

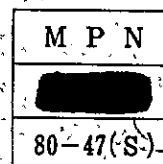
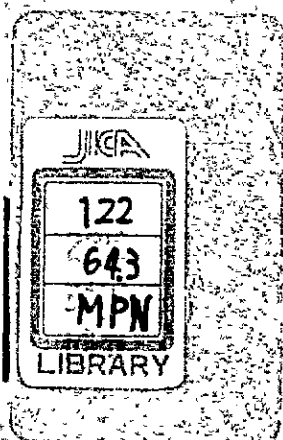
The Kingdom of Thailand
Electricity Generating Authority of Thailand

**UPPER QUA E YAI HYDROELECTRIC
DEVELOPMENT PROJECT
FEASIBILITY REPORT**

— SUMMARY —

June 1980

Japan International Cooperation Agency



The Kingdom of Thailand

Electricity Generating Authority of Thailand

**UPPER QUAE YAI HYDROELECTRIC
DEVELOPMENT PROJECT
FEASIBILITY REPORT**

— **SUMMARY** —

June 1980

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Japan International Cooperation Agency



Nam Chon
Reservoir

Camp Facility

Nam Chon Dam

Thi Khong Pond

Thi Khong Dam

S. SASAKI

国際協力事業団

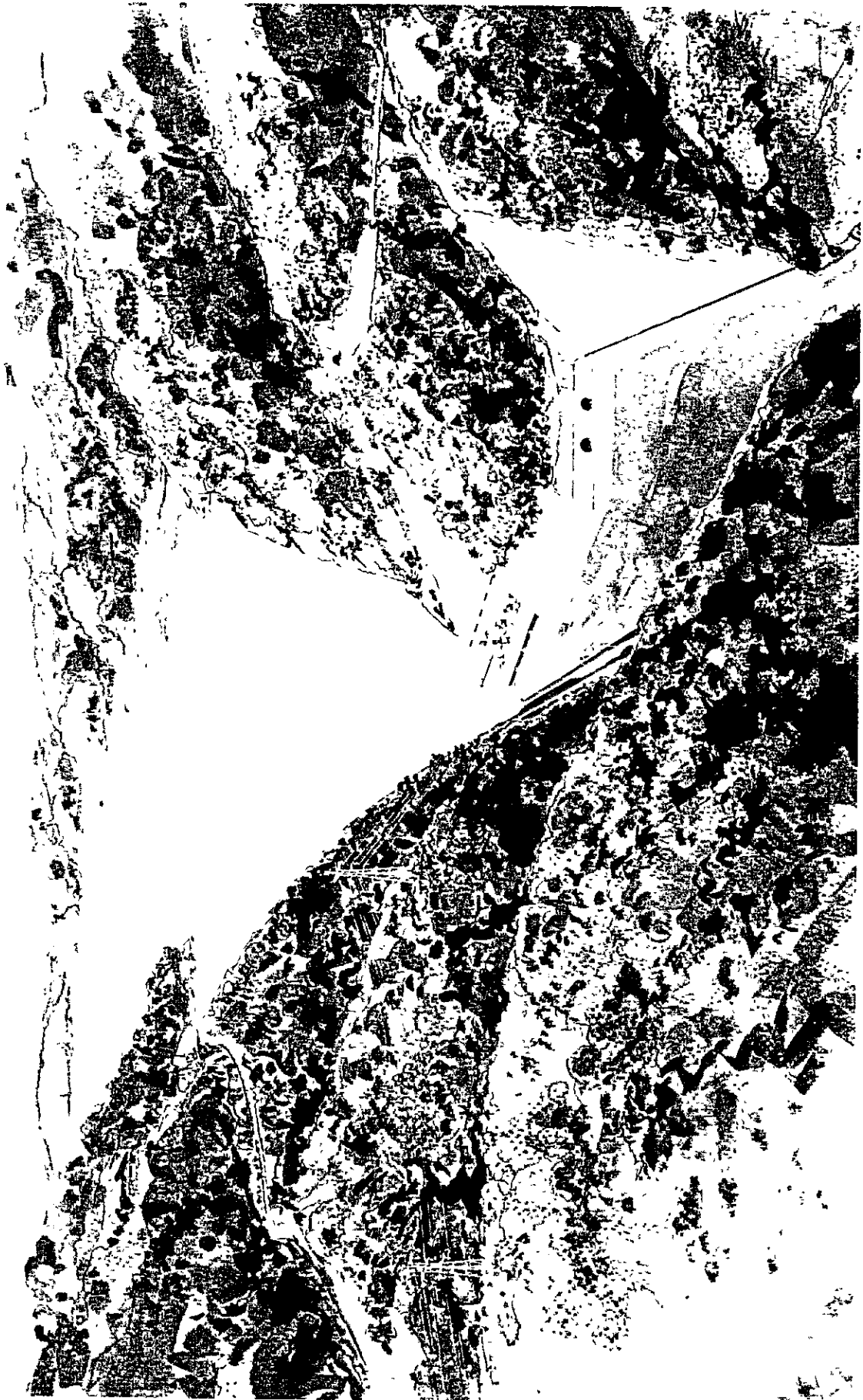
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CONCLUSION AND RECOMMENDATION

CONCLUSION

Output of The Upper Quae Yai Project	Total: 631,000 kw
Nam Chon Power Station	580,000 kw
Thi Khong Power Station	51,000 kw

Type of Dam

Nam Chon dam	Rockfill dam
Thi Khong dam	Concrete gravity dam

Construction Cost	Total project cost	Equivalent to
Nam Chon Project	570.4 million US\$	(11,694 million Bahts)
Thi Khong Project	56.4 million US\$	" (1,156 million Bahts)

Construction Schedule	Start of operation	Construction period
Nam Chon Project	1987	Approx. 6 years
Thi Khong Project	1989	Approx. 4 years

Economic Evaluation

Internal rate of return (discount rate of 10%): 15.2%

RECOMMENDATION

In order to start operation of the Upper Quae Yai Project by 1987, the various investigation works such as geological investigations on the damsite, investigations and laboratory tests of materials energetically being carried out by EGAT at present should be continued to be expedited for the purpose of detail design.

Based on the investigation results, it will be necessary to immediately commence detail design, and also preparation of tender documents and specifications.

Facilities required for construction such as access roads to project sites and buildings should be prepared as early as possible in order to meet planned construction schedules.

1. INTRODUCTION

The early implementation of the Upper Quae Yai Hydroelectric Development Project, a hydroelectric power project with a large-scale reservoir, is expected to meet the increasing electric power demand in Thailand.

Nam Chon Power Station, to be the main power station in this Project, will have a maximum output of 580,000 kW, and will be located 141 km upstream of Srinagarind Power Station.

Thi Khong Power Station, to utilize the head remaining between Nam Chon and Srinagarind, will have a maximum output of 51,000 kW, and will be located at the end of the backwater of Srinagarind Reservoir approximately 8 km downstream from Nam Chon site.

The Upper Quae Yai Project consists of these two power stations, and the total output will be 631,000 kW.

EGAT (Electricity Generating Authority of Thailand) has pushed ahead with development of the Quae Yai River as a major river of Thailand suited for large-scale hydroelectric power development, and planning and field investigations have been carried out for the Upper Quae Yai Project as indicated below.

1972	Reconnaissance by Japanese Government Investigation Team for preparation of reconnaissance report
1974 - 1976	Investigations by an expert dispatched by Japanese Government and formulation of the Quae Yai basin development plan

1978 - 1979	Detailed geological investigations for selection of Project sites by experts dispatched by Japanese Government, and investigations through drillholes and test adits at Project sites, and preparation of topographic maps
1978	Preparation of Preliminary Report by EGAT
1979	Preparation of Pre-feasibility Report by EGAT

2. GENERAL FEATURES OF NAM CHON PROJECT

(1) Location	Approx. 210 km NNE of Kanchanaburi, 98° 54.63' East Longitude, 15° 13.13' North Latitude
(2) Catchment Area	4,908 km ²
(3) Annual Mean Inflow	2,975 x 10 ⁶ m ³
(4) Reservoir	
Normal high water level	El. 370.0 m
Max. high water level	El. 373.8 m
Min. water level	El. 331.0 m
Available drawdown	39.0 m
Total storage capacity (at El. 370.0 m)	5,950 x 10 ⁶ m ³
Effective storage capacity	4,100 x 10 ⁶ m ³
Reservoir surface area (at El. 370.0 m)	137 x 10 ⁶ m ²
(5) Power Generation	
Max. output	580,000 kW
Annual energy production	1,095 x 10 ⁶ kWh
(6) Dam	
Type	Rockfill dam with center core
Crest elevation	El. 376.5 m
Height	185.0 m
Crest length	450.0 m

Dam volume	12.7 x 10 ⁶ m ³
Design flood discharge	5,900 m ³ /sec
Spillway	Tunnel type
	Capacity: 2,500 m ³ /sec
	Inner dia. x Length: No.1 10 m x 820 m No.2 10 m x 860 m
	Gate
	Width x Height: 11.5 m x 10.5 m, 2 ea.
Cofferdam	Crest elevation: El. 250 m
Diversion tunnel	Capacity: 1,600 m ³ /sec
	Inner dia. x Length: No.1 8m-10m x 1,080m No.2 8m-10m x 1,150m
Outlet	Capacity: 100 m ³ /sec
(7) Intake	
Type	Reinforced concrete structure
Gate	Width x Height: 8 m x 10 m, 2 ea.
(8) Pressure Tunnel	Inner dia. x Length: No.1 7.9 m x 370 m No.2 7.9 m x 450 m
(9) Surge Tank	
Type	Chamber type
	Inner dia. x Height: 11 m x 78 m, 2 ea.
(10) Penstock	Inner dia. x Length: 5.0 m x 260 m, 4 ea.
(11) Powerhouse	
Type	Surface, reinforced concrete structure
	Length x Width x Height: 110 m x 20 m x 44 m
Draft gate	Width x Height: 6.0 m x 5.0 m, 4 ea.
(12) Main Electrical Equipment	
Installed capacity	580,000 kW
Turbine	
Type	Vertical-shaft Francis
Number of units	4
Normal effective head	146.5 m
Max. discharge	115 m ³ /sec

