5. 3. 3 Construction of Canal

The present safe channel capacity of the Tha Taphao river is 430 to 350 cu.m/sec, whereas the design discharge is 1,150 cu.m/sec, or about 2.7 times of the safe channel capacity. As an alternative to improvement of the whole length of the Tha Taphao river that runs through the municipality of Chumphon, the construction of new canals has been proposed.

(1) Hua Wang-Phanang Tuk Canal

RID formulated a construction plan of the Hua Wang-Phanang Tuk canal in 1990 to branch off from the Tha Taphao river at Ban Hua Wang about 15 km downstream from X158 station. The construction of the canal with the design capacity of 270 cu.m/sec has been approved by the government.

The Hua Wang-Phanang Tuk canal is divided into 2 sections: upper section between the Tha Taphao river and the Nong Yai reservoir, and the lower section between the reservoir and the junction to the Phanang Tuk river. The proposed Pak Phraek canal with the design capacity of 270 cu.m/sec joins the reservoir, and the design capacity of the lower section is 540 cu.m/sec. The lower section of the canal is used to convey irrigation water for the irrigation blocks E, F and G. The regulator will be constructed across the lower section of the canal to control the water level of the reservoir. Outlines of the Hua Wang-Phanang Tuk canal are as follows:

HUA WANG-PHANANG TUK CANAL

Canal	Discharge (cu.m/sec)	Work Length (m)	Main Works
Upper Section	270	0.6	Head regulator
Lower Section	540	3.9	Tail regulator

As regards the decision of the design discharge of the Sam Kaeo and Hua Wang-Phanang Tuk, canals, the present safe channel capacities of the Tha Taphao river are compared to design capacities necessary for release of flood water of 1,150 cu.m/sec, as an alternative, as given below:

ALTERNATIVE DESIGN DISCHARGE OF THA TAPHAO RIVER

(unit: cu.m/sec)

River and Canal	Discharge		Remarks
	Present	Design	
Design Discharge of Tha Taphao River		1,150	
① Upper Tha Taphao River	430	1,150	
② Hua Wang-Phanang Tuk Canal	-	270	decided
③ Middle Tha Taphao River	430	880	① - ②
④ Sam Kaeo Canal	140	260	decided
⑤ Lower Tha Taphao River	350	620	③ - ④

The above table suggests that the improvement of the Tha Taphao river needs large scale earth works to enlarge the discharge capacity of the river. The improvement plan of the Tha Taphao river is discussed in the para. 5.3.4.

(2) Pak Phraek Canal

The construction of Pak Phraek canal has been proposed to release a portion of flood water from the Tha Taphao river where it flows into the sea through the Nong Yai reservoir and the Phanang Tuk river in consideration of the followings: 1) to save work loads on the improvement of Tha Taphao river over the length of 41 km, 2) to improve drainage conditions along the proposed canal, and 3) to use maintenance roads along the proposed canal for transportation of farm input and output.

The canal route has been selected based on the topographic maps with a scale of 1 : 4,000 prepared by RID and field reconnaissance. The construction plan of the Pak Phraek canal is the alternative to the improvement of the Tha Taphao river as mentioned above, and the design capacity of the canal is determined in relation to the design capacity of the Tha Taphao river. In the course of river improvement planning Tha Taphao river, it is fixed to maintain the present channel capacity (350 cu.m/sec) of the lower reaches of the river by preventive maintenance works. Accordingly, the design capacity of the Pak Phraek canal is determined as 270 cu.m/sec as summarized below:

DESIGN DISCHARGE OF PAK PHRAEK CANAL

(unit: cu.m/sec)

River and Canal	Discharge	Remarks
Design Discharge of Tha Taphao River	1,150	①+②
① Upper Reaches of Tha Taphao River	880	③+④
② Pak Phraek Canal	270	1,150 - 880
③ Hua Wang-Phanang Tuk Canal	270	decided
④ Middle Reaches of Tha Taphao River	610	⑤+⑥
⑤ Sam Kaeo Canal	260	decided
⑥ Lower Reaches of Tha Taphao River	350	decided

For reference, project costs are estimated for 2 alternative cases: 1) improvement of the Tha Taphao river with the Pak Phraek canal, 2) improvement of the Tha Taphao river without the Pak Phraek canal. As can be seen in the following table, the cost of the case 1) is less than that of case 2), thus resulting in selection of case 1) as the proposed plan.

COMPARISON OF PROJECT COSTS

(Unit: million Baht)

River and Canal	Case 1) (Proposed)	Case 2) (Alternative)
Tha Taphao River	(880 cu.m/sec)	(1,150 cu.m/sec)
	357.7	934.6
Pak Phraek Canal	(270 cu.m/sec)	(-)
	197.4	-
Total	555.1	934.6

5.3.4 Improvement of Tha Taphao River

(1) River Improvement

The Tha Taphao river is divided into 3 sections, the upper reaches, middle reaches and lower reaches. The upper reaches cover a distance of 11.3 km between the staring point of the river and the diverging point of the proposed Hua Wang-Phanang Tuk canal with the channel capacity of 430 cu.m/sec, the middle reaches cover a distance of 7.2 km between the diverging point of the Hua Wang-Phanang Tuk canal and the diverging point of the Sam Kaeo canal with the channel capacity of 430 cu.m/sec, and the lower reaches

cover the distance of 22.5 km between the diverging point of the Sam Kaeo canal and the river mouth with the channel capacity of 350 cu.m/sec.

The slope of the lower reaches of the river is a gentle 1 : 8,000 to 10,000 toward the river mouth after passing through the municipality of Chumphon, and river flow is affected by the sea level. The enlargement of channel capacity of the lower reaches needs large scaled earth work over the a total length of 22.5 km and a removal of houses. Therefore, this improvement plan proposes to maintain the present channel capacity of 350 cu.m/sec through preventative maintenance works such as dredging, excavation of river beds and provision of cutoff.

The design capacities of the middle and upper reaches are fixed in connection with the design capacities of the Sam Kaeo canal and Hua Wang-Phanang Tuk canal. As mentioned earlier, the design capacity is fixed at 260 cu.m/sec for the Sam Kaeo canal. Accordingly the design channel capacities of the middle reaches of the river come to 610 cu.m/sec. The design channel capacity of the upper reaches is 880 cu.m/sec. Outlines of the improvement of the Tha Taphao river is as follows:

IMPROVEMENT OF THA TAPHAO RIVER

River	River Length (km)	Work Length (km)	Discharge (cu.m/sec)		Main Works
			Present	Proposed	
Upper Reach	11.3	11.3	430	880	Excavation, levees
Middle Reach	7.2	6.0	430	610	Excavation, levees, cutoff
Lower Reach	22.5	17.0	350	350	Dredging, levees, cutoff
Total	41.0	34.3			

(2) Discharge from the Tha Taphao River Basin

The Tha Taphao river improvement plan is formulated based on the flood discharge of 1,150 cu.m/sec at the confluence of the Rop Ro and Tha Sae river (×158 gauging station). But the plan should be considered with the discharge from the Tha Taphao river basin, i.e. the downstream basin from the confluence.

The Tha Taphao river basin with a total area of 357 sq.km is divided into the following sub-basins.

- Tha Taphao main river basin : 155.3 sq.km
- Phanang Tuk river basin : 132.5 sq.km
  included with Nong Yai area
- Other basins in which tributaries: 69.2 sq.km
  run directly into the sea

  Total 357.0 sq.km

In order to calculate the flood discharge from the said basin at the occurrence of the design discharge of 1,150 cu.m/sec, the hydraulic analysis for the basin of 74.0 sq.km located at just upstream the municipality of Chumphon, the representative sub-basin in the Tha Taphao river basin (tributaries of Tha Taphao river, Khlong Wang Thong and Khlong Ma Yang) as a sample, was made, resulting the following;

FLOOD DISCHARGE OF THE THA TAPHAO RIVER AND THE REPRESENTATIVE TRIBUTARIES AT JUST UPSTREAM THE MUNICIPALITY OF CHUMPHON

River	Occurrence Time (hr)				
	12	54	90	105	126
Main course (Tha Tapao river)1/	14	398	1,091	1,136 2/	1,055
Tributaries (Khlong Wang Thong and Khlong Ma Yang)	30	123	14	21	2
Total	44	521	1,105	1,157	1,057

1/: For easy understanding, the discharges of the main course are not considered in diverted discharges to the canals.

2/: The figure is rounded up to 1,150 cu.m/sec in the study of river improvement plan.

The above table indicates that the tributaries have a peak discharge of 123 cu.m/sec at the 54-hour but the main course has not met with its peak discharge, so that the total discharge, 123 plus 398 cu.m/sec is lower than the design discharge of 1,150 cu.m/sec. While the other total discharge adding 21 cu.m/sec flood from the tributaries to the peak discharge of the main course, 1,136 cu.m/sec at the hour of 105 is beyond the design discharge little more.

Where, it shall pay the attention that the water level of the peak flood in the Tha Taphao river may be higher than the ground level of the both banks,

resulting that the flood from the tributaries cannot drain by natural due to the high water level in the main course,

The pumping drainage of the flood from the tributaries will be available with large amount of operation and maintenance costs so as to be difficult in its employment. Therefore, in order to prevent the low land from the flood by the main course, the provision of dikes with the same elevation as the main course dike along the tributaries, and regulating gates at the mouthes of tributaries will be proposed under the condition that such small problems caused by minor floods as inundation and ill-drainage in the surrounding area will be permitted.

Enlargement of the Tha Taphao river capacity taking account of the flood inflow from the Tha Taphao river basin might not reduce the water level compared with the ground level around area in fact due to the low flat plain, so as to remain the worsen drainage condition in the surrounding area. In addition, the peak discharges from the sub-basins are lower than the design discharge (350 cu.m/sec) of the Tha Taphao river, downstream section from the diversion point of the Sam Kaeo canal.

Therefore, the Tha Taphao river improvement plan is not affected with the flood discharge from the Tha Taphao river basin (the downstream basin from the confluence).

(3) River Mouth Closing Problems

Recently, such problems as reduction of river discharge capacity and worsening operation of fishery boats by river mouth closing phenomena are occurred surrounding the Tha Taphao river mouth, where has developed as a fish poat for inshore fish. RID is responsible for maintenance works of upper reaches of the Tha Tapao river at the two-kilometer point from the mouth, while the Harbor Department controls the lower section from that point and the coast of Thai Gulf.

The Harbor Department has carried out dredging works at the river mouth once per two years, however the works are considered not to be so effective for the river mouth closing problems. It was reported that the water depth along ship route had been shallowed, from 3.5 meters to 1 ~ 2 meters by

the last typhoon "Gay" 1989. After that, the both RID and Harbor Department execute periodical dredging works along the lower reaches of the Tha Taphao river.

In order to treat the said problems, the Harbor Department are preparing the improvement plant but has not completed yet. The provincial office of the Department located near the river mouth made a proposal which is a provision of protection walls made with concrete caisson along the ship route, about 1.5 km, after dredging the lower reaches and the ship routes in the sea. Thereby, the discharge capacity (350 cu.m/sec) of the Tha Taphao river will be maintained by dredging the lower reaches and the river mouth closing problem will be treated under the control of the Harbor Department.

The river slope in the Tha Taphao lower reaches is very gentle as 1 to 8,000 ~ 10,000 and the river flows fluctuate seasonally. While the Tha Taphao river has the river mouth closing problem due to shoal coast of Thai Gulf. The problems are caused by suspended loads around the coast, so that the most effective countermeasure for treatment is flushing the loads by the river-flow. Therefore, for maintenance plan of river mouth, increasing the flushing power with keeping the flow route, and prevention of the river mouth from the suspended loads are effective measures, i.e. the river mouth improvement shall have two basic objectives such as increasing tractive force of flow and prevention of sedimentation arround the mouth.

The preliminary plan made by the provincial office of Harbor Department, that is the provision of protection walls between the river mouth and the island in front of the mouth establishing the northern route of ship, is evaluated to be effective measure, when considered the near-shore current with north direction in the Thai Gulf. However, the river mouth closing is a complicate phenomenon combining such factors as 1) balance of loads from river and sea 2) river mouth scale, and amount and frequency of suspended loads 3) stabilization of beach line, etc.

Consequently, the effective measures will be taken after conduction of basic research and investigation presented in Appendix.

5. 3. 5 Phanang Tuk River

With the implementation of the proposed drainage improvement project of the Tha Taphao river system, new canals of the Hua Wang-Phanang Tuk and Pak Phraek will divert 540 cu.m/sec of flood water from the Tha Taphao river into the Nong Yai reservoir, and afterward flood water is drained into the sea through the Phanang Tuk river. And further, the Phanang Tuk river receives flood water from the Sam Kaeo canal with the design capacity of 260 cu.m/sec to flow into the sea. In the worst case, peak flood discharge of the Phanang Tuk river may come to 800 cu.m/sec.

The present channel capacity of the river is as low as 400 cu.m/sec due to its gentle slope and the influence of the sea levels, thus causing annual flooding over the left bank area which is composed of tidal flats and depressions. On the right bank, rural roads along the river prevent floods from the river to a certain extent, and paddy fields and shrimp ponds are seen there. RID has decided to provide the flood plain on the left bank instead of structural measures with the consent of people living in the area.

The drainage improvement plan of the Tha Taphao river system will provide reinforcement work of the existing dikes on the right bank to protect farm lands, shrimp ponds and villages from flooding of the river. Flood water levels of the flood plain with the land area of 190 ha (1,200 rai) was estimated by solving the non-uniform flow of 800 cu.m/sec starting from the river mouth at the average sea level (-0.06 m MSL). The maximum flood level is assumed to be 2.7 meters above mean sea level with a maximum water depth of 1.5 meters at the depression.

There is less probability that peak flood discharge from 3 canals will arrive at the Phanang Tuk river at the same time, because of differences in arrival time of peak flood among the 3 canals. The assumed flooding situation of the flood plain is given for 3 peak flood discharge as follows:

ASSUMED FLOOD SITUATION OF FLOOD PLAN

Peak Discharge (cu.m/sec)	Maximum Flood Level (m MSL)	Maximum Flood Depth (m)
800	2.7	0.5 - 1.5
700	2.6	0.4 - 1.4
600	2.3	0.1 - 1.1

TABLE 5-1 RECOMMENDED APPLICATION OF FERTILIZER

(Unit : kg/tree/year)

Crop	Formula	Growing Year		
		1 - 3	4 - 6	7 - 9
(1) Coconut (Coconut 25 trees/rai, Young coconut 40 trees/rai)				
First	15 - 15 - 15	0.5 - 1	1 - 2	2 - 3
Second	15 - 15 - 15	0.5 - 1	1 - 2	2 - 3
Third	14 - 14 - 21	0	1 - 2	1 - 2
(2) Pomelo (20 trees/rai)				
First	21 - 7 - 14	0.5 - 1	1 - 1.5	1.5 - 2.5
Second	16 - 16 - 16	0.5 - 1	1 - 1.5	1.5 - 2.5
Third	14 - 14 - 21 or 14 - 9 - 20	0.5 - 1	1 - 1.5	1.5 - 2.5
Fourth	15 - 0 - 0	0	1 - 1.5	2.0 - 3.0
(3) Cashewnut (25 trees/rai)				
First	16 - 11 - 14	0.5 - 1	1 - 2	2.0 - 3.0
Second	15 - 15 - 15	0.5 - 1	1 - 2	2.0 - 3.0
Third	14 - 14 - 21	0	1 - 2	1.0 - 2.0
(4) Durian (20 trees/rai)				
First	21 - 7 - 14	0.5 - 1	1 - 1.5	1.5 - 2.5
Second	12 - 24 - 12	0.5 - 1	1 - 1.5	1.5 - 2.5
Third	14 - 14 - 21	0.5 - 1	1 - 1.5	1.5 - 2.5
Fourth	15 - 0 - 0	0	1 - 1.5	2.0 - 3.0
(5) Mangosteen (20 trees/rai)				
First	21 - 7 - 14	0.5 - 1	1 - 1.5	1.5 - 2.5
Second	12 - 24 - 12	0.5 - 1	1 - 1.5	1.5 - 2.5
Third	14 - 14 - 21	0.5 - 1	1 - 1.5	1.5 - 2.5
Fourth	15 - 0 - 0	0	1 - 1.5	2.0 - 3.0
(6) Paddy				
First	16 - 11 - 14	30 - 50	kg/rai	
Second	46 - 0 - 0	5 - 8	kg/rai	
(7) Pineapple				
First	15 - 15 - 15	50 - 60	kg/rai	
Second	14 - 9 - 20	50 - 60	kg/rai	

Source : Agricultural Extension Office, Chumphon

FIGURE 5-1 PROPOSED CROPPING CALENDAR FOR NONG YAI PROJECT

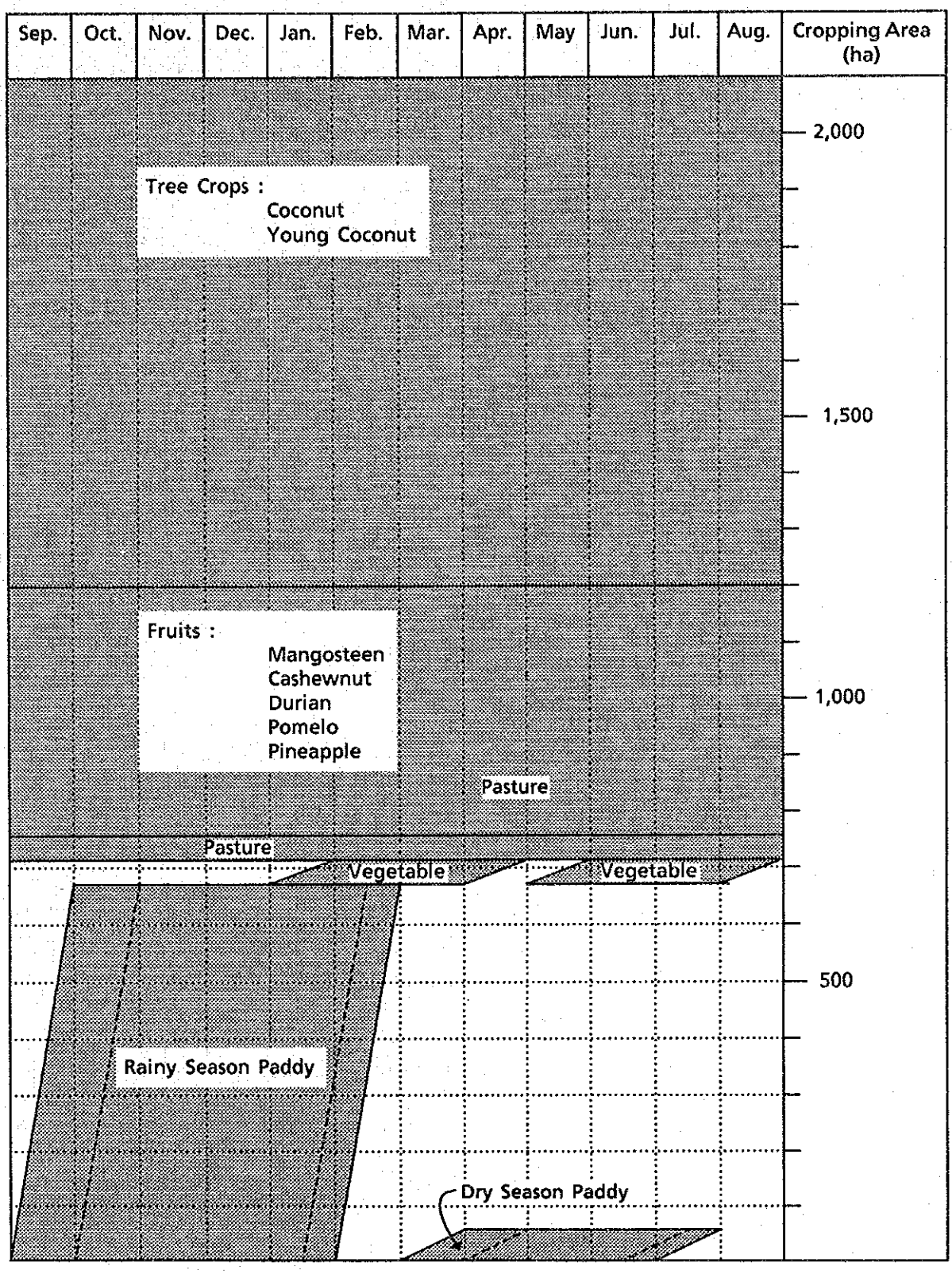


FIGURE 5-2 NONG YAI RESERVOIR OPERATION (CASE 1) (1/2)

