NATIONAL ENERGY AUTHORITY

KINGDOM OF THAILAND

RECONNAISSANCE REPORT

NAM PAI HYDROELECTRIC PROJECT

JULY 1971

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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Preface

In January 1971, the Government of Thailand made a request to the Gevernment of Japan for technical cooperation in conducting a pre-feasibility study of the Khlong Tha Dan Hydro-Electric Development Project located in Central Thailand and a reconnaissance study for the Nam Pai Hydro-Electric Power Development Project in the north-western part of this country. In compliance with this request, the Government of Japan entrusted the Overseas Technical Co-operation Agency (OTCA) with the performance of these aforementioned studies.

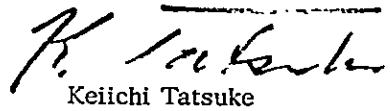
Taking the features of the said projects into account, OTCA dispatched to Thailand a survey team composed of five members from the Electric Power Development Co., Ltd. for the purpose of undertaking field surveys and collecting necessary data during the period from February 3 through March 19, 1971.

After their return to Tokyo, the survey team carried out a series of studies in connection with these projects in full collaboration with well-qualified experts and specialists of the said firm and prepared this report based upon the results of the field studies as well as data obtained during the team's stay in Thailand.

It is reported that the economic situations in the majority of Asian countries are stagnant while the Thai economy has been advancing at a remarkably rapid tempo. During the period of the first economic development plan (1961-1966), her annual economic growth reached 7.2%, and that for the first three years after the commencement of the second economic development plan (1967-1971) grew at a rate of 7.6%. Approximately 30% of the gross domestic product of Thailand is occupied by her agricultural sector with the mining and industrial sectors accounting for 16% of the total. The manufacturing industries have recently been increasing by approximately 12% on the average per annum. Besides, electric power consumed by the industrial sector comprises more than 60% of the total power consumption in Thailand. With an increase of production in the mining and industrial sectors, a large increment in their consumption of electric power can be aniticipated.

For these reasons, it is my sincere hope that this report will be of help in the formulation by the Government of Thailand of its long-range power development programs and the determination of guidelines for conducting the required investigations in the future.

On behalf of OTCA, I would like to take this opportunity to express my heartfelt gratitude for the hospitality and kind cooperation which officials of the Government of Thailand and associated organzations extended to the team during their stay in Thailand.



Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keiichi, Tatsuke, Director General
Overseas Technical Cooperation Agency

Sir:

Submitted herein is a Reconnaisance Report regarding the Nam Pai Electric Power Development Project, Thailand.

The Overseas Technical Cooperation Agency (hereinafter called OTCA), for the purpose of pre-feasibility investigations of the Khlong Tha Dan Project and reconnaissance survey of the Nam Pai Project, sent a survey team consisting of five experts of the Electric Power Development Co., Ltd. (hereinafter called EPDC), to Thailand from February to March 1971. The survey team carried out investigations of topography, geology, hydrology, while also collecting other informations necessary for planning.

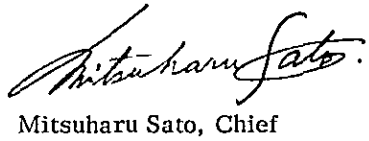
The survey team, on return to Japan, based on the results of investigation and information collected in Thailand, performed analyses of hydrologic data, compared alternative plans, etc. in preparation of this Report.

The Nam Pai Project area is located in the neighborhood of Chiang Mai, the second largest city of Thailand, which is about 620 km North of Bangkok. The Nam Pai River, on which the project is to be planned, flows westward to join the Salween River of Burma.

It was found in this Study that the hydroelectric power development of approximately 200 MW in total capacity could be developed by constructing two high dams of about 116 m and 160 m on the Nam Pai River. The possibility of development of the Project, however, can not be affirmed until sufficient data on hydrology, geology, etc. for the planning are obtained. It would, therefore, be necessary for the study of the Project to make further reconnaissance investigations in the future after such data become availabe to a satisfactory degree.