Output	150,000 kW
Revolving speed	188 rpm
Generator	
Type	3-phase, a.c., synchronous generator
Number of units	4
Capacity	162,000 kVA
Frequency	50 Hz
Main transformer	
Type	3-phase, outdoor, oil-immersed
Number of units	4
Capacity	162,000 kVA
Voltage	230/13.8 kV
Switchyard equipment	
Type	Outdoor SF ₆ gas insulated switchgear
Bus connection system	Double-bus system
Number of transmission lines	2

(13) Transmission Line

Route	Upper Quae Yai to Srinagarind Switchyard (2 cct, 115 km)
	Srinagarind Switchyard to Ban Pong 2 Substation (2 cct, 108 km)
	Ban Pong 2 to Sai Noi Substation (1 cct, 54 km)
Length	277 km
Voltage	230 kV

(14) Telecommunication

Multi-channel radio equipment
Power line carrier equipment
Carrier protective relay signaling equipment
Transmission line fault locating equipment
Mobile radio telecommunication equipment
Data transmitting equipment

3. GENERAL FEATURES OF THI KHONG PROJECT

(1) Location	8 km downstream from Nam Chon site
(2) Catchment Area	5,145 km ²
(3) Annual Mean Inflow	3,090 x 10 ⁶ m ³
(4) Regulating Pond	
Normal high water level	El. 197.0 m
Min. Water level	El. 196.8 m (El. 193.5 m during one unit drop)
Available drawdown	0.2 m
Total Storage capacity (at El. 197.0 m)	16 x 10 ⁶ m ³
Effective storage capacity	0.3 x 10 ⁶ m ³
Pond surface area (at El. 197.0 m)	1.45 x 10 ⁶ m ²
(5) Power Generation	
Max. output	51,000 kW
Annual energy production	93 x 10 ⁶ kWh
(6) Dam	
Type	Concrete gravity
Crest elevation	El. 200.0 m
Height	32 m
Crest length	110 m
Dam volume	46 x 10 ³ m ³
Design flood discharge	2,800 m ³ /sec
Spillway	
Type	Overflow type
Gate	Width x Height: 11.0 m x 13.0 m, 3 ea.
Sand flush gate	Width x Height: 11.0 m x 15.0 m, 1
(7) Intake	
Type	Rainforced concrete structure
Gate	Width x Height: 9.0 m x 17.0 m, 4 ea.

(8) Powerhouse

Type	Surface, reinforced concrete structure
	Length x Width x Height: 65 m x 20 m x 44 m
Draft gate	Width x Height: 9.0 m x 7.0 m, 2 ea.

(9) Main Electrical Equipment

Installed capacity 51,000 kW

Turbine

Type	Vertical-shaft Kaplan
Number of units	2
Normal effective head	12.5 m
Max. discharge	240 m ³ /sec
Output	26,400 kW
Revolving speed	94 rpm

Generator

Type	3-phase, a.c., synchronous generator
Number of units	2
Capacity	27,000 kVA
Frequency	50 Hz

Main transformer

Type	3-phase, outdoor, oil-immersed
Number of units	2
Capacity	27,000 kVA
Voltage	230/13.8 kV

Switchyard equipment

Type	Outdoor, air-insulated
Bus connection system	Single-bus system
Number of transmission lines	1

4. CONSTRUCTION COST AND FINANCIAL PROGRAM

4.1 Nam Chon Project

	Foreign Currency	Local Currency	Total
US\$ (million)	225.6	344.8	570.4
Equivalent to Bahts (million)	4,625	7,069	11,694

4.2 Thi Khong Project

	Foreign Currency	Local Currency	Total
US\$ (million)	24.7	31.7	56.4
Equivalent to Bahts (million)	506	650	1,156

5. CONSTRUCTION SCHEDULE AND START OF OPERATION

5.1 Nam Chon Project

As a result of power demand forecasts, Nam Chon Power Station should start operation in 1987. The construction schedule of the works is as shown in Fig. 11.

5.2 Thi Khong Project

In order to construct this Project economically, the construction period should be scheduled so that the construction facilities for Nam Chon Project can be utilized. Particularly, in order to make diversion works easier, the construction period should be planned in step with water impoundment of Nam Chon Project. Consequently, the start of operation will be in 1989 as shown in the construction schedule of Fig. 12.

6. ECONOMIC ANALYSIS

The results of economic analysis based on an alternative thermal power station are as indicated below.

	<u>with Thi Khong Power Plant</u>	<u>without Thi Khong Power Plant</u>
Benefit (B)	US\$494.1 million (฿10,129 million)	US\$455.3 million (฿9,333 million)
Cost (C)	US\$341.2 million (฿6,995 million)	US\$314.4 million (฿6,445 million)
B - C	US\$152.9 million (฿3,134 million)	US\$140.9 million (฿2,888 million)
B/C	1.45	1.45
Internal rate of return (discount rate 10%)	15.2%	15.0%

7. INVESTIGATION

Calcareous rock formations are distributed in the Quae Yai basin. These formations are generally defective with regard to resistance against permeability. Accordingly, geological investigations were firstly focused on security against reservoir watertightness.

The evaluation of reservoir watertightness was studied by photo geological interpretation, summit level analysis, drainage pattern analysis, and chemical analysis of river water and rocks. Followingly the geological investigations at dam foundations were carried out.

The investigations below were made at Nam Chon and Thi Khong which were selected finally as Upper Quae Yai Project site.

- o Preparation of topographic maps
- o Drillhole for structure foundations

Nam chon site	24 holes, total length 1,783 m
Thi Khong site	4 holes, total length 126 m

- o Test adit and test pit for structure foundations
 - Nam Chon site 3 adits, about 90 m
 - Thi Khong site 2 pits, about 3 m
- o Investigations and laboratory tests for materials
 - Drillhole 5 holes, total 200 m
 - Test pit 30 pits, total 111 m
- o Hydrological investigations

As a result of these investigations and examinations, the reservoir watertightness was made clear and it was judged that both project sites possess adequate bearing strength as foundations for the structures planned. In addition to the above, there would be no special problems on the provisions of the water cutoff of the dams. Furthermore, with respect to dam construction materials, it is assured that sufficient amounts of materials with suitable properties can be obtained in the vicinity of the project sites.