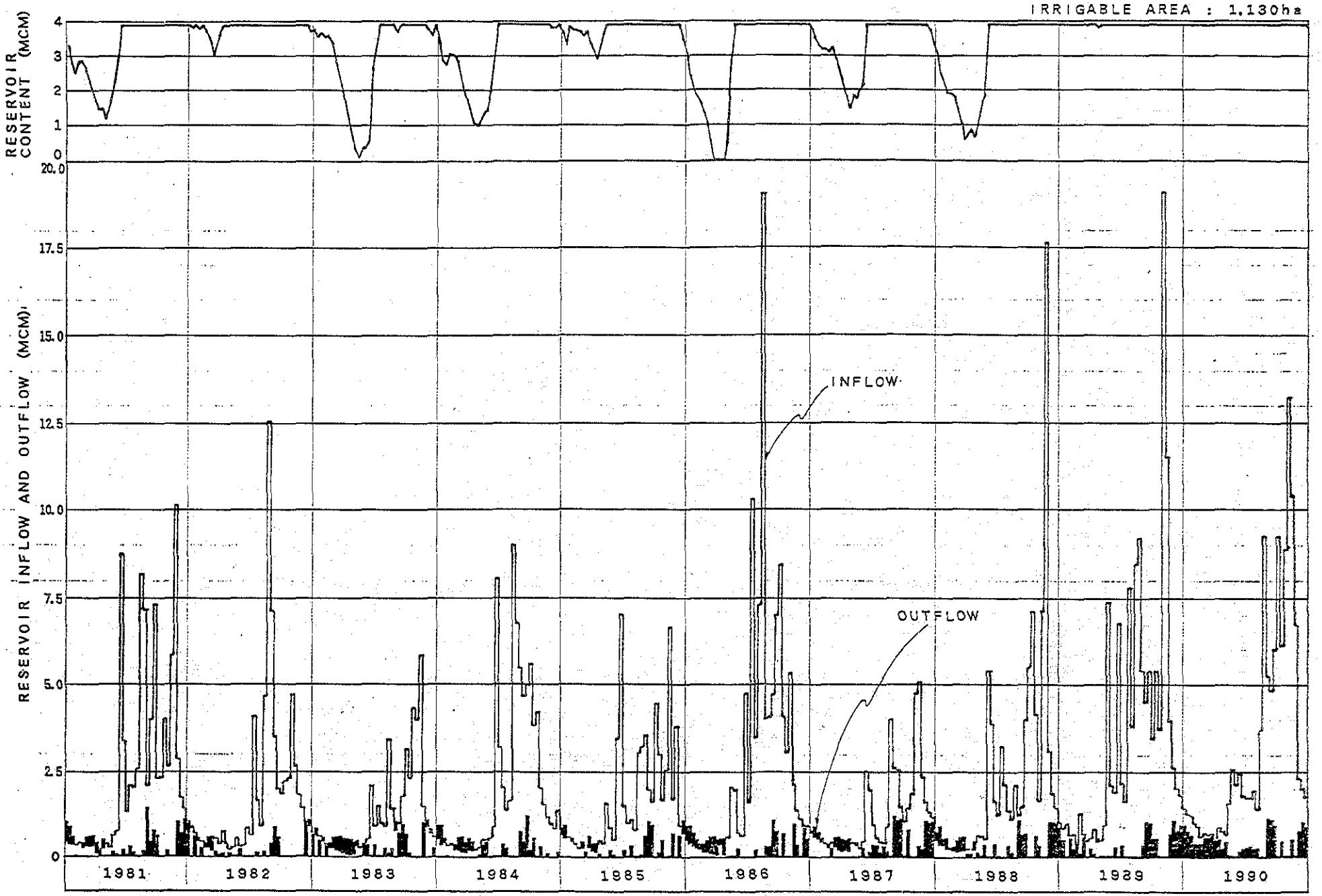
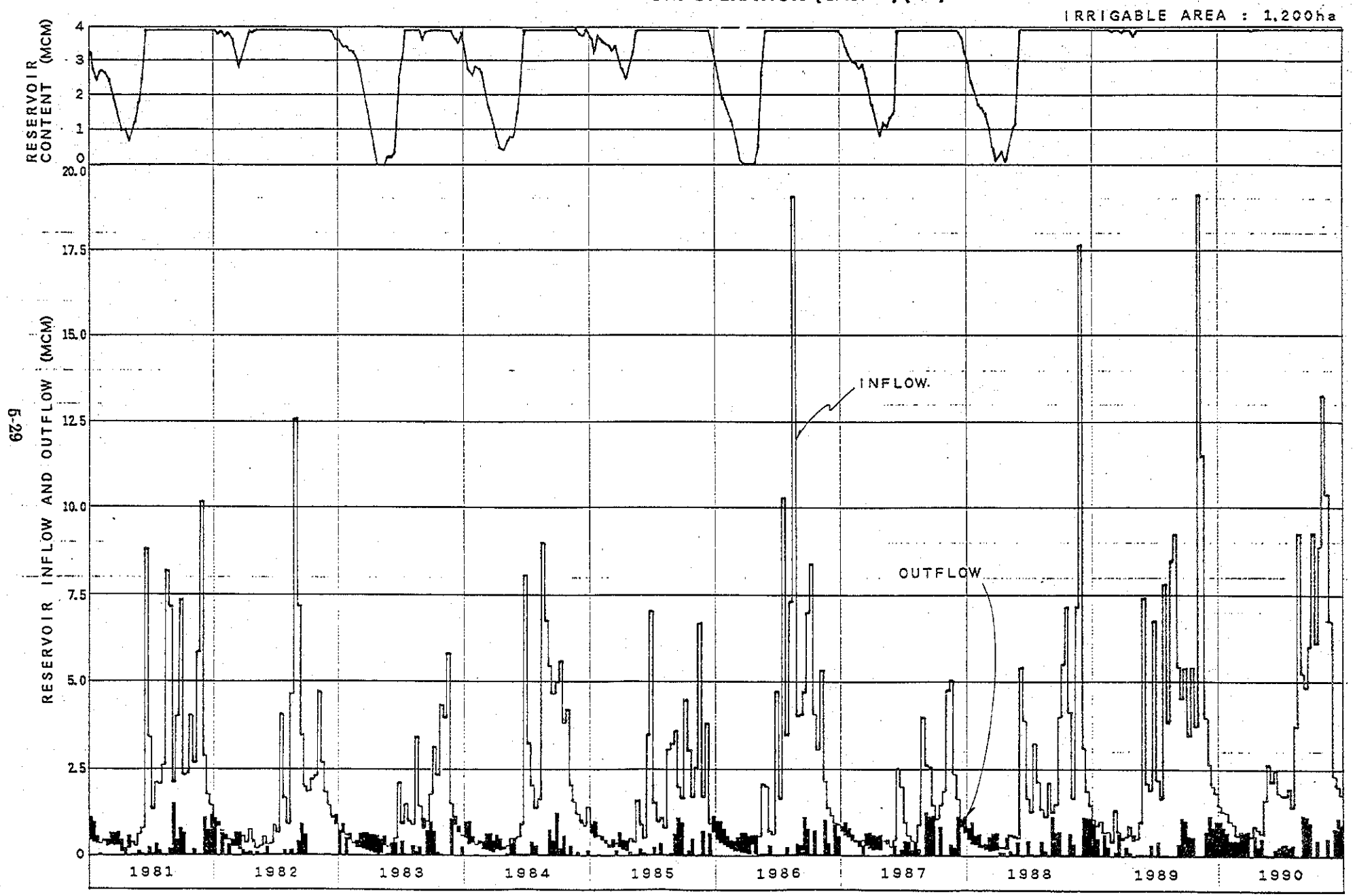


FIGURE 5-2 NONG YAI RESERVOIR OPERATION (CASE 1) (2/2)



CHAPTER 6. PROJECT FACILITIES

CHAPTER 6. PROJECT FACILITIES

6.1 NONG YAI RESERVOIR

The Nong Yai swamp will be developed aiming to harness the water resources for irrigation water, domestic water for the benefit of the area and the reservoir for fish culture in addition to creating a flood bypass of the Tha Taphao river. For these purposes, a total of 4.5 MCM water should be stored in the swamp with provision of dikes at the lower section of the surrounding swamp. The planning of maintenance roads at the higher section is made to connect the dikes.

The planning of dikes is summarized below;
(Detailed ones are shown in the attached drawings.)

- Width of crest : 8.00 m in total (7.00 m of roadway)
- Crest elevation : EL7.50 m MSL
  1.3 m of free-board from the high water level of reservoir (EL 6.20 m MSL)
- Embankment slope: Both slopes of upstream and downstream 1 : 2.00 due to soil material

Excavation materials from the roads and borrowed materials from the reservoir area, prevailing with CL in the unified classification are available for the embankment materials of the dike. The dike with a total of 360 thousands cu.m and a maximum height of 4.50 m is protected with riprap on its upstream slope.

The maintenance road with a total width of 8.0 m at EL7.50 MSL is planned at the higher sections where the dikes are not required. Dikes of 11.4 km and roads of 2.5 km are totaled to 13.9 km, thus enclosing the reservoir.

6. 2 NONG YAI IRRIGATION FACILITIES

6. 2. 1 Diversion Facilities

(1) Design Capacity

The proposed irrigation areas are divided into 7 blocks in consideration of topographic conditions, of which 4 blocks (A to D) surrounding the reservoir are irrigated by pumping up the water from the reservoir; 3 blocks of E, F and G are irrigable from the Lower Hua Wang Phanang Tuk canal by pumping and/or gravity .

The design capacities of diversion facilities for these blocks are planned as below;

DESIGN CAPACITIES OF DIVERSION FACILITIES

Block	Irrigable Area (ha)	Design Capacity (cu.m/sec)	Diversion Type
A	103	0.403	Pumping
B	152	0.612	"
C	62	0.155	"
D	76	0.188	"
E	99	0.431	"
F	108	0.275	"
G	600	1.340	Gravity
Total	1,200	3.404	

(2) Pump Station

a) Design Conditions

Operation plan of Nong Yai reservoir;

- Low water surface (LWS) 3.00 m MSL
- Normal water surface (NWS) 4.50 m MSL
- Active water depth 1.50 m
- High water surface by flood 6.20 m MSL

Design water level of suction sump;

Pump station connected with culvert channel to the reservoir is located on the land side adjacent to the dike in consideration of operation and maintenance conditions. Design water level of suction sump is to be 2.7 m MSL subtracting head loss of 0.3 m from L.W.S.

Design water head of discharge;

Water-head of discharge is estimated adding conveyance losses between suction sump and discharge chamber to the ground level of each irrigation block.

Total pump head;

Total pump head is obtained with actual pump head (discharging water head - suction water head) plus various loss heads. Estimate losses are 2.00 m head loss for pump station and 10% of total friction loss for bending loss and others.

Provision of pump unit;

Two pump units each with a half of maximum discharge demand will be installed in consideration of trouble during operation.

b) Pump Dimension and Scale

Double suction volute-type pump is employed as the irrigation pump taking its economy and easy maintenance into account, and electric energy for motive power of pump is available from the view of economy as reported in Appendix F. Major dimension and scale of pump by each irrigation block is planned as shown below;

PUMP DIMENSION AND SCALE

Irrigation Block	Total Required Capacity (m^3/min)	Total Pump-Head (m)	Head Loss (m)	Required Capacity per Unit (m^3/min)	Pump Dimension
A	24.18	9.3	3.8	12.1	ø350×300mm×30KW×2 units
B	36.72	10.7	2.7	18.4	ø450×350mm×55KW×2 units
C	9.30	6.1	3.6	4.7	ø200×150mm×11KW×2 units
D	11.28	36.8	4.8	5.6	ø250×200mm×55KW×2 units
E	25.86	14.0	3.0	12.9	ø350×300mm×45KW×2 units
F	16.50	20.8	3.8	8.3	ø250×200mm×45KW×2 units

(3) Intake of G Block

a) Location

The intake location of block G is planned at the right bank of Hua Wang Phanang Tuk canal, just upstream of the tail weir provided for retaining the water level.

b) Structural Design

Sill elevation : Sill elevation of intake is designed with 1.5 m MSL, 1.5 m higher than the sill elevation of movable weir (gate) out of the tail weir in order to prevent soil intrusion, so as to provide no sediment pond.

Diversion flow: velocity : For prevention of soil intrusion, about 0.8 m/sec of diversion flow velocity is employed.

Intake width : Intake width (B) is calculated with the following equation.

$B = Q/(h \cdot V) = 1.12 \fallingdotseq 1.5$ m

where,

Q ; Maximum diversion capacity 1.34 m^3/sec

h ; Water depth of inflow 1.5 m
(LWS 3.0 m - EL1.5 m = 1.5 m)

v ; Flow velocity 0.8 m/sec

Screen : Inclined screen with a slope of 1 : 0.3, of which bars of 12 mm thickness at 200 mm interval are placed in front of the diversion structure to bar the entrance of suspended obstacles.

Gate : Sluice gate with rounded water-tight and maintenance gate are installed at the river side and land side respectively.

6. 2. 2 Irrigation Canal

The proposed irrigation canals convey water to a terminal irrigation area of 300 rai (48 ha). Based on the topo-maps with a contour line of 1 m, scaled 1 : 4,000 prepared by the Survey Division, RID and the land use plan prepared during the study period, the canal routes were planned.

(1) Pipe Line

Due to steep slope of the ground, unplasticized polyvinyl chloride pipes are selected for the distribution system in Block C, D and F. The diameter of pipes are designed under the condition of within 2.0 m/sec flow velocity.

Major features of pipe line system in each irrigation block are as follows;

MAJOR FEATURES OF PIPE LINE SYSTEM

Irrigation Block	Pipe Line	Design Capacity (m^3/sec)	Pipe Diameter (mm)	Pipe Line Length (m)
C	C-1	0.105	300	650
	C-2	0.150	400	450
D	D-1	0.048	200	400
	D-2	0.031	200	500
	D-3	0.110	300	650
F	F-1	0.141	300	550
	F-2	0.134	300	950

(2) Open Channel

Irrigation water in such areas as block A, B, E and G is conveyed through open channels from the intakes, since this land mostly consists of flat paddy field. The routs of canals with concrete lining of 5 cm thickness, inversed trapezoid shape are formed along the contour line. Design of section is made under the following conditions;

- Minimum allowable flow velocity : More than 0.5 m/sec for prevention of sedimentation and vegetation phenomena

- Minimum bottom width : More than 0.5 m from the view points of construction methods

The major dimensions of canals of which hydraulic calculation are made with 0.015 of roughness coefficient are summarized as follows;

MAJOR DIMENSIONS OF OPEN CHANNELS

Irrigation Block	Channel	Length (m)	Design Discharge (m^3/min)	Velocity (m/sec)	Bottom Width (m)	Water Depth (m)
A	1	230	0.403	0.81	0.70	0.39
	2	1,580	0.240	0.73	0.70	0.32
B	1	490	0.612	0.89	0.90	0.44
	2-1	170	0.513	0.56	0.80	0.42
	2-2	560	0.222	0.69	0.60	0.30
	3	2,250	0.154	0.55	0.50	0.30
	4	630	0.292	4.90	0.50	0.31
E	1	470	0.431	0.54	0.90	0.49
	2	1,190	0.357	0.95	0.60	0.34
	3	930	0.160	0.55	0.60	0.28
G	-	560	1.340	0.57	1.60	0.82
	2-1	350	1.281	0.57	1.60	0.80
	2-2	940	0.312	0.50	0.80	0.43
	3	2,110	0.173	0.50	0.60	0.32
	5	430	0.969	0.53	1.40	0.73
	6-1	840	0.965	0.53	1.40	0.73
	6-2	460	0.920	0.53	1.40	0.73
	7	600	0.190	0.53	0.60	0.33
	8	520	0;430	0.52	1.00	0.49
	10	1,010	0.114	0.51	0.50	0.26
	11	500	0.301	0.51	0.80	0.40
	13-1	275	0.142	0.53	0.60	0.27
	13-2	760	0.069	0.53	0.60	0.27
	14	835	0.073	0.52	0.50	0.18
	15-17	1,400	0.213	0.52	0.70	0.34
	Total	20,090				

(3) Related Structures

The following related structures of the canals are planned;

Diversion structure	:	Dividing wall distributors for diversion works from the main to lateral canal are employed in consideration of reduction of loss head. Distributors are also equipped with measuring devices to keep accurate water delivery.
Check structure	:	The check structures are not provided because of the comparatively short length of the canal. The canals' water levels may be controlled by the weirs of spill-way and end structures.
Spill-way	:	To release the excess water in excess of the design discharge, spill-way structures are provided at or near the end of the canal.
Crossing structures	:	Crossing structures are designed with concrete pipes at the crossing sections of streams and drainage canals, however an aqueduct is available at the crossing portion of the Sam Kaeo canal.

