6.3.3 Proposed Farming Practices

Together with the introduction of modernized irrigation and drainage system, the improved farming practices will be introduced into the project area to maintain the high crop productivity. The followings are descriptions of proposed farming practices particularly for paddy and other major crops cultivation.

(1) Paddy Cultivation

For the increase of paddy yields, distribution of good quality as well as high yield varieties of seeds are essential. In this context, the RD varieties such as RD-21, RD-23 and RD-25 of non-glutinous rice and RD-4 and RD-10 of glutinous rice, all of which are high yield varieties, Lueng Yai 148, Khao Dawk Mali 105, Hom Ma Li 105 of non-glutinous rice and San Pa-Tong, Mei-nong 62 M, Niew San Pa Tong of glutinous rice, all of which are improved local varieties, are recommended in the project area from the viewpoints of physiology and productivity.

The amount of seed needed is about 5 kg per rai of main paddy field. The required amount of fertilizer for nersery bed (6 - 7% of main paddy field) per rai of main field is about 100 g of urea and 50 g of triple super phosphate respectively. Prior to the seeding, the seed should be selected by a solution of 1.13 specific gravity, and further be treated by using agro-chemicals such as Benlate-T or Homai for disease control.

Land preparation for transplanting will be started a half month before the transplanting in general. The recommended number of seedling per hill is 3-4, and the optimum planting density is about 20 hills per m^2 for high yield varieties and 15 hills per m^2 for local varieties.

Mixed fertilizer of 20 kg per rai will be applied as the basic fertilizer about 5 days before transplanting. Top dressing will be carried out 2 to 3 times; about 15 days after transplanting, at the initial young panicle formation stage and at the full heading stage. The amount of fertilizer will be 15 kg/rai of urea for each dressing time.

Insect and disease control for paddy cultivation should be carried out at the proper time without delay. Recommendable agro-chemicals are Sumithion, Diazinon, etc. for insect control, and Kasumin, Kitazin, etc. for disease control. For rat control, it is proposed to apply zink phosphate at the rate of about 40 g per rai.

Weed control will be carried out 2-3 times according to the condition of the weed growth. The proposed practices for weeding is to use the rotary weeder. For the weed control in future, herbicides may be applied, but careful consideration should be given to their apply because of their adverse effectiveness.

Proper water management is very essential on paddy cultivation. There are critical periods in the life of the rice plant against the shortage of water, i.e. just after sowing or transplanting time, panicle initiation stage, reduction division stage and flowering stage. Proper irrigation management should be introduced according to the growth stage.

At present, harvesting of paddy is being done manually using sickles, and threshing is also being done manually or using animal power. In future, however, the mechanical threshing by means of engine-driven harvester and treadle thresher will be introduced to the area.

(2) Other Major Crops

Other major crops such as mungbeans and tobacco will mainly be cultivated in every sub-project area after harvesting the rainy season paddy.

The standard cultivation methods of these crops are summarized as follows:

(a) Mungbeans

i)	Sowing	- seed ; 6 kg/rai - spacing; 25 cm x 25 cm or row 50 cm and hole 20 cm with dig 4-5 seeds/hole
ii)	Application of fertilizer (1st)	- mixed fertilizer; 6 kg/rai
iii)	Insect control (1st)	- sumithion; 0.15 lit/rai
iv)	Application of fertilizer (2nd)	- mixed fertilizer; 4 kg/rai
v)	Insect and disease control (2nd)	- sumithion; 0.15 lit/rai - fungicide; 0.10 lit/rai
vi)	Harvesting	- by hand, 2 times
vii)	Drying	- 2-3 times

(b) Tobacco

(Nursery)

i)	Application of fertilizer	- NPK fertilizer; 1 kg/5 x 1 m
ii)	Insect control (1st)	- furodal; 150 g/5 x 1 m
iii)	Sowing	- seed mixed with ash; 1 kg/5 x 1 m

iv)	Insect and disease control	- asodrin and lannate

(Main field)

i)	Basic manuring	- mixed fertilizer; 100 kg/rai
ii)	Planting	- mid-Oct. - mid-Nov. - spacing; 50-60 cm x 100 cm or 3,500 trees/rai
iii)	Application of fertilizer (1st)	- urea; 30 kg/rai
iv)	Insect and disease control	- Diazinon; 0.3 lit/rai - Captan ; 0.15 lit/rai
v)	Application of fertilizer (2nd)	- mixed fertilizer; 50 kg/rai
vi)	Insect and disease control	- Sumithion; 0.4 lit/rai - Captan ; 0.15 lit/rai
vii)	Application of fertilizer (3rd)	- urea; 20 kg/rai
viii)	Insect and disease control	- Diazinon; 0.3 lit/rai - Captan ; 0.2 lit/rai
ix)	Harvest	- 5-6 times

Modern cultivation techniques such as introduction of high yield varieties, reasonable fertilizer application method and insect and disease control should be introduced into the area after completion of the project. In order to attain the expected high yields of these crops, it is inevitable to provide not only the above-mentioned modern cultivation techniques but also strengthening of the present agricultural support services.

6.3.4 Farm Inputs and Labour Requirements

(1) Farm Inputs

After implementation of the project, the farm inputs will increase substantially. TABLE 6.1 shows the amount of farm inputs estimated for each crop in "with project" condition. These requirements were estimated based on the experimental data available, input requirement recommended by Provincial Agricultural Extension Service Office, Branch of Economy and Irrigated Agriculture Section, RID. The quantity of fertilizers and agro-chemicals needed will also remarkably increase. As for the farm inputs under "without project" condition, it is considered that the farming conditions will not much change from the present ones, and accordingly, the amount of farm input in case of "without project" is taken to be the same as that of the "present condition" in the estimate of the project benefit.

(2) Labour Requirements

Family labour will mainly be used for farming throughout the year. Some temporary labour will be employed during the period of transplanting and harvesting of paddy and harvesting of tobacco at present. The proposed farming will be practiced basically by family labour with some agro-machinery such as hand tractor, sprayer, thresher and other farming equipment and tools.

TABLE 6.2 shows the labour requirements for the typical farm family in the respective sub-project areas. As is clear from the table, the family labour can cover the labour requirements throughout the year.

6.3.5 Anticipated Crop Yields and Production

With introduction of improved farming practices and proper water management, the crop yield is expected to increase substantially. The following table shows the target yields of major crops and production. The time required for the target yield depends on mainly progress of the agricultural support services. The anticipated build-up period after the implementation of development varies depending on the field conditions. For this project, build-up period of 5 years is taken for every sub-project area, considering the presently well-developed field conditions and the existence of bases for the agricultural support services.

Crops	Yield (kg/rai)	Production (tons/year)				
		Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab	Total
Paddy						
- Local varieties	640	6,480	6,120	2,160	1,440	16,200
- High yield varieties	800	18,900	17,860	6,300	4,200	47,260
Mungbeans	240	1,220	1,150	410	270	3,050
Tobacco	400	2,700	2,560	900	600	6,760

6.3.6 Marketing and Price Prospects

(1) Marketing Prospects of Crops

The demand-supply balance of rice in 1990, when the full development of the project is attained, is estimated as follows:

Population in 1981	55,000
Population growth rate	2.66%
Population in 1990	70,000
Rice consumption per capita	150 kg/year
Total consumption of rice in 1990	10,500 tons
Total rice production in 1990	41,300 tons/1
Surplus	30,800 tons

Note: /1; Conversion factor of paddy to rice is 65%.

From the above estimate, it is expected that the surplus of rice would be 30,800 tons in 1990. This surplus will be exported to the outside of Phetchabun province particularly to the Bangkok market.

The production of mungbeans in the project area is about 1,000 tons at present. About a half of the products are used for home consumption and remainings are directly sold to local market or Bangkok through local merchants. After completion of the project works, about 3,000 tons of mungbeans are expected to be produced in the project area, and most of the products would be marketed to Bangkok or exported abroad.

About 1,600 tons of tobacco are produced at present in the project area, and most of the products are sold to Tobacco Monopoly Office or local merchants except a few home consumption. In some villages in the project area, the purchase price of tobacco by private tobacco companies or brokers is high by about 4 - 5 Baht/kg as compared with that of Tobacco Monopoly Office, and accordingly a large amounts of the products are sold to the private tobacco companies or brokers. After implementation of the project, about 6,700 tons of tobacco will be produced in the area, and most of the products will be marketed not only for domestic consumption in Thailand but also for export to abroad. One of the most important pre-requisites for smooth marketing of tobacco in future is to improve present market channel. The normal marketing flow of tobacco should not be through the tobacco brokers but through Tobacco Monopoly Office under close cooperation of MOF and other authorities concerned.

(2) Price Prospects

(a) Rice/paddy

Economic prices:

Economic prices of rice/paddy at farm gate are estimated on the basis of the projected international market prices forecasted by IBRD for the period of 1990 in 1982 converted constant US Dollars and further taking into account the costs for transportation, processing and others. TABLE 6.3 shows the economic price of rice/paddy at the farm gate estimated for the economic evaluation of the project.

Financial prices:

Financial prices of rice/paddy at farm gate are estimated based on available data on farm gate prices collected through farm economy survey and prevailing local market prices in Phetchabun and Lom Sak districts. The estimated financial prices of rice/paddy are also given in TABLE 6.3.

(b) Other crops

Economic prices of mungbeans and tobacco are estimated on the basis of projected international market prices forecasted by IBRD as shown in TABLE 6.3. Financial prices of the above products at farm gate are estimated based on the data and information collected from the Commercial Office in Phetchabun Province and Agricultural Extension Office and through farm economy survey.

(c) Farm inputs

Economic prices of farm inputs at farm gate are estimated based on the projected international market prices by IBRD. Their financial prices at farm gate are estimated on the basis of the results of farm economy survey carried out in 1982 and referring to the local market prices in Phetchabun and Lom Sak districts (TABLE 6.3).

6.3.7 Farm Budget

From the farmer's viewpoint, the financial evaluations for the cases of "with project" and "without project" are made for the typical farmers in the respective sub-project areas. Calculation of both income and outgo is made based on the production amount of crops, prices of crops estimated and inputs applied under "with project" and "without project" conditions respectively. In this study, both farm income and outgo under "without project" condition are taken to be the same as those of present condition, because it is considered that the farming condition in future will not much change from the present condition without implementation of the project.

The gross income under "with project" condition will increase remarkably after the full development of the project as compared with the income under "without project" condition. Such high income under "with project" condition is attributed to the production increase of rice and upland crops such as mungbeans and tobacco. The income from livestock is deemed to be insignificant.

The crop production cost under "with project" condition will also increase substantially due to application of proper amount of fertilizers and agro-chemicals. Although the living expenses of farmer under "without project" condition would not much change from the present basis, those under "with project" condition would substantially increase by approximately two items as compared with those under "without project" condition mainly due to raising of food consumption.

The following table shows the comparison of income, outgo and balance (capacity to pay) per farm family in both "with project" and "without project" conditions.

(Unit: Baht)

Description	Huai Saduang Yai Sub-project Area		Huai Khon Kaen Sub-project Area		Huai Yai Sub-project Area		Khlong Chaliang Lab Sub-project Area	
	With Project	Without Project	With Project	Without Project	With Project	Without Project	With Project	Without Project
Gross income	56,578	35,694	57,940	32,404	59,313	29,326	57,168	29,970
Farm outgo	48,830	34,908	49,902	32,357	49,527	29,273	49,044	29,921
Balance (capacity to pay)	7,749	786	8,038	47	9,786	53	8,124	49
(US$)	(337)	(34)	(349)	(2)	(425)	(2)	(353)	(2)

6.3.8 Net Incremental Benefit of the Project

The net incremental benefit of the project is defined as the difference between the net production value under "with project" condition and the net production value under "without project" condition. The net production value is further defined as the difference between the gross production value and the gross production cost in both "with project" and "without project" conditions.

The following table shows a summary of the incremental benefit of each sub-project area at the full development stage.

(Unit: 10^3 ฿)

Sub-project	With Project	Without Project	Net Incremental Benefit
Huai Saduang Yai	248,274	113,609	134,665
Huai Khon Kaen	234,933	71,556	163,377
Huai Yai	82,799	23,874	58,925
Khlong Chaliang Lab	55,157	18,235	36,922
TOTAL	621,163	227,274	393,889

6.3.9 Future Improvement of Agricultural Support System

In order to ensure the proposed agricultural development plan and to reap the fruitful project returns, the current agricultural supporting system must be remarkably improved for future with-project stage. Three major setups would be recommended as listed below:

i) Technical advisory committee,
ii) Seed multiplication farm, and
iii) Water users' association.

(1) Technical Advisory Committee

Agricultural extension and research works are administratively supervised by the Agricultural Extension Department and the Agriculture Department respectively. But, both works must be closely connected each other in attaining the advanced farming practices. The personnel concerned to both works should be urgently tied up under a better coordination.

In this connection, it is recommendable that a technical advisory committee would be instituted at the field level for the better coordination. The committee would be composed of the representatives of experimental station, seed center, provincial extension office and water users' association. The committee would be periodically held under the chairmanship of the provincial extension office, and various technical matters related to the agricultural extension and research works would fully be discussed in the committee.

(2) Seed Multiplication Farm

The distribution of tobacco seeds is effectively made by the Thai Tobacco Monopoly and private curing stations in the Phetchabun province at present, though it will be assuredly implemented by the current distribution system in the province even in the future with-project stage. Therefore, there is no constraint for the seeds distribution of tobacco in the Phetchabun province in the future. The seed distribution system for paddy and mungbeans is still under developing in the province at present. Most of the farmers in the project area are using low quality seeds of paddy and mungbeans which are usually purchased from their neighbours and/or private seed growers. The requirement of quality seeds of paddy and mungbeans would be sharply increased in the project area in pace with the future agricultural development.

To overcome the constraints for the seed distribution in the project area, it is recommended that seed multiplication farm should newly be developed and operated in both districts concerned under the guidance and control of the experimental station which is planned to be established in the province. For the smooth operation of the seed farm, the technical advisory committee above-mentioned will also play an leading role of the coordination among various agricultural offices concerned.

(3) Water Users' Association

To smoothly operate terminal irrigation system and to attain equitable water distribution at on-farm level, water users' group would be set up by one terminal irrigation block or about 100 water users, and the group would be federated into water users' association which will be set up under the irrigation system of each sub-project. The setup of the group and the association would be made under the guidance and assistance of RID. The further information and discussion on water users' association are given in ANNEX - IX.

6.4 IRRIGATION AND DRAINAGE DEVELOPMENT PLANS

6.4.1 Available Irrigation Water Resources

The project will depend on the four tributaries of the Pasak river, i.e. the Huai Saduang Yai, the Huai Khon Kaen, the Huai Yai and the Khlong Chaliang Lab, for its irrigation water. The water resources endowed in these tributaries will be exploited by constructing storage dams to the maximum extent as far as their hydrological, topographical and geological conditions allow. The average annual runoff and exploitable water resources at the respective proposed dam sites are assessed and tabulated below:

Rivers	Catchment Area (km^2)	Annual Runoff (MCM)	Storage Capacity (MCM)
Huai Saduang Yai	96	22.4	27.00
Huai Khon Kaen	322	75.1	30.00
Huai Yai	75	19.9	13.25
Khlong Chaliang Lab	77	20.5	6.73

6.4.2 Irrigation Water Requirements

Irrigation water requirements are calculated for the proposed cropping pattern taking the effective rainfall, which is obtained using the curve of rainfall-effective rainfall relationship developed by RID.

Potential evapotranspiration is estimated by two empirical formula; Modified Penman and Radiation Methods, using the meteorological data recorded in the Phetchabun Meteorological Station. The values thus calculated are averaged and used for the calculation of consumptive use of water.

Canal conveyance losses are assumed to be 20% of the diversion water requirements, and the field operation loss are 30% in paddy fields and 40% in upland fields respectively, which make the total irrigation efficiency of 56% for paddy field irrigation and 48% of upland field irrigation.

The peak water requirements and total diversion requirements for each sub-project area are as shown below (ANNEX - VIII).

Sub-project	Unit Design Water Requirements	Diversion Requirements
Huai Saduang Yai	1 lit/sec/ha	5.4 m^3/sec
Huai Khon Kaen	"	5.1 m^3/sec
Huai Yai	"	1.8 m^3/sec
Khlong Chaliang Lab	"	1.2 m^3/sec

6.4.3 Drainage Water Requirements

For the design of suitable drainage improvement plan within a feasible range, the study is made to estimate the drainage requirements for the areas, where the drainage improvement could be practiced economically by gravity. The study is made taking into account the various factors such as topographic conditions, present drainage conditions, soils, groundwater tables, etc., which vary from area to area.

The proposed drainage requirements are estimated for 3-day consecutive rainfall with a 10-year return period, using the rainfall data observed at Lom Sak (for the Huai Saduang Yai and the Khon Kaen sub-project areas) and at Phetchabun (for the Huai Yai and the Khlong Chaliang Lab sub-project areas). The design drainage requirements thus estimated are 4.5 lit/sec/ha in all the service area (ANNEX - VIII).

6.4.4 Irrigation and Drainage Systems

The layout planning of irrigation and drainage systems is made using the topographic maps on the scale of 1/10,000 and 1/50,000 and the results of topographic survey along the proposed main and lateral canals. The followings are brief descriptions of irrigation and drainage canal systems in the respective sub-project areas (PLATE NO. 06 through NO. 08).

(1) Huai Saduang Yai Sub-project Area

The water stored by the Huai Saduang Yai dam will be used for supplementary supply to the Sri Chan and the Pasak Left Bank service area.

The Sri Chan service area has 6,000 rai (960 ha) of net irrigation area, and at present its irrigation water is supplied temporarily from the Pasak river by small pumps. In 1982, the construction of a concrete weir has been started by RID on the Pasak river at about 3 km downstream from the confluence of the Pasak river with the Huai Saduang Yai.

The Pasak Left Bank Irrigation Project covering 31,440 rai (5,030 ha) of irrigable area has been operated by RID. This project was completed in 1968. The project facilities comprise an intake weir located about 8 km downstream from the Sri Chan weir, and 59 km of the main and lateral irrigation canals. Out of the total service area, about 3,670 rai (590 ha) will receive irrigation water from the Huai Khon Kaen reservoir because of the limited water resource of the Huai Saduang Yai.

Since the existing irrigation facilities in these service areas have fully functioned, no rehabilitation and/or up-grading work are considered under the project. The crop intensity would be increased from the present 115% to 135% in future, because more water supply than the present is expected by regulating the river flow.

The water stored by the Huai Saduang Yai dam is released downstream and conveyed to the above two service areas through the Huai Saduang Yai and the Pasak river. The irrigation water for the service areas will be taken off from the Pasak river by the two intake weirs mentioned above. The water thus taken off will be distributed to the irrigation areas using the existing irrigation facilities.

There is no serious drainage problem in this area, because dual-purpose canals of irrigation and drainage have been networked over the area, and accordingly, improvement work of drainage is not included in the project work.