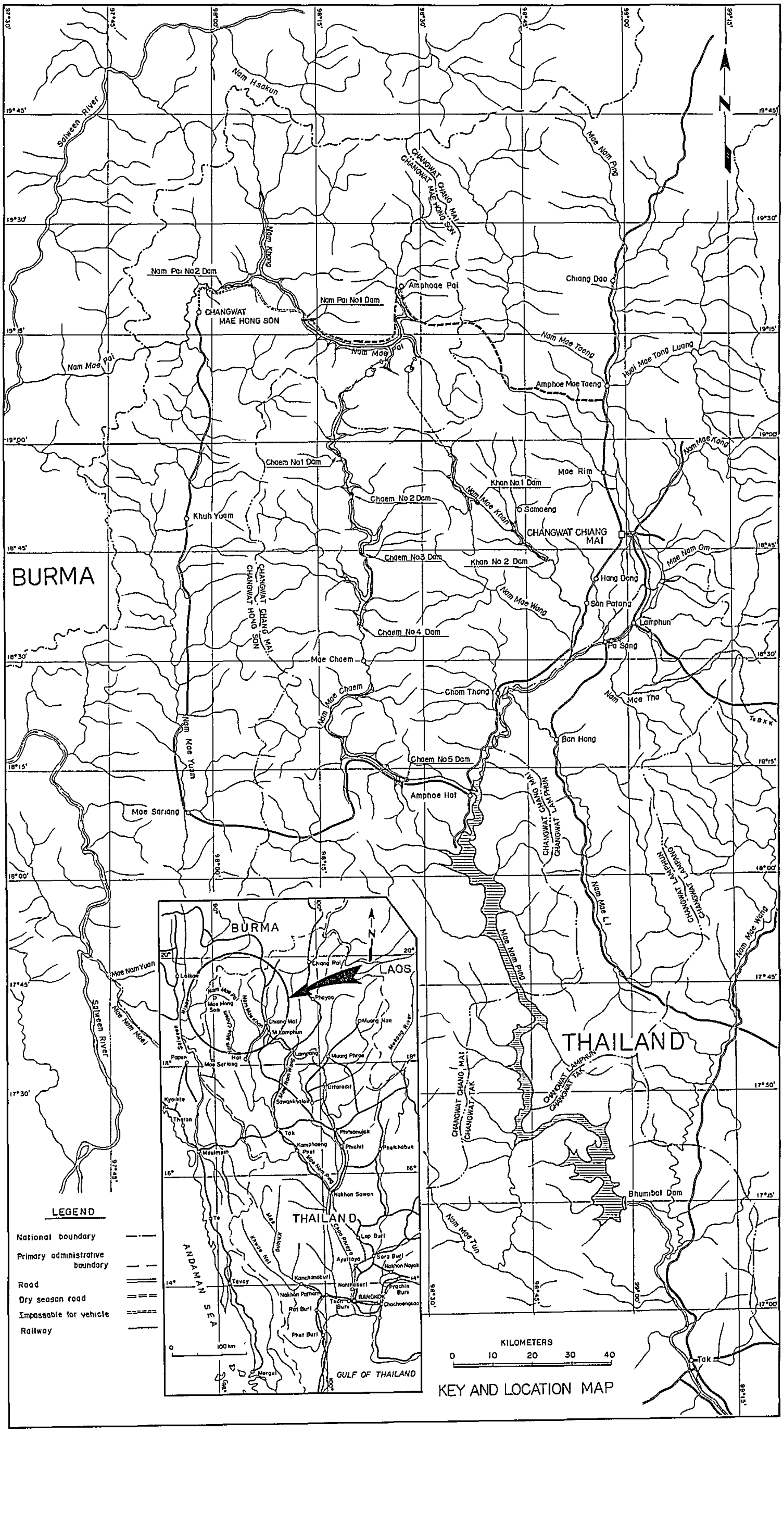
In closing, it is wished to express the heartfelt gratitude to Mr. Nitipat Jalichan, Secretary General of the National Energy Authority, and the officials concerned of the National Energy Authority, the Electricity Generating Authority of Thailand, the Royal Irrigation Department, the Department of Technical and Economic Cooperation of Thailand, the Embassy of Japan, the Government of Japan and OTCA, for their great assistance and cooperation in carrying out the survey.

