be one of the points for improvement though split-application of fertilizer will require some more human labour force.

Green manure cultivation before paddy cultivation is good for increasing soil fertility and Sesbania rostrata is identified as the best crop.

To utilize the remaining soil moisture, short-term crops cultivation before and after rice cultivation is proposed. This matter is discussed in Appendix, however, no actual practices were observed in the areas.

5-5-4. Animal Husbandry

(1) Fodder Crops

Buffalo and cattle are of high importance in the project areas as compared to other regions because farm operation such as ploughing, tilling are mostly done by these animals. Animal husbandry is also important in the project areas not only as labour force but also in farm income and manuring.

The main feeding staff of these livestock is rice straw at present but the calculation under the assumptions that TDN of rice straw is 37.8 percent and harvesting ratio of paddy is 40 percent, shows that less than half of the present number of buffalo and cattle can be fed with the rice straw. It also means more than half of their feeding staffs are supplied with wild grasses and others at present.

The Livestock Development Department (LDD) has been promoting fodder crop cultivation in these areas. Recently LDD started trials to grow fodder crops by spreading seeds from the plane and the results are being evaluated. The crops recommended in the project area by the Department are the following:

Grass	1.	Ruzi grass	(Brachiaria ruziziensis)
	2.	Signal grass	(Brachiaria decumbens)
	3.	Hamil grass	(Panicum maximum)
	4.	Buffel grass	(Cenchrus ciliaris)
Legume	1.	Hamata Stylo	(Stylosanthes Hamata)
	2.	Graham Stylo	
Tree	1.	Leucaena sp.	
	2.	Pigeon pea	(Shrub type)

Some of the above crops have difficulty in producing seed. However, Ruzi grass and Hamata stylo are most adaptable to the environment.

(2) Future of Animal Husbandry

LDD has well organized branch provincial stations such as veterinary, breeding, forage crop, and artificial insemination (except Yasothon) in the two provinces. In each Amphoe, there is one head officer in charge, some veterinary officers and assistants. Through theses stations, their activities are focused on technological improvement for small holding farm, extension and establishment of cattle breed improvement unit in cooperation with private farms and livestock improvement project and so on.

One of the information received in the discussion with experts regarding animal husbandry in the project area is milk calf raising. Milk production in Thailand is growing up so rapidly year by year and the shortage of milk cow has became one of the bottle necks for development. Therefore, raising calf, not to grown up stage, will be one of the appropriate method in animal husbandry in the project.

In dairy cattle improvement program in LDD, there is a project of production of Thai milk cows by using hybrid between Brahman female and Friesian male. This project may offer good chance to the livestock production in the area in future as well.

TABLE 5-1. EVAPOTRANSPIRATION ESTIMATED BY MODIFIED PENMAN METHOD

Station: Ubon Rachathani (Latitude: 15°15, Altitude: 123 m MSL)

Month	Radiation Term						Aerodynamic Term					Adjustment Factor	Reference Crop Evapotranspiration ETo	
	Weighting	Net Radiation (mm/day)					Weighting Factor	Wind Function	Vapour Pressure (mbar)					
	W.	Ra	Rs	Rns	Rnl	Rn	1-W	f(u)	ea	ed	ea-ed	C	mm/day	mm/month
Jan.	0.72	12.2	8.2	6.1	2.0	4.1	0.28	0.57	29.0	18.9	10.1	0.39	4.50	140
Feb.	0.75	13.5	8.8	6.6	2.3	4.3	0.25	0.53	33.4	21.0	12.4	1.07	5.20	146
Mar.	0.78	14.8	9.1	6.8	1.5	5.3	0.22	0.52	39.2	24.3	14.9	1.10	6.42	199
Apr.	0.78	15.6	9.3	7.0	1.3	5.7	0.22	0.51	41.5	27.4	14.1	1.09	6.57	197
May	0.77	15.9	8.9	6.7	1.1	5.6	0.23	0.52	39.6	29.7	9.9	1.01	5.55	172
Jun.	0.77	15.8	7.9	5.9	0.9	5.0	0.23	0.58	38.0	30.4	7.6	0.98	4.77	143
Jul.	0.76	15.8	7.9	5.9	0.9	5.0	0.24	0.58	37.0	30.0	7.0	1.06	5.06	157
Aug.	0.76	15.7	7.4	5.5	0.8	4.7	0.24	0.59	36.1	30.0	6.1	1.04	4.61	143
Sep.	0.76	15.0	7.1	5.3	0.8	4.5	0.24	0.48	35.7	29.6	6.1	1.07	4.41	132
Oct.	0.75	14.0	8.0	6.0	1.2	4.8	0.25	0.58	34.7	26.7	8.0	1.04	4.95	153
Nov.	0.74	12.6	7.9	6.0	1.6	4.4	0.26	0.73	31.7	22.8	8.9	1.01	4.95	148
Dec.	0.72	11.8	7.6	5.7	1.7	4.0	0.28	0.68	28.8	19.9	8.9	0.93	4.25	132
Average	0.76	14.4	8.2	6.1	1.3	4.8	0.25	0.57	35.4	25.9	9.5	1.03	5.10	155

TABLE 5-2. CROPPING CALENDAR AND RELEVANT IRRIGATION FACTOR

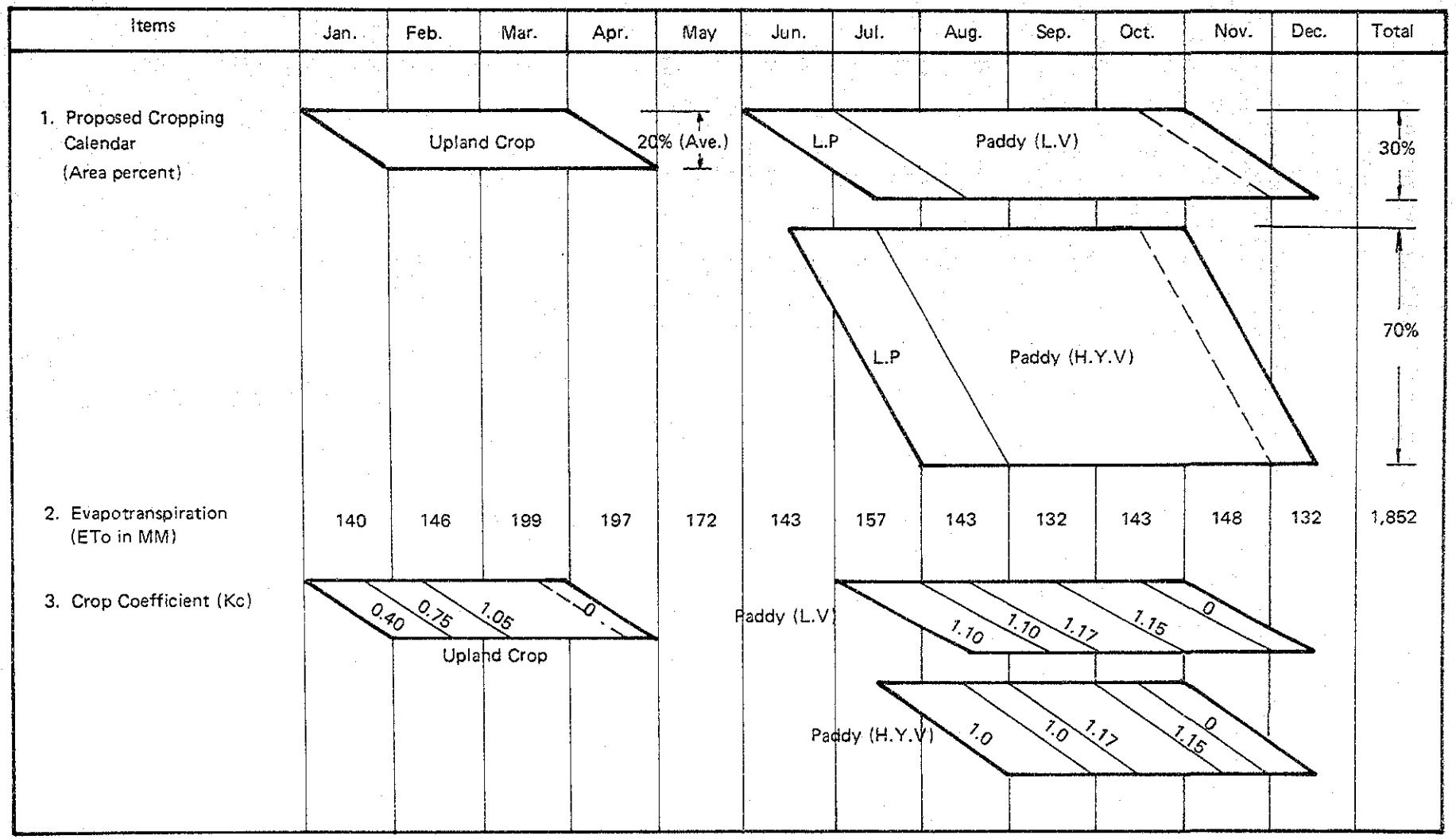


TABLE 5-3. FIELD WATER REQUIREMENT IN 10 DAY BASIS

Unit: mm

(Wet Season Paddy)

Month		Paddy-L.V. (30%)				Paddy-H.Y.V. (70%)				Average
		L P	ET cr.	Perc.	Total	L P	ET cr.	Perc.	Total	
Jun.	E	10	-	-	10	-	-	-	-	3.0
	M	27	-	-	27	3	-	-	3	10.2
	L	47	-	-	47	18	-	-	18	26.7
Jul.	E	55	6	3	64	37	-	-	37	45.1
	M	53	17	7	77	53	2	1	56	62.3
	L	35	28	11	74	53	11	5	69	70.5
Aug.	E	20	37	18	75	49	21	12	82	79.9
	M	3	46	20	69	27	31	13	71	70.4
	L	-	49	22	71	10	42	18	70	70.3
Sep.	E	-	48	20	68	-	45	20	65	65.9
	M	-	49	20	69	-	46	20	66	66.9
	L	-	50	20	70	-	48	20	68	68.6
Oct.	E	-	54	20	74	-	54	20	74	74.0
	M	-	53	20	73	-	54	20	74	73.7
	L	-	43	14	57	-	44	13	57	57.0
Nov.	E	-	31	11	42	-	31	11	42	42.0
	M	-	19	7	26	-	19	7	26	26.0
	L	-	7	2	9	-	7	2	9	9.0
Total		250	537	215	1,002	250	455	182	887	921.5

(Dry Season-Upland Crop)

Month		Upland Crop			
		L P	ET cr.	Perc.	Total
Dec.	E	-	-	-	-
	M	-	-	-	-
	L	13	-	-	13
Jan.	E	27	3	-	30
	M	27	10	-	37
	L	13	18	-	31
Feb.	E	-	29	-	29
	M	-	37	-	37
	L	-	45	-	45
Mar.	E	-	66	-	66
	M	-	70	-	70
	L	-	58	-	58
Apr.	E	-	35	-	35
	M	-	12	-	12
	L	-	-	-	-
Total		80	383	-	463

FIGURE 5-1. RECORDED AND ANALYZED HYDROGRAPH AT M132 STATION IN 1986

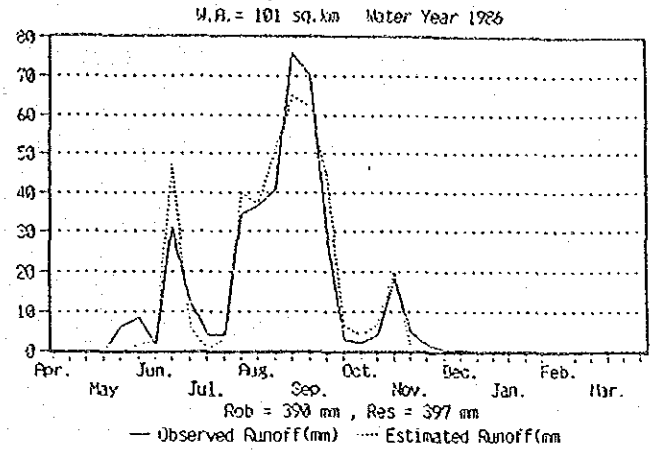
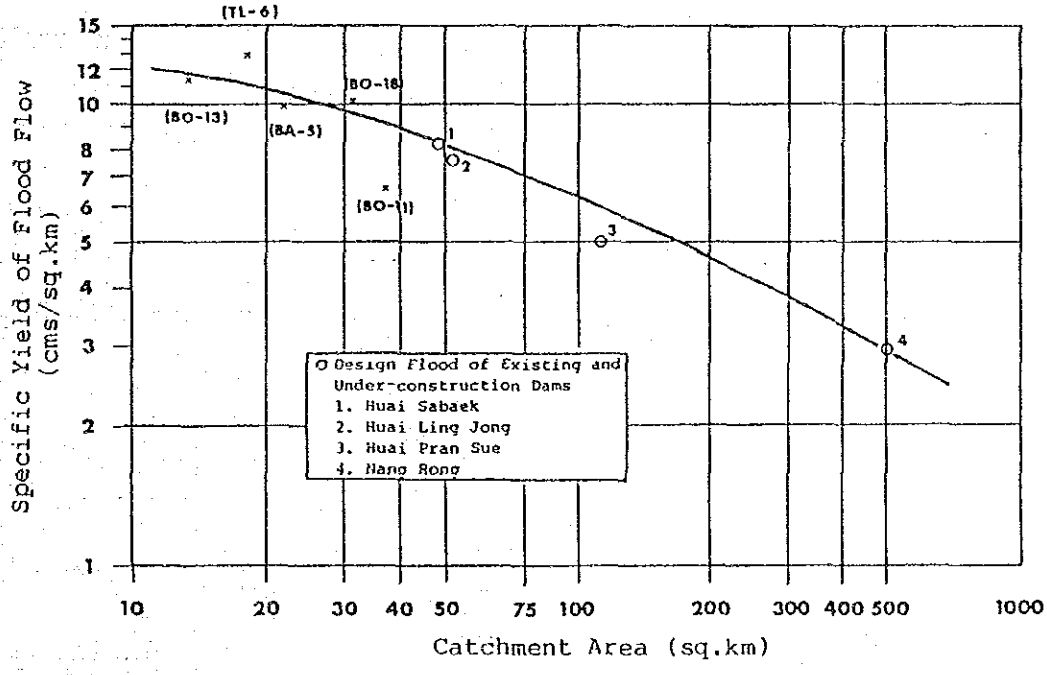


