3.2.3. Institutional Aspects

Related agricultural institutions for the Project area at present are as follows:

- Chanthaburi Horticulture Research Center
- Chanthaburi Provincial Agricultural Extension Office
- Chanthaburi Provincial Agricultural Cooperative Promotion Office
- Amphoe Makham Agricultural Extension Office
- Amphoe Makham Agricultural Cooperative Promotion Office
- Amphoe Makham Agricultural Cooperative

(1) Chanthaburi Horticulture Research Center

Chanthaburi Horticulture Center has established in Amphoe Laem Sing for the purpose of performing research activities on orchard plantation techniques and applications. Outline of the institute is as follows.

Item	Description	Testing Area
Staff	72	
Area	307.2 ha	about 210 ha
Head quarter	88.0 ha	" 55 "
Branch (4)	219.2 ha	" 155

(Note: Branches are located outside the project area.)

Main research item of the center is extension of ripping stage of orchard and of storage life of fruits. Since the extension of ripping stage of fruits would take long time to get results, it is indispensable to research of enhancement for fruits marketability and increase of profits.

Researches on fruit storage are being progressed by the Postharvest Technology Laboratory of the Thailand Institute of Scientific and Technology Research Center. The results of the research are as follows:

Crop	Temperature	Term
Durian	15 - 18°C	1 - 2 weeks
Mangosteen	12°C	1 month
Rambutan	12°C	1 - 2 weeks

However, the term of storage expected for export is 2 or 3 months. According to "Tropical Tree Fruits for Australia Queensland" published by Department of Primary Industries, terms of storage for durian at -24°C and 15°C are reported at 3 months and 3 weeks, respectively.

Since these tests newly require the freezing test facilities, it will be very difficult to instantly complete them. Therefore, it is desirable to promote these tests by providing Demonstration Farm with the freezing test facilities.

At present, with the height of most fruit trees being more than 10 m, incidence of plant disease and insect is hardly known. Prevention measures are therefore seldom undertaken and application of pesticide is not appropriately done. There remains a substantial room for expansion of research activities in various aspects of fruit production with increased research staffs and improved facilities.

(2) Agricultural Extension

Provincial and Amphoe agricultural extension offices are charged with overall activities as concerns agricultural administration inclusive of technical transfer. In recent years, the agricultural extension has been intensified through a World Bank Loan, however, it is still suffering from stuff shortage for implementation of the activity.

Following table shows existing situation of agricultural extension in the area:

Amphoe	Staff	Agricultural Area (ha)	Area/Staff (ha)
Provincial Office	18	228,915	12,718
Muang	11	18,416	1,674
Makham	9	35,153	3,906
Tha Mai	15	86,408	5,760

Source: Chanthaburi Agricultural Extension Office Report, 1986.

(3) Agricultural Cooperative

The agricultural cooperative which composes of eight groups with 9,793 members is the second largest to the saving cooperative of 10 groups with 11,053 members, however the capital of the cooperative is counted at 264.77 million Baht in 1988.

The main activities of the agricultural cooperative are categorized into four, viz., credit, deposit, purchasing and marketing. In 1988, agricultural cooperative showed the biggest credit amount of 230 million Bahts which were mainly derived from 118 million Bahts of short term credit (12 months) and 113 million Bahts of medium term credit (1-3 years) and also its deposit illustrates the biggest amount of 145 million Bahts. The purchasing such as fertilizer, agro-chemicals, rice, feed and daily commodities is amounted to 26 million Bahts and the marketing of farm outputs are recorded at 19 million Bahts.

(4) Private Farmers Group

Aside from agricultural cooperatives mentioned above, 25 private farmers groups are observed in the area. Out of these, 17 groups are for orchard plantation farmers. The major objectives of the groups are to sell the products in considerable price and to provide the information to the members, however, their activities are not so active, because these groups are run by volunteers from the members, therefore they are reluctant to be selected. Some of the groups are practising cooperative purchasing of rice and fertilizers but the intention to cooperative selling of farm outputs are not yet strongly observed.

(5) BAAC

BAAC provides loans only for agricultural purposes, excluding agri-business sector. Farmers who are members of cooperatives are not entitled to borrow directly from BAAC.

Short-term production loans are based upon credit needs per rai, fixed by crop, but adjusted to reflect the local conditions in Changwat. Individual borrowers who are unable to provide collateral are required to join a small informal guarantee group, which enables BAAC to take advantage of the socio-economic sanctions arising from the joint liability characteristics of these groups particularly in the case of repayment. Each member is liable for his/her own loan and loans guaranteed by the group. The maximum loan amount per group member is ฿30,000, but not exceeding 60 percent of the value of the expected marketable surplus produced. For loan between ฿30,000 and ฿1,000,000, the farmer is required to mortgage his assets with BAAC. Interest on these loans is 14 percent with repayment of one-half to one year.

The medium-term loans are mainly provided for procurement of farm machinery and equipment, draught animals and land and refinancing of old debt. The security requirements and interest rate charged are the same as for short-term loans, and the loan repayment period is 3 to 5 years. The long-term loans are offered to individual borrowers for investments in agriculture and refinancing old debt. For investment in agriculture, viz., purchase or develop agricultural resources or invest in agricultural assets which require a lengthy period before the borrower starts to receive a return on his investment, repayment is by installment within the period of up to 15 years or 20 years, in special cases and borrowers should submit their applications (for loan amount in excess of ฿160,000) in the form of detailed long-term agricultural investment projects for BAAC's consideration. Borrowers are also required to furnish an equity contribution of at least 20 percent of the

project's total investment costs and to secure the loan either by the use of two personal guarantors or by mortgaging their fixed assets with BAAC.

BAAC continues to support the growth and development of the agricultural cooperatives and farmers' association staff in its capacity as their primary source of operating funds. Most of the BAAC's loans to cooperatives and associations are made available under cash credit line agreements which are extended for five and three years, respectively, and renewed annually; therefore, these loans function in a manner similar to a revolving fund, and BAAC stipulates the amount to be used for short-and medium-term investments. The loan purposes involve: (a) on-lending to members in the form of short-and medium-term loans for agricultural purposes, (b) purchase of the agricultural inputs and equipment for resale to members, and (c) purchase and marketing of produce from members. The limit on the amount of loans is 12 times the owned funds for cooperatives and 10 times for associations.

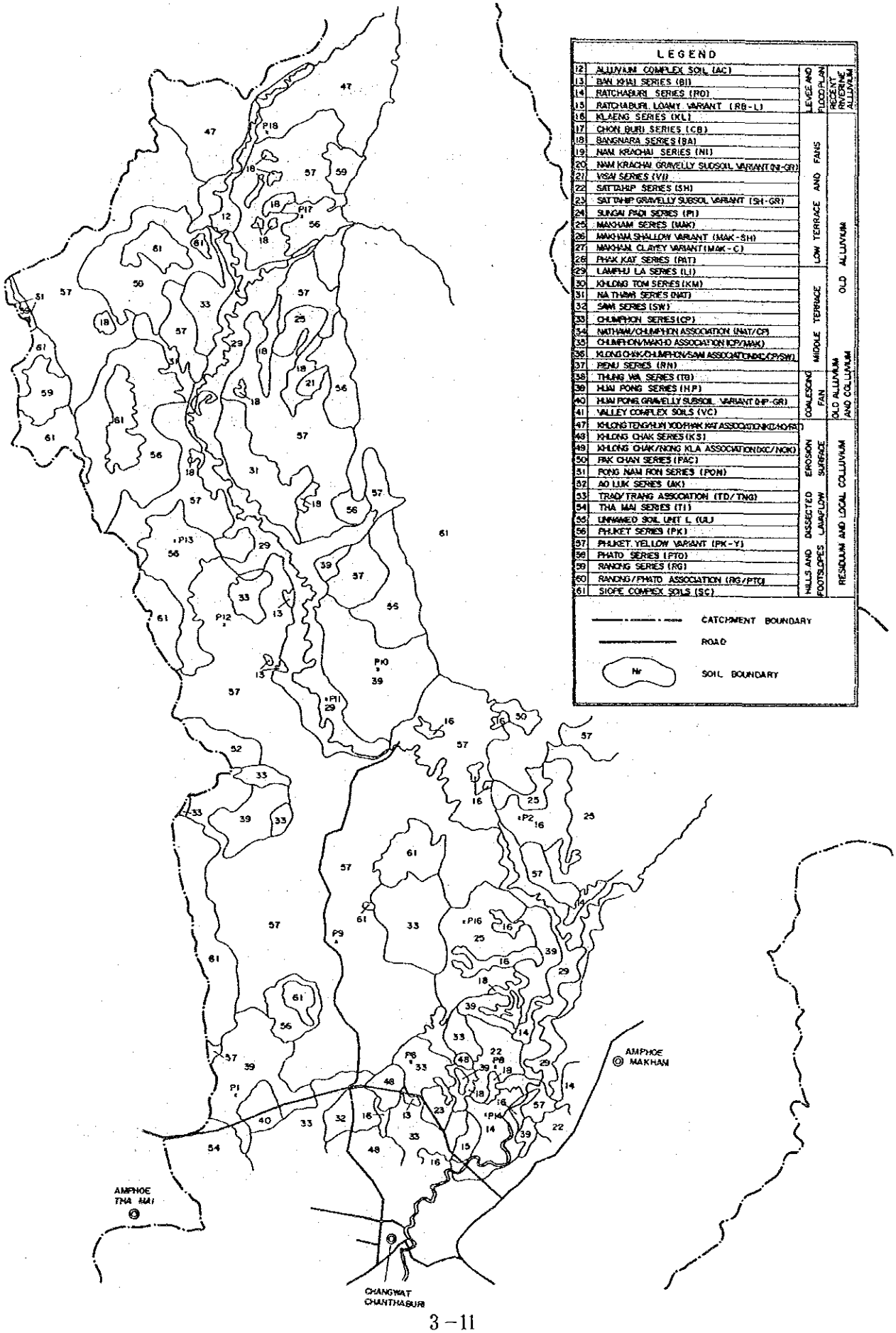
BAAC also provides the long-term loans for construction of the cooperative-owned facilities such as rice mills and storage facilities with the repayment period up to 15 years. Interest rates to cooperatives and associations vary from 6 to 11 percent.

3.2.4. Soil

(1) General Description of Soil Distribution

Soil survey was made mainly to confirm existing soil data of important soil series for crop cultivation. The survey was composed of field observation, 14 auger boring and 57 samples of soil analysis which were performed by RID. 19 soil series are identified in the study area. Main character and land use by soil series are summarized in Appendix-D and soil map is attached in Figure 3-1. General character of the soil distribution in the area is;

FIGURE3-1 SOIL MAP



a) Upper Area: Red Yellow Podzolic Soils

Main series of upper area are Huai Yod and Phuket Yellow Variant.

The soil is characterized by deep effective soil layer, moderately well to well drained, low base saturation and moderate pH 5-6. Topography is undulating to gently rolling. The groundwater level is below 1 - 2 m in all seasons. Parent material is Granite. Main crop for cultivation is cassava.

b) Middle Terrace Areas: Red Yellow Podzolic Soils

Though these soils are suited for tree and upland crop cultivation because of well drainage, moderate soil pH and deep effective soil layer, constraint is topographic condition. Erosion control is necessary for agricultural development.

c) Foot of Mountainous Area: Gray Podzolic Soils

Generally, these soils are suited for upland and tree crop cultivation because of well drainage, deep effective soil layer and moderate soil pH. However, lowland area of these soils is affected by flood and left as an idle land such as shrub forest and grass land.

d) Bank Area of the Chanthaburi River: Yellowish-Brown Lateristic Soils

These soils are mainly distributed in the banks of the Chanthaburi. Fruits cultivation is dominant land use in the area thanks to favorable for irrigation and physical condition of the soils.

e) Down Stream Area: Low Humic Gley Soils

These soils are suited for paddy. Main constraint is flood and poor drainage.

More detailed information of major soil series is explained below.

(2) Characteristics of Main Soil Series

a) Phuket, Yellow Variant (Pk-y) (Typic Paleudults (USDA), Red Yellow Podzolic Soils (National))

The soil series is by far the most widespread soils in the project area; which shares about 36% of the area, and distribute on middle terrace. Main land use is perennial

crop cultivation. These soils are characterized by deep effective soil layer, well drained, high phospharus content, low base saturation and moderate chemical reaction (pH 5-6). Relief is undulating; slopes are from 4 to 20%. Groundwater level is below 2 m throughout the year. Texture is sandy clay loam or sandy clay. Parent material is Granite.

b) Huai Pong (Hp) (Typic Paleudults (USDA), Grey Podzolic Soils (National))

The series mainly distribute on foot of mountain. Main land use is fruits cultivation. The soil is characterized by very deep effective soil layer, well drained, low base saturation and moderate pH. Relief is undulating; slopes are from 2 to 6%. Groundwater level falls to below 2 m during the dry season. Texture is sandy clay loam or sandy loam. Parent material is Colluviate Materials from Granite.

c) Chumphon (Cp) (Typic Paleudults (USDA), Red Yellow Podzolic Soils (National))

The series distribute on middle terrace. The dominant land use is perennial crop cultivation. The series is characterized by well drained, low base saturation and available phospharus content and moderate soil pH. Relief is undulating; slopes are from 3 to 8%. Groundwater level is below 1.5 m throughout the year. Texture is sandy loam or clay loam. The series is formed from old alluvium.

d) MaKham Series (Mak) (Aeric Tropaquepts (USDA), Hydromorphic Gray Podzolic Soils (National))

MaKham series occur on middle terrace. Main land use is paddy, shrub and grass. Physical and chemical characters of the series are deep effective soil layer, somewhat poorly drained, very low CEC and phospharus content and moderate soil pH (5.0 - 6.0). Relief is flat to nearly flat. Groundwater level falls to below 1.5 m almost the year. Texture is sandy loam or loam. The series is formed from old alluvium.

e) Lmphu La (Ll) (Typic Paleudults (USDA), Yellowish Brown Lateritic Soils (National))

The series distributes on middle terrace. Land use of the series is mainly fruits cultivation. The soil series characterized by very deep effective soil layer, well drained, high organic matter, low base saturation and phospharus content and slightly low pH (5,0 - 5.5). Relief is slightly undulating. Groundwater level is below 1 m throughout the year. Texture is clay loam or clay. The series is formed from old alluvium.

f) Klaeng (Kl) (oxic Plinthaqualts(USDA), Low Humic Gley Soils (National))

The series distributes in low terrace. Main land use of the soils is paddy. The series is characterized by deep soil layer, poor drained, low organic matter, CEC, base saturation and available phospharus, and moderate pH in top-soil (5.0 - 6.5) and low pH in sub-soil (4.5 - 5.5). Relief is flat. Water saturation period is for 4 to 5 months per year even in top-soil. Texture is sandy clay loam and clay loam. The series is formed from alluvium.

The distribution area of major soil series are shown in the following table:

Area by Main Soil Series

Soil Series	Area (ha)
Phuket yellow variant	19,245.0
Huai Pong series	1,902.5
Chumphon series	2,425.5
Makham series	850.0
Lmphu La series	2,862.5
Klaeng series	222.5
Others (including mountain)	17,114.5
Total	44,622.5

(3) Results of Soil Survey

Results of soil survey (soil profile and laboratory analysis) are shown in Appendix-D. According to the results, soil acidity was getting low compared with existing data. Soil acidity and free aluminum concentration are closely correlated. Therefore, excess aluminum toxicity might be occurred in the low pH area. Amount of lime requirement to adjust pH 6 is shown in Appendix-D.

(4) Soil Conservation

The soil classification for orchard shows that the soils, which has susceptibility to erosion, are scarce except 2% of mountainous area. This marginal land is rubber planting area where introduction of cover crops or contour cropping is strongly recommended.

3.3. Land Use and Agriculture

3.3.1. Land Use

Grasping the present land use conditions is one of the important factors for the assessment of the existing agriculture and social welfare of the farmers and for the forecast of the future land and water resources development potentials.

