REPORT

ON

DEVELOPMENT OF

THE MAE KLONG RIVER BASIN IN THAILAND

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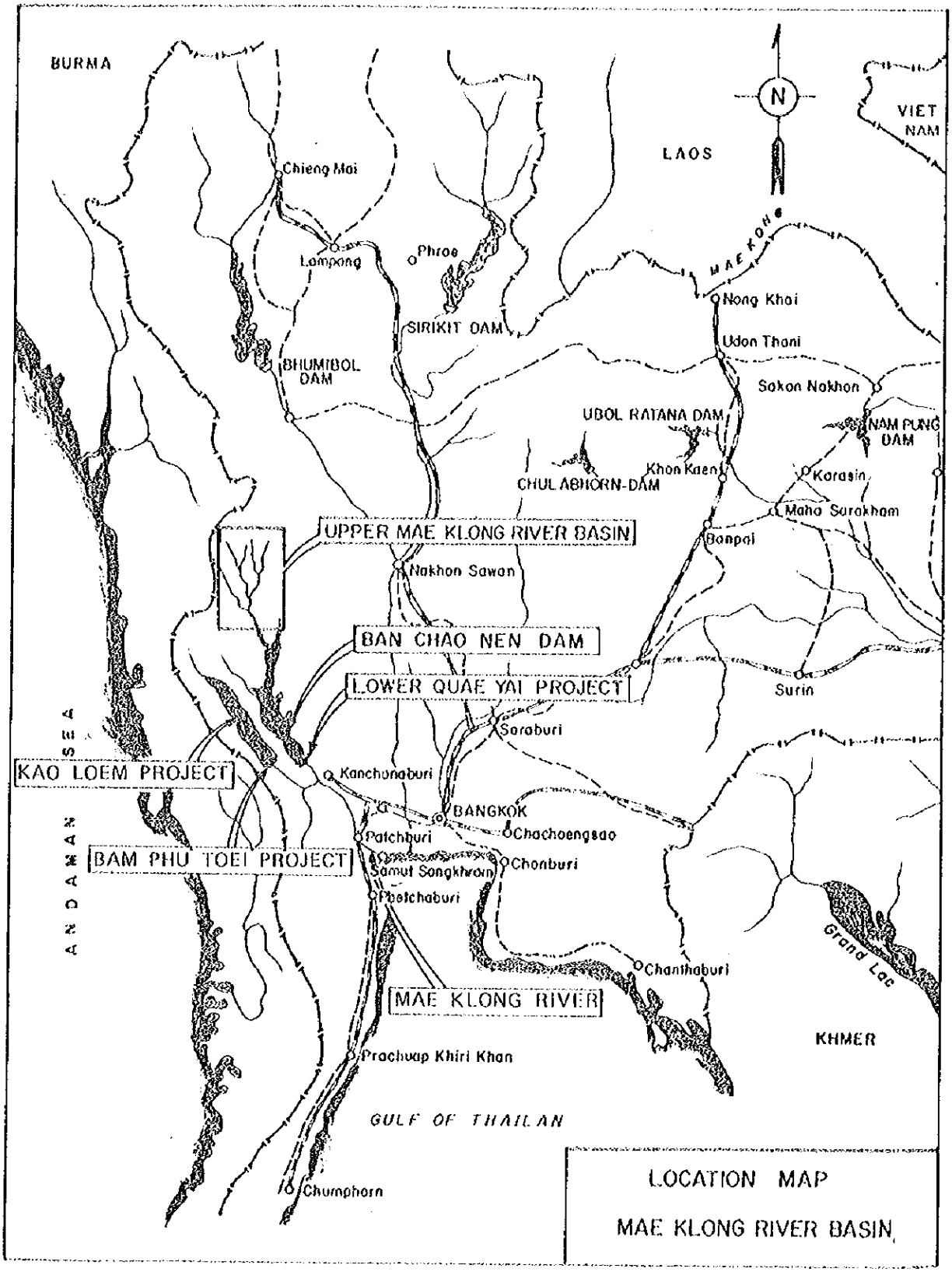
COLOMBO PLAN EXPERT

MARCH 1977

Japan International Cooperation Agency



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1. PREFACE

I had worked for four years from October 1966 to October 1970 with the Yanhee Electricity Authority of Thailand and later the Electricity Generating Authority of Thailand as Japanese Colombo Plan Expert.

In those years Thailand had been experiencing a big growth of its economy and a great demand for electricity.

For the purpose of coping with such electric demand, YEA had planned to develop the Mae Klong River. I and other colleages came to expedite investigations of the hydro-electric potential of the Mea Klong River by the YEA request through the Government of Thailand to the Government of Japan for the technical cooperation under the Colombo Plan. My first reconnaissance over the Quae Yai River was in November 1966 (QYCP - 002 "A Report on the Quae Yai Reconnaissance").

That was the about time when the Ban Chao Nen Project got underway to realization.

After eight years critical situation not only from the technical but also from the political point of view, YEA and EGAT had surmounted all difficulties by its superior management.

I am very glad to see the Ban Chae Nen Project going on well with construction which started from 1975.

I was assigned again as a Colombo Plan Expert to cooperate with EGAT concerning about development of Upper Quae Yai basin.

This time I have worked for two years and my assignment terminated on July 1976.

On this occasion I would like to write my opinion and recommendation about what I have learned for years about the Mae Klong River. Unfortunately during this time I could not go most upstream the Quae Yai River where I eagerly intended to go in and will have many promising sites for the hydroelectric development because of the unrest all over those area by the insurgents and the Burmese refugees. This is a very skeleton plan on the Upper Quae Yai basin based on the 1/50,000 map and a little meterological data.