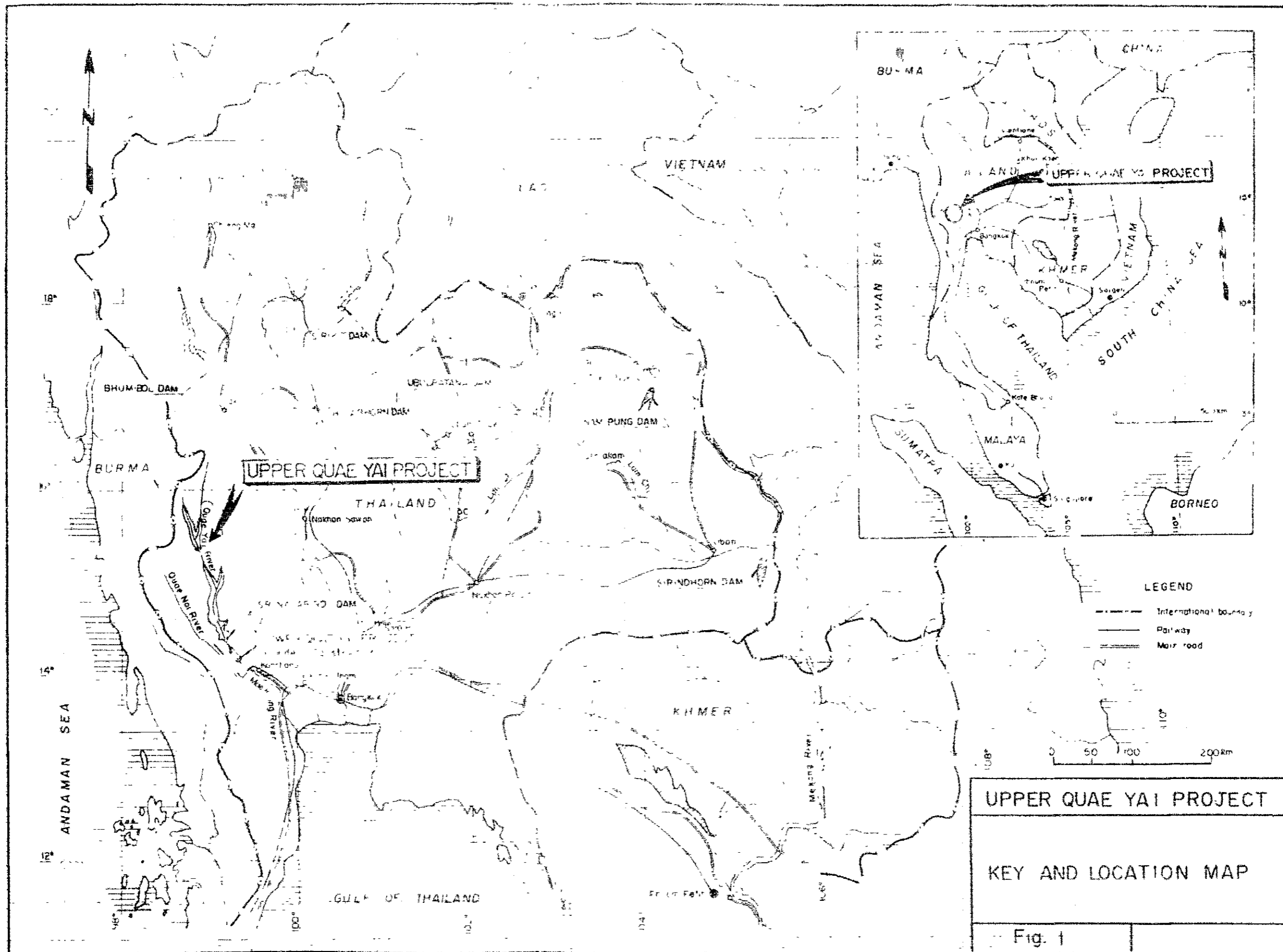
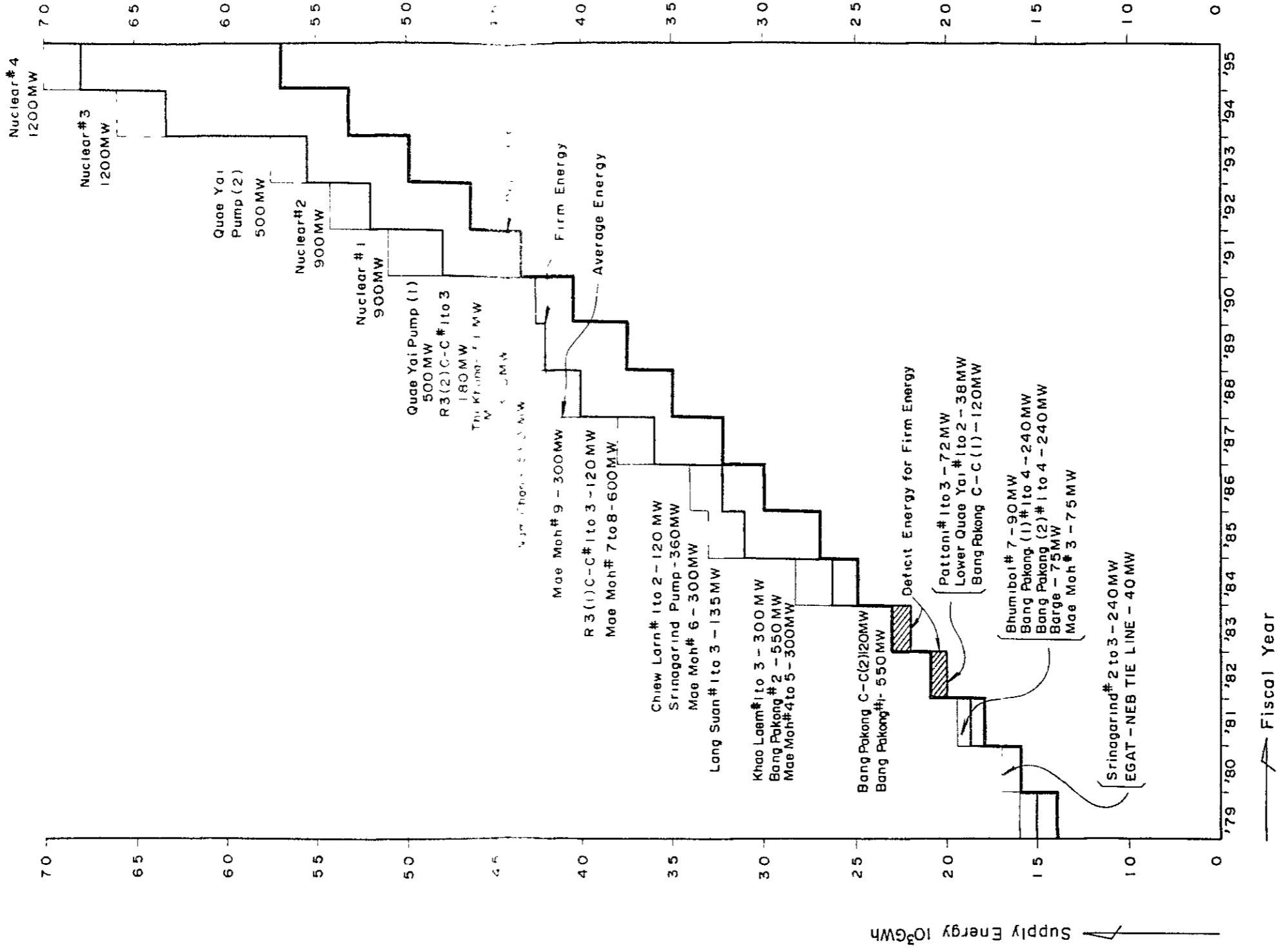