Existing land use map for the Middle Right zone was made through field investigations based on 1/10,000 scale topographical map prepared by RID while 1/50,000 topo-maps were used for the Upper zone (refer to Figure 3-2). Present land use is then summarized as follows:

Land Use by Crop

(unit: ha)

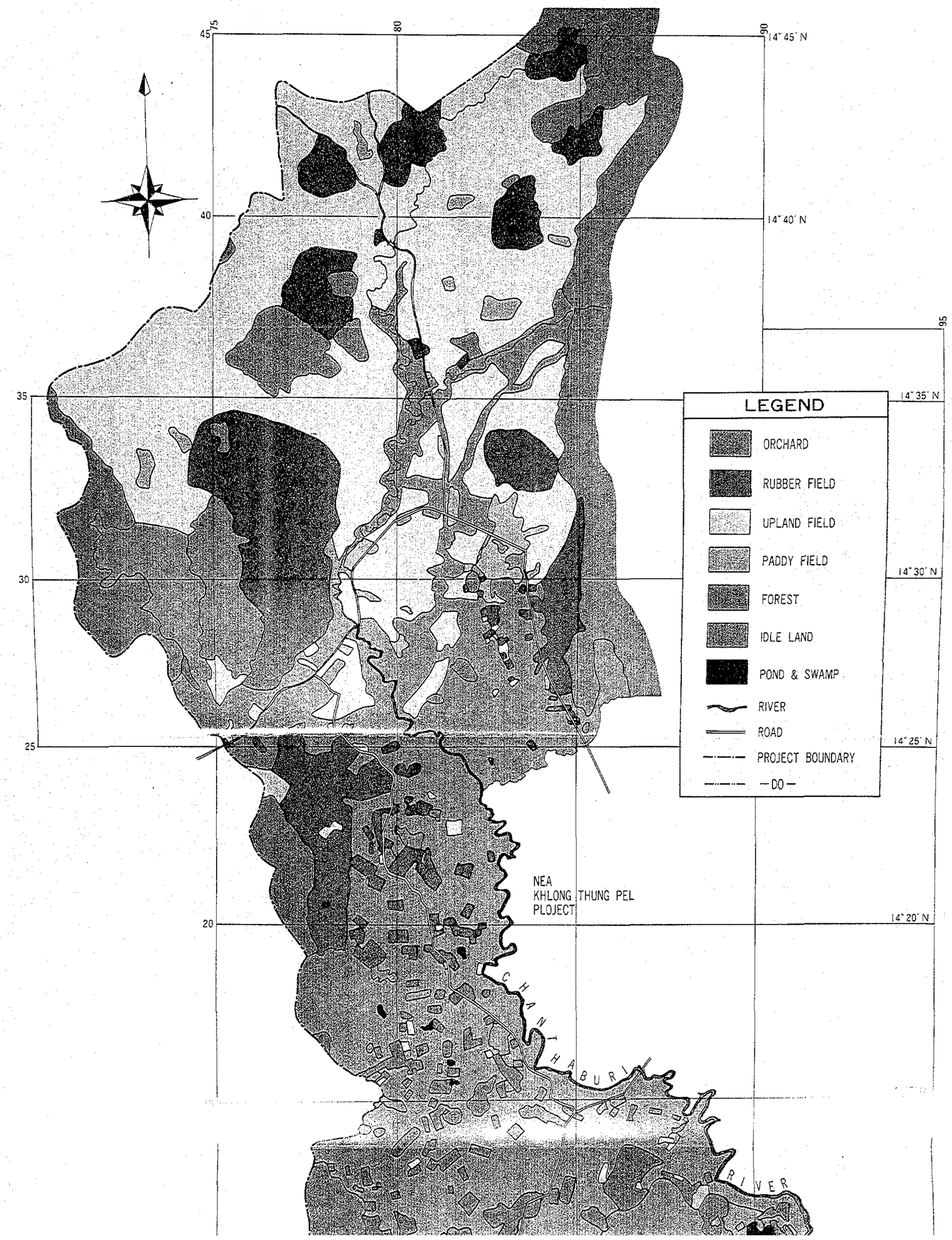
Items	Upper Zone	Middle Right Zone	Total
Paddy	309.3	337.3	646.6
Upland	7,711.6	144.5	7,856.1
Orchard	3,293.9	8,106.1	11,400.0
Rubber	2,689.1	5,677.6	8,366.7
Sub-total	14,003.9	14,265.5	28,269.4
Others	26,616.1	12,844.5	39,460.6
Total	40,620.0	27,110.0	67,730.0

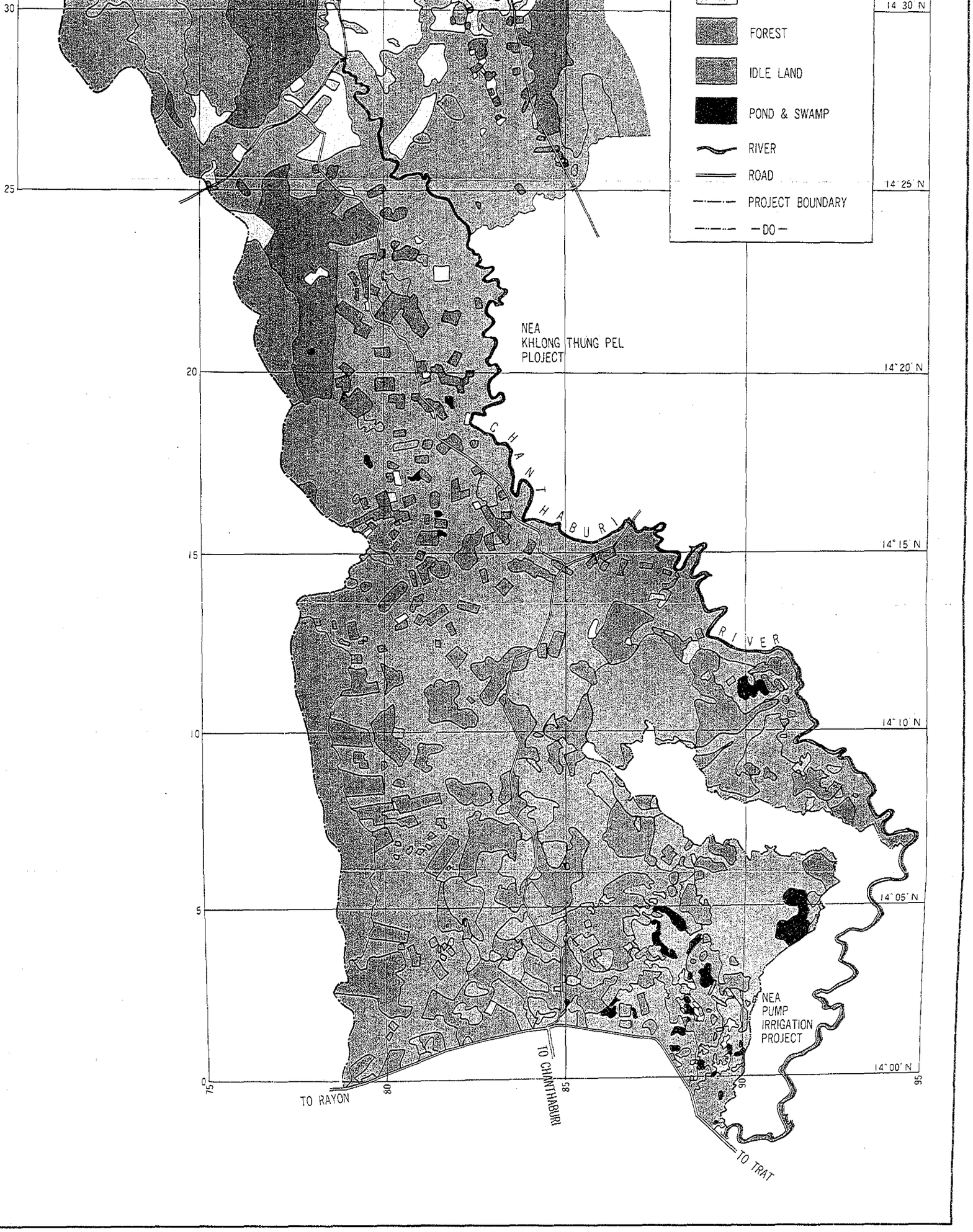
3.3.2. Crops and Crop Production

(1) General

Chanthaburi Province, which is one of the special production localities of durian, rambutan and mangosteen in Thailand, has an agricultural land of 28,270 ha, which is equivalent to 42% of the Project area (67,730 ha). There are approximately 5,100 farms in the population of 22,300, which are engaged in farming activities in an average farm size of 5.5 ha.

FIGURE 3-2 EXISTING LAND USE MAP




FOREST
IDLE LAND
POND & SWAMP
RIVER
ROAD
PROJECT BOUNDARY
—DO—
NEA
KHLONG THUNG PEL
PLOJECT
CHANTHABURI
RIVER
NEA
PUMP
IRRIGATION
PROJECT
TO RAYON
TO CHANTHABURI
TO TRAT
14° 30' N
14° 25' N
14° 20' N
14° 15' N
14° 10' N
14° 05' N
14° 00' N
30
25
20
15
10
5
0
75
80
85
90
95

(2) Farming Type

Being classified mainly as upland field, cassava is the predominant crop in the Upper zone of the Project area, where introduction of perennial crops such as new variety of Para rubber and orchard are also becoming popular. Orchard is commonly grown in the Middle Right zone, and Para rubber is widely planted in the area where irrigation water is insufficient.

The typical types of farming in the Project area are summarized as follows:

- Orchard-based farming.
- Para rubber plus orchard-based farming.
- Cassava plus orchard-based farming.

(3) Farming Practices of Main Crops

The farming practices on durian, rambutan and mangosteen are shown as follows:

Item	Durian	Rambutan	Mangosteen
Propagation	Grafting	Budding	Seedling
Planting Space	----------8x8 - 10x10m ----------		
Fertilizing	- 1st year 0.3-0.5kg/tree, 2nd year increase by 0.5 kg/tree/year ----------		
Compost	----- to be decided by farmers themselves -----		
Weed Control	---------- two wheels mower ----------		
Irrigation	---sprinkler (interval: 4 to 7 days) ---------		
Top Dressing	---------- 2 to 3 times ----------		
Harvesting	---------- by hand ----------		

(4) Crop Production

The major crop and orchard productions in Chanthaburi Province and Amphoe Makham are averaged as follows:

Crops	Chanthaburi Province			Amphoe Makham		
	Area (ha)	Yield (kg/ha)	Products (t)	Area (ha)	Yield (kg/ha)	Products (t)
Rambutan	16,770	9,410	157,805	7,707	12,500	96,338
Durian	17,477	8,048	140,581	4,308	9,350	40,280
Mangosteen	1,963	8,059	15,819	433	8,125	3,518
Para Rubber	42,106	908	38,237	9,989	1,292	12,906
Cassava	31,129	14,476	450,637	2,578	13,960	35,984

Source: Horticulture Statistics 1985/86 - 1987/88 and Chanthaburi Agricultural Extension Office 1985/86 - 1987/88
Refer to Appendix E.

3.3.3. Agricultural Extension Services

Agricultural Extension Office of Amphoe Makham is located at Tambon Makham and the office controls 9 Tambon and 35,153 ha of agricultural land.

The number of staff working in the Agricultural Extension Office is tabulated as follows:

Chief	1 person
Assistant chief	1
Extension worker	4
Home economist	1
Clerk	1
Total	8

Therefore one extension worker is in charge of 2 - 3 Tambon.

The four farmers' groups consisting of 869 members are under the supervision of Agricultural Extension Office. Joint purchasing and forwarding of agricultural inputs/outputs as well as joint selection of fruits are, however, not frequently conducted by the groups.

3.3.4. Storage, Processing and Marketing

There are seldom modernized storage, processing and marketing facilities in the Project area, viz., only 20 rice mills and 2 cassava flowering factories were recorded in 1987. Several cassava chipping factories were newly constructed and being operated now, but another facilities could not be seen in the area.

Generally, farmers are very sensitive to the market price of their farm outputs, accordingly, the harvesting is performed when they meet the price upturn. Paddy and cassava are mostly sold to local merchant and rarely the merchant comes to their farm to buy farm product. The Sala Pak Saeng and Krating are representative local market for orchard. The merchants buy fruits and re-sell to another provinces and Bangkok market normally using 4 wheel truck and pick-up car.

Since freshness is indispensable factor for the customer, the fruits are not usually processed except durian. Low quality and bad-shaped durians are processed to durian cane during slack season, as is often performed by farms using simple tools. Cassava and Para rubber need processing however, due to lack of modernized processing facilities, the most of farm outputs are transported to outside the Project area, especially to Rayong and Chon Buri (refer to Appendix -G).

Some fruit merchants are active in the Project area. They purchase only high quality fruits from contracted farmers at 1.5 - 3 times of average farm gate price and forward them to exporters in Bangkok. The fruits are then, packed and exported to overseas such as Singapore and Hongkong. The export unit price of durian, rambutan and mangosteen has not so much difference, viz. unit export prices are about ฿24/kg for durian, ฿22/kg for rambutan and ฿21/kg for mangosteen, respectively.

3.4. Irrigation Practice

3.4.1. Unit Irrigation Water Requirement

Irrigation water applications as achieved in the area were classified into two categories depending on the source of water, i.e. for area irrigated by river water and for area by pond water. It is important for the study to estimate the total and seasonal variation of water requirement (consumptive use) of crops to be grown in the area. Actual water application being experienced in the field are, however, recognized as the portion of the total requirement that has to be added during dry season by irrigation. Such amounts of water investigated in the field are as follows:

Actual Achievement of Irrigation Water Application

Water Source	Field Experience in liter/tree/day							Total (mm)
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	
River Water	70	110	140	180	180	180	180	314.5
Pond Water	110	100	110	120	120	130	110	242.0
Average	90	105	125	150	150	155	145	278.3

Theoretical methods of estimation of consumptive use of crops, such as the Modified Penman Method, Blaney Criddle Method and Pan-Evaporation Method, were compared with the actual achievement of irrigation water application. An areal conversion rate, or the ratio between areas planted to actually irrigated, of 2.200 derived from the result of sprinkler test conducted at the site of irrigation was used to adjust differences between theoretical estimates and actual applications. Consequently field water requirement estimated through the Modified Penman Method after converted by the said ratio was finally employed in the study for evaluation of availability of water resources.

As for upland crop irrigation, crop calendar and kc-values provided for groundnuts were used to estimate crop consumptions by the Modified Penman Method. Such procedures are presented in Table 3-1.

Taking an overall irrigation efficiency at 0.70 for orchard irrigation and 0.60 for irrigation of second crops to be cultivated in the existing paddy field during dry season, water demand at the point of water source was calculated as shown below. It should be noted here that about 40% and 50% of basin runoff caused by rainfall were considered to be usable for irrigation, functioning as effective rainfall, respectively for areas irrigated by river and pond water.

Unit Irrigation Water Demand

Season	Month	Field Requirement		Irrigation Water Demand	
		Orchard	Second Crop	Orchard	Second Crop
		(1)	(2)	(3)	(4)
Dry	Apr.	3.91	-	25.390	-
	May	3.38	-	21.948	-
	Jun.	2.96	-	19.221	-
Wet	Jul.	2.93	-	19.026	-
	Aug.	2.79	-	18.117	-
	Sep.	2.74	-	17.792	-
	Oct.	3.24	-	21.039	-
	Nov.	3.83	8	24.870	4.444
	Dec.	3.89	77	25.260	42.778
Dry	Jan.	3.98	127	25.844	70.556
	Feb.	3.87	100	25.130	55.556
	Mar.	3.88	11	25.195	6.111
Total:	(cu.m/ha)	1,258	323	8,171	5,383
	Dry*	705	323	4,577	5,383
	Wet**	553	-	3,594	-

Notes: (1) Field requirement in mm/day.
(2) Field requirement in mm/month.
(3) Unit demand = (1)/2.200/0.7x10 (cu.m/ha)
(4) Unit demand = (2)/0.6x10 (cu.m/ha)
* Dry season total
** Wet season total

TABLE 3-1 Crop Water Consumption by Penman

	JANUARY			FEBRUARY			MARCH			APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOVEMBER			DECEMBER		
	1	2	3	1	2	3	1	2	3								1	2	3	1	2	3
FRUIT TREE																						
CROPPING CALENDAR																						
1 Tmax (℃)	31.9			32.2			32.6			33.2	32.2	30.9	30.4	30.3	30.5	31.3	31.4			31.3		
2 Tmin (℃)	19.9			21.8			23.0			23.8	24.4	24.5	24.3	24.3	23.9	23.3	22.1			20.5		
3 Tmean (℃)	25.9			27.8			27.8			28.5	28.3	27.7	27.4	27.3	27.2	27.3	26.8			25.9		
4 ea (mbar)	33.4			35.7			37.4			39.0	38.5	37.2	36.5	36.3	36.1	36.3	35.3			33.4		
5 RHmean (%)	71.5			77.4			79.3			80.8	84.6	86.0	86.2	86.6	87.9	83.9	75.9			70.5		
6 ed (mbar)	23.9			27.6			29.7			31.5	32.6	32.0	31.5	31.4	31.7	30.5	26.8			23.5		
7 (ea-ed)	9.5			8.1			7.7			7.5	5.9	5.2	5.0	4.9	4.4	5.8	8.5			9.9		
8 U (h=2m) (km/ady)	94			62			53			50	43	59	56	59	34	59	112			124		
9 f(u)	0.52			0.44			0.41			0.41	0.39	0.43	0.42	0.43	0.36	0.43	0.57			0.60		
10 1-W (El=3m)	0.25			0.24			0.23			0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24			0.25		
11 (1-W)f(u)(ea-ed)	1.24			0.86			0.73			0.71	0.53	0.51	0.50	0.51	0.38	0.60	1.16			1.49		
12 Ra (12.36°N)	12.7			13.8			15.0			15.7	15.7	15.6	15.6	15.6	15.2	14.3	13.2			12.4		
13 n/N	0.56			0.50			0.47			0.42	0.29	0.18	0.17	0.14	0.18	0.36	0.51			0.57		
14 0.25+0.5n/N	0.53			0.50			0.49			0.46	0.40	0.34	0.34	0.32	0.34	0.43	0.51			0.54		
15 Rs=(12)*(14)	6.73			6.90			7.35			7.22	6.28	5.30	5.30	4.99	5.17	6.15	6.73			6.70		
16 Rns=0.75Rs	5.05			5.18			5.51			5.42	4.71	3.98	3.98	3.74	3.88	4.61	5.05			5.03		
17 f(T)	15.9			16.1			16.3			16.4	16.4	16.2	16.2	16.2	16.1	16.2	16.1			15.9		
18 f(ed)	0.12			0.11			0.10			0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.11			0.13		
19 f(n/N)	0.60			0.55			0.54			0.48	0.36	0.26	0.25	0.23	0.26	0.42	0.56			0.61		
20 Rnl=(17)*(18)*(19)	1.14			0.97			0.88			0.71	0.53	0.38	0.36	0.34	0.38	0.68	0.99			1.26		
21 Rn=Rns-Rnl	3.91			4.21			4.63			4.71	4.18	3.60	3.62	3.40	3.50	3.93	4.06			3.77		
22 W	0.75			0.76			0.77			0.77	0.77	0.77	0.76	0.76	0.76	0.76	0.76			0.75		
23 WRn	2.93			3.20			3.57			3.63	3.22	2.77	2.75	2.58	2.66	2.99	3.09			2.83		
24 (11)+(23)	4.17			4.06			4.30			4.34	3.75	3.28	3.25	3.09	3.04	3.59	4.25			4.32		
25 c	1.06			1.06			1.06			1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06			1.06		
26 ETO (mm/day)	4.42			4.30			4.56			4.60	3.98	3.48	3.45	3.28	3.22	3.81	4.51			4.58		
27 Kc	0.90			0.90			0.85			0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85			0.85		
28 ET (mm/day)	3.98			3.87			3.88			3.91	3.38	2.96	2.93	2.79	2.74	3.24	3.83			3.89		