This report only aims at the reference for further investigation along the Upper Quae Yai basin.

2. UPPER BAN CHAO NEN PROJECTS

I chose about 13 projects for dam construction in the mainstream and tributaries.

Those projects are shown in the map of "Upper part of Quae Yai River from the confluence with Huai Kha Khaeng".

Among them, 8 sites from No.1 to No.8 are the alternative sites which should be selected after detail investigation, and No.9 to No.11 are alternatives too.

In this report I chose No.10 (Huai Thi La Ku) and Huai Nam Chon sites for comparison, because I considered that Huai Nam Chon and Huai Thi La Ku sites are most representative in both groups and I tried to avoid unnecessary effort of precise comparison caluculation at this early stage. Anyway the projects on the main stream will be the major part form the energy's point of view. Specially the adjacent project to the Ban Chao Nen is the biggest though it has many alternatives.

(1) Main stream

(a) Adjacent Project to Ban Chao Nen Project

When I came to work with EGAT, EGAT was about to concentrate its effort in the investigation around Huai Tong Thai area where the Japanese investigation team recommended in their report. ("Reconnaissance Report, Upper Quae Yai Hydro-electric Project", November 1973) I also recommended the Huai Mune Sae site as the next dam to the Ban Chao Nen dam in my report ("A Report on the Quae Noi Reconnaissance", July 1968)

Because the topography around Huai Mune Sae and Huai Tong Thai is very fabourable for dam construction. After through consideration, I found a new idea which is different from the original. As topographical characteristics, the main stream flows in the very steep gorge from the junction with Huai Thi La Ku to Huai Mune Sae.

Even we build a high dam in this area, we can not create a big storage along this revine. The elevation difference between above two points is 45 m or more and the distance is about 25 km, this means that the gradient is reather steep (1 : 550)

The main stream also flows in the same kind of gorge from Huai Rin to the junction with Huai Thi La Ku.

Only Nam Mae Chan, which is a tributary and joins the main stream from the right bank at about 16 km upstream from the junction with Huai Thi La Ku, has very vast plain and plateau. It is clear that we should utilize this vast area for the storage wherever we build a dam at closely upstream from Ban Chao Nen reservoir. Taking these reasons into consideration, I finally planned to build a dam at near the junction with Huai Thi La Ku (No.9, No.10, No.11). By doing this, we can reduce the dam height and dam volume without any loss of reservoir storage. (when a dam is in a narrow gorge, the dam volume is approximately proporational to the cube of dam height.)

Taking Huai Nam Chon and No.10 sites (Huai Thi La Ku) for example, the proposed optimum dam at Huai Nam Chon is as follows;

High Water Level	360 m
Total storage	5,376 MCM
Available drawdown	25 m
Effective storage	2,680 MCM
Dam height	197 m (according to the new survey this figure is about 175 - 180 m)
Dam Volume	15 million m^3

If we consider the same total storage and effective storage at Huat Thi La Ku site, the outline of dam is as follows;

High Water Level	368.8 m
Total storage	5,376 MCM
Available drawdown	23.4 m
Effective storage	2,680 MCM
Dam height	134 m
Dam Volume	4 million m^3

This figures show that the 40 m lower dam at Huai Thi La Ku site can produce the same amount of storage as at Huai Nam Chon site.

Furthermore as the topography at Huai Thi La Ku site is more favourablbe to Huai Nam Chon site, the former dam volume is only about 27 percent of Huai Nam Chon dam.

So it is needless to say that the Huai Thi La Ku site is more promissible than the Huai Nam Chon site if the geological condition is nearly same. Unexpectedly I could not reach the Huai Thi La Ku site this time because of sensitive circumstance in this area.

Fortunately I flew by the helicopter on this area to Amphoe Umphang and took picturos during reconnaissance time in Novermber 1966. (Refer to QYcp-002 "A Report on the Quae Yai Reconnaissance" December 1966) and found that the topography was very suitable for dam construction.

On April 11, 1975, I walked along the main stream from Huai Tong Thai to the No.7 site, and we found that the geological condition was gradually changed from Huai Tong Thai to upstream.

I can not say exactly that the geological condition of No.9, No.10 and No.11 sites is much better than Huai Nam Chon site at this stage.

But this geological change from the limestone to the other is more favourabel indication to No.9, No.10 and No.11 sites.

Table I shows the result of a comparison study between Huai Nam Chon and Huai Thi La Ku sites. In both cases I considered a dam at Huai Thi Khong site (No.0 site is alternative) to fill the head gap between both sites and Ban Chao Nen reservoir. According to the latest survey, the backwater of Ban Chao Nen reservoir reaches near the Huai Thi Khong site.

Concerning about next high dam site upstream from the Ban Chao Nen reservoir, it is very difficult to find a site downstream from No.0 site.

Even No.0 site does not seem economical for the high dam construction because of the reasons mentioned in chapter (a).

In each case of all alternatives from No.0 to No.11 site, we should build one supplementary dam between Ban Cho Nen reservoir and each alternative site to utilize all head along the river.

In the Table I, readers can easily find that Huai Nam Chon and Huai Thi La Ku projects are very feasible and quite competitive from the result of comparison between column (3) + (4) and (5) + (6). From this result, the Huai Thi La Ku project looks better than the Huai Nam Chon project, but it is too early to draw a a hasty conclusion.

Because the difference is not much and is within the range of control by the geological condition. This is an example that the Huai Nam Chon project has alternatives and shows the necessity of more detailed investigation.

(b) Huai Rin project

The main stream flows about 35 km in very steep gorge from Huai Rin dawnstream to the Nam Mae Chan plateau.

