5.2.3. Preliminary Design

(1) General Features of the area and Other Considerations

General features that characterize the Study Area and items to be considered to propose the most suitable irrigation systems are as follows:

- Since storage dams are proposed at an elevated location in rather steep mountainous area, high energy heads are available.
- Topography of beneficial area is complicated and undulated.
- Final destinations of water transmitted are the river channel and farmponds, which lie scattered over the beneficial area.
- About 3,600 ha of farmland are planned to be converted into orchard which may require construction of terminal end irrigation systems with farmponds, small pumping facilities and distribution pipeline systems.
- Proposed irrigation systems are to be technically possible and economically feasible.
- Operation and maintenance of the systems are also to be easy and stable.

(2) Design Standard and Other Necessary Considerations

1) Hydraulic Design of Main Conveyance Systems

a) Hazen-Williams Formula was used to calculate friction loss head of pipeline, with discharge coefficients as shown below:

| Pipe | Discharge Coefficient |
|---|---|
| Steel | 130 |
| Prestressed Concrete | 130 |
| Asbestos Cement | 140 |

b) Taking into account over-loaded and unusual internal pressure and friction mainly due to operation of valves, design velocities of pipe were taken within the following range, as a standard:

| Pipe Diameter (mm) | Design Velocity (m/sec) |
|---|---|
| 75 - 150 | 0.7 - 1.0 |
| 200 - 400 | 0.9 - 1.6 |
| 450 - 800 | 1.2 - 1.8 |
| 900 - 1,600 | 1.3 - 2.0 |

c) In consideration of energy head available at the supply and the required head at the terminal point of pipeline, dynamic hydraulic gradient was taken in a range from 1/1,000 to 2/1,000.

d) The 3% of energy loss, as bend and conversion losses, were added to the total friction losses.

2) Structure Design of Main Conveyance System

a) The pipe trench should be excavated deeply enough so that from 0.60 to 1.00 m of cover can be placed over the pipe to protect it from traffic crossing and soil and other loadings. Standards are given as follows:

- Diameter less than 150 mm : Soil cover = 0.6 m
- Diameter greater than 200 mm: Soil cover = 1.0 m

b) The pipe should be uniformly supported over its entire length on firm stable materials in the trench. Sand bed method of 120 degree type with the following thickness is applied:

| Pipe Diameter (mm) | Thickness (cm) |
|---|---|
| 200 - 450 | 15 |
| 500 - 900 | 20 |
| 1,000 - 1,600 | 30 |

c) Either 40% of static pressure or 3.5 kg/sq.cm is added to the design pressure, as water hammer pressure. Nominal test pressure of the pipe manufactured in Thailand is considered to correspond to the following design pressure.

| Pipe | Test Pressure | Design Pressure |
|---|---|---|
| RC Pipe | 15 kg/sq.cm | 7.5 kg/sq.cm |
| AC Pipe | 15 -do- | 10.0 -do- |

d) Water pressure in the pipe of large diameters, i.e. 1,350 to 1,600 mm, usually varies with a wide range. Two types of the pipe, with thick or standard thickness rated by the 8.5 kg/sq.cm of design pressure, were applied. For smaller or medium diameters, the pipe of standard thickness was always adopted.

3) Selection of Pipe Material

Characteristics of pressure pipes which can be procured in Thailand are summarized as follows:

PVC Pipe

This pipe is characterized by the ready availability, easy handling of light-weight and smooth internal surface. The PVC pipe is supplied with sleeve joints or jointed with rubber gaskets, and is easy for installation. PVC sections are readily available in diameters from 13 to 150 mm.

Asbestos Cement Pressure Pipe

AC pipe is durable and joints are waterproof. AC pipe is suitable for pipeline of relatively high pressure, however, strength is smaller than steel pipes. Sections are readily available for a test pressure of 15 kg/sq.cm in diameters from 100 to 600 mm.

Prestressed Concrete Pipe

PC pipe is durable, but is heavy and suitable for the pipeline of low pressure since reliability of joints is much inferior than those for the other pipes. Diameters from 400 to 1,500 mm are easily available.

Steel Pipe

SP is non-erosive with perfect paint-coated, durable, light-weighted, flexible and strong against a shock.

Joints are welded at the sites and are as much durable as the pipe itself, if welding works are made perfect. SP is suitable for a high pressure water line.

In consideration of pipe characteristics and economy as well, the following pipe materials are selected for use:

| Pipe | Diameter | Remark |
|---|---|---|
| PVC | less than 150 mm | for static pressure<6.5 kg/sq.cm |
| AC | 200 - 600 mm | for static pressure<6.5 kg/sq.cm |
| PC | 700 mm | for static pressure<3 kg/sq.cm |
| SP | 700 - 1,600 mm | for static pressure>3 kg/sq.cm |

4) Diversion Dam

Site Condition:
- River width : 30 m
- Design flood discharge : 315 cu.m/sec
- Geology of river-bed : Granite

Weir Dimension:
- Type of weir : movable weir (roller gate)
- Crest length : 15.0 m x 2 gates
- Crest height : 2.50 m (shell type steel gate)
- Intake water level: W.L.136.00 m
- Intake discharge : 3.500 cu.m/sec (maximum)

5) Regulating Reservoir

Three units of the regulating reservoir of retaining wall type, which is made of reinforced concrete are planned to be installed. Dimensions given are 50 m of length, 50 m of width and 3.5 m of depth of which 2.5 m are effective. Inflow and excess water into and from the reservoir are controlled, respectively, by the submerged disk valve and a spillway. The storage capacity per 1 unit of regulating reservoir is calculated as 6,250 cu.m. The regulating capacity is thus evaluated as;

6,250 cu.m ÷ 2.531 cu.m/sec to 6,250 cu.m ÷ 1.385 cu.m/sec
= 0.7 to 1.3 hr.

6) Other Pumping Facilities

Three units of pumping facility are also planned to be installed to irrigate the areas, which are not covered by the main conveyance pipeline systems.

| Pump Station | Irrigation Block | Water Source | Irrigation Area (ha) | Discharge (cu.m/s) |
|---|---|---|---|---|
| No.1 | 6 | Chanthaburi river | 469.1 | 0.141 |
| No.2 | 11 | -do- | 617.4 | 0.192 |
| No.3 | 21-23 | -do- | 302.8 | 0.091 |

- Number of pumps are planned to be 2 units of equal discharge, with 1 spare unit for each pumping station.
- The 30-minutes peak discharge was taken as the capacity of the discharge pool, as a standard.
- Pump dimensions are as follows:

| Dimension | St.No.1 | St.No.2 | St.No.3 |
|---|---|---|---|
| Design discharge per pump (cu.m/min) | 4.23 | 5.76 | 2.73 |
| Conduction line: length (m) | 2,300 | 4,500 | 2,500 |
| diameter (mm) | 300 | 350 | 250 |
| gradient/1,000 m | 10.2 | 10.1 | 10.3 |
| Lifting head : real head (m) | 45.0 | 50.0 | 45.0 |
| total head(m) | 68.5 | 95.5 | 70.8 |
| Pump suction diameter (mm) | 200 | 250 | 150 |
| Motor output (kw) | 110 | 210 | 75 |

(2) Comparative Study on Possible Alternatives

The following three possible alternative plans were compared for the main conveyance systems of irrigation water.

Alternative Plan-1

- Using most efficiently the energy head usable between the proposed site of the Khlong Ta Liu dam (No.4 site, LWL = 160 m above MSL) and the beneficial area (30 to 100 m), most of water are conveyed to about 11,500 ha of the proposed orchard area by gravity pipeline systems. The main pipeline is installed along the hilly side of the project boundary crossing the Chanthaburi river in order to transmit waters to the right bank of river. The system comprises three regulating reservoirs, water diversion valves/gates and necessary appurtenant structures between intake facility of the storage dam and terminal point of respective pipeline systems. Schematic diagram of water conduction is given in Figure 5-1.

- Effective water heads required in the service area are as follows:

| Area and Zone | Head Required |
|---|---|
| Left bank of Upper zone | 90 to 100 m, MSL |
| Right bank of Upper zone | around 80 m |
| Left bank of Middle Right zone | around 50 m |
| Lower part of Middle Right zone | around 50 m |

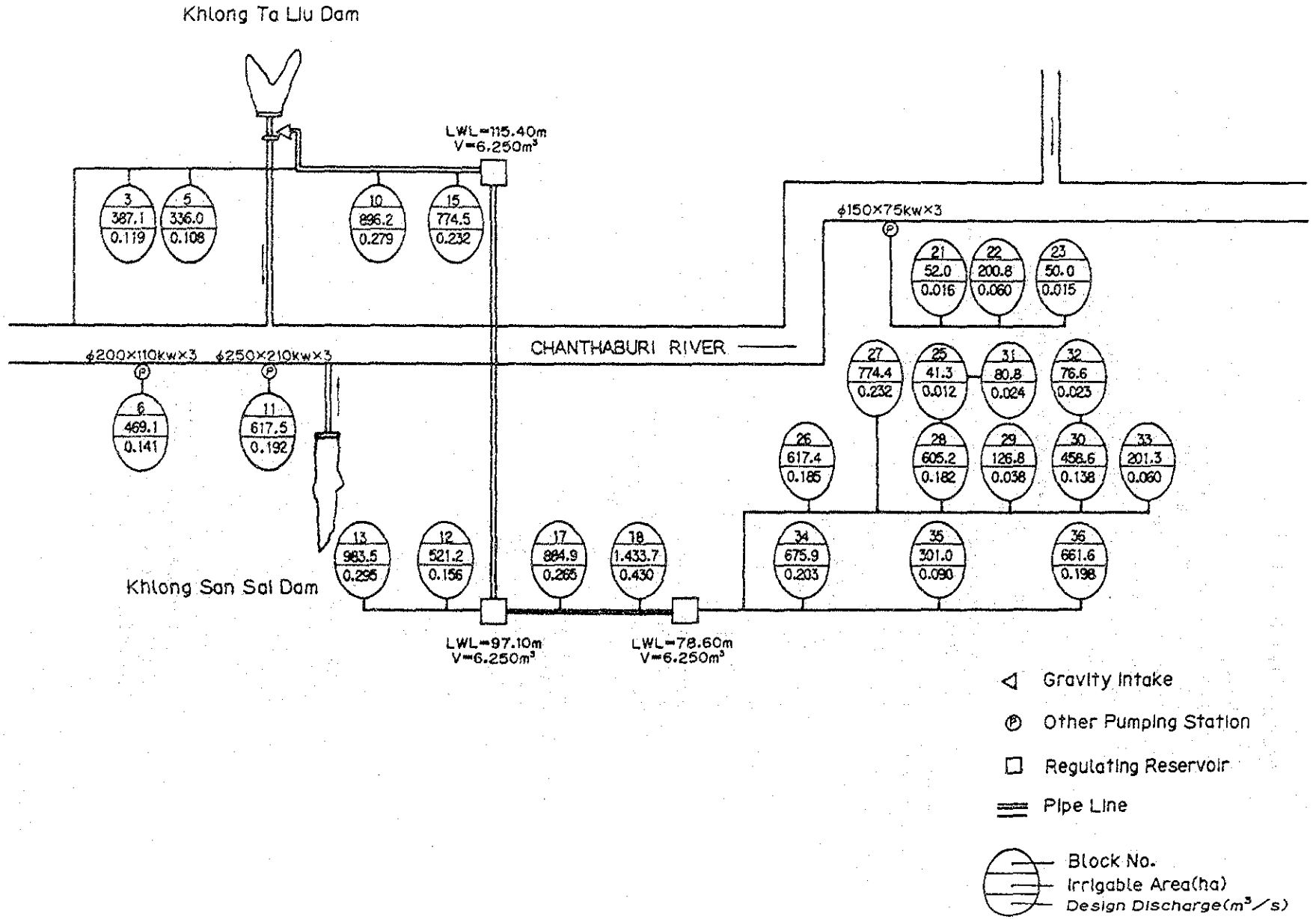
- Being inconveniently located to be irrigated by the main pipeline systems, the right bank of Upper zone and low-lying plain situated along Chanthaburi river near Khao Chok Lao are planned to be irrigated by pumping systems.

- About 70% of irrigable area to be supplied from proposed Khlong Ta Liu dam are situated on the right bank of Chanthaburi river. Taking into account the suitable alignment of pipeline to transmit water across the river and advantage of reducing design pressure, open-type pipeline system is applied for the main conduction line with regulating reservoirs installed at about 10 km interval.

- The upper conduction line is routed at high elevations with about 80% of commandable rate of service area against total area for irrigation, while the alignment of lower line is determined at locations so that waters are supplied to upstream part of khlongs and streams, along which most of existing farmponds are situated.

- Taking easiness and convenience for construction and operation and maintenance into consideration, the first priority was given to the route of existing road in determination of alignment.

FIGURE 5-1 Schematic Diagram of Water Conduction (Alternative Plan-1)



- From the hydraulic calculations given in Appendix-H, available effective water levels along the main conveyance systems are as follows:

| Point | LWL (El.m) | NWL (El.m) |
|---|---|---|
| Diversion Dam | | |
| - Intake water level | | 136.0 |
| - Entrance to pipeline | 133.0 | 135.5 |
| Regulating reservoir-1 | 115.4 | 117.9 |
| Regulating reservoir-2 | 97.1 | 99.6 |
| Regulating reservoir-3 | 78.6 | 81.1 |

Alternative Plan-2

- Taking into account geographical and topographical features of the service area, easiness and safety from operational point of view as well as economical advantage of initial investment, in total five main pumping stations are planned to be constructed along the main course of Chanthaburi river, through which water is diverted and conveyed to the beneficial area of about 2,000 ha as a standard. Schematic flow diagram is shown in Figure 5-2.

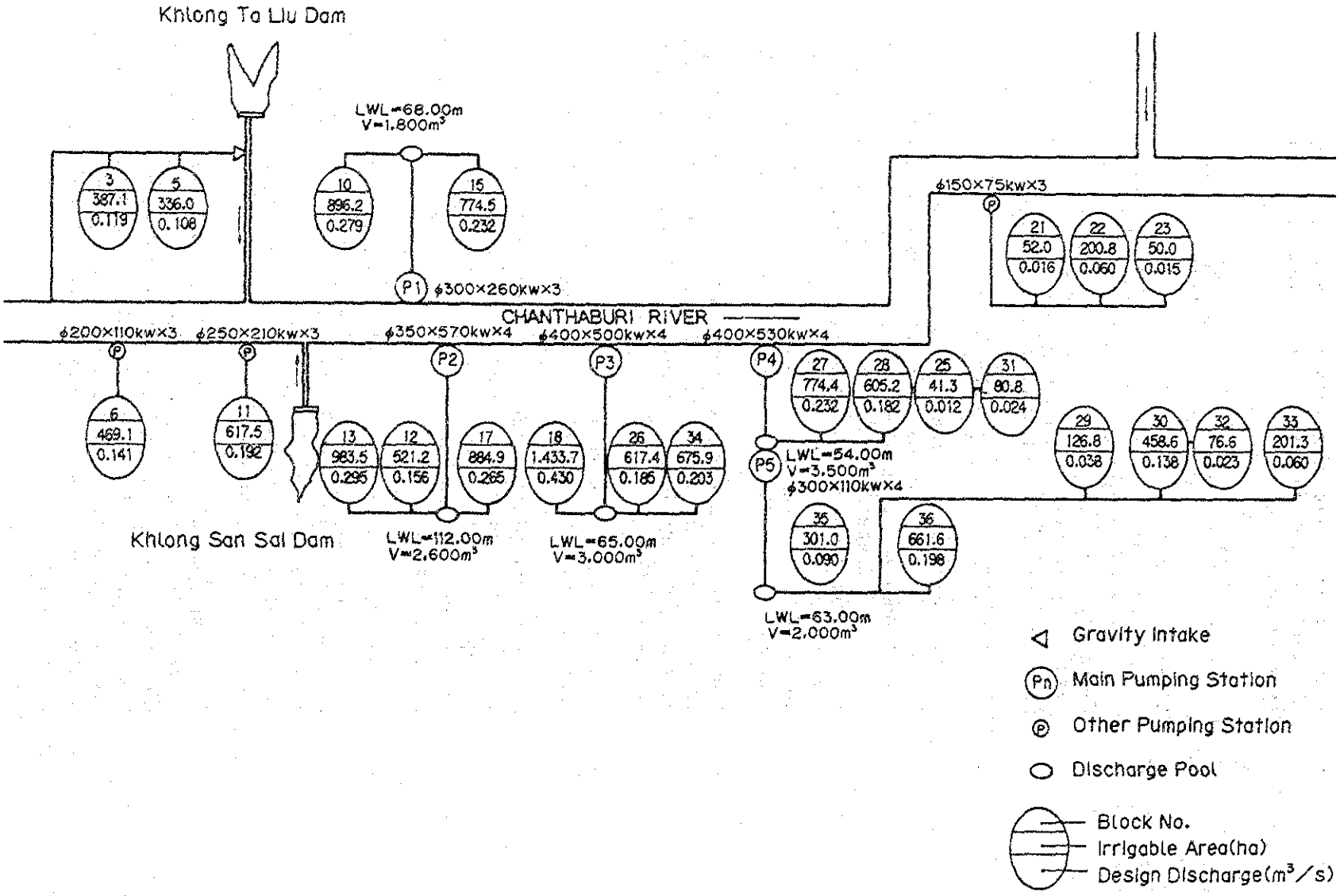
- About 3,300 ha of service area situated in the lower part of the Middle Right zone are divided into two portions, namely upper and lower, each having a pumping station of two-step lifting systems.

- Being separated from the above main pumping systems, three units of relatively small scale pumping facilities are also installed to cover the Right Bank of the Upper zone and low-lying plain located along the Chanthaburi river in the Middle Right zone. In addition, the left bank area in the Upper zone was planned to be irrigated directly with waters from the proposed Khlong Ta Liu dam through gravity pipeline systems.

- In principle pumps are operated 24 hours continuously. Considering advantages in operation and maintenance works and security reason, pumps are divided into three units of equal discharge with one spare unit. In case that the service area is less than 1,000 ha, two units of pump with one spare are installed.

- Discharge pool of a capacity of one hour peak discharge is installed at the outlet of conduction line connected to the pumping station. Same standard and criteria used for the alternative plan-1 were applied correspondingly for design of conveyance and distribution systems downstream of the discharge pool. Hydraulic calculations are given in Appendix-H.

FIGURE 5-2 Schematic Diagram of Water Conduction (Alternative Plan-2)



- Major pump dimensions are as under:

| Station | Total Head (m) | Discharge (cu.m/min.) | Pump Diameter (mm) | Motor Output (kw) |
|---|---|---|---|---|
| No.1 | 67.6 | 10.22 | 300 | 260 |
| No.2 | 106.0 | 14.32 | 350 | 570 |
| No.3 | 80.9 | 16.36 | 400 | 500 |
| No.4 | 71.3 | 19.70 | 400 | 530 |
| No.5 | 26.8 | 10.94 | 300 | 110 |

Alternative Plan-3

- Alternative plan 1 and 2 are combined to propose the Alternative Plan-3. Schematic flow diagram is as per Figure 5-3.