6. 2. 3 Drainage Canal

Natural channels will be improved so as to constitute main drainage canals. Main drainage canals designed under the conditions of non-lined canal with inversed trapezoid shape of 1 : 2.00 side slopes, 1.5 m/sec of allowable flow velocity in maximum, 0.5 m/sec of minimum velocity and applying Manning's Formula with 0.025 of roughness coefficient are formed as follows;

MAJOR DIMENSION OF DRAINAGE CANALS

Canal	Discharge	Canal Slope	Water Depth	Bottom Width	Velocity	Length
	(m^3/sec)	(1/i)	(m)	(m)	(m/sec)	(km)
BR-1	7.0	450	1.13	2.0	1.46	1.90
ED-1	7.4	500	1.43	2.0	1.43	2.20
ED-2	4.3	500	1.24	2.0	1.24	1.20
GD-1	1.1	1,500	0.67	1.5	0.58	4.10
GD-2	6.2	5,000	1.54	4.0	0.57	6.40
GD-3	1.6	1,500	0.73	2.0	0.63	1.40

6.3 CANAL CONSTRUCTION AND IMPROVEMENT

6.3.1 Hua Wang-Phanang Tuk Canal

(1) Route and Type

a) Upper Canal

The upper canal route is planned between the Tha Taphao river and the Nong Yai reservoir, and the inlet is placed at the left bank about 6 km upstream on the Tha Taphao river from the present inlet of the Sam Kaeo canal.

A small drainage canal runs along the proposed route to release floodwater into the Tha Taphao river from the Nong Yai swamp under the present conditions. This route has an enormous advantage because of short canal length of nearly 0.55 km with small embankment volume and easy land acquisition in future.

The upper canal is designed as an open excavated trapezoidal type, and the floodwater level is nearly equivalent to the original ground surface.

b) Lower Canal

The lower canal is planned to quickly drain floodwater from the Nong Yai Reservoir into the existing Phanang Tuk river.

The most advantageous route is to take one through the southeastern end of the Nong Yai reservoir in a southerly direction via low lands.

The canal route has been determined based on the current land use survey and a conference between the RID and land owners during the study peroid of Phase II.

The lower canal will be about 3.9 km long and is an open excavated trapezoidal type, and the floodwater level is nearly equivalent to the original ground surface. Weirs and gates will be installed on the lower canal to prevent saltwater intrusion and control the water level in the Nong Yai reservoir.

(2) Hydraulic Studies

a) Design Conditions

* Design Flood Discharge

  Upper Canal ..... Q = 270 cu.m/sec
  Lower Canal ..... Q = 540 cu.m/sec

* Allowable velocity

  The geological features along the canals are mainly clayey silt which may be susceptible to water erosion, therefore riprap should be provided on the underwater slopes.
  Maximum allowable velocity is Vmax =2.0 m/sec. to safeguard against erosion. And also, minimum allowable velocity is Vmin = 0.7 m/sec to prevent the sedimentation of suspended soils and growth of an aquatic plants.

* Roughness Coefficient: n

  Roughness coefficient applies n = 0.025 considering various influencing factors as surface roughness of riprap and vegetation etc.

b) Hydraulic Analysis

Hydraulic analysis is made by the non-uniform flow method. And the step calculation method is used to obtain water surface conditions at different

section of the canal progressively from a given point of boundary conditions by use of Bernoullis' theory.

The following formula is obtained applying Bernoullis' energy formula to canal section 1 and 2.

Energy Formula

$$\{ H_2 + \frac{1}{2g} (\frac{Q_2}{A_2})^2 \} - \{ H_1 + \frac{1}{2g} (\frac{Q_1}{A_1})^2 \} = he$$

Head Loss : he

$$he = \frac{1}{2} (\frac{n_1^2 \, Q_1^2}{A_1^2 \, R_1^{4/3}} + \frac{n_2^2 \, Q_2^2}{A_2^2 \, R_2^{4/3}}) \, \Delta X$$

Where;

H : Water depth(m)
Q : Discharge (m/sec)
A : Cross section area (m^2)
he : Head loss between section 1 and 2
R : Hydraulic radius (m)
n : Roughness Coefficient
X : Distance along the canal bed between section 1 and 2
g : Acceleration of gravity (m/sec^2)

Numbers attached to H, Q, A, R and n denote section 1 and 2.
Section 1 : Downstream cross section
Section 2 : Upstream cross section
The initial water level of the lower canal is given as follows;

- From weir to the confluence between the Phanang Tuk river and the proposed Lower Phanang Tuk canal.

  Water level at the above confluence is obtained from non-uniform flow computation based on the tidal level in the estuary.

- From the Nong Yai reservoir to weir

A cross section occurring at the critical depth is called the control section, so that the weir portion becomes the control section. The starting figure for computation uses a critical depth at the weir.

The hydraulic analysis has concluded on the following optimal dimensions at the main locations.

STA.	Distance	EL of Canal Bed	Water Level	Water Depth	Velocity	Friction Loss
	m	m	m	m	m/s	m
0 + 000	-	- 2.25	3.53	5.78	0.82	-
1 + 300	1,300	- 0.95	3.61	4.56	1.08	0.10
(Just downstream at the weir)						
1 + 300	-	- 0.95	6.00	6.95	0.82	-
3 + 850	2,550	1.60	6.19	4.59	1.31	0.24
(At the beginning point of the lower Phanang Tuk canal)						

And water level in the Nong Yai reservoir is estimated as follows;

$$\text{Inflow loss} \quad h = f \cdot \frac{V^2}{2g}$$

$$= 0.5 \frac{1.31^2}{2 \times 9.8} = 0.04$$

Water level H.W.S = WL 6.19 + 0.04 = 6.2 m

6. 3. 2 Pak Phraek Canal

(1) Route and Type

The Pak Phraek canal, about 5.5 km in length is planned to introduce floodwater into the northern part of the Nong Yai reservoir through the inlet placed just downstream from the confluence of the Tha Sae river and the Rap Ro river. The canal route will connect with the surrounding existing small

river of the Nong Yai swamp along foot of the mountain near the inlet. And a fixed weir is scheduled to be placed at the inlet to retain the discharge of the Tha Taphao river.

(2) Hydraulic Analysis

a) Design Conditions

* Design Flood Discharge
  Pak Phraek Canal ..... Q = 270 cu.m/sec

* Roughness Coefficient
  Roughness coefficient applies n=0.025 considering such influencing factors as surface roughness of riprap and vegetation etc.

b) Hydraulic Analysis

Hydraulic analysis is made by the same non-uniform flow method as 6.3.1. The same initial water level applies as the water level in the Nong Yai reservoir.

The hydraulic computation has concluded on the following principal hydraulic dimensions at the beginning of canal and just below the point of the weir.

Distance	L	=5,500 m
EL of canal bed	EL	= 5.80 m
Water level	WL	= 8.49 m
Water depth	D	= 2.69 m
Velocity	V	= 1.82 m/s
Friction loss	Hf	= 2.39 m

6. 3. 3 Sam Kaeo Canal Improvement

The Sam Kaeo Canal was constructed as flood prevention measures in 1952. The information collected during the study period indicates that the inlet gates were improved in 1956, and furthermore, when Typhoon Gey occurred in

1989, floodwater released through the gates was actually about 140 cu.m/sec only, in spite of having the design gate discharge as high as 260 cu.m/sec.

The RID considered seriously the fact of heavy damage, and emergency measures were taken for the recovery of original functions by providing a short-cut of about 400 m at the inlet of the Sam Kaeo canal and replace the gates.

And although a large scale short-cut has been planned for the meanders downstream of the Sam Kaeo canal, the plan has been revised due to land acquisition problems during the Phase II field survey.

The revised joint portion of short-cut is at the end point of the lower Phanang Tuk canal. The length of this short-cut is about 800 m.

Following the RID's plan, the canal cross section of short-cut are designed with bottom width of 50 m as large as the existing river. The surface slopes of short-cut canal are 1 to 2.0 and riprap should be placed to protect these slopes from erosion. The crest elevation of the short-cut canal should be EL. 4.50 m the same elevation as that of the lower Phanang Tuk canal end point.

6.4 RIVER IMPROVEMENT

6.4.1 Tha Taphao River

(1) Route and Type

The Tha Taphao river should be improved along the present course. Presently, the river meanders remarkablly both up and downstream from Chumphon city and does not make a smooth flow of floodwater by raising the water level.

The river improvement plan makes of short-cut at the following five(5) places considering the surrounding present land use along the river.

No. of Short-cut	*1 STA.	Existing Rivers Length (m)	Short-cut Length (m)	Shortening Length (m)
1	6 + 530 ~ 8 + 992	2,462	1,116	1,346
2	11 + 506 ~ 14 + 154	2,648	986	1,662
3	14 + 362 ~ 15 + 292	930	264	666
4	20 + 260 ~ 23 + 474	3,214	1,372	1,842
5	23 + 760 ~ 25 + 964	2,204	1,055	1,149
Total		11,458	4,793	6,665

Notes : * 1 Original Station by river suvey.

The banks should be built in the areas prone to flooding because of low-ground, and the slopes of banks apply 1 to 2.0 considering the properties of fill materials and construction manner. Riprap should be placed to protect slopes from erosion. The bank crest should be of 6.0 m wide in view of maintenance and roads for local people.

(2) Hydraulic Studies

a) Design conditions

* Design Flood Discharge

- Between the river mouth and the Sam Kaeo canal inlet

Assuming that river improvement plan (fill plan) is implemented, the river water level around Chumphon City (Original Station No.16+986 to No.18+556) should be below the original ground surface to prevent floodwater. Therefore, the maximum allowable discharge should be defined as the discharge below the natural ground surface.

The maximum allowable discharge obtained from non-uniform flow computation is Q=350 cu.m/sec based on the tidal level (average for 3 year MSL. - 0.06 m) at the estuary.

- Between the Sam Kaeo canal inlet and the Hua Wang canal inlet

  Diverted discharge (Q=260 cu.m/sec) at the Sam Kaeo canal should be added to the above estimated discharge (Q=350 cu.m/sec)

  $$Q = 260 + 350 = 610 \text{ cu.m/sec}$$

- Between the Hua Wang canal inlet and the srarting point of the Tha Taphao river

  Diverted discharge (Q=270 cu.m/sec) at the Hua Wang canal should be added to the above estimated discharge (Q=610 cu.m/sec).

  $$Q = 270 + 610 = 880 \text{ cu.m/sec}$$

* Roughness Coefficient

The roughness coefficient of the river course was estimated by uniform flow calculation based on a Rating Curve prepared in 1990 and longitudinal and cross section of the river at the X158 point, around the starting point of the Tha Taphao river.

Applied discharge	Q = 200 cu.m/sec	
Water depth	H = 3.90 m	(By Rating Curve)
Flow area	A = 184.0 m^2	(By Cross Section)
Wetted perimeter	P = 68.0 m	(By Cross Section)
Hydraulic radius	R = A/P = 2.71m	
River gradient	i = 1/3000	(By Longitudinal Section)
Velocity	V = Q/A = 1.09 m/sec	

Roughness Coefficient (n : By Manning's Formula)

$$n = \frac{1}{V} \cdot R^{2/3} \cdot i^{1/2} = \frac{1}{1.09} \times 2.71^{2/3} \times \left(\frac{1}{3000}\right)^{1/2} = 0.033$$

The Roughness Coefficient for hydraulic calculation should employ n=0.035 considering influencing factors such as vegetation and meanders etc.

The hydraulic analysis has concluded the following principal dimensions at the main locations.

Location	Distance from Estuary	Water Level	N. G. S		Proposed Bank EL.
			Left Bank	Right Bank	
Estuary	-	- 0.06	0.61	0.35	1.00
Confluence of Nong Sai River	6,530	0.89	0.96	0.36	1.92
Chumphon City	14,366	2.43	1.21	3.33	-
Inlet of Sam Kaeo Canal	17,958	3.52	1.37	3.64	4.81
Inlet of Hua Wang Canal	23,961	7.05	1.45	7.26	8.12
Starting Point	35,293	11.62	1.69	8.39	12.70

Notes : 1. N.G.S is natural Ground Surface.
2. Distance from Estuary shows values which five (5) short-cut were completed.

Decreased water depth by short-cuts are as follows;

Short-cut No.	Decreased Water Depth H (m)
1	0.21
2	0.65
3	0.65
4	0.73
5	1.29

Notes : Decreased water depth are shown at the upstream of each short-cut.

6. 4. 2 Nong Sai River

(1) Route and Type

The route makes use of the existing river. Banks should be built at the flood areas along the river below the natural ground surface. It is planned that a berm with 3 m width is made on the shoulder of the river bank and the additional bank having 1 to 2.0 slope is filled with earth materials.

A hydraulic analysis was carried out at a distance of about 8 km west of the Khao Noi towards the Sam Kaeo canal from the confluence of the Tha Taphao River.

(2) Hydraulic Analysis

a) Design conditions

Design flood discharge	:	Q = 51.3 cu.m/sec (1/10 years frequency flood)
Roughness coefficient	:	n=0.035 (apply the same as the Tha Taphao river)
Method	:	non-uniform flow Initial water level is the one at the confluence of Tha Taphao River.

b) Results

Renovation work such as riverbed excavation and enlargement to a width of 9.5 m should be planned due to a lack of flow capacity caused by a narrowing of the upstream end portion.

As the result, a bank of 2.5 m in hight is necessary on the low-ground along the river because the estimated water level is WL.2.2 m at the river's starting point.

6.4.3 Phanang Tuk River

The Phanang Tuk River flows into the Gulf of Thailand in the gathering floodwaters of the Hua Wang Phanang Tuk canal and the Sam Kaeo canal. The Phanang Tuk river is not enlarged and foold water flows temporarily over the left bank area as before.

The existing bank is reinforced by improvement to the right bank area along the river, but the left bank floods an existing road 1 to 2 km north from the river course. The flood situation was studied between the estuary (STA. No.1) and the confluence (STA.6+200) of the Hua Wang Phanang Tuk canal. The design flood discharge applies 800 cu.m/sec under the most critical conditions where both peak flood discharges of the Hua Wang Phanang Tuk canal and the Sam Kaeo Canal occur at the same time.

The hydraulic computation is carried out by non-uniform flow method at approximate 500 m interval. The boundary condition on hydraulic analysis applies the tidal level at the estuary because of sub-critical flows and the hydraulic dimensions are estimated by the step calculation method towards the upstream. The tidal level at the estuary provides the average value (MSL. -0.06 m) for the years 1987, 1989 and 1990, and the roughness coefficient is 0.035 considering the vegetation and topography of the flood area.

In case of a flood discharge of 800 cu.m/sec, the highest water level is 3.5 m in the uppermost portion of the river and 2.7 m at the beginning of the flood area. The maximum flood water depth is about 1.5 m on the low-ground (EL. 1.0 m) and 0.5 m on the high-ground (EL. 2.0 m). And furthermore, cases of flood discharge of 700 cu.m/sec and 600 cu.m/sec are estimated in the same manner.

CHAPTER 7. IMPLEMENTATION AND OPERATION AND MAINTENANCE OF PROJECT

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7.1 IMPLEMENTATION PROGRAM

7.1.1 Executing Agency

The Royal Irrigation Department (RID) will be the executing agency responsible for implementing the Nong Yai - Tha Taphao Development project which is comprised of three sub-projects, River Improvement project, Canal project and Nong Yai Irrigation project.

The Nong Yai - Tha Taphao Development project office which has responsibilities for promoting the project and organizing, coordinating and directing the sub-projects will be set up to facilitate smooth execution of the project under the supervision of the Medium Scale Project Construction Division, RID.

The assignments of the project director whose office may be established in the main office of RID are preparation of detailed designs of engineering works as well as bidding and contracting of construction works. During the construction period, the construction offices established by each sub-project will conduct supervision of works under the direction of the project office.

The construction offices will consist of the administrative division and the engineering division. The administrative division will consist of administrative and accounting section and land acquisition section responsible for budgetting, accounting personnel matters, negotiation of land acquisition and miscellaneous matters. The engineering division will consist of engineering and laboratory sections responsible for supervision of construction works and various tests of soil and concrete from the view points of quality control, and the mechanical section will be provided in the Nong Yai Irrigation office additionally responsible for installation of gates and pumps. The project organization chart for implementation is shown in Figure 7 - 1.

7. 1. 2 Construction Plan

(1) Consulting Services

RID will employ consulting engineers for implementing detailed designs, preparation of tender document and supervision of construction works after the feasibility study.

The consultants associated with engineers and experts in the field of hydrology, rivers, bridges, roads, irrigation, soil mechanics, geology, cost estimates and tendering shall assist RID in the review of project planning, detailed designs of river improvement works, canals, Nong Yai reservoir and irrigation facilities, preparation of construction schedule, cost estimates, preparation of bid documents, tendering and contracting, quality control of construction works and general supervision of the project implementation.

(2) Implementation Mode

The construction of canals, river improvement works and irrigation facilities is scheduled to be completed by the end of 1996, quite a tight schedule, the canal construction particularly is considered as urgent work.

Considering the procurement of huge amounts of construction materials and equipment, and mobilization of a large labor force during such short construction period, it is recommendable to carry out the works on a contract basis against RID's force account basis.

(3) Construction Method

The major construction works consist of the following;

River Improvement project	:	Tha Taphao river 34.3 km, Nong Sai river 8.0 km, Phanang Tuk river 6.2 km
Canal Project	:	Upper Hua Wang Phanang Tuk canal 0.6 km Lower Hua Wang Phanang Tuk canal 3.9 km Pak Phraek canal 5.5 km Sam Kaeo canal 4.8 km

Nong Yai Irrigation: project	Nong Yai reservoir, Irrigation canals included with pipe lines 24.2 km, Drainage canals 17.2 km

The embankment materials for the reservoir's dikes and canals can be obtained from the excavation areas of canals and borrow areas near the structures. The construction materials of sand, gravel and riprap are easily procured from the existing borrow areas and commercial crushing plant, and such materials as cement, steel bars and fuel are also available on the domestic market.

7.1.3 Implementation Schedule

The implementation of the project is scheduled to be completed during the five years from 1992 to 1996. Detailed design work includes the preparation of tender documents for such urgent construction work as Sam Kaeo and Hua Wang Phanang Tuk canals, Nong Yai reservoir and improvement of Tha Taphao river will be undertaken during 1993, and the construction of Hua Wang Phanang Tuk canal and improvement of the Tha Taphao river will be completed in the three year period following the detailed design stage. The other work will spread over 2 years.