Yours respectfully,



Mitsuharu Sato, Chief
Thailand Khlong Tha Dan
and Nam Pai Survey Team

July 1971


BURMA
THAILAND
LAOS
KEY AND LOCATION MAP
KILOMETERS
0 10 20 30 40
LEGEND
National boundary
Primary administrative boundary
Road
Dry season road
Impassable for vehicle
Railway
CHANGWAT CHIANG MAI
CHANGWAT MAE HONG SON
CHANGWAT CHANG MAI
CHANGWAT HONG SON
CHANGWAT CHANG MAI
CHANGWAT LAMPHUN
CHANGWAT LAMPHUN
CHANGWAT LAMPANG
CHANGWAT CHANG MAI
CHANGWAT TAK
CHANGWAT LAMPHUN
CHANGWAT TAK
Nam Pai No2 Dam
Nam Pai No1 Dam
Chaem No1 Dam
Chaem No2 Dam
Chaem No3 Dam
Chaem No4 Dam
Chaem No5 Dam
Khan No.1 Dam
Khan No 2 Dam
Bhumibol Dam
Amphoe Pai
Amphoe Mae Taeng
Amphoe Hot
Chiang Dao
Mae Rim
Samoeng
Hang Dong
San Patong
Lamphun
Pa Sang
Chom Thong
Ban Hong
Mae Chaem
Khuh Yuam
Mae Sariang
Tak
Salween River
Nam Hsakun
Nam Khong
Nam Mae Pai
Mae Nam Ping
Nam Mae Taeng
Huai Mae Tong Luang
Nam Mae Kang
Nam Mae Khan
Mae Nam Om
Nam Mae Wang
Nam Mae Tha
Nam Mae Chaem
Nam Mae Yuam
Nam Mae Li
Nam Mae Tun
Mae Nam Yuan
Mae Nam Moei
To B K K
GULF OF THAILAND
ANDAMAN SEA
100 km
BANGKOK

CONTENTS

CHAPTER 1
INTRODUCTION

The population and the GNP, an index of economic development, of Thailand have indicated annual growth rates of approximately 3% and 8%, respectively,. In compliance with these growths, electric power demand has shown an extremely marked annual rate of increase of an average of 22%. This trend is particularly remarkable in the capital city of Bangkok and its surrounding area. In order to cope with this increase in power demand, the National Energy Authority (hereinafter called NEA) of the Government of Thailand has planned hydroelectric power development in the basins of the Khlong Tha Dan River 120 km northeast of Bangkok and of the Nam Pai River near Chiang Mai, the second largest city in Thailand.

On 19 January 1971, the Government of Thailand requested the Government of Japan to conduct a pre-feasibility survey of the Khlong Tha Dan Basin and a reconnaissance survey of the Nam Pai Basin. The Government of Japan accordingly commissioned the Overseas Technical Cooperation Agency (hereinafter called OTCA) to carry out the operations. OTCA, in view of the fact that the main objective of these surveys was electric power development, organized a survey team comprised of the five engineers named below from the Electric Power Development Co., Ltd. (hereinafter called EPDC) and sent the team to Thailand on February 3, 1971.

Chief	Mitsuharu Sato	Civil Engineer	From 3 Feb. 1971 To 19 Mar. 1971
Member	Hideharu Kashiwagi	Geologist	- ditto -
Member	Tsutomu Kidahashi	Electric Engineer	- ditto -
Member	Katsunori Hashimoto	Planning Engineer	From 3 Feb. 1971 To 4 Mar. 1971
Member	Azuma Tsunoda	Civil Engineer	From 3 Feb. 1971 To 19 Mar. 1971

The survey team, upon returning to Japan, from 20 March to 20 June 1971, carried out studies of the projects at the head office of EPDC based on the information gathered in Thailand under the direction of the Chief Engineer and with the cooperation of engineers of EPDC. Such operations as analyses of hydrologic data, load forecasts, comparison studies of alternative plans, economic evaluation, etc. were performed for the preparation of this Report.

Basic data and reference books obtained during the survey period in Thailand are listed at the back of this Report. This Report has been prepared based on these data.

CHAPTER 2
SUMMARY

2.1 Outline of Project Area

At approximately 620 km North of Bangkok, there is a city of Chiang Mai, the second largest in Thailand. There are mountains at immediately West of Chiang Mai from where the Nam Pai River flows westward through the Changwat Mae Hong Son to the Burmese border to join the Salween River.

On the one hand, the Chaem and Khan rivers originate their flows at the mountain range on the left bank of the Nam Pai River to merge with the Mae Nam Ping River. The vicinity of the junction of the Chaem and Ping rivers is the end of the backwater of the famous Bhumibol Reservoir (power station output 420 MW).

In the vicinity where the Nam Pai River approaches the Burmese border, there is Mae Hong Son City, the capital of Province of Mae Hong Song. Mae Hong Son City is an old city serving as a center for agricultural products. Close to Mae Hong Son City, on a small stream named the Nam Mae Hong Son, NEA is presently constructing a 1,000-kW hydroelectric power station as a part of its rural electrification program.

The distance between Chiang Mai City and Mae Hong Son City is only 120 km, but actually, approach to the latter is extremely difficult. Except a way to take a regular flight which is made 2 to 3 times a week, the only way to reach Mae Hong Son is to detour by an automobile southward and in a clockwise direction, travelling along the Burmese border.

