Consumptive use of crop (actual crop evapotranspiration, ETa) is calculated by multiplying the ETo value by crop coefficient (Kc) corresponding to growth stage of crops, and monthly consumptive use of crop can be calculated.

Crop water requirement on 10-day basis is estimated based on the proposed cropping pattern (Type-I and II), by adding percolation rate of 2.0 mm/day throughout the growing season of paddy and water supply for land preparation of 250 mm.

The crop water requirement for each crop thus estimated are summarized as follows;

Table 5-14 Estimated Crop Water Requirement

Paddy Rice:		
Wet season HYV	:	761 mm
Wet season LV	:	782
Upland Crops:		
Wet Season Upland Crop	:	545
Groundnut	:	549
Soybean	:	619
Watermelon	:	557
Chilli	:	549
Stringbean	:	622
Perennial Crop	:	1,470

c) Diversion Water Requirement

Diversion water requirement is calculated by adding effective rainfall and irrigation efficiency to the crop water requirement.

Annual diversion water requirements for Type-I and II are summarized as 134.6 MCM and 141.1 MCM in the designed year, and 113.0 MCM and 119.5 MCM in the normal year, respectively.

2) Domestic Water Requirement

About 46,200 people live in the Project Area, and are suffering from shortage of domestic water, especially drinking and living water. In the project, such domestic water is included in the water demand to be supplied through the D-28 reservoir.

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

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

5. 5. 3 Irrigation Water Supply Plan

1) Proposed Irrigation Systems

The proposed irrigated area for the project is estimated at 34,000 ha, in the designed year of 1/5-year return period. The irrigation systems consisting of main, lateral/sub-lateral canals in the area are planned based on the available topographic maps.

The proposed irrigation systems for the plan are presented in schematic diagram, with proposed main and lateral/sub-lateral canal alignment, and demarcation of each service unit of about 40 ha on average.

At the head of main irrigation canals, pumping facilities will be needed, because there is no possibility of gravity irrigation.

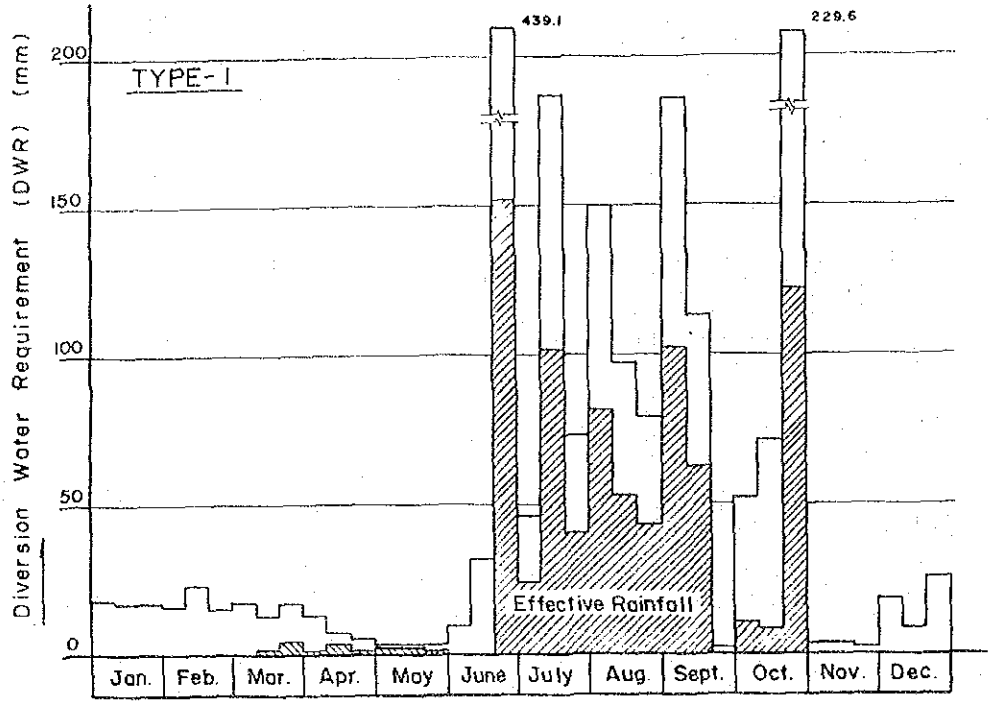
2) Irrigation Method for Paddy Cultivation

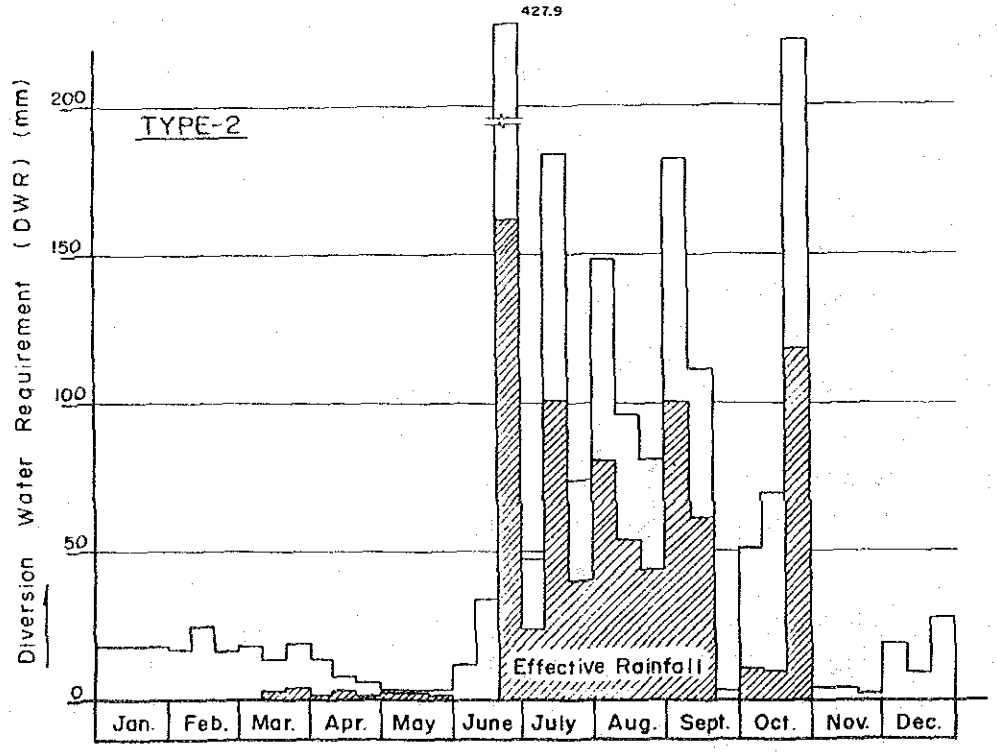
a) Irrigation Method

In general, two types of water distribution methods are being practiced for paddy cultivation, such as simultaneous and rotational water supplies.

- The rotational irrigation method is to be applied at the level of supplemental farm ditches on the farm, at the stage of the land soaking and land preparation stages, and at a time when the available water is scarce.

Figure 5-7 10-Day Fluctuation of Diversion Water Requirement





- The simultaneous irrigation method is to be applied at the crop growing stage and at a time when available water is abundant. However, once water sources are quite seriously limited, water supply method will be shifted to the rotational method.

b) Designed Water Requirement for Main Canals

The peak irrigation water requirement was calculated at 0.930 lit./sec/ha in a return period of 1/10-year. Consequently, the designed water requirement for the main canal commanding about 5,000 to 6,500 ha (31.3 to 40.6 thousand rai) was decided at 1.00 lit./sec/ha considering domestic water requirements.

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

According to the proposed irrigation systems, the irrigated area covered by one lateral canal is ranged widely from about 6,500 ha to 200 ha (40.6 to 1.3 thousand rai).

The lateral and sub-lateral canal capacity are decided as follows;

more than 1,000 ha	:	1.50 lit./sec/ha
1,000 - 200 ha	:	2.10
200 - 40 ha	:	2.90

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

The maximum water requirement is scheduled in the first irrigation period for land soaking with 150 mm for the wet season paddy.

The designed capacity for on-farm facilities is determined as 2.17 lit./sec/ha. One rotation unit is planned to be about 20 ha (125 thousand rai). Consequently, designed capacity of turn-out is decided at 43.4 lit./sec/ha in the typical rotation unit of about 20 ha.

3) Irrigation Method for Upland Crops

a) Proposed Upland Crops and Areas

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

Table 5-15 Cropping Areas by Upland Crop

(unit : ha)

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

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

(1) Measurement of Basic Intake Rate

The following table gives the observed basic intake rate;

Table 5-16 Obtained Basic Intake Rate (Ib)

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

Table 5-17 Physical Properties of Soils[1/]

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

1/ : Average of seven samples
2/ : $P = (Sr - Sa) \times 100 / Sr$

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

(2) Depth and Time Interval of Irrigation Application

Table 5-18 Depth of Effective Root Zone

Upland Crop	Depth of Effective Root Zone (cm)
Groundnut	40
Soybean	40
Watermelon	60
Stringbean	40
Chilli	40

Table 5-19 Estimation of Irrigation Interval

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

Finally, irrigation at five-day intervals was taken for the project.

