3. 4. 4 Supporting Services for Agriculture Development

Data from the farm survey indicate farmers' inquiry for a more effective support system to their agricultural production conditions. In the present local governmental organization, the Agricultural Extension Office in each Amphoe has conducted support services with the cooperation of an agricultural officer at Tambon level. This cooperation, in fact, is very loose. In order to successfully implement the proposed integrated agriculture development, following support services are proposed to be carried out, starting from the priority project area for expanding over the whole Chumphon basin. Table 3-1 presents proposed organization for supporting services.

The extension agent in the Tambon shall get information and techniques from the Agricultural Extension Office at Amphoe and transfer them to local farmers. In order to verify proposed crops in the agriculture development plan, the Agricultural Extension Office shall carry out the test-plantation in the proper places i.e. pilot farms to demonstrate corresponding techniques to farmers.

The Agricultural Extension Office shall prepare enough seed-plants of proposed crops to deliver to subjected farmers through the Agricultural Extension Officer in the Tambon. Regarding fertilizers and pesticides to be used for the proposed crops; if not available or insufficient at local markets, the Agricultural Extension Office shall request these supplies from Central Government with supporting advice from the Provincial Governor.

Institutional farm credits shall be given to farmers engaged in the agricultural development plan at the same time as the project-start. The Agricultural Extension Office shall recommend farmers for this credit to the Bank for Agriculture and Agricultural Cooperatives (BAAC) that provides loans to farmers for annual agricultural production expenses and investment in agricultural assets. The Agricultural Extension Office will help farmers to prepare their production plan, cost estimate and loan repayment plan.

Farmers' professional groups at Tambon level are recommend to be formed in order to strengthen farming techniques and to protect marketing profitabilities: 1) fruit farmer's group, 2) vegetable farmer's group, and 3) livestock farmer's. At the beginning of the project, farmer's groups will be

organized at the village level, and it is expected that farmer's groups will be reorganized to farmer institutions at the Amphoe level. Establishment of a water user's organization is recommended for water management at the on-farm level according to the proposed cropping plan.

3.5 IRRIGATION DEVELOPMENT

3.5.1 General

Of 118 thousand ha of total farm lands, 54 percent of farm lands are cropped to tree crops: 20 percent to fruit trees, 13 percent to paddy and 13 percent to vegetables and field crops. Only 15 percent of farm lands are being irrigated with the existing irrigation projects. Agriculture of 85 percent of farm lands is operated under rainfed conditions and the productivity of agriculture is low due to erratic rainfall that fluctuates seasonally and yearly.

Water resources to be developed will firstly be supplied for irrigation of paddy and cash crops such as fruits, field crops and vegetables with high economic returns. Increase in paddy production is proposed though stabilization of rainy season paddy cropping and introduction of dry season paddy cropping, as the production of paddy in the Study Area is less than local consumption demands. Water requirement estimates of crops at the on-farm level are as summarized below. In addition to dry season irrigation, even in the rainy season supplemental water supply is necessary for successful production of paddy, field crops, and vegetables.

FIELD WATER REQUIREMENT

(unit: mm)

Crop	Paddy	Field Crop Vegetable	Fruit
Rainy Season			
- Water requirement	1,049	937	749
- Effective rainfall	855	838	749
- Irrigation water	194	99	-
Dry Season			
- Water requirement	909	738	590
- Effective rainfall	281	304	304
- Irrigation water	628	434	281
Annual Irrigation Water	822	533	281

Water resources development in the Study Area requires some form of regulation of free-flowing water resources and artificial storage. Run-of-river scheme to divert free-flowing water is not practicable, because in the dry season river flow sharply decreases and there is no surplus flow making allowance for river maintenance flow requirements. Accordingly, water resources development will be proposed by means of water storage.

Proposed irrigation projects will provide reservoirs and irrigation water supply systems down to 50 ha, and on-farm facilities. RID will be in charge of the operation and maintenance of main irrigation facilities. On-farm water management will be made by water user's associations to be organized by farmers.

Irrigation will be accomplished by surface methods: 24 hours of continuous flooding for paddy, furrow irrigation for field crops and vegetables. For fruit trees, surface irrigation with portable pumps and pipes is proposed as irrigation water is applied infrequently for fruit trees. A few farmers employ sprinkler and trickle irrigation systems for high value crops; however, in this project, irrigation by sprinkler and trickle systems is expected to be introduced when farmers have became skillful at irrigated agriculture.

3. 5. 2 Irrigation Water Requirement

Based on the proposed cropping calendars as shown in Figure 3 - 1, irrigation water requirements are calculated. The crop consumptive use (Cu) is estimated by the Modified Penman Method as $Cu = Kc \times ETo$, where Kc is crop factors and ETo is evapotraspiration. Crop factors are derived from the report prepared by the Operation and Maintenance Division, RID in 1990. Evapotranspiration is calculated by the computer program prepared by the Project Planning Division, RID, based on the meteorological data for 30 years from 1961 to 1990 observed at Amphoe Muang Chumphon.

For paddy, water for deep percolation, nursery beds and land preparation is required. The deep percolation through paddy field is estimated at 1 mm/day on average throughout the irrigation period. Nursery beds will be prepared 30 days prior to transplantation of paddy to main fields. The water requirement for nursery beds includes those for land soaking, maintaining

standing water and supplying evaporation and percolation losses. It is assumed that 400 mm of water is required during the entire nursery period covering the nursery bed area (equivalent to 4 percent of transplanting area) for storage scheme. 270 mm of water is needed for land preparation; 200 mm for land saturation and ploughing at the initial stage, and an additional 70 mm to provide standing water at the final stage.

For upland crop fields, pre-irrigation is required for dry season field crop growing during the period of land preparation for sowing in order to replenish the end-of-season water depletion. The pre-irrigation water requirement is estimated at 50 mm for the total area of dry season field crop cultivation.

Not all of the rainfall covering the irrigation area is effective. The amount of rainfall that can be considered effective will depend upon many factors such as rainfall intensity, field storage capacity, water requirement, irrigation method, etc. The average rainfall in Amphoe Chumphon is used as the representative for the total project area and 75 percent of the monthly rainfall is taken as effective rainfall.

Irrigation efficiency is composed of field efficiency, conveyance efficiency of irrigation canal and operation efficiency of irrigation facilities. The main and lateral canals will be lined with concrete but earth canals be applied for the on-farm facilities. The water management will be conducted by RID and water user's group.

In this study, the irrigation efficiency of 55 percents is applied for paddy field and 50 percents, for other crop fields as shown below.

IRRIGATION EFFICIENCY

Item	Paddy	Other Crops
Field Application	0.70	0.60
Conveyance	0.90	0.90
Operation	0.90	0.90
Overall	0.55	0.50

Irrigation water requirements, or diversion requirements at the reservoir are calculated for the proposed 5 cropping patterns in which effective rainfall is considered, as given below:

PROPOSED IRRIGATION REQUIREMENTS

(unit: MCM/1,000 ha)

Month	R. Paddy	R. Paddy + D. Paddy	R. Paddy + D. Field Crop	Field Crop Vegetable	Fruit
Jan.	1.32	1.32	1.32	1.30	0.76
Feb.	-	-	-	1.81	1.26
Mar.	-	5.37	-	2.56	1.88
Apr.	-	2.98	2.20	2.18	1.52
May	-	1.40	1.44	0.56	-
Jun.	-	-	-	0.31	-
Jul.	-	-	-	0.38	-
Aug.	-	-	-	0.33	-
Sep.	3.69	3.69	3.69	0.29	-
Oct.	-	-	-	0.14	-
Nov.	-	-	-	-	-
Dec.	1.86	1.86	1.86	0.81	0.29
Total	6.87	16.62	10.51	10.67	5.71

Notes: R : Rainy Season, D : Dry Season

3. 5. 3 Proposed Irrigable Area

The preliminary water resources development plan has identified the possibilities of developing 52 irrigation projects of the storage scheme : 3 multipurpose projects for irrigation, flood control and domestic / municipal water supply, 3 medium scale irrigation projects including domestic water supply, Nong Yai Swamp development project, and 45 small scale irrigation projects.

With the combined effective storage of about 303 MCM, 41,520 ha of farm land will be irrigable, or 35 percent of the existing farm land, as summarized below:

PROPOSED IRRIGABLE AREA

(unit: ha)

Project	Paddy Fields	Upland Crops & Vegetables	Fruits	Total
Tha Sae	4,490	5,120	250	9,860
Rap Ro	6,150	6,080	290	12,520
Upper Rap Ro	1,360	2,050	100	3,510
Sub - total	12,000	13,250	640	25,890
Upper Kum	-	-	1,100	1,100
Nam Ron	-	-	1,060	1,060
Kaphon	-	-	770	770
Sub - total	-	-	2,930	2,930
Nong Yai	630	40	530	1,200
Small Scale Programs	-	-	11,500	11,500
Sub-Total	630	40	12,030	12,700
Total	12,630	13,290	15,600	41,520

3.6 DISASTER PREVENTION OF FARM LAND

3.6.1 Flood Control

(1) General

The frequent occurrence of floods from the Tha Tapaho river causes substantial damage to crops, farm lands, public facilities and other infrastructure in the low-lying areas along the river including the municipality of Chumphon. The increase in population and property values in flood-threatened lands has caused serious problem in recent years. The peak flood discharge of the Tha Taphao river occurred on November 5, 1989, and it was estimated by RID at 1,200 cu.m/sec at the X158 station, exceeding the safe channel capacity of the river of 430 cu.m/sec. According to the report of the provincial office of Chumphon, 24,000 ha of farm lands were inundated for 3 days, and damage to crops covering 17,800 ha was 841 million Baht.

The practicable measures of reducing flood damage of the Study Area are: (1) reduction of peak flood by reservoirs, (2) increase of discharge capacity by river improvement, and (3) diversion of flood water through floodways. According to the preliminary study of flood control, even if reservoirs are operated to store all flood inflow during flood periods, river improvement and/or construction of floodways are needed as there is a substantial local inflow

between dams and the control point, the head of the Tha Taphao river (or, X158 station).

(2) Design Flood

Flood control is a relative term as it is uneconomical to provide protection from the largest floods. Protection of crops and property, as well as the public benefits, must be evaluated in balancing the annual savings from flood control against construction and maintenance costs. As a rule, some risk must be accepted in the selection of a design flood discharge.

The scale of the proposed dams has been decided with a practicable maximum dam height. Requirements for flood control conflict to some extent with other objectives. The larger the flood space is, the smaller the regulated peak flood flow; however, irrigable area shall be reduced accordingly.

The water resources development plan of the Menam Chumphon basin contains proposals to construct 3 multipurpose reservoirs for water supply and flood control: Tha Sae, Rap Ro and Upper Rap Ro. In order to determine reasonable flood control storage of the multipurpose reservoirs, preparatory economic evaluation of alternative cases with different flood control storage was made by the benefit-cost ratio method at a discount rate of 10 percent. In the alternative cases, flood control storages are predetermined based on the ratios to the total volume of flood water with the different return periods from 20 to 50 years. Flood control storages are expressed in terms of the ratio of flood control storage to the total volume of flood water into the reservoirs.

The project costs include costs for construction of dams, river system improvement, floodways, irrigation systems, and operation and maintenance of the project. Project benefits will be generated from irrigation and savings of annual flood damage. The construction period is assumed to be 3 years from 1994 to 1996 for river improvement and floodways, and 5 years from 1997 to 2001 for the multipurpose reservoirs of Tha Sae and Rap Ro. The economic evaluation suggests that the reservoir with the flood control storage equivalent to 50 percent of the total volume of flood flow will give the highest economic benefit-cost ratio.

In order to determine the magnitude of design flood, the same economic evaluation is also applied to alternative cases with different return periods of 20 to 50 years, in which the flood control storage is determined as 50 percent of the respective design flood inflow. As the flood magnitude increases, the irrigable area decreases from 28,500 ha to 22,200 ha as summarized below:

FLOOD SCALE AND IRRIGABLE AREA

Return Period (year)	Flood Control Storage (MCM)		Flood at X158 (cu.m/sec)	Irrigable Area (ha)
	Rap Ro Re.	Tha Sae Re.		
20	109.8	43.5	1,060	28,500
30	120.1	47.6	1,150	25,900
40	127.5	50.2	1,210	24,000
50	133.5	52.9	1,270	22,200

Re.: Reservoir

As the result of the economic evaluation, the water resources development plan proposes to apply the design flood with the return period of 30 years, which brings about high economic returns, to flood control plan. With the provision of the designed flood control storages, the peak flood discharge with the return period of 30 years of the Tha Tapaho river will be reduced from 1,510 cu.m/sec to 1,150 cu.m/sec.

In addition, another alternative study implies that the multipurpose projects such as the Rap Ro and Tha Sae reservoirs will be able to irrigate approximately 48,500 ha of farmland, if the all storage capacities for flood control in those reservoirs shift to ones for irrigation use. But, for flood mitigation of the Tha Taphao river system, the total 41 km of Tha Taphao river will need to be improved with a design discharge of 1,510 cu.m/sec (30-year frequency flood) enlarged from the present river capacities of 430 cu.m/sec for the upper and middle reaches and 350 cu.m/sec for the lower reaches.

3. 6. 2 Drainage Improvement of River Basin

(1) Tha Tapaho River Basin

The design flood discharge of the Tha Taphao river has been decided at 1,150 cu.m/sec, whereas the present safe channel capacities of the river are 430 cu.m/sec for the upper to middle reaches and 350 cu.m/sec for the lower reaches.

RID has formulated the urgent drainage improvement plan of the Tha Taphao river basin, including the construction of a Hua Wang-Phanang Tuk canal and the rehabilitation of the Sam Kaeo canal. In consideration of the progress of RID projects, the following drainage improvement plan of the Tha Taphao river system has been proposed (details of the project are presented in Chapter 5.3):

DRAINAGE IMPROVEMENT PLAN

River and Canal	Discharge (cu.m/sec)	Length (m)
(1) River Improvement		
- Tha Taphao river	880 - 350	34.3
- Phanang Tuk river	800	6.2
- Nong Sai river	50	8.0
(2) Rehabilitation of Sam Kaeo Canal	260	4.8
(3) Construction of Canal		
- Pak Phraek canal	270	5.5
- Hua Wang-Phanang Tuk canal	270 - 540	4.5

(2) Khlong Chumphon Basin

The Khlong Chumphon, with a catchment area of 449 sq.km, originates in the mountain areas about 30 km west of the municipality of Chumphon. The river runs eastwards and turns its direction to the south near the municipality of Chumphon finally to drain into the sea. The total length of the river is 65 km. The peak flood may not occur at the same time of the peak flood of the Tha Tapaho river because of the shorter arrival time of flood from the Khlong Chumphon basin to the city.

There is no possibility of constructing a large scale reservoir in the river basin of the Khlong Chumphon. The flood mitigation of the river must be based on river improvement. The proposed design discharge of the river is 345 cu.m/sec, which is probable peak flood discharge with a return period of 10 years.

The flood water levels of the river were calculated by solving the non-uniform flow of the design flood of 345 cu.m/sec starting from the river mouth at the mean sea level (- 0.06 m MSL). The river needs levees constructed for a distance of about 40 km from the river mouth for flood prevention. The early implementation of a feasibility study of water resources development of the Khlong Chumphon basin is expected for the promotion of integrated agriculture in the basin.

3.7 WATER RESOURCES DEVELOPMENT

3.7.1 Previous Study

(1) Feasibility Study of Rub Roh Project (NEA)

a) Project Summary

The feasibility study report of the Rub Roh project was prepared in September, 1982 by the National Energy Administration, Ministry of Science, Technology and Energy (NEA). The Rub Roh project is a multipurpose development project for hydropower generation, irrigation and flood control. By the construction of 2 main dams (Kaeng Phra Chao and Khlong Mala) and 3 saddle dams, the project proposes to build a combined reservoir with a gross storage capacity of 1,226 million cubic meter (MCM). The summaries of the combined reservoir and main dams are given below;

COMBINED KHLONG MALA AND RUB ROH RESERVOIR

Total Catchment Area	:	520 sq.km
High Water Level (HWL)	:	110.0 m (MSL)
Low Water Level (LWL)	:	100.5 m (MSL)
Gross Storage Capacity at HWL	:	1,226 MCM
Dead Storage Capacity at LWL	:	610 MCM
Effective Storage Capacity	:	616 MCM
Reservoir Surface Area at HWL	:	80 sq.km

MAIN DAMS

Item	Kaeng Phra Chao	Khlong Mala
Dam Type	Rockfill	Rockfill
Dam Height	54.0 m	70.0 m
Crest Elevation	115.0 m (MSL)	115.0 m (MSL)
Crest Length	225.0 m	396.0 m

With the effective storage of 616 MCM, the project would generate 26.4 MW for firm power, irrigate 90,687 rai (14,500 ha) of farm land by pumping, and prevent low-lying areas along Tha Tapho river from annual floods.

b) Flood Control

The flood control scheme of the Rub Roh project may be summarized as follows;

- With a flood control storage of 210 MCM, floods with a return period of not more than 1,000 years (total flood volume of 199 MCM) will be fully retained, and during flooding periods the reservoir will release a maximum 70 cu.m/sec of water through turbines generating peak power.