The detailed design for the Pak Phraek canal, Nong Yai irrigation facilities and improvement of Nong Sai river will be performed during 1994 and the construction of these works will take place for two years after tendering. So that the project benefits of irrigation and flood control under this project will be obtained after 1997.

The implementation schedule of the project is shown in Figure 7 - 1.

7.1.4 Survey and Investigation

Before and/or during the detailed design stage of the Nong Yai - Tha Taphao Development project, the following subjects shall be attended.

(1) Topo-survey Works

The following survey works are recommended to be carried out.

a) Nong Yai Irrigation Project

i) Topographic map (S = 1/4,000)
- Nong Yai irrigation area : 3,400 ha

ii) Profile (S = 1/2,000) and cross section (S = 1/200, @100 m)
- Reservoir's dike and road : 14.0 km
- Irrigation canal and pipe line : 25.0 km
- Drainage canal : 14.0 km

b) Canal Project

i) Profile (S = 1/2,000) and cross section (S = 1/200, @100 m)
- Hua Wang-Phanang Tuk canal : 5.0 km
- Pak Phraek canal : 6.0 km

c) River Improvement Project

i) Profile (S = 1/2,000) and cross section (S = 1/200, @100 m)
- Proposed five short cuts of Tha Taphao river : 7.0 km

(2) Geological Investigation Works

The following geological investigation works are recommended to be carried out.

a) Boring Investigation (ø 66 m/m)

Site	Drilling Length (m)	W/S.P.T	W/P.T
i) Nong Yai reservoir (Bridge sites)	5 sites × 3-holes × 20 m = 300 m	○	
ii) Hua Wang Phanang Tuk Canal			
- Weir site	3 holes × 30 m = 90 m	○	○
- Bridge and others	2 sites × 3 holes × 20 m = 120 m	○	
iii) Pak Phraek canal			
- Weir site	3 holes × 20 m = 60 m	○	○
- Bridge and others	4 sites × 3 holes × 20 m = 240 m	○	
iv) Tha Taphao river			
- Bridge, sluiceway and others	20 holes × 15 m = 300 m	○	

Note: S.P.T : Standard Penetration Test
P.T : Permeability Test

(3) Installation of Gauging Stations

There are no-gauging stations of rainfall and stream flow within the Nong Yai drainage area of 102 km^2. In order to measure and analyze the inflow from the basin and the effective rainfall in the irrigable area, at least one rainfall and one stream flow gauging stations are recommended to be installed at the places as shown in Drawing 1.5 "Location Map of Meteorology & Hydrology Gauging Stations for Flood Warning System".

(4) Estimation of Sediment Volume in the Nong Yai Reservoir

The floods from the Nong Yai basin of 102 km^2, and the Tha Taphao river through the Hua Wang Phanang Tuk and the Pak Phraek canals enter into the Nong Yai reservoir, causing the sedimentation problem in the reservoir.

The estimation of sediment volume from the Nong Yai basin may be possible based on the data of suspended load on the Rap Ro and Tha Sae rivers measured by RID, however, that from the Tha Taphao river is quite difficult due to a lack of available data so as to recommend conduction of the following matters.

- Estimation of inflow water from the Tha Taphao river to the reservoir at least for 10-years duration
- Measurement of content of suspended materials in flowing water by each degree of flood.

7.2 OPERATION AND MAINTENANCE PLAN

7.2.1 Responsibility

The Nong Yai - Tha Taphao Development project actually consists of two different projects; the Improvement project of Tha Taphao river system and the Nong Yai Irrigation project. Thus, the operation and maintenance plan after completion works is formulated for these two projects.

In consideration of RID's responsibilities for operation and maintenance of the main rivers, and reservoirs and irrigation facilities constructed by RID, the O & M works for the project will be conducted under the responsibility of RID.

The O & M works for the Improvement project of Tha Taphao river system will cover the river improvement project (Tha Taphao river, Nong Sai river, Phanang Tuk river, total length of 48.5 km) and canal project (Sam Kaeo canal, Upper and Lower Hua Wang Phanang Tuk canals and Pak Phraek canal, which have a total length of 14.8 km).

The major tasks of O & M works are as follows;

- Inspection and repair of the facilities constructed
- Observation, and data arrangement and analysis of water levels and discharges of rivers and canals
- Collection and analysis of meteorology especially rainfall data
- Flood forecasting and warning based on the above works
- Precautionary structure at the time of heavy rains and floods

The major tasks of operation and maintenance work for the Nong Yai Irrigation project composed of Nong Yai reservoir, irrigation and drainage canals and pump stations are 1) inspection and repair of the constructed facilities, 2) research of crop water demand and 3) preparation of water allocation program and regulation of water.

7. 2. 2 Organization of O & M

(1) Improvement Project of Tha Taphao River System

The O & M office for Tha Taphao river system will be responsible for such important tasks as maintenance of rivers, 73.7 km in length, and flood forecasting and warning to be established under the supervision of Regional Office 11, RID.

It may be favorable to locate the O & M office near or adjacent to the Chumphon provincial office, RID in consideration of common use of equipment and materials, and convenience of communication with the provincial office.

The O & M office will consist of four sections concerned with administration, mechanics and engineering of Tha Taphao river and canals. The work for analysis of meteorological and hydrological data, and forecasting of flood shall be conducted through close conference with the Hydrology Division RID, particularly in the flood season and the assistance of the aforementioned division will be required.

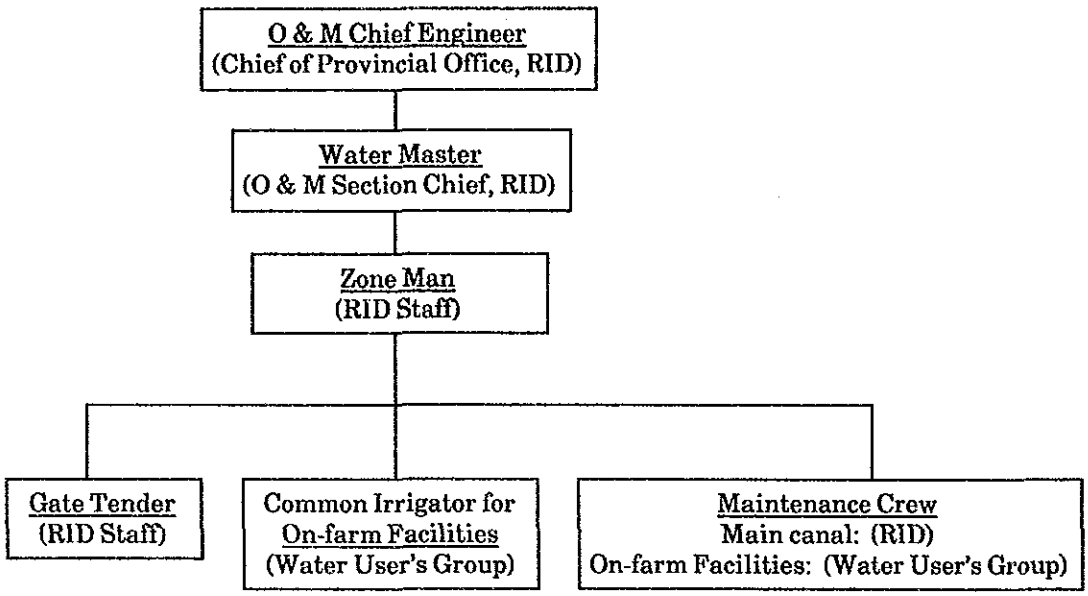
As for flood forecasting and warning, and organizing of precautionary structures at times of heavy rain and flood, establishment of organization and rules will be made based on meeting with Chumphon provincial office and Amphoe offices prior to implementation of the works.

The O & M office will operate all rivers and canals in the Menan Chumphon basin upon completion of such construction works as the three multipurpose reservoirs, Tha Sae, Rap Ro and Upper Rap Ro, river improvement of Tha Sae, Rap Ro, Tha Taphao and Chumphon, and installation of the flood forecasting and warning systems.

(2) Nong Yai Irrigation Project

In consideration of project scale being comparatively small, 2,260 ha of gross project area, 1,200 ha of irrigable area, the Nong Yai O & M section is recommended to be established under the Chumphon provincial office, RID.

The on-farm system will be operated and maintained by the Water User's Group under the supervision of RID. Proposed organization for operation and maintenance of the project is shown as follows;



1) Water Master

The water master will take responsibility for the review and approval of the water allocation programme, and direct the overall works related to O & M.

2) Zone Man

The zone man will prepare water delivery schedules by collecting data and informations of crop water demand, irrigation water distribution, rainfall, etc. The zone man will direct and coordinate gate and pump tenders based on the water delivery schedules approved by the water master. Two zone men may be appointed considering the project scale.

3) Pump and Gate Tenders

The pump and gate tenders will take responsibilities of regulating discharge released from the reservoir to the canals and pipelines, and from canals to the ditches, keeping records on water levels in the reservoir and in the canals, reporting the water level to the zone man on a daily basis. Two tenders under one zone man, total four tenders may be appointed.

The organization chart of operation and maintenance for Nong Yai - Tha Taphao Development project is shown in Figure 7 - 2.

7. 2. 3 Operation and Maintenance Costs

The project offices and warehouses built during the construction period will be utilized for a part of operation and maintenance facilities successively. O & M equipment and materials excluding such available equipment as cars will be newly provided. Accounting for the replacement cost for irrigation pumps (which have a lifetime set at 20 years) the operation and maintenance costs for the project were estimated as follows;

Improvement project of Tha Taphao river system

- Annual O & M cost : 9,577 ('000 Baht)

Nong Yai irrigation project

- Replacement cost of pumps: 19,476 ('000 Baht)
- Annual O & M cost : 4,845 ('000 Baht)

TABLE 7 - 1 IMPLEMENTATION SCHEDULE OF NONG YAI - THA TAPHAO DEVELOPMENT PROJECT

Description	Quantities	1992 Y	1993 Y	1994 Y	1995 Y	1996 Y
[I] 'THA TAPHAO RIVER SYSTEM IMPROVEMENT PROJECT						
1. RIVER IMPROVEMENT PROJECT		F/S	D/D		Construction	
1.1 Tha Taphao river	34.3 km					
1.2 Nong Sai river	8.0 km					
1.3 Phanang Tuk river	6.2 km					
2. CANAL PROJECT			Construction			
2.1 Sam Kaeo canal (rehabilitation)	4.8 km	F/S	D/D	Construction		
2.2 Hua Wang Phanang Tuk canal	4.5 km					
2.3 Pak Phraek canal	5.5 km					
[II] NONG YAI IRRIGATION PROJECT		F/S	D/D	Construction		
1. Nong Yai reservoir (Dike and Road)	13.9 km					
2. Irrigation and Drainage system	1,200 ha					
3. Agricultural Development Facilities	L.S					

FIGURE 7 - 1 PROJECT ORGANIZATION CHART FOR IMPLEMENTATION

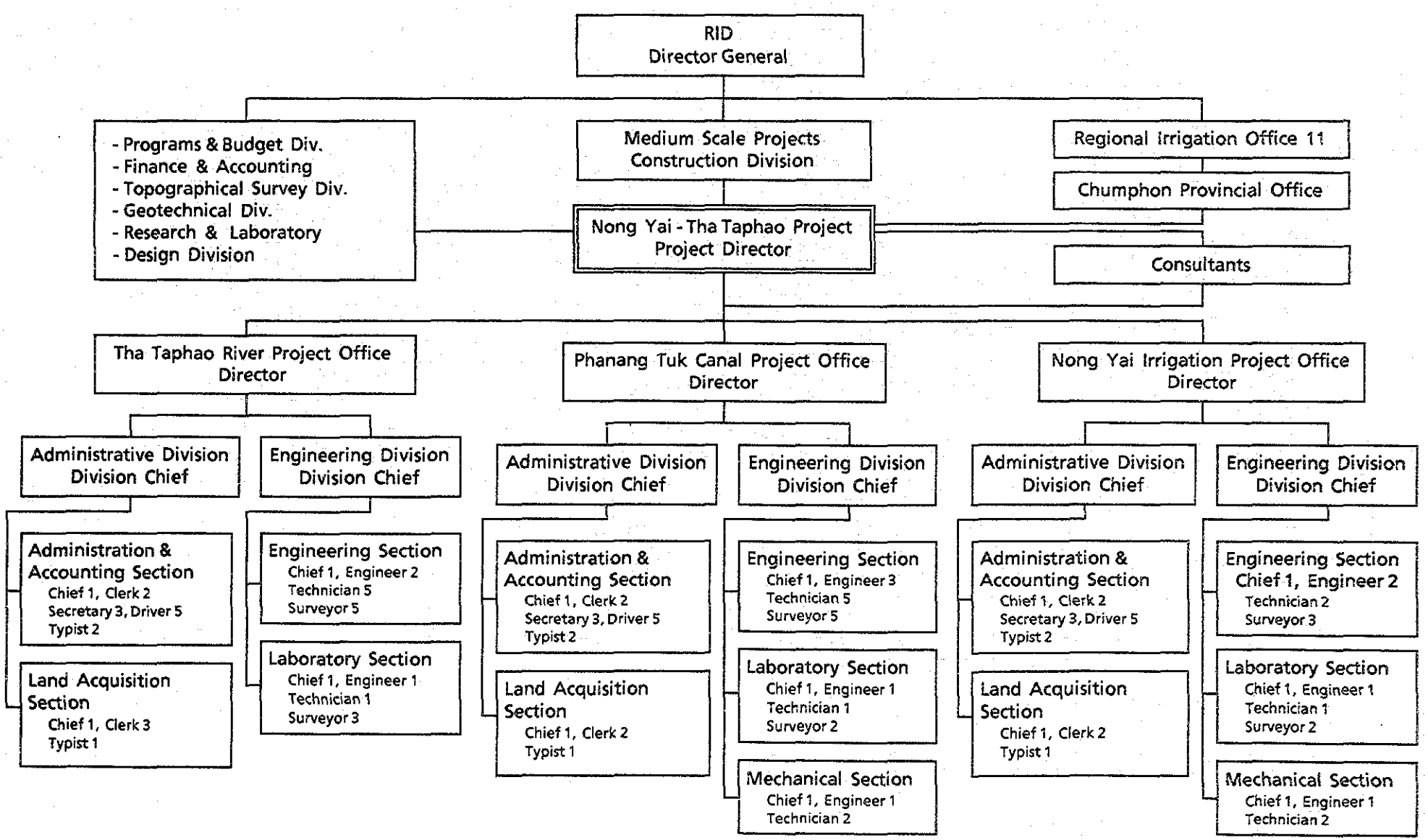
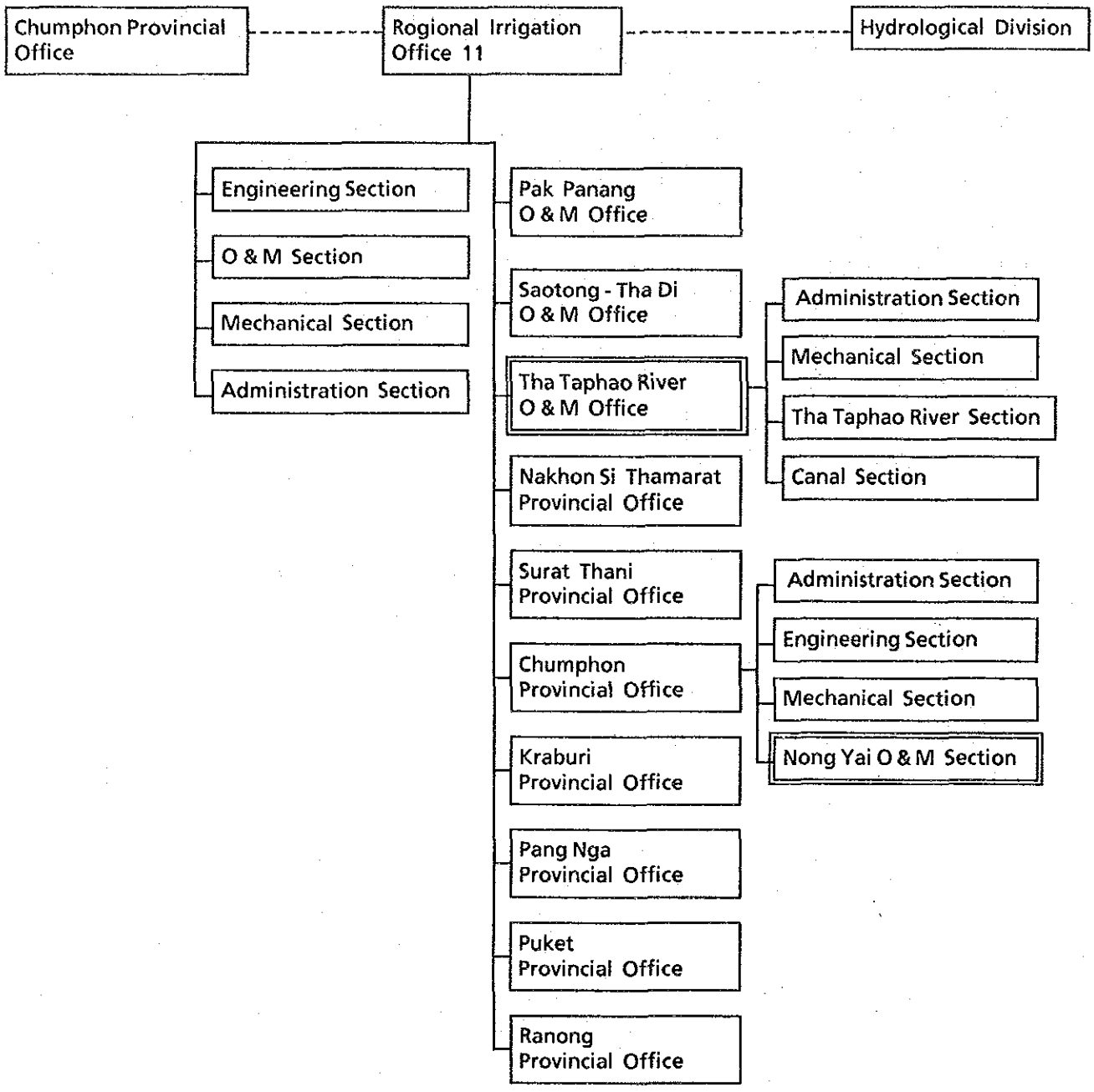


FIGURE 7 - 2 ORGANIZATION CHART FOR O & M



CHAPTER 8. PROJECT COST

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The construction cost was estimated based on the work quantity, current unit rates employed in RID projects and the proposed implementation schedule. The project costs include costs for land acquisition, surveys and investigations, administration and consulting services. 10 percent of physical contingencies area added. Price escalation contingencies are calculated at rates of 1 percent per year for the foreign currency component, and for the local currency component 5 percent per year for 3 years (1992 to 1995) and from then onwards 4 percent per year are applied.