5. 5. 4 Pump Operation Plan

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

Pump operation hours are estimated on 10-day basis, depending upon total irrigation requirement and pump discharge per unit; the following table indicates the estimated pump operation hours in the case of both cropping patterns.

Table 5-20 Pump Facilities

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

Table 5-21 Pump Operation Hours

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

The estimated pump operation hours are mainly concentrated in the land-soaking and preparation and around October corresponding to the late period of the wet season for wet season paddy and for the entire the growing period of dry season crops.

5. 5. 5 Drainage Plan

Inundation by flood discharge is generally caused by the followings;

- No provision of terminal drainage canal.
- Insufficient drainage capacity of existing drainage creeks and small tributaries.

- Reverse flow of drainage discharge from the creeks and tributaries to the field due to their rising water levels.

For the drainage planning, the following countermeasures will be taken;

- Provision of farm drains.
- Dredging of important connecting drainage creeks and tributaries.
- The designed drainage modulus were decided at 8.14 lit./sec/ha for new farm drains.

5. 6 Agricultural Development Plan

5. 6. 1 Selection of Crops and Cropping Patterns

Type-I: For first 5 years after project implementation

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

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

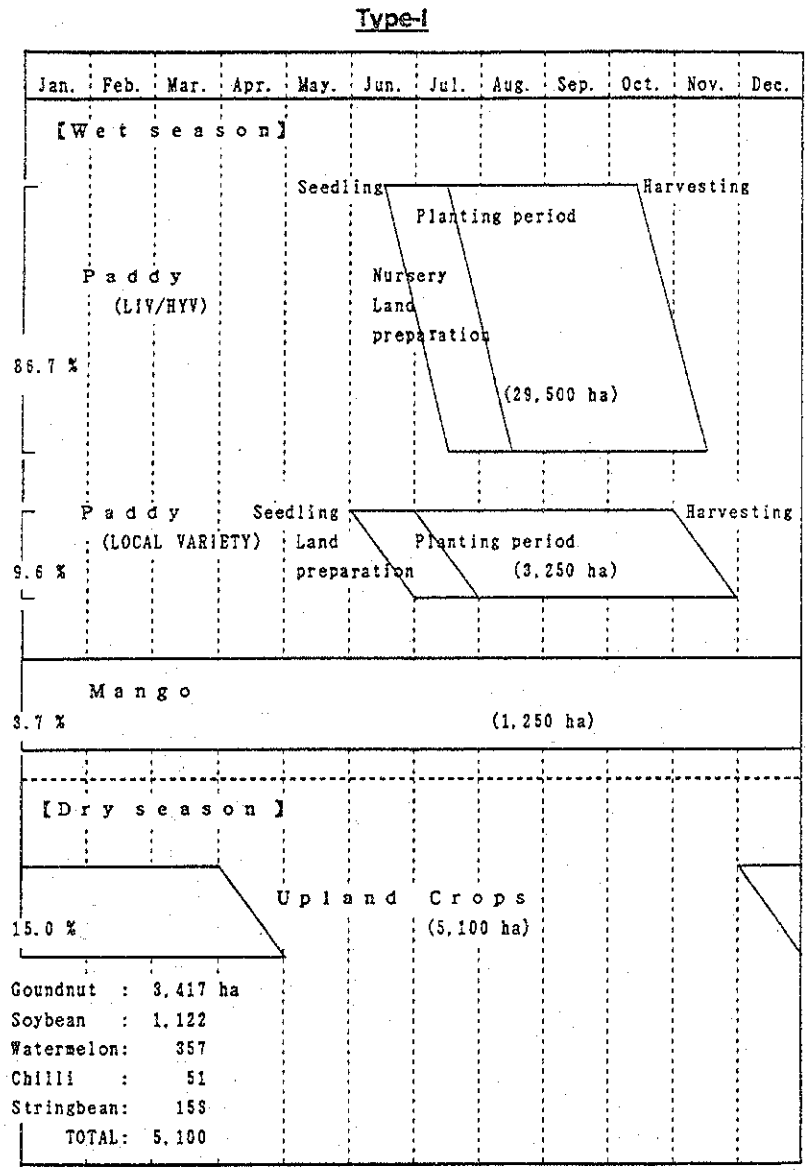
Wet season	Dry season (16%)	Perennial crop
Paddy Vegetable (Cucumber 29%) (Sweet corn 5%) (Stringbean 19%)	+ Groundnut (69%) + Stringbean (3%) Soybean (21%) Chilli (1%) Watermelon(7%)	+ Mango

Introduction of fruits represented by mango as a cash crop will be planned to increase farm income for all farmers in the area. The proposed cropping patterns are shown in Figure 5-8.

5. 6. 2 Yield Projection

The target yields for main crops are set as follows;

Figure 5-8 Proposed Cropping Pattern



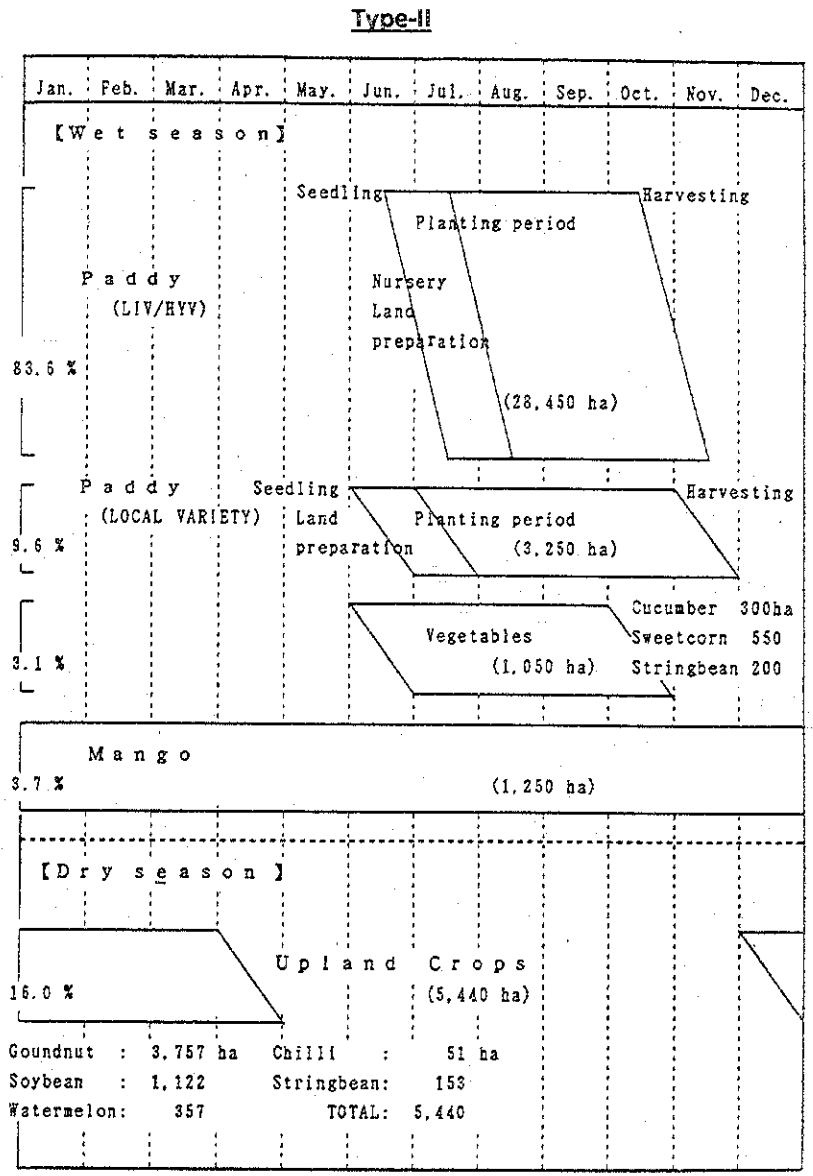


Table 5-22 Proposed Target Yield

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

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

5. 6. 3 Proposed Crop Production

The proposed crop production for each crops are as follows;

Table 5-23 Proposed Crop Production

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

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

5. 6. 4 Farm Management Plan

The present farming pattern in the Project Area is characterized by the single cropping of wet season paddy. Taking the farm size into account, four types of proposed farming patterns, that is, for small-scale farmers, medium-scale farmers (A) and (B), and large-scale farmers are set up in the project. It seems

that an effective farm management will be realized by the introduction of farm mechanization such as power tillers.

The planted areas of dry season crops are set up considering irrigable area, labour requirement, farm income, intensity of farming, and farm size.