- Flood control through the reservoir was run for design floods which were synthesized from designed five-days of continuous rainfall. The estimated peak floods at points on the head of the Tha Tapao river and Phanang Tuk canal are given below;

ESTIMATED PEAK FLOODS

(Unit: cu.m/sec)

Control Point	Return Period (Year)					
	2	5	10	20	50	100
Tha Taphao River						
- Without project	607	1,010	1,299	1,580	1,975	2,277
- With project	445	615	769	922	1,087	1,240
Just Above Phanang Tuk Canal						
- Without project	448	744	960	1,124	1,403	1,617
- With project	361	547	682	782	908	1,054

c) Reservoir Area

About 8,000 ha (or 31,250 rai) of land is to be submerged when the Rub Roh project is implemented. The study report estimated the number of families living in the proposed reservoir area at about 200 as of February, 1982.

In 1985, a concession was granted to two private firms for oil palm plantation in and around the proposed reservoir area. In 1990, there were about 890 ha (or 5,560 rai) of concession lands and about 550 households in the proposed reservoir area, according to a report prepared by RID.

(2) Basic Data of Chumphon Basin Project (RID)

The report on basic data of Chumphon basin project was prepared in May, 1988 by Project Planning Division of RID. The report points out the following problems to be solved for the development of Chumphon basin: 1) Floods, 2) Seawater intrusion to coastal areas during periods of low freshwater flows, and 3) Drought due to lack of a water resources development project.

RID has a preliminary plan to construct two dams (Tha Sae and Rup Roh), of which the Rup Roh damsite is located close to the Rub Roh project proposed by NEA in 1982; however, detailed surveys have not yet been carried out. As a result of the study, the report has concluded the following;

- The main problems to be solved are floods in the Tha Taphao sub-basin and water shortages for agriculture during dry season.
- The implementation of the Rup Roh project may be hard because about 80 percent of the proposed area is occupied for agricultural use and there are about 400 households.
- For the improvement of drainage in the downstream area, priority is given to the Phanang Tuk - Sam Kaeo project.
- New irrigation development in the lower Tha Taphao sub-basin should provide regulators and drainage systems.

(3) Flood Protection and Water Resources Development Project in Chumphon Province (RID)

The report on flood protection and water resources development project in Chumphon province was prepared by Project Planning Division, RID in January, 1990 immediately after Typhoon Gay hit Chumphon province on November 4-6, 1989. RID has set forth a plan to improve flood conditions in the downstream areas and develop water resources for agriculture in Chumphon province. The plan is composed of a short term plan and a long term plan, of which the short term plan includes 1) dredging four natural streams, 2) dredging the Tha Taphao river, and 3) improvement of the Sam Kaeo canal embankment.

As a result of studies, the report recommends the implementation of the following five projects;

1) Construction of a Ban Huan Wang - Phanang Tuk canal,
2) Construction of a Sam Kaeo bypass canal and improvement of the Sam Kaeo regulator,
3) Improvement of the rivers of Tha Sae and Khlong Chumphon,
4) Establishment of hydrometeorological systems and a flood warning system, and
5) Implementation of Rap Ro and Tha Sae projects.

The Rap Ro project proposed by RID has a reservoir area of about 2,000 ha (or 12,250 rai), of which about 1,000 ha (or 6,100 rai) of land is under the control of the Agricultural Land Reform Office (ALRO) and the remaining land is within the wild animal reserve areas. There are about 300 households in the proposed reservoir area. The Tha Sae project proposed by RID has a reservoir area of about 900 ha, of which about 80 percent of land is under the control of ALRO and the remaining land is within the wild animal reserve. About 100 families are living in the proposed reservoir area.

3. 7. 2 Storage Scheme

(1) Selection of Reservoir Sites

a) Large to Medium Scale Reservoir

Flood control and water resources development for irrigation are a key issue for the integrated agricultural development of the Study Area, for which the construction of a reservoir may be one of the most effective engineering measures.

To select proposed reservoir sites, topographically possible reservoir sites were selected based on the topographic maps with the scale of 1 : 50,000 with a contour interval of 20 m. Reconnaissance field surveys were also made

by the study team, and as a result 10 sites were identified as possible reservoir sites from the viewpoint of topography and water resources engineering as summarized as follows:

POSSIBLE RESERVOIR SITES

River Basin	Number of Sites	Assumed Project Scale	
		Large	Medium
Tha Sae	1	1	-
Rap Ro	6	5	1
Chumphon	3	-	3
Total	10	6	4

Of 10 possible sites, 2 sites in the Rap Ro river basin were proposed in 1982 by NEA as large scale multipurpose projects; Kaeng Phra Chao and Ma La reservoir. From the results of reconnaissance field surveys, it was found that most land in the proposed reservoir area of Kaeng Phra Chao and Ma La has been used as agricultural land by a number of farmers and 2 private companies with concessions issued by the government. These 2 sites are screened out from the selection of proposed reservoir sites.

After field reconnaissance surveys were made to obtain firsthand information on the land use of reservoir areas, topography and geology of damsites and availability of construction materials, 8 possible reservoir sites have been evaluated with respect to: (1) water resources potentiality and storage capacity, (2) irrigable area, and (3) civil work including availability of construction materials nearby the damsites and geological conditions of damsites. The 8 sites have more or less the same potential for dam construction from the viewpoint of water resources and civil engineering; however, 2 reservoir sites of Phangan and Kum have not been selected as potential sites because most of the proposed reservoir area has been available for cropping and many farmers are living in the area; approximately 1,000 houses in Phangan and 200 houses in Kum. As a result, 6 sites have been selected as potential reservoir sites for water resources development of the Study Area, as summarized as follows:

POTENTIAL RESERVOIR SITES

Basin	Reservoir	Catchment Area (sq.km)	Assumed Max. Reservoir Capacity (MCM)	Assumed Project Scale
Tha Sae	Tha Sae	338	133	Large
Rap Ro	Rap Ro	503	192	〃
	Upper Rap Ro	106	144	〃
	Nam Ron	21	48	Medium
Chumphon	Upper Kum	16	36	〃
	Kaphon	15	25	〃
Total	6 sites	999	578	

The implementation of the Upper Rap Ro reservoirs is technically feasible, and the proposed reservoir area is mostly composed of forests with 100 to 200 houses, thereby, being selected as the potential reservoir for water resources development of the Menam Chumphon basin; however, the proposed damsite and reservoir area are located within a wildlife sanctuary. For the implementation of the Upper Rap Ro project, careful studies on environmental assessment are needed so as to meet approval for development activity. Under this situation, the priority of the implementation of Upper Rap Ro project will be given next to Rap Ro project.

b) Small Scale Reservoir

In addition to the above 6 reservoirs identified on the topographic maps with the scale of 1 : 50,000 and the contour interval of 20 m, there is a potential for developing small scale reservoirs because of the topography of the Study Area and relatively high rainfall. 45 small scale reservoirs might be constructed in the hilly areas exclusive of the catchment areas of the proposed 6 reservoirs, areas under the ALRO project and wildlife sanctuaries, which was assumed from the experience of the similar water resources development projects in Thailand.

SMALL SCALE RESERVOIRS

Basin	Catchment Area (sq.km)	Nos. of Reservoirs	Reservoir Capacity (MCM)
Tha Sae	228	23	36.4
Rap Ro	98	10	18.6
Tha Taphao	40	4	7.1
Chumphon	86	8	15.8
Total	452	45	77.9

(2) Effective Storage

a) Sedimentation

Sedimentation in reservoirs depends upon such conditions as topography, soil and geology, vegetation, rainfall etc. in the catchment area. There is no sedimentation record in the Study Area, therefore the sediment volume is assumed based on the suspended sediment records observed at RID gauging stations, code 210101 in Tha Sae river and code 210103 in Rap Ro river.

The specific sediment for the Tha Sae and Rap Ro rivers results in 45 and 57 cu.m/sq/km/year respectively on the assumption that the total sediment volume is 1.3 times of the suspended sediment included in the bed load sediment and the unit weight of sediment is 1.3 ton/cu.m. While, applying the Kira's formula the estimated annual specific sediments are 150 and 170 cu.m/sq.km at the Tha Sae and Rap Ro dam sites respectively.

Considering the future development at the surrounding area of reservoir, the sediment will increase, therefore the design annual specific sediment shall be taken as 150 cu.m/sq.km. The design period of sediment for reservoir is considered to be 100 years longer than 80 years, the economic life of the reservoir. Thereby, the design total sediments for potential large dams are as below:

RESERVOIR SEDIMENTATION

Reservoir	Catchment Area (sq,km)	Sediment Volume (MCM)
Tha Sae	338	5.1
Rap Ro	609	9.1
Upper Rap Ro	106	1.6
Nam Ron	21	0.3
Upper Kum	16	0.2
Kaphon	15	0.2

b) Effective Storage

The effective storage for flood control and water use for irrigation and others is given by sub-stracting the proposed sediment volume from the gross

storage capacity. In determing the effective storage, a comparison was made between the annual average inflow and the reservoir capacity. Excepting the Upper Rap Ro reservoir, the effective storage capacities of 5 reservoirs are less than the average annual inflow, thus leading to selection of the effective storage capacity by substracting the sediment volume from the gross storage capacity. The Upper Rap Ro reservoir, however, has the effective storage capacity larger than the average annual inflow. Preliminary water operation was run to determine the effective storage capacity under the hydrologic conditions of 1985, which correspond to a drought year with a return period of 10 years. As a result, the effective storage capacity of the Upper Rap Ro has been fixed at 62.3 MCM. The effective storage capacities of the medium scale reservoirs are assumed to be half of the average annual inflow for conservative estimate because of lack of a river flow information. The proposed effective storage capacities are as follows.

EFFECTIVE STORAGE CAPACITY (1)

(unit : MCM)

Reservoir	Gross Storage	Sediment Volume	Effective Storage
Tha Sae	133.0	5.1	127.9
Rap Ro	192.0	9.1	182.9
Upper Rap Ro	63.9	1.6	62.3
Nam Ron	7.2	0.3	6.9
Upper Kum	7.3	0.2	7.1
Kaphon	5.2	0.2	5.0

For small scale reservoirs, the effective storage capacities are assumed to be one fourth of the average annual inflow due to small reservoir capacity compared with the river inflow as given below:

EFFECTIVE STORAGE CAPACITY (2)

(unit : MCM)

Basin	Gross Storage	Sediment Volume	Effective Storage
Tha Sae	36.4	1.7	34.7
Rap Ro	18.6	0.7	17.9
Tha Taphao	7.1	0.3	6.8
Chumphon	15.8	0.6	15.2
Total	77.9	3.3	74.6

(3) Flood Control Storage

Of the proposed 6 reservoirs, 3 reservoirs of Tha Sae, Rap Ro and Upper Rap Ro will be operated for multipurpose use of flood control, irrigation and domestic / municipal water supply, and the other 3 reservoirs of Upper Kum, Nam Ron, and Kaphon for irrigation and domestic supply as these medium scale reservoirs are only able to control flood runoff from relatively small catchment area of 15 to 21 sq.km, negligible small effect of flood peak reduction when compared to the catchment area at the control point X158 with the catchment area of 1,819 sq.km.

The 3 multipurpose reservoirs will provide empty storage space to store a portion of flood flow with a return period of 30 years. The design floods are synthesized based on probable maximum 5-days continuous rainfalls with the return period of 30 years. The reservoirs will be operated for flood control by automatically discharging floods through the opening of fixed dimensions, not adjustable gate. The advantages of this operation are its simplicity and automatic operation without personnel. The reservoirs have emergency spillways to handle runoff in excess of the design flood. The sizes of the opening are determined by flood routing so as to maintain given flood surcharge water levels of the reservoirs. The proposed flood control storages are given as follows:

FLOOD CONTROL STORAGE

(unit: MCM)

Reservoir	Effective Storage	Flood Control Storage	Water Use Storage
Tha Sae	127.9	47.6	80.3
Rap Ro	182.9	90.2	92.7
Upper Rap Ro	62.3	29.9	32.4

Where, the flood control storage means a reservoir's storage capacity to be stored with a part of and/or whole flood water in order to regulate the flood. The storage capacity is normally planned with the maximum figure of accumulated water volume, i.e. the flood water which is estimated by subtracting the outflow from the inflow is accumulated during flood. (The Details are shown in the Appendix, E-14. Plan of Flood Control Storage).

(4) Water Supply for Domestic and Municipal Use

There are 440 wells in the Study Area for daily water use, but these wells do not satisfy the water demand of 42,300 farm households. The proposed reservoirs will provide domestic water for rural people living in the project areas and Amphoe Phatiu, and municipal water for the town of Chumphon. The water demand is based on 100 ℓ/day per capita, 50 ℓ/day/head of cattle and 20 ℓ/day of swine. The estimated water demand for domestic use is 10 m^3/day/sq.km of the project area.

Being located in the coastal area, Amphoe Pathiu is in urgent need of water supply for domestic use. Therefore, the project proposes to provide domestic water for Amphoe Pathiu, though it is located outside the Study Area. There is less potential to exploit groundwater. The water demand of Amphoe Pathiu is estimated at 5,700 cu.m/day, which will be supplied by the Tha Sae reservoir.

Currently, Chumphon city receives domestic water from the Tha Taphao river, but the utilization of river run-off is limited in its capacity. Thereby, based on the forecast of the city population in 2010, the water supply plan to the city is considered into the water resources development. After 20 years, a total of 6,000 capita will be increased. Assuming a water requirement of 200 ℓ per day per capita, municipal water of 1,200 cu.m per day will be supplied from the 2 reservoirs of Rap Ro and Tha Sae.

(5) River Maintenance Water

When damming a river, from the environmental view point, a certain river flow is required for fish habitation, animals and vegetables near to the river, stabilization of ground water, navigation of boats, and the appearance of the water front, - in short maintaining the river's function. The design discharge for river maintenance is generally applied with droughty discharge, although it depends on the characteristics of each river.

Discharge records at RID gauging stations indicate the followings:

MINIMUM RIVER DISCHARGE

(unit: cu.m/sec)

River	Gauging Station	Catchment Area (sq.km)	Average Min. Flow	Discharge per 100 sq.km
Rap Ro	X46	751	1.71	0.23
Tha Sae	X64	957	1.42	0.15

From the above table, 0.5 cu.m/sec/100 sq.km of discharge is adopted as the river maintenance flow from the reservoirs. The Rap Ro reservoir with a catchment area of 503 sq.km will release the river maintenance flow to maintain the minimum river flow of 3.80 cu.m/sec at the X46 station of the Rap Ro river, and the Tha Sae reservoir will release the river maintenance flow to maintain a minimum river flow of 4.80 cu.m/sec at the X64 station of the Tha Sae river.

(6) Selection of Irrigation Area

a) Selection of Area

Irrigation water will be released for growing paddy, field crops, vegetables and fruit trees. Paddy fields are mainly located on the alluvial plains along the main rivers, the lower Study Area. Upland fields and orchards are mixed with tree crops and are situated on terrace and hills, the upper Study Area. Vegetables are grown around villages, or in orchards as intercropping.

There are about 54,500 ha of farm lands that need irrigation water, water demands which are greater than the potential water resources of 303 MCM. In the selection of irrigable area, potential irrigable areas are marked on the topographic maps (scale of 1 : 50,000) after consideration of topographic information. The 3 multipurpose reservoirs of Tha Sae, Rap Ro and Upper Rap Ro are located in the upstream areas which the potential irrigable areas are in the mid to downstream areas. To convey irrigation water to potential irrigable areas, 2 different systems are technically available: direct water intake from a reservoir and water intake through a diversion weir to be constructed downstream from the reservoir.

The advantage of water intake through a diversion weir is that it is a relatively short length of conveyance canals. However, due to topographic conditions of the area whereby rivers run through valleys in terraces and hills, a diversion structure has to be constructed a considerable distance upstream to raise its water level to a controllable elevation, from where it can flow down by gravity. The construction of a diversion weir across a valley may require a relatively high cost including a spill way for flood release. An alternative to water intake by gravity from a diversion weir is river pumping.

In this basin water resources development plan, direct water intake from a reservoir has been proposed in consideration of the easy operation and lower maintenance costs; however, in the stage of the feasibility study, further studies are recommended to compare the direct water intake system with the construction of diversion weir based on detailed topographic information.

Irrigation areas of the medium scale reservoirs have been selected among the existing orchards located immediatly downstream from the proposed reservoirs so as to apply gravity irrigation.

b) Irrigation Area

In order to determine the irrigation area of the proposed reservoirs, the operation of Tha Sae, Rap Ro and Upper Rap Ro reservoirs was run on a monthly basis under hydrological conditions of 1985, a drought year with a return period of 10 years. Inflows to reservoirs are derived from the data at X64 station for the Tha Sae reservoir, and Kaeng Phra Chao station for the reservoirs of Rap Ro and Upper Rap Ro. In this operation study, water supplies for domestic and municipal uses and river maintenance flows are taken into account. As a result, with the combined effective water storage of 205.4 MCM of 3 multipurpose reservoirs, 25,890 ha of farm lands can be irrigated. The irrigation areas of the medium and small scale reservoirs are estimated based on the effective water storage and the said water operation study. By the installation of the proposed 52 projects, 41,520 ha of farm lands can be irrigated as given below;

IRRIGATION AREA BY RESERVOIRS

Basin	Project	Effective Storage (MCM)	Irrigation Area (ha)
Tha Sae	Tha Sae Multipurpose Project	80.3	9,860
	23 Small Scale Projects	34.7	5,350
Rap Ro	Rap Ro Multipurpose Project	92.7	12,520
	Upper Rap Ro Multi. Project	32.4	3,510
	Nam Ron Medium Scale Project	6.9	1,060
	10 Small Scale Projects	17.9	2,760
Tha Taphao	Nong Yai Project	3.9	1,200
	4 Small Scale Projects	6.8	1,050
Chumphon	Upper Kum Medium Scale Project	7.1	1,100
	KaphonMedium Scale Project	5.0	770
	8 Small Scale Projects	15.2	2,340
Total	52 Projects	302.9	41,520

3.7.3 Development of Nong Yai Swamp

(1) General

The Nong Yai swamp with a lower elevation of around 1 m above the mean sea level (MSL) is located about 4 km northeast of the municipality of Chumphon. The water levels of the swamp rise to around 5 m MSL in the rainy season, resulting in an inundated area of 500 to 700 ha, whereas in the dry season the water levels fall to around 2 to 2.5 m MSL, and an inundated area decreases to about 30 ha, as the water levels of the Tha Taphao river drop. Around the swamp, paddy is grown on low-lying land and fruit trees are grown on the terraces.

