Table VIII-30 GROSS MARGINS FOR MUNG BEANS IN BAHT PER RAI, WET SEASON IN 1984/85: TOTAL AREAS

	1 to 20 Rai	21 to 30 Rai	31 to 40 Rai	41 to 50 Rai	Over 50 Rai	Total
Number of Farms in Survey in Group	5.00	8.00	5.00	8.00	6.00	32.00
Total Area under Activity (Rai)	39.00	217.00	83.00	100.00	198.75	547.75
Number of Plots in Group	5.00	9.00	7.00	10.00	10.00	41.00
Seedings	0.00	0.00	0.00	0.00	0.00	0.00
Seed HYV	0.00	0.00	0.00	0.00	0.00	0.00
Seed Improved	11.92	3.78	12.38	2.73	0.00	4.10
Seed Local	1.42	3.43	1.27	10.20	5.31	4.88
Seed Total	13.34	7.21	13.64	12.94	5.31	8.98
Fert. 16-20-0	0.00	0.00	0.00	0.00	0.00	0.00
Fert. 20-20-0	0.00	0.00	0.00	0.00	0.00	0.00
Amm. Sulphate	0.00	0.00	0.00	0.00	0.00	0.00
Other Fers.	0.00	0.00	0.00	0.00	0.00	0.00
Fert. Total	0.00	0.00	0.00	0.00	0.00	0.00
Pesticide	46.67	34.80	13.95	43.51	15.90	27.22
Weedicide	0.00	0.00	0.00	0.00	0.00	0.00
Hormone	4.31	7.28	3.96	0.64	1.13	3.12
Total Chemicals	50.97	42.09	17.92	44.15	17.03	30.34
Water	0.00	0.00	0.00	0.00	0.00	0.00
Fuels	28.69	27.19	23.10	16.72	9.28	18.27
Lubricants	0.79	6.82	2.00	0.86	0.32	2.21
Total Fuel + Lubri.	29.49	34.01	25.10	17.58	9.60	20.48
Hired Labour	67.69	66.14	75.73	100.50	58.02	71.03
Tractor Costs Hired Machinery Input						
Small Size	8.97	0.47	14.28	10.20	37.84	18.50
Medium Size	0.00	0.00	0.00	0.00	0.00	0.00
Large Size	8.97	14.17	20.00	22.40	6.44	13.38
Total	17.95	14.65	34.28	32.60	44.28	31.88
Rented Machinery Input						
Small Size	0.00	0.00	0.00	0.00	0.00	0.00
Medium Size	0.00	0.00	0.00	0.40	0.00	0.07
Large Size	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.40	0.00	0.07
Total Tractor Costs	17.95	14.65	34.28	33.00	44.28	31.96
Hired Animal	0.00	0.00	0.00	0.00	0.00	0.00
Rented Animal	32.92	0.00	0.00	2.20	0.00	2.75
Total Cost	212.37	164.10	166.67	210.37	134.23	165.53
Production VI B	211.97	136.61	213.03	178.39	135.15	160.65
Production VI KG	81.53	52.54	81.93	68.61	51.98	61.79
Gross Margin	-0.40	-27.49	46.36	-31.98	0.92	-4.88
Owned Machinery Input - Hours Unit						
Small Size	45.90	3.72	4.94	3.71	2.18	6.35
Medium Size	0.00	0.02	0.00	0.02	0.00	0.01
Large Size	0.00	0.00	0.00	0.00	0.00	0.00
Total	45.90	3.74	4.94	3.73	2.18	6.36
Owned Animal - Manday Unit						
Owned Animal	0.00	0.00	0.00	0.00	0.00	0.00
Family and Exchange Labour Inputs in Mandays	2.66	2.74	2.55	3.42	1.08	2.23
Gross Margin per Manday						
Family Labour	-0.15	-10.05	18.18	-9.35	0.85	-2.19

Table VIII-31 GROSS MARGINS FOR MUNG BEANS IN BAHT PER RAI, DRY SEASON IN 1984/85: TOTAL AREAS

	1 to 20 Rai	21 to 30 Rai	31 to 40 Rai	41 to 50 Rai	Over 50 Rai	Total Rai
Number of Farms in Survey in Group	0.00	2.00	3.00	3.00	2.00	10.00
Total Area under Activity (Rai)	0.00	45.00	31.00	65.00	47.00	188.00
Number of Plots in Group	0.00	2.00	8.00	8.00	4.00	27.00
Seeding Rate (kgs.)						
Seedings	0.00	0.00	0.00	0.00	0.00	0.00
Seed HYV	0.00	0.00	0.00	0.00	0.00	0.00
Seed Improved	0.00	3.22	2.32	1.71	3.06	2.51
Seed Local	0.00	0.00	1.19	4.18	0.00	1.64
Seed Total	0.00	3.22	3.52	5.89	3.06	4.15
Fertilizer Rate (kgs.)						
Fert. 16-20-0	0.00	0.00	0.00	0.00	0.00	0.00
Fert. 20-20-0	0.00	0.00	0.00	0.00	0.00	0.00
Amm. Sulphate	0.00	4.44	1.61	0.00	0.00	1.33
Other Fers.	0.00	0.00	0.00	0.00	0.00	0.00
Fert. Total	0.00	4.44	1.61	0.00	0.00	1.33
Pesticide and Hormone (Baht/Rai)						
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00
Weedicide	0.00	0.00	0.00	0.00	25.53	6.38
Hormone	0.00	0.00	0.00	0.00	0.00	0.00
Total Chemicals	0.00	0.00	0.00	0.00	25.53	6.38
Water and Fuel Quantity Unit (Litres)						
Water	0.00	0.00	0.00	0.00	0.00	0.00
Fuels	0.00	0.00	0.35	1.48	0.00	0.57
Lubricants	0.00	0.00	0.00	0.04	0.00	0.01
Total Fuel + Lubri.	0.00	0.00	0.35	1.52	0.00	0.58
Hired Labour (MD)	0.00	3.24	4.84	3.65	0.93	3.07
Tractor Labour (Hours)						
Hired Machinery Input						
Small Size	0.00	0.84	1.00	0.26	0.30	0.53
Medium Size	0.00	0.00	0.00	0.00	0.00	0.00
Large Size	0.00	0.62	0.58	0.46	0.43	0.51
Total	0.00	1.47	1.58	0.72	0.72	1.04
Rented Machinery Input						
Small Size	0.00	0.00	0.00	0.00	0.00	0.00
Medium Size	0.00	0.00	0.00	0.00	0.00	0.00
Large Size	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00
Total Tractor (HR)	0.00	1.47	1.58	0.72	0.72	1.04
Hired Animal (MD)	0.00	0.00	0.00	0.00	0.00	0.00
Rented Animal (MD)	0.00	0.11	0.00	0.14	0.00	0.07
Owned Machinery Input - Hours Unit						
Small Size	0.00	0.00	0.54	2.85	0.00	1.07
Medium Size	0.00	0.00	0.00	0.00	0.00	0.00
Large Size	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.54	2.85	0.00	1.07
Owned Animal - Manday Unit						
Owned Animal	0.00	0.00	0.00	0.00	0.00	0.00
Family and Exchange Labour Inputs in Mandays	0.00	2.03	1.90	7.54	2.84	4.12
Total Mandays	0.00	5.27	6.74	11.19	3.76	7.18

Table VIII-32 LABOUR REQUIREMENTS BY CROP AND OPERATION (1/2)

(Unit: man-day/rai)

Item	Paddy in Wet Season								Paddy in Dry Season			
	Non-Irrigated Area				Irrigated Area							
	H.L/1	F.L/2	E.L/3	Total	H.L	F.L	E.L	Total	H.L	F.L	E.L	Total
Number of Farm Having		64.00				91.00				9.00		
Total Land Use in Rai		3,121.00				3,533.75				110.00		
Cropped Area in Group (Rai)		1,954.00				3,270.00				-		
By Operation												
Nursery	0.00	0.05	0.00	0.05	0.00	0.06	0.00	0.06	0.00	0.02	0.00	0.02
Land Prep.	0.00	0.08	0.00	0.08	0.00	0.25	0.00	0.26	0.00	0.91	0.00	0.91
Planting	1.39	1.14	0.82	3.36	1.83	1.21	0.69	3.73	1.53	2,45	0.00	3.98
Fertilizing	0.00	0.82	0.00	0.82	0.00	0.69	0.00	0.69	0.00	0.00	0.00	0.00
Hormone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pest Control	0.01	0.02	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.01	0.00	0.01
Weeding	0.03	0.13	0.00	0.16	0.00	0.20	0.00	0.20	0.00	0.04	0.00	0.04
Watering	0.00	0.33	0.00	0.33	0.00	0.52	0.00	0.52	0.00	0.29	0.00	0.29
Soil Breaking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Harvesting	1.04	1.15	1.12	3.31	2.85	1.14	1.02	5.01	2.71	1.19	0.10	4.00
Threshing	0.02	0.08	0.12	0.22	0.04	0.10	0.24	0.39	0.14	0.11	0.20	0.45
Winnowing	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.10	0.01	0.11	0.01	0.12	0.03	0.16	0.09	0.05	0.07	0.21
Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sell at Field	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sell at Home	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sell at Market	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	2.50	3.15	2.08	7.73	4.75	3.70	1.99	10.44	4.47	3.07	0.38	9.92

Note: /1: Hired labor
/2: Family labor
/3: Exchange labor

Table VIII-32 LABOUR REQUIREMENTS BY CROP AND OPERATION (2/2)

(Unit: man-day/rai)

Items	Mungbeans (In Dry Season)				Maize (In Wet Season)			
	H.L/1	F.L/2	E.L/3	Total	H.L	F.L	E.L	Total
Number of Farm Having		33.00				8.00		
Total Area Operated for in Group (Rai)		559.75				100.00		
By Operation								
Nursery	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Land Prep.	0.00	0.02	0.00	0.02	0.00	1.00	0.00	0.19
Planting	0.00	0.24	0.00	0.24	1.26	0.26	0.00	1.14
Fertilizing	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.14
Hormone	0.00	0.06	0.00	0.06	0.00	0.00	0.00	0.00
Pest Control	0.00	0.21	0.00	0.21	0.00	0.01	0.00	0.00
Weeding	0.00	0.08	0.00	0.08	0.00	0.04	0.00	3.13
Watering	0.00	0.05	0.00	0.05	0.00	0.32	0.00	0.00
Soil Breaking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harvesting	1.60	1.12	0.14	2.86	2.61	1.23	0.10	2.23
Threshing	0.01	0.10	0.06	0.17	0.15	0.08	0.22	0.33
Winnowing	0.00	0.03	0.01	0.04	0.00	0.00	0.00	0.03
Hauling	0.01	0.06	0.00	0.07	0.10	0.05	0.08	0.02
Transportation	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01
Sell at Field	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Sell at Home	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sell at Market	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.06
Total	1.62	2.00	0.23	3.85	4.12	3.01	0.40	7.18

Note: /1: Hired labor
/2: Family labor
/3: Exchange labor

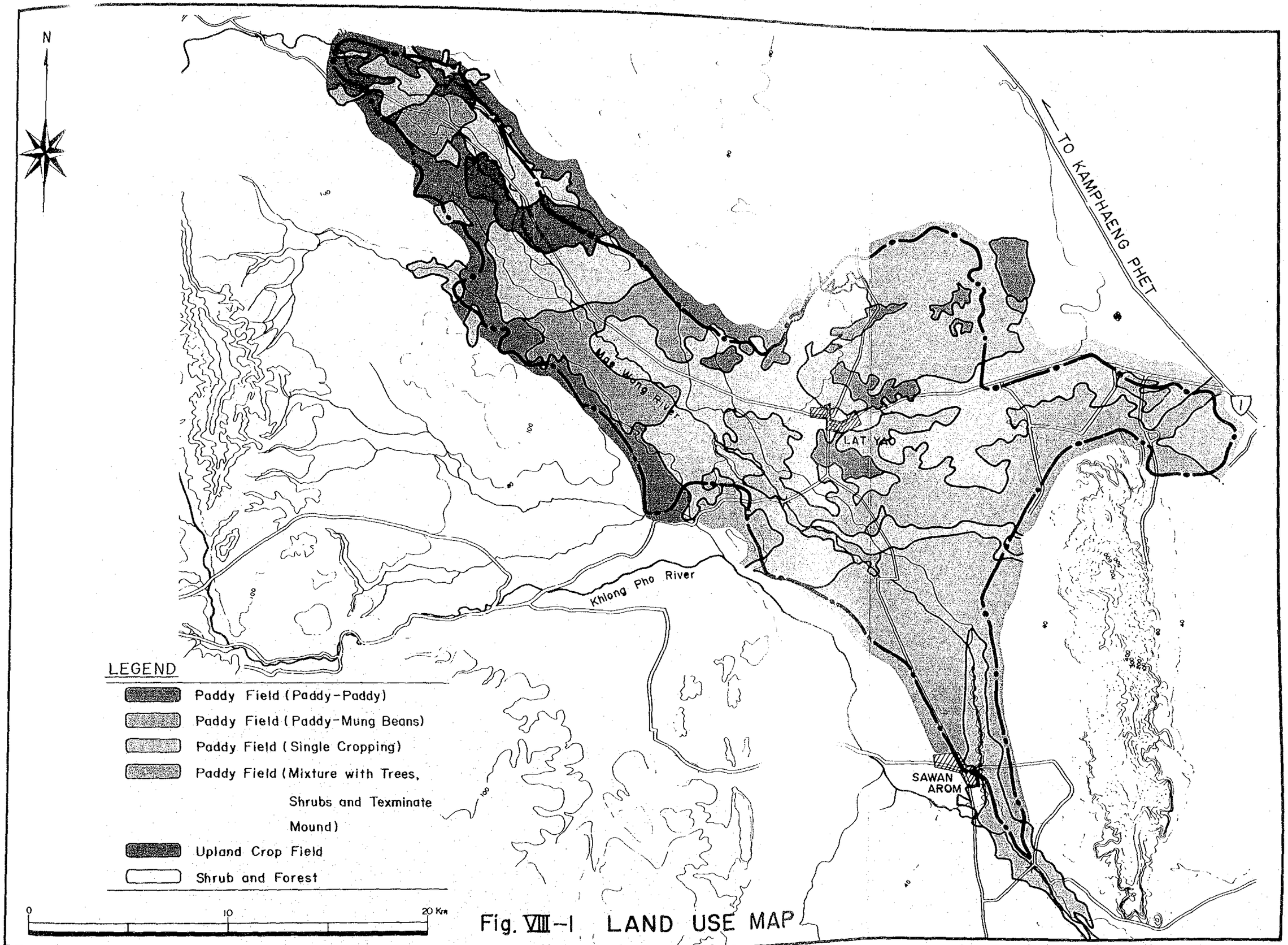


Fig. VIII-1 LAND USE MAP

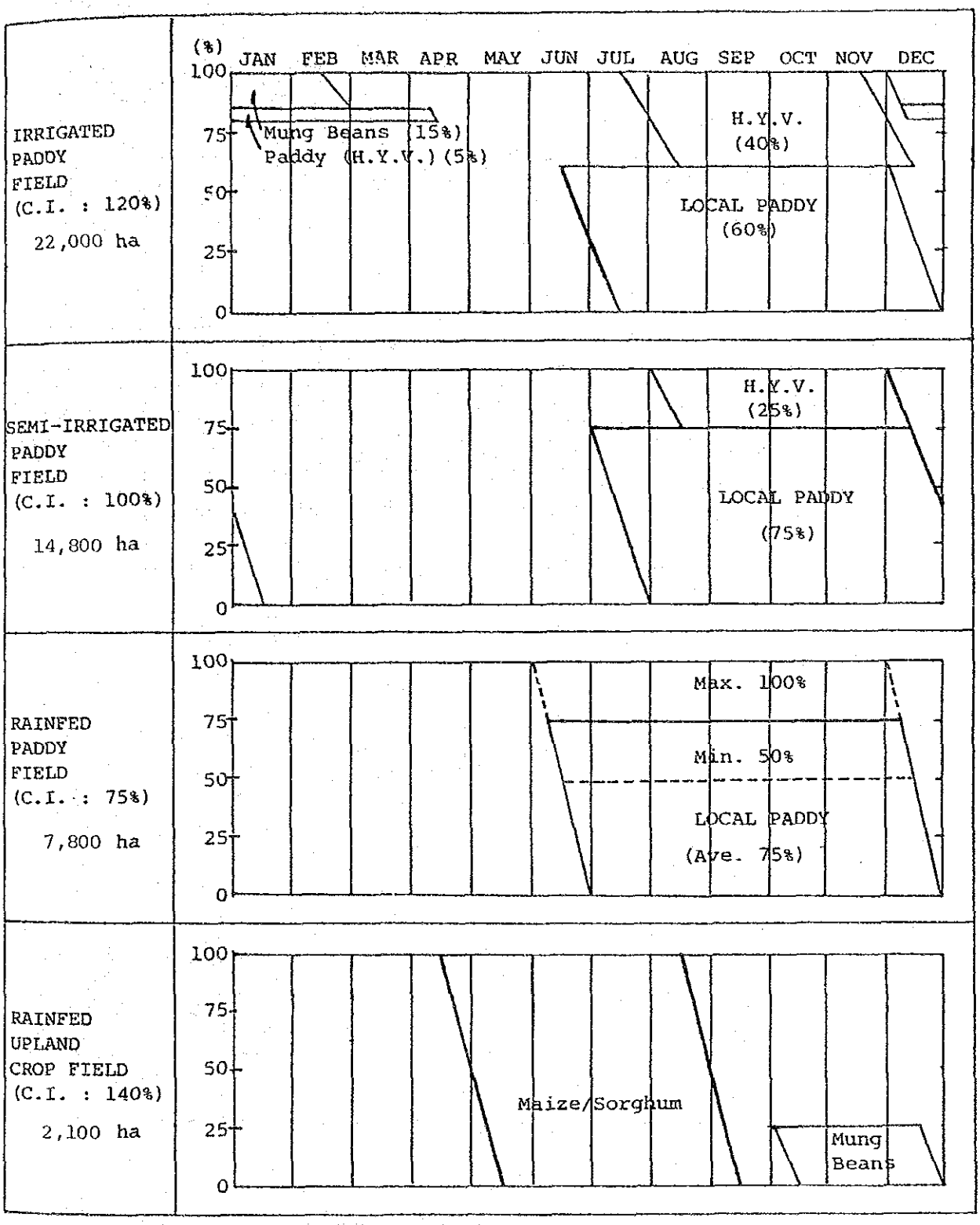
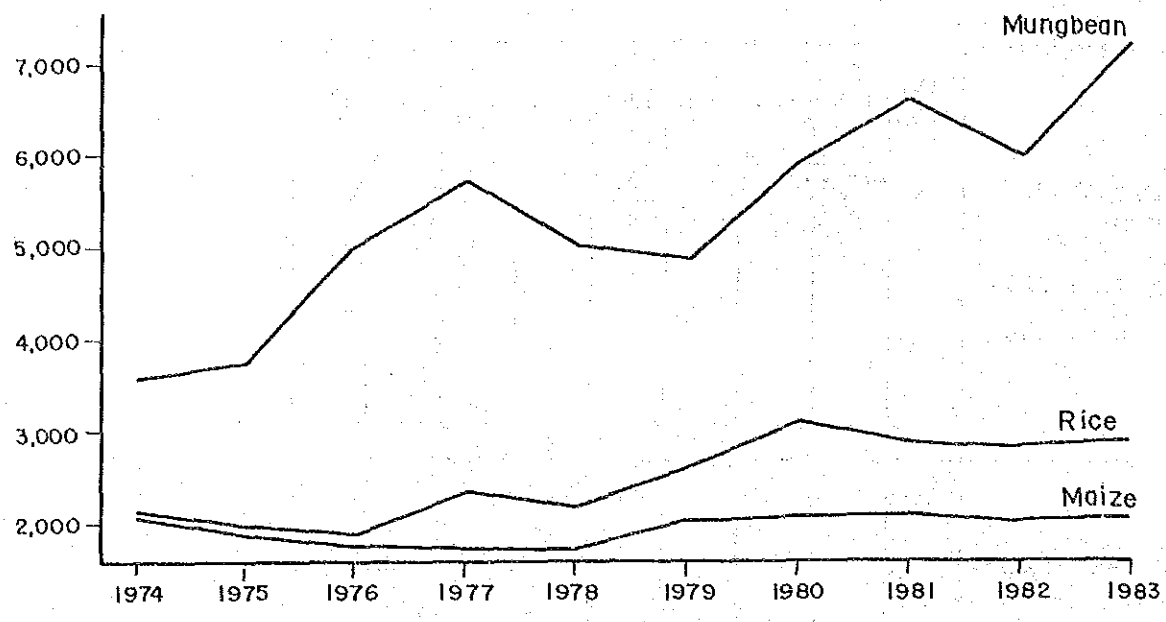
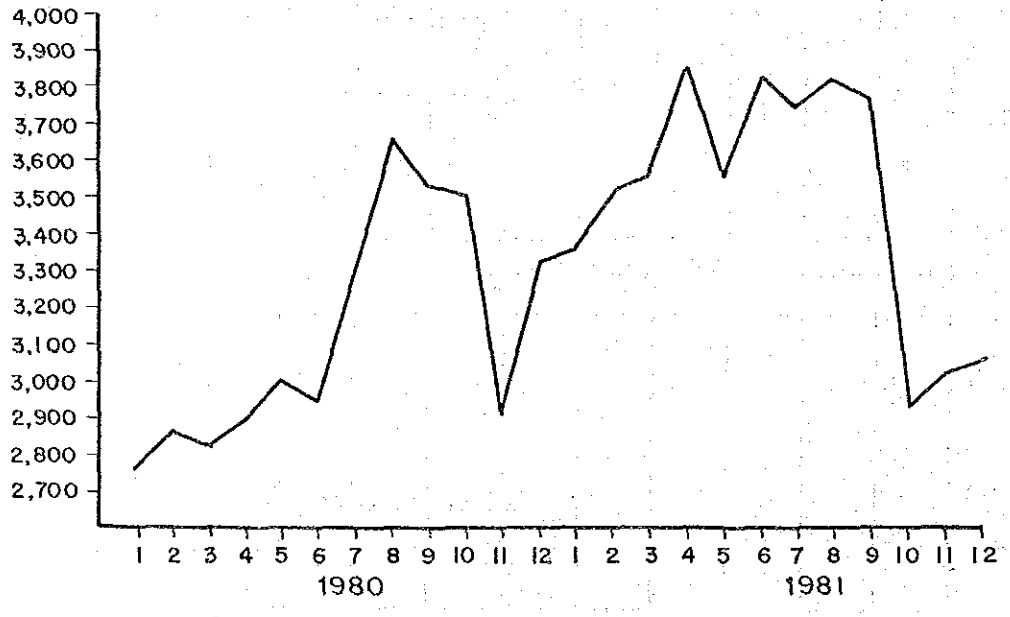