(2) Huai Khon Kaen Sub-project Area

The irrigation area to be served by the Huai Khon Kaen reservoir amounts to 31,880 rai (5,100 ha) consisting of 3,690 rai (590 ha) of the Pasak Left Bank service area and 28,190 rai (4,510 ha) of the Huai Khon Kaen service area. The irrigation water required for the above two areas will be taken directly from the Huai Khon Kaen dam and conveyed to the irrigation areas through two main canals, Right Main Canal (RMC) and Left Main Canal (LMC). The designed discharge at the head of RMC is 1.37 m^3/sec including the irrigation water of 0.734 m^3/sec for the right bank area of the Huai Khon Kaen and 0.59 m^3/sec for the Pasak Left Bank service area, and 0.046 m^3/sec of municipal water. RMC will be connected to the Pasak river near Ban Na Kham, about 1 km upstream of the existing intake weir for the Pasak Left Bank service area, to release the irrigation water for the Pasak Left Bank service area and municipal water into the Pasak river. The design discharge of LMC is 3.776 m^3/sec at its head. The total length of the main canals is 53.5 km consisting of 8.0 km of RMC and 45.5 km of LMC.

For the distribution of irrigation water from the main canals to the service areas, three lateral canals, one Sub-lateral canal from RMC and 18 lateral canals from LMC, will be networked over the area. The total length of the lateral canals is 52.2 km.

The drainage water from the irrigated lands will be evacuated to the Pasak river through the Huai Khon Kaen or 21 improved or newly constructed drainage canals. The total length of the drainage canals is about 72.3 km consisting of 48.7 of improved canals and 23.6 km of newly constructed canals.

(3) Huai Yai Sub-project Area

The irrigation area of 11,250 rai (1,800 ha) is delineated along both banks of the Huai Yai. The area will be served by one main canal with a total length of 8.9 km. The design discharge is calculated to be 1.800 m^3/sec at its head. The main canal will directly be stretched out from the outlet structure of the Huai Yai dam and pass through the left bank area of the Huai Yai.

In order to distribute the irrigation water from the main canal to the respective service areas, three lateral canals with a total length of 17.7 km will be constructed over the area.

The Huai Yai and other three natural streams will be improved for around 21.7 km and used as the drainage canals. In addition some drainage canals with a total length of 5.0 km will newly be constructed.

(4) Khlong Chaliang Lab Sub-project Area

The irrigation water for the total irrigation area of 7,500 rai (1,200 ha) will be released directly from the dam to the main canal. The main canal will be constructed for the design discharge of 1.2 m^3/sec at its head and for the length of 7.4 km. The main canal thus constructed will pass through the left bank area of the Khlong Chaliang Lab.

For the distribution of irrigation water from the main canal to the respective service areas, three lateral canals and one sub-lateral canal with a total length of 13.8 km will be provided in the area.

Four natural streams including the Khlong Chaliang Lab with a total length of 17.2 km will be improved for the use of drainage purposes. Furthermore, 2.8-km long drainage canal will be dug to carry drain water to a natural drainage.

CHAPTER - 7

PROPOSED PROJECT WORKS

7.1 DAM AND RESERVOIR

7.1.1 Dam

(1) Topography of Dam Site

The site for the Huai Saduang Yai is located at about 17 km northeast from the Lom Sak municipality. The gorge at the site is relatively symmetric, having a relatively steep slope. A small saddle extending due behind the left abutment is advantageous for disposition of emergency spillway.

The site for the Huai Khon Kaen dam is located at about 1.5 km east from the Wang Khon Pa village of the Lom Sak district. The site comprises a gorge and two saddles separated by two gentle humps. The channel gut of tributary meanders toward the vicinity of the left bank abutment.

The site for the Huai Yai dam is located at about 25 km northeast from the Phetchabun municipality. The site shapes the narroweast gorge at the debouchment of the Huai Yai valley. The left bank abutment is steeply slanting: the right bank abutment is relatively gentle. Behind the right bank abutment, there extends a shallow saddle which must be embanked. The channel gut of tributary sharply meanders near the dam site and is close to the left bank abutment.

The site for the Khlong Chaliang Lab is located at about 12 km due east from the Phetchabun municipality. The gorge at the site is narrow and V-shaped. The riverbed at the site is only about 20 m wide. Both abutment is rather steep. The left bank abutment has a sufficient altitude for embankment: the right bank abutment is relatively low, and an undulating low ridge stretches from the abutment to northeast.

Topographically, the sites for the Huai Saduang Yai, Huai Khon Kaen and Huai Yai dams are much favourable for constructing earthfill dam. But the gorge at the Khlong Chaliang Lab is too shallow to create medium scale reservoir. To increase storage capacity of the reservoir, the lengthy row ridge stretching out from the right bank abutment must be embanked (see Volume 3. Drawings).

(2) Foundation and Construction Materials

The geological investigation and study clarify that the foundation at each dam site comprising interbedded sandstone and shale is sufficiently stable to support earth embankment. The base rock at each site is partly weathered and cracked. But the permeability of foundation would be readily improvable by grouting. The drilled cores of each dam site evidence that there exists no geological fault and/or fractured stratum.

Core materials obtainable in the reservoir site are slightly fine-grained. The materials more suitable for core zone must be further investigated in the next stage. For the time being, processing of materials would be proposed from the conservative viewpoint: the natural impervious materials would be blended with some amount of coarse materials to obtain higher shearing force and better workability of embankment. The coarse materials would be borrowed in the riverbed near the embankment site and/or at the subsurface layer of the borrow areas. Soil mechanical study on the core materials is compiled in ANNEX - II.

The coarse materials for shell zone also sporadically scatter in and around the reservoir site. To produce a large amount of the coarse materials in the vicinity of embankment site, deep excavation at the terrace and/or the hillside covering the weathered sandstone is essential since such materials are hardly obtainable in the topsoil layer of the reservoir site.

Concrete aggregates and riprap materials would be purchased and hauled from the quarry site developed by a private sector, since the requirement of these materials are too small to exclusively install a crushing plant near the embankment site. These materials for the Huai Saduang Yai and Huai Khon Kaen dams would be purchased at Silalat crushing plant which is located at about 30 km southwest from both dam sites. These materials for the Huai Yai and the Khlong Chaliang Lab would be also purchased at Saluong crushing plant which is located at about 30 km south from the Huai Yai site along the provincial road Route-2271.

(3) Selection of Dam Type

The more common type for small or medium scale dam is classified into earthfill dam, rockfill dam and concrete gravity dam. Among them, rockfill type offers relatively less embankment than earthfill type. Actually however, the rockfill type is unfavourable at each dam site in view of availability of rock materials, since no fresh rock quarry site is expectable within economic hauling distance. The concrete gravity dam would be also left out of consideration in view of topography, foundation and project economy. The earthfill type is the most eligible for each dam site, because the construction of earthfill dam involves utilization of materials in the natural state requiring the minimum processing, and the foundation requirement for the earthfill dam are less stringent than for the other types. In view of the proposed height of each dam and the available materials, zoned type of earthfill dam would be selected for each dam site.

(4) Preliminary Design

(a) Embankment

Roadway requirement and practicability of construction works would be highly regarded in determining crest width of dam. Based on an empirical formula, the crest width for the Huai Khon Kaen dam is determined to be 10 m and the crests for the three remaining dams are 8 m respectively. The surface drainage of the crest would be made by sloping the crest 3% toward the upstream slope. A surfacing by gravels would be made for the crest protection against damages caused by wave splash, rainfall runoff, wind and traffic wear. The gravel of 50 cm thick would be spread all over the crest.

Freeboard for dam must be sufficient to prevent overtopping of embankment by abnormal and severe flooding and wave action of rare occurence. Accounting some allowance for extraordinary situation, the freeboard for the Huai Khon Kaen is conservatively proposed to be 4.5 m, and that for the three remaining dams, also conservatively to be 3.5 m.

A storage dam should have an upstream zone with permeability sufficient to dissipate pore water pressure exerted outwardly. The embankment materials available around each dam site are rather fine and contain less coarse materials. A relatively gentle slope of 1 to 3.0 would be provided for the upstream of embankment of each dam against the rapid drawdown. The upstream slope protection would be extended from the crest to the lowest water level. Hand-placed riprapping would be proposed for the upstream slope protection for each dam. The riprap of 1.0 m thick would be proposed. A well-graded gravel layer of 50 cm would be provided underneath the riprap in order to prevent the compacted materials from washing out through voids in the riprap caused by wave action.

A slope of 1 to 2.5 would be conservatively provided for the downstream of embankment, accounting for the embankment materials available for random zone around the proposed dam site. A 2 m thick vertical filter would be aligned just behind the core zone to lower the phreatic line and to stabilize the downstream portion of dam. Furthermore, to smoothly drain the seepage water in the vertical filter, a horizontal drain would be extended from the foot of vertical filter to the downstream toe of embankment, where a rockfill toe would be placed to quickly drain the seepage water through the horizontal drain. To prevent downstream slope from erosion caused by wind and/or rainfall runoff, a sod-facing would be proposed on the downstream slope. Drainage berms of 2.0 m in width would be provided on the downstream slope, at every 10-m vertical. Besides, to eliminate unsightly gullings and boggy areas, gutters would be placed along the contacts of the toe of embankment with earth abutments and valley floors: the gutters would be composed of dry rocks.

Earthfill dam gradually settles down after completing embankment works. Some amounts of extra-bankings are prerequisite for the respective dams. The height of the banking is determined, based on the data of compaction test and empirical formula, as 1.00 m for Huai Saduang Yai and Huai Khon Kaen dams and 0.60 m for Huai Yai and Khlong Chaliang Lab dams respectively.

The stability of the proposed embankment is examined based on the results of soil mechanical test. The seismic intensity of 0.05 is applied for the stability in reference to the design of the fill dam recently constructed. The well-known Swedish slip circle method is applied for the analysis. Three critical cases are examined in this analysis, as in case of normal water level, in case of immediately after completion of embankment, and in case of rapid drawdown of water level. The result of this study shows that the safety factor of critical slip circle for each case exceeds 1.20; the minimum allowable safety factor, resulting in each embankment previously mentioned being fully stable. The details of analysis are compiled in ANNEX - VII.

(b) Apurtenant Structure

Each proposed dam is provided with two kinds of spillway, i.e. service and emergency spillways. The service spillway functions for relatively low magnitude of flood: it would be designed with a flood of 100-year probability. The emergency spillway has a supplemental function for the service spillway under an extraordinary flood of 500-year probability.

Ungated side channel type is selected for the service spillway, accounting for geologic and topographic conditions, height of dam, size of reservoir and magnitude of anticipated flood. It is composed of side channel weir, transition, chute and energy dissipator. The service spillway for each dam would be aligned close to the top of abutment at each dam site. Flooding water spilt over the weir would be quickly released into existing channel of tributary through the chute and the energy dissipator. To clarify the optimum crest length of the overflow weir, flooding is routed in the reservoir by altering the crest length. The main features of the service spillway are as given below based on the hydraulic calculation:

	Design Discharge (m^3/sec)	Crest Length (m)	Surcharge Head (m)	Side Channel Breadth (m)	Side Channel Depth (m)	Chute Breadth (m)	Chute Depth (m)
Huai Saduang Yai	445.7	105	1.62	6.0 - 10.0	7.2 - 14.2	12.0 - 18.0	5.0 - 12.5
Huai Khon Kaen	821.1	110	2.51	10.0 - 20.0	8.5 - 15.1	25.0	5.0 - 16.0
Huai Yai	289.5	65	1.66	6.0 - 8.0	6.8 - 16.8	10.0	4.0 - 14.0

The service spillway for the Khlong Chaliang Lab dam would be jointly constructed with the emergency spillway because of the topographic constraints. The surcharge head caused by the inflow flood of 248 m^3/sec, 100-year probable flood equivalence, is estimated to be 1.55 m by giving 70 m of the crest length of the overflow weir. The main features of the spillway for the Khlong Chaliang Lab dam can be summarized as follows:

Dam	Outflow after routed (m^3/sec)	Crest Length (m)	Surcharge Head (m)	Side Channel Breadth (m)	Side Channel Depth (m)	Chute Breadth (m)	Chute Depth (m)
Khlong Chaliang Lab	232.0	70.0	1.55	6.0-8.0	6.5-11.5	10.0	5.0-14.0

Each emergency spillway would be aligned on topographic saddle extending behind the abutment excepting the spillway for the Khlong Chaliang Lab dam which would be jointly constructed with service spillway. The discharge increased from the 100-year probable flood to the 500-year probable flood would be spilt out through the emergency spillway. The main feature and hydraulic dimension of each emergency spillway can be summarized as follows:

Emergency Spillway	Design Discharge (m^3/s)	Discharge Shared for Service. S (m^3/s)	Discharge Shared for Emergency. S (m^3/s)	Crest Length of Weir (m)	Surcharge Head (m)
Huai Saduang Yai	577.3	546.5	32.5	70.0	1.91
Huai Khon Kaen	1,069.9	1,025.5	24.4	80.0	2.93
Huai Yai	367.9	338.3	30.2	100.0	1.96
Khlong Chaliang Lab	310.1	244.2	62.1	70.0	1.75

The capacities of both service and emergency spillways and the size of freeboard are also examined by reservoir flood routing under the probable maximum flood (PMF) which is estimated through the hydrological study (ANNEX - I). As clarified in ANNEX - VII and Data Book, each dam can release even the peak of the probable maximum flood through the both spillways with some clearances of the freeboard.

Outlet works comprise a intake tower with an access bridge and an outlet conduit. The intake tower would be constructed by reinforced concrete, equipped with regulators. The hydraulic energy of water offtaken at the tower is dissipated at the bottom of tower, and then, free-flows through the outlet conduit. The outlet conduit would be initially constructed for the river diversion during embankment period, and then would be given a function of outlet facilities. The feature of conduit would, therefore, be decided in view of diversion work plan. The main feature of the outlet works for each dam are as tabulated below:

Dam	Intake Discharge (m^3/s)	No. of Regulator (Nos)	Size of Regulator	Size & Height of Tower (m) x (m)	Span of Bridge (m)	Size & Length of Conduit (m) x (m)
Huai Saduang Yai	5.496	4	1.2 x 1.2	4.0 x 4.0 x 29.0	59	2.0 x 145
Huai Khon Kaen	5.468	5	1.2 x 1.2	4.0 x 4.0 x 37.0	105	2.0 x 200
Huai Yai	1.875	4	0.7 x 0.7	4.0 x 4.0 x 37.5	105	2.0 x 140
Khlong Chaliang Lab	1.277	4	0.6 x 0.6	4.0 x 4.0 x 25.5	62	2.0 x 160

(c) Foundation Treatment

In advance to embankment work, stripping would be made all over the embankment site to completely eliminate organic materials in the top soil to obtain a stable support. The shell zone would be embanked directly on the soil layer after stripping. But, in order to create impervious zone, a key trench would be further excavated at the site of impervious core zone after stripping. Thus, fluvial deposits, highly weathered rock, and argillized strata would be clearly eliminated out of the trench. Curtain grouting would be made directly from the bottom of key trench. The grouting holes would be arranged 3 m meshes at the three longitudinal rows. Immediately after completing the required grouting, the trench would be filled with impervious material for water barrier.

7.1.2 Reservoir

(1) Selected Site

All of the proposed reservoir sites are topographically gentle and rolling and enclosed by low hilly ranges. Each valley to be pooled by constructing dam is rather narrow and shallow. The pocket for each reservoir is not so favourable for storing water. The storage ratio or the storage capacity by embankment volume for each reservoir is as summarized in the following table, together with the impounded area of each reservoir at full water level. As clarified below, the site for the Huai Saduang Yai reservoir is relatively favourable for storing water.

Reservoir	Useful Storage Capacity (MCM)	Storage Ratio	Impounded Area at FWL (km^2)
Huai Saduang Yai	27.00	24.77	2.08
Huai Khon Kaen	30.00	8.80	1.60
Huai Yai	13.25	15.77	1.09
Khlong Chaliang Lab	6.73	8.01	0.65

(2) Physical Characteristics

The elevation-volume and -area curves for each reservoir are developed as given in FIG. 7.1. The normal pool level or the full water level for each reservoir is determined from the result of reservoir operation study. The minimum pool level or the dead water level for each reservoir is determined on the basis of the deposited sediments in the reservoir. The maximum water level is defined as the water level which is equivalent to the normal pool level plus surcharge head caused by the extraordinary flood of 500-year recurrence. The pool level and effective storage depth of each reservoir can be summarized as follows:

Reservoir	Minimum Pool Level	Normal Pool Level	Maximum Pool Level	Effective Storage Depth (m)
Huai Saduang Yai	EL. 174.50	EL. 195.50	EL. 197.50	21.0
Huai Khon Kaen	EL. 187.50	EL. 216.50	EL. 219.50	29.0
Huai Yai	EL. 197.00	EL. 216.50	EL. 218.50	19.5
Khlong Chaliang Lab	EL. 189.00	EL. 206.50	EL. 208.30	17.5

The dead storage capacity is equivalent to the deposited sediment volume for 100 years. The useful storage is estimated by deducting the dead storage capacity from the full storage capacity. The surcharge storage in extraordinary flooding period is also estimated as a retained water capacity in the reservoir: this mainly depends on pool area and capacity of spillway.

Reservoir	Full Storage Capacity (MCM)	Full Storage Capacity (MCM)	Full Storage Capacity (MCM)	Surcharge Storage Capacity (MCM)
Huai Saduang Yai	27.96	0.96	27.00	4.70
Huai Khon Kaen	33.22	3.22	30.00	5.00
Huai Yai	14.00	0.78	13.25	2.10
Khlong Chaliang Lab	7.50	0.77	6.73	1.10

(3) Yield

The firm yield is defined as the maximum quantity of water which can be highly guaranteed during a critical dry period. The irrigation system in each sub-project is proposed so as to tolerate 20% of the period with yield below the normal design value. Therefore, the basic drought year of 20% recurrence is clarified in advance to the estimate of the firm reservoir yield. Based on the results of reservoir operation study, the annual reservoir yield in 1977 is estimated as the firm yield of each reservoir as tabulated below, together with the usable index or the yield by useful capacity. As given below, the Huai Khon Kaen and the Khlong Chaliang Lab dams produce the maximum and the minimum firm reservoir yields, respectively.

Reservoir	Useful Storage Capacity (MCM)	Firm Reservoir Yield (MCM)	Usable Index
Huai Saduang Yai	27.00	28.11	1.04
Huai Khon Kaen	30.00	49.77	1.66
Huai Yai	13.25	13.53	1.02
Khlong Chaliang Lab	6.73	9.87	1.47

(4) Sediments

According to the sediment data recorded in the surrounding watersheds, the suspended sediment yield widely ranges from 26.4 to 163.4 t/km^2/year, averaging about 95 t/km^2/year. Total sediment transport of about 115 t/km^2/year are empirically estimated by adding about 20% to the suspended transports to allow for bed-load contribution. Trap efficiency of each reservoir is assumed to be 95% accounting for the storage capacity-annual inflow ratio of each reservoir. Thus, the total deposited sediments are estimated to be about 110 t/km^2/year or 100 m^3/km^2/year, assuming the specific weight of sediment to be 1.1 t/m^3. The useful life of each reservoir would be assumed to be 100 years which are equivalent to double of the economic life of each sub-project. The total trapped and deposited sediments in each reservoir are estimated as follows. As shown below, the Huai Khon Kaen reservoir shows the largest amount of reservoir sediments and the Khlong Chaliang Lab reservoir has the highest sediment ratio among the four proposed reservoirs.