UPLANDCROP:GROUNDNUT																						
CROPPING CALENDAR																						
ELEMENT																						
I of growing season	61	72	83	94	100	-	-	-	-	-	-	-	-	-	-	-	-	6	17	28	39	50
Crop coefficient (Kc)	1.03	1.03	1.00	0.81	0.54	-	-	-	-	-	-	-	-	-	-	-	0.48	0.50	0.62	0.87	0.99	
	0.99	1.03	1.03	1.00	0.81	0.54	-	-	-	-	-	-	-	-	-	-	-	0.48	0.50	0.62	0.87	
	0.87	0.99	1.03	1.03	1.00	0.81	0.54	-	-	-	-	-	-	-	-	-	-	-	0.48	0.50	0.62	
	0.62	0.87	0.99	1.03	1.03	1.00	0.81	0.54	-	-	-	-	-	-	-	-	-	-	-	0.48	0.50	
Kc average	0.68	0.98	1.01	0.97	0.85	0.78	0.68	0.54	-	-	-	-	-	-	-	-	0.48	0.49	0.53	0.62	0.75	
ETO by Penman(mm/day)	4.42			4.30			4.56			-	-	-	-	-	-	-	4.51			4.58		
ETc (mm/day)	3.9	4.3	4.5	4.2	3.7	3.4	3.1	2.5	-	-	-	-	-	-	-	-	2.2	2.2	2.4	2.8	3.4	
EQUATION					23/															23/		
Normal irrigation(mm)	1/1	1/1	1/1	1/1	24	2/3	1/3	1/24	-	-	-	-	-	-	-	-	1/24	1/3	2/3	24	1/1	
WATER REQUIREMENT																						
(mm/day)	3.9	4.3	4.5	4.2	3.5	2.3	1.0	0.1	-	-	-	-	-	-	-	-	0.1	0.7	1.6	2.7	3.4	
(mm/10day)	39	43	45	42	35	23	10	1	-	-	-	-	-	-	-	-	1	7	16	27	34	
Requirement(mm/month)	127			100			11			-	-	-	-	-	-	-	8			77		

3.4.2. Existing Irrigation Systems and Practices

In order to obtain more detailed information as concerns the location and function of existing irrigation facilities and irrigation practice as well, three sample survey areas were selected in the Project area.

(1) Sample Survey Area-1

Sample survey area-1, representing the area irrigated mainly by river water, was selected from the NEA's Pumping Irrigation Project area. Stretching along the main course of the Chanthaburi river, there exists a farmland belt irrigated by river water. Comprised mainly of these area, NEA has developed the Pump Irrigation Project, which is divided into seven sub-projects each having a pumping station to divert river water for irrigation. Pumping stations P4, P5 and P6 are located in the Middle Right zone of the Chanthaburi river basin, and fortunately cadastral maps have been prepared in these sub-project areas. Exact land uses, source of water and border line showing the limit and extent of area directly receiving river water are the main items for investigation. Figures 3-3 and 3-4 present plans of P6 and P5 area, respectively.

Major items investigated are summarized as follows:

Existing Land Use	P-4 Area (ha)	P-5 Area (ha)	P-6 Area (ha)	Total (ha)
Area irrigated mainly by river surface water (Orchard)	397.1	285.8	451.0	1,133.9
Area irrigated by pond water (do)	18.5	92.7	33.6	144.8
Paddy/Upland Field	3.7	8.7	3.7	16.1
Rubber Field	76.4	167.7	25.8	269.9
Idle land, residential and others	245.2	613.3	566.8	1,425.3
Total	740.9	1,168.2	1,080.9	2,990.0
Length of river bordered on the area irrigated by river water (m)	9,280	6,260	8,560	24,100
Width of area irrigated by river water (m)				
- Mean	428	457	527	472
- Maximum	1,000	1,050	1,250	1,250
- Minimum	50	250	50	50

FIGURE 3-3 Plan of Sample Survey Area-1 (1)

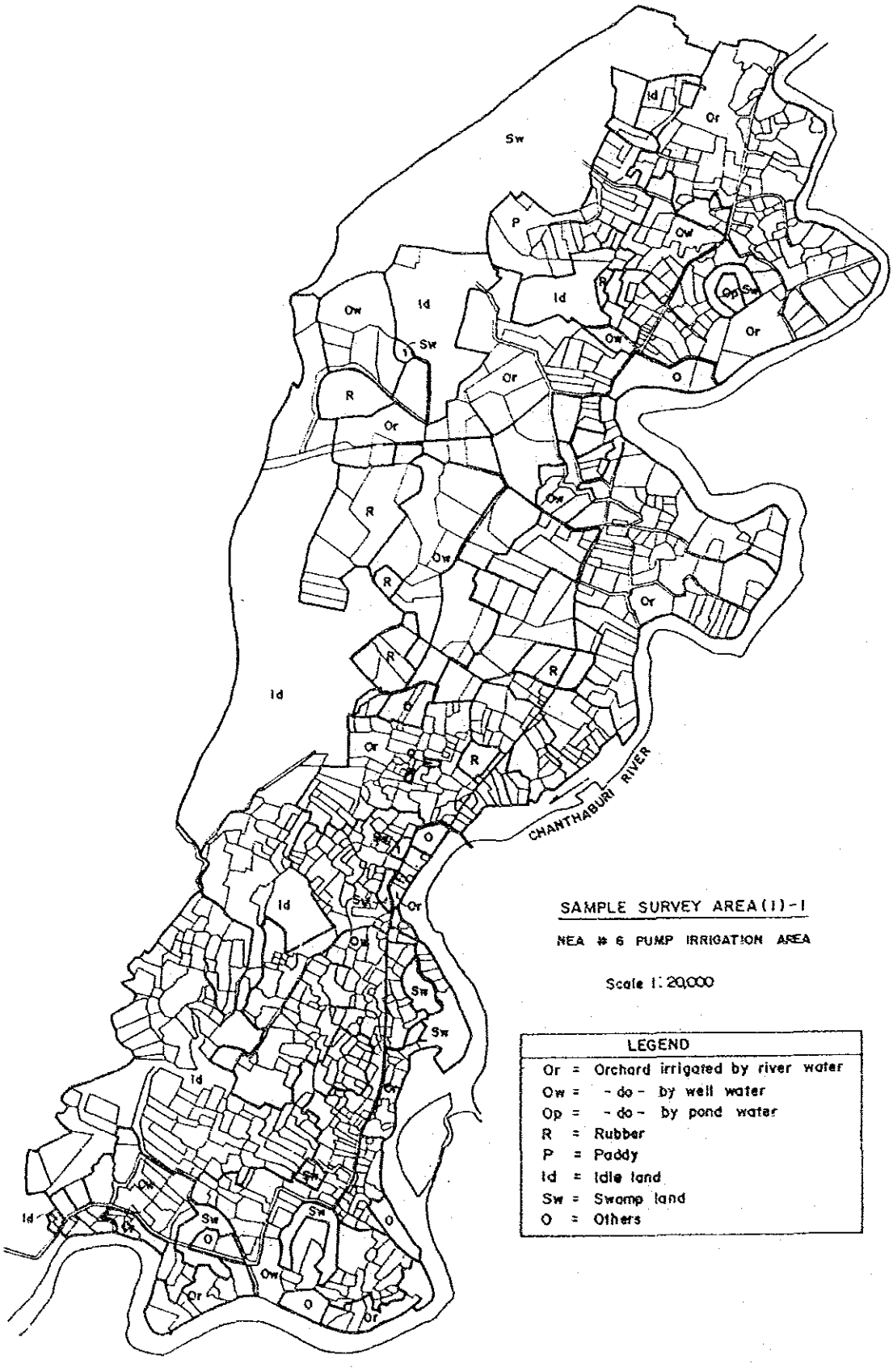
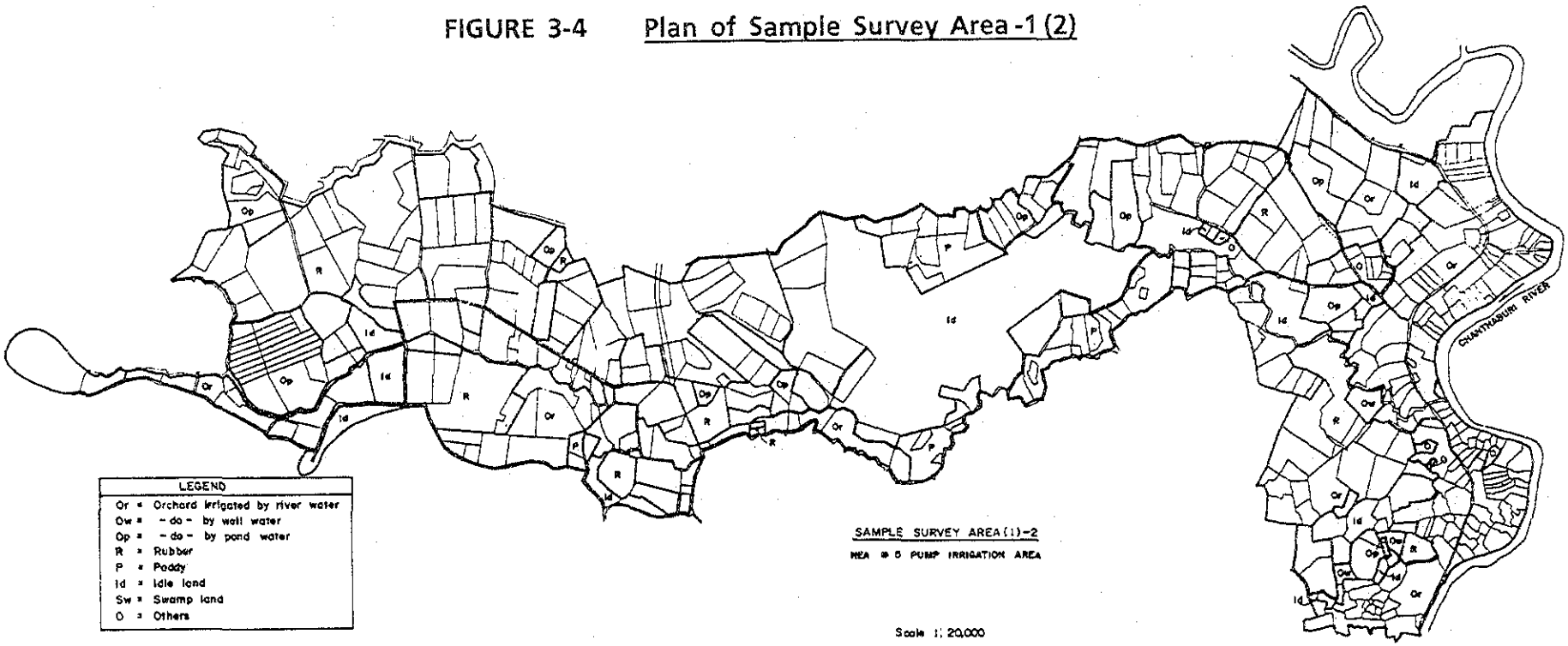


FIGURE 3-4 Plan of Sample Survey Area-1 (2)



It was also intended to investigate location and number of small pumping facilities installed and operated by individual farmers, however, it is no exaggeration to say that almost all farm lots receiving river water have such small pumps and accordingly number of facility is countless.

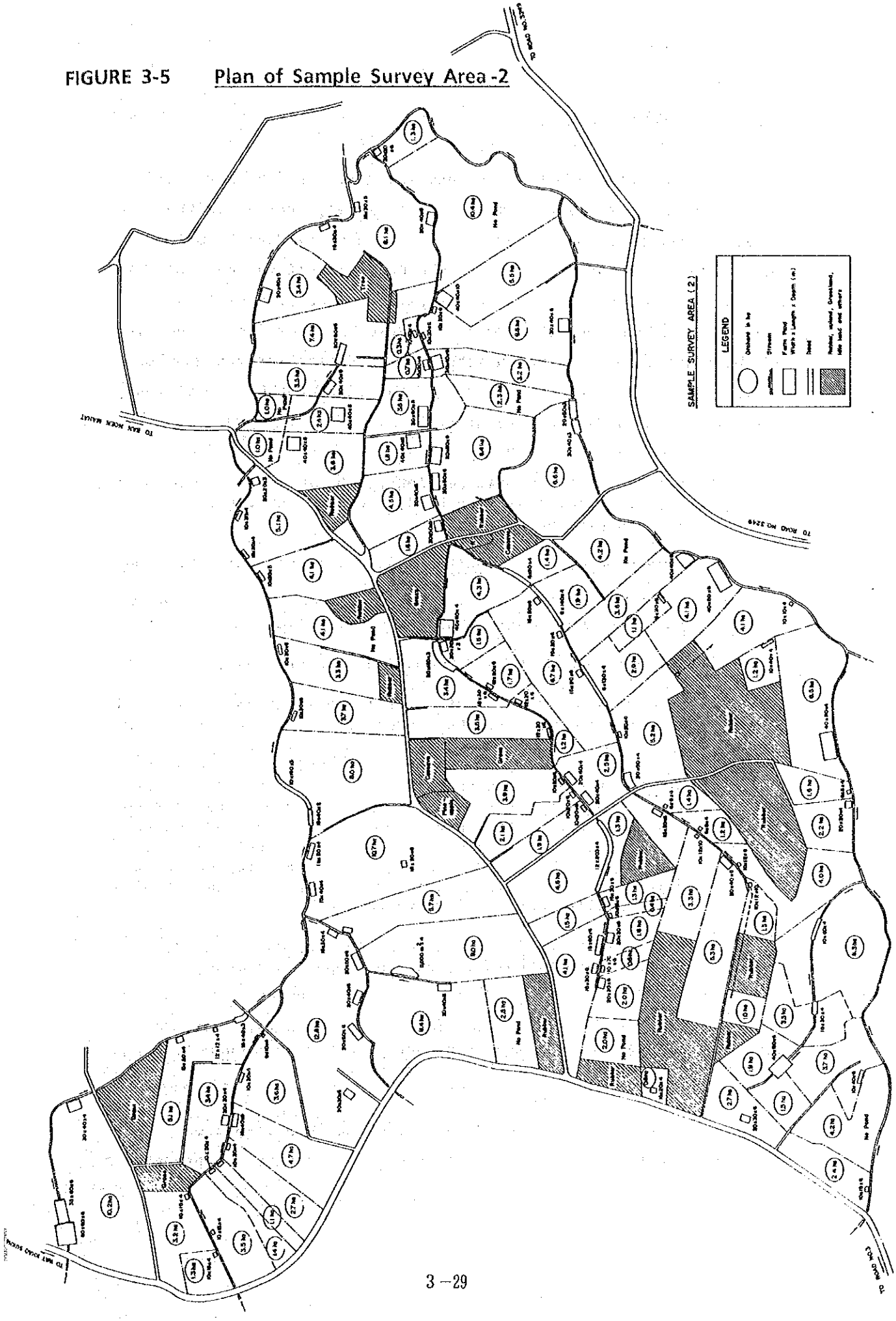
(2) Sample Survey Area-2

Sample area of about 480 ha to represent the orchard dominant area irrigated mainly by pond water, stretching over Tambons Khao Yai Sri and Song Pi Nong, Amphoe Tha Mai, was selected on the 1/10,000 scale topographic map. The 1/5,000 scale aero-photos were also obtained from the Land Office of Amphoe Tha Mai. Major items for investigation were as follows:

- Dimension of farmpond and terminal irrigation facilities, involving size and capacity, source of water, status of water shortage, status of water recovery with respect to timing of irrigation, pump dimension as required for the main pumping plant, size and layout of distribution main and lateral pipelines, and irrigation practice covering duration of irrigation application, interval, amount of water applied and per day irrigation hours.
- Size of landholding classifying into paddy, orchard, pepper, rubber, cassava, upland crops, idle land, residential and others.
- Costs for construction of pond, pump and terminal irrigation facility, and operation and maintenance, especially for electricity or oil.