Fig. VIII-2 Present Cropping Pattern



Source ;
Agricultural Statistic of Thiland 1983/84, MOAC

Fig. VIII-3 Trend of Farm Price Average for Major Crops



Source ;
Office of Agricultural Economic, MOAC

Fig. VIII-4 Seasonal Fluctuation in Farm Price of Rice
(Firet Grade Rice, at Nakhon Sawan)

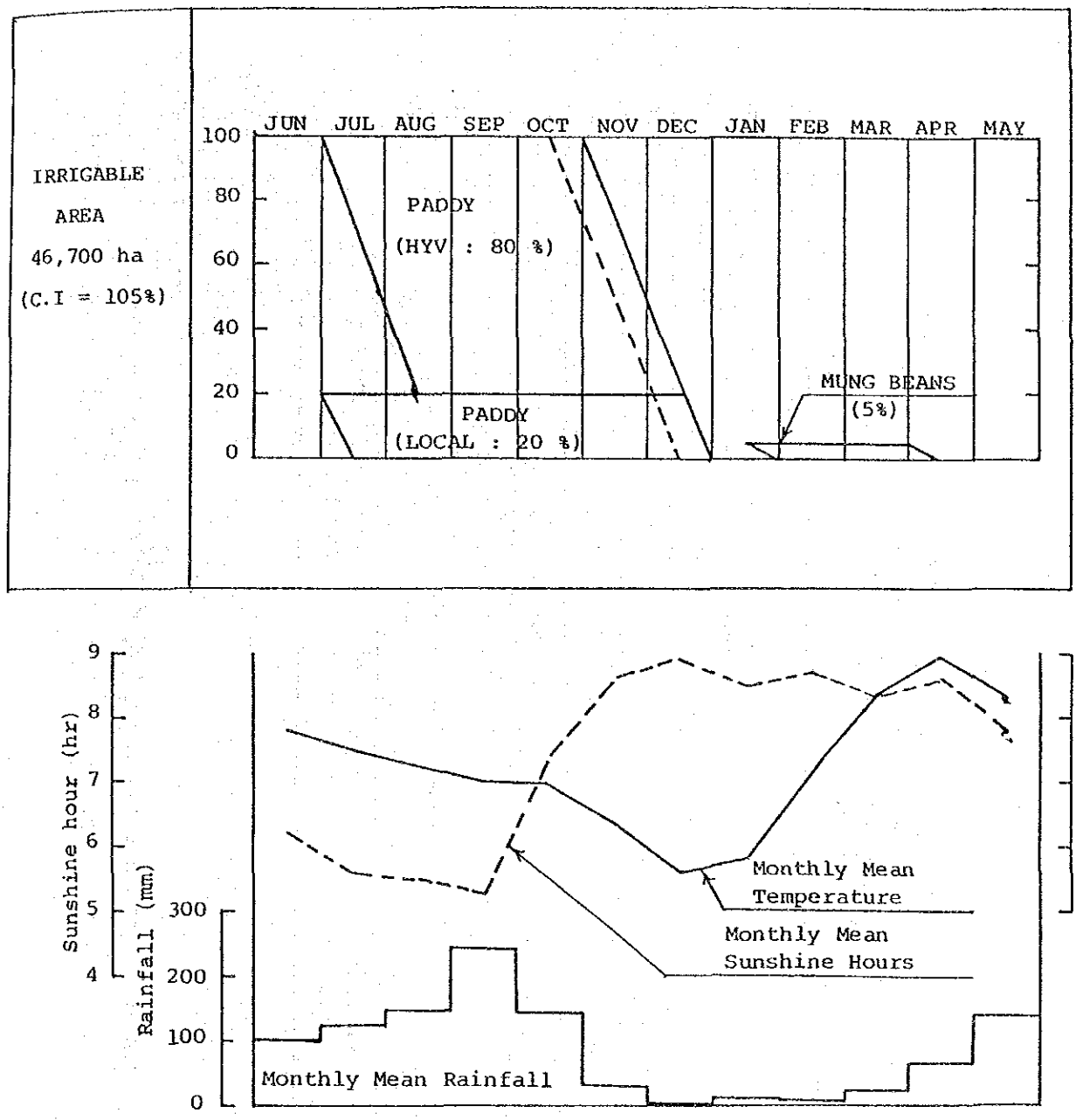


Fig. VIII-5 Proposed Cropping Pattern

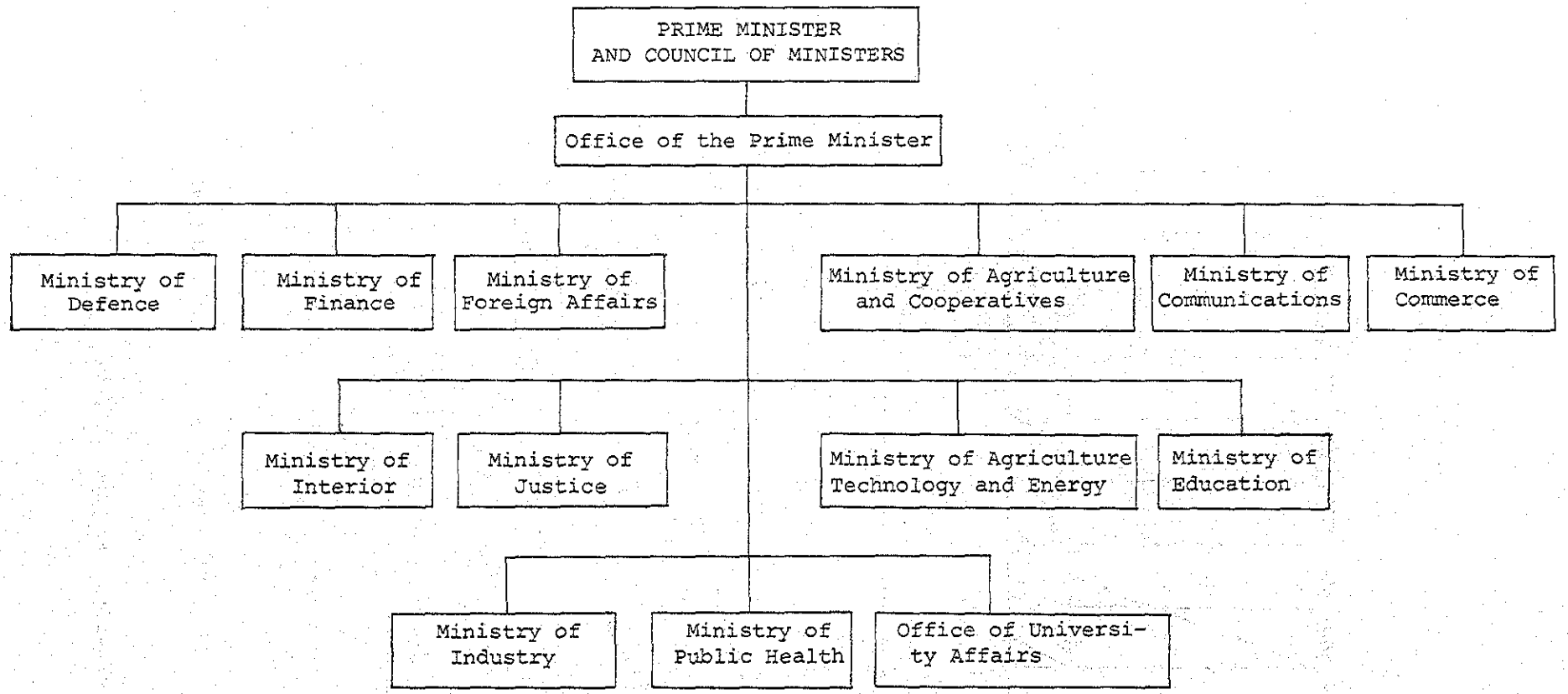
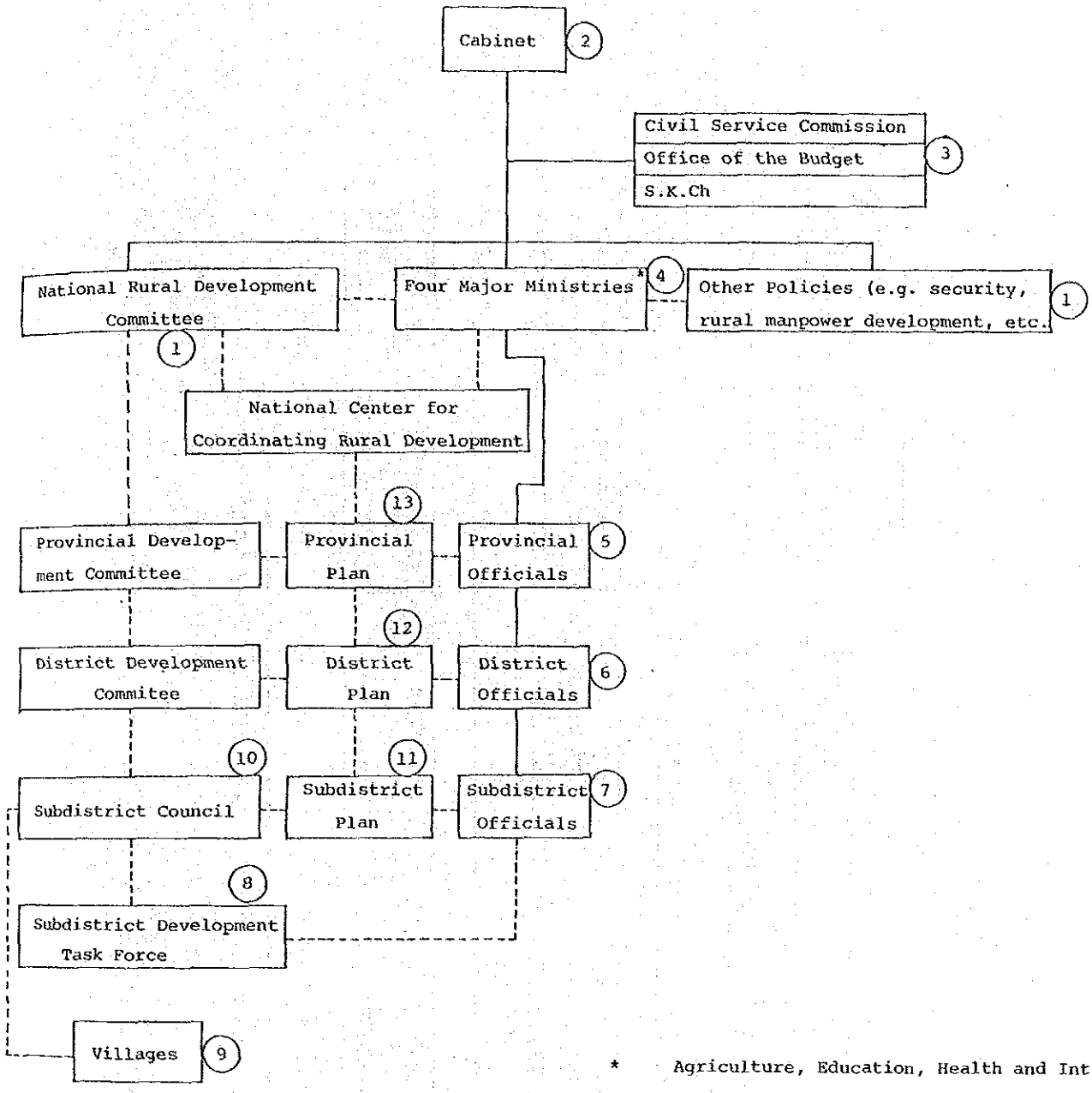


Fig. VIII-6 Organization of Royal Thai Government Ministries



Source: NESDB : Handbook Rural Development Administration System National Center for Coordination of Rural Development, Bangkok, (printed for 1984 planning year).

Fig. VIII-7 Work Flow According to the National Rural Development Committee's New Rural Development System

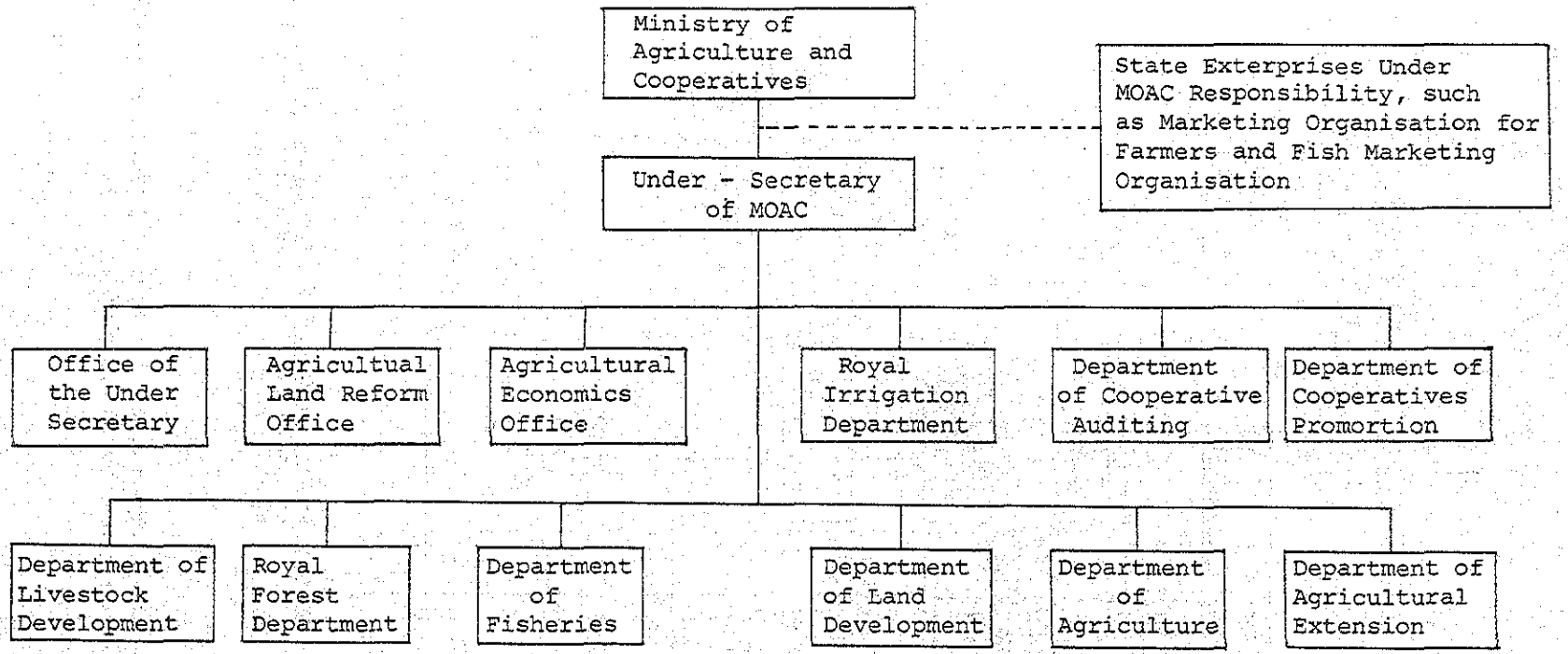


Fig. VIII-8 Organization of the Ministry of Agriculture Cooperatives

Organization

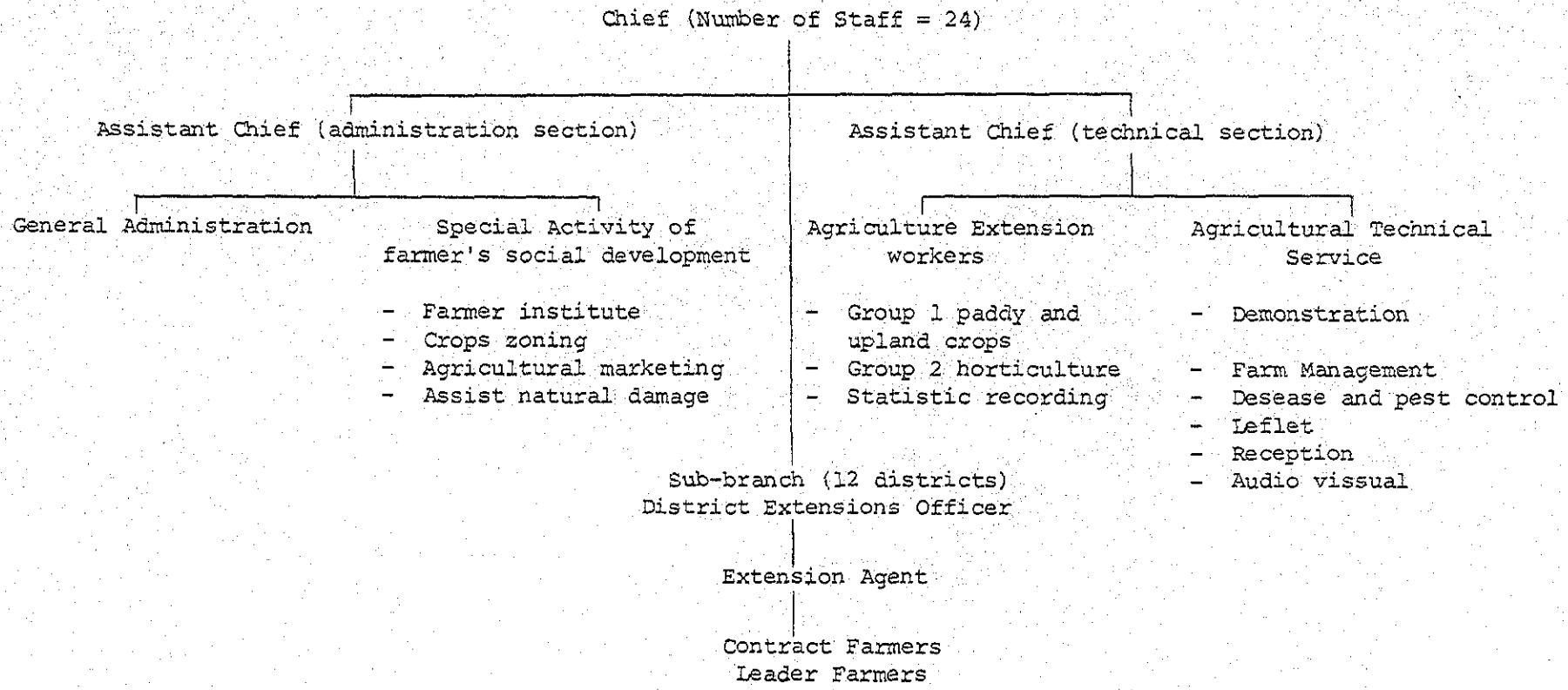


Fig. VIII-9 Nakhon Sawan Provincial Agricultural Office
Department of Agricultural Extension (DAE), MOAC

ANNEX–IX
CONSTRUCTION PLAN AND COST ESTIMATE

ANNEX - IX

CONSTRUCTION PLAN AND COST ESTIMATE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX - IX

CONSTRUCTION PLAN AND COST ESTIMATE

1. CONSTRUCTION PLAN

1.1 Basic Assumption of Construction Planning

1.1.1 Workable days

As for the normal works such as concrete works, foundation treatment works, construction works for irrigation facilities, etc., 25 days per month are applied from the standard construction workable days stipulated by RID.