Reservoir	Drainage Area (km^2)	Reservoir Sediments (MCM)	Sediment Ratio (%)
Huai Saduang Yai	96	0.96	3.6
Huai Khon Kaen	322	3.22	10.7
Huai Yai	75	0.75	5.7
Khlong Chaliang Lab	77	0.77	11.4

(5) Leakage

A north to south folding axis is predominant in the eastern hilly ranges. No tectonic line or no noticeable geological fault is evident in each reservoir site, and furthermore, it is clarified through geological field inspection that fractured rock, permeable volcanic materials and cavernous limestone, which might surely cause serious leakage, are not distributed in each reservoir site. No special treatment would be proposed for the prevention of leakage from each reservoir site.

(6) Operation Study

The operation study for each reservoir is made for 17 years from 1964 to 1980 for the Huai Khon Kaen, the Huai Yai and the Khlong Chaliang Lab dams and 11 years from 1970 to 1980 for the Huai Saduang Yai. The operation rules are presumed as described below.

i) Storage capacity would be adjusted by evaporation and precipitation in the pool area.

ii) Natural inflow would be balanced with total demand to clarify surplus or deficit of water in current month.

iii) Surplus water after balanced would be stored for subsequent month, and deficit water after balanced would be released from reservoir.

iv) Amount of water exceeding the full storage capacity would be spilled out through spillway.

The monthly runoff of the tributary is produced through hydrological analysis. The demand of water comprises irrigation water, municipal water and downstream release requirement. The irrigation requirement is estimated on the basis of meteorological data, proposed cropping pattern and crop intensity of 135% through irrigation study. The municipal water of 4,000 m^3/day would be daily supplied from the Huai Khon Kaen reservoir for the Lom Sak and/or the Phetchabun municipalities throughout the year. The downstream use of 1.0 ℓ/sec/km^2 of watershed would be released from each reservoir throughout the year in due consideration of riparian right of downstream population. The average annual supply and demand for each reservoir can be summarized as follows:

Reservoir	Average Annual Supply (Inflow) (MCM)	Average Annual Irriq. Req. (MCM)	Downstream Use (MCM)	Municipal Water (MCM)
Huai Saduang Yai	22.4	37.2	3.0	-
Huai Khon Kaen	75.1	35.1	10.2	1.5
Huai Yai	19.9	11.7	2.4	-
Khlong Chaliang Lab	20.4	7.8	2.4	-

The operation study of each reservoir is made by monthly basis by use of the estimated supply and demand according to the operation rules above-mentioned. The outcomes are illustrated in FIG. 7.2. The figures show that all of the proposed reservoirs are efficiently operates even in the 20% recurrence of droughty year.

7.2 IRRIGATION AND DRAINAGE FACILITIES

7.2.1 General

The major feature of the project is to supply the optimum irrigation water to the Huai Saduang Yai, the Huai Khon Kaen, the Huai Yai and the Khlong Chaliang Lab sub-project areas from the respective dams. The facilities required for the project include irrigation canals and their relevant structures, drainage facilities and farm roads.

The basis for determining the facility requirements for each function is that enough project facilities be provided in the most effective and economical manner so that each function can be combined with and fully compatible with the other farming operations. Based on the above requirements, the following planning and preliminary design of project facilities for each sub-project area are prepared. The salient features of the project facilities designed are summarized in TABLE 7.1.

7.2.2 Irrigation Canal System

Irrigation canal system to be provided under this project includes all the main, lateral and the sub-lateral canals in three sub-project areas except for the Huai Saduang Yai sub-project area. The proposed layouts of the canals down to the sub-lateral canals are shown in PLATE No.2 through PLATE No.4. The design standards for the canals and their related structures are briefed below:

(1) Canal

Design discharge:

Based on the unit irrigation water requirement of 1.0 lit/sec/ha, the design discharges for the all canals and the related structures are obtained.

Canal lining:

All the main canals are lined with 6 cm thick plain concrete to check seepage from the canal banks and bottom and to protect the inside slope of the canal against erosion.

Velocity:

The maximum and minimum permissible velocities are as follows:

	Maximum Velocity (m/sec)	Minimum Velocity (m/sec)
- concrete-lined canal	1.2	0.8
- earth canal	0.7	0.5

Roughness coefficient:

The following roughness coefficient (after the Manning's formula) is used in the calculation of required canal section.

- concrete-lined canal	0.015
- earth canal	0.025

Inside slope of canal:

The canal inside slope of 1 : 1.5 is adopted for the design of both concrete-lined and earth canals.

(2) Related Structures

A large number of structures are essential for full function of the canal systems. The following structures are proposed:

i) structures of distribution of irrigation water such as turnouts,

ii) structures for regulation of water level such as check gates and drops,

iii) structures for conveyance of irrigation water over or under road, river, stream, etc. such as siphons, aqueducts, culverts and bridges,

iv) structures for protection of canal such as canal spillways and cross drains,

v) structures for measuring canal discharge such as Cipoletti weirs.

7.2.3 Drainage Canal System

The unit drainage water requirement is estimated to be 4.5 lit/sec/ha for all the sub-project areas. The design discharges of respective drainage canals are calculated on the basis of the unit drainage requirement. In design, the existing natural streams and drainage canals are incorporated into the proposed drainage canal network as much as possible.

The related structures to the drainage canals include cross drains and culverts. They are planned and designed with the same principles as those of the related structures for the irrigation canals.

7.2.4 Inspection Road

For the proper operation and maintenance of the project facilities, well arranged inspection roads are of vital importance. Since these roads will be used as village roads and farm roads after the project implementation, the arrangement of the inspection roads should be made considering the existing road network.

The main inspection roads are required for inspection, operation and maintenance of main canals. Considering the future increase of vehicles for the inspection and operation and heavy construction equipment to be required for the canal maintenance and repair, all the main inspection roads are so designed as to have an effective width of 5 meters and to be paved with laterite soil. These roads will also be used for the purpose of farm operation.

The lateral inspection roads are mainly provided alongside the lateral canals. All these roads have an effective width of 3 meters. These roads will also be used for the purpose of farm operation.

7.3 CONSTRUCTION PLAN

7.3.1 General

Each sub-project comprises construction of a medium scale earthfill dam and an irrigation/drainage canal system. Hence, due attention must be paid to a characteristics of earth materials, which directly affect earth moving plan, selection of construction equipment, specification of earth works, etc.

The construction of dam and main canal would be mostly executed by heavy construction equipment. The lateral canal and other minor works would be executed by manpower, resulting in increase of employment opportunity among the local people in and around the project area.

Earth work is mostly commanded by rainfall. Workable days for embankment of impervious materials must be strictly controlled by amount of rainfall. The monthly workable days are estimated at 25 days for normal works and 22 days for embankment of impervious materials on the basis of daily rainfall intensity recorded in the Phetchabun and Lom Sak meteorological stations. The details are given in ANNEX - X.

7.3.2 Dam Construction

According to the results of geological and soil mechanical investigations, talus deposits and terrace deposits obtainable around the embankment site would be borrowed for core zone. The talus deposits are suitable for impervious materials without any processing. But the terrace deposits obtainable in the reservoir site are slightly fine-grained. The materials more suitable for core zone must be quantitatively and qualitatively investigated prior to the commencement of the detailed design stage.

For the time being, processing of materials would be proposed from the conservative viewpoint: the natural terrace deposits would be blended with coarse materials which would be excavated at the riverbed near the embankment site and/or at the subsurface layer of the borrow areas.

The coarse materials for shell zone also sporadically scatter in and around the reservoir site. To produce a large amount of the coarse materials in the vicinity of the embankment site, deep excavation at the terrace and/or the hillside covering the weathered sandstone is essential, since such coarse materials are hardly obtained in the topsoil of the reservoir site.

Most of materials for riprap, filter and drain would be purchased and hauled from crushing plants developed by private sector. The Silalat plant is located at about 30 km southwest of the Huai Saduang Yai dam site, half way from the Phetchabun to the Lom Sak along the Highway Route-21, and the Saluong plant is located at about 30 km due south of the Huai Yai dam site along the district road.

The estimated volumes of embankment and excavated materials and their availabilities, construction schedule, soil conversion rate, etc. are fully scrutinized in order to layout a proper earth moving plan. The details are given in ANNEX - X.

Dam embankment must be safely protected from damage to be caused by flood during construction period. Ten-year probable flood would be applied for the plan of diversion work. The runoff of 10-year recurrence would be temporarily stored in the retention area which would be created by initial embankment and drained by sump pumps through conduit immediately after cease of flooding. Further, small amount of the runoff during the dry season is also stored in the sump created by a small scaled earth closing (cofferdam), and then would be dewatered by pumping.

Stripping and normal soil excavation would be mainly made by bulldozer, and weathered rocks would be excavated by ripper-dozer. Hard rock would be excavated by blasting and collected by bulldozer. After excavated, the materials would be loaded by tractor shovel and hauled by dump truck to spoil area. After excavation of dam core trench, curtain grouting would be executed. After grouting holes are drilled by hydraulic boring machines, mixed cement milk would be poured by grouting pumps.

Embankment materials hauled from borrow area would be spread by bulldozer in specific thickness and compacted by tamping roller and tire roller. The embankment should be strictly controlled by the D-value, and also water content ratio would be checked throughout the construction period. In the dry season, some amount of water would be added to the materials by tank lorry so as to keep to the optimum water content.

Appurtenant structures comprise a service spillway, emergency spillway and outlet works. Concrete for these structures would be mixed by batching plant. A set of fully automatic weighing and mixing plant would be located immediately downstream of the concrete placement site, and rotationally used for four dam sites. The plant would be equipped with a set of mixer, cement silo, belt conveyor, screw conveyor, backet elevator. Furthermore, five sets of agitator trucks would be attached to the plant to smoothly haul the mixed concrete to each placing site.

7.3.3 Canal Construction

Stripping and surface excavation of main canal would be mainly made by bulldozer, and sub-surface and deep excavations by back-hoe shovel, depending the soil condition at the site. Weathered hard rock would be excavated by pick-hummer. Excavation of lateral canal would be made by manpower. Spreading of filling materials would be made by bulldozer, and supplementarily by manpower. Light work such as face smoothing, compaction of canal invert and other minor works would also be executed by manpower. The excavated materials excessive to filling requirement would be spoiled by dump trucks. Shortage in amount of filling requirement would be supplemented by dump truck from specific borrow area.

The main canal in each sub-project is concrete-lined. The concrete linings would be executed immediately after shaping canal section which would be made by back-hoe, bulldozer, and finally finished by manpower. The concrete for lining would be produced by small-scale portable concrete mixer and placed by manpower. Simple sliding concrete form would be used for the lining works. Three or four sets of the sliding form would be prepared at least for each job site to facilitate continuous lining works.

Most of earth works of canal related structures would be done by manpower. The structures are mainly of reinforced concrete. The concrete would be processed by portable mixer and placed by manpower. Wooden form and shutter would be used for the related structures.

7.3.4 Implementation Schedule

In accordance with the implementation priority of the sub-project concluded in the Pre-Feasibility Study, the project would be divided into two packages for stage wise construction as given below:

Package - I	Huai Khon Kaen sub-project Huai Yai sub-project
Package - II	Huai Saduang Yai sub-project Khlong Chaliang Lab sub-project

The dam construction of both sub-projects under Package - I would commence simultaneously in the early 3rd year after commencement. The construction of the Huai Khon Kaen dam would last for four years until the end of the 6th year after commencement, and that of the Huai Yai dam last for three years until the end of the 5th year after commencement. While, the construction of the main and lateral irrigation canals and drainage canals under the Huai Khon Kaen sub-project would last for about two and half years until the mid. of the 7th year after commencement, and that under the Huai Yai sub-project would last about for one and half years until the mid. of the 6th year after commencement.

The dam construction of both sub-projects under Package - II would be commenced simultaneously in the early 7th year after commencement immediately after completion of the Package - I. The construction of the Huai Saduang Yai dam would last for three years until the end of the 9th year after commencement, and that of the Khlong Chaliang Lab dam would also last for three years until the end of the 9th year after commencement. While, the canal construction of the Khlong Chaliang Lab sub-project would be commenced in the mid. of the 9th year after commencement and last for one and half years until the end of the 10th year after commencement. The packaged sub-projects would spend two years for engineering works and loan arrangement prior to the commencement of substantial construction works. Thus, it will take about ten years to complete the whole proposed project works after commencement of the engineering works concerned. The implementation schedule is as barcharted in FIG. 7.3.

7.4 COST ESTIMATE

7.4.1 General

The unit prices are analyzed on the 1982 current price basis prior to cost estimate. For the estimate, the assumptions below-mentioned are made.

(1) The conversion rate between Baht and US Dollar is assumed to be US$1.00 = Baht 23.00 referring to the current exchange rate in Thailand.

(2) All of the construction works would be executed by contract basis. The machinery and equipment required for construction works would be provided by contractors themselves. Therefore, depreciation cost of construction machinery and equipment would be accounted in construction cost. The procurement cost of machinery and equipment would therefore be out of consideration.

(3) Taxes on the construction materials, machinery and equipment to be imported from abroad would be exempted in the cost estimate.

(4) The construction costs integrated by unit costs are divided into foreign and local currency portions. The local currency portion is estimated on the basis of the current price in the Phetchabun Province in August 1982 and the data collected from the on-going and completed irrigation projects around the project area. While, the foreign currency portion is also estimated based on the CIF prices in Bangkok referring to the FOB prices in Japan as of July 1982. All of the work items, materials and equipment are provisionally classified into both local and foreign currency portion as given below:

i) Local Currency Portion

- Labour wages,
- Sand, gravel and wooden materials,
- Fuel, oil, etc.,
- Cement,
- Secondary concrete products,
- Small gates for canals,
- Reinforcement bar,
- 15% of depreciation cost of construction equipment and machinery,
- Inland transportation cost,
- Expenses of engineering services for local consultant,
- General expenses and profit of local contractor,
- Minor and miscellaneous works,
- Land acquisition and compensation, and
- Administration cost

ii) Foreign Currency Portion

- Large gates for dams and canals,
- 85% of depreciation cost of construction equipment and machinery,
- Expenses and fees of engineering services by foreign consultant,
- Contractor's general expenses and profit, and
- Vehicles to be required for the construction supervision and O & M equipment for the project operation.

(5) As regards the physical contingency related to the construction quantities, commissions and changes in unit prices, around 10% equivalence of the direct construction cost is incorporated in the construction cost in view of the preliminary nature of the estimate. While, the price contingency of 6% per annum for the foreign currency portion and 10% per annum for the local currency portion is also incorporated in the construction cost to cover increase of costs due to future price escalation.

(6) Associated costs to be financed by the Government, such as the costs for strengthening the extension services, facilities of water users' association and improvement of social infrastructures are not included in the estimate.

7.4.2 Project Cost

TABLE 7-2 shows an itemized breakdown of the anticipated total project cost of the four proposed sub-projects, and TABLE 7-3 further specifies the breakdowns of respective packaged projects. Both tables can be summarized as follows:

	Whole Project	Package - I	Package - II
Foreign Currency Portion 10^6 ฿ (10^6 US$)	2,024 (88)	1,280 (56)	744 (32)
Local Currency Portion 10^6 ฿ (10^6 US$)	2,460 (107)	1,462 (64)	998 (43)
Total Amount 10^6 ฿ (10^6 US$)	4,484 (195)	2,742 (119)	1,742 (76)

The total project cost is estimated at ฿4,484 million or US$195 million equivalence, comprising ฿2,460 million (55% equivalence of the total Project Cost) of local currency portion and US$88 million (45% equivalence of the total Project Cost) of foreign currency portion.

7.4.3 Operation and Maintenance Cost

Operation and maintenance cost of each sub-project includes salaries of project administration and water control staffs, the materials and casual labour costs for repair and maintenance of project facilities, costs for operating/maintenance of O & M equipment and running cost of all of the project facilities. The operation and maintenance cost annually required for each sub-project is as follows:

Sub-Project	Operation/Maintenance Cost (million ฿)
Huai Saduang Yai	7.7
Huai Khon Kaen	6.1
Huai Yai	2.6
Khlong Chaliang Lab	1.7

7.4.4 Replacement Cost

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

(Unit: 10^3 Baht)

Items	Useful Life (Years)	Replacement Cost			
		Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
Gate (imported)	25	1,206	1,444	924	868
Gate (local made)	25	3,449	3,485	982	813
O & M equipment	10	20,067	15,110	6,031	4,021

CHAPTER - 8

ORGANIZATION AND MANAGEMENT

8.1 ORGANIZATION FOR PROJECT EXECUTION

The Royal Irrigation Department, the Ministry of Agriculture and Cooperatives, will be the executive agency for the Upper Pasak Medium Scale Irrigation Project. It is responsible for engineering and construction of the project works and supervision for the project operation.

The Project Director is appointed for the project implementation on the same level as Deputy Director General of RID and responsible for overall execution of the proposed project. The Director also coordinates activities of all relevant government agencies in connection with the implementation of the project.

The Project Manager is directly responsible for the execution of the project as a chief of the project construction office under the Project Director. The proposed organization structure is shown in FIG. 8.1. Main functions of the project construction office are briefly described as;

(1) Financial arrangement needed for whole construction works,

(2) Engineering works and construction supervision for whole project works,

(3) Assistance to farmers in constructions of terminal irrigation/drainage systems, and

(4) Accounting and management of construction works.

The project construction office consists of one main office and four branch offices. The main office has four sections, such as engineering, construction, operation and administration.

8.2 ORGANIZATION FOR OPERATION AND MAINTENANCE

After completion of the project construction works, the project construction office is re-organized into the project O & M Office under the Region III Office, RID. Since this re-organization would require two years or more, the Project Construction Office will successively be responsible for the operation and maintenance of the project facilities during the transfer period. The project engineer is assigned as a chief of the O & M Office and responsible for operation and maintenance of the reservoir and irrigation and drainage systems down to inlets of tertiary blocks. The operation and maintenance of the tertiary blocks down to the terminal facilities are entrusted to water users' association which will be set up immediately after the completion of the project works. The proposed organization chart is as shown in FIG. 8.2.

The office consists of one main office, two branch offices, and six field offices. The main office is established in the Phetchabun municipality, and two branch offices under the main office are established at the Phetchabun and the Lom Sak municipalities respectively. The field O & M Offices are newly set up or re-organized under both branch offices for every proposed projects and the existing irrigation projects located in both districts.