Figure 3-5 presents a plan of the area surveyed. In total, 109 ponds are installed in the area, and the existing unit capacity of pond per unit area of orchard was estimated at 940 cu.m/ha.

FIGURE 3-5 Plan of Sample Survey Area -2



(3) Sample Survey Area-3

Existing irrigation systems have been operated by a farmer's group, which comprises 45 farmers and 48 gates, irrigating the existing orchard of about 290 ha. Waters are diverted from the Chanthaburi river at the point of the Congrete bridge near the Wat Krating and conveyed through main pipeline of about 8 km long constructed along the #3249 road. Beneficial areas are divided into 9 rotational groups, to which waters are supplied into farmponds for a period of 8 to 13 hours at a time, depending on the size of group. Major items investigated were as follows:

- Dimension of the main pumping plant, inclusive of pump diameter, total lifting head, design discharge and motor/engine output.
- Dimension of main pipeline system including diameter and material.
- Location and structure of turnout facility.
- Boundary and acreage commanded by each turnout.
- Approximate alignment of lateral pipeline and location of farmpond to which waters are supplied.
- Dimension of farmpond and terminal irrigation facilities, involving size and capacity, source of water, status of water shortage, status of water recovery with respect to timing of irrigation, pump dimension as required for the main pumping plant, size and layout of distribution main and lateral pipelines, and irrigation practice covering duration of irrigation application, interval, amount of water applied and per day irrigation hours.
- Size of landholding classifying into paddy, orchard, pepper, rubber, cassava, upland crops, idle land, residential and others.
- Costs for construction of pond, pump and terminal irrigation facility, and operation and maintenance, especially for electricity or oil.

Survey was conducted based on 1/5,000 scale aero-photos obtained from the Land Office, Amphoe Makham. Figure 3-6 presents a

plan of the area surveyed. In total, 72 farmponds are installed in the area. The existing capacity of farmpond per unit area of orchard was thus estimated at about 920 cu.m/ha.

3.4.3. Irrigation Facility

Low pressure pipe systems for irrigation water distribution have been used intensively in the area. The availability of relatively low-cost, light weight rigid plastic pipe has made buried pipe systems especially popular. The use of buried pipe allows the irrigator to take the most direct route from water supply to outlet points and to avoid weed problems and loss of productive land. Seepage and evaporation losses are also eliminated when water is transmitted in a well constructed pipeline. Potable pipe systems laid on the soil surface also have many of advantages of buried pipe systems. If adequate labour is available, they can be removed from fields while cultural operations are in progress. Two general types of on-farm irrigation pipelines are used in the area. The first is the completely portable surface system where water enters the line at the supply such as a well, pond or ditch turnout, and water is applied to the field from the open end of the pipeline or from gated outlet distributed along the line, to which sometimes the portable hose is connected. The second type is a combination of buried and surface pipe where buried permanent line is used to transmit water from the source to the field to be irrigated. Then water is taken to a gated surface pipe through one or more risers.

From field investigations, the average size of orchard for typical orchard farmers is estimated at about 4 ha per household. An interval of water application for rotational irrigation is also reported at 5 days as an average. Waters are supplied to such a terminal irrigation unit either from river channel or from farmpond. A typical layout of terminal end unit of 4 ha is as shown in Figure 3-7. Dimension of major facilities is as follows:

FIGURE 3-6 Plan of Sample Survey Area-3

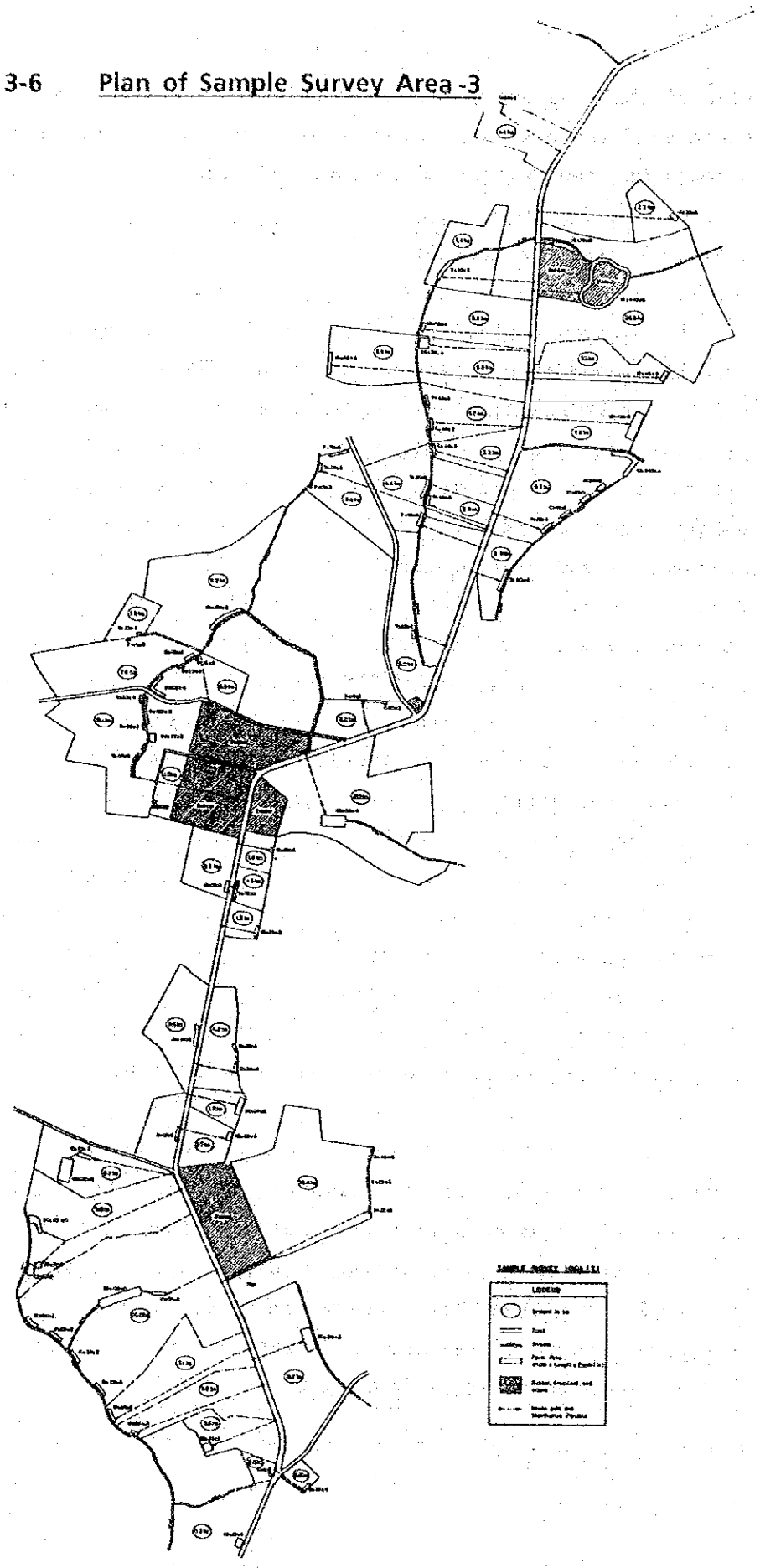
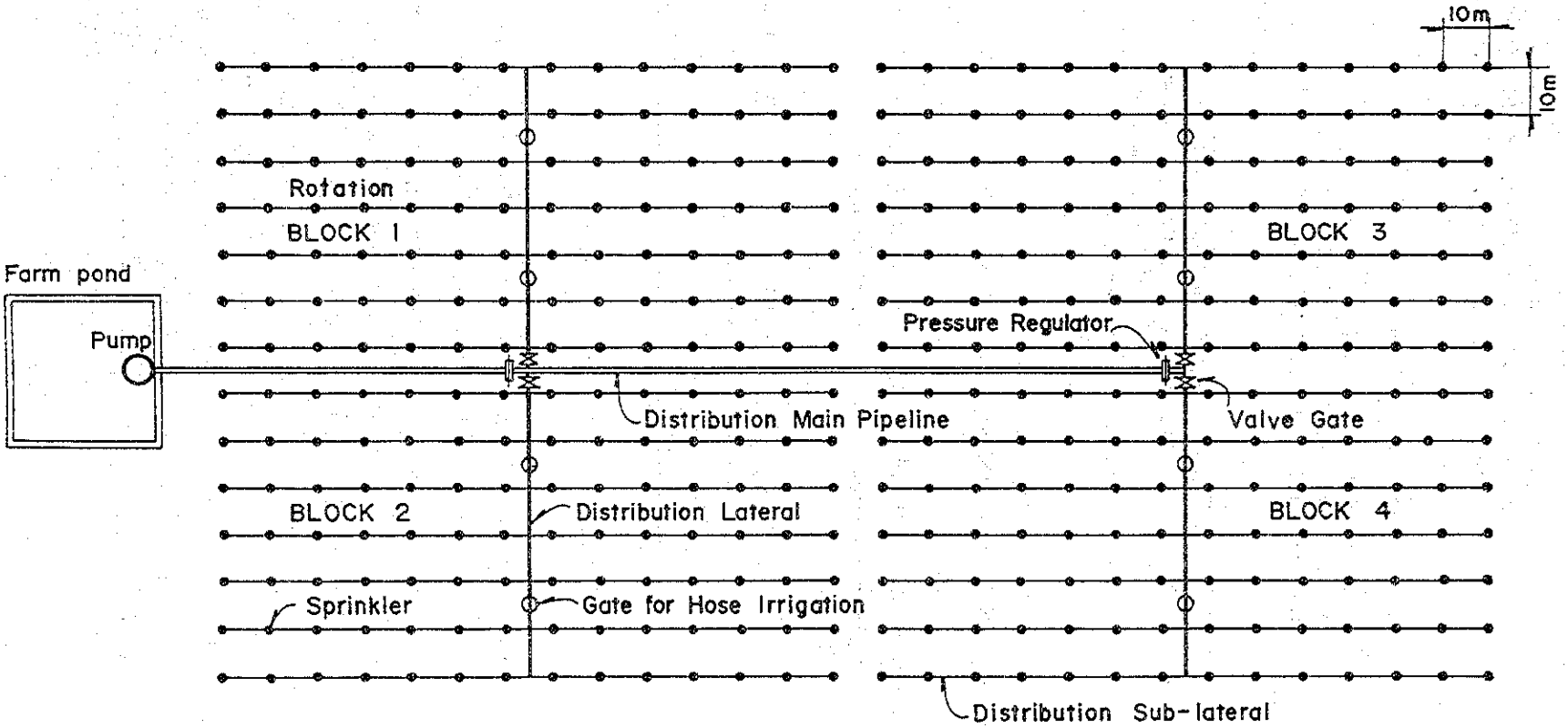


FIGURE 3-7 Typical Layout of Terminal End Facility



Pump Dimension for River Water

- Type : ϕ40 mm volute pump
- Head : 12 m (actual) + 3 m(loss) + 20 m(Sprinkler) = 35 m
- Motor: 0.163x0.144x35x1.15/0.5 = 1.9 2.2 kw

Pump Dimension for Pond Water

- Type : ϕ40 mm volute pump
- Head : 9 m (actual) + 3 m(loss) + 20 m(Sprinkler) = 32 m
- Motor: 0.163x0.144x32x1.15/0.5 = 1.7 2.2 kw

Distribution Main Pipe (12 hr operation)

- 4 ha x 0.6 lit/sec/ha = 0.0024 cu.m/sec
  = 0.144 cu.m/min
- Pipe : ϕ75 mm (1.5"), PVC

Scale of Farmpond

- Effective Capacity = 920 cu.m/ha x 4 ha = 3,680 cu.m

Available effective capacity of farmpond, which was obtained from sample area survey, is summarized as under:

Sample Survey Area	Effective Capacity
Sample Survey Area-2	940 cu.m/ha
Sample Survey Area-3	920 cu.m/ha
Value Employed	920 cu.m/ha

3.4.4. Availability of Irrigation Water

Main water resources in the study area is surface flow and subsurface flow of runoff caused by rainfall. According to the runoff record collected at Ban Puk river-gauge station with catchment area of 671 sq.km, an average annual runoff of the Chanthaburi river is about 896 MCM for a period of 17 years from 1970 to 1986. Runoff during wet season from May to October occupies almost 90% of annual average. Orchard irrigation in the area is done during dry period from November to April, or sometimes the beginning of May, and method of water utilization is classified into two categories; viz. pumping up from rivers and from farmponds.

Current status of water availability in each Tambon is summarized as follows:

Khlong Phlu : Being located upstream-most part, the area receiving water directly from the main course of the Chanthaburi river uses a plentiful water even during a critical dry period. Area utilizing pond water is suffered from shortages.

Takhian Thong : Almost same conditions as above are investigated. In the area receiving river water, frequency of water shortage is reported at once in 7 to 8 years.

Pluang : Almost no surface flow in river channels is seen during dry season. Temporary barrages are constructed and river bed is excavated to keep water level and storage capacity. Frequency of shortage in such area is once in 3 to 4 years.

Wang Saem : No river discharge is observed during months from March to May. Shallow wells are dug on river bed. Water shortages are as often as twice in 3 years.

Numbers of farmpond are distributed in the area with the total effective capacity of 9.3 MCM, which is estimated from sample area survey. Farmponds are filled with the surface runoff and subsurface flow from the catchment, and usually keep full storage at the beginning of irrigation season. Pond storage decreases gradually as the water is diverted for irrigation, however even during critical dry period, some recovery of pond storage is expected from groundwater. Such recovery also decreases as the time passes and about twice as much volume of water as the pond capacity is consequently utilized for irrigation. It is also proved from the hydrological study on water balance of farmpond that such pond inflow during dry season is groundwater runoff, one component of basin runoff caused by rainfall (refer to Appendix-A).

CHAPTER 4. DEVELOPMENT PLAN FORMULATION

CHAPTER 4. DEVELOPMENT PLAN FORMULATION

4.1. Objectives and Project Component

4.1.1. Objectives

Improvement of land and labour productivity, upgrading of market structure and other related systems to add productive value especially of fruit crops are the benefits expected from implementation of the irrigated agricultural development project. On the premise of stable supply of irrigation water, the Project envisages to foster the farmers of complex farming with highly improved agricultural income, by means of constructing necessary irrigation systems composed of storage dams, diversion weirs, conveyance and distribution systems of irrigation water, introducing double cropping on the existing paddy fields, converting a part of rubber and cassava field into orchard, accelerating replantation of high yield variety for rubber and orchard, recommending farming pattern of more productive and practically possible within the framework of existing planting program and farming technique, strengthening research and institutional aspects to investigate irrigation technology, and extending farmers' organization to add values of fruit products and to expect full participation of beneficial farmers for operation and maintenance of the irrigation systems as well as for water management.

4.1.2. Project Component

The project component as concerns integrated agricultural development and irrigation development is summarized as follows:

Integrated Agricultural Development

- To increase crop yield by means of improvement of farming technique and of providing stable sources of irrigation water

- To promote rubber field of local variety to orchard conversion

- To promote a part of upland field, planted mainly to cassava, and paddy field into orchard

- To accelerate organization of agricultural cooperatives and farmer's group aiming at establishment of orchard farming systems of high yield variety and improvement of marketing structure

- To establish demonstration farm and to strengthen research and institutional facilities

Irrigation Development

- To construct and/or rehabilitate storage dams, intake facilities, barrages, regulating reservoirs and other structures for water resources development

- To install conveyance and distribution systems of irrigation water

- To consolidate on-farm irrigation facilities in newly developed area

- To introduce appropriate water management systems

4.2. Integrated Agricultural Development

4.2.1. Land Use and Crop Conversion

The basic concept of future land use plan aims to increase land productivity and farm income through effective utilization of water resources.

To achieve its goal, it is recommendable to convert the local varieties of para rubber, upland crops and paddy into more profitable crops, such as orchard. Introduction of dry season crops as the counterpart of double cropping of paddy, as well as expanding of irrigation area should be effectively accelerated. From the land use planning concept mentioned above, the schemes are established

taking into account the farmers' opinion, Amphoe/Changwat level policy on agricultural development in the area.

1) Paddy

A part of paddy field are converted into orchard in Middle Right zone where small scale paddy rice farmings are scattered in orchard plantation area.

2) Upland Crops

The cassava area will be converted into orchard where land condition is suitable for perennial crop cultivation. Through this conversion, considerable increase of farm income could favorably be expected.

3) Orchard

The orchard cultivated area will be expanded through conversion from Para rubber and cassava cultivated area.

The orchard cultivation will be more remunerative as irrigation water can be supplied stable under the Project.

4) Rubber

Local variety of Para rubber is converted into orchard with irrigation facilities except Amphoe Tha Mai area.

5) Idle Land

Idle land mostly plays significant role as windbreak of the Project area because most of such idle land is occasionally inundated during wet season. Therefore, idle land will be conserved.

In formulating cropping plan, the following standards were adopted based on the result of discussion made between agricultural extension office of Changwat Chanthaburi and Study Team.

- Conversion from cassava to orchard

  The upland crops represented by cassava are converted into orchard. The maximum conversion rate applied is 20% of total upland area for Upper zone and 40% for Middle Right zone, respectively, to reflect the present budgetary status of beneficiaries.

- Conversion from Para rubber to orchard

  In the light of the present budgetary situation of beneficiaries, the maximum conversion rate would be preferable at 20% except Amphoe Tha Mai.