Table 5-24 Numbers of Farm Households According to Crop Production

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

5. 6. 5 Improvement Plan for Rainfed Agricultural Farming

In those cultivated areas to be excluded from the irrigated area, the following improvement of farming methods under rainfed condition could be established.

- Moisture preservation
- Soil preservation
- Green manure cultivation

5. 6. 6 Livestock

The raising conditions for domestic animals in the Project Area are harsh due to high temperatures, from lack of water and of disease. Having closely studied the policy of livestock promotion, the livestock promotion in the area will be considered as follows:

- Raising of buffalo, swine, chicken and duck
- Improvement of breeding
- Introduction of beef cattle

5. 6. 7 Freshwater Fisheries

Freshwater fisheries in Ubon Ratchathani Province are planned as follows:

Breeding location	:	Fish ponds and paddy fields
Number of raising farmers	:	2,388
Total area	:	500 ha
Total production	:	500 ton

Since 1982, freshwater fish culture has been carried out in the Sirindhorn Reservoir of the Lam Dom Noi Project adjoining the Study Area. Considering the results, such species of freshwater fish as Telapia, local carp, common carp and catfish will be encouraged in the area.

5. 7 Resettlement Plan

About 4,330 ha (27.1 thousand rai) of land composed of 1,930 ha (12.1 thousand rai) of farmland and housing lots and 2,400 ha (15.0 thousand rai) of forest land will be submerged at EL.140.0 m, which is the compensation water level. The number of households affected by the water level is estimated to be 324, but this can be reduced to 122 by the provision of low protection dikes, two meters in height.

Table 5-25 Submerged Households and Height of Dike

Case	Location of Dike	Height of Dike	No. of Households	Elevation of Dike
Case - 1	No Dike	-	324	-
Case - 2	EL. 139.0 m	1.50 m	152	EL. 140.5 m
Case - 3	EL. 138.5 m	2.00 m	122	EL. 140.5 m
Case - 4	EL. 138.0 m	2.50 m	91	EL. 140.5 m

One resettlement area is to be located on the right bank covered by Ubon Ratchathani Land Reform Project Area, while the other on the left bank is categorized as reserved forest under the Royal Forestry Department (RFD).

Description	Ban Bua Thiam	Ban Khok Thiam	Ban Fang Phe, Ban Non Chich
Length of Dike (m)	1,060	1,350	1,650
Height of Dike (m)	2.0	2.0	2.0
Catchment Area (sq.km)	17.0	22.2	24.8
Pump Facilities			
Flood Discharge (cu.m/m)	102.0	133.2	148.8
Pump Unit	2	2	2
Pump Discharge/unit(cu./m)	51.0	66.6	74.4
Diameter (mm)	700	800	800
Output (Hp)	45	60	65
Pump Type	VAFP 1/	VAFP	VAFP

Note : VAFP : Vertical axial flow pump

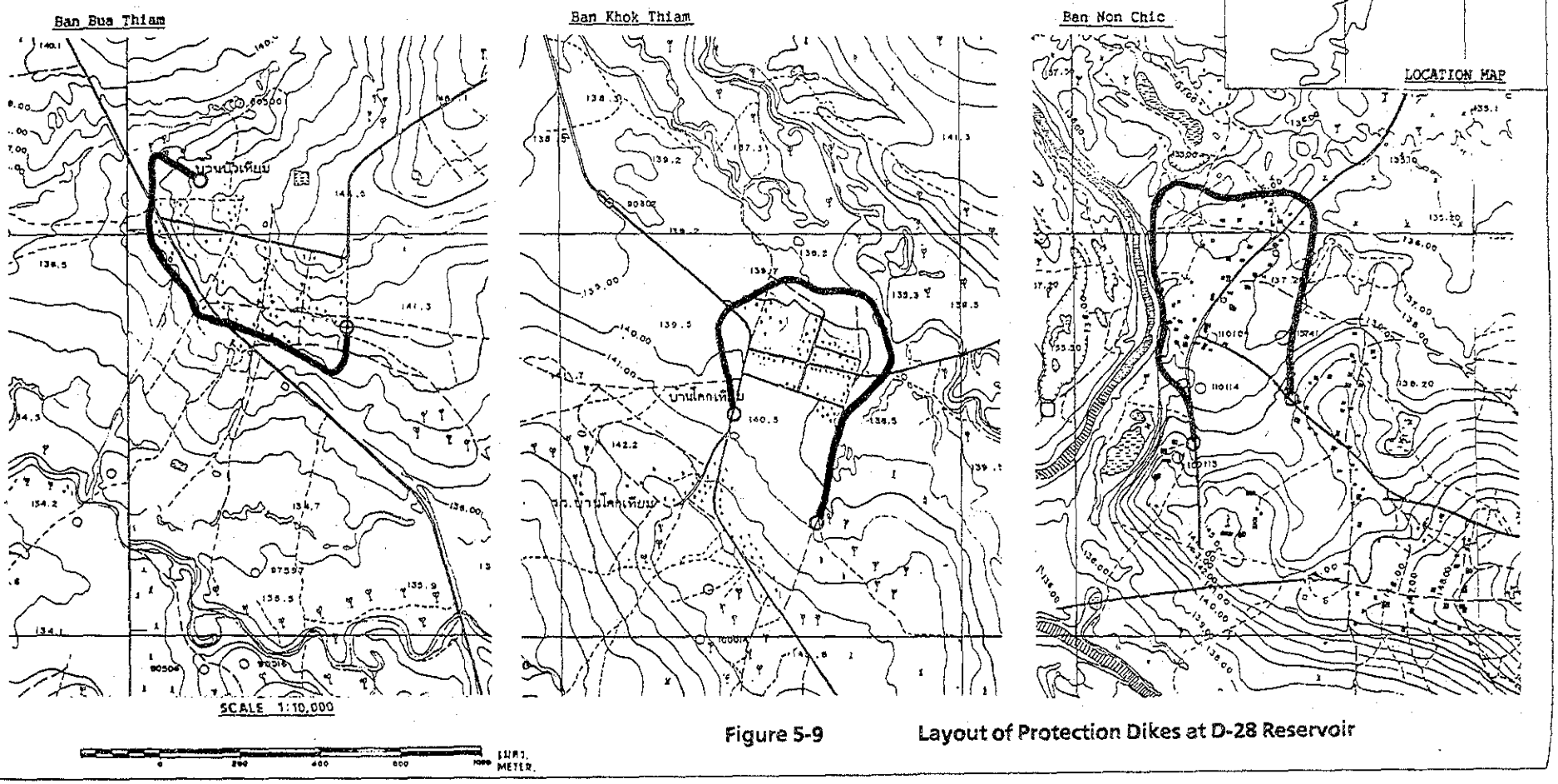


Figure 5-9 Layout of Protection Dikes at D-28 Reservoir

5. 8 Rural Development Plan

The road networks to be provided by the project are as follows:

Table 5-26 Operation And Maintenance Roads

Item	Effective Width (m)	Road Length (km)	Remarks
Feeder Road (main)	6.0	111.4	Laterite pave.
O & M Road (Lateral)	4.0	188.4	Laterite pave.
Total		299.8	
Road Density (m / ha)		8.8	

The total length of the on-farm roads in the Project Area provided by the Water Users' Association is estimated at 360 km, equivalent to 10.6 m/ha.

In addition to the above-mentioned road networks in the rural area, the village community facilities consisting of an open space provided with a shallow well, a comfort room, a processing yard, a sunshade space, afforestation area, and a village pond will be provided. The type of public facilities will be the core of the community on Muban level with the following purposes;

- Village fisheries in which all the villagers would enjoy fishing activities in the village pond to be constructed in order to help increase their protein consumption and to gain additional cash income,
- Domestic water supply by means of a canal system, and
- Agricultural cooperative works equipped with a processing yard.

6. PROJECT ENGINEERING

6. 1 Dam and Reservoir

Table 6-1 Major Features of D-28 Dam and Reservoir

Reservoir	
Average annual rainfall	1,416 m
Catchment area	1,245 sq.km
Average annual run-off	591 MCM
1/5-year probable annual run-off	501 MCM
High water level (HWL)	EL.141.0 m
Normal water level (NWL)	EL.139.5 m
Low water level (LWL)	EL.134.4 m
Reservoir area (at NWL)	39.1 sq.km
Total storage capacity	117.1 MCM
Effective storage capacity	104.6 MCM
Dead storage capacity	12.5 MCM
Dam	
Dam Type	Homogeneous earthfill type
Crest length	2,000 m
Maximum height	21.5 m
Crest elevation	EL.143.0 m
Embankment volume	Approx. 850,000 cu.m
Spillway	
Spillway type	Chute type
Crest length	170 m
Crest elevation	EL.139.5 m
Spillway capacity	641 cu.m/sec
Inflow designed flood (1/500-year probable flood)	1,087 cu.m/sec
Outlet Works	
Type	Concrete-encased pressure pipe conduit
Function	

- to flow down the run-off during the dry season for dam construction work (Qmax = 5.5 cu.m/sec)
- to release stored water into the Dom Yai river for supplemental water supply to the downstream areas.