The Phetchabun branch office controls all the projects in the Phetchabun district such as the Huai Yai and Khlong Chaliang Lab sub-projects and the existing Huai Pa Daeng project, and the Lom Sak branch office controls all the projects in the Lom Sak district such as the Huai Khon Kaen sub-project, and existing Pasak Left Bank and Sri Chan projects.

All the main, branch and field office buildings are appropriated for the O & M office except two construction branch offices.

The main office is responsible for the overall activities necessary for proper operation and maintenance of all the project facilities including preparation of overall O & M program, design and construction/supervision of maintenance and repairing works, budgeting, training of staff, etc. The office consists of five sections such as engineering, O & M, workshop, agricultural service and administrative sections.

8.3 ORGANIZATION FOR FARMERS LEVEL

For the management, operation and maintenance of the irrigation and drainage systems in terminal irrigation unit, the beneficiary farmers organize themselves into the water users' group in each Chaek of about 940 rai (150 ha) consisting of about 100 farm families on an average in the irrigation development area. For good coordination and cooperation, federation of the water users' groups, so called the water users' association, is set up in each irrigation system of the sub-project through affiliation of the water users' groups.

The water users' group is organized in each Chaek consisting of four terminal irrigation units on the initiative of related village and sub-district (Tambon) chief and with guidance and consultation of the water users' center in O & M division, RID and O & M office, before completion of the construction work of the project. After establishing the water users' groups, the group leader (Chaek leader) is elected by the members of the group. The Chaek leader and members take responsibility for operation and management of the terminal irrigation units under mutual cooperative.

Water users' association is established in each irrigation system of sub-project as a federation of the water users' groups as mentioned above. Further, it is strongly proposed to establish the committee of the water users' association for efficient management of each water users' association. The committee is organized by about 25 representatives elected from the Chaek leaders and takes responsibilities not only for water management of the terminal irrigation units, but also for support of farm management of members according to the created condition of the committee. Through the committee, the water users' association is given strong support from all the agricultural supporting agencies in the province, such as RID, the Department of Agricultural Extension, the Bank for Agriculture and Agricultural Cooperatives, etc.

CHAPTER - 9

PROJECT EVALUATION

9.1 GENERAL

The project evaluations are made in order to ascertain the feasibility of the project in view of economic, financial and socio-economic aspects.

The economic feasibility of the project is evaluated in terms of the internal rate of return (IRR) and the net present value (NPV) at the discount rate of 10%. Further, sensitivity analysis is made in order to elucidate the economic viability of the project against the possible changes in estimates of the project costs and benefits from the values used in the basic case for the calculation of IRR, and different discount rates of 8% and 12% for the calculation of NPV.

The financial aspect is evaluated by calculating the capacity to pay for the typical farmers and by preparing the repayment schedule of the project capital cost. The calculation of capacity to pay is to confirm the soundness of the project from the farmers' viewpoint. The repayment schedule is made to estimate the annual subsidy of the Government based on the estimated fund requirements with the assumed financial terms of the conceivable loan and the expected revenue from the project.

The intangible and indirect benefits of the project are briefly assessed in due consideration of the effects of the project on the regional development.

9.2 ECONOMIC EVALUATION

9.2.1 Evaluation of Economic Resources

(1) Standard Conversion Factor (SCF)

The standard conversion factor is taken to be 0.79, following the calculation made by the World Bank in the Staff Working Paper No. 299, 1978.

(2) Economic Prices for Agricultural Outputs and Inputs

The economic prices of farm products such as rice, tobacco and mungbeans and farm inputs such as fertilizers and plant protection are estimated based on the projected international market prices forecasted by IBRD in the long term range in 1982 constant US Dollar. The domestic components are adjusted by the SCF of 0.79 (ANNEX - IV).

(3) Economic Opportunity Cost of Farm Labour

Based on the current wage rate for seasonal labourers required for the transplanting and harvesting of paddy, who are mainly hired from small-hold farmers and tenant farmers, and the present net benefit per labour force per day, the economic opportunity cost of farm labour is estimated at ₱30/man-day.

(4) Economic Opportunity Cost of Unskilled Construction Labour

Considering that the construction requires harder physical work than the farming, the economic opportunity cost of unskilled construction labour is taken to be 25 - 30% higher than that of farm labour. Thus, the economic opportunity cost of unskilled construction labour would be ₱40/man-day.

(5) Construction Conversion Factor (CCF)

The construction of project facilities is carried out by equipment, skilled and unskilled labour. For the economic analysis, the construction conversion factor is estimated as follows:

(a) Traded component

About 52% of the capital cost is included in this category and its conversion factor is 1.00.

(b) Non-traded component

About 45% of the capital cost is included in this category and its conversion factor is 0.79 (SCF).

(c) Unskilled labour

About 3% of the capital cost is included in this category and its conversion factor is 0.67.

(d) CCF

The CCF is calculated to be 0.895 taking the weighted average for the above items.

9.2.2 Economic Cost

The project construction cost broadly includes (1) cost for preparatory works, (2) construction cost for project facilities including the contractor's overhead costs, profit and contract tax, (3) cost for land acquisition and compensation, (4) procurement cost of O & M equipment (first procurement only), (5) administration expenses, (6) engineering services, (7) physical contingencies, and (8) price contingencies. Among the costs mentioned above, all the costs except the contractor's profit, contract tax, land acquisition and price contingencies are counted as the net capital cost to be considered in the economic evaluation. This net capital cost is further converted into the economic capital cost by applying the CCF.

The economic capital cost thus estimated and its annual disbursement for each sub-project are as shown below:

(Unit: 10^3฿)

Year	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
1	10,708	22,343	14,908	15,608
2	18,837	52,276	19,475	20,388
3	91,570	182,168	88,885	88,925
4	113,238	261,625	111,231	110,572
5	106,364	284,899	120,637	104,400
6		250,815	20,011	43,340
7		60,592		
Total	340,717	1,114,718	375,147	383,233

In addition to the above cost, the following costs are counted in the economic cost:

(1) Sunk Cost

- 91.1 million Baht equivalent as of 1982 for the construction of weir and canal system for the Pasak Left Bank service area, and
- 31.9 million Baht equivalent as of 1982 for the construction of the Sri Chan diversion weir.

(2) Costs for Improvement of Existing Canal Systems

- 73.7 million Baht at the present price level for the Pasak Left Bank service area, and
- 18.3 million Baht at the present price level for the Sri Chan service area.

(3) Cost for On-farm Development

Service Area	Cost (10^3฿)
Sri Chan	116
Pasak Left Bank	1,014
Huai Khon Kaen	1,814
Huai Yai	726
Khlong Chaliang Lab	484

9.2.3 Annual Operation and Maintenance Costs

The annual O & M costs estimated in Section 7.4.3 hereof include the depreciation costs of O & M equipment and gates. In the economic evaluation, these costs are already counted as the replacement costs, and accordingly the depreciation costs of O & M equipment and gates are excluded from the O & M costs estimated in Section 7.4.3 hereof. The O & M costs after exclusion of the said depreciation costs are further converted into the economic costs using the CCF of 0.895 as shown below:

Service Area	Economic O & M Cost (10^3₿)
Huai Saduang Yai	5,589
Huai Khon Kaen	5,279
Huai Yai	1,863
Khlong Chaliang Lab	1,242

9.2.4 Replacement Costs

The replacement costs estimated in Chapter 7 hereof are converted into the economic costs using the conversion factor of 1.00 for the gates for the outlet works of dams and O & M equipment and the SCF of 0.79 for the gates of canal structures. The estimated costs are as shown below:

Service Area	Economic Replacement Cost (10^3₿)
Huai Saduang Yai	23,998
Huai Khon Kaen	19,288
Huai Yai	7,711
Khlong Chaliang Lab	5,511

9.2.5 Project Benefits

Only the agricultural benefit and benefits of water release for downstream use and municipal water at the economic prices are counted in the evaluation, and any indirect or intangible benefits are not taken into account.

(1) Agricultural Benefit

The agricultural benefit is evaluated as the difference of net incomes from crops in future between "with project" and "without project". The benefit will come out immediately after the completion of dam construction, even before the completion of the total canal works. The anticipated annual incremental benefit of each subproject area is as shown in the following table:

Sub-Project Area	Net Annual Incremental Benefit (10^3B/)
Huai Saduang Yai	134,665
Huai Khon Kaen	163,377
Huai Yai	58,925
Khlong Chaliang Lab	36,922

(2) Benefits of Water Release for Downstream Use and Municipal Water

A certain amount of water will be released from all four dams throughout the year for the downstream use, and municipal water for Lom Sak city will also be released from the Khon Kaen dam throughout the year. The values of these water are evaluated in monetary terms on the assumption that as the alternative use, these water is used for the crop production. The values thus evaluated are as shown below and counted as the project benefit in the economic evaluation.

Sub-project	Water Value (10^3฿)
Huai Saduang Yai	10,958
Huai Khon Kaen	54,010
Huai Yai	11,920
Khlong Chaliang Lab	11,509

9.2.6 Evaluation

(1) Internal Rate of Return (IRR)

Using the costs and benefits estimated in the above, the cost and benefit streams are firstly prepared shown in ANNEX - XI, then, the IRRs are calculated for each sub-project area, for each development stage and for the overall cases. The calculated results are as shown below:

Sub-project	IRR (%)
Huai Saduang Yai	14.0
Huai Khon Kaen	14.2
Huai Yai	14.7
Khlong Chaliang Lab	10.4
Package - I Development/1	14.3
Package - II Development/2	13.1
Overall Case - I/3	14.3
Overall Case - II/4	13.9

Note: /1; Huai Khon Kaen + Huai Yai

/2; Huai Saduang Yai + Khlong Chaliang Lab

/3; in case the construction of all the sub-project are started concurrently

/4; in case the respective sub-projects are implemented according to the implementation schedule

(2) Net Present Value (NPV)

In order to assess the project viability from the economic viewpoint, the NPVs at the discount rate of 10% are also calculated for the same cases as those of IRRs, and their calculated results are shown below:

Sub-project	NPV (10^3 ฿)
Huai Saduang Yai	183,643
Huai Khon Kaen	321,165
Huai Yai	119,589
Khlong Chaliang Lab	7,694
Package - I Development	440,754
Package - II Development	191,337
Overall Case - I	768,189
Overall Case - II	632,091

(3) Sensitivity Analysis

In order to evaluate further the soundness of the project to the possible changes of economic conditions in future, the sensitivity analyses are made for the following critical conditions in terms of IRR:

i) cost increase for 20% (Case - I)

ii) benefit decrease for 20% (Case - II)

iii) simultaneity of the above two cases (Case - III)

iv) extension of construction period for two years.

In addition, the NPVs at two discount rates, i.e. 8% and 12% are calculated for the examination of the project sensitivity.

The following table shows the results of sensitivity analyses for the respective sub-projects.

Sub-project	IRR (%)				NPV (10^3฿)	
	Case-I	Case-II	Case-III	Case-IV	8%	12%
Huai Saduang Yai	13.0	12.1	11.1	13.5	386,056	67,962
Huai Khon Kaen	12.2	11.7	10.0	12.8	658,199	124,446
Huai Yai	12.5	12.1	10.2	13.1	233,357	51,904
Khlong Chaliang Lab	8.8	8.4	7.0	9.7	59,449	-17,698

From the above calculated results, it can be said that the project would be still sound even in the worst case, i.e. 20% increase of the cost and 20% decrease of the benefit, if the soft loan is expected from bilateral or international organizations.

9.3 FINANCIAL EVALUATION

9.3.1 Financial Cost

Based on the current market prices and costs as of August 1982, the financial cost of each sub-project is estimated as follows:

(Unit: 10^3 ฿)

Sub-project	Foreign Currency	Local Currency	Total
Huai Saduang Yai	384,942	411,340	796,282
Huai Khon Kaen	958,408	1,121,678	2,080,086
Huai Yai	321,422	340,337	661,759
Khlong Chaliang Lab	358,912	587,040	945,952
TOTAL	2,023,684	2,460,395	4,484,079

9.3.2 Capacity to Pay

In order to evaluate the project feasibility from the financial aspect of farmers, typical farm budget analysis is made under "with project" condition. The capacity to pay expected under "with project" condition is as shown below:

Sub-project	Capacity to Pay (฿/family/year)
Huai Saduang Yai	7,749
Huai Khon Kaen	8,038
Huai Yai	9,786
Khlong Chaliang Lab	8,124

9.3.3 Water Charge

It is generally understood that the water charge is imposed to the water users, and the water charge thus collected is spent for the payment of O & M expenditures incurred to the project and for the repayment of the capital cost of the project. In Thailand, however, the farmers traditionally do not pay any water charge directly, but contribute indirectly by paying tax on surplus rice production, export tax and an export premium for rice export, land tax, etc.

As estimated in Chapter 7 hereof, the annual O & M costs required for the each sub-project area are ฿206/rai for the Huai Saduang Yai, ฿215/rai for the Huai Khon Kaen, ฿231/rai for the Huai Yai and ฿232/rai for the Khlong Chaliang Lab. These correspond to about 23% of the capacity to pay in the Huai Saduang Yai sub-project area, 24% in the Huai Khon Kaen sub-project area, 24% in the Huai Yai sub-project area and 27% in the Khlong Chaliang Lab sub-project area. On the other hand, the annual scale of amount for the repayment of foreign currency portion of the capital cost is estimated at ฿620/rai in the Huai Saduang Yai sub-project area (dam cost only), ฿1,635/rai in the Huai Khon Kaen sub-project area, ฿1,553/rai in the Huai Yai sub-project area and ฿2,602/rai in the Khlong Chaliang Lab sub-project area. These repayments would not be covered obviously with the capacity to pay from the viewpoint of the farmer's economy.

The water charge to be collected from the water users should be within a reasonable range in the capacity to pay that could still give sufficient incentive to the farmer. With this view, the prospective water charge is recommended to cover the required O & M costs. This prospective water charge would be the project revenue in the financial evaluation on the project.

9.3.4 Repayment of Project Cost

The financial evaluation of the project is made by examining the repayment capability for the capital cost of the project. For the examination, the cash flow tables using the anticipated project revenue and fund requirement are prepared.

In the examination of repayment capability, it is assumed that the capital required for the project implementation will be arranged under the following conditions:

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

(2) For the local currency portion, the capital is financed by the budget allocation of the Government with no repayment.

Based on the above conditions, the repayment schedule for the foreign currency portion is prepared for the Package-I and Overall Case-II Development mentioned in sub-section 9.2.6 hereof as shown in TABLE 9.1.

9.4 INDIRECT BENEFITS AND SOCIO-ECONOMIC IMPACTS

In addition to the direct benefits stipulated in the economic evaluation, substantial secondary direct benefits steming from the project outputs and induced by project inputs and favourable intangible socio-economic impacts are expected from the implementation of the project.

9.4.1 Increase of Potential Fish Production

After creation of the reservoirs, the potential fish production in the area will be increased to great extent, and it would be possible for the settlers to manage fish culture. The production and net fishery benefit from the proposed four reservoirs are estimated as follows:

Reservoir	Amount of Fish Production (tons/year)	Net Benefit (10^3฿/year)
Huai Saduang Yai	9.1	102
Huai Khon Kaen	6.3	70
Huai Yai	4.7	53
Khlong Chaliang Lab	2.2	25
Total	22.3	250

9.4.2 Possibility of Hydropower Generation

The proposed storage dams, particularly for the Huai Khon Kaen dam, provide a possibility of micro hydropower development, if the water head between the surface water level of the reservoir and the tail water level of the outlet work of dam is effectively harnessed. According to the result of preliminary study, about 2.8 x 10^6 kWh of annual energy output will be produced by operating a micro hydropower plant with an installed capacity of 450 kW (for details, vide ATTACHMENT-3 hereof).

9.4.3 Foreign Exchange Earning

After completion of the project, production of paddy, mungbeans and tobacco will increase to about 63,460 tons of paddy, 3,050 tons of mungbeans and 6,760 tons of tobacco per annum from the present production of 33,830 tons of paddy, 1,000 tons of mungbeans and 1,600 tons of tobacco. Out of these increased productions, it is expected that the marketable rice, mungbeans and tobacco would be about 30,800 tons, 2,400 tons and 5,400 tons after deducting the local consumption. These surplus would increase the annual amount of exports, resulting in the earning of foreign exchange amounting to around 464 million Baht per annum.

9.4.4 Increase of Employment Opportunity to Local People

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

9.4.5 Improvement of Local Transportation

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

9.4.6 Improvement of Sanitary Conditions

The construction of the project works would have a positive effect on the overall ecology of the project area. The health and sanitary conditions would become better with drainage improvement as well as supply of fresh water through the irrigation canals.

CHAPTER - 10

ECOLOGICAL AND ENVIRONMENTAL CONSIDERATIONS

10.1 ASSESSMENTS OF ECOLOGY AND ENVIRONMENTS CAUSED BY THE PROJECT

Construction of the project will cause substantial effects on sociological and natural environments all over the watershed of relevant tributaries and the project area. Such effects should be appropriately assessed at the implementation stage of the project, and proper measures should be taken in parallel with the project works on the basis of the proper assessments. The creation of reservoirs and irrigated agricultural development are two major components which will affect the ecology and environments in the relevant area.

10.1.1 Construction of Dam

(1) Resettlements

There have been scattered about thirty humble shanties in the impounded area of four proposed dams. Most of them have irrigally settled and practiced shifting farming in the area. Prior to the commencement of dam construction, these shanty dwellers should be compensated for withdrawal and/or resettled out of the impounded area according to the local regulation. But these resettlements will never be one of constraints for the project implementation.

(2) Submergence of Cultivated Lands

The shanty dwellers have reclaimed about 300 rai of farm lands in the impounded area of four proposed dams. These lands will submerge under the reservoirs and be useless after the commencement of the respective reservoirs operation. Hence these lands also would be properly compensated for submergence, by the project. As compared with the beneficiary project area, the lands of 300 rai are negligible small. The negative benefit accrued from the submergence will hardly affect the feasibility of the project.

(3) Riverflow Regime

Intensive floods have habitually occurred at each dam site during rainy season and caused sporadical crop damages in the paddy field extending at the downstream of the dam site. While the riverflow has been extremely depleted during dry season and caused serious shortage of irrigation and domestic water, resulting in water pollution in the mainstream of the Pasak river.

In the design of dam spillways, any functions of flood control are not fiven to the reservoirs, but the peak of flood would be cut to small extent due to raise of reservoir water level by the flow depth over the spillway crest. The construction of dams will contribute to slight flood mitigation. While, the respective reservoirs will release considerable amount of water for downstream use throughout year. The domestic water supply for the riparian people in the project area will be highly improved.

(4) Impacts on Fauna and Flora

The area to be submerged by the dam mainly consists of small scale cultivated lands and forests, but this area is extremely small as compared with its total catchment area. Therefore, the creation of reservoir will not seriously affect the vegetation and the wildlife in the relevant watershed.