As I mentioned in the chapter (a), next dam site from the Huai Thi La Ku or Huai Nam Chon project shall be preferably located near the Huai Rin to avoid the slender reservoir portion if possible. The water level near the Huai Rin area is about 390m - 400m, so I select the High Water Level 390m of Huai Thi La Ku and Huai Nam Chon reservoir. This 390m of High Water Level can also utilize the flat plateau of the Nam Mae Chan as the huge storage source.

The Amphoe Umphang and its out-skirt paddy-field lie on about 490 m to 500 m elevation, so I limited the High Water Level of Huai Rin Reservoir at 485 m to avoid inundation of the Amphoe Umphang. The outline of Huai Rin Project is shown in Table II, and these figures show that this project is feasible.

(c) Ban Mae Klong Di project

I chose the site as multipurpose project for irrigation, water-supply, flood-control and local electricity supply.

If we build about 60 m high dam, it can create quite enough storege which can control the total annual inflow of about 250 MCM.

This kind of reservoir will contribute for the local development in the vicinity of the Amphoe Umphang

(2) Tributary

At the beginning I planned Huai Pu Na Pong, Huai Yang, Huai Umphang, Huai Mae Lamung and Huai Phra projects in the leftbank tributaries, and Khao Khat, Huai Ti Wa Su, Huai Yai and Huai Tong Thai projects in the rightbank tributaries. But the study showed that only Huai Mae Lamung, Khao Khat, Huai Yai and Huai Tong Thai were feasible (Table II); especially Huai Yai and Huai Tong Thai projects can be realized only in the case which one of No.9, No.10, and No.11 sites is developed. So I showed the comparison result in Table I between Huai Thi La Ku and Huai Nam Chon projects in which Huai Yai and Huai Tong Thai projects are shown with Huai Thi La Ku project.

(a) Huai Pu Na Pong, Huai Yang, Huai Umphang

These three projects are not feasible when we consider the hydroelectricity only, but if we consider the local development, we can use projects as multipurpose.

Here I just propose these projects for future consideration.

(b) Huai Phra, Huai Ti Wa Su

These two projects are very close to the feasible development, so more detailed study and special device will solve the difficulties in future, particularly the Huai Ti Wa Su is about on the borderline of feasibility.

(c) Huai Yai

This is a quite feasible project with 90 m high dam which can be built by rockfill or concrete and only one project with a long (4,800 m) headrace tunnel. The stored water in the Huai Yai *peservoir is lead throught a long tunnel to the main stream and* is discharged into Huai Thi Khong reservoir (HWL. 250 m), thus the power plant can produce 45 MW with about 220 m head. But this project can not go with the No.1 to No.8 sites with High Water Level 390 m.

(d) Huai Tong Thai

Though the Table II shows this project as feasible, this project has many serious problems about geology. This area is consisted of limestone and the flow disappears at the downstream of proposed dam site (Refer to "Geological Reconnaissance of Dam Site selection"July 1975 by Mr. NAGORN CHOLVISUDHI). This means that more

detailed survey around this area is necessary before making conclusion.

(3) No.O, Huai Thi Khong

No.O site is a alternative of Huai Thi Khong site and has better topography and geological condition.

So in future the comparison study will be necessary, but this time I chose Huai Thi Khong site by its greater storage capacity.

In any cases, the upstream project has a big storage which can control all anual inflow, and Huai Thi Khong or No.O project will use a large amount of generating discharge.

So the spilled water is quite restricted in any cases, but in case of a big flood the water will spill when the storage is not so big.

Though the precise study on the daily base is necessary to find a most favourable storage and other factors, the more the storage is, the more easier the operation is, to avoid the energy loss.

This way of thinking also can be applied to the High Water Level of 200 m and 250 m cases at Huai Thi Khong site.

I chose the Huai Thi Khong of High Water Level 250 m in the plan tentatively because I considered it meaningless to prove deeply into the enerby aspect under such condition as the most basic date concerning about topography, geology and Meterology for the design and cost estimation is not available.

(4) Huai Kha Khaeng

The short time record of river discharge at Onkha showed that the discharge is too small to consider the hydroelectric generation and the topography is also very flat too.

This time I exclude the Huai Kha Khaeng from my report.

(5) Conclusion

A tentatively concluded plan on the upper Quae Yai basin is shown on the Table II and I calculated all items under the presumption that the construction will proceed in consecutive order from downstream to upstream.

I am really convinced that the Upper Quae Yai River has the biggest hydro-electric potential left undeveloped in Thailand.