For flood mitigation measures of the Tha Taphao river, the construction of 2 floodways has been proposed: Hua Wang-Phanang Tuk canal and Pak Phraek canal. Both canals are planned to divert flood water of the Tha Tapahao river and to release flood water to the sea through the Nong Yai swamp. The development of water resources of the swamp has been proposed by constructing dikes and regulators. Stored water in the rainy season will be used for irrigation and domestic purposes mainly in the dry season.

(2) Development Plan

The project will provide 3.9 MCM of effective water storage by the construction of dikes and roads with a total length of 13.9 km, surrounding the swamp. The average annual inflow to the swamp with a catchment area of 102 sq.km is estimated at 81 MCM. With effective water storage of 3.9 MCM, 1,200 ha of farm land will be irrigable.

In the dry season, the swamp water is at present used for small scale inland fisheries by farmers under the guidance of the Provincial Office of Fisheries. With the flood mitigation project of the Tha Taphao river and Nong Yai swamp development project, water control of the swamp will be improved. Shallow depths of the swamp, being around 4 m of the maximum depth, are suitable for fish breeding. The development project of the Nong Yai swamp includes inland fisheries development plans to raise carps, tilapia and others. Water operation for fisheries purposes will not conflict with irrigation purposes.

3. 7. 4 River Diversion

For run-of-river scheme, 2 locations are deemed as potential sites for the construction of diversion weirs from the view point of topography: one is on the Tha Taphao river just downstream from the railway bridge and the other is on the Chumphon river just downstream from the railway bridge. The catchment area at these sites is 2,050 sq.km for the tha Taphao river and 346 sq.km for the Chumphon river, and the average annual runoff of the rivers is expected to be 1,287 MCM for the Tha Taphao river and 418 MCM for the Chumphon river in the case where the proposed 3 multipurpose reservoirs are not constructed. Potential water resources after release of river maintenance flows are given below:

POTENTIAL WATER RESOURCES FOR RUN-OF-RIVER SCHEME

(unit: MCM)

Month	Tha Taphao	Chumphon	Month	Tha Taphao	Chumphon
1	2.4	3.0	7	105.1	34.4
2	-	0.1	8	215.2	84.7
3	-	-	9	144.1	56.5
4	-	0.1	10	189.9	55.0
5	34.6	10.3	11	200.2	68.9
6	65.0	36.3	12	40.2	15.5

As can be seen from the above table, there is no room for diversion of river flows in the dry season. Therefore, the diversion of the free-flowing river for irrigation purposes has not been proposed.

3.7.5 Flood Control

(1) Flood Hydrograph

a) Design Rainfall

Analyses of data on rainfall and river runoff reveal that most heavy floods are caused by 3 to 5-days of continuous rainfall. This study applies a design rainfall of probable maximum 5-day continuous rainfall with a return period of 30 years to flood control scheme. Daily distribution of the design rainfall is based on the results of analyses of historical rainfall patterns : peak daily rainfall will occur on the 3rd day. Storm rainfall induced from atmospheric depression has occurred in a period from June to November in the rainy season. Heavy rain causing flooding is of a moving type with considerably high locality, and there is little possibility that the heavy rainfall of certain probability would take place in the area at quite the same time.

The discharge observation record analysis revealed clearly that the flood magnitude of the Tha Taphao river was dependent upon flooding in the basin of the Rap Ro river with much more rainfall. Distribution of 5 consecutive days of rainfall in the area for the design rainfall establishment shall be based on the total rainfall ratio at each station in the area for 5 consecutive days when the Kaeng Phra Chao Station observed the annual maximum 5 days rainfall. The 5 days rainfall ratio at each gauging station is calculated based on that at the Kaeng Phra Chao Station, base index of 1.00 as follows:

DISTRIBUTION OF DESIGN RAINFALL RATIO

Rap Ro Basin		Tha Sae Basin		Tha Taphao	Outside Area	
K. Prachao	X46	X64	Ta Ngo	Chumphon	Pathiu	Sawi
1.00	0.93	0.69	0.63	0.63	0.50	0.59

The areal design rainfall of the respective catchment areas is determined by the Thiesen method based on the spot rainfall of 503.2 mm at Kaeng Phra Chao and the design rainfall ratio. The overall ratios of the design rainfall of respective places are 1.00 for the Upper Rap Ro, 0.96 for the Rap Ro and 0.68 for the Tha Sae. The design rainfall is arranged on a 3 hour basis according to the actual record of heavy rainfall in 1988 at X46 station. The areal design rainfall with a return period of 30 years is given as follows.

DESIGN RAINFALL

(unit: mm)

Day	Rap Ro Reservoir	Upper Rap Ro Reservoir	Tha Sae Reservoir
1st	50.6	51.6	36.1
2nd	85.0	86.7	60.7
3rd	276.0	281.7	197.2
4th	50.1	51.2	35.8
5th	31.4	32.0	22.4
Total	493.1	503.2	352.2

b) Probable Peak Flood Discharge

Since the flood discharge data are not effective in determining of the probable design rainfall, the design flood was estimated by analytical methods to take account of a probable 5 days consecutive rainfall. The design floods for the proposed damsites and other reference points are estimated by the unit hydrograph developed by Sato's Runoff Function Method. Figure C-9 in Appendix C illustrates the unit hydrograph at 3 hour-intervals at the confluence of the Rap Ro and the Tha Sae rivers.

The peak flood discharge can be obtained by putting probable design rainfall data into the unit hydrograph. The major probable flood discharge at the Rap Ro and Tha Sae basins are estimated as follow. And the flood discharge

at X158 of the Tha Tapho river as the most important reference point is prudently taken as the total of discharge of the above 2 basins.

PROBABLE PEAK FLOOD DISCHARGE
(without project)

Unit : cu.m/sec

Return Period	Rap Ro Basin	The Sae Basin	Tha Taphao X158
(Year)	(803. sq.km)	(1,016 sq.km)	(1,819 sq.km)
2	370	270	640
5	540	390	930
10	670	480	1,150
20	800	570	1,370
30	880	630	1,510
50	980	700	1,680

(2) Flood Control by Reservoir

The water resources development projects of the Chumphon river basin will be implemented in 2 phases. In phase 1 development, 2 multipurpose reservoirs of the Rap Ro and Tha Sae will be constructed, and in phase 2 development the Upper Rap Ro reservoir will be completed. The major dimensions of flood control by reservoirs are summarized below:

FLOOD SPACE AND DESIGN FLOOD

Item	Rap Ro Reservoir	Tha Sae Reservoir
Catchment Area (sq.km)	609.0	338.0
Flood Control Storage (MCM)	120.1	47.6
Design Flood		
- Total inflow (MCM)	240.2	85.2
- Peak inflow (cu.m/sec)	1,120	530

Flood routing of the 2 multipurpose reservoirs of Rap Ro and Tha Sae was carried out based on the predetermined dam heights, flood surcharge levels, effective water storage capacities and inflow hydrographs. The objective is to determine the size of the outlet structure and outflow hydrographs for the given dam heights. The storage volume at respective elevation is estimated based on the topographic maps with the scale of 1 : 50,000 and a contour interval of 20 m. The relationship among inflow, outflow and storage is expressed as a function of time as follows:

$$\frac{i_1 + i_2}{2} t = \frac{O_1 + O_2}{2} t + S_2 - S_1$$

Where, i = inflow rate for a small increment of time
O = outflow rate for a small increment of time
S = rate of storage for a small increment of time
t = time
1 and 2 = subscripts denoting beginning and end of the time interval, respectively.

Reservoir operation for flood control was simulated on a 3-hour basis. In the simulation, evaporation and seepage losses were neglected. The outflow curve representing the depth-discharge relation of the reservoir spillway of conduit structure without gate is predetermined for various sizes of conduits. The size of outlet conduit was fixed to maintain a given flood surcharge level for the design flood with a return period of 30 years, and the outflow hydrographs representing the rate of outflow was prepared as a function of time.

The flood hydrographs are worked out for the outlets of the Tha Sae and Rap Ro rivers by synthesizing the outflow hydrographs from the reservoirs and local runoff from the catchment area between the dams and the river outlet in consideration of time lag of flood arrival: 12 hours for the Rap Ro river and 18 hours for the Tha Sae river. Flood control by reservoirs can be summarized as follows:

FLOOD CONTROL BY RESERVOIR

Item	Rap Ro Reservoir	Tha Sae Reservoir
Reservoir		
- Catchment area (sq.km)	(609)	(338)
- Flood surcharge level (m MSL)	65	100
- Peak inflow discharge (cu.m/sec)	1,120	530
- Peak outflow discharge (cu.m/sec)	410	210
Outlet of River		
- Catchment area (sq.km)	(803)	(1,016)
- Present peak flood (cu.m/sec)	880	630
- Design peak flood (cu.m/sec)	530	610
X158 Station of Tha Taphao River		
- Catchment area (sq.km)	(1,819)	
- Present peak flood (cu.m/sec)	1,510	
- Design peak flood (cu.m/sec)	1,150	

Reservoir operation for flood control will reduce the flood peak from 1,510 cu.m/sec to 1,150 cu.m/sec at X158 station on the Tha Taphao river. The peak flood discharge of 1,150 cu.m/sec corresponds to a probable peak flood discharge with a return period of 10 years should the project not be

impelmented. For flood control of the Tha Taphao river, measures that reduce flood water and peak flood flow are needed because the present channel capacity of the Tha Taphao river is 430 cu.m/sec.

The Rap Ro reservoir controls floods from a catchment area of 609 sq.km, or 76 percent of the total catchment area of the Rap Ro river basin, whereas the Tha Sae reservoir controls only 33 percent of the total catchment area of the Tha Sae river basin. The Tha Sae reservoir reduces peak flood from 530 cu.m/sec to 210 cu.m/sec just downstream from the dam; however, this reduction in peak flow diminishes with distance downstream since the river receives local runoff from other tributaries. At the outlet of the Tha Sae river, about 50 km downstream from the dam, the designed peak flood discharge will be 610 cu.m/sec which is 20 cu.m/sec smaller compared to 630 cu.m/sec of the present peak flood discharge when the dam is not constructed. Operation of the Tha Sae reservoir for flood control will contribute to about 5,000 ha of farm lands subject to annual flooding. The effect of flood control by the Tha Sae reservoir on the Tha Taphao river basin is negligible.

This water resources development plan on the Menam Chumphon basin has been proposed to provide flood control storage of the Tha Sae reservoir for flood mitigation of the Tha Sae river with a view to distributing project benefits over the river basin. In the feasibility study stage, however, it is recommendable to make alternative studies for flood control of the Tha Sae river based on detailed topographic information, i.e. flood mitigation through river improvement without flood control by reservoir. In phase 2 of the water resources development plan of the basin in which the Upper Rap Ro reservoir, a part of flood control storage of the Rap Ro reservoir can be allocated to the Upper Rap Ro reservoir thus, the effective storage capacity of the Rap Ro reservoir for irrigation purpose will be increased. In this case the flood control storage will be 90.2 MCM for the Rap Ro reservoir and 29.9 MCM for the Upper Rap Ro reservoir in proportion to the flood inflow volume.

(3) Improvement of Tha Taphao River System

a) General

Flood water of the Tha Taphao river basin is released into the sea through the Tha Taphao river, Phanang Tuk river and the Sam Kaeo canal.

The Tha Taphao river can be divided into 3 sections for purposes of river improvement planning; the upper reaches, the middle reaches and the lower reaches. The upper reaches cover the sections between the head of the river, or the confluence of the Tha Sae and Rap Ro, and Ban Hua Wang, the middle reaches cover the section between Ban Hua Wang and the Sam Kaeo regulator, and the lower reaches cover the section between the Sam Kaeo regulator and the rivermouth. The present channel capacity of the river is calculated by solving the non-uniform flow of the river based on the canal profiles prepared by RID. The present channel capacity of the river varies from 430 cu.m/sec to 350 cu.m/sec as given below:

PRESENT CAPACITY OF THA TAPHAO RIVER

River Section		Max. Capacity
Upper Reaches	Head to Ban Hua Wan	430 cu.m/sec
Middle Reaches	Ban Hua Wan to Sam Kaeo	430 cu.msec
Lower Reaches	Sam Kaeo to rivermouth	350 cu.m/sec

The Sam Kaeo canal was constructed in 1952 with a design capacity of 260 cu.m/sec in order to divert a portion of flood water from the Tha Taphao river. But the present canal capacity is assumed to be 140 cu.m/sec by RID due to high threshold of the regulator and meandering canal.

Under this situation, RID formulated an urgent improvement plan of flood mitigation of the Tha Taphao river in 1990, immediately after the flood caused by Typhoon Gay. The plan includes the improvement of the Tha Taphao river and Sam Kaeo canal and new construction of a Hua Wang - Phanang Tuk canal. In 1992, the government approved the construction of the Hua Wang - Phanang Tuk canal with a design capacity of 270 cu.m/sec. RID has completed the detailed design work and initiated procurement of right-of-way.

In order to release the design flood of 1,150 cu.m/sec, this water resources development plan proposes to improve the Tha Taphao river system, including the construction of a new floodway for the Pak Phreak canal as shown as follows:

IMPROVEMENT OF THA THE TAPHAO RIVER SYSTEM

River and Canal	Flow Capacity (cu.m/sec)	
	Present	Design
Improvement of Tha Taphao River		
- Upper reaches	430	880
- Middle reaches	430	610
- Lower reaches	350	350
Rehabilitation of Sam Kaeo Canal	140	260
New Construction of Canal		
- Hua Wan-Phanang Tuk	-	270
- Pak Phraek	-	270

New construction of the Pak Phraek canal, which branches off from the Tha Taphao river just downstream from the confluence of the Rap Ro and Tha Sae rivers, has been proposed as the alternative to enlargement in large quantities of the Tha Taphao river along which houses are built. The construction of the Pak Phraek canal has an additional impact on the rural community as follows: 1) drainage conditions of farm lands along the canal will be improved, 2) maintenance roads to be constructed along the canal will have useful functions as rural roads, and 3) the canal can be used as an irrigation canal. Details of the improvement plan will be presented in Chapters 5 and 6.

(4) Flood Warning System

There are 6 rainfall gauging stations and 7 river gauging stations in the Study Area. For flood forecast of the Tha Tapaho river and flood warnings to the rural people in the downstream area, RID sends experts to X158 river gauging station for periods of 5 months from July to November. The river gauging stations involved in flood forecasting of the Tha Taphao river are X46 station of the Rap Ro river, X64 station of the Tha Sae river, and X158 station of the Tha Taphao river, of which X46 and X64 stations have river discharge and water level records while the stations of the Tha Taphao river have water level records (staff gauge) only.

RID forecasts the flood water levels at the gauging station located in the municipality of Chumphon, based on the correlation of the flood water levels between the X158 station and Chumphon city prepared in consideration of time of flood concentration. When floods are forecast, RID gives the Provincial Goverment Office early warnings of floods.

In order to give a fairly accurate forecast of the flood at an early stage, the establishment of a flood forecast and early warning system has been proposed. To this end, gauging stations for rainfall and river flow will be constructed together with a telecommunication system at a rate of 1 rainfall gauging station per 100 sq.km of catchment area. In addition to the 6 existing rainfall stations, 20 automatic rainfall stations will be constructed. It is proposed to install 10 river gauging stations for the proposed reservoirs and 10 river gauging stations for rivers and canals, totaling 20 gauging stations altogether.