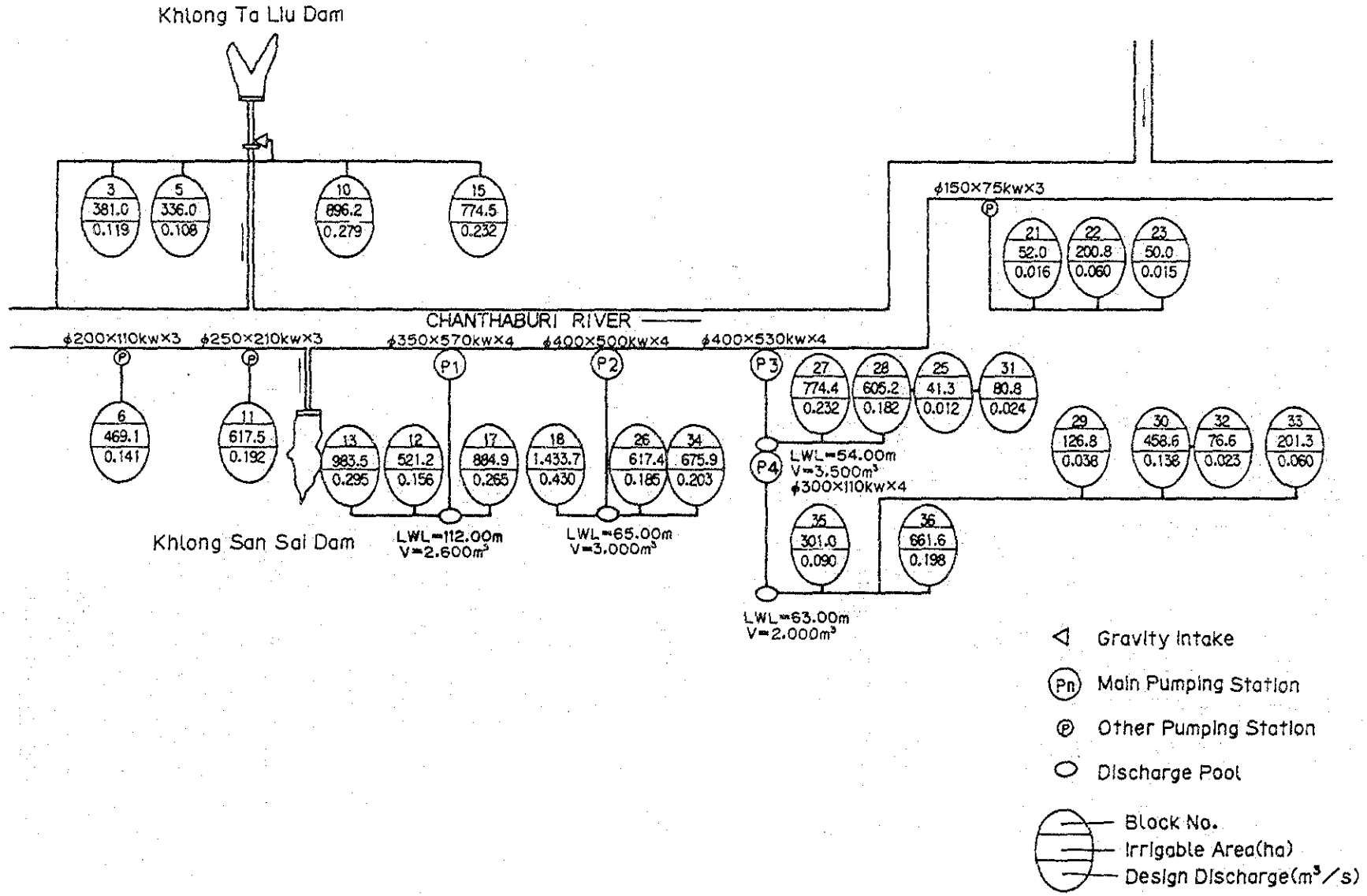
For comparative purposes, initial cost for construction and operation and maintenance costs are preliminarily estimated as under:

Cost Comparison

(unit: million Bahts)

| | Possible Alternative | | |
|---|---|---|---|
| 1. Construction Cost | Plan-1 | Plan-2 | Plan-3 |
| - Storage Dam | 665.0 | 665.0 | 665.0 |
| - Diversion Dam | 16.5 | 4.5 | 8.8 |
| - Regulating Barrage | - | 30.4 | 23.4 |
| - Main Conveyance Pipeline | 559.6 | 251.7 | 260.9 |
| - Main Pumping Station | - | 210.0 | 174.0 |
| - Regulating Reservoir | 11.6 | 32.4 | 27.9 |
| - Other Pumping Station | 102.9 | 102.9 | 102.9 |
| - Lateral/Sub-lateral Pipeline | 86.6 | 86.6 | 86.6 |
| - Connection Pipeline | 39.7 | 39.7 | 39.7 |
| - Terminal End Facilities | 329.4 | 329.4 | 329.4 |
| Total | 1,811.3 | 1,752.6 | 1,718.6 |
| (Rate) | (100.0) | (96.8) | (94.9) |
| 2. Operation and Maintenance Cost (for 45 years) | | | |
| - Personnel Expenses | 31.3 | 85.4 | 74.8 |
| - Electricity | 72.7 | 603.4 | 530.6 |
| - Maintenance Cost | 44.8 | 139.2 | 123.2 |
| - Replacement Cost | 144.0 | 438.0 | 387.6 |
| Total | 292.8 | 1,266.0 | 1,116.2 |
| (Rate) | (100.0) | (432.3) | (381.2) |
| 3. Overall Evaluation | | | |
| Present Worth | 1,192.5 | 1,229.1 | 1,196.8 |
| (ratio) | (1.000) | (1.031) | (1.004) |

FIGURE 5-3 Schematic Diagram of Water Conduction (Alternative Plan-3)



The project facilities as itemized in the above table are classified into two parts; namely, key facility and terminal facility. The key facility to serve up to about 200 ha of irrigation commandable area includes the storage dams, diversion dam, regulating barrage, main conveyance pipelines and main pumping stations, and the remainder is classified as terminal facility. It should be noted here that the project study recommends the Government to construct the key facilities while the beneficial farmers are expected to be responsible for installation of the terminal facilities, as mentioned in Chapter 8.

Evaluation for the possible alternatives from technical point of view and also from viewpoint of operation & maintenance of the proposed system is summarized as follows.

Alternative Plan-1

- Waters are conveyed mainly by gravity system. All facilities are systematically connected with regulating reservoirs of open-type and so operations are expected to be easy and stable.
- Areas to be irrigated by pumping systems are relatively of small scale, resulting in less difficulty in water management.
- Since main pipeline is extended long, suspension of water supply for a relatively long period may occur in case of accident, despite that some of these emergencies may be covered by the function of the regulating reservoirs.

Alternative Plan-2

- Since the areas are irrigated independently by the corresponding main pumping facilities, risks of cutting off the water supply are also dispersed as compared with the Alternative Plan-1.
- An administrator is to be maintained at each pumping station.
- Pump operation is to be controlled so that water level in the river channel be kept within a certain acceptable range and discharge released downstream be assured, and is relatively complicated and difficult.
- Suspension of water supply may occur in case of accident and power stoppage.

Alternative Plan-3

- The plan takes technically a middle position between Alternative Plans 1 and 2, in more close connection with the Plan-2.

From economic point of view, present worth values of construction and operation/Maintenance costs after discounting are summarized as follows:

(unit: million Bahts)

| Item | Plan-1 Amount(Rate) | Plan-2 Amount(Rate) | Plan-3 Amount(Rate) |
|---|---|---|---|
| Construction Cost | 1,811.3(100) | 1,752.6( 97) | 1,718.6( 95) |
| Operation/Maintenance Cost | 292.8(100) | 1,266.0(432) | 1,116.2(381) |
| Present Worth Value | 1,192.5(100) | 1,229.1(103) | 1,196.8(100) |

As an overall evaluation, no significant difference is resulted from the economic evaluation, however, the Alternative Plan-1 is superior in operation and maintenance of the systems as well as in economic advantage of the beneficial farmers, as compared with other plans. Judging from technical aspect mainly of water management, gravity flow type is safety and easy in operating the systems with no difficulty in diverting river water, where complicated rule of operation may be required. Accordingly, the Alternative Plan-1 mainly composed of gravity systems is recommendable for the subject Feasibility Study. A plan of major irrigation facilities is given in the opening page of this report. Table 5-2 and Figure 5-4 summarise the facilities required by the Project.

## 5.3. On-Farm Distribution Systems

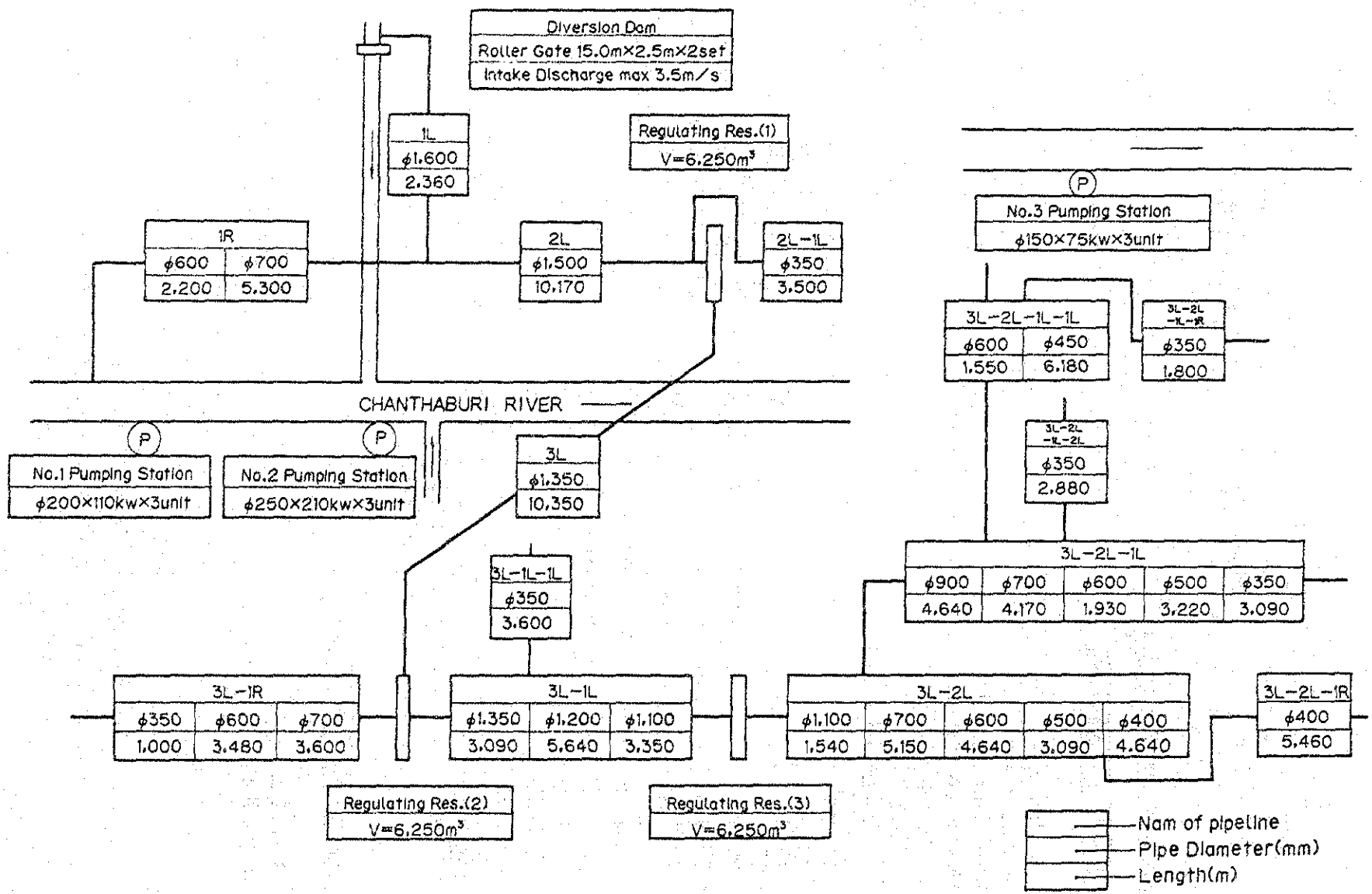
### 5.3.1. General Concept

From the sample area survey regarding the irrigation practice and facilities of on-farm level, the followings were clarified:

TABLE 5-2 Main Irrigation Facility

| Sub-project and Facilities | Quantity | Specification |
|---|---|---|
| **Klong Ta Liu Sub-Project** | | |
| 1. Storage Dam | 1 | Storage Capacity = 35.85 MCM. |
| 2. Diversion Dam | 1 | Maximum Discharge=3.5cu.m/sec |
| 3. Regulating Reservoir | 3 | Total Volume = 18,750 cu.m |
| 4. Pumping Station | 2 | |
| 4.1 No.1 P.S. | 1 | $\phi$200mm x 110kw x 3units |
| 4.2 No.2 P.S. | 1 | $\phi$250mm x 210kw x 3units |
| 5. Main Conveyance Pipeline | | |
| - 1L | 2,360m | $\phi$2,360 mm |
| - 2L | 10,170 | $\phi$1,500 mm |
| - 2L-1L | 3,500 | $\phi$ 350 mm |
| - 3L | 10,350 | $\phi$1,350 mm |
| - 3L-1R | 8,080 | $\phi$ 700 mm ~ 350 mm |
| - 3L-1L | 12,080 | $\phi$1,350 mm ~ 1,100 mm |
| - 3L-1L-1L | 3,600 | $\phi$ 350 mm |
| - 3L-2L | 19,060 | $\phi$1,100 mm ~ 400 mm |
| - 3L-2L-1R | 5,460 | $\phi$ 400 mm |
| - 3L-2L-1L | 17,050 | $\phi$ 900 mm ~ 350 mm |
| - 3L-2L-1L-1L | 7,730 | $\phi$ 600 mm ~ 450 mm |
| - 3L-2L-1L-1R | 1,800 | $\phi$ 350 mm |
| - 3L-2L-1L-2L | 2,880 | $\phi$ 350 mm |
| - 1R | 7,500 | $\phi$ 700 mm ~ 600 mm |
| Total | 111,620 | |
| **Klong San Sai Sub-Project** | | |
| 1. Storage Dam | 1 | Storage Capacity = 10.55 MCM. |
| 2. Pumping Station (No.3 P.S.) | 1 | $\phi$150mm x 75kw x 3units |

FIGURE 5-4 Summary of Main Conveyance Pipeline Systems



- In the area irrigated directly by river water, pumping facility of small scale is installed to irrigate every farm lots.

- Such areas are situated long and narrow along the river course with a width of about 470 m in average.

- For the area irrigated by pond water, one to six farmponds of various size are excavated in every orchard at the lowest location. Accordingly ponds are mainly situated along small streams. Some ponds are installed on river bed while almost are situated nearby the stream but independent.

- Starting from full storage at the end of wet season, pond storage usually decreases with some recovery caused by inflow due to seepage or underground during the irrigation season. Such recovery also decreases as the time passes, and consequently about twice as much volume of water as the pond capacity are normally utilized for irrigation.

- From the hydrological study of pond water balance simulation, it was proved that such pond inflows were included, as a component, in runoff caused by rainfall.

- Small scale pumping facilities and distribution pipeline systems connected to farmponds are already installed to irrigate orchard.

From the above considerations, it is essential to ensure sufficient amount of water in the river channel to meet irrigation requirement for the area receiving river water. For the area irrigating pond water on the contrary, it is the most important and effective to supply waters directly into the pond. Distribution of such farmponds in the area are estimated at 920 cu.m/ha of average farmpond capacity, and according to water balance simulation of the basin, more than 60% of the total water demand required throughout irrigation season are being provided from the storage in the existing farmponds, meaning that the remainder should be supplied from the proposed storage reservoirs to be constructed upstream of the river basin, and that waters are to be conveyed and distributed through main, lateral and sub-lateral pipeline systems to, at least, the terminal point of farmpond.

### 5.3.2. On-Farm Distribution Systems

#### (1) Comparative Study on Possible Alternatives

In order to determine the most suitable type of on-farm distribution systems between the outlet gate/valve of main conveyance pipeline up to the terminal point of supply (i.e. farmponds), two alternative plans were prepared on the sample survey area-2 and compared to recommend technically and economically acceptable facility plan.

Alternative-A

This is the complete plan with waters supplied from diversion gate or valve installed along the main or lateral pipeline and distributed through sub-lateral pipeline of common use to both the existing farmpond and newly developed area. A plan is shown in Figure 5-5.

Alternative-B

This is the incomplete plan with water supplied from the diversion point to the existing farmpond through existing small stream or ditch, and supplied to the newly developed area through sub-lateral or connection pipeline to be constructed along the elevated portion of irrigable area. A plan is shown in Figure 5-6.

Preliminary cost comparison is given as follows:

(unit: Baht/ha)

| Pipeline | Alternative-A | Alternative-B |
|---|---|---|
| Lateral (dia.250-300mm) | 2,620 | 3,850 |
| Sub-lateral (dia.75-150 mm) | 6,150 | 4,500 |
| Connection (dia.50mm) | 6,410 | 610 |
| Total | 15,180 | 8,960 |
| (ratio) | (100) | (0.59) |

FIGURE 5-5 Irrigation Distribution System (Alternative Plan -A)

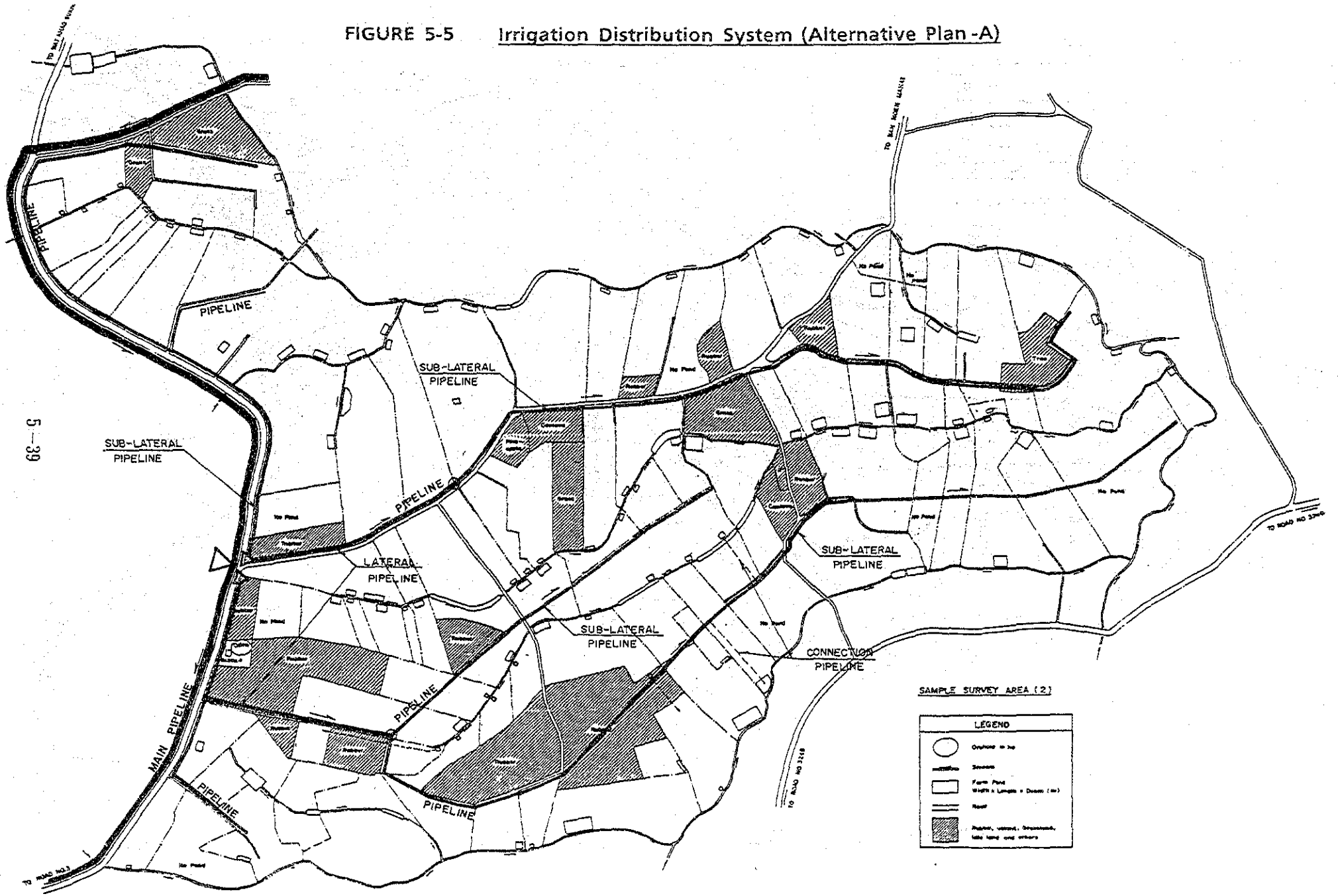
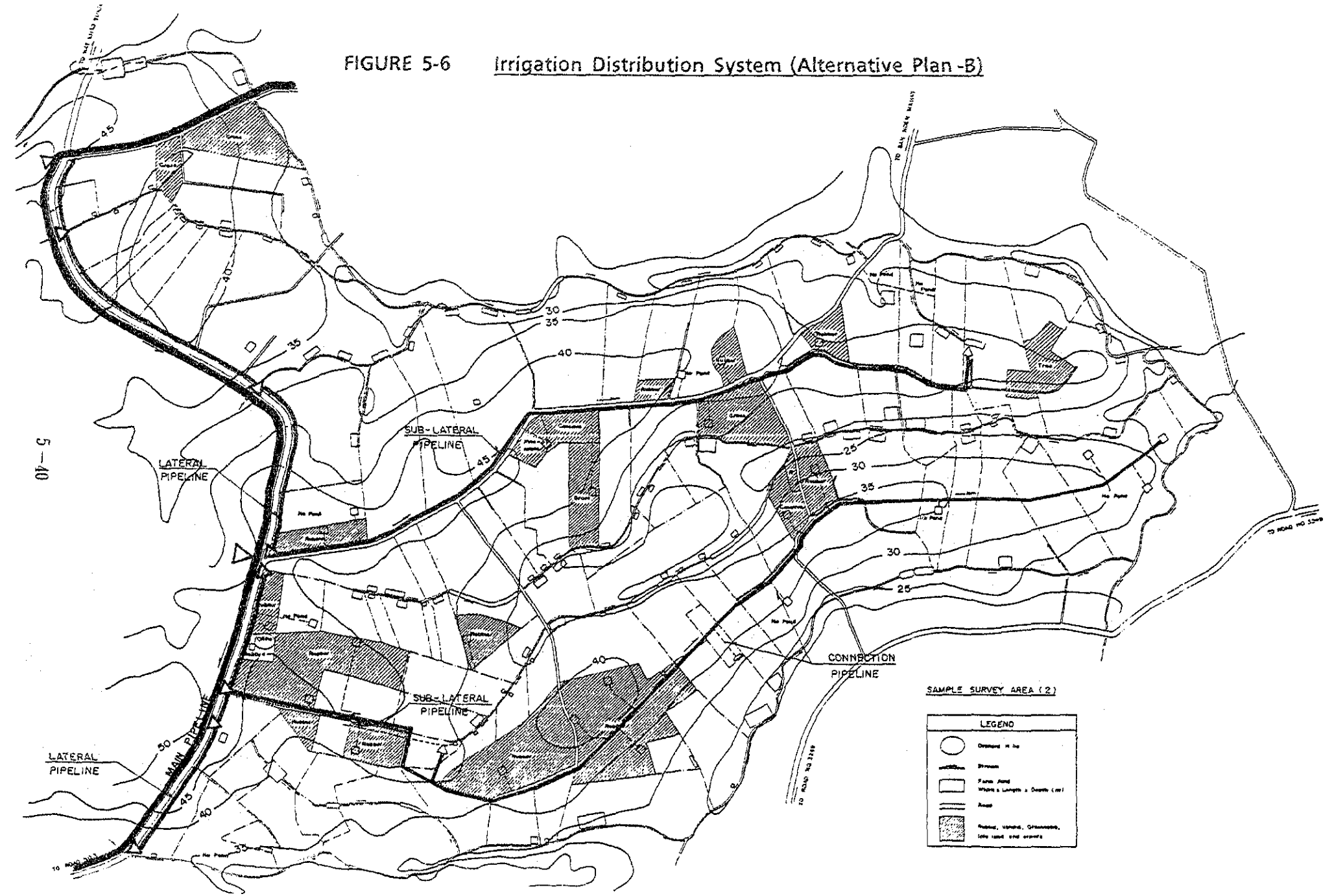