FIGURE 5-2. SPECIFIC YIELD OF FLOOD FLOW



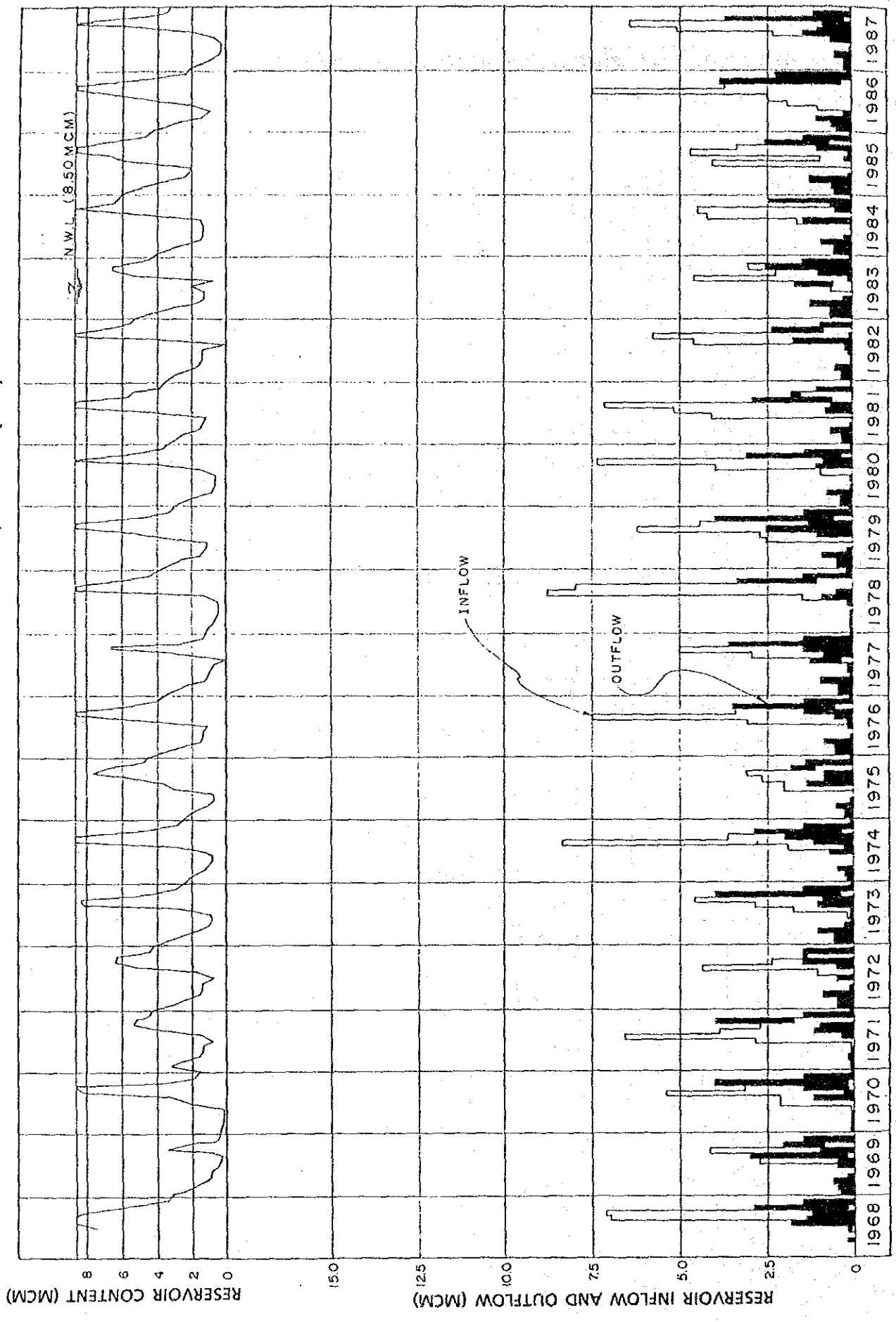


FIGURE 5-3. RESERVOIR OPERATION STUDY ; LAM SE (BA-5)

FIGURE 5-4. RESERVOIR OPERATION STUDY ; HUAI KHUM KHAM (BO-11)

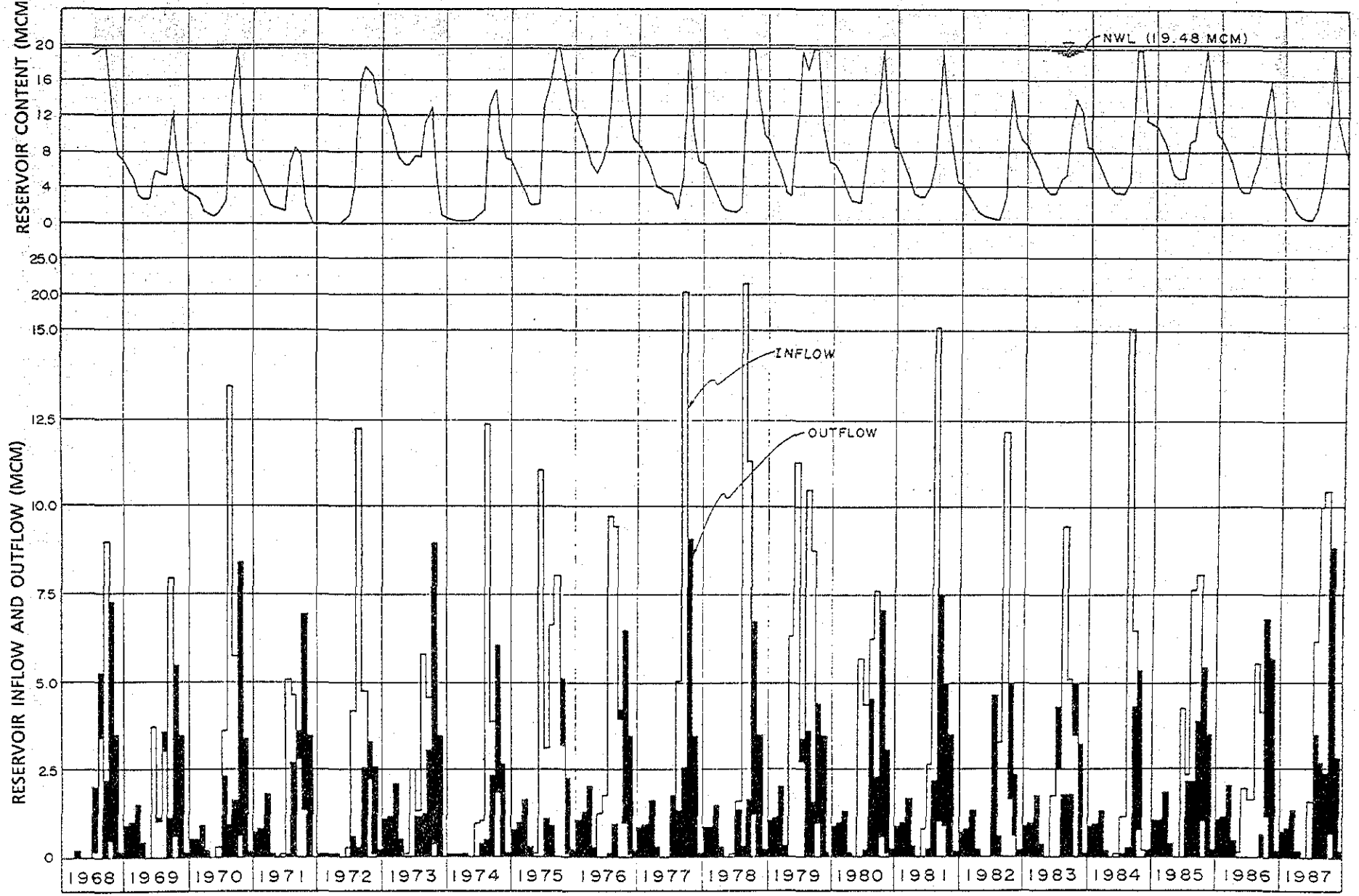


FIGURE 5-5. RESERVOIR OPERATION STUDY ; HUAI KHAM PHAK WAN (BO-13)

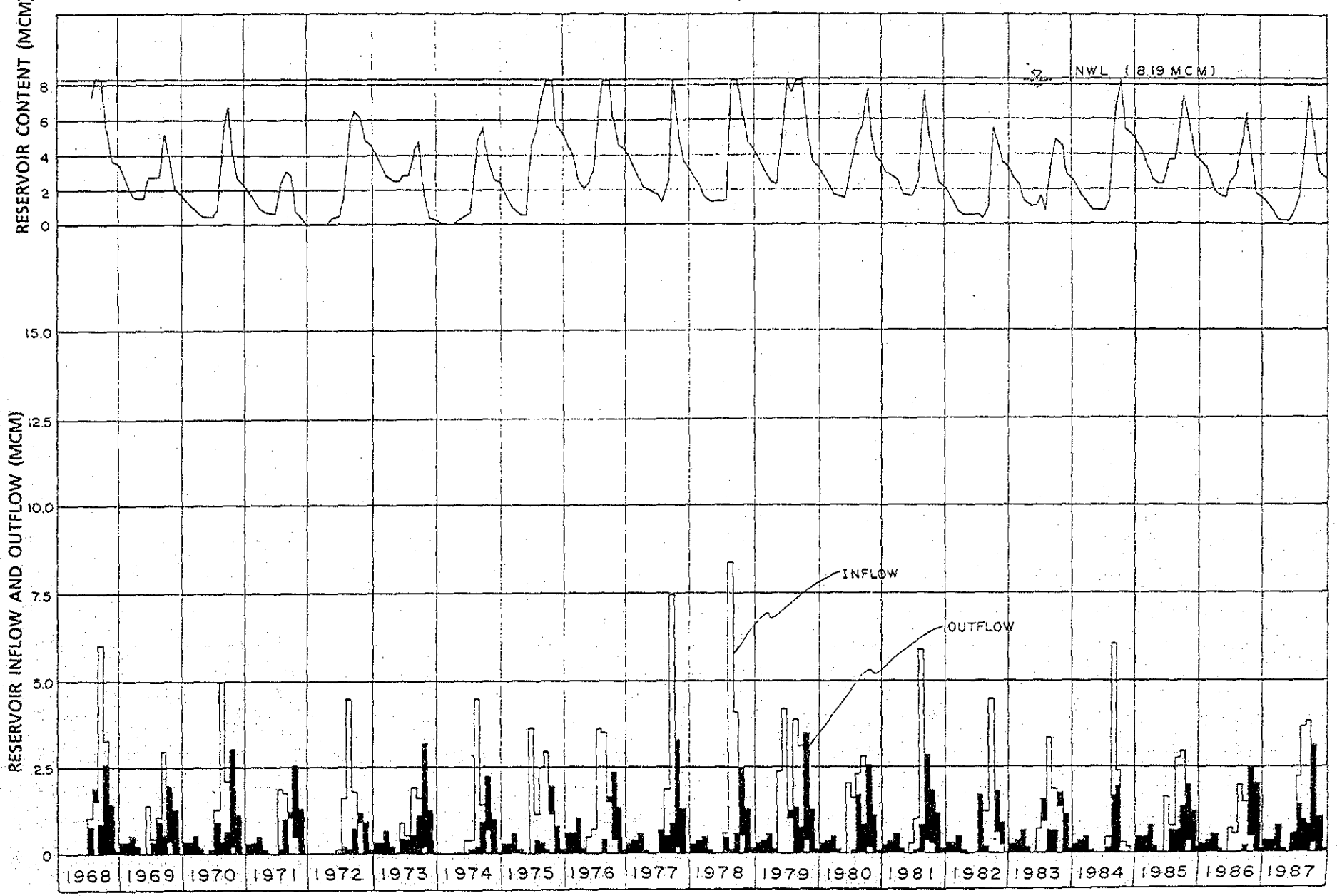


FIGURE 5-6. RESERVOIR OPERATION STUDY ; HUAI NA KHAI (BO-18)