The population of Chiang Mai is approximately 100,000. The electric power supply for the city is from a 12.5 MW steam plant near Lampang City and from the Bhumibol Hydroelectric Power Station. In the neighborhood of the project area, besides Chiang Mai, there are the municipalities of Chiang Rai, Lampang and Lamphun. The population of each city is around 10,000 to 40,000. The Mae and Karen hill-tribes live in the mountain lands of the project area, too.

It is said that tin, coal, fluorite, manganese, antimony, lead and iron ore are produced in the mountains near the project area, but the reserves are unknown and any large-scale

development has not yet been undertaken and none of large-scale factories is seen.

2.2 Problems and Needs for Development

As stated above, there is no prominent industrial development in the project area at present. The fact that the annual population growth rate of the area is 3 to 5% is a problem. For raising living standards and promoting employment, development of industry in the project area is desirable. On the one hand, the need for rural electrification is being stressed. For the industrial development of this area, the National Economic Development Board is said to be contemplating establishment of an industrial estate at Chiang Mai City or at Lamphun City as part of the Third National Economic and Social Development Plan (1972 - 1976). Supply of electric power is an important basic concern for the plans to establish such an estate.

On the other hand, the growth in power demand at the capital city of Bangkok is exceedingly prominent (see the Khlong Tha Dan Project Report). In order to increase the energy production of Bhumibol Power Station which is one of the main electric power sources for Bangkok, an idea to pumping up water of the Nam Pai River across the mountains to the Chaem River or the Khan River to supply additional water to the existing Bhumibol Reservoir downstream has been suggested by a Colombo Plan expert at NEA.

2.3 Summary of Project

A hydroelectric power development plan for the Nam Pai River was studied based on observation data of the catchment area obtained from a light airplane and on a limited amount of other basic data.

As for the basin planning, three proposals described below were examined (see Fig. 1 and Table 4).

Plan 1: Plan of Development of Conventional Type

A No.1 Rockfill Dam approximately 116 m high and a No.1 Power Station of maximum output of approximately 57 MW will be constructed on the upstream part of the Nam

Pai River. A No.2 Rockfill Dam approximately 160 m high and a No.2 Power Station of maximum output of approximately 146 MW will be constructed on the downstream part of the Nam Pai River. The generated power is to be transmitted to Chiang Mai City and Mae Hong Son City.

Plan 2: Plan of Development of Pumping-up Diversion to the Khan River

An alternative dam, height 155 m, of No. 1 Dam in Plan 1 will be constructed in the upstream of the Nam Pai River in order to make a reservoir for pumping-up diversion.

Water of the reservoir will be pumped up by approximately 285 m over a mountain for diverting into the Khan River. The diverted water is to be utilized for power generation at two power stations planned on the Khan River and at the existing Bhumibol Power Station. A trasmission line is to be built between these stations and the the existing Bhumibol Power Station.

Plan 3: Plan of Development of Pumping-Up Diversion to the Chaem River

Water of the reservoir of No. 1 Dam (in Plan 2) will be pumped up by approximately 435 m over a mountain for diverting into the Chaem River. The diverted water is to be utilized for power generation at five power stations planned on the Chaem River and at the existing Bhumibol Power Station. A transmission line is to be built between these stations and the existing Bhumibol Power Station.

As a result of a reconnaissance grade study on the three plans described above, the following conclusions and recommendations were tentatively derived.

Conclusions:

i) There is a possibility that the plan 1 could be developed. However, the plans 2 and 3 are thought to be poor in their economics if they are developed solely for electric power.

ii) In order to study more accurately the feasibility of the basin development plan 1, a sub-reconnaissance survey should be made. For this survey the follwings are recommended.

Recommendations:

i) Provide a runoff and meteorological observation station near the No.1 damsite to obtain adequate hydrologic data necessary for the study.

ii) As limestone is predominant in the bedrock of the Nam Pai River Basin, investigate whether or not cavernous limestone exists in the reservoir area and in the entire basin to study the possibility of leakage from the reservoir.

iii) In determining an appropriate installed capacity and timing of the power development, a study should be made correlated with regional development plans.

CHAPTER 3
HYDROLOGY, TOPOGRAPHY AND GEOLOGY

3.1 Hydrology

The precipitation and runoff observation sites, with periods of observation on which information was obtained in the present field surveys are as shown in Table 1 and 2. As for gaging stations within the catchment area there is only one place, Ban Pang Mu Gaging Station, for which the recorded period is only 4 years and 6 months from July 1965 to December 1969. As for precipitation observation data, the period of record at Chiang Rai is longer than others. So, it was decided to utilize these data for getting a correlation between the observed runoff and the pricipitation. From this correlation, the runoff at Ban Pang Mu Gaging Station was estimated in ten years from 1960 to 1969.