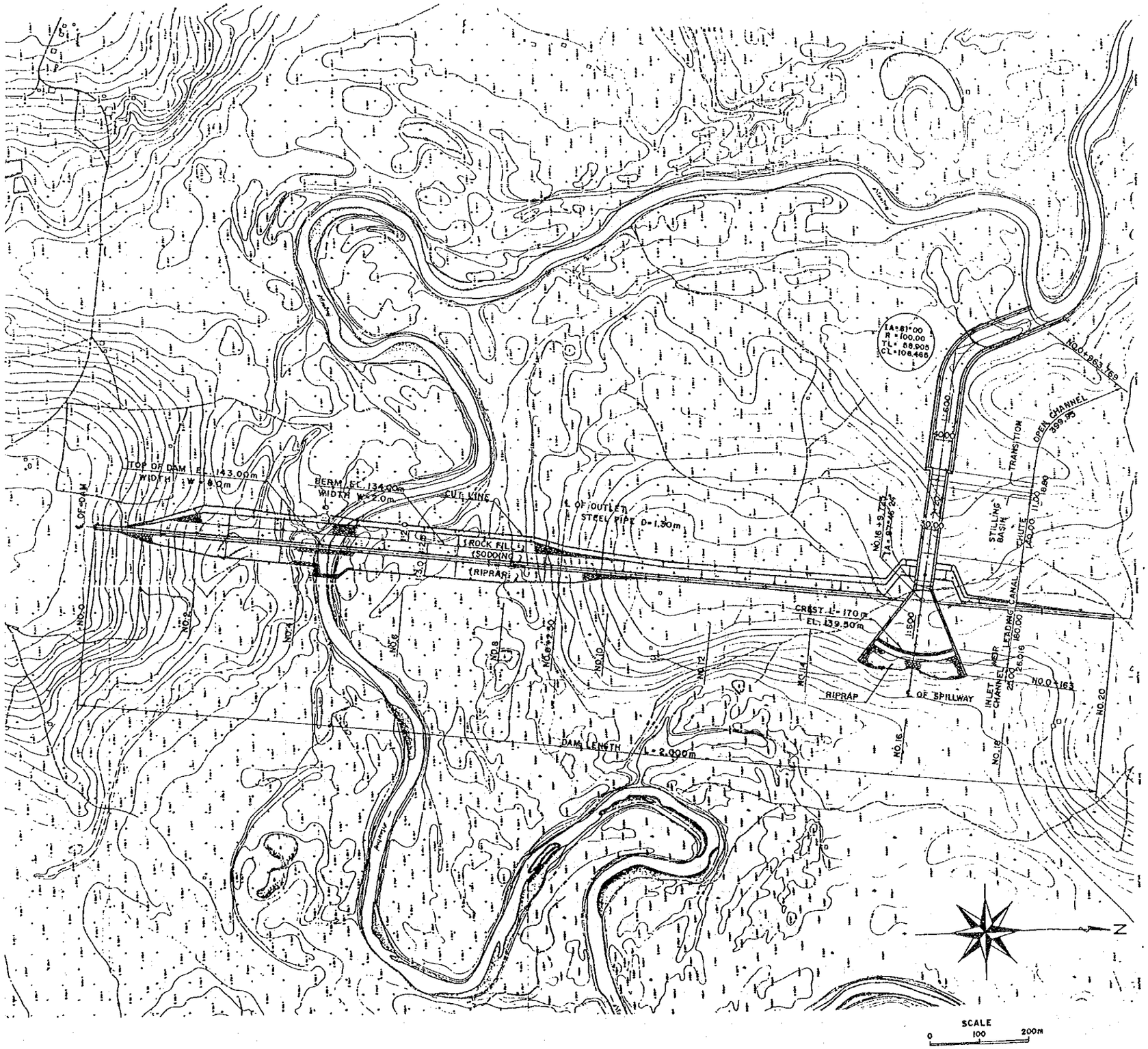
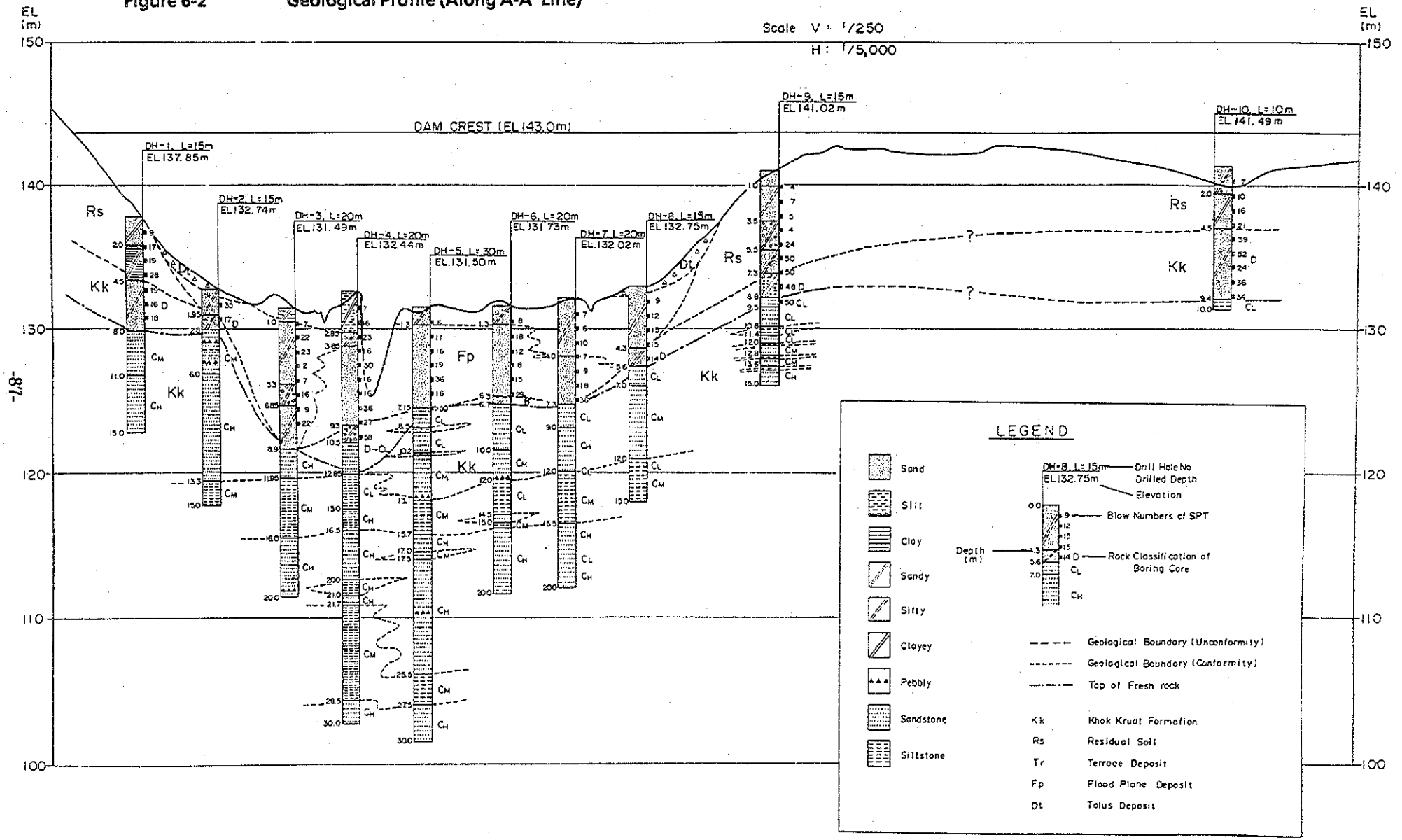