3.8 IMPLEMENTATION SCHEDULE

3.8.1 Multipurpose Project

For flood control, irrigation and water supplies for domestic and municipal use and river maintenance of Tha Taphao river, 3 multipurpose projects of storage scheme will be implemented. With these 3 projects, the peak flood discharge with a return period of 30 years will be reduced from 1,510 cu.m/sec to 1,150 cu.m/sec at the control point X158 of the Tha Taphao river, and 25,890 ha of farm land will be irrigable. Outlines of the multipurpose projects are given below:

MULTIPURPOSE PROJECTS

Project Dimension	Tha Sae	Rap Ro	Upper Ra Ro
Catchment Area (sq.km)	338	503	106
Reservoir Capacity (MCM)			
- Gross Capacity	133.0	192.0	63.9
- Effective Storage	80.3	92.7	32.4
- Flood Control Storage	47.6	90.2	29.9
- Dead Capacity	5.1	9.1	1.6
Dam Crest (m)			
- Length	1,130	260	300
- Height	50	40	25
Irrigation Area (ha)	9,860	12,520	3,510

3. 8. 2 Flood Protection Project

(1) River Improvement

With the flood control program of 3 multipurpose reservoirs, flood protection of the downstream areas will be implemented. The design flood discharge of the Tha Taphao river is 1,150 cu.m/sec. The channel capacities of the Tha Taphao river will be improved to 880 cu.m/sec for the upper reaches and 610 cu.m/sec for the middle reaches together with the construction of the Pak Phraek canal and Hua Wang - Phanang Tuk canal. The present channel capacity of the lower reaches (350 cu.m/sec) will be maintained through preventive measures. The downstream reaches of both Rap Ro and Tha Sae rivers need improving. The design capacities are 530 cu.m/sec and 610 cu.m/sec for the Rap Ro river and the Tha Sae river, respectively.

In the Khlong Chumphon basin, flooding frequently occurs downstream from X53 station with the catchment area of 223 sq.km, resulting in damage to crops and farm land. With respect to flood protection of the Khlong Chumphon, the design flood discharge of 350 cu.m/sec with a return period of 10 years has been proposed at X53 station. Outlines of the river improvement project are presented as follows (For details of the improvement of the Tha Taphao river, refer to Chapter 5 and 6):

OUTLINES OF RIVER IMPROVEMENT PROJECT

River	Discharge (cu.m/sec)	Length (km)	Works
Tha Taphao River			
- Upper reaches	880	11.3	Increasing cross section, short-cut
- Middle reaches	610	6.0	Increasing cross section, short-cut
- Lower reaches	350	17.0	Preventive works, short-cut
Rap Ro River	530	17.0	Increasing cross section
Tha Sae River	620	21.0	Increasing cross section
Khlong Chumphon	350	35.0	Increasing cross section
Total		108.3	

(2) Canal Project

The flood protection project of the Tha Taphao river includes the rehabilitation of the Sam Kaeo canal and new construction of Hua Wang -

Phanang Tuk and Pak Phraek canals. The Sam Kaeo canal's capacity will be rehabilitated to 260 cu.m/sec as originally designed in 1952 by improving the head regulator and canal cross sections. The Pak Phraek canal joins the Nong Yai reservoir. A tail regulator will be constructed across the Lower Hua Wang - Phanang Tuk canal. Outlines of the canal project are given below (For details, refer to Chapters 5 and 6):

OUTLINES OF CANAL PROJECT

CANAL	Discharge (cu.m/sec)	Length (km)	Works
Sam Kaeo Canal	260	4.8	Rehabilitation of gate and canal
Hua Wang-Phanang Tuk Canal			
- Upper reaches	270	0.6	Construction of canal and gate
- Lower reaches	540	3.9	Construction of canal and gate
Pak Phraek Canal	270	5.5	Construction of canal and gate
Total		14.8	

(3) Flood Warning System

In addition to the existing 6 rainfall stations and 7 river gauging stations, the project proposes to establish 20 rainfall stations, 20 river gauging stations and 5 control offices (3 offices at the damsites and 2 offices for river control) for flood forecast and warning as summarized below.

OUTLINES OF FLOOD WARNING SYSTEM

Item	Rap Ro	Tha Sae	Tha Tapaho	Chumphon	Total
(Catchment: sq.km)	(803)	(1,016)	(357)	(449)	(2,625)
Rainfall Station	6	8	2	4	20
River Station	5	3	10	2	20
Control Office	2	1	1	1	5

3.8.3 Irrigation Project

The following medium to small scale irrigation projects will be implemented, of which the medium scale project will provide domestic water for the rural peoples in the project areas. Details of the Nong Yai irrigation project will be discussed in Chapters 5 and 6. Outlines of the medium to small scale irrigation project are as follows:

OUTLINES OF MEDIUM TO SMALL SCALE IRRIGATION PROJECT

Project	River Basin	Effective Storage (MCM)	Irrigation Area (ha)
Medium Scale Project			
- Nam Ron project	Rap Ro	6.9	1,060
- Upper Kum project	Chumphon	7.1	1,100
- Kaphon project	Chumphon	5.0	770
- Nong Yai project	Tha Taphao	3.9	1,200
Sub-total		22.9	4,130
Small Scale Project			
- Tha Sae : 23 projects	Tha Sae	34.7	5,350
- Rap Ro : 10 projects	Rap Ro	17.9	2,760
- Tha Taphao : 4 projects	Tha Taphao	6.8	1,050
- Chumphon : 8 projects	Chumphon	15.2	2,340
Sub-Total		74.6	11,500
Total		97.5	15,630

3. 8. 4 Construction Schedule

The water resources development plan of the Menam Chumphon basin is composed of 3 types of projects: 1) multipurpose projects, 2) flood protection projects including improvement of rivers, construction of canals and establishment of flood warning systems, and 3) medium to small scale irrigation projects. There will be financial conflict with other development projects and limited of engineering capacities when the development projects of the Menam Chumphon basin are planned for implementation on a short-term program.

The implementation of a large scale reservoir involves various kinds of work such as topographic surveys, environmental assessment, socio-economic surveys, engineering surveys, resettlement planning, feasibility studies, land acquisition, detailed designs, tendering and so on. It will be at least 5 years before the commencement of construction works, while the construction of canal projects and river improvement works can be started in an earlier stage.

The water resources development project should be orderly implemented to attain the project benefits at an early stage by avoiding duplication of projects and delay in project implementation. The proposed water resources development project will be implemented over 3 stages starting from 1992.

During the period of stage I development, emphases will be placed on the completion of the flood protection projects; thus, to a certain extent reducing flood damage. Flooding of the Tha Taphao river will not occur more than once in 10 years. The implementation of canal projects with the dual purpose of irrigation and drainage will be completed to improve agricultural productivity of areas where floods are mitigated. The Nong Yai irrigation project will be implemented at this stage.

At the stage II development, 2 multipurpose projects of Tha Sae and Rap Ro will be constructed. On completion of these 2 multipurpose reservoirs with the combined flood control storage of 120 MCM, floods of the Tha Taphao river at X158 will be controlled so as not to occur more than once in 30 years. 22,380 ha of farm lands will receive water from the 2 multipurpose reservoirs. River improvement of Tha Sae and Rap Ro will be carried out at this stage. The construction of medium to small scale irrigation projects will be spread over 2 development stages.

During stage III development, the Upper Rap Ro multipurpose reservoir will be constructed to complete the implementation of the water resources development plan of the Menam Chumphon basin. The irrigation area will be increased from 22,380 ha to 25,890 ha. The proposed implementation schedule is shown in Table 3-2, as summarized below:

Stage I Development (First 5 years: 1992 - 1996)

1) Study and Investigation
   - 2 multipurpose projects of Tha Sae and Rap Ro
   - River improvement projects of Tha Taphao and Khlong Chumphon
   - Canal projects
   - Irrigation projects of Nong Yai, Nam Ron and Kaphon

2) Construction
   - River improvement of Tha Taphao and Khlong Chumphon
   - Rehabilitation and construction of canals
   - Nong Yai irrigation project
   - Start of construction of Nam Ron and Kaphon project
   - Small scale irrigation projects

Stage II Development (Second 5 years: 1997 - 2001)

1) Study and Investigation
   - Upper Rap Ro multipurpose project
   - River improvement of Tha Sae and Rap Ro
   - Flood warning system
   - Irrigation project of Upper Khum

2) Construction
   - 2 multipurpose projects of Tha Sae and Rap Ro
   - River improvement of Tha Sae and Rap Ro
   - Flood warning system
   - Irrigation project of Upper Khum
   - Small-scale irrigation projects

Stage III Development (Third 5 years: 2002 - 2006)

1) Construction
   - Upper Rap Ro multipurpose project

3.9 SELECTION OF PRIORITY PROJECT (S)

3.9.1 Selection Criteria

The chief needs of the Study Area for the integrated agriculture development are to provide irrigation water and to alleviate the threat of floods, so as to reduce constraints to the socio-economic development of the Study Area. Of 4 Amphoe related to the Study Area, only Amphoe Muang Chumphon encompasses the provincial capital, the center of administration and economic activities of the Study Area.

Flood problems of Amphoe Tha Sae are confined to a limited area along the Rap Ro and Tha Sae rivers, and are not serious. On the other hand, being situated in low-lying land along the rivers of Tha Taphao and Chumphon, Amphoe Muang Chumphon confronts both problems of flooding during rainy season and drought during dry season. Accordingly, the priority farm land will be selected in Amphoe Muang Chumphon. In the basin of the Chumphon river, there is few possibility of developing water resources for dry season irrigation.

Based on the considerations mentioned above, selection criteria of the priority project among the proposed projects for the water resources development of the Menam Chumphon basin were established as follows;

1) To have flood mitigation effect to the municipality of Chumphon and the surrounding farm lands.
2) To have irrigation effect to the farm lands around the municipality of Chumphon, predominant farm land in the Study Area.
3) To have high B/C ratio.

3. 9. 2 Project Evaluation and Selecton of Priority Project

In line with the said selection criteria, the following projects were nominated.

1) The Rap Ro and Tha Sae multipurpose projects
2) The Nong Yai - Tha Taphao development project composed of the Nong Yai irrigation project and the drainage improvement project of the Tha-Taphao river system

However, the multipurpose projects need more about 10 years in the implementation of feasibility study, detailed design and construction. From the consideration of immediate treatment of the flood mitigation in and around the municipality of Chumphon, the Nong Yai - Tha Taphao development project of which implementation will be executed with a few environmental problem and resulted with immediate effect was selected as the priority project.

Furthermore, the Nong Yai irrigation project will comparatively have small irrigable area but make a model project for demonstration of the irrigated agriculture development of the Menam Chumphon basin, so as to be effective.

Whereas, the project evaluation for all proposes water resources development projects of the Menam Chumphon basin were preliminarily conducted from the aspects of irrigation and flood control benefits, project implementation and B/C ratio as shown in Table 3-3.

From the said evaluation table, the result is summarized as below:

Project	Evaluation
① Tha Sae Multipurpose Project	It will bring a comparative large irrigation benefit but a small flood control benefit in and around the municipality of Chumphon, limiting the area along the Tha Sae river. It will spend a long term before its implementation but the project implementation is considered not to be difficult because of few environmental problems.
② Tha Sae Multipurpose Project	It will have high effects of irrigation and flood control in and around the municipality of Chumphon, however, the flood control effect shall be worked out after introduction of the Nong Yai-Tha Taphao Development project (④ project). The project implementation needs a long term due to environmental problems. However it has a comparative high B/C raito so as to be expected with early its promotion after the ④ project.
③ Upper Rap Ro Multipurpose Project	It will bring high irrigation benefit under the condition of completion of the Rap Ro Multipurpose project (② project). But its flood control benefit will be quite small independently. Furthermore, the long period of preparatory works is required for treat of environmental problem before implementation of the project. Development of the project has a high possibility because of good B/C ratio.
④ Nong Yai-Tha Taphao Development Project	It should have a effect of demonstrating the irrigation project in spite of its small irrigable area, and a large and immediate effect of flood mitigation in and around the municipality of Chumphon by short construction period. Its B/C ratio is second one next to that of the multipurpose projects. Thereby its early implementation is needed.
⑤ Chumphon River Improvement Project	It will have no effect of irrigation but large effect of flood protection along the Khlong Chumphon rather far the municipality of Chumphon. Future development of the project is expected.

Project	Evaluation
⑥ Medium Scale Project	It will have some irrigation effects in mountainous and hilly areas but no-effect of flood protection to the municipality of Chumphon. The consideration of project implementation will be paid in future.
⑦ Small Scale Project	It will have comparatively large effects of irrigation in hilly area far the municipality of Chumphon, but each project scale will be too small without any flood mitigation effects. The staging development of the project will be taken.

The feasibility study of the priority project was carried out during the phase II study, as presented in Chapter 4. Outlines of the priority project is as follows:

OUTLINES OF PRIORITY PROJECT

① Nong Yai Integrated Agriculture Development

- Project Area
  - Location : Amphoe Chumphon
    Na Cha Ang village, Na Thung village and Bang Luk village
  - Land Area : Gross area of 2,260 ha
    Farm land of 2,019 ha
- Development Plan
  - Water Resources : Development of Nong Yai swamp
    Gross water storage of 4.5 MCM
  - Irrigation : Irrigation area of 1,200 ha
    Construction of irrigation systems
    On-farm facilities development
  - Agriculture : Irrigated Agriculture
    Livestock promotion
    Swamp fisheries promotion

② Improvement of Tha Taphao River System

- Improvement of Tha Taphao River
- Rehabilitation of Sam Kaeo Canal
- Construction of Canal

TABLE 3-1 ORGANIZATION FOR SUPPORTING SERVICES

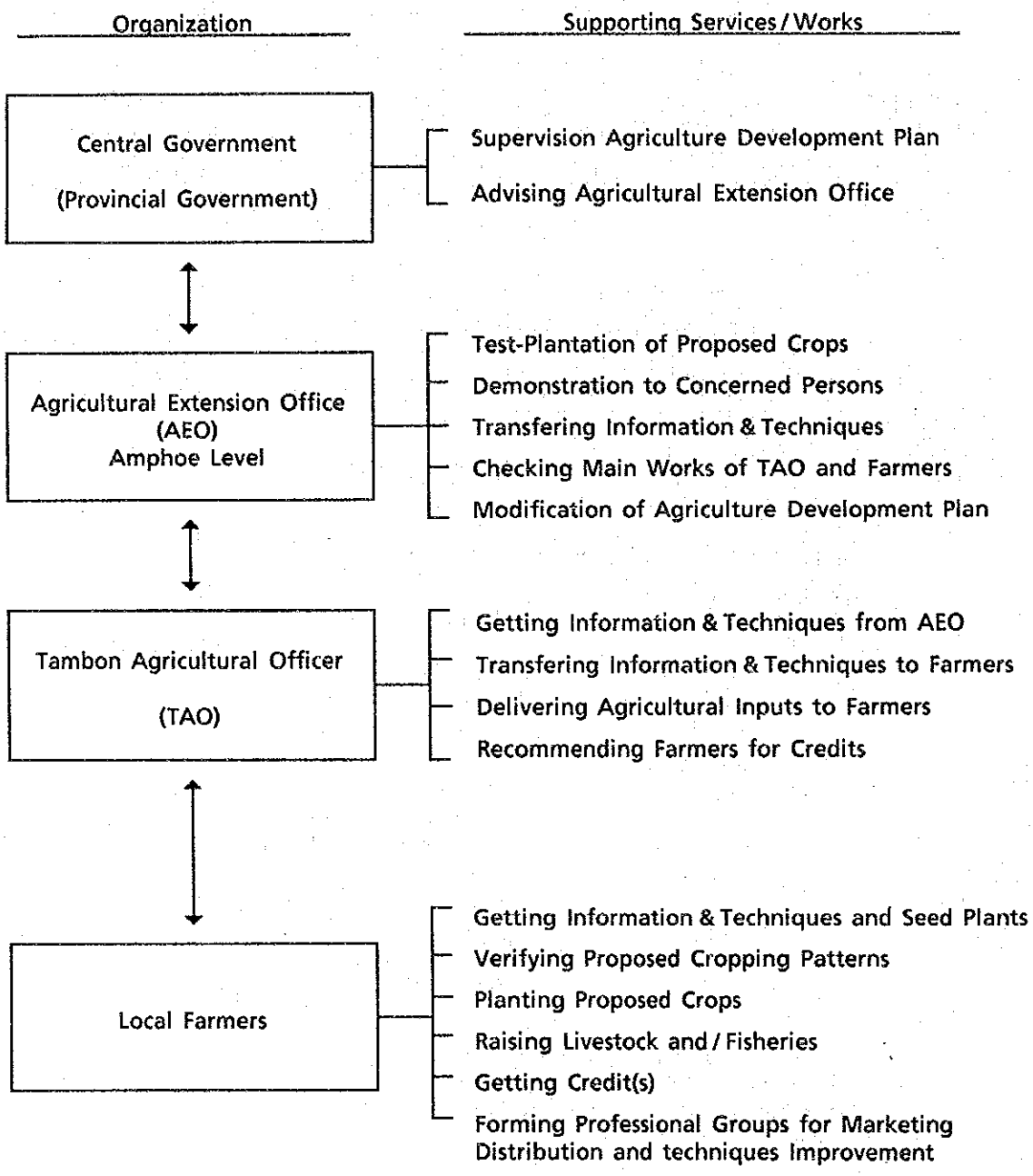


TABLE 3-2 IMPLEMENTATION SCHEDULE OF OVERALL BASIN WATER RESOURCES DEVELOPMENT PROJECT

Decription	Irrigable Area (ha)	1992~1996					1997~2001					2002~2006				
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. MULTIPURPOSE PROJECT																
1.1 Tha Sae Reservoir 1/	9,860	IE A	F/S		D/D											
1.2 Rap Ro Reservoir 2/	12,520	IE A	F/S			D/D										
1.3 Upper Rap Ro Reservoir 3/	3,510						F/S		D/D							
2. FLOOD PROTECTION PROJECT																
2.1 River Improvement Project																
- Tha Taphao River	34.3 km	F/S	D/D													
- Chumphon River	35.0 km	F/S	D/D													
- Rap Ro River	17.0 km							F/S	D/D							
- Tha Sae River	21.0 km							F/S								
- Phanang Tuk River	6.2 km								D/D							
2.2 Canal Project 4/																
- Hua Wang-Phanang Tuk Canal	4.5 km	F/S	D/D													
- Pak Phraek Canal	5.5 km	F/S	D/D													
- Sam Kaeo Canal	4.8 km	F/S	D/D													
2.3 Warning System	L.S								D/D							
3. IRRIGATION PROJECT 5/																
3.1 Medium Scale Project																
- Nam Ron Reservoir (Rap Ro)	1,060		F/S	D/D												
- Upper Kum Reservoir(Chumphon)	1,100						F/S	D/D								
- Kaphon Reservoir (Chumphon)	770			F/S	D/D											
3.2 Nong Yai Reservoir	1,230	F/S	D/D													
3.3 Small Scale Project																
- Tha Sae Basin	2,510															
- Rap Ro Basin	1,300															
- Tha Tapho basin	500															
- Chumphon Basin	1,100															
Total	41,550															

