.

On the other hand, the Francis-type turbine compared with the Pelton-type is small in size and costs less, but its efficiency will drop under conditions of partial load.

A comparison of various cases of combinations of types and numbers of units was made and the total cost was calculated for each case including the cost of penstock and powerhouse building, in addition to that of turbines, generators and transformers. On the other hand, the annual energy production was calculated on the basis of an estimated efficiency for each type of turbine. For the case of one-unit development, the annual losses in energy production for maintenance stoppage were also calculated.

Table 7.7 gives a comparison of annual cost and energy loss for each case of development.

As a result, the plan for two units of the Francis-type turbine was selected for the Liang Power Station as being most economical. For the Sia and Sempam Stations, although the difference with the one-unit proposal is very small, the two Francis units plan is selected as having an overall advantage in view of the convenience in regard to maintenance and operation and in consideration of the condition of local loads.

7.5 ENERGY PRODUCTION

The monthly energy production of the three power stations in the four-years period is shown in Fig. 7.10 to Fig. 7.12. According to these graph the annual available energy production at the generating end of each power station of the Raub Scheme is 98, 800, 000 KWh at the Liang Power Station, 54, 300, 000 KWh at the Sia Power Station and 38, 700, 000 KWh at the Sempam Power Station, totaling 191, 800, 000 KWh.

Table 7. 7 Economic Comparison of Types and Unit Numbers of Turbines

Unit: $M1, 000

Item	Liang P.S.				Sia P.S.				Sempam P.S.			
Type of Unit	Pelton	Francis	Pelton	Francis	Pelton	Francis	Pelton	Francis	Pelton	Francis	Pelton	Francis
Number of Unit	1	1	2	2	1	1	2	2	1	1	2	2
1) Construction Cost												
Electrical Equipments (Turbine, Generator, Transformer, Accessory)	3, 250	2, 390	3, 440	2, 670	2, 600	1, 800	2, 820	2, 140	3, 230	2, 590	3, 460	2, 890
Civil Works (Penstock, Power Station)	3, 110	2, 860	3, 320	3, 120	1, 460	1, 430	1, 600	1, 480	1, 670	1, 560	1, 910	1, 830
2) Sub-Total	6, 360	5, 250	6, 760	5, 790	4, 060	3, 230	4, 420	3, 620	4, 900	4, 150	5, 370	4, 720
3) Annual Cost	500	410	530	450	320	250	340	280	380	320	420	370
4) Energy Generated (MWh)	-1, 000	800	1, 700	0	800	500	400	0	500	100	100	0
5) Energy Loss during Inspection (MWh)	-3, 800	-3, 800	-1, 300	-1, 300	-2, 200	-2, 200	-700	-700	-1, 800	-1, 800	-500	-500
6) (4) + (5) (MWh)	-4, 800	-3, 000	-3, 000	-1, 300	-1, 400	-1, 700	-300	-700	1, 300	1, 900	-400	-500
7) Energy Cost	220	140	140	60	60	80	10	30	60	80	20	20
8) Total (3) + (7)	720	550	670	510	380	330	350	310	440	400	440	390

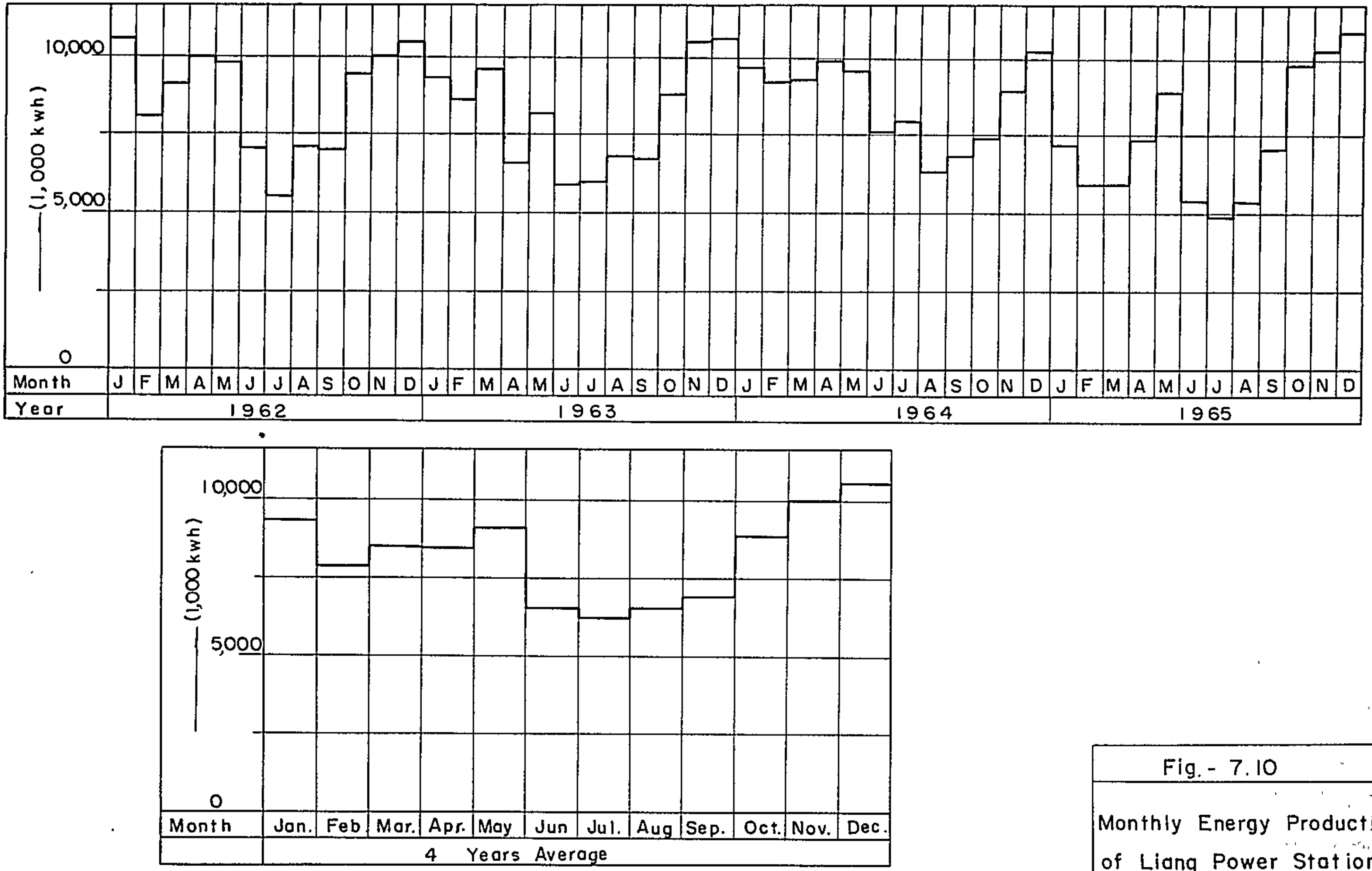
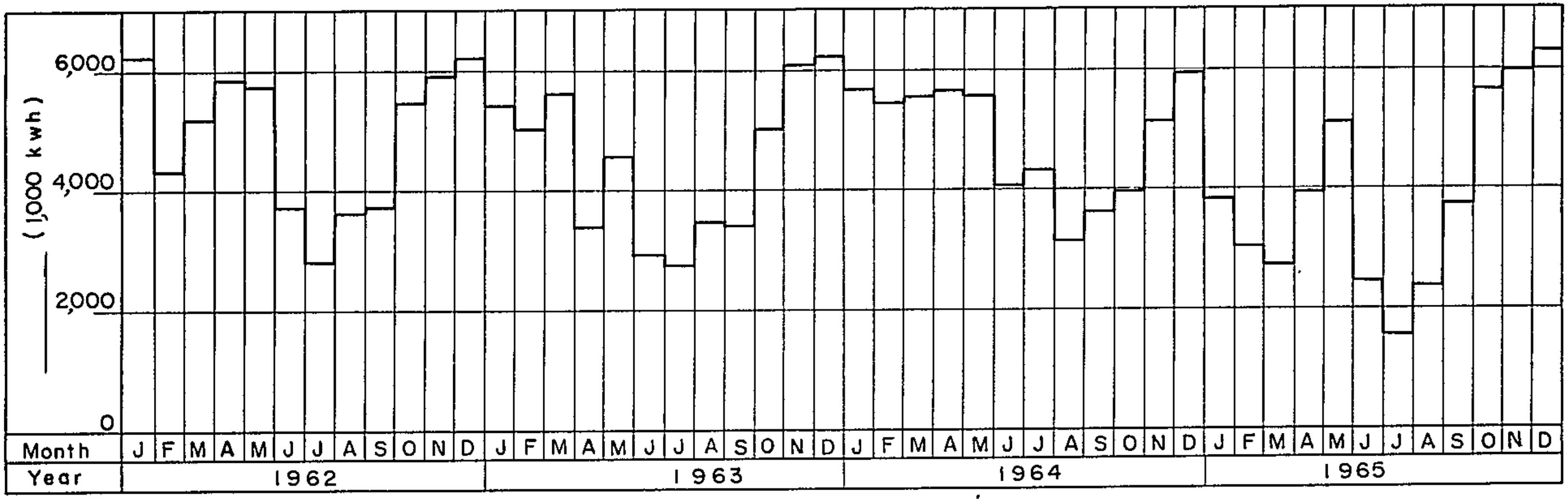


Fig. - 7.10

Monthly Energy Production of Liang Power Station



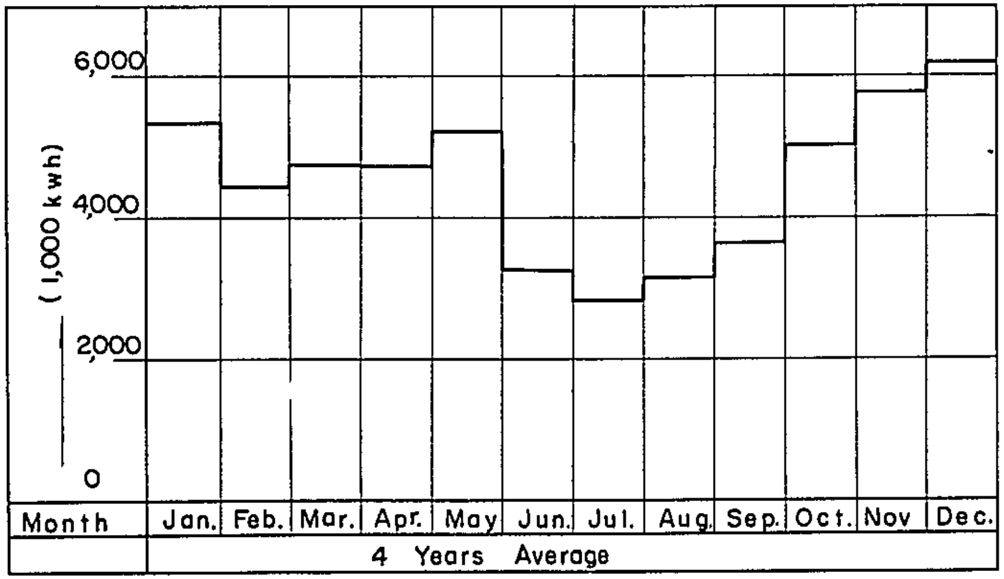
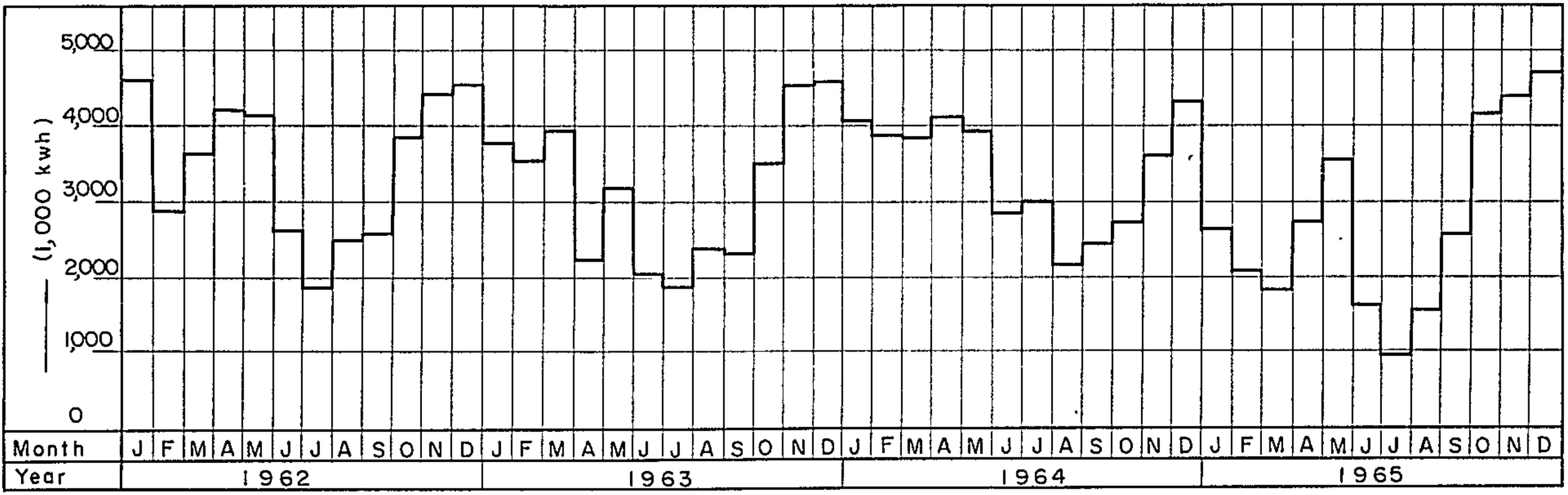


Fig.- 7. 11

Monthly Energy Production of Sia Power Station



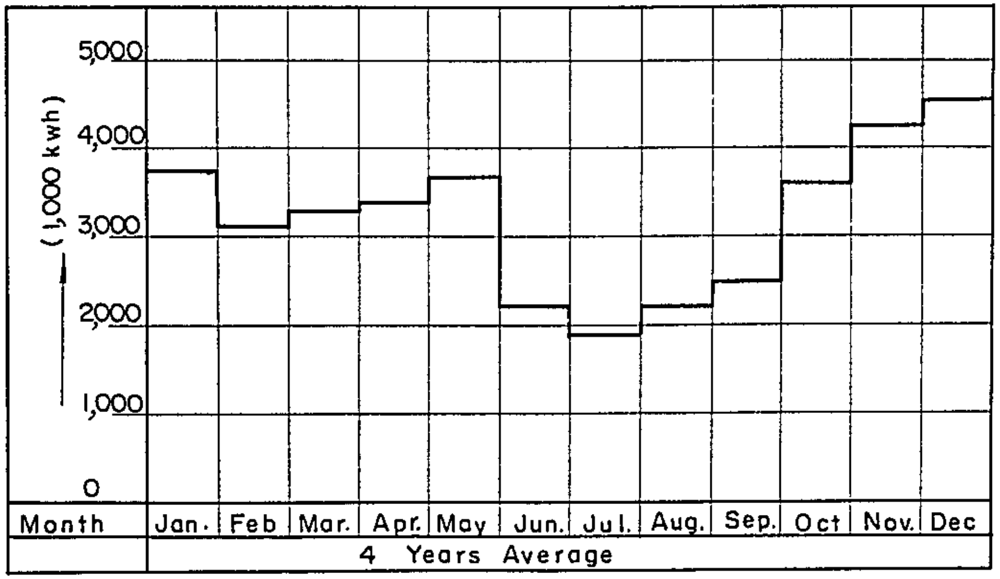


Fig. - 7. 12

Monthly Energy Production of Sempam Power Station.

8. PRELIMINARY DESIGN

8.1 DESIGN

8.1.1 Civil Structures

a) Diversion Dams

All of the diversion dams will be concrete structures. The dams at Liang and Sia can be constructed without difficulty on bedrock because the gravel deposits on the river bed at the dam sites are estimated to be comparatively thin. It is, however, considered to be more economical to construct the dams at Sempam and Hijau on gravel strata instead of on bedrock because the gravel deposits at the two sites are estimated to be fairly deep. In the latter case, concrete cut-off walls are to be constructed in order to prevent seepage of water. Cut-off walls will also be constructed in the weathered overburden and/or gravel deposit on both abutments of the dams.

It will be necessary to confirm the depth of the bedrock by means of drilling before the final designs of the dams are determined, as gravel deposits on river beds at the dam sites are assumed to be deep.

b) Intakes and Desilting Basins

As surveillance of the dam, intake and desilting basin by the custodian is considered possible at all times, the intake at Liang will be located directly upstream of and adjacent to the dam, and its structure shall be such that sediment deposited in front of the intake can be removed by a sand flash gate in order that there will be a unobstructed flow of water into the intake.

The intakes at Sia and Sempam are designed on the dam crest so that there will be a unobstructed flow of water into the intake even if deposition of sediment takes place at the upstream side of the dams, as custodians are not expected to be stationed there all of the time. Trash racks will be installed at the intakes to prevent the inflow of debris into the headrace.

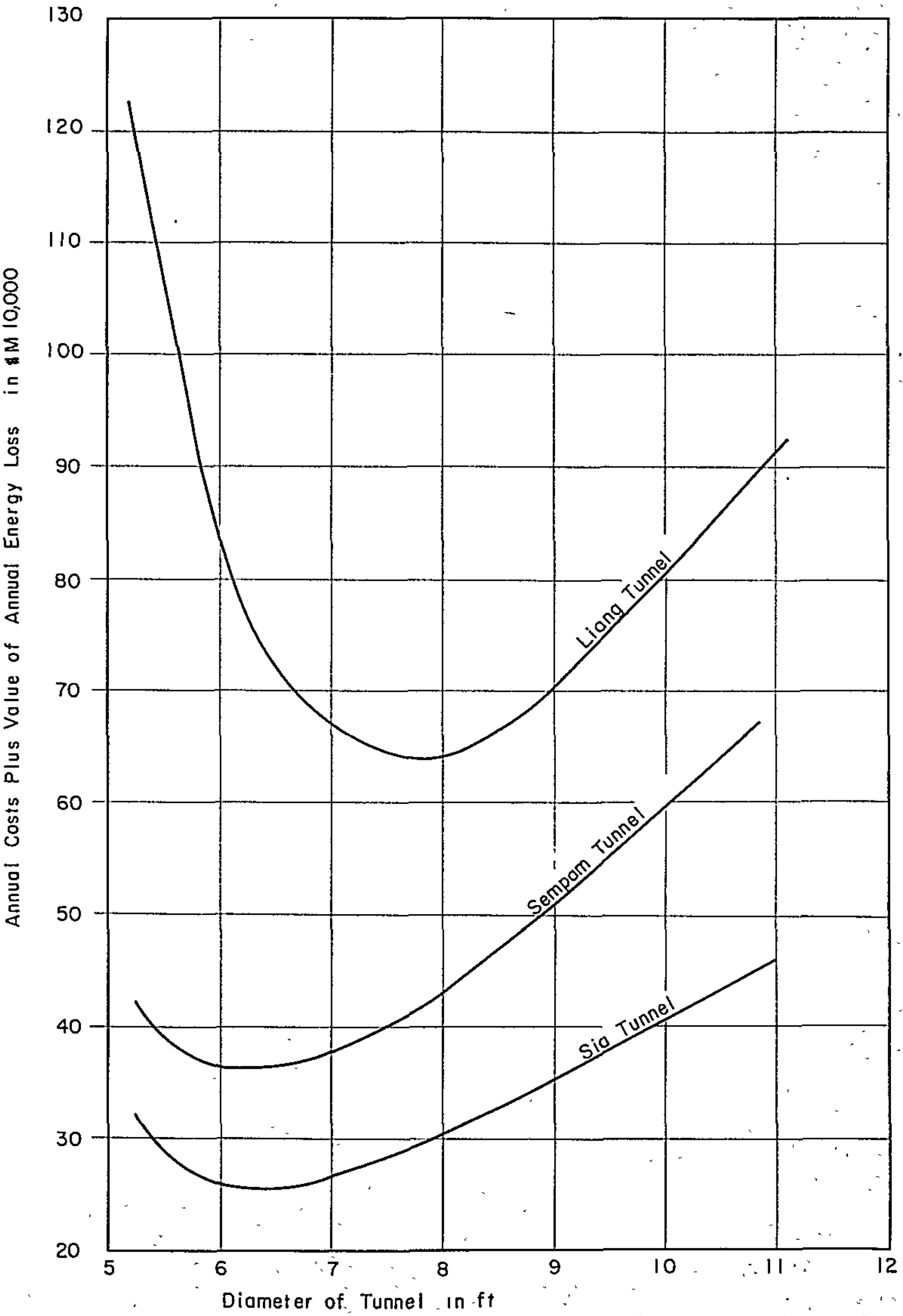
As a great amount of sediment is carried down by all of the rivers, desilting basins will be constructed with adequate capacity to ensure settling of sediment in order to prevent the inflow of sand into the headrace tunnel causing harmful effects on penstocks and turbines. The desilting basins will be of double chamber construction to enable flushing of sand without stopping the power generation.

c) Headrace Tunnels

Except for the branch waterway from Hijau, headraces of all power stations will be pressure tunnels. In selecting the optimum diameters of pressure tunnels, the annual costs and annual energy losses were calculated for various diameters, and the diameters producing the minimum costs were adopted. However, at Sia and Sempam, the minimum diameters which can be excavated effectively by use of conventional machinery are larger than the diameters determined in the manner above mentioned and, therefore, larger diameters were adopted. The results of study are shown in Fig. 8.1.

The cross-sections of all of the tunnels are of horseshoe shape. The main reason for selecting this shape is to facilitate their construction without decreasing conveyance capacity.

Fig.- 8. I. Economical Diameters of Pressure Tunnels



The sections at the entrances of tunnels and at places where rock is not sound due to faults, etc. are designed to be concrete lined. In places other than the sections mentioned above where rock is sound, guniting will be applied throughout the entire distance in order to minimize roughness of cross-sections of the tunnels, and the invert will be lined with concrete.

d) Surge Tanks

The surge tanks will be circular shafts. If a long shaft has to be excavated because of deep overburden, this can be avoided by constructing an access adit from which the shaft could be excavated without penetrating to the ground surface. This method would be economical and would facilitate construction. The surge tank for the Liang Power Station will require a feature to combine the water diverted from the Hijau River. A simple type surge tank is adopted for all power stations. However, a study is advised in order to select the most economical of the various types of surge tanks at the stage of final design, taking into consideration the influences that water hammering have on the cost of penstocks, turbines and generators. In order to prevent instability of surrounding rock due to leakage from the surge tanks, the problem of whether or not to line the shaft with steel plates should be determined after ascertaining the characteristics of the rock surrounding the tanks.

e) Penstocks

The penstocks will be installed above ground on the mountain slopes, except for the connecting sections to the surge tanks and to the power houses. Penstock installed inside a tunnel is obviously disadvantageous from the economic point of view. The diameter of the penstocks was selected after examining the economic factors in the same manner as in the headrace tunnels. The diameters selected are 6 ft. tapering to 4 ft. 3 in. for Liang, 5 ft. tapering to 3 ft. 8 in. for Sia; and 4 ft. 7 in. tapering to 3 ft. 3 in. for Sempam. The penstocks will be aligned on a straight profile and the slopes cut to prepare the ground for the pipes. The cut surfaces will be sodded to prevent sliding and drain ditches will be constructed. Saddles to support the steel pipes will be constructed at suitable spacing on ground with adequate bearing strength obtained by excavating the foundation to appropriate depth depending upon the condition of the soil.

The penstock for Liang crosses the river before it connects to the powerhouse. Although a culvert is adopted for this section, a pipe-line-bridge across the river can be considered.

f) Powerhouse

All of the powerhouses shall be semi-underground structures. Offices and control rooms will be placed above ground. Turbines and generators, however, will be set comparatively deep below the ground surface, in order to construct the foundation on bedrock. As the water levels at the powerhouse sites at times of flood may be fairly high, coffering and care of river during construction of powerhouses should be carefully planned.

The depths of bedrock from the river bed should be confirmed, and geological surveys should be made by drilling in order to determine the final design of the powerhouses. If the bedrock line is much deeper than present estimates, an examination should be made from the economic point of view to see whether or not a more effective utilization of head is possible by lowering the center of generators.

g) Tailraces

At Sia Power Station, the water released from the turbines is discharged directly into the natural bed of the Sia River. At the Liang and Sempam Power Stations, the water released from the turbines will be discharged into the rivers through tailrace tunnels. The tailrace tunnels at both power stations will be non-pressure tunnels and will be concrete-lined throughout their whole length as it is assumed that they will not penetrate through sound rock.

8.1.2 Turbines and Generators

The Liang powerhouse building is a semi-underground structure. If horizontal Francis turbines are adopted, a large floor space will be required and consequently the volume of excavation will be great. Therefore, it is obviously disadvantageous. For these reasons, vertical Francis turbines will be adopted. The turbines of the Sia and Sempam Power Stations will be high-speed small-capacity machines, and horizontal Francis turbines are adopted as they are more convenient for operation and maintenance compared with the vertical machine.

Generators are to be of three phase, enclosed hood, air circulation type and the one-man control system will be adopted.

Power from Liang and Sia Power Stations will be transmitted by 66 KV lines to the connecting transformer at Sempam Power Station from where the power will be transmitted to the Central Network by a 132 KV line, on the other hand, power will also be transmitted to Raub by the existing 11 KV line through 11/3.3 KV transformer at Sempam Power Station, where provision will be made for future addition of transformer and outgoing lines corresponding to growth of local demand.

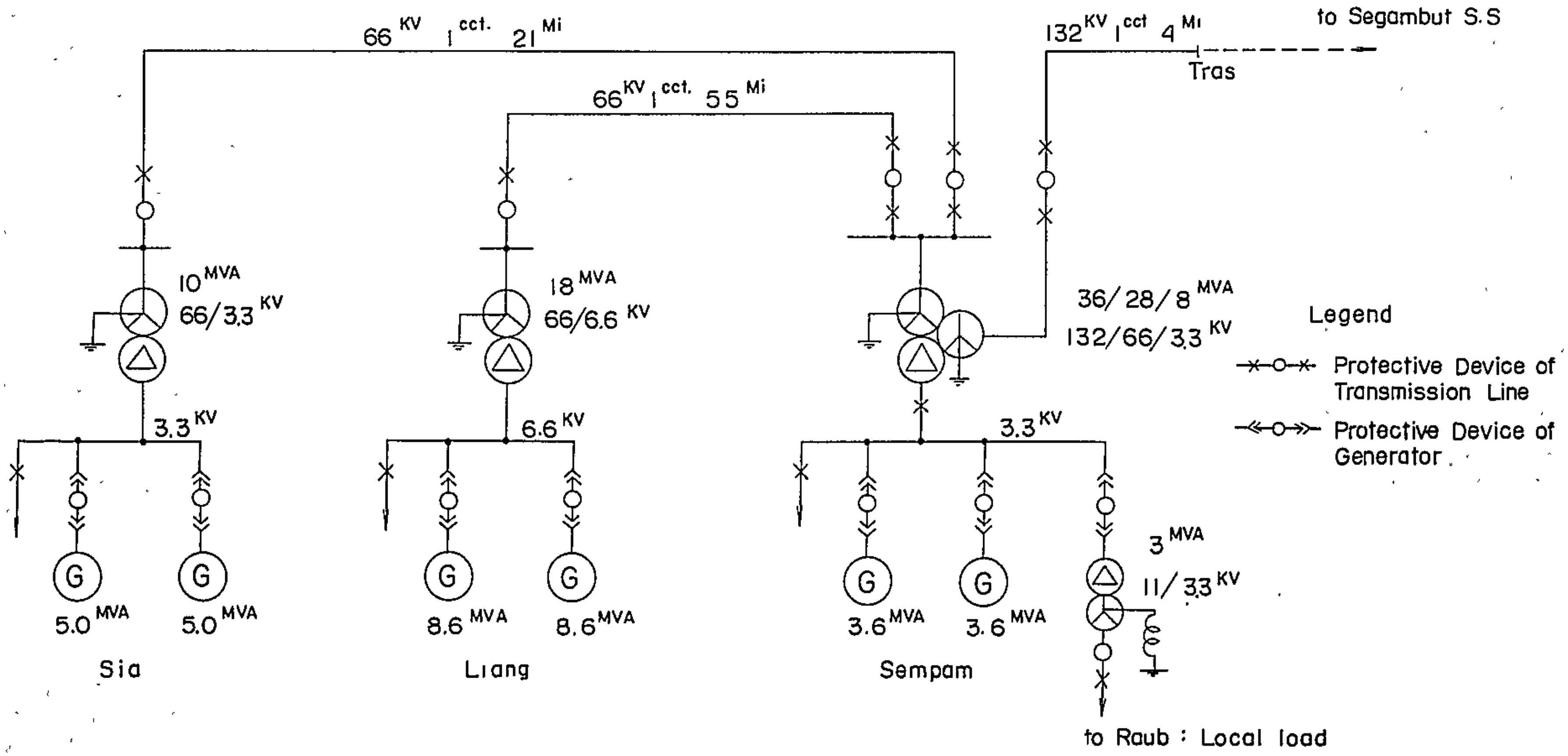
Liang and Sia Power Stations will respectively be equipped with 1 unit each of 18 MVA and 10 MVA outdoor type, three-phase, oil-immersed, self-cooling type transformers. Sempam Power Station will be equipped with a single phase, oil-immersed, air-cooled type transformer with tertiary winding as shown in Fig. 8.2.

8.1.3 Transmission Lines

a) 66 KV Transmission Lines

The conductor for the 66 KV transmission lines from Sia Power Station to Sempam Power Station and from Liang Power Station to Sempam Power Station will be 58 mm sq. ACSR which has been selected as being most suitable both technically and economically, in view of electrical characteristics such as power to be transmitted, voltage drops, power losses etc., and of mechanical characteristics such as stress in conductor due to loads thereon.
The system will be directly grounded and the size of switching surges is estimated to be 2.8 times the normal peak value of line to ground voltage. Four 10 in. x 5-3/4 in. standard suspension insulator discs per string are to be used. As the frequency of lightning is expected to be fairly high in this area, a 38 mm sq. GSC overhead ground wire will be installed for shielding effect, and at the same time counter poise wire will be attached to the foot of towers to reduce ground resistance.
For the transmission line between Sia and Sempam Power Stations, steel poles with guy wires will be used and steel towers between Liang and Sempam Power Stations.

Fig.-8.2. Single Line Diagram of Raub Scheme



b) 132 KV Transmission Line

The 132 KV transmission line between Sempam Power Station and Tras will be directly connected to the same voltage line which NEB is planning to constructed between Tras and Segambut. The conductor will be 160 mm sq. ACSR which is the size that NEB is going to adopt for the line it is proposing to construct. This 132 KV system will be directly grounded. Assuming the value of switching surges to be the same as that estimated for the 66 KV system, one insulator string will consist of 8 discs of 10 in. x 5 3/4 in. standard suspension insulators.
A line of 38 mm sq. GSC overhead ground wire will be strung with counter poise wire at the foot of towers in order to increase anti-lightning characterstics.

8.1.4 General Features of Structures

General features of Liang, Sia and Sempam Power Stations and of transmission lines are as follows:

a) Liang Power Station

Civil Structures

Diversion Dam (Liang)	Concrete gravity type	
	Length of dam crest:	290 ft.
	Height (foundation to overflow crest):	27 ft.
	Concrete Volume:	6,900 c.y.
Diversion Dam (Hijau)	Concrete gravity type	
	Length of dam crest:	200 ft.
	Height:	20 ft.
	Concrete Volume:	5,200 c.y.