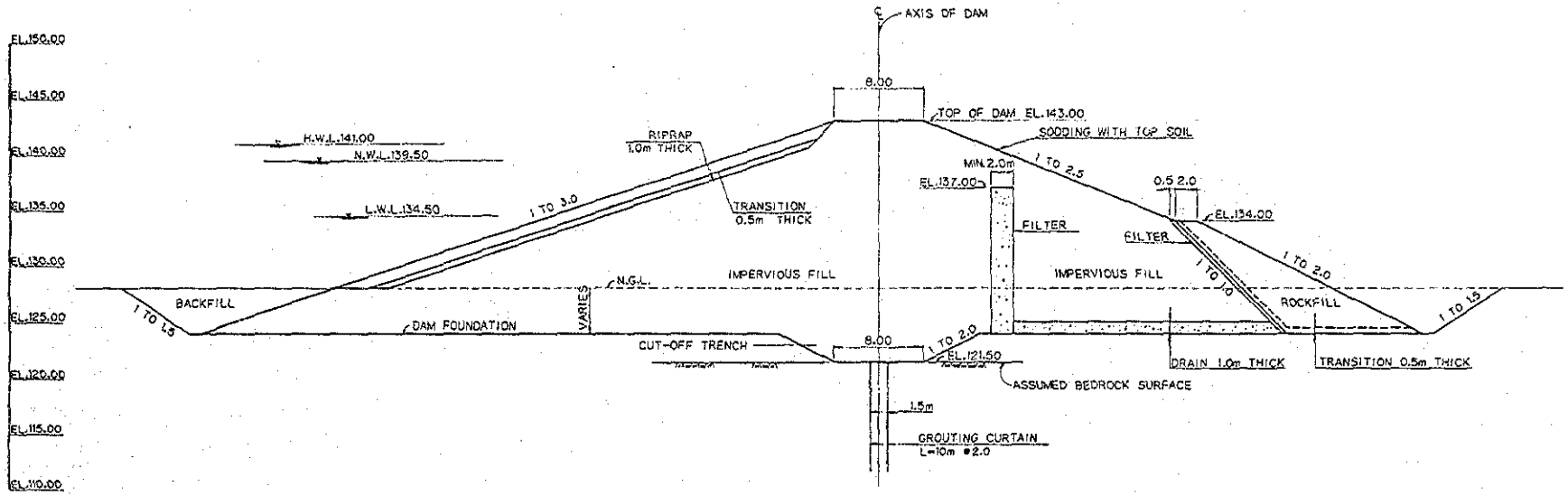
Figure 6-1 Plan Of D-28 Dam

MAJOR FEATURES OF LAM DOM YAI RESERVOIR

ITEM	DESCRIPTION
(1) RESERVOIR	
a) RIVER BASIN	LAM DOM YAI
b) RIVER NAME	LAM DOM YAI
c) WATERSHED AREA (km²)	1,245
d) TOTAL STORAGE (MCM)	117
e) EFFECTIVE STORAGE	105
f) H.W.L. (MSL)	141.0
g) N.W.L. (MSL)	139.5
h) L.W.L. (MSL)	134.4
(2) FOUNDATION	SAND STONE SILT STONE
(3) DAM-BODY	
a) DAM TYPE	HOMOGENEOUS FILL DAM
b) DAM CREST EL (MSL)	143.0
c) DAM HEIGHT (m)	21.5
d) CREST LENGTH (m)	2,000
e) EMBANKMENT (m³)	900,000
f) FOUNDATION TREATMENT	CURTAIN GROUT
(4) SPILLWAY	
a) DESIGN FLOOD (cms)	1,087
b) SPILLWAY CAPACITY (cms)	641
c) SPILLWAY TYPE	CHUTE
d) CREST LENGTH (m)	170
(5) OUTLET	
a) CAPACITY (cms)	5.50
b) CONDUIT Φ (m)	1.30

Figure 6-2 **Geological Profile (Along A-A' Line)**





TYPICAL CROSS SECTION

Figure 6-3 Typical Cross Section of Dam

6. 2 Pumps and Canals

6. 2. 1 Pumping Station

Judging from the comparative study results, electricity is more economical as the pump motive power; it was, therefore, adopted in the project.

Table 6-2 Required Lift Head

Item	Left Bank Area	Right Bank Area
WL at delivery pipe outlet (m)	148.0	158.0
Low water level (m)	134.4	134.4
Actual lift head (m)	13.6	23.6
Total loss heads (m)	2.8	4.8
Total lift head (m)	16.4	28.4

Table 6-3 Outline of Pumps

Item	Left Bank Area	Right Bank Area
Irrigation Area (ha)	8,800	25,200
Pumping Discharge (cu.m/sec)	8.80	25.20
Total Lift Head (m)	16.4	28.4
Diameter (mm)	800	1,000
Number of Sets	6	12
Output (kw/hr)	370	880

Table 6-4 Summaries of Dimensions of Pipelines

Item	Left Bank Area
Diameter (mm)	2,000
No. of Pipeline	3
Pipe Thickness (mm)	20
Foundation	Sandbed at an angle of 180°

The proper dimension of the diversion channel for pump facilities will be B $\geqq$ 20.0 m in bed width, and 1 : 2.0 in side slope to be protected with rip-rap.

6. 2. 2 Irrigation Canals

Main canal ; L = 111.4 km, in which 67.4 km on the left bank
44.0 km on the right bank (with trapezoidal cross section)
Mean gradient I = 1/5,000
Designed discharge q = 1.0 lit/sec/ha (0.16 lit/sec/rai)

Lateral canal ; L = 188.4 km, in which 32.2 km on the left bank
156.2 km on the right bank (with trapezoidal cross section)
Mean gradient I = 1/4,500
Designed discharge q = 1.5 lit./sec/ha (more than 1,000 ha)
q = 2.1 lit./sec/ha (1,000~ 200 ha)
q = 2.9 lit./sec/ha (200~ 40 m)

6. 3 Resettlement Facilities

The required land for resettlement is estimated for each bank at about 300 ha (122 households × 2.4 ha/household).

The minimum land requirements for each household are;

- Residential area	:	0.16 ha (1 rai)
- Farm land	:	2.24 ha (14 rai)
Total		2.40 ha (15 rai)

About 300 ha (1.9 thousand rai) of the land mentioned above are needed for individual plots, and another 300 ha for agricultural and social infrastructures. Therefore, the total resettlement areas are planned to be two sites on the right and left banks of about 300 ha each.

The following facilities will be provided for the resettlement areas;

- Water distribution canals
- Service roads
- Power supply
- Schools, temples and public health centers

The submerged properties are shown below:

- Structural properties
  - Privately-owned structural properties : 122 households
  - Public structural properties
    - Roads and bridges : 6 km
    - Power transmission lines : 6 km
- Land and tree crops
  - Farmland (Paddy field) : 1,930 ha
  - Forest and others : 2,400 ha

7. PROJECT IMPLEMENTATION AND OPERATION

7.1 Project Implementation

7.1.1 Executing Agency of the Project

The executing agency of the project will be the Royal Irrigation Department (RID). RID will execute the detailed design for major project facilities by recruiting a consulting firm, and the construction will be contracted to competing contractors. RID will perform operation and maintenance, and guide the water users' association.

7.1.2 Financing

The foreign currency portion of the project costs will be financed by an international financing agency, while the local currency portion will be provided by the Thai Government.

7.1.3 Construction Mode

A qualified contractor to construct the civil works of the project will be selected by international competitive bidding. The construction of on-farm facilities are basically under the responsibility of the farmers' group to be newly established in the service area.