(Note) 1/ : Flood control, Irrigation water, Domestic water, Municipal water, Supply to A. Phatiu
2/ : Flood control, Irrigation water, Domestic water, Municipal water
3/ : Flood control, Irrigation water, Domestic water
4/ : Flood protection, Irrigation water, Domestic water
5/ : Irrigation water, Domestic water

: F/S, D/D, Buget procedure, Enviromental assessment, Tendering

: Construction term

TABLE 3-3 GENERAL EVALUATION FOR WATER RESOURCES DEVELOPMENT PROJECTS OF THE MENAM CHUMPHON BASIN

Project	App. Project Cost (M฿)	Irrigation Effect	Flood Control Effect	Implementation Term Others	App. B/C	General Evaluation
① Tha Sae Multipurpose P. ┌Tha Sae Dam, Irrigation Facilities └Tha Sae River Improvement	2,780	○ · App.9,860 ha north of Chumphon city	△ · Protection of 1/30 years frequency flood · App. 5,000 ha along the Tha Sae river	△ · About 9 years · App. 100 houses in the reservoir area	△ · 1.18 (1.44)	· Large irrigation effect · Small flood control effect · Long implementation term
② Rap Ro Multipurpose P. ┌Rap Ro Dam Irrigation Facilities └Rap Ro River Improvement	1,760	○ · App.8,240 ha surrounding Chumphon city	○ · Protection of 1/30 years frequency flood · App. 18,900 ha along the Tha Taphao river (needing the Tha Taphao river improvement P.)	× · About 10 years · App. 300~500 houses in the reservoir area	○ · (1.83) (1.64)	· Large irrigation effect · Flood control effect after introduction of Nong Yai - Tha Ta Phao development project · Long implementation term with environmental problems
③ Upper Rap Ro Multipurpose P. ┌Upper Rap Ro Dam └Irrigation Facilities	853	○ · App.3,510+4,280[1/]≒7,790 ha surrounding Chumphon city	× · No effect	△ · About 9 years · App.200~300 houses in the reservoir area	○ · (2.74)	· Large irrigation effect after introduction of Rap Ro multipurpose project · Small flood control effect without Rap Ro reservoir · Long implementation term with environmental problems
④ Nong Yai-Tha Taphao Development P. Tha Taphao River Improvement Canals (Sam Kaeo, Hua Wang Phanang Tuk, Pak Phraek) Nong Yai Reservoir, Irrigation Facilities	220	△ · App. 1,200 ha vicinity of Chumphon city · Demonstration effect	○ · Protection of 1/10 years frequency flood · App. 17,600 ha along the Tha Taphao river	○ · About 5 years	○ · 1.63	· Small irrigation effect but demonstration effect · Large and immediate effect of flood control · Short implementation term
⑤ Chumphon River Improvement P.	1,770	× · No effect	△ · Protection of 1/10 years frequency flood · App. 6,800 ha along the Khlong Chumphon	○ · About 5 years	○ · 1.57	· No irrigation effect · Good effect of flood protection far the Chumphon city · Comparative short term of project implementation
⑥ Medium Scale Project (3 projects) ┌Reservoirs └Irrigation Facilities	660	△ · App. 2,930 ha mountainous and hilly areas	× · No effect	○ · About 5 years	△ · 1.33	· Medium irrigation effect · No flood control effect · Comparative short term of project implementation
⑦ Small Scale Project (45 projects) ┌Reservoir └Irrigation Facilities	2,990	△ · App. 11,500 ha hilly areas	× · No effect	△ · About 10 years	△ · 1.15	· Good irrigation effect but each project is small · No flood control effect · Staging development

1/ : 4,280 ha of irrigable area of the Rap Ro project will be increased by construction of the Upper Rap Ro project, so that such benefit is counted into the benefit of the Upper Rap Ro project.
2/ : The B/C ratios in parentheses will be accomplished after implementation of another projects.
App.: Approximate, P.: Project

FIGURE 3-1 PROPOSED CROPPING PATTERN FOR BASIN DEVELOPMENT

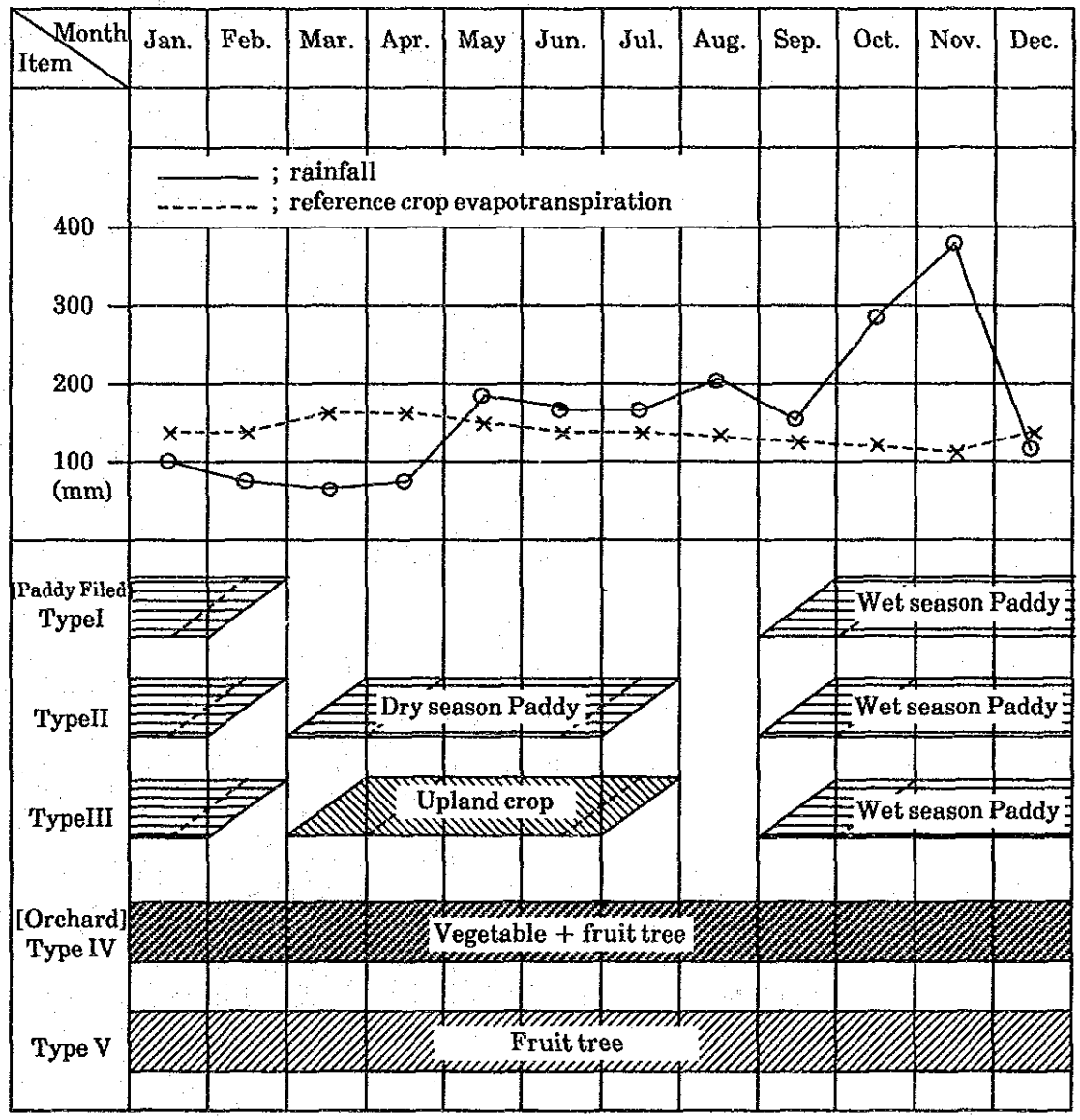
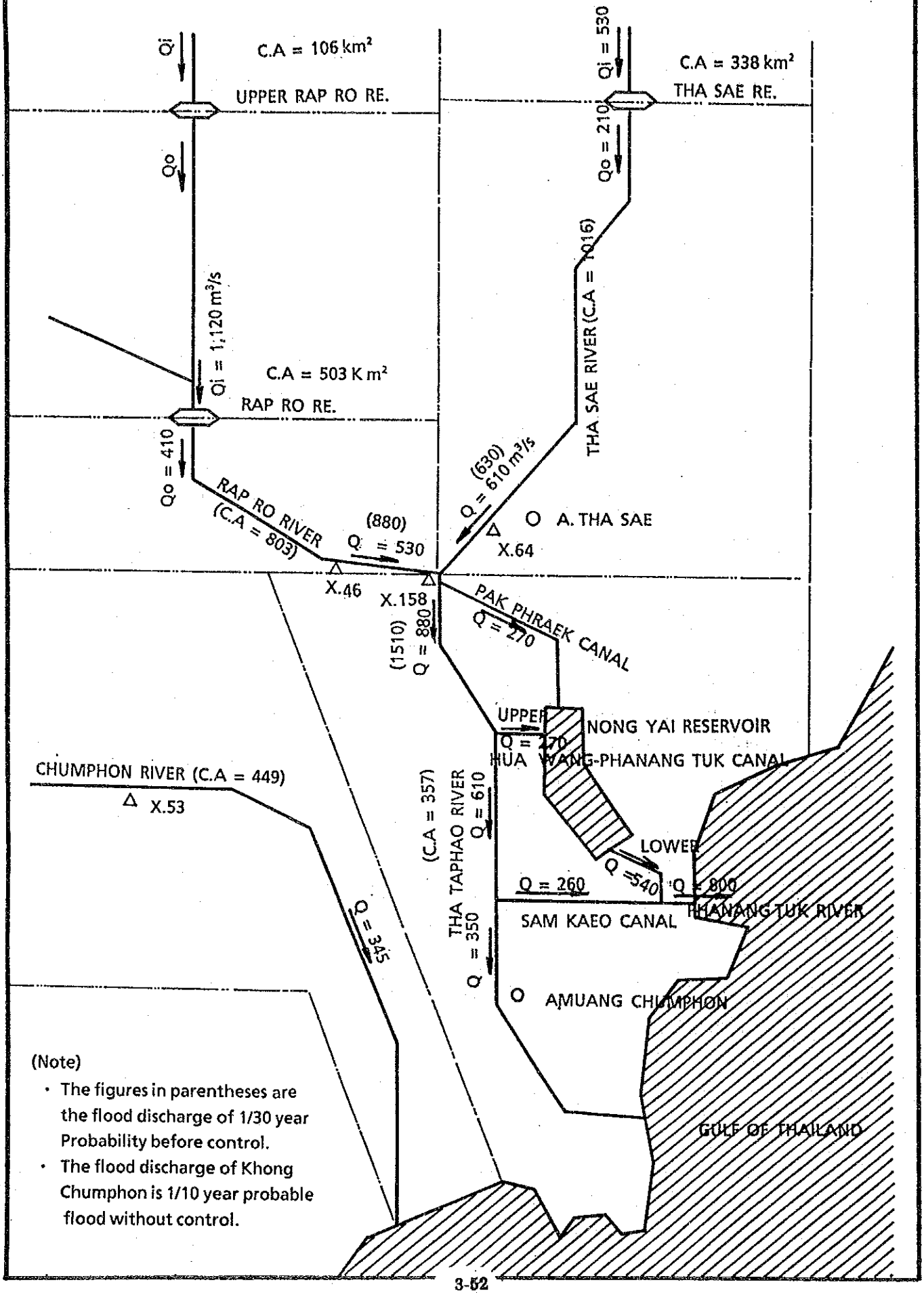


FIGURE 3-2 DISTRIBUTION OF FLOOD DISCHARGE



(Note)

- The figures in parentheses are the flood discharge of 1/30 year Probability before control.
- The flood discharge of Khong Chumphon is 1/10 year probable flood without control.

CHAPTER 4. THE PROJECT AREA

CHAPTER 4. THE PROJECT AREA

4.1 LOCATION AND AREA

The Nong Yai area, the area in which the feasibility study is to be implemented, is located on the alluvial plain of the Tha Taphao river, about 4 km north-eastward of the municipality of Chumphon. The boundaries of the project area with the proposed water resources of the Nong Yai swamp have been defined after considering the river system, land use, road networks and so on. The project area is bounded on the west by the Tha Taphao river, on the east by the proposed Hua Wang-Phanang Tuk canal, and on the south by the small tributaries and roads. In the north the Nong Yai swamp with the maximum water surface area of 700 ha borders the project area.

The gross land area is 2,260 ha exclusive of the Nong Yai swamp. According to the topographic maps with a scale of 1 : 10,000 prepared by RID, aerophotographs with a scale of 1 : 4,000 and the field survey, 2,019 ha of lands, or 89 percent of the total lands, are used for farm crop production as summarized below:

LAND AREA

Land	Area (ha)	Percent
Farm Land		
- Paddy field	716	31.7
- Orchard	1,263	55.9
- Upland field	40	1.8
Sub-total	2,019	89.3
Shrimp Pond	8	0.3
Natural Vegetation	180	8.0
Roads, Villages, etc.	53	2.3
Sub-total	241	10.7
Total	2,260	100.0

4.2 PHYSICAL CONDITION

4.2.1 Topography and Geology

(1) Topography

Nong Yai area is situated in the Tha Taphao river basin, being composed of an alluvial plain with elevations of about 1 to 7 m above mean sea level and hills. The Tha Taphao river meanders southeastward at the upper reaches and then turns to the southward at Ban Hua Wang; the river turns again to the southeastward, after crossing the National Railway, to drain into the Gulf of Thailand. The Sam Kaeo canal was constructed in 1950 to divert flood water of the Tha Taphao river and to supply irrigation water.

A swamp is formed in the low land in the northern part of Nong Yai area from the river flows which come from the northern hills during the rainy season; however, the swamp dries up in dry season. In the central to northern part of the Nong Yai area, the land is formed mostly of terraces, and the alluvial plains are found around Nong Yai swamp and along the rivers.

The alluvial plains predominate in the low-lying area about 1 km north of Sam Kaeo-Phanang Tuk canal. Isolated hills with elevations of around 100 - 200 m MSL are scattered in the surrounding Nong Yai area.

(2) Geology

The basement rock in the Nong Yai area is composed mainly of Carboniferous Matsi formation, and in the western part of the area, the Permian Chumphon formation is observed. The basement rock forms isolated hills surrounding the Nong Yai area. The diluvial deposits overlie the basement rock and form the terraces with elevations of more than 5 m MSL. The alluvial deposits distribute on the surface of the alluvial plains.

A Matsi formation is formed of orthoquartzite, siltstone and shale. The Chumphon formation is formed of bedded fossiliferous limestone and brecciated limestone. The diluvial deposits are composed of mainly stiff cohesive soil, partly sandy soil and partly gravelly soil with various sized

gravel (maximum around 300 mm). The alluvial deposits are composed of very soft cohesive soil and very loose sandy soil.

4. 2. 2 Climate and Hydrology

(1) Climate

The climate of the Nong Yai area is influenced by 2 monsoons with dry and wet season, covering the months of December to April and May to November respectively. The area has rainfall of 1,900 to 2,100 mm per year. There is generally a dry season in February and March. Then, from May, the rainfall remains moderate at around 200 mm per month until September. Rainfall jumps up to 350 mm in November.

The mean monthly temperature varies from 28.5°C in April to 25.0°C in December with an annual average of 26.7°C. The mean monthly evaporation is lowest, 96.1 mm, in November, whereas the highest evaporation, 151.8 mm, was recorded in March, totaling 1,399 mm per year.

(2) Hydrology

The Sam Kaeo canal, running eastward through the southern part of the area, was constructed in 1950' to divert flood water from the Tha Taphao river and to convey irrigation water with a design capacity of 260 cu.m/sec. Water levels at the head regulator are observed by RID; however, discharge records are not available. During the dry season, sea water intrudes into the canal.

Being situated in the north of the Nong Yai area, the Nong Yai swamp stores runoff from the catchment area of 102 sq.km. The water surface area of the swamp extends from 500 to 700 ha at the time of floods, and the swamp capacity becomes approximately 4 million cubic meters (MCM). Water levels are not observed; however, according to flood marks, water levels increased to 5.5 to 6.0 m above mean sea level (MSL).

