TABLE 4-1 POPULATION AND HOUSEHOLD IN THE STUDY AREA

Plan A-1 (Left and Right Bank Areas)

Name of Tambon	Area (sq.km)	No. of Village	Population	No. of Household	No.of Farm Household	Family Size (Pn/hh 1/)	Population Density (Pn/sq.km)
1) Left Bank Areas							
Amphoe Det Udom							
D-1 Muang Det	3.7	0	0	0	0	1.1	0
D-5 Som Sa-at	14.1	2	1,569	260	260	6.0	111.3
D-8 Kaeng	68.9	10	6,287	1,071	1,065	5.9	91.2
D-11 Top Hu	67.8	10	7,709	1,345	1,276	5.7	113.7
D-12 Tha Pho Si	23.4	3	773	136	103	5.7	33.0
D-15 Na Khasem	2.1	0	0	0	0	0.0	0.0
D-18 Kut Rua	1.2	0	0	0	0	0.0	0.0
Sub Total	181.2	25	16,338	2,812	2,704	5.8	90.2
Amphoe Nam Yun							
Y-3 Yang	5.4	1	520	88	85	5.9	96.3
Sub-Total	5.4	1	520	88	85	5.9	96.3
Amphoe Na Chaluai							
N-2 Non Sawan	1.5	0	0	0	0	0.0	0.0
Sub-Total	1.5	0	0	0	0	0.0	0.0
Total	188.1	26	16,858	2,900	2,789	5.8	89.6
2) Right Bank Area							
Amphoe Det Udom							
D-6 Kut Prathai	91.5	10	6,517	1,085	1,051	6.0	71.2
D-7 Klnag	87.2	8	4,500	764	701	5.9	51.6
D-10 Na Yia	39.7	3	5,101	634	616	8.0	128.5
D-12 Tha Pho Si	6.6	1	485	86	80	5.6	73.5
D-14 Bua Ngam	43.4	6	2,674	485	468	5.5	61.6
D-16 Kham Khrang	61.3	7	3,903	723	509	5.4	63.7
D-19 Phon Ngam	37.2	7	6,157	1,138	1,089	5.4	165.5
Sub-Total	366.9	42	29,337	4,915	4,514	6.0	80.0
Total	366.9	42	29,337	4,915	4,514	6.0	80.0
Grand Total	555.0	68	46,195	7,815	7,303	5.9	83.2

Plan B-1 (Righ Bank Area)

Name of Tambon	Area (sq.km)	No. of Village	Population	No. of Household	No.of Farm Household	Family Size (Pn/hh)	Population Density (Pn/sq.km)
Amphoe Det udom							
D-1 Muang Det	3.7	0	0	0	0	0.0	0.0
D-5 Som Sa-at	0.0	0	0	0	0	0.0	0.0
D-6 Kut Prathai	101.5	10	6,517	1,085	1,051	6.0	64.2
D-7 Klang	97.2	8	4,500	764	701	5.9	46.3
D-8 Kaeng	0.0	0	0	0	0	0.0	0.0
D-10 Na Yia	48.8	3	5,101	634	616	8.0	104.5
D-11 Top Hu	0.0	0	0	0	0	0.0	0.0
D-12 Tha Pho Si	6.6	1	485	86	80	5.6	73.5
D-14 Bua Ngam	47.3	6	2,674	485	468	5.5	56.5
D-15 Na Khasem	0.0	0	0	0	0	0.0	0.0
D-16 Kham Khrang	61.3	7	3,903	723	509	5.4	63.7
D-18 Kut Rua	0.0	0	0	0	0	0.0	0.0
D-19 Phon Ngam	37.2	7	6,157	1,138	1,089	5.4	165.5
Sub Total	403.6	42	29,337	4,915	4,514	6.0	72.7
Amphoe Phibun Mangsa han							
P-2 Rai Tai	54.7	11	6,444	1,078	925	6.0	117.8
P-3 Na Pho	70.6	4	4,254	775	662	5.5	60.3
Sub-Total	125.3	15	10,698	1,853	1,587	5.8	85.4
Grand Total	528.9	57	40,035	6,768	6,101	5.9	75.7

Data Source : Provincial Statistical Office, 1/ hh : person per household

Labor Requirement for Whole Crops (Wet and Dry Season)

(unit: %)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec..
Family	3.41	2.85	3.24	5.70	8.02	60.21	79.78	19.84	15.22	48.20	84.71	12.02
Hired	-	0.27	-	0.22	1.24	2.09	3.01	2.19	0.43	4.16	8.25	0.74
Total	3.41	3.12	3.24	5.92	9.26	62.30	82.79	22.03	15.65	52.36	92.96	12.76

Data Source: Farm survey conducted by JICA Study Team

Labor Requirement for Paddy (Wet Season)

(unit: %)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Family	0.93	0.05	-	-	3.25	55.70	77.69	16.42	9.17	32.26	82.93	11.31
Hired	-	-	-	-	-	2.03	2.70	0.57	-	1.94	7.79	0.75
Total	0.93	0.05	-	-	3.25	57.73	80.39	16.99	9.17	34.20	90.72	12.06
Animal	-	-	-	-	3.35	17.80	21.39	5.17	1.03	-	-	-

Data Source: Farm survey conducted by JICA Study Team

4. 3. 4 Farm Size, Farming Pattern and Land Tenure

Farming in the Study Area is characterized by rainfed agriculture in the Northeast region which dominates wet season paddy cultivation and traditional crops such as cassava and kenaf. Groundnut cultivation can be seen in small patches within the area. For domestic consumption, vegetables are cultivated in the small area of house gardens and/or village surroundings. On the other hand, farming in the dry season is under difficult conditions due to lack of irrigation water for agriculture.

1) Farm Size

According to the farm survey, the average farm size in the Study Area is shown as follows;

- Right bank of area : Upper area 4.62 ha (28.9 rai)
  Lower area 4.58 ha (28.6 rai)
- Left bank of area : 4.70 ha (29.4 rai)

2) Farming Pattern

According to the farm survey, the farm households in the Study Area can be classified into upper-area on the right bank, lower area on the right and left banks. The crop grown in these areas is represented by paddy, cassava, kenaf and some dry season crops. The farming pattern is as follows:

Upper Area in Right Bank of the Lam Dom Yai

- Average cultivated area : 4.62 ha (28.9 rai)
  - Paddy field : 4.51 ha
  - Upland field : 0.11 ha
- Average planted area : 4.62 ha (28.9 rai)
- Cropping pattern : Single cropping (wet season)

Crop	Planted Area (ha)	Yield (kg/ha)	Production (kg)
Paddy	4.51	1,400	6,314
Kenaf	0.11	906	100
Total	4.62	Cropping intensity	100%

Lower Area in Right Bank of the Lam Dom Yai

- Average cultivated area : 4.57 ha (28.6 rai)
  - Paddy field : 4.29 ha
  - Upland field : 0.28 ha
- Average planted area : 4.60 ha
- Cropping pattern : Single cropping (wet and a part of dry season)

Crop	Planted Area (ha)	Yield (kg/ha)	Production (kg)
[Wet season]			
Paddy	4.29	1,219	5,230
Cassava (Dry)	0.04	0	0
Kenaf	0.20	1,050	210
Jute	0.04	1,288	52
Sub-total	4.57	-	-
[Dry season]			
Groundnut	0.01	1,606	16
Soybean	0.01	0	0
Cucumber	0.01	20,831	208
Sub-total	0.03	-	-
Total	4.60	Cropping intensity	101 %

Left Bank of the Lam Dom Yai

- Average cultivated area : 4.70 ha (29.4 rai)
  - Paddy field : 3.85 ha
  - Upland field : 0.85 ha
- Average planted area : 4.70 ha (29.4 rai)
- Cropping pattern : Single cropping (wet season)

Crop	Planted Area (ha)	Yield (kg/ha)	Production (kg)
Paddy	3.85	1,673	6,441
Cassava (Dry)	0.23	6,250	1,440
Kenaf	0.62	1,750	1,085
Total	4.70	Cropping intensity	100%

3) Land Tenure

The land tenure in a part of the upstream area on the right bank, Amphoe Det Udom, along the Dom Yai River is already changed to N.S.2 (see next table "Land Tenure Conditions in the Area"), because of the implementation of an agricultural land reform project, but over 60 percent of the land is occupied and provided with land certificate N.S.3 and N.S.3 K, also, at downstream area the land registration has been relatively completed. In addition, the land which has only cultivation and dwelling rights on the left bank accounts for 47 percent, and three percent of the land has Title Deed.

From the results of the farm survey, it can be seen that most farmers are owners. Few households in the villages own no land. Farm workers from these households work as farm laboures on other farms. Actual conditions of land tenure obtained by the farm survey are as follows:

Land Tenure Conditions in the Area

(unit: %)

Type of Land Title Document	Right Bank		Left Bank
	Upstream Area	Downstream Area	
Title Deed 1/	-	-	3.3
N. S. 3 K.	35.9	36.7	21.7
N. S. 3	31.3	26.8	27.8
N. S. 2 (ARLO)	-	-	-
S. K. 1	4.2	5.2	1.2
P. B. T. 6	27.6	20.4	41.9
S. T. K	-	-	-
No Certificate	1.0	10.9	4.1
Total	100	100.0	100.0

Data Source: Farm survey conducted by JICA Study Team

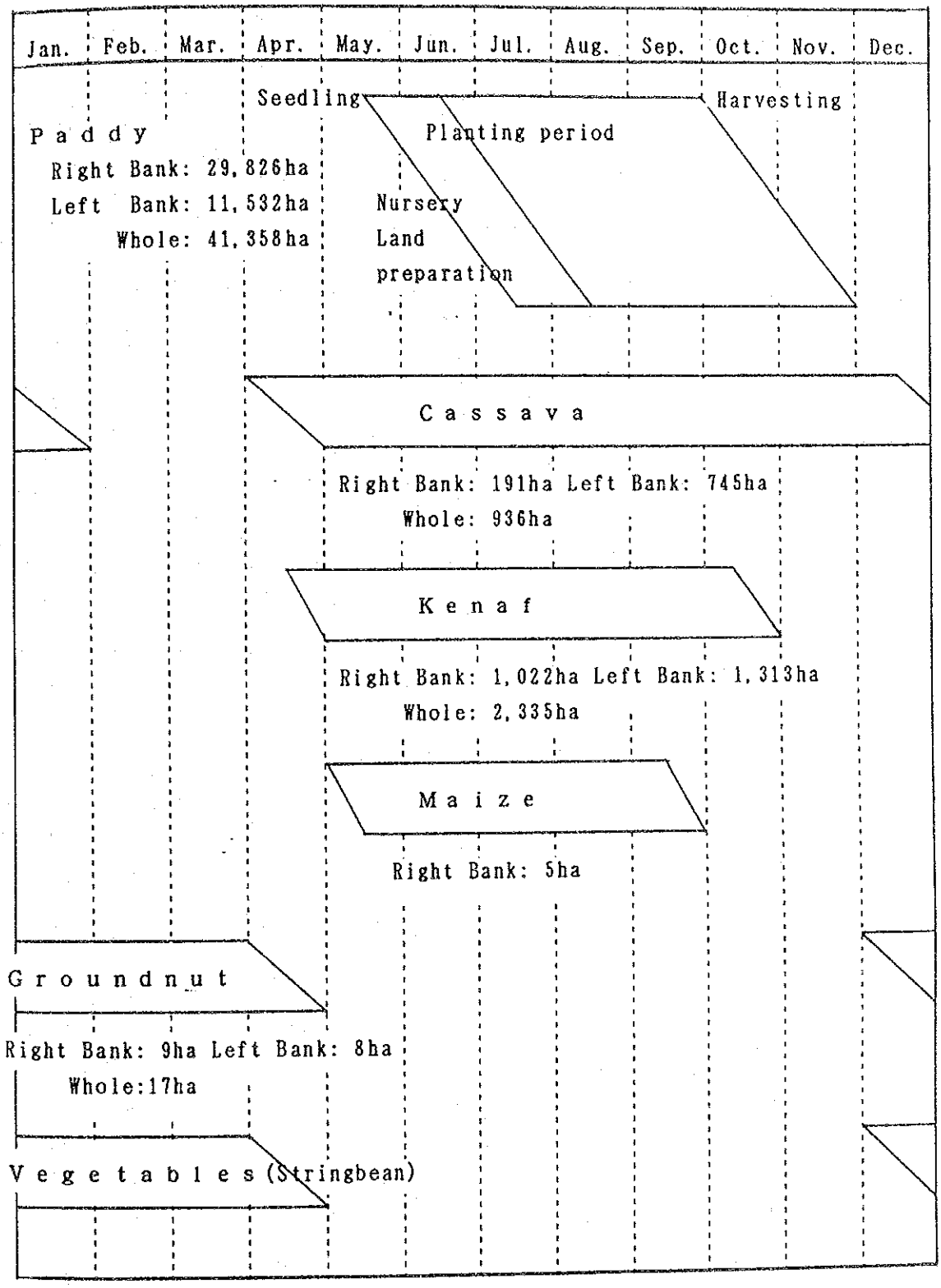
1/ Title Deed : Those possessing a complete land rights certificate.
N.S.3K : Those with land rights usable for transaction. (whose land has already been surveyed)
N.S.3 : Those with a land rights usable for transaction. (whose land has only been confirmed in aerophoto)
N.S.2 : Those with a only cultivation and dwelling rights (whose land is located where land reform has been carried out)
S.K.1 : Those is able to have only cultivation and dwelling (who is obtainable when it is 10 to 15 years after illegal instruction, and the good second generation only is able to apply for N.S.3 in his/her generation)
P.B.T.6 : Those with only cultivation and dwelling rights unusable for Transaction.
S.T.K : Those with only cultivation and dwelling rights incapable of dealing with.
No certificate: Illegal farmer

According to the land tenure survey, the land registration of the submerged area in the upstream area belonging to the ALRO's Land Reform Project, located on the right bank of the Dom Yai river, has already been certificated N.S.2 (ALRO) in 1991.

4. 3. 5 Agricultural Production

The present cropping patterns in the Study Area are shown in Figure 4-1. The total planted area at present is 13,991 ha (87.4 thousand rai) and 31,349 ha (195.9 thousand rai) respectively for left and right bank areas, in which wet season paddy cultivation prevails. A little second paddy (dry season) can also be seen along the small stream. Almost all the areas are paddy and of a typical single crop fed by rain. The proportion of each crop to the total planted area is as follows;

FIGURE 4-1 PRESENT CROPPING PATTERN



Crop	Left Bank Area (%)	Right Bank Area (%)
Paddy	83.5	95.1
Upland Crop	15.5	4.1
Fruit	1.0	0.8

Vegetables such as stringbean, chilli, onion, corn and etc. are cultivated for home consumption of farmers. For fruit trees, the left bank area has mainly mango and the upper right bank area has mango and coconut. Other fruits such as tamarind and sugar-apple are observed in only some Tambon.

Watermelon cultivation is observed in some areas where irrigation water is available, though this is not included in statistical data. Watermelon is superior as a cash crop, and it has high adaptability to sandy soil and drought resistance. Actually, in Lam Dom Noi Irrigation Project adjoining the Study Area, its cultivated area increased 2.4 time i.e., 380 to 890 ha, in five years from 1984/85. During the fieldwork, interviews with production farmers were carried out. Watermelon is presently grown in the rainfed fields of 0.3 to 1.0 ha. These farmers can get yields of 21,000 to 24,000 kg/ha through watering from small ponds, introducing improved varieties, management practices and selection of fruit. With enough furrow irrigation, stabilized production can be expected.

Present Planted Area

Crop	Left Bank Area (ha)	Right Bank Area (ha)	Total
Paddy (Wet Season)	11,532	29,826	41,358
Non-glutinous	5,305	12,780	18,085
Glutinous	6,227	17,046	23,273
Paddy (Dry season)	176	9	185
Upland Crops	2,124	1,235	3,359
Cassava	745	191	936
Kenaf	1,313	1,022	2,335
Maize	-	5	5
Groundnut	8	9	17
Others	58	8	66
Fruit Trees	136	238	374
Mango	75	71	146
Coconut	15	59	74
Others	46	108	154
Vegetable	23	41	64
Total	13,991	31,349	45,340

Data source: National Statistical Office (NSO) 1991

The paddy fields are rainfed, and the productivity of crops is extremely low because of low-fertility sandy soil. Cropping in the dry season from November to April is impossible in the field where the irrigation water can not be obtained. To promote the improvement of productivity and the crop diversification, water resource development is indispensable. The production amount and yield per hectare of each major crop are shown below.

Production and Yield of Major Crops

Crop	Average Yield (kg/ha)	Left Bank Area (ton)	Right Bank Area (ton)
Paddy (Wet Season)	1,250	14,400	37,300
Non-glutinous	1,277	6,800	16,300
Glutinous	1,233	7,600	21,000
Paddy (Dry Season)	3,219	570	29
Upland Crops			
Cassava (dry)	5,629	4,200	1,080
Kenaf	1,431	1,900	1,460
Maize	2,919	-	15
Groundnut	1,312	10	12

Data source: National Statistical Office (NSO) 1988 & 1991

- Farming Practices

1) Paddy Variety

During the field work in Phase II study, interviews with extension workers on farming practices were carried out. The proportions of present paddy usage are as follows;

Khao Dawk Mali 105 (LIV: Non-glutinous)	46.8%
RD 6 (HYV: Glutinous)	30.6
Others (RD 15 & Local Variety)	22.6

Note: LIV : Local improved variety
HYV : High yielding variety

The HYV is a photosensitive, late maturing variety of rice represented by RD 6. The Khao Dawk Mali 105 of LIV is also a photosensitive, late maturing variety. The latter crop has high marketability owing to its improved taste, though the yield is low.

2) Utilization of Farming Inputs

In recent year, the use of chemical fertilizers has been gradually increased. According to the farm survey, the farmers in the area make use of 98 kg mixed fertilizer per hectare for paddy, and 154 kg/ha for cassava and 129 kg/ha for kenaf. As pesticide the small amount, 17.2 percent of the planted area for paddy, is applied.

3) Manpower

The annual labor requirement for farming is 358.6 man-days in total. The family labor force and hired labor force are estimated at 336.4 man-days and 22.2 man-days, respectively. As described in the paragraph of 4.3.3, the labor requirement in the area shows remarkable fluctuation according to the season. Presently, the labor balance is tightness on land preparation and transplanting periods from June to July and harvesting in November. In this period, family labor is fully employed, and therefore, the hired labor is employed to make up the deficit. However, because of the unstabilized rainfed farming, the replacement of labor by farm mechanization has not advanced very far even for intensive work.

4) Animal Labor Power

In general, 2.13 head of buffalo per household are utilized for labor power. The annual labor requirement for draft animals is estimated at 3.18 head and 47.78 head for land preparation for nursery bed and paddy fields, respectively. In addition, 1.62 head of animal labor is required for upland crops during the wet season and 1.64 head during the dry season.

5) Agricultural Machinery

The annual machinery utilization for paddy cultivation is estimated at 8.46 hours per farm. Land preparation for nursery beds and paddy fields, watering and other operations are estimated at 0.26, 1.85 and 2.38 and 3.97 hours, respectively. Other wet season crops (sweet corn, cassava and kenaf etc.) utilize 2.17 hours including 1.39 hours for land preparation.

4.3.6 Animal Husbandry

Animal husbandry in the Study Area is comprised of cattle, buffalo, swine, chickens and ducks. The Provincial Livestock Office in Ubon Ratchathani is pushing hard for the planning and promotion of animal husbandry, but the raising conditions in the area are harsh. The numbers of livestock in the area is as follows:

Livestock in the Study Area

Livestock	Left Bank Area	Right Bank Area	Total
Cattle	1,491	2,608	4,099
Buffalo	6,562	16,928	23,490
Swine	953	2,240	26,683
Chicken	28,093	68,613	96,706
Duck	7,058	19,605	26,663

For the raising farms, buffalo and cattle are owned for both property and labor force. In the left and right bank areas, an average raising buffalo and cattle per farm household is about 3.2 and 3.1 head, respectively. Currently, 50 percent of farming depends on buffaloes and/or cattle energy. The replacement of animal power by farm mechanization cannot be said to be sufficient.