  The Para rubber trees in Tha Mai area had almost been retransplanted to new varieties supported by the government subsidization.

- Conversion from paddy to orchard

  This plan is conducted in Middle Right zone with 20% of maximum rate.

- Double cropping plan in paddy field

  The plan will be carried out on a block which have at least 10 ha of area and 20% of double cropping intensity would be considered from viewpoint of the present budgetary status of beneficiaries.

  This plan was set up at Upper zone and as the double crop, groundnuts, soybean and vegetables are planted at the land portion of 8%, 8% and 4%, respectively.

Accordingly, the proposed land use plans of the project are summarized as shown below.

(unit: ha)

Present	Projected Land Use				Total
	Orchard	Rubber	Upland	Paddy	
Orchard	11,392.1	-	-	-	11,392.1
Rubber	1,139.4	7,227.3	-	-	8,366.7
Upland	2,283.7	-	5,572.4	(61.9)1/	7,856.1
Paddy	53.2	-	-	593.4	646.6
Total	14,868.4	7,227.3	5,572.4	593.4	28,261.5

1/ 61.9 ha: Double cropping area in dry season

4.2.2. Projected Crop Production

(1) Cropping Area

In addition to three major fruit crops, groundnuts, soybean, and vegetables are introduced and irrigated as the second crop of paddy. Proposed irrigation area under the Project is summarized as follows:

Crops	Existing (ha)	Developed (ha)	Total (ha)
Durian	3,981.3	1,208.1	5,189.4
Rambutan	6,273.3	1,923.0	8,196.3
Mangosteen	1,137.5	345.2	1,482.7
Sub-total	11,392.1	3,476.3	14,868.4
Groundnuts	-	24.8	24.8
Soybean	-	24.7	24.7
Vegetables	-	12.4	12.4
Sub-total	-	61.9	61.9
Total	11,392.1	3,538.2	14,930.3

(2) Target Yield

1) Orchard

The present yield which is delicately affected by meteorological conditions shows much fluctuation.
To set up the target yield, considerations were carefully made to the followings;

i) The average yield for the recent three years reported in the agricultural statistics on Amphoe Makham.

ii) The empirical advice from Provincial Agricultural Extension Office.

iii) The experimental result of Chanthaburi Horticulture Research Center.

iv) The results of the field survey for orchard farmers. As a general rule, orchard target yield was established under the assumption that various farming activities such as fertilization, pesticide, fungicide, irrigation and weed control are fully achieved.

In order to determine the target yield of three fruits, the following procedures were adopted for the study.

i) to estimate per tree production by tree age.

ii) to estimate whole production born during the bearing period.

iii) to estimate average production through dividing whole production by bearing period.

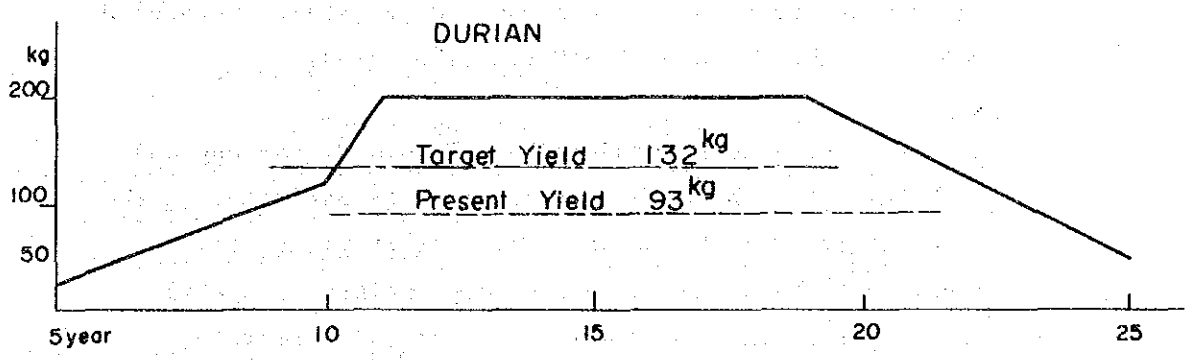
Transition of orchard yield and per tree production by tree age are shown in Figure 4-1.

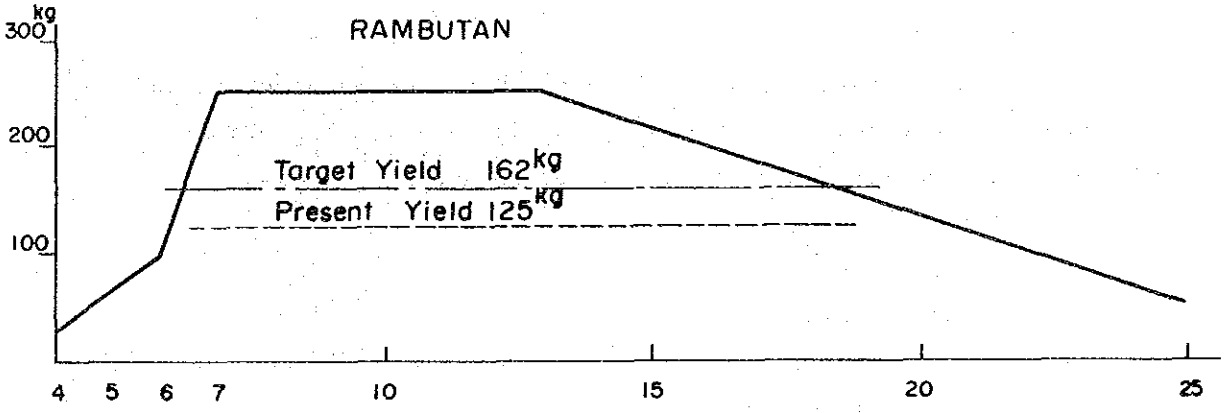
Accordingly, the target yield is set up as follows.

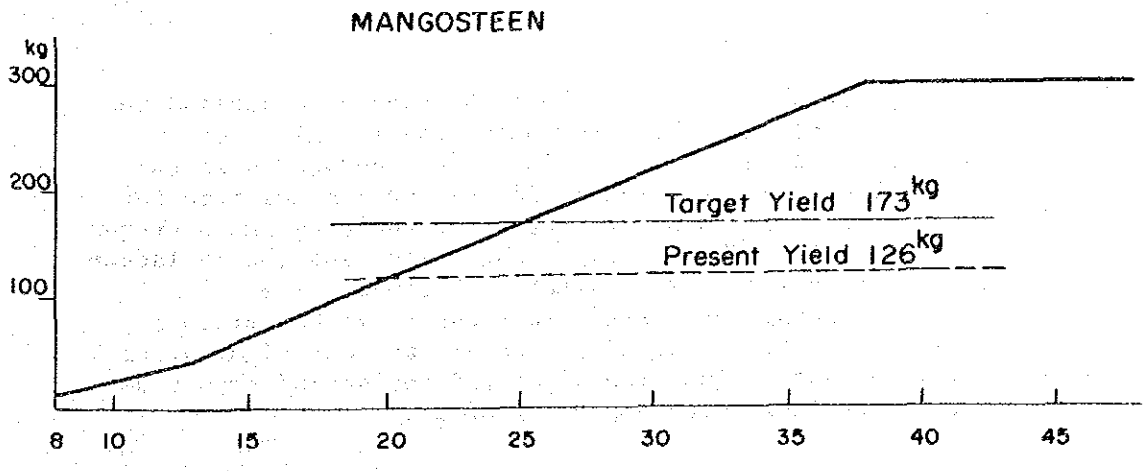
Durian	12.0 - 14.3 t/ha	1,900 - 2,300 kg/rai
Rambutan	15.3 - 17.0 "	2,400 - 2,700 "
Mangosteen	16.2 - 18.0 "	2,600 - 2,900 "

As illustrated in Figure 4-1, the target yield set up above are average of each fruit tree production during their life.

FIGURE 4-1 TRANSITION OF ORCHARD YIELD PER TREE







2) Upland Crops

The major varieties of soybean planted in Thailand are Sojo-4 and Sojo-5. The target yield is estimated at 1,900 kg/ha which belongs the medium of target yield prepared by DOAE with the range of 1,560 to 2,190 kg/ha.

The groundnuts to be produced are Tainan 9, Lampang and Sukhothai, for which the target yield is estimated in the same manner at 1,900 kg/ha. This target yield will be expected to be achieved through appropriate irrigation water, agricultural extension service and farmers' self-efforts.

(3) Cultivation Method by Crop

Cultivation method and cropping calendar for major crops and orchard are described in Table 4-1 and Figure 4-2. The primary items discussed for the cultivation method are as follows:

- Planting period
- Plant distance
- Fertilizing/1
- Number of nursery/ha
- Irrigation period
- Farm management/2
- Harvest period

/1 Fertilizer grade of 15-15-15 or 16-16-16 should be applied for younger plants but when they grow older the low nitrogen fertilizer such as 13-13-21 or 8-24-24 is recommended at the rate of 2.5 kgs/tree for 10-year old tree or 4.5 kgs/tree for 20-year old tree. It is noted that after applying low nitrogen fertilizer, the trees became rigid and strong and the incidence of phytophthora disease is remarkably lessened. The application is being made once a year but it is better to be divided into two times. The first should be done right after harvesting to restore the tree vigor and the second should be employed before flower-bud-appearing stage.

/2 The 4-5 years of cover crop cultivation for newly planted orchard is recommended for additional cash income and soil conservation.

(4) Crop Production

The fruit production is being influenced largely by the insufficient amount of rainfall during dry months. With the Project, such productivity will be highly improved through the stable supply of irrigation water, which would in turn raise the combined effect of agro-chemicals and fertilizers.

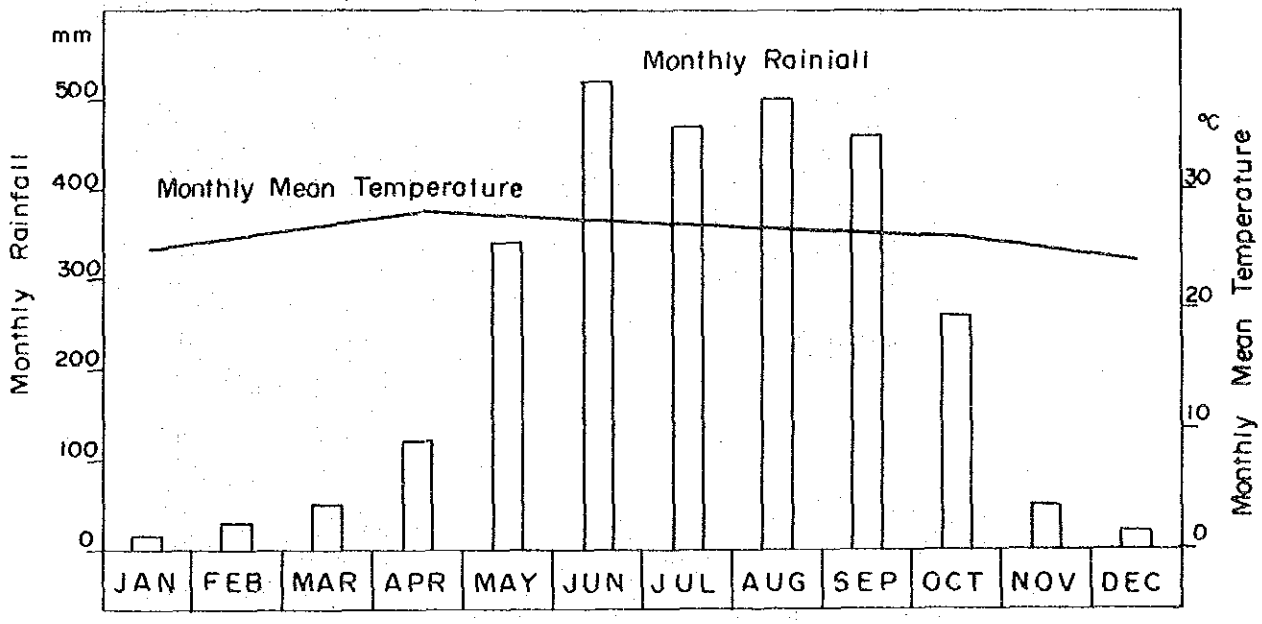
Crop production is thus estimated as follows:

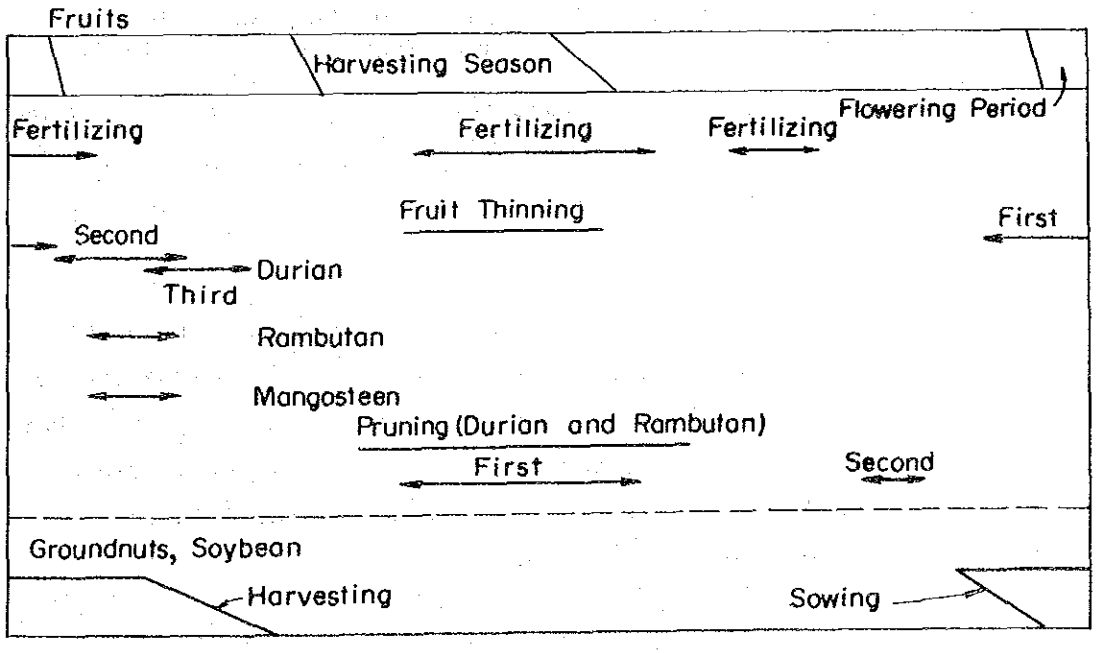
Crops	Area (ha)	Yield/ha (kg)	Production (t)
Rambutan	8,196.3	16,200	132,780
Durian	5,189.4	13,200	68,500
Mangosteen	1,482.7	17,300	25,651
Sub-total	14,868.4	-	226,931
Groundnuts	24.8	1,900	47
Soybean	24.7	1,900	47
Vegetable	12.4	15,000	186
Sub-total	61.9	-	-
Total	14,930.3	-	-

Table 4-1. Cultivation Method by Crop

Item	Planting/ Seeding Period	Pant Distance (m)	Basic Fertilizer	Seed Quantity	Irrigation Period	Top Dressing	Weeding (time)	Pesticide (time)	Other (time)	Harvest Period
Durian NBT[1/]	Jun-Sep	10x10	0.5-2 kg/tree	100 tree/ha	Oct-May	-	2-4	1-2	-	-
NB [2/]	-	-	2 "	"	do	2 kg/tree	2-3	5-7	fruit thinning 3 pruning 2-3	May-Jul
Rambutan NBT	Jun-Sep	10x10	0.5-2 kg/tree	100 tree/ha	do	-	2-4	1-2	-	-
BT	-	-	2 "	"	do	2 kg/tree	2-3	5-7	fruit thinning 1 Pruning 2	May-Jul
Mangosteen NBT	Jan-Sep	10x10	0.5-2 kg/tree	100 tree/ha	do	-	2-4	1-2	-	
BT	-	-	2	"	do	2	2-3	5-7	fruit thinning 1	May-Jul
Groundnuts	Dec.	0.3x0.2	156 kg/ha	75 kg/ha without peel	Dec-Mar	-	2	0-1	-	Apr.
Soybean	Dec.	0.25x0.25	156 kg/ha	44 kg/ha	30	-	2	0-1	-	Apr.
Vegetables	Dec.		800 kg/ha		do	200	3	2-3	-	Mar-Apr.

FIGURE 4-2 CROPPING CALENDAR





Production increase expected from implementation of the Project is summarized as follows:

Crops	Condition	/1 T.Y. (t/ha)	/2 P.Y. (t/ha)	/3 Diff (t)	Area (ha)	/4 Increase P. (t)
Rambutan	Exist./5	16.2	12.5	3.7	6,273.3	23,211
	New /6	16.2	0	16.2	1,923.0	31,153
	Sub-total	-	-	-	8,196.3	54,364
Durian	Exist.	13.2	9.35	3.85	3,981.3	15,328
	New	13.2	-	13.2	1,208.1	15,947
	Sub-total	-	-	-	5,189.4	31,275
Mangosteen	Exist.	17.3	12.6	4.7	1,137.5	5,346
	New	17.3	-	17.3	345.2	5,972
	Sub-total	-	-	-	1,482.7	11,318
Total					14,868.4	96,957
Groundnuts	New	1.9	-	1.9	24.8	47
Soybeans	New	1.9	-	1.9	24.7	47
Vegetables	New	15.0	-	15.0	12.4	186
	Sub-total	-	-	-	61.9	280
Grand Total		-	-	-	14,930.3	97,237

/1: Target yield /2: Present Yield /3: Incremental
/4: Increased Production /5: Existing plantation
/6: New plantation.