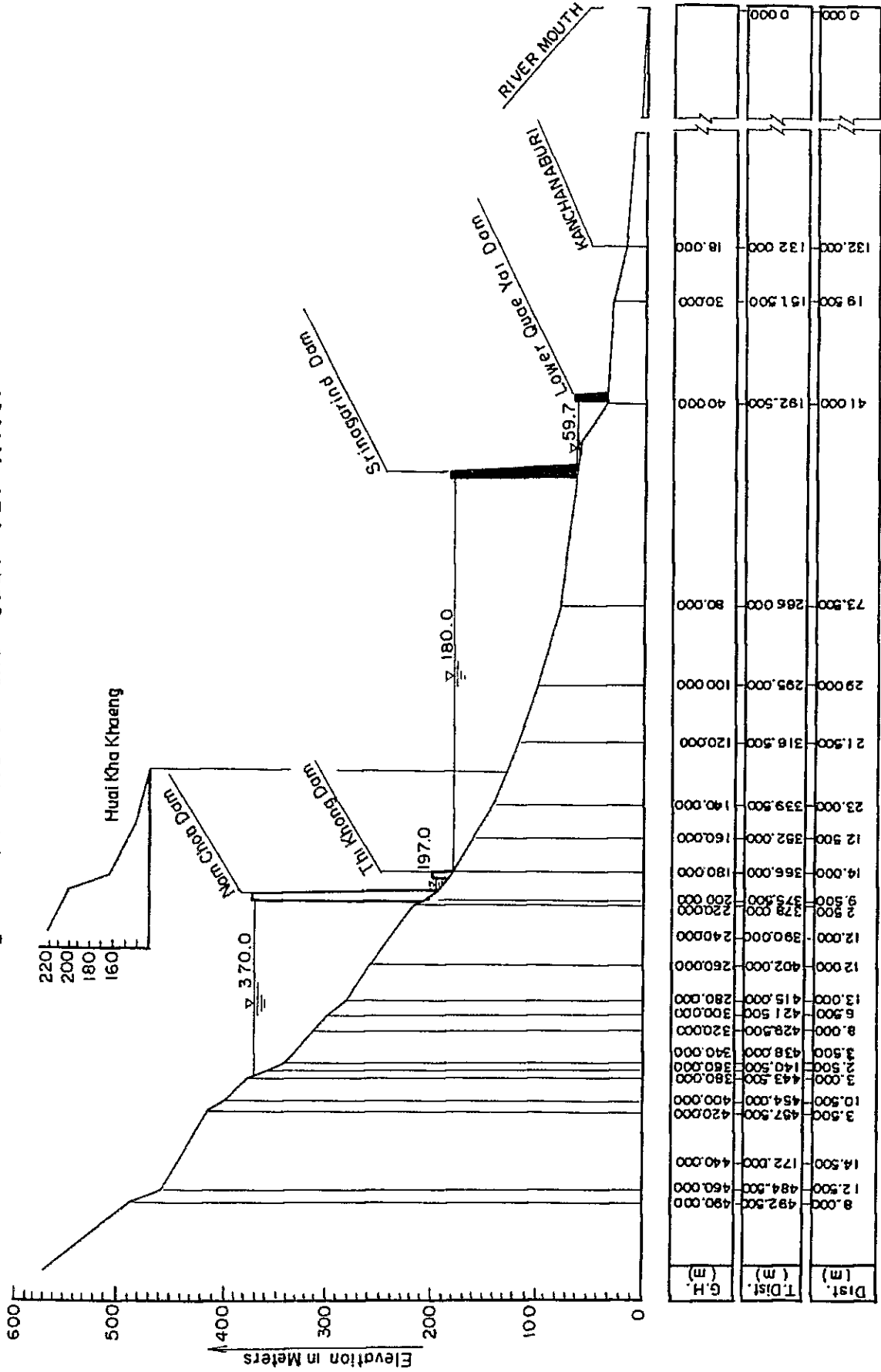
Fig 2 Yearly Energy Balance in GWh

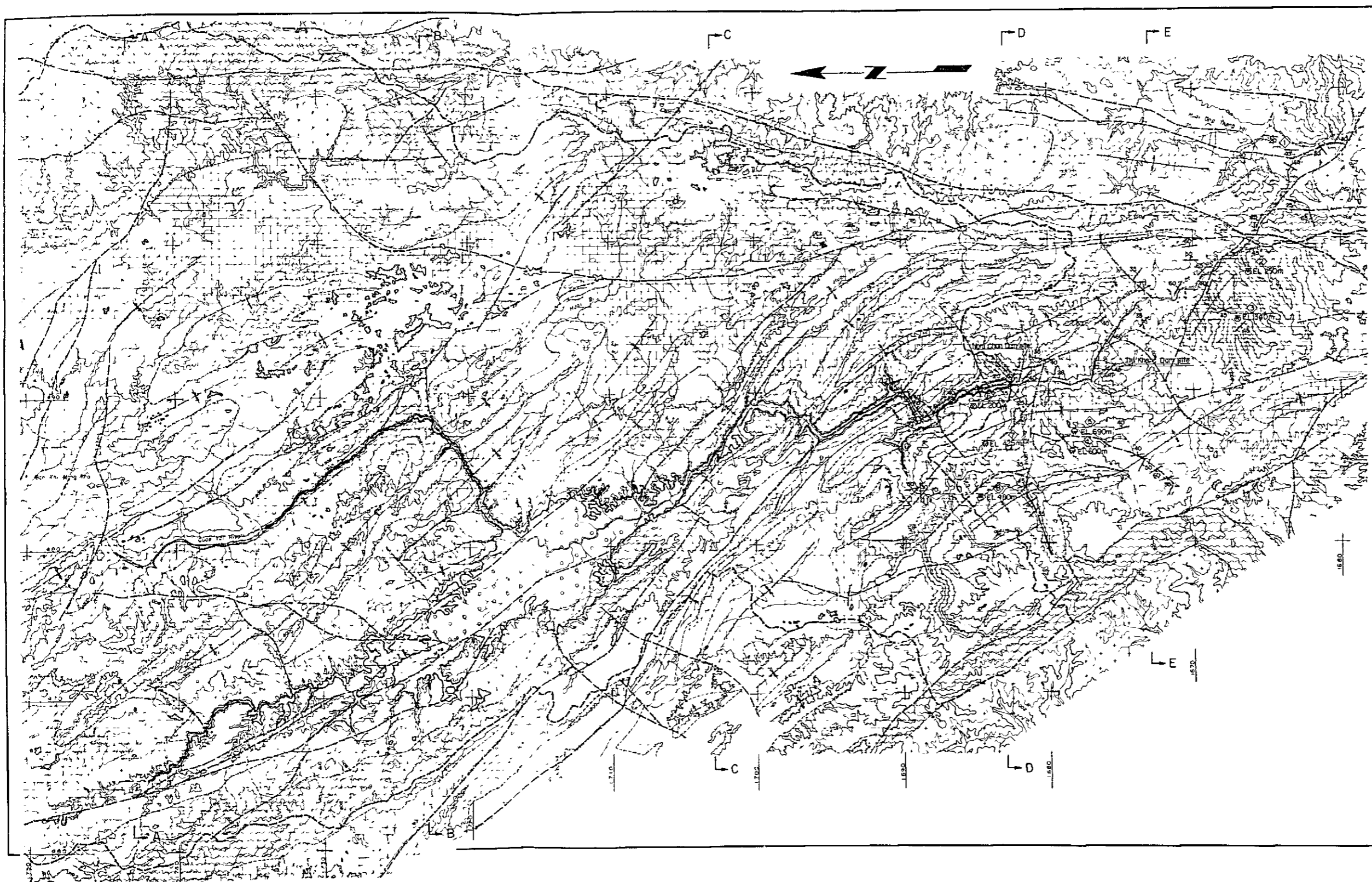


Note: Fiscal Year '79 '79 Oct to '80 Sep.

· GWh = 10⁹ Wh

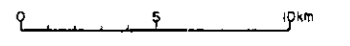
Fig. 3 Profile of the Quae Yai River





LEGEND

Cenozoic		Tertiary system	Gravel, sand, silt and clay
Mesozoic		Granite	
		Formation D	Pure limestone, dolomite and dolomitic limestone, near base often red conglomerate, karst in some places
Paleozoic		Formation C	Shale, sandstone, calcareous shale, calcareous sandstone, conglomerate and thin impure limestone, locally alternation
		Formation B	Banded calcareous sandstone, banded sandy limestone and alternation of sandstone and shale