1) Cattle/Buffalo

a) Feed and Water

Buffaloes and/or cattle are raised on pasturage. Owing to the small intake of the pulse family as pasture, compared with the total amount of digestible nutrition (TDN), the digestible crude protein (DCP) intake standard is extremely low. In addition, water shortages in the dry season cause decreases in the feed intake by insufficient water intake.

b) Causes of Impediment to Breeding

Natural conditions of high temperature and high humidity in the area are the main causes for the lower feed intake and low productivity. In the tropical zone, there are numerous parasites and diseases, in addition to malnutrition of livestock. These causes produce serious damage to livestock.

Harmful insects, such as the sting fly, scabies tick, gnat, mosquito, horsefly, cattle bloodsucking fly damage directly or indirectly through transmission of infectious diseases.

2) Swine

Swine-raising in the area is generally practiced in the house garden and they are fattened on leftover food. It takes about one year to increase the weight 40 to 50 kg per head. Productivity is extremely low compared with modern swinery. For this reason, introduction of improved breeds and improvement of feedstuff with the aim of increasing productivity is required.

3) Poultry

In the Study Area, Chickens (1 to 20 chickens) are fed in the home garden. For farmers, chickens as easy-to-obtain animal food and sources of cash income are staple domestic fowl.

4.3.7 Inland Fisheries

Inland fisheries in the Study Area depend on freshwater fish in the river, swamp, pond and flooded area. In these circumstances, detailed data on the fish culture at present are incomplete. According to the 1988 statistics of the Department of Fisheries (DOF), the fish pond production and paddy fields together are estimated at 39 ton and 49 ton respectively, in Amphoe Det Udom and Phibun Mangsahan, which includes the Study Area. This amount entails the consumption per capita of only 0.5 kg in a family.

According to interviews with extension workers in the area, Telapia, cat fish, local carp, common carp and so on are the main species for freshwater fish. Rice bran and animal dung are used as feed for fish culture. Freshwater fish are staple protein for farmer. To improve the present situation, the following projects are being operated by the Freshwater Fishery Promotion Center since 1991.

i) Freshwater Fish Promotion Project : Det Udom & Phibun Mangsahan 4 places (32 ha)

ii) Freshwater Fishery Development Project : Det Udom 40 farms

4. 3. 8 Marketing of Agricultural Crops

Most agricultural products including paddy rice produced in the area are shipped and dealt with directly middlemen. On the other hand, surrounding farmers of rice mill sell paddy to the rice mills.

1) Rice

Paddy produced in the area is shipped to large-scale rice millers in Saraburi, Surin and Bangkok and its outskirts, after collocation from farms by rice millers, middlemen of Tambon Muang Det, Amphoe Det Udom where an important role as the marketing center is performed for farm products in the southern part of Ubon Ratchathani Province, and middlemen scattered along the national route 2171 which links Tambon Muang Det with Amphoe Nam Yun. Besides, in the villages, some farmers deal with village marchants and individual transporters as small-scale traders.

Merchant (middleman) : Tambon Muang Det .. 12 merchants
Along the 2171 ..... 8 merchants

On the other hand, there are three large rice mills in Tambon Muang Det. A rice mill has a milling capacity of 100 ton/day, but their work rate is about 60 percent at present. These rice mills deal with middleman and buy rice from farmers directly. 90 percent of rice milled by them is shipped to rice brokers in Bangkok who survey daily market prices in the Bangkok and international markets, and over to exporters. The rest (10 percent) is sent to and consumed within Ubon Ratchathani Province. Market prices in Bangkok show high prices from July to September, every year. The quantity of rice shipment for Bangkok from rice mills in Tambon Muang Det, Amphoe Det Udom in 1990/91 was about 4,000 tons.

2) Upland Crops

Cassava, kenaf and groundnuts produced in the area are collected directly from farms by middleman who conduct transaction through market channels.

Cassava	:	it is mainly shipped to a large tapioca factory in Nakhon Ratchasima, and the rest is shipped to factories in Chon Buri and Chachoengsao.
Kenaf	:	it is shipped to a large jute factory in Nakhon Ratchasima.
Groundnuts	:	it is shipped to two small processing factories (exshelling and selecting) in Tambon Muang (urban), Ubon Ratchathani.

In the case of cassava and kenaf, the factories adjoining the Study Area also buy them directly from farms.

4. 3. 9 Agricultural Supporting Services

Agricultural supporting services in the Study Area are conducted by i) Agricultural Extension Offices established in each Amphoe, ii) Ubon Freshwater Fishery Promotion Center and Ubon Office, iii) Marketing Organization for Farmers (MOF) in Tambon Muang (urban), Ubon Ratchathani Province and Det Udom Office, iv) The Bank for Agriculture and Agricultural Cooperatives (BAAC) in Tambon Muang Det, Amphoe Det Udom. In addition, there are two agricultural cooperatives in the area.

1) Agricultural Extension Services

The agricultural extension activities in the Study Area are conducted through Agricultural Extension Offices in each Amphoe. In these extension offices, an extension worker is assigned for each Tambon. As a lower branch of these offices, the Agricultural Center is established and has an individual village-based extension agent as volunteer. The activities are carried out based on the National Agricultural Extension Project (NAEP) concept. However, the activities are presently limited and inadequate.

2) Marketing Support

The MOF and BAAC carry out marketing support for farmers. The supporting activities by the MOF are mainly selling fertilizer to farmers at low prices. The BAAC assists the producing farmer with specific promotion crops in agricultural financing and marketing, and coordinates between farmer and private company. The producing farmers of cashew nuts in the area are assisted and supported by Muang Det District Branch, BAAC.

3) Freshwater Fishery Promotion

In the Study Area, Ubon Freshwater Fishery Promotion Center, Department of Fisheries, is conducting the production and distribution of fry fish, and extension activities. In Amphoe Det Udom and Phibun Mangsahan, the Freshwater Fish Production Promotion Project is aiming at an increase in freshwater fish production by improvement of water quality, and the Freshwater Fishery Development Project as a pilot project are being conducted from last year (1991).

4) Agricultural Credit

For a member of BAAC's Client Group organized in each village of the area, Muang Det District Branch, BAAC, carries out the agricultural financing services. In Amphoe Det Udom occupying a large area within the Study Area, 173 groups are organized with 2,058 members. The total amount of loans (FY 1990) for annual crops which commands the majority of loans was 30,525,300 Baht (72 percent of the total loan). On the other hand, BAAC assists the cooperatives' members in agricultural financing through agricultural cooperatives.

5) Agricultural Cooperatives

Established agricultural cooperatives exist in each Amphoe and the Lam Dom Yai Agricultural Cooperatives in Amphoe Det Udom. The main activities of these cooperatives are selling agricultural inputs and agricultural financing for members.

4. 3. 10 Farm Household Economy

As the result of the farm survey conducted during Phase II study, the farm household economies in the upper and lower areas located on the right and left banks of the Lam Dom Yai river have been roughly analyzed. The results are shown below;

Present Farm Household Economy in the Study Area

(unit: Baht)

Item	Left Bank Area	Right Bank Area	
		Upper Area	Lower Area
Cropping Area	4.70 ha (29.40 rai)	4.62 ha (28.88 rai)	5.20 ha (28.60 rai)
Farm Income	32,072	23,037	23,621
Off-farm Income	8,002	12,934	10,266
Gross Income	40,074	35,971	33,887
Expenditure			
Production Cost	7,123	7,142	5,577
Living Expense	24,000	18,856	17,259
Sub-total	31,123	25,998	22,835
Surplus of Farm Household Economy	8,951	10,692	11,051
Family Labor	16,740	9,973	12,095
Surplus of Farm Household Economy (including family labor)	-7,192	-2,806	-1,044

Note : Farm household economy is the average of each area in the Project Area.
Data Source: Farm Survey

According to the results mentioned above, it is clear that the farm household economy in each area in the Study Area is supported by family labor. Off-farm income is mainly obtained from off-farm works in and around the village, and accounts for 20 to 36 percent of the gross income. The gross income per capita is estimated at 6,480 Baht on the right bank, but 5,867 in the left bank is lower than that of the right bank. Also, the income in the area falls below the gross income per capita (6,798 Baht) in Northeast Thailand, estimated by OAE. The gross income per capita in the Whole Kingdom is estimated at 35,574 Baht.

CHAPTER V. DEVELOPMENT PLAN

CHAPTER V. DEVELOPMENT PLAN

5.1 Objectives and Components Of the Project

5.1.1 Objectives of the Project

As described in the Overall Basin Study, the following factors impeding development in the Lam Dom Yai basin and cause serious poverty are as follows;

Irrigation water shortage

- The rainfall concentrate in the wet season, while little rainfall concentrate in the dry season, thus the cropping rate in the dry season is extremely low value.
- Due to flat topography, only a few dam-sites are formed, therefore stable irrigation water supply can not be confirmed. Consequently, almost all the agricultural land has been fed by rain, resulting in low agricultural productivity.
- As the alluvial aquifers in the area have a low yield, groundwater can seldom be used as irrigation water.
- The upper-basin of the Lam Don Yai is prohibited for entry as it is on the national defense boundary. Since the medium and small-scale reservoirs have been functioning firstly for the national boundary defense and secondly for irrigation, the water can not be released from them, such that only a limited area can be irrigated.

Deteriorated soil conditions

- Consisting mostly of sandy soil, the agricultural land has low field capacity with low organic matter content and low fertility, resulting in low productivity of crops.

In balance of farming crop disproportion and undeveloped marketing

- The main crop is wet season paddy which occupies 85 percent of the entire cropping area.

- From the viewpoint of agro-product marketing, the introduction of a new crop is not interesting for the local people because of traditional habits and customs and from lack of knowledge.

- Agro-product marketing has been undeveloped, because the area is far from metropolitan area.

Others

- Illegal land opening by reckless tree-felling grown mostly in the national forest, bring about disordered forest destruction and environmental deterioration.

Accordingly, the objectives of the overall irrigated agricultural development plan in the Lam Dom Yai basin are to establish the development plan mentioned below, in order to remove the above-stated factors impeding development, and to improve the existing conditions.

- Since almost all agricultural land in the area has been fed by rain, the water resources development plan in the Lam Don Yai basin should be established so as to introduce irrigated agricultural in the river basin as far as possible.

- More than 90 percent of annual rainfall in the basin concentrating in the wet season, the river run-off at this time is remarkably large amount, as much water resources facilities as possible should be set up in order to utilize the river run-off in the wet season effectively.

- In the case of establishing a farming plan, the establishment of supplemental irrigation water supply for the paddy fields in the wet season should come foremost. An introduction plan for upland farming in the dry season using the remaining irrigation water should be formulated, and cropping pattern be established.

- For the area left under rainfed agriculture, a concrete improvement plan should be drawn up and be implemented.

- A concrete land utilization plan for forestry should be drawn up and implemented.

According to the above-mentioned development objectives, the development plan in the overall river basin was drawn up, a staged development plan for the primarily selected high priority projects was made,

and the D-28 reservoir project was finally selected as the top priority project for the Feasibility Study.

The main objectives of the agricultural development plan in the area selected area are to i) irrigate the benefited areas just downstream of the reservoir and downstream of Lam Som by the dam to be constructed on the middle-reaches of the Lam Dom Yai, pumping stations and irrigation canals, aiming at yield increases in paddy and others crops, ii) raise agricultural productivity and then iii) upgrade the living standards of the farmers in the area. In order to meet the requirements mentioned above, the following facility plan should be set up in the project;

- Dam construction:

  The benefited area is to be determined by the scale of dam (reservoir capacity). The said scale of dam will be determined by topography and geology, economy of construction works inclusive of compensation against submergence, and social environmental conditions.

- Resettlement of farmers to be submerged:

  As the proposed site for the resettlement of those farmers which will be submerged is the most important factor to determine success or failure of the project, ALRO (Agricultural Land Reform Office) project area located on the right bank of the La Dom Yai in the D-28 reservoir area, has been regarded.

  In case the irrigation network supplying irrigation water to the resettlement area is constructed as a part of the compensation aiming at intensive farming, there will be a distinct possibility that the irrigation network will become a model for the project areas in the future.

- Construction of pumping station:

  Considering the topography, geography, etc. and regarding canal network plans, such technical dimensions as location of pumping station, type of pump, pump head, pump facilities, number of required pump units will be need to be determined.

- Establishment of a canal networks:

  Since irrigation and drainage controls using a water resource and canal networks are required for raising land productivity, the basic plan of phased canal development in the Study Area should be set up.

By linking the D-28 reservoir with D-7 and D-24 reservoir, and forming D-7 + D-28 + D-24, the D-28 reservoir will receive water released from D-7 reservoir, and distribute it by way of D-24 reservoir to the benefited areas. Then a more effective irrigation plan can be achieved. This future plan, therefore, should be taken into consideration.

5. 1. 2 Components of the Project

The project components will be made with the following development concept to achieve the development objectives mentioned in the above.

1) Water Resources Development

Current crop cultivation in the Study Area has been relying upon unstable rainfall to result in low productivity in crop productivity. The existing water resources available in the area are limited only to those provided by RID, DLD, NEA, DOLA and ALRO, of which areas are estimated at about 850 ha (5.3 thousand rai), equivalent to only 1.2 percent of Project Area of 71,700 ha (448.1 thousand rai).

Accordingly, water resource development by means of an adequate storage reservoir is essential for the project. For this purpose, the D-28 storage dam for water resource development should be constructed. Along with the dam construction, after a prudent and precise survey on the number and scale of farm households and paddy fields, etc. to be submerged, the resettlement plan should be established, and a model resettlement plot be planned in the Project Area.

2) Irrigation and Drainage Canal System Development

There is no irrigation and drainage canal systems except in above mentioned small areas. Therefore, new irrigation canal systems involving pumping station, irrigation and drainage canals should be newly provided for utilizing the stored water resources effectively. In addition, such on-farm facilities as farm ditches, farm drains and farm roads will be newly provided taking into account irrigation requirements and methods in the terminal farm area.

The distribution and management methods for irrigation water should also be established with the establishment of an adequate water management organization in the Project Area.

3) Introduction of Irrigated Agriculture

An irrigated agricultural plan should be established to include the following subjects;

- Suitable land-use plan and cropping pattern should be established to realize maximum utilization of water and land resources.
- An optimum farming practice plan considering farming mechanization should be formulated to increase the agricultural productivity and farmers' income. The increases in crop yields and cropping intensity in the dry season are planned by means of irrigation water supply and improved farming techniques. Namely, together with the establishment of wet season paddy farming through irrigation, the cropping pattern for upland crops during the dry season will be established and promoted.

4) Improvement of Agricultural Supporting Services

It is essential to strengthen the following agricultural extension services for the achievement of successful irrigated agricultural development in the Project Area and promotion of agricultural activities;

- Water User's Association with the participation of farmers should be organized with the support of related government agencies

concerned, in order to carry out the necessary operation and maintenance work for irrigation facilities. Adequate water distribution activities are to be improved and strengthened through the organization, and village ponds will be built in respective villages for contributing to rural development.

- Animal husbandry and inland fishery by reservoir and village ponds will be established to increase farming households' income.

5.2 Formulation of Optimum Project Scale

5.2.1 Delineation of Project Area

According to the Overall Basin Study on the Lam Dom Yai Basin Irrigation Project described in Part I, the Study Area for the project was delineated in the areas developed on both banks of the Dom Yai river, which seems to have potential for irrigation projects from the viewpoint of topographic, soil and available water resource conditions.

The following table indicates these delineated potential areas for the Feasibility Study.

Selected Potential Areas for Feasibility Study

Area	Left Bank Area (ha)	Right Bank Area (ha)	Total (ha)
Gross Area	18,810	52,890	71,700
Cultivable Area	14,400	35,920	50,320

5.2.2 Formulation of Alternative Plan

1) Proposed Cropping Intensity and Irrigation Demand

The following three cases of alternative cropping intensity in the case of proposed Type-I cropping pattern, to be described in paragraph 5.6 "Agricultural Development", were set up in order to analyze the relationship between cropping intensity in the dry season and the scale of wet season paddy.

The irrigation water requirement corresponding to the respective cropping intensity was calculated as shown below. Descriptions of irrigation water requirement are also given in paragraph 5.5, "Irrigation and Drainage Development Plan".

Alternative Cropping Intensity

Case	Wet Season	Dry Season	Total	Demand
(%)	(%)	(%)	(%)	(mm)
Case-1	100	10	110	277
Case-2	100	15	115	333
Case-3	100	25	125	388

Note: Wet season crop : Paddy
Perennial crop : Mango
Dry season crop : Groundnut, soybean watermelon, chilli, etc.

Through the monthly basis reservoir operation study and using the inflow discharge and irrigation water requirement, the following can be ascertained:

- The increase of dry season cropping area will have significant influence on the reduction of the wet season irrigable area in the designed year of return period 1/5-year, as shown in Figure G-1, Annex G. The following table indicates the relationship between irrigation areas and crop benefits with each cropping intensity.

Irrigation Area and Crop Benefits in Different Intensity

Description	110%	115%	120%
1. Irrigation Area (ha)			
Wet Season Paddy	42,760	32,750	26,770
Perennial Crop (Mango)	1,640	1,250	1,030
Dry Season Upland Crop	4,440	5,100	5,560
Total	48,840	39,100	33,360
2. Crop Benefit (million Baht)	300.3	234.7	195.9

As can be seen from the above table, the cropping pattern with low cropping intensity during the dry season will bring higher crop benefits than that of high cropping intensity. This fact will conform to the project policy of stabilizing the wet season paddy

cultivation with an equal distribution of supplemental irrigation water to as much of the area as possible.

- On the other hand, when crop diversification during the wet season is considered, which will be part of government policy for agricultural development in the country, a area of only 10 percent of crop diversification acreage seems to be a little small. However, judging from the prevailing conditions such as consumption of upland crops in and around the Project Area, present marketing and transportation systems, capacity of post harvest facilities, etc. it seems to be difficult to increase the cropping acreage of upland crops on a large scale.

- Under these situations, 115 percent of cropping intensity (100 percent in the wet season and 15 percent in the dry season, respectively) is planned for the project.

2) Dam and Reservoir Scale

The D-28 reservoir area and its capacity were estimated using RID and ALRO topographic maps of 1/10,000 in scale as shown below. It was indicated in Figure 6-6.

D-28 Reservoir Area and Capacity According to Water Level

Water Level	Water Surface Area	Reservoir Capacity (Gross)
(EL.m)	(sq.km)	(MCM)
125.7	0.00	0.00
132.0	0.79	2.49
134.0	5.67	8.95
136.0	14.59	29.21
137.0	19.10	48.62
138.0	24.24	68.04
139.0	34.84	97.58
140.0	43.27	136.63
141.0	50.00	180.00
142.0	63.17	243.07

Note: Dead storage capacity is 12.47 MCM at low water level at EL.134.35 m

The following three cases of alternative plans on dam and reservoir scale were set up considering, i) the present topographic conditions, ii) the overflow depth of water on spillway crest (h = 1.5, 2.0 and 2.5 m), and iii) land and household compensations to be caused by the dam's construction.

Alternative Reservoir Scale

Case	Overflow Depth of Water	Normal Water Level (NWL)
	(m)	(EL.m)
Case-1	h = 1.5	137.0 - 141.5
Case-2	h = 2.0	137.0 - 141.0
Case-3	h = 2.5	137.0 - 140.5

The studies on the optimum scale of D-28 reservoir for these alternative plans will be discussed hereinafter.

5. 2. 3 Reservoir Operation Study

1) Irrigable Area

The daily basis of reservoir operation studies in each reservoir size varying from normal water level of 137.0 m to 141.5 m were made for the period of 30 years from 1961 to 1990, in order to find out the optimum scale of project planning. As a result, it was revealed that the following areas could be irrigated at each water level, in case of a cropping intensity of 115 percent and a 1/5-year return period.