FIGURE 5-6 Irrigation Distribution System (Alternative Plan -B)



Technical and economic evaluations are then summarized as follows:

Alternative-A

Waters released from upper systems (main pipeline or pumping plants) can be transmitted most efficiently with this system and well managed water delivery can also be expected. On the other hand, construction cost is rather high as compared with the Alternative-B.

Alternative-B

Construction cost of the system is lower than that for Alternative-A, since the plan is not quite complete especially for the existing orchard. Even so however, newly developed area, to which distribution pipeline systems are provided along the higher location, can enjoy stable irrigation similar to the Alternative-A. On the other hand, water intake from the existing stream or ditch to each pond may be comparatively inconvenient due to lack of connecting facilities.

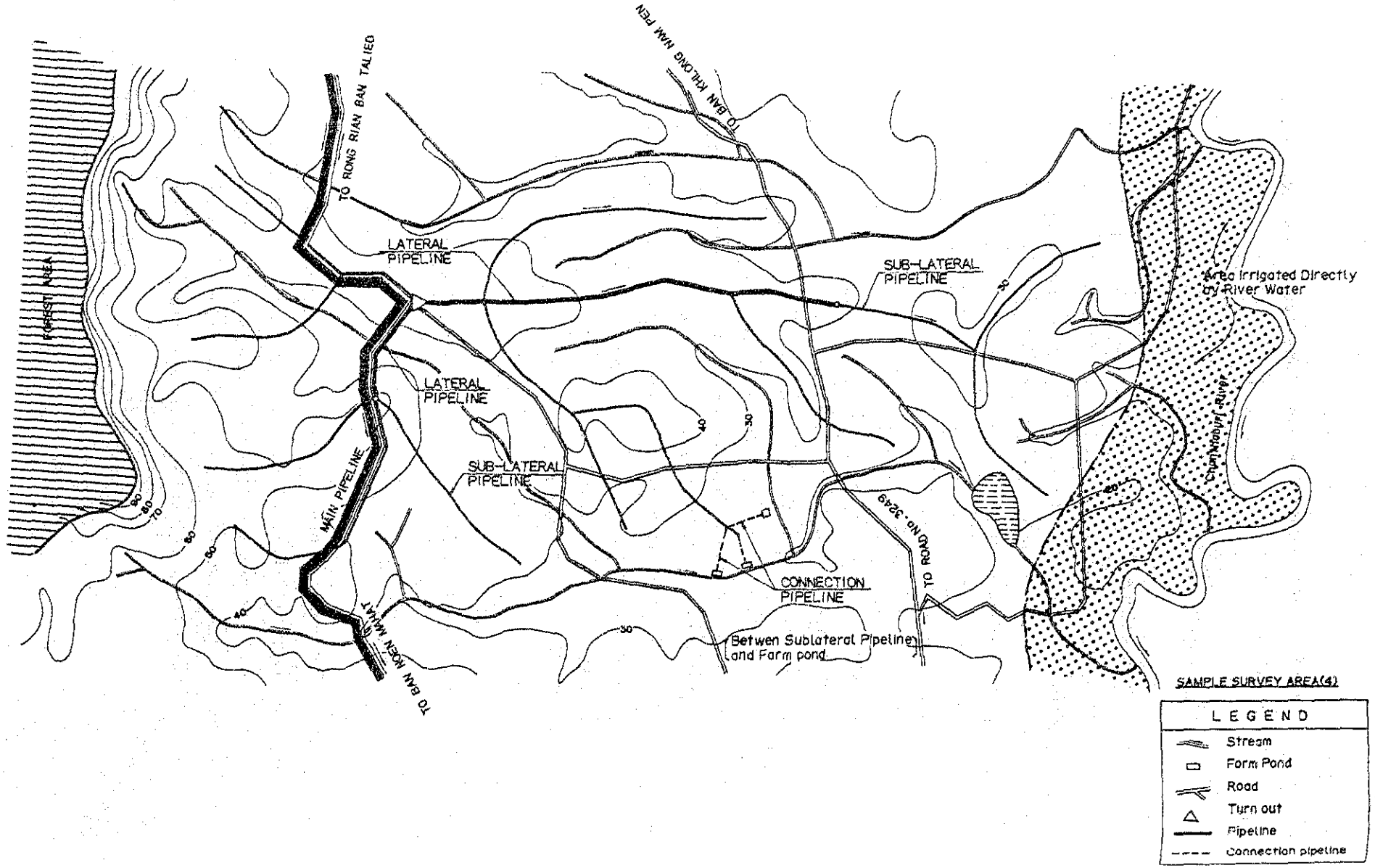
As the result of comparative study, the Alternative Plan-A is recommendable from technical and operational points of view.

(2) Sample Design of On-Farm Distribution Systems

1) Lateral/Sub-Lateral Pipeline

The sample survey area-2, as discussed previously in Chapter 3.4.2, and additional sample area-4 selected on 1/10,000 scale topo-map as shown in Figure 5-7 were used to make sample design of lateral/sub-lateral pipeline systems up to on-farm distribution facilities.

FIGURE 5-7 Plan of Sample Area -4



Lateral/Sub-lateral Pipeline

| Item | Sample Area-2 (m/ha) | Sample Area-2 (Baht/ha) | Sample Area-4 (m/ha) | Sample Area-4 (Baht/ha) |
|---|---|---|---|---|
| Irrigable Area (ha) | 374 | | 520 | |
| Lateral Pipeline (dia.250-350mm) | 4.5 | 2,620 | 5.2 | 3,150 |
| Sub-lateral Pipe (dia. 75-200mm) | 24.9 | 6,150 | 26.2 | 4,150 |
| Total | | 8,770 | | 7,300 |
| Average | | | 8,030 | |

2) Connection Pipe

One to several farmponds are owned by an orchard farmer in the area. The Project envisages to supply water to one of these farmponds. Connection pipe to link lateral/sub-lateral pipeline with farmpond is estimated from results of investigation made in sample survey areas-2 and 3, as follows:

| Item | Sample Area-2 | Sample Area-3 | Total |
|---|---|---|---|
| Nos. of Farmers | 93 | 45 | 138 |
| Irrigated Orchard (ha) | 342.1 | 289.3 | 631.4 |
| Density of Farmpond to be Supplied (Pond/ha) | | | 0.22 |
| Connection Pipe: 250m/pond = 250 x 0.22 = 55m/ha | | | |

5.3.3. Terminal End Facilities

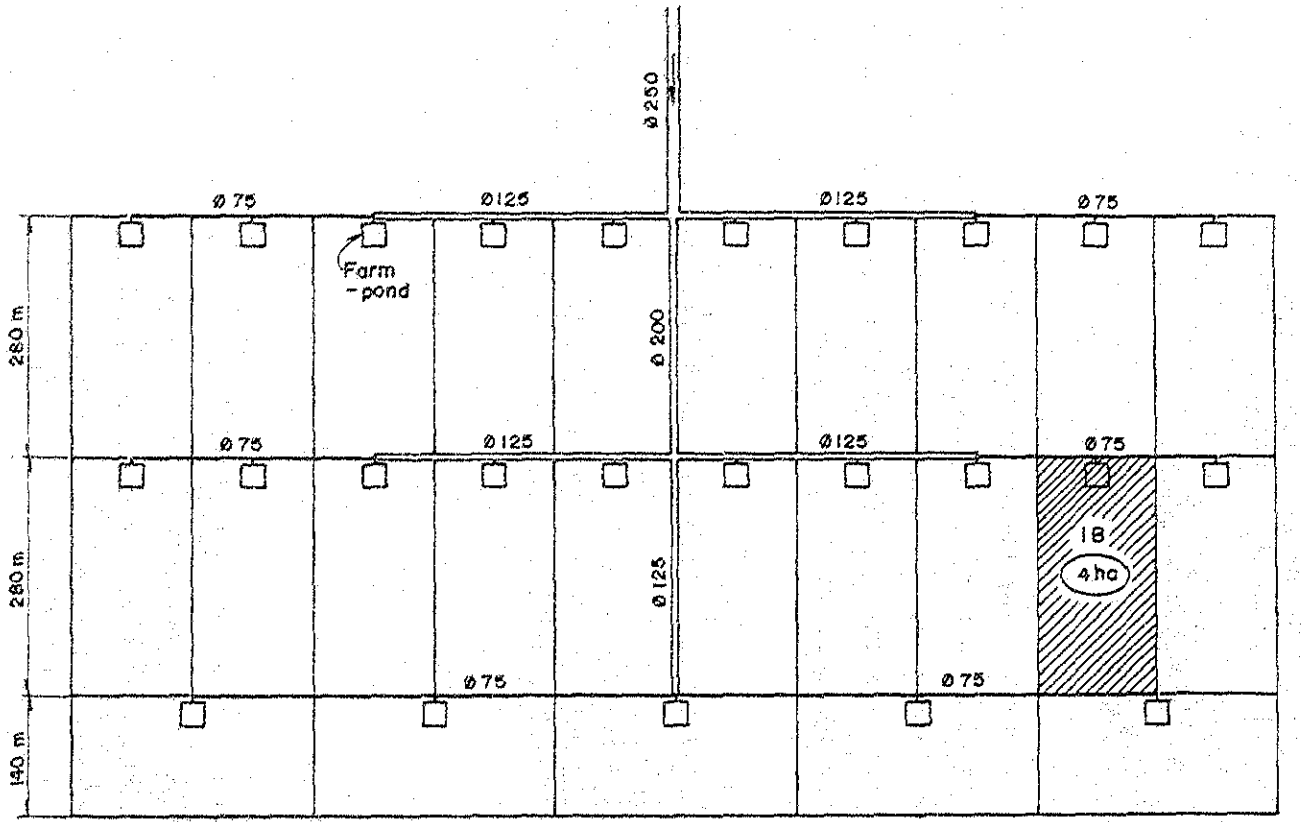
(1) Terminal Service Unit of Irrigation

About 100 ha, as an average of minimum, commandable by a turnout at lateral or sub-lateral pipeline level are considered as the terminal service unit of irrigation. An ideal layout of the terminal irrigation unit is as given in Figure 5-8.

(2) Terminal End Irrigation Facility

The average size of orchard for typical orchard farmer is estimated at about 4 ha per household, as previously described in 3.4.3. A typical layout of terminal end irrigation facility and

FIGURE 5-8 Ideal Layout of Irrigation Unit (100 ha)




1B : Terminal Irrigation Block

| Nos of 1B | q (m/sec) | Ø (mm) | L (m) |
|---|---|---|---|
| 15 | 0.0160 | 200 | 280 |
| 5 | 0.0080 | 125 | 1,680 |
| 2 | 0.0024 | 75 | 2,240 |

major dimensions of such facilities are also given in the above sub-section 3.4.3. In the area where existing crops such as rubber, cassava and paddy are planned to be converted into orchard by the Project, terminal end irrigation facilities including farmpond, pump and on-farm distribution systems of sprinkler irrigation are to be installed in addition to the construction of irrigation systems up to the lateral or sub-lateral level. Additional investment would be as follows:

| Facility | Investment (Baht/ha) | Remarks |
|---|---|---|
| Farmpond | 29,094 | 930(cu.m/ha)x1.58x18.0(฿/cu.m)x1.10 |
| Pump | 2,250 | 9,000(฿/4.0ha) |
| Sprinkler System | 37,500 | 6,000(฿/rai)x6.25(rai/ha) |
| Total | 68,844 | |

## 5.4. Demonstration Farm

Demonstration farm occupies 10ha with orchard plantation plot of 8 ha and other 2 ha for building spaces. The required facilities and equipment of demonstration farm for smooth implemetation of the programmes are summarized as follows:

(1) Land Space

Gross area : 10 ha
Orchard farm : 8 ha (planting area 7.5 ha)
Building area : 2 ha

(2) Building

| Item | Capacity | Unit |
|---|---|---|
| Office and meeting room | 140 $m^2$ | 1 |
| Laboratory | 200 " | 1 |
| Lecture room | 100 " | 1 |
| Thermo-hygrostal room | 30 " | 1 |
| Refrigerating room | 20 " | 1 |
| Freezing room | 20 " | 1 |
| Storing room | 30 " | 1 |
| Warehouse | 70 " | 1 |
| Sorting house | 100 " | 1 |
| Farm tool house | 100 " | 1 |
| Farmers' room | 80 " | 1 |
| Garage | 60 " | 1 |
| Residence | 120 " | 1 |
| -do- | 100 " x 6 | 6 |
| -do- | 80 " x 9 | 9 |
| Total | 2,390 $m^2$ | |

(3) Machinery and Vehicles

| Item | Capacity | Unit |
|---|---|---|
| Tractor | 20 PS | 1 |
| Power sprayer | 5 " | 2 |
| Power duster | 5 " | 2 |
| Trailer | 1 t | 1 |
| Mower | 7.5 PS | 4 |
| Ladder truck | L = 20 m | 4 |
| Pick-up | 2 t | 4 |
| Jeep | | 2 |
| Motorcycle | | 5 |

(4) Laboratory Equipment ---------- one set

# CHAPTER 6. PROJECT IMPLEMENTATION PROGRAM

# CHAPTER 6. PROJECT IMPLEMENTATION PROGRAM

## 6.1. Project Management and Implementation

### 6.1.1. Project Lead Agency

There are numbers of the governmental agencies which have been providing services for water resources and related agricultural development in the subject Project area. Such agencies under the Ministry of Agriculture and Cooperatives (MOAC) are; 1) Royal Irrigation Department (RID) which would be responsible for design, construction and O & M of the storage dams, diversion dam, main conveyance pipeline networks up to the outlets into the terminal service units and regulating reservoirs, provide technical assistance in organizing water user's groups in each terminal irrigation unit and extend technical assistance to each water user's group in planning, designing, implementing construction, O & M and water management works within its service area, 2) Department of Agricultural Extension (DOAE) which would play an important role for extension services on all agricultural commodities except livestock, marine fishery and forestry, 3) Department of Fishery (DOF) responsible for servicing both the marine and freshwater fisheries in all aspects of production and marketing with exception of the extension of services for small pond fishery, 4) Department of Agriculture (DOA) responsible for research on all field crops including rubber, 5) Department of land Development (DLD) responsible for implementation of programmes related to soil and water conservation inclusive of land classification, 6) Cooperative Promotion Department (CPD) responsible to promote establishment of cooperatives, 7) Office of Rubber Replanting Aid Fund (ORRAF) responsible to operate accelerated rubber replanting programme, and 8) Royal Forest Department (RFD) which is responsible to regulate developments and to implement watershed management programme in the national reserved forest area.

Under the Ministry of Interior, Department of Local Administration (DOLA) would be responsible for the Changwat administration consisting of Changwat office, Amphoe offices, Tambon and Muban councils as well as local administration comprising Changwat Administration, Municipality and Sanitary District, and Community Development Department (CDD) would be responsible to assist and help Muban people in identifying and planning the rural development schemes. National Energy Administration (NEA) of the Ministry of Science and Technology would have a responsibility to implement water resources development scheme by constructing a storage dam and hydropower generation plant and to implement pump irrigation project to be operated by the electricity supplied from the hydropower station.

Aside from the sole responsibility of RID for the construction and subsequent operation and maintenance of major civil works, the key issue for successful implementation of the subject Project should focus upon realization of the participation of beneficial farmers to the implementation of the proposed agricultural water development programme by sharing a part of initial and O & M costs required, through the promotion of organization of active farmer's or irrigator's group with subsequent development of on-farm level facilities.

It would therefore be essential and serious to coordinate a concerted effort of various governmental agencies being coupled with increasing participation of the Changwat Administration.