Intake (Liang)	Reinforced concrete structure	
	Maximum discharge	220 cfs
Intake (Hijau)	Maximum discharge:	30 cfs
Desilting Basin (Liang)	Double chamber type	
	Effective capacity:	620 c.y.
Desilting Basin (Hijau)	Double chamber type	
	Effective capacity:	100 c.y.
Headrace (Liang)	Pressure tunnel	
	Length:	21, 800 ft.
	Shape:	Horseshoe
	Inside diameter:	8' -0"
	Maximum discharge:	220 cfs
Headrace (Hijau)	Non-pressure tunnel	
	Length:	5, 100 ft.
	Shape:	Horseshoe
	Inside diameter:	6' -10"
	Maximum discharge:	30 cfs
Surge Tank	Simple type	
	Inside diameter:	20 ft.
	Height:	90 ft.
Penstock	Welded steel, ring-girder type	
	Length:	2, 400 ft.
	Number of Lines: (Branching into 2 near the powerhouse)	1
	Inside diameter:	
	Single section;	6' -0" ~ 4' -3"
	Double section;	2' -4"
Powerhouse	Semi-underground type, reinforced concrete structure	

Tailrace	Non-pressure tunnel	
	Length:	380 ft.
	Shape:	Horseshoe
	Inside diameter:	7' -10"
	Maximum Discharge:	250 cfs
Electrical Equipment		
Turbine	Type: Vertical shaft Francis type	
	Number of units:	2
	Output:	7, 600 KW
	Maximum discharge:	125 cfs x 2
	Revolutions:	1, 000 rpm
Generator	Type: Vertical shaft, enclosed hood, air circulation type	
	Number of units:	2
	Capacity:	8, 600 KVA
	Frequency:	50 c/s
Transformer	Type: Three-phase, oil-immersed self-cooling, outdoor type	
	Capacity:	18 MVA
	Voltage:	66/6. 6 KV
	Number of units:	1
Outdoor Switchyard	Transmission voltage:	66 KV
	Number of outgoing circuit:	1
Sia Power Station		
Civil Structures		
Diversion Dam	Concrete gravity type	
	Length of dam crest:	300 ft.
	Height:	54 ft.

	Concrete Voume:	13, 800 c.y.
Intake	Dam crest intake type	160 cfs
	Maximum discharge	
Desilting Basin	Double chamber type	
	Effective capacity:	460 c.y.
Headrace	Pressure tunnel	
	Length:	11, 100 ft.
	Shape:	Horseshoe
	Inside diameter:	6' -10"
	Maximum discharge:	160 cfs.
Surge Tank	Simple type	
	Inside diameter:	17 ft.
	Height:	72 ft.
Penstock	Welded steel, ring-girder type	
	Length:	2, 900 ft.
	Number of lines: (Branching into 2 near the powerhouse)	1
	Inside diameter:	
	Single section:	5' -0" ~ 3'-8"
	Double section:	2'-0"
Powerhouse	Semi-underground type, reinforced concrete structure	
Tailrace	Open channel	
	Length:	100 ft.
	Maximum discharge:	160 cfs
Electrical Equipment		
Turbine	Type: Horizontal shaft, Francis type	
	Number of units:	2
	Output:	4, 400 KW

	Maximum discharge:	80 cfs x 2
	Revolutions:	1,000 rpm
Generator	Type: Horinzontal shaft, enclosed hood, air circulation type	
	Number of units:	2
	Capacity:	5,000 KVA
	Voltage:	3.3 KV
	Frequency:	50 c/s
Transformer	Type: Three-phase, oil-immersed, selfcooling, outdoor type	
	Capacity:	10 MVA
	Voltage:	66/3.3 KV
	Number of units:	1
Outdoor Switchyard	Transmission voltage:	66 KV
	Number of outgoing circuit:	1
Sempam Power Station		
Civil Structures		
Diversion Dam	Concrete gravity type	
	Length of dam crest:	290 ft.
	Height:	30 ft.
	Concrete Volume:	9,400 c.y.
Intake	Dam crest intake type	
	Maximum discharge	130 cfs
Desilting Basin	Double chamber type	
	Effective volume:	400 c.y.
Headrace	Pressure tunnel	
	Length:	16,000 ft.
	Shape:	Horseshoe
	Inside diameter:	6' -10"

	Maximum discharge:	130 cfs
Surge Tank	Simple type	
	Inside diameter:	17 ft.
	Height:	75 ft.
Penstock	Welded steel, ring-girder type	
	Length:	1, 530 ft.
	Number of lines: (Branching into 2 near the 1 powerhouse)	
	Inside diameter:	
	Single section:	4'-7"(-) 3' - 3"
	Double section:	1' - 8"
Powerhouse	Semi-underground type, reinforced concrete structure	
Tailrace	Non-pressure tunnel	
	Length:	260 ft.
	Shape:	Horseshoe
	Inside diameter:	5' - 8"
	Maximum discharge:	130 cfs
Electrical Equipment		
Turbine	Type: Horizontal shaft, Francis type	
	Number of units:	2
	Output:	3, 300 KW
	Maximum discharge:	65 cfs x 2
	Revolutions:	1, 000 rpm
Generator	Type: Horizontal shaft, enclosed hood, air circulation type	
	Number of units:	2
	Capacity:	3, 000 KVA
	Frequency:	50 c/s

Transformer

Type: Outdoor type, single-phase, forced oil, air cooled, with tertiary winding

Capacity: 36/28/8 MVA

Voltage: 132/66/3.3 KV

Number of units: 4 (Spare: 1)

Outdoor Switchyard

Transmission voltage: 66 KV/132 KV

Number of outgoing circuits: 2/1

d) Transmission Lines

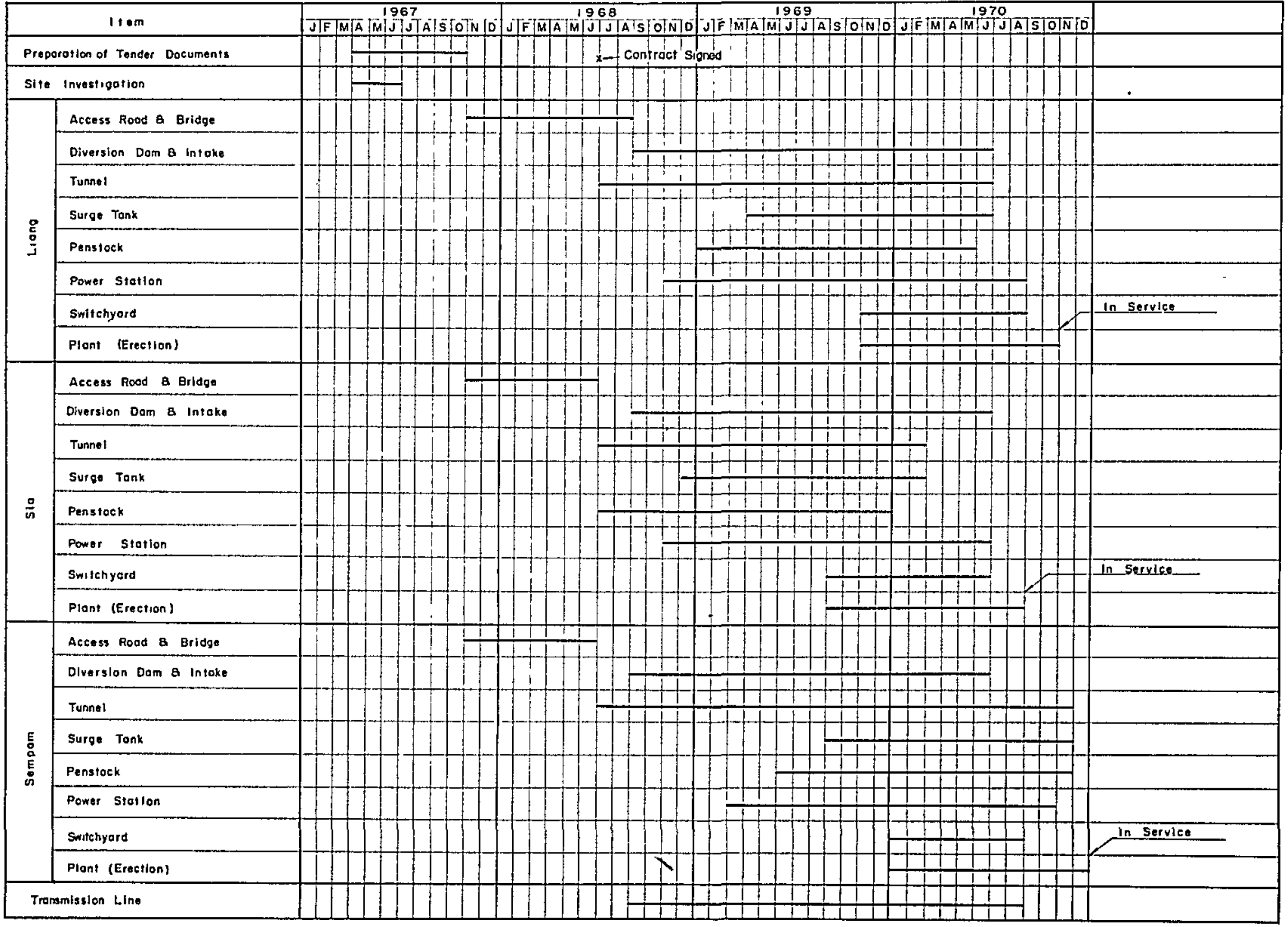
	Sia P.S. - Sempam P.S.	Liang P.S. - Sempam P.S.	Sempam P.S. - Tras
Length (Miles)	11	5.5	4
Voltage (KV)	66	66	132
Circuits	1	1	1
Conductor	58□ ACSR	58□ ACSR	160□ ACSR
Insulator			
Type	15,000 lb.	15,000 lb.	25,000 lb.
	10" x 5-3/4"	10" x 5-3/4"	10" x 5-3/4"
Quantity	4	4	8
Support	Steel pole	Steel tower	Steel tower

8.2 CONSTRUCTION SCHEDULE AND CONSTRUCTION METHODS

8.2.1 Construction Schedule

Should the main construction works of the Raub Hydroelectric Development Scheme be started in July 1968, the three power stations of the Scheme will be completed in succession in the latter part of 1970. Taking into consideration the construction methods and quantities of work described in paragraph 8.2.2, an optimum construction schedule which will require the minimum capital expenditure, including interest during construction, was studied.

Fig - 8.3 Construction Schedule



The construction schedule proposed, as a result of the study, is given in Fig. 8.3.

Construction periods for Liang, Sia and Sempam Power Stations are 28, 26 and 30 months respectively. These construction periods will be greatly influenced by the construction of tunnels, but the construction schedule can be maintained by providing access adits at appropriate places to enable simultaneous excavation of the tunnels from several faces.

It is estimated that approximately one year and a half will be required for the preparation of final designs and until the award of construction contracts. Therefore, the definite study must be started in April 1967 in order that the power stations are ready for operation in the latter part of 1970. To meet this schedule, the road construction work, mainly improvement of the existing logging roads should be completed by June 1968.

8.2.2 Method of Construction

a) Construction Road, Camps and Power

Construction materials and equipment will be transported over the highway from Kuala Lumpur to Raub. There are logging roads, 10 ft wide, passing the sites of the Liang and Sia Power Stations. These roads branch off from the highway connecting Raub and Kg. S. Chin, north-northeast of Raub. A new access road will have to be constructed to reach the Sia intake site. There is a road to the existing Sempam Power Station, and a logging road leading to the Sempam Intake site.

Prior to the main works, these logging roads should be widened and improved, and new access roads from the logging roads should be constructed to the power station sites. Temporary roads branching off from these roads should be constructed by contractors as needed. The total distance of the roads in miles will be as follows:

	Liang	Sia	Sempam	Total
New roads	0.6	2.0	0.6	3.2
Improved roads	13.7	3.7	8.4	26.0
Total	14.3	5.9	9.0	29.2

Camps and offices for the consulting engineer should be built in Raub. Camps and other temporary buildings for contractors may also be built near each site as there is sufficient space available. Electric power required for the construction will be between 800 and 1,000 KW. In Raub Town, 1,235 KW of hydro and 898 KW of diesel power generating capacities are available at present. As the maximum load in this district now is between 600 and 700 KW, these facilities are capable of supplying electric power needs for construction uses.

However, in view of the time required and the costs involved to construct the permanent connecting transmission lines from the three power stations to Raub, prior to executing the main works, it has been decided to install required capacities of diesel generating equipment at each construction site.

b) Procurement of Construction Materials and Aggregate

Cement and reinforcing steel required for the scheme will be about 32,000 tons and 2,000 tons respectively, and these can be procured domestically. Steel support required for tunnels will be about 1,200 tons, which will be imported.

The amount of aggregate required will be about 180,000 tons, which will be taken from natural deposits of sand and gravel in the downstream area of the Liang River from the standpoint of quality and quantity. A part of excavated materials from tunnels can also be used. However, before the construction works are started, it will be desirable to make a thorough investigation of river deposit and excavated material.

c) Construction of Main Structures

In the Raub Scheme, the works that are most important and which will control the construction period are the tunnels, the total combined length of which are 48, 800 ft.

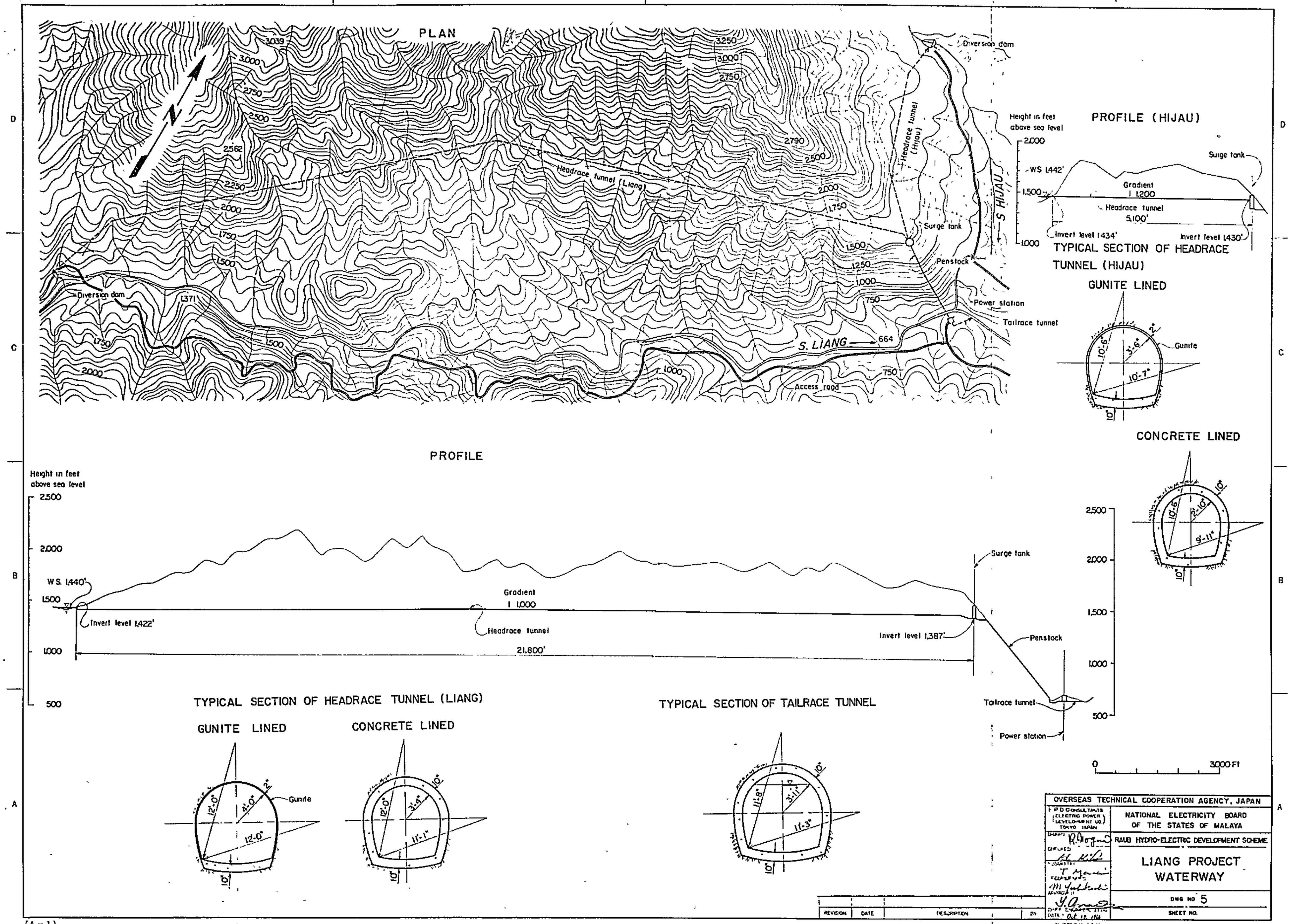
In order to complete the work within the scheduled construction periods, temporary roads should first be built from the above mentioned access roads to the adits before excavation is started.

As most parts of the tunnels are aligned to pass through hard granite, guniting will be executed for the purpose of safety, except around portals where concrete lining will be required.

It is desirable that, as excavation progresses, guniting be executed as a safety precaution.

With regard to surge tanks, the construction should be carried out efficiently in a manner that the top air shaft and the bottom penstock line be excavated first and excavated material be removed from the bottom and then concrete placed from the top of the shaft.

Gates, penstocks and electrical equipments will be installed upon completion of foundation works. These equipments will be landed at Port Swettenham, and hauled to the site by trucks. Installation work of these equipments should be scheduled in an orderly manner to prevent loss of time.



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TOKYO JAPAN

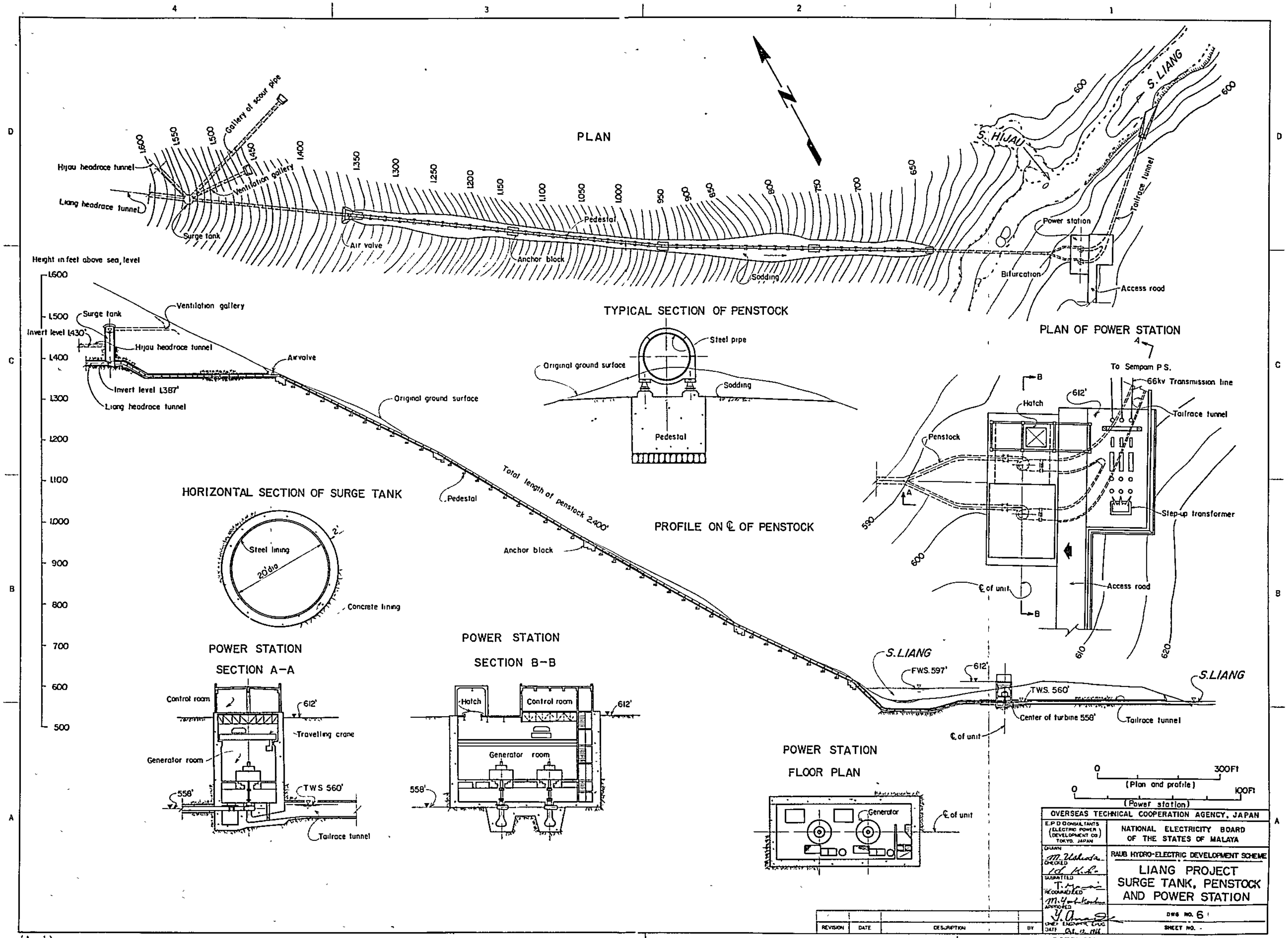
NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

LIANG PROJECT WATERWAY

DRAWN R. Nogami
CHECKED
SUBMITTED T. Yamai
M. Yoshitaki
APPROVED
Y. Amano
CHIEF ENGINEER
DATE Oct. 12, 1961

DWG NO 5
SHEET NO.



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(ELECTRIC POWER DEVELOPMENT CO)
TOKYO, JAPAN

NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

DRAWN M. Uchida
CHECKED
SUBMITTED T.
RECOMMENDED M.
APPROVED Y.
CHIEF ENGINEER, EPDC
DATE Oct. 13, 1966

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

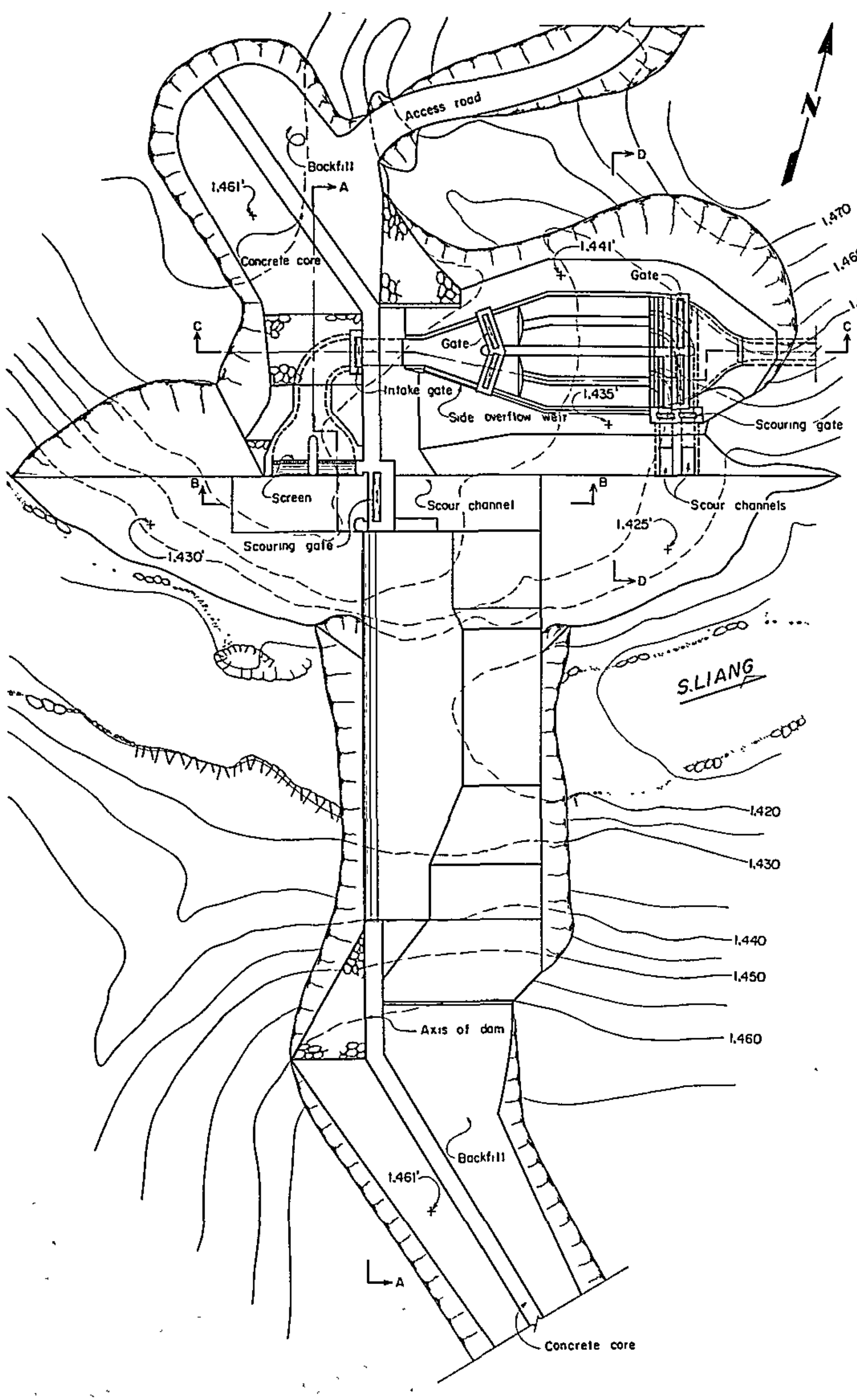
LIANG PROJECT
SURGE TANK, PENSTOCK
AND POWER STATION

DWG NO. 6
SHEET NO. -

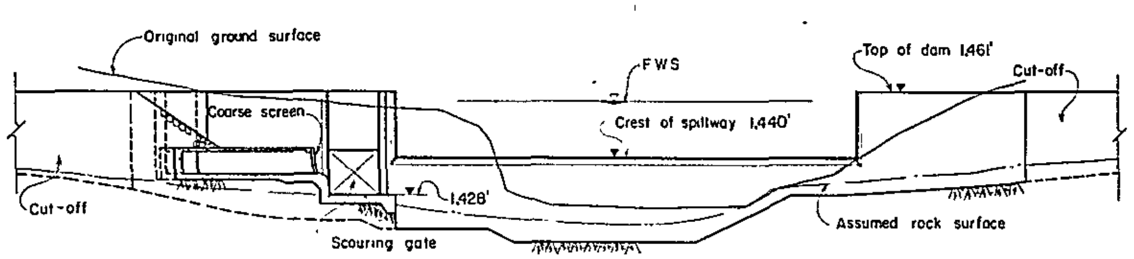
REVISION	DATE	DESCRIPTION	BY

(A-1)

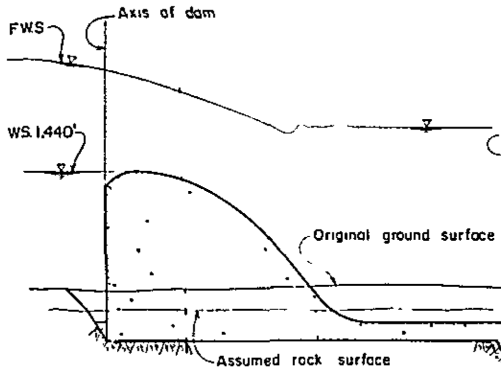
PLAN



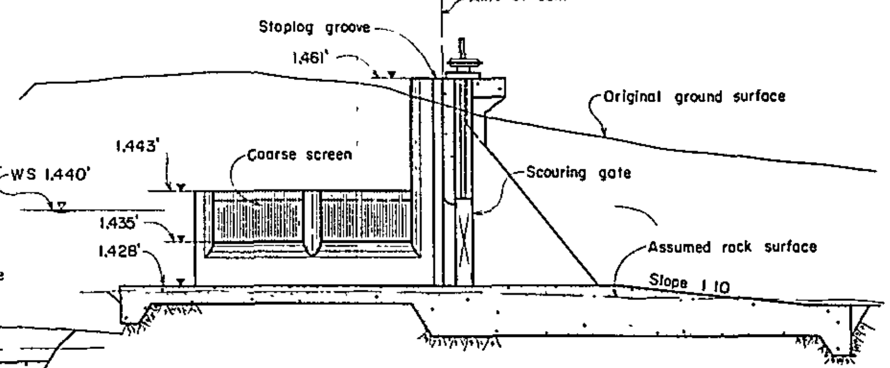
SECTION A-A



TYPICAL SECTION OF SPILLWAY



SECTION B-B



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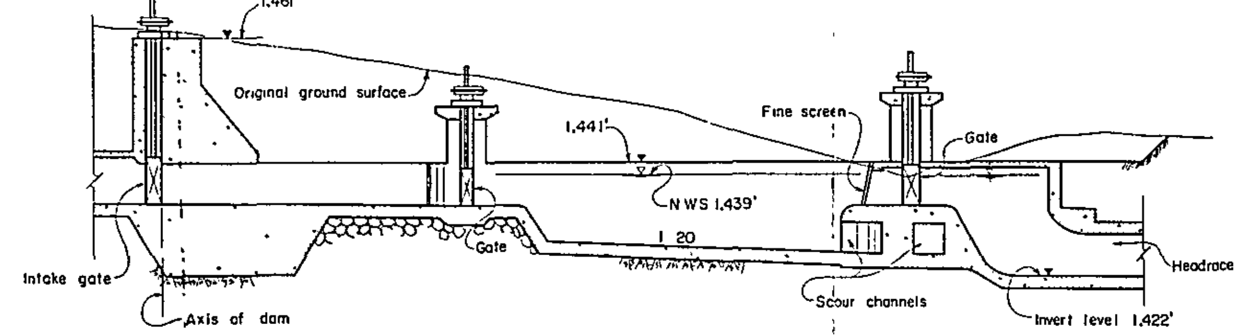

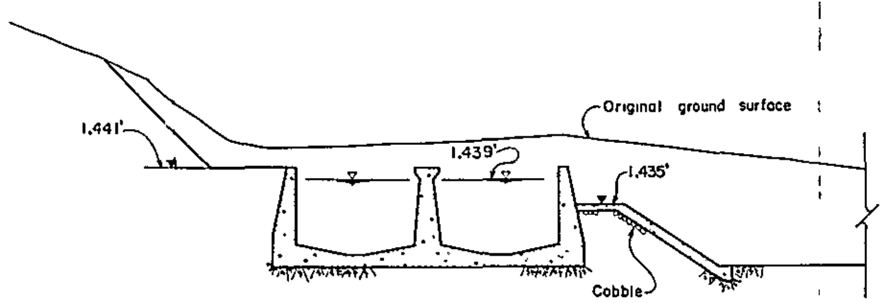

0 100Ft
(Plan, section A-A)

0 50Ft
(Others)

REVISION	DATE	DESCRIPTION	BY

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OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

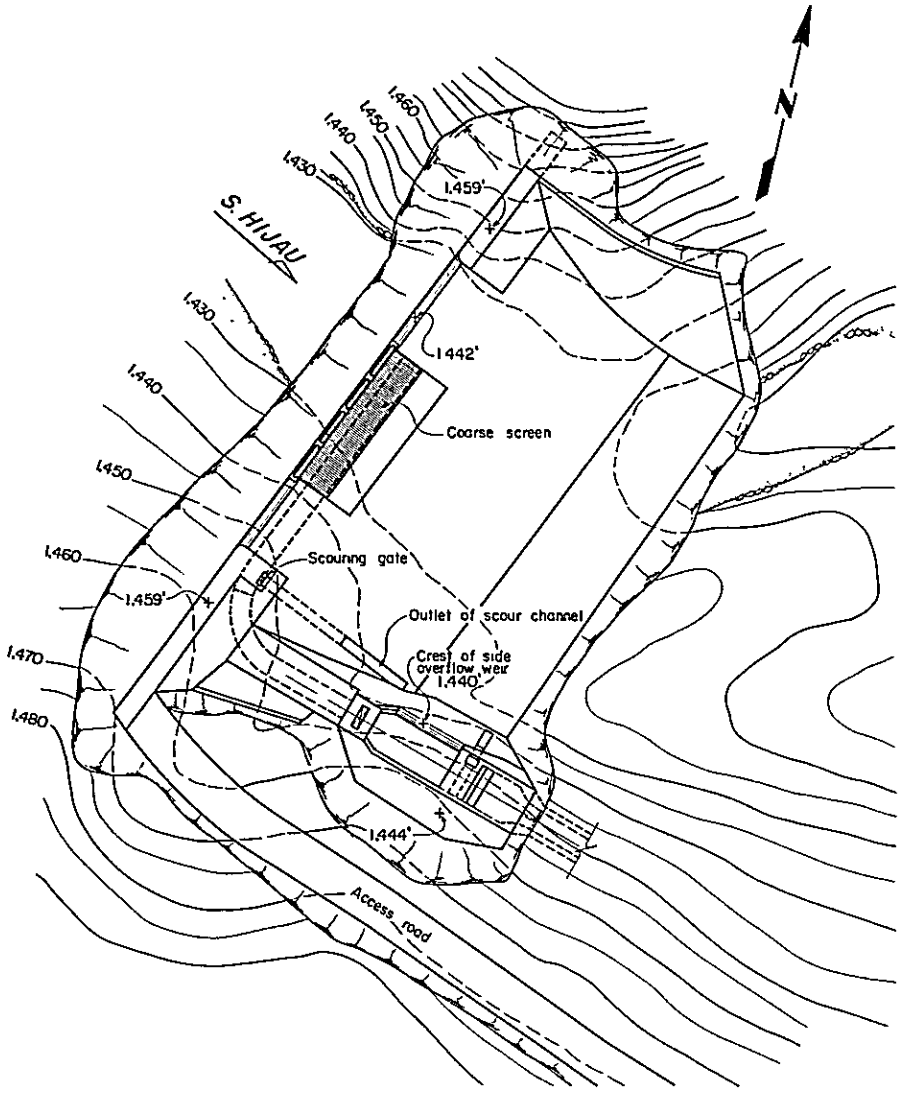
LIANG PROJECT
DIVERSION DAM
AND DESILTING BASIN

DRAWN M. Taga
CHECKED
SUBMITTED T. Mama
RECOMMENDED M. Yoshikoshi
APPROVED Y. A
CHIEF ENGINEER, EPDC
DATE Oct 13, 1966

DWG NO. 7
SHEET NO.