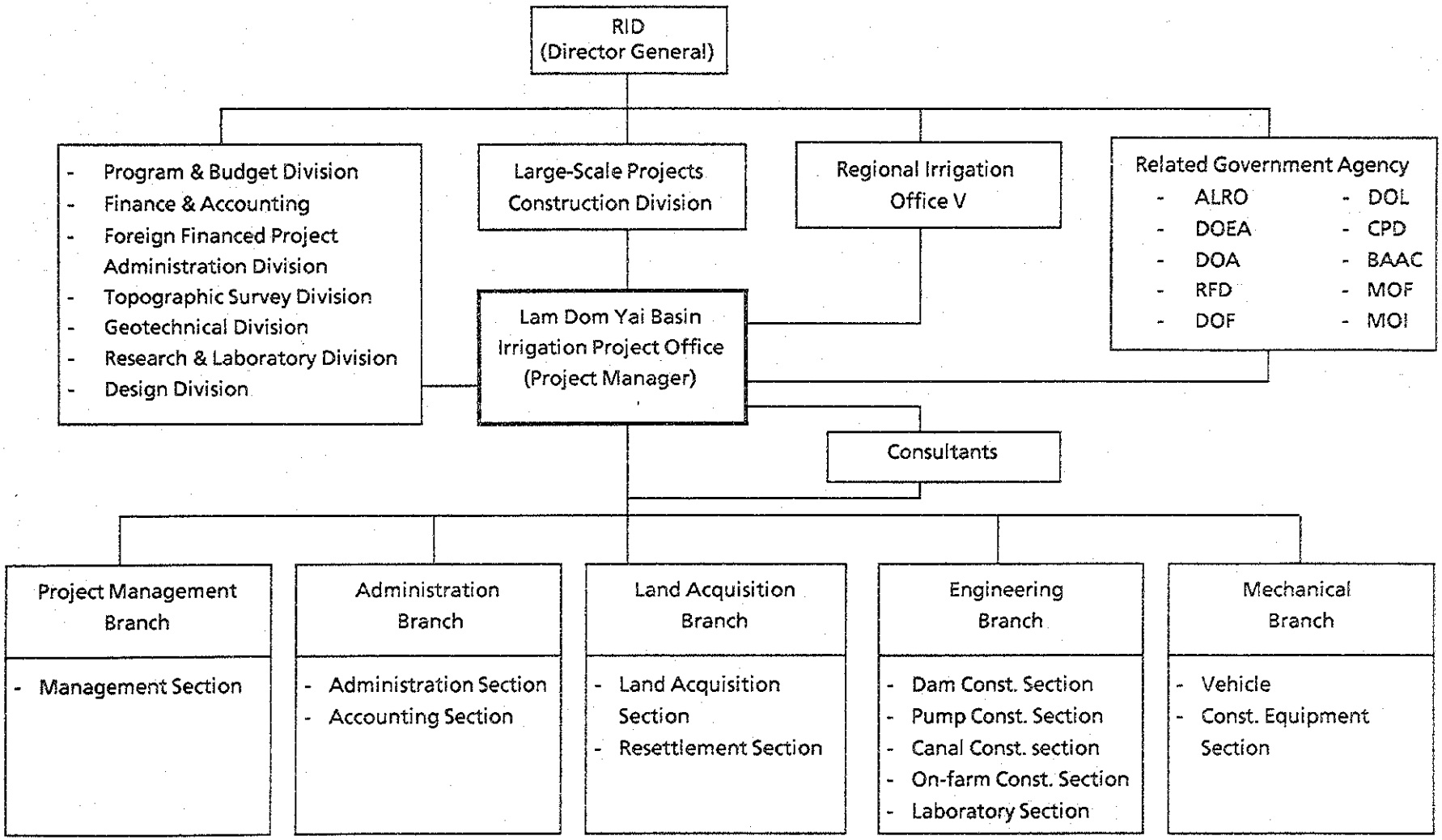
7.1.4 Land Acquisition

The following table provides the estimated land acquisition area ;

Table 7-1 Land Acquistion

Item	Area
Reservoir area	4,330 ha
Dam Construction	16.0 ha
Pump Construction	0.2
Canal Construction	928.3
Total	944.5 ha

Figure 7-1 Proposed Organization Chart for Project Implementation



7.2 Construction Plan

Table 7-2 Work Volume of Dam

Item of Works		Work Volume
1. Dam		
Excavation	(cu.m)	790,000
Grouting/Test-hole	(m)	8,300
Embankment	(cu.m)	850,000
2. Outlet		
Excavation	(cu.m)	24,000
Pipe Installation	(m)	100
Concrete	(cu.m)	600
3. Spillway		
Excavation	(cu.m)	219,000
Concrete	(cu.m)	24,000

Table 7-3 Work Volumes of Pump Facilities

Work Items		Left Bank	Right Bank	Total
Earth Works	(cu.m)			
Excavation		61,400	119,500	180,900
Backfill		6,200	5,000	11,200
Concrete Works	(cu.m)	2,300	6,600	8,900
Pump House	(sq.m)	250	520	770
Sub-station, Transformer		L.S	-	-

Table 7-4 Work Volumes of Irrigation Canal Works

Work Items		Main Canal	Lateral Canal	Total
Stripping	(cu.m)	914,000	1,633,000	2,547,000
Excavation	(cu.m)	1,241,000	731,000	1,972,000
Embankment	(cu.m)	1,523,000	2,967,000	4,490,000
Concrete Lining	(cu.m)	40,000	56,000	96,000
Pipe Line	(km)	4.0	-	4.0

Table 7-5 Work Volumes of On-Farm Facilities

Items		Sample-1 Ban Nong Yang	Sample-2 Ban Khitum
Irrigation area	(ha)	38.9	54.4
Main Farm Ditch	(m)	500	500
Supplemental Farm Ditch	(m)	1,400	2,320
Farm Drain	(m)	480	1,020
Farm Road	(m)	500	500
On-Farm Turnout	(place)	3	5
On-Farm Outlet	(place)	11	15
Road Crossing	(place)	2	1

7. 3 Implementation Schedule of the Project

Figure 7-2 shows the implementation schedule of the project.

7. 4 Operation and Maintenance Plan

The Proposed organization chart for the O/M Project Office is shown in Figure 7-3. The Project Area will be divided into about 34 Zone Areas (average 1,000 ha each) and 170 Irrigation Blocks (average 200 ha each) in total under the responsibility of RID. The operation and maintenance costs were estimated at 32.6 million Baht per annum as shown below.

Table 7-6 Operation and Maintenance Cost

(unit : '000 Baht)

Depreciation	Cost
Salary and wages	10,404
Administration and general expenditure	1,561
Pump operation cost	14,963
Equipment repair and maintenance cost	4,421
Fuel cost	875
Office maintenance cost	380
Total	32,604

8. PROJECT COSTS

8. 1 Conditions of Cost Estimation

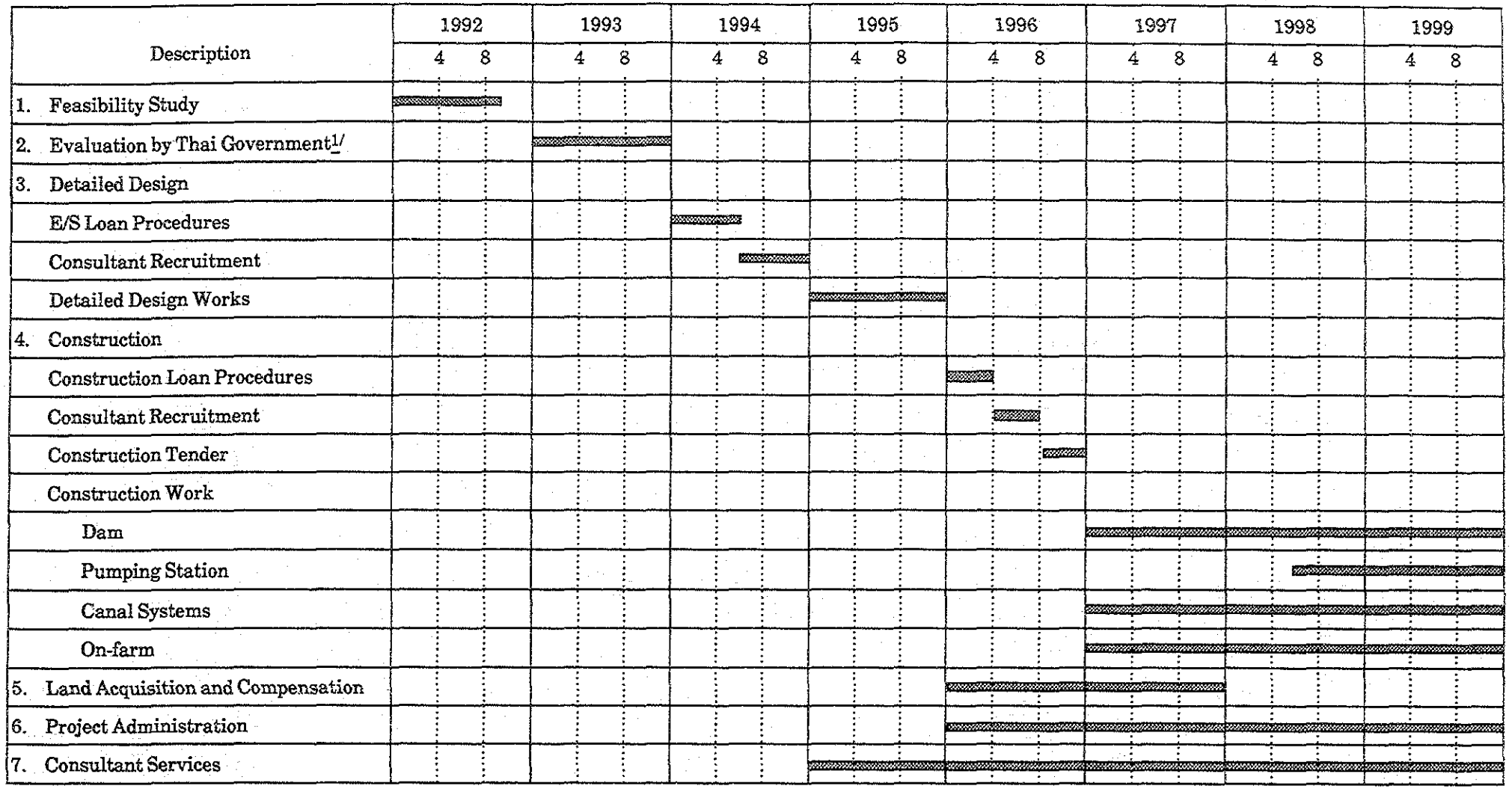
The project costs are estimated under the following conditions ;

1) The civil works are to be constructed on a contract basis. The construction machinery and equipment required for construction will be provided by the contractors. Therefore, only depreciation costs of machinery and equipment are included in the estimated construction cost.

2) The project consists of construction costs and associated costs. The project cost components are shown in Table 8-1.