### 6.1.2. Project Executing Agency and Organization

A special board to be chaired by MOAC is recommendable to be organized as the Coordinating and Steering Committee for the implementation of the proposed Agricultural Water Development Project, for both overall planning and decision-making functions at the national level. The Committee would have its members comprising

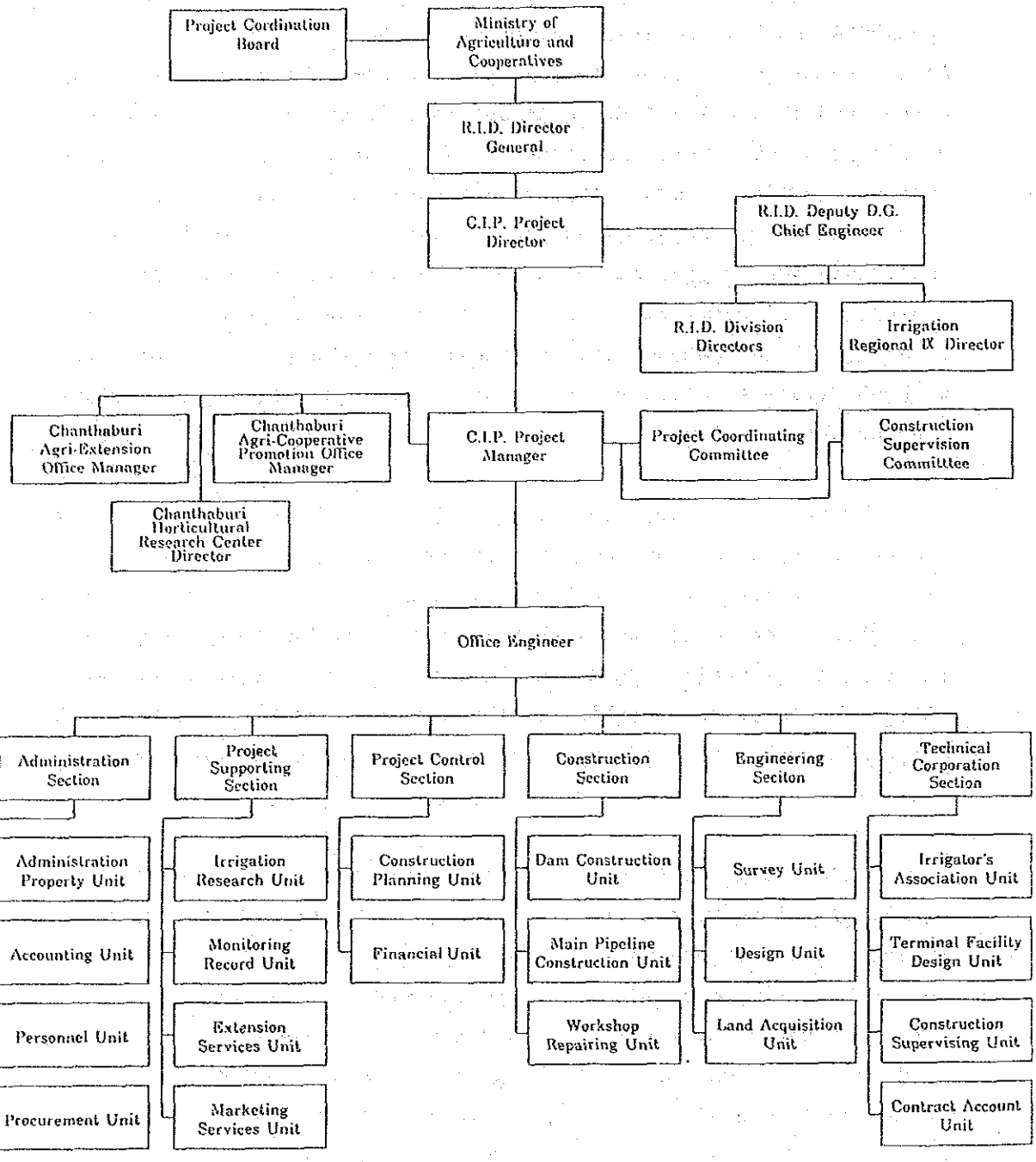
all agencies concerned including RID, DOA, DOAE, DLD, DOF, CPD, ORRAF and RFD, the Governor of Changwat Chanthaburi, representatives from DOLA and CDD, general manager of the Bank for Agriculture and Agricultural Cooperatives (BAAC), the representatives of the Budget Bureau and the National Economic and Social Development Board, and of NEA as an observer. Main functions of the Committee would be to determine policy, approve the Project component plans and budgets, ensure the coordination of various activities and to resolve the implementation programme, which would be achieved by means of evaluating and monitoring progress of the Project implementation. An existing Changwat Development Committee would be fully mobilized with the Project policy structure and would serve as a coordinating body at Changwat level.

The major construction works of the Project are composed of two storage dams, diversion dam, three pumping stations and main pipeline systems with about 110 km long in total. The Royal Irrigation Department (RID), which has the prominent experience in the similar-natured projects to the Chanthaburi Irrigation Project (CIP), should be responsible for the execution of the Project. The proposed organization of execution body is illustrated in Figure 6-1.

Project organizations for implementation of RID projects are usually lined up by the Project Director, Project Manager, Office Engineer and Section Chiefs. The Project Director is comprehensively responsible for the project implementation. The Project Manager is, under the control of the Project Director, fully responsible for execution of the project works. The Office Engineer is assigned to assist the Project Manager in overall project works.

The Administrative Section will be responsible for administration property, accounting, personnel affairs, procurement and the other miscellaneous matters.

Figure 6-1 Proposed Organization of Project Implementation




Note R.I.D. : Royal Irrigation Department
C.I.P. : Chanthaburi Irrigation Project

The Engineering Section is in charge of necessary topographic survey for design of pipeline systems under the cooperation of the Survey Division of RID Head Office, detailed design of dams and main irrigation facilities under the supervision of the Design Division of RID Head Office, and arrangement for land acquisition.

The Construction Section is in charge of construction supervision and inspection of the works on contract basis, repairing works and water and electric supply.

The Project Control Section is responsible for construction planning, preparation of tender documents inclusive of specifications and cost estimate, and budget allocation schedule.

The Project Supporting Section is in charge of carrying out education of beneficial farmers on water management, keeping records not only of the progress of civil works but also of agricultural development inclusive of that of socio-economic sectors during the course of implementation of project works, and also execution of agricultural extension services together with related agencies concerned of MOAC.

The Technical Corporation Section will be responsible for establishment of irrigator's group and its association and federation structures, technical and administrative assistance for survey, design, construction supervision and accounting of construction contract and so forth.

### 6.1.3 Committees

The Project Coordinating Committee in local level will be organized by RID's Project Manager as a Chairman, representatives of the local Agricultural Extension Office and the Agricultural Cooperative Promotion Office, and BAAC' Chanthaburi branch manager and others as occasion demands, and the consultants staff and RID Regional Director as observers, if necessary.

The Committee meeting is held twice a month for the project execution and assessment. In this meeting, the following matters are discussed for deepening the mutual understanding;

- Assessment of actual results;
- Implementation schedule;
- Extension services;
- Upbringing of the cooperatives;
- Education and training in water management techniques; and
- Other works related to the projects.

This kind of meeting is quite indispensable to secure the smooth progress of the works.

The Construction Supervision Committee is also set up to check the work progress and quality of work performed by contractors under the chairmanship of a related division director of RID.

6.1.4. Establishment of Irrigators' Group Organization

(1) General Background

As a general policy of agricultural development project in Thailand, the government has taken a policy to share the total investment by government until when the beneficiary farmers become stable and they can repay the investment. On the other hand, post-project O & M services for major facilities are commonly undertaken by RID and the farmers take the responsibility for O & M works at on-farm level.

The beneficial farmers in the Project area, however, have managed a rather large scale orchard plantation, and they have obtained huge amount of net production incomes as compared with other crop grower, such as para rubber, cassava and paddy rice. According to the financial farm budget analysis of the concerned

farmers, capacity of beneficial farmers solvency would be enough to contribute to a certain extent to the project implementation. The amount of their solvency, after deducting the cost of living allowances from annual net production cost, ranges from ฿70,000 to ฿137,000.

As is discussed in the latter paragraph, it is judged that the line of demarcation of construction works to be drawn between national government and beneficial farmers should be determined on the basis of appropriate policy in order to support the current government policy. Chapter 8 of this report verifies the beneficialies' solvency for main irrigation facilities covering upto 200ha commandable area.

(2) Establishment of Irrigator's Association

The management of construction and O & M works of irrigation facilities by the beneficial farmers is quite uncommon in Thailand. Preparatory process and farmer's understanding/consensus for the project implementation is therefore vitally important. National government, especially RID, should pay careful attention and promotion prior to commencement of the Project for smooth execution of the Project.

During the pre-construction period of the Project and/or early stage of the construction works, the irrigator's association should be established constituted with irrigator's groups which will be organized within the boundary of terminal irrigation network or irrigation service unit with about 200 ha commandable area and/or about 70 household orchard growers.

After irrigator's groups were established and developed well under control or guidance by RID or CPD, those irrigator's groups

shall be re-organized into the irrigator's association in order to reduce administrative and operation/maintenance costs within their territory. As a final goal of beneficial farmer's organization, the federation of irrigator's association will be established after creation of stable management on orchard production and appropriate operation/maintenance work accomplishment in the project area. The proposed organization chart of irrigator's association is illustrated in Figure 6-2.

(3) Specific Tasks of Irrigator's Group or Association

The farmer's groups or association relating to farm production will cover the following various tasks: operation/maintenance of irrigation/drainage facilities, procurement of farming materials, crediting, sales of materials, agri-extension services, management of fruit marketing and so forth. At present, however, a variety of agricultural policies taken by government will cause difficulties in making up a comprehensive organization in a short period.

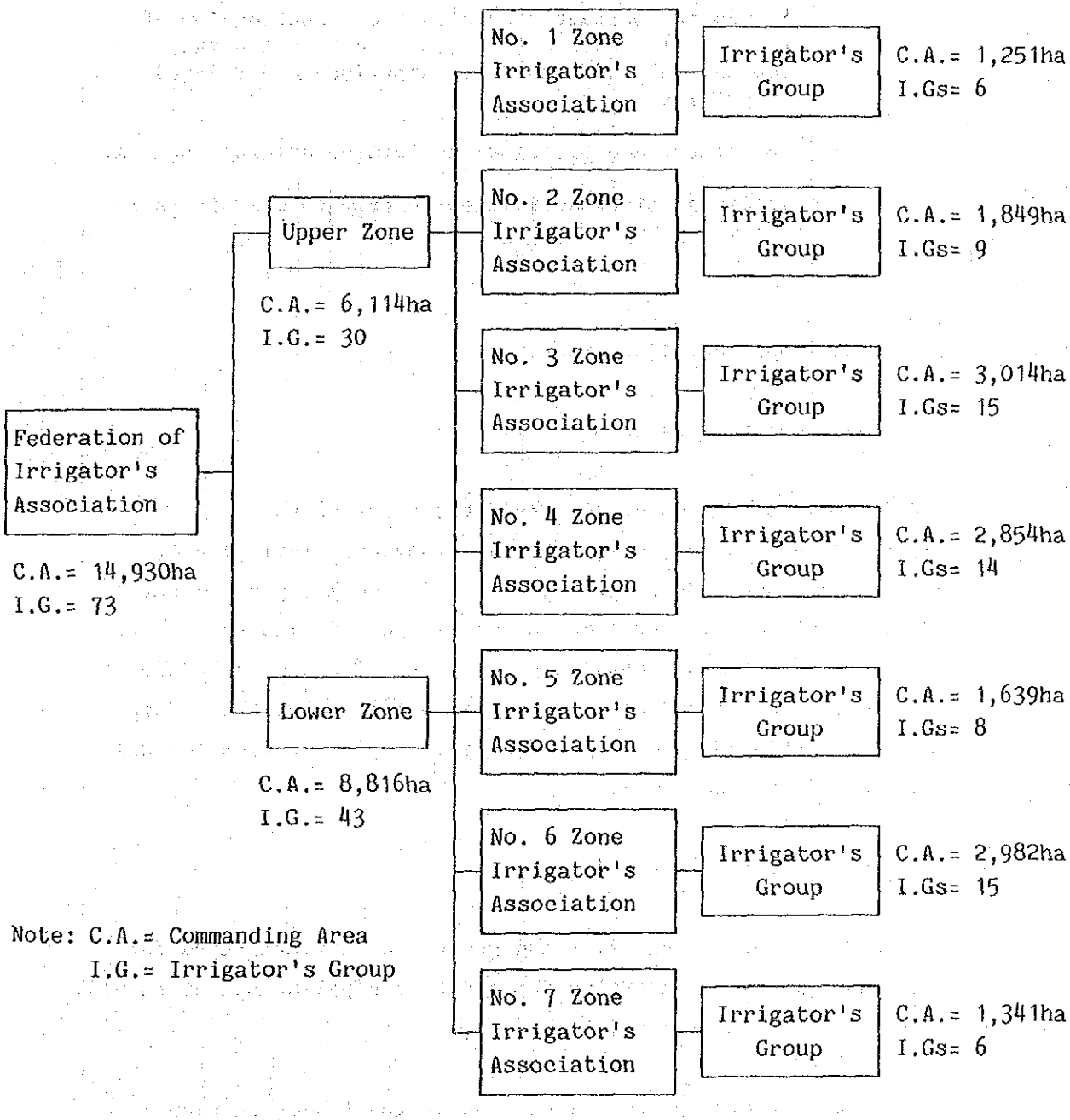
From these viewpoints, the major tasks of the Irrigator's Group (IG) or Irrigator's Association (IA) should be, in principle, to carry out management of terminal facilities construction under supervising of RID, O & M, rehabilitation of facilities within their territory, and to collect the necessary irrigation fee and amortization of loan for terminal facilities. Major tasks are summarised as follows:

1) Terminal facility construction/O & M

- To assist RID for project planning, survey, design and construction supervision.
- To conduct land acquisition negotiation for proposed facility within their territory.
- To carry out operation and maintenance work below 200 ha command area.

Figure 6-2 Organization of Irrigator's Association

Khlong Ta Liu Sub-project : C.A. = 12,697ha, I.Gs = 62
Khlong San Sai Sub-project : C.A. = 2,233ha, I.Gs = 11




Note: C.A.= Commanding Area
I.G.= Irrigator's Group

2) Administration

- To collect necessary irrigation fee.
- To prepare detailed irrigation schedule and management plan.
- To manage contract accounting for construction of terminal irrigation facilities such as lateral, sub-lateral and connection pipelines and related structures.
- To collect amortization fee from beneficial farmers.
- To manage other activities related to administrative work.

## 6.2. Project Implementation Program

### 6.2.1. Implementation Program

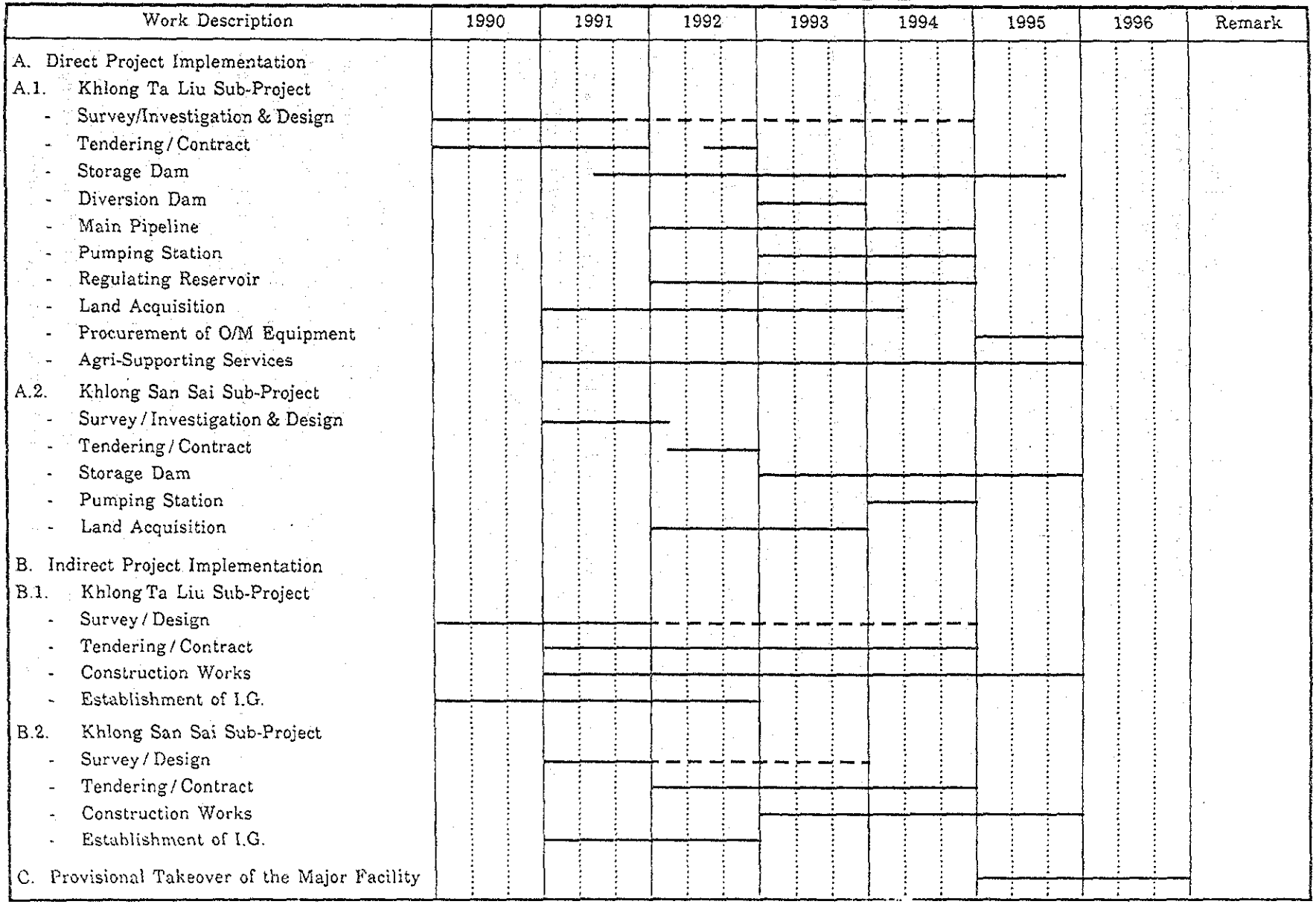
The major work items of the Project consist of the survey/investigation and design, tender procedures inclusive of preparation of tender documents, construction works, procurement of O & M equipment, agricultural extension services including irrigation research, and consulting services. The time schedule of the respective work items has been worked out based on the concept hereinafter mentioned, and proposed project implementation schedule is illustrated in Figure 6-3.

(1) Survey, Investigation and Design

Detailed topographic survey and geological investigation for proposed storage dams, diversion dam and main pipeline system should be started in the first project year.

The detailed design and preparation of the tender documents should be possibly completed within the previous fiscal year of

Figure 6-3 Project Implementation Program



commencement of construction works. Therefore, the design work schedule shall be established following the construction schedule in advance. Preparation of tender document shall also be completed in parallel with design works.

(2) Construction Schedule

The construction works will be undertaken on contract basis following the current governmental policy, and will be commenced from middle of second project year, taking into consideration the above-mentioned pre-construction works. It is proposed to complete the Project construction works in five years taking into account the embankment volume of Khlong Ta Liu dam and its construction schedule, staffing capacity of RID, tendency of the budgetary support in Baht and so forth.

(3) Procurement of O & M Equipment

Procurement of operation and maintenance equipment will start from six project year, and inspection and inland transportation to the site shall be completed within the same project year.

(4) Agricultural Supporting Services

The agricultural supporting services such as demonstration farm management, extension of orchard production technology and research on irrigation technique, and promotion of agri-cooperative activities will be rendered from the second project year. It is desirable to continue such services even after the completion of the project works.

(5) Consulting Services

The consulting services to assist the Thai officials concerned in design, preparation of tender documents and agricultural

supporting services shall start in the beginning of the first project year, and the consultants personnel both foreign and local will render services up to provisional takeover of the completed facilities.

### 6.2.2. Optimum Construction Schedule

The construction period for Khlong Ta Liu Sub-Project has been determined at five year period and three years for Khlong San Sai Sub-Project, taking into account the actual tendency in budgetary arrangement for similar-natured irrigation projects and gaining efficiently project benefit.

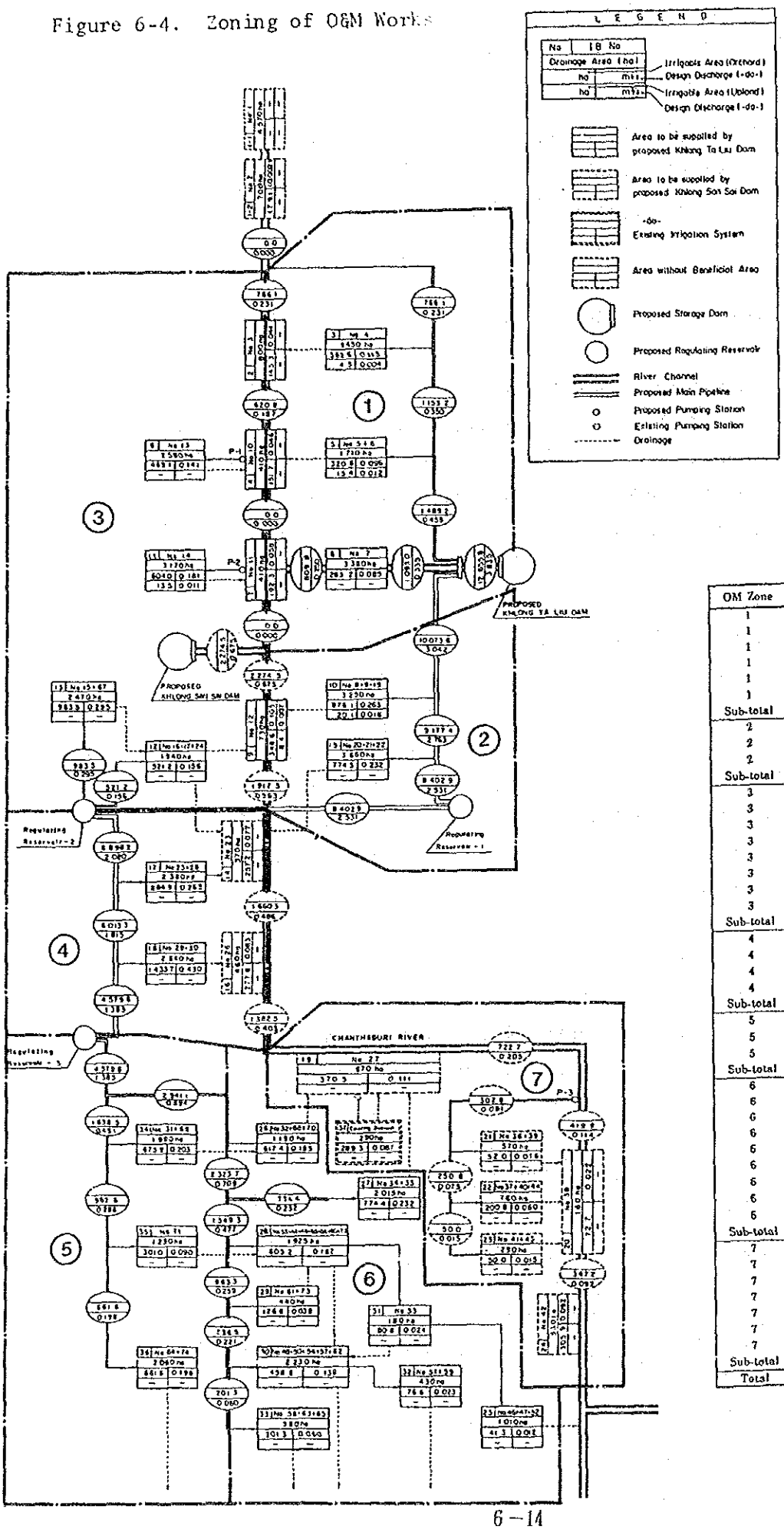
## 6.3. Operation and Maintenance

### 6.3.1. Zoning of the Project Area

In general, the service unit for operation and maintenance is determined based on the irrigation system network with commanding area of about 10,000 rai (1,600 ha) as a general standard of RID, length of canals and number of facilities.