4. 2. 3 Landform and Soils

(1) Landform

Soil profiles of the representative site were studied in order to review and modify the existing detailed reconnaissance soil map at a scale of 1 : 100,000 prepared by DLD. Soil profiles were investigated by excavating pits and using hand augers. Samples were taken from each layer to analyze the physical and chemical properties of the soil (refer to APPENDIX B). Soil distribution in the project area is shown in APPENDIX B. The distribution of soils is generally related to the landform sequence. Landforms in the project area can be classified into 6 types as follows:

LANDFORMS AND AREA

Landforms	Area (ha)	(%)
Old and recent beach ridges	269	9.6
Active tidal flats and depressions	256	9.1
Plains (lower terrace and flood plain)	922	32.9
Undulating and rolling terrain	807	28.8
Hills (Khao Na Cha-Ang)	6	0.2
Swamp (Nong Yai swamp)	543	19.4
Total	2,803	100.0

Soils distributed in the old and recent beach ridges are sandy soils, i.e. the Bacho series (Typic Quartzipsamments, USDA Soil Taxonomy) and Ban Thon series (Typic Tropohumods), formed by accumulation of sand and shells due to the tidal current and the strong waves. This topography covers about 269 ha, which is about 9.6 percent of the project area. An area for coconut palm trees is developed on a part of this land and the rest is covered with shrub and grass.

Soils distributed on the active tidal flats and depressions are characterized by fine and medium texture soils i.e. the Bang Pakong series (Typic Sulfaquents) and Wan Priang series (Typic Tropaquents), formed from sea water or brackish water sediments. This topography covers about 256 ha, which is about 9.1 percent of the project area and is used to grow mangroves and nipa palm trees. But now some in part of this area is being converted to shrimp ponds.

Soils distributed in the plains are of a very fine and fine texture soils and consist of the Tha Muang series (Typic Ustifluvents), Bangnara series (Typic Paleaquults) and Klaeng series (Oxic Plinthaquults), formed from recent fluvial deposits. This topography covers about 922 ha, which is about 33 percent of the project area and is used for paddy rice and vegetables cultivation in the relatively lower areas and for cultivation of fruit trees, coconut palm trees and others in the relatively higher areas.

Soils distributed on the undulating and rolling terrains are of medium and coarse texture and consist of the Kohong series (Typic Paleaquults), Sawi series (Typic Paleudults), Pathiu series (Typic Paleudults), Chumphon series (Typic Paleudults), formed from old river sediments. The topography covers about 807 ha, which is about 29 percent of the project area, and land is widely used to grow fruit trees, coconut palm trees and others.

(2) Soils

The soils in the project area are classified into 4 orders (USDA Soil Taxonomy), that is, Ultisols (1,092 ha, 39%), Entisols (914 ha, 32.6%), Spodosols (224 ha, 8%), Histosols (30 ha, 1%). All soil series in the project area have deep effective soil depth. Some soil series (Bangnara, Klaeng, Wan Priang, Bang Pakong, Narathiwat series) are poorly drainage. All soil series have inferior chemical properties such as very strongly acidic, except in case of Entisols (medium acid), low cation exchange capacity, low base saturation percentage, low organic matter except for the Narathiwat and Bang Pakong series, and very low available phosphate.

Two problem soils can be observed in the project area, e.g. saline soil and potential acid sulfate soil. According to the Saline Soil Research Laboratory of DLD, only Wan Priang series is located in the project area. However, according to the survey, saline soil was identified in the Bangnara series distributed on the north of the Sam Kaeo canal, which is used as paddy field. This salinity may be caused by irrigation water taken in from the Sam Kaeo canal where sea water or brackish water comes inside. Therefore paddy yield may decrease by 10 to 25 percent, judging from the ECe value (FAO Irrigation and drainage paper No.33, 1979). The Wan Priang series land is used for coconut palm tree production and for shrimp ponds.

Potential acid sulfate soil, distributed in the active tidal flats and depression in the project area, is used for the production of coconut palm tees, orchards in some parts, and the rest is planted with nipa palm trees; however some places are currently converted into shrimp ponds.

In consideration of the above observations, following management will be required for furthering agricultural development in the project area, 1) As potential acid sulfate soils contain a high content of pyrite (FeS2) under submerged and reduced condition, once pyrite is oxidized by drainage or exposure to air, sulfuric acid is produced and the pH of the soil decrease to 3.0. To prevent pyrite from oxidization, the groundwater level should be controlled and kept above the layer rich in pyrite, 2) Irrigation water of good quality should be used for saline soil areas in order to leach soluble salts from saline soil, 3) Drainage facilities are needed not only for the ill-drained field but for saline soil areas, 4) proper soil improvement measures are needed for strongly acid soil areas, and 5) proper manuring practices are needed for all types of soils in the project area.

LANDFORM AND SOIL

Symbol	Soil Series Name	Subgroup	Order	Area (ha)	Area (rai)	(%)
	Old and Recent Beach Ridges			269	1,683	9.6
Bc	Bacho series	Typic Quartzipsamments	Entisols	45	284	1.6
Bh	Ban Thon series	Typic Tropohumods	Spodsols	224	1,400	8.0
	Active Tidal Flat s and Depressions			256	1,601	9.1
Bpg	Bang Pakong series	Typic Sulfaquents	Entisols	50	311	1.8
Wp	Wan Priang series	Typic Tropaquents	Entisols	176	1,103	6.3
Nw	Narathiwat series	Typic Tropofibrists	Histosols	30	188	1.1
	Plains (Lower Terrace and Flood Plain)			922	5,757	32.9
Tm	Tha Muang series	Typic Ustifluvents	Entisols	540	3,373	19.3
Ba	Bangnara series	Typic Paleaquults	Ultisols	293	1,829	10.4
Kl	Klaeng series	Oxic Plinthaquults	Ultisols	89	555	3.2
	Undulating and Rolling Terrain			807	5,045	28.8
Lan	Lang Suan series	Typic Quartzipsaments	Entisols	103	642	3.7
Kh	Kohong series	Typic Paleaquults	Ultisols	468	2,926	16.7
Sw	Sawi series	Typic Paleudults	Ultisols	67	417	2.4
Pw	Pathiu series	Typic Paleudults	Ultisols	142	890	5.1
Cp	Chumphon	Typic Paleudults	Ultisols	27	170	1.0
	Hills			6.3	39	0.2
SC	Slope Complex			6.3	39	0.2
	Swamp			543	3,394	19.4
	Nong Yai Swamp			543	3,394	19.4
Total				2,803	17,519	100.0

(1) USDA Soil Taxonomy

4.3 AGRICULTURE

4.3.1 Land Use

Of the 2,260 the ha of total land, 2,019 ha are used for crop production as paddy fields, upland fields and orchards. The present land use of farm lands is given below:

PRESENT FARM LAND USE

(unit: ha)

Farm Land	Tambon			Total	%
	Bang Luk	Na Cha Ang	Na Thung		
Paddy Field	149	211	356	716	35.4
Mixed Orchard	141	377	572	1,090	54.0
Tree Crops					
- Coconut	26	8	110	144	
- Para rubber	-	5	-	5	
Sub-total	26	13	110	149	7.4
Upland Field	30	10	-	40	2.0
Mixed Farm Field	1	23	-	24	1.2
Total	347	634	1,038	2,019	100.0

Of the total farm lands of 2,019 ha, the mixed orchards of coconut with mangosteen, durian, pomelo and other fruits occupy as much as 54 percent of the total farm lands, being followed by paddy fields of 35 percent. Fruit trees are grown as backyard gardens. Some fruit trees are mixed with coconut trees. In the mixed farm fields, vegetables and field crops are cultivated with coconut trees.

There exist 383 ha of fallow land: 121 ha of paddy fields and 262 ha of orchards. The main reasons why farmers leave land fallow are 1) water shortages, and 2) low economic returns, according to the survey in 1990 by the NESDB (NRD-2C). Other reasons are flooding and low soil fertility.

The land use type in the project area is related to the landform sequence. For instance, paddy is planted on the relatively lower land of the plain, while fruit trees are planted on the relatively higher land of the plain and the undulating and rolling terrain. Non farm land is used for shrimp ponds and the remainder is covered with nipa palm, shrub and natural grass lands. Hills are used for borrow pits and those soils are used for road improvements and development of building land.

4. 3. 2 Main Crops and Yields

In general, the farm crop production in the area is typically carried out in the southern style based on tree crops and fruit, so-called mixed orchard mainly with coconut trees. About 200 ha of coconut trees were destroyed by Typhoon Gay in 1989, and farmers are still trying to replant their orchards with other crops such as young coconut, durian, mangosteen, pomelo and others recommended by the Provincial Office of Agriculture.

Coconut cultivation has a large share of the crop production in the area, amounting to about 42 percent of the total cropping area. Of 716 ha of the total paddy fields, 565 ha of paddy fields are cropped to rainy season paddy. Cropping of dry season paddy is limited to 30 ha area around the swamp. No double cropping of paddy is practiced because of inundation in the rainy season and water shortage in the dry season. Vegetables are grown in Ban Luk village near the swamp such as cucumber, beans, pepper and white ground. The present cropping area and yields are given as follows:

CROPPING AREA AND YIELDS

Crop	Cropping Area (ha)	Cropping Area (%)	Yield (ton/ha)
Paddy			
- Rainy season paddy	565	28.0	1.63
- Dry season paddy	30	1.5	1.94
- Fallow	121	6.0	
Sub-total	716	35.5	
Tree Crop			
- Coconut	749	37.0	3,600 (1/)
- Young coconut	100	5.0	
Sub-total	849	42.0	
Fruit			
- Mangosteen	54	2.7	2.19
- Cashew nut	32	1.6	1.13
- Durian	30	1.5	4.38
- Pomelo	20	1.0	5,000 (1/)
- Pineapple	16	0.8	
- Fallow	262	13.0	
Sub-total	414	20.5	
Vegetable	40	2.0	
Total	2,019	100.0	

Notes: (1) = fruits/ha

4.3.3 Farming

All paddy is transplanted. Rainy season paddy is transplanted in September in anticipation of heavy rainfall and is harvested in February. Rainy season paddy cropping along the Tha Taphao river is unsteady because of flooding. About 50 percent of paddy farmers use the improved varieties as recommended by the Provincial Office of Agriculture: 70 percent of farmers in Na Cha Ang village, 45 percent of farmers in Na Thung village and 30 percent of farmers in Ban Luk village. Most farmers apply fertilizer; however, the quantity of fertilizer applied was less than the recommended quantity. The survey by the Provincial Office of Agriculture revealed that in Na Cha Ang village 43 percent farmers applied fertilizer in the proper time, whereas in Na Thung Village it was only 3 percent.

Coconut trees have long been cultivated; however, about 75 percent of coconut farmers have voiced the opinion that high economic returns cannot be expected from the traditional variety of coconut. According to the farm survey mentioned above, 40 percent of farmers applied manure and 64 percent of farmers chemical fertilizer, but all farmers did not apply fertilizer in the quantity as recommended at the proper time.

4.3.4 Farm Size and Land Tenure

(1) Farm Size

According to the data of NRD-2C in 1990, the average farm size of paddy farmers is small compared to other regions. It is less than 0.8 ha on the average for about 50 percent of the total paddy farmers. The same is observed in the 3 villages. The farm size of paddy is given as follows:

AVERAGE FARM SIZE OF PADDY

(Unit: Nos. of farm household)

Tambon	Farm Size (ha)				Total
	0.16~0.80	0.80~1.60	1.60~3.20	3.20~8.00	
Na Thung	61	39	11	-	111
Ban Luk	141	70	27	14	252
Na Cha Ang	135	100	44	27	306
Total	337	209	82	41	669

The average farm size of the area is 1.06 ha for coconut, 0.84 ha for orchard and 0.43 ha for upland field. The Average farm size other than paddy farms is derived from the data of NRD-2C, as summarized below:

AVERAGE FARM SIZE OTHER THAN PADDY

Tambon	Coconut		Orchard		Field Crops	
	Nos. of Farm	ha	Nos. of Farm	ha	Nos. of Farm	ha
Na Thung	156	1.23	12	1.28	-	-
Bang Luk	18	0.80	72	0.80	46	0.64
Na Cha Ang	396	1.01	100	0.16	35	0.16
Total	570	1.06	184	0.48	81	0.43

(2) Land Tenure

About 75 percent of farmers are owner farmers. Tenant farmers make up only 2 percent of the total farmers; however, it is remarkable that 20 percent of farmers are landless. According to the NRD-2C data, 36 percent of farmers are landless in Na Thung village, whereas there is no landless farmer in Ban Luk village, as shown below:

LAND TENURE

(unit: percent of farmers)

Tambon	Owner	Owner Tenant	Tenant	Landless
Na Thung	61.5	0.4	1.8	36.3
Bang Luk	92.4	6.7	0.9	-
Na Cha Ang	86.9	6.5	2.8	3.8
Total	74.5	3.3	2.0	20.2

4. 3. 5 Livestock Raising

96 farm households raise 307 heads of cattle at 3 villages. The Department of Livestock and the Office of Accelerated Rural Development encourage farms to raise cattle for increasing their farm income, and farmers in the area have willingness to extend cattle raising for sale. According to information obtained from interviews, problems to be solved are lack of pasture land in the dry season, floods in the rainy season and shortage of investment capital. 76 farmers raise water buffaloes mainly as on extra labor force for land preparation of paddy fields.

LIVESTOCK RAISING

Livestock	Na Thung	Ban Luk	Na Cha Ang	Total
Cattle				
- Nos. of Cattle	143	59	105	307
- Nos. of Farms	23	18	55	96
Water Buffaloes				
- Nos. of Buffaloes	16	194	133	343
- Nos. of Farm	1	30	45	76
Swine				
- Nos. of Swine	418	189	493	1,100
- Nos. of Farm	42	84	73	199
Poultry				
- Nos. of Poultry	70	-	7,020	7,090
- Nos. of Farm	3	-	96	99

4. 3. 6 Inland Fisheries

Besides shrimp culture, catfish and freshwater fishes are raised by 38 farmers around the Nong Yai swamp and along the Tha Taphao river. The total water area is 1.38 ha with 45 ponds. The largest scale ponds are constructed in 2 Muban of Ban Luk village which is located between the Tha Taphao river and Nong Yai swamp with a total water area of 0.59 ha, or 55 percent of the total pond area. The problems prevailing in the area are floods in the rainy season, disease, lack of knowledge, high prices of fish feeding, and little demand for catfish in the municipality of Chumphon. Inland fisheries in the area are summarized according to data from the Provincial Office of Fisheries as follows:

INLAND FISHERIES

Tambon	Nos. of Farmers	Nos. of Ponds	Total Area (ha)
Na Thung	10	10	0.39
Bang Luk	20	27	0.70
Na Cha Ang	8	8	0.19
Total	38	45	1.28

4.4 IRRIGATION AND DRAINAGE

4.4.1 Irrigation

A part from farm land irrigated by small portable pumps owned by farmers, agriculture of most farm land in the project area depends on intermittent rainfall. RID has devised an irrigation program to install 33 units of irrigation pumps with diameters of 6 - 8 inches in 1992 in the river basins of Rap Ro, Tha Sae and Tha Taphao, totaling 2,160 ha of irrigable area. Two units of pump are allocated to the Tha Taphao river basin for the rainy season irrigation of 180 ha of paddy fields.

The Nong Yai area may be divided by hills into 2 sub-areas: the northern part and southern part. In the northern part, water tolerable local varieties of paddy such as Nang Phaya, Luang Pratue, Kao Surat, are grown under the influence of floodwater levels of the Nong Yai swamp. As the water levels of the swamp decrease during the dry season, dry season paddy and vegetables are cropped in the land around the swamp depending on soil moisture.

In the southern part of the area, the Sam Kaeo canal, running eastwards across the central portion of the area, functions as the main canal with dual purpose of irrigation and drainage. In the rainy season canal, water is drawn to the paddy fields, and when water levels of the canal drop during the dry season, farmers operate their own pumps for lifting water for irrigation; however, during the period of 3 months from February to April when the canal water levels drop sharply, water in the canal cannot be used for irrigation as sea water intrudes into the canal.

4.4.2 Drainage

The Nong Yai area may also be divided into 2 sub-areas for drainage planning purpose. In the northern area excess water is drained to the Tha Taphao river through the Nong Yai swamp. The water levels of the swamp rise to 5 - 6 m above mean sea level due to lower drainage capacity of natural river channels to connect the swamp with the river. After that, the water levels of

the swamp gradually drop to reach around 2 - 2.5 ms above mean sea level during the period from April to May.

In the southern section, the ground elevation of the paddy fields is only 0.5 - 3.0 m above mean sea level. Excess water from the paddy fields is drained to the Sam Kaeo canal; however, many small swamps are formed in the depressions with ground elevation of less than 1 m above mean sea level. Excess water from the farm lands with ground elevation of 1.0 - 4.5 m above mean sea level, (higher than the ground elevation of the farm lands in the northern part of the area), is drained into the Sam Kaeo canal or the Nong Sai river, one of the main tributaries of the Tha Taphao river.