On the other hand, suspension of construction works for dam embankment is usually caused by heavy rainfall which affects on a moisture control of impervious materials.

Suspension of these earth works would be assumed as following criteria which is modified from Japanese criteria taking account of meteolorogical conditions in Thailand.

Daily Rainfall Intensity	Suspension of Work
0 to 10 mm	0 day
10 to 30 mm	1 day
30 to 50 mm	2 days
50 to 100 mm	3 days
more than 100	4 days

Monthly and annual mean suspension days are estimated on the basis of the above criteria and the daily rainfall records in Pangmakha (Cord No. 12081) for recent 13 years, and the computed result is shown in Table IX-1.

The result of workable days shows that less than 25 days of the standard workable days concentrate in the wet season from May to October. Therefore, workable days for imprevious materials were decided to be computed days in wet season and 25 days in dry season, and total 286 days in a year shown as below:

Workable Days

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
General Works	25	25	25	25	25	25	25	25	25	25	25	25	300
Impervious Material	25	23	24	25	23	17	24	25	25	25	25	25	286

1.1.2 Definition of earth material

The abbreviation of earth materials on the construction plan would be correlated with the geological definition as given in the table below:

Earth Materials of the Construction Plan	Abbrevi-ation	Geological Definition
Sand, Filter, Drain	S	Sand, Gravel
Common soil, Top Soil	C/S, T/S	Talus deposit De-composed Granite
Gravel & Weathered Rock	G, W/R	Weathered Granite Group Weathered Green Rock
Excavated Rock	R	Green Rock*, Granite Group

Note: *: Quartzite, Calc-silicate, Schist

1.1.3 Conversion rate of earth materials

Earth volume should be counted according to their status. Earth materials naturally placed as they are, increase in volume after excavation and decrease after compaction. These changes in volume should be counted for the estimation of earth work capacity by construction equipment.

The conversion rate of earth volume is assumed as follows:

Earth Materials	Status of Material		
	In Place	Excavated	Compacted
S	1.00	1.20	0.95
C/S, T/S	1.00	1.25	0.90
G, W/R	1.00	1.20	1.00
R	1.00	1.60	1.30

1.1.4 Basic method of earth works

Earth works consist of excavating, loading, hauling, spreading and compacting. Since there are various methods for these earth works, due consideration must be made on the choice of the suitable method. Earth works of the big volumes would be depended on a heavy duty equipment.

Following equipments would be basically introduced on these earth works of the Project.

Earth Works	Earth Materials	Proposed Equipments
Eacavation	Sand, Common Soil, Gravel	Bulldozer, Back-hoe Shovel
	Weathered Rock	Ripper dozer, Back-hoe Shovel
	Rock	Blasting & Bulldozer
Loading	Any kind of Excavated Materials	Tractor Shovel, Back-hoe Shovel
Hauling	Any kind of Excavated Materials	Dump Truck
Spreading	Any kind of Excavated Materials	Bulldozer
Compacting	Impervious Materials	Tamping Roller
	Coarse Materials	Vibration-Roller, Tire-Roller
	Common Soil	Compactor, Tamper

1.2 Dam Construction

1.2.1 Earth moving plan

Materials for core zone is to be obtained from the borrow area after stockpiling for moisture control. The location of the borrow area is downstream right side terrace about 2 km from the damsite.

Semi-pervious materials will be mainly obtained from the borrow area located at about 2 km upstream and also supplied by the excavated common soil from service spillway, emergency spillway and diversion canal.

Rock materials are obtained from the service spillway and emergency spillway. In case of lack of those rock materials, supplemental rocks around the emergency spillway can be adoptable as a quarry site.

Common soils, weathered rocks and small size of rocks will mainly be obtained from the excavated materials at the service spillway and emergency spillway.

Filter and drain materials will be obtained from muck of diversion tunnel and river sand.

Taking into account these available materials, conversion rate of earth, most economical construction method, etc., the earth moving plan for the dam is confirmed as shown in Table IX-2.

1.2.2 Construction procedure of the dam

After the preparatory works such as access roads, office yard, motor pools, etc., the dam construction works will be commenced from the beginning of dry season. As the dam length is as wide as 400 m and the river width becomes very small about 20 m to 30 m during dry season, the excavation works of dam foundation, river diversion canal and diversion tunnel can be progressed almost in parallel. Foundation treatment should be made from riverbed in order to enable earlier dam embankment works and remaining both sides treatment works might be gradually carried out prior to the dam embankment. Excavation of spillway would be executed in parallel with the dam embankment, because the useful excavated materials are planned to haul directly to the dam, and concrete works would be carried out after completion of the excavation. Construction of intake facilities could be carried out on a proper occasion without relation to the dam construction. After completion of those major works, plug works of diversion tunnel would be executed.

1.2.3 Construction method

(1) Diversion tunnel

As a diameter of the tunnel is rather big, excavation works would be divided into two sections of upward and downward. Excavation of upper section would be executed by blasting and picking, and excavated materials would be gathered by bulldozer, loaded by side dump loader and hauled by dump truck. Concrete lining of upper section would be executed by using steel form after completion of the excavation. Excavation and concrete lining of down section would be proceeded after completion of above upper section of concrete lining.

(2) Excavation of dam foundation

Stripping and normal soil excavation would be mainly made by bulldozer and back-hoe shovel, while weathered rock would be excavated by ripper dozer. Rock materials would be broken by blasting and gathered by bulldozer.

A part of excavated weathered rock and rock would be directly spread by bulldozer to dam for embankment materials following to the earth moving plan, and remaining materials would be hauled by dump truck to the soil area.

(3) Foundation treatment

After excavation of the dam core trench, curtain grouting would be executed. After completion of grout hole drilling by hydraulic boring machines, cement milk mixed by mortal mixer would be poured into the holes under the controlled pressure by grouting pump. For making sure the grouting condition, test hole would be drilled and grouting efficiency would be checked by observation of the lifted core. If non-effective condition is observed, supplemental grouting around there is required.

(4) Embankment

According to the earth moving plan estimated in Table IX-2, embankment materials to be transported from the proposed areas would be spread by bulldozer at the specified thickness and compacted by suitable compacting machines. The specified thickness of spreading, numbers of compaction runs and suitable compacting machines are proposed as follows:

Zone	Thickness of Spreading (cm)	Compaction (runs)	Compaction Machine
Core Zone	20	6	Tamping Roller
Filter & Drain	30	3	Vibration Roller
Semi-pervious Zone	25	6	Tire Roller
Transition Zone	50	4	Vibration Roller
Rock Zone	100	0	Bulldozer

Impervious materials of core zone would be strictly controlled by the D-value, therefore, stock-piling of eacavated materials from borrow area is required for pre-controlling of moisture content. Other materials would be supervised by the relation between minimum and maximum dry density. The water contents of compacted materials would be checked throughout the construction period and in case of a low water content ratio, some amount of water would be added to the materials by tank lorry so as to approximate the optimum water content.

(5) Construction of spillway

After completion of excavation works of spillway following to the earth moving schedule for dam embankment, concrete works would be commenced.

Fine aggregate of concrete could be supplied from river sand. No coarse materials could be found in and around the damsite as a result of geological survey. As considerable big amount of coarse materials would be required for concrete of the spillway, continuous and constant supply of the materials from market would be unexpected. Therefore, it is planned that the materials would be produced by aggregate production plant installed at the quarry site near the emergency spillway.

Concrete would be mixed by fully automatic batching plant and placed mainly by concrete pump and supplementally by manpower.

(6) Construction of intake facility

Before completion of dam construction, concrete works of intake structure would be executed in parallel with the construction of spillway by same method.

Outlet steel pipe of 3 m diameter in diversion tunnel would be set up on the suddle concrete by using trolley and jack, and concreted to the anchor bar by welding. Joint of pipes would be made by welding from both inside and outside.

(7) Plug works

After completion of intake facilities, plug works would be made. After closing slide gate of inlet, plug concrete of inlet would be placed immediately by concrete pump.

Main plug concrete located in the center of tunnel would be placed by same method from downstream side.

1.2.4 Major temporary works

(1) Concrete batching plant

Specification of the batching plant is proposed as follows, taking into account of the proposed quantity and placement plan of concrete for the relevant structures.

Fully Automatic Batching Plant	($0.7m^3$ mixer x 2 sets)	1 set
Cement Silo	(200 tons)	1 set
Belt Conneyor	(L = 80 m)	1 set
Belt Conveyor	(L = 20 m)	1 set
Screw Conveyor	(L = 10 m)	1 set
Backet Elevator	(L = 25 m)	1 set
Stock Bin for Sand and Aggregate		3 sets
Agitator Truck	($3.2 m^3$)	5 sets

The plant can produce 150 m^3/day of concrete. This arrangement is illustrated in Fig. IX-1.

(2) Aggregate production plant

Around 70,000 tons of aggregate would be required for concrete placing of spillway and intake facility within one year. Therefore, taking conservative measurement, 400 ton/day of the plant production would be required.

Specification of the aggregate production plant is proposed as follows:

1.	Grizzly Hopper	1 set
2.	Apron Feeder, heavy duty type	1 set
3.	First Joe Crasher	1 set
4.	Second Joe Crasher	1 set
5.	Hydro Cone Crasher	1 set

6.	First Ripple Flow Screen	1 set
7.	Second Ripple Flow Screen	1 set
8.	Belt Conveyor	6 sets
9.	Water Pump and Others	L.S.

Flow chart of the aggregate production plant is illustrated in Fig. IX-2.

(3) Electric power station

Concrete plant and aggregate production plant would require about 400 kW in total of electricity.

Taking into account of a poor supply condition of electricity at the site, electric power station would be installed and two sets of diesel generators which can produce 500 kVA of electricity would be required.

(4) Muddy water treatment

When the river water would become muddy during construction by excavation of dam foundation, foundation treatment of curtain grouting and so on, construction of reservoir which can store the muddy water would be required at the certain downstream of damsite.

1.3 Construction of irrigation facilities

1.3.1 Canal construction

(1) Earth works

Stripping and surface excavation of the main canals and laterals would be mainly made by bulldozer, and sub-surface and deep excavation, by back-hoe shovel depending on the soil condition at the working site. Weathered rocks, which are hard and beyond capacity of back-hoe shovel, would be excavated by pick-hummer. Manpower would contribute to the sub-lateral canals construction, face smoothing, compacting of canal invert and other lateral works.

The excavated materials excessive of filling requirement would be transported to a spoil area. In case of lacking the materials for filling, the materials would be supplemented from borrow area selected around the working site.

Spreading of filling materials would be mainly made by bulldozer and supplementally by manpower. Materials for laterite pavement would be transported from a borrow area, spread by bulldozer, and compacted by tire roller.

(2) Concrete lining

A part of proposed main canals and laterals in the Khlong Saingu irrigation area would be lined with 10 cm thick concrete. After completion of earth works, concrete lining works would be started. Concrete would be produced by portable concrete mixer, and placed by manpower.

Simple sliding concrete form removed by manpower would be used for the lining. Three or four sets of the slide forms would be required for making continuous lining works every day.

1.3.2 Intake weir

The construction works of intake weir would be mainly executed during dry season in due consideration of magnitude of flooding in the river.

And, furthermore, the construction of the weir would be executed by dividing into two portions, i.e., scoring sluice portion and weir body portions, and the former would be done prior to the latter taking account of the diversion of river flow during the construction.

A cofferdam would be also mounted with riverbed materials to enclose the under constructed portion.

Excavation works of the site surrounded by the cofferdam would be mainly made by back-hoe shovel and supplementally by manpower, and excavated excess materials would be hauled to a spoil area.

Concrete would be produced by several number of portable concrete mixers and placed using backet hanged by truck-crane.

1.3.3 Related structures

Minor works of related structures such as turnout, culvert, cross drain, and so on would be mainly executed by manpower using portable concrete mixer.

1.4 Implementation Schedule

The project implementation schedule is shown in Fig. IX-3. The first two years would be necessary time for preparation of tendering, survey and mapping works, detailed design works, mobilization, and construction of offices and quarters. The actual construction works would be commenced from the third year. Dam construction including diversion tunnel, foundation treatment, spillway and intake facility will need five years in total. In this schedule, dam embankment would be started from the fourth year after excavation and completed at the middle of the seventh year.

After completion of dam construction, about six months would be required for plug works of diversion tunnel and minor works such as pavement of dam crest, set up of guard rail, construction of operation house, cleaning works of site and so on.

2. COST ESTIMATE

2.1 Basic Assumptions

The construction cost is estimated based on the following conditions.

(1) The unit prices are analyzed in constant mid-1985 current price basis prior to cost estimate.

(2) The exchange rate used in the estimate is shown as follows:

US$1.0 = ฿27 = ¥240

(3) Construction works would be executed by full contract basis. The machinery and equipment required for construction works would be provided by the contractors themselves. Threfore, depreciation costs of machinery and equipment are considered in the estimate of the construction unit cost.

(4) Taxes on the construction materials, machinery and equipment to be imported from abroad are excluded in the cost estimate.

(5) The construction cost integrated by unit costs is divided into foreign and local currency portions. Local currency portion is estimated on the basis of the current price in Nakhon Sawan in August 1985 and of the data cojlected from the on-going projects around the project area. Foreign currency portion is estimated based on the CIF prices at Bangkok.

Labour and material costs surveyed and those classifications of foreign and local portions are shown in Table IX-3 and Table IX-4.

(6) The physical contingency, 10% of direct construction of cost is included in the construction cost in view of preliminary nature of the estimate.

(7) Price contingency is also taken into account at an annual escalation rate of 5% for foreign currency portion and 7% for local currency portion.

(8) The associated costs to be financed by the Government, such as the costs for strengthening the extension services, facilities of the water user's association, and improvement of the social infrastructures are not included in the estimate.

2.2 Financial Construction Cost

Financial construction cost comprises direct construction cost, land acquisition, resettlement, compensation, O & M equipment, administration, engineering services, physical contingency and price contingency. The direct construction cost consists of construction costs of dam, irrigation facilities and office and quarters, including contractor's profit, overhead and taxes.

The total construction costs of the project are estimated at 3,001.9 million Baht, comprising 1,038.0 million Baht (34.6% equivalence of the total construction cost) of local currency portion and 1,963.9 million Baht (65.4% equivalence of the total construction cost) of foreign currency portion. The summary of the construction cost are shown in Table IX-5.

The breakdown of the cost estimate is shown in Table IX-6 through Table IX-11.

2.3 Annual Disbursement Schedule

The annual disbursement schedule is worked out based on the construction implementation schedule. The details are stated in Table IX-12.

2.4 Annual Operation and Maintenance Costs

The annual operation and maintenance costs including the salaries of project administration and water control staffs, the materials and labour costs for repair and maintenance of O & M equipment, and running cost of project facilities. The annual operation and maintenance costs are estimated at 32.0 million Baht (Tables IX-13, IX-14).

2.5 Replacement Cost

Some of the facilities, especially mechanical works have shorter useful life than the civil works and require replacement at a certain time within the project useful life. The Table IX-15 shows the useful life and replacement cost of the mechanical works.

Table IX-1 SUSPENSION & WORKABLE DAYS BY RAINFALL INTENSITY FOR IMPERVIOUS MATERIALS OF DAM

Year	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	Total
1970	4	12	8	9	14	13	11	0	1	0	0	2	74
1971	4	10	4	2	10	11	4	0	0	0	0	0	45
1972	1	8	7	0	6	9	11	2	1	0	0	4	49
1973	2	17	9	6	1	13	5	0	0	0	0	6	59
1974	5	7	4	8	6	19	14	3	0	5	2	4	77
1975	2	7	5	9	10	12	10	3	0	0	1	1	60
1976	1	10	4	2	9	13	7	3	0	0	0	0	49
1977	5	5	2	3	5	9	3	0	1	0	1	0	34
1978	3	8	5	9	8	13	7	0	0	0	0	0	53
1979	2	6	8	4	4	16	1	0	0	0	0	1	42
1980	4	3	9	7	10	15	8	0	0	0	0	0	56
1981	3	3	5	4	10	7	5	6	0	0	0	0	43
1982	0	8	4	8	5	15	7	0	0	1	0	1	49
Total	36	104	74	71	98	165	93	17	3	6	4	19	690
Mean Suspension	3	8	6	6	8	13	7	1	0	1	0	2	55
Workable Day	27	23	24	25	23	17	24	29	31	30	28	29	310

Table IX-2 EARTH MOVING PLAN OF UPPER MAE WONG DAM

EXCAVATION \ EMBANKMENT AND BACKFILL			D A M					DIVERSION DAM				SERVICE SPILLWAY	EMERGENCY SPILLWAY	SPOIL AREA	REMARKS
			CORE	FILTER & DRAIN	SEMI-RERVIOUS	TRANSITION	ROCK	CORE	FILTER	ROCK	RIPRAP	BACKFILL	BACKFILL		
			(360,300)	(213,200)	(493,500)	(630,600)	(857,500)	(19,800)	(16,300)	(51,100)	(3,000)	(16,600)	-	452,100	
D A M	T/S	104,300													
	C/S	14,000												118,300	
	W/R	14,000				14,000 (14,000)									
	R	42,200				42,200 (54,900)									
DIVERSION DAM	T/S C/S.	14,600												14,600	
SERVICE SPILLWAY	T/S	39,700				31,000						18,400			
	C/S	54,900				(27,900)						(16,600)		45,200	
	W/R	87,400				52,400 (52,400)	17,500 (17,500)							17,500	
	R	508,800				101,700 (132,200)	356,200 (463,000)							50,900	
EMERGENCY SPILLWAY & QUARRY SITE	T/S C/S	152,900												152,900	
	W/R	229,300				229,300 (229,300)									
	R	382,200				92,200 (119,900)	290,000 (377,000)								
DIVERSION CANAL	T/S	18,500						13,900							
	C/S	15,500						(12,500)						20,100	
	W/R	22,700								22,700 (22,700)					
	R	56,700								21,800 (28,400)	2,300 (3,000)			32,600	
DIVERSION TUNNEL	R	15,100		15,100 (19,600)											
BORROW AREA (Down Stream)	T/S	102,100													
	C/S	408,400	400,300 (360,300)					8,100 (7,300)							
BORROW AREA (Up Stream)	T/S	54,800													
	C/S	548,300			548,300 (493,500)										
RIVER SITE	S	199,400		183,900 (194,600)					15,500 (16,300)						
	G														

Table IX-3 UNIT COST OF LABOUR

(at Nakhon Sawan and Uthai Thani)

No.	Item	Unit	Perdium	Remarks
			(Baht)	
1.	Labour	md	60	
2.	Foreman	md	120	
3.	Carpenter	md	90	
4.	Head of Carpenter	md	120	
5.	Stone Worker	md	60	
6.	Head of Stone Worker	md	90	
7.	Steel Worker	md	90	
8.	Head of Steel Worker	md	120	
9.	Asphalt-Mix Worker	md	60	
10.	Driver	md	110	
11.	Operator	md	110	
12.	Mechanical	md	90	
13.	Head of Operator & Mechanical	md	120	

Table IX-4 UNIT COST OF MATERIALS (1/3)

(at Nakhon Sawan)

No.	I t e m	Unit	Cost	Component		Unit Cost	
				L	F	Local	Foreign
			฿	%	%	฿	฿
1	Aggregate for concrete			95	5		
	coarse	m^3	235			223	12
	fine	m^3	150			143	7
2	Gravel for road pavement	m^3	130	95	5	124	6
3	Stone for masonry work	m^3	210	95	5	200	10
4	Portland cement	t	1,950	30	70	585	1,365
5	Concrete admixture	lit	320	5	95	16	304
6	Wood		95	5			
	Hard wood for house	m^3	9,000			8,550	450
	Soft wood for form	m^3	6,200			5,890	310
7	Sod	m^2	8	100	0	8	0
8	Reinforcing steel bar			40	60		
	Deformed SD 30	t	9,500			3,800	5,700
	Round SR 24	t	9,100			3,640	5,460
9	Wire for binding, Ø0.8 mm	Kg	15	40	60	6	9
10	Nail	Kg	15.4	50	50	7.7	7.7
11	Gabion wire	Kg	16	50	50	8	8
12	Structure steel	Kg	13.2	10	90	1.3	11.9
13	Metal Form	m^2	800	0	100	0	800
14	Asphalt			100	0		
	straight	t	6,000			6,000	0
	emulsion	t	7,500			7,500	0
15	Fuel			50	50		
	Diesel oil	ltr	7			3.5	3.5
	Gasoline, regular	ltr	11.0			5.5	5.5
16	Dynamite	Kg	90	0	100	0	90
17	Detonator	pc	22	0	100	0	22
18	Rubber water stop			0	100		
	Type A B = 230 mm	m	170			0	170
	Type B B = 150 mm	m	150			0	150
	Type C B = 150 mm (straight)	m	130			0	130