Irrigable Area at Various Water Levels

Normal Water Level (NWL)	Reservoir Capacity		Irrigable Area
	Gross	Effective	
(EL.m)	(sq.km)	(MCM)	(ha)
137.0	48.62	36.15	13,200
137.5	58.33	45.86	16,700
138.0	68.04	55.57	20,100
138.5	82.81	70.34	24,300
139.0	97.58	85.11	28,300
139.5	117.10	104.63	34,000
140.0	136.63	124.17	40,300
.	.	.	.
.	.	.	.
141.5 (max)	216.47	204.00	53,100

2) Scale of Compensation

The quantities of compensation for farm land and households by the construction of D-28 reservoir are estimated based on the ALRO topographic map (1/10,000 in scale), land use map, aerial-photograph and also on the field works. Figure 5-1 indicates the quantities of those compensations by each water level.

Following table shows one of the sample of submerged land in the village of Ban Fang Phe, Tambon Phon Sawan.

- No. of households : 112 households
- No. of people : 532 persons
- Area of land
  - Paddy field : 214.9 ha (1,343 rai)
  - Upland field : 12.3 ha (77 rai)
  - Forest : 4.6 ha (29 rai)
  - Others : 160.8 ha (1,005 rai)
  - Total : 392.6 ha (2,454 rai)

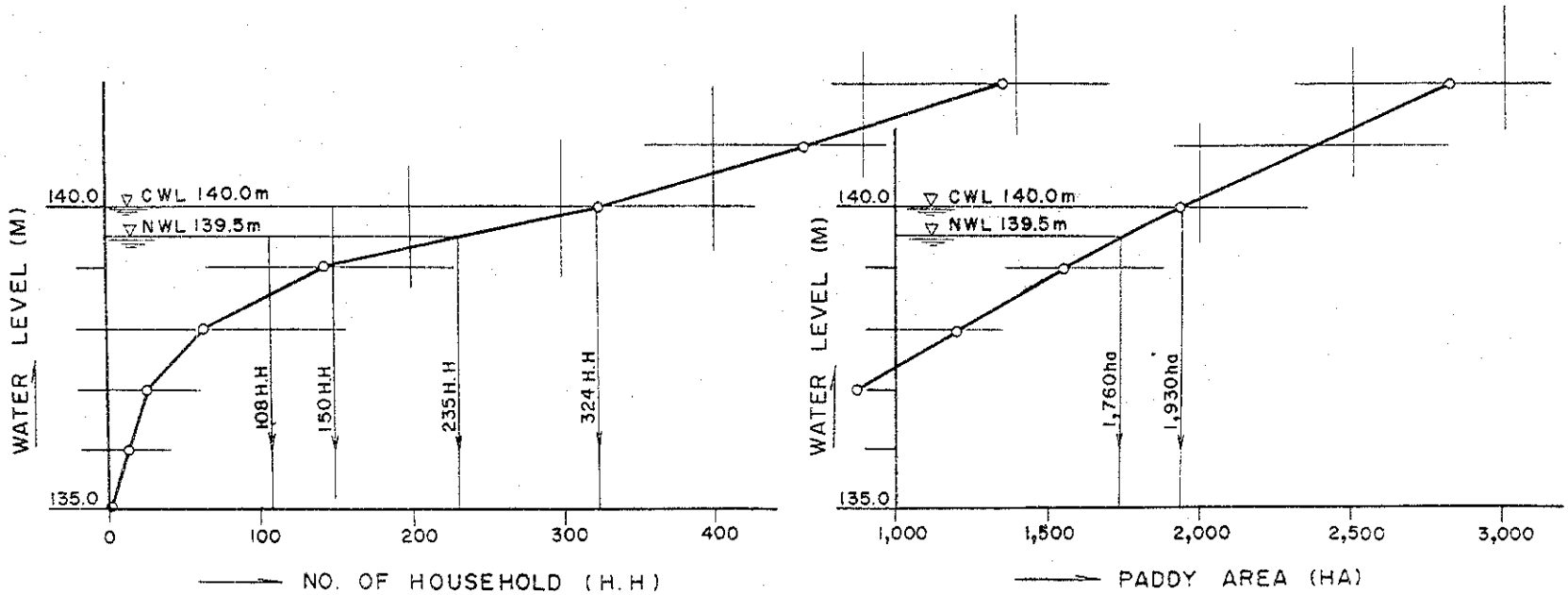
5. 2. 4 Optimum Scale of Project Planning

The optimum scale of project planning should be made considering the following factors;

- Available water and land resources
- Project economy
- Social aspects as land and household compensations

In the study, all of these factors were taken into consideration, and the comparison in terms of project cost consisting of dam and compensation costs solely was made as shown in Annex Figure 5-2. The followings are revealed through the study;

- The project cost per hectare becomes small in accordance with elevation of reservoir water level, because of more expansion of beneficial area. However, the required costs with an alternation of overflow depth of spillway, h = 1.5, 2.0 and 2.5 m, respectively



Data Source : - Aero-photograph in 1/4,000 and topogrpahic map in 1/10,000, 1983, ALRO
- Statistical data of household, 1983 - 1991, Statistical Province Office of Ubon Ratchathani

FIGURE 5-1 NO. OF HOUSEHOLDS AND PADDY FIELD AREA IN RESERVOIR AREA ACCORDING TO ELEVATION

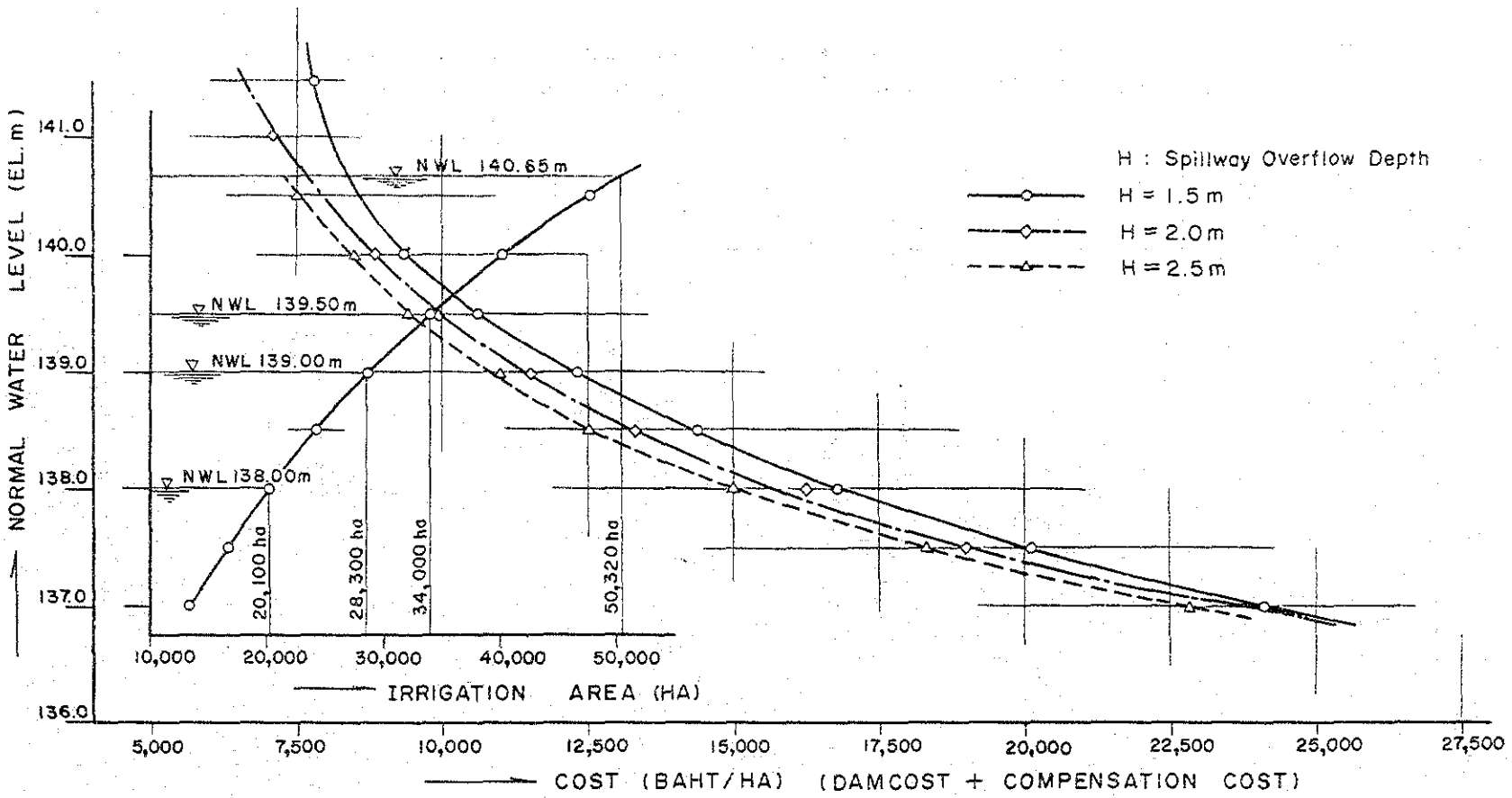


FIGURE 5-2 RELATIONSHIP AMONG NORMAL WATER LEVEL, IRRIGATED AREA, AND DAM COSTS

are not so different, although the cost in case of alternative plan of Case-3 having a overflow depth of h = 2.5 m is the lowest.

- From viewpoint of water supply for potential land of 50,320 ha (314.4 thousand rai), which is situated on the both banks of the Dom Yai river in the downstream of the proposed D-28 reservoir, normal water level (NWL) should be EL.140.65 m above mean sea level. In this water level, however, large scale compensation problems will be taken place, that is, 2,240 ha (14.0 thousand rai) of farm land and 420 of households.

- On the other hand, in order to minimize the compensation problems mentioned above, the normal water level should be around EL.138.0 m, because the number of households living in the reservoir area sharply increases around this elevation, as shown in Figure 5-1. In this case, however, the project costs per hectare become high with about 15,000 - 16,800 Baht/ha, which will lead to a low project economy for the project.

Under this situation, desirous normal water level will be in the range between the elevation of EL.139.0 m and EL.139.5 m as shown in Figure 5-2. Therefore, comparative studies on the following four cases of alternative plans were made to find out the optimum scale of project planning.

Comparison of Optimum Project Plan

Item	Normal Water Level EL.139.0 m (Plan-1)		Normal Water Level EL.139.5 m (Plan-2)	
	Plan 1-1	Plan 1-2	Plan 2-1	Plan 2-2
Normal Water Level (EL.m)	139.0	139.0	139.5	139.5
Spillway Overflow Depth (m)	1.5	2.0	1.5	2.0
Spillway Length (m)	180.0	80.0	170.0	70.0
Effective Capacity (MCM)	85.1 (100) 3/	85.1 (100)	104.6 (123)	104.6 (123)
Irrigation Area ('000 ha)	28.3 (100)	28.3 (100)	34.0 (120)	34.0 (130)
Const. Cost ('000 Baht/ha) 1/	12.3 (100)	11.6 (94)	10.6 (86)	10.0 (81)
Compensation Cost 2/	1,760 (100)	1,760 (100)	1,930 (110)	1,930 (110)
Farm Land (ha)	235 (100)	235 (100)	324 (138)	324 (138)
Household (h.h)				

1/ : Construction costs include of dam embankment cost, spillway cost, and compensation cost.

2/ : Compensation water level;
Plan-1 : EL.139.5 m
Plan-2 : EL.140.0 m

3/ : Figures in parenthesis show the proportion in case that the figures in Plan 1-1 is assumed to be 100.

From the results of the studies, the following can be ascertained;

- The increasing ratio of irrigation area in case of Plan-2 will be 1.2 times compared with that of Plan-1, while the decreasing ratio of project cost will be 0.86 - 0.81 times. Therefore, Plan-2 will be considered as the better plan from an economical viewpoint.
- On the other hand, in terms of compensation for lost farm land and houses in the reservoir area, Plan-2 will be unfavorable due to the large scale of compensation problems. However, these problems could be reduced by the provision of a protection dike along the village perimeters in the reservoir area.
- Therefore, designed normal water level is decided at EL.139.5 m, with an overflow depth of h= 1.5 m and proposed irrigation area of 34,000 ha (212.5 thousand rai), on the premise that the protection dike will be provided.

5. 2. 5 Compensation Water Level of D-28 Reservoir

The compensation water level was analyzed on a daily basis of D-28 reservoir operation study for a period of 30 years, 1961 to 1990, based on the following conditions;

- Designed normal water level : EL.139.5 m
- Designed overflow water depth : h = 1.5 m
- Proposed irrigation area : 34,000 ha (212.5 thousand rai)

According to the operation study, the spillage from the reservoir will usually occur for the period of four months from the end of July to the end of November in an average year, and presents 34 cm of maximum water height from normal water level (NWL), as shown in Figure 5-4.

On the other hand, the maximum and minimum spillage will occur in 1984 and 1981 with a maximum and minimum water height of 55 cm and 20 cm, respectively.

Using these results, the compensation water level (CWL) for the D-28 reservoir area is decided to be EL.140.0 m above the mean sea level, as

indicated below, which corresponds to about maximum water height during the period of 30 years.

Study on Compensation Water Level

Cases	Normal Water Level (NWL)	Rising Water Height	Compen. Water Level (CWL)
	(EL.m)	(m)	(EL.m)
Maximum	139.5	0.55	140.05
Minimum	139.5	0.12	139.62
Average	139.5	0.34	139.84

5. 2. 6 Selection of the Project Area

1) Alternative Project Area

Selection of the Project Area, covering a proposed irrigation area of 34,000 ha (212.5 thousand rai), was studied considering the necessary physical facilities such as pumps and irrigation canal systems.

For the purposes of these studies, the following four cases of alternative plans were set up;

Plan A

Plan A-1: The Project Area is selected on both banks of the Lam Dom Yai with an independent pumping station. The irrigation area is 8,800 ha (55.0 thousand rai) on the left bank and 25,200 ha (157.5 thousand rai) on the right bank, respectively, which mostly belong to Amphoe Det Udom.

Plan A-2: Location and irrigation systems of this plan are the same as those of Plan A-1, but two pumping stations will be provided for the right bank area, in order to anticipate a the reduction in required pump power.

Plan B

Plan B-1: The Project Area is located on the right bank area only extending its lower parts adjacent to provincial primary road 217.

TABLE 5-1 COMPARISON STUDY ON PROPOSED IRRIGATION SYSTEMS

Item	Plan A							Plan B			
	Plan A-1			Plan A-2				Plan B-1	Plan B-2		
	AR-1	AR-2	Total	AR-1	AR-2		Total	AR-1	AR-1		Total
1. Irrigation Area (ha)	8,800	25,200	34,000	8,800		25,200	34,000	34,000		34,000	34,000
2. Project Facilities											
2.1 Pump Facilities											
Pump	P-1	P-2	-	P-1	P-2	P-3	-	P-1	P-1	P-2	-
Area covered by Pump	8,800	25,200	-	8,800	25,200	25,200	-	34,000	34,000	34,000	-
Design Discharge,Q (cu.m/sec)	8.80	25.20	34.00	8.80	25.20	25.20	59.20	34.00	34.00	34.00	68.00
No. of Pump Unit	6	12	18	6	15	15	36	16	20	20	40
Pump Capacity per Unit,q (cu.m/min.)	88.0	126.0	-	88.0	100.8	100.8	-	127.5	102.0	102.0	-
Total Head,Ht (m)	16.4	28.4	-	16.4	14.2	14.2	-	29.4	14.7	14.7	-
Pump Type	UMFP 1/	UMFP	-	UMFP	UMFP	UMFP	-	UMFP	UMFP	UMFP	-
Pump Bore,D (mm)	800	1,000	-	800	800	800	-	1,000	900	900	-
Power per Pump Unit,P (kw)	370	880	-	370	360	360	-	910	380	380	-
2.2 Irrigation Canal											
Main Canal Length, L1 (km)	67.4	44.0	111.4	67.4		44.0	111.4	67.5		67.5	67.5
Lat./Sub-Lat. Canal Length,L2 (km)	32.2	156.2	188.4	32.2		156.2	188.4	229.2		229.2	229.2
3. Construction Cost (million Baht)											
3.1 Pump Facilities	107.7	512.2	619.9	107.7	261.9	261.9	631.5	706.2	368.6	368.6	737.2
3.2 Pipeline		476.0	476.0			476.0	476.0	476.0		476.0	476.0
3.3 Irrigation Canal											
Main Canal	182.0	118.8	300.8	182.0		118.8	300.8	236.3		236.3	236.3
Lateral / Sub-Lateral	80.5	390.5	471.0	80.5		390.5	471.0	504.2		504.2	504.2
Total	370.2	1,497.5	1,867.7	370.2	261.9	1,247.2	1,879.3	1,922.7	368.6	1,585.1	1,953.7

Note: 1/ UMFP : Uertical Mixed Flow Pump

Plan B-2: Location and irrigation systems of this plan are the same as those of Plan B-1, but two pumping stations will be provided for the same reasons mentioned in Plan A-2.

The comparison studies on the four cases of construction costs consisting of pump and irrigation canal systems were conducted as shown in Table 5-1. As seen in the table, the construction cost of Plan A-1 is the lowest, and followed by those of Plan A-2, Plan B-1 and Plan B-2. Therefore, regarding the selection of Project Area, Plan A-1 and Plan B-1 were evaluated in more detail from technical and economical viewpoints as indicated in hereinafter.

2) Selection of Proposed Project Area

The detailed layout of pumps and canal systems for both Plan A-1 and Plan B-1 were made on the basis of topographic map of 1/10,000 in scale. Table 5-2 gives the study result. As observed in the table, Plan A-1 expresses better project economy compared with Plan B-1. Therefore, Plan A-1 having benefited areas on both banks of the Dom Yai river was selected as the project plan, that is, an irrigation area of 8,800 ha (55.0 thousand rai) on the left bank area and 25,200 ha (157.5 thousand rai) on the right bank area.

In the case of Plan A-1, if basin-wide water resources development as mentioned in the Overall Basin Study, Part-I, in which linkage plan formed by D-7 + D-28 + D-24 has been formulated, would be realized, the proposed left bank pump facilities and irrigation canal systems would be utilized as a part of the whole irrigation system. However, some expansion of these facilities would be needed, in accordance with the proposed scale of project planning in the basin as mentioned in Part-I.

TABLE 5-2 MAJOR PROJECT FEATURES OF PLAN A-1 AND PLAN B-1

Item	Plan A-1	PlanB-1
1. Area and Administration		
Area	55,500	52,890
Amphoe	Det Udom	Det Udom
	Na Chaluai	Phibun Mangsahan
No. of Tambon	Nam Yun	
No. of Village	14	9
	68	57
2. Household and Population		
Total Household	7,815	6,768
Farm Household	7,303	6,101
Population	46,195	40,035
Family Size	5.9	2.9
Population Density	83.2	75.7
3. Proposed Land Use		
Cultivation Area (ha)	34,000	34,000
Forest and Others (ha)	21,500	18,890
Total	55,500	52,890
4. Project Facilities		
D-28 Dam and reservoir		
Dam Crest Elevation (m)	EL. 143.0	
Compensation Water Level (CWL) (m)	EL. 140.0	
High Water Level (HWL) (m)	EL. 141.0	
Normal Water Level (NWL) (m)	EL. 139.5	
Reservoir Area (sq.km)	39.1 (at NWL)	
Total Storage Capacity	117.1	
Effective Storage Capacity	104.6	
Pumping Station		
Pumping Station (site)	2	1
Total Pump Discharge (cu.m/sec)	34.0	34.0
Total Output (kw×unit)	370 × 6 (left)	910 × 16
	880 × 12 (right)	
Irrigation Canal		
Main Canal (km)	111.4	67.5
Lateral / Sub-lateral Canal (km)	188.4	229.2
5. Cost (million Baht)		
Project Cost	1,867.3	1,922.7
O & M Cost	32.6	34.7
6. Project Crop Benefit (million Baht)	381.7	385.1
7. EIRR	9.0	8.0

5.3 Land-Use Plan

5.3.1 Basic Concept of Land-Use Plan

The Project Area under rainfed conditions in the northeast region of Thailand suffers from unstable rainfall for agricultural crops as well as unfavorable social constraints such as outflow of labor and a lower income than that in the urban area.