The project beneficial area having about 14,930 ha has been divided into seven zones taking into account the pipeline networks and their location and boundary as illustrated in Figure 6-4. The commanding acreage in each zone is summarized below.

Figure 6-4. Zoning of O&M Works




| OM Zone | Series No. | Irrigable Area | Sub-Project |
|---|---|---|---|
| 1 | 2 | 72.9 | Ta Liu |
| 1 | 3 | 387.1 | " |
| 1 | 4 | 75.9 | " |
| 1 | 5 | 336.0 | " |
| 1 | 7 | 96.2 | " |
| 1 | 8 | 283.2 | " |
| Sub-total | (6) | 1,251.3 | |
| 2 | 9 | 178.5 | San Sai |
| 2 | 10 | 896.2 | Ta Liu |
| 2 | 15 | 774.5 | " |
| Sub-total | (3) | 1,849.2 | |
| 3 | 2 | 72.6 | Ta Liu |
| 3 | 4 | 75.8 | " |
| 3 | 6 | 469.1 | " |
| 3 | 7 | 96.1 | " |
| 3 | 9 | 178.5 | San Sai |
| 3 | 11 | 617.5 | Ta Liu |
| 3 | 12 | 521.2 | " |
| 3 | 14 | 983.5 | " |
| Sub-total | (8) | 3,014.3 | |
| 4 | 14 | 257.2 | San Sai |
| 4 | 16 | 277.8 | " |
| 4 | 17 | 884.9 | Ta Liu |
| 4 | 18 | 1,433.7 | " |
| Sub-total | (4) | 2,853.6 | |
| 5 | 34 | 675.9 | Ta Liu |
| 5 | 35 | 301.0 | " |
| 5 | 36 | 661.6 | " |
| Sub-total | (3) | 1,638.5 | |
| 6 | 25 | 41.3 | Ta Liu |
| 6 | 26 | 617.4 | " |
| 6 | 27 | 774.4 | " |
| 6 | 28 | 605.2 | " |
| 6 | 29 | 126.8 | " |
| 6 | 30 | 458.6 | " |
| 6 | 31 | 80.8 | " |
| 6 | 32 | 76.6 | " |
| 6 | 33 | 201.3 | " |
| Sub-total | (9) | 2,982.4 | |
| 7 | 19 | 370.5 | San Sai |
| 7 | 20 | 72.7 | " |
| 7 | 21 | 52.0 | " |
| 7 | 22 | 200.8 | " |
| 7 | 23 | 50.0 | " |
| 7 | 24 | 305.9 | " |
| 7 | 37 | 289.3 | " |
| Sub-total | (7) | 1,341.2 | |
| Total | | 14,930.5 | |

(unit: ha)

| Name of Zone | Commanding Acreage | | Total |
|---|---|---|---|
| | Khlong Ta Liu | Khlong San Sai | |
| A. Upper Zone | | | |
| No.1 Zone | 1,251 | - | 1,251 |
| No.2 Zone | 1,671 | 179 | 1,850 |
| No.3 Zone | 2,836 | 178 | 3,014 |
| Sub-Total | 5,758 | 357 | 6,115 |
| B. Lower Zone | | | |
| No.4 Zone | 2,319 | 535 | 2,854 |
| No.5 Zone | 1,638 | - | 1,638 |
| No.6 Zone | 2,982 | - | 2,982 |
| No.7 Zone | - | 1,341 | 1,341 |
| Sub-Total | 6,939 | 1,876 | 8,815 |
| Total | 12,697 | 2,233 | 14,930 |

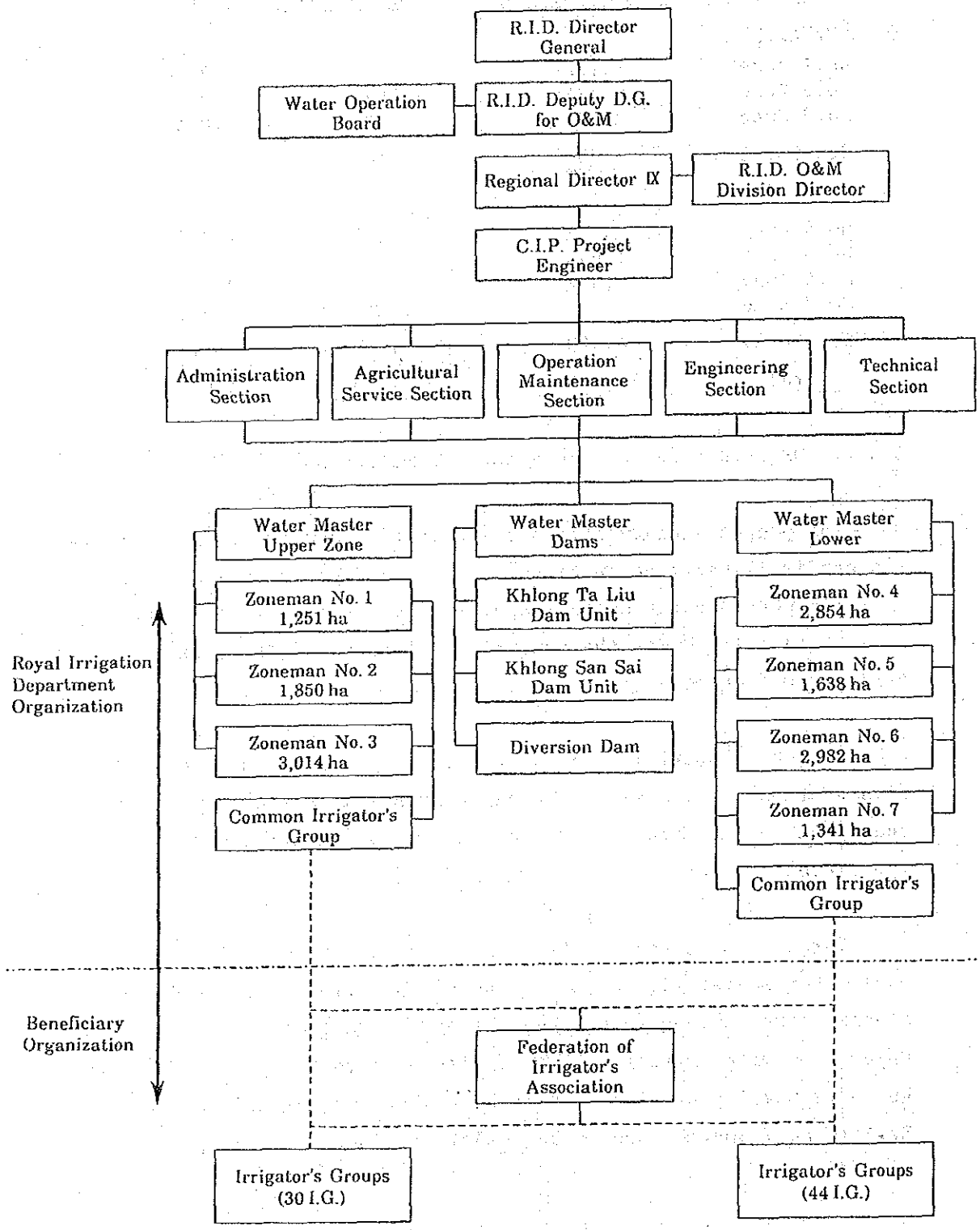
6.3.2. Organization for Operation and Maintenance

The proposed organization for operation and maintenance of the Project is illustrated in Figure 6-5. The Project Engineer will be fully responsible for overall operation and maintenance of the project facility under the control of Director of Irrigation Regional Office No.9.

The Chanthaburi Irrigation Project (CIP) O & M Office will have five sections in charge of the administration, agricultural service, operation and maintenance, technical, and engineering services under the Project Engineer.

Three water masters will be assigned under the O & M section. Dams water master will be in charge of operation/maintenance of two storage dams (Khlong Ta Liu and Khlong San Sai) and diversion dam. Upper Zone water master will supervise No.1 to No.3 zonemen and No.1 and No.2 pumping station. Lower Zone water master will supervise No.4 to No.7 zonemen and No.3 pumping station.

Figure 6-5 Proposed Organization of Operation and Maintenance



Besides, one zoneman will control about five Common Irrigators (CI), each of them responsible for about 400 ha of orchard land. Number of CI to be assigned to the Project will be about 36 persons.

The office, in general, will be in charge of the O & M of the irrigation facilities upto the distribution point where commandable area is around 200 ha.

In principle, irrigator's group which is organized by beneficial farmers having their orchards in the command area of about 200 ha, will be responsible for operation and maintenance of the irrigation facilities downstream of the said distribution point. Under the conditions, one group will consist of about 70 farm households among whom three farmers' foreman will be selected. The farmers' foreman will be in charge of both O & M and water management and collection of required irrigation fee from the concerned farmers.

### 6.3.3. Management

The Project Engineer will be responsible to make formal and additional report to the Director of Regional Irrigation Office No.9, Chonburi, regarding the irrigation schedule and facilities maintenance plan, and be responsible to control/review the various works on water utilization programming, repairing and improving facilities and so forth.

The Administration Section will be in charge of general matters inclusive of budgeting, accounting, personnel affairs and management of the office properties. The Mechanical Section will be responsible for operation and maintenance of equipment and vehicles, etc., under the Office, and formulate a plan for mobilization of equipment. The Engineering Section will be responsible for survey, design, construction and improvement of canals and related facilities inclusive of repairing works. The Agricultural Service

Section shall play an important role to work out cropping plans by service areas, to secure coordination with and among the other agencies and offices, to plan farmers' education and training, and to conduct the yield surveys, and to follow up irrigation research in demonstration farm.

The O & M Section will be responsible to carry out water management and general O & M of the facilities based on the O & M guideline mentioned below;

The Water Masters assigned to the storage dams, diversion dam and the entire areas will be responsible for guidance and supervision of the zonemen and common irrigators in the respective areas in charge.

The major tasks are shown below;

i) In consultation with the Agricultural Service Section staff, to determine an irrigation requirement in the area.

ii) To measure and control the water to be supplied at the diversion points so as to meet the water requirement keeping the losses at minimum.

iii) To prepare water release schedule and rules based on the irrigation requirements and cropping patterns furnished by the other Water Masters. (duty of the Water Master in charge of O & M of the dams).

iv) To measure and record the discharges from major distribution point on the supply basis, and prepare discharge data so as to materialize a proper water management (duty of the Water Masters in charge of O & M of the Upper and Lower Zone irrigation facility).

v) To give guidance and supervision to farmers' foremen in water management and O & M of on-farm facilities.

Zonemen and Common Irrigators should assist Water Master in carrying out proper water distribution in the area in charge and in giving guidances to farmers' groups.

### 6.3.4. Required Equipment, Facilities and Staff

#### (1) Operation and Maintenance Office

The operation and maintenance office will be utilized as the Project Office after completion of the construction works.

#### (2) Operation and Maintenance Equipment

The following equipments are recommended to be introduced for post project operation and maintenance works.

| | | | |
|---|---|---|---|
| - | Bulldozer | 15 ton | 1 unit |
| - | Backhoe | 0.40 $m^3$ | 2 units |
| - | Trackcrane | 5 ton | 2 units |
| - | Track | 6 ton | 2 units |
| - | Pickup | 2 ton | 3 units |
| - | Wagon Jeep | | 2 units |
| - | Motor cycle | | 5 units |
| - | Office equipment | | 1 L.S |

#### (3) Staffing

The following staffs will be required to meet the requirement in O & M and education/training of the beneficial farmers.

| Designation | Officer | Permanent Employee | Temporary Employee |
|---|---|---|---|
| Project Engineer | 1 | - | - |
| Section Chief | 5 | - | - |
| Administration | - | 2 | 4 |
| Agricultural Service | - | 2 | 2 |
| O & M | 1 | 3 | 3 |
| Engineering | - | 3 | 3 |
| Technical | - | 2 | 5 |
| Water Master | - | 3 | - |
| Zoneman | - | 7 | - |
| Skilled Operator | - | 7 | 7 |
| Common Irrigator | - | 7 | 29 |
| Total | 7 | 36 | 53 |

### 6.3.5. Annual Operation and Maintenance Cost

The operation and maintenance cost per annum has been estimated based on the zoning plan, proposed organization, required man-power, capacity of pumping plant and its operation hours, etc.

(Unit: 1,000 Baht)

| Item | Amount | Remarks |
|---|---|---|
| A. Salaries/Wages | | |
| Officers | 630 | 90,000฿/P |
| Permanent Employee | 1,944 | 54,000 " |
| Temporary Employee | 1,431 | 27,000 " |
| Sub-total | 4,005 | |
| B. Supply of Materials | 500 | |
| C. Maintenance Cost | 1,624 | 0.1% of civil work cost |
| D. Electricity for Pump | 1,671 | 2,800 hrs/yr x 790 kw |
| Total | 7,800 | |

### 6.3.6. Special Issue on the Water Management in the Basin

Irrigated service areas in the Project boundary depend mostly on the water to be supplied from the proposed storage dams. In consideration of seasonal pattern of rainfall as well as of runoff in the service area, the reservoir water has a significant importance for crops in dry season, where less water is only available. In these area under such situation, it must be intolerable and irresistible that the water supply from the reservoir be interrupted. It is therefore necessary that the reservoir is so operated as to ensure its storage by April or beginning of May, when the rain again visits the area.

The operation of a reservoir is undertaken in a way that two purposes confronting each other can be adjusted. The first objective is to promote water release effectively in response to the demand of the service area. However, as a result, promotion of

water release accelerates consumption of available storage in the reservoir. Secondly, some countermeasure for unforeseen drought is needed. In preparation for the present and future drought, water release is rather restricted intending preservation and restoration of the storage. After categorized as above, water demand requested by beneficiaries takes the initiative in the former category and the initiative of the supplier side from aspect of reservoir control is superior in the latter. In addition, in the latter category, regulations are required for the reservoir administrator to control amount of water to be released. This kind of competition can also be found everywhere in the service area. For example in the terminal service unit of irrigation, water supplied upstream can be easily diverted by the beneficiary located upstream resulting no excess water for irrigation in the downstream area.

To achieve the target yield of productive land with expanded irrigation area, full participation of beneficial farmers, who are the ultimate users of the Project, in a functional organization of operation of water management up to the on-farm level would inevitably be necessary. Supplemented with technical methods and procedures to regulate such water competition between supply and end users, improved moral of water utilization among water users and regulation from a functional organization of water management are to be accompanied.

From the facility plan recommended by the Project, the final destination in the proposed irrigation systems for delivery of water to the crops are the existing natural river channel and farmpond, both from which waters are diverted directly through farmer's small scale pumping facilities and distributed to the site of irrigation. Water are released from the proposed storage dams through the existing channel of Chanthaburi river or through main conveyance pipeline, and diverted directly from river channel or gated turnout installed along main conveyance pipeline through lateral/sub-lateral pipeline and connection pipe into the farmpond.

Irrigator's group (IG) is recommended to be organized at every turnout of lateral pipeline level, in order to function for equitable water distribution at farm level and for suitable O & M of irrigation facilities in the service area of each IG, which would cover various size of service area with a standard coverage of 200 ha, consisting of 60 to 80 members.

As a final goal of the beneficial farmers' organization, irrigator's association (IA) would also be organized in every O & M zone along main conveyance pipeline constituted by IGs. The role of IA is to coordinate IGs under its administration and to help and cooperate with RID and other project implementation agencies in operating and maintaining irrigation systems for regulation and equitable water distribution. IAs would cover 1,200 to 3,000 ha of service area with an average of about 2,000 ha or 10 IGs.

To achieve the above target, technology and knowledges of irrigation engineers in RID, cooperative promotion specialists in CPD, agricultural extension specialists in DOAE, community organizers in CDD and other administrative personnel in Changwat Chanthaburi should be combined.

There are 7 farmer's groups who have been operating irrigation systems in and around the Project area. Regulation and organizational setup established are almost same for all irrigation systems, each having a committee for operation and maintenance of the project. The committee consists of chairman, vice-chairman, secretary, assistant to secretary, financial section in charge and accounting section in charge. As a high ranking organization, a Water User's Association has also been organized by 6 groups situated in Amphoe Tha Mai. In operation of water management, each group is divided into several sub-groups of rotation irrigation, to which waters are supplied for 8 to 13 hours at a time, in accordance with the size of sub-groups. This experience actually achieved in the area would be usefully examined to set up organizations required by the Project for water management.

## 6.4. Environmental Impact Evaluation

It is stated in the manual entitled "Guidelines for Preparation of Environmental Impact Evaluation" provided by National Environment Board (NEB) in April, 1979 that an initial step to be taken in the first or preliminary stages of project planning is to carry out an Initial Environmental Examination (IEE) for submittal for review by NEB, and that if the IEE indicates a follow-up study is needed then an appropriate EIS (Environmental Impact Statement) report is to be prepared in sufficient scope and detail by the agency or individual who proposes the project. The IEE is essentially an initial examination of the environmental effects potentials of a proposed project, which would be done within a very limited budget based mostly on the preliminary information at hand or on information that can be readily obtained. The environmental parameters to be included in the IEE are the same as in a full-scale EIS study, however, the objective is not to make the actual detailed evaluation for each environmental parameter, but rather to reach a decision on whether such evaluations are needed.