Table IX-4 UNIT COST OF MATERIALS (2/3)

No.	I t e m	Unit	Cost	Component		Unit Cost	
				L	F	Local	Foreign
			฿	%	%	฿	฿
19	Elastic filler			0	100		
	0.02 cm thickness	m^2	160			0	160
	0.01 cm thickness	m^2	130			0	130
20	RC pipe L = 1.0 m			90	10		
	ø 300 mm	m	280			252	28
	ø 500 mm	m	490			441	49
	ø 600 mm	m	630			567	63
	ø 800 mm	m	940			846	94
	ø 1,000 mm	m	1,220			1,098	122
21	I-PC Concrete garder			80	20		
	0.20x0.35x0.34x4.0 m	pc	1,200			960	240
	0.20x0.35x0.34x5.0 m	pc	1,400			1,120	280
	0.20x0.35x0.34x6.0 m	pc	1,700			1,360	340
	0.20x0.35x0.34x7.0 m	pc	2,100			1,680	420
	0.20x0.35x0.34x8.0 m	pc	2,600			2,080	520
	0.20x0.33x0.42x9.0 m	pc	3,200			2,560	640
	0.20x0.33x0.42x10.0 m	pc	3,900			3,120	780
	0.20;0.33x0.42x12.0 m	pc	6,300			5,040	1,260
22	Solid box garder			80	20		
	0.30x0.99x6.0 m	pc	7,100			5,680	1,420
	0.40x0.99x8.0 m	pc	12,100			9,680	2,420
	0.40x0.99x10.0 m	pc	15,500			12,400	3,100
	0.50x0.99x12.0 m	pc	21,800			17,440	4,360
	0.60x0.99x14.0 m	pc	26,600			21,280	5,320
23	Concrete bridge			80	20		
	B = 7.00 Span< 12.0 m	m	44,000			35,200	8,800

Table IX-5 UNIT COST OF MATERIALS (3/3)

No.	I t e m	Unit	Cost	Component		Unit Cost	
				L	F	Local	Foreign
			฿	%	%	฿	฿
24	Steel pipe Class II L=6 m			20	80		
	ø ½"	pc	115..			23	92
	ø ¾	pc	150			30	120
	ø 1"	pc	210			42	168
	ø 1½"	pc	270			54	216
	ø 1½"	pc	310			62	248
	ø 2"	pc	440			88	352
	ø 2½"	pc	570			114	456
	ø 3"	pc	730			146	584
25	Welding bar			0	100		
	ø 2.6 mm	Kg	32			0	32
	ø 3.2 mm	Kg	29			0	29
	ø 4.0 mm	Kg	24			0	24
26	Fence post 0.1x0.1x2.7 m	pc	95	100	0	95	0
27	Hand rail H = 1.2 m	m	550	20	80	110	440
28	PVC pipe ø 20 mm	pc	26	50	50	13	13
	(L = 4.0 m) ø 25 mm	pc	36			18	18
	ø 35 mm	pc	45			22.5	22.5
	ø 40 mm	pc	59			29.5	29.5
	ø 55 mm	pc	88			44	44
	ø 100 mm	pc	306			153	153
29	Electric power charge	kWH	2.6	50	50	1.3	1.3
30	Log ø 5" x 5 m	pc	260	100	0	260	0
	ø 6" x 6 m	pc	590			590	0
	ø 8" x 10 m	pc	720			720	0
	ø 10" x 12 m	pc	1,000			1,000	0
31	Barbed Wire	m	3	40	60	1.2	1.8

Table IX-5 SUMMARY OF FINANCIAL CONSTRUCTION COST FOR MAE WONG IRRIGATION SCHEME (Case 301)

	Total ($\times 10^6$ ฿)	Foreign Currency ($\times 10^6$ ฿)	Local Currency ($\times 10^6$ ฿)
1. Construction Cost (including Overhead, Profit and Tax)			
1.1 Dam Construction	1,051.0	807.3	243.7
1.2 Irrigation Facilities	638.8	367.8	271.0
1.3 Office & Quarters	24.2	-	24.2
Sub-total	1,714.0	1,175.1	538.9
2. Land Aquisiton, Resettlement & Compensation	28.0	-	28.0
3. O & M Equipment	44.6	40.5	4.1
4. Administration	42.9	-	42.9
5. Physical Contingency	183.0	121.6	61.4
6. Engineering Services	235.3	194.9	40.4
Sub-total	533.8	357.0	176.8
Total	2,247.8	1,532.1	715.7
7. Price Contingency	647.3	414.1	233.2
Grand Total (Financial Cost)	2,895.1	1,946.2	948.9

(Exchange Rate : US$ 1 = ฿ 27 = ¥ 240)

Table IX-6 SUMMARY OF DIRECT CONSTRUCTION COST OF UPPER MAE WONG DAM AND IRRIGATION FACILITIES

	Total ($\times 10^6$ ฿)	Foreign Currency ($\times 10^6$ ฿)	Local Currency ($\times 10^6$ ฿)
1. Dam Construction			
- Preparatoty Works	26.9	20.7	6.2
- River Diversion	84.3	56.9	27.4
- Dam Body	557.1	440.5	116.6
- Foundation Treatment	10.5	8.0	2.5
- Spillway	140.0	86.8	55.2
- Intake and Outlet Facilities	94.4	89.1	5.3
- Access Road	11.0	7.9	3.1
- Overhead	32.3	24.8	7.5
- Profit	60.0	46.1	13.9
- Tax	34.5	26.5	8.0
Sub-Total	1,051.0	807.3	243.7
2. Irrigation Facilities			
- Preparatory Works	16.3	9.4	6.9
- Intake Weir	9.1	5.5	3.6
- Main Canal	133.7	81.7	52.0
- Lateral & Sub-Lateral Canal	338.0	209.2	128.8
- Drainage Canal	23.0	17.6	5.4
- Land Reclamation	41.6	-	41.6
- Overhead	19.6	11.3	8.3
- Profit	36.5	21.0	15.5
- Tax	21.0	12.1	8.9
Sub-Total	638.8	367.8	271.0
Total	1.689.8	1,175.1	514.7

(Exchange Rate: US$1.00 = ฿27 = ¥240)

Table IX-7 BREAKDOWN OF DIRECT CONSTRUCTION COST OF UPPER MAE WONG DAM (1/3)

Item	Unit	Q'ty	Cost (10^3฿) Total	FC	LC
1. Preparatory Works			26,900	20,700	6,200
2. River Diversion			84,300	56,900	27,400
2-1. Diversion Tunnel					
Excavation	m^3	15,100	11,627	9,060	2,567
Concrete	m^3	2,780	5,560	3,475	2,085
Backfill Grounting	m^3	1,270	1,294	850	444
Plug Concrete	m^3	1,360	2,720	1,700	1,020
Others	L.S.		17,383	12,369	5,014
2-2. Diversion Canal					
Excavation					
Top Soil and Common Soil	m^3	34,000	2,249	1,740	509
Weathered Rock	m^3	22,700	2,297	1,784	513
Rock	m^3	56,700	13,740	10,742	2,998
Concrete Lining	m^3	1,000	11,574	3,677	7,897
2-3. Diversion Dam					
Excavation					
Top Soil and Common Soil	m^3	14,600	1,270	978	292
Hauling					
Common Soil	m^3	22,000	1,306	1,001	305
Weathered Rock	m^3	22,700	1,382	1,060	322
Rock	m^3	24,100	1,927	1,479	448
Sand	m^3	15,500	879	669	210
Embankment					
Core Zone	m^3	19,800	391	306	85
Filter Zoner	m^3	16,300	611	489	122
Rock Zone	m^3	51,100	485	378	107
Riprap	m^3	3,000	70	54	16
2-4. Others	L.S.		7,676	5,181	2,495
3. Dam Body			557,100	440,500	116,600
3-1. Earth Works					
Excavation of Foundation					
Top Soil and Common Soil	m^3	118,300	10,292	7,926	2,366
Weathered Rock	m^3	14,000	1,273	985	288
Rock	m^3	42,200	10,669	8,354	2,315
Excavation and Hauling from Service Spillway					
Common Soil	m^3	31,000	2,330	1,791	539
Weathered Rock	m^3	69,900	7,324	5,647	1,677
Rock	m^3	457,900	124,455	97,257	27,198
Excavation and Hauling from Emergency Spillway and Quarry Site					
Weathered Rock	m^3	229,000	31,876	24,457	7,419
Rock	m^3	382,000	121,856	94,888	26,968
Excavation and Hauling from River Diversion					
Rock	m^3	15,100	929	708	221
Borrow Area(Down Stream)					
Top Soil	m	102,100	2,919	2,266	653
Common Soil	m	400,300	39,267	30,062	9,205

Table IX-7 BREAKDOWN OF DIRECT CONSTRUCTION COST OF UPPER MAE WONG DAM (2/3)

Item	Unit	Q'ty	Cost (10^3฿) Total	FC	LC
Borrow Area (Up Stream)					
Top Soil	m^3	54,800	1,566	1,216	350
Common Soil	m^3	548,300	31,142	23,905	7,237
River Site					
Sand and Gravel	m^3	199,400	14,395	11,026	3,369
3-2. Embankment					
Core Zone	m^3	360,300	9,078	7,133	1,945
Filter Zone	m^3	213,200	7,995	6,396	1,599
Semi Pervious	m^3	493,500	7,796	6,020	1,776
Transition Zone	m^3	630,600	20,556	16,458	4,098
Rock Zone	m^3	857,500	8,145	6,345	1,800
3-3. Crest Treatment					
Others			22,693	17,642	5,051
3-4. Observation Instruments			30,000	30,000	
3-5. Others	L.S.		50,655	40,048	10,607
4. Foundation Treatment			10,500	8,000	2,500
4-1. Dams and Service Spillway					
Curtain Grounting	m	9,215	7,544	5,666	1,878
Test Hole	m	984	1,056	854	202
4-2. Emergency Spillway					
Curtain Grounting	m	812	664	499	165
Test Hole	m	81	86	70	16
4-3. Tunnel					
Curtain Grounting	m	200	245	184	61
Test Hole	m	20	32	26	6
4-4. Others	L.S.		686	523	163
5. Spillway			140,000	86,800	53,200
5-1. Service Spillway					
Earth Works					
Excavation : Top Soil and Common Soil	m^3	63,600	4,216	3,250	966
Weathered Rock	m^3	17,500	1,834	1,414	420
Rock	m^3	50,900	13,832	10,810	3,022
Backfilling		16,600	648	500	148
Concrete Works					
Concrete	m^3	54,300	72,245	40,458	31,787
R.F. bar	t	1,629	18,690	12,888	5,802
Form	m^2	25,500	2,088	1,071	1,017
Others	L.S.		11,355	7,039	4,316
5-2. Emergency Spillway					
Excavation					
Top Soil	m^3	152,900	2,369	1,850	519
Concrete Works					
Concrete	m^3	6,690	8,900	4,984	3,916
R.F. bar	t	201	2,301	1,587	714
Form	m^2	3,144	257	132	125
Others	L.S.		1,382	855	527

Table IX-7 BREAKDOWN OF DIRECT CONSTRUCTION COST OF UPPER MAE WONG DAM (3/3)

Item	Unit	Q'ty	Cost (10^3฿)		
			Total	FC	I.C
6. Intake and Outlet Facilities			94,400	89,100	5,300
Reinforced Concrete	m^3	3,260	4,337	2,429	1,908
Plain Concrete	m^3	2,040	4,080	2,550	1,530
Form	m^2	5,500	450	231	219
R.F. Bar	t	260.8	2,991	2,063	928
Gate	L.S.		24,300	24,300	
Steel Pipe	L.S.		42,777	42,777	
Screen	m^3	70	5,600	5,600	
Gate Chamber	m^2	58	579	324	255
Discharge Meter	L.S.		800	800	
Others	L.S.		8,591	8,107	484
7. Access Road			11,000	7,900	3,100
Laterite Pavement Road	m	20,000	7,640	5,820	1,820
Asphalt Pavement Road	m	5,000	3,400	2,095	1,305
Grand Total			944,000	720,900	223,100

Table IX-8 BREAKDOWN OF DIRECT CONSTRUCTION COST OF IRRIGATION FACILITIES (1/3)

Item	Unit	Quantity	Cost (10^3B) Total	F.C.	L.C.
1. Preparatory Works			16,360	9,418	6,942
2. Intake Weir			9,061	5,497	3,564
2-1. Intake Weir - A			7,186	4,382	2,804
Excavation	m^3	4,600	69	55	14
Backfilling	m^3	300	4	3	1
Embankment (A)	m^3	4,300	58	44	14
Embankment (B)	m^3	20,200	1,779	1,347	432
Smoothing of Face	m^2	14,700	18	-	8
Sod Facing	m^2	11,000	308	-	308
Reinforced Concrete	m^3	1,870	2,488	1,393	1,095
Reinforcement Bar	ton	113	1,297	894	403
Metal Form	m^2	1,300	107	55	52
Wooden Scaffolding	m^3	600	75	6	69
Riprap Protection	m^3	270	65	3	62
Stoplog	m^3	6	37	2	35
Side Gate (2.0x1.5)	nos	2	53	42	11
Side Gate (2.0x2.5)	nos	4	175	140	35
Others	L.S.		653	398	255
2-2. Intake Weir - B			1,875	1,115	760
Excavation	m^3	900	14	11	3
Embankment (A)	m^3	900	12	9	3
Embankment (B)	m^3	10,200	898	680	218
Smoothing of Face	m^2	8,300	10	-	10
Sod Facing	m^2	7,600	213	-	213
Reinforced Concrete	m^3	240	320	179	141
Reinforcement Bar	ton	15	172	119	53
Metal Form	m^2	340	28	14	14
Riprap Protection	m^3	80	19	1	18
Stoplog	m^3	3	19	1	18
Others	L.S.		170	101	69

Table IX-8 BREAKDOWN OF DIRECT CONSTRUCTION COST OF IRRIGATION FACILITIES (2/3)

Item	Unit	Quantity	Cost (10^3฿)		
			Total	F.C.	L.C.
3. Main Canal			133,638	81,651	51,987
Stripping	m^3	220,200	3,193	2,466	727
Excavation	m^3	184,400	2,766	2,194	572
Embankment (A)	m^3	184,400	2,471	1,881	590
Embankment (B)	m^3	550,400	48,491	36,712	11,779
Laterite Pavement	m^3	55,100	6,001	4,546	1,455
Smoothing of Face	m^2	663,400	796	-	796
Sod Facing	m^2	405,800	11,362	-	11,362
Lining Concrete	m^3	12,800	17,664	9,891	7,773
Metal Form	m^2	80,900	6,726	3,398	3,328
Related Structure					
- Culvert	nos	2	243	146	47
- Check Structure	nos	53	9,196	5,362	3,334
- Turnout	nos	63	4,908	2,772	2,136
- Water Measuring Device	nos	5	662	475	187
- Spillway	nos	6	1,904	1,103	801
- Drop	nos	5	1,977	1,168	809
- Syphon	nos	3	1,189	582	607
- Bridge	nos	3	1,940	1,032	908
Others	L.S.		12,149	7,423	4,726
4. Lateral & Sub-Lateral Canal			337,960	209,182	128,778
Stripping	m^3	635,000	9,208	7,112	2,096
Excavation	m^3	202,600	3,725	2,755	970
Embankment (A)	m^3	202,600	2,715	2,067	648
Embankment (B)	m^3	1,743,000	153,558	116,258	37,300
Laterite Pavement	m^3	46,200	5,032	3,812	1,220
Smoothing of Face	m^2	2,356,300	2,828	-	2,828
Sod Facing	m^2	1,175,300	32,908	-	32,908
Lining Concrete	m^3	860	1,187	665	522
Metal Form	m^2	5,900	483	248	235
Related Structure					
- Culvert	nos	38	4,617	2,766	1,851
- Check Structure	nos	244	42,334	26,986	15,348
- Turnout	nos	274	21,345	12,056	9,289
- Water Measuring Device	nos	27	3,569	2,562	1,007
- Spillway	nos	12	3,808	2,206	1,602
- Syphon	nos	8	3,172	1,898	1,254
- Cross Drain	nos	8	3,170	1,552	1,618
- Bridge	nos	21	13,577	7,222	6,355
Others	L.S.		31,244	19,348	11,896

Table IX-8 BREAKDOWN OF DIRECT CONSTRUCTION COST OF IRRIGATION FACILITIES (3/3)

Item	Unit	Quantity	Cost (10^3₱)		
			Total	F.C.	L.C.
5. Drainage Canal			23,059	17,619	5,440
Excavation	m^3	1,186,900	17,803	14,124	3,679
Related Structure					
- Culvert	nos	26	3,159	1,893	1,266
Others	L.S.		2,097	1,602	495
6. Land Reclamation			41,638	-	41,638
Land Reclamation (A)	ha	1,000	30,593	-	30,593
Land Reclamation (B)	ha	1,100	7,260	-	7,260
Others	L.S.		3,785	-	3,785
Grand Total			561,716	323,367	238,349

Table IX-9 BREAKDOWN OF DIRECT CONSTRUCTION COST OF OFFICE AND QUARTERS

Item	Unit	Quantity	Local Currency ($\times 10^3$฿)
1. Main Office	m^2	1,200	4,800
2. Branch Office	m^2	800	2,800
3. Repair Shop	m^2	800	1,600
4. Store House	m^2	3,000	3,000
5. Quarters	m^2	2,000	4,000
6. Motor Pool	m^2	10,000	3,000
7. Land Preparation for Office		L.S.	5,000
Total			24,200

Table IX-10 PROCUREMENT COST OF MAJOR EQUIPMENT FOR OPERATION AND MAINTENANCE

Equipment	Unit Price ($\times 10^6$Yen)	Required No.	Amount ($\times 10^6$Yen)
1. Back-hoe, 0.3 m^3	12.4	5	62.0
2. Bulldozer, 11 ton	13.1	5	63.5
3. Wheal Loader, 1.2 m^3	9.3	2	18.6
4. Motor Grader, 9.5 ton	12.2	1	12.2
5. Water Tanker, 5 m^3	5.9	1	5.9
6. Tire Roller, 8 - 10 ton	8.9	2	17.8
7. Tamper, 80 kg	0.3	10	3.0
8. Soil Compactor, 90 kg	0.3	10	3.0
9. Concrete Mixer, 0.2 m^3	0.5	5	2.5
10. Submergible Pump, ϕ150	0.6	10	6.0
11. Generator, 5 KVA	0.6	3	1.8
12. Trailer Truck, 28 ton	16.7	1	16.7
13. Dump Truck, 11 ton	9.2	2	18.4
14. Dump Truck, 2 ton	1.9	5	9.5
15. Cargo Truck w/Crane, 4 ton	4.9	2	9.8
16. Cargo Truck w/Crane, 2 ton	2.9	2	5.8
17. Ordinary Truck, 6 ton	3.9	2	7.8
18. Truck, 1.5 ton pick-up	1.7	3	5.1
19. Jeep, four wheel drive	2.1	5	10.5
20. Sedan, 6 persons	1.8	2	3.6
21. Repair shop tools		L.S.	14.3
22. Spare Parts (20% of above)		L.S.	60.0
Total			359.8 (40.5×10^6฿)

Table IX-11 BREAKDOWN OF ENGINEERING SERVICES

(Unit: 10^6B)

Description	Total	Foreign Currency	Local Currency
I Detailed Design			
1. Remuneration			
Foreign Consultant (180 M/M)	50.6	50.6	-
Local Consultant (225 M/M)	20.2	20.2	-
2. Direct Cost	21.2	10.6	10.6
3. Mapping & Investigation	15.0	-	15.0
Sub-Total	107.0	81.4	25.6
II. Construction Supervision			
1. Remuneration			
Foreign Consultant (290 M/M)	81.6	81.6	-
Local Consultant (190 M/M)	17.1	17.1	-
2. Direct Cost	29.6	14.8	14.8
Sub-Total	128.3	113.5	14.8
Total	235.3	194.9	40.4