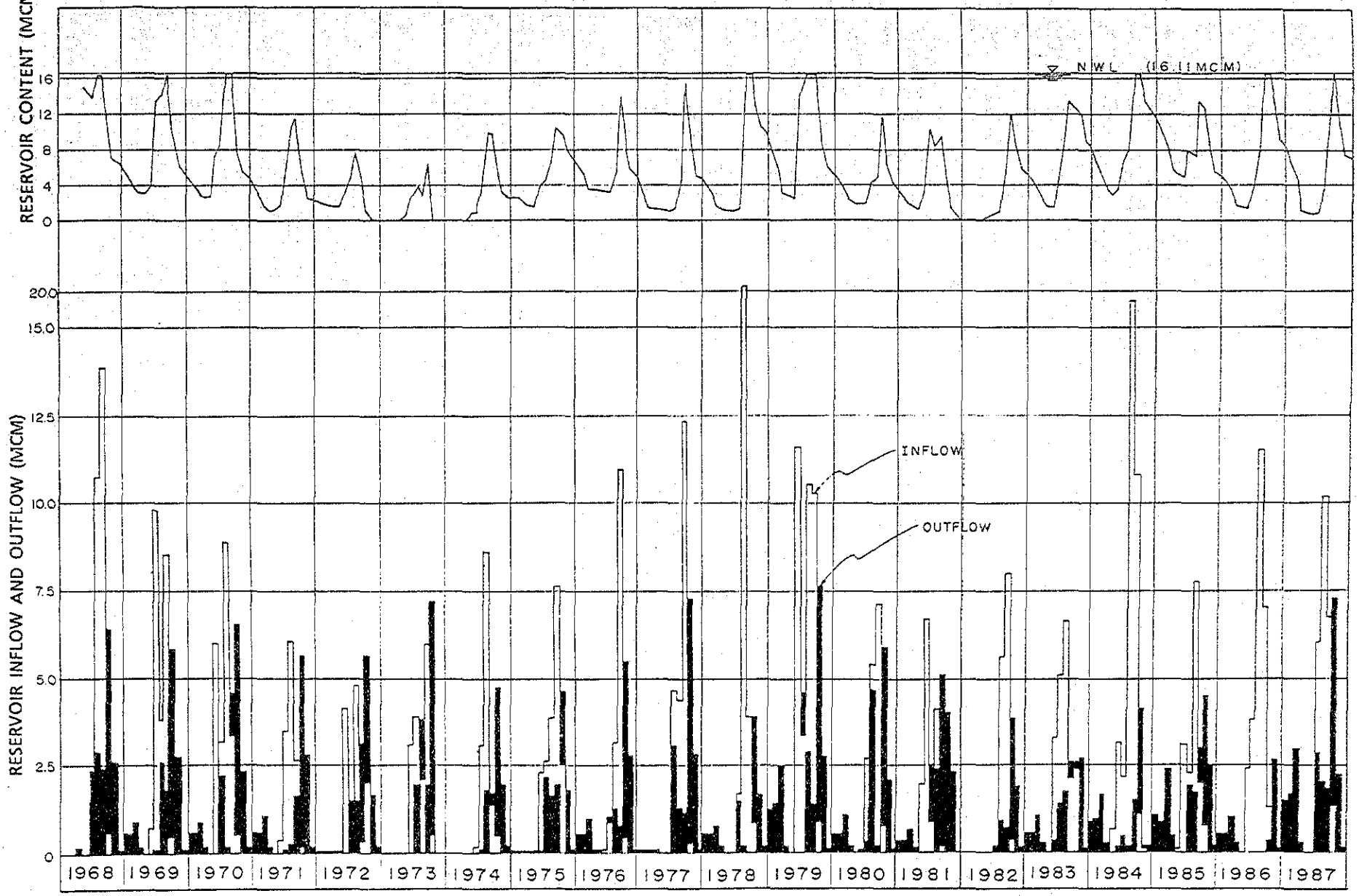


FIGURE 5-7. RESERVOIR OPERATION STUDY ; HUAI SOOB (TL-6)

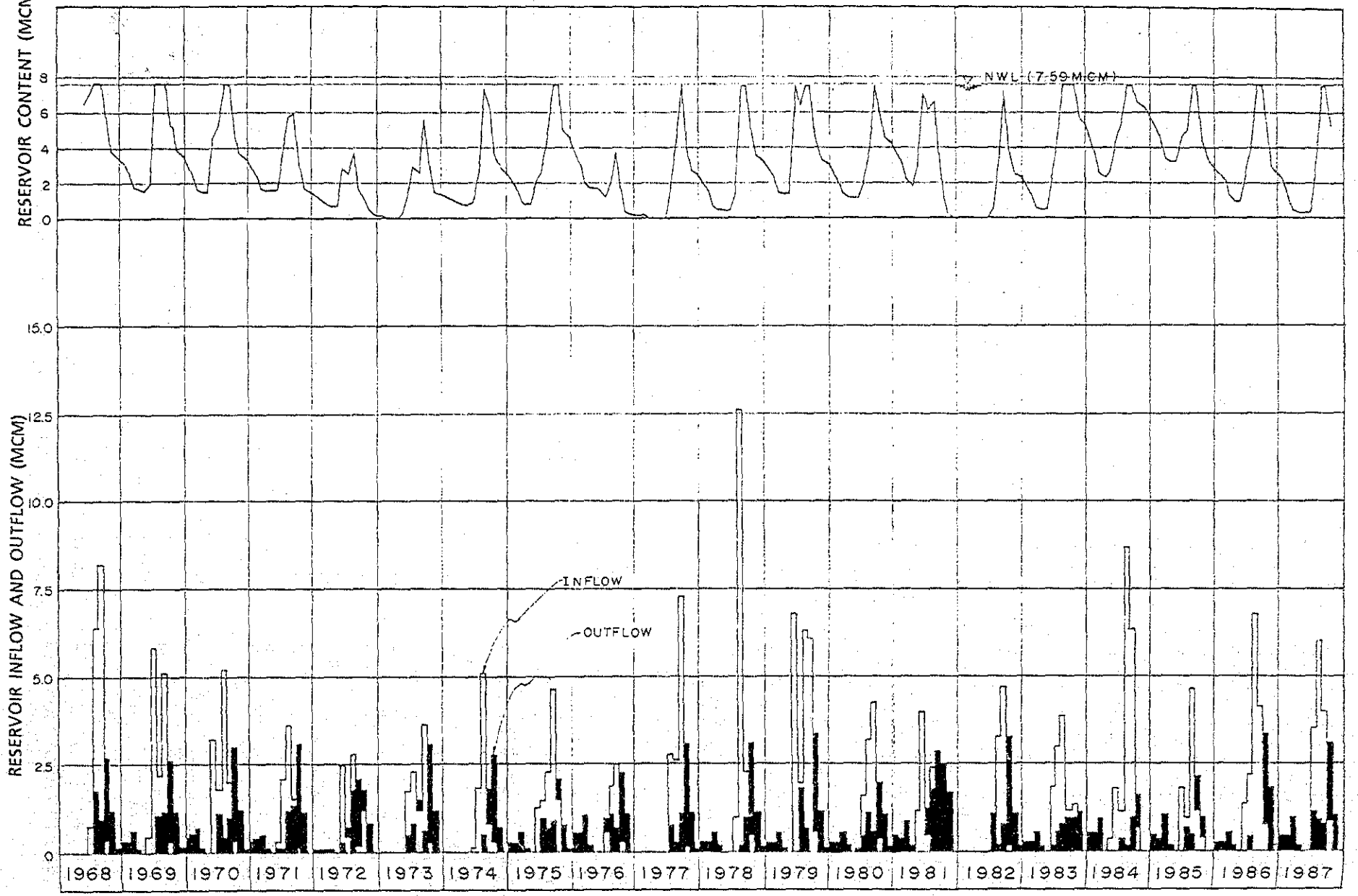
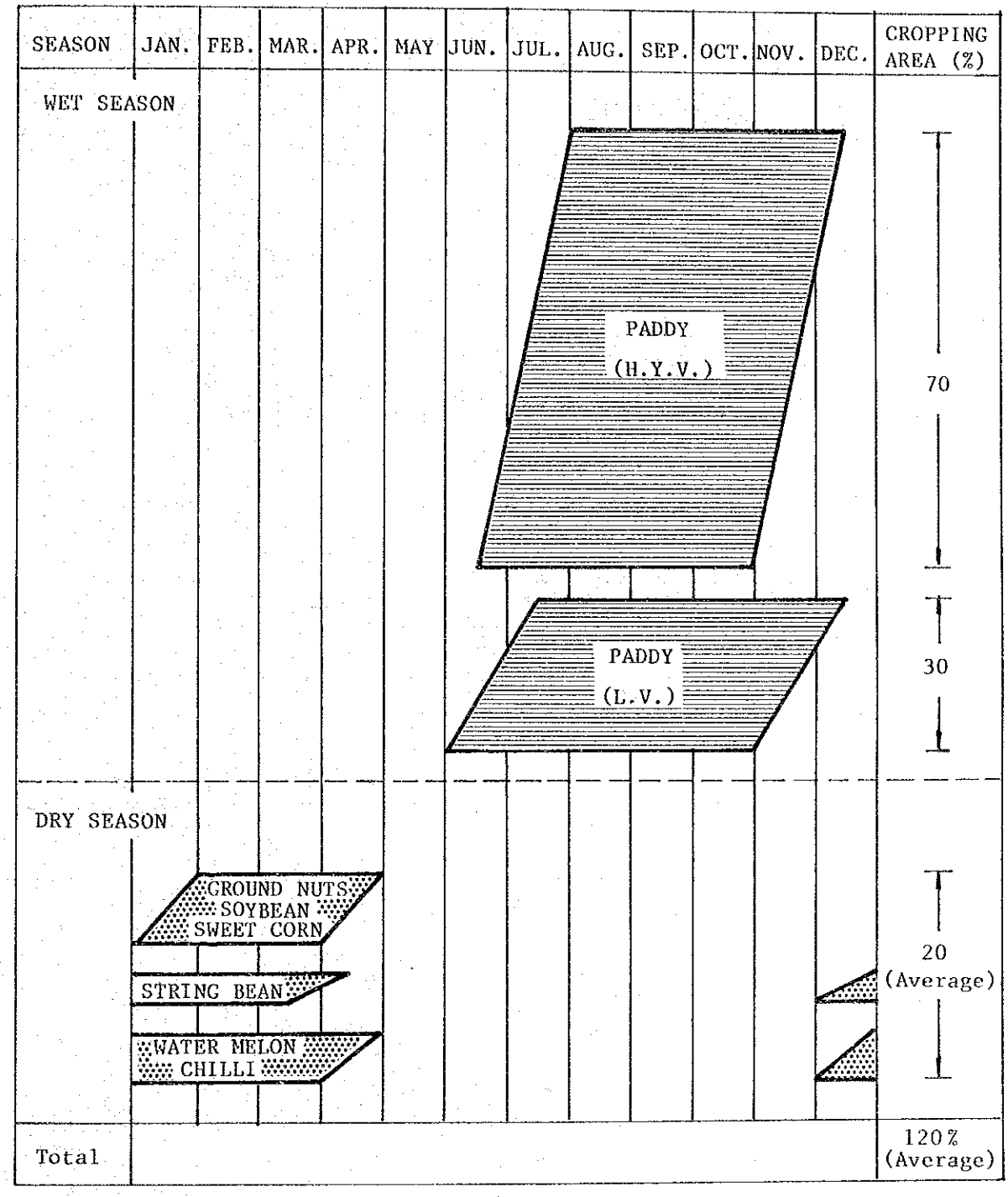


FIGURE 5-8. PROPOSED CROPPING PATTERN



CHAPTER VI. PROJECT ENGINEERING

CHAPTER VI. PROJECT ENGINEERING

6-1. Dam and Reservoir

6-1-1. Geological Conditions

(1) Lam Se Dam Site

The bed rocks in this dam site are heavily weathered and the overburden is thick with seven to 10 m thickness. Better quality rocks other than C_L class rocks are found at the deeper part of the dam foundation. The good quality rocks with poor cracks are confirmed in the left and right abutment area but are not confirmed in the bed rock area.

The unconsolidated deposits at the river bed area and the highly weathered zone in the right abutment are composed of very pervious zone with more than 100 Lugeon values. However, the highly weathered zone from the river bed area to the left abutment is composed of the comparatively impervious zone with the Lugeon values of less than 10 Lugeons. In the bed rocks, although the impervious zone is confirmed at the deeper parts in the left saddle dam area and the right abutment, the left abutment and the river bed area are dominated by the pervious zone with the Lugeon values from 10 to 50 Lugeons and the impervious zone is not confirmed in these area.

Although SM (silty sand), SC (sandy clay) and ML (sandy silt) predominated in the area where the grade of weathering is not so high, CL (silty clay) is widely distributed in the whole areas.

(2) Huai Khum Kham Dam Site

The highly weathered zone of the dam site is shallow and outcrops of the bed rocks are confirmed at the river bed and the reservoir area. Therefore, better quality rocks other than C_M class rocks are also found at the shallow part of the river bed with three to four meter depth.

The unconsolidated deposits at the river bed area and the highly weathered zone in the abutment area are mainly composed of pervious zone with the Lugeon values of more than 50 Lugeons. Although the impervious zone with the Lugeon values of less than 5 Lugeons in the bed rocks is confirmed at the deeper part of the left and right abutments, the river bed area is dominated by the pervious zone with the Lugeon values of more than 10 Lugeons and the impervious zone is unconfirmed.

Generally, SM (silty sand; about 0.5 m thickness) underlies the top soil and overlies GC (highly weathered laterite layer; sandy clay with lateritic pebble) with one to two and half meter thickness which is adequate to the impervious materials. At the deeper part with more than two to three meter, SM or ML to CL (highly weathered sandstone; silty sand or sandy silt to silty clay) predominates.

(3) Huai Kham Phak Wan Dam Site

The unconsolidated alluvium deposits and highly weathered zone are thinly distributed in the dam site. The bed rocks crop out in places along the river bed area and in the reservoir area. Sandstone in the bed rocks is of good quality rocks with poor cracks mainly composed of the C_H class rocks, and siltstone includes rich cracks and its rock quality is inferior to sandstone.

The impervious zone is confirmed only at the deeper part in the right abutment. The dam foundation is generally composed of the pervious zone with the high Lugeon values of more than 100 Lugeons in the river bed area and at the shallow parts in the left and right abutment.