3.2 Topography and Geology

This area is a mountainous region covered by dense forests. The topography is generally not very rugged on the southern side of the Nam Pai River, and there are few places where bare rocks are exposed. On the other hand, the topography on the northern side of the Nam Pai River is fairly rugged and at high elevations there are areas where slightly flat karst are spread out. This region is situated in a large orogenic zone stretching north from the Malay Peninsula to the People's Repunlic of China. There are strata of many kinds of geological ages from the Cambrian Period to the Tertiary and Quaternary periods, which are arranged in a more or less north-south direction along fold axes. There are many species of distributed rocks and these are listed in Table 3. Of these rocks, the igneous rock such as the granite and the granodiorite are most widely distributed.

Granite, the Rat Buri Formation and the Thung Song Formation are predominant in the catchment area of the Nam Pai River upstream from Mae Hong Song City. The Rat Buri Formation is comprised mostly of limestone, while also in the Thung Song Formation limenstone is predominant with interbeds of calcareous shale and sandy shale. The Rat Buri Formation pre-

sents a karst unique to limestone areas, and there are many small irregularities with lots of sink holes.

According to topographical maps (scale 1:50,000), there seems to be a huge polge in the east of the Nam Khong River, a tributary of the Nam Pai River, at the bottom of which the Nam Lang or the Nam Pa Mai Daeng River flows. They are mouthless streams and not connected with any river running into the sea, and it is surmised that the water falls into the ponor of a limestone cave at the lowest part. The catchment area of the polje is extremely large being more than 500 sq.km and it is not known to where the river connects. Along the Nam Khong River there are two or three other mouthless streams of smaller scale seen on the topographical maps.

In the Nam Mae Chaem Basin upstream from Hot City, the distributions of granite and the Kanchanaburi Series are unique. The latter, as shown in the previous table, is mainly consisted of sedimentary rocks such as shale and sandstone, but there are local distributions of Rat Buri limestone at some places.

In the catchment areas of the Nam Mae Chaem and the Nam Mae Khan, geological conditions are generally good due to wide distribution of granite, but there are distributions of the Rat Buri Formation at some places.

3.3 Summary of Plan of Development

Table 4 shows a summary and result of analysis of alternative plans described in Chapter 2.3.