Table IX-12 ANNUAL DISBURSEMENT SCHEDULE OF MAE WONG IRRIGATION SCHEME

	Total F.C.	Total L.C.	1st year F.C.	1st year L.C.	2nd year F.C.	2nd year L.C.	3rd year F.C.	3rd year L.C.	4th year F.C.	4th year L.C.	5th year F.C.	5th year L.C.	6th year F.C.	6th year L.C.	7th year F.C.	7th year L.C.
1. Construction Cost																
1.1 Dam Construction	807.3	243.7	-	-	-	-	80.7	24.4	121.1	36.6	161.5	48.7	242.2	73.1	201.8	60.9
1.2 Irrigation Facilities	367.8	271.0	-	-	-	-	-	-	18.4	13.6	117.7	86.7	117.7	86.7	114.0	84.0
1.3 Office & Quarters	-	24.2	-	-	-	-	-	24.2	-	-	-	-	-	-	-	-
Sub-Total	1,175.1	538.9	-	-	-	-	80.7	48.6	139.5	50.2	279.2	135.4	359.9	159.8	315.8	144.9
2. Land Aquisition, Resettlement and Compensation	-	28.0	-	-	-	14.0	-	14.0	-	-	-	-	-	-	-	-
3. O & M Equipment	40.5	4.1	-	-	-	-	-	-	-	-	-	-	20.3	2.1	20.2	2.0
4. Administration	-	42.9	-	-	-	-	-	3.7	-	4.7	-	10.3	-	12.9	-	11.3
5. Physical Contingency	121.6	61.4	-	-	-	1.4	8.1	6.6	14.0	5.5	27.9	14.6	38.0	17.5	33.6	15.8
6. Engineering Services	194.9	40.4	48.8	15.4	32.6	10.2	22.7	3.0	22.7	3.0	22.7	3.0	22.7	2.9	22.7	2.9
Sub-Total	357.0	176.8	48.8	15.4	32.6	25.6	30.8	27.3	36.7	13.2	50.6	27.9	81.0	35.4	76.5	32.0
Total	1,532.1	715.7	48.8	15.4	32.6	25.6	111.5	75.9	176.2	63.4	329.8	163.3	440.9	195.2	392.3	176.9
7. Price Contingency	414.1	233.2	1.2	0.5	2.5	2.3	14.5	11.9	32.8	14.3	81.0	49.0	135.7	73.7	146.4	81.5
Grand Total (Financial Cost)	1,946.2	948.9	50.0	15.9	35.1	27.9	126.0	87.8	209.0	77.7	410.8	212.3	576.6	268.9	538.7	258.4

Table IX-13 ANNUAL OPERATION AND MAINTENANCE COST

Item	Amount (10³฿)
1. Salaries & Wages	
1.1 Staff salaries	1,037
1.2 Labour wages (200 M/M @฿1,500)	300
2. Office Expenses	31
3. Operation and Maintenance Cost	
3.1 Depreciation of O & M Equipment	9,315
3.2 Dam	5,369
3.3 Irrigation	15,970
Total	32,022

Table IX-14 O & M STAFF SALARY

Item	Required Number	Monthly Rate (฿)	Annual Amount (10³฿)
Project Engineer	1	10,000	10
Sr. Irrigation Engineer	3	8,000	24
Jr. Irrigation Engineer	7	5,000	35
Zonemen	30	4,000	120
Sub-total	41		189
Gate Tender	10	5,000	50
Canal Tender	150	3,000	450
Sub-total	160		500
Hydrographer	5	6,000	30
Surveyor	5	4,000	20
Draftsman	2	4,000	8
Agronomist	5	7,000	35
Sub-total	17		93
Mechanical Engineer	2	7,000	14
Mechanic/Electrician	2	7,000	14
Communication Technician	2	5,000	10
Radio Operator	5	5,000	25
Sub-total	11		63
Administrator	10	7,000	70
Accountant	2	6,000	12
Store Keeper	4	5,000	20
Typist	3	5,000	15
Driver	15	5,000	75
Sub-total	34		192
Total	263		1,037

Table IX-15 REPLACEMENT COST

Item	Useful Life (Year)	Replacement Cost (10^6฿)
1. O & M Equipment	10	44.6
2. Project Facilities		45.5
(1) Dam	25	27.6
(2) Weir	25	0.3
(3) Irrigation Facilities	25	17.6

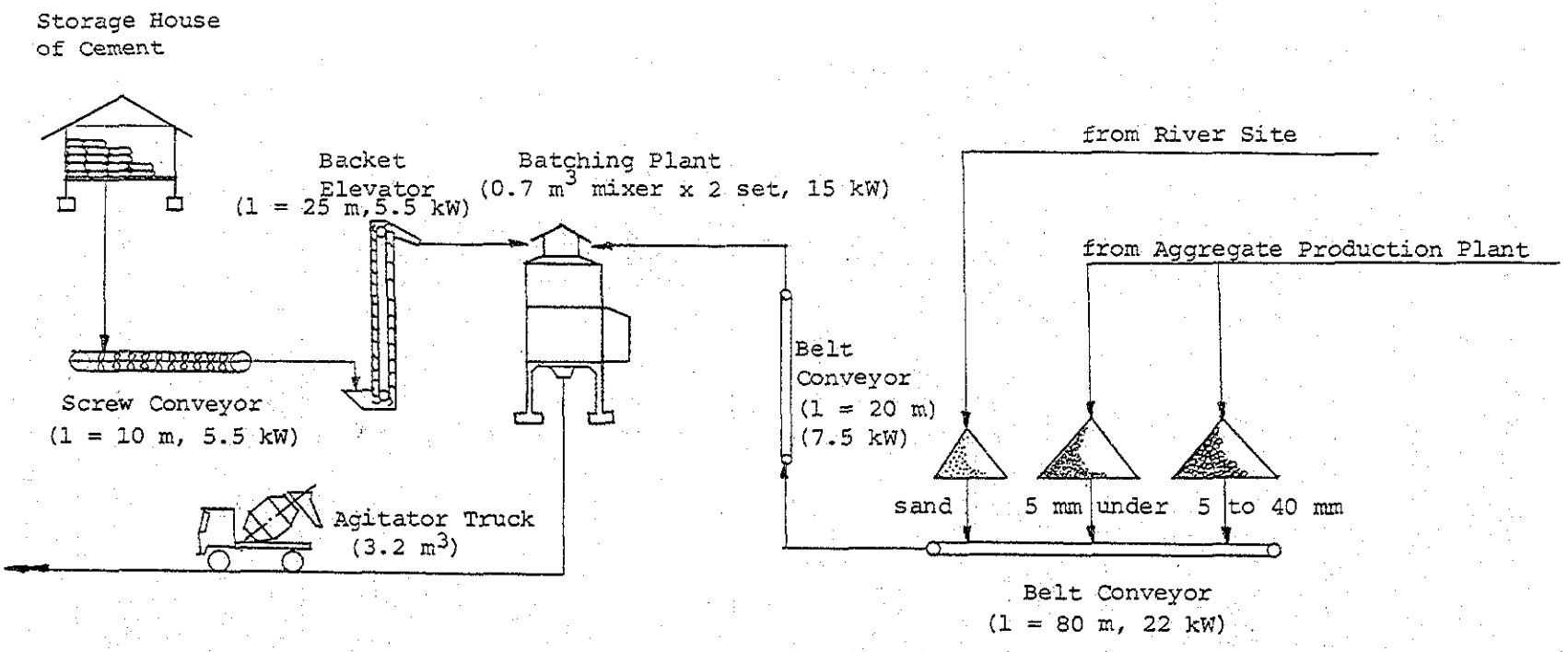


Fig. IX-1 Flow Chart of Concrete Plant

No.	Specification
①	Grizzly Hopper, 350-400 mm Mesh
②	Apron Feeder, Heavy Duty, 11 kW
③	Brake Joe Crasher, 95 kW
④	Belt Conveyor, 22 kW
⑤	Return Conveyor, 11 kW
⑥	Return Conveyor, 3.7 kW
⑦	Ripple Flow Screen, 11 kW
⑧	Ripple Flow Screen, 11 kW
⑨	S-T Joe Crasher, 37 kW
⑩	Hydro Cone Crasher, 75 kW
⑪	Belt Conveyor, 7.5 kW
⑫	Belt Conveyor, 1.5 kW
⑬	Belt Conveyor, 1.5 kW

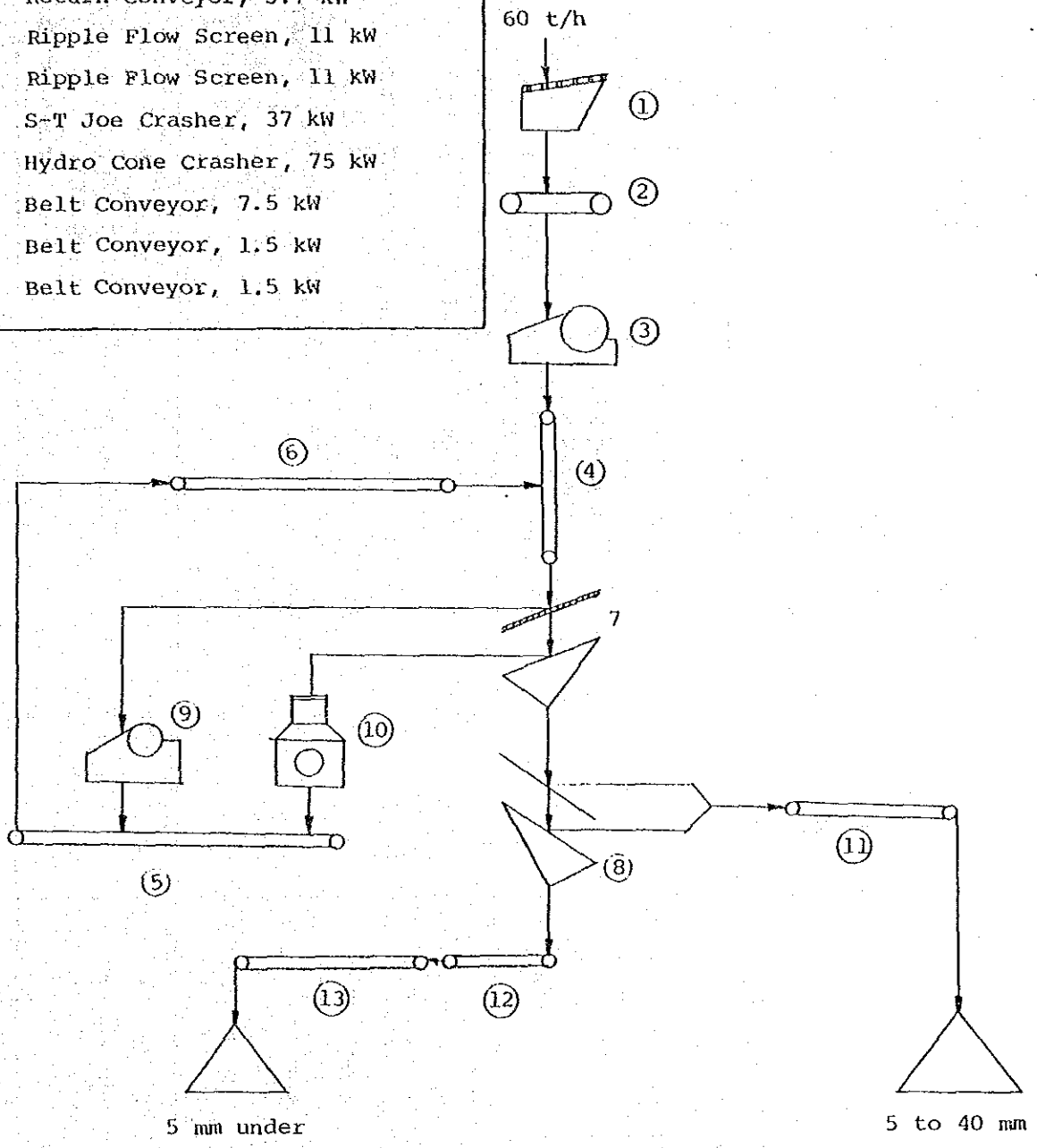


Fig. IX-2 Flow Chart of Aggretate Production Plant

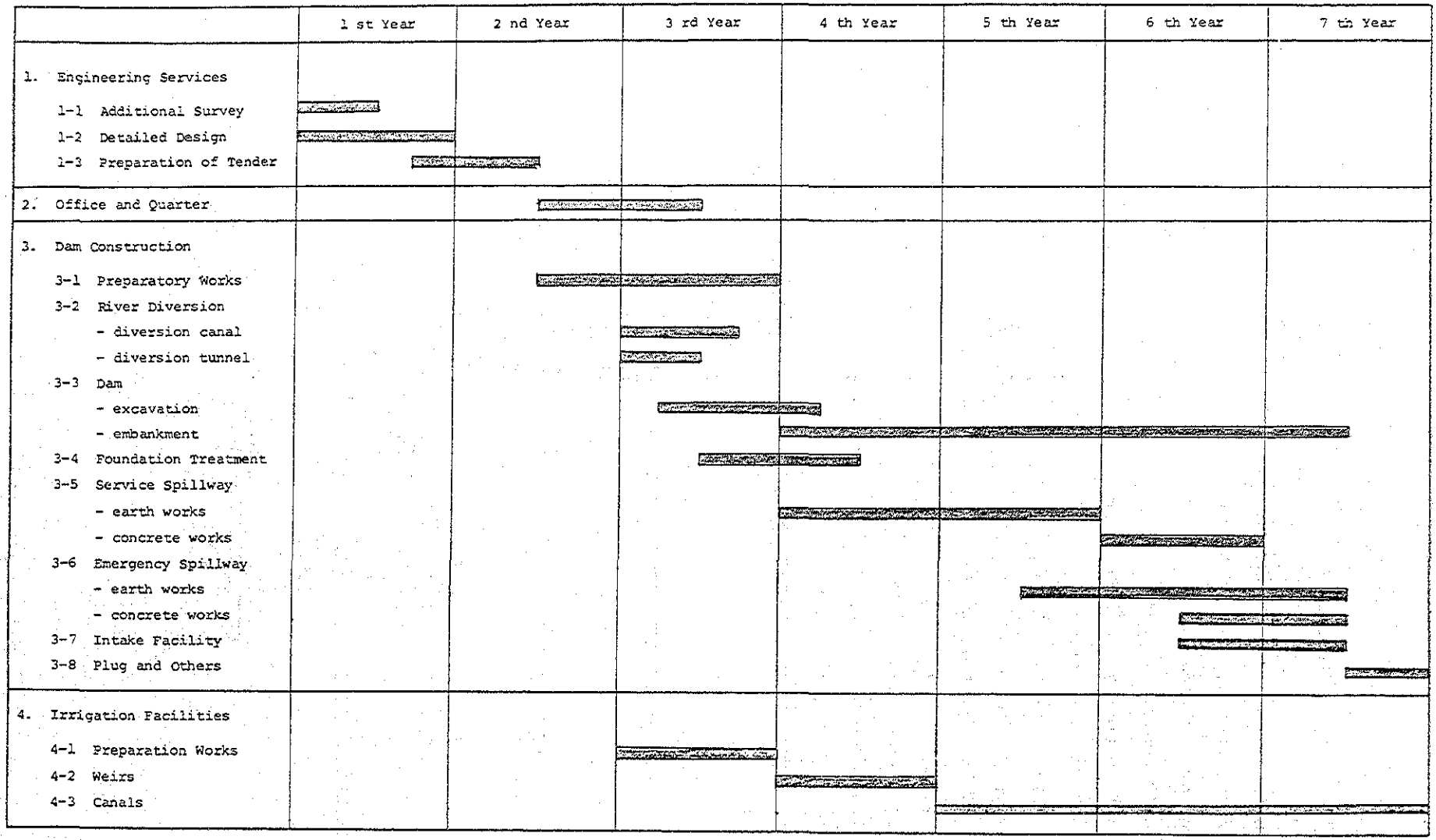


Fig. IX-3 Implementation Schedule of Mae Wong Irrigation Scheme

ANNEX–X
PROJECT EVALUATION

ANNEX - X

PROJECT EVALUATION

TABLE OF CONTENTS

LIST OF TABLES

ANNEX - X

PROJECT EVALUATION

1. GENERAL

The preliminary economic evaluation was carried out for 11 alternative development options as part of the project optimization process discussed in ANNEX-III and Chapter V of the Main Report. The height of the Upper Mae Wong dam had been fixed at 57 m, corresponding to a reservoir storage capacity of 250 MCM, this being the optimum size of the dam which also made optimum use of the available water resources.

The results from these initial evaluations, which revealed a number of economically feasible options, led to selection of the proposed development for an area of 291,900 rai (46,700 ha), enabling a cropping intensity of 105%. The development area includes 230,000 rai (36,800 ha) of the existing irrigation areas and 61,900 rai (9,900 ha) of the extension area on the right bank of the Mae Wong river. In this ANNEX-X, overall project evaluation is discussed in detail for this selected one particular case.

The project evaluation has involved making an assessment of project feasibility in view of economic, financial and socio-economic aspects. The economic feasibility is first evaluated by calculating the internal rate of return (IRR) and the net present value (NPV) at the discount rate of 10%. Sensitivity analyses have also been made in order to elucidate the economic viability of the project against the changes in the benefits, build-up period, construction period and project costs.

Financial evaluation has been carried out by analysing the effect of the Project on a typical farm budget and by preparing the repayment schedule of the project capital cost.

The socio-economic impacts from the implementation of the Project have also been briefly studied.

2. ECONOMIC EVALUATION

2.1 Basic Assumptions

The economic evaluation has been made on the following basic assumptions:

(1) The construction period will be seven (7) years including two (2) years for detailed design and preparatory works.

(2) The economic useful life of the Project will be 50 years.

(3) All prices are expressed in constant mid-1985 prices.

(4) The exchange rate of US$1.00 = ฿27.0 = ¥240 as of mid-1985 are used throughout.

(5) Only irrigation benefit is counted in the evaluation, and any benefits to be derived from the fishery, hydropower generation, water release for downstream areas, etc., are not taken into account.

2.2 Evaluation of Economic Factors

For evaluation of economic prices and costs, the following criteria have been used:

2.2.1 Standard convention factor (SCF)

Tariff and trade restrictions introduce a distortion in the price relationship between trade goods and non-traded goods. In order to evaluate the project costs and benefits with respect to world market prices, a SCF of 0.92 has been applied to the price of non-traded goods and services. This figure has commonly been adopted in Thailand, as it has been recommended by IBRD in the Staff Working Paper No. 609, 1983.

2.2.2 Transfer payment

From the viewpoint of the international economy, the transfer payments such as contract tax, duty, subsidy and interest are considered as a domestic monetary movement without direct productivity. These transfer payments are, therefore, excluded from the project cost as far as the economic analysis is concerned.

2.2.3 Economic prices for agricultural outputs and inputs

The economic prices for farm products such as paddy and mung beans and farm inputs such as fertilizers and agro-chemicals have been estimated on the basis of the projected international market prices forecasted for the year of 1995 by IBRD in the long-term range in 1983 constant US dollar. The IBRD forecasted prices are adjusted to 1985 constant price level using the factor of 0.977 based on manufacturing unit value (MUV) index computed by IBRD. The domestic components are adjusted by SCF of 0.92. (See ANNEX-VIII)

2.2.4 Economic opportunity cost of farm labour

At present, a large part of the farm labour requirement are generally met by family labour. Seasonal labourers required for transplanting and harvesting are mainly hired from neighbours or small and/or tenant farmers in nearby area at the rate of ฿40/man-day. A general shortage of labour has been observed during the wet season. On the contrary, farm work is scarce during the dry season and the demand for farm labour decreases accordingly. Daily wages also fall by about 20 - 30% to an average ฿30/man-day during the dry season. With the implementation of

the Project and a future situation with increased agricultural production, the average dry season wage rate would most likely increase to the level of the wet season wage rate. It is assumed that the present market wage rate is close to the economic rate. The adjusted conversion factor for farm labour is therefore taken as 1.00 x 0.92 (SCF) being wage rate of ฿37/man-day both for the wet and dry seasons.

2.2.5 Economic opportunity cost of unskilled construction labour

During the wet season, which is the season of peak demand for farm labour, the construction activities would slow down and labour would be less required. During the dry season, the Project would require more construction labour and such non-farm employment would be an attractive alternative for many of the local labour because of scarce farm work. In the case of short supply of unskilled construction labour, sufficient labour could be drawn from nearby areas. This suggests that the economic opportunity cost of unskilled labour corresponds to that of hired farm labour.

The fact observed in the Mae Wong area shows that, however, local labour require at least a 50% premium to be attracted to the construction work since it is harder work than in agriculture. This has been reflected in the financial wage rate that is an average ฿60/man-day, but should not in determination of the corresponding economic opportunity cost.

The economic opportunity cost of unskilled construction labour may be assumed to equal that of hired farm labour of ฿30/man-day during the dry season. Related to the average financial wage rate of ฿60/man-day, this would give a conversion factor of (฿30/฿60) x 0.92 = 0.46.