TABLE I

COMPARISON BETWEEN HUAI THI LA KU AND HUAI NAM CHON

DESCRIPTION	(1) HUAI YAI	(2) HUAI TONG THAI	(3) HUAI THI LA KU	(4) HUAI THI KHONG	(1)-(2) + (3)-(4)	(1)+(3) +(4)	(3)-(4)	(5) HUAI ANM CHON	(6) HUAI THI KHONG	(5)-(6)
1. Catchment Area (km^2)	181	137	4,570	5,261				5.063	5,261	
2. Annual Inflow ($10^6 m^3$)	118	89	2,974	3,424				3.295	3,424	
3. Dam and Reservoir										
Type of Dam	Rockfill or Concrete	Rockfill	Rockfill or Concrete	Rockfill				Rockfill	Rockfill or Concrete	
Crest Elevation (m)	575	495	395	255				395	205	
Height of Dam (m)	90	68	150	80				205	30	
Volume of Dam ($10^6 m^3$)	2.500	1.200	7.000	4.300	15.000	13.800	11.300	25.000	300	25.300
Normal Highwater Level (m)	570	590	390	250				390	200	
Reservoir Area at N.H.W.L. (km^2)	2.8	2.9	164.5	10.7				182	3.6	
Total Storage Volume ($10^6 m^3$)	76	65	8,400	417	8.958	8.893	8,817	10.000	54	10.054
Drawdown (m)	25	26	21	10				19.8	4	
Effective Storage Volume ($10^6 m^3$)	51	55	2,974	104	3,184	3,129	3,078	3,295	13.5	3,308.5
4. Power Plant										
Max. Discharge (m^3/s)	17.2	10.3	483	530				529	535	
Standard Head (m)	304.7	227.4	130	63.7				180.4	15.66	
Installed Capacity (MW)	45	20	540	290	895	875	830	820	72	892
Annual Energy Generation (MKWH)	86	43	924	521	1,574	1,531	1,445	1,420	128	1,548
5. Cost and Benefit										
Construction Cost (10^6 B)	763	400	4,685	2,988	8,836	8,436	7,673	7,757	1,213	8,970
Annual Cost (C) (10^6 B)	55	29	339	217	640	611	556	562	88	650
Annual Benefit (B) (10^6 B)	73	34	758	442	1,307	1,273	1,200	1,198	105	1,303
Surplus Benefit (B-C) (10^6 B)	18	5	419	225	667	662	644	636	17	653
Benefit Cost Ratio B/C	1.33	1.17	2.24	2.04	2.04	2.08	2.16	2.13	1.19	2.00
Unit Cost per KWH (Satang)	63	67	37	42	41	40	38	40	69	42

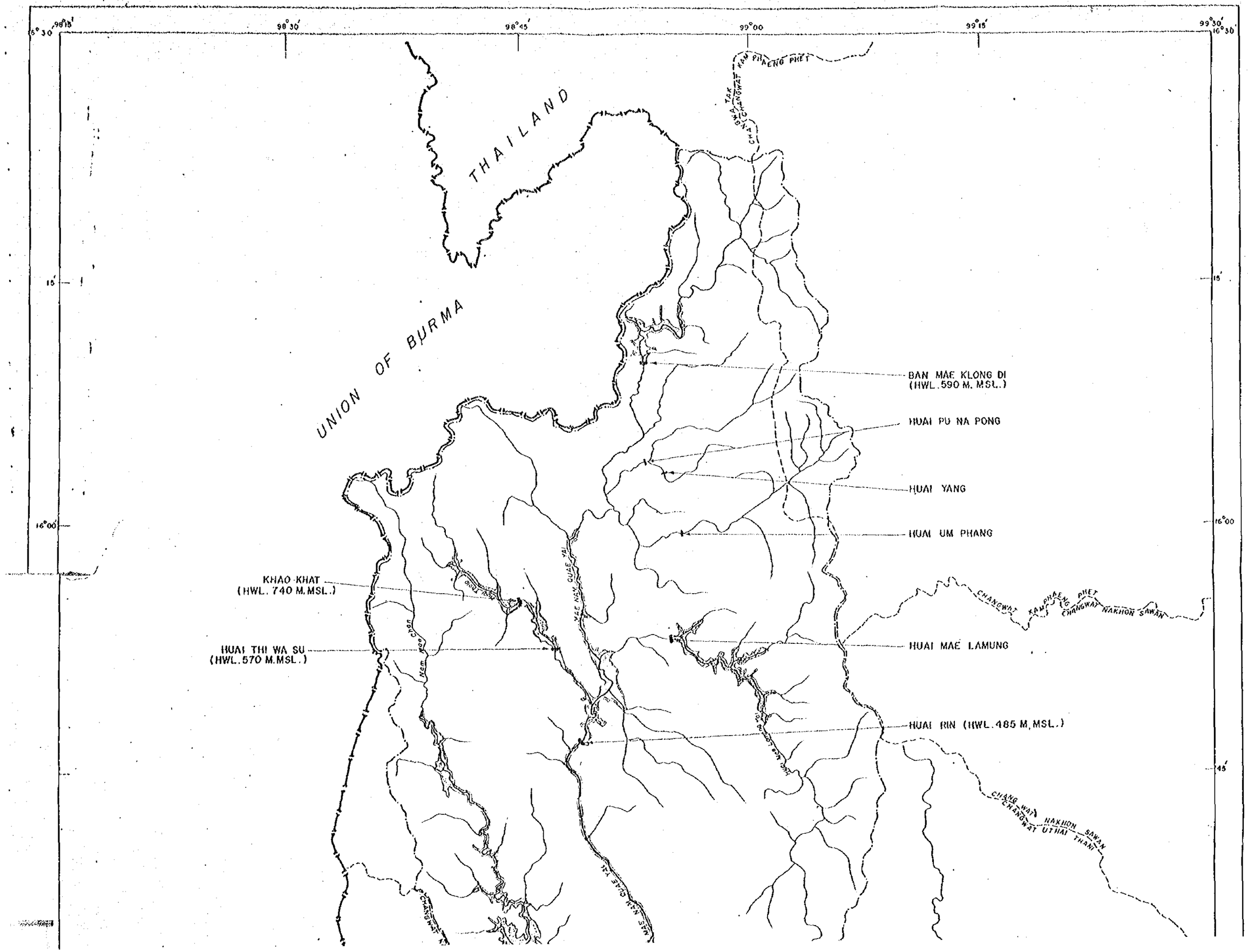
Note: - Energy decrease at downstream sites is deducted from annual benefit in each case