After creation of the reservoir, the river water system will be changed from fluvial system to stationary water system. This will make it impossible for fish to go up and down the stream. The food-chain in the river will be changed subsequently from the chain of periphyton - aquatic insect - stream fishes, to the chain of plankton - fishes, and species of fish will also be changed. In other words, the aquatic life including periphyton, aquatic insect and fish is expected to adjust themselves to the new circumstances.

It is quite difficult to assess the impacts on fauna and flora in the relevant watershed, because no data and information are available at all at present. Actually however, the anticipated impacts are negligible since the impounded area of each dam is extremely narrow.

(5) Land Sliding

The water level at each reservoir will seasonally fluctuate according to inflow of flooding and release of irrigation water. The water periphery of each reservoir is geologically stable but topographically steep. Landslidings, therefore, might be sporadically caused by the repeated fluctuation of water level. Careful maintenance of the periphery should be made after the commencement of each reservoir operation.

(6) Water Quality

One of the influential factors to water quality after creation of the reservoirs is the inflow of organic matters to the reservoirs. Future increase in inflow of organic matters to the reservoirs will however be extremely small because of less population and less agricultural activities in the catchment area. Another factor influencing the water quality in the reservoir is unlogged trees in the submerged area. The unlogged trees will change its material and leave organic matter in the water which will affect water quality. Other conceivable affects of the reservoir will be prolongation of muddy water flow and lowering of water temperature in the downstream of the Pasak river, if the water is taken from the deeper portion of the reservoir.

(7) Degradation of Riverbed

After completion of the dam in the upper reaches of the river, most of the sediment discharge will be checked by dam, and there will be less supply of sediment loads to the downstream. This would cause the riverbed degradation from upstream to downward, and it may affect the downstream structures, though this problem will occur in remote future; in the order of 50 years. When new structures are constructed downstream of the river, this matter should be taken into consideration. Meanwhile, the degradation will surely reduce the magnitude of flooding along the lowlying plain, and exert favourable influences on the environments of the downstream area.

10.1.2 Development of Irrigated Agriculture

(1) Impacts of Fertilizer and Chemical Use

After completion of the irrigation project, the intensive farming will be practiced, and more fertilizer and agricultural chemicals will be used without considering the environmental problems which give adverse effects on wildlife and human. These problems are mainly associated with the persisitence of pesticides.

(2) Impacts on Water-borne Diseases

After completion of the project, a plenty of water will be led from the river to the project area. This change of circumstances will create more chances for spreading and propagation of water-borne diseases, such as malaria, distomiasis, denque fever, cholera, tyhoid fever, filariasis, etc.

(3) Change of Soil Productivity

The soil forming process will be changed remarkably after start of irrigation. Gleization will predominate over the project area, and metallic elements in soils such as iron, aluminium and manganese will become soluble. These compounds are translocated to and accumulated in subsoils. Excess iron frequently causes plant physiological problems, especially Akagare Type-I. Besides, leaching of bases from rooting zones degrades soil fertility by the repeated irrigation and drainage.

10.2 ENVIRONMENTAL CONSIDERATIONS AND MEASURES

(1) Fish and Wildlife

Quality, temperature, and mobility of water area critically important to the survivals of fish and wildlife. The quantity of pollutants which will enter the stream during construction period should be kept to the minimum. For the future fishery development, care should be taken to avoid the destruction of vegetation in the reservoir areas. Standing trees debris left in the reservoir area may provide habitats for several species of fish. Certain aquatic plants may be desirable for water birds feedings such as ducks, coots, etc.

(2) Recreation

The rapid increase of rural population around the Phetchabun and Lom Sak municipality will cause a significant increase in the use of reservoir for recreational activities. In fact, in the existing Huai Pa Daeng reservoir, fishing and boating have been enjoyed by local people. Provision, therefore, should be made to obtain the maximum recreational benefits from the completed reservoirs.

(3) Viewpoint of Design

Design requirements for environmental consideration should be devoted to the accomplishment of three goals as,

i) keeping natural beauty of the surrounding area intact,

ii) creating esthetically satisfying structures and land scapes, and

iii) causing minimal disturbance to the areal ecology.

Based on the above goals, borrow areas should have their final slopes flattened to conform with the surrounding area and yet be flat enough for easy reseedings. Scenic overlooks should be provided for viewing the dam and reservoir. The river diversion works should be such that excessive siltation created during construction will not find its way into the downstream water. Unusable materials from excavation should be spoiled in the reservoir area. As much natural vegetation as possible should be left in place. Borrow area should be vegetated with grasses, trees, and shrubs, soon after the job is completed. All slopes cut adjacent to the reservoir area should be reseeded and mulched. Erosion control should be started at the beginning of the job. Roads, cutslopes, and borrow areas should be provided with terrace, berms, or other check structures if required.

(4) Water, Land and Human

In order to minimize environmental problem on water, land, and human resources, the following considerations and measures are recommendable:

- i) To avoid inflow of pollutants caused by construction works,
- ii) To guide farmers for proper use of fertilizer and chemicals under irrigated agriculture,
- iii) To practice appropriate farming, such as fertilization, deep tillage, and liming, and
- iv) To make a long term improvement in hygiene and sanitation.

TABLES

SUMMARY OF ANNUAL RUNOFF

WATER YEAR	Lom Sak Area				Phetchabun Area			
	Saduang Yai (MCM)	Khon Kaen (MCM)	Yield ℓ/s/km^2	Runoff Coefficient (%)	Yai (MCM)	Chaliang Lab (MCM)	Yield ℓ/s/km^2	Runoff Coefficient (%)
1964	35.4	118.8	11.7	27.7	40.1	41.1	16.9	33.0
65	21.6	72.5	7.1	21.8	17.2	17.7	7.3	22.7
66	21.4	71.9	7.1	25.9	22.2	22.7	9.4	25.9
67	20.6	69.2	6.8	23.5	17.5	17.9	7.4	22.2
68	22.4	75.3	7.4	22.3	15.3	15.7	6.5	18.9
69	20.2	67.9	6.7	22.6	20.7	21.2	8.7	24.9
70	23.2	77.9	7.7	23.2	26.8	27.5	11.3	27.4
71	19.1	64.1	6.3	20.4	12.0	12.4	5.1	18.1
72	16.7	56.0	5.5	18.8	15.5	15.9	6.5	20.1
73	11.7	39.3	3.9	15.4	20.4	20.9	8.6	26.9
74	17.5	58.5	5.8	16.6	11.5	11.8	4.9	15.7
75	18.9	63.5	6.3	19.7	14.6	15.0	6.2	21.0
76	27.4	91.9	9.0	23.7	34.7	35.7	14.6	32.7
77	13.0	43.3	4.3	16.2	13.6	14.0	5.8	19.2
78	42.7	14.3	14.1	34.4	31.5	32.3	13.3	32.3
79	16.6	55.6	5.5	17.9	8.4	8.6	3.5	15.2
80	32.0	107.2	10.5	27.2	16.9	17.3	7.1	22.7
Average	22.4	75.1	7.4	22.2	19.9	20.5	8.4	24.4

STRATIGRAPHYCAL TABLE

AGE	GROUP	FORMATION	SYMBOL	GEOLOGICAL ASPECT
QUATERNARY			Qa	Alluvial deposit.
			Qt	Terrace gravel, talus, delluvial deposit
TERTIARY		CHALIANG LAB	Cl	Shale, yellowish gray Calcareous mudstone
LOWER – MIDDLE JURASSIC	KHORAT	PHRA WIHAN	Pw	Sandstone with shale
LOWER JURASSIC	KHORAT	PHU KRADUNG	Pk	Shale Sandstone
UPPER TRIASSIC	KHORAT	NAM PHONG	np	Sandstone Conglomerate Shale
			hl	Conglomerate
PERMO TRIASSIC		HUAI HIN LAT	ht	Tuff Agglomerate
MIDDLE PERMIAN		NAM DUK	nd	Shale Sandstone Limestone
LOWER – MIDDLE PERMIAN		PHA NOK KHAO	pn	Limestone Chart Shale
IGNEOUS ROCKS			G	Granite, diorite, gabbroic diorite

AMOUNT OF FARM INPUTS AT PRESENT

	Rainy Season Paddy (L.V)	Rainy Season Paddy (H.Y.V)	Mungbeans	Tobacco	Maize
Seed (kg/rai)	5.0	6.0	5.0	3,500/1	3.0
Fertilizer					
Urea (kg/rai)	-	-	-	-	-
Mixed fertilizer (kg/rai)	-	-	-	100	-
Agro-chemicals					
Insecticides (lit/rai)	0.1	0.1	0.5	1.0	0.1
Fungicides	-	-	-	-	-
Rodenticides	-	-	-	-	-

/1 : No. of Seedling

Source: - Farm Economy Survey, 1982
- Provincial Agricultural Office, 1982

PRESENT LABOR REQUIREMENT FOR CROPS

(Unit: men/days)

	Rainy Season Paddy (L.V)	Rainy Season Paddy (H.Y.V)	Mungbeans	Tobacco	Maize
Nursery	0.07	0.07	-	0.33	-
Land preparation /1					
Plowing	0.49	0.49	0.07	0.12	0.37
Harrowing	0.52	0.52	0.08	0.15	0.01
Paddling	-	-	-	0.32	-
Transplanting or sowing	2.66	3.18	0.18	5.22	1.38
Weeding	0.85	1.03	-	1.46	1.36
Fertilizing	-	-	-	3.65	-
Spraying	0.10	0.13	0.30	2.47	0.19
Harvesting	3.31	4.00	2.76	10.50	2.15
Threshing	1.91	2.11	0.24	6.89	0.30
Others	-	-	-	-	-
Total	9.91	11.53	3.63	31.11	5.77

/1 : - including by tractor

Source: - Farm Economy Survey, 1982
- Branch of Economy Section, RID, 1981

FARM GATE PRICES OF MAJOR FARM PRODUCTS AND INPUTS

	Item	Unit Price (Baht/kg, lit. or head)	Remarks
Farm Products,	Rice	5.3	
	Paddy	2.8	Dry paddy
	Maize	2.4	
	Mungbeans	8.5	
	Soybeans	7.0	
	Peanuts	6.4	
	Tobacco	28.0	
Seed,	Paddy	4.0	
	Maize	6.0	
	Mungbeans	10.0	
	Soybeans	9.0	
Seedling,	Tobacco	35.0	1,000 trees
Fertilizer,	Urea	6.0	
	Mixed fertilizer	8.0	
Agro-chemical,	Insecticides	180.0	1 liter
	Fungicides	150.0	1 liter
	Rodenticides	2.0	100 g
Livestock,	Cattle	6,500	
	Buffalo	10,000	
	Swine	1,700	
	Chicken	37	
	Duck	40	
	Egg (chicken)	1	1 piece
Agro-equipment,	Hand tractor	30,000	
	Sickle	20	
Labor,	Light	30	1 person/day
	Heavy	40	1 person/day
	Land preparation by tractor	150	per rai

Source: - Farm Economy Survey together with village survey, 1982
- Commercial Office in Phetchabun Province, 1982
- Agricultural Office in Phetchabun and Lom Sak District, 1982

TABLE 6.1

TABLE 6.2

FUTURE AMOUNT OF FARM INPUTS

	Rainy Season Paddy (L.V)	Rainy Season Paddy (H.Y.V)	Mungbeans	Tobacco
Seed (kg/rai)	5.0	5.0	6.0	4,000*
Fertilizer				
Urea (kg/rai)	10	15	-	50
Mixed fertilizer (kg/rai)	10	20	10	150
Agro-chemicals				
Insecticides (lit./rai)	0.40	0.40	0.30	1.0
Fungicides (lit./rai)	0.20	0.20	0.10	0.50
Rodenticides (gr./rai)	40	40	30	-

Reference Data: Farm Economy Survey, 1982

Provincial Agricultural Office, 1982

Branch of Economy Section, RID, 1981

Branch of Irrigated Agriculture Section, RID, 1981

* : No. of Seedling

LABOR REQUIREMENTS FOR THE TYPICAL FARM FAMILY

(Unit: man-days)

Crops	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
Paddy				
- local varieties	27.6	28.2	31.3	29.2
- high yield varieties	72.9	74.6	82.9	77.1
Mungbeans	7.2	7.3	8.1	7.6
Tobacco	77.5	79.2	88.0	81.8
Other upland crops	125.6	115.0	83.4	100.1
Total	310.8	304.3	293.7	295.8
Available family labours	750.0	750.0	750.0	750.0
Balance	+439.2	+445.7	+456.3	+454.2

TABLE 6.3

ECONOMIC AND FINANCIAL PRICES OF MAJOR FARM INPUTS AND OUTPUTS

Item		Financial Prices (฿/ton or lit.)	Economic Prices (฿/ton or lit.)	Remarks
Farm Products,	Rice (L.V.)/1	5,200	11,500	
	(H.Y.V.)	5,500	12,100	
	Paddy (L.V.)/1	2,700	7,500	Dry paddy
	(H.Y.V.)	2,800	7,900	Dry paddy
	Maize	2,400	3,900	
	Mungbeans	8,500	13,000	
	Soybeans	7,000		
	Tobacco	28,000	43,100	
Seed,	Paddy	4,000	10,000	
	Maize	6,000	9,000	
	Mungbeans	10,000	15,000	
Seedling,	Tobacco	35	53	1,000 trees
Fertilizer,	Urea	6,000	10,600	
	Mixed fertilizer	8,000	12,800	
Agro-chemical,	Insecticides	180	300	Liter
	Fungicides	150	250	Liter
	Rodenticides	2	3	100 g
Livestock,	Chicken	37		1 head
	Duck	40		1 head
	Egg	1.5		1 head
Labor	Light	60.0	30.0/2	1 person/day
	Heavy	80.0	40.0/3	1 person/day

/1: About 95% of price for H.Y.V.

/2: ฿34/man-day in 1990 after inclusion of the real increase at the rate of 1.5%/year.

/3: ฿45/man-day in 1990 after inclusion of the real increase at the rate of 1.5%/year.

SALIENT FEATURES OF PROJECT FACILITIES

- DAM AND RESERVOIR -

Description	Name of Dam			
	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
I. Reservoir				
(1) Drainage Area (km^2)	96	322	75	77
(2) Total Storage Capacity ($x10^3m^3$)	27,960	33,220	14,000	7,500
(3) Dead Storage Capacity ($x10^3m^3$)	960	3,220	750	770
(4) Useful Storage Capacity ($x10^3m^3$)	27,000	30,000	13,250	6,730
(5) High Water Level (m)	EL.197.50	EL.219.50	EL.218.50	EL.208.30
(6) Full Water Level (m)	EL.195.50	EL.216.50	EL.216.50	EL.206.50
(7) Dead Water Level (m)	EL.174.50	EL.187.50	EL.197.00	EL.189.00
(8) Reservoir Area at Full Water Level (km^2)	2.08	1.60	1.09	0.65
(9) Effective Stored Depth (m)	21.0	29.0	19.5	17.5
II. Dam				
(1) Dam Crest Elevation (m)	EL.199.00	EL.221.00	EL.220.00	EL.210.00
(2) Freeboard (m)	3.5	4.5	3.5	3.5
(3) Dam Height (m)	38.0	57.0	38.0	35.3
(4) Dam Crest Length (m)	467.0	950.0	816.0	1259.0
(5) Dam Crest Width (m)	8.0	10.0	8.0	8.0
(6) Embankment Slope				
Upstream	1:3.0	1:3.0	1:3.0	1:3.0
Downstream	1:2.5	1:2.5	1:2.5	1:2.5
(7) Embankment Volume				
Core zone (m^3)	179,200	544,200	152,300	158,800
Shell zone (m^3)	821,200	2,783,000	619,900	628,800
Total (m^3)	1,000,400	3,327,200	772,200	787,600
III. Spillway				
III-1. Service Spillway				
(1) Design Discharge (m^3/s)	445.7	821.1	289.5	244.2
(2) Type	side channel	side channel	side channel	side channel
(3) Crest Length (m)	105.0	110.0	65.0	70.0
(4) Overflow Depth (m)	1.62	2.51	1.66	1.55
III-2. Emergency Spillway				
(1) Desigh Discharge (m^3/s)	577.3	1,069.9	367.6	310.1
(2) Type	chute	chute	chute	side channel
(3) Crest Length (m)	70.0	80.0	100.0	70.0
(4) Overflow Depth (m)	1.91	2.93	1.96	1.75
IV. Outlet Work				
(1) Design Discharge (m^3/s)	5,496	5,468	1,875	1,277
(2) Intake Tower				
Section (m x m)	4.0 x 4.0	4.0 x 4.0	4.0 x 4.0	4.0 x 4.0
Height (m)	29.0	37.0	37.5	25.5
(3) Outlet Conduit				
Diameter (m)	2.0	2.0	2.0	2.0
Length (m)	145.0	200.0	140.0	160.0
(4) Span of Bridge (m)	59.0	105.0	105.0	62.0

TABLE 7.1 (2)

SALIENT FEATURES OF PROJECT FACILITIES

- IRRIGATION AND DRAINAGE CANALS -

DESCRIPTION	HUAI KHON KAEN SUB-PROJECT	HUAI YAI SUB-PROJECT	KHLONG CHALIANG LAB SUB-PROJECT
1. Source of irrigation	Huai Khon Kaen Reservoir	Huai Yai Reservoir	Khlong Chaliang Lab Reservoir
2. Net irrigation area	5,100 ha	1,800 ha	1,200 ha
3. Maximum diversion water requirement	5.1 m^3/sec	1.8 m^3/sec	1.2 m^3/sec
4. Irrigation facilities			
Main Canal	2 Nos.	1 No.	1 No.
- Type of canal	trapezoidal concrete lined	trapezoidal concrete lined	trapezoidal concrete lined
- Side slope of canal	1 : 1.5	1 : 1.5	1 : 1.5
- Length	53.5 Km	8.9 Km	7.4 Km
- Width of inspection road	6.0 m (effective width: 5.0 m)	6.0 m (effective width: 5.0 m)	6.0 m (effective width: 5.0 m)
Lateral and sub-lateral canal	22 Nos.	3 Nos.	4 Nos.
- Type of canal	trapezoidal unlined	trapezoidal unlined	trapezoidal unlined
- Side slope of canal	1 : 1.5	1 : 1.5	1 : 1.5
- Length	52.2 Km	17.7 Km	13.8 Km
- Width of inspection road	4.0 m (effective width: 3.0 m)	4.0 m (effective width: 3.0 m)	4.0 m (effective width: 3.0 m)
Related structures			
- Culvert	40 Nos.	11 Nos.	5 Nos.
- Inverted siphon	17 Nos.	5 Nos.	3 Nos.
- Drop structure	38 Nos.	41 Nos.	48 Nos.
- Check structure	86 Nos.	21 Nos.	19 Nos.
- Check & Drop structure	38 Nos.	23 Nos.	16 Nos.
- Turnout	21 Nos.	2 Nos.	3 Nos.
- Farm turnout	132 Nos.	52 Nos.	34 Nos.
- Spillway	19 Nos.	8 Nos.	4 Nos.
- Measuring device	22 Nos.	3 Nos.	4 Nos.
- Cross drain	21 Nos.	5 Nos.	2 Nos.
- Bridge	18 Nos.	21 Nos.	2 Nos.
5. Drainage facilities			
- Length of canal	72.3 Km	36.7 Km	20.0 Km
- Related structure (culvert & cross drain)	7 Nos.	2 Nos.	1 No.