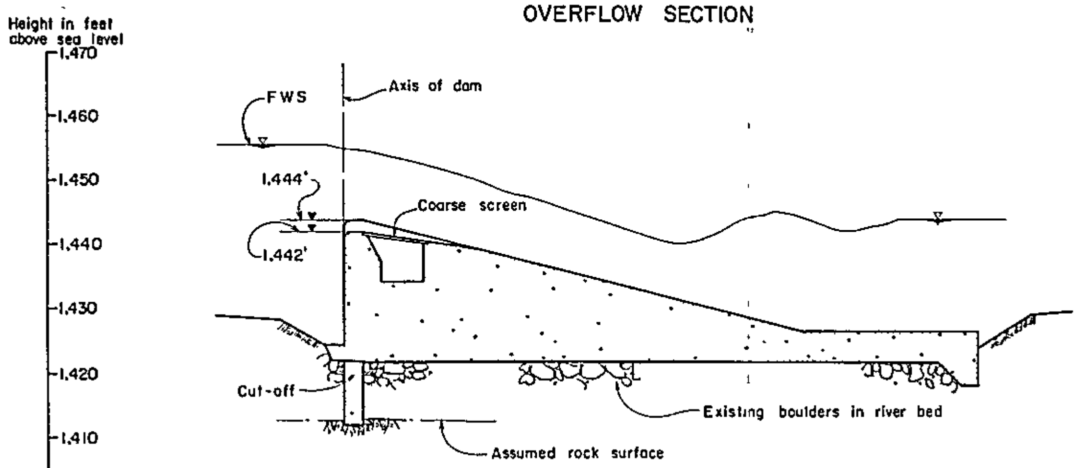
電源開発株式会社
日本国 東京

PLAN

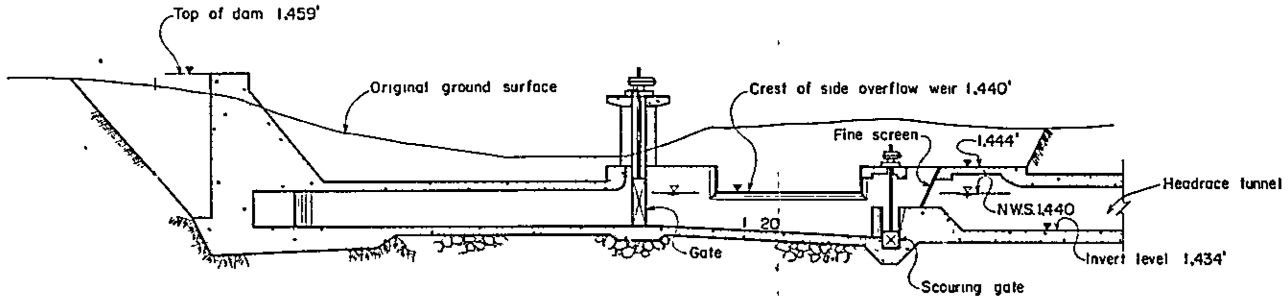


TYPICAL SECTION OF DAM

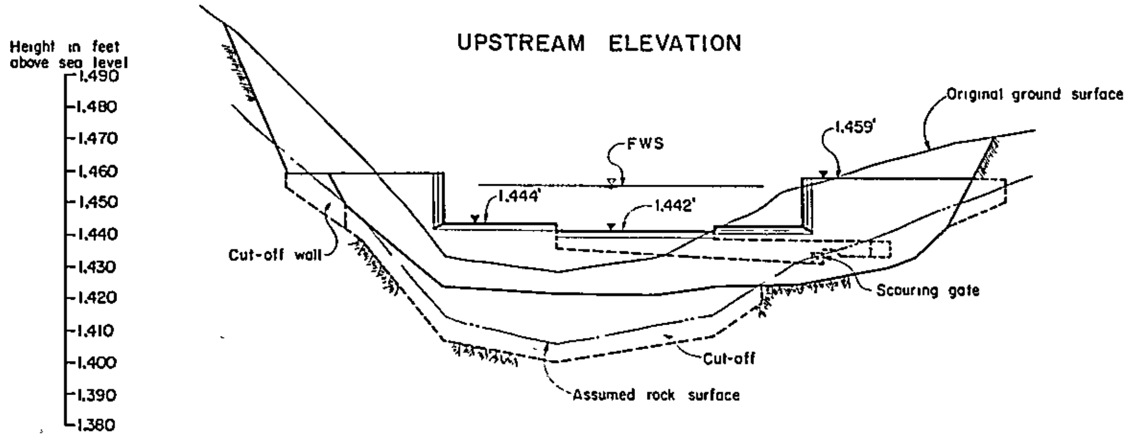
OVERFLOW SECTION



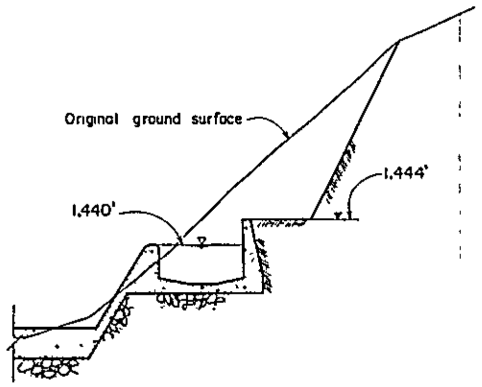
LONGITUDINAL SECTION OF DESILTING BASIN



UPSTREAM ELEVATION



TYPICAL CROSS SECTION OF DESILTING BASIN



0 — 100Ft
(Plan and upstream elevation)

0 — 50Ft
(Typical section of dam and sections of desilting basin)

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TOKYO JAPAN

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DRAWN M. Mizue
CHECKED W. Kibe
SUBMITTED T. Yamai
RECOMMENDED: M Yoshikoshi
APPROVED Y. Amano
CHIEF ENGINEER, EPDC
DATE Oct. 12, 1966

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

LIANG PROJECT
HIJAU DIVERSION DAM AND DESILTING BASIN

DWG NO. 8
SHEET NO.

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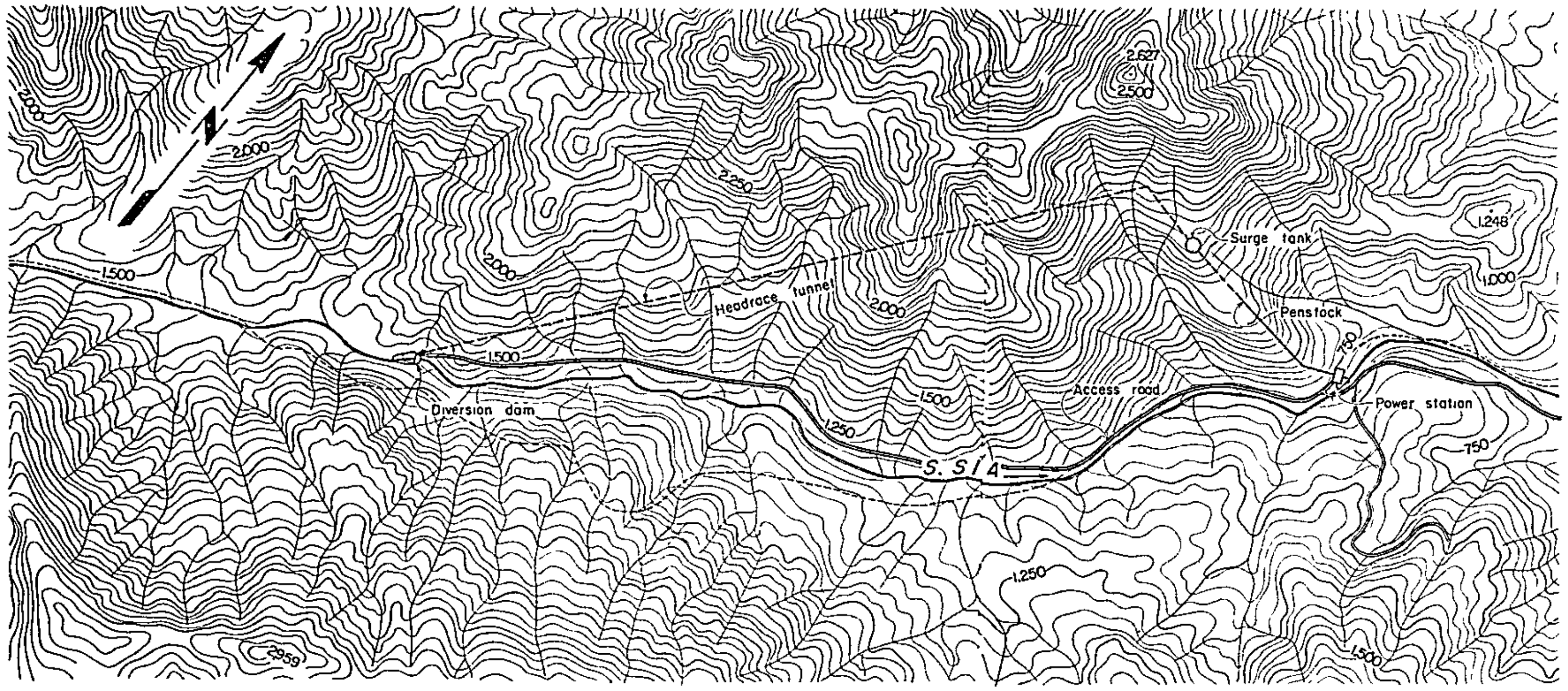
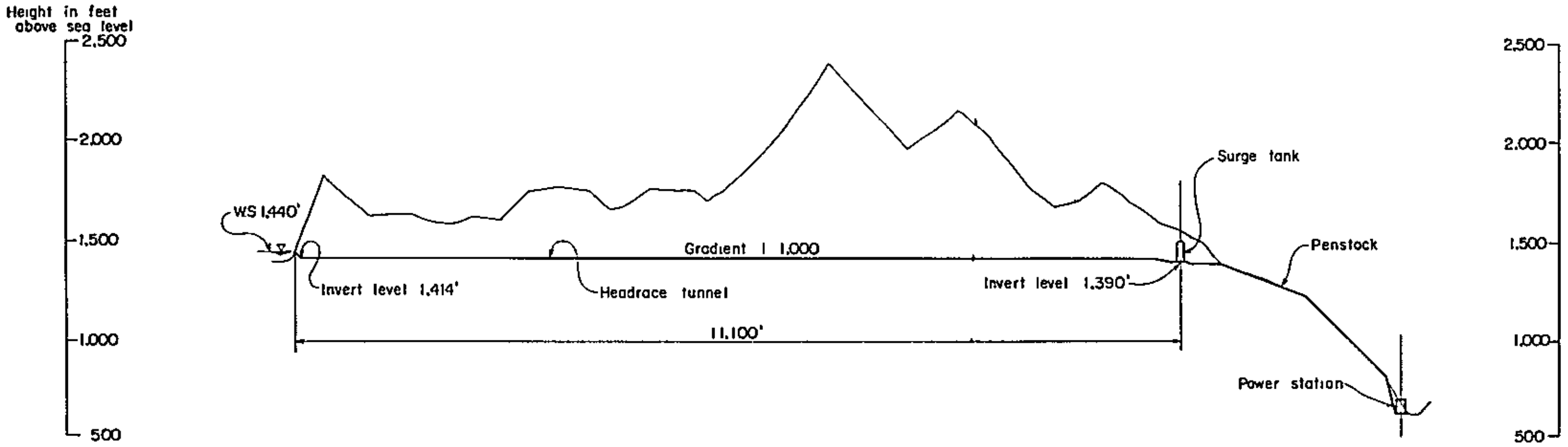
日本国 東京

PLAN

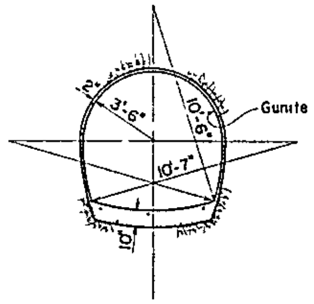


PROFILE

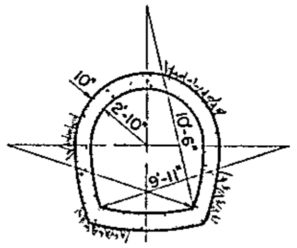


TYPICAL SECTION OF HEADRACE TUNNEL

GUNITE LINED



CONCRETE LINED



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TOKYO JAPAN

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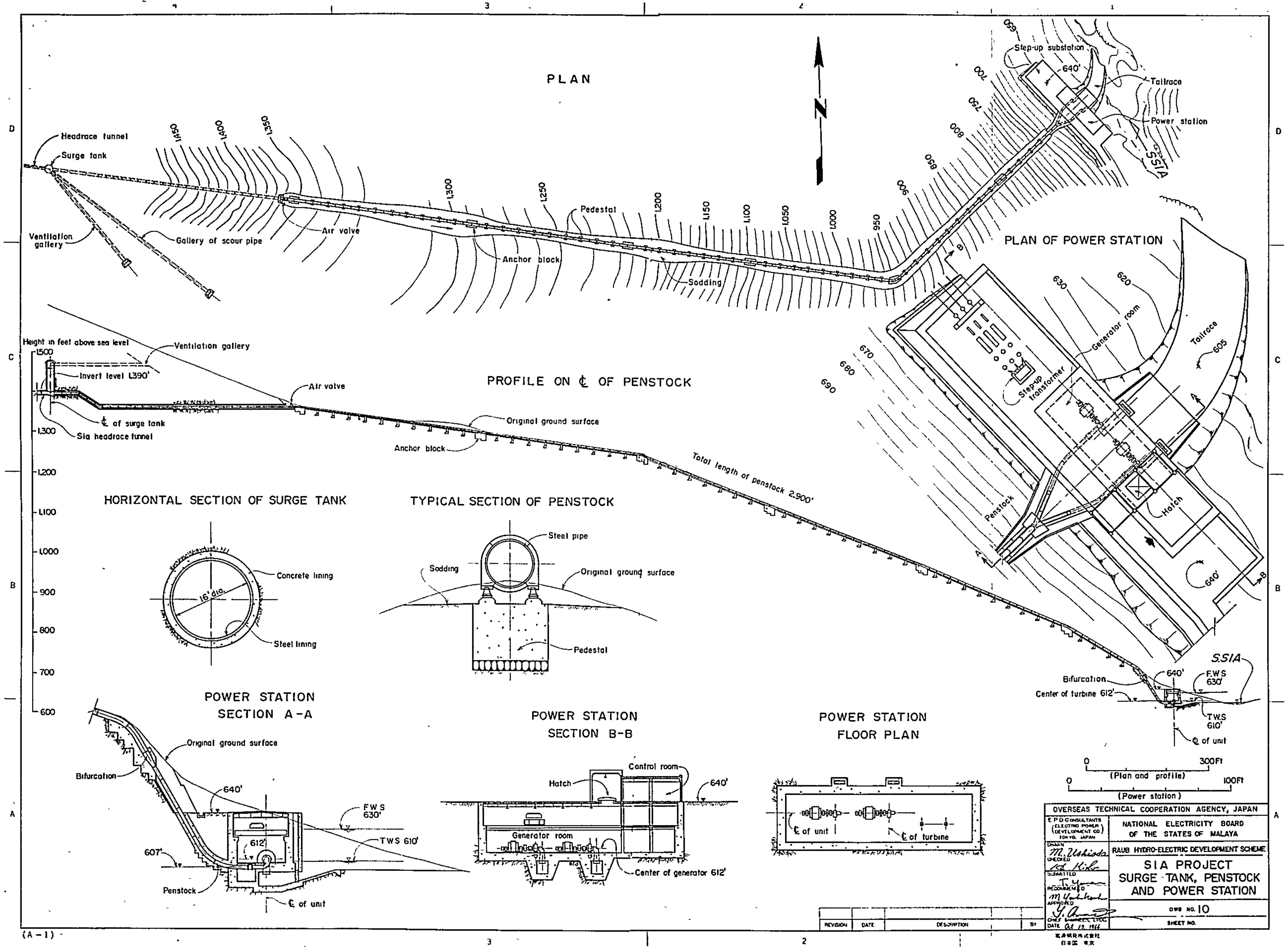
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

DRAWN R Mogami
CHECKED
SUBMITTED T. Yamai
RECOMMENDED M. Yoshikawa
APPROVED Y. Amano
DATE Oct 13, 196

SIA PROJECT
WATERWAY

DWG NO. 9
SHEET NO



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(ELECTRIC POWER DEVELOPMENT CO.)
TOKYO, JAPAN

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OF THE STATES OF MALAYA

DRAWN M. Ushioda
CHECKED
SUBMITTED
RECOMMENDED M Yoshioka
APPROVED
CHIEF ENGINEER, EPDC
DATE Oct 13, 1966

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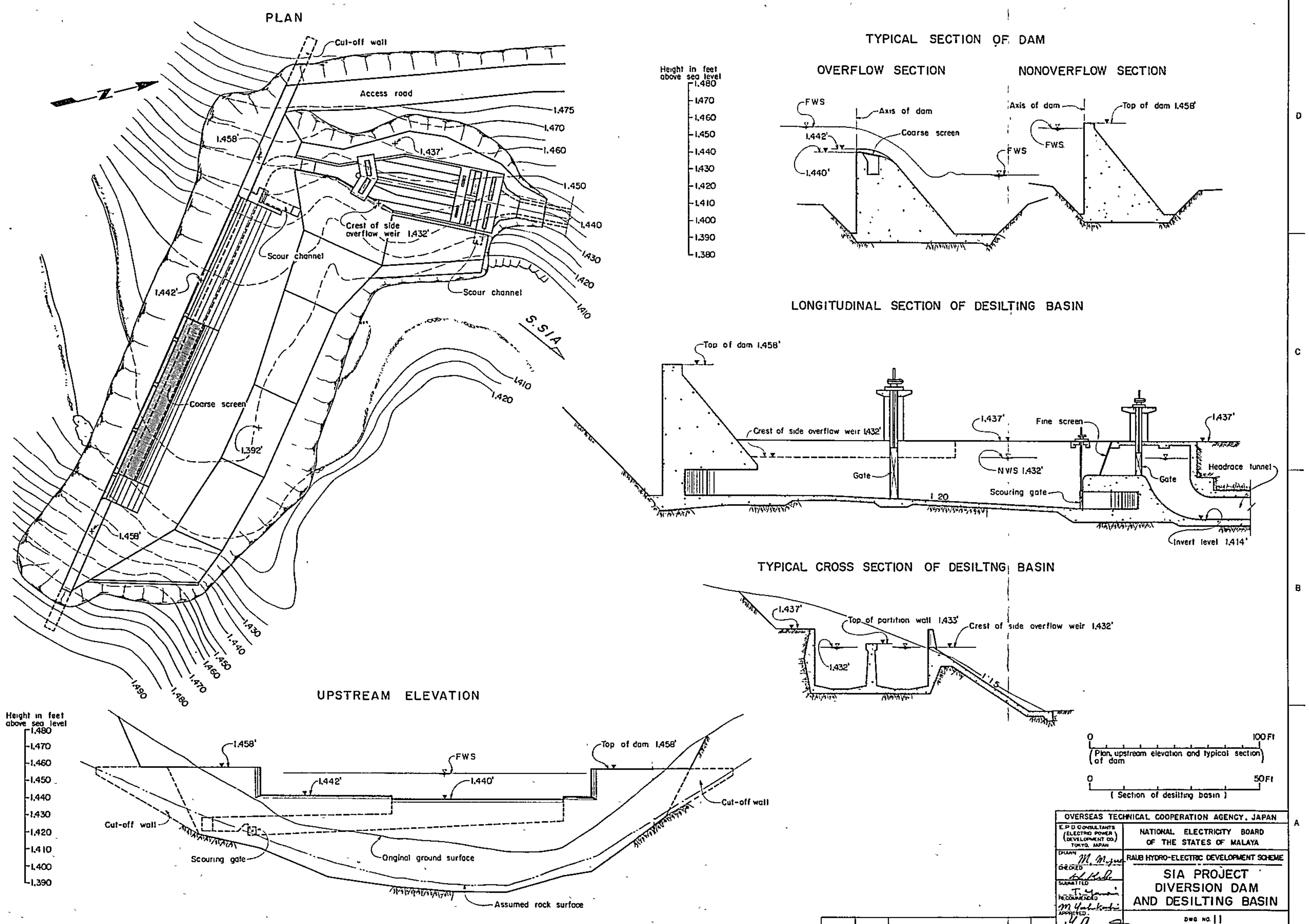
日本国 東京

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

SIA PROJECT
SURGE TANK, PENSTOCK
AND POWER STATION

DWG NO. 10
SHEET NO.



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(ELECTRO POWER DEVELOPMENT CO.)
TOKYO, JAPAN

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OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

SIA PROJECT
DIVERSION DAM
AND DESILTING BASIN

DRAWN M. Mizu
CHECKED
SUBMITTED T. Yama
RECOMMENDED M. Yoshikoshi
APPROVED Y. Ama
CHIEF ENGINEER EPDC
DATE Oct 17 1966

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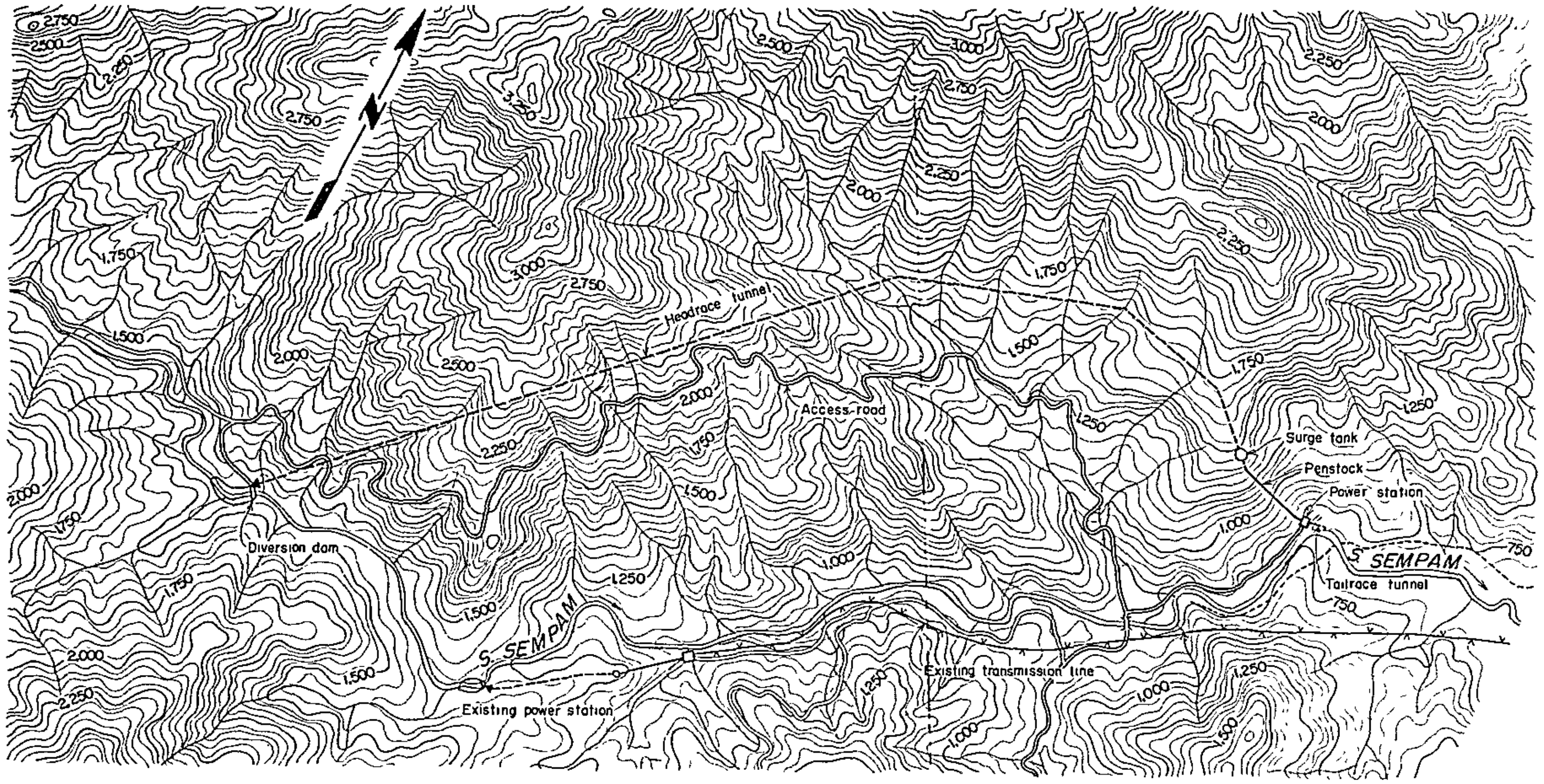
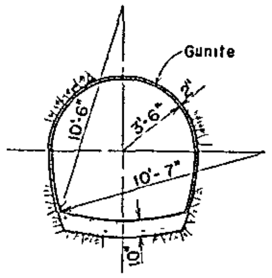
PLAN



TYPICAL SECTION OF HEADRACE AND TAILRACE TUNNEL

GUNITE LINED



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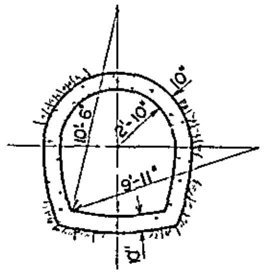
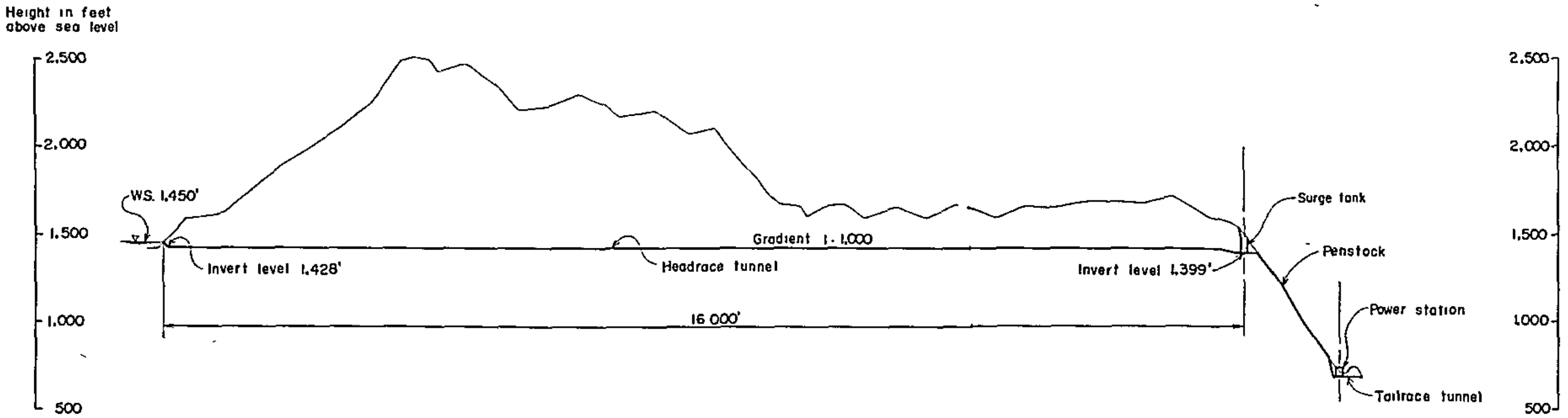


PROFILE



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TOKYO JAPAN

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DRAWN R. Nogami
CHECKED K. Kiko
SUBMITTED T. Yamane
RECOMMENDED M. Yoshikawa
APPROVED Y. Arao
CHIEF ENGINEER, EPDC
DATE Oct. 12, 1961

RAUB HYDRO-ELECTRIC DEVELOPMENT SCHEME

SEMPAM PROJECT
WATERWAY

DWG NO. 12
SHEET NO.

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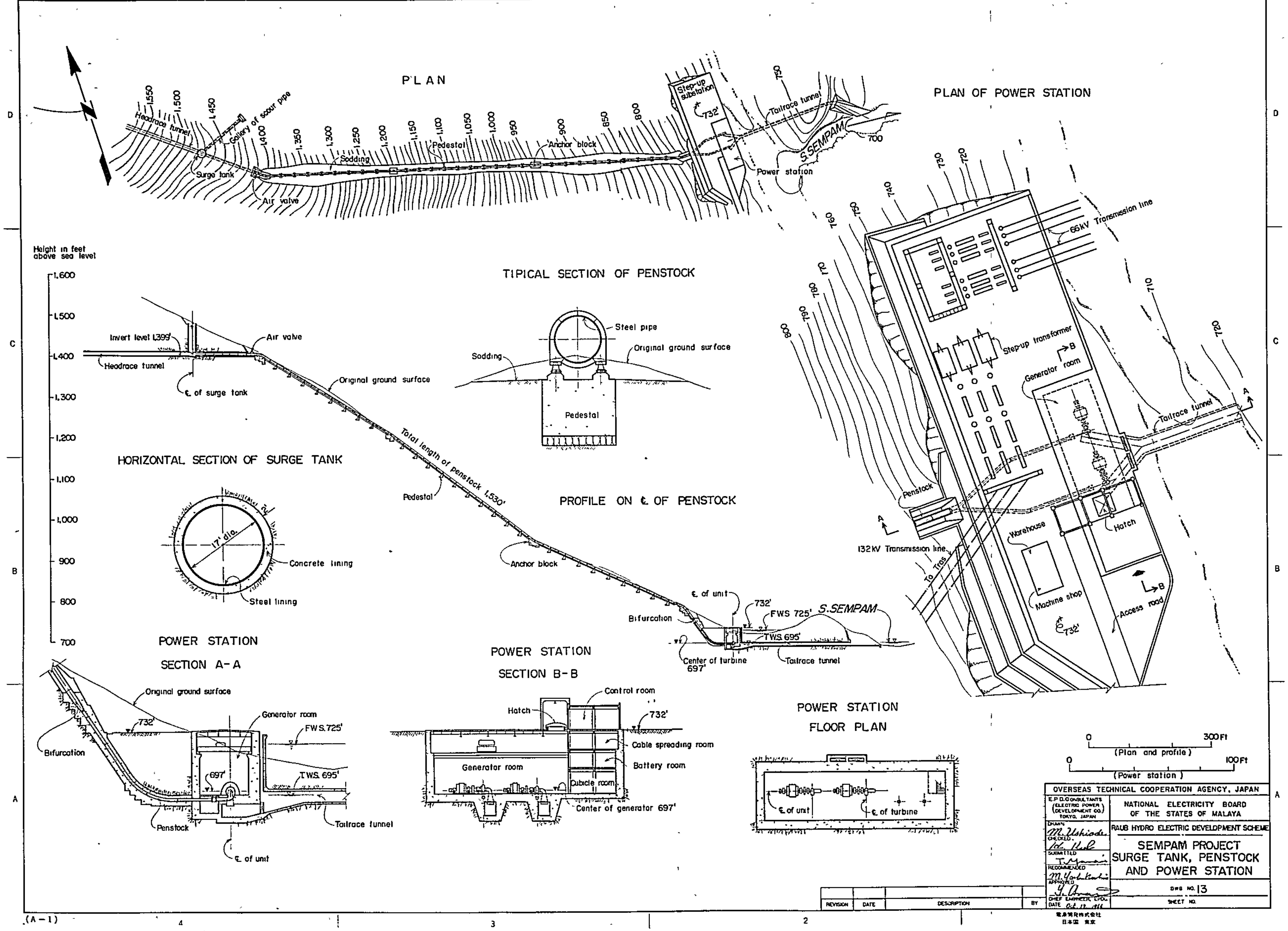

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(ELECTRIC POWER DEVELOPMENT CO.)
TOKYO, JAPAN

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RAUB HYDRO ELECTRIC DEVELOPMENT SCHEME

SEMPAM PROJECT
SURGE TANK, PENSTOCK AND POWER STATION

DRAWN M. Ushioda
CHECKED
SUBMITTED
RECOMMENDED M. Yoshitaki
APPROVED
CHIEF ENGINEER, EPDC
DATE Oct. 12. 1961

DWG NO. 13
SHEET NO.