Under the circumstances, the proposed land-use for the project was formulated in accordance with prevailing topography, soil conditions, land classification, land-use, and the following considerations;

- The existing cultivation land is defined as the benefited area of the project, and no expansion of cultivation land by means of land reclamation is planned.
- As stated in paragraph 4.2.3 "Soil and Land Classification", about 44 percent of total land in the Study Area of 71,700 ha (448.1 thousand rai) is categorized as land suitable for paddy cultivation. Therefore, this land, especially land class as L1, L2 and L4 will be used for wet season paddy field.
- A part of the above mentioned land classes, L1, L2 and L4, land classes of L5 and L6, which are situated on relatively high land near the proposed irrigation canal will be utilized for crop diversification in both wet and dry seasons by such upland crops as stringbean.
- A part of the land of class L1 will be used for perennial crops such as mango and other tree crops.
- The remaining land in the existing upland crop is planned to be utilized for upland crops under rainfed conditions. In these areas cassava and kenaf will be planted.
- About five percent of the cultivation land will be used for the right-of-way of project facilities such as canals and roads.

5.3.2 Proposed Land-Use Plan

Based on the above mentioned concept for proposed land-use, the proposed land-use for the Project Area was planned as shown in Table 5-3.

TABLE 5-3 PROPOSED LAND-USE PLAN

(unit : ha)

Land Category	Present Land-Use			Proposed Land-Use													
				Left Bank Area					Right Bank Area					Project Area			
	Left Bank Area	Right Area	Total	Cultivation Area		Forest	Village / Others	Sub-Total	Cultivation Area		Forest	Village / Others	Sub-Total	Cultivation Area		Forest	Village / Others	Total
				Irrigated	Rainfed				Irrigated	Rainfed				Irrigated	Rainfed			
1. Cultivation Area																		
Paddy Field	11,530	19,900	31,430	6,840	2,200	1,910	580	11,530	18,900	-	-	1,000	19,900	25,740	2,200	1,910	1,580	31,430
Upland Field	2,280	1,290	3,570	1,400	970	-	110	2,280	1,220	-	-	70	1,290	2,620	770	-	180	3,570
Fallow Land	590	910	1,500	560	-	-	30	590	860	-	-	50	910	1,420	-	-	80	1,500
Sub-total	14,400	22,100	36,500	8,800	2,970	1,910	720	14,400	20,980	-	-	1,120	22,100	29,780	2,970	1,910	1,840	36,500
2. Others																		
Forest	4,240	14,170	18,410	-	-	4,240	-	4,240	4,220	-	9,950	-	14,170	4,220	-	14,190	-	18,410
Village / Others	170	420	590	-	-	-	170	170	-	-	-	420	420	-	-	-	590	590
Sub-Total	4,410	14,590	19,000	-	-	4,240	170	4,410	4,220	-	9,950	420	14,590	4,220	-	14,190	590	19,000
Total	18,810	36,690	55,500	8,800	2,970	6,150	890	18,810	25,200	-	9,950	1,540	36,690	34,000	2,970	16,100	2,430	55,500

5.4 Water Resource Development Plan

5.4.1 River Run-off

1) Run-off Systems

The Dom Yai river is about 240 km in length and joins to the Mae Nam Mun at the west of Phibun Mangsahan. Before the Lam Dom Yai flows into the Mea Nam Mun, many tributaries join the river from left and right banks. Hilly areas in the middle-reaches and flat plain in the middle to lower-basin are formed by those tributaries.

The proposed dam-site is located about 180 km upstream of the junction and has 1,560.9 sq.km (975.6 thousand rai) of watershed area. Out of this area, mountainous areas with dense forests cover about 30 percent or more in the upper-basin. Upland fields in the elevated terrace and rainfed paddy in the lowland areas expand over the middle- and lower- basin with the elevation of 130 to 140 m above mean sea level. Many tributaries such as Huai Yang, Huai Bon, Huai Khum having watershed areas of less than 300 sq.km (187.5 thousand rai) and other small streams are also flowing into the Lam Dom Yai.

Discharge records converted to the specific discharges show different figures between the Ban Fang Phe and Det Udom observatories, especially in case of large flood discharges. This phenomenon is caused by the existence of the Lam Som that is the biggest tributary flowing into the Lam Dom Yai between the Ban Fang Phe and Det Udom. The Lam Som has 1,100 sq.km (687.5 thousand rai) of watershed area flowing down through open forests and agricultural lands in the most parts. The river sections of the Lam Dom Yai before joining the Lam Som is 20 to 25 m in river width. Moreover, around five meter difference in height can be seen between river-bed and ground surface of surrounding areas. After the Lam Som flows into the Lam Dom Yai, the basic dimensions changes to about 50 m in river width and 20 m more difference in height.

Generally, to evacuate the excess river flow at the flood times, tributaries in the Lam Dom Yai inundate surrounding lowland areas along the river course. These conditions lead to a decrease in peak discharge values at the main drainage course, though annual run-off coefficient shows the same

values compared with the other river basins. On the contrary, peak discharge will increase when large tributaries join the main drainage course compared with rivers having small tributaries. This phenomenon can be understood as the major reasons for the difference of a specific discharge between the Ban Fang Phe and Det Udom observatories.

As stated in the previous paragraph, six reservoir projects have been planned in the proposed watershed area. Among them, the two projects of Huai Palan Sua and Huai Chanla have been completed and those watershed areas are 114.7 sq.km (71.7 thousand rai) and 54.0 sq.km (33.8 thousand rai), respectively. Remaining projects to be implemented occupy 145.4 sq.km (90.9 thousand rai) of watershed area. Thus, the direct watershed area of the proposed D-28 dam accounts for 1,246.8 sq.km (779.3 thousand rai) out of the total area of 1,560.9 sq.km (975.6 thousand rai).

2) Designed Flood

In order to determine the designed flood of the proposed dam facilities, analyses of observed flood records and estimation of flood by analytical method using rainfall records have been made.

a) Observed Flood Records

At the installed gauging stations (M80 of RID and 53801 of NEA), annual momentary peak discharge (flood) has been recorded during 24-years for M80 and 21-years for 53801. Using these discharge records, probable floods and their specific discharges can be calculated as follows;

Probable Flood and Specific Discharge

Return Period	M80 (Det Udom) A = 3,363 sq.km		53801 (Ban Fang Phe) A = 1,410 sq.km	
	(1)	(2)	(1)	(2)
1,000	3,779.0	1.124	563.9	0.400
500	3,157.5	0.939	526.9	0.374
200	2,449.1	0.728	478.3	0.339
100	1,990.7	0.592	441.7	0.313
50	1,592.2	0.473	404.9	0.287
10	868.5	0.258	317.0	0.224
5	629.6	0.187	275.9	0.195

Note: (1) :Flood discharge (cu.m/sec)
(2) : Specific discharge (cu.m/sec/sq.km)

As a recorded maximum flood, 1,924 cu.m/sec and 400 cu.m/sec had been observed in 1972 at M80 and 53801, respectively.

b) Flood Discharge using the Rainfall Records

By using the rainfall records, probable flood discharge at the proposed dam-site can be estimated. One day and three consecutive days' rainfall values are considered for estimation with return periods of less than 100-year and over 100-year, respectively. As for the peak position on a day basis arrangement of hyetograph, rear heading type is applied taking the trends of the observed rainfall pattern into account. Following one day or n-day consecutive and hourly rainfall record are employed for estimation.

One day or n-day rainfall	:	point rainfall value of Nam Yun rainfall-gauge station
Hourly rainfall	:	observed value at Northeastern Region Meteorological Center in Ubon Ratchathani

To analyze the hyetograph for probable flood, rainfall intensity during the unit time is calculated by means of a specific coefficient method (Talbot type), since actual hyetograph of the certain rainfall is not available. Flood concentration time is estimated by the Luziha formula and hourly distribution is made by integration of the rainfall intensity equation.

On the basis of those pre-calculation results, probable floods at the proposed dam-site are calculated for each return period by the run-off function method, and the results are summarized as follows;

Estimated Probable Flood

Return Period (year)	Peak Flood Discharge (cu.m / sec)	Specific Discharge (cu.m / sec / sq.km)
1,000	1,143.8	0.733
500	1,086.7	0.696
200	1,010.1	0.647
100	819.6	0.525
50	781.5	0.501

c) Designed Flood Discharge

The probable flood discharges estimated by the analytical method at the proposed dam-site will be employed as the designed flood of the project taking into consideration the present conditions of water level observatories related to the proposed dam-site and the conservative estimation of flood discharge. The values employed for the project show the medium values compared with the Ban Fang Phe and Det Udom flood discharges.

RID's criteria for the spillway design discharge is as follows;

- In cases where the watershed area is less than 50 sq.km ..... Flood discharge with return period 50-year
- In cases where the watershed area is more than 50 sq.km .... Flood discharge with return period 100-year

For the spillway design of the proposed dam, return period of 1/500-year flood is conservatively adopted taking into account the RID's criteria and the scale of the watershed area of the dam. The following is the summary of the designed flood, and comparison of designed flood in other reservoir projects in Thailand is made as shown in Figure 5-3.

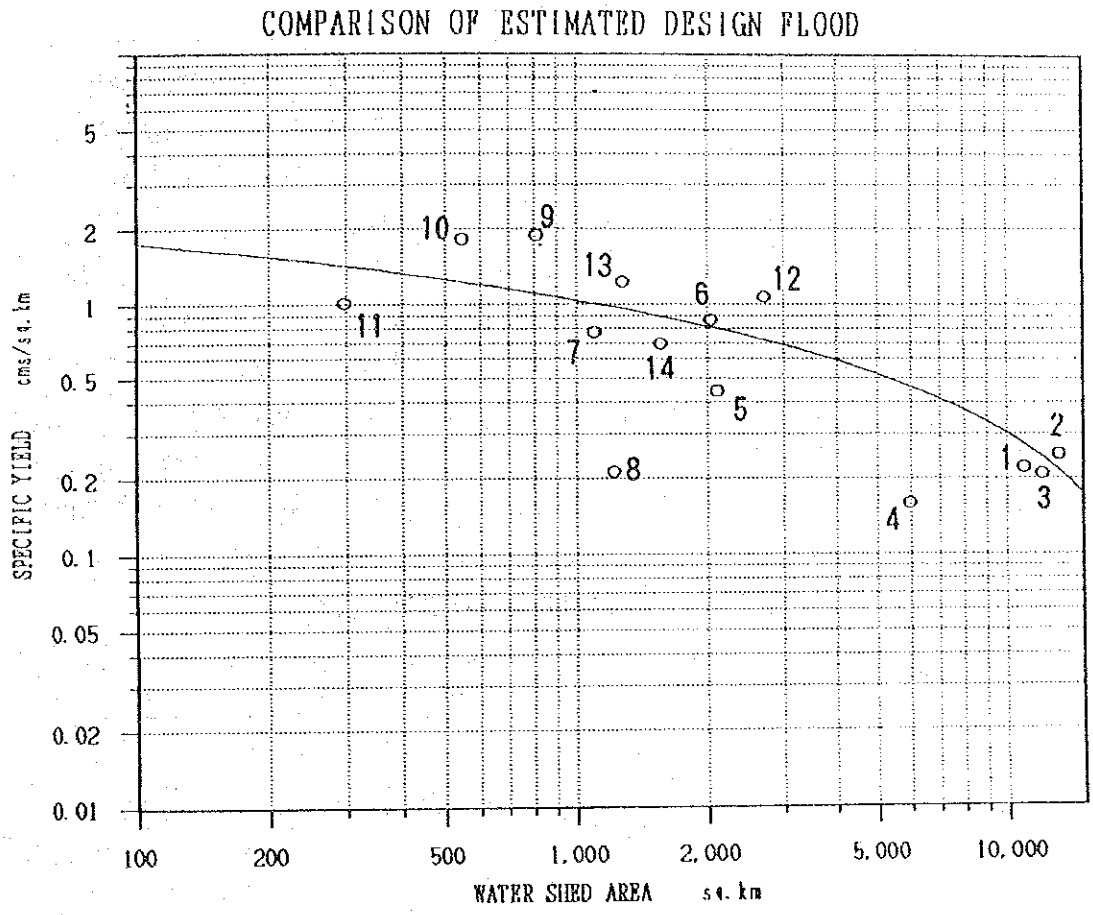
Return Period	Probable Flood (cu.m/sec)
500	1,086.7

For the designed discharge of the temporary diversion facilities, an average specific discharge of the Ban Fang Phe and Det Udom will be used. The designed value is as follows;

Designed Flood Discharge of Diversion Facilities

Return Period	Specific Discharge (cu.m/sec/sq.km)			Probable Flood at Dam-site (cu.m/sec)
	53801	M80	Mean	
10	0.225	0.258	0.242	377.0
5	0.196	0.187	0.192	298.9
3	0.172	0.142	0.157	245.1
2	0.150	0.109	0.130	202.1

FIGURE 5-3 COMPARISON OF DESIGNED FLOOD



No.	Name of Reservoir
1	SRINAGARIND
2	SIRIKIT
3	UBOLRATANA
4	LAM PAO
5	SIRINDHORN
6	PRANBURI
7	NAM UM
8	KRASIEO
9	LAM PHRA PHLOENG
10	CHULABHORN
11	NAM DUNG
12	KIU LOM
12	MAE NGAT
14	LAM DOM YAI

d) Probable Maximum Flood (PMF)

Basic dimensions of the proposed dam facilities will be checked by the probable maximum flood (PMF) defined theoretically as greatest flood.

Estimating the PMF, PMP (possible maximum precipitation) was calculated by means of a statistical procedure by referring to the Operational Hydrology Report No.1, "Manual for Estimation of Probable Maximum Precipitation", the World Meteorological Organization.

The values of annual maximum daily rainfall in the Nam Yun and hourly rainfall at the Northeastern Regional Meteorological Center are employed for the statistical analysis. For the reference of the estimated PMP value, the same analyses are also made on the Nakhon Phanom, Roi Et, Mukdahan and Ubon Ratchathani observatories. The results are as follows;

Probable Maximum Flood (PMF)

Station	Mean Annual Rainfall	Recorded Maximum Daily Rainfall	Estimated PMP
	(mm)	(mm)	(mm)
Nam Yun	1,356.1	180.8	503.1
Nakhon Phanom	2,282.9	459.2	806.6
Roi Et	1,395.3	203.6	503.4
Mukdahan	1,446.8	269.4	565.8
Ubon Ratchathani	1,634.0	203.9	534.6

The probable maximum flood (PMF) is estimated as shown below, taking the same procedure of probable flood as mentioned in b) of this paragraph.

- Probable Maximum Precipitation (PMP) : 503.1 mm/day
- Probable Maximum Precipitation (PMP) : 142.7 mm/hr
- Equation for rainfall intensity : 13,563.58 / (t+2.96)
- Probable Maximum Flood : 2,553.1 cu.m/sec

3) Sediment

Suspended sediment volume of the Lam Dom Yai has been measured at the gauging stations of M80 in Det Udom and 53801 in Ban Fang Phe. No

significant increase or decrease of inflow sediment value has been observed in the past records. On the basis of these observed records, mean annual value of specific inflow sediment of the Lam Dom Yai will be evaluated in the range of 60 to 42 cu.m/sq.km/year on an average. As the designed sediment volume of the proposed reservoir, 100 cu.m/sq.km of annual inflow sediment volume is conservatively adopted.

5. 4. 2 Water Requirement

The water requirement to be released from the dam are for irrigation and domestic purposes. The subsequent transactions with these subjects, especially regarding irrigation water requirement, the detailed descriptions will be given in paragraph 5. 5 "Irrigation Plan".

1) Irrigation Requirement

Irrigation Area

The irrigation area of the project was decided at 34,000 ha (212.5 thousand rai) with the proposed cropping intensity of 115~116 percent under the designed year of 1/5-year, as described in paragraph 5.2.4 "Optimum Scale of Project Planning."

Irrigation Water Requirement

The irrigation water requirement for the project was decided based on the proposed cropping pattern, and will be released from the reservoir taking into account crop water requirement, effective rainfall and water losses. Table 5-4 shows the monthly basis irrigation water requirement estimated in this way.

2) Domestic Water Demand

Domestic water demand for local peoples' living and village pond water will be supplied through the proposed canal systems. The domestic water demand is estimated at 8,220 cu.m/day, which is equivalent to about 0.10

cu.m/sec throughout a year 68,650 people × 0.10 cu.m/day/capita + village pond water), of which details are given in paragraph 5.5.2

5.4.3 Water Utilization Plan

1) Water Balance Study

Water balance study of the proposed D-28 reservoir was made for a period of 30 years from 1961 to 1990 on a daily basis. Major premises of the study are as follows;

Reservoir inflow	:	Run-off on a daily basis at the proposed dam-site is calculated by the developed Tank Model. 95 percent of the inflow volume is counted as the effective inflow volume. The remaining five percent is the river maintenance flow in the lower-basin.
Reservoir loss	:	Evaporation from the reservoir surface and seepage from the reservoir-bed are counted as reservoir losses. 70 percent of the Pan evaporation value and 1.0 mm/day of the reservoir area are considered as the evaporation from the reservoir surface and seepage from the reservoir-bed, respectively.
Irrigation demand	:	Irrigation water based on the proposed cropping pattern of Type-I and Type-II will be supplied from the reservoir.
Domestic water supply	:	Domestic water demand will be released from the reservoir combined with the irrigation water demand.
Optimum scale	:	Permissible water shortage of the proposed reservoir is seven times during the calculation period of 30 years. This frequency is equivalent to 1/5-year return period.

Summaries of the water balance study are shown in Table 5-4. As the results of calculation, proposed irrigation areas in each cropping pattern can be summarized as follows. The reservoir water levels recover the normal water level of EL.139.5 m every year because of normal floods in the wet season.

Type-I :	wet season paddy	32,750 ha	(204.7 thousand rai)
	dry season vegetable	5,100 ha	(31.9 thousand rai)
	perennial crop	1,250 ha	(7.8 thousand rai)
Type-II :	wet season paddy	31,700 ha	(198.1 thousand rai)
	Wet season vegetable	1,050 ha	(6.6 thousand rai)
	dry season vegetable	5,440 ha	(34.0 thousand rai)
	perennial crop	1,250 ha	(7.8 thousand rai)

An annual mean spillage from the reservoir is estimated at 396 MCM for irrigation demand of Type-I and 392 MCM for Type-II as against 591 MCM of an annual mean inflow. Generally, the spillage from the reservoir will start from the beginning of August. It ceases at the beginning of November. From the results of 30years reservoir operation, conditions of the spillage are expressed as follows;

Beginning and end of spillage;

Earliest	:	31 May	4, October
Average	:	beginning of August	beginning of November
Latest	:	18, September	30, November

Duration of spillage;

Longest	:	1 June to 27 November
Average	:	beginning of August to beginning of November
Shortest	:	18 September to 29 October

Reservoir water level during the spillage is estimated dividing the total spillage volume in a day by reservoir area. The water heights above the normal water level are 0.550 m in maximum, 0.118 in minimum and 0.354 on an average. Such water height variation is expressed in Figure 5-4.