SM (silty sand to sandy silt) with about 0.5 m thickness underlies the top soil and overlies GC (highly weathered laterite layer) with 0.5 to one meter thickness which is adequate to the impervious materials. Furthermore, the weathered zone of the bed rocks which underlies GC retains the rock texture owing to comparatively lower weathering than other dam sites and is mostly composed of SM and ML.

(4) Huai Na Khai Dam Site

The unconsolidated alluvium deposits and highly weathered zone are thinly distributed in the dam site. The bed rocks crop out in places along the river bed area and in the reservoir area. The shallower area than 10 m depth is dominated by sandstone of the Khok Kruat Formation, which includes rich parallel cracks and is mainly composed of the C_L class rocks. The cracks in the bed rock decrease and the C_H class rocks increase in the deeper area of more than 10 m depth.

The unconsolidated deposits at the river bed area and the highly weathered zone near the ground surface are composed of the very pervious zone with the Lugeon values of more than 50 Lugeons. The impervious zone with the Lugeon values of less than 10 Lugeons is confirmed at the deeper area in the left and right abutments. The shallow area in whole dam foundation and

deeper part in the river bed area are dominated by the pervious zone with the values of more than 10 Lugeons.

SM (silty sand) with one to two meter thickness underlies the top soil and overlies GC to GM (highly weathered laterite layer) with the thickness of maximum one meter. Furthermore, CL to SC (weathered zone of the bed rock) underlies the weathered laterite layer.

(5) Huai Soob Dam Site

The dam foundation is dominated by sandstone, alternated layers of siltstone, shale and sandstone, and coarse grained sandstone with granules and pebbles. Sandstone is mainly composed of the good quality rocks more than C_H class with poor cracks, and the alternated layer is composed of the C_M to C_L class rocks with rich cracks along the bedding planes. The thickness of the highly weathered zone in the whole dam site area and the unconsolidated alluvium deposits in the river bed area is generally three to four meter and the bed rocks are existing at the comparatively shallow area.

The unconsolidated alluvium deposits and the highly weathered zone in the left abutment to the river bed area are composed of the very pervious zone with the high Lugeon values of more than 100 Lugeons, although the highly weathered zone in right abutment area is composed of the impervious zone with the values of less than 10 Lugeons. The bed rock area is dominated by the pervious zone with the Lugeon values of more than 10 Lugeons except the deeper area from the river bed area to the right abutment area and the left side area of the left abutment where the impervious zone is distributed.

SM to SC (silty sand to clayey sand) with one and half to two meter thickness underlies the top soil and overlies the weathered laterite layer composed of GC (silty clay with laterite layer) and CL (silty clay which is the completely weathered laterite layer even the granules and pebbles weathered to produce reddish brown mottled clay) which are adequate to the impervious materials.

6-1-2. Reservoir

The selected five proposed dam and reservoir sites are scattered over the basin; namely, one site in the Sebai basin, three sites in the Sebok basin and one site in the Tung Lung basin. These sites are located on the gentle hills with the elevations of 130 ~ 180 m above the mean sea level, and consist mainly of clear forest, paddy fields and others. Dam axes are designed at the most appropriate locations from the view point of engineering, and in decision

of dam heights attention is given not to submerge residential area, house and temple. Major dimensions of the proposed reservoirs are summarized below;

Major Dimensions of Proposed Reservoirs

Project	Total Storage (MCM)	Reservoir Area (ha)	Submergence	
			Farm Land (ha)	Road (km)
Lam Se	8.84	340	75	6.0
Huai Khum Kham	20.03	535	70	3.5
Huai Kham Phak Wan	8.39	300	-	-
Huai Na Khai	18.78	675	295	-
Huai Soob	7.87	235	-	1.0

Table 6-1 gives information on the proposed reservoirs. The reservoir area and capacity curves were based on topographic maps scaled 1:10,000 for Lam Se, Huai Khum Kham, Huai Kham Phak Wan and Huai Na Khai, and topographic maps scaled 1:4,000 for Huai Soob. Topographic maps of dam and reservoir sites were prepared in June 1989 by RID. The maximum reservoir capacities were determined by the topographic conditions of the reservoir sites for Lam Se, Huai Khum Kham, Huai Na Khai and Huai Soob, while the maximum reservoir capacity of Huai Khum Kham project was set up through reservoir operation studies because possible reservoir capacities were larger than the annual average inflow.

The total sediment in the reservoirs was estimated at 150 (cu.m/sq.km/year) x catchment area (sq.km) x 100 years. Excepting for Huai Na Khai, the low water levels are determined to be corresponding with the estimated surface level of sediment. The low water level of Huai Na Khai reservoir is set at a little higher level than the estimated surface level of sediment so as to command the project area by gravity.

6-1-3. Dam Design

(1) Construction Materials

Soil investigation for embankment materials was carried out by RID covering 62 test pits and 184 auger boring. RID also undertook laboratory tests; dispersive identification test for 34 samples, physical property test for 48 samples and mechanical soil test for 19 samples. The followings are the results of the said soil investigation and soil tests;

- Dispersive soils that are not adequate for the embankment materials due to high erosive characteristic were not found at the proposed borrow areas except for only two samples obtained along the Lam Se river.
- Soils at the proposed borrow areas are mainly composed of CL, SM, GC, and SC, and among which CL material is dominant.
- Three dam sites of Lam Se, Huai Khum Kham and Huai Soob have sufficient quantity of impervious materials for dam construction, however, additional investigation of borrow area is needed for two sites of Huai Kham Phak Wan and Huai Na Khai due to rather small amount of impervious materials found at the proposed borrow areas.
- Riprap, sand and gravel are available around the project areas.

(2) Dam-body

(a) Dam Type

The earth fill type dam is recommended for the project, judging from the topographic and geological conditions of the sites as well as the quality and quantity of construction materials available at the sites, and the economy of construction work.

Dam Type

Project	Dam Type
Lam Se	Homogeneous fill dam with earth blanket
Huai Khum Kham	Zone fill dam with curtain grout
Huai Kham Phak Wan	- do -
Huai Na Khai	- do -
Huai Soob	- do -

Dam design is based on the following criteria:

- Width of dam crest : 6.00 m
- Free-board : 2.00 m above HWL
- Slope, Upstream : 1:3.0
  Downstream : 1:2.5
- Seismological acceleration : k = 0.05 g

(b) Stability Analysis

The stability of dam-body was analyzed by applying computer program on the following conditions;

- Method : Slip circle slice method
- Cases : Two cases - up and downstream
- Condition
  - Water level : Normal full water level (NWL)
  - Seismic force : 0.05 g (100%)
  - Seepage : Steady flow state at NWL Kv/Kh = 1/5

Such zones as riprap, rockfill and drain were not considered in stability analysis. Results of analysis are summarized below;

Safety Factor of Critical Circle Slice

Dam	Upstream	Downstream
Lam Se	1.232	1.239
Huai Khum Kham	1.213	1.442
Huai Kham Phak Wan	1.340	1.579
Huai Na Khai	1.281	1.517
Huai Soob	1.258	1.489

The above table shows that all dams fill the minimum requirements for stability, i.e, the safety factor of more than 1.2.

(3) Foundation Treatment

Based on the geological conditions, the amount of construction materials and easiness of constructions method at each project site, grouting and earth blanket method are applicable for seepage control in the dam foundation.

Since the rock surfaces are shallow and the rock layers are of relatively high permeability at the dam sites except for Lam Se, the grouting method is applicable to the seepage control through foundations. From the experiences, three rows of curtain grout and two rows of blanket grout with a 1.5 meters row interval and 3 meters hole interval are proposed. Drilling will be made from the pre-excavation line which is set up one meter above the final excavation line of core trench.

As for the Lam Se dam site, the earth blanket method is proposed because of deep soil layers with relatively impervious permeability and sufficient amount of core materials at the borrow area. The maximum required length of the earth blanket at the river bed is approximated to 140 m from the dam axis, taking into account the allowable seepage through the foundation.

(4) Spillway

The design discharge for spillway stated below has been estimated based on the probable flood with a return period of 100 years, taking into account the flood storage above the normal water surface level and, flood routing.

Spillway Design Discharge

- Unit : cu.m/s -

Dam	Catchment Area (sq.km)	Peak Inflow	Design Discharge
Lam Se	22.4	222	67
Huai Khum Kham	36.8	239	107
Huai Kham Phak Wan	13.5	157	56
Huai Na Khai	31.3	316	78
Huai Soob	18.5	239	134

Note: The spillway is of the duck bill type weir.

(5) Outlet

Design discharges for outlet facilities are determined based on the peak irrigation diversion requirements as follows;

Outlet Design Discharge

- Unit: cu.m/s -

Dam	Design Discharge	
	Left Bank	Right Bank
Lam Se	0.90	0.86
Huai Khum Kham	2.29	1.87
Huai Kham Phak Wan	1.52	-
Huai Na Khai	3.36	-
Huai Soob	0.61	0.86

In case that the conduit pipe is laid on the ground i.e. embedded in the dam-body, tension stress and/or deformation settlement shall be caused around the area contacted with the pipe. The conduit pipe therefore shall be embedded in the original ground (rock-bed).

Table 6-2 presents the major features of proposed dams.

6-1-4. Impact of Project on Environment

Prior to the construction of the project, the assessment of impact of the construction of dam and reservoir on the environment might be needed in conformity with the guideline for preparation of environmental impact evaluation prepared by the National Environmental Board (NEB) in April, 1979. In this study, general view of the impact of the project on the environment is made as follows;

① By retaining excess water during the rainy season for use in the dry season, effective use of water resources can be made. The proposed reservoirs to be built on the rivers which are dry up at present in the dry season can be used for fish culture and consumption by rural residents.

② In and around the project areas, agricultural productivity is very low because paddy cropping is practiced under the rainfed condition, and increased production of paddy to meet the increasing demand has been attained by the expansion of arable land by means of clearing forest, sometimes illegally. The implementation of the proposed irrigation project will contribute not only directly to the improvement of agricultural productivity but also to the conservation of forest through the restraint of clearing forest, as indirect effect.

③ In the project areas which have a meteorological characteristic of pronounced dry and rainy season, high floods caused by tropical depression often bring about flood damage to farm crops, roads and rivers. By retaining flood water with the proposed reservoir, flood damages along the downstream shall be alleviated to a large extent.

④ In general, there may be little negative impact on the environment because the project scale is relatively small. Tropical and subtropical diseases of malaria, schistosomiasis and filaria are endemic at swamp areas. Further studies are needed whether

swampy areas to be formed around the proposed reservoirs cause habitants of carriers of endemic disease, or not.

6-2. Canal and Village Pond

6-2-1. Irrigation Canal

(1) Canal Alignment

The layout of the canal system was made based on the topographic maps with a scale of 1:4,000. The alignment of canals is planned to enable the paddy field to be irrigated by gravity, running in parallel with contour lines as far as possible so that the number of appurtenant structures like drops and the quantity of earthwork are reduced to a certain extent. Main and lateral canals are designed to be trapezoid channels with concrete lining having a conveyance capacity of 1.60 l/sec/ha (0.26 l/sec/rai). Canals will be constructed to command a project area down to a terminal irrigation block of 16 ha (100 rai).

(2) Design of Irrigation Canal

Irrigation canals with a bottom width of more than 0.5 m are designed with concrete lining, taking into consideration that the soil in the service area consists of pervious sandy materials.

Canal standard cross section is designed as shown in Figure 6-1.

(3) Related Structures of Canals

The following related structures of canals are planned:

- Head regulators will be provided to divert irrigation water from the main to lateral canal or from the lateral to sub-lateral. Distributors will also be installed as measuring devices at the head of the structure to keep accurate water diversion.
- Farm turnouts will be placed at the head of service units and designed by a pipe barrel of 400 mm in diameter with a steel slide gate as measuring devices.
- Check structures will be provided at the downstream of the head regulator and turnout, and used to control diversion water and

maintain a certain water level of canal. The check structures are designed with a overflow weir of duck bill type.

- Check/drop structures are designed at the place where dissipation of surplus energy is required due to different elevation of canal water level. One check/drop structure is employed for 1.00 m different elevation and the structure is provided with manually operated slide gate.

- Siphons will be provided at places where canals cross the existing streams to release the flood from streams into the river. Precast concrete pipe is used for siphons with a discharge of less than 3.0 cu.m/sec and the cast-in-place concrete for a discharge of more than 3.0 cu.m/sec. The flow in the siphon is designed at high velocity in order to avoid clogging of siltation in the pipe.

- Spillways of the side channel overflow type will be provided on the canal to spill the excess water into the canal. The waterway will be of weir with sharp crest type.

- Crossing structures will be provided to release the canal water under free flow conditions at the crossing points of canal and road. The crossing structure is designed with the precast concrete pipe for discharge of less than 2.0 cu.m/sec, and the cast-in-place concrete for discharge of more than 2.0 cu.m/sec.

- Cross drain structures will be provided to release the side-slope flow. Precast concrete pipe of 1.0 m diameter with double barrels are used.

- Tail regulators will be provided at the end of canal to discharge water to the drain.

(4) Major Features of Canals

The layout of the canal networks is shown in the Drawings, and the summary of the major features of the canal is as follows:

Description		Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob	Total
A. Main Canal							
- Irrigable Area	(ha)	1,100	2,600	950	2,100	920	7,670
- Total Length	(km)	19.33	44.25	12.20	26.77	28.21	130.76
- Maximum Discharge (cu.m/sec)		0.90	2.29	1.52	3.37	0.86	
B. Lateral Canal							
- Nos. of Lateral		7	13	6	11	7	44
- Total Length	(km)	11.42	27.72	12.91	21.14	12.37	85.56

On-farm facilities will be implemented as a ditch and dike project under the control of the Operation and Maintenance Division of RID.