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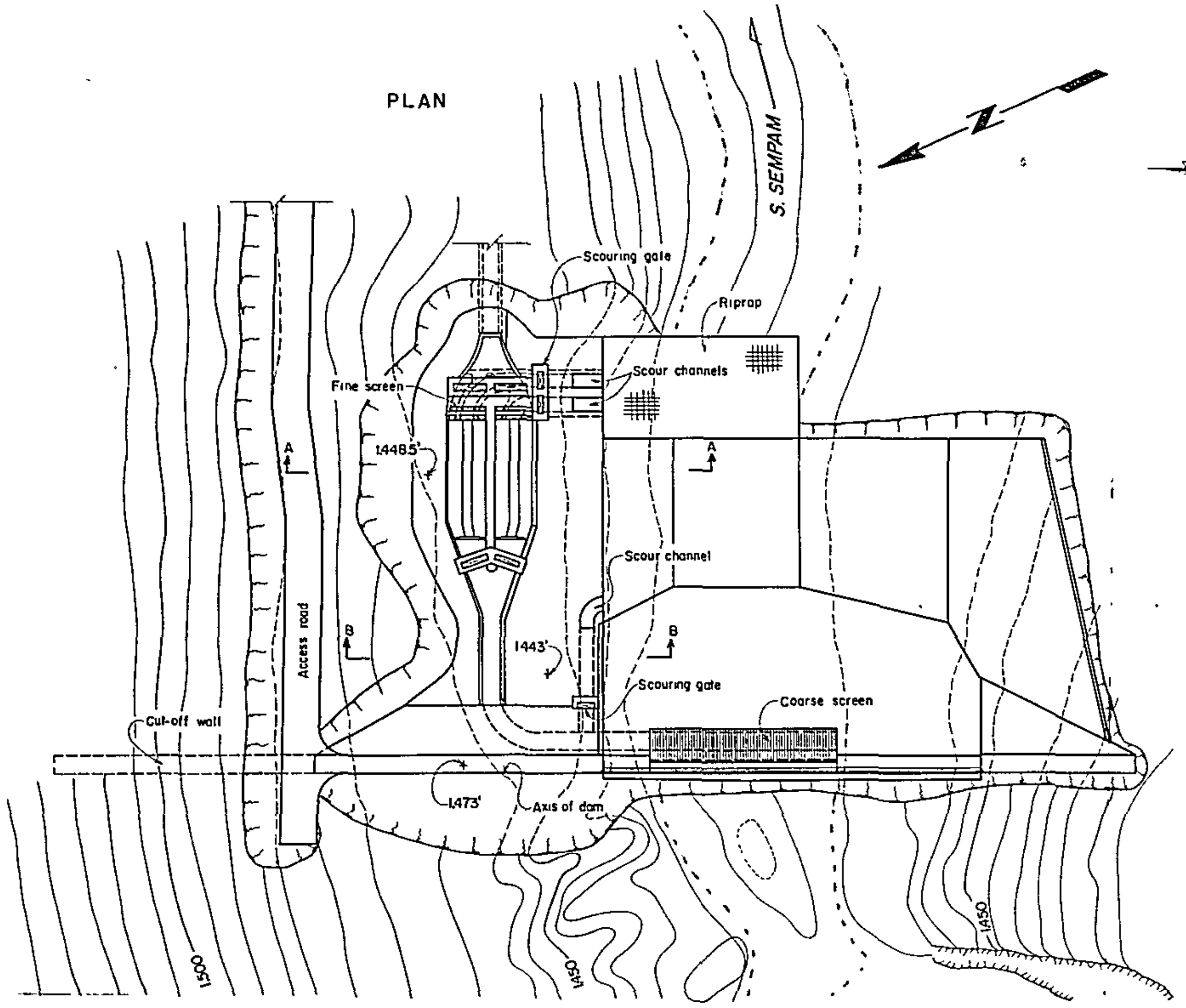
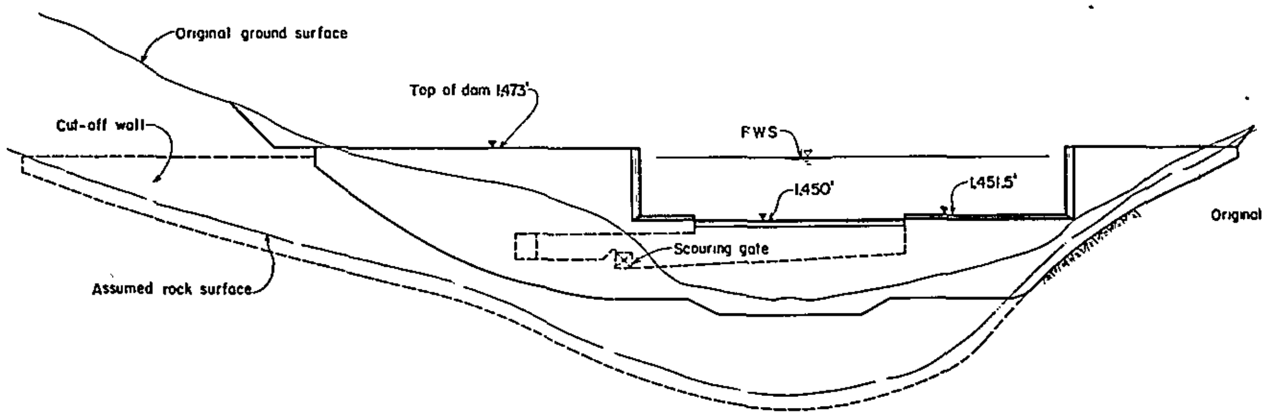
日本国 東京

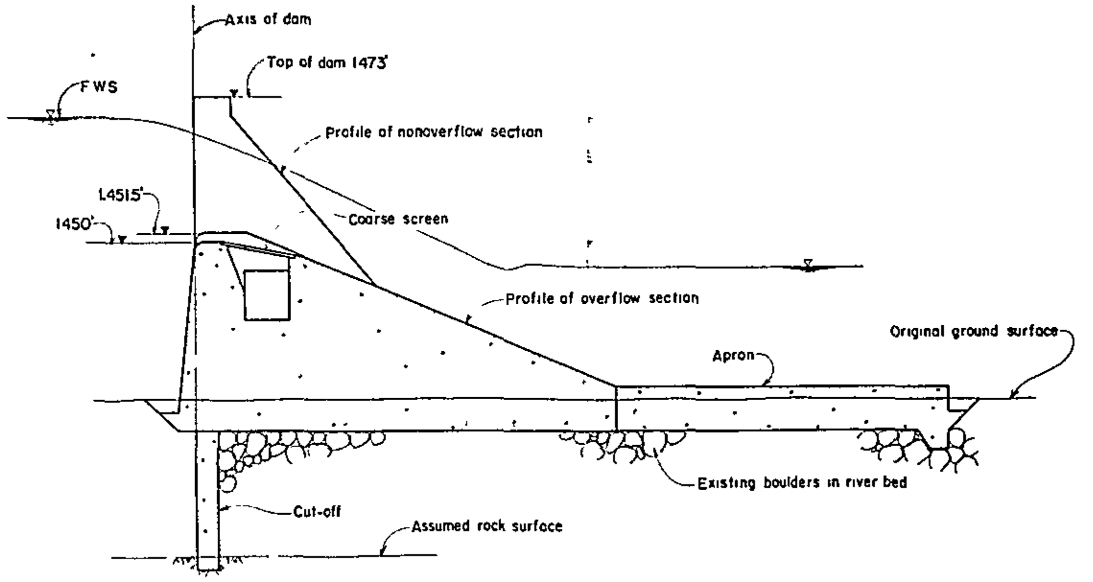
PLAN



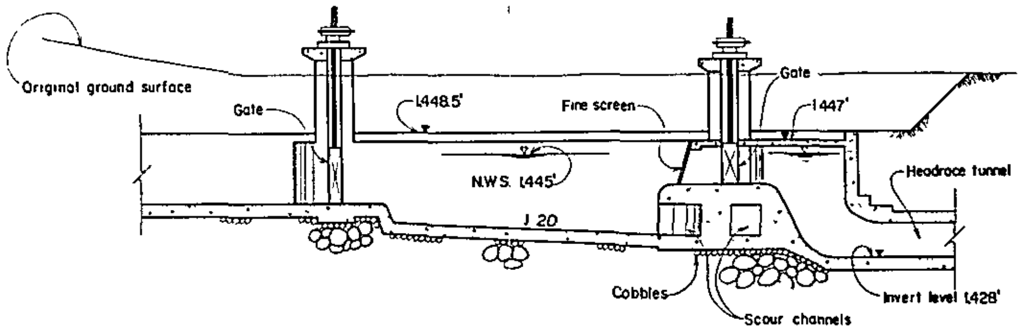
UPSTREAM ELEVATION



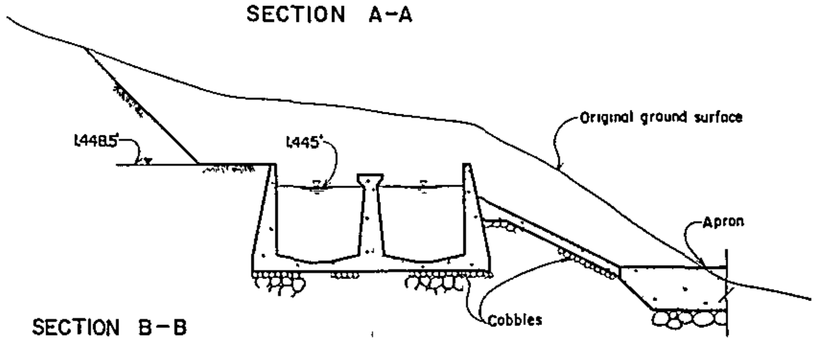
TYPICAL SECTION OF DAM



LONGITUDINAL SECTION OF DESILTING BASIN



SECTION A-A



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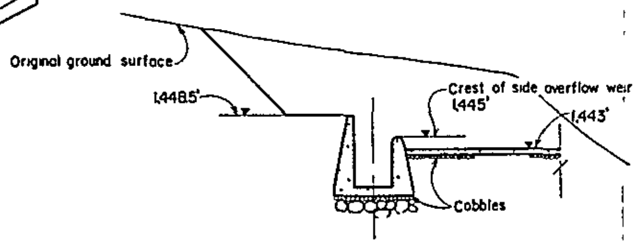

0 100Ft
(Plan, and elevation of dam)

0 50Ft
(Others)

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

E.P.D.C CONSULTANTS
(ELECTRIC POWER DEVELOPMENT CO.)
TOKYO, JAPAN

NATIONAL ELECTRICITY BOARD
OF THE STATES OF MALAYA

RAUB HYDRO-ELECTRIC DEVEROPMENT SCHEME

SEMPAM PROJECT
DIVERSION DAM
AND DESILTING BASIN

DRAWN M. Taga
CHECKED K. Kubo
SUBMITTED T. Iyanai
RECOMMENDED M. Yoshikoshi
APPROVED Y. Ano
CHIEF ENGINEER, EPDC
DATE Oct. 17. 1966

DWG NO. 14
SHEET NO.

REVISION	DATE	DESCRIPTION	BY

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9. CONSTRUCTION COSTS

9.1 BASIC CONDITIONS

Construction costs of the Raub Scheme were estimated on the basis of price levels of May, 1966, including necessary contingencies, and taking into consideration the natural conditions of the job sites, scale of construction works and present technological standards.

The basic conditions for estimating the construction costs are as follows:

a) Scope: The construction cost is estimated for Liang, Sia and Sempam Power Stations and also for the transmission line connecting these power stations to the 132 KV transmission line planned by NEB.

b) Quantities of Works: The quantities of works are estimated on the basis of the drawings attached to this Report, and where necessary detailed drawings were made.

c) Primary Cost: Costs of domestically procured materials and labour are based on price levels of May, 1966. Costs of materials to be imported are based on CIF Port Swettenham price levels of May, 1966.

d) Unit Prices of Construction Works: The data used for calculation are based on the actual costs of general construction works in Malaysia and also on experience from similar works in Japan. Unit prices of major items are calculated by the quantity method. In other words, types and total hours of use of equipment are first determined based on the construction schedules and work quantities. Secondly, on the basis of the above factors, the direct construction costs consisting of necessary cost of labour, material and equipment are calculated. Then, the unit prices of each item of work are obtained by adding the indirect costs of all temporary facilities and contractor's administration cost necessary for the smooth operation of the equipment and facilities. Unit prices for other items are calculated on the basis of the actual costs obtained from domestic works in Malaysia and that of similar works in Japan, taking into consideration the local conditions. Miscellaneous costs which are not definitely known at the stage of preliminary design are included under item "others".

Foreign Currency and Domestic Currency: The construction cost is divided into two parts: domestic currency requirement and foreign currency requirement. The domestic currency requirement includes wages for the domestic labourers, cost of living of administrative and technical staff of the contractor, and cost of domestically procured materials and construction equipments. The foreign currency requirement includes all other costs.

f) Interest During Construction: Interest during construction is calculated at 5.75 percent and 6 percent for foreign currency and domestic currency respectively.

g) Import Duties: Import duties on gates, penstocks and electrical equipments are assumed to be exempted, but duty on imported construction materials and equipments are included as needed.

h) Service Facilities: Cost for service facilities required by NEB and the consulting engineer are included in a lump sum.

i) General Expenses: Salaries, office expenses and other necessary expenditures at the construction sites and headquarters required by NEB in the execution of the Raub Scheme during the construction period are included in a lump sum.

j) Engineering and Supervisory Costs: Engineering and supervisory costs are calculated for the entire Raub Scheme and then allocated to each power station according.to the respective output.

k) Contingencies: Contingencies are included for each item of work at a rate of 20 percent for civil works and 5 percent for hydraulic and electrical equipments.

9.2 SUMMARY OF CONSTRUCTION COSTS

a) Generating Facilities

The estimated total construction cost for Raub power generating facilities is $M 45, 600, 000 of which $M 25, 030, 000 is in foreign currency and $M 20, 570, 000 is in domestic currency.

The breakdown is shown in Table 9. 1, 9.2 and Appendix - 3. The phased expenditure during the construction period is shown in Table 9.3.

b) Connecting Transmission Line

The estimated construction cost for the transmission lines connecting each power station of the Raub Scheme to the 132 KV transmission line between Kuala Lumpur - Raub planned by NEB is $M 1, 450, 000 of which $M 870, 000 is in foreign currency and $M 580, 000 is in domestic currency. The breakdown is shown in Table 9.4.

Table 9.1 Summary of Estimated Costs of Raub Hydro-Electric Development Scheme (In millions of $M)

Item	Liang			Sia			Sempam			Grand Total		
	Foreign Currency	Domestic Currency	Total	Foreign Currency	Domestic Currency	Total	Foreign Currency	Domestic Currency	Total	Foreign Currency	Domestic Currency	Total
Civil works	5.90	6.92	12.82	3.05	3.87	6.92	3.50	4.25	7.75	12.45	15.04	27.49
Hydraulic Equipments	1.06	0.19	1.25	0.79	0.14	0.93	0.49	0.09	0.58	2.34	0.42	2.76
Electrical Equipments	2.40	0.27	2.67	1.92	0.22	2.14	2.60	0.29	2.89	6.92	0.78	7.70
Service Facilities	0.015	0.135	0.15	0.01	0.08	0.09	0.01	0.05	0.06	0.035	0.265	0.30
General Expenses	-	0.72	0.72	-	0.43	0.43	-	0.45	0.45	-	1.60	1.60
Investigations	0.025	0.055	0.08	0.02	0.04	0.06	0.02	0.04	0.06	0.065	0.135	0.20
Engineering	0.78	0.42	1.20	0.42	0.23	0.65	0.39	0.21	0.60	1.59	0.86	2.45
Interest during Construction	0.72	0.69	1.41	0.42	0.36	0.78	0.49	0.42	0.91	1.63	1.47	3.10
Grand Total	10.90	9.40	20.30	6.63	5.37	12.00	7.50	5.80	13.30	25.03	20.57	45.60

Table 9.2 (1) Estimated Costs of Liang Project

(In thousands of $M)

	Items	Total Cost	*Foreign* Currency	*Domestic* Currency
1.	Civil Works	12,880	5,900	6,920
1.1	Access Roads & Bridges	985		985
1.2	Diversion Dam	1,127	484	643
	on Liang River	731	313	418
	on Hijau River	396	171	225
1.3	Intake & Desilting Basin	399	158	241
	on Liang River	322	127	195
	on Hijau River	77	31	46
1.4	Headrace Tunnel	5,651	3,111	2,540
	from Liang intake	4,572	2,511	2,061
	from Hijau intake	1,079	600	479
1.5	Surge Tank	406	209	197
1.6	Penstock	648	311	337
1.7	Powerhouse	1,140	520	620
1.8	Switchyard	55	22	33
1.9	Tailrace	151	79	72
1.10	Operators' Quarters	125	20	105
1.11	*Contingencies*	2,133	986	1,147
2.	Hydraulic Equipment	1,250	1,060	190
2.1	Gates	162	138	24
2.2	Trash racks	36	30	6
2.3	Liner-plate	72	60	12
2.4	Penstock	880	748	132

Item		Total Cost	Foreign Currency	Domestic Currency
2.5	Butterfly Valve	40	34	6
2.6	Contingencies	60	50	10
3.	Electrical Equipments	2, 670	2, 400	270
3.1	Turbines	661	548	113
3.2	Generators	803	710	93
3.3	Transformers	220	207	13
3.4	Accessories	862	817	45
3.5	Contingencies	124	118	6
4.	Service Facilities	150	15	135
5.	General Expenses	720	-	720
6.	Investigations	80	25	55
7.	Engineering - design, specification, supervision	1, 200	780	420
8.	Interest during Construction	1, 410	720	690
9.	Grand Total	20, 300	10, 900	9, 400

Table 9.2 (2) Estimated Costs of Sia Project

(In thousands of $M)

Items		Total Cost	Foreign Currency	Domestic Currency
1.	Civil Works	6, 920	3, 050	3, 870
1.1	Access Roads & Bridges	572	-	572
1.2	Diversion Dam	875	372	503
1.3	Intake & Desilting Basin	196	77	119
1.4	Headrace Tunnel	2, 142	1, 186	956
1.5	Surge Tank	352	187	165
1.6	Penstock	570	275	295
1.7	Powerhouse	830	370	460
1.8	Switchyard	72	40	32
1.9	Tailrace	28	12	16
1.10	Operators' Quarters	125	20	105
1.11	Contingenies	1, 158	511	647
2.	Hydraulic Equipments	930	790	140
2.1	Gates	81	69	12
2.2	Trash rack	54	45	9
2.3	Liner-plate	72	60	12
2.4	Penstock	640	544	96
2.5	Butterfiy Valve	40	34	6
2.6	Contingencies	43	38	5
3.	Electrical Equipments	2, 140	1, 920	220
3.1	Turbines	445	366	79
3.2	Generators	628	562	66
3.3	Transformers	145	133	12

Items		Total Cost	Foreign Currency	Domestic Currency
3.4	Accessories	820	769	51
3.5	Contingencies	102	90	12
4.	Service Facilities	90	10	80
5.	General Expenses	430	-	430
6.	Investigations	60	20	40
7.	Engineering - design, specification, supervision	650	420	230
8.	Interest during Construction	780	420	360
9.	Grand Total	12,000	6,630	5,370

Table 9.2 (3) Estimated Costs of Sempam Project

(In thousands of $M)

Items		Total Costs	Foreign Currency	Domestic Currency
1.	Civil Works	7,750	3,500	4,250
1.1	Access Roads & Bridges	604	-	604
1.2	Diversion Dam	751	326	425
1.3	Intake & Desilting Basin	177	70	107
1.4	Headrace Tunnel	3,174	1,762	1,412
1.5	Surge Tank	178	93	85
1.6	Penstock	330	136	194
1.7	Powerhouse	880	400	480
1.8	Switchyard	110	48	62
1.9	Tailrace	129	64	65
1.10	Operators' Quarters	125	20	105
1.11	Contingencies	1,292	581	711
2.	Hydraulic Equipments	580	490	90
2.1	Gates	81	69	12
2.2	Trashrack	36	30	6
2.3	Liner-plate	72	60	12
2.4	Penstock	320	272	48
2.5	Butterfly Valve	40	34	6
2.6	Contingencies	31	25	6
3.	Electrical Equipments	2,890	2,600	290
3.1	Turbines	387	312	75
3.2	Generators	533	483	50
3.3	Transformers	612	554	58

Items		Total Costs	Foreign Currency	Domestic Currency
3.4	Accessories	1,218	1,120	98
3.5	Contingencies	140	131	9
4.	Service Facilities	60	10	50
5.	General Expenses	450	-	450
6.	Investigations	60	20	40
7.	Engineering - design, specification, supervision	600	390	210
8.	Interest during Construction	910	490	420
9.	Grand Total	13,300	7,500	5,800

Table 9.3 Phased Expenditure of Raub Hydroelectric Development Scheme (In Millions of $M)

Year	Quarter	Foreign Currency		Domestic Currency		Total
		For Quarter	Cumulative	For Quarter	Cumulative	Cumulative
1967	1	-	-	-	-	-
	2	0.01	0.01	0.16	0.16	0.17
	3	0.41	0.42	0.34	0.50	0.92
	4	0.39	0.81	0.97	1.47	2.28
1968	1	-	0.81	0.93	2.40	3.21
	2	-	0.81	0.93	3.33	4.14
	3	3.62	4.43	1.71	5.04	9.47
	4	3.65	8.08	1.73	6.77	14.85
1969	1	2.15	10.23	1.69	8.46	18.69
	2	2.15	12.38	1.71	10.17	22.55
	3	2.17	14.55	1.70	11.87	26.42
	4	2.16	16.71	1.69	13.56	30.27
1970	1	2.55	19.26	2.21	15.77	35.03
	2	2.54	21.80	2.19	17.96	39.76
	3	2.11	23.91	1.88	19.84	43.75
	4	1.12	25.03	0.73	20.57	45.60

Table 9.4 Estimated Costs of Transmission Lines
(In thousands of $M)

Items		Total Costs	Foreign Currency	Domestic Currency
1.	Transmission Lines	900	585	315
1.1	Sia-Sempam P.S. (66 KV)	455	310	145
1.2	Liang-Sempam P.S. (66 KV)	235	135	100
1.3	Sempam P.S. - Tras (132 KV)	150	100	50
1.4	Contingencies	60	40	20
2.	Service Facilities	40	10	30
3.	General Expenses	50	-	50
4.	Investigations	60	20	40
5.	Engineering - design, specification, supervision	300	200	100
6.	Interest during Construction	100	55	45
7.	Grand Total	1,450	870	580

10. ECONOMIC EVALUATION

10.1 EFFECTIVE POWER AND EFFECTIVE ENERGY

a) Local Consumption

The power and energy output of each power station in the Raub Scheme are described in Chapter 7. The total demand at the generating end in Raub, Fraser's Hill, and Kuala Lipis, are shown in Table 10.1. Assuming an average loss rate of 5 percent against these demands during the serviceable life of the plants, the annual average effective energy will be 98,300,000 KWh.

b) Power Transmitted to Central Network

The power stations in the Raub system will transmit surplus electric energy to the Central Network for 39 years after start of operation and will contribute to the balancing of supply and demand as shown in Figs. 3.4 and 3.5. Other than the firm demand, secondary demand which will enable fuel savings at the existing steam power stations is expected. These are demands which can be anticipated from the view point of economical operation of the system. Assuming an average loss rate of 3 percent at the Segambut Sub-station during the serviceable life of the plants, the average effective electric energy will be 85,700,000 KWh. (Firm, 19,800,000 KWh; secondary, 65,900,000 KWh)

Table 10.1 Estimated Demand at Generating End

Unit: MWh

Year	Local	To Central Network		Year	Local	To Central Network	
		Firm	Secondary			Firm	Secondary
1971	8,100	80,200	103,500	2001	91,800		100,000
1972	8,800	78,800	104,300	2002	98,800		93,000
1973	9,500	77,300	105,000	2003	106,800		85,000
1974	10,300	75,800	105,800	2004	106,800		76,000
1975	10,800	74,100	106,600	2005	124,800		67,000
1976	12,100	72,300	107,500	2006	133,800		58,000
1977	13,100	70,300	108,400	2007	141,800		50,000
1978	14,300	68,200	109,400	2008	149,800		42,000
1979	15,400	65,900	110,500	2009	156,800		35,000
1980	16,800	63,500	111,600	2010	163,800		28,000
1981	18,200	60,800	112,800	2011	169,800		22,000
1982	19,700	58,000	114,100	2012	174,800		17,000
1983	21,300	55,000	115,500	2013	178,800		13,000
1984	23,200	52,100	117,000	2014	182,600		9,000
1985	25,200	48,100	118,500	2015	185,200		6,600
1986	27,300	44,300	120,200	2016	187,800		4,000
1987	29,600	40,200	122,000	2017	189,100		2,700
1988	32,100	35,800	123,900	2018	189,800		2,000
1989	34,800	31,100	125,900	2019	190,300		1,500
1990	37,800	26,000	128,000	2020	190,700		1,100
1991	41,000	20,500	130,300	2021	191,100		700
1992	44,500	14,600	132,700	2022	191,800		
1993	48,300	8,200	135,300	.	.		
1994	52,400	1,400	138,100	.	.		
1995	56,900		135,100	.	.		
1996	61,700		130,300	For 8 years	191,800 x 8		
1997	66,600		125,200	.	.		
1998	72,200		119,600	.	.		
1999	78,200		113,600	.	.		
2000	84,700		107,100	2030			
		Annual Average			100,600	20,400	70,800

Note: The entrire output of the Raub Scheme will be consumed locally and in the Central Network immediately after start of operation.

It is assumed that local demand will grow gradually after start of operation, and up to and including 1994, the firm output will be supplied to meet local demand and the balance, on a diminishing scale annually, transmitted to the Central Network. All secondary output will be transmitted to the Central Network.

In and after 1995, all firm output of the Raub Scheme is assumed to be consumed locally and that additional firm energy will be received from the Central Network. Therefore, the Raub Scheme will be able to suppl secondary output only to the Central Network.

10.2 ANNUAL COST AND ENERGY COST

10.2.1 Annual Cost

As described in Chapter 9, the estimated construction costs of generating plants and connecting transmission lines are $M45, 600, 000 and $M 1, 450, 000 respectively.

The construction cost of the transmission line between Tras and Segambut Sub-station is estimated to be $M 3, 960, 000. Of this cost, $M 3, 036, 000 is considered to be chargeable to the Raub Scheme as the cost of the transmission line between Tras and Segambut, which will be used in common with the Bentong Scheme, should be allocated to the Raub and Bentong Schemes in proportion to output.

Therefore, the total construction costs for generating and transmission facilities up to Segambut Sub-station will be $M 50, 086, 000.

Construction costs of each facility and serviceable years are shown in Table 10.2.

Table 10.2 Construction Cost of Raub Hydroelectric Development Scheme (Including Transmission Lines to Segambut Sub-station)

Unit: $10^3$$M

	Year	Total	Foreign Currency	Domestic Currency
Civil Works	60	20, 300	11, 349	8, 951
Hydraulic Equipment	40	12, 000	6, 919	5, 081
Electric Equipment (including transmission lines)	35	17, 786	10, 378	7, 408
Total		50, 086	28, 646	21, 440

Note: Overhead cost prorated in each item.

The average annual cost of this project is shown in Table 10.3.

Table 10.3 Annual Cost of Liang, Sia and Sempam Power Stations

Unit: 10^3\$M

		Investment cost	fsp %	fcr % at 60 years	Annual cost
1)	Replacement of Hydraulic Equipments at 40 yrs.				
	Foreign Currency (i = 5.75%)	6,919	10.69	5.96	44
	Domestic Currency (i = 6.00%)	5,081	9.72	6.19	31
	Sub-total	12,000			75
2)	Replacement of Electrical Equipments at 35 yrs.				
	Foreign Currency (i = 5.75%)	10,378	14.14	5.96	87
	Domestic Currency (i = 6.00%)	7,408	13.01	6.19	60
	Sub-total	17,786			147
3)	Amortization of Initial Investment				
	Foreign Currency (i = 5.75%)	28,646	-	5.96	1,707
	Domestic Currency (i = 6.00%)	21,440	-	6.19	1,327
	Sub-total	50,086			3,034
4)	Maintenance & Operation				
	Salaries and Wages				200
	Maintenance of Machines and Equipments	(29,786 x 0.7%)			209
	Maintenance of Structures	(20,300 x 0.5%)			102
	Sub-total				511
5)	Administration Expense	(50,086 x 0.25%)			125
6)	Total Annual Cost				3,892

Note: (1) & (2): Present worth of replacement cost of equipment uniformly distributed over 60 years.

(3): Initial investment uniformly distributed over 60 years.

fsp: Single payment present worth factor

fcr: Capital recovery factor

i: Annual interest

10.2.2 Energy Cost

Dividing the average annual cost of $M 3, 892, 000 of the Raub Hydroelectric Development Scheme by the effective electric energy of 184, 000, 000 KWh, the average energy cost is 2.11 cts/KWh.

10.3 COMPARISON WITH ALTERNATIVE SCHEMES

As alternatives of the Raub Scheme for local demand, transmission of power to Raub area from the Port Dickson Thermal Power Station now being constructed, or construction of diesel power plants of appropriate scale at each of these districts can be considered. The energy costs of these two alternatives compared on the basis of a serviceable life of 25 years for thermal stations is shown below.

Units: cts/unit

	Generating Cost	Transmission & Transforming Cost	Total
Transmission from Port Dickson Thermal P.S.	3.7	3.0	6.7
Individual diesel plant by district	6.8		6.8

As the power to be supplied to the Raub area from Port Dickson Thermal Power Station will be extremely small compared to the power to be supplied to the Central Network, the cost of the transmission line between Port Dickson and Segambut is not allocated to the alternative plan and, consequently, this cost does not include the transmission and transforming cost. As a result of the study, it is found that there will be no substantial difference between the two alternatives, however, diesel generation was selected as the alternative plan in consideration of the fact that it is more practical.