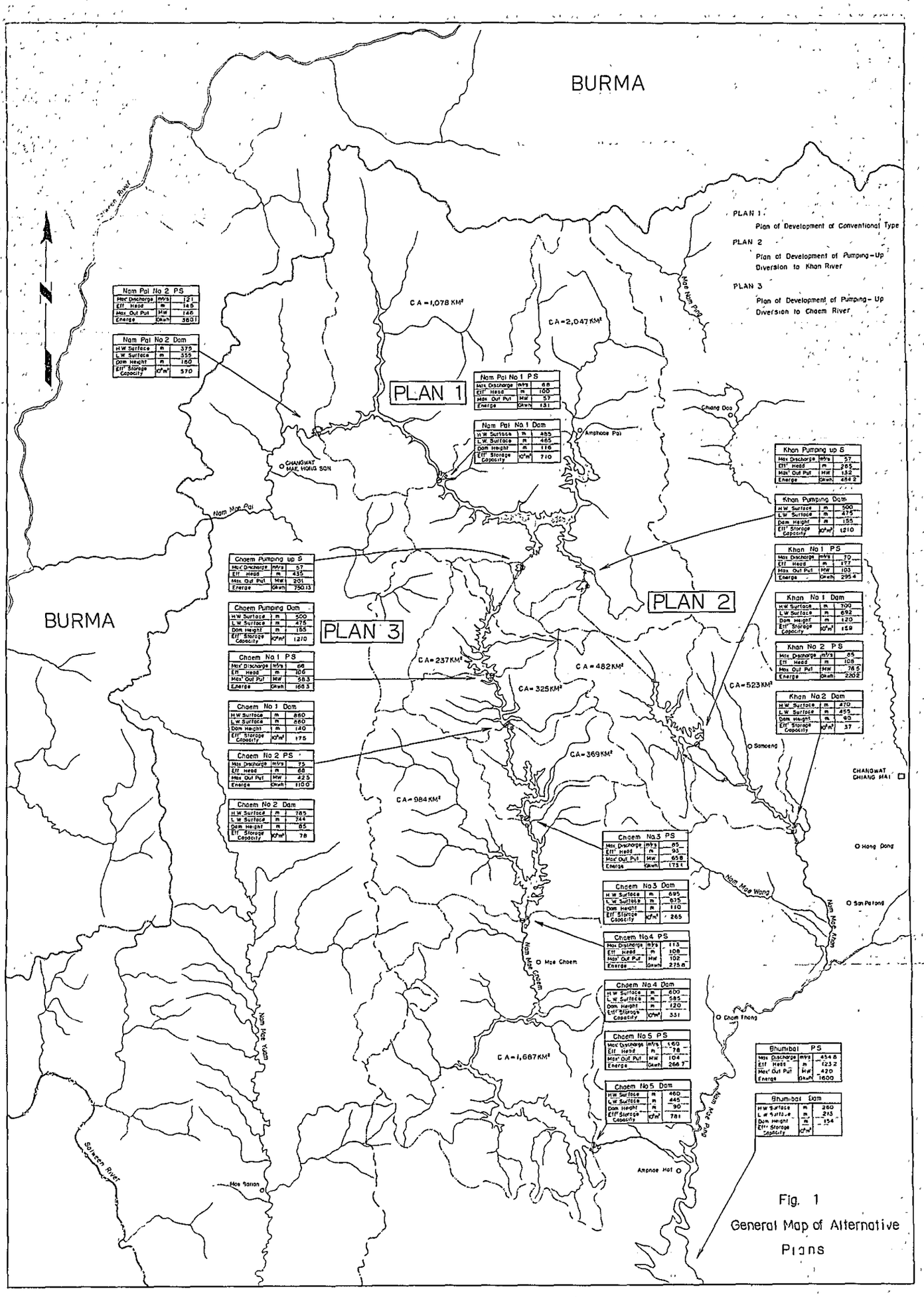
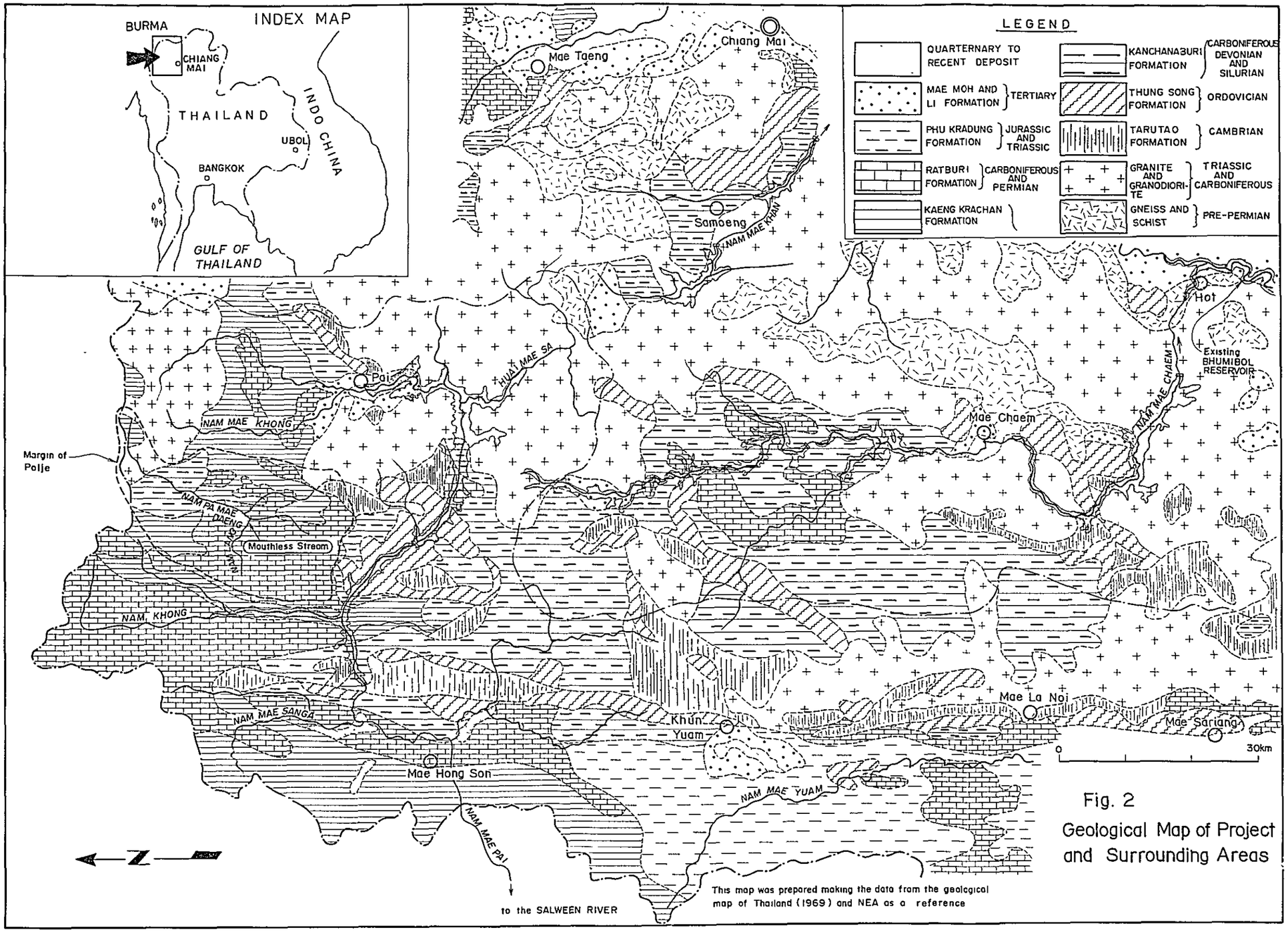