2.2.6 Construction conversion factor (CCF)

The individual financial costs for major project components are split into four (4) categories of transfer payment, unskilled labour, non-traded costs and traded foreign costs, for each of which an economic/financial conversion factor is applied. The construction conversion factor (CCF) that is the weighted average of the above components, is calculated as 0.87 for the dam and 0.84 for the irrigation work, as shown in Table X-1.

2.3 Economic Benefits

The irrigation benefits are primarily derived from the increased crop production attributable to a stable irrigation water supply. These benefits are estimated as the difference of the annual net crop production values under future under with and without project conditions.

The net production value is defined as the difference between the gross production value and the crop production cost. The net production values under future with and without project conditions are summarized as follows (for details, see ANNEX-VIII):

Calculation of Net Production Value

Description	Without Project	With Project	Increment
1. Planted area (ha)			
(a) Irrigated paddy			
- Wet season paddy	22,000	46,700	24,700
- Dry season paddy	1,100	-	-
- Mung beans	3,300	2,300	-
(b) Semi-irrigated paddy			
- Wet season paddy	14,800	-	-
(c) Rainfed paddy			
- Wet season paddy	7,800	-	-
(d) Rainfed upland			
- Maize	2,100	-	-
- Mung beans	800	-	-
2. Unit yield (ton/ha)			
(a) Irrigated paddy			
- Wet season paddy	2.8	4.4	1.6
- Dry season paddy	3.5	-	-
- Mung beans	0.6	1.2	0.6
(b) Semi-irrigated paddy			
- Wet season paddy	1.6	-	2.8
(c) Rainfed paddy			
- Wet season paddy	1.3	-	3.1
(d) Rainfed upland			
- Maize	2.2	-	-
- Mung beans	0.5	-	-
3. Crop production (tons)			
(a) Paddy	98,400	205,500	107,100
(b) Mung beans	2,400	2,800	400
(c) Maize	4,600	-	-
4. Unit price (฿/ton)			
(a) Paddy	4,230	4,230	-
(b) Mung beans	6,920	6,920	-
(c) Maize	2,470	-	-
5. Unit production cost (฿/ha)			
(a) Irrigated paddy			
- Wet season paddy	4,270	5,680	1,410
- Dry season paddy	4,930	-	-
- Mung beans	2,250	3,660	1,410
(b) Semi-irrigated			
- Wet season paddy	3,780	-	1,900
(c) Rainfed paddy			
- Wet season paddy	3,480	-	2,200
(d) Rainfed upland			
- Maize	2,660	-	-
- Mung beans	2,250	-	-

Description	Without Project	With Project	Increment
6. Gross production value (million ฿)			
(a) Paddy	420.0	869.3	449.3
(b) Mung beans	16.5	19.1	2.6
(c) Maize	11.4	-	-11.4
7. Total production cost (million ฿)			
(a) Paddy	182.3	265.2	82.9
(b) Mung beans	9.2	8.4	-0.8
(c) Maize	5.6	-	-5.6
8. Net production value (million ฿)			
(a) Paddy	237.7	604.1	366.4
(b) Mung beans	7.3	10.7	3.4
(c) Maize	5.8	-	-5.8
Total	250.8	614.8	364.0

According to the proposed construction plan, the existing irrigation system will have been partly up-graded in 6th year of construction and completed in 7th year, so that crop production can be assumed to increase gradually after partial completion of the irrigation works. All the construction works, including those for the dam, will be completed by the end of 7th year, and the benefits are expected to increase year by year after full start of irrigation with the dam and attain the maximum level in 12th year after start of construction.

It is assumed that the irrigation benefit will initially accrue from up-grading of the existing irrigation facilities in 6th year by 10% of full incremental benefits and 20% in 7th year, and after completion of dam construction, it will gradually increase during the build-up period of 5 years from 60% in 8th year to 100% in 12th year, as shown below:

Year	Irrigation Benefit (million ฿)
1st	0
2nd	0
3rd	0
4th	0
5th	0
6th	36.4
7th	72.8
8th	218.4
9th	254.8
10th	291.2
11th	327.6
12th	364.0
:	:
50th	364.0

2.4 Economic Cost

2.4.1 Capital cost

The project cost broadly comprises (1) cost for preparatory works, (2) construction cost for project facilities including contractor's overhead, profits and contract tax, (3) cost for land acquisition, (4) cost for compensation and resettlement, (5) administration expenses, (6) procurement cost of O/M equipment, (7) expenses for engineering services, (8) physical contingencies and (9) price contingencies. All these costs are estimated on a financial basis as given in ANNEX-IX.

The financial costs are convented into the economic costs by applying the CCF for each of major components (see Table X-1):

	Cost Component	Financial Cost (Million ฿)	CCF	Economic Cost (Million ฿)
(1)	Dam & Reservoir	1,051.0	0.87	914.4
(2)	Irrigation Works	638.8	0.84	536.6
(3)	Office Quarters	24.2	0.77	18.6
(4)	Land Acquisition, Resettlement & Compensation	28.0	0.92	25.8
(5)	O/M Equipment	44.6	0.99	44.2
(6)	Administration	42.9	0.92	39.5
(7)	On-farm Development /1	-		11.4
(8)	Physical Contingencies (10%)	183.0	-	159.1
(9)	Engineering Services	235.3	0.89	209.4
(10)	Price Contingencies	647.3	-	-
	Total	2,895.1		1,959.0

Note: /1: The cost for on-farm development is not included in the financial cost estimate since the on-farm development is to be executed by the farmers themselves. It should be, however, included in the economic project cost (see Table X-2).

2.4.2 Annual operation and maintenance costs

The annual O & M cost estimated in ANNEX-IX includes the depreciation cost of O & M equipment and gates. In the economic evaluation, however, the depreciation is taken as the replacement cost, and accordingly it is excluded from the economic O & M cost. The O & M cost

after exclusion of the said depreciation cost is then converted into the economic cost using respective CCF for each item:

	Description	Financial Cost (Million ฿)	Conversion Factor/1	Economic Cost (Million ฿)
(1)	Salaries & Wages	1.34	0.73	0.98
(2)	Office Expenses	0.03	0.83	0.02
(3)	O & M for Project Facilities			
	(a) Dam	5.37	0.81	4.35
	(b) Irrigation	15.97	0.80	12.78
	Total	22.71		18.13

Note: /1: See Table X-1

2.4.3 Replacement cost

The replacement costs estimated in ANNEX-IX comprise (1) O & M equipment in every 10 years and (2) gates and their attachments in 25 years after project implementation. These costs are converted into the economic costs using a specific CCF of 0.99 for imported goods:

	Description	Useful Life (year)	Financial Cost (Million ฿)	Conversion Factor	Economic Cost (Million ฿)
(1)	O & M Equipment	10	44.6	0.99	44.2
(2)	Facilities				
	(a) Dam	25	27.6	0.99	27.3
	(b) Irrigation Works	25	17.9	0.99	17.7

2.4.4 Annual cost flow

The economic cost flow is prepared on the basis of the construction schedule.

(Unit: Million ฿)

Year	Capital Cost	O & M Cost	Replacement Cost
1	57.1	0	0
2	47.1	0	0
3	158.2	0	0
4	207.6	0	0
5	430.7	0	0
6	558.0	7.2	0
7	500.3	10.9	0
8	0	18.1	0
⋮	⋮	⋮	⋮
17	0	18.1	44.2
⋮	⋮	⋮	⋮
27	0	18.1	44.2
⋮	⋮	⋮	⋮
32	0	18.1	45.0
⋮	⋮	⋮	⋮
37	0	18.1	44.2
⋮	⋮	⋮	⋮
47	0	18.1	44.2
⋮	⋮	⋮	⋮
50	0	18.1	0

2.5 Internal Rate of Return (IRR)

The economic internal rate of return is calculated on the basis of the flows of economic benefits and costs mentioned above (see Table X-3). The calculated result is:

IRR = 13.0%

2.6 Net Present Value (NPV)

The net present value at the discount rate of 10% is also calculated for the selected case on the same assumptions mentioned above, and the calculated result is:

NPV = 475 million Baht

2.7 Sensitivity Analysis

In order to evaluate the soundness of the Project against the possible changes in future economic conditions, sensitivity analyses are made for the following cases:

Case-1: 10% project cost increase due to unforeseen geological and topographical conditions and unexpected increases of material costs

Case-2: 10% project benefit decrease due to unexpected decrease in forecasted price of farm products and in crop yields

Case-3: Two years overrun of build-up period due to unexpected inefficiency in O & M management and agricultural extension services

Case-4: Two years overrun of construction period due to unexpected inefficiency of contractors and unforeseen reasons

The effectes of these changes on IRR and NPV (discounted at 10%) are summarized as shown below (Details are given in Table X-4):

Case	IRR (%)	NPV (Million ฿) 10%
Case-1	11.9	331
Case-2	11.8	284
Case-3	12.5	406
Case-4	11.8	285

2.8 Results of Economic Evaluation

From the above results, the Project could be justified economically with IRR of 13.0% and NPV of 475 million Baht at the discount rate of 10%. The sensitivity analyses indicate that the economic feasibility of the Project is rather insensitive to the possible changes.

3. FINANCIAL ANALYSIS

3.1 General

The financial feasibility of the Project is evaluated from the viewpoint of farmer's economy. The study on the repayment schedule of the capital cost is also made by preparing the cash flow table.

3.2 Financial Cost

The financial cost estimated on the basis of the current prices as of mid 1985, is as follows (see ANNEX-IX):

(Unit: Million ฿)

Foreign Currency	Local Currency	Total
1,946.2	948.9	2,895.1

In this estimate, the price contingencies of 6% per annum for local currency portion and 5% per annum for foreign currency portion are included. The annual disbursement schedule for the required financial cost is given in ANNEX-IX.

3.3 Farm Budget Analysis and Payment Capacity

In order to evaluate the Project from the financial aspect of the farmers, the farm budget analyses on different sizes of farmers are made under both future with and without project conditions as shown in ANNEX-VIII.

The payment capacity is recognized as the ability of the project-benefited farmers to bear the expenses required for operation and maintenance of the project facilities as well as for repayment of capital cost. The payment capacity is measured by the difference of net disposable reserves under future with and without project conditions, which the farmers can actually earn from the Project after all the farm expenses and living costs are deducted from the gross farm income.

The payment capacity under the Project at the full development stage is estimated:

PAYMENT CAPACITY

(Unit: ฿ farm/year)

Farm Size	Average Farm Size rai	Average Farm Size ha	Existing Irrigation Area (36,800 ha)	Reinfed Area (9,900ha)	Weighted Average
(1) Small Size Farm (less than 20 rai)	7.5	1.2	6,800	10,100	7,500
(2) Medium Size Farm (21 - 50 rai)	28.1	4.5	24,600	38,900	27,600
(3) Large Size Farm (more than 51 rai)	75.0	12.0	66,100	103,300	74,000

Note: A: Average farm size
B: Payment capacity (฿/farm/year)

The increased net disposable reserve would offer the incentives for farm re-investment and further development to the farmers, and the substantial payment capacity would enable the farmers, if necessary, to make some payment for irrigation water.

3.4 Water Charges

If water charges are not collected from the project-benefited farmers, all the costs incurred by the Project will entirely be borne by the Government. It may become a heavy burden to the Government. It is generally recognized in other countries that some water charges are necessarily imposed to the participants to cover the expenses for operation and maintenance and partly the repayment of the capital costs. In Thailand, the participating farmers are not imposed any water charges, but contribute indirectly to the government revenue by selling their rice surplus at low price which enable the exporters to contrive the export tax and premium and also by paying directly land tax to the local government.

Under present circumstances, the Government would not impose the water charge to the farmers. In future, however, the Government might start collecting water charges with some economical changes. In such case, the water charges should be determined within the farmer's payment capacity. If water charge would cover the annual O & M cost, it would amount to ฿220 per rai per annum at 1995 price level. This corresponds to about 22% of the payment capacity as shown below:

Farm Size	Average Farm Size (rai)	Water Charge (A) (฿/year)	Payment Capacity (B) (฿/year)	(A)/(B) %
Small Farm	7.5	1,650	7,500	22
Medium Farm	28.1	6,180	27,600	22
Large Farm	75.0	16,500	74,000	22

In the financial evaluation, any water charge is not taken into account.

3.5 Anticipated Revenue

Water charge will not be collected from the farmers. No direct project revenue is therefore anticipated. However, the Government will receive indirectly some revenue from the Project as rice export duties, rice export premium and municipal tax. These indirect incremental revenue would amount to about 46.1 million Baht per annum in total under present regulations, as shown below:

Incremental Revenue	Amount (Million ฿)
Export Duties	16.8
Export Premium	19.4
Municipal Tax	9.9
Total	46.1

3.5.1 Export duties

The export duties are imposed upon the export amount of rice at the rate of 2.5% against the basic price announced by the Ministry of Commerce. The exportable amount of rice to be produced in the Project area is about 105,000 tons (see ANNEX-VIII). The basic prices for different quality of rice are averaged at ฿6,410 per ton. The anticipated export duties will therefore amount to about 16.8 million Baht.

3.5.2 Export premium

A certain rate of export premium is imposed to the exporters upon the export amount of rice. The average rate of export premium for average quality of rice is about ฿185 per ton. It is expected that the Government will receive about 19.4 million Baht as export premium annually for the exportable surplus of 105,000 tons.

3.5.3 Municipal tax

The municipal tax is paid by rice mills and exporters at the average rate of 2.2% for handling amount of rice valued at the current market price. The municipal tax will increase by about 9.9 million Baht for 105,000 tons of increased surplus at current market price of ฿4,300 per ton.

3.6 Repayment of Project Cost

It is assumed that the capital required for the project implementation will be arranged under the following conditions:

(1) For foreign currency portion, the capital is financed by bilateral or international organizations with an interest rate of 3.5% per annum for a repayment period of 30 years including 10 year grace period.

(2) For local currency portion, the capital is arranged by the budget allocation without no repayment.

Based on the above conditions, the repayment schedule for the foreign currency portion is prepared as shown in Table X-5.

3.7 Result of Financial Evaluation

The Project will bring about a great improvement in farm budget, and give an incentive for farm reinvestment to the farmers. The Project could be justified from the farmer's viewpoint.

Since no financial revenue is expected from the Project, difficulties are involved in justifying the financial feasibility of the Project. Following could, however, be said from financial viewpoint of the Project. During the repayment period of 30 years for foreign loan, the average amount of the government budget allocation required for covering the loan repayment, loan interest and O & M costs is about ฿116 million as shown in Table X-5. The indirect financial revenue from the Project in terms of export duties, export premium, municipal tax and land tax is, on the other, estimated at about ฿50.2 million. Although it is not direct project return, it means that the Project will contribute such amount to the government budget. The farmers who will not pay any water charge and receive a large economic return, will spend their increased income for various purposes and the economic activities will thereby be enhanced. Increased tax revenue will also be expected from such future economic circumstances.

4. SOCIO-ECONOMIC IMPACTS

In addition to the direct project benefits counted in the economic evaluation, various secondary and intangible benefits and/or favourable socio-economic impacts are expected from the implementation of the project. The major socio-economic impacts are described hereunder.

(1) Possibility of hydropower generation

The proposed Upper Mae Wong dam will provide a possibility of hydropower development. According to the preliminary study results, about 15,240 MWH of annual every output will be produced with an installed capacity of 6,500 kW at the Upper Mae Wong dam. The construction cost will be about 150 million Baht or 10 Baht/kWH.

(2) Increase of potential fish production

After creation of the reservoir, the potential fish production will be increased to a great extent, and it would be made possible for the farmers to manage stable aquaculture of valuable fishes. The estimated fish production in the reservoir is about 170 tons per annum which corresponds to a value of 8 million Baht per annum.

(3) Effective use of return flow

After implementation of the Project, about 53 MCM of return flow will drift down the Mae Wong river to other river basins in the wet season. About 4,800 ha of the paddy fields in the downstream basin could be irrigated with this return flow. The return flow in the dry season will be about 2 MCM. It could be utilized as a domestic water source in the Mae Wong area.

(4) Revenue from forestry resources

The forests with some economic value are observed in some parts of the reservoir area. The total net value is estimated at about 33 million Baht for a total merchandable timber volume of about 136,000 m^3, after deducting all the costs needed for logging and selling. These profits could be obtained by selling the timber trees in advance of the inundation.

(5) Foreign exchange earning

After completion of the projects, significant increase in crop production is expected. With the increased production, the marketable surplus of paddy and mung beans will also be increased. The estimated marketable surplus would be about 105,000 tons of rice and about 2,800 tons of mung beans.

These surplus would increase the annual amount of exports, resulting in the foreign exchange earning equivalent to around 945 million Baht per annum.

(6) Increase of employment opportunity

Employment opportunity to the local people will be increased by the project implementation, and a favourable impact will be given to the national economy. Furthermore, the employee will be able to gain more experience, technical know-how, skillfulness in the various working fields. These accumulations would be applied to the future development in the region.

(7) Improvement of local transportation

The local transportation will be improved much by the construction of the operation and maintenance road along the irrigation canals. The expanded road system will not only enhance the economic activities but also contribute to inter-regional accessibility and communication.

(8) Mitigation of flood damages

Flood control is not considered primary in the Projects. However, incidental flood control could be realized to some extent by the operation of reservoir, especially in early part of the wet season.

Table X-1 STRUCTURE OF FINANCIAL AND ECONOMIC COST (IN PERCENT)

Cost Component	Financial Cost				Economic Cost				Weighted Conversion Factor
	Local Cost			Foreign Cost	Local Cost			Foreign Cost	
	Transfer Payment	Unskilled Labour	Others		Transfer Payment	Unskilled Labour	Others		
Capital Cost									
1. Dam & Reservoir	9	5	17	69	-	2	16	69	0.87
2. Irrigation Works	9	10	28	53	-	5	26	53	0.84
3. Office & Quarters	9	15	76	-	-	7	70	-	0.77
4. Land Acquisition	-	-	100	-	-	-	92	-	0.92
5. Resettlement & Compensation	-	-	100	-	-	-	92	-	0.92
6. O & M Equipment	-	-	10	90	-	-	9	90	0.99
7. Administration	-	-	100	-	-	-	92	-	0.92
8. Engineering Services	10	-	15	75	-	-	14	75	0.89
9. On-farm Development	10	80	10	-	-	34	9	-	0.43
O & M Cost									
1. Salaries & Wages	10	20	70	-	-	9	64	-	0.73
2. Office Expenses	10	-	90	-	-	-	83	-	0.83
3. O & M Expenses									
a. Dam	9	5	86	-	-	2	79	-	0.81
b. Irrigation	9	10	81	-	-	5	75	-	0.80

Note: The conversion factor for the transfer payments like taxes and duties is 0, compared to 0.46 for unskilled construction labour, 0.92 for other local costs and 1.00 for foreign costs. Last column indicates the specific economic conversion factor for each cost component.