6-2-2. Drainage Canal

There exist a number of small channels connected to the main rivers, which will be used as main drainage canals with some improvement works. The design capacity of drainage canals in the service area is estimated at 5.8 l/sec/ha (0.9 l/sec/rai) for Lam Se, 6.5 l/sec/ha (1.0 l/sec/rai) for Huai Khum Kham, Huai Kham Phak Wan, Huai Na Khai and 6.7 l/sec/ha (1.1 l/sec/rai) for Huai Soob. The standard cross section of drainage canal is designed as shown in Figure 6-2.

The summary of the major features of the drainage canal is as follows:

Description	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob	Total
- Maximum Drainage Area (ha)	161	320	193	-	243	
- Maximum Discharge (cu.m/sec)	0.95	2.08	1.25	-	1.63	
- Total Length (km)	3.79	3.42	1.01	-	2.28	10.50

6-2-3. Village Pond

Each village in the project area will be provided with one village pond with a capacity of about 16,000 cubic meters. The pond shall be surrounded 4 sides by earth dike in order to prevent inflow of undesirable water. Typical layout of a village pond is shown in Figure 6-3. Number and type of village pond is as follows:

Type	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob	Total
Type 1; 10 rai	2	1	-	-	1	4
Type 2; 5 rai	1	3	1	1	-	6
Type 3; 3 rai	2	7	4	9	4	26
Total	5	11	5	10	5	36

TABLE 6-1. DIMENSION OF PROPOSED RESERVOIR

Description		BA-5 (Lam Se)	BO-11 (Huai Khum Kham)	BO-13 (Huai Kham Phak Wan)	BO-18 (Huai Na Khai)	TL-6 (Huai Soob)
(1) Catchment Area	(sq.km)	22.4	36.8	13.5	31.3	18.5
(2) Annual Rainfall	(mm)	1,641	1,714	1,714	1,670	1,670
(3) Annual Runoff	(MCM)	13.5	23.3	8.6	20.1	11.9
(4) Total Storage	(MCM)	8.84	20.03	8.39	18.78	7.87
(5) Dead Storage	(MCM)	0.34	0.55	0.20	2.67	0.28
(6) Sediment Volume	(MCM)	0.34	0.55	0.20	0.47	0.28
(7) Effective Storage	(MCM)	8.50	19.48	8.19	16.11	7.59
(8) H.W.L.	(El.m)	179.0	163.1	144.5	137.9	162.6
(9) N.W.L.	(El.m)	178.0	162.0	143.5	137.0	161.5
(10) L.W.L.	(El.m)	171.4	152.2	136.5	132.3	153.0
(11) Sediment EL	(El.m)	171.4	152.2	136.5	130.0	153.0
(12) Water Surface Area at N.W.L.	(ha)	278.8	453.7	237.7	559.6	190.8

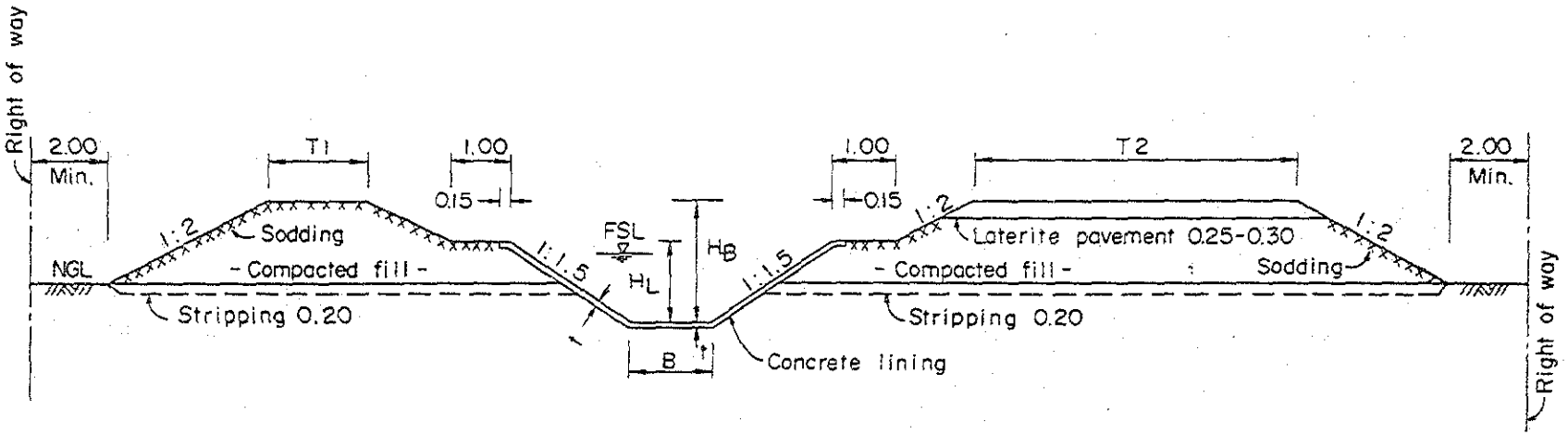
TABLE 6-2. MAJOR FEATURE OF PROPOSED DAMS (1/2)

Description	BA-5 (Lam Se)	BO-11 (Huai Khum Kham)	BO-13 (Huai Kham Phak Wan)	BO-18 (Huai Na Khai)	TL-6 (Huai Soob)
(1) Dam-body					
- Dam Type	Earth Fill	ditto	ditto	ditto	ditto
- Crest Elevation (El.m)	181.0	165.0	146.5	140.0	164.5
- Crest Length (m)	1,680	1,150	1,320	2,750	1,630
- Crest Width (m)	6.0	6.0	6.0	6.0	6.0
- Height (m)	16.0	20.5	14.5	17.5	19.5
- Slope: Up-stream	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0
: Down stream	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5
- Volume (1,000 cu.m)	331	355	401	600	391
(2) Foundation Treatment					
- Lowest Trench EL. (El.m)	165.0	144.5	132.0	122.5	145.0
- Treatment Method	Earth Blanket	Grouting	Grouting	Grouting	Grouting
- Max. Length or Depth (m)	140.0	12.0	12.0	15.0	13.0
(3) Spill-way					
- Deak Inflow (cu.m/s)	222	239	157	316	239
- Design Discharge (cu.m/s)	67	104	56	78	134
- Spill-way Type	Duck Bill Type	ditto	ditto	ditto	ditto
- Crest Elevation (El.m)	178.0	162.0	143.5	137.0	161.5

TABLE 6-2. MAJOR FEATURE OF PROPOSED DAMS (2/2)

Description	BA-5 (Lam Se)	BO-11 (Huai Khum Kham)	BO-13 (Huai Kham Phak Wan)	BO-18 (Huai Na Khai)	TL-6 (Huai Soob)
- Crest Length (m)	40.0	50.0	30.0	50.0	60.0
- Width of Canal (m)	7.0	9.0	7.0	8.0	10.0
- Structure Length (m)	175	432	219	248	208
- Total Length (m)	465	702	419	678	645
(4) Outlet					
a) Left Outlet	1	1	1	1	1
- Design Discharge (cu.m/s)	0.90	2.29	1.52	3.36	0.61
- Diameter of Conduit (m)	0.80	1.20	1.10	1.50	0.70
- Structure Length (m)	97.5	116.8	97.8	-	98.0
b) Right Outlet	1	1	Non	Non	1
- Design Discharge (cu.m/s)	0.86	1.87	-	-	0.86
- Diameter of Conduit (m)	0.80	1.10	-	-	0.80
- Structure Length (m)	97.5	104.3	-	-	95.5

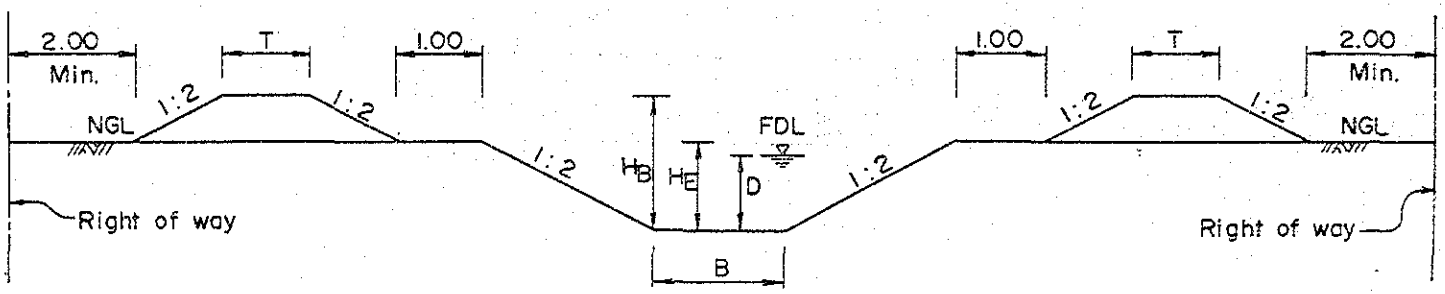
FIGURE 6-1. TYPICAL CROSS SECTION OF LINED CANAL



Details of Lined Canal Cross Section

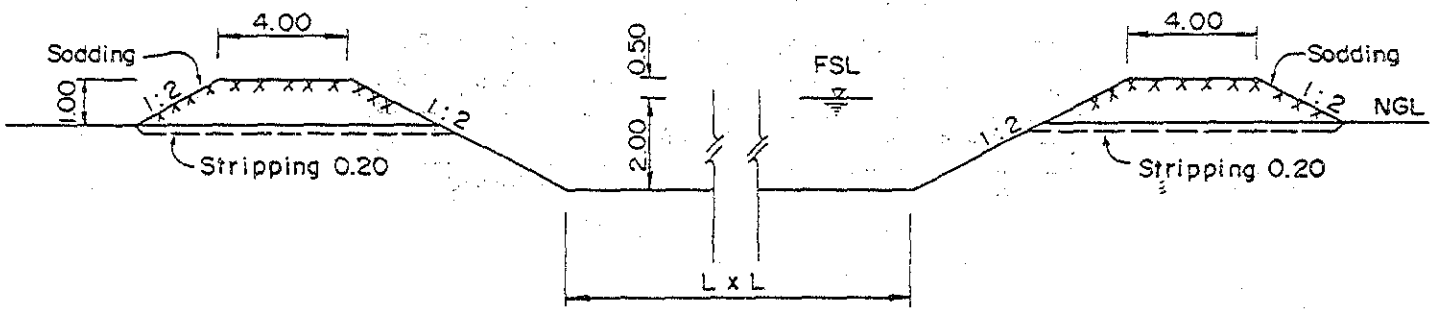
Type	Q m^3/s	B m	H_L m	H_B m	T1 m	T2 m	t m
L 1	3.74-2.90	1.40	1.55	1.95	2.00	6.00	0.07
L 2	3.03-2.35	1.30	1.40	1.80	2.00	6.00	0.07
L 3	2.41-2.09	1.20	1.30	1.70	2.00	6.00	0.07
L 4	2.08-1.62	1.10	1.25	1.65	2.00	4.00	0.05
L 5	1.79-1.38	1.00	1.20	1.60	2.00	4.00	0.05
L 6	1.35-1.17	0.90	1.10	1.50	2.00	4.00	0.05
L 7	1.21-0.85	0.80	1.00	1.40	2.00	4.00	0.05
L 8	0.97-0.69	0.70	0.85	1.15	2.00	4.00	0.05
L 9	0.79-0.40	0.60	0.75	1.05	2.00	4.00	0.05
L10	0.49-0.15	0.50	0.65	0.95	2.00	4.00	0.05

FIGURE 6-2. TYPICAL CROSS SECTION OF DRAINAGE CANAL



Dimension						
Type	Q m^3/s	B m	D m	H_E m	H_B m	T m
E1	2.63 – 1.85	2.00	1.10	1.40	1.80	1.50
E2	2.01 – 1.44	1.80	1.00	1.30	1.70	1.50
E3	1.53 – 1.07	1.60	0.90	1.20	1.60	1.00
E4	1.10 – 0.77	1.40	0.80	1.00	1.40	1.00
E5	0.76 – 0.47	1.20	0.70	0.90	1.30	1.00
E6	0.50 – 0.22	1.00	0.60	0.80	1.20	0.50
E7	0.23 – 0.13	0.80	0.50	0.70	1.10	0.50
E8	0.13 – 0.07	0.60	0.40	0.60	1.00	0.50

FIGURE 6–3. TYPICAL CROSS SECTION OF VILLAGE POND



Dimension

Type	Area of Pond ha (rai)	Dimension L x L m	Depth m
1	1.6 (10)	130 x 130	2.00
2	0.8 (5)	90 x 90	2.00
3	0.48(3)	70 x 70	2.00

CHAPTER VII. IMPLEMENTATION AND OPERATION AND MAINTENANCE OF PROJECT

CHAPTER VII. IMPLEMENTATION AND OPERATION AND MAINTENANCE OF PROJECT

7-1. Implementation Program

7-1-1. Executing Agency

The Royal Irrigation Department (RID) will be the executing agency responsible for implementing the Sebai-Sebok irrigation project, with the assistance and cooperation by other government agencies concerned in their respective fields. The project would be implemented under a loan from an international financing agency as a package project composed of five projects of Lam Se, Huai Khum Kham, Huai Kham Phak Wan, Huai Na Khai and Huai Soob.