The project costs are divided into 2 components of local currency and foreign currency. The foreign currency component is the amount of the costs required for procurement of machinery, equipment, spare parts and materials to be imported, and parts of costs required for procurement of machinery, equipment, spare parts and materials to be manufactured in Thailand. The total project costs amount to 1,977 million Baht at a 1992 price level. A foreign exchange rate of US$1.00 = Baht 25.0 = Yen 125 has been applied. Table 8 - 1 presents the project cost as summarized below:

PROJECT COST

(Unit: Million Baht)

Project	Local Currency	Foreign Currency	Total	Foreign (%)
① Drainage Improvement of Tha Taphao River System				
- River project	353.0	188.8	541.8	35
- Canal project	658.8	439.6	1,098.4	40
Sub-total	1,011.8	628.4	1,640.2	39
② Nong Yai Agriculture Development	205.6	130.8	336.4	39
Total	1,217.4	759.2	1,976.6	38

The project will be implemented over 5 years from 1992 to 1996. The annual disbursement schedule is summarized as follows:

ANNUAL DISBURSEMENT SCHEDULE

(Unit: Million Baht)

Year	Local Currency	Foreign Currency	Total
1992	18.8	11.6	30.4
1993	175.0	52.0	227.0
1994	330.9	189.2	520.1
1995	447.6	290.1	737.7
1996	245.1	216.3	461.4
Total	1,217.4	759.2	1,976.6

TABLE 8-1 PROJECT COST OF NONG YAI - THA TAPHAO DEVELOPMENT

(1) River Improvement Project

Description of Works	Total Cost ('000 Baht)		
	Total	F/C	L/C
1. Construction Cost			
1.1 Preparatory Works	3,800	1,440	2,360
1.2 Tha Taphao river	250,099	131,425	118,674
1.3 Nong Sai river	47,792	22,407	25,385
1.4 Phanang Tuk river	33,724	14,640	19,084
Sub-Total	335,415	169,912	165,503
2. Associated Cost			
2.1 Land Acquisition & Compensation	95,285	0	95,285
2.2 Pre-engineering (3%)	10,062	0	10,062
2.3 Administration (5%)	16,771	0	16,771
2.4 Consulting Services (5%)	16,771	0	16,771
Sub-Total	138,889	0	138,889
Base Cost	474,304	169,912	304,392
3. Physical Contingencies (10%)	47,430	16,991	30,439
Total	521,734	186,903	334,831
4. Price Contingency	20,089	1,928	18,161
Project Cost	541,823	188,831	352,992

(2) Canal Project

Description of Works	Total Cost ('000 Baht)		
	Total	F/C	L/C
1. Construction Cost			
1.1 Preparatory Works	1,900	720	1,180
1.2 Sam Kaeo canal	314,008	163,893	150,115
1.3 Hua Wang Phanang Tuk canal	303,979	159,656	144,323
1.4 Pak Phraek canal	132,969	71,272	61,697
Sub-Total	752,856	395,541	357,315
2. Associated Cost			
2.1 Land Acquisition & Compensation	112,880	0	112,880
2.2 Pre-engineering (3%)	22,586	0	22,586
2.3 Administration (5%)	37,643	0	37,643
2.4 Consulting Services (5%)	37,643	0	37,643
Sub-Total	210,751	0	210,751
Base Cost	963,607	395,541	568,066
3. Physical Contingencies (10%)	96,361	39,554	56,807
Total	1,059,968	435,095	624,873
4. Price Contingency	38,403	4,468	33,936
Project Cost	1,098,371	439,563	658,809

(3) Nong Yai Irrigation Project

Description of Works	Total Cost ('000 Baht)		
	Total	F/C	L/C
1. Construction Cost			
1.1 Preparatory Works	1,900	720	1,180
1.2 Nong Yai reservoir	101,721	46,854	54,867
1.3 Irrigation & Drainage System	111,330	67,644	43,686
1.4 Agricultural Development Facilities	5,497	2,498	2,999
Sub-Total	220,448	117,716	102,732
2. Associated Cost			
2.1 Land Acquisition & Compensation	45,824	0	45,824
2.2 Pre-engineering (3%)	6,613	0	6,613
2.3 Administration (5%)	11,022	0	11,022
2.4 Consulting Services (5%)	11,022	0	11,022
Sub-Total	74,482	0	74,482
Base Cost	294,930	117,716	177,214
3. Physical Contingencies (10%)	29,493	11,772	17,721
Total	324,423	129,488	194,935
4. Price Contingency	12,006	1,336	10,670
Project Cost	336,429	130,824	205,605
Grand Total	1,906,125	751,486	1,154,639
Grand Project Cost	1,976,623	759,217	1,217,406

CHAPTER 9. PROJECT EVALUATION

CHAPTER 9. PROJECT EVALUATION

9.1 GENERAL CONCEPT

9.1.1 Basic Premises

The 2 main purposes of the project are establishment of integrated agriculture and drainage improvement of the Tha Taphao river system. Despite of its adjacency of the provincial headquarters, the Nong Yai area has performed typical agriculture of the South with high density of farming households. The area is subject to annual floods, causing damages to agricultural production and the daily life of local inhabitants. Among several projects proposed for the integrated agriculture and water resources development of the Menam Chumphon basin, the Nong Yai - Tha Taphao development project has been selected as the priority project. The priority selection is based on the following criteria:

1) The representative area of the whole basin for possible development of cultivation of paddy, fruit trees, tree crops and vegetables, livestock raising and inland fisheries,
2) Need for urgent development due to its low agricultural productivity as a result of flooding and irrigation water shortage, and
3) Effect of demonstrating the implementation of the project.

9.1.2 Project Components

To attain the project objectives, the Nong Yai - Tha Taphao development project will implement the following development plans: 1) water resources development, 2) irrigated agriculture development, 3) livestock-raising development, 4) swamp fisheries development, 5) agriculture development supporting services, and 6) drainage improvement of the Tha Taphao river system as summarized as follows:

1) Water Resources Development of the Nong Yai Swamp
   - Effective water storage : 3.9 MCM

- Construction of dikes and roads : 13.9 km

2) Irrigated Agriculture Development
   - Irrigation area : 1,200 ha
   - Irrigation canal : 24.2 km
   - Drainage canal : 17.2 km

3) Livestock Raising Pilot Project
   - Beef cattle : 80 heads
   - Pig : 200 heads
   - Pasture land : 38 ha (240 rai)
   - Nos. of member farmers : 20 farmers

4) Swamp Fisheries Development
   - Water surface area : 543 ha (3,400 rai)
   - Stock of fish seed : Tilapia, carps

5) Agriculture Development Supporting Services
   - Farmers' groups
   - Demonstration farms

6) Drainage Improvement of Tha Taphao River System
   - River improvement : Tha Taphao river, Nong Sai river
   - Canal rehabilitation : Sam Kaeo canal
   - Canal construction : Hua Wang-Phanang Tuk Pak Phraek

9.1.3 Method of Evaluation

Methods of project evaluation include 1) economic evaluation, 2) financial analysis on the basis of balance in revenue and expenditure of beneficial farmers, and 3) environmental impact study by project implementation.

(1) Economic Evaluation

The economic evaluation judges the project viability in terms of direct contribution to the national economy. In general, there are 3 methods for judging the project viability for development: benefit-cost ratio (B/C ratio), net present value (NPV) and economic internal rate of return (EIRR). In this evaluation, the EIRR is applied.

The benefits employed in the economic evaluation are an increase in crop production and livestock-raising for Nong Yai agriculture development and prevention of flood damage for drainage improvement of the Tha Taphao river system. Benefits from swamp fisheries are not accounted for the economic evaluation due to its small amount in monetary terms. The sensitivity analysis has been carried out to evaluate possible risks for the following 3 cases:

1) 10 percent reduction in project benefit
2) 10 percent increase in project cost
3) 2 years delay in completion of project

(2) Farm Budget Analysis of Representative Farms

The financial feasibility of the project is evaluated by the farm budget analysis of representative farms with the farm size of 1.44 ha (9 rai) in cases of "without project" and "with project".

(3) Environmental Impact

The evaluation of environmental impacts is based upon predicted changes on natural, living and production conditions resulting from project implementation for judging the effects caused by these changes. For the evaluation on the natural environment, effects of problem soils and water resources as well as aqua-biosystems caused by the construction of canals are the main items to be considered. For evaluating the production conditions, the effects of project implementation of the integrated agriculture on production conditions of the project will be evaluated. As for the effects of project implementation on the local inhabitants, the socioeconomic conditions will be examined.

9.2 PROJECT COST AND BENEFIT

9.2.1 Economic Project Cost

The project costs consist of 2 parts, the Nong Yai agriculture development and the drainage improvement of the Tha Taphao river system.

The project costs and prices applied to economic evaluation are estimated on the basis of information and data obtained up to July 1992. The financial project costs are converted into economic project costs by deducting the price escalation contingencies, and applying conversion factors of 0.88 to construction costs and 0.92 to costs for administration and engineering, as given below:

SUMMARY OF PROJECT COSTS

(unit: Million Baht)

Project	Financial Cost	Economic Cost
① Nong Yai Agriculture Development	336.43	249.96
② Drainage Improvement of Tha Taphao River System		
- River improvement	541.82	379.90
- Canal construction	1,098.37	840.95
Sub-total	1,640.19	1,220.85
Total	1,976.62	1,470.81

In addition to operation and maintenance costs of 2,910 thousand Baht per year including costs for personnel, administration and periodical repairs of the project facilities, the Nong Yai agriculture development project will uncut costs amounting to 1,935 thousand Baht per year for operation of pumping stations. Replacement costs of 19,476 thousand Baht of pumps and motors are considered. Operation and maintenance costs for drainage improvement are estimated at 9,577 thousand Baht. The estimated annual disbursement schedule of the initial cost is as follows:

ANNUAL DISBURSEMENT SCHEDULE

(unit: Million Baht)

Year	Agriculture Development Project	Drainage Improvement Project	Total
1992	-	16.33	16.33
1993	9.21	118.65	127.86
1994	57.77	317.49	375.26
1995	112.78	445.57	558.35
1996	70.20	322.81	393.01
Total	249.96	1,220.85	1,470.81

9. 2. 2 Project Benefit

From the viewpoint of the national economy, directly and indirectly associated benefits will be created from the project. Direct benefits will be derived from irrigation, livestock raising, domestic water supply, inland fisheries for the agriculture development, of which benefits from irrigation and livestock- raising are financial evaluated in order to compare the benefits with the investment costs for the whole duration of the project. The benefits from the drainage improvement are estimated based on reduction of losses.

(1) Irrigated Agriculture

Irrigation benefits are represented the increase in the net income from crop production which would result from project unplementation compared with the case of no project being implemented. With the implementation of the Nong Yai agriculture development project, 1,200 ha (7,500 rai) of farm lands will be irrigated including: 630 ha (3,937 rai) of paddy fields, 530 ha (3,313 rai) of mixed orchard and 40 ha (250 rai) of upland fields. In calculating crop benefits, it is assumed that 5 years will be needed for paddy, pineapple and vegetables until the full project benefits are gained and 10 years for fruit. The estimated annual benefit from crop production is 43.85 million Baht when target yields are attained.

BENEFIT OF CROP PRODUCTION

Crop		Net Production Value (NPV)		
		Without Project	With Project	Incremental NPV
Paddy :	Rainy Season	0.42	3.68	3.26
	Dry Season	0.01	0.49	0.48
Tree Crops		3.27	13.33	10.06
Fruit :	Mangosteen	0.01	5.90	5.89
	Cashew nut	0.97	2.99	2.02
	Durian	1.75	15.05	13.30
	Pomelo	0.64	7.23	6.59
	Pineapple	1.14	2.98	1.84
Vegetables		0.76	1.17	0.41
	Total	8.97	52.82	43.85

(2) Livestock Raising Benefits

According to the results of the farm survey of the Nong Yai project area, annual net production values of livestock raising of cattle and pigs are 1.6 million Baht, and production costs are 0.68 million Baht per year, thus resulting in annual net production values of 0.92 million Baht. With the implementation of the proposed livestock raising pilot project, it can be expected that 800 farm households will be engaged in livestock raising with the average raising amount being 7.2 million Baht; therefore, the incremental net production values come to 6.28 million Baht per year, corresponding to an economic benefit of 5.9 million Baht.

(3) Drainage Improvement

The frequent flooding of the Tha Tapaho river causes damage to crops, farm lands, irrigation facilities, roads and bridges. And occasionally flood damages extend to livestock, shrimp ponds, houses and private property, when tropical storms and typhoon affect to the area. The flood discharge-flood damage relation ship is prepared based on topographic maps with scales of 1 : 50,000 and contour intervals of 10 meter with spot elevations, and the Nong Yai area maps with a scale of 1 : 10,000 and contour intervals of 1 meter, profiles of rivers and flood damage records for 1988 and 1989.

In case of a peak flood discharge of 1,510 cu.m/sec, which is a probable maximum flood with a return period of 50 years, 27,400 ha of land will be inundated including 21,600 ha of farm lands, 760 ha of shrimp ponds, 1,800 head of cattle, 27,500 houses and 81 factories.

While, in case of the flood discharge of 1,150 cu.m/sec (10 years frequency flood), 17,600 of farm lands, 760 ha of shrimp ponds, 1,200 head of cattle, 16,600 houses and 72 factories will be damaged by the flood.

With the implementation of the drainage improvement project of the Tha Taphao river system, a flood with a peak discharge of 1,150 cu.m/sec and the return period of 10 years will be released into the sea. In estimating losses, direct losses that can be determined in monetary values are accounted, and indirect losses such as traffic delays, loss of income and interruption of business are not considered. Benefits from the proposed project are computed by

comparing the losses expected both without and with the project, as given below:

Probable annual losses without project	:	462.1 million Baht
Probable annual losses with project	:	160.8 million Baht
Saving losses	:	301.3 million Baht

9.3 ECONOMIC EVALUATION

The economic profitability of the proposed project from the standpoint of the national economy has been evaluated by the economic internal rate of return (EIRR). The EIRR is a discount rate at which the difference between the present worth of benefits and the present worth of costs is zero. A period of analysis for calculating the economic internal rate of return is fixed at 30 years. The estimated economic internal rate of return is given as follows:

ECONOMIC INTERNAL RATE OF RETURN

Project	EIRR (%)
Nong Yai Agriculture Development Project	9.5
Drainage Improvement of Tha Taphao River System	18.7
	17.1

The overall EIRR including both the agriculture development projects and drainage improvement project is estimated at 17.1 percent, being higher than the opportunity cost of capital in Thailand, which is approximate 10 to 12 percent. This economic internal rate of return has proved that the implementation of the proposed project is feasible from the viewpoint of the national economy. The individual EIRR of the Nong Yai agriculture development project is relatively low, at 9.5 percent. However, agriculture is the most important economic activity in the Thai economy in spite of its low productivity. The implementation of the project will play an important role in attaining the national development objectives through effective utilization of available natural and human resources, and correcting the differentials in production and quality of life among regions of the country.

For the purpose of judging potential risks during the implementation and operation of the project, it has been tested for its sensitivity to decreases in project benefits, increases in project costs and extension of construction period. In a case where the completion of the project construction is delayed for 2 years, the economic internal rate of return is reduced to 13.3 percent.

SENSITIVITY TEST

Test Case	EIRR (%)
10% Reduction of Benefit	15.5
10% Cost Overrun	15.7
2 Years Delay in Project Completion	13.3

9.4 FARM BUDGET ANALYSIS

9.4.1 Representative Farm

In order to evaluate the financial impact on beneficiary farmers from the implementation of the Nong Yai agriculture development project, farm budget analyses have been made for representative farms in cases of project implementation and without project implementation. Results of the farm survey indicate that average farm size is 1.44 ha (9 rai), farming patterns may be classified into 2 types of 1) paddy farming with mixed orchard and livestock raising and 2) mixed orchard farming with livestock raising, with 20 percent of farm lands are fallow. With the implementation of the proposed irrigation project, most of tree crops will be replaced by fruit trees according to the land use plan. The farm size of selected representative farms for their farm budget analysis is given below:

FARM SIZE OF REPRESENTATIVE FARM

Farm Land	Paddy Farm		Orchard Farm	
	Without Project	With Project	Without Project	With Project
Total Land Area (rai)	9.0	9.0	9.0	9.0
Cropping Area (rai)				
- Paddy	3.6	4.5	-	-
- Fruit	0.9	1.8	1.4	3.6
- Tree Crop	2.7	2.7	5.8	5.4
Total	7.2	9.0	7.2	9.0

For livestock raising both representative farms will raise 2 heads of beef cattle and 4 heads of pig.

9. 4. 2 Farm Income

Net farm income of the representative farms is calculated according to the above cropping plan. Estimates of households expenditure and off-farm income are based on the results of the farm survey. Half of the present off-farm income is counted in farm budget analysis of with project case, as they may have workable capacity for off-farm labor for their relatively small farm size. The estimated net income of the representative farms is summarized as follows:

NET INCOME OF REPRESENTATIVE FARM

(unit: Baht)

Item	Paddy Farm		Orchard Farm	
	Without Project	With Project	Without Project	With Project
Farm Net Income				
- Crop	6,800	30,500	11,600	53,500
- Livestock	2,300	9,000	2,300	9,000
Sub-total	9,100	39,500	13,900	62,500
Off-farm Income	38,900	19,500	38,900	19,500
Total Farm Income	48,000	59,000	52,800	82,000

With the implementation of the Nong Yai agriculture development project, the net farm income will be increased from 9,100 Baht to 39,500 Baht for paddy farms, and from 13,900 Baht to 62,500 Baht for orchard farms, about 4.5 times the present net income.