10.4 ANNUAL BENEFIT OF RAUB SCHEME

For the local demand, the benefit of the Raub Scheme will be evaluated as being equal to the generating cost of the diesel generating plant. Diesel generating units of 500 KW capacity are to be installed corresponding to growth of demand. As for the firm power to be transmitted to the Central Network, the benefit is obtained on the basis of the generating cost of electricity produced by a steam power plant with two 60 MW units similar to the Port Dickson Thermal Power Plant. As for the secondary energy, the benefit will be evaluated as being equal to the variable component of the generating cost of Connaught Bridge Thermal Power Plant, as it will contribute to the reduction of fuel consumption at the existing steam power plant. The benefit of the Raub Scheme for the various categories of electricity produced thereby are estimated as follows.

Local	7.0 cts/KWh	(See Table 10.4)
Central Network (firm power)	3.6 cts/KWh	(See Table 10.5)
Central Network (secondary power)	2.3 cts/KWh	(See Table 10.6)

The evaluation for local demand will be made at the outgoing end of the high tension feeder at each point of demand. For the power to be transmitted to the Central Network, the evaluation will be made at the transmitting end of the Segambut Sub-station.

Table 10.7 shows the annual effective energy according to the above classification, and the benefit during the 60 years serviceable life converted into 1971 present worth by the capital recovery method which is then uniformly distributed over the serviceable life.

Table 10.4 Annual Cost of Alternative Diesel Plant
(500 KW unit)

Interest and depreciation $M	23,280	Investment: 465.6 $M/KW Depreciation: 15 years
Fuel	26,280	Utilization factor: 30% Thermal efficiency: 12,000 BTU/KWh
Operation & Maintenance	4,580	2% of Construction Cost
Salaries and Wages	25,000	
Lubricants and others	6,420	
Administration	3,600	
Total	$M89,160	

Unit cost of energy is estimated at 7.0 cts taking into consideration loss in station of 2.5%.

Table 10.5 Annual Cost of Alternative Steam Plant

Interest and depreciation	$M 6,477,000	Investment: 702.5 $M/KW Depreciation: 25 years
	7,621,000	Utilization factor: 50% Thermal efficiency: 11,000 BTU/KWh Cost of fuel: 19.5 cts/gallon
Operation & Maintenance	2,607,000	
Salaries and Wages	750,000	
Repairs	1,688,000	2% of construction cost
Others	169,000	
Administration	260,000	
Total	$M16,965,000	3.2 cts/KWh

Units cost of energy is estimated at 3.6 cts taking into consideration loss in station of 6% and transmission loss of 4%.

Table 10.6 Variable Component in Generating Cost of Connaught Bridge Thermal Plant

Fuel	$M 4,203,000	Investment: $M 40 x 10^6 Depreciation: 25 years
Operation & Maintenance	176,000	Utilization factor: 30% Thermal efficiency: 15,000 BTU/KWh
Repair	160,000	0.4% of construction cost
Others	16,000	
Administration	18,000	
Total	$M 4,399,000	2.1 cts/KWh

Unit cost of energy is estimated at 2.3 cts taking into consideration loss in station of 6% and transmission loss of 2%.

Table 10.7 Annual Benefits of Raub Scheme

Years	Effective Energy in MWh			Annual Benefit in $M			1971 Present Worth in $M		
		Central Network			Central Network			Central Network	
	Local	Firm	Secondary	Local	Firm	Secondary	Local	Firm	Secondary
1971	7, 700	77, 790	100, 400	539, 000	2, 800, 440	2, 309, 200	508, 980	2, 644, 460	2, 180, 580
1972	8, 360	76, 440	101, 170	585, 200	2, 751, 840	2, 326, 910	521, 820	2, 453, 820	2, 074, 910
1973	9, 030	74, 980	101, 850	632, 100	2, 699, 280	2, 342, 550	532, 230	2, 272, 790	1, 972, 430
1974	9, 790	73, 530	102, 630	685, 300	2, 647, 080	2, 360, 490	544, 880	2, 104, 690	1, 876, 830
1975	10, 260	71, 880	103, 400	718, 200	2, 587, 680	2, 378, 200	539, 220	1, 942, 830	1, 785, 550
1976	11, 500	70, 130	104, 280	805, 000	2, 524, 680	2, 398, 440	570, 750	1, 740, 480	1, 700, 490
1977	12, 450	68, 190	105, 150	871, 500	2, 454, 840	2, 418, 450	583, 470	1, 643, 520	1, 619, 150
1978	13, 590	66, 150	106, 120	951, 300	2, 381, 400	2, 440, 760	601, 410	1, 505, 520	1, 543, 050
1979	14, 630	63, 920	107, 190	1, 024, 100	2, 301, 120	2, 465, 370	611, 290	1, 373, 540	1, 471, 580
1980	15, 960	61, 600	108, 250	1, 117, 200	2, 217, 600	2, 489, 750	629, 770	1, 250, 060	1, 403, 470
1981	17, 290	58, 980	109, 420	1, 210, 300	2, 123, 280	2, 516, 660	644, 240	1, 130, 220	1, 339, 620
1982	18, 720	56, 260	110, 680	1, 310, 400	2, 025, 360	2, 545, 640	658, 610	1, 017, 950	1, 279, 440
1983	20, 240	53, 350	112, 040	1, 416, 800	1, 920, 600	2, 576, 920	672, 410	911, 520	1, 223, 010
1984	22, 040	50, 440	113, 490	1, 542, 800	1, 815, 840	2, 610, 270	691, 480	813, 860	1, 169, 920
1985	23, 940	46, 660	114, 950	1, 675, 800	1, 679, 760	2, 643, 850	709, 200	710, 870	1, 118, 880
1986	25, 940	42, 970	116, 590	1, 815, 800	1, 546, 920	2, 681, 570	725, 590	618, 150	1, 071, 560
1987	28, 120	38, 990	118, 530	1, 968, 400	1, 403, 640	2, 726, 190	742, 870	529, 730	1, 028, 860
1988	30, 500	34, 730	120, 180	2, 135, 000	1, 250, 000	2, 764, 140	760, 700	445, 470	984, 860
1989	33, 060	30, 170	122, 120	2, 314, 200	1, 086, 120	2, 808, 760	778, 730	365, 480	945, 150
1990	35, 910	25, 220	124, 160	2, 513, 700	907, 920	2, 855, 680	798, 600	288, 450	907, 250
1991	38, 950	19, 890	126, 390	2, 726, 500	716, 040	2, 906, 970	817, 950	214, 810	872, 090
1992	42, 280	14, 160	128, 720	2, 959, 600	509, 760	2, 960, 560	838, 450	144, 420	838, 730
1993	45, 890	7, 950	131, 240	3, 212, 300	286, 200	3, 018, 520	859, 290	76, 560	807, 450
1994	49, 780	1, 360	133, 960	3, 484, 600	48, 960	3, 081, 080	880, 210	12, 370	778, 280
1995	53, 870		131, 050	3, 770, 900		3, 014, 150	899, 740		719, 180
1996	58, 430		126, 390	4, 090, 100		2, 906, 970	921, 500		654, 940
1997	63, 270		121, 440	4, 428, 900		2, 793, 120	942, 030		594, 100
1988	68, 590		116, 010	4, 801, 300		2, 668, 230	964, 580		536, 050
1999	74, 290		110, 190	5, 200, 300		2, 534, 370	986, 500		480, 700
2000	80, 470		103, 890	5, 632, 900		2, 389, 470	1, 008, 850		427, 950
2001	87, 210		97, 000	6, 104, 700		2, 231, 000	1, 032, 300		377, 260
2002	93, 860		90, 210	6, 570, 200		2, 074, 830	1, 049, 260		331, 350
2003	101, 460		82, 450	7, 102, 200		1, 896, 350	1, 071, 010		285, 970
2004	110, 010		73, 720	7, 700, 700		1, 695, 560	1, 096, 580		241, 450
2005	118, 560		64, 990	8, 299, 200		1, 494, 770	1, 116, 240		201, 050
2006	127, 110		56, 260	8, 897, 700		1, 293, 980	1, 130, 000		164, 340
2007	134, 710		48, 500	9, 429, 700		1, 115, 500	1, 130, 620		133, 750
2008	142, 310		40, 740	9, 961, 700		937, 020	1, 127, 660		106, 070
2009	148, 960		33, 950	10, 427, 200		780, 850	1, 114, 670		83, 470
2010	155, 610		27, 160	10, 892, 700		624, 680	1, 100, 160		63, 090
2011	161, 310		21, 340	11, 291, 700		490, 820	1, 076, 100		46, 780
2012	166, 060		16, 490	11, 624, 200		379, 930	1, 046, 180		34, 190
2013	169, 860		12, 610	11, 890, 200		290, 030	1, 010, 670		24, 650
2014	173, 170		8, 920	12, 142, 900		205, 160	975, 070		16, 470
2015	175, 940		6, 400	12, 315, 800		147, 200	933, 540		11, 160
2016	178, 400		3, 880	12, 488, 000		89, 240	894, 140		6, 390
2017	179, 650		2, 620	12, 575, 500		60, 260	850, 100		4, 070
2018	180, 310		1, 940	12, 621, 700		44, 620	805, 260		2, 850
2019	180, 790		1, 460	12, 655, 300		33, 580	763, 110		2, 020
2020	181, 170		1, 070	12, 681, 900		24, 610	721, 600		1, 400
2021	181, 550		680	12, 708, 500		15, 640	673, 550		830
2022	182, 210			12, 754, 700					
	.			.					
	.			.					
	.			.					
2030	182, 210			12, 754, 700			4, 704, 190		
Total							47, 367, 360	26, 211, 570	37, 544, 740
		Capital recovery factor at 60 yrs = 6. 1%					2, 889, 410	1, 598, 910	2, 290, 230
							Grand Total	6, 778, 550	

Note: Average interest rate is 5. 9%

10.5 COST-BENEFIT RATIO

The annual cost of the Raub Scheme is $M 3, 892, 000 as shown in Table 10.3, and the average annual benefit is $M 6, 779, 000 as shown in Table 10.7. Therefore, the annual surplus benefit is approximately $M 2, 887, 000 and the benefit-cost ratio is 1.74

There are other benefits such as contribution to the industrial development of the underdeveloped areas and to the national economy by saving imported fuel, but these have not been considered in the cost-benefit study.

In accordance with the letter from NEB dated April 20, 1966, an economic evaluation of the Raub Scheme was made by the"Assessment" method adopted by NEB.

The economic evaluation in accordance with the said method is given in Appendix-4.

APPENDIX - 1. HYDROLOGICAL DATA

Precipitation STATION Fraser's Hill CATCHMENT AREA sq. km Raub, Malaysia

RIVER, IN THE BASIN OF (St. No. 75) ELEVATION 4200 feet UNIT inch S ° ' W ° '

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1921	-	-	-	-	-	-	-	-	-	-	-	4.07	
2	10.72	4.53	20.89	15.02	9.19	6.27	3.32	2.11	7.07	9.54	14.25	18.85	121.76
3	14.61	2.48	9.27	6.40	4.89	3.99	1.92	2.39	3.06	12.43	7.81	12.72	81.97
4	18.01	8.14	12.04	15.68	14.16	5.31	3.44	4.93	9.66	9.17	11.99	10.52	123.05
5	17.39	9.82	10.25	12.47	3.37	2.21	5.03	5.20	11.77	15.95	29.87	15.14	138.47
6	15.24	10.56	4.33	10.17	2.65	9.76	3.39	3.30	9.79	11.51	12.68	36.51	129.89
7	18.24	10.61	14.36	15.54	5.29	1.51	2.97	2.17	10.50	10.80	15.13	9.88	117.00
8	8.44	4.69	4.55	7.49	5.94	2.59	8.35	1.73	4.51	8.66	14.77	11.75	83.45
9	8.66	3.43	13.00	11.45	10.05	6.53	0.12	4.39	7.86	10.23	16.65	5.53	97.91
1930	6.68	2.23	5.92	7.61	5.78	5.77	3.52	7.73	7.09	20.05	8.80	12.72	93.90
1	12.90	7.61	7.57	13.32	15.48	7.89	4.72	4.36	4.53	9.11	15.22	16.26	118.97
2	10.39	12.00	12.69	14.05	8.32	3.86	3.45	7.25	5.18	13.09	15.52	9.14	114.94
3	18.35	3.67	9.88	13.37	16.21	2.50	4.84	8.95	5.78	4.75	13.45	9.90	111.65
4	15.31	4.27	12.80	10.73	2.80	9.95	3.36	6.15	5.03	16.03	13.13	6.23	106.04
5	8.92	11.84	10.66	4.95	2.49	5.69	2.27	8.27	4.89	10.56	7.53	15.44	93.53
6	14.25	6.39	8.00	10.72	11.62	4.56	0.68	10.39	6.16	12.24	7.17	13.03	105.21
7	12.51	7.42	6.38	13.68	7.38	5.37	5.92	2.67	9.77	11.71	16.38	9.93	109.12
8	7.12	6.21	12.48	11.91	11.51	2.71	3.78	3.47	5.79	18.06	4.64	8.05	95.73
9	11.92	6.06	7.97	11.93	7.02	3.47	1.05	3.16	6.22	10.06	9.95	8.59	87.40
1940	6.00	6.50	0.69	5.95	10.15	5.75	5.34	5.45	4.70	11.52	20.25	9.24	91.54
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	8.08	5.95	10.59	11.86	11.71	3.81	3.63	2.55	11.98	12.29	9.62	14.75	106.82
7	7.43	6.09	11.44	16.33	11.39	4.24	5.60	5.32	8.05	7.46	4.13	16.60	104.08
8	10.61	8.23	7.57	7.94	7.75	2.33	8.30	6.85	5.82	11.61	11.61	4.81	93.43
9	6.51	9.35	6.77	11.07	15.26	5.01	10.42	5.81	8.10	3.73	13.96	11.53	107.52
1950	8.23	11.94	8.49	10.49	13.15	5.43	5.59	10.05	7.73	10.54	14.27	9.58	115.49
1	23.63	4.93	6.26	12.17	9.15	3.08	8.60	4.99	11.26	-	-	10.53	-
2	9.59	17.38	13.18	8.03	-	3.60	2.46	3.08	9.08	9.25	16.18	-	-

Precipitation STATION Fraser's Hill (St. No. 75) CATCHMENT AREA ______ sq km Raub, Malaysia

RIVER, IN THE BASIN OF ______ ELEVATION 4,200 feet UNIT inch S ° ′ W ° ′

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1953	9.75	11.75	12.25	12.05	8.51	6.19	7.85	2.24	9.44	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	5.87	12.46	7.99	9.57	6.85	8.13	11.90	16.31	14.03	18.35	-
6	18.50	7.46	14.93	13.16	10.47	4.95	7.75	4.46	7.83	15.03	6.80	13.39	124.73
7	3.83	1.71	12.66	9.04	11.55	3.43	5.24	3.30	7.80	13.71	20.44	21.23	113.94
8	7.86	3.43	5.40	5.84	3.65	2.14	0.85	3.38	3.95	9.79	14.15	7.56	68.00
9	7.85	3.95	14.72	9.37	8.48	6.97	1.42	6.94	6.92	16.64	14.62	14.74	112.62
1960	8.72	9.23	7.50	13.66	5.35	3.41	5.24	5.39	7.14	9.46	14.69	9.68	99.47
1	11.88	10.91	5.77	14.69	6.67	5.51	2.69	5.92	6.33	7.48	18.14	16.17	112.16
2	15.18	5.76	13.44	5.59	8.99	8.27	1.61	8.93	7.30	11.85	16.34	8.11	111.37
3	6.89	7.04	7.08	2.50	7.49	4.17	6.64	7.18	7.53	12.57	26.03	12.49	107.61
4	13.26	8.76	6.22	11.48	7.12	8.19	9.43	3.30	4.75	7.88	11.41	10.24	102.04
5	2.47	5.65	4.29	9.97	13.71	3.33	3.08	6.59	7.54	13.03	14.78	18.78	103.22
Average '21-'65	11.30	7.10	9.50	10 70	8.80	4.80	4.30	5.20	7.20	11.00	13.80	12.60	106.00

Precipitation STATION Bentong Hospital (St. No. 63) CATCHMENT AREA ____ sq.km Raub, Malaysia

RIVER, IN THE BASIN OF ____ ELEVATION 320 feet UNIT inch S ° ' W ° '

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1901	-	-	-	-	-	-	-	-	-	8.02	16.94	11.26	-
2	7.83	6.21	4.34	11.49	-	1.18	2.92	2.14	9.16	14.11	22.33	18.17	-
3	8.06	6.38	2.44	3.83	5.35	4.28	0.70	6.89	6.33	3.99	6.49	6.57	61.31
4	25.74	4.46	2.00	6.02	6.39	2.64	4.94	5.81	6.73	7.11	5.79	9.65	87.28
5	6.96	4.39	3.69	6.63	7.01	3.92	3.96	5.33	4.14	15.90	16.69	8.51	87.13
6	11.13	5.61	4.81	8.01	9.75	6.71	1.02	7.87	2.04	11.71	7.98	16.46	93.10
7	2.78	3.44	7.28	4.35	6.15	7.97	4.45	0.74	5.54	7.62	10.80	9.28	70.40
8	10.15	9.33	9.52	5.06	6.48	5.28	6.89	4.67	10.66	13.45	11.58	6.67	99.74
9	22.12	9.12	14.44	7.23	5.01	9.16	2.06	5.24	4.25	8.80	4.88	6.09	98.40
1910	7.53	8.32	15.17	9.02	2.80	5.75	4.00	5.58	3.30	10.40	3.30	16.90	92.07
1	6.98	3.90	7.45	6.84	3.97	4.48	1.20	6.03	6.93	13.55	19.64	17.07	98.04
2	4.09	7.51	7.30	5.55	8.39	3.37	2.18	4.56	3.18	10.57	11.50	15.59	83.79
3	7.73	6.80	2.87	10.30	10.90	9.31	1.51	6.76	7.91	7.30	16.46	24.27	112.12
4	9.20	3.33	5.06	16.65	1.79	12.70	2.05	4.35	5.65	17.13	9.85	9.68	97.44
5	5.99	2.90	6.71	5.47	4.77	11.52	13.12	5.75	9.93	6.62	10.44	11.27	94.49
6	2.71	1.63	13.81	1.84	7.83	4.32	5.05	9.25	2.62	3.89	5.09	7.16	65.20
7	12.43	5.57	16.53	8.70	3.49	8.79	2.64	8.42	6.18	4.17	12.44	12.10	101.46
8	7.63	6.78	5.95	4.83	12.79	6.66	3.75	7.03	7.60	8.39	32.83	10.44	114.68
9	9.62	6.15	5.71	11.56	8.16	1.49	3.22	5.95	7.27	6.08	6.13	10.73	82.07
1920	5.53	4.31	4.82	6.15	6.91	5.53	0.00	3.75	2.39	3.36	6.93	4.46	54.14
1	8.44	2.37	9.47	15.50	6.76	6.16	3.29	7.20	2.80	12.05	7.65	8.29	89.98
2	9.21	7.30	17.10	8.93	4.89	6.96	1.25	4.92	4.42	13.59	14.14	9.29	102.00
3	8.44	3.47	6.02	8.74	4.08	4.15	1.87	2.19	3.75	11.70	6.80	10.50	71.71
4	15.22	5.51	7.26	13.40	10.36	4.02	4.22	4.57	9.66	8.20	6.95	12.88	102.25
5	9.88	6.20	11.06	14.15	6.42	4.72	4.07	5.52	9.44	10.89	22.94	12.64	117.93
6	12.22	15.80	4.78	9.79	7.12	6.12	3.77	5.70	7.15	14.40	13.93	31.23	132.01
7	20.15	12.95	7.88	11.87	1.91	2.18	3.27	6.07	10.24	11.83	12.29	10.02	110.66
8	3.85	3.28	4.67	6.04	8.90	2.52	8.01	2.65	1.78	11.19	14.78	12.97	80.64
9	4.51	4.69	12.88	8.25	12.02	2.78	3.60	3.58	8.40	8.19	10.29	9.38	88.57
1930	9.13	2.67	5.08	6.15	3.28	7.03	1.65	3.88	3.54	19.35	8.62	5.42	75.80
1	14.97	1.89	5.17	8.25	12.43	4.96	6.34	2.03	9.22	7.51	15.70	14.28	102.75
2	7.75	9.16	13.13	8.05	10.61	5.81	3.87	7.42	6.00	6.75	7.11	6.67	92.33

Precipitation STATION Bentong Hospital (St. No. 63) CATCHMENT AREA sq.km Raub, Malaysia

RIVER, IN THE BASIN OF ELEVATION 320 feet UNIT inch S ° ' W ° '

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1933	12.40	2.78	9.58	11.34	13.20	3.84	2.76	5.82	4.49	5.02	14.80	8.45	94.48
4	15.50	12.78	11.81	15.17	3.81	8.53	5.32	7.28	2.78	15.79	7.03	4.73	110.53
5	5.84	4.24	5.42	4.02	8.50	6.89	3.31	9.49	4.14	11.66	7.07	15.96	86.54
6	12.56	2.63	5.94	9.05	15.48	3.16	2.45	6.52	7.40	13.34	7.97	10.91	97.41
7	7.00	12.86	5.10	12.77	10.67	8.55	4.67	2.70	5.53	8.23	15.37	9.93	103.38
8	7.03	6.78	9.64	9.87	10.59	2.93	6.11	6.69	5.07	5.18	4.42	8.50	82.81
9	12.38	4.87	6.95	6.53	4.02	6.01	1.40	2.27	10.92	8.84	8.55	11.48	84.22
1940	6.10	4.95	3.72	5.30	8.35	6.21	3.69	4.59	5.32	9.78	14.58	7.65	80.24
1	5.76	2.85	6.84	7.05	10.82	2.00	2.59	3.37	6.81	6.70	11.32	19.37	85.48
2	8.27	9.51	5.23	13.21	9.41	1.15	1.28	7.02	3.20	5.70	14.20	21.21	99.39
3	3.29	7.32	10.90	7.56	6.69	1.19	0.47	5.69	3.01	5.82	7.56	14.45	73.95
4	9.45	10.82	3.06	6.93	6.09	8.19	2.73	4.96	6.90	14.14	11.71	3.96	88.94
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	8.60	12.61	8.42	17.47	-
8	4.51	6.68	10.60	4.59	3.05	1.60	9.80	1.27	5.98	7.84	17.01	5.58	78.51
9	5.47	6.07	9.10	12.95	7.82	5.69	4.57	11.29	9.00	6.62	4.56	7.09	90.23
1950	12.11	11.28	6.02	17.37	8.35	1.49	4.27	8.58	3.58	8.37	12.08	4.77	98.27
1	12.04	5.43	5.64	7.10	6.91	3.13	9.34	4.88	9.77	9.19	15.28	9.76	98.47
2	10.19	14.32	7.53	8.31	6.89	0.76	2.54	5.94	8.52	9.27	14.76	7.36	96.39
3	12.87	15.91	9.14	21.11	7.32	3.27	6.11	2.34	9.54	9.70	3.07	10.78	111.16
4	8.34	7.25	3.45	6.55	8.97	2.15	8.07	4.67	6.13	13.65	7.59	11.15	87.97
5	11.40	2.39	3.44	5.59	9.60	9.59	2.84	6.58	6.08	15.86	6.30	7.16	86.83
6	13.02	3.01	7.68	6.83	6.78	10.91	8.00	3.51	5.94	15.51	12.16	6.95	100.30
7	4.42	4.92	11.80	8.34	9.63	2.65	7.25	1.61	6.90	8.53	17.13	16.26	99.44
8	9.43	2.22	3.53	2.73	4.45	3.85	0.60	3.65	1.80	7.90	13.48	7.30	60.94
9	4.98	1.98	9.12	6.13	9.97	7.53	2.04	5.50	4.24	17.57	15.47	9.08	93.61
1960	4.13	5.44	4.61	11.07	9.69	2.20	4.74	2.63	5.43	10.43	14.33	6.51	81.21
1	3.96	9.42	6.04	8.03	6.88	2.25	6.06	3.82	6.73	4.29	8.49	14.01	79.98
2	9.52	1.79	14.78	6.09	5.04	5.93	1.81	10.39	6.75	7.82	15.10	10.11	95.13
3	6.08	5.93	3.89	1.16	14.21	2.52	5.21	-	5.24	10.49	5.24	-	-
4	5.24	10.49	5.24	7.43	10.84	8.88	-	3.88	5.69	9.08	11.62	11.44	-

Precipitation STATION Bentong Hospital (St. No. 63) CATCHMENT AREA ____ sq. km Ruab, Malaysia

RIVER, IN THE BASIN OF ____ ELEVATION 320 feet UNIT inch S ° ′ W ° ′

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1965	1.98	5.93	6.28	7.74	11.72	4.80	3.06	7.93	6.72	16.77	15.32	15.11	103.36
Average '02-'65	8.90	6.30	7.50	8.50	7.40	5.10	3.90	5.60	6.10	10.00	11.50	11.00	91.20

WATER LEVEL(H) AND DISCHARGE(Q) STATION Sia CATCHMENT AREA 31.0 sq.Mi Raub, Malaysia

Sia DIVER. IN THE BASIN OF Lipis ELEVATION UNIT H(ft), Q(cfs) YEAR 1965

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1							3.0	112.89			5.1	371.95	1
2							2.9	104.30			4.5	282.62	2
3							2.8	96.04			4.4	268.93	3
4							2.7	88.13			4.4	268.93	4
5							2.8	96.04			4.4	268.93	5
6							2.8	96.04			4.3	255.57	6
7							2.7	88.13			4.7	311.04	7
8							2.8	96.04			4.7	311.04	8
9							2.9	104.30			5.6	455.74	9
10							2.7	88.13			5.7	473.52	10
11							2.7	88.13			5.0	356.21	11
12							2.8	96.04			4.9	340.81	12
13							3.5	160.96			5.0	356.21	13
14							3.3	140.71			4.7	311.04	14
15							2.9	104.30			5.1	371.95	15
16							4.0	217.54			7.4	827.82	16
17					2.6	80.56	4.6	296.66			6.1	548.04	17
18					2.6	80.56	4.0	217.54			5.6	455.74	18
19					2.8	96.04	3.4	150.67			5.7	473.52	19
20					2.8	96.04	3.4	150.67			5.2	388.03	20
21					2.9	104.30	3.4	150.67			5.3	404.44	21
22					2.9	104.30	3.2	131.10			5.1	371.95	22
23					2.7	88.13	3.1	121.82			5.1	371.95	23
24					2.7	88.13	3.1	121.85			5.7	473.52	24
25					3.0	112.89	3.0	112.89	5.3	404.44	6.4	607.50	25
26					3.0	112.89	3.2	131.10	4.5	282.62	5.5	438.30	26
27					3.1	121.82	3.1	121.82	4.6	296.66	5.4	421.20	27
28					3.1	121.82	3.9	205.54	4.3	255.57	5.1	371.95	28
29					3.4	150.67	4.1	229.88	4.5	282.62	5.0	356.21	29
30					3.1	121.82	4.9	340.81	4.6	296.66	5.0	356.21	30
31							5.1	371.95			5.0	356.21	31
TOTAL					40.7	1479.97	102.8	4632.66	27.8	1818.57	161.1	12227.08	TOTAL
MEAN													MEAN

ANNUAL TOTAL (cfs-d)

WATER LEVEL (H) AND DISCHARGE (Q) .... (½)

WATER LEVEL(H) AND DISCHARGE(Q) STATION Sia CATCHMENT AREA 31.0 sq.mi Raub, Malaysia

Sia RIVER, IN THE BASIN OF Lipis ELEVATION m UNIT H(ft), Q(cfs) YEAR 1966

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	5.0	356.21	4.4	268.93	4.0	217.54	3.4	150.67	3.7	182.57			1
2	4.8	325.75	4.2	242.55	3.9	205.54	3.4	150.67	3.8	193.89			2
3	4.7	311.04	4.2	242.55	3.9	205.54	3.4	150.67	3.5	160.96			3
4	4.6	296.66	6.1	548.04	3.8	193.89	3.7	182.57	3.4	150.67			4
5	4.6	296.66	5.2	388.03	3.8	193.89	3.4	150.67	3.3	140.71			5
6	4.6	296.66	4.6	296.66	4.0	217.54	3.4	150.67	3.3	140.71			6
7	4.5	282.62	4.5	282.62	4.1	229.88	3.6	171.60	3.3	140.71			7
8	4.5	282.62	4.4	268.93	4.0	217.54	3.3	140.71	3.2	131.10			8
9	4.6	296.66	4.3	255.57	4.0	217.54	3.3	140.71	3.2	131.10			9
10	5.2	388.03	4.3	255.57	3.8	193.89	3.5	160.96	3.2	131.10			10
11	5.3	404.44	4.2	242.55	4.1	229.88	3.6	171.60	3.2	131.10			11
12	4.7	311.04	4.2	242.55	3.9	205.54	3.3	140.71	3.1	121.82			12
13	4.6	296.66	4.1	229.88	3.8	193.89	3.6	171.60	3.1	121.82			13
14	5.1	371.95	4.1	229.88	3.7	182.57	3.5	160.96	3.1	121.82			14
15	4.6	296.66	4.2	242.55	3.7	182.57	4.1	229.88	3.1	121.82			15
16	4.5	282.62	4.2	242.55	3.7	182.57	3.5	160.96					16
17	4.4	268.93	4.0	217.54	3.7	182.57	3.4	150.67					17
18	4.3	255.57	4.3	255.57	3.8	193.89	3.4	150.67					18
19	4.3	255.57	4.3	255.57	3.7	182.57	3.3	140.71					19
20	4.3	255.57	5.6	455.74	3.8	193.89	3.3	140.71					20
21	4.3	255.57	4.5	282.62	3.6	171.60	3.3	140.71					21
22	4.2	242.55	4.3	255.57	3.6	171.60	3.4	150.67					22
23	4.4	268.93	4.2	242.55	3.5	160.96	3.5	160.96					23
24	6.6	648.84	4.1	229.88	3.6	171.60	3.8	193.89					24
25	5.5	438.30	4.1	229.88	3.5	160.96	3.6	171.60					25
26	5.0	356.21	4.0	217.54	3.4	150.67	3.9	205.54					26
27	4.7	311.04	4.0	217.54	3.7	182.57	3.7	182.57					27
28	4.5	282.62	4.0	217.54	3.7	182.57	3.5	160.96					28
29	4.5	282,62			4.1	229.88	3.4	150.67					29
30	4.4	268.93			3.6	171.60	3.4	150.67					30
31	4.4	268.93			3.5	160.96							31
TOTAL	145.7	9756.46	122.6	7556.95	117.00	5937.70	104.9	4836.61					TOTAL
MEAN	4.7	315.00	4.4	270.00	3.8	191.00	3.5	161.00					MEAN

WATER LEVEL(H) AND DISCHARGE(Q) STATION Liang CATCHMENT AREA 75.9 saMi Raub, Malaysia