Remarks: The present yield of Rambutan and Durian was estimated from Amphoe Makham Agricultural Statistics, 1985-1987.

The present yield of mangosteen is based on the estimation of Provincial Agricultural Extension Office which shows a little bit higher than statistical average. Under the Project, the yield must be increased to about 12.6 - 14.0 t/ha.

Considerable yield increase will be anticipated under with project situation, however, the yield without project situation is considered to remain constant, because it is commonly reported that the orchard without adequate irrigation water could not increase yield even though sufficient farm inputs such as fertilizers, agro-chemicals are favorably provided.

4.2.3. Agricultural Supporting Services

(1) Demonstration Farm

Establishment of demonstration farm is strongly recommended in order to apply and extend the result of works achieved by the existing Chanthaburi Horticulture Research Center. For the first 5 years, about 10 ha of farmer's orchard is rented tentatively to carry out research and experience activities, and after 5 years' period all activities are transferred to the newly established irrigation demonstration farm.

Proposed plan of demonstration farm is summarized as below:

1) Area 10 ha

Farm	8 ha
Building and others	2 ha

2) Organization and Staffing

Description	Staff	Assistant	Driver & Labor
Director	1		
Irrigation	1	2	
Orchard cultivation	1	2	
Plant protection	1	2	20
Storage	1	1	
General affairs	1	1	
Accounting	1	1	
Total	7	9	20

3) Occupation

- Research for water requirement
- Research for irrigation method
- Research for improvement of irrigation system
- Research for pesticide method

- Research for yield by tree ages
- Research for fruit storage method
- Research for marketing system (sorting, packing etc.)
- Training for agricultural extension workers and farmers

4) Farm Facilities
- Comprehensive irrigation facilities
- Farm road and drainage canal etc.

5) Building
- Office, meeting room and laboratory
- Lecture room
- Storage facilities
- Sorting and packing house
- Warehouse
- Garage
- Residence

6) Farm Machinery and Vehicles

(2) Agricultural Extension Office and Horticulture Research Center

1) Agricultural Extension Office

a) Increase of the extension worker

As mentioned in the present situation, Amphoe Makham Agricultural Extension Office meets shortage of extension workers. Tambon Khlong Phlu and Takhian Thong in Upper zone of Project area have been cropping mainly cassava and therefore experience of cultivating orchard is poor. Furthermore, one extension worker is in charge of above two Tambons.

After the Project, 2,474 ha of farm land will be converted to orchard, and at least 4 extension workers are required to be increased in Agricultural Extension Office.

In Middle Right zone, 994 ha of farm land will be newly converted to orchard. No serious problem is pointed out in this zone since the zone consists of 2 Amphoes, 4 Tambons and there are many pioneers of orchard plantation.

b) Installation of Telephone

Telephone service is not available at Makham Agricultural Extension Office and Tambon Offices. For the smooth operation of agricultural extension services, installation of telephone is recommendable.

2) Chanthaburi Horticulture Research Center

Chanthaburi Horticulture Research Center was founded in 1986. Formerly, it has been operated as Horticulture Research Branch Station. The consolidation of the experimental equipment and buildings have been completed in 1988.

The research activities will soon be started and the following researches will be studied:

- extension of harvest period
- extension of storage term of fruits
- enhancement of fruits quality
- control of diseases and harm insects
- plant breeding
- water requirement of irrigation

4.2.4. Agricultural Cooperatives and Farmer's Group

(1) Agricultural Cooperatives

Agricultural cooperatives are established and being operated in every Amphoe, however their activities are not always vital inspite of earnest propagative activities by Chanthaburi Cooperative Office. Since cooperative fruit selection, uniform lapping and subsequent

cooperative forwarding give strong influence on the market price of orchard, the establishment of marketing and quality control system through the increase of cooperative members is desirable. It is also recommended that the Government's subsidization to assist their activities is favorably boosted.

(2) Farmers' Group

There are two types of farmers' groups controlled mainly by Agricultural Cooperative and by Agricultural Extension Office. Since they go along the same lines, the unification to proceed the cooperative selling (buying) of farm outputs (inputs), joint farm management and quality control are recommended. Tremendous fruit production can be anticipated under the project situation, therefore joint forwarding of fruit can be considered as being helpful for farmers to recover the marketing risk and also to save transport cost. Marketing research should be promoted by group basis and this activities would bring about the strong intension for export among the farmers.

4.3. Irrigation Development

4.3.1. Irrigable Area

The area of 67,730 ha covered by the subject Feasibility Study involves the Upper and Middle Right zones of the Chanthaburi river basin, excluding the areas commanded by NEA's Pump Irrigation and Khlong Thung Pen projects. Represented by durian, rambutan and mangosteen, fruit crops are the predominant crops for irrigation in the area. Of the 28,269.4 ha presently used as farmland, 11,400.0 ha (40.3%) are planted to fruit crops, 8,366.7 ha (29.6%) to rubber, 7,856.1 ha (27.8%) to upland crops represented by cassava, and 646.6 ha (2.3%) are cropped with paddy. Tambon-wise planted area as of 1987/88 are summarized as follows:

Crop-wise Land Use by Tambon

(unit: ha)

Tambon (Amphoe)	Paddy	Upland	Orchard	Rubber	Others	Total
Khlong Phlu	242.0	6,874.3	1,780.0	2,119.4	19,414.3	30,430.0
Takhian Thong	318.1	671.2	1,321.6	919.9	8,439.2	11,670.0
Pluang	14.0	71.5	4,086.6	2,377.0	3,750.9	10,300.0
Wang Saem	17.7	-	397.5	140.2	374.6	930.0
Tha Luang	4.8	-	227.5	189.4	1,078.3	1,500.0
Salang	50.0	12.8	945.1	1,326.6	2,395.5	4,730.0
Tha Chang	-	8.0	90.1	128.6	43.3	270.0
(Tha Mai)	-	218.3	2,551.6	1,165.6	3,964.5	7,900.0
Total	646.6	7,856.1	11,400.0	8,366.7	39,460.6	67,730.0

Currently in the area, only fruit crops including pepper are being irrigated. After careful examination of the existing land use and farming patterns in zones, some rubber fields and upland fields, where cassava is mainly planted at present, are planned to be converted into orchard. Second crops, such as groundnuts, soybeans and vegetables, are also introduced in some part of existing paddy field during dry season. Such crop conversion plans are summarized as follows:

Summary of Crop Conversion Plan

(unit: ha)

Zone	Water Source	Existing Orchard	Converted from Paddy	Converted from Upland	Converted from Rubber	Orchard Sub-total	Second Crops	Total
Upper	River*	1,534.9	-	986.3	79.3	2,592.6	46.1	2,638.7
	Pond	1,759.0	-	1,256.4	160.0	3,175.4	15.8	3,191.2
	Total	3,293.9	-	2,242.7	239.3	5,768.0	61.9	5,829.9
Middle Right	River	1,390.0	53.2	20.9	115.4	1,579.5	-	1,579.5
	Pond	6,716.1	-	20.1	784.7	7,520.9	-	7,520.9
	Total	8,106.1	53.2	41.0	900.1	9,100.4	-	9,100.4
Grand Total		11,400.0	53.2	2,283.7	1,139.4	14,868.4	61.9	14,930.3

Note: * : Existing orchard of 7.9 ha situated in Tambon Khlong Phlu are excluded from irrigation plan.

Irrigation Area (ha)

Land Use		Acreage
Orchard:	Existing	11,392.1
	Developed	3,476.3
Double Cropping on Paddy		61.9
Total		14,930.3

4.3.2. Water Demand and Allocation

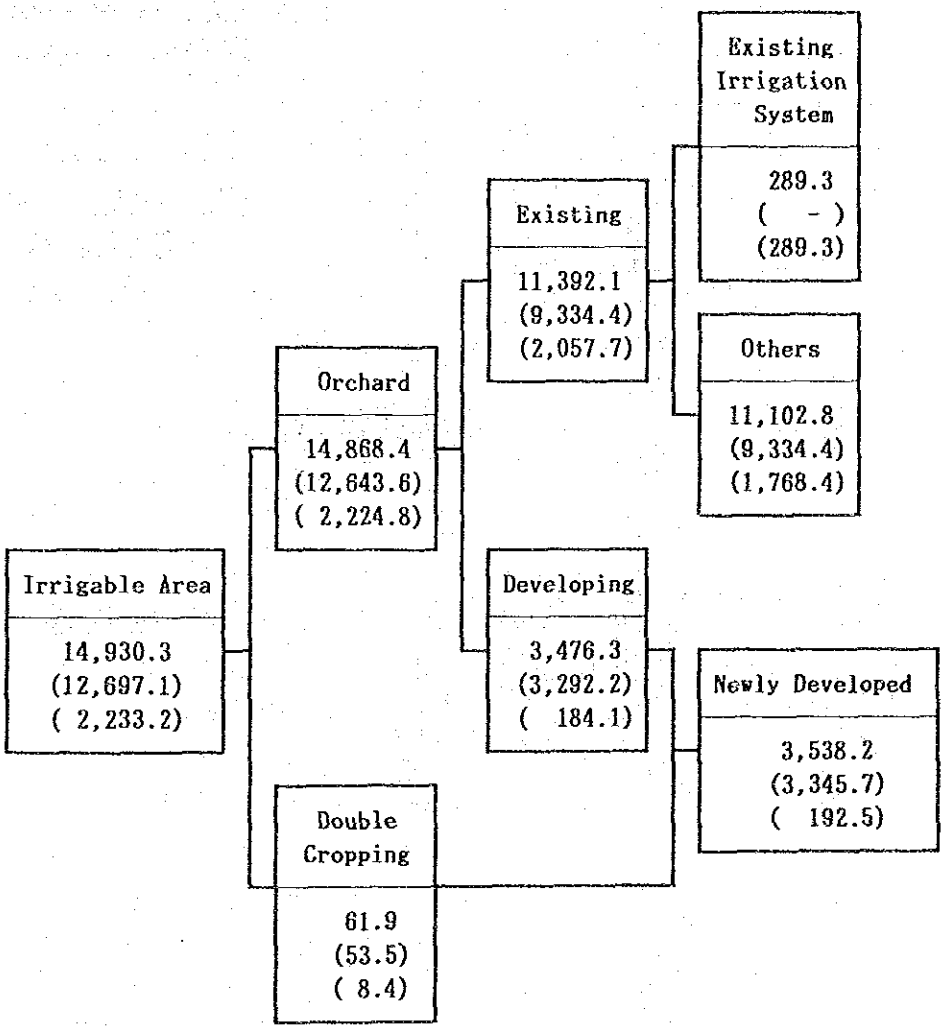
On the basis of the proposed plan of crop conversion and location and possible capacity of the proposed storage dams, irrigation diagram was prepared as shown in Figure 4-3. The entire service area was divided into 79 irrigation blocks. In consideration of topographic location and elevation of irrigation blocks and available energy head of water sources, fundamental allocation of water between water sources and beneficial areas was determined as follows:

- Khlong Ta Lui Dam : (No.4 dam) Using high energy head available at damsite, waters are conveyed to about 12,700 ha of irrigable area mainly by gravity.

- Khlong San Sai Dam: (No.5 dam) Relatively low water head is available at the site. Waters are distributed mainly to the area situated along the main course of Chanthaburi river, where waters are directly diverted from the river.

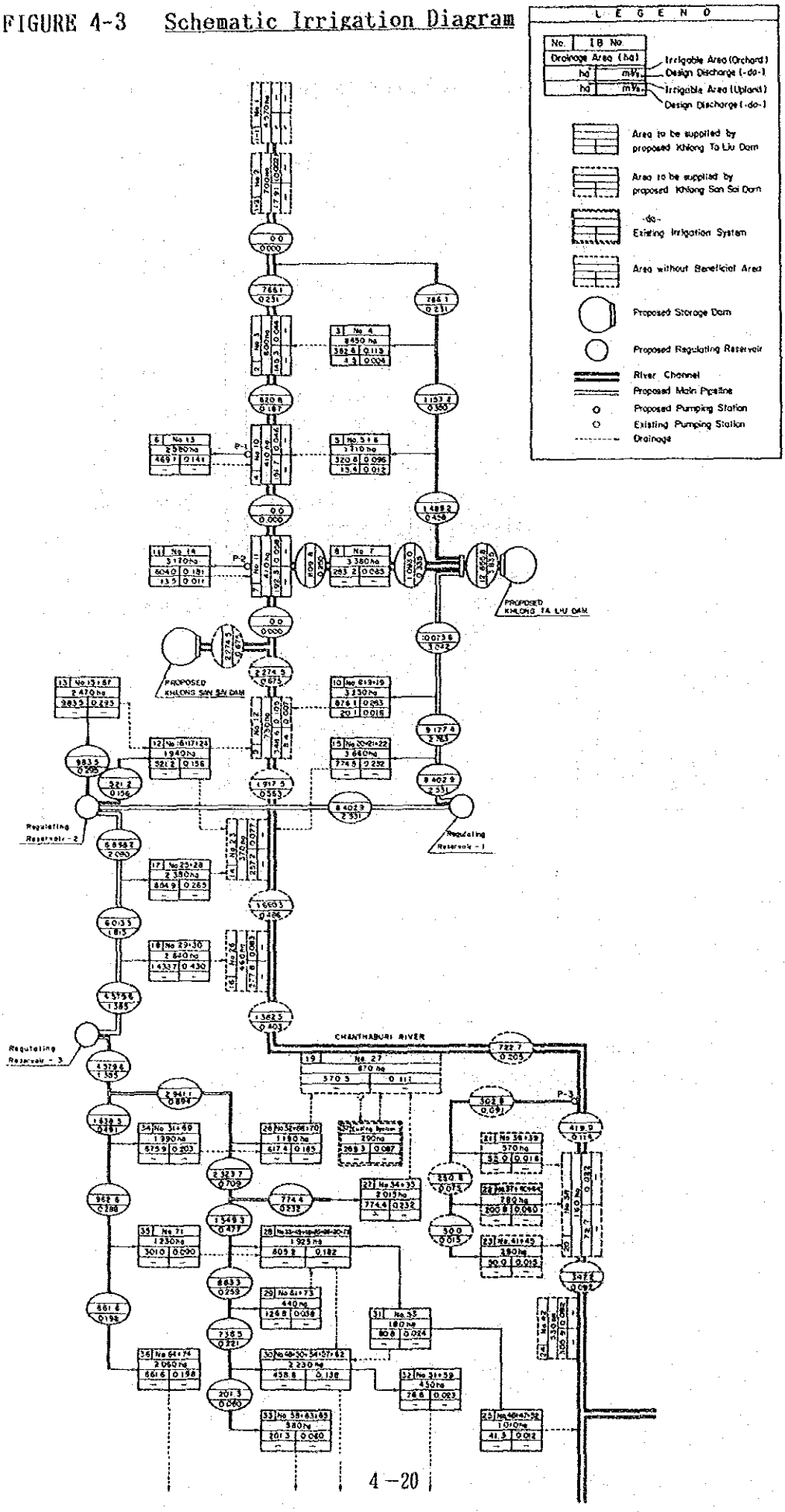
The proposed allocation of water is summarized as follows:

(unit: ha)



Notes: Upper parenthesis Khlong Ta Liu Dam
Lower parenthesis Khlong San Sai Dam

FIGURE 4-3 Schematic Irrigation Diagram



4.3.3. Required Storage Capacity

Proposed dams are so operated as to release water just to meet the demand requested from the beneficiaries whenever there remains excess water in the reservoir. To determine the capacity of reservoir to satisfy such requirement in a critical dry period, computations for water balance simulation were made with 10-daily time step for the recent 20 years from 1967 upto 1986. Annual maximum required capacities of the proposed dams so computed were put into statistical analysis to evaluate the capacity required for the standard drought years, which would occur once in 5, 7 and 10 years.

Fundamental assumptions employed in the water balance study were as follows:

Physical Condition of Reservoir

Topographically possible maximum capacities of the proposed Khlong Ta Liu and Khlong San Sai dams are considered respectively as some 43.2 and 12.9 MCM. Required capacities of dams for the standard dry years are determined through the water balance simulation within the technically acceptable range.

Reservoir Losses

Only evaporation losses from the reservoir surface were considered in the study. Other losses such as seepage loss and direct rainfall on the reservoir surface, as the negative loss, were eliminated from the water balance simulation study.

Rate of Usable Runoff in Irrigation Block

In irrigation blocks, runoff caused by rainfall may be usable for irrigation. In areas irrigated by water from rivers and tributaries, about 80% of runoff concentrated into rivers will be pumped up for irrigation. Such pumping operation may continue only during daytime or 12 hours a day, in spite of the fact that river runoff would occur throughout a day. A rate of usable runoff was thus estimated as 80% multiplied by 12/24, which is equivalent to 40%. On the other hand in the area irrigated by pond water, runoffs are always stored in a pond if there is excess capacity. Unfortunately, however, ponds are not installed everywhere to catch 100% of areal runoffs. A usable rate was then simply assumed to be about 50%.

