Agricultural credit: The main sources of institutional credit are (1) the Bank for Agriculture and Agricultural Cooperatives (BAAC). (2) the Agricultural Cooperatives and (3) the Farmers' Marketing Organization. Agricultural loans are extensively utilized for the purchase of equipments, land, seasonal inputs and hire of labour. In addition, large portion of farmers receives consumer goods and farm inputs on credit terms from local merchants.

Input distribution: All farm inputs are supplied by the private merchant; however, credit-linked inputs such as fertilizers are increasingly supplied through the credit institutions themselves. Fertilizer is obtained from the Farmers' Marketing Organization at Bahts 4,200/ton for cash and Bahts 4,400/ton on crecit terms for compound fertilizer (16-20-0).

3.3.4 Existing irrigation projects

There exist one large scale irrigation project, five medium scale irrigation projects and 50 small scale irrigation projects in the Sakae Krang river basin. These projects have mainly been inplemented during the recent 5 years by RID in response to the local people's request in the basin. The location map of existing irrigation projects is shown in Fig. 3.3.5.

(1) Large scale irrigation project

The Thap Salao Irrigation Project is the only large scale irrigation project in the basin. The irrigation service area of 88,000 rai (14,080 ha) is located in the southeastern part of the basin and extends west to east along the both banks of the Thap Salao river which is the main water source of the project. The major facilities of the project comprise a diversion weir constructed across the main stream of the Thap Salao river and main and lateral irrigation canal system. At present, the project is suffering from irrigation water shortage. The main reasons are as follows:

- There exist three local-made weirs which cover the areas of 35,000 rai (5,600 ha) in total. Much irrigation water to the areas is taken without proper water management.

- Since 1970, the upstream area of the project was rapidly opened from the forest to the agricultural land. Consequently, the run-off phenomena from the basin upstream of the project were severely changed. No stable perennial flow is presently expected.

For solution of water shortage problem, RID intends to implement the Thap Salao Dam Project.

(2) Medium scale irrigation project

(a) Wang Kun Pao and Khun Lard Boriban regulators

There exist two channels to divert the water of the Mae Wong river. These channels were constructed by farmers themselves more than 20 years ago. After construction of these channels, much water of the Mae Wong river was diverted through these channels to outside of the Mae Wong river basin. Subsequently, downstream areas of the Mae Wong river were suffered from irrigation water shortage. In response to the farmer's request downstream of the Mae Wong river, RID constructed the regulators at the heads of these channels in 1975 to 1977, namely Wang Kun Pao Regulator and Khun Lard Boriban Regulator.

The Wang Kun Pao Regulator is located at the left bank of the Mae Wong river, 8 km downstream of the proposed Lower Mae Wong Dam. The Regulator covers the irrigation service area of 105,000 rai (16,800 ha). The Khun Lard Boriban Regulator is located at the left bank of the Mae Wong river, 40 km downstream of the proposed Lower Mae Wong Dam. The irrigation service area covered by the Regulator is 55,000 rai (8,800 ha). No records on diversion water amount from the Mae Wong river at both regulators are available.

(b) Khlong Nam Hom irrigation project

The Khlong Nam Hom area of 10,000 rai (1,600 ha) is located at the right bank of the Mae Wong river, middle part of the Mae Wong river basin. The main water source for irrigation is the Mae Wong river. The return flow from the small scale irrigation project areas along the left bank of the Khlong Pho river is used for augmentation of irrigation for the area. The major facilities of the project comprise a diversion weir constructed in 1975 to 1976 by RID and canal system constructed by farmers.

(c) Wang Rom Klao irrigation project

The Wang Rom Klao area of 12,500 rai (2,000 ha) is located at both banks of the Sakae Krang river, 10 km downstream of confluence of the Mae Wong and Khlong Pho rivers. The main water sources are the Mae Wong, the Khlong Pho and the Huai Thap Salao rivers. The major facilities of the project consist of an earth fill dam, spillway, intake structures and canal systems constructed by farmers.

(d) Khlong Yang irrigation project

The Khlong Yang area of 7,500 rai (1,200 ha) is located at the right bank of Huai Thap Salao river, 7 km upstream of confluence of the Huai Thap Salao and Sakae Krang rivers. The water source is the Huai Thap Salao river. The main facilities of the project consist of a diversion weir, three (3) intake structures and canal systems. These facilities were constructed in 1950 to 1954 and deteriorated at present. Rehabilitation works are required.