The present household expenditure is applied to the farm budget analysis. The representative orchard farm is able to maintain its household expenditure by farm income; moreover, the orchard farm is able to earn a disposable income of 39,000 Baht per year. The surplus income is shown in the following:

SURPLUS INCOME

(unit: Baht)

Item	Presentative Farm	
	Paddy Farm	Orchard Farm
Household Income		
- Farm income	39,500	62,500
- Off-farm	19,500	19,500
Total	59,000	82,000
Household Expenditure	43,000	43,000
Surplus of Income	16,000	39,000

9. 5 EVALUATION ON ENVIRONMENTAL IMPACT

9. 5. 1 Natural Environment

(1) Topography and Geology

The Nong Yai area is composed of a predominantly alluvial plain with elevation of 1 to 7 meters above mean sea level with some isolated hills. In the northern part of the Nong Yai area, the Nong Yai swamp is formed by streams coming from the northern hills during the rainy season. The swampy area becomes smaller in the dry season. Tha Tapao river flows on the western side of this Nong Yai area. The areas of alluvial plain predominate in the low-lying area above Sam Kaeo canal, around Nong Yai swamp and along water streams. Isolated hills with an elevation of around 100 - 200 m MSL are scattered across the Nong Yai area and the surrounding country side.

The basement rock in Nong Yai area is mainly composed of the Carboniferous Matsi formation. In the western part of the area, the Permian Chumphon formation is observed. This basement in made up of isolated hills in Nong Yai area.

These topographic and geological aspects are retained in the project but the construction of the Huai Wang-Phanang-Tuk canal (which will connect the Tha Tapao river to the Nong Yai reservoir and, then, Nong Yai reservoir to the Phanang Tuk river) is the main consideration in environmental impacts.

(2) Soils

The main factor related to environmental impacts in this project would be problem soils in the area. Especially, the South of Thailand, where the project is taken place, has largely problem soils expanded over its whole area from north to south. In its southern part, the peat soil is dominantly expanded over the region. Besides, hardpan soil and areas exploited by tin mining pose also fundamental problem-soils in this region.

The project is located in the northern part of the South which is relatively lesser affected by problem soils than its southern part. Problem soils in this part are observed in various kinds, scattering in relatively small portions over the area. The Nong Yai area located in its northern part possesses basic problem soils of this kind.

Firstly, main problem soils are saline soil of Wang Phriang series and potential acid sulfate soil of Bang Pakong series. The saline soil of Wang Phriang series which EC value is more than 4 ms/cm is observed near the coastal area of Phanang Tuk bay, distributed over an area of 176.4 ha or 6.3 percent of the Nong Yai area. This saline soil is considered affected to vegetation unless leaching, natural or artificial, is occurred. The potential acid sulfate soil of Bang Pakong series, however, has a smaller area of 50 ha or 1.8 percents of the area of Nong Yai located into 2 portions below Sam Kaeo canal linking to the saline soil area, where coconut and nippa palm are largely grown.

Other problem soils in the Nong Yai area are the acid soils of the Bangnara series, and Klaeng series, apart from the soil of Narathiwat series. These soils have an inferior drainage effect and low fertility. In fact, these soils expand into the lowlands where annual floods induce flood-borne mud which improves the soils fertility, constituting natural improvement. In these problem soils, the Bangnara series are potentially saline soils which cover an area of 293 ha or approximately 10.4 percent of the Nong Yai area.

The flooding effects till now, therefore, have improved these problem soils in properties. Flood control, therefore, to be useful for irrigation must take into account the increased soil fertility resulting from flooding where necessary.

(3) Water Sources

Tha Tapao river and Nong Yai reservoir are the main water sources for the project as a result of the main feature of irrigation-agriculture to be developed. With the construction of the Huai Wang-Phanang Tuk canal, which passes through the Nong Yai reservoir, the water sources of Tha Tapao river and Nong Yai reservoir will be unified in one system which also includes the Sam Kaeo canal. Up till now, with the construction of the Sam Kaeo regulator, the water in the Sam Kaeo canal has become saline due to the intrusion of tidal sea water. With the construction of a new floodway to connect the Sam Kaeo canal at its terminal, the water level in the canal will be maintained to prevent saline water intrusion into the area which has caused problems for the agricultural production of local farmers.

A summary analysis of surface water sources in the area is shown as follows.

WATER QUALITY OF SURFACE WATER SOURCES

Location	pH	Conductivity (mS/cm)	Turbidity (NTU)	DO (ppm)	Salinity (%)	Remarks
Nov.'91						
X.158	7.0	0.09	10	6.4	0	Tha Taphao River.
Paddy Field	6.2	0.16	80	7.5	0	Near Nong Yai Swamp
Nong Yai Swamp	7.1	0.06	30	6.8	0	Storage Water
Sam Kaeo Canal	7.1	0.18	10	5.4	0	Near the Regulator
Jun.'92						
X.158	7.5	0.15	30	6.6	0	Junction of Rap Ro
Nong Yai Swamp	7.0	0.26	39	4.6	0.01	Upper part
Tha Taphao	7.8	0.12	35	5.9	0	Sam Kaeo Conjunction

This implies that the quality of surface water sources related to the Project will be in better conditions after the conjunction of floodway from the Tha Tapao river to the terminal of the Sam Kaeo canal. The properties of underground water in the Nong Yai area are not safe use without treatment. The Project, however, implies the use of surface water to attain its objectives. The construction related to the Project aims to eliminate the effects of underground water on the project-works.

(4) Ecological System

In terms of ecological systems effected by the project, the construction of the Huai Wang-Phanang Tuk canal would be considered as the main factor to the aqua-system of the Tha Tapao river and Nong Yai swamp. The biosphere in this area is mainly composed certain types of fish. As the storage of water as well as the maintaining of fresh water quality in natural conditions of Tha Tapao river and Nong Yai swamp will be affected by the project, this biosphere will not be altered by the work. Besides, the inland fishery program plans to release more fish fries in these water bodies in order to maintain this bio-sphere. Apart from the aqua-system, the wildlife sanctuary is not included in the Nong Yai area which is a small portion of land linked to the municipality of Chumphon.

9. 5. 2 Human Use Values

(1) Irrigated Agriculture

The development of water resources for irrigation by using the Nong Yai swamp for water storage contributes to both aspects of an available water use for agricultural purposes and the prevention of damage caused by inundation in the area. Basically, this will form the basis for irrigated agriculture higher benefits with irrigated cropping instead of rainfed cropping as up to now. Besides, the annual submergence, even in 2 - 3 days, in lowlands has caused damages to young plans to fruit trees and vegetables. The drainage system can contribute to the protection of young plants, especially for fruit trees considered very important to be protected from submergence in the early stages.

(2) Flood Control

The Nong Yai area is located in the most flood-affected area of the Chumphon basin. The location is below the conjunction of 2 main surface water streams Tha Sae and Rap Ro and, also, nearby Tha Tapao river formed by 2 aforementioned water streams, offering basic conditions for flooding its lowlands in the rainy season or during occasional storms in the region.

In addition, there are 2 more factors regarding floods in the Nong Yai area, which are that the Sam Kaeo canal is made like a tributary of Tha Tapao river passing through the southern part and Nong Yai swamp acts as a water-catchment area located in its northern part.

These conditions have caused annual flooding in the area up to now. The construction of a floodway passing through Nong Yai reservoir and the improvement works of Tha Tapao river and Sam Kaeo canal will basically contribute to flood control in the area for a designed period of 10 year-return.

This will, firstly, reduce physical damage caused by floods and, secondly, offer the necessary conditions for stable agricultural production, and for improving the quality of life.

(3) Communications

A new rural road network made by the embankment road around Nong Yai reservoir to connect to other rural roads in the Nong Yai area will contribute to better connections to remote villages in the area around Nong Yai reservoir. This new rural road network will be added to the present road network based on the national road No.3180 and form a better communication system in Nong Yai area. With this better communication system, the marketing distribution system of agricultural products will be improved accordingly.

(4) Marketing Distribution Network

The installation of Tambon Na Cha Ang market will contribute to the distribution of agricultural products and necessary goods in the Nong Yai area. This Tambom market will serve as the base for the distribution network of agricultural products from Tambon to the Amphoe market and from Amphoe market to provincial central markets.

(5) Cultural Heritages

The detailed study on construction of floodway and improvement works of the Tha Tapao river and Sam Kaeo canal is designed to prevent damage to the cultural heritages such as Wat, historical or archaeological

places etc. In Nong Yai area, some places of cultural heritages can be observed (see RID Materials in Appendix).

9. 5. 3 Consideration on Environmental Impact

From the environmental evaluation on 3 aspects of natural environment, production conditions and quality of life, there is no serious problem for the environmental evaluation to be subjected to recommending further studies at the moment. The proposed reservoir capacity is 4.5 million cubic meter and is classified as a medium scale project. Project implementation, however, should be aware of the following points:

1) Cultural heritages in the area should be secured from damage by the project implementation.
2) The construction of the canals and river improvement works should ensure the following security:
   - Safe communications and schooling in the area
   - No flood damage to local people at the floodway terminal
   - Proper compensation and rehabilitation for affected people
3) Application of agricultural production chemicals such as pesticides etc. shall not affect properties of soils or water in the area.

9. 6 OVERALL EVALUATION OF PROJECT

The Nong Yai integrated agriculture development project has been proposed in the frame work of the integrated agriculture and water resources development of the Menam Chumphon basin. The Chumphon basin has potential for developing integrated agriculture with the provision of flood control from its relatively high annual rainfall. In order to develop water resources in a rational way, the starting work of the project in the Nong Yai area has an important role for initiating the development of the whole basin.

The economic feasibility of the Nong Yai - Tha Taphao development project has been demonstrated as indicated by its economic internal rate of return of 17.1 percent. The individual economic internal rate of return for the

agricultural development might not be so attractive as the economic indicators. Agriculture, however, is still the most important sector in the Thai economy despite its low productivity. Apart from the profitability of the project from the standpoint of the national economy, the project will have significant financial impact on the farmers in the project area.

Regarding social impact of this project, the stability of daily life of local inhabitants including residents in the municipality of Chumphon will be assured by mitigating the flood threat, which may encourage the socioeconomic development of the province of Chumphon.

The implementation of the proposed project has no significant negative impact on the environment of the project area, when the following countermeasures are taken to the construction work of the canals, reservoir and river improvement: 1) protection of cultural, historical heritages, and 2) proper compensation and rehabilitation of affected inhabitants.

ANNEX - 1: ASSIGNMENT AND COUNTERPART PERSONNEL

(1) Advisory Committee

Name	Assignment
1) Mr. Yoshikazu MATSUURA	Chairman of the Committee, Ministry of Agriculture, Forestry and Fisheries (MAFF)
2) Mr. Hiroshi ISHIDA	Irrigation and Drainage, MAFF
3) Mr. Junichiro SOMEI	Agriculture, MAFF

(2) Study Team

Name	Assignment
1) Mr. Kunio OTA	Team Leader / Disaster Prevention
2) Mr. Yoshiteru TSUNODA	Co-Team Leader / Irrigation and Drainage
3) MR. Hiroshi OGURA	Meteorology and Hydrology
4) Mr. Harunobu INOUE	Soil and Land Use
5) Mr. Masaharu DOI	Soil Engineering and Geology
6) Dr. Kumpal Puapanichya	Agriculture
7) Mr. Kenji MOCHIDA	Design and Cost Estimate
8) Mr. Bogo ABE	Agricultural Economy and Project Evaluation

(3) Thai Side Working Group

Name	Assignment	Designation/Division
1) Mr. Kicha Polpasai	Team Leader (Phase I)	Deputy Director General for Technical
2) Mr. Chamroon Chindasanguan	Team Leader (Phase II)	Deputy Director General for Engineering
3) Mr. Maitri Poolsup	Assistant Team Leader (PhaseI)	Director of Project Planning Div.
4) Mr. Kitla Thepalaglekha	Assistant Team Leader (Phase II)	Acting Director of Project Planning Div.
5) Mr. Preeda Wongdoiwang	Assistant Team Leader (Phase I)	Director of Regional Irrigation Office 11
6) Mr. Chanchai Kllonhom	Assistant Team Leader (PhaseII)	Director of Regional Irrigation Office 11

Name	Designation/Division	
7) Mr. Mongkol Chuleewan	Representative from Land and Law Div.	
8) Mr. Suksan Pocharassaengkul	Representative from Data Processing Div.	
9) Mr. Thera Wongsamuth	Chief of Engineering Section, Medium Scale Project-Construction Div.	
10) Mr. Jamras Jindasa-guan	Representative from Large Scale Project Construction Div. (Phase I)	
11) Mr. Osot Charnvej	Agronomist, Representative from O & M Div.	
12) Dr. Siripong Hungsapreug	Representative from Foreign Financed Project Administration Div.	
13) Mr. Manus Kumnoedmanee	Representative from Program and Budget Div.	
14) Mr. Danai Triyadhen	Chief of Soil Classification Section, GTD	
15) Mr. Monhien Kangsastiam	Chief of Research and Laboratory Div.	
16) Mr. Direk Khiewmaneewong	Research and Laboratory Div.	
17) Mr. Narong Sopak	Representative from Survey Div.	
18) Mr. Paisan Sunthornsathien	Representative from Design Div.	
19) Mr. Arthorn Chatchawansaisin	Representative from Hydrology Div.	
20) Mr. Samart Chokkanapitark	Chief of Engineering Section, Region 11 (Phase I)	
21) Mr. Vudhichai Chulakesa	Chief of Section 3, PPD	
22) Ms. Supa Sing-intara	Chief of Economic Section, PPD	
23) Mr. Triphan Mekjaroon	Chief of Environmental Section, PPD	
24) Mr. Siripong Chonsiripanlert	PPD Section 2	
25) Mr. Suthi Songvoravit	Secretary (Phase I)	Chief of Section 1, PPD
26) Mr. Suwit Thanopanuwat	Secretary (Phase II)	Acting Chief of Section 1, PPD
27) Mr. Thanar Suwattana	Assistant Secretary	PPD Section 1
28) Mr. Nattavuth Watananusan	Assistant Secretary	PPD Section 1

(4) RID Officers Concerned

Name	Designation/Division
1) Mr. Prasert Militangul	Director of Hydrology Div.
2) Mr. Prasert Chantaraniyom	Director of Geo-Technical Div.
3) Mr. Witaya Samaharn	Director of Research & Laboratory Div.
4) Mr. Sakulwatara Chantarobol	Director of Operation & Maintenance Div.
5) Mr. Sawet Yasarawan	Director of Design Div.
6) Mr. Somphot Sukhumpanich	Director of Data Processing Div.
7) Mr. Somphorn Thupthong	Acting Director of Topographical Survey Div.
8) Mr. Nopadon Sungsirin	Chief of Chumphon Province Office
9) Mr. Sirivit Klinpukdee	Office Engineer of Chumphon Province
10) Ms. Wannarattana Janyarungruang	GTD
11) Mr. Wichit Sriwisead	GTD
12) Mr. Prasit Akkakraisri	GTD
13) Mr. Sawad Tungarunsil	GTD
14) Mr. Sa-ngat On-num	PPD Economic Section
15) Mr. Santi Tinnakorn	PPD Economic Section
16) Ms. Apiradee Audnoonpong	PPD Economic Section
17) Ms. Walaiporn Rasmidatta	PPD Economic Section
18) Mr. Charoon Roo-Kheb	PPD Section 1
19) Mr. Prasert Mahakij	Regional Office 11
20) Mr. Mongkol Chuleewan	Land and Law Div.

ANNEX - 2: LIST OF REFERENCE DATA

No.	Tile	Published	Remarks
[General]			
1.	Summary of Seventh National Economic and Social Development Plan (1992 ~ 1996)	NESDB	*
2.	Operation Plan (1992 ~ 1996)	MOAC	
3.	Organization Chart of Regional Irrigation Office 11	RID	
4.	Feasibility Study of Rub Roh Project, 1982	NEA	*
5.	Report on Flood Protection and Water Resources Development Project in Chumphon Province, Jan. 1990	RID	
[Meteorology & Hydrology]			
1.	Climatological Data for the Period (1961 ~ 1990 / Chumphon Station) and Prachuap Khiri Khan Station	MD	*
2.	Tide Tables, Thai Waters Mae Nam Chao Phraya ~ Gulf of Thailand and Andaman Sea 1991	Royal Thai Navy	
3.	Rainfall Data at X46A, X64 and GT6 Station	RID	
4.	Rainfall Data at A. Muang, A Pathiu, A. Tha Sae, A. Kra Buri, A. Bang Saphan and A. Sawi Station	MD	
5.	Rainfall Data at Kaeng Phra Chao and Ban Ta Ngo Station	NEA	
6.	Runoff Data at X46A, X46, X64, X158 and X53 Station	RID	
7.	Runoff Data at Kaeng Phra Chao, Khlong Mala and Ban Ta Ngo Station	NEA	
8.	Report on Typhoon Gay (8929), 2533	MD	
9.	Tracks of Tropical Cyclones Over Thailand and Its Neighbouring Area 1951 ~ 1980	MD	
10.	South Flood Warning Vol. 1, Khlong Tha Taphao Basin, Oct. 1990	RID	

Note: * shows data in English

No.	Tile	Published	Remarks
[Soil & Geology]			
1.	Geological Map of Thailand (1/500,000), Southern Sheet	DMR	*
2.	Hydrogeological Map of Thailand (1/500,000), Southern Sheet	"	*
3.	Geological Map of Thailand (1/250,000) - Chumphon Province - Prachuap Khiri Khan Province	"	*
4.	Wells Drilled in Changwat; Chumphon/Prachuap Khiri Khan	"	*
5.	Standard for Geological Investigation/Storage Dams and Appurtenant Structures	RID	*
6.	Geological Report Khlong Chumphon, Changwat Chumphon 1973	RID	
7.	Geological Report Khlong Chumphon, Changwat Chumphon 1975	"	
[Water Resources & Irrigation]			
1.	Summary of Irrigation Projects in Chumphon Province, 1992	RID	
2.	Water Resources Development in Thailand (Large-Medium Scale Project), Jul. 1988	"	*
3.	Water Resources Development in Thailand (Small Scale Project) Jul. 1988	"	*
4.	List of Existing Projects, ARD, as of 1991	ARD	
5.	List of Existing Projects DLD, as of 1991	DLD	
6.	Crop Coefficient and Pan Coefficient, Oct. 1990	RID	
7.	Report on the Typhoon and Floods in Chumphon Province during 4 to 9 Nov. 1989	RID	
8.	List of Sediment Station, Drainage Area and Mean Annual Sediment	RID	
9.	Medium-Phase Work Plan Oct. 1991	RID	
10.	Thailand Oilpalm Research and Development Project, 1989	FAO	
11.	Water Consumption for Upland Crops	Agriculture Extension Office	