Table X-2 ECONOMIC COST FOR ON-FARM DEVELOPMENT

1. Financial cost for on-farm development in the model area of 8,160 ha.

	Work Item	Quantity	Unit Cost (₱)	Amount (10^3₱)
a.	Canals	133,460 m	19.0	2,536
b.	Drains	95,330 m	16.0	1,525
c.	Related structure	L.S.	-	609
	Total			4,670

2. Total on-farm development cost for a whole irrigation area of 45,700 ha (financial)

46,700 ha/8,160 ha x 4,670 = 26.7 million ₱

3. Calculation of Economic Cost

a.	Financial Cost	26.7 million ₱
b.	Conversion Factor/1	0.43
c.	Economic Cost (a x b)	11.4 million ₱

Note: /1: see Table X-1

Table X-3 COST AND BENEFIT STREAM
(ORIGINAL CASE)

(Unit: Million ฿)

Year in Order	Cost				Benefits
	Capital Cost	O & M Cost	Repayment Cost	Total	
1	57.1	0	0	57.1	0
2	47.1	0	0	47.1	0
3	158.2	0	0	158.2	0
4	207.6	0	0	207.6	0
5	430.7	0	0	430.7	0
6	558.0	7.2	0	565.2	36.4
7	500.3	10.9	0	511.2	72.8
8	0	18.1	0	18.1	218.4
9	0	18.1	0	18.1	254.8
10	0	18.1	0	18.1	291.2
11	0	18.1	0	18.1	327.6
12	0	18.1	0	18.1	364.0
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
17	0	18.1	44.2	62.3	364.0
18	0	18.1	0	18.1	364.0
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
27	0	18.1	44.2	62.3	364.0
28	0	18.1	0	18.1	364.0
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
32	0	18.1	45.0	63.1	364.0
33	0	18.1	0	18.1	0
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
37	0	18.1	44.2	62.3	364.0
38	0	18.1	0	18.1	364.0
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
47	0	18.1	44.2	62.3	364.0
48	0	18.1	0	18.1	364.0
.	.	.	.	.	.
50	0	18.1	0	18.1	364.0

IRR: 13.0%

Table X-4 COST AND BENEFIT STREAM FOR SENSITIVITY ANALYSIS (1/4)

Case-1: 10% Project Cost Increase (Unit: Million ฿)

Year in Order	Cost				Benefits
	Capital Cost	O & M Cost	Repayment Cost	Total	
1	62.8	0	0	62.8	0
2	51.8	0	0	51.8	0
3	174.0	0	0	174.0	0
4	228.4	0	0	228.4	0
5	473.8	0	0	473.8	0
6	613.8	7.9	0	621.7	36.4
7	550.3	12.0	0	562.3	72.8
8	0	19.9	0	19.9	218.4
9	0	19.9	0	19.9	254.8
10	0	19.9	0	19.9	291.2
11	0	19.9	0	19.0	327.6
12	0	19.9	0	19.9	364.0
:	:	:	:	:	:
17	0	19.9	48.6	68.5	364.0
18	0	19.9	0	19.9	364.0
:	:	:	:	:	:
27	0	19.9	48.6	68.5	364.0
28	0	19.9	0	19.9	364.0
:	:	:	:	:	:
32	0	19.9	49.5	69.4	0
33	0	19.9	0	19.9	0
:	:	:	:	:	:
37	0	19.9	48.6	68.5	364.0
38	0	19.9	0	19.9	364.0
:	:	:	:	:	:
47	0	19.9	48.6	68.5	364.0
48	0	19.9	0	19.9	364.0
.	.	.	.	.	.
50	0	19.9	0	19.0	364.0

IRR: 11.9%

Table X-4 COST AND BENEFIT STREAM FOR SENSITIVITY ANALYSIS (2/4)

Case-2: 10% Benefit Decrease (Unit: Million ฿)

Year in Order	Cost				Benefits
	Capital Cost	O & M Cost	Repayment Cost	Total	
1	57.1	0	0	57.1	0
2	47.1	0	0	47.1	0
3	158.2	0	0	158.2	0
4	207.6	0	0	207.6	0
5	430.7	0	0	430.7	0
6	558.0	7.2	0	565.2	32.8
7	500.3	10.9	0	511.2	65.5
8	0	18.1	0	18.1	196.6
9	0	18.1	0	18.1	229.3
10	0	18.1	0	18.1	262.1
11	0	18.1	0	18.1	294.8
12	0	18.1	0	18.1	327.6
:	:	:	:	:	:
17	0	18.1	44.2	62.3	327.6
18	0	18.1	0	18.1	327.6
:	:	:	:	:	:
27	0	18.1	44.2	62.3	327.6
28	0	18.1	0	18.1	327.6
:	:	:	:	:	:
32	0	18.1	45.0	63.1	327.6
33	0	18.1	0	18.1	327.6
:	:	:	:	:	:
37	0	18.1	44.2	62.3	327.6
38	0	18.1	0	18.1	327.6
:	:	:	:	:	:
47	0	18.1	44.2	62.3	327.6
48	0	18.1	0	18.1	327.6
.	.	.	.	.	.
50	0	18.1	0	18.1	327.6

IRR: 11.8%

Table X-4 COST AND BENEFIT STREAM FOR SENSITIVITY ANALYSIS (3/4)

Case-3: 2 Years Overrun of Build-up Period (Unit: Million ¥)

Year in Order	Cost				Benefits
	Capital Cost	O & M Cost	Repayment Cost	Total	
1	57.1	0	0	57.1	0
2	47.1	0	0	47.1	0
3	158.2	0	0	158.2	0
4	207.6	0	0	207.6	0
5	430.7	0	0	430.7	0
6	558.0	7.2	0	565.2	36.4
7	500.3	10.9	0	511.2	72.8
8	0	18.1	0	18.1	218.4
9	0	18.1	0	18.1	237.8
10	0	18.1	0	18.1	259.0
11	0	18.1	0	18.1	282.0
12	0	18.1	0	18.1	307.0
13	0	18.1	0	18.1	331.7
14	0	18.1	0	18.1	331.7
:	:	:	:	:	:
17	0	18.1	44.2	62.3	364.0
18	0	18.1	0	18.1	364.0
:	:	:	:	:	:
27	0	18.1	44.2	62.3	364.0
28	0	18.1	0	18.1	364.0
:	:	:	:	:	:
32	0	18.1	45.0	63.1	364.1
33	0	18.1	0	18.1	364.0
:	:	:	:	:	:
37	0	18.1	44.2	62.3	364.0
38	0	18.1	0	18.1	364.0
:	:	:	:	:	:
47	0	18.1	44.2	62.3	364.0
48	0	18.1	0	18.1	364.0
.	.	.	.	.	.
50	0	18.1	0	18.1	364.0

IRR: 12.5%

Table X-4 COST AND BENEFIT STREAM FOR SENSITIVITY ANALYSIS (4/4)

Case-4: 2 Years Overrun of Construction Period (Unit: Million ¥)

Year in Order	Cost				Benefits
	Capital Cost	O & M Cost	Repayment Cost	Total	
1	57.1	0	0	57.1	0
2	45.8	0	0	45.8	0
3	166.4	0	0	166.4	0
4	200.7	0	0	200.7	0
5	288.3	0	0	288.3	0
6	288.2	7.2	0	295.4	36.4
7	288.1	9.1	0	297.2	47.3
8	312.1	10.0	0	322.1	58.3
9	311.9	10.9	0	322.8	72.8
10	0	18.1	0	18.1	218.5
11	0	18.1	0	18.1	254.9
12	0	18.1	0	18.1	291.3
13	0	18.1	0	18.1	327.7
14	0	18.1	0	18.1	364.0
:	:	:	:	:	:
19	0	18.1	44.2	62.3	364.0
20	0	18.1	0	18.1	364.0
:	:	:	:	:	:
29	0	18.1	44.2	62.3	364.0
30	0	18.1	0	18.1	364.0
:	:	:	:	:	:
34	0	18.1	45.0	63.1	364.0
35	0	18.1	0	18.1	364.0
:	:	:	:	:	:
39	0	18.1	44.2	62.3	364.0
40	0	18.1	0	18.1	364.0
:	:	:	:	:	:
50	0	18.1	0	18.1	364.0

IRR: 11.8%

Table X-5 FINANCIAL CASH FLOW STATEMENT

(Unit: Million Baht)

Year	Year in Order	Cash Outflow						Cash Inflow				Balance (B)-(A)	Accumulated Loan
		Project Cost	O & M Cost	Replacement Cost	Loan Interest	Loan Repayment	Total Outflow (A)	Foreign Loan	Government Budget	Government Subsidy	Total Inflow (B)		
1987	1	65.9			1.8	-	67.7	50.0	15.9	1.8	67.7	0	50.0
1988	2	63.0	-	-	3.0	-	66.0	35.1	27.9	3.0	66.0	0	85.1
1989	3	213.8	-	-	7.4	-	221.2	126.0	87.8	7.4	221.2	0	211.1
1990	4	286.7	-	-	14.7	-	301.4	209.0	77.7	14.7	301.4	0	420.1
1991	5	623.1	-	-	29.1	-	652.2	410.8	212.3	29.1	652.2	0	830.9
1992	6	845.5	12.8	-	49.3	-	907.6	576.6	268.9	62.1	907.6	0	1,407.5
1993	7	797.1	19.2	-	68.1	-	884.4	538.7	258.4	87.3	884.4	0	1,946.2
1994	8	-	32.0	-	68.1	-	100.1	-	-	100.1	100.1	0	1,946.2
1995	9	-	32.0	-	68.1	-	100.1	-	-	100.1	100.1	0	1,946.2
1996	10	-	32.0	-	68.1	-	100.1	-	-	100.1	100.1	0	1,946.2
1997	11	-	32.0	-	64.7	97.3	194.0	-	-	194.0	194.0	0	1,848.9
1998	12	-	32.0	-	61.3	97.3	190.6	-	-	190.6	190.6	0	1,751.6
1999	13	-	32.0	-	57.9	97.3	187.2	-	-	187.2	187.2	0	1,654.3
2000	14	-	32.0	-	54.5	97.3	183.8	-	-	183.8	183.8	0	1,557.0
2001	15	-	32.0	-	51.1	97.3	180.4	-	-	180.4	180.4	0	1,459.7
2002	16	-	32.0	-	47.7	97.3	177.0	-	-	177.0	177.0	0	1,362.4
2003	17	-	32.0	44.6	44.3	97.3	218.2	-	44.6	173.6	218.2	0	1,265.1
2004	18	-	32.0	-	40.9	97.3	170.2	-	-	170.2	170.2	0	1,167.8
2005	19	-	32.0	-	37.5	97.3	166.8	-	-	166.8	166.8	0	1,070.5
2006	20	-	32.0	-	34.1	97.3	163.4	-	-	163.4	163.4	0	973.2
2007	21	-	32.0	-	30.7	97.3	160.0	-	-	160.0	160.0	0	875.9
2008	22	-	32.0	-	27.3	97.3	156.6	-	-	156.6	156.6	0	778.6
2009	23	-	32.0	-	23.8	97.3	153.1	-	-	153.1	153.1	0	681.3
2010	24	-	32.0	-	20.4	97.3	149.7	-	-	149.7	149.7	0	584.0
2011	25	-	32.0	-	17.0	97.3	146.3	-	-	146.3	146.3	0	486.7
2012	26	-	32.0	-	13.6	97.3	142.9	-	-	142.9	142.9	0	389.4
2013	27	-	32.0	44.6	10.2	97.3	184.1	-	44.6	139.5	184.1	0	292.1
2014	28	-	32.0	-	6.8	97.3	136.1	-	-	136.1	136.1	0	194.8
2015	29	-	32.0	-	3.4	97.3	132.7	-	-	132.7	132.7	0	97.5
2016	30	-	32.0	-	0	97.5	129.5	-	-	129.5	129.5	0	0

Foreign Loan: Annual interest of 3.5% for repayment period of 30 years including 10-year grace period.

ANNEX–XI
ENVIRONMENTAL STUDY

ANNEX - XI

ENVIRONMENTAL STUDY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX - XI

ENVIRONMENTAL STUDY

1. SCOPE OF ENVIRONMENTAL STUDY

1.1 NEB Guideline

Dam and irrigation projects are generally considered influential in altering the environmental resources. The National Environmental Board (NEB) worked out "Guidelines for Preparation of Environmental Impact Evaluations" in 1979, with a view to conserving the environmental resources in Thailand. All the development agencies who propose to undertake construction of any new projects are requested by NEB to prepare an appropriate "Environmental Impact Statement (EIS)" in accordance with the said guidelines and to submit it to NEB for review and further actions.

The detailed EIS is required if the main features of the proposed project exceed the following guideline:

(1)	Effective storage	:	100 MCM
(2)	Reservoir area	:	15 km^2
(3)	Irrigation area	:	80,000 rai

The proposed Mae Wong Irrigation Scheme is larger than the above guideline in scale and therefore the detailed EIS will be required.

The environmental study required by NEB comprises manifold items of environmental impact evaluations. They are classified into four (4) categories as follows:

(1) Physical resources

a. Surface water hydrology
b. Surface water quality
c. Groundwater hydrology
d. Groundwater quality
e. Soils
f. Geology/Seismology
g. Erosion/Sedimentation
h. Climate

(2) Ecological resources

a. Fisheries
b. Aquatic biology
c. Wildlife
d. Forests

(3) Human use values

a. Agriculture/Irrigation
b. Aquaculture
c. Water supplies
d. Navigation
e. Recreation
f. Power
g. Flood control
h. Dedicated area uses
i. Industry
j. Agro-industry
k. Mineral development
l. Highway/Railway
m. Land use

(4) Quality of life values

a. Socio-economic
b. Resettlement
c. Cultural/Historical
d. Aesthetic
e. Archaeological
f. Public health
g. Nutrition

In case of large scale dam/irrigation development like the Mae Wong Irrigation Scheme, a full-scale environmental study is required for preparation of the detailed EIS which will cover all the above items with appropriate analysis and recommendations in sufficient detail. However, such full-scale environmental study has not been included in the "Scope of Work for Feasibility Study on Sakae Krang River Basin Irrigation Project" for the reasons that (1) such environmental study will be made more efficiently after the project feasibility is surely verified and (2) NEB requirement for environmental impact evaluations has not been clearly specified yet and no detailed specifications for the required study and/or environmental standards have not been made available yet, therefore difficulties are involved in making such full-scale environmental study in sufficient detail within the limited time of study period under the present frame-work of the feasibiliby study.

Such being the case, only preliminary study is possibly carried out at the present stage of the study for the purpose to point out the present environmental problems and the anticipated alteration in environmental resources which may be caused by the project construction.

1.2 Scope of Environmental Study

The following method of environmental study was mutuallly agreed between RID and the JICA study team in the meeting held on March 14, 1985.

(1) Study area

The study area covers the Mae Wong river basin of 2,170 km^2 which may receive more or less environmental impacts by the development of dam and irrigation under the Mae Wong Irrigation Scheme.

(2) Study items

The environmental study required by NEB comprises manifold items of environmental impacts evaluations. In order to cover all the items, enormous efforts will be required for collection of data and information. All these items are, therefore, classified as listed in Table XI-1.

a) For the items already included in the original scope of the feasibility study, additonal data collection is made by the JICA study team in close cooperation with RID and the study results in those fields obtained through the feasibility study are fully utilized in the environmental impacts evaluations.

b) For the remaining items which are not included in the original scope of the feasibility study, additional survey and data collection are required. RID is requested to make such survey and data collection to the extent that RID considers necessary. These study items are divided into two (2) groups: 1) the items which the JICA study team would assist RID to make the additional survey and data collection, and 2) the items that RID would be solely responsible for the additional survey and data collection.

The JICA study team makes the required study on the basis of the data and information to be collected in the above manner, and prepares a report on the environmental impacts evaluations as a part of the feasibility study (not official EIS).

The major items that the JICA study team has carried out the additional survey and data collection are as follows:

(1) Ecological resources : - fisheries
- aquatic biology
- terrestrial wildlife
- forest

(2) Human use values : - aquaculture

(3) Quality of life values : - resettlement

2. PHYSICAL RESOURCES

2.1 Surface Water Hydrology

2.1.1 Present condition

(1) General aspect

The Mae Wong river originates from the mountaineous terrain near the western border of Thailand. It flows southeast through Lat Yao and merges with the Khlong pho river at Sawan Arom.

The Mae Wong river basin extends over the northern part of the Sakae Krang river basin with a total area of 2,170 km^2, which is about 1/3 of the Sakae Krang river basin. After cutting through the mountain ridges of Khao Chonkan located about 14 km downstream from the damsite, the river flows into the vast alluvial plain where agricultural lands extend. The average river gradient at downstream reaches about 1/1,500 and total river length is about 200 km.

(2) Hydrologic station

There are two streamflow gaging stations along the Mae Wong river. The station CT-5A is located at downstream edge of watershed area, and has been operated by RID since 1969. The station CT-4 is located at middle reach of the river or about the center of irrigation area. Observation at CT-4 has been made since 1975.

The runoff data at station CT-5A are considered fairly accurate. The runoff analysis for the Mae Wong river was therefore made on the basis of the actual runoff records and the generated streamflow by tank model at CT-5A for the periods from 1954 to 1983.

(3) Annual stream flow

Fig. XI-1 shows annual series of actual runoff record at CT-5A from 1969 to 1983. Yearly fluctuation of streamflow is remarkably large. The annual runoff amount is recorded at 0.09 MCM/km^2 in 1977 and 0.88 MCM/km^2 in 1983, while the average runoff is 0.38 MCM/km^2 for the recorded period.

(4) Monthly stream flow

The average monthly flow pattern at the gaging station CT-5A is shown in Fig. XI-2.

The river runoff from the basin watershed is characterized by long low flow in period from December to July. Wet season flow occurs from August to November, which is primarily due to the influence of the southwest monsoon. The highest flow usually occurs in October and the lowest flow occurs in April or March. Wet season flow is about 80% of total annual flow.

(5) Flood

Present flood condition

Flood probability was applied for the annual maximum floods recorded in the Sakae Krang Basin. The calculated results of flood probability at Upper Mae Wong Dam are shown below:

Return period	m^3/sec
10	480
20	630
100	1,010
200	1,210
500	1,490
1000	1,730

Note: Specific discharge at CT-7 is applied.

The calculated floods by the rational formula, which was applied to derive a peak flood discharge from the rainfall intensity with different probability, are as follows:

(Unit: m^3/sec)

Dam	Return Period		
	1/10	1/100	1/200
Upper Mae Wong	857	1,334	1,481

Flood damage

Data on the flood damage caused by the floods in 1981 and 1983 were obtained from provincial offices at Nakhon Sawan and Uthai Thani. In Nakhon Sawan province, damaged sub-districts are Mae Lae, Huai Nam Hom, Wang Sarn and Muban Lat Yao in case of November, 1981 flood. Four persons were lost in Lan Sak and Muban Uthai Thani District in 1981. Five persons were lost in Sawang Arom, lan Sak and Thap Than District in 1983. The number of damaged houses were 58 in 1981 and 134 in 1983.

In case of November, 1981 flood, 310,000 rai of farmlands (7% of the total area of Uthai Thani Province) were flooded and 70,000 rai of them were damaged. In case of 1983 floods, 151,000 rai of farmland were damaged. Public facilities such as roads, bridges, weirs, government offices, temples, etc. were also damaged.

Although every district gets flood damages, three districts (Lan Sak, Sawang Arom and Thap Than) seem to have heavier damages. They are surrounded by the Khlong Pho and Thap Salao rivers.

To repair the flood damages in 1983, the Uthai Thani provincial Office had, at first, spent about 1.2 million Bahts from its temporary reserve and later spent about 18.0 million Bahts, which was granted by the Local Administrative Department.

Flood control

The annual peak flood scales are considerably reduced as it is shown in the comparison of the annual maximum flood for the conditions of with and without reservoir. These are summarized as follows.

Dam	Ave. Annual Inflow (MCM/yr)	Regulated by Dam (MCM/yr)	Regulated Percent (%)	Ave. Max. Flood without Dam (m^3/sec)	Ave. Max. Flood with Dam (m^3/sec)	Reduced Percent (%)
Upper Mae Wong	209.5	162.6	78	41.2	15.4	63

2.1.2 Environmental impact by the Project

(1) Formation of reservoir

The construction of the reservoir will change the original free flowing water of the Mae Wong river. Major limnological aspects of the Upper Mae Wong reservoir are as follows:

Reservoir	Full storage level EL. 204.5 m	Dead storage level EL. 180 m
Max depth	34.5 m	10 m
Shore line	41.3 km	16.6 km
Surface area	17.6 km^2	3.0 km^2
Shallow area below 10 m depth	7.9 km^2	-

(2) Reservoir water level

Fig. XI-3 shows the reservoir water level regulated for irrigation, which was derived from the irrigation water balance study for 30 years from 1954 to 1983. The frequency of reservoir water drawdown to the dead water level of the elevation 180 m is about 17% during 30 years.

(3) Formation of thermocline

The thermocline of the reservoir is evaluated by the values parameters, So/g and V/g, where So is rexervoir surface area in million m^2, g is reservoir inflow and V is reservoir storage volume in MCM (Source: Japanese Environmental Agency). It is generally accepted that the thermocline is formed in the reservoir when the values of So/g and V/g exceed the index values of 0.1×10^6 for So/g and 3×10^6 to 4×10^6 for V/g respectively. Taking reservoir inflow at 6.6 m^3/sec reservoir storage volume of 230 MCM and the reservoir surface area of 17.6 km^2, the values of the parameters will be calculated at:

$$So/g = 3 \times 10^6 \text{ and } V/g = 35 \times 10^6$$

Both greatly exceed the index values. The Upper Mae Wong reservoir will have a distinctive character easy to form thermocline. The thermocline is usually formed during the transition period between cooler season and hotter season. Once the thermocline is formed in the reservoir, the dissolved oxygen reduced and water quality will become worse.

These physico-chemical conditions created by the formation of thermocline are destructed by decline of the reservoir water level to the dead storage level. Climate conditions such as temperature and wind also affect the conditions. Since the reservoir water level will largely fluctuate for supply of irrigation water, the formation of thermocline will often be renewed and therefore, any protective reservoir operation against the thermocline will not be required.

(4) Evaporation loss

The average evaporation from the reservoir is to be about 6% of the reservoir annual inflow to the reservoir.

(5) Release water

As shown in Fig. XI-4, the regulation of surface water by the Mae Wong dam will not cause the changes in seasonal flow pattern and the volume in the downstream section from the damsite.

When rainfall is little, water requirement will become large and the released water will increase. The released water will decrease during the flood season in comparison with the present flow conditions.

(6) Flood control

The flood control may cause the reduction of sediment and nutrient supplies. The Mae Wong river has a watershed of 315 km^2 at Ban Taling Sun except the Upper Mae Wong reservoir and watershed. During flood season, even if no water is released from Upper Mae Wong dam, 23 MCM of water on an average will flow per month at near Ban Taling Sun.