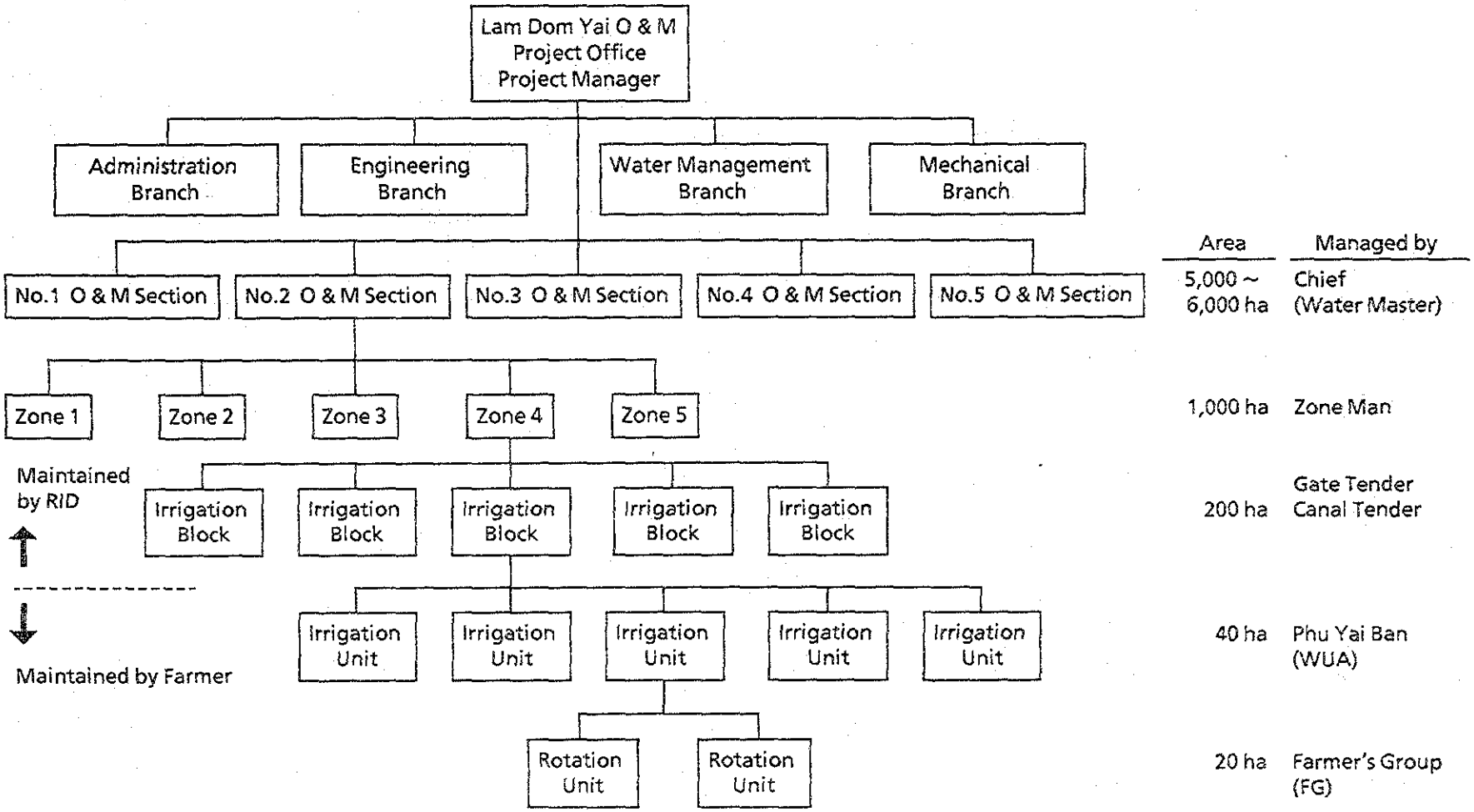
3) The exchange rate between Thai Baht and U.S. Dollar is fixed as follows ; U.S. Dollar = 25.0 Thai Baht

Figure 7-2 Implementation Program for the Project



1/ : including environmental aspects and economic viability

Figure 7-5 Proposed organization Chart for Operation and Maintenance of Project Facilities



4) The physical contingency related to the construction and associated costs is set at 10 percent of the direct costs. The price escalation is predicted applying the international inflation index established by the World Bank.

5) The following overhead costs were taken into account in the project costs;

- Management and operation : 3.5 percent of material and wage costs
- Profit : 6.5 percent of material and wage costs
- Taxes : 4.1 percent of the above two items

8.2 Project Costs

Summary of the project costs is shown in the following table ;

Table 8-1 Project Cost

(unit: million Baht)

Item	F/C	L/C	Total
1. Civil Works			
1.1 Preparatory Works	2	19	21
1.2 Dam Works	150	135	285
1.3 Pump Facilities	595	24	619
1.4 Canal Works	612	536	1,148
1.5 Resettlement Works	29	350	379
Sub-Total	1,388	1,064	2,452
2. On-Farm Development			
2.1 On-Farm Facilities	307	218	525
2.2 Community Center	6	6	12
Sub - Total	313	224	537
3. Land Acquisition	0	66	66
4. Engineering and Administration			
4.1 Consulting Services	97	34	131
4.2 Administration	7	14	21
Sub-Total	104	48	152
5. O & M Equipment	38	6	44
6. Total (1 - 5)	1,843	1,407	3,250
7. Physical Contingencies (10%)	184	141	325
8. Total (6 - 7)	2,027	1,548	3,575
9. Price Escalation	734	537	1,271
10. Grand Total			
With On-Farm and Rural Dev.	2,761	2,085	4,846
Without On-Farm and Rural Dev.	2,297	1,751	4,048

Table 8-2 Annual Disbursement Schedule

(unit : million Baht)

Year	F/C	L/C	Total
1995	26.0	9.0	35.0
1996	31.4	85.3	116.7
1997	505.9	598.1	1,104.0
1998	909.6	765.0	1,674.6
1999	1,289.2	626.9	1,916.1
Total	2,762.1	2,084.3	4,846.4

9. PROJECT EVALUATION

The project justification was made through a study of project feasibility from economic, financial and socio-economic aspects.

The economic feasibility was worked out by calculating the economic internal rate of return (EIRR). Sensitivity analysis was made in order to elucidate the economic viability of the project against the change in prices, delay in implementation, cost over-run and yield.

Financial analysis was also made by typical farm budget analysis and cost recovery including joint cost allocation.

The social effects and economic impacts from the implementation of the Project are treated in an intangible-benefit study and environmental impact evaluation.

9.1 Project Benefits

The following benefits to be produced by implementation were taken into account in the project :

- Crop benefits
  - Net production value (cropping Type-I) : 277,932 thousand Baht
  - Net production value (cropping Type-II) : 344,014
- Fishery benefits
  - In paddy field (Annually) : 32,388 thousand Baht
  - In reservoir : 1,015
  - In village pond (community center) : 574
- Others
  - Feeder road benefit (Annually): : 3,737 thousand Baht
  - Domestic water supply : 2,488
- Negative benefit by submersion : 918

It is assumed that the target years of crop production will be attained five years after the completion of the project.

In addition to the tangible-benefits mentioned above, various intangible benefits and socio-economic impacts are expected from project implementation. The major intangible benefits will be as follows;

- Creation of new job opportunity
- Improvement of local transportation
- Improvement of sanitary condition
- Upgradement of water front environment

9.2 Economic Project Costs

1) Economic Project Costs

The project costs consist of the direct project cost as well as the indirect project costs. All these costs are estimated on a financial basis.

Economic Costs of the project are estimated as follows ;

Table 9-1 Economic Cost

(unit: '000 Baht)

Item	Total Cost	1st Year 1995	2nd Year 1996	3rd year 1997	4th year 1998	5th year 1999
F/C	1,683,946	21,456	25,000	284,888	535,502	817,100
L/C	1,225,171	7,397	65,005	361,608	439,763	351,398
Total	2,909,117	28,853	90,005	646,496	975,265	1,168,498

2) Annual Operation and Maintenance Costs

The financial cost does not include the depreciation cost of O & M equipment. This financial cost is converted into economic cost using a conversion factor of 0.9. Annual operation and maintenance costs are estimated at 31.1 million Baht.

3) Replacement Costs

Pumps and gates are replaced at intervals of 25 years. Equipment and instruments for O & M are replaced at intervals of 10 years.

9.3 Economic Internal Rate of Return

Economic indicators of the project will be presented by Net Present Value (NPV), Benefit/Cost Ratio (B/C) and Economic Internal Rate of Return (EIRR). The results of these calculation are shown as below ;

EIRR = 9%

Table 9-2 Project Evaluation

Item	Discount Rate		
	8%	10%	12%
N.P.V (1,000 Baht)	155,156	- 361,506	- 655,781
B/C ratio	1.06	0.84	0.67

9. 4 Sensitivity Analysis

A sensitivity analysis was made based on the following four parameters;

- Increase of construction cost
- Overdue construction period
- Reduction of benefits
- Delay in realization of benefits

Table 9-3 Results of Sensitivity Analysis

Case	EIRR (%)
1. Original	9
2. Price/Yield of Farm Products	
10% of decline/decrease	8
20% of decline/decrease	7
3. Production Costs	
10% of increase	8
4. Construction Costs	
10% of increase	8
20% of increase	7
5. Delay of Production Target	
1 year	8
2 year	7
3 year	7
6. Combination with 2 and 4	
Each 10%	7
Each 20%	6

9. 5 Financial Analysis of Typical Farmers

The farm budget of typical farmers was analyzed taking into account profit and loss statements and cash flows.