Existing Pond Capacity

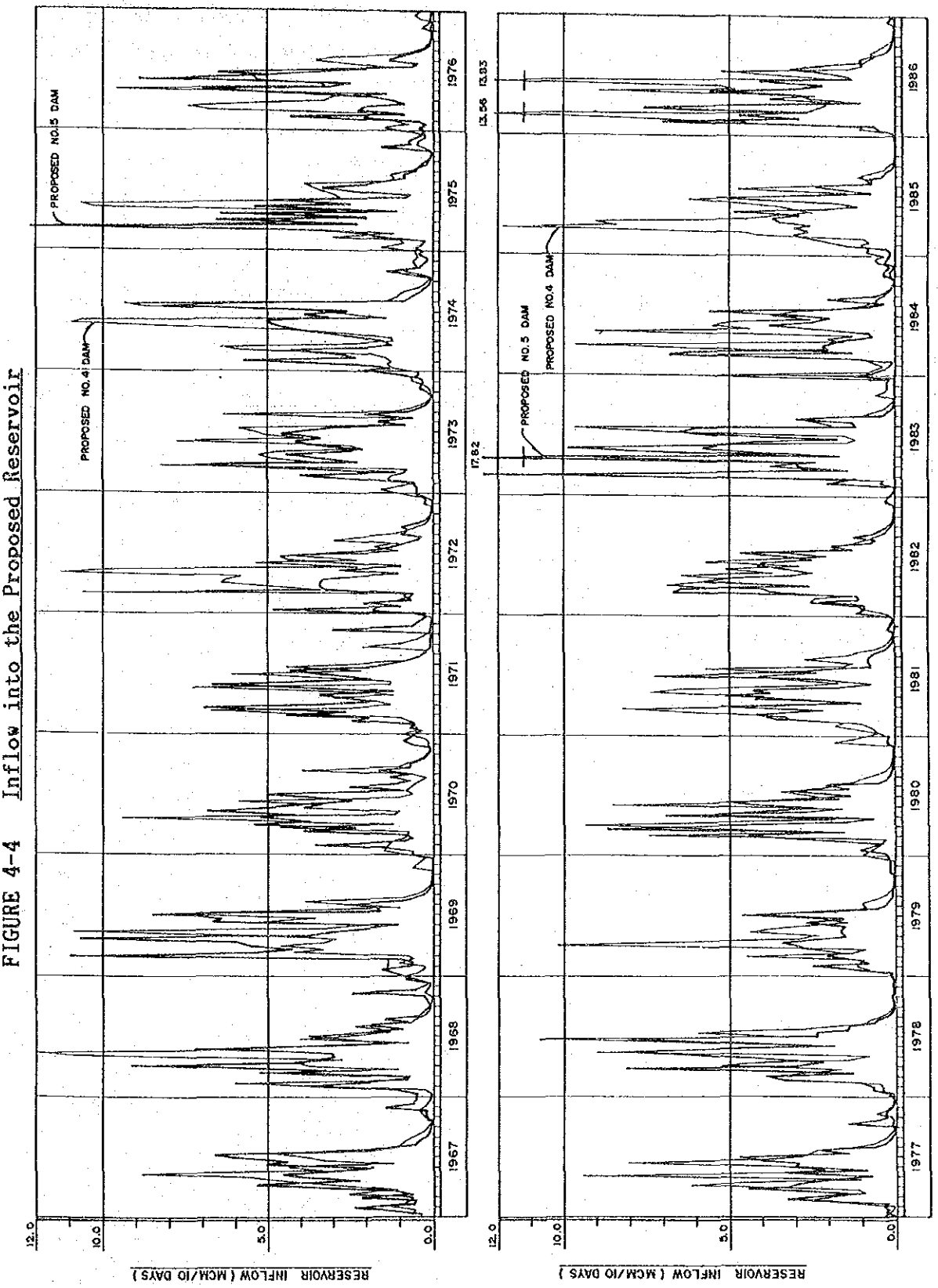
As regards the existing available capacity of farm ponds in the area, results from detailed field investigation conducted in the sample areas (2) and (3) were summarized, as follows, to produce an estimated value of 920 cu.m per hectare.

Farm Pond Capacity in Sample Survey Area

Sample Area	Planted Area (ha)	Nos. of Pond	Pond Capacity (cu.m)	Unit Capacity (cu.m/ha)	Safety Factor	Capacity Used (cu.m/ha)
Area-2	342.1	109	458,820	1,341	0.7	940
Area-3	289.3	72	379,222	1,311	0.7	920
Capacity Used in Study						920

In accordance with the proposed plan of cropping area conversion and other basic assumption as mentioned above, computations were made to simulate balance of water between source and user. Figure 4-4 illustrated fluctuation of inflows into the proposed dams and simulated results of reservoir storage are given

FIGURE 4-4 Inflow into the Proposed Reservoir



in Figure 4-5. From series of computation, the required capacities of the proposed dams with respect to the frequency of drought were evaluated as below:

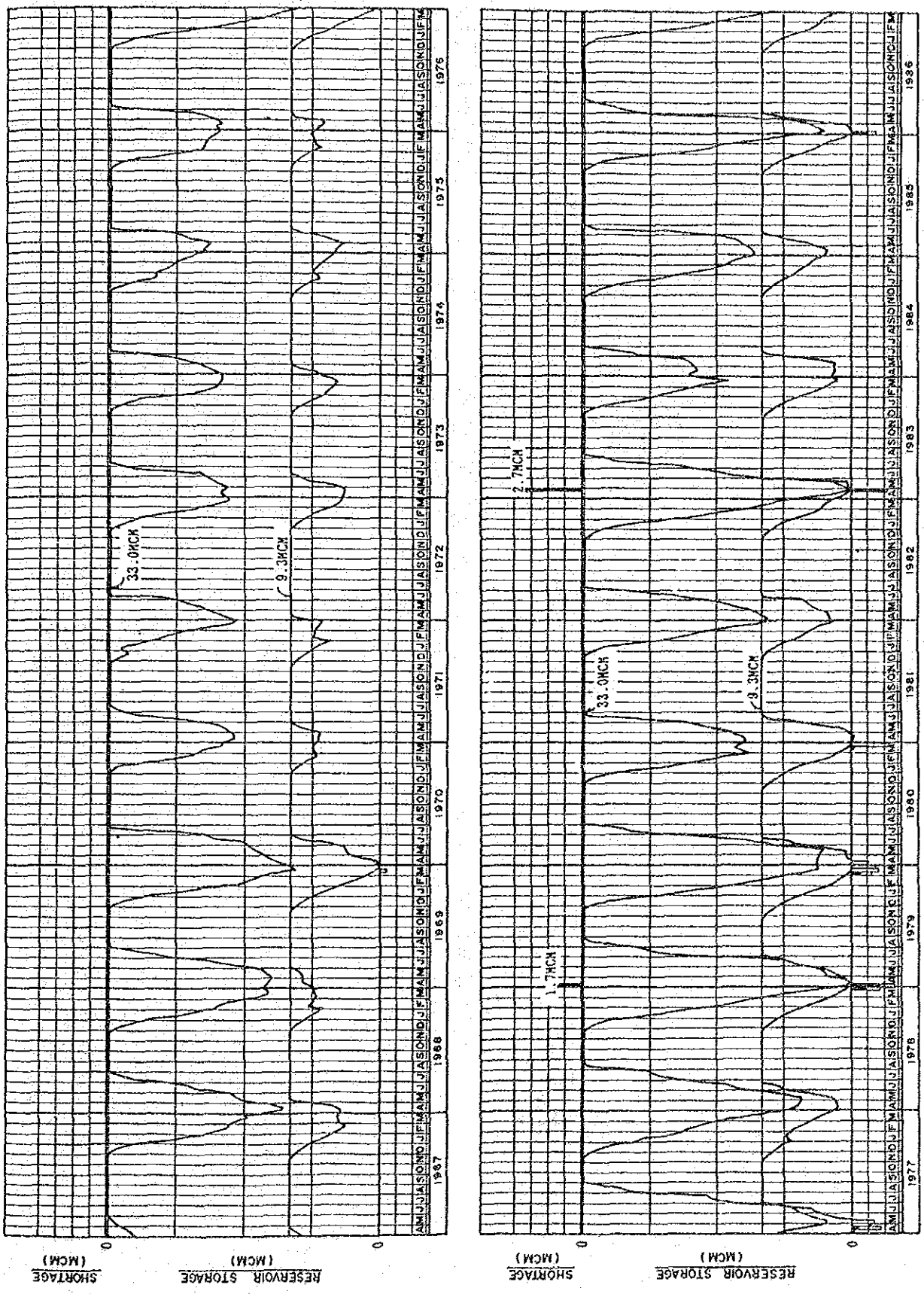
Required Capacity of Proposed Dams in MCM

Dam	Probability of Drought 1/5	1/7	1/10
Khlong Ta Liu Dam (No.4 dam)	28.0	30.5	33.0
Khlong San Sai dam (No.5 dam)	7.9	8.6	9.3
Total	35.9	39.1	42.3

From computations, allocation of water among sources and users as an average in 20-year period from 1967 to 1986 is as follows:

Direct Water Source:	River Water		Pond Water		Total	
Period (Month) :	11-4	5-10	11-4	5-10	11-4	5-10
Irrigation Area (ha)	4,807.4		10,122.9		14,930.3	
- Orchard	4,759.0		10,109.4		14,868.4	
- Double cropping	48.4		13.5		61.9	
Irrigation Demand (MCM)	22.1	17.1	46.4	36.3	68.5	53.4
- Orchard	21.8	17.1	46.3	36.3	68.1	53.4
- Double Cropping	0.3	-	0.1	-	0.4	-
Water Source (MCM)	22.1	17.1	46.4	36.3	68.5	53.4
- River Runoff	8.6	17.1	-	-	8.6	30.0
- Initial Pond Storage	-	-	9.3	0.0	9.3	0.0
- Pond Inflow	-	-	18.3	36.3	18.3	36.3
- Proposed Storage Dam	13.5	0.0	18.8	0.0	32.3	0.0

FIGURE 4-5 Simulated Results of Reservoir Storage



CHAPTER 5. PROJECT FACILITIES

CHAPTER 5. PROJECT FACILITIES

5.1. Storage Dam

5.1.1. General Concept

Main water resources in the Project area is surface flow and subsurface flow of runoff caused by rainfall. The annual average runoff discharge at the drainage area of 677.3 sq.km is 914 MCM based on data of Hydrology Division of RID at Ban Puk gauging station.

The Project area has sufficient water resources for irrigation water development. The manners for effective utilization of these water resources are to store water in the reservoir during wet season and to release water to the irrigable area during dry period.

The 19 damsites were selected and studied during the pre-feasibility study for the purpose of water resources development in the Project area.

As a result of the Study, it was judged that the location of damsites was more advantageous in the mountain area and hilly area from the viewpoint of social condition (mainly land acquisition of orchard land), reservoir scale, topography and geological condition.

In the Feasibility Study, the proposed irrigable area consists of Upper zone and Middle Right zone. Therefore, No.1, No.2, No.4, and No.5 damsites which are located at the hilly and mountainous areas have been selected.

5.1.2. Preliminary Site Selection

The detail reconnaissance of four damsites was performed in order to select the most suitable damsite among them on the basis of topo-map of scales 1/1,000 and 1/4,000, prepared by RID.

Main factors related to damsite selection are as follows:

- Topography

  Topography of the other three (3) damsites except the Khlong Ta Liu damsite shows wide river bed and slopes of both abutments are gentle. Therefore these damsites are not recommendable from topographic point of view.

- Geology

  It is presumed that permeability of No.1 and No.2 dam foundation is high judging from geologial reconnaissance.

- Fill Materials

  Impervious material (Borrow area) are not found around No.1 and No.2 damsites.

- Location of Damsite

  All damsites are located at favorable position for irrigation. Taking irrigation method of gravity type into consideration, No.4 dam located at high elevation is the most suitable.

- Reservoir Scale

  As shown in Appendix H.1, reservoir scale is large in order of No.4 damsite, No.1 damsite, No.5 damsite and No.2 damsite.

- Water Cost

The following table shows water cost based on the preliminary quantity of work of each dam.

Name of Dam	Live Storage Capacity 1/	Water Cost: Dam Volume	Assumed Construction Cost 2/	Assumed Water Cost 3/
	(MCM)	(10^3 cu.m)	(M฿)	(฿/cu.m)
No.1	29.74	9,350	935	3.17
No.2	8.76	885	88.5	0.98
No.4	34.65	5,000	750	2.08
No.5	9.80	600	60	0.59

Notes: 1/ Live storage capacity except No.4 dam is limited by the topographical conditions of damsite.
2/ Dam cost not including land acquisition and compensation. Unit cost of three dams except No.4 dam adopt tentatively 100 Baht/cu.m. No.4 dam's unit cost adopts 150 Baht/cu.m^3 because of rockfill dam.
3/ Water cost can be estimated by annual cost and water demand.

Combination of No.4 dam and No.5 dam is the most suitable among four dams from the viewpoints of all aspects considered.

5.1.3. Site Topography, Geology and Fill Materials

(1) Geological Survey of Damsite

Geological survey was carried out at four damsites, i.e. No.1, No.2, No.4, and No.5 damsites. Geological reconnaissance was first performed in and around damsites based on topo-maps of damsite 1:1,000 scale and those of reservoir 1:4,000 scale which have recently made by RID. Then it was judged that No.4 (Khlong Ta Liu) and No.5 (Khlong San Sai) damsites had priority to be constructed. The summary of geological survey is as follows:

Damsite	Method and Amount
Khlong Ta Liu (No.4)	Drilling: 3 holes, 300 m in total Permeability test: 3 holes, 57 times
Khlong San Sai (No.5)	Drilling: 4 holes, 100 m in total Permeability test: 4 holes, 20 times Standard penetration test: for surface soft layers.

(2) Topography and Geology

1) Khlong Ta Liu Damsite

Topography

The damsite is planned to be placed in the valley of the Khlong Ta Liu river which traverses mountain area with summits 1,000 - 1,500 m in elevation. Elevation of riverbed around the planned damsite is about 140 m.

The right abutment composes a part of a ridge which has tops 340 m to 360 m in elevation, a base about 400 m wide and slope 20 to 30 degree in gradient. On the proposed dam axis, there is a nicked point of gradient on the slope at around 190 m in elevation, and the slope shows more gentle gradient below the point.

The left abutment is a part of big massive mountains with summits 500 to 700 m in elevation and with slope 25 to 35 degree in gradient. On the dam axis, the slope shows gentle gradient of about 15 degrees in the middle part.

The river is 20 to 30 m wide and is accompanied with terraces three meter in specific height. Base of the valley is rather wide with width of 100 to 130 m.

Damsite and neighbouring area is covered with naturally-grown trees and is assigned to a reserved forest by the government.

Geology

Basement rock of the damsite is granite partly with hard shale. Overburden comprises talus deposit on both abutment and river deposit along the riverbed.

Granite is light gray, hard and moderate to coarse-grained, and is moderately jointed. Joints trend dominantly N 0°W to N 50°W in strike and 40° to 90°NE in dip, whereas those dipping with a low angle are seen in places. Outcrops are found in some places along the riverbed and on steep slope of higher part.

Heavily weathered part like earth is poorly developed on the abutments. However, it is possible that the basement is weathered to depths along small faults and joints, or is loosened because it is presumed that mountains around the damsite have been exposed on the ground for long geological periods.

Hard shale is found at right bank of the river about 300 m upstream of the dam axis and near a conjunction of main tributaries more upstream, showing penetrated by granite veins or captured by granite as a xenolith. Laminate of sandstone was seen in a part of shale.

Talus deposit lies dominantly near the proposed dam axis and in foot part of right bank downstream of the axis. That is mainly composed of rubbers of granite of various sizes.

River deposit underlies bottom of the valley and has thickness about 5 m in area of river terrace. comprising gravel of granite and hard shale of various sizes.

It is possible that there is a considerable large fault zone along the valley judging from linear shape of the valley and rather big width of the valley which conflicts with prevalence of hard rock.

Presence or not and dimensions of the fault zone, thickness of overburden and weathered zone, and properties of basement rock will be roughly cleared after the drilling survey and seismic exploration by Thailand government will be completed.

According to a geological map 1:250,000 scaled, named 'CHAGWAT CHANTHABURI' published by above-mentioned authorities, the shale and granite belong to Pong Name Rom Formation of Triassic age.

2) Khlong San Sai Damsite

Topography

The damsite is located in a gentle hilly area with tops 50 to 60 m in elevation and with slopes two to five degree (ten degree near riverbed) in gradient. Conditions of topography resemble those of No.2 damsite. The main river of damsite is 10 to 15 m wide and meanders with amplitude of 50 to 100 m. Elevation of the riverbed is about 30 m near the proposed dam axis. There is a streamlet of a few meters wide at the distance 150 to 200 m left side of the main river, flowing almost parallel to the river.

The damsite and neighbouring area are cultivated mainly with rubber trees on the right abutment and with cassava and rubber trees on the left abutment.

Geology

The damsite and neighbouring area is underlain by weathered granite except small area along riverbed where river deposit covers the surface.

Weathered granite is classified into the following four zones from preliminary analysis of drilling cores.

I Zone: Heavily weathered Granite

All feldspars and most of micas have been changed to clays, forming soft sandy clay to clayey sand. Uppermost part has become soil accompanied with concentration of iron or dehydration.