Water shortages of the stored water in the reservoir occurs up to seven times during the period of water balance study of 30 years. Those shortages occur at the beginning of June, which corresponds to the early period of land

TABLE 5-4 SUMMARY RESULTS OF WATER BALANCE STUDY

SUMMARY OF THE WATER BALANCE STUDY

PROJECT SITE : D-28
DRAINAGE AREA : 1246.8 sq.km

IRRIGATION AREA
CROPPING PATTERN TYPE-I
PADDY : 32750 ha
UPLAND CROP (DRY): 5100 ha
PERENNIAL CROP : 1250 ha

RESERVOIR CAPACITY
TOTAL :117.107 MCM
EFFEC. :104.639 MCM
DEAD : 12.468 MCM
RESERVOIR WATER LEVEL
N.W.L. :139.500 m
DEAD :134.350 m

YEAR	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	YEAR END W.L.	YEAR END STORAGE	SPILLAGE	SHORTAGE
	mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1961	1455.5	622.199	120.915	61.082	138.895	95.249	430.957	0.000
1962	1472.7	635.505	112.367	55.547	138.773	91.187	439.888	0.000
1963	1496.1	630.378	84.700	51.850	138.929	96.415	457.091	0.000
1964	1446.8	629.504	119.203	55.706	138.862	94.152	425.380	0.000
1965	1337.9	513.342	140.944	49.374	137.232	49.706	341.800	0.000
1966	1606.5	663.850	136.455	46.102	138.881	94.787	422.005	-18.970
1967	1535.3	632.620	87.537	56.788	138.910	95.759	455.694	0.000
1968	1347.0	604.153	84.691	55.900	138.747	90.347	438.773	0.000
1969	1328.6	505.276	89.067	53.265	138.842	93.488	334.535	0.000
1970	1401.6	555.757	131.921	55.998	138.297	76.431	357.101	0.000
1971	1242.4	475.285	89.673	47.689	138.593	85.388	308.223	-3.023
1972	1413.4	521.965	85.960	50.274	138.958	97.384	348.723	-1.069
1973	1037.9	285.521	117.283	46.827	138.689	88.463	124.961	-8.899
1974	1355.7	435.328	82.969	47.022	138.863	94.189	277.842	0.000
1975	1808.7	919.322	81.351	51.331	139.084	101.791	733.069	0.000
1976	1460.8	614.927	89.429	54.992	139.042	100.309	441.238	0.000
1977	968.1	258.544	171.230	46.975	138.221	74.227	99.990	-46.499
1978	1404.4	542.116	213.752	43.687	138.943	96.892	275.772	-40.860
1979	1231.4	486.243	145.973	59.173	138.699	88.776	264.897	0.000
1980	1286.6	440.458	104.510	46.567	138.895	95.240	260.900	0.000
1981	1170.1	323.858	89.734	52.453	138.856	93.953	154.198	0.000
1982	1489.5	563.173	83.885	48.791	138.968	97.747	398.539	0.000
1983	1346.4	564.713	154.696	54.251	138.872	94.486	330.790	0.000
1984	1879.2	1100.850	177.525	47.344	139.019	99.501	816.434	-0.512
1985	1220.9	479.518	134.975	58.746	138.922	96.176	265.154	0.000
1986	1509.5	674.611	88.423	56.668	139.016	99.415	492.553	0.000
1987	1504.9	712.752	91.339	56.123	139.096	102.185	526.876	0.000
1988	1582.8	790.047	181.148	62.663	139.013	99.278	509.666	0.000
1989	1260.8	540.806	115.523	54.005	138.971	97.846	345.692	0.000
1990	1889.9	1007.625	82.033	60.443	139.111	102.724	809.901	0.000
AVE.	1416.4	591.008	116.307	52.921	138.807	92.783	396.288	-3.994

SUMMARY OF THE WATER BALANCE STUDY

PROJECT SITE : D-28
DRAINAGE AREA : 1246.8 sq.km

IRRIGATION AREA
CROPPING PATTERN TYPE-II
PADDY : 31700 ha
UPLAND CROP (WET): 1050 ha
UPLAND CROP (DRY): 5440 ha
PERENNIAL CROP : 1250 ha

RESERVOIR CAPACITY
TOTAL :117.107 MCM
EFFEC. :104.639 MCM
DEAD : 12.468 MCM
RESERVOIR WATER LEVEL
N.W.L. :139.500 m
DEAD :134.350 m

YEAR	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	YEAR END W.L.	YEAR END STORAGE	SPILLAGE	SHORTAGE
	mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1961	1472.7	622.199	128.435	60.038	138.872	94.465	425.265	0.000
1962	1472.7	635.505	118.543	54.506	138.744	90.233	434.932	0.000
1963	1496.1	630.378	90.842	50.625	138.901	95.461	452.178	0.000
1964	1446.8	629.504	126.246	54.452	138.834	93.198	419.595	0.000
1965	1337.9	513.342	146.973	48.740	137.258	50.252	334.923	0.000
1966	1606.5	663.850	142.339	45.920	138.853	93.830	419.913	-21.076
1967	1535.3	632.620	94.120	55.598	138.882	94.805	450.315	0.000
1968	1347.0	604.153	91.306	54.619	138.718	89.393	433.447	0.000
1969	1328.6	505.276	96.012	52.040	138.814	92.534	328.825	0.000
1970	1401.6	555.757	136.514	55.274	138.306	76.696	352.034	0.000
1971	1242.4	475.285	95.145	46.827	138.566	84.544	306.484	-4.786
1972	1413.4	521.965	94.468	48.546	138.930	96.430	344.735	-3.753
1973	1037.9	285.521	123.367	45.737	138.560	87.508	123.735	-12.661
1974	1355.7	435.328	91.270	45.736	138.835	93.234	270.852	0.000
1975	1808.7	919.322	88.474	50.403	139.062	100.990	726.739	0.000
1976	1460.8	614.927	96.701	54.085	139.020	99.528	434.880	0.000
1977	968.1	258.544	176.947	45.996	138.203	73.702	99.569	-51.058
1978	1404.4	542.116	216.885	42.880	138.915	95.938	275.748	-42.722
1979	1231.4	486.243	153.511	58.224	138.671	87.861	258.270	0.000
1980	1286.6	440.504	111.809	45.072	138.866	94.286	255.193	0.000
1981	1170.1	325.496	96.760	51.229	138.828	92.999	150.502	0.000
1982	1489.5	563.173	90.389	47.402	138.940	96.793	393.443	0.000
1983	1346.4	564.713	161.930	52.911	138.844	93.532	324.891	0.000
1984	1879.2	1100.850	183.387	46.190	138.991	98.547	816.434	-5.205
1985	1220.9	479.518	140.909	57.843	138.898	95.349	259.980	0.000
1986	1509.5	674.611	95.402	55.732	138.989	98.460	486.649	0.000
1987	1504.9	712.752	98.148	55.163	139.068	101.231	521.046	0.000
1988	1582.8	790.047	186.878	61.880	138.985	98.324	504.687	0.000
1989	1260.8	540.806	123.529	52.881	138.943	96.892	338.798	0.000
1990	1889.9	1007.625	87.965	59.716	139.084	101.770	804.690	0.000
AVE.	1417.0	591.064	122.840	51.876	138.783	91.960	381.625	-4.709

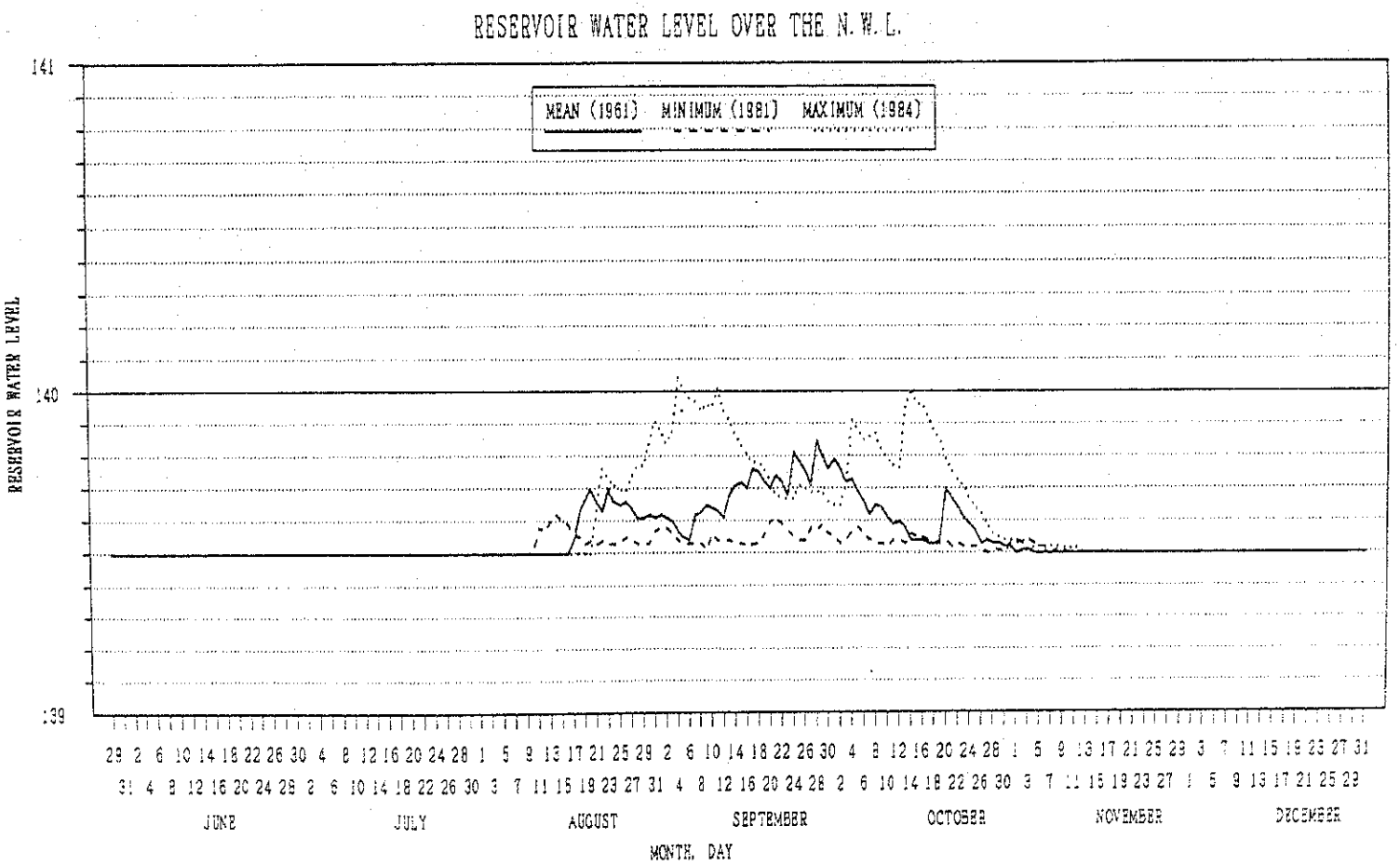


FIGURE 5-4 RESERVOIR WATER LEVEL ABOVE THE NORMAL WATER LEVEL

preparation in the wet season paddy cultivation. The irrigable areas in the water shortage years are as follows;

Irrigable Area in Water Shortage Year

(unit: ha)

Year	Cropping Pattern Type-I			Cropping Pattern Type-II			
	Dry Season	Wet Season	Perennial	Dry Season	Wet Season		Perennial
	Upland	Paddy	Crop	Upland	Paddy	Upland	Crop
normal	5,100	32,750	1,250	5,440	31,700	1,050	1,250
1966	3,000	18,750	1,250	3,100	17,450	600	1,250
1971	4,620	29,550	1,250	4,750	27,430	920	1,250
1972	4,950	31,750	1,250	4,950	28,690	960	1,250
1973	4,500	28,750	1,250	4,580	26,460	890	1,250
1977	3,000	18,750	1,250	3,060	17,250	600	1,250
1978	3,510	22,150	1,250	3,700	21,130	720	1,250
1984	5,070	32,550	1,250	5,230	30,430	1,020	1,250
Average	4,092	26,035	1,250	4,195	24,120	815	1,250

2) Reservoir Operation Rule

As a result of the water balance study, the following reservoir operation rules were established.

Restricted Reservoir Water Level

(unit : WL.m)

Date		Reduction Ratio of Irrigation Area					
		100%	90%	80%	70%	60%	50%
Jan.	1	139.30					
Feb.	15	138.30					
Apr.	1	137.30					
May	1	136.70	137.10	136.80	136.50	136.10	135.60
Jun.	15	136.00	136.45	136.20	135.80	135.45	135.05
Jul.	1	135.00	135.70	135.45	135.15	134.90	-
Jul.	15	134.70	134.80	-	-	-	-
Aug.	1	134.70					
Aug.	15	139.50					
Oct.	15	139.50					

When the reservoir water level reaches W.L. 134.70 m, the irrigated area on and after that day should be reduced to 50 percent of the area at the stage.

Figure 5-5 indicates the proposed rule curve for reservoir operation.

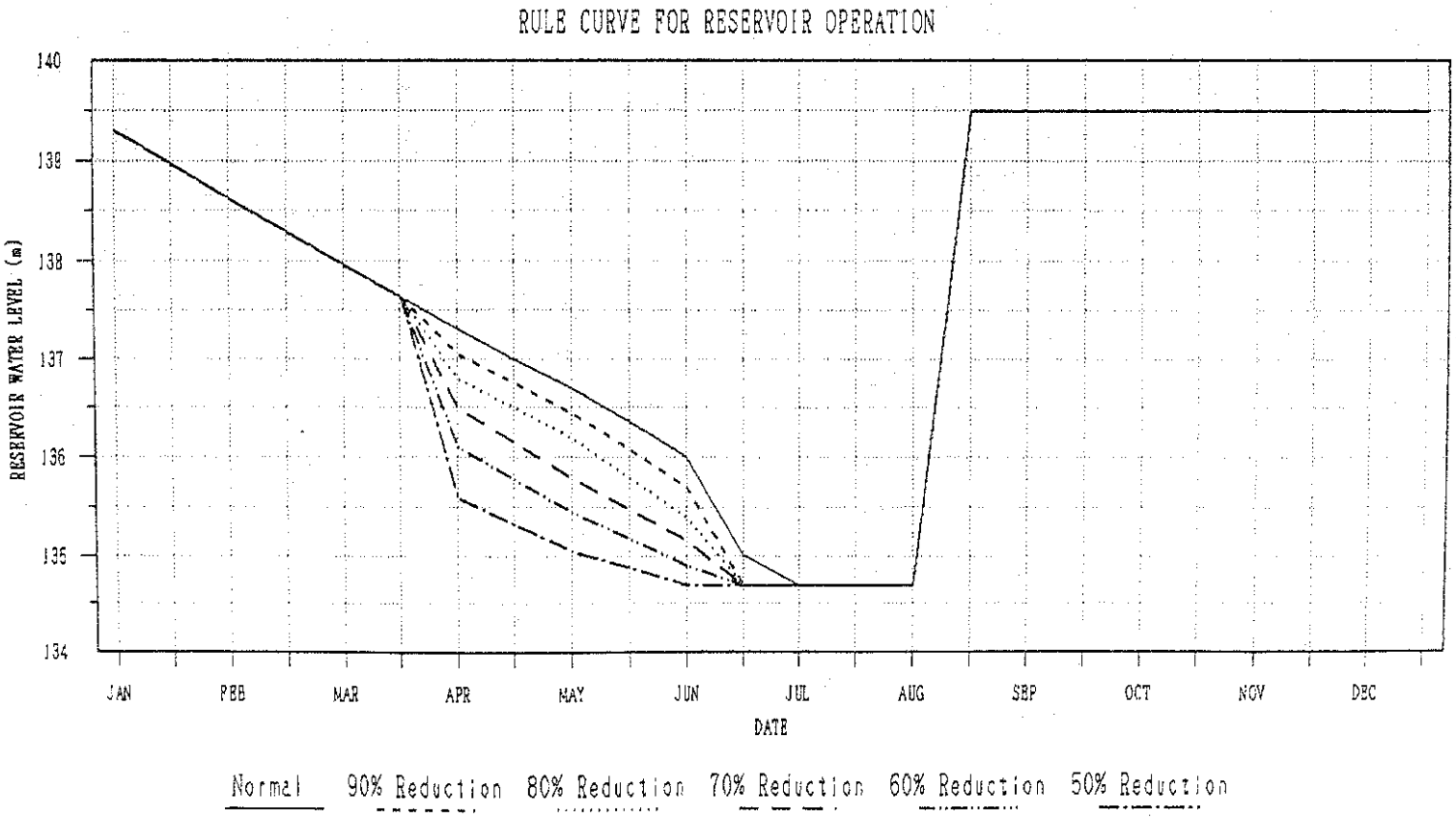


FIGURE 5-5 PROPOSED RESERVOIR OPERATION CURVE

5. 5 Irrigation and Drainage Development Plan

5. 5. 1 Irrigation Plan

1) Irrigation Water Requirement

a) Proposed Cropping Pattern

The following two types of cropping patterns were formulated in the project;

Type-I : (for first five years after project implementation)
Wet season : Paddy rice + Perennial crop
Dry season : Upland crop + Perennial crop

Type-II : (for the following 45 years)
Wet season : Paddy rice + Upland crop + Perennial crop
Dry season : Upland crop + Perennial crop

As mentioned previously, the cropping intensity for Type-I cropping patterns is 115 percent, 100 percent in the wet season and 15 percent in the dry season, while that for Type-II cropping pattern is 116 percent, 100% in the wet season and 16 percent in the dry season. These cropping intensities were analyzed considering such project requirement that the major objectives of irrigation for crops are supplemental water supply for the wet season paddy to stabilize and increase the yield of the wet season paddy.

b) Crop Water Requirement

Reference crop evapotranspiration (ETo) is estimated as presented below by applying the modified Penman Method using the climatological data observed at Ubon Ratchathani station (1961 - 1990).

Reference Crop Evapotranspiration (ETo)

Month	ETo	Month	ETo
Jan.	4.3	July	4.5
Feb.	5.2	Aug.	4.3
Mar.	5.8	Sep.	4.0
Apr.	6.1	Oct.	4.3
May	5.4	Nov.	4.5
Jun.	4.5	Dec	4.1
		Average	5.0

Consumptive use for crop (actual crop evapotranspiration, ETa) is calculated by multiplying the ETo value by crop coefficient (Kc) corresponding to growth stage of crops, and monthly consumptive use for crop is shown in Table F-8, in Annex F.

Crop water requirement on a 10-day basis is estimated based on the proposed cropping pattern. In this estimation, the following values are counted;

- Percolation rates in paddy field are assumed at 2.0 mm/day throughout the growing season of paddy.
- Additional water supply for land preparation of paddy field is decided at 250 mm.

The crop water requirements by crops thus estimated can be summarized as follows;

Estimated Crop Water Requirement

Paddy Rice:		
Wet season HYV	:	761 mm
Wet season LV	:	782
Upland Crops:		
Wet Season Upland Crop	:	545
Groundnut	:	549
Soybean	:	619
Watermelon	:	557
Chilli	:	549
Stringbean	:	622
Perennial Crop	:	1.470

c) Diversion Water Requirement

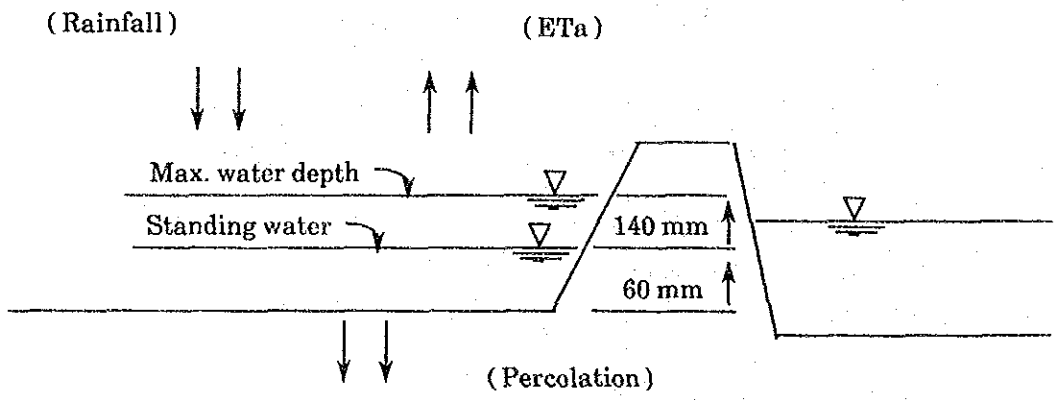
Diversion water requirement is calculated by adding effective rainfall and irrigation efficiency to the crop water requirement. The criteria for calculation of the effective rainfall and irrigation efficiency is as follows;

Effective Rainfall

Effective rainfall for paddy field is estimated by analyzing the daily water balance study between the rainfall and crop water requirement based on the following conditions;

- The minimum standing water in the field is 60 mm.
- The rainfall water depth of more than 200 mm (a notch on the levee is placed at the height of 200 mm) in the field will be drained as waste water.
- Irrigation water will be supplied to a depth of 80 mm in the field, if water depth becomes lower than the minimum standing water depth of 60 mm.