Natural rivers run through the farm lands in the area to drain off excess water into the Nong Yai swamp and the rivers of Tha Taphao and Nong Sai. The density of the natural rivers is about 400 m per sq.km, less than the densities of 1.0 - 1.5 km per sq.km prevailing in irrigation areas. High water levels in the rainy season of the Tha Taphao river make worse drainage of the Nong Yai area. The estimated safe channel capacity of the Tha Taphao river is 430 cu.m/sec, whereas the probable peak flood discharge with a return period of 2 years of the river is 640 cu.m/sec. To improve the drainage condition of the Nong Yai area, improvement of the Tha Taphao river and Sam Kaeo canal is essential.

4. 5 SOCIO-ECONOMY

4. 5. 1 Administrative Units

Administratively the Nong Yai area is shared by 3 Tambon in the northeast of Amphoe Muang Chumphon; they are Tambon Na Cha Ang on the eastern side of Nong Yai swamp, Tambon Bang Luk on the western side and Tambon Na Thung south of the Sam Kaeo canal.

ADMINISTRATIVE UNITS

Province	Amphoe	Tambon	Nos. of Villages
Chumphon	Muang Chumphon	Na Thung	6
		Bang Luk	4
		Na Cha Ang	5

4. 5. 2 Population and Households

The total population of 15 villages (Muban) related to this area was 10,803 in 1991 with an average population density of approximate 320 persons per sq.km, about 2 times the average population density of Amphoe Muang Chumphon (185 persons per sq.km). The distribution of population and households can be summarized as follows:

POPULATION AND HOUSEHOLDS

Tambon	Population	Total Household	Farm Household	Average Families
Na Thung	5,580	1,088	477	5.1
Bang Luk	1,728	357	344	4.8
Na Cha Ang	3,495	649	413	5.4
Total	10,803	2,094	1,234	5.2

The Nong Yai area is basically an agrarian area with some specific variations, especially in Tambon Na Thung, developing towards residential areas linked to the municipality of Chumphon. Most households in the area have engaged in agricultural production, except for some villages in Tambon Na Thung where about 60 percent of households work in official and private jobs.

4. 5. 3 Infrastructures and Social Services

(1) Road and Transportation

National road No. 3180 from Amphoe Muang Chumphon to Amphoe Pathiu passes through the middle of the Nong Yai area from the southwest to the northeast, providing a backbone for the network of rural roads in this area. This trunkroad is paved with concrete, meanwhile rural roads which connect villages with the trunkroad are of laterite pavement. The total length of the trunkroad within the Nong Yai are is about 10 km.

Next to the trunkroad is the railway connecting the Southern Region to the Central Region of Thailand. The railway crosses the trunkroad at 2 places at a distance of about 2 km from the town of Chumphon. The rural road network in this area is considered sufficient for communication purpose, except

for the sharp curves and difficult configurations of some rural roads and some portions which are provel to flooding.

(2) Rural Electrification

Of 15 villages related to the area, 14 are supplied with rural electrification networks from the Provincial Authority of Electricity, apart from the remote village (Muban) of Don Ta Bow at Tambon Na Thung. The ratio of electrification is 98 percent for Tambon Na Thung, 60 percent for Tambon Ban Luk and 76 percent for Tambon Na Cha Ang, on a household basis, with an average of 80 percent.

(3) Water Supply

Except for Tambon Na Thung linked to the municipality of Chumphon where city water is supplied to some parts, the other Tambon of Bang Luk and Na Cha Ang, especially for the latter, have suffered from a lack of domestic water. Local inhabitants collect rain water in jars for drinking and water from shallow wells of ARD, home-made etc. for domestic use but the quality of well-water in many areas of Tambon Bang Luk and Tambon Na Cha Ang is reportedly very hard, even for domestic use.

(4) Public Health

Regarding health services, each Tambon has a health center for caring for minor health problem. For serious cases, patients will be sent to proper hospitals in the municipality of Chumphon for treatment. There are no serious health problems as of now in the Nong Yai area, except for the safety of drinking water.

(5) Marketing

There is only a small market near the Na Cha Ang railway station for distribution of agricultural products and some daily goods. Local inhabitants have acquired a proper marketing and distribution system for supporting their agricultural production.

4. 5. 4 Agricultural Economy

In general the Nong Yai area is an agrarian area with 3 fundamental characteristics: its location is adjacent to the municipality of Chumphon, and its southern style of agriculture based on specific natural potential and local traditional socioeconomic activities. There are 1) smaller farm sizes compared to the national average of 2.9 ha, 2) farming is based on coconut cultivation, and 3) there are relatively high off-farm incomes to be carried.

The average farm size is small. According to the data of the Ministry of Interior, the average farm size is 0.3 ha for Tambon Na Thung which is located close to the municipality of Chumphon, 0.7 ha for Tambon Na Cha Ang and 1.7 ha for Tambon Bang Luk. Paddy fields, on the other hand, are limited to low land with an average coverage of about 34 percent of the total farm land.

The second characteristic observed concerns the present land use in these 3 Tambon. Coconut trees have been grown on about 46 percent of the total farm land: 48 percent for Tambon Na Thung, 64 percent for Tambon Na Cha Ang and 31 percent for Tambon Bang Luk. Income from coconuts is considerably poor due to the low farm gate price of 2 - 3 Baht per fruit. Coconut trees, however, produce fruits all the year round without intensive farming care. Coconut, therefore, is considered as a low but steady income source in the agriculture activity of the Southern Thailand.

Tambon Na Thung, which is located near to the municipality of Chumphon has limited farm land, and carries out agriculture of coconut production, fruits and vegetables in home gardens. Tambon Na Cha Ang, which belongs to the upland and coastal areas has insufficient agricultural water, grows also more coconut and a little paddy. In addition, some villages of this Tambon in the coastal areas, outside of the Nong Yai area, have conducted shrimp culture deriving high income in recent years. Tambon Bang Luk located near to water resources of Tha Taphao river and Nong Yai swamp has mainly cultivated paddy with approximately 43 percent of the total farm land, whereas coconut occupies 31 percent of the total farm land.

(2) Farm Economy

The aspect of farm economy in the Nong Yai area implies that there is a trend towards earning off-farm income as the farm land is limited. Being located near to the municipality of Chumphon, the Nong Yai area has relatively good off-farm job opportunities compared to other regions. Tambon Na Thung has many farmers with side jobs working in the town. In the other 2 Tambon, Na Cha Ang and Bang Luk, women work in processing and packing cashew nut or running pig farms.

The farm survey conducted during this study period has revealed that the average off-farm income is higher than the average on-farm income at all 3 Tambon. Main source of off-farm income is wage labour. The average annual income of sample farm households is summarized as follows:

AVERAGE ANNUAL INCOME OF FARM HOUSEHOLDS

(unit: 1,000 Baht)

Item	Na Thung	Na Cha Ang	Bang Luk
Gross Income			
- Farm income	13	19	20
- Off-farm income	93	58	24
Total	106	77	44
Expenditure			
- Farm expenditure	8	14	17
- Living expense	50	40	27
Total	58	54	44
Net Income	48	23	0

According to the results of the farm survey, projects demanded by farmers for increasing their farm income are in order of priority 1) irrigation water, 2) farm credit, 3) agricultural supporting services including training, information on farming, and marketing, and 4) enlargement of farm land.

CHAPTER 5. NONG YAI - THA TAPHAO DEVELOPMENT PLAN

CHAPTER 5. NONG YAI - THA TAPHAO DEVELOPMENT PLAN

5.1 PROJECT COMPONENTS

In order to accomplish the development objective of increasing the income level of the farmers through agriculture development, water resources development with control of flood and water distribution to farm land, and intensive backup from agricultural extension services, this project proposes to implement the following development plans:

Nong Yai Agriculture Development

1) Agriculture Development
   - Increase in yields and crop intensities
   - Irrigated agriculture
   - Improvement of rainfed agriculture
   - Promotion of cattle raising
   - Promotion of swamp fisheries
   - Strengthening of agricultural supporting services
2) Water Resources Development
   - Rehabilitation of Nong Yai swamp
3) Irrigation Development
   - Construction of irrigation systems
   - Development of on-farm facilities for irrigation
   - Water management by water users' groups
4) Drainage Improvement
   - Construction of main drainage canals
   - Development of on-farm facilities for drainage

Drainage Improvement of Tha Taphao River System

1) Improvement of Rivers
   - Tha Taphao river
   - Phanang Tuk river
   - Nong Sai river
2) Rehabilitation of Sam Kaeo Canal
3) Construction of Canals
   - Pak Phraek canal
   - Hua Wang-Phanang Tuk canal

5.2 NONG YAI AGRICULTURE DEVELOPMENT PROJECT

5.2.1 Agriculture Development

(1) Land Use

According to the results of the soil suitability analysis for intensive irrigated agriculture, soils in the lower terrace and flood plains are suitable for paddy cultivation. As cashew nut requires sandy soils with good drainage condition and a low water table, the Ban Thon series distributed in the active tidal flats, Kohong series, Lan Suan series and Chumphon series distributed in the undulating terrain are assessed to be suitable for cashew nut cultivation. Other fruit trees require only deep effective soil depth. Therefore, most of the soil series are suitable for fruit growing.

In the project area there is little land to be converted into farm land. Some land, excluding areas with nipa palm trees, can be converted into orchard and pasture lands. 38 ha of this land will be developed as pasture land for the proposed cattle raising pilot project. Land with nipa palm trees may be converted to shrimp ponds in the future.

It has been proposed that increasing the agricultural production can be achieved by introducing irrigated agriculture for paddy and fruit trees. Intensive irrigated agriculture implies irrigation water supply, adequate drainage conditions, and soil improvement with the proper amount of fertilizer application. The proposed land use is as follows:

PROPOSED LAND USE

(Unit: ha)

Land Use Type	Area (ha)	Percentage
Farm Land		
- Paddy field	630	27.9
- Orchard	1,370	60.6
- Upland field	78	3.5
Sub-total	2,078	91.9
Shrimp Pond	8	0.4
Nipa Palm and Grass Land	64	2.8
Road, River and Others	110	4.9
Sub-total	182	8.1
Total	2,260	100.0

(2) Crop Selection

The proposed crops are selected in consideration of 1) soil suitability, 2) marketability, 3) farmers' experience and technology, 4) farmers' intention, and 5) guidelines of the Department of Agriculture and the Department of Agricultural Extension. As for soil suitability, there is no serious problem when irrigation and drainage are introduced and proper application of fertilizer is practiced. The forecast for market demand is not easy; however, the increase in cropping area of fruit trees and replacement of traditional coconut with young coconut have both been proposed.

According to a farm survey of 15 villages conducted by the Department of Agriculture, 12 villages wish to increase paddy cropping. This is evidenced by the farm survey for 80 samples in the project area; only 4 farmers have paddy surplus for sale; 50 farmers buy rice for consumption. Next to paddy, farmers wish to cultivate pomelo, mangosteen, durian, vegetables, young coconut, pineapple, and cashew nut, all of which are being grown around the project area.

The cropping intensity of paddy fields will be increased to 109 percent by introducing double cropping of paddy for 9 percent of paddy fields, or 60 ha of paddy field. Fruit trees of pomelo, mangosteen, durian, cashew nut and pineapple will be planted to 383 ha of the present fallow lands. 38 ha of pasture lands will be developed. The proposed cropping calendar is shown in Figure 5 - 1. By introducing irrigation and application of fertilizer, yields will be increased. The proposed yields have been projected in consideration of other similar projects and guidelines of the government agencies concerned. Table 5 - 1 shows the recommended application of fertilizer by the Department of Agricultural Extension.

PROPOSED CROPPING AREA AND YIELD

Crops		Area (ha)	Yield (ton/ha)
Paddy	: Rainy season paddy	630	3.13
	Dry season paddy	60	4.06
Tree Crops	: Coconut	728	7,500 1/
	Young coconut	170	13,400 1/
Fruit	: Mangosteen	135	7.80
	Cashew nut	60	1.75
	Durian	135	7.50
	Pomelo	110	9,400 1/
	Pineapple	32	40.60
Vegetable		40	25
Pasture		38	
	Total	2,138	

Note : 1/ : fruits/ha

(3) Livestock Development

To meet the increasing demand for meat, cattle-raising is being promoted by the government agencies concerned. South Thailand has topographical conditions suitable for pasture land and/or intercropping pasture land. Farmers in the project area raise livestock such as cattle, water buffaloes, swine and poultry to supplement their farm incomes. According to the farm survey, livestock income in the project area is second to crop income, amounting about 4,000 Baht a year per household on an average. Farmers hope to increase livestock raising, but only on a small and medium scale. By implementing the proposed Nong Yai agriculture development project and the drainage improvement project of the Tha Taphao river system, inundation of the rivers and swamp will be mitigated, thus, eliminating one of the constraints to livestock raising. This Nong Yai agriculture development project proposes to promote cattle raising at Tambon Bang Luk as a pilot project, where farmers show a willingness to increase cattle raising.

a) Pilot Area

The public land in Tambon Bang Luk on the eastern side of the Nong Yai swamp, presently being subject to annual inundation, will be developed as the pilot project area. Promotion programs for cattle raising will be implemented targeting the two villages of Bang Luk and Na Cha Ang. 38 ha of pasture lands will be developed.

b) Plan for Livestock Development

A livestock farmers' group will be organized composed of 20 farmers. Each farmer will raise individually 4 beef cattles and 10 pigs. Recommended varieties are American Braman and Hindo-Brazil for beef cattle, and Middle Yorkshire and Small Yorkshire for pig. Approximately 2 rai of land will be used to construct a pilot farm comprising grazing lands, livestock barns, and an office building and other facilities.

c) Raising Target

The pilot farm will attempt to improve profitability and methods of cattle and swine raising. The following is a guideline for raising cattle and swine:

RAISING TARGET

Item	Cattle	Swine
Nursing		
- Nursing period (month)	6	1
- Weight (kg)	120	15
Raising		
- Raising period	12	5
- Weight (kg)	280	90
Fattening		
- Fattening period	7	1
- Weight (kg)	400	100
Total Raising period	25	7

d) Feed Supply

Beef cattle require an average of 3.5 kg of total digestive nutrients (TDN) per head a day. The total amount of TDN is provided with roughage as basic feed stuff. Pigs need an average food of 4 kg per head a day. The bulk of this feed will consist of bran to be purchased. The TDN may consist of approximate 35 percent of roughage (pasture grass and rice straw), and the daily and annual amount of roughage required are 10 kg/day per head of cattle, and 3.65 ton a year for 40 heads of cattle. Good pasture yields about 25 ton a year for 40 head of cattle. Good pasture yields about 25 ton of grass per ha. As the average utilization rate is 30 percent, 7.5 ton of roughage can be used. This means that 1 ha of pasture can support 2 head of cattle.

(4) Inland Swamp Fisheries Development

Regarding the use of the water bodies of the Nong Yai swamp which has a maximum water surface area of 543 ha, the development of inland fisheries has been proposed in order to meet fish demand for home consumption. The water depths of the swamp are 2.5 m in the rainy season and 1.0 m in the dry season, which may provide suitable water depths for inland fisheries. Fish seeds will be supplied by the Provincial Office of Fisheries. Main species to be stocked are Tilapia, Thai carp, Indian carp, grass carp and others. With stocks of 4,000 seeds per ha, an annual catch of 200 kg per ha can be expected. Management of swamp fisheries will be under the control of a farmers' group chaired by the chief of the village concerned.

(5) Supporting Services for Agriculture Development

a) Agricultural Extension Services

Data from the farm survey indicate that farmers' desire for a more effective supporting system for their agricultural production is very high. In the present local government organization, the Agricultural Extension Office in each Amphoe has conducted supporting services with the cooperation of an agricultural agent at the Tambon level. The agricultural supporting services for the Nong Yai project will cover the fields of 1) training of crop production technology, 2) supply of farm input materials, 3) provision of farm credit, 4) improvement of marketing, and 5) organization of farmers' groups.

The training of farmers for cropping will be conducted by extension agents under the responsibility of Amphoe Offices of the Department of Agricultural Extension. To this end, it is proposed to establish 1 demonstration farm at each village for paddy, orchard and vegetable cropping. Improvement of facilities of the Na Cha Ang market is also proposed. In order to improve farm production and quality of products, the government agencies concerned will give information on marketing to farmers' groups through the provincial offices.

b) Bank for Agriculture and Agricultural Cooperatives

To enable farmers to increase their productivity and raise their incomes, institutional credit plays an important role in national agricultural development plans. The Bank for Agriculture and Agricultural Cooperatives (BAAC) established in 1966 covers virtually all districts in the country. For the successful implementation of orchard and livestock development where several years are required to recover the investment, farm credit provided by BAAC is to be applied.

Farmers can apply for farm credit, either individually or in groups. For administrative purposes, individual farmers are organized into client groups. Group members select a leader who coordinates between the farmers and BAAC. There is no limit to the number of groups which may be organized within a village. BAAC can lend to 2 specific types of farmer institutions: Agricultural Cooperatives, which are usually Amphoe-level organizations registered with the Cooperatives Promotion Department: and Farmers Associations, which are usually Tambon-level organizations, under the authority of the Department of Agricultural Extension.

Lending operations with individual farmers can be classified as follows: 1) loans for annual agricultural production expenses, and 2) loans for investment in agricultural assets. The latter type loans are classified into 2 types of medium-term loans and long-term loans. For orchard and cattle-raising that require more than 5 years for recovery, long term loans may be applicable. Loan repayment periods are as follows:

REPAYMENT PERIOD OF LOAN

Type	Normal	Maximum
Short Term	12 months	18 months
Medium Term	3 years	5 years
Long Term	5~15 years	20 years

The bank's interest policy has been to maintain interest rates below the level charged by commercial banks. At present the commercial banks' prime rate is 15.5 percent, and the normal BAAC rates to individual clients are as follows.