SUMMARY OF CONSTRUCTION COST

	Item	Total (10^3 Baht)	Foreign Currency (10^3 Baht)	Local Currency (10^3 Baht)
1.	Direct Construction Cost	1,984,979	1,032,359	952,620
1.1	Dam Construction			
	- Preparatory Works	107,523	75,302	32,221
	- Dam	1,027,013	606,822	420,191
	- Service Spillway	276,176	128,645	147,531
	- Emergency Spillway	22,279	9,254	13,025
	- Outlet Works	26,519	8,302	18,217
	- Overhead	51,082	28,990	22,092
	- Profit	94,866	53,839	41,027
	- Tax	52,976	30,065	22,911
	Sub-Total	1,658,434	941,219	717,215
1.2	Canal Construction			
	- Preparatory Works	33,124	12,692	20,432
	- Main Canal	167,097	58,397	108,700
	- Lateral Canal	45,044	6,299	38,745
	- Drainage Canal	5,685	2,505	3,180
	- Overhead	9,476	2,973	6,503
	- Profit	16,967	5,364	11,603
	- Tax	9,152	2,910	6,242
	Sub-Total	286,545	91,140	195,405
1.3	Office and Quarters	40,000	-	40,000
2.	Land Acquisition & Compensation			
	- Dam (Compensation)	2,200	-	2,200
	- Canal (Acquisition)	6,350	-	6,350
	Sub-Total	8,550	-	8,550
3.	O & M Equipment	45,229	41,879	3,350
4.	Administration	146,252	-	146,252
	Total	2,185,010	1,074,238	1,110,772
5.	Physical Contingency	218,498	107,423	111,075
6.	Engineering Services	253,920	196,710	57,210
	Total	2,657,428	1,378,371	1,279,057
7.	Price Contingency	1,826,651	645,313	1,181,338
	GRAND TOTAL	4,484,079	2,023,684	2,460,395

CONSTRUCTION COST FOR PACKAGE

(Unit: 10^3 Baht)

	Item	PACKAGE I Huai Khon Kaen, Huai Yai			PACKAGE II Huai Saduang Yai, Khlong Chaliang Lab		
		Total	Foreign	Local	Total	Foreign	Local
1.	Direct Construction Cost	1,392,424	723,127	669,297	592,555	309,232	283,323
1.1	Dam Construction						
	- Preparatory Works	72,127	51,119	21,008	35,396	24,183	11,213
	- Dam	686,133	409,668	276,465	340,880	197,154	143,726
	- Service Spillway	184,027	91,154	92,873	92,149	37,491	54,658
	- Emergency Spillway	18,396	6,250	12,146	3,883	3,004	879
	- Outlet Works	12,778	4,121	8,657	13,741	4,181	9,560
	- Overhead	34,071	19,680	14,391	17,011	9,310	7,701
	- Profit	63,274	36,549	26,725	31,592	17,290	14,302
	- Tax	35,333	20,410	14,923	17,643	9,655	7,988
	Sub-Total	1,106,139	638,951	467,188	552,295	302,268	250,027
1.2	Canal Construction						
	- Preparatory Works	30,647	11,911	18,736	2,477	781	1,696
	- Main Canal	154,100	54,251	99,849	12,997	4,146	8,851
	- Lateral Canal	36,312	5,314	30,998	8,732	985	7,747
	- Drainage Canal	5,503	2,423	3,080	182	82	100
	- Overhead	8,257	2,674	5,583	1,219	299	920
	- Profit	15,138	4,915	10,223	1,829	449	1,380
	- Tax	8,248	2,688	5,560	904	222	682
	Sub-Total	258,205	84,176	174,029	28,340	6,964	21,376
1.3	Office and Quarters	28,080	-	28,080	11,920	-	11,920
2.	Land Acquisition and Compensation						
	- Dam (Compensation)	1,080	-	1,080	1,120	-	1,120
	- Canal (Acquisition)	5,575	-	5,575	775	-	775
	Sub-Total	6,655	-	6,655	1,895	-	1,895
3.	O & M Equipment	21,141	19,575	1,566	24,088	22,304	1,784
4.	Administration	71,965	-	71,965	74,287	-	74,287
	Total	1,492,185	742,702	749,483	692,825	331,536	361,289
5.	Physical Contingency	149,217	74,270	74,947	69,281	33,153	36,128
6.	Engineering Service	153,334	118,787	34,547	100,586	77,923	22,663
	Total	1,794,736	935,759	858,977	862,692	442,612	420,080
7.	Price Contingency	947,109	344,071	603,038	879,542	301,242	578,300
	GRAND TOTAL	2,741,845	1,279,830	1,462,015	1,742,234	743,854	998,380

TABLE 9.1
(1)

FINANCIAL CASH FLOW STATEMENT (Package I)

(Unit: 10^3฿)

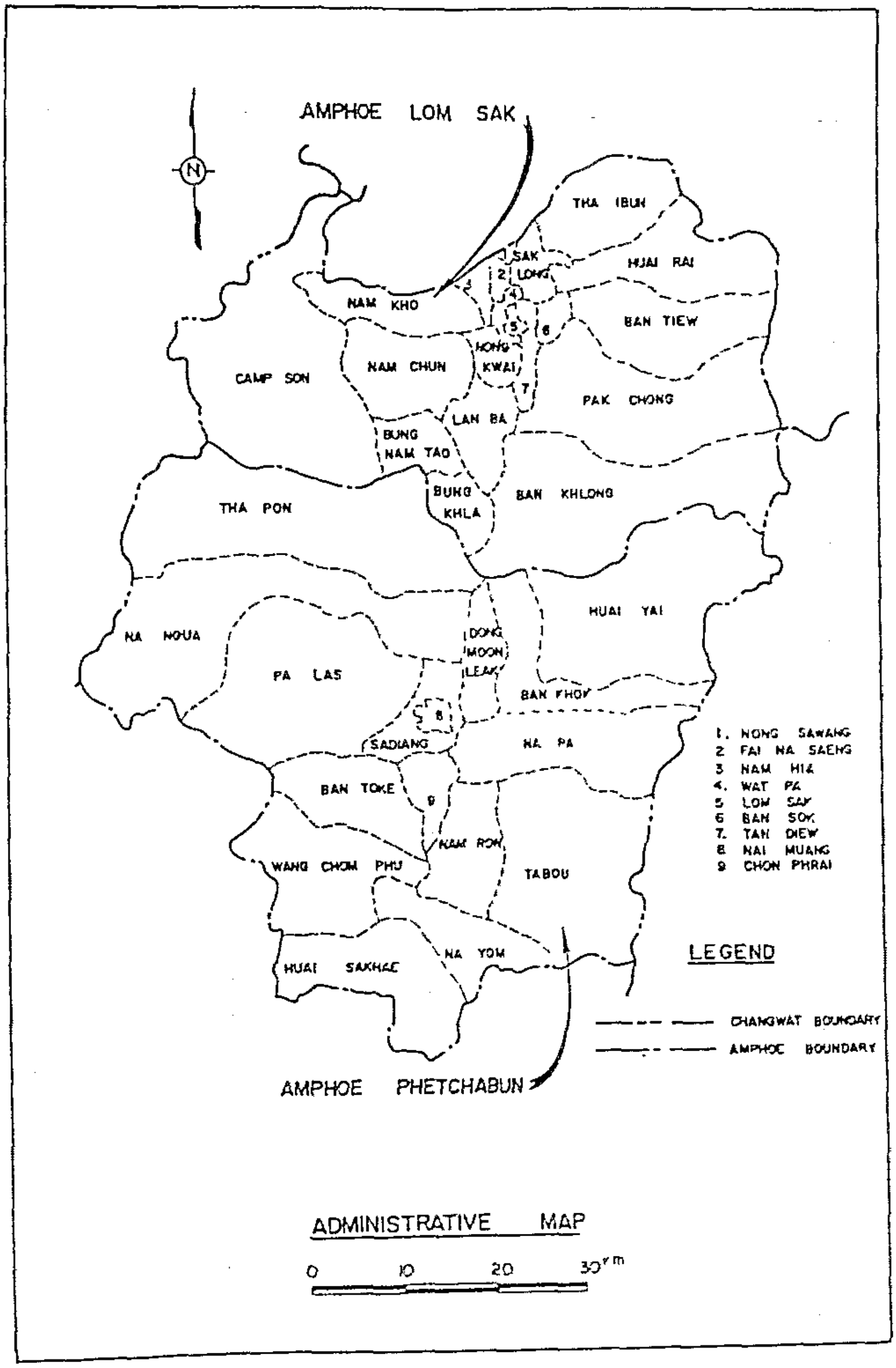
Year	Year in Order	Loan Disburse-ment	Accu-mulated Loan	Cash Outflow: O & M Cost	Cash Outflow: Repaym't of Loan Interest	Cash Outflow: Repaym't of Loan Capital	Cash Outflow: Total Outflow (A)	Cash Inflow: Project Revenue	Cash Inflow: Governm't Subsidy	Cash Inflow: Total Inflow (B)	Balance Repay-ment (B)-(A)
1984	1	31,172	31,172	-	1,091.0	-	1,091.0	-	1,091.0	1,091.0	0
1985	2	55,057	86,229	-	3,018.0	-	3,018.0	-	3,018.0	3,018.0	0
1986	3	229,599	315,828	-	11,054.0	-	11,054.0	-	11,054.0	11,054.0	0
1987	4	321,002	636,830	-	22,289.1	-	22,289.1	-	22,289.1	22,289.1	0
1988	5	360,439	997,269	-	34,904.4	-	34,904.4	-	34,904.4	34,904.4	0
1989	6	230,320	1,227,589	1,883	42,965.6	-	44,848.6	1,883	42,965.6	44,848.6	0
1990	7	52,241	1,279,830	6,346	44,794.1	-	51,140.1	6,346	44,794.1	51,140.1	0
1991	8		1,279,830	7,148	44,794.1	-	51,942.1	7,148	44,794.1	51,942.1	0
1992	9		1,279,830	7,737	44,794.1	-	52,531.1	7,737	44,794.1	52,531.1	0
1993	10		1,279,830	8,248	44,794.1	1,558.6	54,600.7	8,248	46,352.7	54,600.7	0
1994	11		1,278,271.4	8,647	44,739.5	4,311.5	57,698.0	8,647	49,051.0	57,698.0	0
1995	12		1,273,959.9	8,647	44,588.6	15,791.4	69,027.0	8,647	60,380.0	69,027.0	0
1996	13		1,258,168.5	8,647	44,035.9	31,841.5	84,524.4	8,647	75,877.4	84,524.4	0
1997	14		1,226,327.0	8,647	42,921.4	49,863.5	101,431.9	8,647	92,784.9	101,431.9	0
1998	15		1,176,463.5	8,647	41,176.2	61,379.5	111,202.7	8,647	102,555.7	111,202.7	0
1999	16		1,115,084.0	8,647	39,027.9	63,991.5	111,666.4	8,647	103,019.4	111,666.4	0
2000	17		1,051,092.5	8,647	36,788.2	63,991.5	109,426.7	8,647	100,779.9	109,426.7	0
2001	18		987,101.0	8,647	34,548.5	63,991.5	107,187.0	8,647	98,540.0	107,187.0	0
2002	19		923,109.5	8,647	32,308.8	63,991.5	104,947.3	8,647	96,300.3	104,947.3	0
2003	20		859,118.0	8,647	30,069.1	63,991.5	102,707.6	8,647	94,060.6	102,707.6	0
2004	21		795,126.5	8,647	27,829.4	63,991.5	100,467.9	8,647	91,820.9	100,467.9	0
2005	22		731,135.0	8,647	25,589.7	63,991.5	98,228.2	8,627	89,581.2	98,228.2	0
2006	23		667,143.5	8,647	23,350.0	63,991.5	95,988.5	8,647	87,341.5	95,988.5	0
2007	24		603,152.0	8,647	21,110.3	63,991.5	93,748.8	8,647	85,101.8	93,748.8	0
2008	25		539,160.5	8,647	18,870.6	63,991.5	91,509.1	8,647	82,662.1	91,509.1	0
2009	26		475,169.0	8,647	16,630.9	63,991.5	89,269.4	8,647	80,622.4	89,269.4	0
2010	27		411,177.5	8,647	14,391.2	63,991.5	87,029.7	8,647	78,382.7	87,029.7	0
2011	28		347,186.0	8,647	12,151.5	63,991.5	84,790.0	8,647	76,143.0	84,790.0	0
2012	29		283,194.5	8,647	9,911.8	63,991.5	82,550.3	8,647	73,903.3	82,550.3	0
2013	30		219,203.0	8,647	7,672.1	62,432.9	78,752.0	8,647	70,105.0	78,752.0	0
2014	31		156,770.1	8,647	5,487.0	59,680.1	73,814.1	8,647	65,167.1	73,814.1	0
2015	32		97,090.0	8,647	3,398.2	48,200.1	60,245.3	8,647	51,598.3	60,245.3	0
2016	33		48,889.9	8,647	1,711.1	32,150.0	42,508.1	8,647	33,861.1	42,508.1	0
2017	34		16,739.9	8,647	585.9	14,128.1	23,361.0	8,647	14,714.0	23,361.0	0
2018	35		2,611.8	8,647	91.4	2,611.8	11,350.2	8,647	2,703.2	11,350.2	0
2019	36		0	8,647	0	0	8,647.0	8,647	0	8,647.0	0

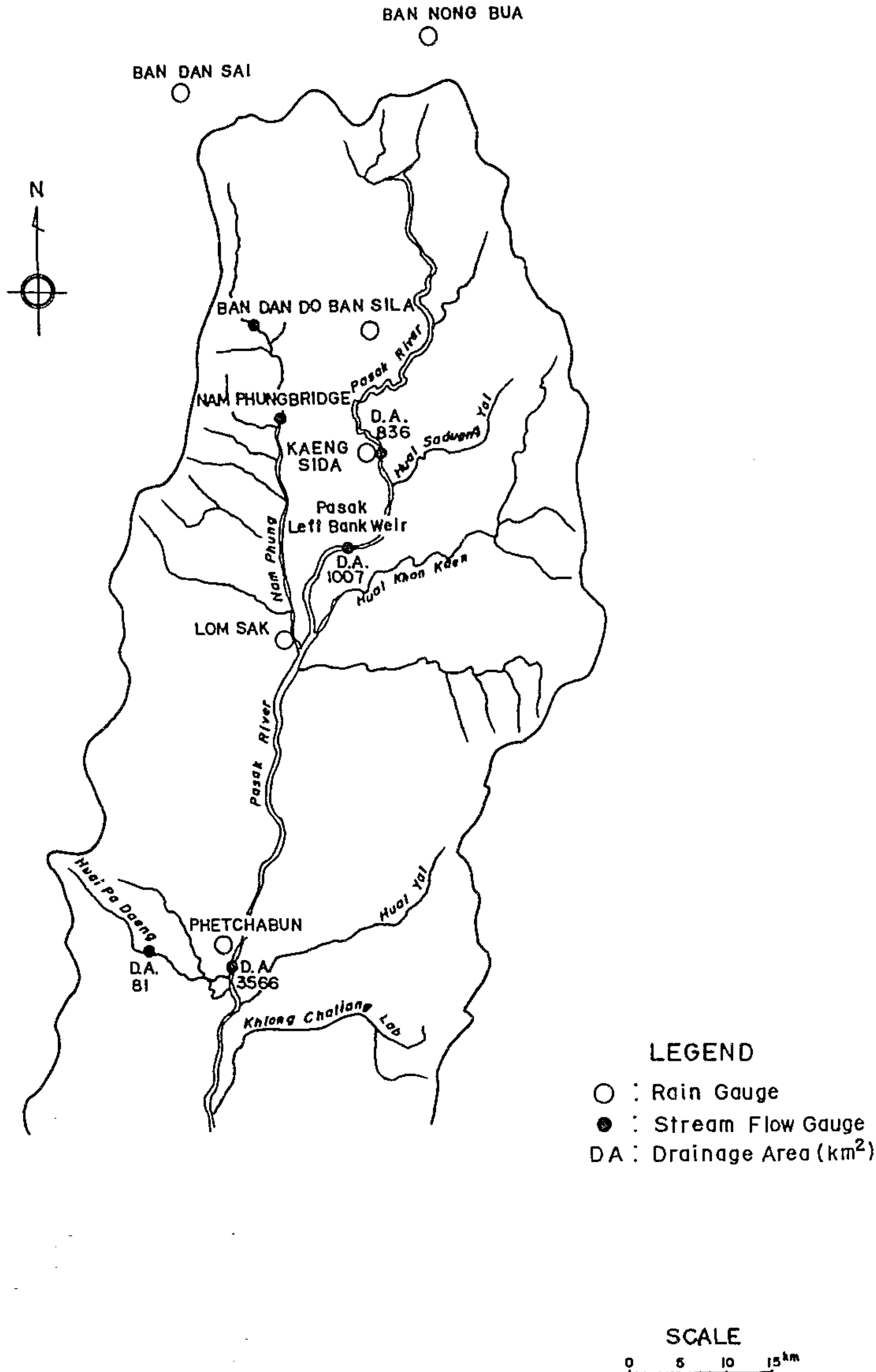
FINANCIAL CASH FLOW STATEMENT (Overall Case II)

(Unit: 10^3฿)