Illustration of Water Balance in Paddy Field



For the effective rainfall for upland crop, TRAM (total readily available moisture) value of 25 mm is planned as the depth of maximum effective rainfall.

Irrigation Efficiency

The irrigation efficiency would be determined on the basis of the prevailing topography, irrigation method and so forth. In the project, the following irrigation efficiencies are adopted;

Irrigation Efficiency

Item	Paddy Field	Upland Field
	(%)	(%)
Application efficiency	80	70
Operation efficiency	80	80
Conveyance efficiency	85	90
Overall efficiency	55	50

In accordance with the above mentioned procedures, a 10-day basis of diversion water requirement is estimated for 30 years (1961- 1990) (see, Table F-12 and Table F-13 in Annex F).

Annual diversion water requirements in the case of the designed year with return period of 1/5-year and the normal year are summarized as follows;

Annual Deversion Water Requirement

Item	Cropping Pattern	
	Type-I	Type-II
	(MCM)	(MCM)
Designed Year	134.6	141.1
Normal Year	113.0	119.5

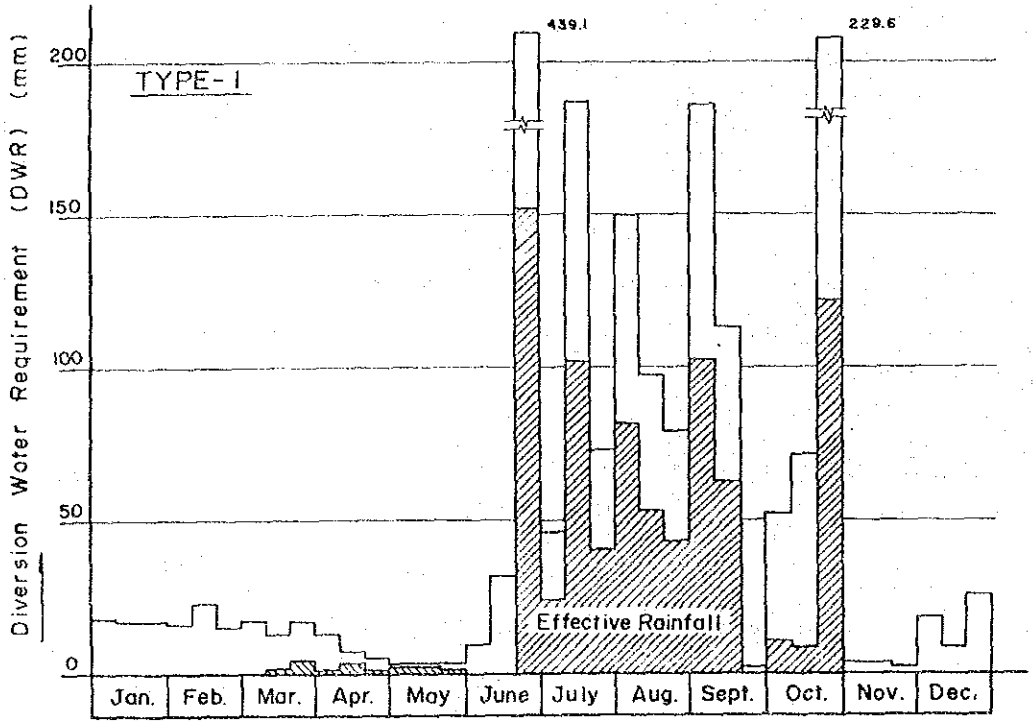
Figure 5-6 indicates 10-day fluctuation of diversion water requirement in the case of the designed year.

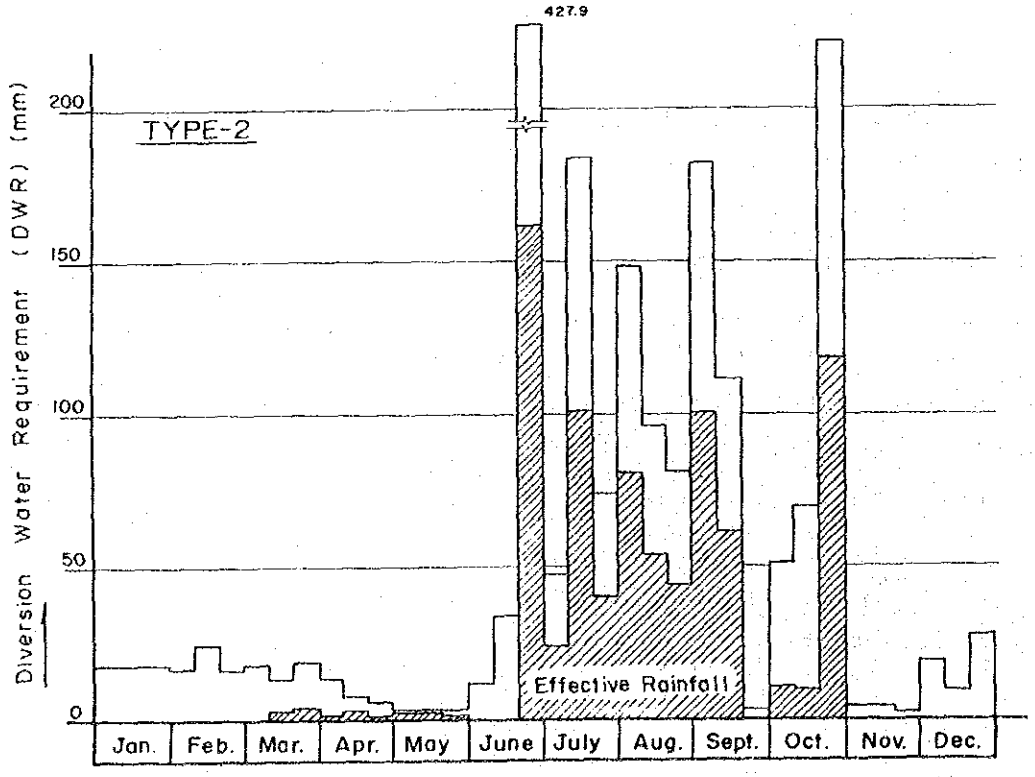
d) Domestic Water Requirement

According to the statistical analysis of population, about 46,200 people live in the Project Area. They are suffering from shortages of domestic water, especially drinking and living water. In the project, such domestic water is included in the water demand to be released from D-28 reservoir.

Annual domestic water requirement is calculated at 3.00 MCM on the following assumptions;

FIGURE 5-6 10-DAY FLUCTUATION OF DIVERSION WATER REQUIREMENT





- Present population of about 46,200 people will be increased to about 68,600 people, 20 years later with an annual population growth rate of two percent.
- Drinking and household water could be estimated at 2.50 MCM at target year with daily consumption of 100 lit./ day-capita.
- Other miscellaneous domestic water of 0.50 MCM is counted in the estimation of total domestic water requirement.

5. 5. 2 Irrigation Water Supply Plan

1) Proposed Irrigation Systems

The proposed irrigation area for the project is planned to be 34,000 ha (212.5 thousand rai), corresponding to the designed year of 1/5-year return period. The irrigation systems consisting of main, lateral/sub-lateral canals in the area are planned based on the available topographic maps of 1/10,000 and 1/50,000.

The proposed irrigation systems are presented in schematic diagrams, in accordance with the proposed main and lateral/sub-lateral canal alignments and demarcation of each service unit.

At the head of the main irrigation canals, pumping facilities will be needed, because the D-28 reservoir's water level fluctuates from a normal water level of EL. 139.5 m to a low water level of El. 134.35 m which is not sufficient to allow water distribution by gravity flow into the proposed irrigation area of 34,000 ha (212.5 thousand rai).

2) Irrigation Method for Paddy Cultivation

a) Irrigation Method

The water distribution method for paddy cultivation will generally be selected and decided in accordance with available water resources, rotation areas, cropping pattern and growing stages of crops, crop water requirement,

irrigation facilities in the systems, etc. In general, the following two types of water distribution methods are practiced for paddy cultivation, such as simultaneous and rotational irrigation water supplies;

i) Rotational irrigation method is to be applied at the level of supplemental farm ditches on the farm, at the stage of the land soaking and land preparation stages, and at times when the amount of available water is scarce.

ii) Simultaneous irrigation method is to be applied at the crop growing stage and at times when the amount of available water is abundant. However, once water sources are quite seriously limited, water supply methods will be shifted to the rotational method.

b) Designed Water Requirement for Main Canals

Unit water requirement (duty of water) for designing the main canals is decided based on the following considerations;

i) To take into account the effective rainfall in the field for the estimation of the unit water requirement, because the maximum irrigation water requirement will occur for the land soaking and preparation period from the beginning of June to the middle of August. During there periods, much rainfall can usually be expected in the area as 267 mm in June, 273 mm in July and 328 mm in August on an average.

ii) To provide canal capacity to meet basically the water requirement in the drought year of return period 1/10-year.

According to these considerations, the 10-day basis peak irrigation water requirement at the land soaking and preparation stage was estimated from water balance study for the 30-year period, 1961 to 1990. As a result, it was revealed that the peak irrigation water requirement was calculated at 0.930 lit./sec/ha in return period of 1/10-year. Consequently, the designed irrigation water requirement for the main canal , which will cover a Section Area of about 5,000 to 6,500 ha (31.3 to 40.6 thousand rai), was decided at 1.00 lit./sec/ha, considering the domestic-use water requirement.

c) Designed Water Requirement for Lateral/Sub-lateral Canals

According to the proposed irrigation systems, irrigation areas which are covered by one lateral canal have wide ranges in size, e. i, from about 6,500 ha (40.6 thousand rai) down to 200 ha (1.3 thousand rai). Under these conditions, the basic concept for designing the canal capacity of a lateral canal is as follows;

i) Irrigation area can be typically classified as shown below,

Section Area	:	more than 1,000 ha (6.3 thousand rai)
Zone Area	:	1,000 ha
Irrigation Block	:	200 (1,000 ha × 1/5)
Irrigation Unit	:	40 (200 ha × 1/5)
Rotation Unit	:	20 (40 ha × 1/2)

ii) The land preparation period from the start to the end of land- soaking and preparation works will depend on the size of the irrigation area covered by each lateral canal. In calculating the unit water requirement, the following land preparation periods are planned;

more than 1,000 ha	:	60 days
1,000 - 200	:	38
200 - 40	:	34

iii) Factors of effective rainfall are not taken into consideration in planning of canal capacity.

For the planning of lateral and sub-lateral canal capacity to meet paddy cultivation, the weighted average crop water requirement on a 10-day basis is calculated, based on the cropping pattern, irrigation schedule and water requirement for land soaking and preparation. The following indicates a summary of these calculations;

Section Area (more than 1,000 ha)	:	1.50 lit./sec ha
Zone Area (1,000 - 200 ha)	:	2.10
Block Area (200 - 400 ha)	:	2.90

In the above calculation, the following water requirement during land soaking and preparation is counted. The irrigation water is to be supplied three times in a month.

1st irrigation	:	150 mm
2nd irrigation	:	39 mm
3rd irrigation	:	61 mm
Total		250 mm

d) Designed Water Requirement for On-farm (Terminal) Facilities

The designed capacity for on-farm facilities is determined considering the maximum water requirement at a peak stage, which usually occurs during the period of land soaking and preparation stages. The maximum water requirement is scheduled in the 1st irrigation for land soaking with 150 mm for the wet season paddy.

Assuming that this amount of water will be supplied within 10-days in the one rotation unit of about 20 ha (125.0 rai), the designed water requirement for on-farm facilities can be calculated at 2.17 lit./sec/ha (150 mm $\times$ 10^{-3} $\times$ 1.0 ha $\times$ 10^4 $\times 10^3$ / (86,400 $\times$ (1 - 0.20) $\times$ 10 days). Consequently, designed capacity of turn-out is decided at 43.4 lit./sec in the typical rotational unit of about 20 ha.

3) Irrigation Method for Upland Crops

a) Proposed Upland Crops and Areas

Major upland crops to be introduced in the project are groundnut, soybean, watermelon, stringbean, and chilli. The cropping areas by crops in each type of cropping pattern are summarized as follows;

Cropping Areas by Upland Crop

(unit: ha)

Crops	Type-I (Dry Season)	Type- II (Dry Season)	Type- II (Wet Season)
Groundnut	3,417	3,757	-
Soybean	1,122	1,122	-
Watermelon	357	357	-
Stringbean	153	153	1,050
Chilli	51	51	-
Total	5,100	5,440	1,050

b) Depth and Time Interval of Application of Irrigation for Upland Crops

1) Measurement of Intake Rate

Intake rates were measured by using cylinder infiltrometers at seven sites in the Study Area, in order to plan an adequate irrigation method and water amounts to be applied to the crops.

The following table gives the obtained basic intake rate, based on field observations.

Obtained Basic Intake Rate (Ib)

	Location	Ib
		(mm/hr)
1.	Ban Rai Tai	14.7
2.	Ban Nachan	4.8
3.	Ban Kaon Charoon	33.1
4.	Ban Mai Pattana	15.1
5.	Ban Wari Udom	15.6
6.	Ban Non	54.1
7.	Ban Nong Khu	16.4

Note; see Annex F, Figure 5-9 .

In parallel with the intake rate measurement, soil sampling at seven sites were made, to analyze the physical properties of the soils in the field such as particle size, soil texture, specific gravity, porosity, field capacity and wilting point, of which laboratory tests were made at RID Laboratory in Pakkred. In these soils samples, the soils were taken from four layers with 20 cm intervals at one site of 70 cm in depth.

The results of the soils analysis are summarized as follows;

Physical Properties of Soils[1/]

Depth (D)	Real Specific Gravity (Sr)	Apparent Specific Gravity (Sa)	Porocity (P) 2/	Field Capacity (Fc)	Wilting Point (Wp)
(cm)	(g / cm3)	(g / cm3)	(%)	(%)	(%)
10	2.68	1.80	32.7	8.8	6.3
30	2.70	1.81	33.0	13.4	7.3
50	2.70	1.82	32.6	16.3	8.3
70	2.72	1.88	30.8	23.1	10.2

1/ : Average of seven samples
2/ : $P = (Sr - Sa) \times 100 / Sr$
Detail are given in Annex F, Table F-26.

From the figures mentioned above, the furrow irrigation method would be suitable for water supply to the upland crops.

2) Depth and Time Interval of Irrigation Application

The depth and time interval of irrigation application are determined in the following procedures;

i) Determination of effective root zone
ii) Determination of moisture extraction pattern
iii) Calculation of available moisture of each soil layer within the effective root zone
iv) Calculation of total readily available moisture (TRAM)
v) Determination of depth and time interval of irrigation application

Depth of Effective Root Zone

The depth of effective root zone was determined on the basis of field survey and collected data on the root zone, and is shown below;

Groundnut	:	40 cm
Soybean	:	40 cm
Watermelon	:	60 cm
Stringbean	:	40 cm
Chilli	:	40 cm

Moisture Extraction Pattern

The consumptive rate of soil moisture is the so-called "moisture extraction pattern" which will be determined based on field investigations. However, due to the lack of such data, the following pattern was applied;

Percent of Depth	Ratio of Moisture Extraction
(%)	(%)
0 - 25	40
25 - 50	30
50 - 75	20
75 - 100	10

Available Moisture in Each Soil Layer within Effective Root Zone

Available moisture (AM) is obtained from the following equation;

$$AM = 1/100 \times (Fc - Wp) \times Sa \times D \text{ (cm)}$$

where; Fc = Water holding capacity after 24 hours for soil saturation (%)
Wp = Moisture ration at wilting point (%)
Sa = Apparent specific gravity (g/ cm^3)
D = Depth of soil in each soil layer (mm)

Total Readily Available Moisture (TRAM)

Consumed Moisture = Available Moisture/Ratio of Moisture Extraction

The layer presenting the minimum value obtained from the above equation is the restricting layer of moisture, and its value becomes the Total readily Available Moisture (TRAM), that is, the net amount of water to be replaced, which is given in Annex F, Table F-27 to Table F-28.

Interval of Irrigation Application

The time interval of irrigation application is obtained by dividing the TRAM values by the maximum crop evapotranspiration as follows;

Estimation of Irrigation Interval

Upland Crop	TRAM	Maximum Evapotranspiration	Irrigation Interval
	(mm)	(mm/day)	(day)
Groundnut	25.3	5.5	4.6
Soybean	25.3	6.2	4.1
Watermelon	40.8	5.2	7.8
Stringbean	25.3	6.2	4.1
Chilli	25.3	5.5	4.6

From the viewpoint of water management, the same irrigation interval of water supply is favorable, therefore, five days of irrigation interval was planned for the project.

5. 5. 3 Pump Operation

The following pump facilities to lift irrigation water will be provided, adjacent to the D-28 reservoir.

Pump Facilities

Item	Left Bank Area	Right BankArea
Irrigated Area (ha)	8,800	25,200
Pump Discharge (cu.m / sec)	8.80	25.20
Total Lift Head (m)	16.40	28.40
Diameter (mm)	800	1,000
Number of Pump Sets (unit)	6	12
Output (kw)	370	880

Pump operation hours were estimated on a 10-day basis, depending upon total irrigation requirement and pump discharge per unit, and the following table indicates the estimated annual pump operation hours in cases of designed and normal years.