No.	Tile	Published	Remarks
[Agriculture]			
1.	Agricultural Statistics of Thailand Crop Year 1989/90	Center for Agri. Statistics Office of Agri. Economy	
2.	Agricultural Development Plan of Changwat Chumphon/Changwat Prachuap Khiri Khan, 2535 ~ 2539	MOAC	
3.	Target Yield of Each Major Crops	MOAC	
4.	Soil Efficiency and Other Agricultural Condition of Chumphon/Prachuap Khiri Khan	MOAC	
5.	Agricultural Statistics in Brief Crop Year 1990/91	Center for Agri. Statistics Office of Agri. Economy	
[Soil & Land Use]			
1.	Detailed Reconnaissance Soil Map of Chumphon Province (1/100,000), 1972	DLD	
2.	Land Use Plan of Chumphon Province, 1990	"	
3.	Land Use Plan of Prachuap Khiri Khan Province, 1990	"	
4.	Soil Classification map of Chumphon Province (1/50,000), 1990	"	for study area
5.	Plan of Land Use in the Area Damaged by Typhoon "Gay" in Chumphon Province (1/250,000), 1985	"	
6.	Present Land Use Map of Chumphon Province (1/100,000), 1985	"	
7.	Present Land Use Maps of Prachuap Khiri Khan Province (1/100,000), 1985	"	for study area
8.	Present Land Use Maps of A. Tha Sae, Muang and Pathiu (1/50,000), 1990	"	
9.	Detail Reconnaissance Soil Map of Prachuap Khiri Khan Province (1/100,000), 1972	"	
10.	Soil Classification Map of Prachuap Khiri Khan Province (1/50,000), 1990	"	
11.	DLD Development Plan (2535 ~ 2539)	"	
12.	Reserve Forest Area Map, 1991	RFD	
13.	Soil Suitability of Amphoe Muang, Chumphon 1991	DLD	

No.	Tile	Published	Remarks
[Socio-Economic]			
1.	Development Plan (1992 ~ 1997) of A. Muang, A. Tha Sae, A. Pathiu	Chumphon Provincial Office	
2.	Base Data of Village Level for A. Muang, A. Tha Sae, A. Pathiu and A. Bang Saphan Noi	NESDB	
3.	Agriculture Economy	MOAC	
4.	Thailand Foreign Agricultural Trade Statistics 1989 ~ 1990	Center for Agri. Statistics Office of Agri. Economy	
5.	Present and Trend Condition of Agricultural Economy, 2534	MOAC	
6.	ALRO Annual Book 1989	ALRO	
7.	Guideline for Environment Evaluation	NEA	
8.	Environmental Quality Standard	NEA	
9.	Administrative Maps for the Study Area	RID	
10.	Socio-Economic Information of Changwat Chumphon	Chumphon Provincial Office	
11.	Basic Data of Tambon Bang Luk, Nacha Ang and Na Thung (3 volumes)	Department of Town and Country Planning (MOI)	
[Engineering]			
1.	Seismic Data and Building Code in Thailand, 2533	MD	
2.	Unit Cost of Works, 1991	RID, Planning Div. and Budget	
3.	Price List of Construction materials, 1991	Book for Construction Materials	
4.	Design Drawings for Sam Kaeo Canal	RID	
[Maps]			
1.	Topographical Maps of Study Area (1/250,000)	RID	
2.	Topographical Maps of Study Area (1/50,000)	〃	
3.	Profile and Cross Section of Tha Taphao, Rap Ro, Tha Sae and Chumphon Rivers	〃	
4.	Topo-survey Maps for Nong Yai Swamp and a Part of Chumphon Basin (1/10,000)	〃	
5.	Profile and Cross Section of Ban Huai Wang-Phanang Tuk Canal	〃	

ANNEX - 3: SURVEY AND INVESTIGATION BY RID

In Accordance with the minutes of meeting agreed upon between JICA and RID on March 22, 1991, RID has undertaken a topographic survey, geological investigation and soil investigation. In addition, water quality investigation and farm survey, as well as supplemental soil and geological survey, were carried out by RID in terms of Feasibility Study as presented hereinafter.

3-1 TOPOGRAPHIC SURVEY AND MAPPING

The topographic survey was made in Nong Yai area including the swamp, rivers and canals, and the following maps and drawings were prepared:

TOPOGRAPHIC MAPS AND DRAWINGS

Description		Quantity	Nos. of Sheet
1. Topographic Map			
- Nong Yai area :	1/10,000	60 sq.km	2
- Nong Yai swamp :	1/4,000	5.5 sq.km	2
2. Profile and Cross Secion of River/Canal			
- Tha Taphao river :	plan, 1/4,000	39.8 km	12
	section, 1/200	@200 m	65
- Tha Sae river :	plan, 1/25,000	45 km	4
	section, 1/200	@500 m	31
- Rap Ro river :	plan, 1/25,000	58.5 km	3
	section, 1/200	@500 m	24
- Chumphon river :	plan,1/4,000	24 km	7
	section, 1/200	@100 m	46
	plan, 1/25,000	27.2 km	3
	section, 1/200	@500 m	13
- Nong Sai river :	plan, 1/4,000	11.9 km	4
	section, 1/200	@100 m	20
- Sam Kaeo canal :	plan, 1/4,000	12.4 km	4
	section, 1/200	@200 m	13
3. Canal Route Map			
- Hua Wang-Phanag Tuk canal :	plan, 1/4,000	8 km	3
- Pak Phraek canal :	plan, 1/4,000	7.5 km	3

3-2 SOIL INVESTIGATION

Ten pits for the representative 8 soil series in Nong Yai area were investigated. Pits were dug to a depth of 150 cm for profile observation, which was followed by an auger examination to 250 cm in depth below the bottom of the pit. 90 auger investigations were made by the grid method (1 auger per 25 ha) to a depth of 150cm.

62 samples from soil profiles and 57 samples from 13 augers were collected for soil analysis. Chemical and physical properties of soil samples were analyzed by the Soil Science Laboratory of the Research and Laboratory Division, RID. Items to be analyzed are as follows: (1) Bulk density, (2) Soil texture, (3) pH (H_2O, KCl, $CaCl_2$), (4) Total carbon, (5) Total nitrogen, (6) Available Phosphate (Bray 2), (7) Cation Exchange Capacity, (8) Exchangeable Cation, (9) Electric conductivity.

3-3 GEOLOGICAL AND SOIL INVESTIGATION

RID carried out geological investigations of the foundation ground at the sites of proposed heavy structures by drilling. Summary of geological investigations is shown as follows:

SUMMARY OF GEOLOGICAL INVESTIGATION

Site	Nos. of Bore Hole	Drilling Length (m)	S.P.T. (time)	Permeability Test (time)
1. Head Regulator				
- Sam Kaeo canal	3	51.45	55	22
- Hua Wang-Phanang Tuk canal	3	53.55	56	23
- Pak Phraek canal	3	43.85	46	20
2. Tail Regulator				
- Phanang Tuk canal	3	97.35	99	46
3. Road Crossing Site				
- Ban Hua Sila	2	21.65	23	-
- Ban Khuan Sarika	2	21.65	23	-
- Ban Khuan Sarika	2	18.25	20	-
4. Pumping Station				
- Nong Yai	2	14.15	16	-
- Ban Thab Tanot	2	57.90	59	-
Total	22	379.80	397	111

To grasp the geological and soil conditions along the proposed canals, the following bore hole and auger hole tests were executed by RID and the study team.

1. Hua Wang-Phanang Tuk canal

- Bore hole (unit)	:	28
- Drilling length (m)	:	128.75
- S. P. T. (time)	:	141

2. Pak Phraek canal

- Auger hole (unit)	:	17
- Drilling length (m)	:	73.70

3. Irrigation canal

- Auger hole (unit)	:	7
- Drilling length (m)	:	15.1

3-4 WATER QUALITY

15 water samples were collected for water quality analysis : 5 samples from wells (groundwater), 8 samples from surface water including Nong Yai swamp and small canals, and 2 samples from soil test pits. Items to be analyzed are : (1) pH, (2) Electric conductivity, (3) Total solid (TS), (4) Total disoluble solid (TDS), (5) Soluble sodium percentage, (6) Sodium absorption ratio (SAR), (7) Residual sodium percentage (SSP), (8) Boron, (9) Iron, (10) Total hardness, (11) Silica, (12) Cation (Ca, Mg, Na, K, NH_4), (13) CO_3, HCO_3, Cl, SO_4, NO_3, PO_4.

Six water samples were collected from Tha Taphao river (3 samples), Phanang Tuk canal (2 samples) and Nong Yai swamp (1 sample), and the following items were tested : (1) pH, (2) Electric conductivity. (3) Turbidity, (4) Dissolved oxygen (DO), (5) Temperature, and (6) Salinity.

3-5 FARM SURVEY

To obtain basic data concerning socio-economic and farming conditions of farmers in the study area for proper references to project planning, a farm survey was carried out by RID and the study team. To this end, the survey items cover (1) the level of living conditions of farmers including incomes, expenditures, public services available, problems and so on, and (2) farmers' requirements and their attitude toward agricultural development plans.

The survey team applied to chiefs of villages for assistance during the survey. Each chief called 4 to 8 farmers for interview on a random basis. 288 sample farmers were interviewed by the survey team based on the questionaire. Data were collected by RID for data processing by computers at Irrigation Engineering Center.

ANNEX - 4: SCOPE OF WORK AND MINUTES OF MEETING

SCOPE OF WORK

FOR

THE FEASIBILITY STUDY

ON

THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT

PROJECT OF THE MENAM CHUMPHON BASIN

AGREED UPON BETWEEN

ROYAL IRRIGATION DEPARTMENT

AND

THE JAPAN INTERNATIONAL COOPERATION AGENCY

BANGKOK, MARCH 22, 1991

LECK JINDASANGUAN
DIRECTOR GENERAL,
ROYAL IRRIGATION DEPARTMENT,
MINISTRY OF AGRICULTURE AND
COOPERATIVES

YOSHIKAZU MATSUURA
LEADER,
THE PRELIMINARY STUDY TEAM,
THE JAPAN INTERNATIONAL
COOPERATION AGENCY

I. INTRODUCTION

In response to the request of the Government of the Kingdom of Thailand, the Government of Japan has decided to undertake the feasibility study on the Integrated Agriculture and Water Resources Development Project of the Menam Chumphon Basin (hereinafter referred to as "the Study") within the general framework of technical cooperation between Japan and Thailand, which is set forth in the Agreement on Technical Cooperation between the Government of Japan and the Government of the Kingdom of Thailand signed on November 5, 1981.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan, will undertake the Study in close cooperation with the authorities concerned of Thailand.

The present document sets forth the Scope of Work with regard to the Study.

II. OBJECTIVES OF THE STUDY

The objectives of the Study are;

1. to formulate the integrated agriculture and water resources development plan of the Menam Chumphon Basin.
2. to conduct a feasibility study on selected priority project(s).
3. to undertake on-the-job training of the Government's officials in the course of the study.

III. STUDY AREA

The study area is to cover approximately 2,700 km^2
(Location map attached in Annex 2)

IV. SCOPE OF THE STUDY

In order to achieve the above objectives, the Study will cover the following items.

PHASE I STUDY

1. Collection and analysis of the relevant existing data and information, and field survey including:

(1)Natural condition
   a. Topography
   b. Meteorology and hydrology
   c. Geology and soil
   d. Others
(2)Agriculture
   a. Land use and tenure
   b. Cropping pattern and yield
   c. Agro-economy and institution
   d. Others
(3)Agricultural infrastructure
   a. Irrigation and drainage
   b. Farm road
   c. Other rural infrastructure
(4)Socio-economic situation
   a. Population, household and farmers
   b. Regional socio-economy and farm household economy
   c. Extension services
   d. Social and farmer's organizations
   e. Agricultural credit
   f. Farmer's intention
   g. Others
(5)Other information related to the project
   a. Administrative organizations related to the project
   b. Environmental impact
   c. Others

2. Review of existing agricultural plan, water resources development plan and flood control plan.

3. Formulation of an integrated agriculture and water resources development plan of the Menam Chumphon Basin.

PHASE II STUDY

1.Feasibility Study on priority project(s) based on the results of the Phase I Study

The Study covers the following items;

(1) Additional field survey, data collection and analysis including;
   a. Hydrology and meteorology
   b. Geology and soil classification
   c. Land use and tenure
   d. Cropping pattern and yield
   e. Irrigation and drainage
   f. Inundation problem, flood damage
   g. Water requirement for crop and domestic use
   h. Regional socio-economy and farm household economy

i. Social and farmer's organizations
j. Construction materials
k. Environment
l. Others

(2) Formulation of an agricultural development plan.
(3) Formulation of irrigation and drainage development plan (including flood control for agricultural lands).
(4) Preliminary design of the major structures of the project.
(5) Formulation of the operation and maintenance plan of irrigation and drainage.
(6) Preparation of the implementation schedule.
(7) Estimate of the project costs and benefits.
(8) Recommendation .

V. THE STUDY SCHEDULE

The Study will be carried out in accordance with the tentative schedule attached in Annex 1.

VI. REPORTS

JICA will prepare and submit the following reports in English to the Government of the Kingdom of Thailand.

1. Inception Report
   Thirty (30) copies at the commencement of the Phase I Study.
2. Progress Report(I)
   Thirty (30) copies at the end of the field work of the Phase I Study.
3. Interim Report
   Thirty (30) copies at the commencement of the Phase II Study.
4. Progress Report(II)
   Thirty (30) copies at the end of the field work of the Phase II Study.
5. Draft Final Report
   Thirty (30) copies within one (1) month after the end of the Phase II Study.
   The Government of the Kingdom of Thailand shall provide its comments on the Draft Final Report within one (1) month after its reception.
6. Final Report
   One hundred (100) copies within two (2) months after the receipt of the comments on the Draft Final Report.

VII. UNDERTAKING OF THE GOVERNMENT OF THE KINGDOM OF THAILAND

1. To facilitate smooth conduct of the Study, the Government of the Kingdom of Thailand shall take necessary measures;
   (1) to secure the safety of the Study Team,
   (2) to permit the members of the Japanese Study Team, to enter, leave and sojourn in Thailand for the duration of their assignment therein, and exempt them from alien registration requirements and consular fees,
   (3) to exempt the members of the Japanese study Team from taxes, duties, fees and other charges on equipment, machinery and other materials brought into Thailand for the conduct of the Study,
   (4) to exempt the members of the Japanese Study Team from income tax and other charges of any kind imposed on or in connection with any emoluments or allowance paid to the members of the Japanese Study Team for their services in connection with the implementation of the Study,
   (5) to provide necessary facilities to the Japanese Study Team for remittances as well as utilization of the funds introduced into Thailand from Japan in connection with the implementation of the Study,
   (6) to secure permission for entry into private properties or restricted areas for the conduct of the Study, according to prevailing regulations of the Government of the Kingdom of Thailand,
   (7) to secure permission to use all data and documents related to the Study in Japan,
   (8) to provide medical services as needed. Its expenses will be chargeable on the members of the Japanese Study Team.

2. The Government of the Kingdom of Thailand will bear claims, if any arises, against the members of the Japanese Study Team resulting from, occuring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Japanese Study Team.

3. Royal Irrigation Department, Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID") shall act as counterpart agency to the Japanese Study Team and also as coordinating body in relation with other governmental and non-governmental organization concerned for the smooth implementation of the Study.

4. RID shall, at its own expense, provide the Japanese Study Team with the following, in cooperation with other agencies concerned, if necessary:
   (1) Available data and information related to the Study
   (2) Counterpart personnel
   (3) Suitable office with necessary equipment and furniture
   (4) Necessary number of vehicles with drivers
   (5) Credentials or identification cards to the members of the Japanese Study Team
   (6) Supplementary engineering survey
      a. topographic survey
      b. geological survey
      c. soil analysis

VIII. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures;

1. To dispatch, at its own expense, the Study Team to Thailand,
2. To persue technology transfer to the Thai counterpart personnel in the course of the Study.

IX. OTHERS

JICA and RID shall consult with each other in respect of any matter that may arise from or in connection with the Study.

J. MC
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TENTATIVE SCHEDULE

Item \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WORK IN THAILAND		▬	▬	▬					▬	▬	▬	▬			▬	O		
WORK IN JAPAN	▭					▭	▭	▭	▭				▭	▭				
REPORTS	△			△					△			△			△			△
	INC/R			P/R (I)					INT/R			P/R (II)			DF/R			F/R

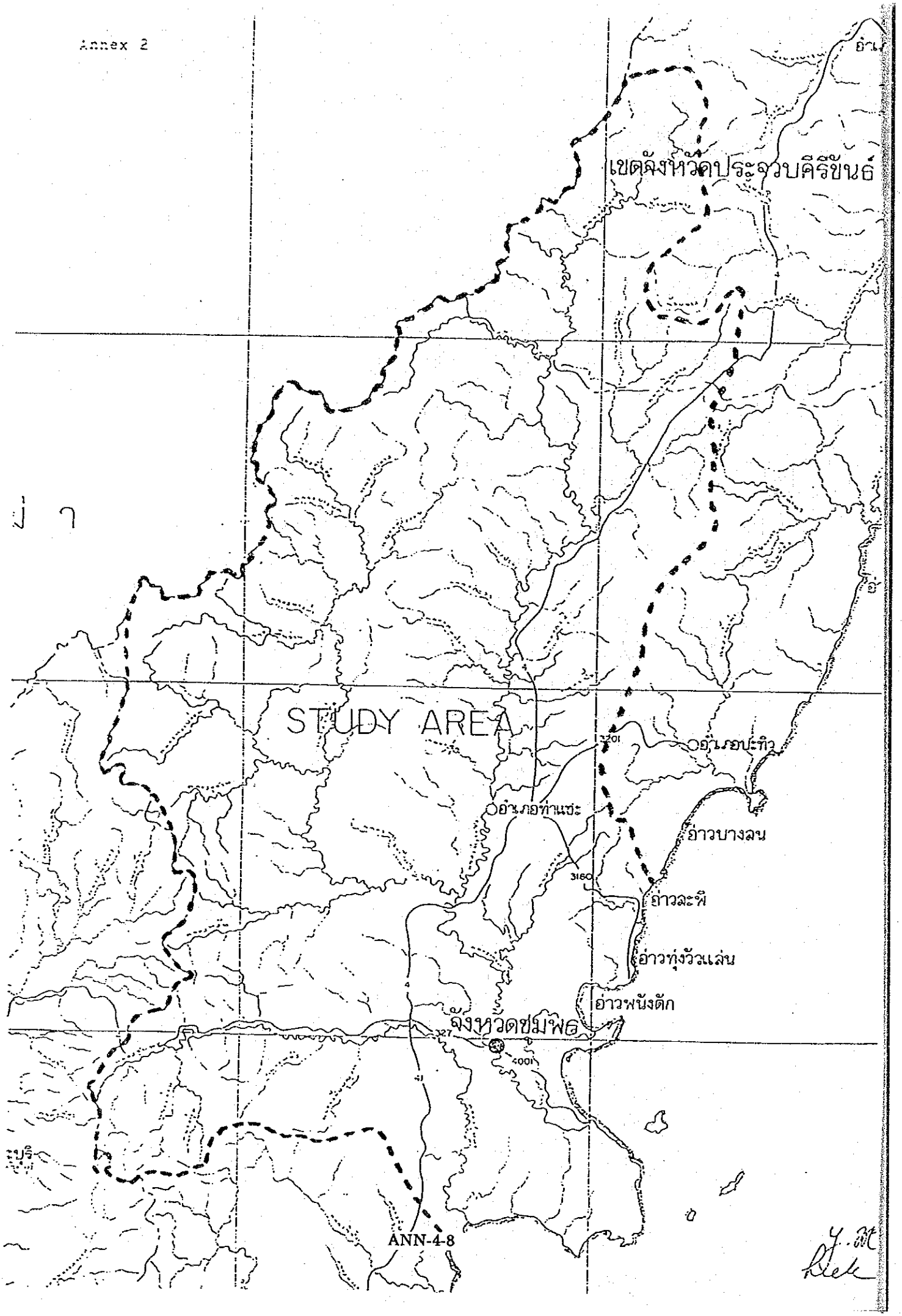
(Remarks) INC/R : Inception Report P/R : Progress Report