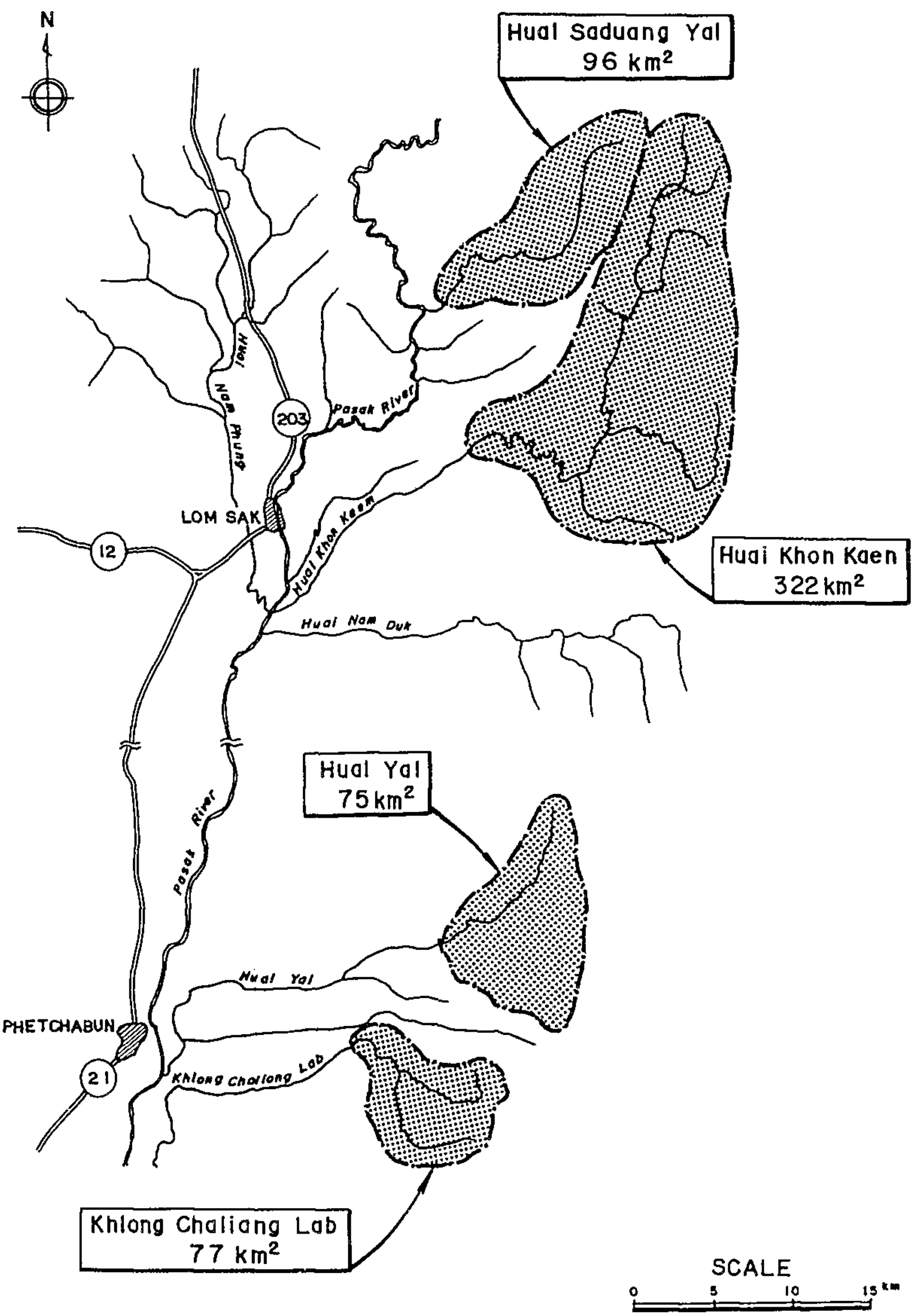
Year	Year in Order	Loan Disburse-ment	Accu-mulated Loan	Cash Outflow: O & M Cost	Cash Outflow: Repaym't of Loan Interest	Cash Outflow: Repaym't of Loan Capital	Cash Outflow: Total Outflow (A)	Cash Inflow: Project Revenue	Cash Inflow: Governm't Subsidy	Cash Inflow: Total Inflow (B)	Balance Repay-ment (B)-(A)
1984	1	31,172	31,172	-	1,091.0	-	1,091.0	-	1,091.0	1,091.0	0
1985	2	55,057	86,229	-	3,018.0	-	3,018.0	-	3,018.0	3,018.0	0
1986	3	229,599	315,828	-	11,054.0	-	11,054.0	-	11,054.0	11,054.0	0
1987	4	321,002	636,830	-	22,289.1	-	22,289.1	-	22,289.1	22,289.1	0
1988	5	386,674	1,023,504	-	35,822.6	-	35,822.6	-	35,822.6	35,822.6	0
1989	6	265,499	1,289.003	1,883	45,115.1	-	46,998.1	1,883	45,115.1	46,998.1	0
1990	7	236,488	1,525,491	6,346	53,392.2	-	59,738.2	6,346	53,392.2	59,738.2	0
1991	8	233,164	1,758,655	7,148	61,552.9	-	68,700.9	7,148	61,552.9	68,700.9	0
1992	9	237,125	1,995,780	7,737	69,852.3	-	77,589.3	7,737	69,852.3	77,589.3	0
1993	10	27,904	2,023,684	14,705	70,828.9	1,558.6	87,092.5	14,705	72,387.5	87,092.5	0
1994	11		2,022,125.4	16,019	70,774.4	4,311.5	91,104.9	16,019	75,085.9	91,104.9	0
1995	12		2,017,813.9	16,709	70,623.5	15,791.4	103,123.9	16,709	86,414.9	103,123.9	0
1996	13		2,002,022.5	17,361	70,070.8	31,841.5	119,273.3	17,361	101,912.3	119,273.3	0
1997	14		1,970,181.0	18,103	68,956.3	51,175.2	138,234.5	18,103	120,131.5	138,234.5	0
1998	15		1,919,005.8	18,103	67,165.2	64,450.2	149,718.4	18,103	131,615.4	149,718.4	0
1999	16		1,854,555.6	18,103	64,909.4	76,274.6	159,287.0	18,103	141,184.0	159,287.0	0
2000	17		1,778,281.0	18,103	62,239.8	87,932.8	168,275.6	18,103	150,172.6	168,275.6	0
2001	18		1,690,348.2	18,103	59,162.2	99,789.0	177,054.2	18,103	158,951.2	177,045.2	0
2002	19		1,590,559.2	18,103	55,669.6	101,184.2	174,956.8	18,103	156,853.8	174,956.8	0
2003	20		1,489,375.0	18,103	52,128.1	101,184.2	171,415.3	18,103	153,312.3	171,415.3	0
2004	21		1,388,190.8	18,103	48,586.7	101,184.2	167,873.9	18,103	149,770.9	167,873.9	0
2005	22		1,287,006.6	18,103	45,045.2	101,184.2	164,332.4	18,103	146,229.4	164,332.4	0
2006	23		1,185,822.4	18,103	41,503.8	101,184.2	160,791.0	18,103	142,688.0	160,791.0	0
2007	24		1,084,638.2	18,103	37,962.3	101,184.2	157,249.5	18,103	139,146.5	157,249.5	0
2008	25		983,454 0	18,103	34,420.9	101,184.2	153,708.1	18,103	135,605.1	153,708.1	0
2009	26		882,269.8	18,103	30,879.4	101,184.2	150,166.6	18,103	132,063.6	150,166.6	0
2010	27		781,085.6	18,103	27,338.0	101,184.2	147,625.2	18,103	129,522.2	147,625.2	0
2011	28		679,901.4	18,103	23,796.5	101,184.2	143,083.7	18,103	124,980.7	143,083.7	0
2012	29		578,717.2	18,103	20,255.1	101,184.2	139,542.3	18,103	121,439.3	139,542.3	0
2013	30		477,533.0	18,103	16,713.7	99,625.6	134,442.3	18,103	116,339.3	134,442.3	0
2014	31		377,907.4	18,103	13,226.8	96,872.8	128,202.6	18,103	110,099.6	128,202.6	0
2015	32		281,034.6	18,103	9,836.2	85,392.8	113,332.0	18,103	95,229.0	113,332.0	0
2016	33		195,641.8	18,103	6,847.5	69,342.7	94,293.2	18,103	76,190.2	94,293.2	0
2017	34		126,299.1	18,103	4,420.5	50,009.0	72,532.5	18,103	54,429.5	72,532.5	0
2018	35		76,290.1	18,103	2,670.2	36,734.1	57,507.3	18,103	39,404.3	57,507.3	0
2019	36		39,556.0	18,103	1,384.5	24,909.7	44,397.2	18,103	26,294.2	44,397.2	0
2020	37		14,646.3	18,103	512.6	13,251.5	31,867.1	18,103	13,764.1	31,867.1	0
2021	38		1,394.8	18,103	48.8	1,394.8	19,546.6	18,103	1,443.6	19,546.6	0
2022	39		0	18,103	0	0	18,103.0	18,103	0	18,103.0	0

FIGURES

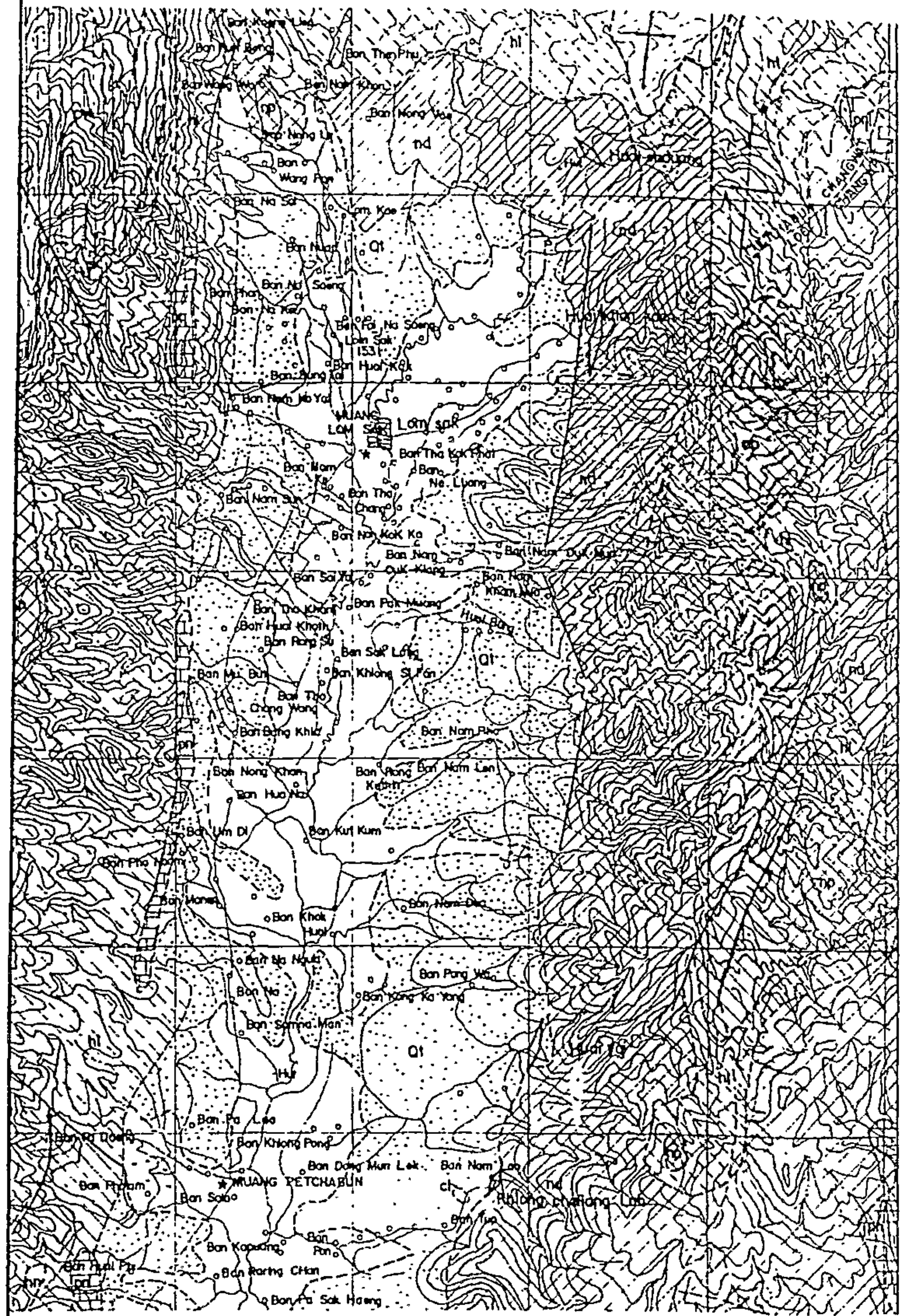

AMPHOE LOM SAK
N
THA IBUN
SAK LONG
HUAI RAI
NAM KHO
BAN TIEW
NONG KWAI
CAMP SON
NAM CHUN
PAK CHONG
LAN BA
BUNG NAM TAO
BUNG KHLA
BAN KHLONG
THA PON
HUAI YAI
NA NOUA
DONG MOON LEAK
PA LAS
BAN KHOK
SADIANG
NA PA
BAN TOKE
NAM RON
WANG CHOM PHU
TABOU
HUAI SAKHAE
NA YOM
1. NONG SAWANG
2 FAI NA SAENG
3 NAM HIA
4. WAT PA
5 LOM SAK
6 BAN SOK
7. TAN DIEW
8 NAI MUANG
9 CHON PHRAI
LEGEND
CHANGWAT BOUNDARY
AMPHOE BOUNDARY
AMPHOE PHETCHABUN
ADMINISTRATIVE MAP
0 10 20 30 km



LOCATION OF GAUGING STATION
(Upper Pasak Basin)



WATERSHED OF EACH TRIBUTARY



N

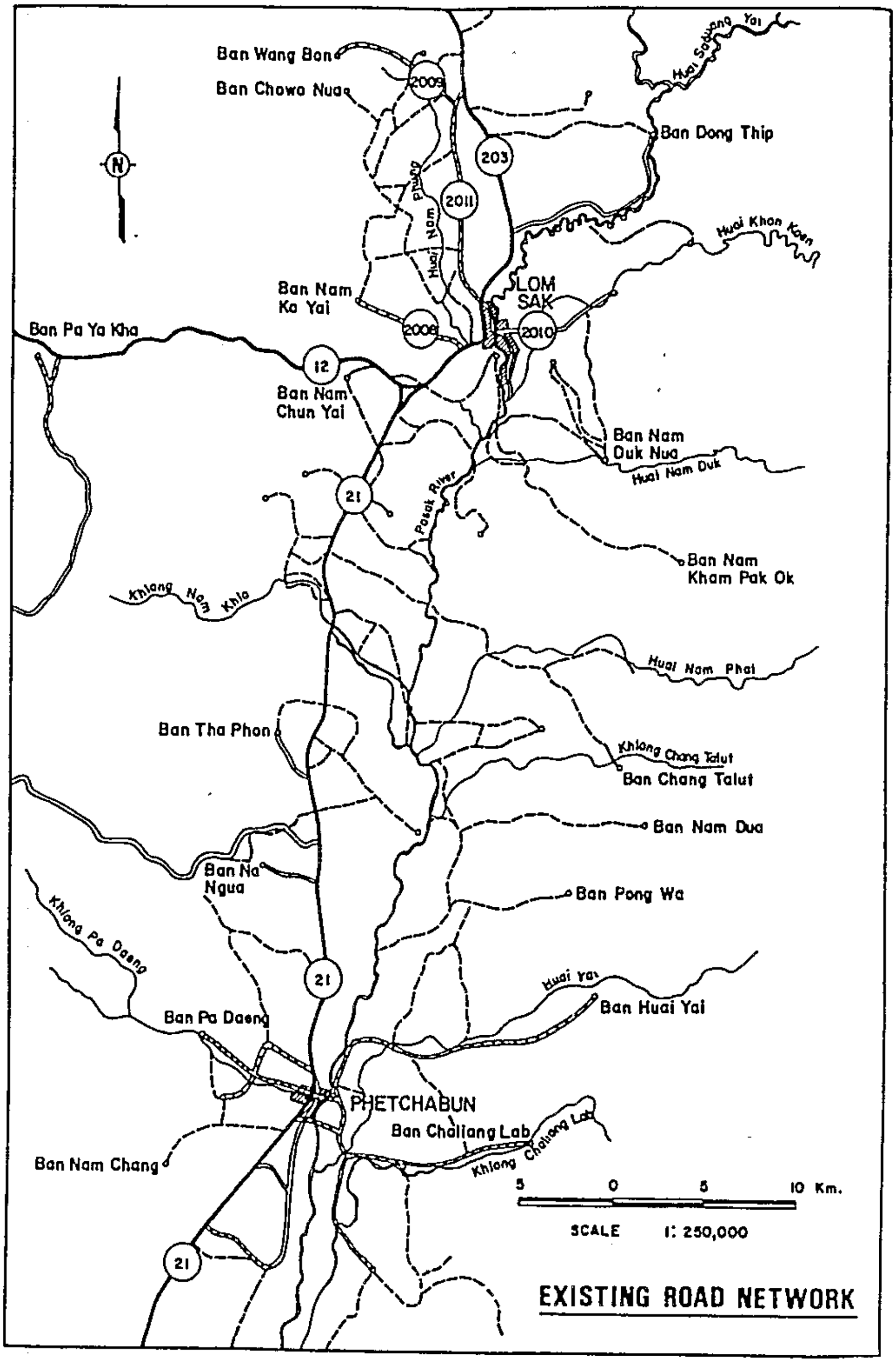
		FORMATION	GROUP	AGE
Qa	Alluvial deposit			QUATERNARY
Qt	Terrace gravel, talus, colluvial deposit			
	UNCONFORMITY			
cl	Shale : yellowish gray, calcareous. mudstone : white, calcareous wellbedded	CHALIANG LAB		TERTIARY
	UNCONFORMITY			
pw	Sand stone, white pink orthoquartzitic cross bedded massive pebble layering on the upper bed, with some reddish brown and gray shale	PHRA WIHAN	KHORAT	LOWER MIDDLE JURASSIC
pk	Shale, brown, reddish brown, purplish red, micaceous siltstone, sandstone brown, gray, micaceous small scale cross bedded, with some lime-noduled conglomerate.	PHU KRADUNG		LOWER JURASSIC
np	Sandstone; reddish brown. brown, cross-bedded. conglomerate; pebbles of quartz, quartzite chert red siltstone. up to 10 cm. in diameter shale siltstone brown, reddish brown.	NAM PHONG		UPPER TRIASSIC
hl	Tuff, agglo merate rhyolite			PERMO TRIASSIC
	UNCONFORMITY			
pd	Shale, gray to black, sandstone, yellowish brown. fine-grained; limestone, lense and bedded. highly disturbant.	NAM DUK		MIDDLE PERMIAN
pn	Limestone, gray massive to thick bedded chert; black noduled or thin bedded. with thin bedded, gray shale	PHA NOK KHAO		LOWER - MIDDLE PERMIAN
	IGNEOUS ROCKS			
G	Granite, diorite gabbroic diorite			