TABLE II

GENERAL DESCRIPTION OF THE UPPER QUARE YAI PROJECT

DESCRIPTION	HUAI RIN	HUAI THI LA KU	HUAI THI KHONG	MAIN STREAM TOTAL	HUAI MAE LAMUNG	KHAO KHAT	HUAI YAI	HUAI TONG THAI	TRIBUTARY TOTAL	TOTAL
(1) Catchment Area (km^2)	2,630	4,570	5,261		660	191	181	137		
(2) Annual Inflow (10^6m^3)	1,712	2,974	3,424		430	134	118	89		
(3) Dam and Reservoir										
Type of Dam	Rockfill or Concrete	Rockfill or Concrete	Rockfill		Rockfill	Rockfill	Rockfill or Concrete	Rockfill		
Crest Elevation (m)	490	395	255		605	745	575	495		
Height (m)	100	150	80		120	70	90	68		
Volume of Dam (10^6m^3)	1,900	7,000	4,300	13,200	5,000	1,900	2,500	1,200	10,600	23,800
Normal Highwater Level (m)	485	390	250		600	740	570	490		
Reservoir Area at N.H.L. (km^2)	33.2	164.5	10.7		13.3	10.9	2.8	2.9		
Total Storage Volume (10^6m^3)	945	8,400	417	9,762	390	162	76	65	693	10,455
Drawdown (m)	25	21	10		25	20	25	26		
Effective storage Volume (10^6m^3)	640	2,974	104	3,718	225	124	51	55	455	4,173
(4) Power Plant										
Max Discharge (m^3/s)	395	483	530		66	22.1	17.2	10.3		
Standard Head (m)	73.7	130	62.7		98.7	163.2	304.7	227.4		
Installed Capacity (MW)	150	540	290	980	56	31	45	20	152	1,132
Annual Energy Generation (MKWH)	301	924	521	1,746	101	49	86	43	279	2,025
(5) Cost and Benefit										
Construction Cost (10^6฿)	1,757	4,685	2,988	9,430	1,010	589	763	400	2,762	12,192
Annual Cost (C) (10^6฿)	127	339	217	683	73	43	55	29	200	883
Annual Benefit (B) (10^6฿)	255	539	442	1,236	79	44	73	34	230	1,466
Surplus Benefit (B-C)(10^6฿)	128	200	225	553	6	1	18	5	30	583
Benefit Cost Ratio B/C	2.00	1.59	2.04	1.81	1.08	1.02	1.33	1.17	1.15	1.66
Unit Cost per KWH (Satang)	42	37	42	39	72	88	64	67	72	44
						Headrace Tunnel L = 500 m Dia = 2.9 m	Headrace Tunnel L = 4,800 m Dia = 2.6 m	Headrace Tunnel L = 1,800 m Dia = 2.1 m Divert Tunnel L = 1,150 m D = 1.8 m		