		Formation A	Quartzite, sandstone, slate and schist
		Metamorphic rocks	Schist and semischist
		Strike and dip of strata	
		Strike and dip of fault	
		Fault (Assumed)	
		Axis of anticline	
		Axis of syncline	
		Axis of fold (assumed)	
		Geologic boundary	
		Sink hole	
		Swallet	
		Spring	
		Running water	(This mark shows the locality number in the table of the report)



UPPER QUAE YAI PROJECT	
GEOLOGY	
RESERVOIR AREA PLAN	
Fig 4	March, 1980

Fig. 5 Storage Capacity and Surface Area at Nam Chon Site

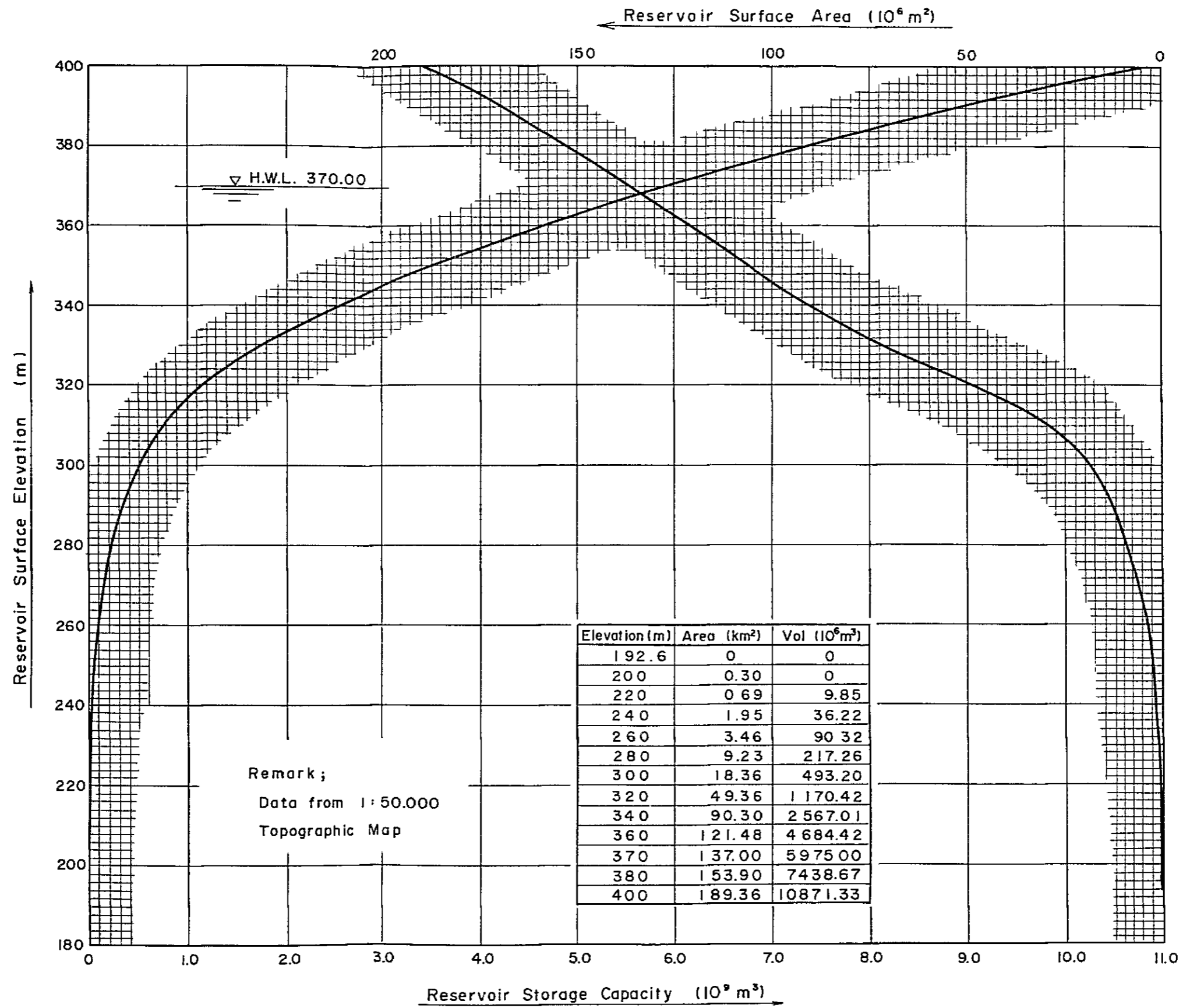
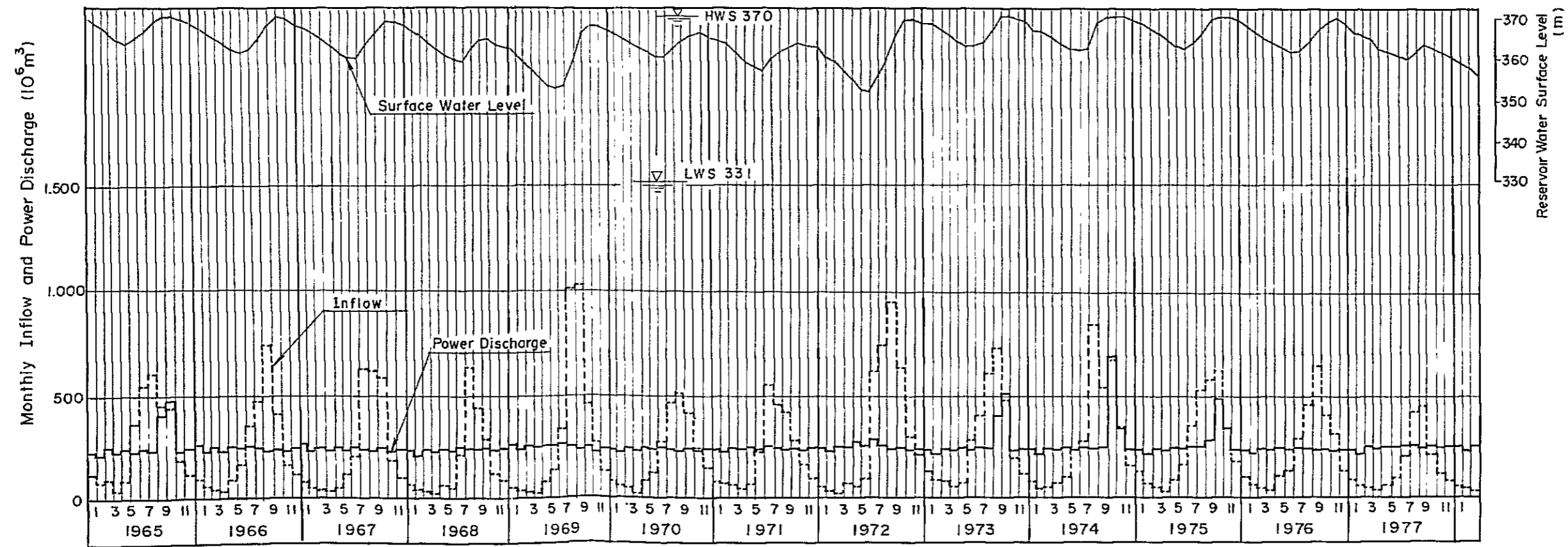
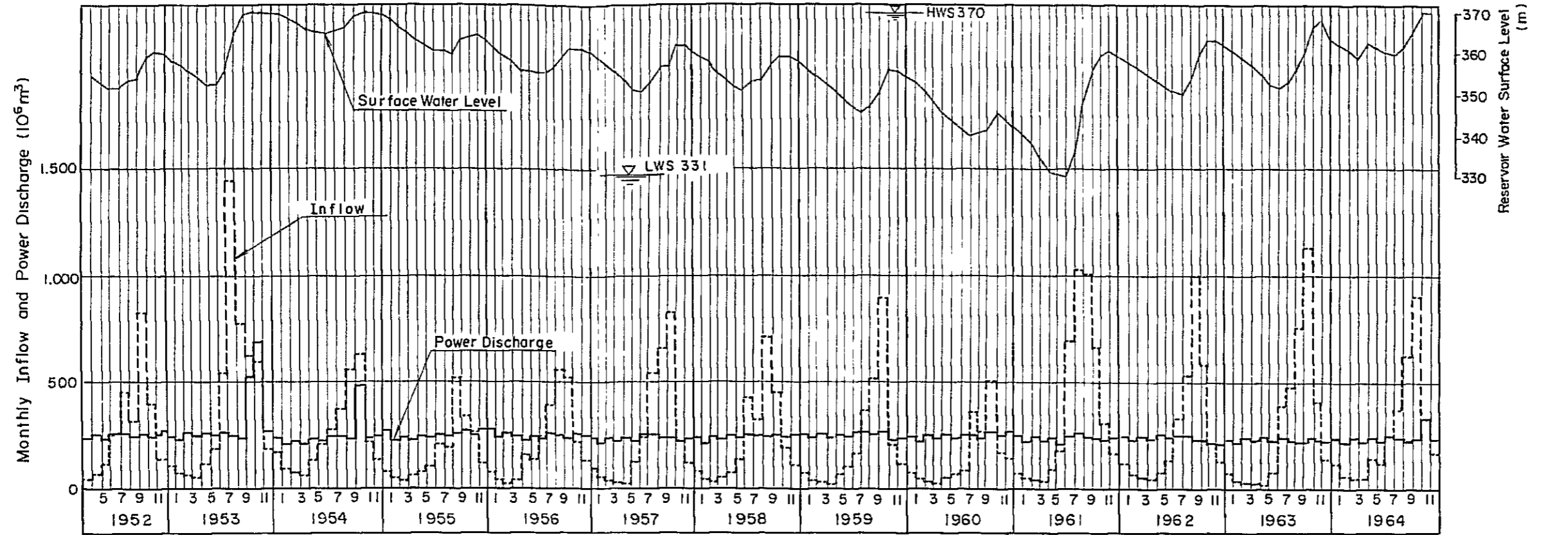
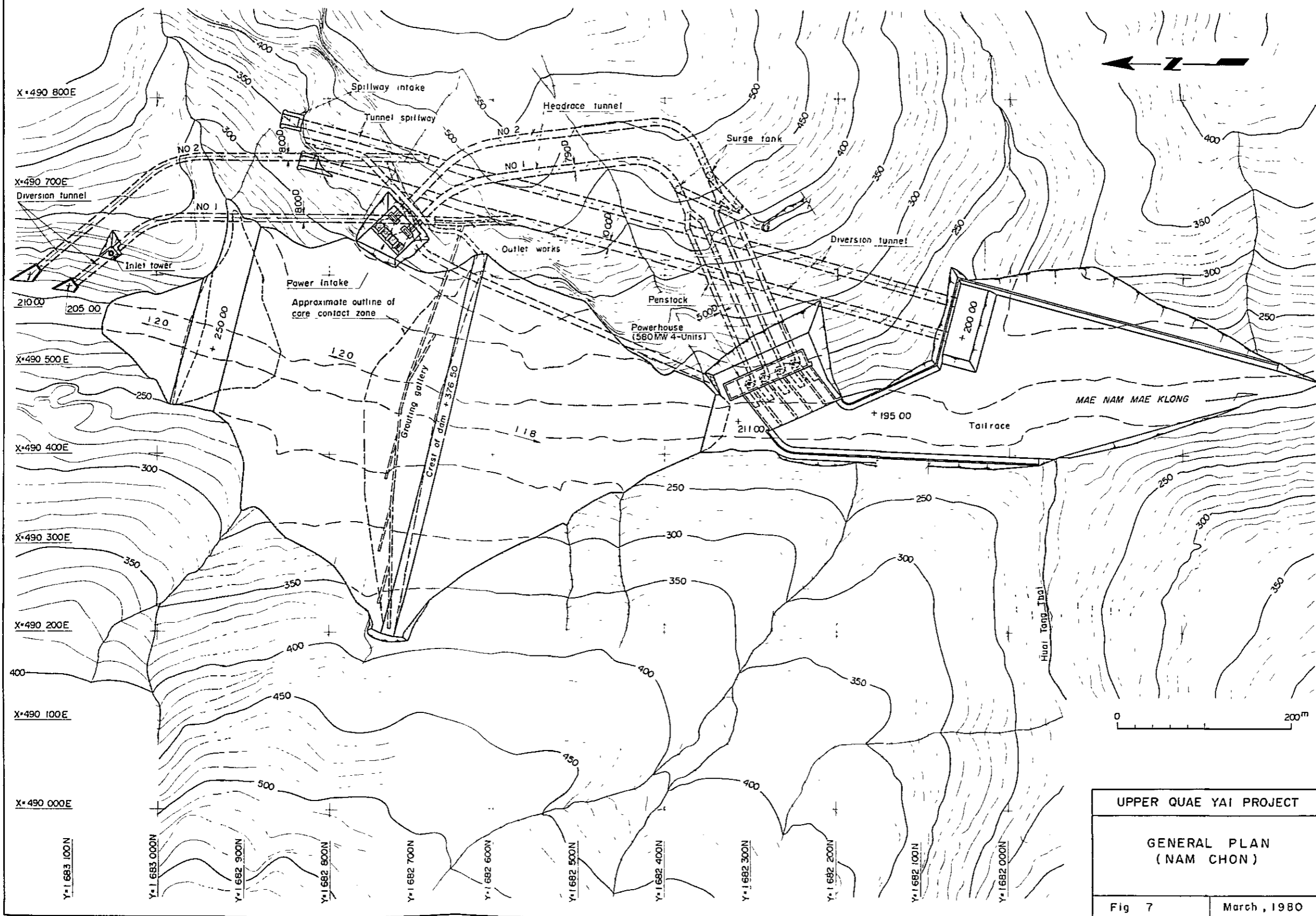