Fig. 1
General Map of Alternative Plans



This map was prepared making the data from the geological map of Thailand (1969) and NEA as a reference

Fig. 2
Geological Map of Project and Surrounding Areas

Table 1 Existing Run-off Data

Station	River	C.A (KM^2)	Latitude	Longitude	60'	61'	62'	63'	64'	65'	66'	67'	68'	69'	70'
Pha Bong	Nam Mae Samat	589	19° 10.2' N	98° 00'E						July					
Pang. Mu	Nam Pai	3,770	19°21.5' N	97°57.9'E						July					
Mae Hong Son	Nam Mae Hong Son	43.6	19°16 9' N	98°0.94'E						Apr.					
San Pa Tong	Nam Mae Khan	1,060	18° 42.0'N	98°48.8' E											

Table 2 Existing Precipitation Data

Station	51'	52'	53'	54'	55'	56'	57'	58'	59'	60'	61'	62'	63'	64'	65'	66'	67'	68'	69'	70'
Pha Bong															May					
Pang Mu															Apr.					
San Pa Tong																				
Ban Khlong Si Sook																				
Chiang Rai																				

Table 3 Strata Distributed in the Area to the West of Chiang Mai

Period	Sedimentary Rock			Igneous Rock	Metamorphic Rock
	Group	Formation	Rock (Deposit)		
Quarternary Recent			Alluvium, Eluvium and River Gravel		
Tertiary	KRABI	MAE MOT and L1	Fluvialtile Deposit, Clay, Sand, Marl, Bituminus Shale, Lignite and Terrace Deposit		
Jurassic and Triassic	KHORAT	PHU PHAN and PHRA WIHAN	Micaceous Shale, Siltstone, Micaceous Sandstone and Conglomerate		
Triassic				Granite and Granodiorite	
Carboniferous and Permian	RAT BURI	RAT BURI	Limestone interbeded with Shale, Sandstone, Mudstone, Conglomerate and Volcanic Tuff		
Pre-Permium					Gneiss and Schist
Carboniferous, Devonian, and Silurian	TANAOSI	KAENG KRACHAN KANCHANA BURI	Greywake, Mudstone, Silt-Stone, Limestone, Black or Gray Shale and Sandstone Shale, Sandstone, Sandy Shale Phyllite, Argillite, Quartzite Slate and Limestone		
Ordovician	THUNG SONG	THUNG SONG	Limestone interbeded with Calcareous Shale and Sandy Shale		
Cambrian	TARUTAO	TARUTAO	Red Shale and Sandy Shale		

Table 4. Summary of Alternative Plans

Item \ Plan		Plan 1 Plan of Development of Conventional Type	Plan 2 Plan of Development of Pumping-up Diversion	Plan 3 Plan of Development of Pumping-up Diversion
Nam Pai No.1 Reservoir				
Catchment Area	km^2	-	2,047	2,047
Height of Dam	m	-	155	155
Nor. H.W.L.	m	-	500	500
Total Storage Capacity	10^6m^3	-	2,260	2,260
Effective Drawdown	m	-	25	25
Effec. Storage Capacity	10^6m^3	-	1,210	1,210
Pumping-up Station				
Max. Head	m	-	285	435
Max. Discharge	m^3/S	-	57	57
Annual Available Diversion Discharge	10^6m^3	-	601	601
Required Power for Pumping-up	MW	-	132	201
Required Energy for Pumping-up	10^6kWh	-	484.2	750.1
Diversion Tunnel				
Length and Diameter	km x m	-	penstock: ϕ 2.8 m, Non-pressure Tunnel: 23.3 km x 3.5m	penstock: ϕ4.3m, Non-pressure Tunnel: 8.6 km x 3.5m
Construction Cost of Diversion Facilities:	10^6 Baht	-	1,765.0	1,831.9