Note: -Energy decrease at downstream sites is deducted from annual benefit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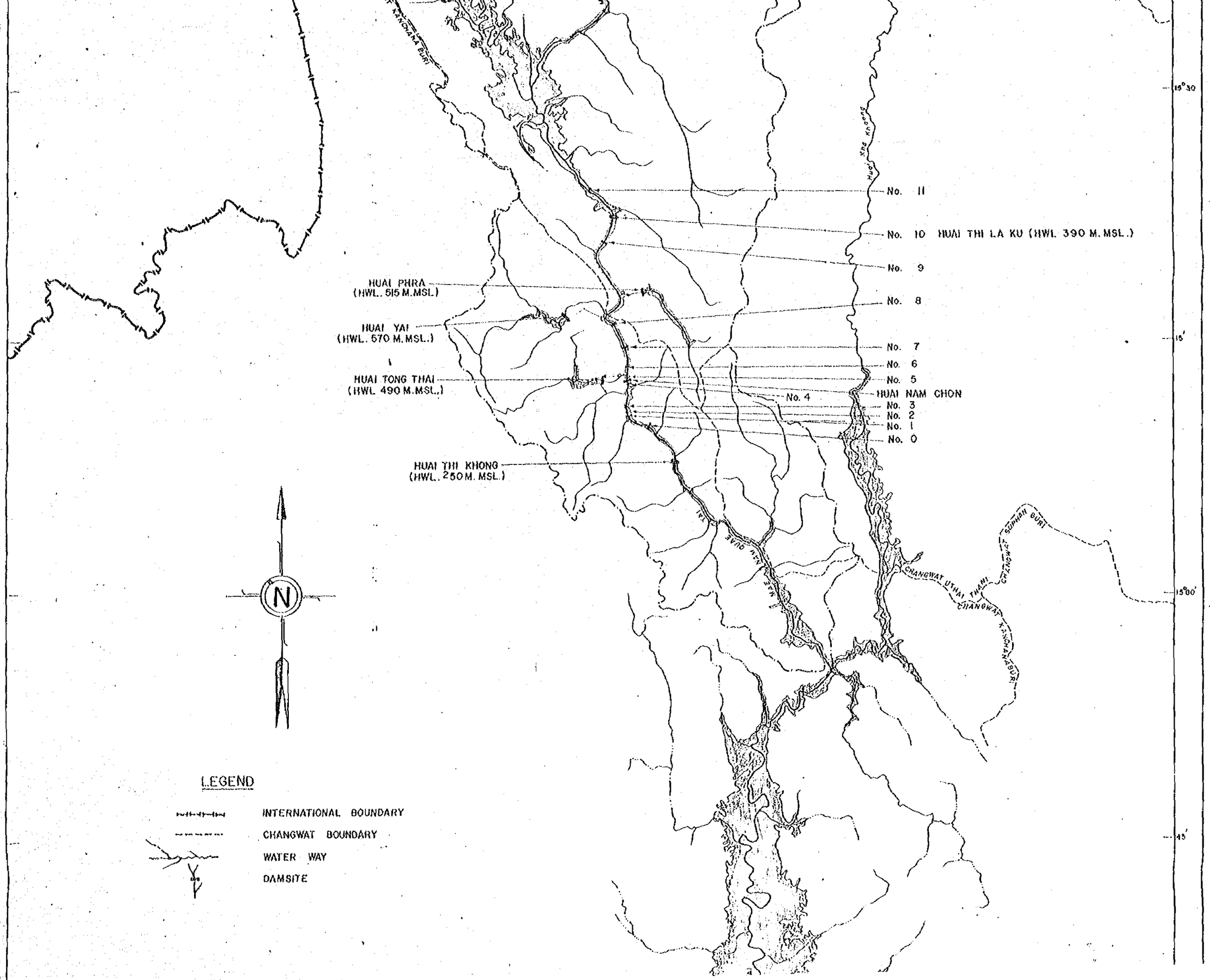
THAILAND
UNION OF BURMA
CHANGWAT TAK
CHANGWAT KAMPHAENG PHET
BAN MAE KLONG DI
(HWL. 590 M. MSL.)
HUAI PU NA PONG
HUAI YANG
HUAI UM PHANG
KHAO KHAT
(HWL. 740 M.MSL.)
HUAI THI WA SU
(HWL. 570 M.MSL.)
CHANGWAT KAMPHAENG PHET
CHANGWAT NAKHON SAWAN
HUAI MAE LAMUNG
HUAI RIN (HWL. 485 M. MSL.)
CHANG WAT NAKHON SAWAN
CHANGWAT UTHAI THANI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No. 11
No. 10 HUAI THI LA KU (HWL. 390 M. MSL.)
No. 9
HUAI PHRA
(HWL. 515 M.MSL.)
No. 8
HUAI YAI
(HWL. 570 M.MSL.)
No. 7
No. 6
HUAI TONG THAI
(HWL. 490 M.MSL.)
No. 5
HUAI NAM CHON
No. 4
No. 3
No. 2
No. 1
No. 0
HUAI THI KHONG
(HWL. 250 M. MSL.)
CHANGWAT SURIN
CHANGWAT SUPHAN BURI
CHANGWAT UTHAI THANI
CHANGWAT KANCHANABURI
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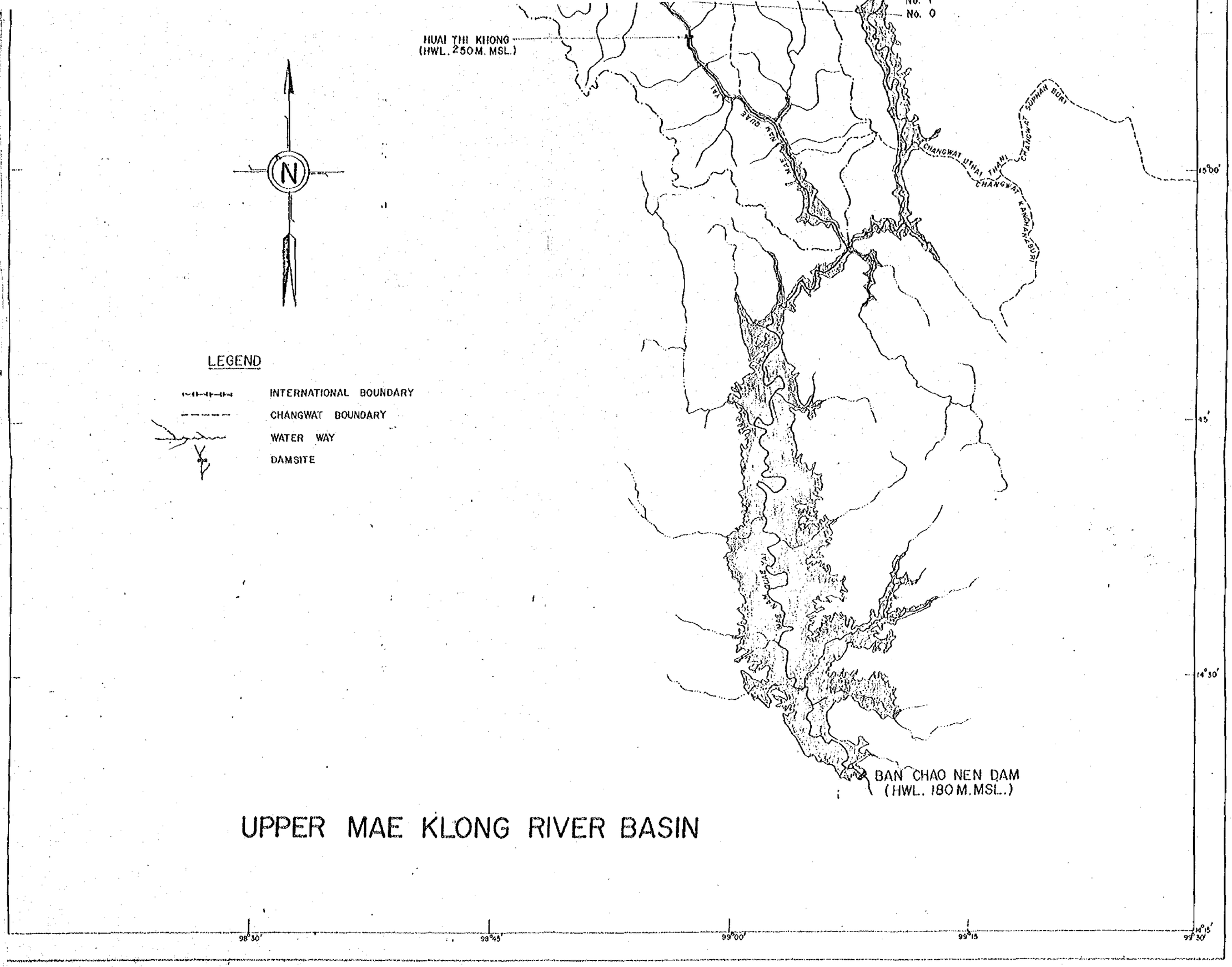

UPPER MAE KLONG RIVER BASIN

3. Lower Ban Chao Nen Project(Ban Tha Thung Na)

At the early beginning when the investigation on the Mae Klong River was started, I came to join the investigation with YEA staffs.