For the successful implementation of the project, RID will appoint a project director to be responsible for the promotion and coordination of five projects under the supervision of Medium Scale Project Construction Division. The assignments of the project director are preparation of detail design of engineering works as well as bidding and contracting of construction works. The construction works will be supervised by five construction offices to be established. The proposed organization for project implementation is given on Figure 7-1.

7-1-2. Consulting Services

RID will employ consulting engineers in the fields of dam, canal, civil work, geology, irrigation and bidding. The consultants shall assist RID in the review of project planning, detail design of dam and canal, cost estimate, preparation of bid documents, tendering and contracting, quality control of construction works and general supervision of the project implementation.

The total input of consulting services is 85 man-months, including 50 man-months for Thai consultants and 35 man-months for foreign consultants, for detail design stage, and 150 man-months for construction supervision stage including 100 man-months for Thai consultants and 50 man-months for foreign consultants.

7-1-3. Construction Planning

The construction of major works will be executed on a contractual basis. The project provides for five dams of fill type and 216 km long irrigation canals

with concrete lining. Embankment materials can be borrowed within the proposed reservoir areas and in the vicinity of the reservoirs. Sand, gravel and riprap are available at the existing borrow areas located around the project areas.

The construction of dams is divided into two sections of right and left abutment, since dams have a relatively long length, and will be executed in the following sequence;

Sequence	Works
(1)	Excavation of right core trench up to pre-excavation line
(2)	Grouting of right abutment and construction of right outlet
(3)	Excavation of over-burden of 1.0m in right abutment
(4)	Backfill of core trench in right abutment and shifting of river diversion
(5)	Embankment of right section and excavation of left core trench up to pre-excavation line
(6)	Grouting of left abutment and construction of left outlet
(7)	Excavation of over-burden of 1.0 m in left abutment
(8)	Backfill of core trench in left abutment
(9)	Embankment of left section
(10)	Closing of river diversion section during dry season

7-1-4. Implementation Schedule

The project will be implemented over eight years from 1990 to 1997. RID will commence the detailed topographic surveys of canal and dam sites in the second half of 1990. The detail design will be completed in two years 1991 to 1992 by employing consultants.

The construction of five dams is scheduled to start in the dry season of 1993 with the construction periods of two years for Lam Se, Huai Khum Kham and Huai Kham Phak Wand and three years for Huai Na Khai and Huai Soob. The construction of canals and on-farm facilities will commence one year before the completion of dam construction with a construction schedule of two years.

In accordance with the above mentioned schedule, construction works will be completed in April, 1996 to start irrigation for rainy season paddy in 1997 for three projects of Lam Se, Huai Khum Kham and Huai Kham Phak

Wan, while the construction of two projects of Huai Na Khai and Huai Soob will be completed in April, 1997. Figure 7-2 shows the implementation schedule of the project.

7-2. Post Project Operation and Maintenance

7-2-1. Responsibility

RID is responsible for the operation and maintenance of major project works consisting of dams, reservoirs, and irrigation and drainage systems. For operation and maintenance of the Sebai-Sebok irrigation project, it is proposed for provincial RID Offices of Ubon Ratchathani and Yasothon to set up O & M VI division and two branch offices in Ubon Ratchathani and one branch office in Yasothon.

The operation and maintenance of on-farm facilities will be carried out by farmers under the close advice and supervision by RID provincial offices. Figure 7-3 gives the proposed organization for operation and maintenance of the project.

7-2-2. Staffing Plan

The responsibility of operation and maintenance of branch O & M offices located in Sebai-Sebok basin in Ubon Ratchathani province covers the following existing projects;

Project	Irrigation Area	
	- ha -	- rai -
1. Huai Pho	720	4,500
2. Rong Nam Sap	67	419
3. Phuttha Utthayan	2,560	16,000
4. Nong Chang Yai	1,200	7,500
5. Sa Saming	120	750
6. Huai Thamkhae	1,680	10,500
Total	6,347	39,669

While, the responsibility of branch O & M office in Yasothon province covers the following existing projects.

Project	Irrigation Area	
	- ha -	- rai -
1. Huai Ling Jhon	2,400	15,000
2. Huai Sa Back	1,920	12,000
Total	4,320	27,000

① Water Master

The water master will take responsibility for the review and approval of water allocation programme of each cropping season and inspection and supervision of maintenance works. The water master is responsible for 100,000 rai (16,000 ha). Therefore, the provincial RID office of Ubon Ratchathani is proposed to have one more water master to handle Sebai-Sebok project.

② Zoneman

The zoneman will take responsibility of the compilation of information necessary for water allocation, such as crop water demand, irrigation water distribution, rainfall and cropping pattern, water allocation schedule and regulation of water by giving instruction to the gate tender. A zoneman is proposed to superintend the service area of about 5,000 rai. Hence, the provincial RID office of Ubon Ratchathani will require 11 additional zonemen in total, while Changwat Yasothon requires two additional zonemen.

③ Gate Tender

The gate tender will take responsibility of regulating discharge released from the reservoir to the canal and from canal to the ditch, making record on water levels in the reservoir and in the canal and reporting the water level to the zoneman on daily basis. The gate tender is proposed to cover an area of about 2,500 rai (400 ha) per person. Total 22 gate tenders will be newly recruited for Sebai-Sebok project.

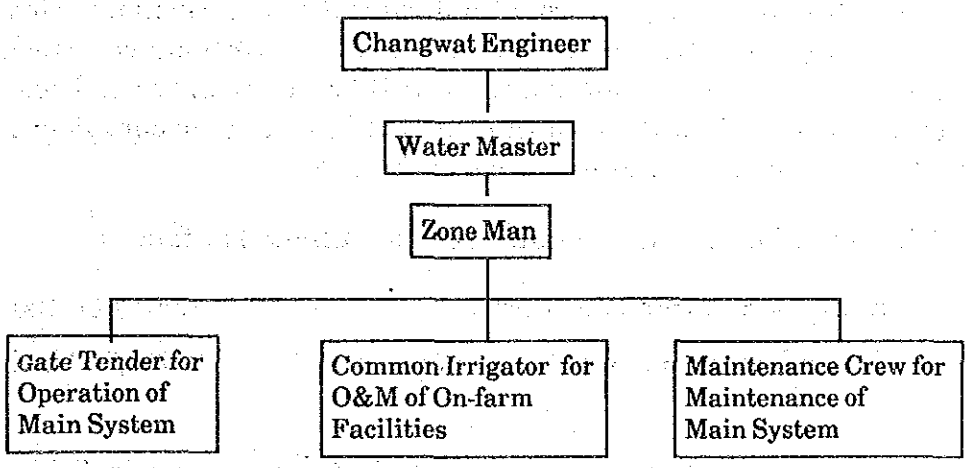
④ The maintenance crew will take charge of all kinds of maintenance work such as cutting weeds, cleaning silt in the canal, repairing damaged concrete work etc. One maintenance group is proposed for the provincial RID office of Ubon Ratchathani. Lam Se project under the provincial RID office of Yasothon will be maintained by

the existing group. A maintenance crew is proposed to consist of one foreman, two carpenters, one steel setter, one plasterer and 10 common labors. Seven persons including one foreman, one carpenter and five common labors are proposed for Lam Se project as additional crews.

The manpower requirement for operation and maintenance of the projects is summarized in Table 7-1.

7-2-3. Organization

Proposed organization for operation and maintenance of the project at provincial and project level is shown as follows;



(1) Operation

Water delivery schedule in each cropping season will be made by the zoneman while the instruction by the zoneman will be given to the gate tender to discharge the required amount of water from reservoir to canal and from canal to ditch. In the ditch, water will be allocated by the common irrigator elected among the farmers. In case of rain during water delivery, schedule must be adjusted by the zoneman and the instruction of adjustment shall be given to the gate tender to regulate the flow. The common irrigator will be informed of the adjustment as well in order to revise the delivery schedule to the farmers. In case of water shortage, a rotation schedule must be established and informed to the common irrigator.

(2) Maintenance

The regular minor maintenance will be carried out twice a year each time before the wet and dry cropping seasons in which the main systems will be done by the Changwat maintenance crew, and the on-farm system will be done by the Water User's Group under the supervision of the zoneman. The minor maintenance in the main systems will be mainly for removal of silt deposit and weed cleaning along the banks of the canals and the maintenance of the on-farm systems will be mainly for weeding in the ditch.

For the maintenance road along the canal and other structures, it must be done by the task force of Changwat Operation and Maintenance Section.

7-2-4. Cost of Operation and Maintenance

The office and facilities provided during the construction period of the major works will be utilized for operation and maintenance office. The equipment for operation and maintenance will be newly provided because the construction works will be done on the contract basis and no equipment except transportation vehicles will be remained at the site.

The operation and maintenance cost is estimated as follows;

- Equipment purchasing cost 7,991,000 Baht
- Annual operation and maintenance cost 9,681,000 Baht

List of equipment to be procured for O & M use is shown in Table 7-2.

7-3. Additional Survey and Investigation

The feasibility study was based on the topographic maps of dam sites, reservoir areas and project areas and geological investigations of dam axes, as presented previously. The following additional survey and investigation are proposed to be undertaken during the stage of detail design. (Details are presented in Appendix F).

① Topographic Survey

- Borrow area
- Dam sites
- Construction sites of spillway and outlet

- Canal and road routes

② Geological Investigation

- Seismic exploration
- Boring including coring, permeability test and standard penetration test

③ Soil Investigation

- Test pit
- Auger boring
- Laboratory test including physical property test and mechanical soil test

TABLE 7-1. ESTIMATED MANPOWER REQUIRED FOR OPERATION AND MAINTENANCE

(Unit : Person)

Item \ Project	Lam Se (BA-5)	H. Khum Kham (BO-11)	H. Kham Phak Wan (BO-13)	H. Na Khai (BO-18)	H. Tung Lung (TL-6)	Total
Irrigable Area (Rai)	6,870	16,250	5,930	13,120	5,750	47,920
Changwat Office	Yasothon	Ubon-Ratchathani				
Branch	II	I		II		
° Water Master (100,000 rai/person)	-	1				1
° Zone-man (5,000 rai/person)	2	4	2	3	2	13
° Gate Tender (2,500 rai/person)	3	7	3	6	3	22
° Maintenance Crew		1 Group				
Foreman	1		1			2
Carpenter	1		2			3
Plasterer	-		1			1
Steel Setter	-		1			1
Common Labor	5		10			15

TABLE 7-2. O & M EQUIPMENT

	Description	Lam Se	H. Khum Kham	H. Kham Phak Wan	H. Na Khai	H. Tung Lung	Total
			Branch I		Branch II		
1.	Moter Grader, 125 HP	-	1		1		2
2.	Loader Backhoe	-	1		1		2
3.	Flat Bed Truck, 4 Ton	-	1		1		2
4.	Pick-up Truck	1	1		1		3
5.	Station Wagon, 4 x 4	-		1			1
6.	Motor Bicycle, 125 CC	3	7	3	6	3	22
7.	Diesel Generating Set, 15 KVA	-		1			1
8.	Diesel Generating Set, 5 KVA	-		1			1
9.	300 A-DC Arc Welder	-		-			-
10.	4" Centrifugal Pump	1	1		1		3
11.	3" Centrifugal Pump	-	-		-		-
12.	Concrete Mixer, 7 cu.ft	-		1			1
13.	Air Compressor, 15 cfm.	-		1			1
14.	Air Compressor, 170 cfm.	-		-			-
15.	Back-fill V. braling Tamper	-		1			1
16.	Conc. Vibrator, 1/2"	-		1			1
17.	Gas Welding & Cutting Outfit	-		1			1
18.	Electric Hand Drill, 1/2"	-		1			1
19.	Electric Bench Drill, 1/2"	-		1			1
20.	Electric Portable Grinder	-		1			1
21.	Electric Bench Grinder W/brash	-		1			1
22.	Hydraulic Jack, 10 ton	-		1			1
23.	Hydraulic Jack, 5 ton	-		1			1
24.	Chain Hoist, 5 ton	-		1			1
25.	Hand Toil Set for Field Workshop	-		1			1