Fig. 6 Inflow, Power Discharge and Reservoir Water Surface at Nam Chon Power Station

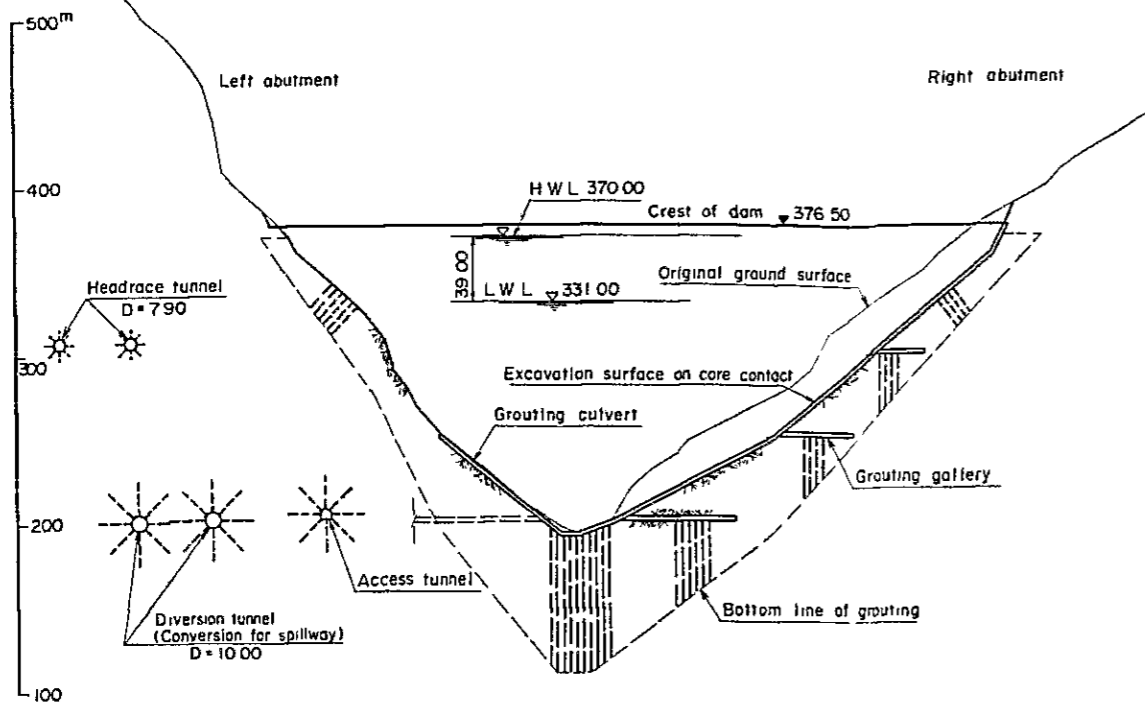


GENERAL PLAN FOR NAM CHON PROJECT

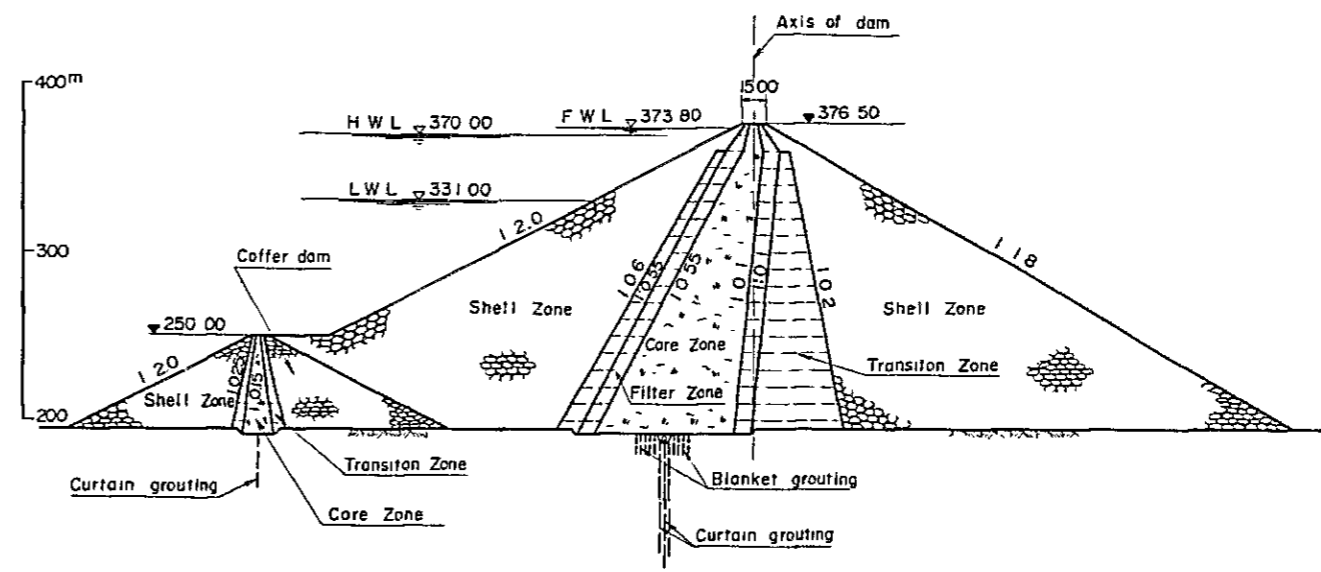


UPPER QUAE YAI PROJECT	
GENERAL PLAN (NAM CHON)	
Fig 7	March, 1980

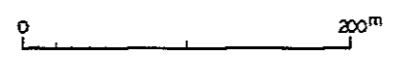
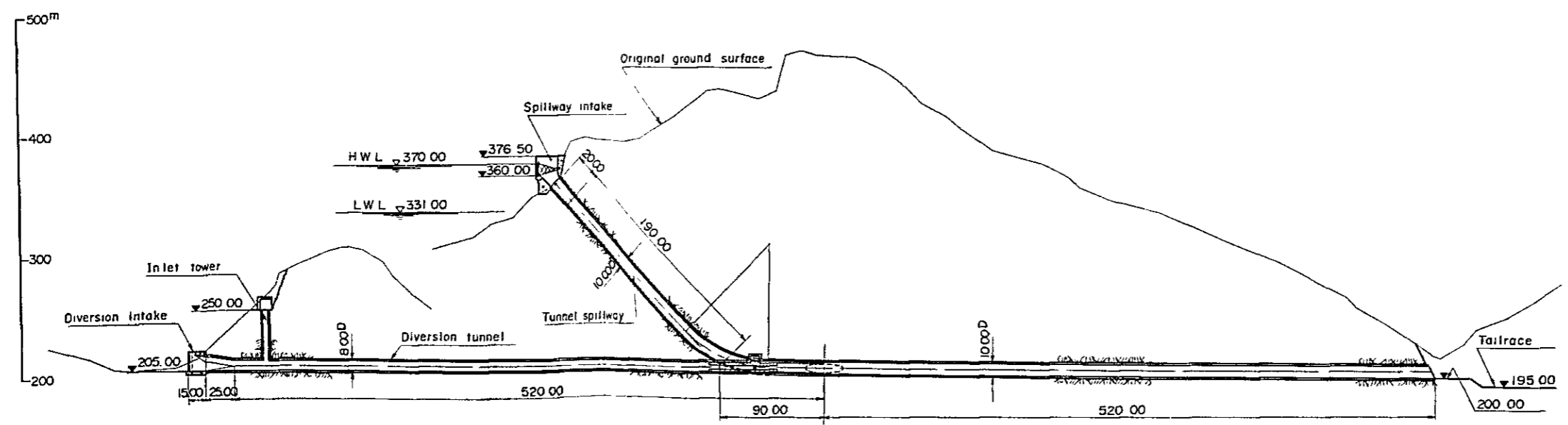
PROFILE ALONG AXIS OF DAM