Liang DIVER, IN THE BASIN OF Lipis ELEVATION UNIT H(ft), Q(cfs) YEAR 1965

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1							4.4	162.82	6.1	481.36	6.0	457.96	1
2							4.3	149.33	6.5	580.81	5.6	370.18	2
3					4.2	136.42	4.2	136.42	6.1	481.36	5.9	435.14	3
4					4.4	162.82	4.3	149.33	6.2	505.35	6.2	505.35	4
5					4.1	124.10	4.5	176.89	6.0	457.96	6.0	457.96	5
6					4.1	124.10	4.3	149.33	6.1	481.36	5.7	391.25	6
7					4.3	149.33	5.2	291.73	5.8	412.90	5.8	412.90	7
8					4.5	176.89	4.6	191.55	5.2	291.73	5.7	391.25	8
9					4.3	149.33	4.3	149.33	5.6	370.18	6.7	634.03	9
10					4.1	124.10	4.3	149.33	5.4	329.79	7.0	718.24	10
11					4.0	112.36	4.4	162.82	5.2	291.73	6.1	481.36	11
12					4.0	112.36	4.7	206.78	5.1	273.57	6.0	457.96	12
13					4.0	112.36	5.1	273.57	5.3	310.46	6.1	481.36	13
14					4.1	124.10	4.8	222.61	5.8	412.90	6.3	529.92	14
15					5.1	273.57	4.6	191.55	6.4	555.07	6.7	634.03	15
16					4.2	136.42	5.6	370.18	6.8	661.52	6.6	607.13	16
17					4.1	124.10	5.4	329.79	6.9	689.59	7.1	747.48	17
18					4.0	112.36	6.5	580.81	5.9	435.14	6.5	580.81	18
19					4.1	124.10	5.3	310.46	6.1	481.36	6.8	661.52	19
20					4.4	162.82	5.6	370.18	6.0	457.96	6.5	580.81	20
21					4.7	206.78	5.8	412.90	6.5	580.81	6.2	505.35	21
22					4.2	136.42	5.1	273.57	6.4	555.07	6.0	457.96	22
23					4.1	124.10	4.8	222.61	5.8	412.90	6.5	580.81	23
24					4.2	136.42	4.9	239.01	5.7	391.25	6.5	580.81	24
25					4.6	191.55	4.8	222.61	5.9	435.14	6.3	529.92	25
26					4.9	239.01	5.2	291.73	5.9	435.14	6.6	607.13	26
27					4.7	206.78	6.4	555.07	5.9	435.14	6.1	481.36	27
28					4.7	206.78	5.9	435.14	5.8	412.90	6.2	505.35	28
29					4.8	222.61	6.0	457.96	6.2	505.35	6.1	481.36	29
30					4.5	176.89	7.3	807.70	5.7	391.25	6.0	457.96	30
31							7.4	838.68			6.0	457.96	31
TOTAL					121.4	4388.98	160.0	9481.79	178.3	13517.05	193.8	16182.61	TOTAL
MEAN					4.4	156.80	5.2	306.00	6.0	451.00	6.3	522.00	MEAN

ANNUAL TOTAL (cfs-d

WATER LEVEL (H) AND DISCHARGE (Q) .... (%)

WATER LEVEL(H) AND DISCHARGE(Q) STATION Liang CATCHMENT AREA 75.9 sq.Mi Raub, Malaysia

Liang RIVER, IN THE BASIN OF Lipis ELEVATION m UNIT H(ft), Q(cfs) YEAR 1966

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	6.0	457.96	5.6	370.18	5.1	273.57	5.1	273.57	5.8	412.90			1
2	5.8	412.90	5.5	349.69	5.1	273.57	5.0	256.00	5.7	391.25			2
3	5.7	391.25	5.5	349.69	5.1	273.57	5.0	256.00	5.5	349.69			3
4	5.6	370.18	6.9	689.59	5.2	291.73	7.1	747.48	5.5	349.69			4
5	5.6	370.18	6.0	457.96	5.3	310.46	6.0	457.96	5.4	329.79			5
6	5.5	349.69	5.6	370.18	5.2	291.73	5.6	370.18	5.4	329.79			6
7	5.5	349.69	5.5	349.69	5.2	291.73	5.6	370.18	5.4	329.79			7
8	5.4	329.79	5.5	349.69	5.1	273.57	5.9	435.14	5.3	310.46			8
9	5.5	349.69	5.4	329.79	5.0	256.00	5.6	370.18	5.2	291.73			9
10	6.8	661.52	5.3	310.46	4.9	239.01	5.7	391.25	5.2	291.73			10
11	6.4	555.07	5.4	329.79	5.5	349.69	5.7	391.25	5.2	291.73			11
12	5.7	391.25	5.4	329.79	5.1	273.57	5.5	349.69	5.1	273.57			12
13	5.6	370.18	5.2	291.73	4.9	239.01	5.6	370.18	5.2	291.73			13
14	6.7	634.03	5.2	291.73	4.9	239.01	5.3	310.46	5.4	329.79			14
15	5.8	412.90-	5.2	291.73	4.9	239.01	5.4	329.79	5.2	291.73			15
16	5.6	370.18	5.3	310.46	4.9	239.01	5.2	291.73					16
17	5.5	349.69	5.1	273.57	5.3	310.46	5.1	273.57					17
18	5.4	329.79	5.4	329.79	5.1	273.57	5.0	256.00					18
19	5.3	310.46	5.5	349.69	5.5	349.69	5.0	256.00					19
20	7.0	718.24	5.8	412.90	5.9	435.14	5.1	273.57					20
21	5.5	349.69	5.7	391.25	5.2	291.73	5.4	329.79					21
22	5.4	329.79	5.7	391.25	5.0	256.00	5.6	370.18					22
23	5.8	412.90	5.5	349.69	5.0	256.00	5.6	370.18					23
24	5.4	329.79	5.5	349.69	4.9	239.01	6.0	457.96					24
25	6.6	607.13	5.4	329.79	4.9	239.01	5.5	349.69					25
26	6.3	529.92	5.2	291.73	4.8	222.61	6.0	457.96					26
27	6.5	580.81	5.2	291.73	5.2	291.73	6.1	481.36					27
28	5.8	412.90	5.1	273.57	5.7	391.25	5.6	370.18					28
29	5.8	412.90			6.6	607.13	5.5	349.69					29
30	5.7	391.25			5.4	329.79	5.5	349.69					30
31	5.7	391.25			5.2	291.73							31
TOTAL	180.9	13232.97	153.6	9806.80	161.1	9139.09	166.3	10916.86					TOTAL
MEAN	5.8	427.00	5.5	350.00	5.2	295.00	5.6	364.00					MEAN

WATER LEVEL (H) AND DISCHARGE (Q) .... (½)

WATER LEVEL(H) AND DISCHARGE(Q) STATION Sempam CATCHMENT AREA 33.5 sq.Mi Raub, Malaysia

Sempam DIVER. IN THE BASIN OF Lipis ELEVATION UNIT H(ft), Q(cfs) YEAR 1965

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1							1.2	61.06	2.8	296.07	2.3	203.68	1
2							1.0	44.09	2.7	276.21	2.2	187.26	2
3							1.0	44.09	2.6	257.04	2.4	220.78	3
4							0.8	29.88	2.5	238.57	2.9	316.61	4
5							0.8	29.88	2.5	238.57	2.8	296.07	5
6							0.8	29.88	2.4	220.78	2.6	257.04	6
7							1.1	52.23	2.2	187.26	2.7	276.21	7
8							1.5	91.69	2.1	171.54	2.5	238.57	8
9							1.4	80.79	2.0	156.51	2.9	316.61	9
10							1.2	61.06	2.0	156.51	3.1	359.77	10
11							1.5	91.69	1.9	142.17	2.9	316.61	11
12							2.0	156.51	1.8	128.51	3.1	359.77	12
13							1.7	115.55	1.8	128.51			13
14							2.0	156.51	1.9	142.17			14
15							2.0	156.51	2.8	296.07	2.8	296.07	15
16							2.4	220.78	3.0	337.85	2.9	316.61	16
17									3.0	337.85	3.0	337.85	17
18									2.5	238.57	3.2	382.39	18
19									2.8	296.07	2.9	316.61	19
20							2.6	257.04	2.8	296.07	2.8	296.07	20
21							2.7	276.21	2.8	296.07	2.8	296.07	21
22							2.3	203.68	2.9	316.61	2.7	276.21	22
23							2.0	156.51	2.7	276.21	2.7	276.21	23
24							2.1	171.54	2.6	257.04	2.8	296.07	24
25							1.9	142.17	2.5	238.57	2.9	316.61	25
26							2.3	203.68	2.6	257.04	2.8	296.07	26
27							2.2	187.26	2.6	257.04	2.7	276.21	27
28					1.1	52.23	2.3	203.68	2.5	238.57	2.7	276.21	28
29					1.4	80.79	2.1	171.54	2.5	238.57	2.7	276.21	29
30					1.2	61.06	2.7	276.21	2.4	220.78	2.6	257.04	30
31							3.1	359.77			2.7	276.21	31
TOTAL					3.7	194.08	50.7	4031.49	74.2	7139.40	80.1	8413.70	TOTAL
MEAN					1.2	64.80	1.9	149.50	2.5	238.00	2.6	271.00	MEAN

$Q_1=$ + H+ H^2, $Q_2=$ + H+ H^2,

ANNUAL TOTAL (cfs-d)

WATER LEVEL (H) AND DISCHARGE (Q) .... (%)

WATER LEVEL(H) AND DISCHARGE(Q) STATION Sempam CATCHMENT AREA 33.5 sq Raub, Malaysia

Sempam RIVER, IN THE BASIN OF Lipis ELEVATION ____ m UNIT H(ft), Q(cfs) YEAR 1966

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	2.7	276.21	2.3	203.68	1.8	128.51	1.8	128.51					1
2	2.6	257.04	2.2	187.26	1.8	128.51	1.8	128.51					2
3	2.5	238.57	2.2	187.26	1.8	128.51	1.8	128.51					3
4	2.4	220.78	2.5	238.57	1.9	142.17	3.4	429.68					4
5	2.4	220.78	2.5	238.57	2.2	187.26	2.5	238.57					5
6	2.4	220.78	2.5	238.57	2.0	156.51	2.5	238.57					6
7	2.4	220.78	2.2	187.26	2.2	187.26	2.1	171.54					7
8	2.3	203.68	2.0	156.51	2.0	156.51	2.1	171.54					8
9	2.3	203.68	2.0	156.51	1.9	142.17	2.0	156.51					9
10	2.8	296.07	2.0	156.51	1.8	128.51	2.1	171.54					10
11	2.7	276.21	2.1	171.54	2.1	171.54	2.2	187.26					11
12	2.6	257.04	2.1	171.54	1.9	142.17	2.0	156.51					12
13	2.4	220.78	2.1	171.54	1.9	142.17	2.1	171.54					13
14	2.9	316.61	1.9	142.17	1.7	115.55	2.1	171.54					14
15	2.6	257.04	1.9	142.17	1.7	115.55	2.0	156.51					15
16	2.5	238.57	2.1	171.54	1.7	115.55	1.8	128.51					16
17	2.4	220.78	1.9	142.17	1.8	128.51	1.7	115.55					17
18	2.4	220.78	2.1	171.54	1.9	142.17	1.7	115.55					18
19	2.4	220.78	2.2	187.26	2.0	156.51	2.0	156.51					19
20	2.3	203.68	2.5	238.57	2.1	171.54	1.7	115.55					20
21	2.3	203.68	2.1	171.54	1.8	128.51	1.8	128.51					21
22	2.3	203.68	2.1	171.54	1.7	115.55	1.8	128.51					22
23	2.5	238.57	1.9	142.17	1.7	115.55	2.2	187.26					23
24	3.1	359.77	2.0	156.51	1.6	103.27	2.1	171.54					24
25	2.7	276.21	1.9	142.17	1.6	103.27							25
26	2.6	257.04	1.8	128.51	1.6	103.27							26
27	2.5	238.57	1.8	128.51	2.0	156.51							27
28	2.4	220.78	1.9	142.17	2.6	257.04							28
29	2.4	220.78			2.6	257.04							29
30	2.3	203.68			2.1	171.54							30
31	2.3	203.68			2.0	156.51							31
TOTAL	77.4	7417.08	58.8	4843.86	59.5	4555.24							TOTAL
MEAN	2.5	239.00	2.1	173.00	1.9	147.00							MEAN

$Q_1 = 0.59 + 9.04 \quad H + 34.46 \quad H^2, \quad Q_2 = \quad + \quad H + \quad H^2, \quad Q_3 = \quad + \quad H + \quad H^2$

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq Mi Raub, Malaysia

Perting RIVER, IN THE BASIN OF Bentong ELEVATION m UNIT H(ft),Q(cfs) YEAR 1961

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1			2.6	355.23	1.7	178.13	1.4	132.55	1.6	162.19	1.7	178.13	1
2			1.6	162.19	1.8	194.82	1.3	118.85	1.7	178.13	1.7	178.13	2
3			1.5	147.00	1.3	118.85	1.2	105.89	1.6	162.19	1.7	178.13	3
4			1.4	132.55	1.4	132.55	1.2	105.89	1.6	162.19	1.7	178.13	4
5			1.3	118.85	1.3	118.85	1.3	118.85	2.1	249.37	1.8	194.82	5
6			1.7	178.13	1.2	105.89	1.8	194.82	1.8	194.82	1.6	162.19	6
7			1.9	212.26	1.4	132.55	1.6	162.19	1.6	162.19	1.5	147.00	7
8			1.5	147.00	1.4	132.55	1.3	118.85	1.6	162.19	1.6	162.19	8
9			1.3	118.85	1.2	105.89	1.2	105.89	1.6	162.19	1.6	162.19	9
10			1.3	118.85	1.0	82.23	1.2	105.89	1.5	147.00	1.7	178.13	10
11			1.8	194.82	1.2	105.89	1.2	105.89	1.6	162.19	2.2	269.05	11
12			1.9	212.26	1.8	194.82	1.2	105.89	1.6	162.19	2.1	249.37	12
13			1.6	162.19	1.9	212.26	1.6	162.19	1.6	162.19	1.7	178.13	13
14			2.2	269.05	1.5	147.00	1.5	147.00	1.6	162.19	1.7	178.13	14
15			1.8	194.82	1.3	118.85	1.2	105.89	1.6	162.19	2.3	289.47	15
16			1.4	132.55	1.2	105.89	1.3	118.85	1.6	162.19	1.7	178.13	16
17			1.2	105.89	1.2	105.89	1.3	118.85	1.6	162.19	2.0	230.44	17
18			1.2	105.89	1.2	105.89	1.3	118.85	1.5	147.00	2.8	402.81	18
19			2.0	230.44	1.3	118.85	1.3	118.85	1.6	162.19	2.7	378.65	19
20			1.2	105.89	1.6	162.19	1.3	118.85	1.9	212.26	2.3	289.47	20
21			1.2	105.89	2.0	230.44	1.3	118.85	1.7	178.13	2.3	289.47	21
22			1.1	93.69	1.6	162.19	1.3	118.85	1.6	162.19	2.1	249.37	22
23			1.1	93.69	1.3	118.85	1.3	118.85	1.9	212.26	2.0	230.44	23
24			1.2	105.89	1.3	118.85	1.4	132.55	2.0	230.44	1.9	212.26	24
25			1.2	105.89	1.3	118.85	1.3	118.85	2.1	249.37	2.0	230.44	25
26			1.2	105.89	1.4	132.55	2.3	289.47	2.5	332.57	2.2	269.05	26
27	2.6	355.23	1.2	105.89	1.3	118.85	2.2	269.05	2.0	230.44	2.2	269.05	27
28	1.2	105.89	1.3	118.85	1.4	132.55	2.0	230.44	1.8	194.82	2.2	269.05	28
29	1.2	105.89	1.3	118.85	1.3	118.85	1.7	178.13	1.8	194.82	2.6	355.23	29
30	1.6	162.19	1.4	132.55	1.3	118.85	1.9	212.26	1.8	194.82	2.7	378.65	30
31	3.2	506.92	1.7	178.13			2.0	230.44			2.7	378.65	31
TOTAL	9.8	1236.12	46.3	4669.92	42.1	4050.67	45.4	4508.52	52.1	5579.10	63.0	7494.35	TOTAL
MEAN	-	-	1.5	151.00	1.4	135.00	1.5	145.50	1.7	186.0	2.0	242.0	MEAN

$Q_1 =$ 8.74+ 36.13 H+ 37.36 H^2. $Q_2 =$ + H+ H^2. $Q_3 =$ + H+ H^2

WATER LEVEL (H) AND DISCHARGE (Q) ………… (½)

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq. Mi Raub, Malaysia

Perting RIVER, IN THE BASIN OF Bentong ELEVATION ____ m UNIT H(ft),Q(cfs) YEAR 1962

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	2.7	378.65	2.1	249.37	1.3	118.85	2.0	230.44	2.4	310.65	1.4	132.55	1
2	3.1	479.77	1.9	212.26	1.3	118.85	2.3	289.47	2.4	310.65	1.4	132.55	2
3	3.2	506.92	1.9	212.26	1.6	162.19	2.5	332.57	2.2	269.05	1.5	147.00	3
4	3.1	479.77	1.8	194.82	1.7	178.13	2.3	289.47	2.1	249.37	1.4	132.55	4
5	2.8	402.81	1.7	178.13	2.1	249.37	2.1	249.37	2.0	230.44	1.4	132.55	5
6	2.5	332.57	1.7	178.13	2.0	230.44	2.5	332.57	1.9	212.26	1.5	147.00	6
7	2.4	310.65	1.6	162.19	1.7	178.13	2.9	427.71	2.2	269.05	1.6	162.19	7
8	2.2	269.05	1.6	162.19	1.6	162.19	2.6	355.23	1.8	194.82	1.4	132.55	8
9	2.1	249.37	1.6	162.19	1.5	147.00	2.4	310.65	1.8	194.82	1.3	118.85	9
10	2.0	230.44	1.6	162.19	1.5	147.00	2.3	289.47	2.0	230.44	1.4	132.55	10
11	1.9	212.26	1.6	162.19	1.4	132.55	2.0	230.44	2.3	289.47	1.4	132.55	11
12	2.0	230.44	1.6	162.19	1.3	118.85	1.9	212.26	2.2	269.05	1.4	132.55	12
13	1.9	212.26	1.6	162.19	1.3	118.85	2.1	249.37	2.8	402.81	1.4	132.55	13
14	1.8	194.82	1.7	178.13	1.7	178.13	2.0	230.44	2.7	378.65	1.6	162.19	14
15	1.9	212.26	1.6	162.19	2.7	378.65	2.0	230.44	3.2	506.92	1.4	132.55	15
16	2.3	289.47	1.5	147.00	1.7	178.13	2.1	249.37	2.4	310.65	1.4	132.55	16
17	1.9	212.26	1.8	194.82	1.6	162.19	1.9	212.26	2.1	249.37	1.4	132.55	17
18	2.2	269.05	1.6	162.19	2.3	289.47	2.0	230.44	2.1	249.37	1.3	118.85	18
19	3.3	534.82	1.7	178.13	2.1	249.37	2.0	230.44	2.0	230.44	1.3	118.85	19
20	3.2	506.92	1.6	162.19	1.7	178.13	1.8	194.82	1.9	212.26	1.3	118.85	20
21	3.4	563.46	1.5	147.00	1.7	178.13	2.1	249.37	2.0	230.44	1.5	147.00	21
22	2.6	355.23	1.5	147.00	1.6	162.19	1.9	212.26	1.9	212.26	1.7	178.13	22
23	2.4	310.65	1.4	132.55	1.6	162.19	1.7	178.13	1.8	194.82	1.5	147.00	23
24	2.3	289.47	1.4	132.55	2.2	269.05	1.6	162.19	1.7	178.13	1.3	118.85	24
25	2.2	269.05	1.7	178.13	1.9	212.26	1.7	178.13	1.7	178.13	1.3	118.85	25
26	2.1	249.37	1.7	178.13	2.7	378.65	1.8	194.82	1.6	162.19	1.3	118.85	26
27	2.1	249.37	1.4	132.55	2.1	249.37	1.6	162.19	1.6	162.19	1.4	132.55	27
28	2.0	230.44	1.4	132.55	2.2	269.05	1.9	212.26	1.5	147.00	2.3	289.47	28
29	1.9	212.26			2.5	332.57	2.9	427.71	1.5	147.00	2.0	230.44	29
30	1.9	212.26			2.5	332.57	3.0	453.37	1.4	132.55	1.6	162.19	30
31	1.9	212.26			2.2	269.05			1.4	132.55			31
TOTAL	73.3	9668.38	45.8	4725.41	57.3	6491.55	63.9	7807.66	62.6	7447.80	44.1	4327.71	TOTAL
MEAN	2.4	312.0	1.6	169.0	1.8	209.0	2.1	260.0	2.0	240.0	1.5	144.10	MEAN

$Q_1 =$ 8.74 + 36.13 $H +$ 37.36 H^2, $Q_2 =$ + $H +$ H^2, $Q_3 =$ + $H +$ H^2

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq.Mi Raub, Malaysia

Perting DIVER. IN THE BASIN OF Bentong ELEVATION ______ UNIT H(ft), Q(cfs) YEAR 1962

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	1.4	132.55	1.0	82.23	1.4	132.55	1.9	212.26	1.8	194.82	2.5	332.57	1
2	1.3	118.85	1.1	93.69	1.4	132.55	1.9	212.26	2.2	269.05	2.2	269.05	2
3	1.2	105.89	1.1	93.69	1.5	147.00	1.8	194.82	2.2	269.05	2.4	310.65	3
4	1.2	105.89	1.0	82.23	1.8	194.82	1.8	194.82	1.8	194.82	2.0	230.44	4
5	1.2	105.89	1.1	93.69	1.5	147.00	1.5	147.00	1.7	178.13	2.3	289.47	5
6	1.5	147.00	1.5	147.00	2.1	249.37	1.4	132.55	2.1	249.37	2.7	378.65	6
7	1.3	118.85	1.0	82.23	1.7	178.13	1.3	118.85	2.3	289.47	2.5	332.57	7
8	1.4	132.55	1.0	82.23	1.7	178.13	1.5	147.00	1.9	212.26	2.3	289.47	8
9	1.6	162.19	1.3	118.85	2.1	249.37	2.6	355.23	1.7	178.13	2.1	249.37	9
10	1.3	118.85	1.2	105.89	1.5	147.00	2.2	269.05	1.7	178.13	2.0	230.44	10
11	1.2	105.89	1.2	105.89	1.4	132.55	1.9	212.26	1.7	178.13	2.1	249.37	11
12	1.2	105.89	1.2	105.89	1.3	118.85	2.9	427.71	2.3	289.47	2.4	310.65	12
13	1.2	105.89	1.0	82.23	1.2	105.89	2.0	230.44	1.9	212.26	2.6	355.23	13
14	1.2	105.89	2.3	289.47	1.2	105.89	1.9	212.26	2.1	249.37	2.3	289.47	14
15	1.2	105.89	2.6	355.23	1.2	105.89	2.2	269.05	2.5	332.57	2.4	310.65	15
16	1.2	105.89	1.8	194.82	1.4	132.55	2.7	378.65	2.4	310.65	2.1	249.37	16
17	1.2	105.89	1.3	118.85	1.3	118.85	2.5	332.57	2.5	332.57	2.0	230.44	17
18	1.1	93.69	1.3	118.85	1.8	194.82	2.4	310.65	2.4	310.65	1.9	212.26	18
19	1.1	93.69	1.8	194.82	1.7	178.13	2.2	269.05	2.9	427.71	2.3	289.47	19
20	1.1	93.69	1.3	118.85	1.4	132.55	2.0	230.44	3.6	622.99	2.1	249.37	20
21	1.1	93.69	1.7	178.13	1.3	118.85	2.3	289.47	3.1	479.77	2.1	249.37	21
22	1.1	93.69	1.4	132.55	1.3	118.85	1.8	194.82	2.6	355.23	1.9	212.26	22
23	1.0	82.23	1.4	132.55	1.2	105.89	1.7	178.13	2.3	289.47	2.2	269.05	23
24	1.1	93.69	1.2	105.89	1.3	118.85	1.7	178.13	2.1	249.37	1.8	194.82	24
25	1.1	93.69	2.4	310.65	1.7	178.13	1.7	178.13	2.1	249.37	1.8	194.82	25
26	1.0	82.23	2.0	230.44	1.3	118.85	1.6	162.19	2.2	269.05	1.8	194.82	26
27	1.0	82.23	1.5	147.00	1.2	105.89	1.7	178.13	2.0	230.44	2.1	249.37	27
28	1.0	82.23	1.5	147.00	1.1	93.69	1.6	162.19	1.9	212.26	2.2	269.05	28
29	1.1	93.69	1.5	147.00	1.1	93.69	1.7	178.13	2.0	230.44	2.1	249.37	29
30	1.2	105.89	1.4	132.55	1.4	132.55	1.5	147.00	2.4	310.65	1.9	212.26	30
31	1.3	118.85	1.4	132.55			1.6	162.19			1.8	194.82	31
TOTAL	37.1	3292.92	44.5	4462.94	43.5	4267.13	59.5	6865.43	66.4	8355.65	66.9	8148.97	TOTAL
MEAN	1.2	106.0	1.4	143.9	1.45	142.2	1.9	221.8	2.2	278.2	2.2	262.2	MEAN

ANNUAL TOTAL (cfs-d)	75861.55

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sqMi Raub, Malaysia

Perting RIVER, IN THE BASIN OF Bentong ELEVATION m UNIT H(ft), Q(cfs) YEAR 1963

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	2.2	269.05	2.5	332.57	1.7	178.13	1.5	147.00	1.1	93.69	1.4	132.55	1
2	2.6	355.23	2.3	289.47	1.9	212.26	1.5	147.00	1.1	93.69	1.4	132.55	2
3	2.3	289.47	1.9	212.26	2.3	289.47	1.5	147.00	1.2	105.89	1.4	132.55	3
4	2.0	230.44	1.7	178.13	1.8	194.82	1.5	147.00	2.0	230.44	1.3	118.85	4
5	2.0	230.44	1.7	178.13	1.6	162.19	1.5	147.00	1.8	194.82	1.3	118.85	5
6	2.0	230.44	1.6	162.19	1.6	162.19	1.4	132.55	1.6	162.19	1.3	118.85	6
7	1.9	212.26	1.6	162.19	1.6	162.19	1.4	132.55	1.8	194.82	1.3	118.85	7
8	1.9	212.26	1.7	178.13	1.8	194.82	1.3	118.85	2.7	378.65	1.4	132.55	8
9	1.8	194.82	1.9	212.26	2.6	355.23	1.3	118.85	2.3	289.47	1.4	132.55	9
10	1.7	178.13	2.0	230.44	1.8	194.82	1.5	147.00	1.5	147.00	1.3	118.85	10
11	1.8	194.82	1.6	162.19	1.7	178.13	1.6	162.19	1.4	132.55	1.3	118.85	11
12	1.7	178.13	1.7	178.13	1.6	162.19	1.5	147.00	1.4	132.55	1.2	105.89	12
13	1.6	162.19	1.7	178.13	1.6	162.19	1.4	132.55	1.4	132.55	1.2	105.89	13
14	1.6	162.19	2.6	355.23	1.6	162.19	1.9	212.26	1.3	118.85	1.2	105.89	14
15	1.6	162.19	1.8	194.82	2.1	249.37	1.4	132.55	1.4	132.55	1.2	105.89	15
16	1.6	162.19	1.7	178.13	2.5	332.57	1.4	132.55	1.3	118.85	1.2	105.89	16
17	1.6	162.19	1.6	162.19	2.0	230.44	1.4	132.55	1.4	132.55	1.1	93.69	17
18	1.6	162.19	1.7	178.13	1.7	178.13	1.3	118.85	1.5	147.00	1.1	93.69	18
19	1.5	147.00	2.1	249.37	1.8	194.82	1.3	118.85	1.8	194.82	1.1	93.69	19
20	1.6	162.19	2.2	269.05	1.9	212.26	1.3	118.85	1.6	162.19	1.1	93.69	20
21	1.6	162.19	1.8	194.82	1.8	194.82	1.3	118.85	1.5	147.00	1.1	93.69	21
22	1.5	147.00	2.0	230.44	2.1	249.37	1.3	118.85	3.7	653.88	1.1	93.69	22
23	2.3	289.47	1.7	178.13	2.3	289.47	1.2	105.89	2.4	310.65	1.2	105.89	23
24	2.3	289.47	1.6	162.19	2.2	269.05	1.2	105.89	2.0	230.44	1.2	105.89	24
25	1.9	212.26	1.7	178.13	2.1	249.37	1.2	105.89	2.0	230.44	1.4	132.55	25
26	1.9	212.26	2.4	310.65	2.1	249.37	1.2	105.89	1.7	178.13	1.1	93.69	26
27	1.6	162.19	2.2	269.05	2.1	249.37	1.2	105.89	1.6	162.19	1.4	132.55	27
28	1.6	162.19	1.9	212.26	1.8	194.82	1.2	105.89	1.5	147.00	1.3	118.85	28
29	1.7	178.13			1.7	178.13	1.2	105.89	1.7	178.13	1.4	132.55	29
30	1.7	178.13			1.6	162.19	1.2	105.89	1.5	147.00	1.2	105.89	30
31	2.1	249.37			1.6	162.19			1.5	147.00			
TOTAL	56.8	6300.48	52.9	5976.81	58.6	6616.56	41.1	3877.82	52.7	5826.98	37.6	3395.30	TOTAL
MEAN	1.8	203.00	1.9	213.80	1.9	212.80	1.4	129.10	1.7	188.00	1.3	113.10	MEAN

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq. Mi Raub, Malaysia

Perting DIVER, IN THE BASIN OF Bentong ELEVATION UNIT H(ft), Q(cfs) YEAR 1963

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	1.1	93.69	1.0	82.23	1.5	147.00	1.3	118.85	2.4	310.65	2.5	332.57	1
2	1.1	93.69	0.9	71.52	1.4	132.55	1.2	105.89	2.3	289.47	2.5	332.57	2
3	1.2	105.89	0.9	71.52	1.5	147.00	1.2	105.89	2.1	249.37	2.4	310.65	3
4	1.7	178.13	1.0	82.23	1.3	118.85	1.1	93.69	2.5	332.57	2.5	332.57	4
5	1.4	132.55	1.3	118.85	1.6	162.19	1.1	93.69	2.5	332.57	2.6	355.23	5
6	1.2	105.89	1.3	118.85	1.2	105.89	1.2	105.89	2.1	249.37	2.5	332.57	6
7	1.2	105.89	2.2	269.05	1.2	105.89	1.5	147.00	2.2	269.05	2.6	355.23	7
8	1.2	105.89	2.9	427.71	1.2	105.89	1.9	212.26	2.7	378.65	2.3	289.47	8
9	1.7	178.13	2.7	378.65	1.1	93.69	1.9	212.26	2.7	378.65	2.4	310.65	9
10	1.3	118.85	2.7	378.65	1.0	82.23	1.7	178.13	2.4	310.65	2.3	289.47	10
11	1.3	118.85	2.8	402.81	1.0	82.23	1.5	147.00	2.1	249.37	2.5	332.57	11
12	1.3	118.85	3.0	453.37	1.0	82.23	1.3	118.85	2.2	269.05	2.3	289.47	12
13	1.2	105.89	1.7	178.13	1.0	82.23	1.4	132.55	2.5	332.57	2.2	269.05	13
14	1.1	93.69	1.3	118.85	1.3	118.85	2.0	230.44	4.5	927.87	2.2	269.05	14
15	1.4	132.55	1.2	105.89	1.1	93.69	2.3	289.47	3.0	453.37	2.3	289.47	15
16	1.2	105.89	1.1	93.69	1.0	82.23	2.2	269.05	2.7	378.65	2.0	230.44	16
17	1.1	93.69	1.1	93.69	1.1	93.69	1.9	212.26	2.6	355.23	1.9	212.26	17
18	1.1	93.69	1.1	93.69	1.8	194.82	1.9	212.26	2.5	332.57	1.8	194.82	18
19	1.0	82.23	1.2	105.89	1.2	105.89	1.9	212.26	2.4	310.65	1.8	194.82	19
20	1.0	82.23	1.2	105.89	1.9	212.26	1.9	212.26	2.5	332.57	2.3	289.47	20
21	1.0	82.23	1.5	147.00	1.8	194.82	1.9	212.26	2.3	289.47	2.3	289.47	21
22	1.0	82.23	1.2	105.89	1.4	132.55	1.7	178.13	2.2	269.05	2.1	249.37	22
23	1.0	82.23	1.1	93.69	1.9	212.26	1.6	162.19	3.3	534.82	2.0	230.44	23
24	1.0	82.23	1.2	105.89	2.0	230.44	1.6	162.19	2.9	427.71	2.0	230.44	24
25	0.9	71.52	1.2	105.89	1.5	147.00	1.8	194.82	2.3	289.47	1.9	212.26	25
26	1.0	82.23	1.4	132.55	1.4	132.55	2.6	355.23	2.1	249.37	2.0	230.44	26
27	1.1	93.69	1.2	105.89	1.3	118.85	2.0	230.44	2.1	249.37	2.7	378.65	27
28	1.3	118.85	1.3	118.85	1.3	118.85	1.8	194.82	2.5	332.57	2.2	269.05	28
29	1.4	132.55	1.2	105.89	1.4	132.55	1.8	194.82	2.3	289.47	1.9	212.26	29
30	1.3	118.85	1.0	82.23	1.4	132.55	2.0	230.44	2.7	378.65	1.9	212.26	30
31	1.0	82.23	1.1	93.69			1.9	212.26			1.8	194.82	31
TOTAL	36.8	3275.00	46.0	4948.62	40.8	3901.72	53.1	5737.55	75.6	10352.85	68.7	8521.86	TOTAL
MEAN	1.2	105.80	1.5	159.20	1.4	130.10	1.7	184.90	2.5	345.00	2.2	275.00	MEAN