Aside from the above definition, the NEB Guideline for Initial Environmental Examination also states that any sizeable dam/reservoir project will certainly require full-scale EIS analysis. Dam and reservoir projects usually cause a major alternation in the hydrologic regime of the watershed involved, they usually result in a drastic alternation of the physical and ecological setting in the immediate vicinity of the project and also these effects may continue far downstream to the area of final discharge of the stream and beyond. In addition they usually result in establishment of new access road to upstream areas in the watershed, resulting in impacts on forests, wildlife, mineral development and agricultural practices throughout the watershed. The EIS study should also include effects on people involving problems of resettlement and of alternation in socio-economic patterns. Such effects are not only adverse but also essential

gains may be evaluated in power and food production, flood control, water supply, aquaculture newly developed, recreation, navigation, etc. The EIS study is therefore to be undertaken during the stages of the planning and construction, and also the dam filling and stabilizing, with the recommended time schedule prepared by NEB as given in Figure 6-6. Environmental parameters to be included in the EIS report for dam/reservoir project are thus summarised as follows:

Environmental Effects common to Dam/Reservoir Project

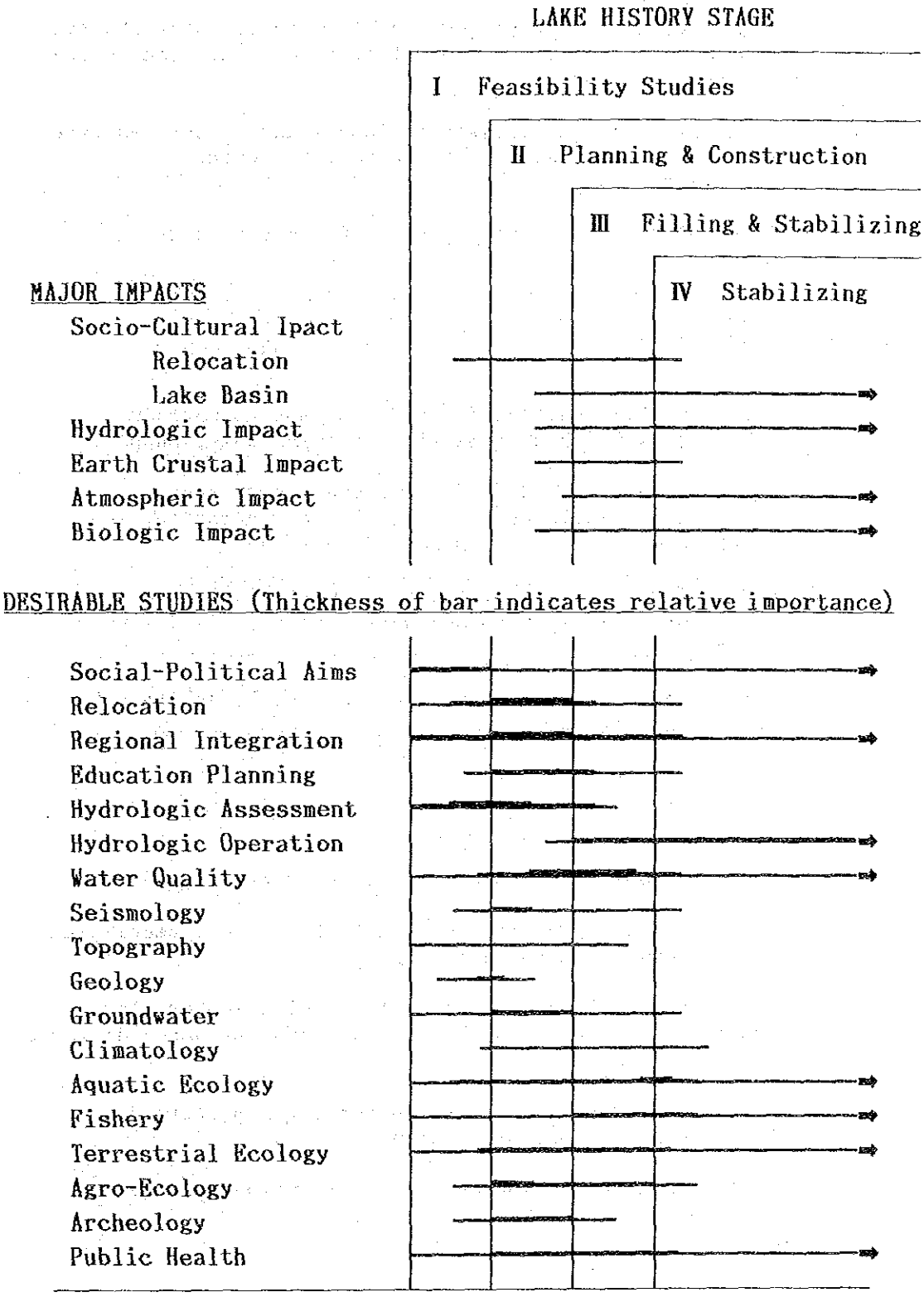
(1) Physical Resources

- Surface water hydrology: possible changes in hydrological regime by comparing the typical hydrographs for normal, drought and flood year conditions and mass water balance, both for before and after project conditions.
- Surface water quality: effect of storage on physical, biological and dissolved mineral constituents parameters, for both the reservoir and river downstream.
- Groundwater: quality and quantity of groundwater, both in reservoir vicinity and river downstream.
- Soils: soil erosion in the watershed as well as the irrigation aspects.
- Geology and seismology: adequacy of foundation conditions for structural stability and anticipated earthquake hazards in the region.
- Sediments and erosion: sedimentation in the reservoir.
- Climate: possible changes in microclimate in the project vicinity.

(2) Ecological Resources

- Fisheries: loss in existing riverline fisheries and expected new fishery situation in the reservoir and in the altered river.
- Aquatic biology: expected new ecology in the reservoir and on the affected downstream riverline zone.

FIGURE 6-6 TIMING RECOMMENDABLE FOR ENVIRONMENTAL ACTIVITIES



- Wildlife: impact of project on wildlife in watershed area and in downstream, and new wildlife to be created by the project.

- Forests: impact of project in inundating forest reserves especially from the aspects in soil and water conservation.

- Reservoir ecology: anticipated environment in the new reservoir.

(3) Human Use Values

- Water supply: availability of water for downstream communities for both domestic and rural water supply.

- Aquaculture: potentials for improved downstream aquaculture resulting from low flow augmentation, and brackish water fishery in downstream area.

- Navigation: effect of low flow augmentation caused by supply of river maintenance water, especially during dry period.

- Flood control: flood control effects to be achieved by the reservoir storage.

(4) Quality of Life Values

- Socio-economics: welfare of affected rural population.

- Resettlement: problems involved in the resettlement plan of the population to be inundated.

- Public health: anticipated health/sanitation problems especially for altering hazards of water-oriented diseases in the region.

- Nutrition: probable effects on nutrition pattern due to the altered fishery production.

- Recreation: recreation and aesthetic values of the new reservoir systems.

## Irrigation Project

Irrigation aspects also need to be evaluated in terms of the following:

- Crop and food production: estimated impact on types and amounts of crops to be produced, and the resulting increase in food production.
- Institutional requirement: plans for reorientation and training of the farmers to make the adjustment to irrigated farming including plans for extension services, farmers' cooperatives, and service center for furnishing training, credit, ready purchase of farm inputs, ready marketing, etc.
- Irrigation distribution: plans for distribution and use of the irrigation water.
- Soil fertility: loss of soil fertility caused by continuous irrigation.
- Return-flow: effect of return-flow on river water salinity.
- Agro-industries: potentials for agro-industrial development in the irrigation areas.
- Agricultural chemicals: effecfts of runoff from farming areas containing residues of fertilizers and toxic chemicals on stream ecology and effects of toxic chemicals on terrestrial wildlife.

# CHAPTER 7. COST ESTIMATE

# CHAPTER 7. COST ESTIMATE

## 7.1. Basic Concept on Cost Estimate

### 7.1.1. General Description

The construction works will be conducted on contract basis following the governmental policies currently enforced in Thailand. The whole construction works which consists of "direct works" taken care by national government and "indirect works" managed by beneficial farmers group are proposed to be completed within the five-years period, which is estimated taking into account the quantity of works, budgetary support and staffing capability of RID.

The project cost comprises the costs for survey/detailed design, civil works, land acquisition, agricultural supporting services including demonstration farm for applied orchard irrigation research, procurement of operation/maintenance equipment, administration, engineering services as well as physical and price contingencies.

The unit cost for construction works includes construction materials, labour and equipment to be used, overhead charges, taxes and profit for the contractor. The cost is estimated on the basis of the prices and manner employed by RID.

As regards foreign and local currency portion for major construction materials, the following rates are applied:

| Materials | Foreign Currency (%) | Local Currency (%) |
|---|---|---|
| Cement | 60 | 40 |
| Reinforcement bar | 70 | 30 |
| Steel pipe | 70 | 30 |
| PC pipe | 40 | 60 |
| AC pipe | 70 | 30 |
| Construction equipment | 80 | 20 |
| Pumping plant | 70 | 30 |

The basis of applied unit cost is Thai fiscal year 1989 prices.

7.1.2. Details of Project Cost

(1) Cost of Civil Works

This item includes the construction costs for the project which are estimated based on respective unit costs including construction materials, fuel and oil, labour, and depreciation and repairing cost of the construction equipment. The civil works are composed of the followings;

1) Storage dam: including the diversion tunnel, foundation treatment, embankment of dambody, spillway, intake facility, and access road

2) Diversion dam: including the construction works of the main dambody, floodway and intake facility as well as discharge control devices

3) Main pipeline: including the construction works of the main pipeline from the intake point upto the terminal point of about 200 ha commandable area, involving pipeline, control valves, air values, blow-off-values, and distribution values

4) Regulating reservoir: regulating reservoir with concrete pavement, inlet/outlet pipe with control values, and spillway

5) Main pumping station: including suction pool, delivery pool, pump house, pumping plants and related devices.

(2) Land Acquisition

This item includes the cost required to purchase or compensate the land to be occupied by proposed storage dam and reservoir, access road, diversion dam, main pipeline system, regulating reservoir and main pumping station, and also to promote reforestation of adjacent area outside of new reservoir.

(3) Agricultural Supporting Services

This item covers the cost for agricultural supporting services necessary for smooth implementation of the project including 8 ha of applied orchard irrigation research demonstration farm and related instruments/buildings.

(4) Operation and Maintenance Equipment

This item includes procurement of equipment for post project operation/maintenance such as bulldozer, backhoe, truckcrane, truck and vehicles etc. The cost of equipment and spare parts is estimated based on CIF Bangkok including only the inland transportation cost of them.

(5) Administration Cost

This cost is estimated at about 8% of the above-mentioned investment cost items (1) to (4), taking into account actual costs required in the similar projects.

(6) Engineering Services Fee

This cost includes consulting fees for detailed design of the proposed facilities and construction supervision, survey and investigation cost to be undertaken by RID and the cost for overseas training of the governmental officials concerned.

(7) Physical Contingency

The allocation of contingency is made to cover minor differences between the actual and estimated quantities, unexpected difficulties in construction works and so forth. The contingency equivalent to 10% of the above-mentioned items has been employed.

(8) Price Escalation

Price escalation of 1.1% per annum for the foreign currency portion and 6.4 percent for the local currency portion are allowed respectively. Therefore, the adopted percentage of the total price escalation is estimated at 11.4%.

## 7.2. Total Investment Cost and Disbursement Schedule

### 7.2.1. Total Investment Cost

The total investment cost for both the Direct and Indirect Project, including the cost for price escalation but excluding the interest during the construction period, is estimated at 2,527 million Baht (equivalent to US$101 million), of which about 1,644 million Baht will be foreign currency component and about 883 million Baht shares local currency component.

The project cost is summarized in Table 7-1, and detailed cost breakdown is also given in Table 7-2.

Table 7-1. Summary of Project Cost

(unit: Million Baht)

| Work Description | Khlong Ta Liu | Khlong San Sai | Total |
|---|---|---|---|
| A. Direct Project Cost | | | |
| 1. Civil Works | 1,534 | 86 | 1,620 |
| 2. Land Acquisition | 14 | 28 | 42 |
| 3. Agri-Supporting Services | 51 | - | 51 |
| 4. Operation/Maintenance | 15 | - | 15 |
| 5. Administration Cost | 123 | 9 | 132 |
| 6. Engineering Services | 184 | 17 | 201 |
| 7. Physical Contingency | 192 | 14 | 206 |
| Total (1 - 7) | 2,113 | 154 | 2,267 |
| (Foreign Currency) | (1,483) | (88) | (1,571) |
| (Local Currency) | ( 630) | (66) | ( 696) |
| 8. Price Escalation | 236 | 24 | 260 |
| Total (1 - 8) | 2,349 | 178 | 2,527 |
| B. Indirect Project Cost | | | |
| 1. Civil Works | 374 | 17 | 391 |
| 2. Engineering Services | 45 | 2 | 47 |
| 3. Physical Contingency | 37 | 3 | 40 |
| Total (1 - 3) | 456 | 22 | 478 |
| (Foreign Currency) | ( 316) | (16) | ( 332) |
| (Local Currency) | ( 140) | ( 6) | ( 146) |
| 4. Price Escalation | 55 | 3 | 58 |
| Total (1 - 4) | 511 | 25 | 536 |
| C. Grand Total (A + B) | 2,860 | 203 | 3,063 |
| (Foreign Currency) | (1,881) | (111) | (1,992) |
| (Local Currency) | ( 979) | ( 92) | (1,071) |

Table 7 - 2 Project Cost

Unit : 1,000

| Cost Item | Khlong To Liu Sub-Area | | | Khlong San Sai Sub-Area | | | Grand Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Foreign C. | Local C. | Total | Foreign C. | Local C. | Total | Foreign C. | Local C. | Total |
| A. Direct Project Cost | | | | | | | | | |
| 1. Civil works | | | | | | | | | |
| 1.1 Storage Dam | 693,189 | 137,306 | 830,495 | 55,289 | 14,213 | 69,502 | 748,478 | 151,519 | 899,997 |
| 1.2 Diversion Dam | 14,036 | 8,564 | 22,600 | – | – | – | 14,036 | 8,564 | 22,600 |
| 1.3 Main Pipeline | 417,100 | 194,100 | 611,200 | – | – | – | 417,100 | 194,100 | 611,200 |
| 1.4 Regulating Reservoir | 7,164 | 9,936 | 17,100 | – | – | – | 7,164 | 9,936 | 17,100 |
| 1.5 Pumping Station | 36,110 | 16,390 | 52,500 | 11,670 | 5,330 | 17,000 | 47,780 | 21,720 | 69,500 |
| Sub - total | 1,167,599 | 366,296 | 1,533,895 | 66,959 | 19,543 | 86,502 | 1,234,558 | 385,839 | 1,620,397 |
| | | | | | | | | | |
| 2. Land Acquisition | – | 14,342 | 14,342 | – | 27,751 | 27,751 | – | 42,093 | 42,093 |
| 3. Agri-Supporting S. | 21,000 | 29,547 | 50,547 | – | – | – | 21,000 | 29,547 | 50,547 |
| 4. Operation / Maintenance | 11,880 | 2,970 | 14,850 | – | – | – | 11,880 | 2,970 | 14,850 |
| 5. Administration Cost | – | 122,700 | 122,700 | – | 9,100 | 9,100 | – | 131,800 | 131,800 |
| 6. Engineering Services | 147,253 | 36,813 | 184,066 | 13,800 | 3,500 | 17,300 | 161,053 | 40,313 | 201,366 |
| Sub - total | 180,133 | 206,372 | 386,505 | 13,800 | 40,351 | 54,151 | 193,933 | 246,723 | 440,656 |
| Total (1 - 6) | 1,347,732 | 572,668 | 1,920,400 | 80,759 | 59,894 | 140,653 | 1,428,491 | 632,562 | 2,061,053 |
| 7. Physical Contingencies | 134,768 | 57,232 | 192,000 | 8,041 | 6,106 | 14,147 | 142,809 | 63,338 | 206,147 |
| Total (1 - 7) | 1,482,500 | 629,900 | 2,112,400 | 88,800 | 66,000 | 154,800 | 1,571,300 | 695,900 | 2,267,200 |
| 8. Price Escalation | 67,000 | 168,600 | 235,600 | 5,600 | 18,600 | 24,200 | 72,600 | 187,200 | 259,800 |
| Grand Total | 1,549,500 | 798,500 | 2,348,000 | 94,400 | 84,600 | 179,000 | 1,643,900 | 883,100 | 2,527,000 |
| | | | | | | | | | |
| B. Indirect Project Cost | | | | | | | | | |
| 1. Lateral / Sub-Lateral | 70,665 | 32,291 | 102,956 | 1,795 | 819 | 2,614 | 72,460 | 33,110 | 105,570 |
| 2. Connection Pipe | 27,426 | 13,701 | 41,127 | 696 | 348 | 1,044 | 28,122 | 14,049 | 42,171 |
| 3. On-farm Facility | 161,232 | 69,098 | 230,330 | 9,276 | 3,975 | 13,251 | 170,508 | 73,073 | 243,581 |
| Total (1 - 3) | 259,323 | 115,090 | 374,413 | 11,767 | 5,142 | 16,909 | 271,090 | 120,232 | 391,322 |
| 4. Physical Contingency | 25,932 | 11,509 | 37,441 | 2,700 | 680 | 3,380 | 28,632 | 12,189 | 40,821 |
| 5. Engineering Cost | 31,445 | 13,401 | 44,846 | 1,530 | 570 | 2,100 | 32,975 | 13,971 | 46,946 |
| Total (1 - 5) | 316,700 | 140,000 | 456,700 | 15,997 | 6,392 | 22,389 | 332,697 | 146,392 | 479,089 |
| 6. Price Escalation | 14,400 | 40,500 | 54,900 | 703 | 2,208 | 2,911 | 15,103 | 42,708 | 57,811 |
| Grand Total | 331,100 | 180,500 | 511,600 | 16,700 | 8,600 | 25,300 | 347,800 | 189,100 | 536,900 |
| | | | | | | | | | |

### 7.2.2. Disbursement Schedule

The disbursement schedule for both direct and indirect project cost is summarized as shown in Table 7-3 and detailed schedules for Khlong Ta Liu sub-project and Khlong San Sai sub-project are given in Tables 7-4 and 7-5 respectively. These disbursement schedules are prepared based on the implementation programmes mentioned previously in paragraph 6.2.1.

Table 7-3. Summary of Disbursement Schedule

(unit: Million Baht)

| Project Year | Khlong Ta Liu | | | Khlong San Sai | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Foreign | Local | Total | Foreign | Local | Total | Foreign | Local | Total | (%) |
| A. Direct Cost | | | | | | | | | | |
| 1990 | 77.9 | 30.7 | 108.6 | - | - | - | 77.9 | 30.7 | 108.6 | ( 4.3) |
| 1991 | 87.7 | 93.1 | 180.8 | 7.9 | 2.3 | 10.2 | 95.6 | 95.4 | 191.0 | ( 7.6) |
| 1992 | 295.7 | 180.5 | 476.2 | - | 28.7 | 28.7 | 295.7 | 209.2 | 504.9 | (20.0) |
| 1993 | 408.3 | 195.6 | 603.9 | 17.5 | 19.0 | 36.5 | 425.8 | 214.6 | 640.4 | (25.3) |
| 1994 | 581.1 | 240.5 | 821.6 | 59.8 | 30.8 | 90.6 | 640.9 | 271.3 | 912.2 | (36.1) |
| 1995 | 98.9 | 58.2 | 157.1 | 9.2 | 3.8 | 13.0 | 108.1 | 62.0 | 170.1 | ( 6.7) |
| Total | 1,549.6 | 798.6 | 2,348.2 | 94.4 | 84.6 | 179.0 | 1,644.0 | 883.2 | 2,527.2 | (100.0) |
| B. Indirect Cost | | | | | | | | | | |
| 1990 | 15.2 | 7.1 | 22.3 | - | - | - | 15.2 | 7.1 | 22.3 | ( 4.2) |
| 1991 | 32.5 | 15.8 | 48.3 | 1.5 | 0.5 | 2.0 | 34.0 | 16.3 | 50.3 | ( 9.4) |
| 1992 | 62.4 | 32.2 | 94.6 | 0.5 | 0.1 | 0.6 | 62.9 | 32.3 | 95.2 | (17.7) |
| 1993 | 92.8 | 50.4 | 143.2 | 5.4 | 2.9 | 8.3 | 98.2 | 53.3 | 151.5 | (128.2) |
| 1994 | 63.8 | 36.4 | 100.2 | 5.4 | 2.9 | 8.3 | 69.2 | 39.3 | 108.5 | (20.2) |
| 1995 | 64.4 | 38.6 | 103.0 | 3.9 | 2.2 | 6.1 | 68.3 | 40.8 | 109.1 | (20.3) |
| Total | 331.1 | 180.5 | 511.6 | 16.7 | 8.6 | 25.3 | 347.8 | 189.1 | 536.9 | (100.0) |