INT/R : Interim Report DF/R : Draft Final Report

F/R : Final Report

O Comments on DF/R by Thai side

Annex 2


เขตจังหวัดประจวบคีรีขันธ์
STUDY AREA
อำเภอปะทิว
อำเภอท่าแซะ
อ่าวบางลน
อ่าวละพิ
อ่าวทุ่งวัวแล่น
อ่าวพนังตัก
จังหวัดชุมพร
3201
3160
4001
327
41

MINUTES OF MEETING

THE FEASIBILITY STUDY

ON

THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT

PROJECT OF THE MENAM CHUMPHON BASIN

BANGKOK, MARCH 22, 1991

LECK JINDASANGUAN
DIRECTOR GENERAL,
ROYAL IRRIGATION DEPARTMENT,
MINISTRY OF AGRICULTURE AND
COOPERATIVES

YOSHIKAZU MATSUURA
LEADER,
THE PRELIMINARY STUDY TEAM,
THE JAPAN INTERNATIONAL
COOPERATION AGENCY

The Preliminary Study Team for the Feasibility Study on the Integrated Agriculture and Water Resources Development Project of the Menam Chumphon (hereinafter referred to as "the Study"), headed by Mr. Yoshikazu Matsuura and organized by the Japan International Cooperation Agency (hereinafter referred to as "JICA"), visited Thailand from 14 March 1991 to 23 March 1991 in order to clarify the request further made by the Government of the Kingdom of Thailand, and to discuss the draft Scope of Work for the Study proposed by the Team.

Both sides exchanged views and had a series of discussions with the officials of Royal Irrigation Department, Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID") and conducted a field survey in the study area.

As a result of discussions, both sides came to an agreement on the Scope of Work, which was signed and exchanged on March 22, 1991 (The list of officials attending the discussion is attached in Annex).

The salient results of the discussions are as follows;

1. Both sides agreed that medium scale dam shall be studied in the Study, if necessary, for the purpose of flood control for agricultural lands and irrigation.

2. RID requested that, in undertaking the study of flood control for agricultural lands, due consideration shall be paid to the situation of co-existence of agricultural lands and public facilities including private houses; and also the possibility of installation of sand sedimentation prevention works at the Tha Tapao River Mouth for securing flood discharge capacity.
   Japanese side took note of such request.

3. Both sides confirmed that RID shall prepare necessary information on the environmental aspects of the project(s), if necessary, both in Phase I and Phase II of the Study, and that Japanese side shall mention about the environmental survey in the Final Report, at the same level of 5-3 Environmental impact Evaluation, Chapter 5 Project Implementation, the Feasibility Study on the Agricultural Water Resources Development Project of Bang Pakong River Basin.

4. Both sides confirmed that RID shall undertake following field surveys and analysis in connection with the Study:

   (1) Topographic mapping (scale : 1:15,000)
   at several potential major structure sites and areas concerned for Phase I Study

   (2) Topographic mapping (scale : 1:10,000) of selected project area(s) and topographic survey (scale : 1:4,000) at selected major structure sites for Phase II Study

(3) Boring at selected major structure sites and other geological surveys for Phase II Study

5. RID requested the Japanese side to provide the following equipment for the implementation of the Study.

(1). Water quality field kit (Portable)
4 parameters can be measured, namely PH, DO, EC, Temp.

(2). Current meter (Portable)
Range of flow velocity (0.30 - 5 m/sec)
probably with changeable propeller and adjustable weight.

Japanese side took note of such request.

Y. M
Leek

ANNEX

LIST OF PARTICIPANTS

RID official

1. Mr. Leck Jindasanguan	Director General
2. Dr. Boonyok Vadhanaphuti	Senior Expert for Water Resources Planning & Development
3. Mr. Prida Wongdoiwang	Director of Regional Irrigation Office 11
4. Mr. Suthi Songvoravit	Chief of Project Planning Section 1
5. Dr. Siripong Hungspreug	Project Planning Division
6. Mr. Thanar Suwattana	Counterpart Engineer
7. Mr. Ronnapop Pipatboonyarat	Counterpart Engineer
8. Mr. Hideshiro KIKUCHI	JICA Expert

The Preliminary Study Team

1. Mr. Yoshikazu MATSUURA	Leader
2. Mr. Katsumi OTANI	Coordinator
3. Mr. Junichiro SOMEI	Agriculture
4. Mr. Kiyoshi SEKINE	Irrigation & Drainage

MINUTES OF MEETING

THE FEASIBILITY STUDY
ON
THE INTEGRATED AGRICULTURE
AND
WATER RESOURCES DEVELOPMENT PROJECT
OF
THE MENAM CHUMPHON BASIN

AGREED UPON BETWEEN
ROYAL IRRIGATION DEPARTMENT
AND
JICA STUDY TEAM

In accordance with the Scope of Work for the Feasibility Study on the Integrated Agriculture and Water Resources Development Project of the Menam Chumphon Basin agreed upon between Royal Irrigation Department, Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") dated March 22, 1991, JICA dispatched to Thailand the Study Team headed by Mr.Kunio OTA and the Advisory Committee for the study headed by Mr.Junichiro SOMEI on October 23, 1991.

30 Copies of the Inception Report were submitted to RID through JICA. Both sides exchanged views and had a series of discussions with the officials of RID headed by Mr.Maitri Poolsup, Director of Project Planning Division, on the study of the Integrated Agriculture and Water Resources Development Project of the Menam Chumpon Basin.

As a result of discussions, both sides came to an agreement on the Inception Report (The list of officials attending the discussions is attached in Annex). The salient results of the discussions are as follows :

1. RID accepted the content of the Inception Report as explained by the Team Leader of the JICA Study Team.

2. RID officials, however, requested 2 large-scale dams of Tha Sae and Rap Ro should be included in the Phase 2 (Feasibility-Study) of this project. The JICA Study Team insisted that this request for study on these 2 large-scale dams will be covered in a review-study in Phase 1 but excluded from the Feasibility-Study in Phase 2 as agreed between both governments in the Minutes of Meeting on 22 March, 1991.

3. Both sides, RID and the JICA Study Team, agreed to mutually cooperate for a fruitful study for this project.

Maitri Poolsup

J. S

BANGKOK
October 25, 1991

Maitri Poolsup

MAITRI POOLSUP
DIRECTOR,
PROJECT PLANNING DIVISION,
ROYAL IRRIGATION DEPARTMENT

KUNIO OTA
LEADER,
STUDY TEAM,
THE JAPAN INTERNATIONAL
COOPERATION AGENCY

WITNESS

J. Somei

JUNICHIRO SOMEI
ADVISORY COMMITTEE
FOR THE STUDY
THE JAPAN INTERNATIONAL
COOPERATION AGENCY

LIST OF PARTICIPANTS

RID Official

1. Mr.Maitri Poolsup	Director of Project Planning Division
2. Mr.Suthi Songvoravit	Chief of Project Planning Section 1
3. Mr.Samart Chokkanapitark	Chief of Engineering Branch Irrigation Office 11
4. Mr.Siripong Sholsiripunlert	PPD Engineer
5. Mr.Thanar Suwattana	Civil Engineer PPD 1
6. Mr.Nattavuth Watananusan	Civil Engineer PPD 1
7. Mr.Yukihiro NAGASAWA	Colombo Plan Expert

JICA

(Advisory Committee for the Study)

1. Mr.Junichiro SOMEI	Member, Advisory Committee
2. Mr.Katsumi OTANI	Coordinator

(Study Team)

1. Mr.Kunio OTA	Leader/Disaster Prevention
2. Mr.Yoshiteru TSUNODA	Irrigation and Drainage
3. Mr.Hiroshi OGURA	Meteorology and Hydrology
4. Mr.Bogo ABE	Agro-economy and Project Evaluation

Maitri Poolsup

J. S

MINUTES OF DISCUSSIONS

THE FEASIBILITY STUDY
ON
THE INTEGRATED AGRICULTURE
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OF
THE MENAM CHUMPHON BASIN

AGREED UPON BETWEEN

ROYAL IRRIGATION DEPARTMENT

AND

JICA STUDY TEAM

In accordance with the Scope of Work for the Feasibility Study on the Integrated Agriculture and Water Resources Development Project of the Menam Chumphon Basin agreed upon between Royal Irrigation Department, Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") dated March 22, 1991, 30 copies of the Progress Report (I) were submitted to RID through JICA.

A series of discussions was made between the JICA Study Team headed by Mr. Kunio OTA and the Working Group of RID for this project headed by Mr. Kicha Polpasi, Deputy Director General for Technics. As a result of discussions, both sides came to an agreement on the Progress Report (I); the list of officials attending the discussions is attached in Annex. The Salient results of the discussions are as follows:

1. RID accepted the contents of the Progress Report (I).

2. The scoring criteria for evaluation of possible reservoir sites shall be reconsidered so as to include a parameter regarding the Government policy on land use, i.e. national reserve forest, wildlife sanctuary area, etc. The ranking of possible reservoir sites, therefore, might be changed.

3. In consideration of strong request made by the local government of Chumphon province for the urgent implementation of two reservoirs of Tha Sae and Rap Ro, RID requested the JICA Study Team to convey RID's wishes to JICA to undertake the feasibility study of these two reservoirs by the JICA Study Team in the Phase II study.

Maitri Poolsup

4. For the survey on environmental assessments, RID will provide the JICA Study Team with initial basic information for the project implementation according to the minutes of meeting for this study agreed upon between RID and JICA on March 22, 1991; however, it is not necessary to be at the same level of the feasibility study on the agricultural water resources development project at Bang Pakong river basin.

5. The JICA Study Team agreed to consider these comments and to convey to JICA the request from RID for the feasibility study of two reservoirs, Tha Sae and Rap Ro, to be included in the Phase II Study.

Bangkok
January 31, 1992

Maitri Poolsup

MAITRI POOLSUP
Assistant Leader of
Working Group,
Director of Project
Planning Division,
Royal Irrigation Department

K. Ota

KUNIO OTA
Leader of the Study Team,
Japan International
Cooperation Agency

LIST OF PARTICIPANTS

RID Officials

1.	Mr. Maitri Poolsup	Assistant leader of Working Group Director of Planning Division (PPD)
2.	Mr. Suksan Pocharassaengkul	Data Processing Division
3.	Mr. Thera Wongsamuth	Chief of Engineering Section, Medium Scale Project Construction Division
4.	Mr. Osot Charnvej	Agronomist, Operation and Maintenance Division (OMD)
5.	Mr. Manus Kumnoedmanee	Program and Budget Division
6.	Mr. Danai Triyadhen	Chief of Land Classification Section, Geo-Technical Division (GTD)
7.	Mr. Mondhien Kangsastiam	Chief of Research and Labolatory Division
8.	Mr. Narong Sopak	Survey Division
9.	Mr. Arthon Chatchawansaisin	Hydrology Division
10.	Mr. Samart Chokkanapitark	Chief of Engineering Section, Region 11
11.	Mr. Kitla Thepalagleka	Chief of Section 2, PPD
12.	Mr. Vudhichai Chulakesa	Chief of Section 3, PPD
13.	Ms. Supa Sing-intara	Chief of Economic Section, PPD
14.	Mr. Triphan Mekjaroon	Chief of Environmental Section, PPD
15.	Mr. Suthi Songvoravit	Secretary of Working Group Chief of Section 1, PPD
16.	Mr. Siripong Chonsiripanlert	Section 2, PPD
17.	Mr. Thanar Suwattana	Assistant Secretary Section 1, PPD

Maitri Poolsup

18.	Mr. Nattavuth Watananusan	Assistant Secretary Section 1, PPD
19.	Mr. Nopadon Sungsirin	Chief of Chumphon Province Office
20.	Mr. Sirivit Klinpukdee	Office Engineer of Chumphon Province Office
21.	Ms. Wannarattana Janyarungruang	GTD
22.	Mr. Charoon Roo-kheb	Section 1, PPD
23.	Mr. Tananchai Tamapirom	Section 3, PPD
24.	Mr. Supote Rujirakul	Section 3, PPD
25.	Mr. Prapas Sriwilai	Program and Budget Division
26.	Mr. Suvej Kitchakarn	Section 1, PPD
27.	Ms. Chawee Wongprasitiporn	Section 1, PPD
28.	Mr. Charoon Dookhob	Section 1, PPD

Colombo Plan Expert

1.	Mr. Hideshiro KIKUCHI	Advisor to PPD

JICA Study Team

1.	Mr. Kunio OTA	Team Leader
2.	Mr. Yoshiteru TUNODA	Irrigation and Drainage
3.	Mr. Masaharu INOUE	Soil and Land Use
4.	Dr. Kumpol Puapanichya	Agriculture
5.	Mr. Bogo ABE	Agro-economy and Project Evaluation

Maitri Poolsuppa

MINUTES OF MEETING

THE FEASIBILITY STUDY
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AGREED UPON BETWEEN
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In accordance with the Scope of Work for the Feasibility Study on the Integrated Agriculture and Water Resources Development Project of the Menam Chumphon Basin (hereinafter referred to as "the Study") agreed upon between Royal Irrigation Department, Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") signed on March 22,1991, JICA dispatched to Thailand a study team for the Phase II Study headed by Mr. Kunio OTA on June 1, 1992, and submitted to RID 30 copies of the Interim Report.

The Study Team had a series of discussions and exchanged views on the Interim Report of the Study with the officials concerned of RID headed by Mr. Chamroon Chindasangan, Deputy Director General (A list of participants attended the discussions is attached in Annex).

The salient results of the discussions are as follows:

(1) RID, in general, accepted the contents of the Interim Report main issues of which are integrated agriculture and water resources development plan and the selection of priority project.

(2) Main components of the Feasibility Study in Phase II proposed by the Stydy Team are the improvement works of the Tha Taphao river and the integrated agricultural development of the priority project area.

RID accepted, in principle, its basic concept with the following comments,of which the Study Team took notes :

1) Tributaries of the Tha Taphao river are to be considered for the formulation of drainage plan.

Since improvement and maintenance of the coastal areas is under the control of the Harbour Department, it is not recommendable to include studies on sedimentation prevention works at the river-mouth.

2) Regarding the Chumphon river, although the studies on improvement works of this river are not included in the Feasibility Stydy, the necessity of these studies is to be mentioned in the Final Report.

3) It was reconfirmed that new canal works, which are to be planned in the priority project, will have dual functions of drainage and irrigation.

BANGKOK
June 5, 1992

CHAMROON CHINDASANGUAN
DEPUTY DIRECTOR GENERAL
ROYAL IRRIGATION DEPARTMENT

KUNIO OTA
LEADER OF THE STUDY TEAM
JAPAN INTERANTIONAL
COOPERATION AGENCY

WITNESS

YOSHIKAZU MATSUURA
CHAIRMAN OF ADVISORY COMMITTEE,
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex : List of Participants

(1) RID OFFICIALS

1. MR. CHAMROON CHINDASANGUAN, Deputy Director General
2. MR. KITLA THEPALAGLEKHA, Acting Director, PPD
3. MR. SUWIT THANOPANUWAT, Acting Chief, PPD-1
4. MR. THANAR SUWATTANA, Civil Engineer 6, PPD

(2) JICA ADVISORY COMMITTEE

1. MR. YOSHIKAZU MATSUURA, Chairman of Advisory Committee
2. MR. NORIO MATSUDA, Project Coordinator

(3) JICA STUDY TEAM

1. MR. KUNIO OTA, Leader
2. MR. YOSHITERU TSUNODA, Sub-Leader
3. MR. BOGO ABE, Member in charge of Socio-Economy
4. MR. KENJI MOCHIDA, Member in charge of Design and Cost Estimate

MINUTES OF MEETING

THE FEASIBILITY STUDY
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Both sides exchanged views and had a series of discussions with the officials of RID headed by Mr. Chamroon Chindasanguan, Deputy Director General of RID, on the study of field work in Thailand of Phase II Study (List of participants is attached in Annex). As a result of discussions, both sides came to an agreement on the Progress Report (II). The salient results of the discussions are as follows:

1. Regarding Nong Yai irrigation area, RID considers two irrigation blocks of D and F located on elevated lands to be costly for pumping irrigation, and, if these lands are cropped with tree crops, careful consideration will be needed. The JICA study team explained that according to field reconnaissance survey on present land use, major parts of the two blocks are being used as mixed orchard and have been proposed to be included in the project. Results of land suitability analysis will be presented in the Final Report.

2. RID has proposed to increase the discharge capacity of Sam Kaeo canal by shortcut of the meandering portions and excavation of the canal beds, not by widening of the canal. The proposed route of the downstream reach of Sam Kaeo canal has been fixed by RID, and RID provided the JICA study team with drawings and related data of the proposed route.

3. The design discharge of Phanang Tuk canal is estimated at 800 cu.m/sec for the lower reach of the canal, and is released to the sea through provision of flooding areas. RID requested the JICA study team to present hydraulic dimensions of this canal in time of flooding. Hydraulic data on flood release of the lower reach of this canal will be presented in the Final Report.

4. The improvement of Chumphon river and Nang Sai river will be mentioned in the Final Report, when it is deemed necessary.

5. The institutional development plan of the Nong Yai Integrated Agriculture Development Project including farmer's groups will be proposed in the Final Report.

6. Further data and information concerning engineering works especially for irrigation facilities will be presented in the Final Report.