$Q_4 =$ + H+ H^2, $Q_5 =$ + H+ H^2,

ANNUAL TOTAL (cfs-d) 68731.55

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq Mi Raub, Malaysia

Perting RIVER. IN THE BASIN OF Bentong ELEVATION m UNIT H(ft), Q(cfs) YEAR 1964

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	2.0	230.44	1.6	162.19	2.0	230.44	1.6	162.19	2.4	310.65	1.6	162.10	1
2	2.6	355.23	1.6	162.19	1.9	212.26	2.2	269.05	2.2	269.05	1.3	118.85	2
3	2.1	249.37	1.8	194.82	1.8	194.82	1.8	194.82	2.0	230.44	1.5	147.00	3
4	2.0	230.44	2.0	230.44	1.7	178.13	1.6	162.19	1.9	212.26	1.6	162.19	4
5	1.9	212.26	1.6	162.19	1.7	178.13	1.5	147.00	1.9	212.26	1.4	132.55	5
6	1.8	194.82	1.7	178.13	1.8	194.82	1.5	147.00	2.6	355.23	1.3	118.85	6
7	1.7	178.13	2.0	230.44	1.8	194.82	1.4	132.55	1.9	212.26	1.4	132.55	7
8	1.7	178.13	1.6	162.19	1.8	194.82	1.5	147.00	3.3	534.82	1.4	132.55	8
9	1.9	212.26	1.9	212.26	1.7	178.13	2.6	355.23	2.8	402.81	1.3	118.85	9
10	1.8	194.82	2.9	427.71	1.6	162.19	2.4	310.65	2.8	402.81	1.3	118.85	10
11	1.7	178.13	1.9	212.26	1.7	178.13	2.2	269.05	2.3	289.47	1.4	132.55	11
12	1.6	162.19	1.7	178.13	3.0	453.37	2.1	249.37	2.1	249.37	1.4	132.55	12
13	1.6	162.19	1.8	194.82	2.1	249.37	2.4	310.65	2.0	230.44	1.4	132.55	13
14	1.6	162.19	1.8	194.82	2.1	249.37	2.4	310.65	1.9	212.26	1.6	162.19	14
15	1.7	178.13	1.8	194.82	2.2	269.05	2.4	310.65	1.9	212.26	1.9	212.26	15
16	1.6	162.19	1.8	194.82	1.8	194.82	2.4	310.65	1.8	194.82	1.9	212.26	16
17	2.8	402.81	2.5	332.57	1.9	212.26	2.4	310.65	2.0	230.44	1.6	162.19	17
18	2.5	332.57	2.2	269.05	1.7	178.13	2.4	310.65	1.8	194.82	1.6	162.19	18
19	2.1	249.37	1.9	212.26	1.6	162.19	2.4	310.65	1.7	178.13	1.5	147.00	19
20	3.9	717.89	1.9	212.26	1.7	178.13	2.4	310.65	1.6	162.19	1.5	147.00	20
21	2.6	355.23	2.0	230.44	2.2	269.05	2.4	310.65	1.7	178.13	1.5	147.00	21
22	2.2	269.05	2.0	230.44	1.9	212.26	2.4	310.65	2.0	230.44	1.4	132.55	22
23	2.1	249.37	1.9	212.26	1.7	178.13	2.4	310.65	1.9	212.26	1.4	132.55	23
24	2.1	249.37	1.8	194.82	1.7	178.13	2.4	310.65	1.7	178.13	2.3	289.47	24
25	2.0	230.44	1.9	212.26	1.7	178.13	2.4	310.65	1.6	162.19	2.2	269.05	25
26	1.9	212.26	1.8	194.82	1.7	178.13	2.4	310.65	1.5	147.00	1.6	162.19	26
27	1.8	194.82	2.4	310.65	1.7	178.13	2.4	310.65	1.5	147.00	1.7	178.13	27
28	1.7	178.13	2.5	332.57	1.7	178.13	2.7	378.65	1.4	132.55	1.5	147.00	28
29	1.7	178.13	2.2	269.05	1.7	178.13	2.9	427.71	1.4	132.55	1.5	147.00	29
30	1.6	162.19			1.7	178.13	2.5	332.57	1.5	147.00	1.5	147.00	30
31	1.6	162.19			1.6	162.19			1.6	162.19			
TOTAL	61.9	7384.74	56.5	6505.68	56.9	6311.92	66.5	8344.78	60.7	7126.23	46.5	4699.11	TOTAL
MEAN	2.0	236.20	1.9	224.30	1.8	203 80	2.2	277.80	2.0	229.90	1.55	156.50	MEAN

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sqMi Raub, Malaysia

Perting DIVER, IN THE BASIN OF Bentong ELEVATION UNIT H(ft), Q(cfs) YEAR 1964

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	1.4	132.55	1.4	132.55	1.1	93.69	1.2	105.89	1.8	194.82	1.8	194.82	1
2	1.3	118.85	1.4	132.55	1.2	105.89	1.1	93.69	1.6	162.19	2.5	332.57	2
3	1.3	118.85	1.3	118.85	1.4	132.55	1.1	93.69	1.6	162.19	2.1	249.37	3
4	1.3	118.85	1.3	118.85	1.7	178.13	1.1	93.69	1.4	132.55	1.8	194.82	4
5	1.3	118.85	1.3	118.85	1.7	178.13	1.1	93.69	1.3	118.85	1.7	178.13	5
6	1.6	162.19	1.2	105.89	1.6	162.19	1.1	93.69	1.3	118.85	1.6	162.19	6
7	1.5	147.00	1.2	105.89	1.7	178.13	1.2	105.89	1.7	178.13	1.6	162.19	7
8	1.8	194.82	1.2	105.89	1.6	162.19	1.3	118.85	2.0	230.44	1.8	194.82	8
9	1.7	178.13	1.2	105.89	1.2	105.89	1.3	118.85	1.5	147.00	2.1	249.37	9
10	1.7	178.13	1.1	93.69	1.3	118.85	1.1	93.69	1.9	212.26	3.2	506.92	10
11	1.5	147.00	1.1	93.69	1.7	178.13	1.6	162.19	1.6	162.19	2.3	289.47	11
12	1.4	132.55	1.4	132.55	1.5	147.00	1.2	105.89	1.8	194.82	2.0	230.44	12
13	1.4	132.55	2.1	249.37	1.3	118.85	1.1	93.69	1.5	147.00	1.8	194.82	13
14	1.3	118.85	1.5	147.00	1.8	194.82	1.4	132.55	1.4	132.55	2.0	230.44	14
15	1.2	105.89	1.6	162.19	1.5	147.00	1.1	93.69	1.8	194.82	1.7	178.13	15
16	1.8	194.82	1.4	132.55	1.5	147.00	1.0	82.23	2.1	249.37	1.6	162.19	16
17	2.1	249.37	1.4	132.55	1.4	132.55	1.5	147.00	1.7	178.13	1.6	162.19	17
18	1.5	147.00	1.2	105.89	1.3	118.85	1.6	162.19	1.7	178.13	2.4	310.65	18
19	1.4	132.55	1.2	105.89	1.2	105.89	1.5	147.00	1.7	178.13	2.6	355.23	19
20	1.4	132.55	1.3	118.85	1.2	105.89	2.0	230.44	1.5	147.00	2.0	230.44	20
21	1.4	132.55	1.3	118.85	1.2	105.89	1.7	178.13	1.9	212.26	2.1	249.37	21
22	1.5	147.00	1.2	105.89	1.2	105.89	2.0	230.44	2.1	249.37	2.4	310.65	22
23	2.4	310.65	1.2	105.89	1.2	105.89	2.0	230.44	2.2	269.05	2.3	289.47	23
24	1.9	212.26	1.2	105.89	1.6	162.19	2.1	249.37	2.3	289.47	2.4	310.65	24
25	1.8	194.82	1.2	105.89	1.5	147.00	1.7	178.13	3.3	534.82	2.1	249.37	25
26	1.6	162.19	1.0	82.23	1.2	105.89	1.7	178.13	2.4	310.65	2.2	269.05	26
27	2.1	249.37	1.1	93.69	1.2	105.89	1.5	147.00	2.1	249.37	2.2	269.05	27
28	1.6	162.19	1.0	82.23	1.1	93.69	1.4	132.55	2.0	230.44	2.2	269.05	28
29	1.5	147.00	1.2	105.89	1.1	93.69	1.7	178.13	1.9	212.26	2.2	269.05	29
30	1.4	132.55	1.2	105.89	1.8	194.82	2.6	355.23	1.9	212.26	2.3	289.47	30
31	1.5	147.00	1.4	132.55			1.8	194.82			2.0	230.44	31
TOTAL	48.6	4958.93	39.8	3664.32	42.0	4032.46	45.8	4620.86	55.0	6189.37	64.6	7774.82	TOTAL
MEAN	1.6	160.00	1.3	118.2	1.4	134.20	1.5	149.10	1.8	206.00	2.1	250.50	MEAN

ANNUAL TOTAL (cfs-d)	71613.22

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq.Mi Raub, Malaysia

Perting RIVER. IN THE BASIN OF Bentong ELEVATION m UNIT H(ft), Q(cfs) YEAR 1965

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	1.8	194.82	1.3	118.85	1.1	93.69	1.4	132.55	1.8	194.82	1.2	105.89	1
2	1.8	194.82	1.4	132.55	1.1	93.69	1.5	147.00	2.2	269.05	1.2	105.89	2
3	1.8	194.82	1.3	118.85	1.1	93.69	1.2	105.89	2.3	289.47	1.2	105.89	3
4	1.7	178.13	1.4	132.55	1.1	93.69	1.3	118.85	2.2	269.05	1.3	118.85	4
5	1.6	162.19	1.4	132.55	1.1	93.69	2.0	230.44	1.6	162.19	1.3	118.85	5
6	1.6	162.19	1.3	118.85	1.0	82.23	1.8	194.82	1.5	147.00	1.1	93.69	6
7	1.5	147.00	1.7	178.13	1.0	82.23	1.3	118.85	1.5	147.00	1.2	105.89	7
8	1.5	147.00	1.5	147.00	1.1	93.69	1.2	105.89	2.3	289.47	1.2	105.89	8
9	1.5	147.00	1.3	118.85	1.4	132.55	1.1	93.69	2.2	269.05	1.1	93.69	9
10	1.5	147.00	1.2	105.89	1.1	93.69	1.1	93.69	1.9	212.26	1.1	93.69	10
11	1.5	147.00	1.2	105.89	1.0	82.23	1.1	93.69	1.8	194.82	1.0	82.23	11
12	1.4	132.55	1.5	147.00	1.0	82.23	1.4	132.55	1.8	194.82	1.0	82.23	12
13	1.3	118.85	1.8	194.82	1.1	93.69	1.4	132.55	1.5	147.00	1.0	82.23	13
14	1.3	118.85	1.5	147.00	1.0	82.23	1.3	118.85	1.9	212.26	1.0	82.23	14
15	1.3	118.85	1.4	132.55	1.0	82.23	1.3	118.85	1.7	178.13	1.2	105.89	15
16	1.3	118.85	1.4	132.55	1.0	82.23	1.7	178.13	1.6	162.19	1.4	132.55	16
17	1.3	118.85	1.7	178.13	1.0	82.23	1.9	212.26	1.7	178.13	1.0	82.23	17
18	1.3	118.85	1.3	118.85	0.9	71.52	1.9	212.26	1.5	147.00	0.9	71.52	18
19	1.3	118.85	1.2	105.89	0.9	71.52	1.9	212.26	1.6	162.19	1.2	105.89	19
20	1.3	118.85	1.2	105.89	1.3	118.85	1.9	212.26	1.9	212.26	1.3	118.85	20
21	1.2	105.89	1.2	105.89	1.9	212.26	1.7	178.13	1.8	194.82	1.2	105.89	21
22	1.3	118.85	1.2	105.89	1.7	178.13	1.8	194.82	2.4	310.65	1.3	118.85	22
23	1.3	118.85	1.2	105.89	1.3	118.85	1.5	147.00	1.9	212.26	1.1	93.69	23
24	1.3	118.85	1.2	105.89	1.0	82.23	1.2	105.89	1.9	212.26	1.1	93.69	24
25	1.4	132.55	1.1	93.69	1.1	93.69	1.2	105.89	1.7	178.13	1.0	82.23	25
26	1.3	118.85	1.1	93.69	1.2	105.89	1.2	105.89	1.5	147.00	1.0	82.23	26
27	1.3	118.85	1.1	93.69	1.1	93.69	2.0	230.44	1.5	147.00	1.0	82.23	27
28	1.2	105.89	1.1	93.69	1.2	105.89	1.5	147.00	1.4	132.55	1.2	105.89	28
29	1.2	105.89			1.4	132.55	1.4	132.55	1.3	118.85	1.1	93.69	29
30	1.7	178.13			2.0	230.44	1.3	118.85	1.3	118.85	1.1	93.69	30
31	1.6	162.19			1.3	118.85			1.2	105.89			
TOTAL	44.4	4290.11	37.2	3470.96	36.5	3274.27	44.5	4431.79	54.4	5916.42	34.0	2946.15	TOTAL
MEAN	1.4	142.80	1.3	123.90	1.2	105.60	1.5	147.80	1.8	190.90	1.1	98.30	MEAN

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sqMi Raub, Malaysia

Perting DIVER. IN THE BASIN OF Bentong ELEVATION UNIT H(ft), Q(cfs) YEAR 1965

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	1.0	82.23	0.9	71.52	1.6	162.19	1.6	162.19	2.4	310.65	2.7	378.65	1
2	1.0	82.23	1.0	82.23	1.8	194.82	1.3	118.85	2.4	310.65	2.4	310.65	2
3	1.0	82.23	1.0	82.23	1.3	118.85	1.2	105.89	2.5	332.57	2.3	289.47	3
4	0.9	71.52	0.9	71.52	1.3	118.85	1.3	118.85	2.7	378.65	2.2	269.05	4
5	0.9	71.52	0.8	61.55	1.4	132.55	1.3	118.85	2.3	289.47	2.2	269.05	5
6	1.3	118.85	1.0	82.23	1.8	194.82	1.4	132.55	2.1	249.37	2.2	269.05	6
7	1.2	105.89	1.4	132.55	1.6	162.19	2.2	269.05	2.0	230.44	2.5	332.57	7
8	0.9	71.52	1.0	82.23	1.5	147.00	2.0	230.44	1.9	212.26	2.6	355.23	8
9	0.9	71.52	1.3	118.85	1.5	147.00	1.7	178.13	1.9	212.26	4.7	1003.83	9
10	1.0	82.23	0.9	71.52	1.1	93.69	1.8	194.82	1.8	194.82	6.2	1668.86	10
11	1.0	82.23	0.8	61.55	1.0	82.23	2.7	378.65	1.6	162.19	2.8	402.81	11
12	0.9	71.52	0.7	52.34	1.5	147.00	2.1	249.37	1.5	147.00	2.8	402.81	12
13	0.9	71.52	0.6	43.87	1.4	132.55	1.8	194.82	2.1	249.37	2.7	378.65	13
14	0.9	71.52	1.1	93.69	1.1	93.69	2.2	269.05	3.0	453.37	3.1	479.77	14
15	0.8	61.55	0.8	61.55	1.2	105.89	2.0	230.44	3.8	685.51	3.0	453.37	15
16	0.8	61.55	1.5	147.00	1.0	82.23	3.7	653.88	3.3	534.82	2.8	402.81	16
17	0.7	52.34	1.2	105.89	1.3	118.85	3.1	479.77	3.4	563.46	2.9	427.71	17
18	0.7	52.34	1.3	118.85	1.2	105.89	3.4	563.46	2.6	355.23	2.8	402.81	18
19	0.9	71.52	0.8	61.55	1.3	118.85	2.7	378.65	2.5	332.57	3.0	453.37	19
20	0.8	61.55	1.0	82.23	1.2	105.89	3.2	506.92	2.5	332.57	2.8	402.81	20
21	0.8	61.55	1.0	82.23	2.1	249.37	2.4	310.65	2.9	427.71	2.6	355.23	21
22	0.7	52.34	0.9	71.52	1.3	118.85	2.1	249.37	2.7	378.65	2.5	332.57	22
23	0.7	52.34	0.8	61.55	1.1	93.69	2.1	249.37	2.4	310.65	2.4	310.65	23
24	0.7	52.34	1.8	194.82	1.1	93.69	2.0	230.44	2.3	289.47	2.7	378.65	24
25	0.8	61.55	2.6	355.23	1.3	118.85	1.9	212.26	2.4	310.65	2.8	402.81	25
26	0.8	61.55	1.5	147.00	1.9	212.26	2.3	289.47	2.5	332.57	2.6	355.23	26
27	0.8	61.55	1.3	118.85	1.7	178.13	2.3	289.47	2.3	289.47	2.6	355.23	27
28	0.8	61.55	1.3	118.85	2.0	230.44	2.1	249.37	2.2	269.05	2.5	332.57	28
29	1.6	162.19	1.1	93.69	1.8	194.82	2.2	269.05	2.7	378.65	2.4	310.65	29
30	0.9	71.52	1.1	93.69	1.6	162.19	2.5	332.57	2.8	402.81	2.5	332.57	30
31	0.7	52.34	1.1	93.69			2.5	332.57			2.3	289.47	31
TOTAL	27.8	2248.20	34.5	3116.07	43.0	4217.32	67.1	8549.22	73.5	9926.91	86.6	13108.96	TOTAL
MEAN	0.9	72.50	1.1	100.30	1.4	140.80	2.2	276.50	2.5	330.20	2.8	424.50	MEAN

ANNUAL TOTAL (cfs-d)	55496.38

WATER LEVEL (H) AND DISCHARGE (Q) .... (2/2)

WATER LEVEL(H) AND DISCHARGE(Q) STATION Perting CATCHMENT AREA 40.5 sq.Mi Raub, Malaysia

Perting RIVER. IN THE BASIN OF Bentong ELEVATION ______ m UNIT H(ft), Q(cfs) YEAR 1966

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		DATE
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	
1	2.3	289.47	2.5	332.57	2.0	230.44	2.1	249.37	2.3	289.47			1
2	2.2	269.05	2.2	269.05	1.7	178.13	2.1	249.37	2.2	269.05			2
3	2.1	249.37	2.2	269.05	1.8	194.82	2.1	249.37	2.0	230.44			3
4	2.0	230.44	2.3	289.47	1.8	194.82	2.1	249.37	1.8	194.82			4
5	2.0	230.44	2.4	310.65	1.8	194.82	1.8	194.82	1.8	194.82			5
6	1.9	212.26	2.2	269.05	1.7	178.13	3.9	717.89	1.8	194.82			6
7	1.8	194.82	2.0	230.44	1.9	212.26	2.2	269.05	1.8	194.82			7
8	1.8	194.82	2.0	230.44	1.9	212.26	2.9	427.71	1.7	178.13			8
9	1.9	212.26	2.1	249.37	1.8	194.82	2.8	402.81	1.6	162.19			9
10	3.0	453.37	1.9	212.26	1.8	194.82	2.4	310.65	1.7	178.13			10
11	2.7	378.65	2.0	230.44	1.9	212.26	2.3	289.47	1.6	162.19			11
12	2.2	269.05	1.9	212.26	1.8	194.82	2.7	378.65	1.6	162.19			12
13	2.0	230.44	1.8	194.82	1.7	178.13	2.9	427.71	1.6	162.19			13
14	2.0	230.44	1.8	194.82	1.7	178.13	2.4	310.65	1.6	162.19			14
15	2.3	289.47	1.9	212.26	1.6	162.19	2.2	269.05	1.8	194.82			15
16	2.2	269.05	2.3	289.47	1.5	147.00	2.0	230.44					16
17	2.2	269.05	2.3	289.47	1.7	178.13	1.9	212.26					17
18	2.3	289.47	2.6	355.23	1.8	194.82	1.9	212.26					18
19	2.0	230.44	2.8	402.81	2.0	230.44	2.2	269.05					19
20	2.2	269.05	2.1	249.37	1.9	212.26	2.0	230.44					20
21	2.5	332.57	2.3	289.47	1.7	178.13	1.9	212.26					21
22	2.2	269.05	2.3	289.47	1.6	162.19	2.0	230.44					22
23	2.3	289.47	2.0	230.44	1.5	147.00	2.1	249.37					23
24	3.7	653.88	1.9	212.26	1.6	162.19	2.1	249.37					24
25	2.9	427.71	1.8	194.82	1.7	178.13	2.1	249.37					25
26	2.5	332.57	1.7	178.13	1.6	162.19	2.7	378.65					26
27	2.3	289.47	1.7	178.13	2.1	249.37	2.4	310.65					27
28	2.2	269.05	1.9	212.26	2.4	310.65	2.1	249.37					28
29	2.3	289.47			2.1	249.37	1.9	212.26					29
30	2.2	269.05			2.1	249.37	2.1	249.37					30
31	2.6	355.23			2.1	249.37							
TOTAL	70.8	9038.93	58.9	7078.28	56.3	6171.46	68.3	8741.50					TOTAL
MEAN	2.3	291.00	2.1	252.80	1.8	199.20	2.3	290.50					MEAN

Temperature STATION Raub CATCHMENT AREA sq. km Raub, Malaysia

RIVER. IN THE BASIN OF ELEVATION m UNIT °F N 3 ° 47 E 101 ° 51 '

YEAR		JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1950	Max	89	93	92	91	92	92	91	92	92	91	90	88	
	Min	69	68	68	70	67	70	67	66	68	68	67	68	
1951	Max	90	91	91	92	92	94	92	93	91	91	91	89	
	Min	65	68	64	66	68	68	68	67	69	67	70	70	
1952	Max	88	91	92	92	91	91	92	92	91	92	90	91	
	Min	68	68	71	71	70	68	67	67	68	69	68	66	
1953	Max	90	90	90	92	90	92	94	90	90	91	91	90	
	Min	68	67	68	70	70	-	69	69	68	69	69	68	
1954	Max	90	90	90	93	91	92	90	90	90	89	88	87	
	Min	69	68	69	69	69	67	68	68	67	67	67	67	
1955	Max	87	89	92	93	93	92	91	91	90	90	91	90	
	Min	68	67	68	66	67	66	68	67	67	67	67	66	
1956	Max	92	90	92	92	92	91	92	91	91	91	92	88	
	Min	66	67	67	69	68	68	67	67	68	68	68	67	
1957	Max	92	91	92	92	92	91	91	91	90	91	90	90	
	Min	68	67	68	69	67	69	69	68	68	69	68	69	
1958	Max	90	90	91	91	91	91	94	92	94	92	91	91	
	Min	67	68	69	69	69	-	68	69	69	69	69	67	
1959	Max	90	92	91	92	91	91	91	91	91	91	91	90	
	Min	66	69	69	69	69	69	68	68	68	68	69	68	
1960	Max	90	91	92	93	94	93	92	92	91	93	90	90	
	Min	69	68	69	69	70	70	69	69	68	69	69	70	
1961	Max	88	89	93	91	92	92	93	93	91	91	90	90	
	Min	68	65	70	70	69	68	68	69	68	69	69	68	
1962	Max	87	90	92	94	-	95	93	92	-	-	-	-	
	Min	67	67	69	70	-	68	68	66	68	-	-	-	
1963	Max	-	-	-	-	-	-	94	93	90	-	-	90	
	Min	-	-	-	-	-	-	69	68	-	-	-	68	

Relative Humidity STATION Raub CATCHMENT AREA sq. km Raub, Malaysia

RIVER. IN THE BASIN OF ELEVATION UNIT % N 3° 47' E 101 ° 51'

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL TOTAL
1950	66	60	61	67	63	64	61	60	61	63	67	65	
1951	71	62	59	64	58	61	58	61	62	65	68	73	
1952	71	62	66	64	65	60	61	60	59	64	66	63	
1953	61	61	65	62	64	62	64	62	64	64	61	60	
1954	65	63	60	62	62	62	62	61	60	61	61	65	
1955	64	64	62	62	63	63	62	63	61	60	61	64	
1956	-	-	-	-	-	-	-	-	-	-	-	-	
1957	62	58	57	54	60	50	61	-	59	65	63	74	
1958	62	62	63	59	63	60	61	61	59	61	62	62	
1959	60	57	53	62	62	63	61	61	61	-	-	63	
1960	59	62	54	61	60	60	61	61	61	61	65	63	
1961	67	60	60	62	60	59	55	62	60	61	64	66	
1962	72	57	58	57	-	-	57	59	62	-	-	-	
1963	-	-	-	-	-	-	-	-	66	-	-	-	

APPENDIX - 2

TRANSMISSION SCHEME

APPENDIX - 2 TRANSMISSION SCHEME

With respect to the transmission system for transmitting the power· generated at the three power stations, mainly to Segambut Sub-station and partially to local loads, the three routes described below were compared and examined.

		Voltage (KV)	Distance (miles)	Conductor
Plan A	Sia P.S. - Sempam P.S.	66	21	58□ ACSR
	Liang P.S. - Sempam P.S.	66	5.5	58□ "
	Sempam P.S. - Tras	132	4	160□ "
Plan B	Sia P.S. - Liang P.S.	66	17.5	58□ ACSR
	Liang P.S. - Sempam P.S.	66	5.5	80□ "
	Sempam P.S. - Tras	132	4	160□ "
Plan C	Sia P.S. - Liang P.S.	132	11	160□ ACSR
	Liang P.S. - Sempam P.S.	132	5.5	160□ "
	Sempam P.S. - Tras	132	4	160□ "

Plan A: In this plan, both Sia Power Station and Liang Power Station will be connected by independent single circuit 66 KV lines to Sempam Power Station. A 132/66 KV connecting transformer will be installed at Sempam Power Station, where the power will be stepped up to 132 KV and transmitted to Segambut via Tras, on a single circuit transmission line.

The route was selected for the Sia - Sempam line so that most of the route will run parallel to a road instead of passing through deep jungle regions. Therefore, hauling of materials and erection work will be comparatively easy. For supporting the line, steel poles will be adopted. The route between Liang Power Station and Sempam Power Station will pass through steep mountains and deep jungle areas, as the distance is short and no other alternative route can be considered from the economical point of view. Steel towers will be most economical as line supports for this route.

Plan B: In this plan, Sia Power Station will be connected to the Sempam Power Station via the Liang Power Station by the construction of a 66 KV single circuit transmission line. A 132/66 KV connecting transformer will be installed at Sempam Power Station as in the case of Plan A. The route between Sia Power Station and Liang Power Station will run paralled to a road for the same consideration made for Plan A. Steel poles will be used as line supports.

The same route as in Plan A will be adopted between Liang Power Station and Sempam Power Station. In consideration of the transmitting capacity, voltage drop and loss, 80$^{\square}$ ACSR conductor will be adopted.

From the standpoint of system reliability, this plan will be inferior to Plan A because in case of an accident on the line between Liang Power Station and Sempam Power Station, the operation of Sia and Liang Stations will be stopped.

Plan C: The system in this plan will be the same as in Plan B, except that the voltage will be 132 V in the entire system. The route between Sia Power Station and Liang Power Station, however, will pass through mountain area and is shortened by 11 miles. The route between Liang Power Station and Sempam Power Station will be the same as in Plans A and B. The connecting transformer (132 KV/66 KV) can be eliminated in this plan.

Construction costs, annual costs and energy losses for the three alternatives, including outgoing facilities and connecting transformers are shown in Table 2.1.

In comparing the annual cost and KWh loss of each plan, it is found that Plan C reveals the minimum cost and energy loss followed by Plan A, however, there is practically no difference between the two plans.

In consideration of reliability of system operation and construction problems, Plan A is most favourable.