FIGURE 7-1. PROJECT ORGANIZATION CHART FOR IMPLEMENTATION

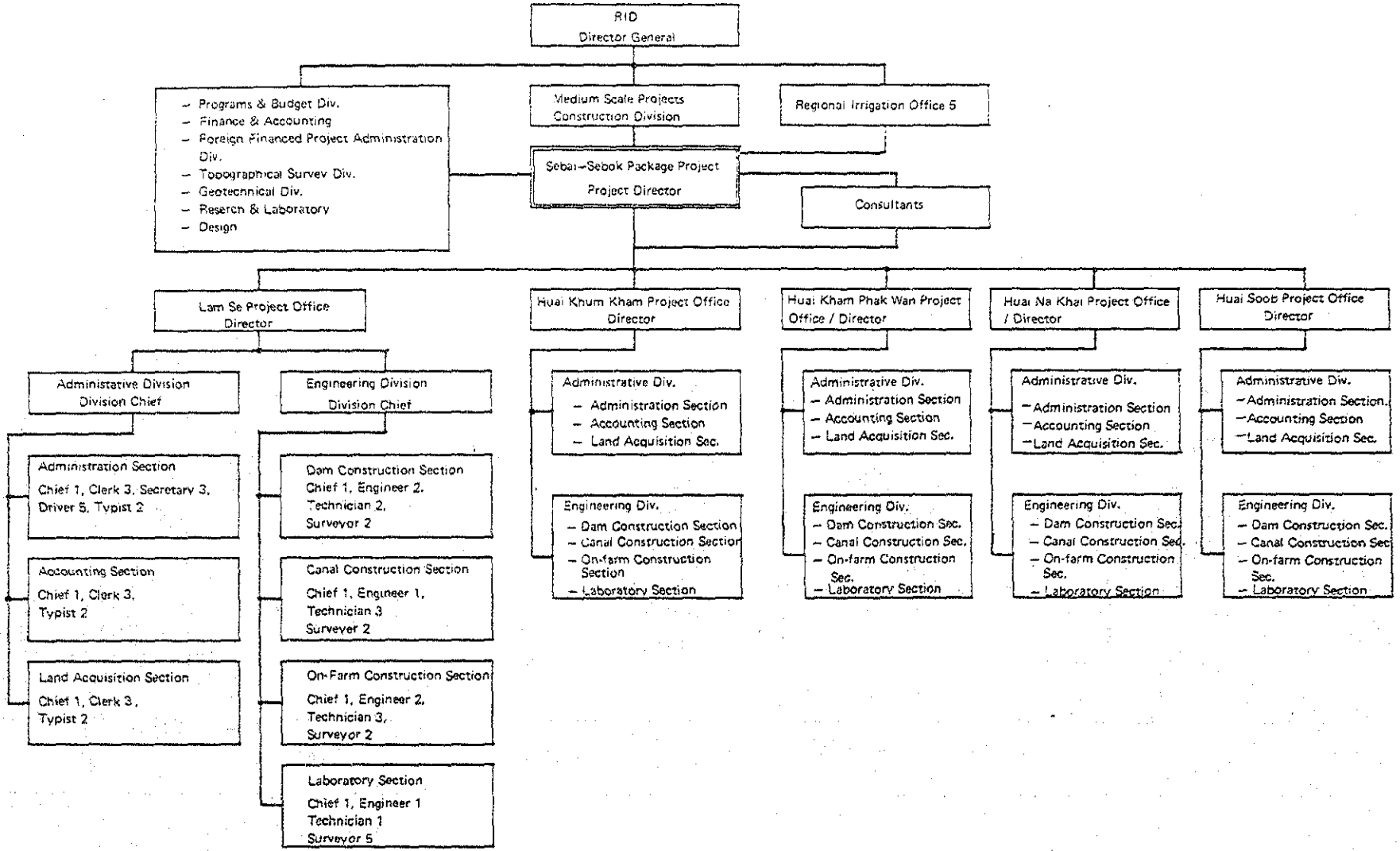


FIGURE 7-2. IMPLEMENTATION SCHEDULE OF SEBAI SEBOK BASIN IRRIGATION PROJECTS

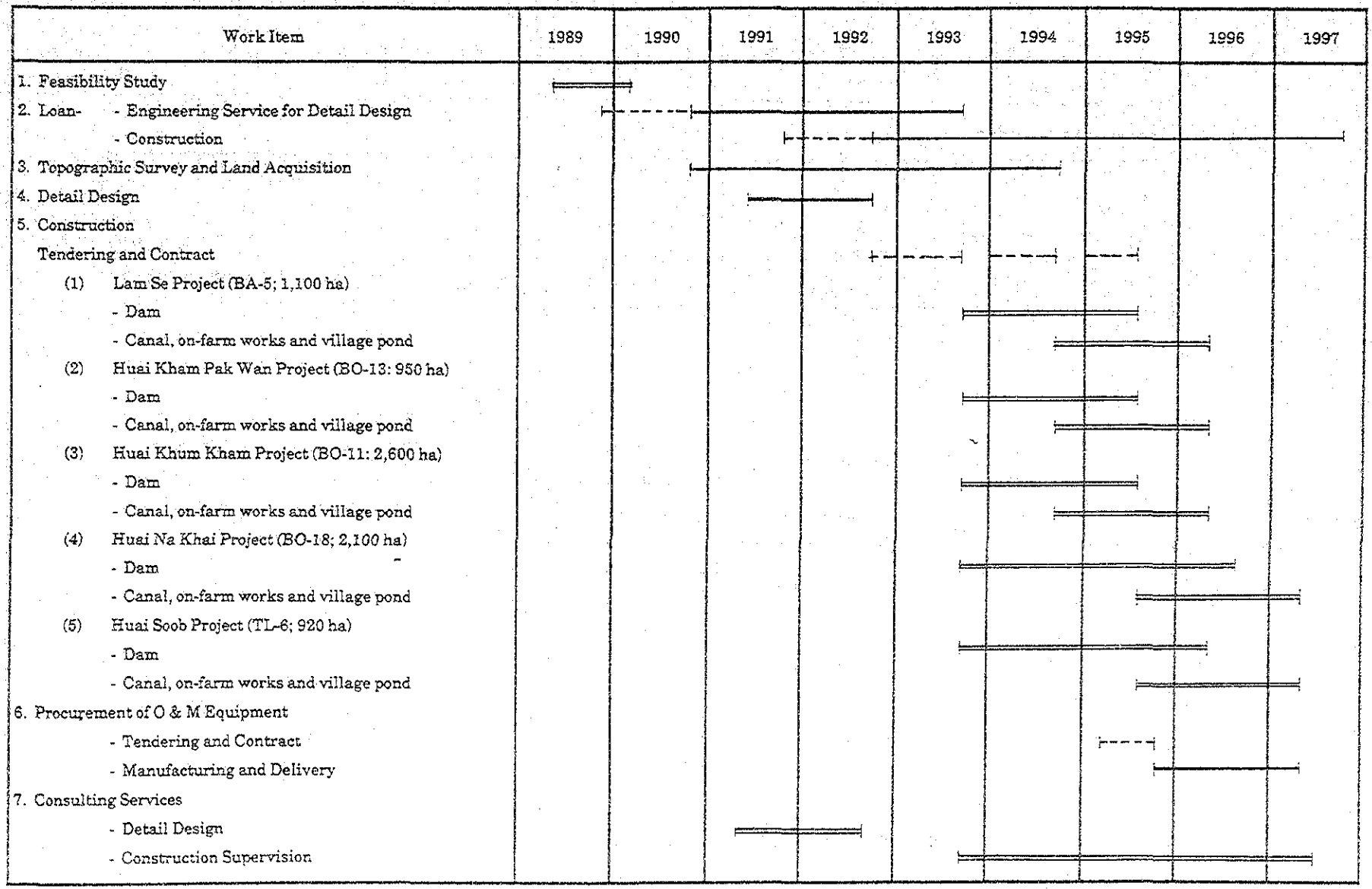
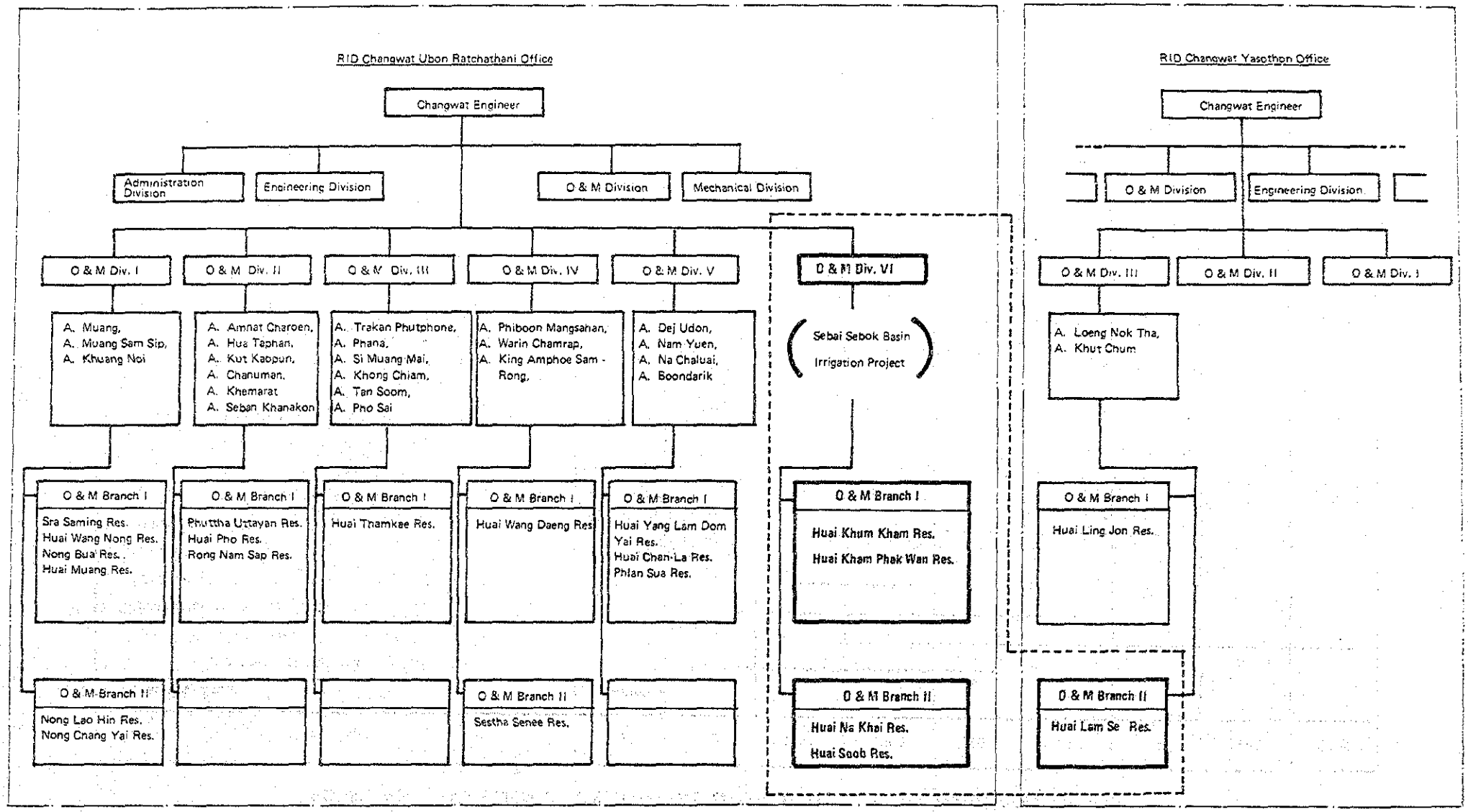


FIGURE 7-3. ORGANIZATION CHART OF SEBAI SEBOK BASIN IRRIGATION PROJECTS



CHAPTER VIII. PROJECT COST

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The construction cost was estimated based on the work quantity and current unit rates employed in RID projects and the proposed implementation schedule. The project cost includes costs for procurement of O & M equipment, land acquisition, survey and investigation, administration and consulting services. 10 percent of physical contingencies were added. Price escalation contingencies were calculated at rates of one percent per year for foreign currency component and four percent per year for local currency component.

The project cost is divided in two components of local currency and foreign currency. The foreign currency component is the amount of costs required for procurement of machinery, equipment, spare parts and materials to be imported, parts of costs required for procurement of machinery, equipment, spare parts and materials to be manufactured in Thailand, and the remuneration of consultants.

The total project cost amounts to 1,517 Baht million at a 1989 price level, of which 722 Baht million (or, equivalent to 48 percent) are foreign currency component. A foreign exchange rate of US$1.00 = Baht 25.00 = Yen 140 has been applied. Table 8-1 presents the project cost as summarized below;

Project Cost

- Unit: Baht million -

Project	Local Currency	Foreign Currency	Total	Foreign (%)
Lam Se	108.9	93.3	202.2	46
Huai Khum Kham	225.0	205.5	430.5	48
Huai Kham Phak Wan	113.8	104.7	218.5	48
Huai Na Khai	199.7	179.0	378.7	47
Huai Soob	147.7	139.7	287.4	49
Total	795.1	722.2	1,517.3	48

Annual disbursement schedule based on the implementation schedule of the project is summarized as follows;

Annual Disbursement

- Unit: Baht million -

Year	Local Currency	Foreign Currency	Total
1990	6.5	4.4	10.9
1991	7.7	15.9	23.6
1992	4.4	13.8	18.2
1993	64.2	43.5	107.7
1994	194.3	219.6	413.9
1995	304.8	247.6	552.4
1996	178.3	144.4	322.7
1997	34.9	33.1	68.0
Total	795.1	722.2	1,517.3

Tables of 8-2 to 8-7 give the costs for individual projects.