Power Station		Nam Pai No.1	Nam Pai No.2	Total	Mae Khan No.1	Mae Khan No.2	Total	Nam Chaem No.1	Nam Chaem No.2	Nam Chaem No.3	Nam Chaem No.4	Nam Chaem No.5	Total
Reservoir													
Catchment Area	km^2	2,047	1,678		482	523		337	325	369	984	1,687	
		2,047	3,725	3,725	2,529	3,052	3,052	2,384	2,709	3,078	4,062	5,749	5,749
Height of Dam	m	116	160		120	90		140	85	110	120	90	
Nor. H.W.L.	m	485	375		700	470		880	765	695	600	460	
Effective Drawdown	m	20	20		8	15		20	21	20	15	15	
Effective Storage Capacity	10^6m^3	710	570		159	37		175	76	265	331	781	
Annual Inflow	10^6m^3	601	1,093		742	896		700	795	903	1,192	1,687	
Power Plant													
Effective Head	m	100	145		177	108		106	68	93	108	78	
Max. Discharge	m^3/S	68	121		70	85		66	75	85	113	160	
Installed Capacity	MW	57	146	203	103.0	76.5	179.5	58.3	42.5	65.8	102.0	104.0	372.6
Annual Energy Production	10^6kWh	131.0	380.1	511.1	295.4	220.2	515.6	168.3	110.0	173.1	275.8	266.7	993.9
Construction Cost	10^6Baht	743.3	1,031.4	1,774.7	1,328.0	749.5	3,842.5	822.2	539.7	691.6	927.1	1,030.8	5,843.3

CHAPTER 4
LIST OF BASIC DATA

I. Topographical Map

Scale of 1:250,000	8 sheets	Sheet No. NE 47-2, 47-3 47-7, 47-10, 47-11, 47-14, 47-15
Scale of 1:50,000	47 sheets	Sheet No. 4567 (I), 4568 (I-III) 4569 (I, II), 4665 (I-IV) 4667 (I-IV), 4668 (II, III), 4669 (II, III), 4670 (II, III), 4765 (I-IV), 4766 (I-IV), 4768 (I-IV), 4769 (IV-IV), 4770 (III), 4866 (III, IV), 4867 (III, IV), 4868 (III, IV), 4767 (I-IV)
Scale of 1:10,000	26 sheets	Sheet No. 1 - 26

II. Aerial Photography

Scale of 1:40,000	57 sheets	Project Area

III. Highway Map

Scale of 1:1,000,000	1 sheet	Northern region
Scale of 1:1,000,000	1 sheet	Central region
Scale of 1:1,000,000	1 sheet	Southern region
Scale of 1:1,000,000	1 sheet	North-Eastern region

IV. Hydrological Data

(a) Daily precipitation

Ban Pang Mu	5 yrs.	1966 (Apr.) - 1970 (Dec.)
Pha Bong	5 yrs.	1966 (May) - 1970 (Dec.)
San Pa Tong	4 yrs.	1967 (Jan.) - 1970 (Dec.)
Chiang Rai	6 yrs.	1962 (Jan.) - 1967 (Dec.)

(b) Daily discharge

Ban Pang Mu	5 yrs.	1965 (Jul.) - 1967 (Dec.)
Pha Bong	5 yrs.	1965 (Jul.) - 1969 (Dec.)
Mae Hong Son	3 yrs.	1966 (Apr.) - 1968 (Dec.)

(c) Year book

1965 Hydrologic Data	1	
1966 Hydrologic Data	2	Volume I, II
1967 Hydrologic Data	1	Volume II

(d) Daily max. and min. temperature

Ban Pang Mu	3 yrs.	1968 - 1970

(e) Daily evaporation

Ban Pang Mu	3 yrs.	1968 - 1970

(f) Location maps

Location of hydrologic stations	1 sheet	1970 NEA
Location of stream gaging stations	1 sheet	1965 RID
Location of hydrologic observation stations	1 sheet	1968 RID

V. Geological Data

Geological Map of Nam Pai River Basin	1 sheet

VI. Electrical Data

Thailand Electric Power Load Forecast	1
Electric Power in Thailand 1969	1
Electric Power Statistics for Thailand (1969)	1
Hydroelectric Power Potential in thailand	1
Projections of Sectional Outputs and Employment	1
Electric Rate Schedule	3 sheets