I was very emphatic about the necessity of a regulating dam downstream from Ban Chao Nen at Ban tha Ta On or Ban Wan Kula.

In compliance of my proposal, YEA carried out the topographic survey and completed 1:500 scale map of Ban Tha Ta On and Ban Wang Kula damsites.

After my second reconnaissance on the Quae Noi River, I submitted "A Report on the Quae Noi Reconnaissance" in July 1968.

In this report I recommended the topographic survey in the reservoir area of Ban Wang Kula and Ban tha Ta On based on the High Water Level 60m.

In the "Feasibility Report, Quae Yai No.1 Hydroelectric Project" March 1968, prepared by EPDC, the Ban Wang Kula dam with Right Water Level 59m wad proposed specially aimed at pumping scheme for the second stage of 360MW installation. When I came back to Thailand on July 1974 after 4 years' absence, no active movement was seen in EGAT itself and in EPDC too.

Just at that juncture when I had been talking about the regulating dam from time to time, the debate about the pumping scheme for the second stage of Ban Chao Nen project cropped out.

In connection with these circumstances, EGAT was incited to recall the effectiveness of regulating dam, and to start investigation.

At the time I was asked to make a plan and to arrange Japanese government cooperation for the dispatch of a investigation team as soon as possible.

Original function assigned for the regulating dam was to regulate the discharge during peak hours and to secure the enough storage for pumping up of water into Ban Chao Nen reservoir after completion of the second stage installation.

The power generation at the attached power house to dam was also in our consideration.

Another pumped storage scheme of 1,000 MW was proposed by the Japanese investigating team ("Reconnaissance Report, Upper Quae Yai Hydro-Electric Project", November 1973), by using this regulating reservoir as the lower pond.

Thus the required storage for the regulating dam had been increased from about 14MCM to more than 20MCM.

As the Ban Tha Ta On or Ban Wang Kula dam cannot create more than 20MCM effective storage, I selected the Ban Tha Thung Na dam site at about 2km downstream from Ban Wang Kula site and recommended the Topographical survey of dam site and reservoir area furthermore to carry out the geological investigation by the core boring and pit excavation.

Now all necessary data except the topographic map in the reservoir are available by EGAT staffs' effort.

To our joy, Japanese government sent an investigation team in November 1975 which was composed of 3 civil engineers, one geologist and one co-ordinator and they are about to finish a feasibility report pretty soon.

During their stay I discussed many factors about Ban Tha Thung Na project with them and we reached agreement at most points.

But I still worrying about the High Water Level of reservoir, because this power plant has low head of generation and even very small increase or decrease of head will affect very much to the economy of this project.

Though the head increase at this project act adversely to the energy at Ban Chao Nen power plant, the study about the head increase at this project should be very carefully accomplished.

4. Ban Chao Nen Project

I am very glad to see the construction of Ban Chao Nen Project with satisfactory progress. This project is the beggest in Southeast Asia and will be the main supply source in future EGAT's system.

According to the present plan, Ban Chao Nen Project will commence operation at the end of 1979. At that time, the elevation of reservoir will be about 153 ~ 155 m and the storage volume about 8,587 million m^3.

This level is 15 m lower than the lowest water level and the storage to the lowest water level is about 4,600 million m^3(approximately annual inflow).

I dont know the reason why the commencement of generation should be earlier than the time when the water level will reach the rule-curve level.

It is understandable that the reason is based on the irrigation requirement

and Ban Chao Nen dam should release the water to meet the downstream water shortage.

My rough calculation shows that the earlier start of generation is not economical from the energy's point of view, because of low head generation for a quite long time.

Taking the Bhumiphong dam for instance, if the start of releasing water could be dalayed for one year, the Bhumiphong dam had never suffered from the low water-level of reservoir and produced more electric energy up to now.

I can understand that Royal Irrigation Department pushed YEA to start generation for the irrigation purpose and YEA itself was under the national pressure.

As every dam has its own operation standard and rule-curve which is determined by the long-range planning, the start of operation before the water-level reaches the level of rule-curve is not normal procedure.

In another words, the rule of reservoir operation should be carefully studied before operation not only for the electric generation but also for irrigation and other purposes.

Once the rule is fixed, all participants of multipurpose dam should wait the time which is comformed with the planned condition of reservoir.

In Ban Chao Nen case, the comprehensive study about the fundamental reservoir operation and the most optimum rule for all purposes should be carefully carried out.

This will lead this project to the most ideal direction, and this project will demonstrate the maximum power in the respective field.

5. Quae Noi River (ANOTHER TRIBUTARY OF MAE KLONG RIVER)

I submitted "A Report on the Quae Noi Reconnaissance" in July 1968, and also sent the letters to Mr. Kasame and to the minister of National Development in April 1969.

I am reluctant to write quite same comment as I wrote in the report and the letter 7-8 years ago.

It is better to quote the phrases in the letter than to use unnecessary words now.