II Zone: Moderately Weathered Granite

Though the structure of granite remains clearly, cohesion among rock-forming minerals is almost lost and is easily decomposed into minerals showing like sands. Feldspars are half changed to clay.

N-Value is more than 50 in almost cases. Only sandy cuttings are recovered if water is applied in drilling.

III Zone: Lightly Weathered Granite

This granite has intermediate characteristics between of II and IV zones and is recovered half as sandy cuttings and another half as columnar cores in drilling. Feldspars are a little altered.

IV Zone: Fresh Granite

Granite is almost fresh. Columnar cores are mainly recovered in drilling. Steeply-dipping cracks which is sheared a little but tightly cemented in most cases are seen.

I Zone is 11 to 13 m thick on both abutments and is more sandy in upper part four to five meter thick. Around the riverbed, this zone is worn away.

II Zone is 3.5 to 5 m thick around the riverbed and on the right abutment, and is more than nine meter thick on the left abutment.

As a whole, it is presumed that the weathered zones are thicker on the left bank and thinner on the right bank.

River deposit is composed of soft silty sand to clayey sand and shows thickness less than a few meters.

(3) Fill Materials

Fill materials are classified into impervious material, semi-pervious material, pervious material and filter-drain material.

The Khlong San Sai dam is filled by impervious material because of earthfill type. As the result of geological and fill materials reconnaissance around the damsite, a considerable weathered soil of granite distributes widely on the surface layer with thickness of 4-5.0 m.

This is suitable for an impervious material.

The volume of Khlong San Sai dam is approximately 570,800 cu.m, and volume of borrow area is estimated roughly at more than two (2) times as much as the fill quantity required.

Borrow areas of the Khlong Ta Liu dam are located on the skirts of mountain at the distance of 3.5 to 6.0 km downstream from the damsite. Material at the borrow area is weathered soil of granite, and its properties are almost same as the impervious material

obtained from the Khlong San Sai damsite. Filter and drain materials are gathered from the sand-gravel layer formed by the river at the skirt of mountain.

The quarry site is located in the mountain having a summit elevation of 400 m situated on the confluence of two rivers at the distance about 700 m upstream from the damsite.

Rock (pervious material) is mainly composed of hard granite, where hard shale is partly observed. These rocks are very favorable for pervious material of a rockfill dam.

Weathered rock materials, which cover these rocks, will be used as semi-pervious material.

5.1.4. Preliminary Design

(1) Storage Dam

1) Reservoir Scale

The reservoir scale of both dams is decided by irrigation water requirement obtained through water balance simulation. 10-year drought runoff is applied for deciding the reservoir scale in aiming at irrigation planning.

The design water level of reservoir is obtained from Height-Volume and Height-Area Curve (Refer to Appendix-H and H.7).

The dam scale is determined by the manner described on "Design Criteria of Dam" in Appendix-H.10.

Reservoir and dam scale is shown in Table 5-1 in the succeeding page.

Table 5-1 DAM DIMENSION OF KHLONG TA LIU DAM AND KHLONG SAN SAI DAM

NAME OF DAM	SQ.KM	KHLONG TA LIU DAM	KHLONG SAN SAI DAM
DRAINAGE AREA	SQ.KM	70.20	44.50
ANNUAL RUNNOFF DISCHARGE			
*AVERAGE	MCM	76.79	65.67
*10-YEAR DROUGHT	MCM	56.49	49.03
RESERVOIR SCALE			
*SEDIMENTATION	MCM	1.2	0.75
*LIVE STORAGE CAPACITY	MCM	34.65	9.80
*TOTAL STORAGE CAPACITY	MCM	35.85	10.55
*RESERVOIR AREA IN FWL	ha	163	264
*LOW WATER LEVEL	M	LWL 161.50	LWL 35.20
*FULL WATER LEVEL	M	FWL 213.50	FWL 42.70
*HIGH WATER LEVEL	M	HWL 215.00	HWL 43.70
DAM SCALE			
*DAM CREST ELEVATION	M	EL 217.50	EL 46.20
*EL.OF MIN. CORE TRENCH	M	EL 130.00	EL 25.00
*DAM HEIGHT	M	87.50	16.2
*CREST LENGTH	M	618.0	954.60
*DAM VOLUME	CU.M	4,701,000	570,800
*UPSTREAM DAM SLOPE	—	2.5	3.0
*DOWNSTREAM DAM SLOPE	—	2.0	2.5
SPILLWAY			
*DESIGN FLOOD DISCHARGE	cu.m/s	315.0	125.0
*OVERFLOW DEPTH	M	1.5	1.0
*CREST LENGTH	M	90.0	63.0
INTAKE			
* MAX. DISCHARGE	cu.m/s	3.835	0.675

(2) Selection of Dam Type

Dam type is mainly classified into a fill dam and concrete dam. The proposed damsites have a gentle topography and wide valley. A shape of valley is generally expressed by a ratio of dam height and width of valley. The ratio of Khlong Ta Liu dam and Khlong San Sai dam is 7.5 and 51, respectively.

A fill dam is more suitable than a concrete dam taking these ratio into consideration.

The appropriate type of fill dam at the both proposed damsite is selected based on dam height, fill materials' distribution around the site, topography of both abutments and geology of foundation.

The dam type selected at the both damsites is as follows:

Khlong Ta Liu damsite	:	Rockfill dam
Khlong San Sai damsite	:	Earthfill dam

The detail description for the selection of dam type is shown in "Selection of Dam Type" in Appendix-H.

(3) Route and Type of Spillway

The spillway route of both damsites is placed on the right side as the most appropriate location judging from the topographical and geological conditions.

The type of spillway to the proposed dams was determined as an uncontrolled spillway (spillway without gate) for the following reasons:

- Spillway with gate is required artificial operation and daily maintenance. And also, spillway with gate is not suitable for important facilities such as dam which there needs strict operation and maintenance.

- Spillway gate has possible dangerousness caused by delay and mishandling of gate operation.

The shape of overflow section is mainly decided by topographical conditions.

The shape of Khlong Ta Liu dam's spillway adopts side channel type because the contour line cross at right-angle to dam axis.

In case of Khlong San Sai dam, the shape is most suitable for chute type.

The hydraulic jump basin of USBR type II is adopted as an energy dissipator to the both dams.

(4) Diversion Works

During the dam construction period, the flow of the river is changed through the diversion works.

The Khlong Ta Liu damsite has steep topography at the both abutments and the width of riverbed is not so wide. And also the river discharge is large. So, it is most suitable for this damsite to apply diversion tunnel. This tunnel is placed on the right side.

Coffer dam having about 20 m height is placed on the upstream course of damsite during the dam construction period.

The design flood discharge of the diversion tunnel and coffer dam is 225 cu.m/s for 10-year return period. The tunnel is designed with circular type of 5.4 m diameter.

The diversion works at the Khlong San Sai damsite adopts channel type because the width of damsite is very wide having about 600 m.

(5) Intake Facilities

Intake facility of the Khlong Ta Liu dam uses the diversion tunnel. After the completion of dam construction, a steel pipe is installed inside of the diversion tunnel and this steel pipe is joined by drop-inlet constructed in the reservoir.

Intake facility of the Khlong San Sai dam uses bottom outlet type laid under the dam.

(6) Foundation Treatment

1) Excavation and Remove

The dam foundation is planned on a hard rock and/or base with N-value exceeding 20. Therefore, loose and soft layers are excavated and removed deep enough upto the effective foundation for dam construction.

2) Grouting

Grouting is carried out in order to control seepage water through rock foundation.

Grouting planned at the Khlong Ta Liu damsite is as follows:

Main Curtain Grouting	:	L = 16,500 m
Supplementary Curtain Grouting	:	L = 9,900 m
Blanket Grouting	:	L = 8,800 m

The foundation of the Khlong San Sai dam is formed by heavily weathered zone of granite. Therefore, foundation treatment is especially not necessary for seepage water control.

Detailed explanation on the foundation treatment is shown in Appendix-H.

5.1.5. Construction Plan and Schedule

(1) Basic Conditions

1) Workable Day

Earth works are mostly affected by rainfall. Therefore, monthly mean workable days during the construction period are estimated by the daily rainfall records of the recent 10 years at the Amphoe Muang station.

From the results, the workable days of each works are employed as follows;

Items of Works	Workable Day per Month	
	Wet Season	Dry Season
Fill of Impervious Zone	16	25
Fill Except Impervious Zone	21	25
Normal Earth Work	21	25
Concrete Works	25	25
Gouting Works	25	25
Tunnel Works	25	25

2) Work Volume

The work volume for construction of Khlong Ta Liu dam and Khlong San Sai dam is as follows;

Items of Works	Khlong Ta Liu Dam	Khlong San Sai Dam
Diversion Tunnel	5.4 m dia. circular shaped Length L = 660 m	-
Fill of Dam	4,701,000 cu.m	570,800 cu.m
Grouting	Length L = 32,500 m	-
Spillway Excavation	427,000 cu.m	180,000 cu.m
Spillway Concrete	24,000 cu.m	15,000 cu.m
Intake	Steel pressure pipe encased concrete 1,200 mm dia. Length 332 m	Steel pipe encased concrete 700 mm dia. Length 95 m

(2) Construction Method

1) Diversion Works

During the period of construction of dam and its appurtenance facilities, diversion structure is required to divert the flow and flood of the river for the purpose of the performing construction works at the damsite.

In case of Khlong Ta Liu dam, diversion tunnel is suitable judging from the damsite topographical condition. The construction of diversion tunnel should be carried out first and foremost. The full face excavation method will be employed because the tunnel section is as small as about 35.8 sq.m.

Motor grouting should be injected after finishing concrete works.

After the completion of diversion tunnel works, the coffer dam should be constructed at the upstream of dam.

In case of Khlong San Sai dam, diversion channel method is most suitable because of wide topographical condition having long crest length of about 990 m.

2) Excavation Works

After finishing the construction of diversion works, excavation works are commenced at the dam foundation, the foundation of structures, borrow area and quarry site etc.

Excavation works are categoriged as follows:

i) Stripping and Common Excavation

Main machinery used for stripping and common excavation works is as follows;

Excavation	:	32 ton Bulldozer
Loading	:	3.3 cu.m Tractor Shovel or 3.3 cu.m Wheel Loader
Hauling	:	15 ton Dump Truck

ii) Rock Excavation

Main machinery used for rock excavation is as follows;

Excavation	:	Blast (bench cut method)
Gathering	:	3.2 ton Bulldozer
Loading	:	3.3 cu.m Wheel Loader
Hauling	:	20 ton Dump Truck

3) Fill Works

After completion of the stripping, common and rock excavation and required foundation treatment works, the fill works are commenced at zones of impervious, filter, semi-pervious and pervious by proper equipments with adequate method.

The quantities of fill materials for each zone are as follows:

(unit: cu.m)

Fill Zone	Khlong Ta Liu Dam	Khlong San Sai Dam
Impervious	887,000	574,000
Filter & Drain	395,000	34,000
Semi-pervious	1,598,000	-
Pervious	1,821,000	-
Riprap	-	17,500
Filter for Riprap	-	5,300
Total	4,701,000	570,800

The utilization plan of fill materials in each zone is as follow:

Material	Khlong Ta Liu Dam	Khlong San Sai Dam
Impervious	Borrow area	Borrow area
Filter & Drain	Sand & gravel layer formed by river	Same place as Khlong Ta Liu dam
Semi-pervious	Quarry site Spillway	-
Pervious	Quarry site Spillway Tunnel	-
Riprap	-	Purchase
Filter for Riprap	-	Purchase

In the Feasibility Study stage, the compaction manner of fill materials is planned tentatively as shown below; however, the actual compaction method in the implementation stage should be decided after performing the rolled embankment test.

Compaction Manners

Fill Zone	Thickness of Spread (cm)	No. of Pass	Compaction Machinery
Impervious	20	8	10 ton Tamping Roller with vibrator
Filter & Drain	30	5	10 ton Flat Roller with vibrator
Semi-pervious	40	5	- ditto -
Pervious	100	5	- ditto -

4) Concrete Works

The total concrete volume in concrete works becomes about 37,000 cu.m for Khlong Ta Liu dam and about 15,700 cu.m for Khlong San Sai dam including all concrete structures such as diversion tunnel, spillway and intake facilities etc.

Fresh concrete is batched and mixed at batching plant installing two mixers, each having a capacity of 0.75 cu.m. The capacity of the plant is planned to be 26 cu.m/hr (0.75 x 2 x 20 batches x 85%).

5) Foundation Treatment

After the completion of core trench excavation of dam, grouting works is commenced along core trench. Drilling of grout holes and injection should be done from top of remained 1.0 m on the design core trench elevation. Foundation treatment is carried out by blanket grouting, supplementary curtain grouting and main curtain grouting. Injection is done by stage method.

(3) Construction Schedule

Construction schedules about Khlong Ta Liu dam and Khlong San Sai dam are determined in consideration of machinery combination based on quantities of earth works and concrete works.

Each construction schedule is shown in Figure 6-3.

5.2. Main Conveyance Pipeline Systems

5.2.1. General Concept

The major irrigation scheme to be proposed by the Project is to store wet-season runoff in reservoirs to be constructed upstream, and to utilize storage for irrigation mainly for orchard during dry season. It is also essential to utilize available river runoffs most effectively, and in consideration of efficient use of existing small irrigation facilities installed along the river courses, it is the most important to determine the type and scale of facilities for water sources as well as for terminal irrigation from the operational and economic point of view.

Spray irrigation systems represented by a mini-sprinkler system for orchard and a drip or trickle irrigation with fixed pipes for pepper are predominant in the area. These irrigation methods of water-saving type have been taken root with improvement of sprinkler heads in the area, and no reverse effect is reported. These method will therefore be major even in future.

Considerations to be made for plan and design of irrigation facility are as follows:

- Guarantee of stable water source:
  Development of storage type water source of stable and low cost is required for irrigation in dry season.
- Efficient use of existing facility:
  Existing on-farm irrigation facilities are to be utilized most efficiently. Moreover, natural river channels are utilized as water conveyance facility.
- Easy operation and maintenance of facility:
  Simple, easy and convenient operation and maintenance is essential for successful achievement of the Project target.

- Regulating function within irrigation system:
  Major irrigation facilities are storage dam, existing river and tributary as conveyance facility, main irrigation canal or pipe, and pump. The need to control the rate and duration at the point of application is important to obtain high irrigation efficiency. For surface methods, large facility sizes reduce the application time and labor requirements. For the Project, however, it is essential to minimize the scale of facility. In consideration of the most effective use of available river runoff and project economy, flow capacities are determined in principle to be a 24-hour discharge. In the terminal site of irrigation, however, operations are made during daytime or 12 hours. The existing available capacity of farmpond is therefore useful to expect in-field controls responsive to flow volumes, head, duration, etc., to apply desired irrigation.

- Selection of rational conveyance system:
  Closed pipeline systems are considered to be most advantageous as delivery systems to connect terminal facility and water source or pump facility, in consideration of easiness for operation and maintenance, compensation, economized size and structure in response to topographic condition, prevention of obstacles flowing into conveyance and distribution systems, and others.

- Project economy:
  The proposed systems are to be economically feasible considering not only initial investment but also operation and maintenance costs.

- Design and construction standard:
  The proposed systems are to be suitable in view of local and standard conditions for design and construction.

All of technical and other aspects as mentioned above are combined to recommend the most suitable conveyance systems of irrigation water required for the subject Project.

5.2.2. Irrigation Scheme

Excluding the rubber plantation area of 1,407 ha situated in the Upper zone, 2,990 ha and 12,830 ha commanded by NEA's Pump Irrigation and Khlong Thung Pen Projects, both located in the Middle Right zone, the proposed land use plans are summarized as follows:

Proposed Area for Irrigation

(unit: ha)

Crop and Water Source	Proposed Storage Dam		Total
	Khlong Ta Liu	Khlong San Sai	
Orchard Irrigation	12,643.6	2,224.8	14,868.4
- River water	3,126.3	1,632.7	4,759.0
- Pond Water	9,517.3	592.1	10,109.4
Second Crop Irrigation	53.5	8.4	61.9
- River Water	40.0	8.4	48.4
- Pond Water	13.5	-	13.5
Total	12,697.1	2,233.2	14,930.3
- River Water	3,166.3	1,641.1	4,807.4
- Pond Water	9,530.8	592.1	10,122.9

Design irrigation discharges during the peak period of irrigation in January are as follows:

Design Irrigation Discharges

Water Source	Orchard		Second Crop	
	Area (ha)	Discharge (cu.m/s)	Area (ha)	Discharge (cu.m/s)
Khlong Ta Liu Dam	12,643.6	3.793	53.5	0.042
Khlong San Sai Dam	2,224.8	0.667	8.4	0.007
Total	14,868.4	4.460	61.9	0.049

Storage reservoirs to be proposed to meet the above requirements are the Khlong Ta Liu dam (No.4 site) and the Khlong San Sai dam (No.5 site), respectively with effective storage capacities of 33.0 and 9.3 MCM. From the schematic diagram of irrigation water distribution as previously shown in Figure 4-3, the beneficial areas by type of irrigation system is accumulated as under:

Irrigation System (Facility)	Area (ha)
Main Conveyance System	11,604.1
Direct Lifting up by Farmer's Pump	2,405.9
Lifting by Unified Pump (Upper)	617.5
-do- (Lower)	302.8
Total	14,930.3