TABLE 9-4 Results of Financial Analysis of Typical Farmers

(unit : Baht)

Typical Farmer		Gross Income	Production Cost	Living Expense	Repayment Interest	O/M charge	Surplus
Right Bank							
Upper area	w/o	23,035	6,424	18,855	0	0	- 2,244
	w	70,249	23,524	18,555	49	1,805	26,015
Lower area	w/o	23,595	4,988	17,259	0	0	1,348
	w	68,971	23,000	17,259	92	1,717	26,903
Left Bank:							
	w/o	32,072	6,527	24,000	0	0	1,545
	w	79,761	27,933	24,000	113	1,574	26,141

Note: w/o = Without Project
w = With Project (the target year of type-II)

9. 6 Project Justification

The economic internal rate of return (EIRR) for all sectors was estimated at nine percent.

The opportunity cost rate (OCR) of capital of the Northeast region is estimated at some 10 percent, taking into account that it is an autonomous regional economy with limited development potential. Consequently, this EIRR of nine percent shows that the project is economically feasible, as it may be expected to further the Northeast's economic development.

Furthermore, in order to improve the traditional farming practices and vitalize the depressed rural circumstance through poverty eradication, to increase agricultural productivity and income of rural people, and to contribute to the local economy, by the introduction of irrigated agriculture in the area, the project plan is recommended to be implemented in the early stage, although the estimated EIRR of nine percent seems to be a little bit low.

10. ENVIRONMENTAL IMPACT ANALYSIS

10.1 Environmental Impact Evaluation

10.1.1 Introduction

The proposed Lam Dom Yai Basin Irrigation Project has its main project features larger than the scale given in the guideline of National Environmental Board (NEB), and hence, the detailed Environmental Impact Statements or EIS (Environmental Impact Study) will be required by law. The following shows the main features of the Project and NEB's guideline;

Table 10-1 Main Features of the Project and NEB's Guideline

Project Feature	Scale	Scale given in NEB's Guideline
Effective storage	104.6 MCM	100 MCM
Reservoir area	43.3 sq.m	15 sq.km
Irrigation area	34,000 ha	12,800 ha
	(212,500 rai)	(80,000 rai)

The environmental study comprises manifold items of environmental impact evaluation. They are primarily classified into the following categories;

- Environmental setting
  - Aquatic ecosystem
  - Terrestrial ecosystem
  - Social setting

- Environmental integration in the project

10.1.2 Environment Interaction by Project

1) During construction phase

a) Water quality in Lam Dom Yai downstream of the reservoir will certainly deteriorate in terms of turbidity and suspended solids. However, this impact will only be on a short-term basis.

b) Water released the from reservoir is expected to be clear, resulting from the impoundment effect. It is anticipated that some erosion will take place along the downstream basin of Lam Dom Yai, in order to balance the natural sediment regime of the river.

c) It is expected that the Dissolved Oxygen (DO) level in the immediate downstream area will be reduced, but it will eventually be re-aerated along the river course. At an early stage of impoundment, water is expected to be polluted due to organic biomass in the reservoir area. However, the water quality will be improved after a certain period of time.

d) With respect to public health conditions, the spreading of malaria among construction workers and the problem of respiratory diseases and water-borne diseases will give cause for anxiety in the workers' camps under improper sanitation conditions. The problems of accident, violence and work injuries will also be common in this phase.

2) During operation phase

a) After impoundment, potential changes anticipated are the changes in the downstream river regime and water quality due to storage and control of water release. These changes would include ;

- Reduction in peak flows and downstream flood level
- Run-off increase in the dry season by released water
- Changes in erosion and sediment patterns
- Fluctuation of the released water influencing oxygen and nutrient concentration

b) It is very likely that the creation of the impoundment will provide suitable habitats for major mosquito-borne diseases such as malaria and hemorrhagic fever. The problem of schistosomiasis may be a potential health hazard for the communities in the Project Area. Therefore, a good public health program may be necessary.

c) The reservoir is underlain by salt formation. However, since the rock salt lies relatively deep, it is possible that the salinity effects may not be serious. Nevertheless, detailed investigation into this problem is needed to confirm the impact.

d) The reservoir will provide a large body of water serving the villages around the reservoir and, in particular, the irrigable lands on both the banks of the Lam Dom Yai downstream of the reservoir. Socio-economic benefits of reservoir fish production, that is ,provisions of additional income and a source of protein to the people, are expected to have effects at local and regional levels. The effects of dam blockage on fish migration needs detailed studies.

e) As the reservoir is flooded, permanent loss of agricultural land and forest land within the reservoir area will occur. The destroyed areas where animals live, impoundment of water and noise generated while the project is being implemented, will affect local fauna. The existing wildlife in this area are of common species and probably not abundant. Therefore, the impact of the project on wildlife in the reservoir area is expected to be small.

f) It is expected that the roads constructed to the reservoir will encourage forest encroachment and illegal cutting, especially along the road sides. The protection of the forest, particularly the forestland outside the reservoir area has to be seriously considered, requiring close cooperation for forest control with the offices concerned and the local people in the watershed area.

g) Social effects caused by the dam construction project include inconvenience among villagers who have to be evacuated from the area. Their discomforts and anxieties seem to be from the uncertainty of their future living conditions, the fear of being separated from relatives, friends and familiar neighbourhood, and the fear that their new social environment would be different. These problems may require strong public campaign at the early stages of the project development. Resettlement sites should not be so far away and special attention should be paid to compensation payment which should be fair and paid properly and immediately once the agreement is made.

h) It appears that there area no major prehistorical sites for objects of archaeological value found in the reservoir area to be submerged by water. A thorough archaeological investigation should conducted to confirm the above conclusion.

Preliminary studies were only carried out at the current stage of the study for the purpose of pointing out present environmental problems and constraints and the anticipated alternation in environmental resources, either positive or negative, probably to be caused by project implementation.

11. CONCLUSION AND RECOMMENDATIONS

11.1 Conclusion

As a result of the Overall Basin Study for the Lam Dom Yai Basin Irrigation Development Project, the Lam Dom Yai Lower Project with D-28 reservoir was selected as one of top priority from the 29 sub-basin development projects.

The Feasibility Study of the Project was conducted carefully. The Project's main purpose is to supply irrigation water with domestic and fishery uses.

As stated above, it has been ascertained that the Project is of high priority as the development of a water supply for attaining quick benefits is essential to the Project Area in order to accelerate regional development.

It is, therefore, concluded that after the above prudent findings, the Project is technically feasible and economically viable.

11.2 Recommendations

a) The project implementation schedule for the Lam Dam Yai overall basin development should be phased in conformity to water demand tendency, urgency of water supply policy, effectiveness of investment, etc.

b) The facilities plan and cost estimates made in this Feasibility Study should be re-examined at the detailed design stage to enhance their precision, and also topographic survey and geological investigation including dispersive soil tests should be carried out for further detailed design, land acquisition and construction works, if necessary.

c) Based on the understanding of the basic concept of good water management in which the limited water source should positively be utilized in the project, the irrigation and drainage plans should be implemented. Besides, RID should educate and cooperate with farmers to be benefited to implement the construction works and the proper operation and maintenance of the

terminal irrigation and drainage facilities in order to execute quick yielding of the proposed crop production.

d) The organization of the project implementation and their operation and maintenance should be strongly functioned, because of fairly large irrigation schemes and technical implementation programs.

e) Especially, the water management for main project facilities as dam and main/lateral irrigation canals will be quite important. It should be unifiedly controlled by the RID technical officials.

f) The water management board on a provincial level should be organized to coordinate the water distribution plan based on the water demand requested from respective sectors and irrigation blocks for effective water utilization.

g) So as to bring the cultivation technic of diversification crops and transportation system on a higher level, administratively and financially assisting countermeasures by the related government agencies for such agricultural supporting services as agricultural extension, farmers' organization, credit, circulation system, etc. will be required.

h) In the time of the implementation of the Project with storage dam, pumps and irrigation canal constructions, not only the technical and economic examinations, but also social or environmental considerations should inevitably be needed according to the result of the environmental impact study to be carried out by the third party.

i) The resettlement areas for the people and the areas to be submerged by D-28 dam should be finally determined after the more detailed investigation and study.

g) Since any arrears in the planned construction schedule will have an influence upon the economy of the investment, construction work needs to be kept to schedule.

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