Table 7 - 4 Project Cost of Khlong Ta Liu Sub-Project

Unit : Millon Baht

| Cost Item | 1990 | | 1991 | | 1992 | | 1993 | | 1994 | | 1995 | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FC | LC | FC | LC | FC | LC | FC | LC | FC | LC | FC | LC | FC | LC | Total |
| A. Direct Project Cost | | | | | | | | | | | | | | | |
| 1. Civil works | | | | | | | | | | | | | | | |
| 1.1 Storage Dam | – | – | 44.69 | 22.42 | 64.61 | 15.30 | 183.25 | 30.33 | 336.17 | 58.06 | 64.47 | 11.20 | 693.19 | 136.31 | 830.50 |
| 1.2 Diversion Dam | – | – | – | – | – | – | 14.04 | 8.56 | – | – | – | – | 14.04 | 8.56 | 22.60 |
| 1.3 Main Pipeline | – | – | – | – | 166.84 | 77.64 | 125.13 | 58.23 | 125.13 | 58.23 | – | – | 417.10 | 194.10 | 611.20 |
| 1.4 Regulating Reservoir | – | – | – | – | 2.39 | 3.32 | 2.39 | 3.31 | 2.38 | 3.31 | – | – | 7.16 | 9.94 | 17.10 |
| 1.5 Pumping Station | – | – | – | – | – | – | 15.05 | 6.85 | 21.06 | 9.54 | – | – | 36.11 | 16.39 | 52.50 |
| Sub - total | – | – | 44.69 | 22.42 | 233.84 | 96.26 | 339.86 | 107.28 | 484.74 | 129.14 | 64.47 | 11.20 | 1,167.60 | 366.30 | 1,533.90 |
| 2. Land Acquisition | – | – | – | 13.10 | – | 0.50 | – | 0.50 | – | 0.24 | – | – | – | 14.34 | 14.34 |
| 3. Agri - Supporting Services | – | – | 14.00 | 15.10 | 7.00 | 9.20 | – | 1.80 | – | 1.80 | | 1.65 | 21.00 | 29.55 | 50.55 |
| 4. Operation / Maintenance Equipment | – | – | – | – | – | – | – | – | – | – | 11.88 | 2.97 | 11.88 | 2.97 | 14.85 |
| 5. Administration Cost | – | 12.27 | – | 18.40 | – | 24.54 | – | 24.54 | – | 24.54 | – | 18.41 | – | 122.70 | 122.70 |
| 6. Engineering Services | 70.00 | 14.00 | 19.30 | 5.70 | 19.30 | 5.70 | 15.45 | 4.60 | 15.40 | 4.60 | 7.80 | 2.21 | 147.25 | 36.81 | 184.06 |
| Sub - total (2 - 6) | 70.00 | 26.27 | 33.30 | 52.30 | 26.30 | 39.94 | 15.45 | 31.44 | 15.40 | 31.18 | 19.68 | 25.24 | 180.13 | 206.37 | 386.50 |
| Total (1 - 6) | 70.00 | 26.27 | 77.99 | 74.72 | 260.14 | 136.20 | 355.31 | 138.72 | 500.14 | 160.32 | 84.15 | 36.44 | 1,347.73 | 572.67 | 1,920.40 |
| 7. Physical Contingencies | 7.00 | 2.63 | 7.80 | 7.47 | 26.01 | 13.62 | 35.53 | 13.87 | 50.01 | 16.03 | 8.42 | 3.61 | 134.77 | 57.23 | 192.00 |
| Total (1 - 7) | 77.00 | 28.90 | 85.79 | 82.19 | 286.15 | 149.82 | 390.84 | 152.59 | 550.15 | 176.35 | 92.57 | 40.05 | 1,482.50 | 629.90 | 2,112.40 |
| 8. Price Escalation | 0.85 | 1.84 | 1.89 | 10.86 | 9.55 | 30.64 | 17.48 | 42.97 | 30.93 | 64.13 | 6.30 | 18.16 | 67.00 | 168.60 | 235.60 |
| Total (1 - 8) | 77.85 | 30.74 | 87.68 | 93.05 | 295.70 | 180.46 | 408.32 | 195.56 | 581.08 | 240.48 | 98.87 | 58.21 | 1,549.50 | 798.50 | 2,348.00 |
| B. Indirect Project Cost | | | | | | | | | | | | | | | |
| 1. Lateral / Sub-lateral Pipeline | – | – | 7.07 | 3.23 | 14.13 | 6.46 | 21.20 | 9.69 | 14.13 | 6.46 | 14.14 | 6.45 | 70.67 | 32.29 | 102.96 |
| 2. Connection Pipeline | – | – | 2.74 | 1.37 | 5.49 | 2.74 | 8.23 | 4.11 | 5.49 | 2.74 | 5.48 | 2.74 | 27.43 | 13.70 | 41.13 |
| 3. On-farm Facility | – | – | 16.12 | 6.91 | 32.25 | 13.82 | 48.37 | 20.73 | 32.25 | 13.82 | 32.24 | 13.82 | 161.23 | 69.10 | 230.33 |
| Total (1 - 3) | – | – | 25.93 | 11.51 | 51.87 | 23.02 | 77.80 | 34.53 | 51.87 | 23.02 | 51.86 | 23.01 | 259.33 | 115.09 | 374.42 |
| 4. Engineering Services | 15.00 | 6.70 | 3.30 | 1.34 | 3.30 | 1.34 | 3.30 | 1.34 | 3.30 | 1.34 | 3.24 | 1.34 | 31.44 | 13.40 | 44.84 |
| 5. Physical Contingencies | – | – | 2.57 | 1.15 | 5.23 | 2.34 | 7.70 | 3.43 | 5.23 | 2.34 | 5.20 | 2.25 | 25.93 | 11.51 | 37.44 |
| Total (1 - 5) | 15.00 | 6.70 | 31.80 | 14.00 | 60.40 | 26.70 | 88.80 | 39.30 | 60.40 | 26.70 | 60.30 | 26.60 | 316.70 | 140.00 | 456.70 |
| 6. Price Escalation | 0.20 | 0.40 | 0.70 | 1.80 | 2.00 | 5.50 | 4.00 | 11.10 | 3.40 | 9.70 | 4.10 | 12.00 | 14.40 | 40.50 | 54.90 |
| Total (1 - 6) | 15.20 | 7.10 | 32.50 | 15.80 | 62.40 | 32.20 | 92.80 | 50.40 | 63.80 | 36.40 | 64.40 | 38.60 | 331.10 | 180.50 | 511.60 |
| | | | | | | | | | | | | | | | |
| C. Grand Total (A + B) | 93.05 | 37.84 | 120.18 | 108.85 | 358.10 | 212.66 | 501.12 | 245.96 | 644.88 | 276.88 | 163.27 | 96.81 | 1,880.60 | 979.00 | 2,859.60 |
| | | | | | | | | | | | | | | | |

Table 7 - 5 Project Cost of Khlong San Sai Sub-Project

Unit : Million Baht

| Cost Item | 1990 | | 1991 | | 1992 | | 1993 | | 1994 | | 1995 | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FC | LC | FC | LC | FC | LC | FC | LC | FC | LC | FC | LC | FC | LC | Total |
| A. Direct Project Cost | | | | | | | | | | | | | | | |
| 1. Civil works | | | | | | | | | | | | | | | |
| 1.1 Storage Dam | – | – | – | – | – | – | 12.80 | 3.20 | 36.92 | 9.50 | 5.58 | 1.50 | 55.30 | 14.20 | 69.50 |
| 1.2 Pumping Station | – | – | – | – | – | – | – | – | 11.67 | 5.33 | – | – | 11.67 | 5.33 | 17.00 |
| Sub - total | – | – | – | – | – | – | 12.80 | 3.20 | 48.59 | 14.83 | 5.58 | 1.50 | 66.97 | 19.53 | 86.50 |
| | | | | | | | | | | | | | | | |
| 2. Land Acquisition | – | – | – | – | – | 20.00 | – | 7.75 | – | – | – | – | – | 27.75 | 27.75 |
| 3. Administration Cost | – | – | – | – | – | 1.60 | – | 1.90 | – | 5.07 | – | 0.53 | – | 9.10 | 9.10 |
| 4. Engineering Services | – | – | 7.00 | 1.80 | – | – | 2.30 | 0.60 | 2.30 | 0.60 | 2.20 | 0.50 | 13.80 | 3.50 | 17.30 |
| Sub - total (2-4) | – | – | 7.00 | 1.80 | – | 21.60 | 2.30 | 10.25 | 2.30 | 5.67 | 2.20 | 1.03 | 13.80 | 40.35 | 54.15 |
| Total (1 - 4) | – | – | 7.00 | 1.80 | – | 21.60 | 15.10 | 13.45 | 50.89 | 20.50 | 7.78 | 2.53 | 80.77 | 59.88 | 140.65 |
| 5. Physical Contingencies | – | – | 0.70 | 0.20 | – | 2.20 | 1.50 | 1.35 | 5.11 | 2.10 | 0.72 | 0.27 | 8.03 | 6.12 | 14.15 |
| Total (1 - 5) | – | – | 7.70 | 2.00 | – | 23.80 | 16.60 | 14.80 | 56.00 | 22.60 | 8.50 | 2.80 | 88.80 | 66.00 | 154.80 |
| 6. Price Escalation | – | – | 0.20 | 0.30 | – | 4.90 | 0.90 | 4.20 | 3.80 | 8.20 | 0.70 | 1.00 | 5.60 | 18.60 | 24.20 |
| Total (1 - 6) | – | – | 7.90 | 2.30 | – | 28.70 | 17.50 | 19.00 | 59.80 | 30.80 | 9.20 | 3.80 | 94.40 | 84.60 | 179.00 |
| | | | | | | | | | | | | | | | |
| B. Indirect Project Cost | | | | | | | | | | | | | | | |
| 1. Lateral / Sub-lateral Pipeline | – | – | – | – | – | – | 0.90 | 0.41 | 0.90 | 0.41 | – | – | 1.80 | 0.82 | 2.62 |
| 2. Connection Pipe | – | – | – | – | – | – | 0.40 | 0.20 | 0.30 | 0.15 | – | – | 0.70 | 0.35 | 1.05 |
| 3. On-farm Facility | – | – | – | – | – | – | 3.10 | 1.40 | 3.10 | 1.30 | 3.07 | 1.28 | 9.27 | 3.98 | 13.25 |
| Total (1 - 3) | – | – | – | – | – | – | 4.40 | 2.01 | 4.30 | 1.86 | 3.07 | 1.28 | 11.77 | 5.15 | 16.92 |
| 4. Engineering Services | – | – | 1.40 | 0.35 | 0.40 | 0.09 | 0.30 | 0.08 | 0.30 | 0.08 | 0.30 | 0.08 | 2.70 | 0.68 | 3.38 |
| 5. Physical Contingencies | – | – | 0.10 | 0.05 | 0.10 | 0.01 | 0.50 | 0.21 | 0.50 | 0.16 | 0.33 | 0.14 | 1.53 | 0.57 | 2.10 |
| Total (1 - 5) | – | – | 1.50 | 0.40 | 0.50 | 0.10 | 5.20 | 2.30 | 5.10 | 2.10 | 3.70 | 1.50 | 16.00 | 6.40 | 22.40 |
| 6. Price Escalation | – | – | – | 0.10 | – | – | 0.20 | 0.60 | 0.30 | 0.80 | 0.20 | 0.70 | 0.70 | 2.20 | 2.90 |
| Total (1 - 6) | – | – | 1.50 | 0.50 | 0.50 | 0.10 | 5.40 | 2.90 | 5.40 | 2.90 | 3.90 | 2.20 | 16.70 | 8.60 | 25.30 |
| | | | | | | | | | | | | | | | |
| C. Grand Total (A + B) | – | – | 9.40 | 2.80 | 0.50 | 28.80 | 22.90 | 21.90 | 65.20 | 33.70 | 13.10 | 6.00 | 111.10 | 93.20 | 204.30 |

# CHAPTER 8. PROJECT EVALUATION

# CHAPTER 8. PROJECT EVALUATION

## 8.1. General

### 8.1.1. General Concept

The Project will contribute to the achievement of the Government's national objectives of improving national incomes, alleviating unemployment and underemployment in the province, and improving socio-economic conditions. The stable irrigation water supply to "Middle Right and Upper zone of the Chanthaburi river basin will be the major program under the Project.

The Project is consistent with the Government's plans for acceleration of stable fruits production and maximizes the improvement of the private sector in the province. The Project corresponds to the Government's sectoral objectives and strategies for the agriculture and trading.

There is considerable scope to improve the management and accelerate the development of the provincial natural resources of Chanthaburi. NGOs will be involved in transportation and marketing of farm inputs and outputs.

The Project provides the infrastructures required to increase fruit areas by 3,476 ha with 97,000 ton of production increase; 20% of Para rubber and paddy and 30-40% of cassava area will be converted into orchard.

### 8.1.2. Beneficiaries

The population of Project area are estimated at 26,000 with 5,700 households of which 90% are engaging agriculture. Most of the farm household in the area will benefit directly or indirectly from

the Project. The direct benefits consist of: (i) 900 of cassava production farms, and (ii) 3,900 of orchard and Para rubber production farms. It is difficult to estimate the indirect beneficiaries, however, additional full-time jobs and tremendous man-days of temporary jobs will become available.

The Project will also benefit farm input dealers and traders as well as entrepreneurs, manufacturers and contractors involved in the construction of the Project.

## 8.2. Methodology

### 8.2.1. Economic Analysis

Economic analysis measures of the affect of the Project from viewpoint of national economy. All the inputs and outputs which concern the Project are valued as international border price. The major traded goods and services are valued at the marginal international price taking into account a quality differential where applicable, and adjusted to economic costs allowing for transport, handling, storage and processing. The non-traded and minor traded goods and services are also converted to resource costs allowing for transportation charge excluded or subsidy and tax included. Economic pricing is done based on World Bank primary commodity price forecasts (December 1987), which indicates the price projections of the major commodities until 2000, expressed in March 1985 constant dollars, converted to local currency at the official exchange rate of $1.00 = ₱25.50. The standard conversion factor and the other conversion factors to apply to the costs for producing goods and services (not tariff in case of utilities and transport) are estimated based on the estimation by World Bank and ADB (refer to J.2.3 of Appendix J).

To realize the full economic benefit of the Project, the following conditions are essentially to be provided:

i) Completion of construction of all infrastructure in accordance with the construction schedule provided in Figure 6-3, and

ii) Organic coordination between the implementation agencies and line agencies.

The economic benefits consist of the value of incremental orchard and crop production, less the incremental production costs and the value of crop and orchard production foregone resulting from the construction of dams and pipeline systems. EIRR method is employed in the analysis and economic elasticity of the Project by adopting sensitivity analysis.

8.2.2. Financial Analysis

The most important aspect of the project viability concerns the financial impact on farm households in the Project area. Through the farm budget analysis on typical farm household models in the area, the solvencies for repayment from the standpoint of farm economy would be analyzed and consequently, the affordability to pay for the Project by beneficial farmers are justified.

There exists three major farming systems in the area, namely, orchard based, orchard plus Para rubber based and cassava plus orchard based farming systems, and toward each farming system, typical farm household model is applied.

The land resources, household consumption, production disposal, household expenditure and financial analysis are detailed for each household model. The land resources which includes the lands actually owned and for rent are classified by fruit and crop, and each fruit is further categorized by tree stage (matured and immatured) based on the result from "Survey for Area Proportion and Yield by Tree Age" conducted by Study Team. The household consumption and the production disposal were resulted from farm economy survey; viz. 5% of mangosteen, 2% of durian and 1% of rambutan are consumed by the family members in the present and these percentages are considered to be the same in the future situation.

While other crops/orchards are considered as; i) paddy is consumed at 100 kg/person/year, ii) all cassava and Para rubber productions are sold and iii) the other fruits consumption follows in the same manner as mangosteen.

The household expenditure was estimated by farm household model based on the farm economy survey and supplemental direct interviews to the farmers.

The farm budget analysis was made using above mentioned data allowing for yield differential arising from the Project. The Project shall be evaluated as family cash balance (disposable income: total cash income minus total cash expenditures), because the Project will not improve the living standard of the beneficiaries unless the farm households are able to generate surplus cash for non-cash expenditures.

The solvency for the repayment was estimated toward each farm model. To estimate the solvency, the following formula was used.

$$AP = DI \times \frac{FI}{TI}$$

where;

AP ... Solvency for the Project per year
DI ... Disposable income
FI ... Farm cash income
TI ... Total cash income

The affordability to pay for the Project by the beneficiaries were judged applying the following formula.

$$RR = \frac{TR}{IR}$$

where;

RR ... Income repayment ratio
TR ... Affordability to pay for the Project by the beneficiaries
IR ... Total incremental return by the Project

In this formula, IR is measured as incremental solvency derived from the Project and TR is calculated as uniform amortization for principal and interest provided that the beneficiaries' charges are loaned from the National Treasury.

The income repayment ratio is the index which indicates the repayment affordability by the beneficiaries, and it could be justified under the condition with less than 0.4 of RR.

## 8.3. Identification of Project Benefit

### 8.3.1. Tangible Benefit

The direct benefits of the Project are calculated based on the proposed cropping pattern, yields and areas, allowing for the economic costs of farm inputs and outputs. The net economic value of production in the future situation and annual net incremental value of production at full development is summarized below. General and specific assumptions and other related data/index applied in benefit quantification are outlined in Appendix-J.

| | Khlong Ta Liu Sub-Project | | Khlong San Sai Sub-Project | |
|---|---|---|---|---|
| | (Existing Area) | (Newly P. Area) | (Existing Area) | (Newly P. Area) |
| Acreage (ha) | ..... 25,278.9 .... | | ..... 2,982.6 ..... | |
| Without Project | | | | |
| Total NPV(฿'000) | 932,421 | 33,235 | 178,573 | 2,673 |
| With Project | | | | |
| Total NPV(฿'000) | 1,256,670 | 384,893 | 250,663 | 21,659 |
| Incremental NPV (฿'000) | 324,249 | 351,658 | 72,090 | 18,986 |
| Percentage (%) | 48% | 52% | 79% | 21% |
| Total (฿'000) | 675,907 | | 91,076 | |

The net production value (NPV) for overall project under the without project situation amounts to 1,147 million Baht and increase to 1,914 million Baht under the with project situation, so annual net incremental value of production at full development is computed at 767 million Baht as shown in Table 8-1. The benefit accrual of each sub-project is detailed in Appendix-J.

8.3.2. Intangible Benefit

(1) Non-Quantified Benefit

The Project will have indirect benefits which are not included in the estimation of the financial and economic benefits, these are discussed below:

- The augmentations of off-farm income and non-farm income under the Project are not quantified. The Project will create a number of full-time and temporary jobs, however these subsequent incomes are not considered in the financial analysis.

- The savings of the expenses in drought year; viz. irrigation water, hired labor for watering etc., are to be realized under with project situation, however, these savings are not quantified.

- The direct benefits accruing from the access road to damsite are not quantified. The direct benefits from this road construction are taken as vehicle operating cost savings (consumer surplus) and development benefits (producer surplus), however these benefits are extremely small and negligible as compared with substantial benefits from dam construction.

- The other small and negligible benefits incidental to the Project are not quantified.

(2) Non-Quantifiable Benefit

The following benefits are to be identified as non-quantifiable benefits which can not be measured numerically, however these are

Table 8-1 Incremental Net Production Value */

(Unit ; B '000)

| | Durian | Rambutan | Mangosteen | P. Rubber | Cassava | Groundnut | Paddy | Vegetable | Total |
|---|---|---|---|---|---|---|---|---|---|
| I. Without Project | | | | | | | | | |
| I. 1 Khlong Ta Liu Sub-Project | | | | | | | | | |
| - Existing Area | 441,689 | 227,819 | 92,485 | 141,771 | 27,736 | - | 921 | - | 932,421 |
| - Newly Planted Area | - | - | - | 21,827 | 11,320 | - | 88 | - | 33,235 |
| - Sub-total | 441,689 | 227,819 | 92,485 | 163,598 | 39,056 | - | 1,009 | - | 965,656 |
| I. 2 Khlong San Sai Sub-Project | | | | | | | | | |
| - Existing Area | 96,555 | 49,643 | 20,223 | 11,230 | 795 | - | 127 | - | 178,573 |
| - Newly Planted Area | - | - | - | 2,296 | 372 | - | 5 | - | 2,673 |
| - Sub-total | 96,555 | 49,643 | 20,223 | 13,526 | 1,167 | - | 132 | - | 181,246 |
| I. 3 Total | 538,244 | 277,462 | 122,708 | 177,124 | 40,223 | - | 1,141 | - | 1,146,902 |
| II. With Project | | | | | | | | | |
| II. 1 Khlong Ta Liu Sub-Project | | | | | | | | | |
| - Existing Area | 648,258 | 315,647 | 130,515 | 136,494 | 25,027 | - | 729 | - | 1,256,670 |
| - Newly Planted Area | 226,933 | 111,634 | 45,695 | - | - | 157 | - | 474 | 384,893 |
| - Sub-total | 875,191 | 427,281 | 176,210 | 136,494 | 25,027 | 157 | 729 | 474 | 1,641,563 |
| II. 1 Khlong San Sai Sub-Project | | | | | | | | | |
| - Existing Area | 141,712 | 68,781 | 28,539 | 10,813 | 717 | - | 101 | - | 250,663 |
| - Newly Planted Area | 12,778 | 6,208 | 2,573 | - | - | 25 | - | 75 | 21,659 |
| - Sub-total | 154,490 | 74,989 | 31,112 | 10,813 | 717 | 25 | 101 | 75 | 272,322 |
| II. 3 Total | 1,029,681 | 502,270 | 207,322 | 147,307 | 25,744 | 182 | 830 | 549 | 1,913,885 |
| III Incremental Net Production Value | 491,437 | 224,808 | 94,614 | △29,817 | △14,479 | 182 | △311 | 549 | 766,983 |

*/ For detail, see Tables J.2.17 to J.2.26 of Appendix J.

taken for the influential effectiveness toward the nearby provinces and all over Thailand.