TABLE 8-1. PROJECT COST SUMMARY

- Unit: ฿1,000 -

Cost Item	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob	Total
Preparatory Work	2,574	2,574	1,872	2,574	1,872	11,466
Dam	67,188	102,277	89,163	126,570	107,176	492,374
Canal	40,564	134,177	37,943	77,220	64,032	353,936
Overhead, Profit and Taxes	15,159	32,842	17,722	28,354	23,781	117,858
Sub-total (1)	125,485	271,870	146,700	234,718	196,861	975,634
On-farm and Village Pond	11,660	25,569	9,383	19,994	9,656	76,262
O & M Equipment	1,510	3,668	1,402	2,912	1,295	10,787
Land Acquisition	6,024	6,607	1,203	9,576	1,953	25,363
Survey and Investigation	3,156	3,506	2,812	4,217	3,068	16,759
Administration	3,310	7,171	3,869	6,191	5,192	25,733
Consulting Services	9,245	22,452	8,585	17,830	7,924	66,036
Sub-total (2)	34,905	68,973	27,254	60,720	29,088	220,940
Base Cost (1 + 2)	160,390	340,843	173,954	295,438	225,949	1,196,574
Physical Contingencies	16,039	34,084	17,395	29,544	22,595	119,657
Price Contingencies	25,813	55,639	27,185	53,661	38,849	201,147
Project Cost	202,242	430,566	218,534	378,643	287,393	1,517,378

TABLE 8-2. DISBURSEMENT SCHEDULE OF TOTAL PROJECT

- Unit: ฿1,000 -

Cost Item	1990	1991	1992	1993	1994	1995	1996	1997	Total
Preparatory Works	-	-	-	11,466	-	-	-	-	11,466
Dam	-	-	-	49,191	229,182	172,667	41,334	-	492,374
Canal	-	-	-	-	42,536	155,859	127,290	28,251	353,936
Overhead, Profit and Taxes	-	-	-	8,334	37,335	45,139	23,169	3,881	117,858
Sub-total (1)	-	-	-	68,991	309,053	373,665	191,793	32,132	975,634
On-farm and Village Pond	-	-	-	-	-	34,959	33,891	7,412	76,262
O & M Equipment	-	-	-	-	-	-	5,394	5,393	10,787
Land Acquisition	-	-	-	9,549	10,031	5,783	-	-	25,363
Survey and Investigation	8,379	8,380	-	-	-	-	-	-	16,759
Administration	1,287	1,287	2,573	5,146	5,146	5,146	3,861	1,287	25,733
Consulting Services	-	10,995	13,178	4,173	10,838	11,431	10,691	4,730	66,036
Sub-total (2)	9,666	20,662	15,751	18,868	26,015	57,319	53,837	18,822	220,940
Base Cost (1 + 2)	9,666	20,662	15,751	87,859	335,068	430,984	245,630	50,954	1,196,574
Physical Contingencies	967	2,066	1,576	8,785	33,506	43,099	24,563	5,095	119,657
Price Contingencies	294	895	893	11,045	45,295	78,306	52,507	11,912	201,147
Project Cost	10,927	23,623	18,220	107,689	413,869	552,389	322,700	67,961	1,517,378

TABLE 8-3. DISBURSEMENT SCHEDULE OF LAM SE PROJECT

- Unit: ฿1,000 -

Cost Item	1990	1991	1992	1993	1994	1995	1996	1997	Total
Preparatory Works	-	-	-	2,574	-	-	-	-	2,574
Dam	-	-	-	7,397	33,770	26,021	-	-	67,188
Canal	-	-	-	-	8,112	24,338	8,114	-	40,564
Overhead, Profit and Taxes	-	-	-	1,370	5,755	6,919	1,115	-	15,159
Sub-total (1)	-	-	-	11,341	47,637	57,278	9,229	-	125,485
On-farm and Village Pond	-	-	-	-	-	8,745	2,915	-	11,660
O & M Equipment	-	-	-	-	-	-	755	755	1,510
Land Acquisition	-	-	-	3,012	3,012	-	-	-	6,024
Survey and Investigation	1,578	1,578	-	-	-	-	-	-	3,156
Administration	165	165	331	662	662	662	498	165	3,310
Consulting Services	-	1,539	1,845	584	1,517	1,600	1,497	663	9,245
Sub-total (2)	1,743	3,282	2,176	4,258	5,191	11,007	5,665	1,583	34,905
Base Cost (1 + 2)	1,743	3,282	2,176	15,599	52,828	68,285	14,894	1,583	160,390
Physical Contingencies	174	328	218	1,560	5,283	6,829	1,489	158	16,039
Price Contingencies	51	146	121	2,091	7,482	12,615	3,020	287	25,813
Project Cost	1,968	3,756	2,515	19,250	65,593	87,729	19,403	2,028	202,242

TABLE 8-4. DISBURSEMENT SCHEDULE OF HUAI KHUM KHAM PROJECT

- Unit: ฿1,000 -

Cost Item	1990	1991	1992	1993	1994	1995	1996	1997	Total
Preparatory Works	-	-	-	2,574	-	-	-	-	2,574
Dam	-	-	-	9,934	57,300	35,043	-	-	102,277
Canal	-	-	-	-	26,835	80,506	26,836	-	134,177
Overhead, Profit and Taxes	-	-	-	1,719	11,560	15,876	3,687	-	32,842
Sub-total (1)	-	-	-	14,227	95,695	131,425	30,523	-	271,870
On-farm and Village Pond	-	-	-	-	-	19,177	6,392	-	25,569
O & M Equipment	-	-	-	-	-	-	1,834	1,834	3,668
Land Acquisition	-	-	-	3,303	3,304	-	-	-	6,607
Survey and Investigation	1,753	1,753	-	-	-	-	-	-	3,506
Administration	359	359	717	1,434	1,434	1,434	1,075	359	7,171
Consulting Services	-	3,738	4,480	1,419	3,685	3,887	3,635	1,608	22,452
Sub-total (2)	2,112	5,850	5,197	6,156	8,423	24,498	12,936	3,801	68,973
Base Cost (1 + 2)	2,112	5,850	5,197	20,383	104,118	155,923	43,459	3,801	340,843
Physical Contingencies	211	585	520	2,038	10,412	15,592	4,346	380	34,084
Price Contingencies	68	239	282	2,640	14,425	28,323	8,981	681	55,639
Project Cost	2,391	6,674	5,999	25,061	128,955	199,838	56,786	4,862	430,566

TABLE 8-5. DISBURSEMENT SCHEDULE OF HUAI KHAM PHAK WAN PROJECT

- Unit: ฿1,000 -

Cost Item	1990	1991	1992	1993	1994	1995	1996	1997	Total
Preparatory Works	-	-	-	1,872	-	-	-	-	1,872
Dam	-	-	-	9,298	54,013	25,852	-	-	89,163
Canal	-	-	-	-	7,589	22,765	7,589	-	37,943
Overhead, Profit and Taxes	-	-	-	1,535	8,464	6,680	1,043	-	17,722
Sub-total (1)	-	-	-	12,705	70,066	55,297	8,632	-	146,700
On-farm and Village Pond	-	-	-	-	-	7,037	2,346	-	9,383
O & M Equipment	-	-	-	-	-	-	701	701	1,402
Land Acquisition	-	-	-	361	842	-	-	-	1,203
Survey and Investigation	1,406	1,406	-	-	-	-	-	-	2,812
Administration	193	193	387	774	774	774	581	193	3,869
Consulting Services	-	1,429	1,713	542	1,409	1,486	1,390	616	8,585
Sub-total (2)	1,599	3,028	2,100	1,677	3,025	9,297	5,018	1,510	27,254
Base Cost (1 + 2)	1,599	3,028	2,100	14,382	73,091	64,594	13,650	1,510	173,954
Physical Contingencies	160	303	210	1,438	7,309	6,459	1,365	151	17,395
Price Contingencies	49	138	123	1,730	10,079	11,993	2,790	283	27,185
Project Cost	1,808	3,469	2,433	17,550	90,479	83,046	17,805	1,944	218,534

TABLE 8-6. DISBURSEMENT SCHEDULE OF HUAI NA KHAI PROJECT

- Unit: ฿1,000 -

Cost Item	1990	1991	1992	1993	1994	1995	1996	1997	Total
Preparatory Works	-	-	-	2,574	-	-	-	-	2,574
Dam	-	-	-	11,920	28,862	50,813	34,975	-	126,570
Canal	-	-	-	-	-	15,444	46,332	15,444	77,220
Overhead, Profit and Taxes	-	-	-	1,991	3,966	9,104	11,172	2,121	28,354
Sub-total (1)	-	-	-	16,485	32,828	75,361	92,479	17,565	234,718
On-farm and Village Pond	-	-	-	-	-	-	14,996	4,998	19,994
O & M Equipment	-	-	-	-	-	-	1,456	1,456	2,912
Land Acquisition	-	-	-	2,873	2,873	3,830	-	-	9,576
Survey and Investigation	2,108	2,109	-	-	-	-	-	-	4,217
Administration	310	310	619	1,238	1,238	1,238	928	310	6,191
Consulting Services	-	2,969	3,558	1,127	2,926	3,086	2,886	1,278	17,830
Sub-total (2)	2,418	5,388	4,177	5,238	7,037	8,154	20,266	8,042	60,720
Base Cost (1 + 2)	2,418	5,388	4,177	21,723	39,865	83,515	112,745	25,607	295,438
Physical Contingencies	242	538	418	2,172	3,986	8,352	11,275	2,561	29,544
Price Contingencies	72	226	231	2,764	5,272	14,279	24,691	6,126	53,661
Project Cost	2,732	6,152	4,826	26,659	49,123	106,146	148,711	34,294	378,643

TABLE 8-7. DISBURSEMENT SCHEDULE OF HUAI SOOB PROJECT

- Unit: ฿1,000 -

Cost Item	1990	1991	1992	1993	1994	1995	1996	1997	Total
Preparatory Works	-	-	-	1,872	-	-	-	-	1,872
Dam	-	-	-	10,642	55,237	34,938	6,359	-	107,176
Canal	-	-	-	-	-	12,806	38,419	12,807	64,032
Overhead, Profit and Taxes	-	-	-	1,719	7,590	6,560	6,152	1,760	23,781
Sub-total (1)	-	-	-	14,233	62,827	54,304	50,930	14,567	196,861
On-farm and Village Pond	-	-	-	-	-	-	7,242	2,414	9,656
O & M Equipment	-	-	-	-	-	-	648	647	1,295
Land Acquisition	-	-	-	-	-	1,953	-	-	1,953
Survey and Investigation	1,534	1,534	-	-	-	-	-	-	3,068
Administration	260	260	519	1,038	1,038	1,038	779	260	5,192
Consulting Services	-	1,320	1,582	501	1,301	1,372	1,283	565	7,924
Sub-total (2)	1,794	3,114	2,101	1,539	2,339	4,363	9,952	3,886	29,088
Base Cost (1 + 2)	1,794	3,114	2,101	15,772	65,166	58,667	60,882	18,453	225,949
Physical Contingencies	180	312	210	1,577	6,516	5,867	6,088	1,845	22,595
Price Contingencies	54	146	136	1,820	8,037	11,096	13,025	4,535	38,849
Project Cost	2,028	3,572	2,447	19,169	79,719	75,630	79,995	24,833	287,393

TABLE 8-8. CONSULTING COST ESTIMATE (DETAIL DESIGN)

(unit: yen)

1. Foreign Currency Portion	
(1) Remuneration	
- Foreign Consultants - 35 M/M	77,000,000
- Local Consultants - 50 M/M	33,600,000
(2) Allowance for Foreign Personnel	5,880,000
(3) Out-of-Pocket Expense	3,180,000
(4) Unallocated Contingencies	5,940,000
Total (1)	125,600,000
(Baht Equivalent:	22,429,000)

2. Local Currency Portion	(Baht)
(1) Allowance for Local Personnel	105,000
(2) Local Communication	300,000
(3) Local Transportation	628,000
(4) Salaries for Supporting Staff	330,000
(5) Costs for Printing	300,000
(6) Unallocated Contingencies	81,000
Total (2)	1,744,000
Total (1+2)	฿24,173,000

Note: Exchange rate of ฿1.00 = ¥5.6

TABLE 8-9. CONSULTING COST ESTIMATE (SUPERVISION)

(unit: yen)

1. Foreign Currency Portion	
(1) Remuneration	
- Foreign Consultants - 50 m/m	110,000,000
- Local Consultants - 100 M/M	67,200,000
(2) Allowance for Foreign Personnel	8,400,000
(3) Out-of Pocket Expenses	6,760,000
(4) Unallocated Contingencies	9,400,000
Total (1)	201,800,000
(Baht Equivalent:	36,036,000)
2. Local Currency Portion	
(1) Allowance for Local Personnel	2,100,000
(2) Local Communication	960,000
(3) Local Transportation	476,000
(4) Salaries for Supporting Staff	1,056,000
(5) Costs for Printing	960,000
(6) Unallocated Contingencies	275,000
Total (2)	5,827,000
Total (1+2)	฿41,863,000

Note: Exchange rate of ฿1.00 = ¥5.6

CHAPTER IX. PROJECT EVALUATION

CHAPTER IX. PROJECT EVALUATION

9-1. Comparison of Project Cost and Benefits

9-1-1. Project Cost

The project cost consists of capital cost and operation and maintenance cost. Tax for transfer payment was deducted form the financial project cost. And the deducted financial project cost was converted to the economic project cost by multiplying by 0.88 of the conversion factor for construction.

The total capital cost excluding price contingencies during the construction period of five projects is estimated at 1,316 million Baht (171,600 Baht/ha, 27,500Baht/rai) on a financial base, which is equivalent to 870 million Baht (113,400 Baht /ha, 18,200 Baht/rai) on an economic base. Like the capital cost, the proposed operation and maintenance cost per year reaches 9.68 million Baht (1,262 Baht/ha, 202Baht/rai) on the financial base and 6.66 million Baht (Baht 867/ha, 139Baht /rai) on the economic base.

On the assumption that the project will be started in 1990, the disbursement of project cost is tabulated in Table 9-1.

9-1-2. Project Benefits

From the national economic point of view, directly and indirectly associated benefits will be created from the project. Direct benefits will be derived from irrigation, fisheries and water supply for domestic and cattle watering use, of which benefits of irrigation and fisheries were monetarily evaluated in order to compare the benefits attributable to the project with the investment costs for whole duration of the project. Benefits from the water supply were not accounted in monetary terms for the economic evaluation of the project as the benefits were expected to be negligible. The direct benefits of the project are the increase in final production attributable to the works carried out, i.e. gross production less intermediate consumption of goods and services, all evaluated in terms of opportunity cost. Table 9-2 presents the project benefits from crop and fisheries.

(1) Irrigation and Fisheries Benefits

Irrigation benefits are the increase in the net income from crop production resulting from the application of irrigation water and reduction in damages from drought. Crop benefits will be derived from paddy production for