Pump Operation Hours

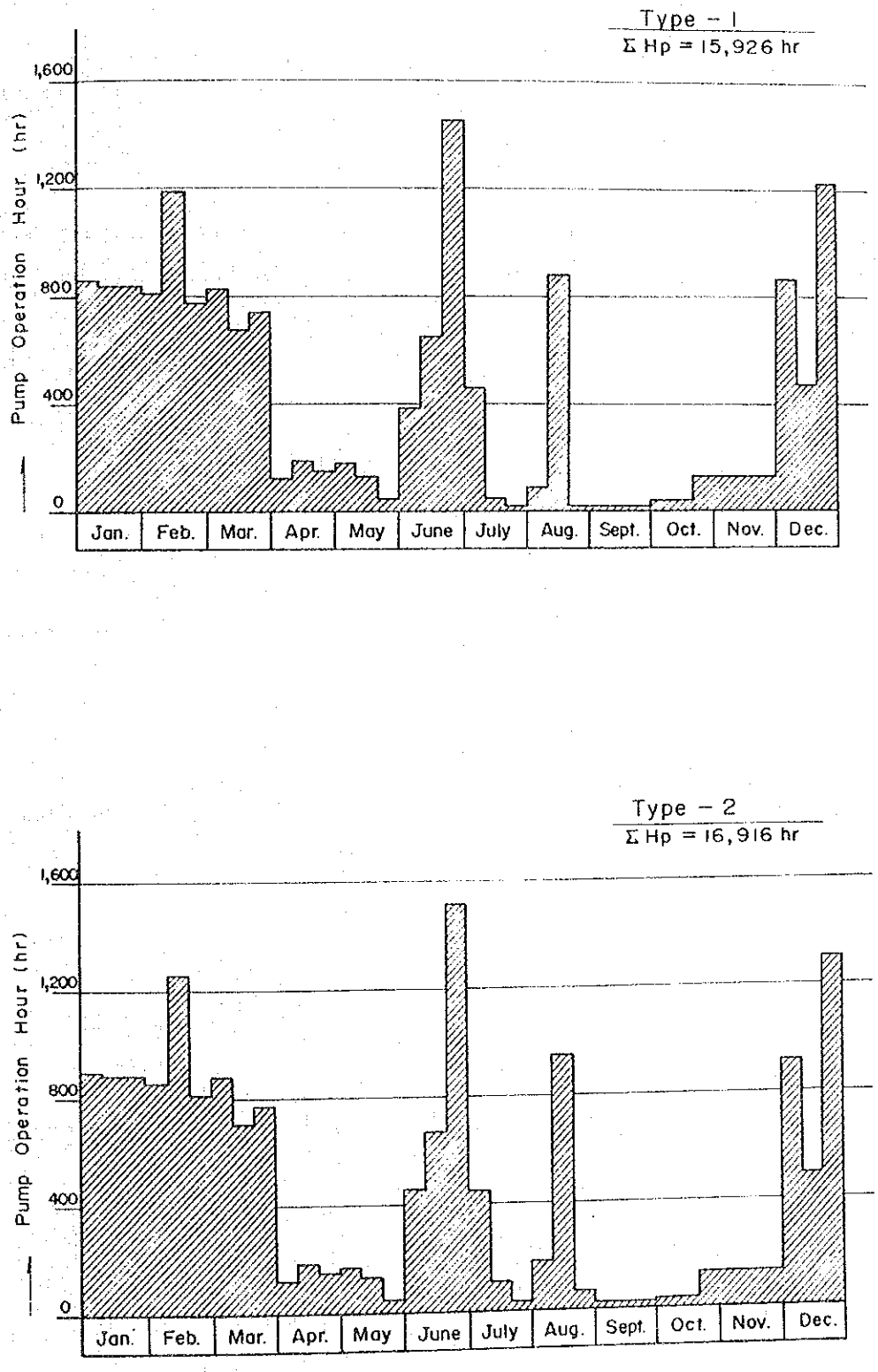
Item	Left Bank Area	Right Bank Area	Total
	(hr)	(hr)	(hr)
Cropping patter Type-I	5,164	10,321	15,485
〃 Type-II	5,493	10,982	16,475

The estimated pump operation hours are mainly concentrated for the land-soaking and preparation and around October corresponding to the latter end of wet season paddy and throughout the growing period of dry season crops, as shown in Figure 5-7.

5. 5. 4 Drainage Plan

According to the drainage survey in the Project Area, it was discovered that inundation from flood discharges in the field is generally caused by the following;

FIGURE 5-7 10-DAY FLUCTUATION OF PUMP OPERATION HOURS



- No provision for terminal drainage canals at farm level for prevailing rainfed farming,
- Insufficient drainage capacity of the existing drainage creeks and small tributaries, which are connected with the main drainage river of the Dom Yai river,
- Reverse flow of drainage discharge from the larger creeks and tributaries to the field, due to the rising water level in these creeks and tributaries.

For the drainage planning of the project, farm drains at the farm level will be provided in the areas to be irrigated, so as to meet the drainage requirement of crop diversification during the wet season. Furthermore, some connecting drainage creeks and tributaries to the main existing drainage river should be improved by means of dredging the settled soils.

1) Designed Rainfall

There exist six rainfall observation stations in and around the Lam Dom Yai basin. The following table indicates the estimated probable 1-day, 2-day, and 3-day consecutive rainfalls for return periods of 1/5 and 1/10-years.

Probable Rainfall For Drainage Study

Station	1-Day Rainfall		2-Day Rainfall		3-Day Rainfall	
	1/5	1/10	1/5	1/10	1/5	1/10
Ubon Ratchathani	133.5	154.2	167.2	191.5	194.4	219.3
Phibun Mangsahan	154.8	186.1	193.3	236.9	214.2	259.3
Det Udom	118.5	135.0	148.7	170.3	174.7	198.4
Buntarik	132.0	158.5	168.2	201.1	195.0	229.7
Kantharalak	101.1	118.8	134.7	157.3	161.9	187.2
Nam Yun	117.6	128.8	140.7	159.2	167.5	187.7

For the designed rainfall, 118.5 mm of 1-day rainfall observed at Det Udom, which corresponds to a return period of 1/5 year, is selected for the drainage study, and the following equation was adopted to analyze the hourly distribution for the selected rainfall.

$$R_t = 0.4014 \times t^{0.287} \times R_{24}$$

where; Rt : Hourly rainfall (mm)
t : Time duration (hr)
R_{24}: 24 hour rainfall (mm)

According to the application of this equation, maximum hourly rainfall is estimated at 47.6 mm/hr (see Annex F, Figure F-9).

2) Designed Drainage Modulus

The flood run-off analysis at the farm level was made applying Ekdahl's method, which is expressed as follows;

$$1/2\,(I_1 + I_2) \times \triangle t - 1/2\,(0_1 + 0_2) \times \triangle t = S_2 - S_1$$

where;

I_1 : Inflow at time t_1
I_2 : Inflow at time t_2
O_1 : Outflow at time t_1
O_2 : Outflow at time t_2
S_1 : Field storage at time t_1
S_2 : Field storage at time t_2

In the above application, the following considerations were taken into account:

- Paddy field located in a relatively flat area plays the function of storing the rain water.
- The stored water in the paddy field is discharged through a notch provided in each plot to the farm drain, which is a terminal drainage canal at the on-farm level.
- Notches and farm drains will control run-off discharge from the paddy fields to the farm drains.

Results of analysis are given in Annex F, Figure F-9, and the peak run-off discharge of q = 8.14 lit/sec/ha, was decided as drainage modulus for drainage planning in the project. This modulus will be used for planning of newly provided farm drains at the farm level. In applying the above modulus, no consideration on area-reduction factor is planned, since such newly provided farm drains cover relatively small areas of about 20 ha.

5. 6 Agricultural Development Plan

5. 6. 1 Selection of Crops

1) Wet Season Paddy

As described in paragraph 4.3.5, the wet season paddy planted and grown from May to October is the most staple crops in the Project Area. However, the natural conditions in the area frequently cause the abnormal and severe droughts at the beginning of the wet season and the period from July to August. Therefore, its yield is extremely low compared with that of other regions.

In order to prevent crop damage due to these droughts, the D-28 storage reservoir was proposed for the project. Accordingly, the water stored in the reservoir will be mainly used for irrigating the wet season paddy. In the area, the planting rate of paddy such as the improved local variety of Khao Dawk Mali 105, high yield variety of RD 6 and RD 15, and local variety are estimated at 45, 45 and 10 percent, respectively.

2) Dry Season Crops

In the dry season, irrigation water will be supplied to the benefited area of 15 percent for cropping pattern Type-I and 16 percent for Type-II. The planting of groundnut, soybean, watermelon, chilli and vegetables represented by stringbean was proposed. The standard cropping patterns are formulated, as shown below, taking into account interviews with the village chief, consultations with extension workers of Provincial and Amphoe Agricultural Extension Offices concerning soil quality, farmers' experience, agricultural policy and marketability of the crops in and around the Project Area.

3) Wet Season Vegetable (Type-II)

Improvement in productivity of paddy is a pressing need for the Project Area. Besides, crop diversification is indispensable to increase and stabilize the incomes for every farmer. Planting such crops as vegetable and fruit which have high value added and income elasticity is recommended in the Seventh National Development Plan (1992-1996). In the wet season, a portion of

irrigation water will be supplied to the vegetable area to promote the development effect. The introduced crops are really limited but crops as shown below will be selected taking into account disease and each insect damage, technical propriety and each farmer's intentions.

Type-I: For first 5 years after project implementation

Wet season	Dry season (15%)	Perennial crop
Paddy	+ Groundnut (67%) + Stringbean (3%) Soybean (22%) Chilli (1%) Watermelon(7%)	+ Mango

Type-II: For the following 45 years after Type-I

Wet season	Dry season (16%)	Perennial crop
Paddy Vegetable (Cucumber 29%) (Sweet corn 5%) (Stringbean 19%)	+ Groundnut (69%) + Stringbean (3%) Soybean (21%) Chilli (1%) Watermelon(7%)	+ Mango

Introduction of fruits represented by mango as a cash crop should be planned to increase farm incomes in the area. The proposed cropping patterns are shown in Figure 5-8 and 5-9.

5. 6. 2 Yield Projection

The target yields for the main crops is set taking into account the achievement of similar projects and the experimental results of the rice and upland crop research centers related to the Project Area. However, this yield will be attained under the conditions where the appropriate distribution and management of irrigation water, installation of terminal irrigation facilities, establishment of irrigated farming techniques, effective extension activities on guidance and technical assistance by agricultural extension services, and

FIGURE 5-8 PROPOSED CROPPING PATTERN (TYPE-I)

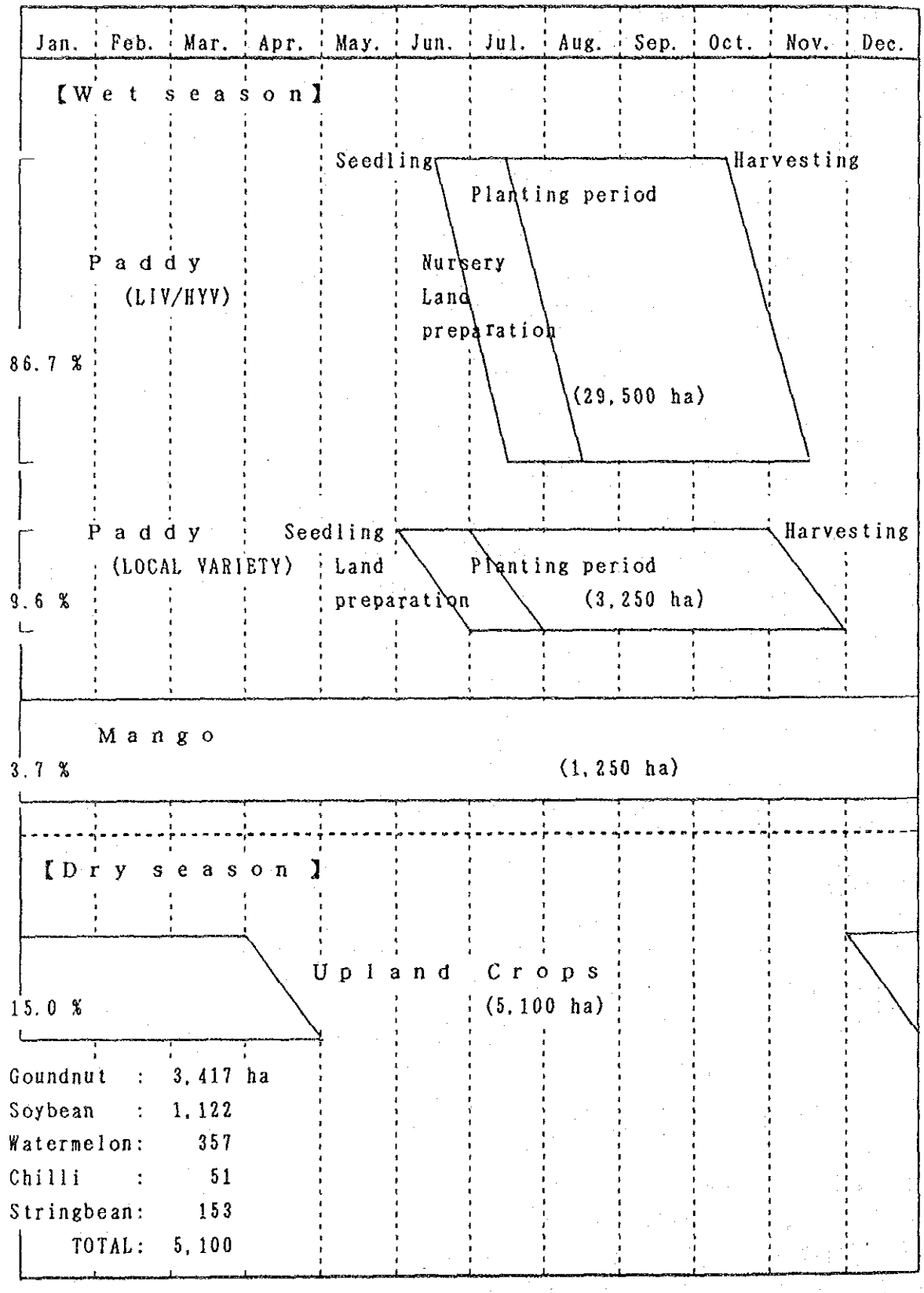
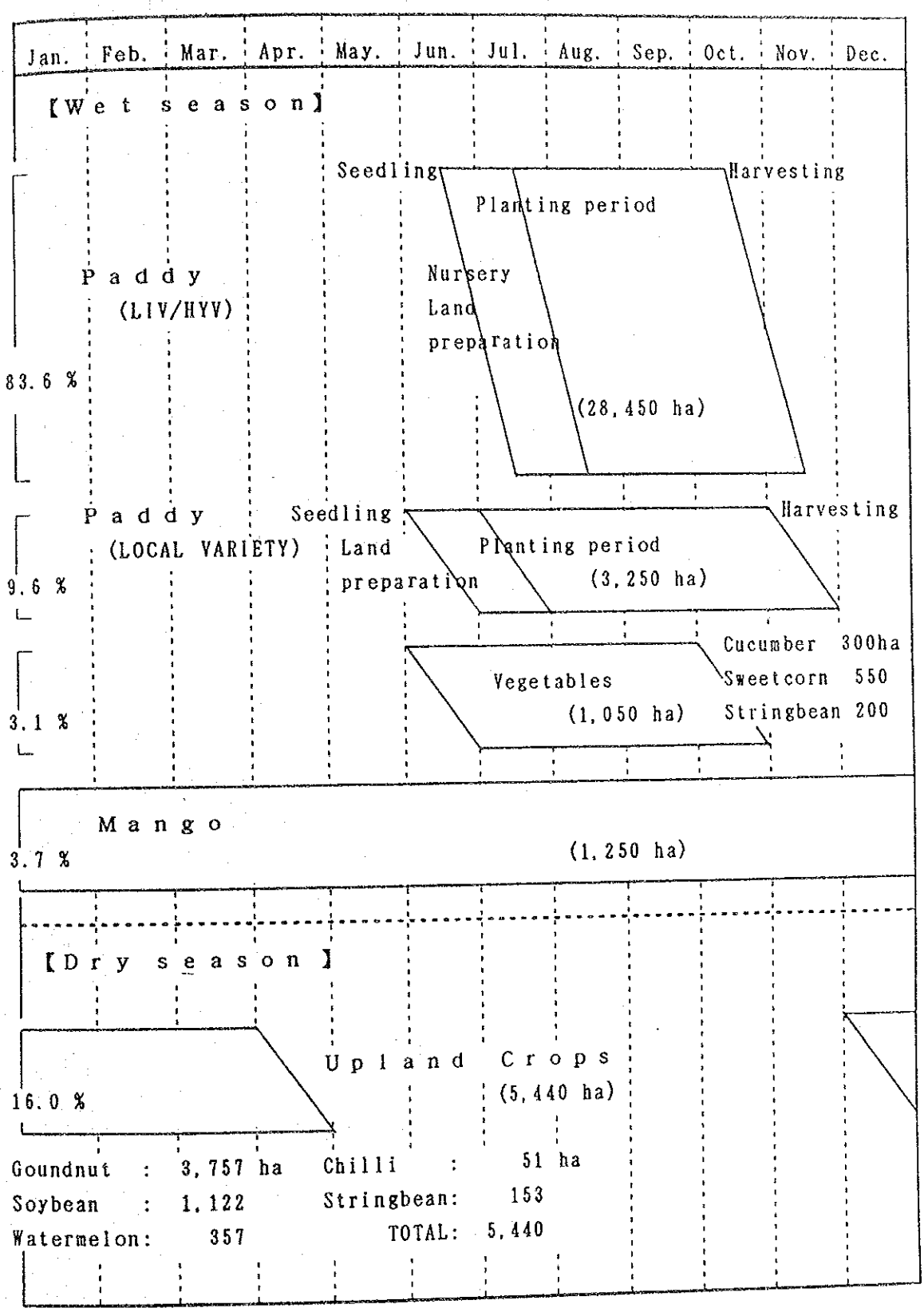


FIGURE 5-9 PROPOSED CROPPING PATTERN (TYPE-II)



agricultural financing supported by the public banking system are all fully provided.

Proposed Targeted Yield

Crop	Target Yield (kg/ha)	Target Yield (kg/rai)
Wet season paddy	3,438	550
Groundnut (*)	1,563	250
Soybean (*)	1,250	200
Watermelon (*)	25,000	4,000
Chilli (Fresh) (*)	15,625	2,500
Stringbean (*)	9,375	1,500
Mango	9,375	1,500
Cucumber (+)	15,625	2,500
Sweet Corn (+)	12,500	2,000
Stringbean (+)	9,375	1,500

Note: (*)Wet season vegetable
(+)Dry season crop
The target yield will be attained in the fifth year after completion of the project implementation.

1) Paddy

According to the Agricultural Statistics of Thailand, crop year 1989/90, average yield of paddy in Ubon Ratchathani Province was estimated at 1,300 kg/ha over the past three years (1986/87 to 1989/90). This is the lowest yield in the Northeast region. The yield of Khao Dowk Mali 105 is obtained at 3,100 kg/ha under appropriate fertilization, irrigation and pest control in the Rice Research Center. Besides, the yield survey by National Statistics Office (NSO) in 1988 reports that the yield of second rice is 3,200 kg/ha on the 185 ha of irrigated paddy field during the dry season. According to the current yield survey by quadrant sampling of Amphoe Extension Offices in Amphoe Det Udom and Phibun Mangsahan, the yields of local variety, RD 6 and Khao Dowk Mali 105 were reported to be 2,100 kg/ha, 2,400 kg/ha and 2,500 kg/ha, respectively. Hence, it is expected that the target yield will be achieved by the prerequisites mentioned above.

2) Groundnut

Groundnuts in and around the Project Area are a major crop which is expected to increase in its production since the pulse plant makes a soil productivity reinforced. For this crop, the target yield at 1,563 kg/ha is approved by the Field Crop Research Center in Amphoe Phibun Mangsahan.

3) Soybean

The planting of soybeans will contribute to the improvement of soil fertility. It is a valuable plant for food protein. Consequently, the growing of soybean is encouraged as a promotion crop by the government. Heretofore, in the Project Area, the good yields for this crop could not be obtained because of poor irrigation water supply. However, the target yield will be set at 1,250 kg/ha taking into account efficacy of irrigation.

4) Watermelon

Watermelon is presently grown as a second upland crop under rainfed conditions in the area. With an irrigation water supply, stabilized production with high yield will be expected in future. The growing as a second crop produces the prevention of damage by continuous cropping. The target yield is planned at 25,000 kg/ha.

5) Chilli

The planting of chilli needs sophisticated technique for its farming. Accordingly, this crop will be introduced to a limited area after due investigation of soil conditions. Well-qualified farming guidance for farmers is indispensable. The target yield for fresh chilli is anticipated at 15,625 kg/ha.

6) Stringbean

In the Project Area, farmers cultivate vegetables in their home gardens on a small scale for domestic consumption. Cabbage, chinese cabbage, onion, garlic, cucumber, stringbean, shallots etc. as main vegetables are grown. They are carried into the local markets by farm women. In this study,

vegetables are represented by stringbean which is widely grown in the area. The target yield is planned at 9,375 kg/ha.

7) Mango

As described in 4. 3. 5 "Agricultural Production", the fruit production area and its kinds are considerably limited in the Study Area. Mango has the largest area because of its adaptable to sandy soil. Other reasons pointed out as good factors for mango production are well drains on farms and dryness during flowering stage of January to March. Besides, mango can get marketing support service from the government and it is selected as a recommended crop in the Seventh National Development Plan.