Table 2.1 Comparison of Transmission Routes

Alternatives	A	B	C
(1) Annual energy loss (MWh)	4,000	4,740	2,530
(2) Construction costs ($M)			
Transmission line	1,203,700	1,110,000	1,352,000
Feeders	1,124,000	1,197,000	1,783,000
Connecting transformer	333,000	333,000	-
Total	2,660,700	2,640,000	3,135,000
(3) Annual costs ($M)	31,900	31,700	37,600
(4) Value of energy loss ($M)	18,000	21,300	11,400
(5) Total (3) + (4) ($M)	49,900	53,000	49,000

APPENDIX- 3

BREAKDOWN OF ESTIMATED CONSTRUCTION COSTS

a) Estimated Construction Cost of Liang Scheme

Unit: $M

Item		Unit	Quantity	Unit price	Amount
1.	Civil Works				12, 820, 000
1.1	Access Road & Bridge				985, 000
(1)	New road, paved	ft	3, 200	35	112, 000
(2)	Improved road, paved	ft	32, 800	15	492, 000
(3)	Improved road, unpaved	ft	38, 100	10	381, 000
1.2.1	Diversion Dam in Liang				731, 000
(1)	Excavation	cu. yd.	27, 500	5.5	151, 250
(2)	Concrete	cu. yd.	6, 900	46	317, 400
(3)	Furnishing and placing reinforcing steel	t	20	450	9, 000
(4)	Others	Lump sum			253, 350
1.2.2	Diversion Dam in Hijau				396, 000
(1)	Excavation	cu. yd.	9, 560	5.5	52, 580
(2)	Concrete	cu. yd.	5, 190	54	280, 260
(3)	Furnishing and placing reinforcing steel	t	10	450	4, 500
(4)	Others	Lump sum			58, 660
1.3.1	Intake & Desilting Basin in Liang				322, 000
(1)	Excavation	cu. yd.	10, 180	5.5	55, 990
(2)	Concrete	cu. yd.	2, 340	77	180, 180
(3)	Masonry with mortar	sq. yd.	240	25	6, 000
(4)	Furnishing and placing reinforcing steel	t	130	450	58, 500
(5)	Others	Lump sum			21, 330

	Item	Unit	Quantity	Unit price	Amount
1.3.2	Intake & Desilting Basin in Hijau				77,000
(1)	Excavation	cu.yd.	2,920	5.5	16,060
(2)	Concrete	cu.yd.	520	77	40,040
(3)	Masonry with mortar	sq.yd.	120	25	3,000
(4)	Furnishing and placing reinforcing steel	t	30	450	13,500
(5)	Others	Lump sum			4,400
1.4.1	Headrace Tunnel in Liang				4,572,000
(1)	Excavation for tunnel	cu.yd.	48,520	62	3,008,240
(2)	Concrete in tunnel lining	cu.yd.	1,830	107	195,810
(3)	Concrete in tunnel invert	cu.yd.	4,520	62	280,240
(4)	Guniting	sq.yd.	39,060	17	664,020
(5)	Furnishing and placing steel support	t	260	1,000	260,000
(6)	Furnishing and placing reinforcing steel	t	120	450	54,000
(7)	Others	Lump sum			109,690
1.4.2	Headrace Tunnel in Hijau				1,079,000
(1)	Excavation for tunnel	cu.yd.	9,810	62	608,220
(2)	Concrete in tunnel lining	cu.yd.	1,050	107	112,350
(3)	Concrete in tunnel invert	cu.yd.	900	62	55,800
(4)	Guniting	sq.yd.	6,470	17	109,990
(5)	Furnishing and placing steel support	t	140	1,000	140,000
(6)	Furnishing and placing reinforcing steel	t	50	450	22,500
(7)	Others	Lump sum			30,140

	Item	Unit	Quantity	Unit price	Amount
1.5	Surge Tank				406,000
(1)	Open excavation	cu.yd.	260	7	1,820
(2)	Excavation, for vertical shaft	cu.yd.	1,620	85	137,700
(3)	Excavation, for tunnel	cu.yd.	1,280	62	79,360
(4)	Concrete, in shaft lining	cu.yd.	790	107	84,530
(5)	Concrete, in tunnel lining	cu.yd.	220	107	23,540
(6)	Furnishing and placing steel support	t	20	1,000	20,000
(7)	Furnishing and placing reinforcing steel	t	60	450	27,000
(8)	Others	Lump sum			32,250
1.6	Penstock				648,000
(1)	Excavation	cu.yd.	25,200	7	176,400
(2)	Excavation, for tunnel	cu.yd.	1,940	62	120,280
(3)	Concrete, for tunnel lining	cu.yd.	650	107	69,550
(4)	Concrete	cu.yd.	2,010	77	154,770
(5)	Furnishing and placing steel support	t	20	1,000	20,000
(6)	Furnishing and placing reinforcing steel	t	70	450	31,500
(7)	Others	Lump sum			75,500
1.7	Powerhouse Sub-structure				1,140,000
(1)	Slope cutting	cu.yd.	2,580	5.5	14,190
(2)	Foundation excavation	cu.yd.	4,860	25	121,500
(3)	Concrete	cu.yd.	1,990	77	153,230

	Item	Unit	Quantity	Unit price	Amount
(4)	Furnishing and placing reinforcing steel	t	90	450	40,500
(5)	Others	Lump sum			65,580
	Sub total				395,000
	Super-structure	Lump sum			745,000
1.8	Switchyard				55,000
(1)	Excavation	cu.yd.	500	5.5	2,750
(2)	Concrete	cu.yd.	520	77	40,040
(3)	Furnishing and placing reinforcing steel	t	20	450	9,000
(4)	Others	Lump sum			3,210
1.9	Tailrace Tunnel				151,000
(1)	Open excavation	cu.yd.	500	5.5	2,750
(2)	Excavation, for tunnel	cu.yd.	940	62	58,280
(3)	Concrete, in tunnel lining	cu.yd.	260	107	27,820
(4)	Concrete, in tunnel invert	cu.yd.	80	62	4,960
(5)	Other concrete works	cu.yd.	220	77	16,940
(6)	Furnishing and placing steel support	t	20	1,000	20,000
(7)	Furnishing and placing reinforcing steel	t	30	450	13,500
(8)	Others	Lump sum			6,750
1.10	Operaters' Quarters	Lump sum			125,000
1.11	Contingencies	Lump sum			2,133,000
2.	Hydraulic Equipments				1,250,000
2.1	Gates	Lump sum			162,000

Item	Unit	Quantity	Unit price	Amount
2.2 Trashracks		Lump sum		36,000
2.3 Liner-plate		Lump sum		72,000
2.4 Penstock		Lump sum		880,000
2.5 Butterfly Valve		Lump sum		40,000
2.6 Contingencies		Lump sum		60,000
3. Electrical Equipments				2,670,000
3.1 Turbines		Lump sum		661,000
3.2 Generators		Lump sum		803,000
3.3 Transformers		Lump sum		220,000
3.4 Accessories		Lump sum		862,000
3.5 Contingencies		Lump sum		124,000
4. Service Facilities		Lump sum		150,000
5. General Expenses		Lump sum		720,000
6. Investigations		Lump sum		80,000
7. Engineering - design, specification and supervision		Lump sum		1,200,000
8. Interest during Construction		Lump sum		1,410,000
9. Grand Total		Lump sum		20,300,000

b) Estimated Construction Cost of Sia Scheme

Unit: $M

	Item	Unit	Quantity	Unit price	Amount
1.	Civil Works				6,920,000
1.1	Access Roads & Bridges				572,000
(1)	New road, paved	ft	1,700	35	59,500
(2)	Improved road, paved	ft	20,000	15	300,000
(3)	New road, unpaved	ft	8,500	25	212,500
1.2	Diversion Dam				875,000
(1)	Excavation	cu.yd.	17,820	5.5	98,010
(2)	Excavation, for tunnel	cu.yd.	260	62	16,120
(3)	Concrete	cu.yd.	13,830	46	636,180
(4)	Furnishing and placing reinforcing steel	t	20	450	9,000
(5)	Others	Lump sum			115,690
1.3	Intake & Desilting Basin				196,000
(1)	Excavation	cu.yd.	6,360	5.5	34,980
(2)	Concrete	cu.yd.	1,300	77	100,100
(3)	Masonry with mortar	sq.yd.	240	25	6,000
(4)	Furnishing and placing reinforcing steel	t	90	450	40,500
(5)	Others	Lump sum			14,420
1.4	Headrace Tunnel				2,142,000
(1)	Excavation, for tunnel	cu.yd.	20,650	62	1,280,300
(2)	Concrete, in tunnel lining	cu.yd.	1,310	107	140,170
(3)	Concrete, in tunnel invert	cu.yd.	2,070	62	128,340
(4)	Guniting	sq.yd.	16,120	17	274,040

	Item	Unit	Quantity	Unit price	Amount
(5)	Furnishing and placing steel support	t	220	1,000	220,000
(6)	Furnishing and placing reinforcing steel	t	70	450	31,500
(7)	Others	Lump sum			67,650
1.5	Surge Tank				352,000
(1)	Open excavation	cu.yd.	390	7	2,730
(2)	Excavation, for vertical shaft	cu.yd.	900	85	76,500
(3)	Excavation, for access tunnel	cu.yd.	2,140	62	132,680
(4)	Concrete, in shaft lining	cu.yd.	310	107	33,170
(5)	Concrete, in tunnel lining	cu.yd.	390	107	41,730
(6)	Furnishing and placing steel support	t	30	1,000	30,000
(7)	Furnishing and placing reinforcing steel	t	50	450	22,500
(8)	Others	Lump sum			12,690
1.6	Penstock				570,000
(1)	Excavation	cu.yd.	9,260	7	64,820
(2)	Excavation, for tunnel	cu.yd.	2,320	62	143,840
(3)	Concrete, in tunnel lining	cu.yd.	790	107	84,530
(4)	Concrete	cu.yd.	2,400	77	184,800
(5)	Furnishing and placing steel support	t	90	450	40,500
(6)	Furnishing and placing reinforcing steel	t	30	1,000	30,000
(7)	Others	Lump sum			21,510

	Item	Unit	Quantity	Unit price	Amount
1.7	Powerhouse Sub-structure				830,000
(1)	Slope cutting	cu.yd.	8,980	5.5	49,390
(2)	Foundation excavation	cu.yd.	3,000	25	75,000
(3)	Concrete	cu.yd.	1,900	77	146,300
(4)	Furnishing and placing reinforcing steel	t	56	450	25,200
(5)	Others	Lump sum			59,110
	Sub-total				355,000
	Super-structure	Lump sum			475,000
1.8	Switchyard				72,000
(1)	Excavation	cu.yd.	3,180	5.5	17,490
(2)	Concrete	cu.yd.	600	77	46,200
(3)	Furnishing and placing reinforcing steel	t	15	450	6,750
(4)	Others	Lump sum			1,560
1.9	Tailrace				28,000
(1)	Excavation	cu.yd.	2,160	5.5	11,880
(2)	Concrete	cu.yd.	100	77	7,700
(3)	Furnishing and placing reinforcing steel	t	10	450	4,500
(4)	Others	Lump sum			3,920
1.10	Operators' Quarters	Lump sum			125,000
1.11	Contingencies	Lump sum			1,158,000
2.	Hydraulic Equipments				930,000
2.1	Gates	Lump sum			81,000
2.2	Trashrack	Lump sum			54,000

Item		Unit	Quantity	Unit price	Amount
2.3	Liner-plate	Lump sum			72,000
2.4	Penstock	Lump sum			640,000
2.5	Butterfly Valve	Lump sum			40,000
2.6	Contingencies	Lump sum			43,000
3.	Electrical Equipments				2,140,000
3.1	Turbines	Lump sum			445,000
3.2	Generators	Lump sum			628,000
3.3	Transformers	Lump sum			145,000
3.4	Accessories	Lump sum			820,000
3.5	Contingencies	Lump sum			102,000
4.	Service Facilities	Lump sum			90,000
5.	General Expenses	Lump sum			430,000
6.	Investigations	Lump sum			60,000
7.	Engineering - design, specification and supervision	Lump sum			650,000
8.	Interest during Construction	Lump sum			780,000
9.	Grand Total				12,000,000

c) Estimated Construction Cost of Sempam Scheme

Unit: $M

	Item	Unit	Quantity	Unit price	Amount
1.	Civil Works				7,750,000
1.1	Access Roads & Bridges				604,000
(1)	New road, paved	ft	3,200	35	112,000
(2)	Improved road, paved	ft	18,000	15	270,000
(3)	Improved road, unpaved	ft	22,200	10	222,000
1.2	Diversion Dam				751,000
(1)	Excavation	cu.yd.	9,160	5.5	50,380
(2)	Excavation for tunnel	cu.yd.	390	62	24,180
(3)	Concrete	cu.yd.	9,390	46	431,940
(4)	Concrete for retaining wall	cu.yd.	520	77	40,040
(5)	Furnishing and placing reinforcing steel	t	20	450	9,000
(6)	Others	Lump sum			195,460
1.3	Intake & desilting Basin				177,000
(1)	Excavation	cu.yd.	5,720	5.5	31,460
(2)	Concrete	cu.yd.	1,230	77	94,710
(3)	Masonry with mortar	sq.yd.	240	25	6,000
(4)	Furnishing and placing reinforcing steel	t	70	450	31,500
(5)	Others	Lump sum			13,330
1.4	Headrace Tunnel				3,174,000
(1)	Excavation for tunnel	cu.yd.	29,290	62	1,815,980
(2)	Concrete in tunnel lining	cu.yd.	2,420	107	258,940
(3)	Concrete in tunnel invert	cu.yd.	2,840	62	176,080

	Item	Unit	Quantity	Unit price	Amount
(4)	Guniting	sq.yd.	21,180	7	360,060
(5)	Furnishing and placing steel support	t	380	1,000	380,000
(6)	Furnishing and placing reinforcing steel	t	130	450	58,500
(7)	Others	Lump sum			124,440
1.5	Surge Tank				178,000
(1)	Open excavation	cu.yd.	390	7	2,730
(2)	Excavation for vertical shaft	cu.yd.	840	85	71,400
(3)	Excavation for tunnel	cu.yd.	490	62	30,380
(4)	Concrete in shaft lining	cu.yd.	330	107	35,310
(5)	Concrete in tunnel lining	cu.yd.	80	107	8,560
(6)	Furnishing and placing steel support	t	10	1,000	10,000
(7)	Furnishing and placing reinforcing steel	t	20	450	9,000
(8)	Others	Lump sum			10,620
1.6	Penstock				330,000
(1)	Excavation	cu.yd.	6,430	7	45,010
(2)	Excavation for tunnel	cu.yd.	520	60	32,240
(3)	Concrete in tunnel lining	cu.yd.	200	107	21,400
(4)	Concrete	cu.yd.	1,620	77	124,740
(5)	Furnishing and placing steel support	t	20	1,000	20,000
(6)	Furnishing and placing reinforcing steel	t	50	450	22,500
(7)	Others	Lump sum			64,110

	Item	Unit	Quantity	Unit price	Amount
1.7	Powerhouse Sub-structure				880,000
(1)	Slope cutting	cu.yd.	8,080	5.5	44,440
(2)	Foundation excavation	cu.yd.	3,660	25	91,500
(3)	Concrete	cu.yd.	2,420	77	186,340
(4)	Furnishing and placing reinforcing steel	t	51	450	22,950
(5)	Others	Lump sum		-	69,770
	Sub-total				415,000
	Super-structure	Lump sum		-	465,000
1.8	Switchyard				110,000
(1)	Excavation	cu.yd.	5,080	5.5	27,940
(2)	Concrete	cu.yd.	990	77	76,230
(3)	Furnishing and placing reinforcing steel	t	10	450	4,500
(4)	Others	Lump sum			1,330
1.9	Tailrace Tunnel				129,000
(1)	Excavation	cu.yd.	2,160	5.5	11,880
(2)	Excavation for tunnel	cu.yd.	550	62	34,100
(3)	Concrete in tunnel lining	cu.yd.	210	107	22,470
(4)	Concrete in tunnel·invert	cu.yd.	60	62	3,720
(5)	Concrete	cu.yd.	220	77	16,940
(6)	Furnishing and placing steel support	t	20	1,000	20,000
(7)	Furnishing and placing reinforcing steel	t	30	450	13,500
(8)	Others	Lump sum		-	6,390

Item		Unit	Quantity	Unit price	Amount
1.10	Operators' Quarters	Lump sum			125,000
1.11	Contingencies	Lump sum			1,292,000
2.	Hydraulic Equipments				580,000
2.1	Gates	Lump sum			81,000
2.2	Trashracks	Lump sum			36,000
2.3	Liner-plate	Lump sum			72,000
2.4	Penstock	Lump sum			320,000
2.5	Butterfly Valve	Lump sum			40,000
2.6	Contingencies	Lump sum			31,000
3.	Electrical Equipments	Lump sum			2,890,000
3.1	Turbines	Lump sum			387,000
3.2	Generators	Lump sum			533,000
3.3	Transformers	Lump sum			612,000
3.4	Accessories	Lump sum			1,218,000
3.5	Contingencies	Lump sum			140,000
4.	Service Facilities	Lump sum			60,000
5.	General Expenses	Lump sum			450,000
6.	Investigations	Lump sum			60,000
7.	Engineering - design, specifications and supervision	Lump sum			600,000
8.	Interest during Construction	Lump sum			910,000
9.	Grand Total				13,300,000

APPENDIX - 4

ECONOMIC EVALUATION BY THE METHOD STATED IN "RAUB HYDROELECTRIC DEVELOPMENT, AN ECONOMIC ASSESSMENT BY NEB"

APPENDIX - 4 ECONOMIC EVALUATION BY THE METHOD STATED IN "RAUB HYDROELECTRIC DEVELOPMENT; AN ECONOMIC ASSESSMENT BY NEB"

In accordance with the letter from NEB dated April 20, 1966, an economic evaluation of the Raub Scheme is made by the method in the title document. The results are shown in Table 4.1.

The cost at generating end of each power station is as follows:

Liang	1.21 cts/units
Sia	1.41 "
Sempam	2.26 "
As a whole	1.48 "

If the cost of transmitting to the receiving end by a 66 KV and 132 KV line is added, the energy cost of the Raub Scheme will be 1.73 cts/units.

Table 4.1 Raub Hydro-Electric Development Scheme Economic Justification (In Thousands of $M)

Generated End

	Liang	Sia	Sempam	Total
Capital Costs	20,300	12,000	13,300	45,600
Value of Firm Power at 610 $M per KW	4,148	1,586	1,098	-
Residual Valve	16,152	10,414	12,202	38,768
Interest & Depreciation 6.14%	992	639	749	2,380
Maintenance & Operation, including Administration	203	120	133	456
Total Annual Costs	1,195	759	882	2,836
Units Generated (Gwh)	99	54	39	192
Costs per Units (cts)	1.21	1.41	2.26	1.48

Received End

Transmission	
Capital Costs	4,486
Interest & Depreciation 6.5%	292
Maintenance & Operation, including Administration	52
Total Annual Costs	344
Annual Costs	
Generation	2,836
Transmission	344
Total	3,180
Annual Received (Gwh)	184
Costs per Units (cts)	1.73

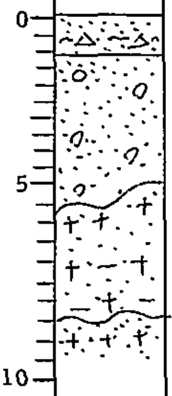
APPENDIX - 5

TEST PIT AND ADIT LOGS

LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_I-1	Size 3' -0" in diameter	Co-ordinates W 4035
Feature		575
Location INTAKE DAM, Right Bank		Ground Level 1451'-5"

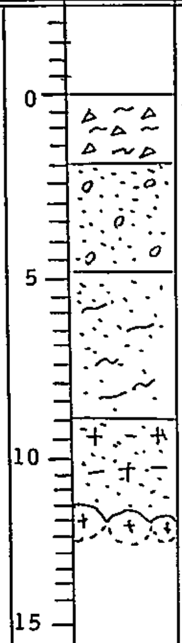
Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		1451'-5"	Top soil
1' -4"			Gravel and sand, river deposits, composed of Granite, Quartzite, Chert and Slate boulders under size 2" ∅. (Boundary plane of unconformity)
4' -5"		1447'-0"	
5 - 9"		1445'-8"	Granite soil, brownish yellow, degenerated from Granite boulder.
7' -9"		1443'-8"	
			Pit stopped by Granite boulder.

Commenced 11/5/66	Logged Y.N.	Scale 1" to 5' -0" E.P.D.C.
Completed 11/5/66	Traced Date	Sheet No. 1 of 10 TOKYO

LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_1-1'	Size 3'-0" in diameter	Co-ordinates W 4035
Feature		N 575
Location INTAKE DAM, Right Bank		Gound Level 1451'-5"



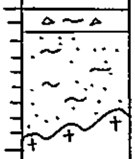
Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		1451'-5"	Top soil
2' -0"		1449'-5"	Gravel and sand, river deposits, composed of Granite and Slate boulders under size 1" ϕ
4' -5"		1447'-0"	Sand, brownish yellow, river deposit, contained Granite soil degenerated from boulders.
8'-6"		1442'-11"	Granite soil, reddish brown with white spotted, consisted of quartz and kaolin.
11'-5"		1440'-0"	Pit stopped by Granite boulder.

Commenced 14/5/66 Completed 15/5/66	Logged Y.N. Traced Date	Scale 1" to 5'-0" Sheet No.2 of 10 E.P.D.C. TOKYO

LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P$_1$-2	Size 3'-0" in diameter	Co-ordinates W 4034
Feature		N 575
Location INTAKE DAM, Right Bank		Ground Level 1468'-10"

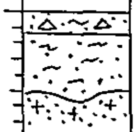
Depth below Ground Level		Legend	Reduced Level	Description of Strata and Remarks
0	0		1468'-10"	Top soil with Humus, dark.
0' - 8"			1468'- 2"	Soil, reddish yellow, river deposits.
3' - 5"			1465'-5"	Pit stopped by Granite boulder.
	5			

Commenced 11/5/66	Logged Y.N.	Scale 1" to 5' - 0" E.P.D.C.
Completed 11/5/66	Traced	
	Date	Sheet No. 3 of 10 TOKYO

LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_1-2'	Size 3' - 0" in diameter	Co-ordinates W 4034 N 575
Feature		
Location INTAKE DAM, Right Bank		Ground Level 1468'-10"

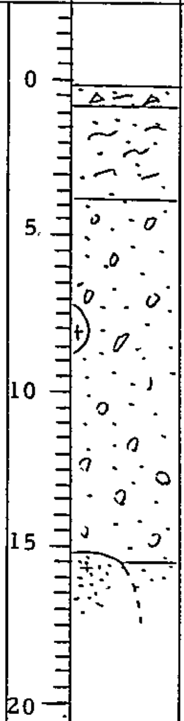
Depth below Ground Level		Legend	Reduced Level	Description of Strata and Remarks
0	0		1468'-10"	Top soil, with Humus, dark.
0'- 8"			1468'- 2"	Soil, reddish brown, river deposits.
2'- 0"			1466'-10"	Pit stopped by Granite boulder.
	5			

Commenced 12/5/66	Logged Y.N.	Scale 1" to 5' - 0"
	Traced	E.P.D.C.
Completed 12/5/66	Date	Sheet No.4 of 10 TOKYO

LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_1-2"　　Size 3' - 0" in diameter　　Co-ordinates W 4034
Feature　　N 575
Location INTAKE DAM, Right Bank　　Ground Level 1468'-10"

Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		1468'-10"	
0' - 8"		1468'- 2"	Top soil with Humus, dark.
			Soil, yellow, river deposit.
3' - 5"		1465'-5"	Gravel and soil, river deposits, consisted of Granite, Quartzite and Slate boulders, and of quartz and kaolin degenerated from Granite boulders.
14'-10"		1454'-0"	Pit stopped by Granite boulder.

Commenced 12/5/66	Logged Y.N.	Scale 1" to 5'-0"	E.P.D.C.
Completed 13/5/66	Traced Date	Sheet No. 5 of 10	TOKYO

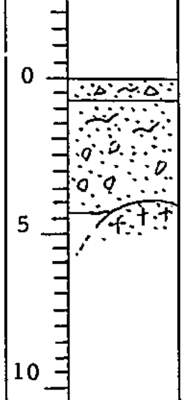
LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_1-3　Size 3'- 0" in diameter　Co-ordinates W 4035

Feature　N 577

Location INTAKE DAM, Left Bank　Ground Level 1467'

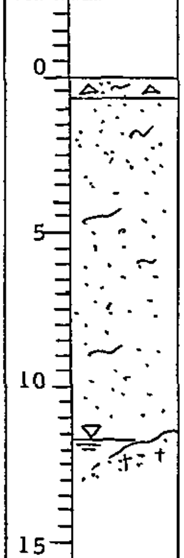
Depth below Ground Level	Legend	Reduced Level.	Description of Strata and Remarks
0		1467'	Top soil with Humus, dark.
0' - 8"		1466'-4"	Soil, reddish brown brownish yellow, with gravel consisted of Granite boulders under size 8" ϕ.
4' - 4"		1462'-8"	Pit stopped by Granite boulder.

Commenced 13/5/66	Logged Y.N. Traced	Scale 1" to 5'-0" E.P.D.C.
Completed 14/5/66	Date	Sheet No. 6 of 10 TOKYO

LIANG HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_1-4	Size 3' - 0" in diameter	Co-ordinates W 3747
Feature		N 729
Location POWER STATION		Ground Level 584'



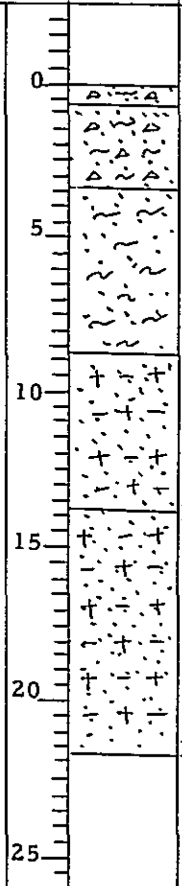
Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		584'	
0' -8"		583'-4"	Top soil with Humus, dark.
			Sand included soil, brownish yellow, river deposits.
11'-11"		572'-1"	Underground water surface level 572'-1".
			Pit stopped by Granite boulder.

Commenced 21/5/66	Logged Y.N.	Scale 1" to 5' - 0"	E.P.D.C.
	Traced		
Completed 21/5/66	Date	Sheet No. 7 of 10	TOKYO

SIA HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_2-1	Size 4'-0" in diameter	Co-ordinates W3880
Feature		N1402
Location SURGE TANK		Ground Level 1323'



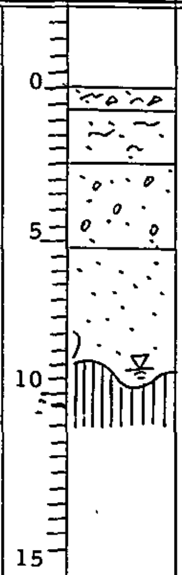
Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		1323'	
0'- 8"		1322'-4"	Top soil with Humus, dark.
3'-4"		1319'-8"	Clay with quartz, yellow.
8'-6"			Soil, reddish brown, degenerated from Granite.
		1314'-6"	
			Granite soil, reddish brown with white spotted, consisted predominately of quartz and kaolin.
13'-7"		1309'-5"	
			Granite completely weathered, reddish brown with much white spotted, but still possessing a recognizable granitic fabric.
21'-3"		1301'-9"	The original felspars are completely decomposed to clay minerals which remain as grains of clay.

Commenced 12/5/66	Logged Y.N.	Scale 1" to 5' -0"	E.P.D.C.
Completed 13/5/66	Traced Date	Sheet No. 8 of 10	TOKYO

SEMPAM HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_3-1	Size 3'-0" in diameter	Co-ordinates W 3579
Feature		N 435
Location POWER STATION		Ground Level 717'-3"



Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		717'-3"	
0' - 8"		716'-7"	Top soil with Humus, dark.
2'- 6"		714'-9"	Soil, yellow.
5'- 3"		712'-0"	Gravel and soil, yellow, river deposits.
			Sand, yellowish white, river deposits.
8'-10"		708'-5"	
			Underground water surface level 708'-2".
			Shale, dar, rather weathered.

Commenced 17/5/66	Logged Y.N.	Scale 1" to 5' - 0"
Completed 18/5/66	Traced Date	Sheet No. 9 of 10 E.P.D.C. TOKYO

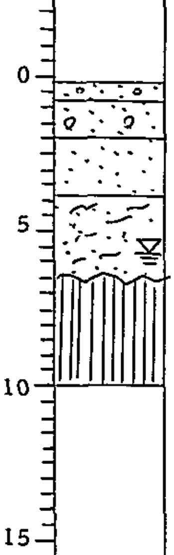
SEMPAM HYDROELECTRIC PROJECT

TEST-PIT LOG

Test-Pit No. P_3-1'
Feature
Location POWER STATION

Size 3' -0" in diameter

Co-ordinates. W 3577
N 435
Ground Level 718'-11"

Depth below Ground Level	Legend	Reduced Level	Description of Strata and Remarks
0		718' -11"	Top soil with Humus, dark.
0'- 8"		718' - 3"	
1'-10"		718'- 1"	Gravel and sand, river deposits.
		717'- 4"	Sand, brown, river deposits.
			Clay with gravel, dark.
6'- 8"		712'- 3"	Underground water surface level 712'-8".
			Shale, dark, rather weathered.
10'-6"		708' - 5"	Shaly sandstone, dark grey, sound.

Commenced 18/5/66
Completed 19/5/66

Logged Y.N.
Traced
Date

Scale 1" to 5'-0"
Sheet No. 10 of 10

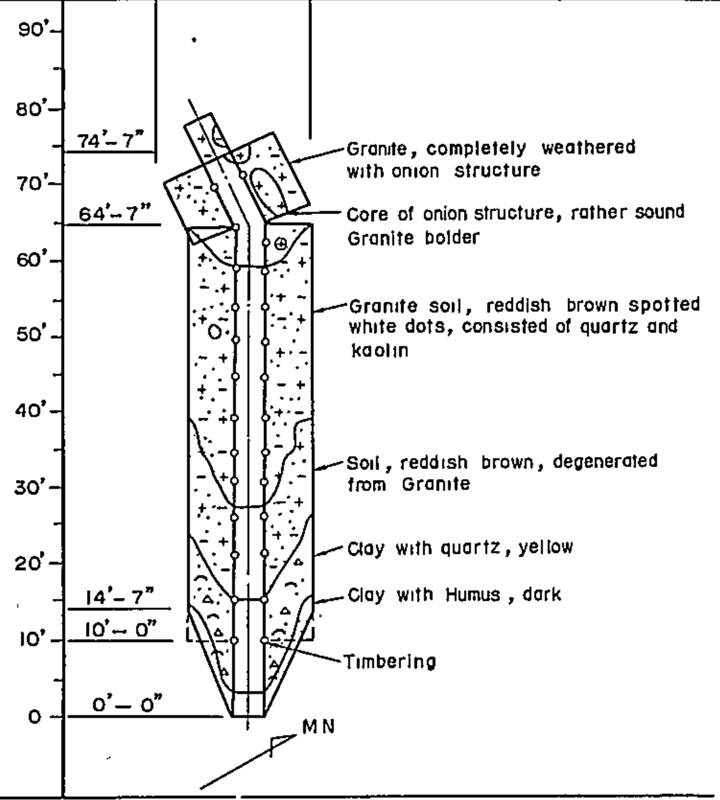
E.P.D.C.
TOKYO

LIANG HYDRO-ELECTRIC PROJECT

TEST-ADIT LOG

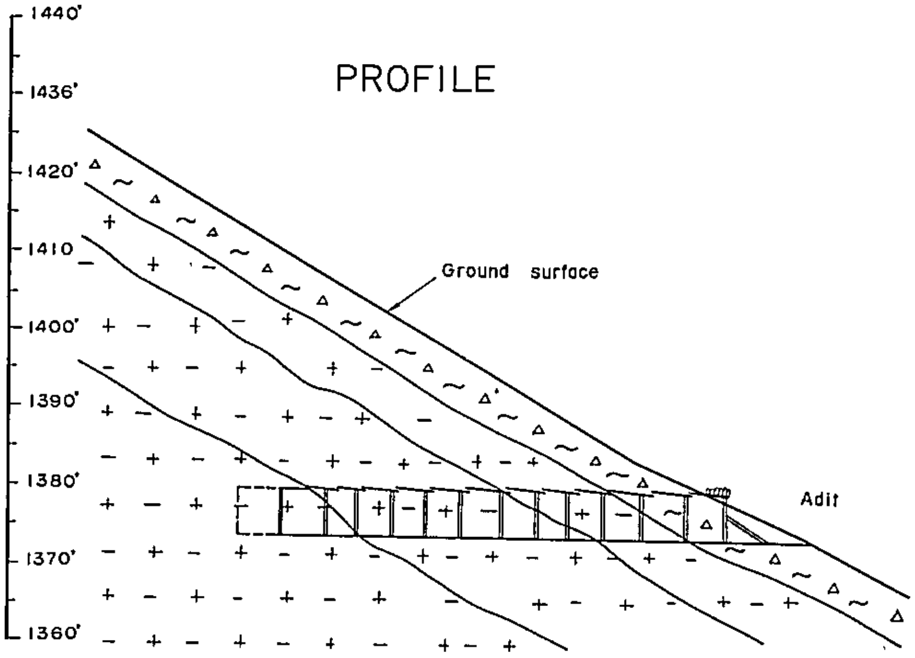
Test-Adit No A₁-1	Size 6"x 4"	Co-ordinates W 3776
Feature	Direction N 60° W	N 747
Location SURGE TANK		Formation Level 1374'

Measure	Length	Log	Description of Strata and Remarks



COMMENCED 11/5/66 COMPLETED 19/5/66	LOGGED Y N. TRACED DATE Oct/13/1966	SCALE 1" to 15'-0" SHEET No 1 of 2	E P D.C TOKYO

PROFILE

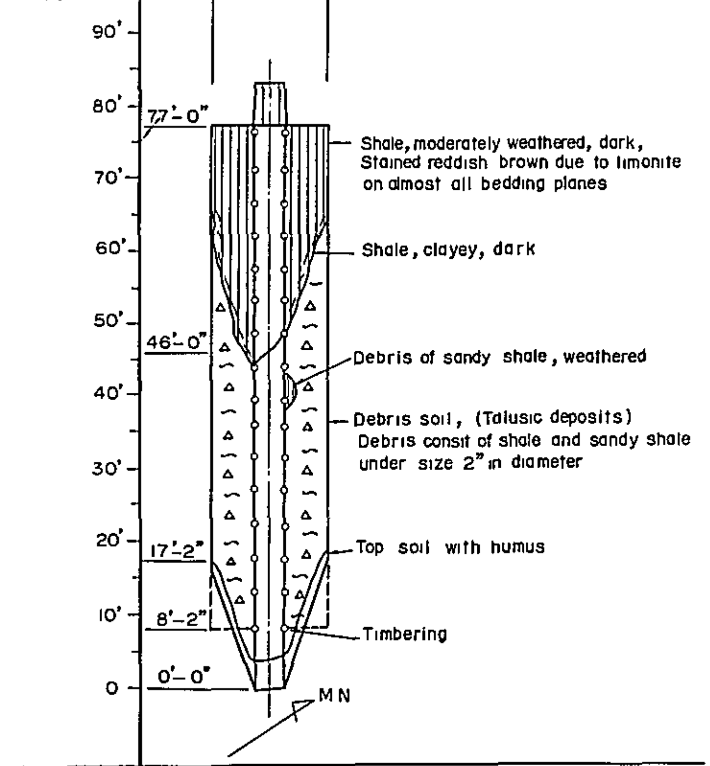


SEMPAM HYDRO-ELECTRIC PROJECT

TEST- ADIT LOG

Test - Adit No A₂- 1	Size 6"x 4"	Co-ordinates W 3600
Feature	Direction N55°W	N 441
Location SURGE TANK		Formation Level 1316'

Measure	Length	Log	Description of Strata and Remarks



COMMENCED 27/4/66 COMPLETED 13/5/66	LOGGED Y N TRACED DATE Oct/13/1966	SCALE 1" to 15'-0" SHEET No.2 of 2	E P D C TOKYO

PROFILE