TYPICAL SECTION OF DAM

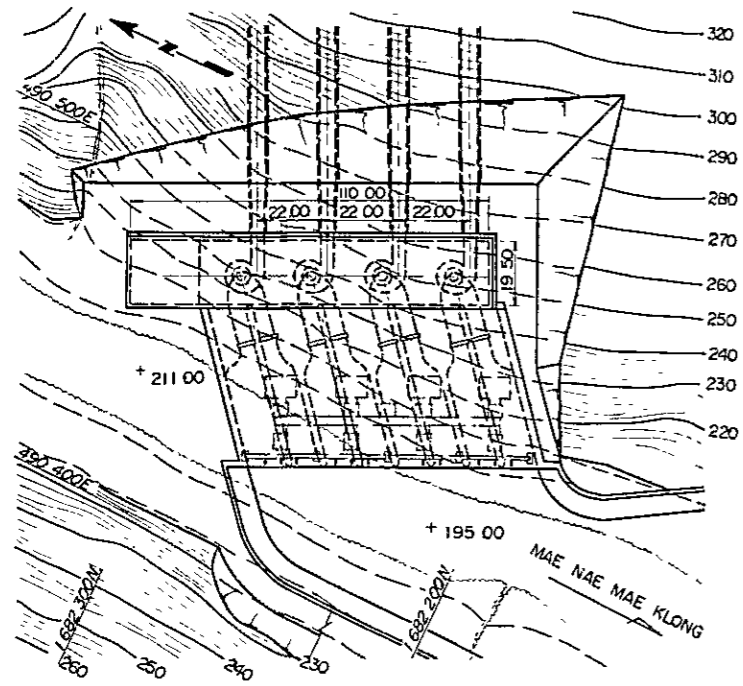


PROFILE OF DIVERSION TUNNEL NO.1 AND TUNNEL SPILLWAY NO.1

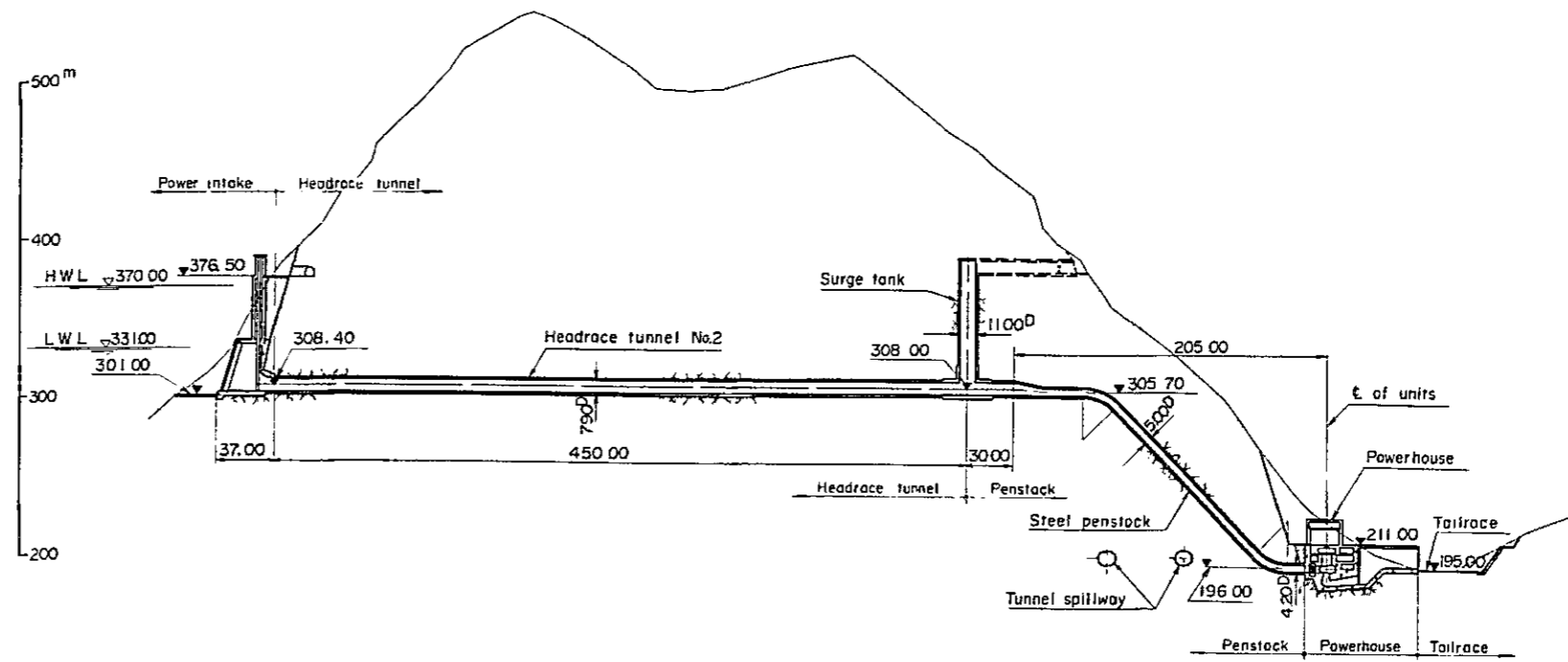


UPPER QUAE YAI PROJECT	
TYPICAL PROFILE & SECTION PRINCIPAL STRUCTURE (NAM CHON)	
Fig 8	March, 1980

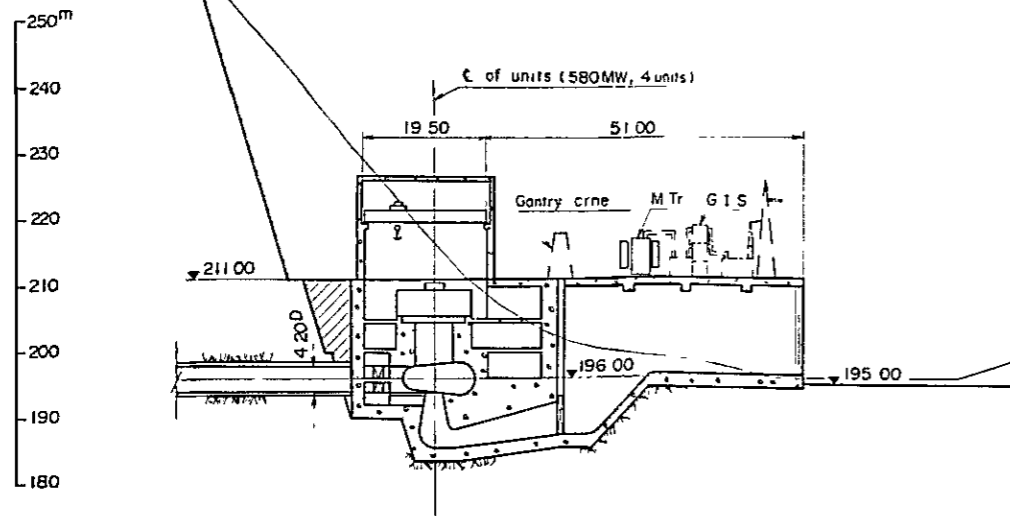
PLAN



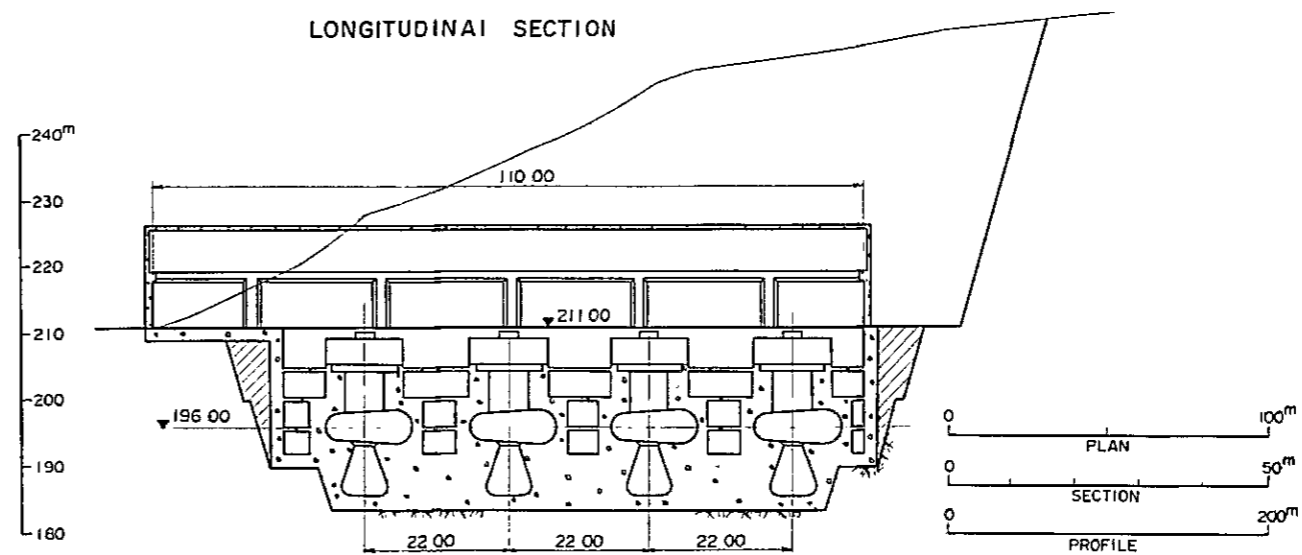
PROFILE OF HEADRACE TUNNEL NO.2 AND PENSTOCK NO.4



TRANSVERSE SECTION



LONGITUDINAL SECTION



UPPER QUAE YAI PROJECT

PLAN, PROFILE & SECTION
POWER INTAKE~POWER HOUSE
(NAM CHON)

Fig 9

March, 1980

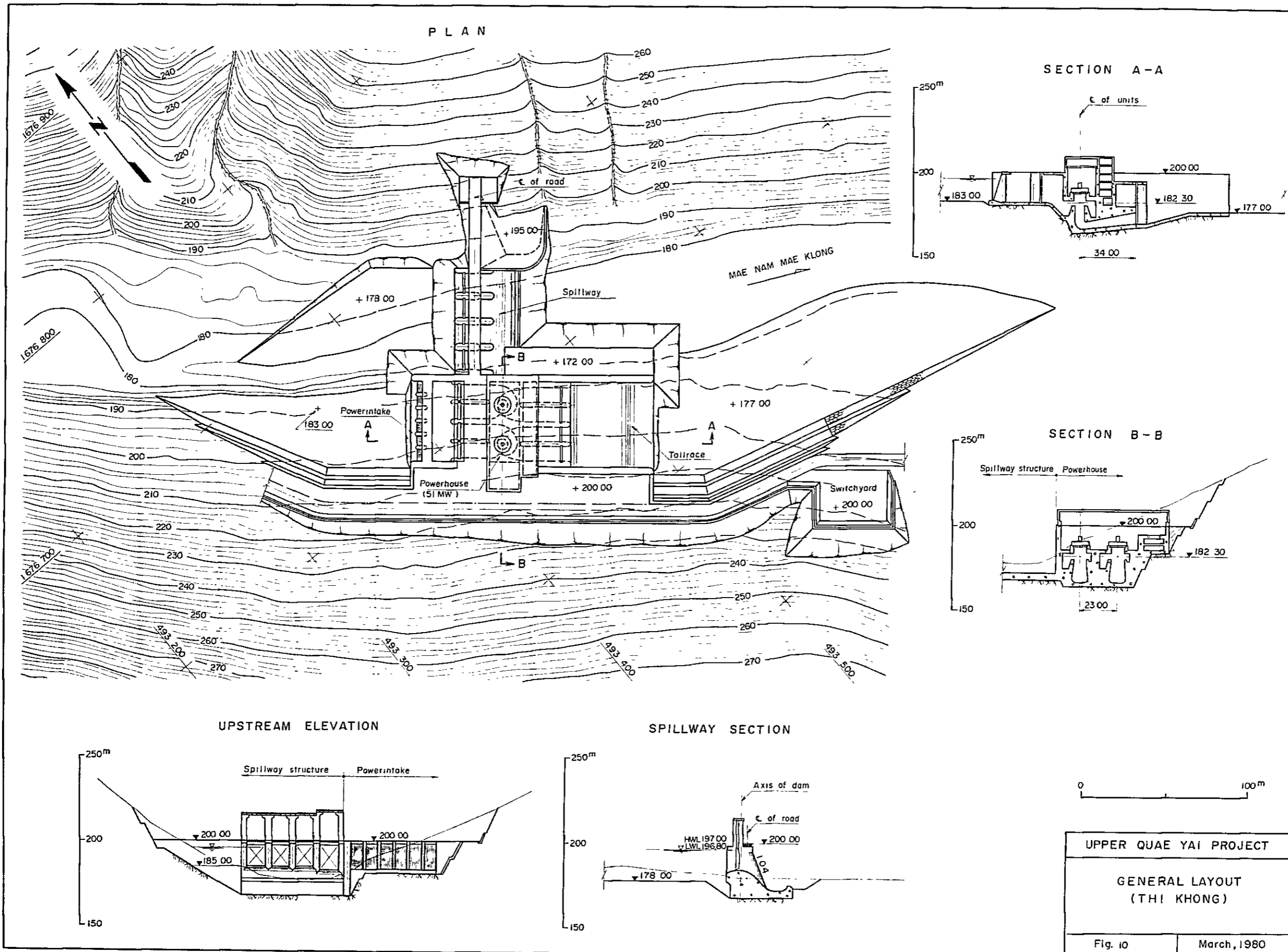


Fig. 11 Construction Schedule of Nam Chon Project

Description		Item	Unit	Quantity	1981	1982	1983	1984	1985	1986	1987	Notes
Preparation Works			L.S.	1	[Gantt bar from 1981 to 1982]							
Construction Facilities			L.S.	1	[Gantt bar from 1981 to 1983]							
Clearing			L.S.	1	[Gantt bar from 1981 to 1982]							
Care of River			L.S.	1	[Gantt bar from 1981 to 1982]							
Diversion Tunnel	No. 1	Ex.	m ³	239,000	[Gantt bar from 1981 to 1982]							
	No. 2	Con.	m ³	72,500	[Gantt bar from 1981 to 1983]							
Dam	Ex.	m ³	901,700	[Gantt bar from 1982 to 1985]								
	Gro.	m ³	60,000	[Gantt bar from 1982 to 1985]								
	Em.	m ³	12,700,000	[Gantt bar from 1982 to 1985]								
Spillway	Ex.	m ³	840,000	[Gantt bar from 1981 to 1982]								
	Con.	m ³	62,100	[Gantt bar from 1982 to 1983]								
	Gate	L.S.	1	[Gantt bar from 1982 to 1983]								
Intake	Ex.	m ³	160,000	[Gantt bar from 1982 to 1983]								
	Con.	m ³	39,000	[Gantt bar from 1982 to 1983]								
	Gate	L.S.	1	[Gantt bar from 1982 to 1983]								
Outlet Works	Ex.	m ³	10,300	[Gantt bar from 1982 to 1983]								
	Con.	m ³	11,400	[Gantt bar from 1982 to 1983]								
	Gate	L.S.	1	[Gantt bar from 1982 to 1983]								
Headrace	Ex.	m ³	65,000	[Gantt bar from 1982 to 1983]								
	Con.	m ³	21,600	[Gantt bar from 1982 to 1983]								
	Gro.	L.S.	1	[Gantt bar from 1982 to 1983]								
Surge Tank	Ex.	m ³	38,000	[Gantt bar from 1982 to 1983]								
	Con.	m ³	14,000	[Gantt bar from 1982 to 1983]								
	Gro.	L.S.	1	[Gantt bar from 1982 to 1983]								
Penstock	Ex.	m ³	32,000	[Gantt bar from 1982 to 1983]								
	Con.	m ³	10,800	[Gantt bar from 1982 to 1983]								
	S.P.	L.S.	1	[Gantt bar from 1982 to 1983]								
Powerhouse	Ex.	m ³	261,000	[Gantt bar from 1982 to 1983]								
	Con.	m ³	70,000	[Gantt bar from 1982 to 1983]								
	Con.(S.S)	m ³	40,000	[Gantt bar from 1982 to 1983]								
Tailrace	Ex.	m ³	243,000	[Gantt bar from 1982 to 1983]								
	Con.	m ³	34,500	[Gantt bar from 1982 to 1983]								
	Gate	L.S.	1	[Gantt bar from 1982 to 1983]								
Electrical Equipment			L.S.	1	[Gantt bar from 1982 to 1983]							
Transmission Line			L.S.	1	[Gantt bar from 1982 to 1983]							
Switchyard Equipment			L.S.	1	[Gantt bar from 1982 to 1983]							

← Commencement of Filling Reservoir

Close Gate

Close Gate

← Start of Operation

Ex. : Excavation
 Con. : Concrete
 Em. : Embankment
 Gro. : Grout Injection
 Incl. In. : Inclined Shaft
 A.T. : Access Tunnel
 O. Ex. : Open Excavation

Tra. : Trashrack
 V. : Valve

S.P. : Steel Pipe

S.S. : Super Structure

Down Access T. Incl. Ex. Entrance Down

Wall Con.