Therefore, the influence to the river fishery and sediment supply will not become serious problem.

(7) Alterlation of discharge in the service area

The details concerning the return flow has been described in ANNEX-III (WATER BALANCE STUDY).

Fig. XI-5 shows the comparison of river discharges between the present and future conditions at CT-5A. The variation pattern will not change significantly. The river discharge after the dam construction could be expected to be little except for a year when the rainfall is extremely small.

2.2 Surface Water Quality

2.2.1 Present condition

(1) Field investigation

The field investigation on water quality was made at 6 sites shown in Fig. XI-6 during 17 to 21 August, 1985. Water samples were collected from the mid depth of the central stream at site No. 2 and 6 by using sample bottle directly. On the other hand, field measurements which comprise transparency, flow velocity, water temperature, hydrogen ion concentration and dissolved oxygen were made at all the sites.

Water quality was studied for the following items:

Items/Site	1	2	3	4	5	6
1. Transparency	O	O	O	O	O	O
2. Water temperature	O	O	O	O	O	O
3. Flow velocity	O	O	O	O	O	O
4. Hydrogen ion concentration	O	O	O	O	O	O
5. Dissolved oxygen	O	O	O	O	O	O
6. Chemical oxygen demand		O				O
7. Biological oxygen demand		O				O
8. Suspended solid		O				O
9. Toatal solid		O				O
10. Phosphate-p		O				O
11. Ammonia-N		O				O
12. Nitrite-N		O				O
13. Nitrate-N		O				O
14. Kjeldhal-N		O				O
15. α BHC		O				O
16. β BHC		O				O
17. Aldrin		O				O
18. Dieldrin		O				O
19. Heptachlor		O				O
20. Heptachlor epoxide		O				O

Other items such as chloride ion, calcium ion, and sodium ion were investigated in the field of irrigation study.

Water samples were kept in a ice box and brought back to the laboratory of National Environmental Board (NEB) and analysed according to the procedure of NEB Laboratory.

(2) Result

Transparency

Transparency of the water body was more than 30 cm at all sites. It can be judged that water body is clear.

Water temperature

Water temperature varied between 27.2°C and 32.5°C.

Flow velocity

Flow verocity was between 0.52 m/sec and 1.38 m/sec.

Hydrogen ion concentration

Hydrogen ion concentration varied between pH 6.5 and 7.7. In this range aquatic life is inhabitable.

Dissolved oxygen (DO)

Dissolved oxygen varied from 7.8 to 10.55 mg/ℓ. The concentration was nearly saturated and/or over-saturated at all sites. This could be attributed to the turbulance within the stream, phytoplankton and benthic algae.

Chemical oxygen demand(COD) and Biological oxygen demand(BOD)

COD was 6.98 mg/ℓ at site No. 2 and 4.65 mg/ℓ at site No. 6. These high COD concentration suggests that the water body of the Mae Wong river contains a considerable amount of organic matter.

BOD was 1.02 mg/ℓ at site No. 2 and 0.40 mg/ℓ at site No. 6 respectively. It seems that the organic matter here is stable against bacterial activity, because the ratio COD/BOD indicates greater than that in usual water.

Suspended solid (SS) and Total solid (T-S)

Suspended solid was 23 mg/ℓ and Total solid was 90 mg/ℓ at sites 2 and 6. It seems that the great difference between SS and TS is due to those of the organic matter such as humic substances.

Inorganic nutrients and Kjeldhal nitrogen

The concentrations of inorganic nutrients such as Ammonia-N and Phosphate-P were very low, while concentration of Kjeldhal-N as organic nitrogen was relatively high, showing 1.53 mg/ℓ at the site No. 2. It seems that the concentration of both inorganic and organic nutrients is low in the upstream of Upper Mae Wong dam.

Pesticide

α BHC concentration was 0.014 µg/ℓ at site No. 2 and 0.013 µg/ℓ at site No. 6. γ BHC concentration was 0.009 µg/ℓ at site No. 2 and 0.006 µg/ℓ at No. 6. Heptachlor concentration was 0.083 µg/ℓ and 0.092 µg/ℓ at the respective sites. Heptachlor epoxide concentration was 0.005 µg/ℓ and non detectable at the respective sites. Dieldrin concentration was 0.050 µg/ℓ and 0.077 µg/ℓ at the respective sites. Aldrin concentration was 0.030 µg/ℓ and 0.022 µg/ℓ at the respective sites.

2.2.2 Environmental impact by the Project

During dam construction phase

(1) Turbidity and siltation

During dam construction, soils on the slopes will be washed down into the river stream by surface runoff. These soils particles will increase the turbidity and siltation of the stream.

However, these problems associated with soil erosion due to dam construction can be minimized by providing the sedimentation basins.

(2) Soil erosion

Soil erosion around damsite during its construction can be minimized by employing the appropriate construction practices and by vegetation on the sloping area after construction.

Environmental impact by reservoir impoundment

(1) Organic content

After impoundment, the flooded trees and soil particles would increase the level of organic matter in the reservoir water. In addition, the growth of algae would also increase the level of organic matter. In the bottom layer, the organic contents would raise BOD concentration level in the water.

(2) Dissolved oxygen consumption

In the lower parts of the reservoir, the dissolved oxygen would be utilized by the biological activity, so that the level would decrease as the depth of reservoir increase.

When the thermal stratification develops, the bottom layer becomes anaerobic, where the organic decomposition is active under these anaerobic condition. And wind-drifting causes the upwelling of anaerobic water which reduces dissolved oxygen in the upper layer.

(3) Suspended solid and total solid

Greater part of total solid will runoff from the water body of the reservoir because the ratio of SS to T-S inflowed into the reservoir is much smaller.

(4) Nutrients

It is expected that nutrient such as nitrogen and phosphorus will be abundant due to regeneration of organic matter in the reservoir and through water-sediment interface. Nutrient enrichment will makes the productivity of aquatic life increase.

(5) Pesticide

Pesticide concentration will not increase because of little loading to the reservoir.

Environmental impact of downstream and wateruse area

(1) Renewal of lower dissolved oxygen

The water released from the reservoir, which has the low concentration of dissolved oxygen, would return to the normal level by the time of using at wateruse area due to turbulence and photosynthesis of phytoplankton in the stream.

(2) Nutrient supply

Inorganic nutrients will not decrease, and organic matter in the stream will increase due to accumulation of the solid matter in the reservoir. Nutrient will be useful to increase the productivity of aquatic life and fertilize the irrigation land.

(3) Pesticide concentration

The pesticide concentration will be slightly increased due to loading through runoff from the cultivated land. However, the present flow of the Mae Wong river will not decrease and the pesticide use in the cultivated land will not significantly increase. Also the toxic pesticide will not be used. The farmers will be guided by the agricultural extension workers for proper use of the pesticides. By these reasons, it is expected that the pesticide concentration in the river water will not exceed the published drinking water quality standard level (see Table XI-2).

(4) Eutrofication of river water

Increase of fertilizer use will cause eutrofication in the river water, and outflow of nutrients will alter the composition of fish population, though productivity of aqutic life will increase.

2.3 Erosion and Sedimentation

2.3.1 Reservoir sedimentation

Sediment inflow is usually calculated based on suspended and bed load. Suspended and bed loads were estimated at 179,000 ton/year (71 m^3/km^2/year) and 182,974 t/year (112 m^3/km^2/year), respectively.

In the dam plan, the sedimentation rate has been estimated at about 300 m^3/km^2/year in the reservoir as safety measurement is considered.

2.3.2 Agradation

In the upstream of the dam, the river bed will be elevated because of back sand at the edge of the reservoir. The elevation of the river bed will cause flooding in the riparian area at the reservoir edge. However, in the dam design, it is planned that the land of reservoir rim upto the flood water level 207.5 m are to be compensated, and the cost was counted in the project cost. Therefore, environmental impact by change of transportation mechanism of sediment is very little.

2.3.3 Degradation

On the contrary, in the downstream of the damsite, the reduction in sediment supply will cause a degradation of river bed. Careful consideration will be taken in the design of such structures as diversion weir and bridge on the downstream river channel.

2.4 Groundwater

It is often apprehensive that irrigation water will create water logging and salinity built-up. This is always true in such area where the topography is of depression and the soil or geological formation contains salinity. It was learnt from the existing irrigation projects in many countries that most of water logging in the irrigation projects are created by the ineffective use of irrigation water and by poor drainage of surface water. High groundwater table is not considered major reason for water logging where the aquifer develops to the downstream.

In the Mae Wong irrigation area, the topography has gentle slope and aquifer develops along the river courses and is connected to the Central Chao Phraya Plain. Permeability of the aquifer is estimated from the field experimental data and is sufficiently large at about 5×10^{-3} cm/sec. The depth of aquifer will be about 30 to 50 m.

According to the water quality analysis on the river water and existing irrigation canal water and soil analysis in the benefit area, there was no evidence found to indicate water salinity built-up in the groundwater.

2.5 Soils

2.5.1 Physiography

From physiographic point of view, the lands in the Mae Wong river basin and the proposed irrigation area are classified as follows:

Land-Form Categories	Mae Wong River Basin		Proposed Irrigation Area	
	km2	%	km2	%
1. Flood Plain	-	-	-	-
2. Semi-recent fan and alluvium	544	25.1	271	54.7
3. Low terraces	187	8.6	185	37.4
4. High terraces	546	25.1	39	7.9
5. Dissected erosion surface	256	11.8	-	-
6. Mountains	638	29.4	-	-
Total	2,171	100.0	495	100.0

The major soils covering the Mae Wong irrigation area are those on (1) semi-recent fan and alluvium with 544 km^2 and (2) low terraces of old alluvium with 187 km. These occupy 92% of the total area other land are not suitable for irrigation scheme due to the topographic reason and soil condition, i.e. sandy and/or gravelly texture, shallow soil depth and low inherent fertility.

2.5.2 Soil classification

A total of "12 soil series" are identified by the land categories of (1) semi-recent alluvium, (2) low terraces and (3) high terraces.

Details on each soil series are described in ANNEX-VII. The major soil series covering the semi-recent fan and alluvium are those of Nakhon Pathom, Phetchaburi and Mae Sai with 24,200 ha and these soil series occupy 89.2% of the total area in the semi-recent fan and alluvium. Deum Bang and Pak Tho series are dominant soils on the low terraces and occupy 87% of low terraces.

2.5.3 Slope complex soils

The slope complex soils were found in the reservoir areas due to the steep hillside slopes along the tributary channels. These soils are considered as miscellaneous land-form on mountains and hills of various rock type. Soils of sloope complex are relatively shallow, but locally may be deep as pockets. They are highly variable with a great potential for erosion.

2.6 Geology

The Mae Wong river basin is geologically divided roughly into two parts; the western Paleozoic zone and the eastern Mesozoic part by a Tertiary volcanic belt running along latitude of about E-99°-30', or along the Khao Chonkan mountain ranges.

The irrigation area is located within the eastern Mesozoic part, in which a vast Khorat Plateau develops, having a more gentle, almost flat, geostructure.

The proposed Upper Mae Wong damsite and reservoir are located within the western Paleozoic zone which has a distinct N-S geological structure, suffuring the Burmese-Malaya geosynclinal movement of meridional trend. These geostructural modes are thought to have been formed as a result of the crustral movements during the Mesozoic and Tertiary periods.

Major geologic features of reservoir and damsite are Uthai Thani complexes of Proterozoic precambrian quartzite, calc-silicate and schist, Plaeozoic to Cambrian quartzite, phillite and schist, and Mesozoic granite groups intruding or pushing into the said old rocks.

2.7 Climate

The Mae Wong river basin is characterized by two pronounced season, one dry from November to April, the other wet during the rest of the year. The former is affected by the southwest monsoon and the later is affected by the northeast monsoon. September is generally the month of the heaviest precipitation during the southwest monsoon season.

2.7.1 Temperature

Fig. XI-7 shows the monthly temperature patterns at Nakhon Sawan. The mean temperature observed at Nakhon Sawan is about 28.5°C. The coolest month is December with the mean monthly temperature of 25.2°C while the hottest one is April with 31.9°C. The mean temperature of Upper Mae Wong watershed seems to be as low as 2 - 5°C compared with Nakhon Sawan. The lowest mean temperature at CT-5A were observed in December and June with about 20°C.

2.7.2 Humidity

The patterns of the mean monthly relative humidity are shown in Fig. XI-8.

The mean monthly relative humidity usually ranges from 61% in March to 82% in September. While the mean maxima are constant range from 86.9% to 95.5% all year round, the mean minimum varies more, from 39.1% to 66.4%. Generally speaking, the relative humidity is high in the southwest monsoon season and in the northeast monsoon season it is usually low.

2.7.3 Evaporation

Fig. XI-9 shows the pattern of the monthly evaporation. The mean annual pan evaporation is 2,089 mm. The mean monthly evaporation has the maximum of 260 mm in April and the minimum of 128 mm in September.

2.7.4 Wind

The prevailing wind direction is south from February to October while from November to January it varies between east and north under the northeast monsoon influence.

2.7.5 Rainfall

There are 4 stations located within the Mae Wong river basin and no rainfall station is located in the watershed of the Upper Mae Wong dam. The nearest station is CT-5A, about 13 km downstream from the damsite. The average monthly rainfall for the above 4 stations are as follows:

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
73	163	128	132	179	262	150	40	6	10	12	25

During the wet season from May to October, heavy precipitation occurs due to the southwest monsoon. In the period of the dry season from November to April, the rainfall is scarce varying from 6 mm in December to 73 mm in April.

Within the Mae Wong river basin, the rainfall distribution is almost even, varying from 1,120 mm/year at the downstream to 1,320 mm/year at the upstream area.

2.8 Preliminary Evaluation on Physical Resources

The influence by the dam construction and the irrigation development to the physical resources occures will mainly be derived from the change of water regime. The effects by erosion, sedimentation, groundwater, soils, geology and climate are extremely small or negrigible.

Although various effects by the change of the water regime will appear in the reservoir and the service area, most of them will give favourable changes for the present environmental circumstances.

The construction of the dam and reservoir yields huge amount of water. The regular supply of water to the downstream area from the reservoir will produce social and economical benefit as well. Furthermore, the regular supply of water will give the favourable alternation to the ecology.

3. ECOLOGICAL RESOURCES

3.1 Present Condition of Aquatic Biology

3.1.1 Aquatic biology

(1) Plankton

Planktonic organism was surveyed from 17 to 21, August, 1985. Composition of planktonic organism in the upstream reach is shown in Table XI-3.

Planktons found out in the stream flow are classified into phylum Cyanophyta, Chlorophyta, Bacillariophyto, Euglenophyta, Rotifera and Arthopoda. The dominant phytoplankton is phylum Bacillariophyta and main genuses are Achnanthes, Amphora, Cymbella, Diatoma, Melosira, Navicula, Nitzschia and Synedra. Zooplankton collected was mainly Rotifera. The density of plankton ranges from 2,000 to 20,000 per/lit.

(2) Benthos

Megalo benthos, which includes the insect and mollusca, was observed directly in situ and Paloemonidae, Reridae, Gomphidae, Chironomus sp, Goniobasis sp, Pseudodon sp, Corbiculidae were found out in the river.

(3) Aquatic weeds/plants

Aquatic weed/plant was also surveyed from 1 to 3, August and from 17 to 21, August 1985. Composition of Aquatic weed observed in the upstream reach from Ban Taling Sun are shown in the Table XI-4. 13 species of aquatic weed were found out. Standing crop of aqua-weeds was estimated at about 190 tons in the reservoir area.

(4) Fish population

Table XI-5 shows the result of composition and standing crop of the fish population per 100 m^2, which have been obtaind by field survey made from 17 to 21, August, 1985.

Species collected by field survey were 11 species and dominant species were Barilius guttatus and Barilius Koratensis, Acanthopsis choirorynchos. Species collected from fisherman, which were caught by hook, were Mystus numurus, Notopterus notopterus. But, by collecting the information from the fishermen, other fishes have been also caught in the Mae Wong river as following species: Ophiocephalus striatus, Fulta alba, Mastacemvelus armatus armatus, Carias macrocephalus, Clarias balrachus and Leiocassis siamensis siamensis.

Although Clarias macrocephalus and Clarias batrachus were not collected within this survey period, they are very valuable fish, selling in the Ban Taling Sung at about 40 to 50 Bath per kg. These species were mainly caught in the head of the reservoir area. Since artificial breeding is developed in recent years, the aquatic culture of above fishes is promising in the reservoir area.

(5) Estimation of standing crop of fish population

In order to estimate standing crop of fish population, surface water area of river flow was measured in the river section from the damsite to the head of the reservoir. This area was estimated approximately as 0.38 Km^2 (238rai). The result of estimation of standing crop at this field survey is as follows. (except the poisson method samples)

- upstream length of the river : 12.8 km (the main stream)
- average surface water width : 24.2 m (mean of 4 stations)
- surface water area : 0.31 km^2, 194 rai
- average standing crop per 100 m^2 : 448.74 g/100 m^2
- Standing crop : 1.39 t

The dominant sepcies were as follows:

Mista coleucus marginatus	Pla Kiyok	0.07 ton
Berilius guttatus	Pla nang ao	0.60 ton
Berilius Koratensis		0.31 ton

3.1.2 Environmental impact by the Project

(1) Impact on Aquatic biology

New ecology in the reservoir

New ecosystems in the reservoir area will increase the productivity of aquatic life due to impoundment.

Major changes in the reservoir are increase of water area, decrease of flow velocity, loading of nutrient from the land, bottom quality and decomposition of trees or plants in the reservoir. Standing crop of Diatom (Bacylariophyceae) or Blue green algae, Chrolophyceae having planktonic life will increase. Under these circumstance, Rotatoria and planktonic arthropoda as Copepoda and Brachiopoda will increase in the reservoir.

Benthic fauna may be changed from the oligosaparobicaual to the eutrophic due to large consumption of dissolved oxygen through decompositions of organic matter in the bottom layer of reservoir.

With eutrophication of reservoir water, floating weeds will spread in the reservoir. Excess proparation of these floating weeds is undesirable for fishery and dam management. Some counter-plants will be needed to maintain the favorable conditions of the reservoir.

Other aqua weeds can grow on the shore line and shallow area which topographical condition is suitable to growth of these plants.

New ecology in the downstream

The present benthic fauna will change to poor species by the degradation but biological productivity will not decrease of stream-flow beeing stable.

(2) Impact on the fisheries

Upstream fishery

After impoundment, present fishery in the upstream reach will have be changed. However, new chance of the fishery in the reservoir will enlarge the fishery activities.

Downstream fishery

The reduction of fish production will not occur because of large migratory species, which is caught by local fishermen during flood season, being little.

(3) Potential of fishery development

Study on fishery development potential

Fig. XI-10 shows the relation between the surface area and fishery production, which is expressed as the following formula:

$$\log C = 0.003A + 2.19$$

where, C: fishery production (tons)
A: reservoir surface area (km^2)

Applying the above formula, the expected fishery production is estimated:

$$\log C = 0.003 \times 17\ km^2 + 2.19$$

$$C = 174 \text{ tons}$$

Market prices of all the kinds of fish in the country was averaged at 45.8 Baht in 1982 (see Table XI-7). This estimated price may not be accurate enough for estimate of economic value for fishery development because of simple average. The weighted average price was not available.

Economic value of the fish production in the reservoir will be about 8 million Baht per year in the case of the above price. Careful management of fishery resources control will increase the production values in the reservoir, for example, considering releasing more expensive fishes into the reservoir and making proper maintenance for the continuous production.

New fisheries situation in the reservoir

After impoundment, the Upper Mae Wong reservoir will form better conditions for fisheries resources. Surface water area is 17 km^2. Depth and shoreline are 30 m and 41.3 km at full storage level, respectively. The complicated lay of shoreline and spacious shallow area are very valuable to increase the fish population in the reservoir, because they are useful for fish population as shelter, spawning ground and recruitment ground of fish resources (Fig. XI-11).

Fish hatchery and artificial propagation

It will be expected that fish hatchery and artificial propagation operation will be introduced to accelerate the development of new fisheries in the reservoir by cooperation of Department of Fisheries. At the first phase, these operations are efficient for increasing the popoulation of herbivorous or omnivorous fish, though they are not sold at high price. After that, releasing of carnivorous fish (for example, Clarias sp. and snake head) may be considered to form the complicated ecosystem in the reservoir. Such artificial management for fishery resources will guarantee the continuous production of fish in the reservoir.

Development of downstream fisheries

It is expected that the nutrients in the river water will slightly increase due to decomposition of organic matter in the reservoir and fertilizing in the irrigation area. Productivity of fish in the river water will increase, except the case of high comsumption of nutrients by the aqutic plants. By this reason, it is expected that aquatic culture such as pond culture and cageculture will be developed in downstream fisher.