INTEREST (%)

Loan Type	Loan Amount (Baht)		
	Below 60,000	60,000 ~ 1,000,000	Above 1,000,000
Short Term	12.5	Prime rate minus 1	Prime rate plus 1
Medium Term	12.5	Prime rate minus 1	Prime rate plus 1
Long Term	11.5	Prime rate minus 2	Prime rate

BAAC loans may be secured in any of the following ways: 1) through a joint-liability agreement between at least 5 and not more than 30 farmer borrowers, 2) by a declaration by at least 2 people approved by BAAC, 3) through the mortage of unencumbered immovable property, and 4) with government securities or cash deposits.

5. 2. 2 Irrigation and Drainage Plan

(1) Irrigation Water Requirement

Irrigation water requirements are estimated for the following 4 proposed cropping types: 1) type 1 of rainy season paddy, 2) type 2 of double cropping of paddy, 3) type 3 of mixed orchard, and 4) type 4 of vegetable. Consumptive water requirements (Cu) are estimated by the Modified Penman Method as $Cu = Kc \times ETo$, where Kc is consumptive use crop coefficient and ETo is reference crop evapotranspiration. In addition to Cu, 1.0 mm/day of deep percolation and 270 mm of water for land preparation are added to paddy, and 50 mm of water of pre-irrigation for vegetable in the dry season. The field water requirements are given below:

FIELD WATER REQUIREMENTS

Month	Type 1 (R. Paddy)	Type 2 (Double Paddy)	Type 3 (Orchard)	Type 4 (Vegetable)
Jan.	142.8	142.8	108.3	148.9
Feb.	17.4	17.4	110.2	151.6
Mar.	-	337.6	136.5	187.7
Apr.	-	219.8	132.0	181.5
May	-	218.7	118.2	162.5
Jun.	-	146.7	108.6	149.3
Jul.	-	16.2	111.4	153.1
Aug.	-	-	109.3	150.3
Sep.	321.4	321.4	106.2	146.0
Oct.	167.4	167.4	101.5	139.6
Nov.	178.6	178.6	94.2	129.5
Dec.	191.1	191.1	103.3	142.0
Total	1,018.7	1,957.7	1,339.7	1,842.0

The diversion water requirements at the reservoir are determined taking account of effective rainfall and water losses in the operation of irrigation. The irrigation efficiencies are proposed to be 0.55 for paddy and 0.50 for other crops. Effective rainfall for irrigation is assumed as given in the following table, in which R represents amount of rainfall

EFFECTIVE RAINFALL

(unit: mm)

Crop	Effective Rainfall	Upper Limit	
		Month	10 Days
Paddy	0.75 × R	200	70
Other than Paddy	0.75 × R	120	40

(2) Irrigation Area

According to the land use plan, the cropping area is 630 ha for paddy, 898 ha for tree crops, 472 ha for fruit, 40 ha for field crops and 38 ha for pasture, totaling 2,078 ha of cropping area. The stored water in the reservoir will firstly be supplied for irrigation of paddy, vegetable and fruit trees that have high response to irrigation, and then, for young coconut where the water resources are sufficient.

In order to determine an appropriate irrigation area, reservoir operations of the Nong Yai reservoir were run on the 10-day basis for the period of 10 years based on the hydrological conditions from 1981 to 1990. As a result, the following 2 alternative cases are selected for further consideration:

CASE STUDIES FOR PROPOSED IRRIGATION AREA

(unit: ha)

Crop		Case 1	Case 2
Paddy :	Rainy Season	570	570
	Double Cropping	60	60
Fruit		460	530
Vegetable		40	40
	Total	1,130	1,200
Nos. of Year in water shortage		1	2

The irrigation plan by reservoir is normally conducted with one time water shortage for 10 years. In such case, the proposed Nong Yai reservoir can irrigate the farmland of 1,130 ha. One the other hand, when increasing the irrigable area of 70 ha totaled to 1,200 ha of irrigation area, the water shortages may occur at 2 times in a 10-year period.

In order to extend the irrigation area as much as possible to a reasonable extent, the irrigation plan proposes to select 1,200 ha of farm lands for irrigation, allowing water shortages in 2 years of a 10-year period. In drought years, water-saving irrigation will be applied by means of intermittent irrigation and rotational irrigation. Fruit trees with deep root zone can tolerate water shortages.

(3) Irrigation Facilities

a) Irrigation Block

The proposed irrigation area of 1,200 ha is divided into 7 irrigation blocks in consideration of topography and land use. 6 irrigation blocks with the irrigation area of 600 ha located around the Nong Yai reservoir will be supplied with water by pumping. Being located in the lower part of the project area, irrigation block G with an irrigation area of 600 ha will receive water by gravity from the reservoir through the proposed diversion weir across the Lower Hua Wang-Phanag Tuk canal; however, for field irrigation of 318 ha of farm lands in irrigation block G, water will be lifted from the proposed irrigation canals. The proposed irrigation area by irrigation block is given below:

IRRIGATION AREA BY BLOCK

(Unit: ha)

Irrigation Block	Paddy (1)	Paddy (2)	Fruit	Vegetable	Total	Intake
A	60	6	17	20	103	Pumping
B	96	10	36	10	152	Pumping
C	13	1	38	10	62	Pumping
D	17	2	57	-	76	Pumping
E	72	8	19	-	99	Pumping
F	26	3	79	-	108	Pumping
G	286	30	284	-	600	Gravity weir
Total	570	60	530	40	1,200	

Note: (1) = rainy season paddy, (2) = double paddy cropping

The four irrigation blocks of A, B, C and D lift water directly from the reservoir, and the 3 blocks of E, F and G from the Lower Hua Wang-Phanang Tuk canal. In blocks C, D and F, canals are of pipes due to their steep topography, and in other blocks, canals are of open channel structure with concrete lining.

b) Intake Facilities

The pumping stations will be operated on a 12-hour per day basis, whereas the intake weir for use of irrigation block G will be operated for 24 hours a day. The capacity of the intake facilities is determined by the following formula:

$$W.D = \Sigma [I.A \times N.W.R / I.E) \div O.H]$$

W. D	:	Capacity of intake facility
I. A	:	Irrigation area
N. W. R	:	Net water requirement
I. E	:	Irrigation efficency
O.H	:	Irrigation operation hour

The peak irrigation water requirements occur in September. The proposed capacities of the intake facilities are given below:

CAPACITIES OF INTAKE FACILITIES

Item	Irrigation Block							Total
	A	B	C	D	E	F	G	
Irrigation Area (ha)	103	152	62	76	99	108	600	1,200
Capacity (cu.m/sec)	0.40	0.61	0.16	0.19	0.43	0.28	1.34	3.41
(ℓ/sec/ha)	3.9	4.0	2.5	2.5	4.4	2.5	2.2	

(4) Drainage Plan

The removal of excess irrigation water and rainfall from the soil surface is necessary to prevent crop damage. Heavy rain falls mostly for 3 consecutive days. In consideration of the water storage function of paddy fields and water tolerance of crops, the following criteria for planning of a drainage system are proposed:

Design rainfall : - maximum probable 3 days consecutive rainfall with a return period of 5 years in the municipality of Chumphon

- 254.7 mm

Drainage modulus : - 80 percent of the design rainfall to be drained for the 3-day period

- 67.9 mm/day
- or, 7.9 ℓ/sec/ha

RID applies the reduction factor to design of drainage canals depending on the size of the drainage area after consideration of the characteristics of rainfall prevailing in Thailand. In this drainage plan, the reduction factor is not applied because the drainage area is only 5.54 sq.km. 6 main natural channels in the project area will be improved for use as main drainage canals. The following table gives the designed capacities of the main drainage canals, in which the unit drainage discharge of 15.3 ℓ/sec/ha is employed for inflow from the hilly area.

DESIGN CAPACITY OF MAIN DRAINAGE CANAL

Block	Drainage Canal	Drainage Area (ha)			Capacity (cu.m/sec)
		Project Area	Outside	Total	
B	BD - 1	114	398	512	7.0
E	ED - 1	140	413	553	7.4
	ED - 2	81	238	319	4.3
G	GD - 1	142	-	142	1.1
	GD - 2	304	250	554	6.2
	GD - 3	207	-	207	1.6

5. 2. 3 Nong Yai Reservoir

(1) Development Plan

The Nong Yai swamp with a catchment area of 102 sq.km is being used for irrigation of farm lands around the swamp. The water levels of the swamp rise to over 5 meter above mean sea level and the swamp area increases to about 700 ha in the flood season. And in the dry season the water levels drop to 2.0 - 2.5 meter above mean sea level with the inundation area of not more than 30 ha. The rehabilitation of the swamp has been proposed to provide 4.5 MCM of storage as a reservoir by constructing dikes and a regulator. In addition to

water resources development, the project has the following impact on the rural community: 1) the reservoir may be used for inland fisheries, 2) farm lands around the swamp will be saved from flooding, 3) dikes and maintenance roads will be used for transportation of farm input and output, and 4) the reservoir will provide a recreational area for people around the project area.

(2) Proposed Water Level and Water Storage

The water surface of the swamp will be confined to public land with ground elevation of not more than 6 meters above mean sea level by construction of dikes. Some existing paddy fields are excluded from the reservoir area, the proposed water surface area is 543 ha (or, 3,400 rai). The proposed retention water level is determined with these considerations: 1) to increase irrigable area by gravity as much as practicable, and 2) not to make worsen the drainage conditions of farmland around the reservoir. Furthermore, the flood water of the canals of Hua Wang-Panang Tuk and Pak Phraek are drained into the reservoir, of which the design capacity is 540 cu.m/sec in total. The high water level (H.W.L) in the reservoir is estimated to 6.20 meters above mean sea level through the hydraulic calculation based on the control point, i.e. the crest of the weir which will be construction in the Lower Hua Wang-Panang Tuk canal. The relation between the water levels and water storage is prepared based on the topographic maps with a scale of 1 : 4,000 of RID. The results of several case studies, on water levels and water storage are proposed as presented in the next paragraph.

(3) Reservoir Operation Study

In order to determine the proper irrigation area of the proposed Nong Yai reservoir with effective water storage of 3.9 MCM, the reservoir operation was simulated on a 10-day basis for 10 years from 1981 to 1990, based on the following conditions:

- Inflow to Reservoir : synthesized from records observed at X46 and X46A stations
- Effective Rainfall : calculated from rainfall records for 30 years from 1961 to 1990 in the municipality of Chumphon
- Water Demand : Irrigation and domestic use in the project area

- Reservoir Losses : evaporation from reservoir (70% of pan evaporation) and seepage through reservoir of 0.03%/day of total storage of reservoir

Figure 5-2 shows the results of reservoir operation for 2 cases: case 1 with the irrigation area of 1,130 ha and case 2 with the irrigation area of 1,200 ha. As was presented in the previous paragraph of 5.2.2, this irrigation plan has selected 1,200 ha of farm lands as the proposed irrigation area.

(4) Sedimentation of Reservoir

The Nong Yai reservoir having with the major objectives of a part of flood-way and water resources for irrigation will be confronted with a sedimentation problem which will be caused by the flood water from its watershed and the Tha Taphao river through the two canals, Pak Phraek and Upper Hua Wang Phanang Tuk.

The sediment loads arising from the three natural rivers, Lamu, Khi Nak and Krut rivers (the total watershed of 102 km^2) is estimated to 15,300 m^3/year (150 m^3/km^2/year $\times$ 102 km^2) as reported in the former para.

Whereas, the sediment volume arising from the flood-ways may be estimated based on data for the annual consecutive inflow to the reservoir and the contexture of suspended soils of the flood, however no-data are presently available, so that the preliminary study on the matter is conducted as below.

a) Particle Size of Suspended Soil

When judging the average flow velocity of Tha Taphao river at the diversion point of Hua Wang Phanang Tuk canal from Mrs. Shinohara and Tsubaki formulas, such small soil particles less than 2.0 mm in diameter as fine sand, silt and clay may be suspended in the flow.

b) Sediment per 1,000 cu.m of Flood Water

The settlement phenomena of suspended soil will occur in the reservoir because of reduction of flow velocity, so that the soil particles of 2.0 mm to 0.001

mm size in diameter will settle in the reservoir in consideration of the theory of soil particle settlement.

On the assumption that the suspended soils are composed of fine sand of 10%, silt of 40% and clay of 40% in weight, approximate 0.38 tons of suspended soils per 1,000 cu.m of flood water will be occurred in the reservoir.

c) Annual Suspended Loads

The annual inflows from the Tha Taphao river to the reservoir are approximately estimated to 149.1 MCM and 63.8 MCM in case of the multipurpose reservoirs and of no-reservoirs respectively presuming that the inflows cause during rainy season from August to December. Under the said assumption, the annual suspended loads are estimated as follows;

Without the multipurpose reservoirs:		45,000 cu.m/year
With the multipurpose reservoirs	:	20,000 cu.m/year

d) Treatment of Sediment

The Nong Yai reservoir is planned to have a sediment capacity of 600,000 cu.m below the low water surface (3.00 m M.S.L).

Therefore, the sedimental soils included with the sediment of 15,300 cu.m/year from the reservoir's watershed may be dredged by dredger(s) once per 10 years and 15 years in case of the multipurpose reservoirs and no-reservoirs respectively. The such dredged materials may be good for the agriculture because of fertile soils.

Consequently, it is recommended that the further study shall be undertaken based on the investigation as presented in para. (4) of Chapter 7. 1. 4.

(5) Major Dimensions of the Nong Yai Reservoir

The proposed major dimensions of the Nong Yai reservoir are given as follows (details are discussed in Chapter 6):

MAJOR DIMENSION OF NONG YAI RESERVOIR

Item			Dimension
① Location			Amphoe Muang Chumphon, Tambon of Bang Luk, Na Cha Ang and Na Tung
② River Basin			Tha Taphao river
- River			3 tributaries : Lam, Khi Nak and Krut
- Catchment area			102 sq.km
- Annual average rainfall			1,780 mm (1981 - 1990)
- Annual average inflow			81.1 MCM (1981 - 1990)
③ Reservoir			
- Reservoir area			543 ha
- Water level	:	High water level	6.2 m MSL
		Retention level	4.5 m MSL
		Low water level	3.0 m MSL
- Storage	:	Total storage	4.5 MCM
		Effective storage	3.9 MCM
④ Dikes and Ring Roads			
- Total length			13.9 km
- Crest elevation			7.5 m MSL
- Crest width			8.0 m

5.3 DRAINAGE IMPROVEMENT OF THA TAPHAO RIVER SYSTEM

5.3.1 General

In order to mitigate the threat of flooding from the Tha Taphao river, the construction of multipurpose reservoirs has been envisaged by RID. As the first stage, a feasibility study of 2 projects of the Tha Tapaho and Rap Ro has been started by RID. With the combined flood control storages of 167.7 million cubic meter in 2 reservoirs of Rap Ro and Tha Sae as proposed in this water resources development project, the peak flood discharge with a return period of 30 years will be reduced from 1,510 cu.m/sec to 1,150 cu.m/sec at X158 station of the Tha Taphao river.

Flood water of the Tha Taphao river basin is drained into the sea at present through the river and the Sam Kaeo canal that branches off from the Tha Taphao river. The present channel capacities are 430 cu.m/sec for the Tha Taphao river and 140 cu.m/sec for the Sam Kaeo canal. Immediately after heavy floods in November 1989, RID formulated an emergency plan for flood mitigation of the Tha Taphao river. The plan includes the construction of the

Hua Wang-Phanang Tuk canal and the improvement of the Sam Kaeo canal. Detailed design of these canals has progressed.

For successful implementation of the proposed agricultural development of the Nong Yai area, the threat of flood should be reduced. To this end, the integrated agriculture development project has proposed to improvement of the drainage conditions of the Tha Taphao river system. The design flood discharge of 1,150 cu.m/sec is almost equivalent to the probable maximum flood discharge with a return period of 10 years without flood control by reservoirs. Taking the improvement plan by RID into account, the drainage improvement plan of the Tha Tapaho river system has been proposed. The proposal is outlined in the following;

5. 3. 2 Rehabilitation of Sam Kaeo Canal

The Sam Kaeo canal was constructed in 1952 to divert a portion of flood water from the Tha Tapaho river to drain into the sea through the Phanang Tuk river. The original design capacity was 260 cubic meter/second; however, the present safe channel capacity is reduced to 140 cu.m/sec. RID has decided to rehabilitate the canal instead of enlarging its capacity. The discharge capacity of the Sam Kaeo canal will be rehabilitated to 260 cu.m/sec by improvement of the head regulator, dredging and cutoff of meandering channels. The total work length of the canal is 4.8 km.

The canal water is used for irrigation of crops along the canal. In the dry season, however, sea water enters the canal as the water level of the canal falls. Farmers living along the canal have a strong wish to build a tail regulator to check the intrusion of sea water. Under the present situation where water resources for dry season irrigation is not provided, the construction of the tail regulator has a negligible effect on agriculture along the canal, when the estimated construction cost of about 91 million Baht is compared with expected benefits. As presented in the irrigation development plan, the Nong Yai irrigation project will supply water for domestic use, as well as irrigation, for people in the project area including areas along the Sam Kaeo canal.