On the other hand, the possibility of introducing tamarind has been investigated. Tamarind requires greater soil fertility than the mango. Its production districts in the area are restricted, and also it is difficult to find a market for this crop after the implementation of the project. Therefore, tamarind was judged as the second-best crop in the project. In this study, proposed fruit trees are represented by mango, and the target yield was set at 9,375 kg/ha, taking into account the present production in the area as well as achievements of similar projects.

8) Wet Season Vegetables (Type-II)

Cucumber is grown by pole culture seeding in April to June and harvesting is from June to September. This crop roots only skin-deep and its growth is damaged by high humidity. On the other hand, appropriate watering is required, because a drought also damages its growth. It is possible to produce cucumber year-around in the Project Area because of its adaptability to extreme of temperature. According to the agro-economic survey during the field study, the yield is reported to be 20,000 kg/ha during dry season on the lower right bank area. A target yield of 15,625 kg/ha will be feasible. During six to ten days after flowering, fruit makes a rapid growth, therefore, harvesting should be carried out with attention to hypertrophy.

Drought causes low quality of sweet corn and low yields before and after heading time. Systematic watering by irrigation is indispensable. According to the agro-economic survey during the wet season, the yield of sweet

corn was reported to be 25,000 kg/ha on a little area in left bank of the Project Area. The yield of 15,000 kg/ha will be feasible with the planting density 0.75 m × 0.35 m. The target yield at 12,500 kg/ha will be achieved.

Because stringbeans have adaptability to soil and temperature, it can be cultivated year-round with the irrigation water supply in the project. At present this crop is planted in the irrigable area during dry season. There are two types of variety such as dwarf and climbing. The latter variety is diffused among farmers owing to its high yield. In the project the climbing variety is expected to yield 9,375 kg/ha.

5. 6. 3 Proposed Crop Production

The proposed crop productions for each crops are as follows, in which proposed cropping intensity is 115 percent of Type-I and 116 percent of Type-II, 100 percent for the wet season and 15 or 16 percent for the dry season, respectively.

Proposed Crop Production

Crop	Planted Area		Production		Yield
	Type-I	Type-II	Type-I	Type-II	
	(ha)	(ha)	(ton)	(ton)	(kg/ha)
Wet season paddy	32,750	31,700	112,595	108,985	3,438
Groundnut (*)	3,417	3,757	5,341	5,872	1,563
Soybean (*)	1,122	1,122	1,403	1,403	1,250
Watermelon (*)	357	357	8,925	8,925	25,000
Chilli (Fresh) (*)	51	51	797	797	15,625
Stringbean (*)	153	153	1,434	1,434	9,375
Mango (*)	1,250	1,250	11,719	11,719	9,375
Cucumber (+)		300		4,688	15,625
Sweet corn (+)		550		6,875	12,500
Stringbean (+)		200		1,875	9,375
Total	39,100	39,400			

Note: (*) Dry season crops (+) Wet season vegetables

5. 6. 4 Farm Management Plan

The present farming pattern in the Project Area is characterized by single cropping of wet season paddy. Taking into account the farm size, the following proposed farming patterns are set up in the project. It seems that an

effective farm management will be realized by the introduction of farm mechanization based on power tiller. Vegetables and fruits are represented by stringbean and mango, respectively.

Small-Scale Farmers

- Average cultivated area : 2.18 ha (13.6 rai)
- Average planted area : 3.39 ha (14.9 rai)
- Cropping intensity : 109.6%
- Cropping pattern

Type-I & Type-II : Wet season paddy + Dry season crops + Fruit

Crop	(a) Planted Area	(b, c) Production	(d) Yield
	(ha)	(ton)	(kg/ha)
a. Wet season paddy	2.01	6.91	3,438
b. Chilli	0.16	2.50	15,625
c. Stringbean	0.05	0.47	9,375
d. Mango	0.17	1.59	9,375
Total	2.39		

Medium-Scale Farmers (A) (Small-medium farmers)

- Average cultivated area : 3.90 ha (24.4 rai)
- Average planted area : 4.35 ha (27.2 rai)
- Cropping intensity : 111.5%
- Cropping Pattern

Type-I : Wet season paddy + Dry season crops + Fruit

Type-II : Wet season paddy + Dry season crops + Fruit + Wet season vegetables

Crop	(a) (b, c) Planted area		(d) (e) Production		Yield
	Type-I	Type-II	Type-I	Type-II	
	(ha)	(ha)	(ton)	(ton)	(kg/ha)
a. Wet season paddy	3.73	3.57	12.82	12.27	3,438
b. Watermelon	0.40	0.40	10.00	10.00	25,000
c. Stringbean	0.05	0.05	0.47	0.47	9,375
d. Mango	0.17	0.17	1.59	1.59	9,375
e. Stringbean		0.16		1.50	9,375
Total	4.35	4.35			

Medium-Scale Farmers (B) (Large-medium farmers)

- Average cultivated area : 5.47 ha (34.2 rai)

- Average planted area : 7.53 ha (47.1 rai)
- Cropping intensity : 137.7%
- Cropping Pattern

Type-I : Wet season paddy + Dry season crops + Fruit

Type-II : Wet season paddy + Dry season crops + Fruit + Wet season vegetables

Crop	(a) Planted area Type-I (ha)	(b, c) Planted area Type-II (ha)	(d) Production Type-I (ton)	(e) Production Type-II (ton)	Yield (kg/ha)
a. Wet season paddy	5.30	4.98	18.22	17.12	3,438
b. Groundnut	2.01	2.01	3.14	3.14	1,563
c. Stringbean	0.05	0.05	0.47	0.47	9,375
d. Mango	0.17	0.17	1.59	1.59	9,375
e. Sweet corn		0.32		4.00	12,500
Total	7.53	7.53			

Large-Scale Farmers

- Average cultivated area : 7.28 ha (45.5 rai)
- Average planted area : 9.33 ha (58.3 rai)
- Cropping intensity : 128.2%
- Cropping Pattern

Type-I : Wet season paddy + Dry season crops + Fruit

Type-II : Wet season paddy + Dry season crops + Fruit + Wet season vegetables

Crop	(a) Planted area Type-I (ha)	(b, c) Planted area Type-II (ha)	(d) Production Type-I (ton)	(e) Production Type-II (ton)	Yield (kg/ha)
a. Wet seaon paddy	7.11	6.87	24.44	23.62	3,438
b. Soybean	2.00	2.00	2.50	2.50	1,250
c. Stringbean	0.05	0.05	0.47	0.47	9,375
d. Mango	0.17	0.17	1.59	1.59	9,375
e. Cucumber		0.24		3.75	15,625
Total	9.33	9.33			

The planted areas of dry season crops are allocated considering the irrigable area, labor requirement, farm income, intensity of farming and farm size. Consequently, the number of farm households and its proportion of the total beneficial farmers are as follows;

Crop	No. of Farm Households	Proportion	Crop	No. of Farm Households	Proportion
		(%)			(%)
Dry Season Crop			Wet Season Crop		
Groundnut	1,710	23.4	Sweet corn	1,720	23.6
Soybean	560	7.7	Cucumber	1,250	17.1
Watermelon	900	12.3	Stringbean	1,250	17.1
Chilli (fresh)	320	4.4	Wet season		
Stringbean	3,060	41.9	Crop		
Mango 1/	7,300	100.0			

1/ : Mango is perennial crop

5. 6. 5 Improvement Plan for Rainfed Agricultural Farming

Depending on the site conditions of the arable land, some cultivated areas will be excluded from the irrigable area in the project. The areas to be irrigated will be fixed by the physical boundary. Therefore, the following types of beneficiaries will appear among farmers;

- Whole land is included in the irrigated area.
- A part of land belongs to the irrigated area.
- Whole land remains under rainfed conditions.

In those cultivated areas to be excluded from the benefited area, the following improvements in farming methods under rainfed conditions could be established;

1) Moisture Preservation

Moisture preservation and reduction of evaporation from the soil surface are required for non-irrigated areas. Mulching by utilization of pulse plants functioning as inter-cropping with main crops (cassava and maize), will be considered. Mulching is not effective for drought but is useful for the prevention of soil erosion by heavy rain by helping the infiltration of surface water.

2) Soil Preservation

For soil preservation, it is necessary to prevent the declining of soil fertility resulting from erosion. In sloping areas, the introduction of contour farming will be recommended. In this case, paving with grasses will be required to protect the catch drain and the drainage canal. After prevention of soil erosion is realized, input of compost or green manure and introduction of pulse plants for nitrogen fixation will be conducted.

3) Green Manure Cultivation

The area covers sandy soil with poor organic substances. Under the circumstances, the principle of soil preservation for rainfed paddy field is to increase the organic matter of soil by means of green manure application.

5. 6. 6 Livestock and Freshwater Fisheries

1) Livestock

As mentioned in paragraph 4.3.6, "Animal Husbandry" the raising conditions of domestic animals in the Project Area are harsh due to high temperatures, lack of water, and disease. Having studied on the policy of livestock promotion in the Master Plan of Ubon Ratchathani prepared for the Seventh National Economic and Social Development Plan (1992-1996), the livestock promotion in the area was planned as follow;

Det Udom	:	buffalo, swine, chicken, duck
Phibun Mangsahan	:	buffalo, duck

Improvement of Breeding

In the Project Area, the lower feed intake is one of the causes of low productivity. Pasturage and animal-raising in the home garden are common. Therefore, positive feed supply will bring about an improvement in their productivity. In fact, it is essentials to make a plan for increasing the feed use of small-scale farmers through the diffusion of low price feed, grass land development and by-product usage. On the other hand, the change in farmers' attitude to health control of domestic animals will be expedited and the

guidance of animal hygiene (vaccinations) should be strengthened. Through the field activity of technicians from the livestock office, appropriate guidance on these matters for farmers is anticipated.

Introduction of Beef Cattle

The Beef Cattle Raising Promotion Project in the Northeastern region was started in 1991, and Amphoe Nam Yum was designated as one of the four project areas. The purpose of the project is the improvement of beef cattle by introduction of the Australian Brahman race. Each breeding farmer has grass land of 16 ha (100.0 rai) and over. The outline of the project is as follows;

Year	Number of Cattle introduced	Number of Farmer
1991	1,000	200
1992	500	100
1993	500	100
Total	2,000	400

In order to promote livestock in the area, the realization of new project similar to the project mentioned above is desired.

2) Freshwater Fishery

According to the Master Plan of Ubon Ratchathani Province, prepared for the Seventh National Economic and Social Development Plan (1992 - 1996), freshwater fishery is planned as follows;

Breeding location	:	Fish ponds and paddy field
Number of raising farmers	:	2,388
Total area	:	500 ha (3.1 thousand rai)
Total production	:	500 ton

In conformity to the above development plan, the fish culture will be planed at the paddy fields and village ponds provided at community center. The results of fish culture in rainfed paddy fields in and around the basin are reported as below;

North-east Rainfed Agricultural Development (NERAD) Project:

Stock rate : 9,400 fry/ha (3 - 5 cm fries)
Fish yield : 274 kg/ha (1985) (Maximum 78 kg/ha)
For explanation, see Annex H.

Sebai-Sebok Basin:
Fish yield : 618 kg/ha (1986/87)

Lam Dom Yai Basin:
Fish yield : 133 - 800 kg/ha

The fish yield at paddy fields in the basin is unstable among Amphoes, as described in 2.7.5 "Livestock and Inland Fishery". Of farmers engaged in fish culture at the paddy fields, 55 percent are concentrated in Amphoe Warin Chamrap, Det Udom and Phibun Mungsahan. The potential of fish culture in these Amphoes is relatively high.

The fish culture on rainfed paddy fields is restricted considerably by natural, land and technical conditions. In the project plan, fish culture on partial irrigated paddy fields will be planned in order to help increase farmers' protein consumption and to generate additional cash income. Many of the limiting factors under rainfed conditions can be removed by following methods.

- Increase in stock rate and control of fry loss through irrigation water supply.
- Improvement of fish culture conditions through on-farm facility development (preventing fish from escaping and injurious fish from invading).
- Increase in by-products of paddy (rice bran) with the project implementation and its use as fish feed.
- Use of animal dung for fish feed.
- Establishment of appropriate fish raising method on paddy field with the help of Ubon Ratchathani Freshwater Fish Development Center.

At present, farmers in the Project Area are interested in fish culture at paddy fields and the results are comparatively high. Hence, the stock rate and the target yield will be set at 20,000 fry/ha and 500 kg/ha, respectively. It is expected that intensive fish culture will be promoted by irrigation water

supply. Moreover, fish cultures have an effect on soil nutrient availability during the paddy grain-filling stage and reduce of some pests, diseases and weed species. The NERAD Project reported that these influences for paddy cultivation are reflected as 10 to 20 percent increase in paddy yield.

The fish culture in village ponds will be expected not only to produce more yield, but also encourage demonstration or extension effects among farmers. According to the overall basin study, the average yield among the above three Amphoes is relatively high at 2,700 kg/ha. The unit scale of ponds planned for raising fish will be small, such as 34 m × 34 m × 0.8 m. The maximum level at present, 4,053.9 kg/ha (1989) in Amphoe Warin Chamrap, will be feasible with completion of management for fish culture after implementation of the project, and the target yield will be set up at 4,000 kg/ha.

In the project plan, the freshwater fish culture in the D-28 reservoir will be planned. Since 1982, freshwater fish culture has been operated at the Sirindhorn reservoir of the Lam Dom Noi Project adjoining the Project Area. Considering the results of this operation, such species of freshwater fish as Telapia, Local carp, Common carp and Cat fish will be encouraged. Accordingly, the following production on the same level as the Lam Dom Noi Project can be expected.

Fish Catch In Sirindhorn Reservoir

Year	Fish Catch		Unit Price
	(ton)	('000 Baht)	(Baht/kg)
1982	387.6	2,626	6.8
1983	476.8	3,216	6.7
1984	697.1	5,145	7.4
1985	1,273.2	7,377	5.8
1986	562.4	3,337	5.9
1987	357.1	4,755	13.3
1988	-	-	-
1989	305.0	6,840	22.4

5. 6. 7 Supporting Services Plan

This project is a large-scale irrigation plan within the Lam Dom Yai basin, where the unfavorable area for the basic condition of farming is located. The introduction of new crops is also planned in the project. In order to achieve the aims of this project, it is requisite to provide appropriate supporting services for farmers through the improvement of the agricultural environment, including marketing, by means of the coordinated work of agencies concerned and private companies. Moreover, a change in farmers' consciousness away from their conservative views regarding the traditional farming methods should be promoted.

The following agricultural supporting services for farmers are expected.

1) Agricultural Extension Services

a) Cropping Technology of Paddy

With the implementation of the project, paddy cultivation of the Project Area will make an overall change from present rainfed cultivation to irrigated cultivation by the introduction of an organized irrigation system. In the project area, it is the first experience of irrigated paddy farming. Accordingly, technical assistance for irrigated paddy cultivation is expected to be provided by the Agricultural Extension Office. Extension workers and agents are trained in appropriate irrigation technology from RID and Ubon Ratchathani Rice Research Center, and they will transfer the results of the technology obtained to farmers.

As most of the farmers in the area have a conservative mentality and low levels in farming and education, the strengthening of technical assistance for village agents and progressive farmers will be sought, in order to carry out smoothly technical transfer to farmers .

b) Cropping Technology for New Crops

Concerning newly introduced upland crops and fruit, extension workers will be trained continuously regarding irrigated farming techniques at

the Ubon Ratchathani Field Crop Research Center. The technique obtained at the center will be transferred to farmers at the village level in the same way as paddy.

In particular, fruit growing will be under contract with private companies, supported by BAAC. Therefore, the growers will obtain the guidance for farming technique and quality control from contract companies.

c) Provision of Post-harvest Facilities and Their Operation

Post-harvest facilities will be provided at each village under the support of BAAC and the Agricultural Extension Offices. Through the provision of these facilities, farmers can avoid the disadvantages in the market of farm products by gaining an advantage over the existing marketing system. Operation of the constructed facilities and marketing of the collected farm products will be conducted by proper farmers' institutions.

d) Raising Technology of Freshwater Fisheries

Raising technology of freshwater fisheries in the dam reservoir, village ponds and paddy fields will be obtained from Ubon Ratchathani Freshwater Fish Promotion Center, Department of Fisheries. By referring to the similar irrigation projects in the Northeast region, an appropriate raising fish method will be diffused.

e) Organization of Farm Machinery and Water Users Association

The introduction of farm machinery will be accelerated by the improvement of farm income through the diversification of farming. Amphoe Agricultural Extension Office will conduct the guidance of operation and maintenance for farmers, and also request the support from Ubon Institute for Skill Development (UBISD).

The assistance and guidance of the organization and operation for water users' association will be conducted by RID Irrigation Office V.

f) Agricultural Credit

The greater portion of annual crops is actually cultivated through credit services rendered by BAAC. With the implementation of the project, the cultivated area of annual crops will increase from 34,637 ha (216.5 thousand rai) to 38,190 ha (238.7 thousand rai), and the credit to farming will also increase the demand. Farmers of the BAAC's client group organized in the area is only 28 percent of the whole farmers, therefore, organization of the group and participation of farmers will be accelerated. The credit project for small-scale and poor farmers in the Northeast region is being conducted by BAAC. Owing to the fact that small-scale and poor farmers constitute the majority in the area, financing priority will be given to them.

2) Farmers' Institutions

As stated above, the project aims to diversify the farming by the stabilized paddy cultivation and introduction of new upland crops through the provision of irrigation systems. With a view to realize the target of agricultural production on the basis of this plan, establishment of water user's association and strengthening of agricultural cooperatives and farmers' group are indispensable.

a) Water Users' Association

In order to carry out operation and maintenance of irrigation facilities, distribution of irrigation water from intake point to fields and water management, a water users' association with the participation of beneficiaries of said facilities will be established. Information on organization and administration of the association is will be given in the paragraph of 7.4 "Operation and Maintenance Plan".

b) Strengthening of Agricultural Cooperatives and Farmers' Group

Agricultural cooperatives existing in the Project Area are performing limited activities such as credit services and sales inputs. The cooperative Promotion Department (CPD) urges the establishment of a marketing center for farm products, in order to establish the priority in the markets for all the cooperatives. The establishment of a marketing center in Det Udom and Lam Dom Yai Agricultural Cooperatives is expected.

Through the strengthening the institutions by accelerating the participation of farmers' group, the formation of a wholesome rural community is encouraged. The strengthening of the institutions is a main point for the provision of post-harvest facilities and its operating system.

5. 6. 8 Processing and Marketing Plan

Processing facilities for farm products in the Project Area and its surrounding areas satisfy a need for actual crop production. Presently, the working capacity rate of a rice mill is 60 percent at the maximum, i.e. 60 tons/day. Most newly introduced crops are oil crops and the oil factories are concentrated in Bangkok and Nakhon Ratchasima. There is no plan to try to attract such agro-industry to Ubon Ratchathani Province even under the National Seventh Plan and policy. The marketing channel of oil crops as soybean does not exist. Therefore, it is desirable that the marketing system for oil crops is established at Det Udom Agricultural Cooperatives, Tambon Det Muang, under support from CPD, adjoining the area.

Concerning chilli, Amphoe Muang, Ubon Ratchathani is well-known throughout the country as a chilli production area and the marketing channel is established strongly. Processing facilities of chilli are situated in Bangkok. Chilli producers ship directly unprocessed products to factories. Accordingly, chilli introduction to the Project Area can be easily incorporated into existing market channels.

As to watermelon as newly introduced crop, Lam Dom Noi Irrigation Project Area, adjoining the area, constitutes its main production area. Accordingly, watermelon introduction to the area can be easily incorporated into existing market channels.

As to tree crops, Det Udom District Branch, BAAC has been conducting the assistance and coordination of marketing and promotion for cashew nuts and mango. Therefore, it is easy to find a market for these crops and the marketing system is in existence.

For these reasons, the processing facilities for farm products are not taken into account in the project plan. However, it will be possible to begin agro-industries when the Project Area becomes a stabilized production area.