"According to RID report, they already gave up this area (Ban Phu Toei area)

because of the poor foundation and removed the investigation forces to the Kao Kwang Site (1)." "I can not help to say that it is sheer waste to abandon such a promising site as it would be developed for a big reservoir only after the objective reconnaissance works." "It sounds countradictive for us in this great epoch when the artificial satellite is going to reach (2) the moon." "Here my proposal is to try the full-scale investigation all over this territory, because I am convinced that the treatment of the foundation of dam is not so far beyond the existing technical ability in the world, and now nobody can conclude whether the result of investigation will be fruitful or not."

In these phrases, if readers only substitute Kao Loem for (1) and reached for (2) these phrases are still my hearty comment.

I know that the Australian Government is co-operating with EGAT about investigation on the Quae Noi River.

The entrusted Snowy Mountain Group is earnestly working and concentrating its effort into investigation around the Kao Loem area.

I hope that its result will come out successfully and the Kao Loem project will be feasible because this project is a powerful alternative of Ban Phu Toei project.

At present I am not sure whether the Kao Loem project is feasible or not, and Ban Phu Toei project too.

But one thing clear for us is that Ban Phu Toei has more potential not only from the hydro-electric point of view and also water supply.

In this reconnaissance time, the most important way of investigation is a inductive judgment, so we should never conclude the final decision in a hurry before we finish the comparative study for all cases which come into our mind by the comprehensive investigation result.

From the economical study of Ban Phu Toei project under the same scale as in my report, its investment limit for construction will be around 15 billion Baht.

From this figure we can easily imagine how big amount of money can be possibly invested into the foundation treatment.

Furthermore I would like to explain about the leakage water from reservoir

through the limestone cave, because people has too much concern about the lime-stone cave.

Suppose there is a limestone cave with diameter of 3 m through the dam axis from upstream to downstream.

Taking an assumption that the length is 10km, the upstream water level in 140m (High Water Level of Ban Phu Toei) and the downstream 50m (Normal Water Level of river).

The total annual amount of leaked water is about 350MCM which is only 5.6% of total annual inflow of 6,200MCM and less than the evaporation loss from the reservoir surface.

So if the leakage does not affect to the stability of dam we do not need to pay too much attention to the lime stone cave.

And if we can find the caves luckily, the treatment is not difficult by the present engineering capability at some additional expense.

Thailand can not be called rich in the hydro-electric potential, and specially the Mae Klong River and the Nam Sai Yai area are only favoured near the Bangkok Metropolitan area.

As the Quae Noi River has big potential like the upper Ban Chao Nen basin, this development will affect greatly on the long-range energy plan in Thailand.

Even it will take quite a long time(tens years period), it is utterly worthwhile to investigate and proceed an ideal development.

6. General Recommendation

(1) River-flow Gauging stationand Weather Observation station From the beginning of investigation on the Mae Klong River ten year's ago, I have recommended the installation of several gauging stations and weather observation stations along the river.

I know that most EGAT staff have feeling that the river-flow gauging and weather observation are out of EGAT's field so the Meteorological Department should take care of them.

Such feeling comes out as the result that all river gauging stations and weather observation stations which EGAT is in charge were realized and authorized or discontinued operation before they were realized and

authorized.

The longer the record is, the more useful, therefore we should keep recording continuously as long as possible.

When we consider the fact that all natural phenomena pass by and never return, such practice of installation and cancellation of facilities is not desirable for the planning purpose.

The stations in operation should be kept running as long as possible, and no stations in operation should not be discontinued.

Furthermore new stations along the river should be installed as many as possible, because too small number of stations are in operation in the Mae Klong River basin.

Although this kind of work is very conservative and thankless, first thing which EGAT should start now is the installation of river gauging stations and weather observation stations, if EGAT is planning the development of Mae Klong River basin.

(2) Levelling and Topographic survey

The first-class levelling survey is also very important to proceed planning and development. At present the levelling survey is finished between Kanchanaburi and Huai Nam Chon area, so further work is to go upstream beyond Umphang.

The mapping by aerial photograph is useful to study the geology all over the Mae Klong River basin and to design the access road, transmission line and the others.

As a matter of course the topographic maps at all alternative dam-sites and powerstations including appurtenant structures are necessary too.

(3) Study past and search future

I repeated several same recommendations in this report as I wrote in my former reports, and again I should write my comment with unwilling mood.

According to my impression which I have had during past six year's work with EGAT staff, EGAT staff are working very sincerely and always searching new know-how.

Among the eastern proverbs, two proverbs are as follows; "Study past and search future" and "Search close first and go further". EGAT staff are so anxious to study the new and attractive field and look reluctant to practice the plain and thankless work. Though people have such tendency commonly, EGAT staff are not exception in this aspect.

EGAT will face the shortage of installed capacity in a few years unless the nuclear power plant will not be able to join the system. Of course the thermal power-plant can replace the nuclear power-plant, but is considered less economical in the world.

EGAT will have to introduce the nuclear power-plant regardless of safety as the alternative of thermal in future.

To my regret, in Thailand and Japan the public can not understand the nuclear power-plant and even don't try to understand.

For EGAT, it will be more hard to have the public consent from now, but this will be surely fruitful in the not far future anyway.

This kind of days is the time when EGAT staff should study the past data and records. Out of those studies, EGAT might find some important key to solve the question of the day. Some will make EGAT staff recall the importance and necessity of a project, or will suggest additional investigation.

Sometimes practice is more hard than study, specially the thankless work such as in survey and investigation field is apt to be disliked and be kept at a distance.

But these thankless works are the must which we should meet at the beginning of a project and some people should take care of them whether willing or not.

I hope EGAT management staff to understand and evaluate the necessity of fundamental works such as planning and survey works which is usually behind the stage of construction and recognize the hardship that some people have been undergoing in the unfrequented jungle.