- Vitalization and stabilization of provincial economy through the increase of fruits production could be expected, however it is impossible to quantify.

- The expansion of economic life span of fruits trees brought about by the provision of considerable irrigation water could surely anticipated, however the production increase based on this hypothesis is too risky to measure.

- Encouragement of cooperative spirit among farmers and merchants through the formation of various organizations such as irrigators' associations, and merchants' unions is significant benefits, but impossible to measure.

- Utilization of damsite as recreation spot and tourist industry would be proceeded in the future, however it can not be measured so far.

- Areal differential between northern part and southern part of Chanthaburi would be moderated; a part of these benefits are quantified through the financial analysis but the bulk of these are impossible to enumerate.

## 8.4. Economic Analysis

### 8.4.1. Economic Project Cost

The direct financial costs and benefits are quantified and converted to economic prices for the purpose of estimating the economic internal rate of return (EIRR).

The total economic cost of the overall project is amounted to 2,636 million Bahts, of which 907 million Bahts is for construction of dams, 16 million baht is for regulating reservoir, 67 million Bahts is for pumping station, 592 million Bahts is for main pipeline, 143 million Bahts is for lateral and sub-lateral pipelines, 232 million Bahts is for terminal end facilities and 679 million Bahts is for project management. The economic costs

includes physical contingencies but excludes the price escalation, land acquisition costs and other Government's taxes and subsidizations. The annual economic operation and maintenance costs (economic recurrent costs) amount to 22 million Bahts after completion of the Project. The breakdown of the economic project cost is tabled in Appendix-J.

8.4.2. Economic Internal Rate of Return

The six cases categorized by proposed dam capacities were evaluated adopting EIRR method, the risk analysis using six cases of sensitivity analysis were also examined.

The six cases evaluated in this analysis were tabled as follows;

| Case | Dam Capacity (MCM) | | Beneficial Area (ha) | | | |
|---|---|---|---|---|---|---|
| | Khlong Ta Liu | Khlong San Sai | Khlong Ta Liu | | Khlong San Sai | |
| | | | (Existing) | (Newly P.) | (Existing) | (Newly P.) |
| Case 1 | 33.0 | 9.3 | 9,351.4 | 3,345.7 | 2,040.7 | 192.5 |
| Case 2 | 43.2 | 12.9 | 9,351.4 | 3,345.7 | 2,040.7 | 192.5 |
| Case 3 | 33.0 | - | 9,351.4 | 3,345.7 | - | - |
| Case 4 | - | 9.3 | - | - | 2,040.7 | 192.5 |
| Case 5 | 43.2 | - | 9,351.4 | 3,345.7 | - | - |
| Case 6 | - | 12.9 | - | - | 2,040.7 | 192.5 |

Note: Case 1 indicates proposed project scale.

The overall project Economic Internal Rate of Return (EIRR) is estimated at 14.62%. About 90% of the project benefit is attributable to Khlong Ta Liu Sub-Project and wherein 50% is derived from newly planted area of Upper zone. Since however this benefit composes a large part of overall benefits (Approx. 46% of overall benefit), the benefit accrual is expected at four to eight year after the completion of the project, therefore the project EIRR is not so much affected by it. EIRRs of each case study are summarized below, wherein Khlong San Sai Sub-Project shows comparatively high EIRRs due to higher occupancy rate of existing orchard area.

| Case | Project EIRR | | |
|---|---|---|---|
| | Khlong Ta Liu | Khlong San Sai Sub-Project | Overall Project |
| Case 1 | - | - | 14.62 |
| Case 2 | - | - | 14.23 |
| Case 3 | 13.60 | - | - |
| Case 4 | - | 32.90 | - |
| Case 5 | 13.24 | - | - |
| Case 6 | - | 31.80 | - |

8.4.3. Sensitivity Analysis

The sensitivity analysis highlighted the effects of changes in parameters tabled as follows;

| | EIRR (%) |
|---|---|
| - Base Case | 14.62 |
| - Two-Year Delay in Benefit Accrual | 12.38 |
| - Five-Year Delay in Benefit Accrual | 10.16 |
| - Benefit minus 10% | 13.59 |
| - Cost plus 10% | 13.72 |
| - Two-Year Delay in Project Commencement | 14.61 |
| - Five-Year Delay in Project Commencement | 14.59 |

The project EIRR is the most sensitive to delay in the accrual of benefits. EIRR declines from 14.62 % in base case to 12.38% in two-year delay and to 10.16% in five-year. A 10% decline in benefits due to price or yield decreases results in EIRR falling from 14.62% to 13.59%. An increase in costs has a little impact on EIRR.

8.5. Financial Analysis

8.5.1. Definition of Farm Model

Three farm models classified by the typical farming system in the area are established based on the statistical data and the farm economy survey. The farm household size is constant and no increase

of family member are considered in the future (assuming 4.7% of population increase would be absorbed in additional households). The household models and their physical parameters are shown in the following:

| Farming System/ Household Model | Area | Estimated Farm Household | Land Holding Area (rai)* Total | Durian | Rambutan | Other Orchard | Para Rubber | Cassava | Other |
|---|---|---|---|---|---|---|---|---|---|
| 1. Model 1 (Orchard) | Middle-Right | 1,500 | 27.40 | 6.53 | 17.70 | 1.10 | 1.07 | - | 1.0 |
| 2. Model 2 (Orchard + Para Rubber) | -ditto- | 2,400 | 28.38 | 4.18 | 6.78 | 2.06 | 14.75 | - | 0.61 |
| 3. Model 3 (Cassava + Orchard) | Upper | 900 | 38.36 | 4.39 | 5.86 | - | 6.33 | 18.67 | 3.11 |

Note: * ... Land holding area includes the lands actually owned and for rent and excluding the residential area (Approx. 0.8 rai per farm).

8.5.2. Farm Budget Analysis

The annual net cash incomes of 3 models show the mushroom growth under with project situation. It is expected that the annual cash income under with project situation will increase ranging from 138% to 210% of that under the present situation. The highest increase is realized in Model 3 farm on a cassava plus orchard production farm and the lowest increase is in Model 1 on a orchard production farm.

Measures of family cash balance indicate that farm households will increase significantly their disposable cash income for non-food expenditures such as education, recreation as well as for future expansion of agriculture and ensure households' contribution to the project charge. The Model 3 farm shows the highest increase of 246%, and to the contrary Model 1 denotes the lowest of 166% compared with the those in the present situation. (refer to Tables 8-2 to 8-4).

Table 8-2. Annual Net Farm Income

(units: Baht, %)

| Household Model | Present (1989) | With Project (2005) | Percentage Increase |
|---|---|---|---|
| Model-1 Orchard-based Farm | 199,289 | 292,872 | 147 |
| Model-2 Para Rubber + Orchard Based Farm | 126,906 | 232,714 | 183 |
| Model-3 Cassava + Orchard Based Farm | 116,286 | 265,467 | 228 |

Table 8-3. Annual Family Cash Balance

(units: Baht, %)

| Household Model | Present (1989) | With Project (2005) | Percentage Increase |
|---|---|---|---|
| Model-1 Orchard Bread Farm | 139,892 | 231,644 | 166 |
| Model-2 Para Rubber + Orchard Based Farm | 80,097 | 175,214 | 219 |
| Model-3 Cassava + Orchard Based Farm | 85,086 | 209,409 | 246 |

Table 8-4. Annual Cash Income

(units: Baht, %)

| Household Model | Present (1989) | With Project (2005) | Percentage Increase |
|---|---|---|---|
| Model-1 Orchard Based Farm | 255,802 | 351,938 | 138 |
| Model-2 Para Rubber + Orchard Based Farm | 167,238 | 278,548 | 167 |
| Model-3 Cassava + Orchard Based Farm | 155,578 | 326,097 | 210 |

Comparing with the result from farm economy survey, the net farm income deriving from financial analysis is considered to be more or less high. The reasons are explained as follows;

- The farms who possess the bulk of immatured fruit trees are unexpectedly surveyed in farm economy survey.
- The farmers were very hesitant to reply about their budgetary status.

It might be true that the farms which entered into orchard production lately have not yet reached the net farm income analyzed by farm budget analysis, however as the trees are getting matured, their farm budget is unaffectedly approached to analyzed one.

## 8.6. Finance and Cost Demarcation of the Project

### 8.6.1. Existing Government Financed Project

Since the establishment of the Land Consolidation Act in 1974, the farmers are asked to contribute a portion of the project costs for the on-farm water supply and drainage system. However, there are not so many projects on which this enforcement is practically applied so far. Within large scale construction projects implemented so far, only a few projects are planned under the levy on the beneficiaries, which ranges from ฿100 - 200/rai at most and the most of them cover - in the long run - only less than 50% of total project costs.

In general, there are scarce example in the developing countries, where the full cost recoveries for a large scale irrigation project are accomplished before. In this regard, the World Bank has reported once that cost recovery rates which are dealt with by the Bank in several projects averaged only 30% of the total costs (includes operation and maintenance costs). Therefore 30% of cost recovery rates would be one of the touchstone of the analysis. (refer to "Government's Subsidization" of Appendix J)

### 8.6.2. Alternative Study on Cost Allocation

This section seeks to verify whether the project costs for the facilities from distribution point of 200ha commandable area downwards are payable by the beneficialies' financial capability of the present and the future situation, and if possible, what to extent of the facilities. The alternatives are also discussed here.

#### (1) Beneficiaries' Solvency

The capability to pay was estimated assuming that irrigation would be undertaken on the farmers' own initiative through their private distribution pipelines and irrigation facilities. Since however, most farmers are pumping from the river or pond except the drought year, it may be difficult to levy undue charges. The remote farmers from the river or pond would be the most substantial beneficiaries, and at present, their net returns per hectare is about ฿45,500 for orchard based farms, ฿28,000 for Para rubber plus orchard based farms and ฿19,000 for cassava plus orchard based farms, respectively.

The beneficiaries' solvency by typical farm model was calculated adopting aforesaid formula and resulted as ฿137,000/HH for orchard based farms, ฿76,000/HH for Para rubber plus orchard based farms and ฿79,000/HH for cassava plus orchard based farms, which correspond to ฿33,300/ha, ฿29,600/ha, and ฿28,800/ha, respectively (refer to Table 8-5).

#### (2) Beneficiaries' Affordability

Beneficiaries' affordability is defined as willingness-to-pay for the project by the beneficial farmers. As the beneficiaries' affordability, 40% of incremental beneficiaries' solvency arising from increase of fruits production was applied (refer to Table 8-6).

Table 8-5. Beneficiaries' Solvency (at Present)

| No. | Item | Unit | Model-1 (Orchard) | Model-2 (Para Rubber + Orchard) | Model-3 (Cassava + Orchard) |
|---|---|---|---|---|---|
| (1) | Family Cash Balance | Baht | 139,892 | 80,097 | 85,086 |
| (2) | $\frac{\text{Farm Cash Income}}{\text{Total Cash Income}} \times 100$ | % | 97.7 | 94.4 | 92.9 |
| (3) | (1) x (2) | Baht | 136,624 | 75,649 | 79,028 |
| (4) | Rounded-off | Baht | 137,000 | 76,000 | 79,000 |
| (5) | Orchard Area | Ha | 4.12 | 2.57 | 2.74 |
| (6) | Solvency per Hectare | Baht | 33,252 | 29,572 | 28,832 |

Table 8-6. Affordability-to-Pay for the Project

| No. | Item | Unit | Model-1 (Orchard) | Model-2 (Para Rubber + Orchard) | Model-3 (Cassava + Orchard) |
|---|---|---|---|---|---|
| (1) | Beneficiaries' Solvency (at Present) | Baht | 137,000 | 76,000 | 79,000 |
| (2) | Beneficiaries' Solvency ("With" Project) | Baht | 228,000 | 169,000 | 202,000 |
| (3) | Difference | Baht | 91,000 | 93,000 | 123,000 |
| (4) | (3) x 0.4 | Baht | 36,400 | 37,200 | 49,200 |
| (5) | Rounded-off | Baht | 36,000 | 37,000 | 49,000 |
| (6) | Orchard Area ("With" Project) | Ha | 4.12 | 2.57 | 2.74 |
| (7) | Affordability-to-Pay (Per Hectare) | Baht | 8,738 | 14,397 | 17,883 |

Beneficiaries affordability was estimated as ฿36,000/HH for orchard based farms, ฿37,000/HH for Para rubber plus orchard based farms and ฿49,000/HH for cassava plus orchard based farms, which correspond to per hectare basis at ฿8,700, ฿14,400 and ฿17,900, respectively.

(3) Cost Allocation

The beneficiaries' affordability and costs to be recovered were compared. The future land use plan of three typical farms classifies existing area and newly planted area; the former represents unchanged area by the Project and the latter includes converted orchard and double cropped area from other annual/perennial crops.

Based on the change of land utilization on three farm models brought about the Project, the project costs to be recovered by each farm model were analyzed by sub-project, by the project demarcation and by water source and subsequently, these amounts were compared with their affordability to pay for the Project; the results and case studies are shown as follows and cost allocation of initial investment adopted to Base Case is detailed in Table 8-7.

(unit: Baht/ha)

| Sub-Project | Khlong Ta Liu | | Khlong San Sai |
|---|---|---|---|
| Water Source | River Water | Farmpond | River Water |
| Type 1: Orchard-based Farms | | | |
| - Cost Recovery | | | |
| i) Base case | 9,190(26) | 9,450(26) | 2,112(6) |
| ii) Alt. 1 | 17,645(49) | 49,482(137) | 7,113(20) |
| iii) Alt. 2 | 17,320(48) | 47,761(133) | 2,112(6) |
| - Affordability | 36,000 | 36,000 | 36,000 |

## Table 8-7 Cost Allocation of Initial Investment

(Unit : Million Baht)

| Construction Work | Khlong Ta Liu Sub-Project (12,897.1ha) | | | | | | | | | Khlong San Sai Sub-Project (2,233.2ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Cost | River Water Source Area (772.5ha) | | | | Farm Pond Source Area (11,924.6ha) | | | | Initial Cost | River Water Source Area (2,233.2ha) | | | |
| | | Existing Area | | Developing Area | | Existing Area | | Developing Area | | | Existing Area | | Developing Area | |
| | | ha or % | Amount | ha or % | Amount | ha or % | Amount | ha or % | Amount | | ha or % | Amount | ha or % | Amount |
| 1. Dam with Structure | 830.50 | 474.1ha (61.4%) | 31.0 | 298.4ha (38.6%) | 19.5 | 8,877.3ha (74.4%) | 580.6 | 3,047.3ha (25.6%) | 199.4 | 69.50 | 2,040.7ha (91.4%) | 63.5 | 192.5ha (8.6%) | 6.0 |
| 2. Diversion Dam | 22.60 | 190.1ha | 0.2 | 196.9ha | 0.4 | 8,877.3ha | 16.4 | 3,047.3ha | 5.6 | - | | - | | - |
| 3. Main Pipeline | 611.20 | 100.1ha | 5.0 | 196.9ha | 9.8 | 8,877.3ha | 444.0 | 3,047.3ha | 152.4 | - | | - | | - |
| 4. Regulating Res. | 17.10 | - | - | - | - | 8,877.3ha | 14.8 | 1,401.6ha | 2.3 | - | | - | | - |
| 5. Sub-pumping Station | 52.50 | - | - | - | - | 34.0ha | 1.6 | 1,052.6ha | 50.9 | 17.00 | 237.0ha | 13.3 | 65.8ha | 3.7 |
| Sub-total | 1,533.90 | | 36.2 | | 29.7 | | 1,057.4 | | 410.6 | 86.50 | | 76.8 | | 9.7 |
| 6. Lateral/Sub-lateral | 102.96 | 474.1ha | 3.8 | 298.4ha | 2.4 | 8,877.3ha | 72.0 | 3,047.3ha | 24.8 | 2.62 | 2,040.7ha | 2.4 | 192.5ha | 0.2 |
| 7. Connection Pipe | 41.13 | 474.1ha | 1.5 | 298.4ha | 1.0 | 8,877.3ha | 28.8 | 3,047.3ha | 9.8 | 1.05 | 2,040.7ha | 1.0 | 192.5ha | 0.1 |
| 8. On-farm Facility | 230.33 | - | - | 298.4ha | 20.5 | - | - | 3,047.3ha | 209.8 | 13.25 | - | - | 192.5ha | 13.3 |
| Sub-total | 374.42 | | 5.3 | | 23.9 | | 100.8 | | 244.4 | 16.92 | | 3.4 | | 13.6 |
| Total | 1,908.32 | | 41.5 | | 53.6 | | 1,158.2 | | 655.0 | 103.42 | | 80.2 | | 23.3 |
| - Cost per ha | B150,296 | | B87,534 | | B179,625 | | B130,468 | | B214,944 | B46,310 | | B39,300 | | B121,039 |
| - Government | B120,807 (80.4%) | | B76,355 (87.2%) | | B99,532 (55.4%) | | B118,933 (91.2%) | | B134,742 (62.7%) | B38,733 (83.6%) | | B37,634 (95.8%) | | B50,390 (41.6%) |
| - Beneficiary | B29,489 (19.6%) | | B11,179 (12.8%) | | B80,093 (44.6%) | | B11,535 (8.8%) | | B80,202 (37.3%) | B7,577 (16.4%) | | B1,666 (4.2%) | | B70,649 (58.4%) |

(cont'd.)

Type 2: Orchard+Rubber)-based Farms

| | | | |
|---|---|---|---|
| - Cost Recovery | | | |
| i) Base case | 11,288(31) | 11,430(31) | 6,878(19) |
| ii) Alt. 1 | 18,433(50) | 37,672(102) | 11,018(30) |
| iii) Alt. 2 | 18,156(49) | 35,592(96) | 6,878(19) |
| - Affordability | 37,000 | 37,000 | 37,000 |

Type 3: Orchard+Cassava)-based Farms

| | | | |
|---|---|---|---|
| - Cost Recovery | | | |
| i) Base case | 19,233(39) | 19,348(39) | 14,529(30) |
| ii) Alt. 1 | 29,262(60) | 48,973(100) | 20,263(41) |
| iii) Alt. 2 | 28,871(59) | 44,724(91) | 14,529(30) |
| - Affordability | 49,000 | 49,000 | 49,000 |

Remarks: Base Case, Alt. 1, Alt. 2 in this table are classified based on the item number in Table 8-7; viz. item 1-5 (Base Case), 1 (Alt. 1), 1-2 & 5 (Alt.2), are to be charged by the Government, in turn. The figures on this table are calculated on the assumption that the other items mentioned above are charged by the beneficiaries in question. The figures in parentheses indicate percentage of cost recovery amount to affordability.

The total repayment period of 15 years, with 5 years of grace period and an annual interest of 12.5% was assumed. The conditions of the loan was based on the BAAC's long-term loans for agricultural development project.

The table denotes that the full cost recovery is accomplished only in Base Case at 10% to 40% of beneficiaries' affordability. This situation would not be so hard for the farmers to pay additional costs for operation and maintenance. Two alternative studies show brightly that the orchard based farms at farmpond area of Khlong Ta Liu sub-project have no affordability to pay for the Project under the cases of alternative 1 and 2. Therefore, Base Case should be applied for the subject cost allocation between the Government and the beneficiaries.

## 8.7. Project Justification

### (1) Financial Viability

Through the implementation of the Project, considerable increase of family cash income compared with present condition ranging from 47% to 110% can be expected and consequently, the beneficiaries can contribute to the charge for the project cost at 10-40% of beneficiaries affordability, therefore, the Project is concluded to be financially viable.

Beneficiaries' charges to the Project recommended through the analysis amounted to 374.42 million Baht for Khlong Ta Liu sub-project and 16.92 million Baht for Khlong San Sai sub-project, which correspond to approx. 20% and 16% of the initial project costs, respectively. Since the government has not asked the beneficiaries of cost recovery for the project so far, approx. 20% charge from the beneficiaries is favorably justifiable even though this rate is lower than the WB's touchstone of 30%.

### (2) Economical Feasibility

The Project EIRR was computed at 14.62% which is about 1.6% higher than the rate for opportunity cost of capital in Thailand of 13%. Sensitivity analysis also denoted that the Project has sufficient elasticity against the various kinds of the project risks, thus, economical feasibility of the Project was also ensured.