A.T.

Incl. Con.

Incl. Ex.

Incl. Con. Gate

T.Ex. O.Ex.

Con. O. Con.

Tra.

V.

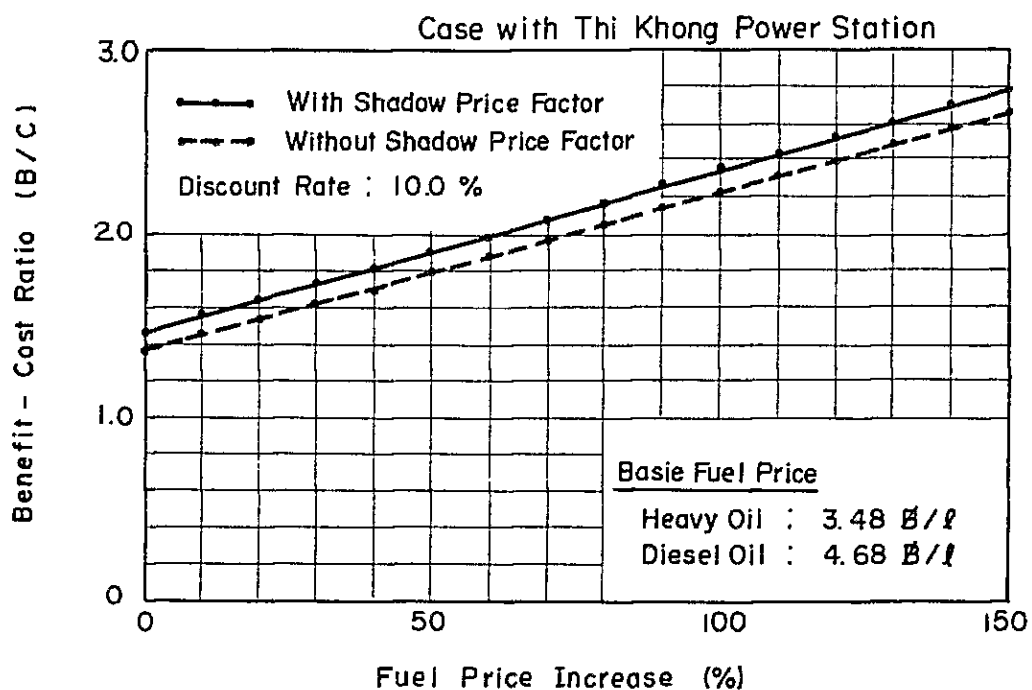
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Fig. 12 Construction Schedule of Thi Khong Project

Description	Unit	Quantity	1985	1986	1987	1988	1989
Preparation Works	L.S.	1	1985				
Construction Facilities	L.S.	1	1985				
Clearing	L.S.	1	1985				
Care of River	L.S.	1	1985		1987		
Excavation	m ³	720,000	1985	1986	1987		
Concrete (Dam & Spillway)	m ³	46,000		1986			
Concrete (Intake)	m ³	24,000			1987		
Concrete (Powerhouse)	m ³	35,000			1987	1988	
Concrete (Tailrace)	m ³	10,000			1987	1988	
Gate (Spillway)	L.S.	1		1986			
Gate (Intake)	L.S.	1				1988	
Gate (Tailrace)	L.S.	1				1988	
Switchyard	L.S.	1				1988	
Electrical Equipment	L.S.	1			1987	1988	
Transmission Line	L.S.	1				1988	

Start of Operation
↓

Fig. 13 Sensitivity Analysis (2 A)



Sensitivity Analysis (2 B)

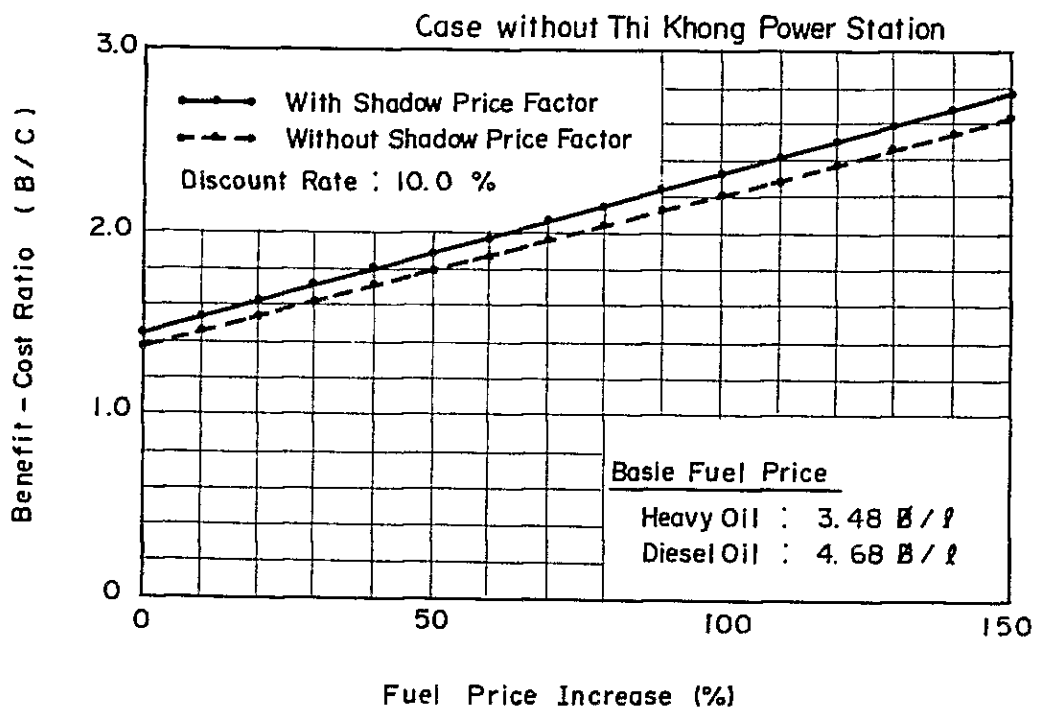


Table-1 Nam Chon Project Construction Cost

Item	Currency US\$ (Million)		Total US\$ (Million)
	Foreign	Local	
Preparation Works			
Camp, Road, Compensation and Contingency	14.2	45.7	59.9
Civil Works			
Diversion, Outlet Works and Care of River	6.1	20.1	26.2
Dam	59.5	45.8	105.3
Spillway	5.9	15.5	21.4
Intake, Headrace, Surge Tank and Penstock	4.1	17.0	21.1
Powerhouse and Tailrace	3.4	17.1	20.5
Miscellaneous	2.4	3.5	5.9
Contingency	7.9	11.6	19.5
Sub-total	89.3	130.6	219.9
Hydraulic Equipment			
Spillway Gates	1.5	0.3	1.8
Outlet Valve	1.1	0.3	1.4
Intake Gates	2.0	0.3	2.3
Penstock	6.9	2.3	9.2
Draft Gates	0.8	0.1	0.9
Contingency	0.8	0.8	1.6
Sub-total	13.1	4.1	17.2
Electrical Equipment	56.7	10.0	66.7
Transmission Line and Telecommunication	40.2	16.5	56.7
Engineering Fee	12.1	8.1	20.2
Total	225.6	215.0	440.6
Interest During Construction	—	107.9	107.9
Import Duties	—	21.9	21.9
Total Project Cost (Million US\$)	225.6	344.8	570.4
(Million Bahts)	4,625	7,069	11,694

Table-2 Thi Khong Project Construction Cost

Item	Currency US\$ (Million)		Total US\$ (Million)
	Foreign	Local	
Preparation Works			
Camp, Road, Compensation and Contingency	0.9	2.3	3.2
Civil Works			
Dam and Spillway	1.0	4.3	5.3
Intake, Powerhouse, Tailrace and Switchyard	3.2	9.7	12.9
Care of River	0.2	0.2	0.4
Miscellaneous	0.1	0.4	0.5
Contingency	0.5	1.4	1.9
Sub-total	5.0	16.0	21.0
Hydraulic Equipment			
Spillway Gates	1.4	0.3	1.7
Intake Gate, Trashrack and Draft Gate	1.6	0.3	1.9
Contingency	0.1	—	0.1
Sub-total	2.1	0.6	3.7
Electrical Equipment	14.3	2.5	16.8
Engineering Fee	1.4	0.9	2.3
Total	24.7	22.3	47.0
Interest During Construction	—	6.8	6.8
Import Duties	—	2.6	2.6
Total Project Cost			
(Million US\$)	24.7	31.7	56.4
(Million Bahts)	506	650	1,156

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