SYMBOLS

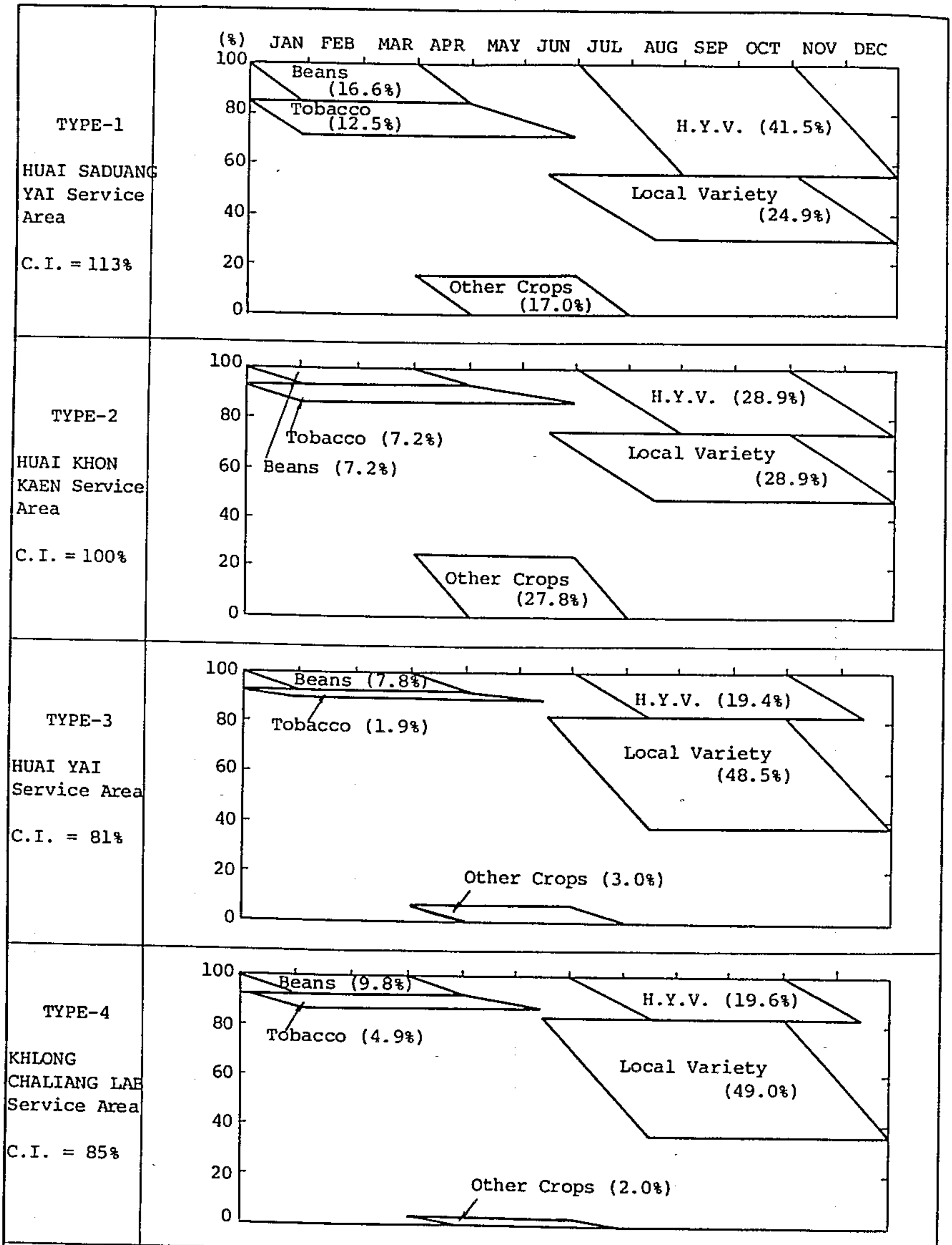
- Boundary
- Anticline, with plunging direction
- Syncline with plunging direction
- Fault

5 0 5 10 km
SCALE

GEOLOGICAL MAP

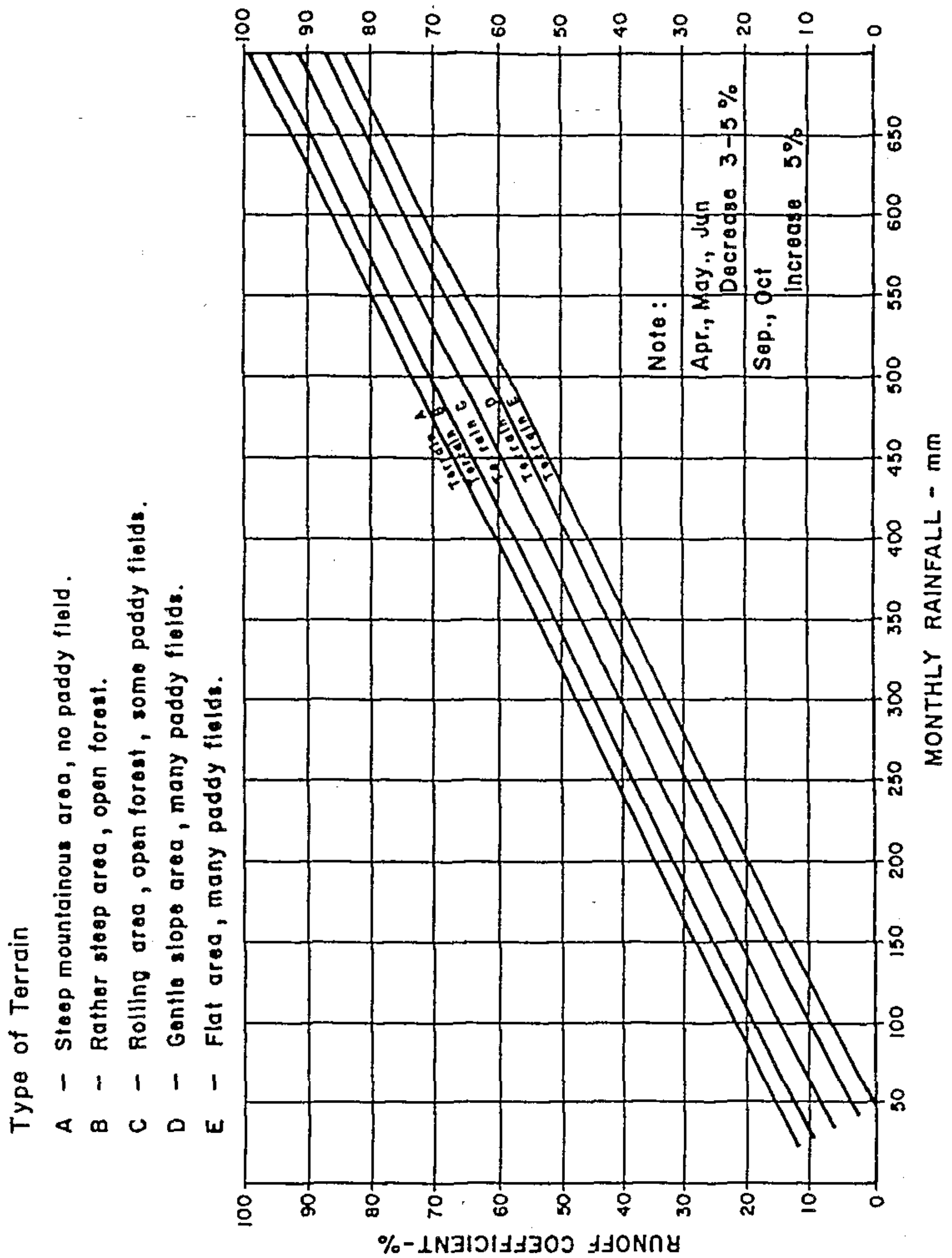


EXISTING ROAD NETWORK



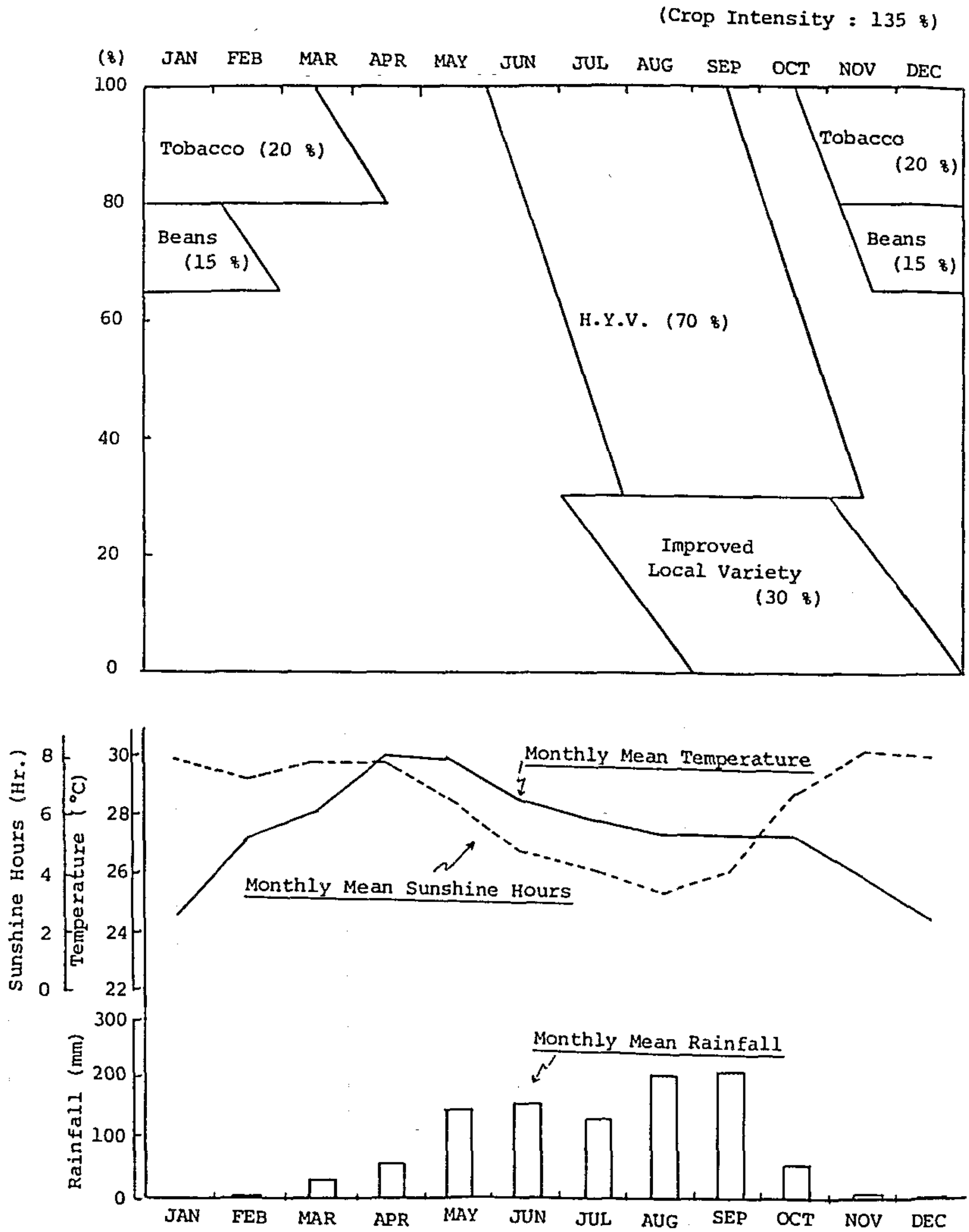
Note: Other upland crops field shown in the above pattern is expected to be changed to paddy field.

PRESENT CROPPING PATTERN

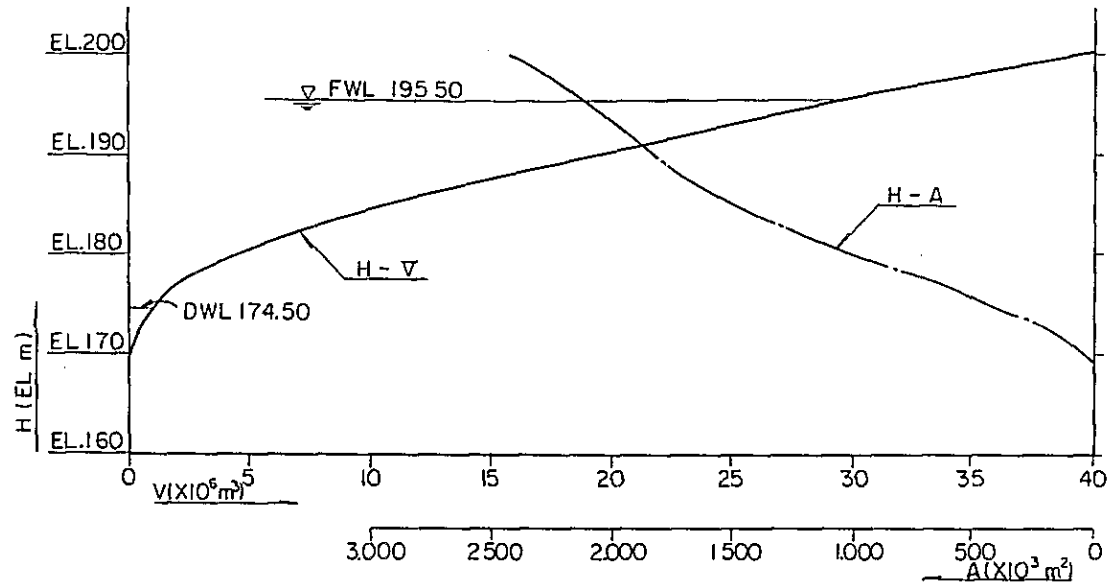


RUNOFF COEFFICIENT

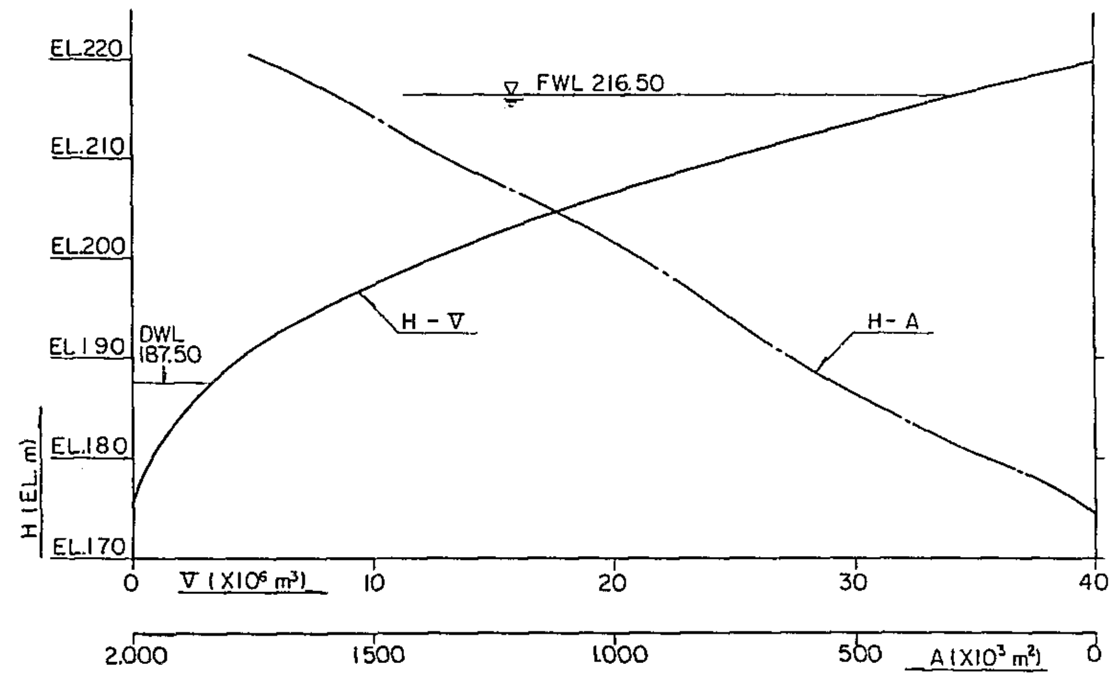
(Developed by RID)



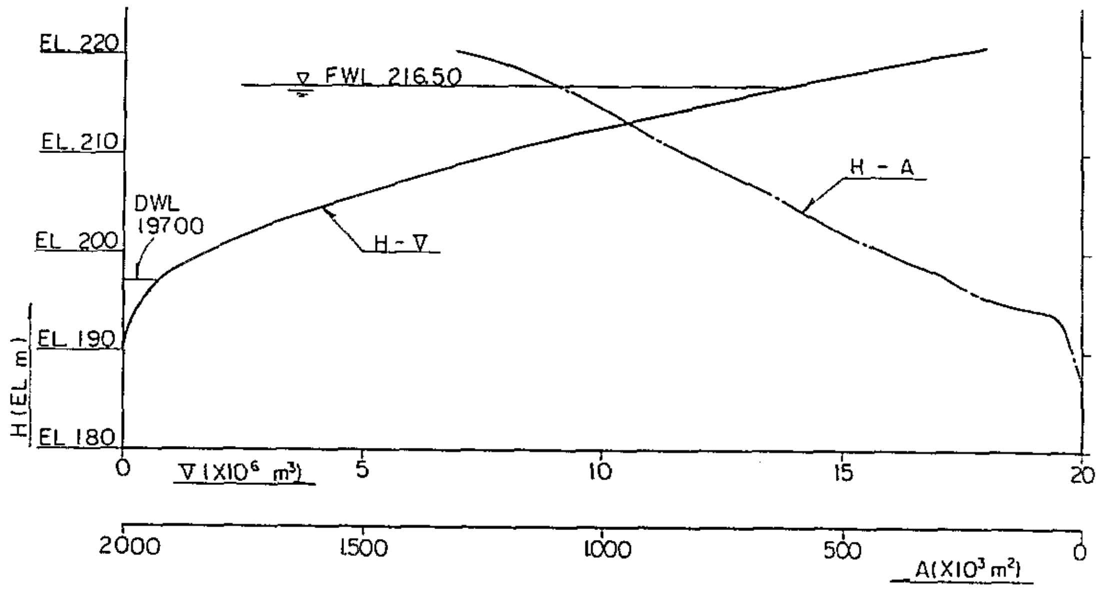
PROPOSED CROPPING PATTERN



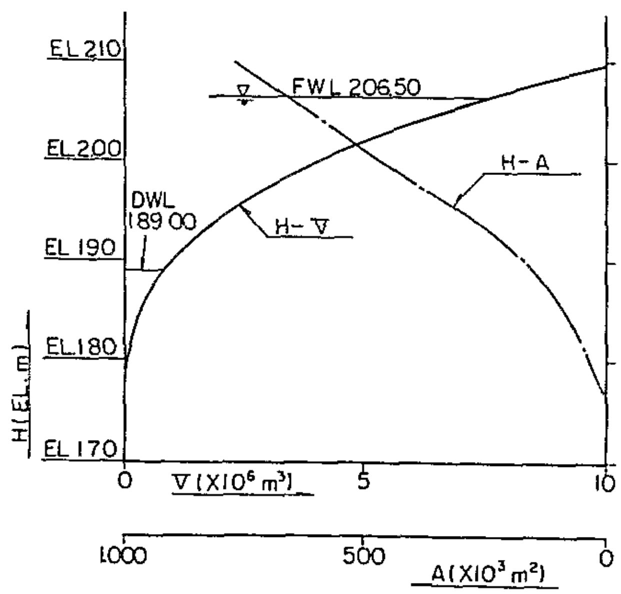
STORAGE CAPACITY AND INUNDATED AREA
(1) HUAI SADUANG YAI



STORAGE CAPACITY AND INUNDATED AREA
(2) HUAI KHON KAEN



STORAGE CAPACITY AND INUNDATED AREA
(3) HUAI YAI



STORAGE CAPACITY AND INUNDATED AREA
(4) KHLONG CHALIAND LAB