(3) Small scale irrigation projects

There exist small scale irrigation projects of 50 in number. The total irrigation service area of all projects is 256,600 rai (41,050 ha) which consist of 60,500 rai (9,680 ha) of the Mae Wong river basin, 53,800 rai (8,600 ha) of the Khlong Pho river basin, 66,500 rai (10,640 ha) of the Thap Salao river basin and 75,800 rai (12,130 ha) of the Khok Khwai river basin, respectively. Most of the projects were constructed by RID in 1980 to 1984 and have canal system constructed by farmers.

(4) Pump irrigation services from RID

RID Regional Office VII provides pump irrigation services with free charge for the farmers who have rainfed paddy field along the rivers and streams in the basin. About 35 portable pump units are usually used for such services. The regulations of the services are as follows:

- Operation hours of pump unit are 22 hrs/day,
- Irrigation service period is 120 days, and
- The regulations limit farmers receiving the service for only one crop season, wet season or dry season.

The Regional Office VII allocates the budget of 1 to 1.5 million Bahts per annum for the services.

3.4 AGRICULTURAL CONSTRAINTS

About 0.32 million people lived in the Sakae Krang river basin primarily rely on agriculture. Farm household accounts for about 70% of the total household. Others are mostly engaged in trading, transportation, and public administration which support the agricultural activities.

Agriculture contributes to about 45% of gross regional product, while it accounting for only about 25% of GDP in national economy. Agriculture has been and will continue to be the most important key determinant in regional economy of the basin area.

Paddy rice is by far the most important crop, grown on about 75% of the total agricultural land. Paddy cultivation is concentrated in the rainy season and extremely limited in the dry season, because the dependable water resources are completely exhaused during the dry season. The planted area of paddy, even in the rainy season, widely fluctuates year by year depending on the endowed rainfall and river flow. The paddy yield is directly affected by total depth of annual rainfall. After harvesting the rainy season paddy, the farmers grow upland crops mainly mung beans in the very limited area where irrigation water is readily available. It is not common that dry season paddy is planted as a second crop.

About 61% of the existing paddy fields, or 534,000 rai (85,500 ha) in area, are presently covered with the existing irrigation schemes. However, most of the paddy fields still remain under rainfed condition. Present water balance study on existing condition indicates that the dependable water resources in not sufficient for supplying the irrigation water throughout the growth period of rainy season paddy, to a whole irrigation area. The preliminary result of the study implies that only about 58% of the existing irrigation area are actually served with water supplies and others are laid under rainfed condition under normal rainfall condition.

Most of the irrigation canals aligned in the existing paddy fields are unlined. These canals are generally deteriorated due to improper maintenance. The density of the existing canal network is very low. This makes equitable distribution of irrigation water difficult. No technical drainage system has been provided so far in the existing irrigation area. Most of the existing canal have dual function of irrigation and drainage. This substantially contributes to repeated use of the limited water resources.

The present farming practices is still of conventional; local varieties are still predominant, use of fertilizers is limited, agro-chemicals for plant protection are not used, use of certified extension seeds is very rare, etc. These apparent limitations for agricultural production increase come from present unreliable water availability, because most of the imporved farming practices are possibly introduced only under the condition that irrigation water is assured.

The Sakae Krang river basin is endowed with vast land resources suitable for agricultural production. Nevertheless, land productivity is still very low, due to various problems and constraints involved in the current agriculture.

The problems are manifold; however, the most important single constraint to agricultural development in the basin is the lack of assured irrigation facilities coupled with the shortage of available water. The rainy season paddy crop often suffers from moisture stress at critical periods of growth, resulting in total or partial crop damages. There is a great concern among the farmers in the basin for such almost regular drought conditions than crop damages from any other causes. Other constraints such as yield limitations of local variety, low input use and inadequate crop management should become secondary in importance when considered against regular crop damages caused by present irregularity in water supply.

3.5 BASIC STRATEGIES FOR DEVELOPMENT

The Kingdom of Thailand sustained about 8% of the economic growth rate during the recent decade of 1970's. Such rapid stride of the economic growth in the country caused serious and complex economic problems and social tensions (for detail, see Chapter II). In order to overcome such problems and tensions, the Fifth Economic and Social Development Plan (1982-1986) has been set out containing long term strategies and new approaches. Major objectives given in the Development Plan are:

(1) to restructure the key productive sectors like agriculture so as to improve the current economic and financial situations,

(2) to reduce absolute poverty and accelerate rural development in backward areas, and

(3) to uplift rural living standard as well as strive more equitable distribution of income.

Two provinces of Nakhon Sawan and Uthai Thani where most of the Sakae Krang river basin are included, have about 2.6% of the Kingdom's population. The share of the provinces in GDP is however only less than 1.3%. The relatively poor position of the area is also indicated by its lag in per capita income; the average in past five years amounts to about 3,670 Bahts, corresponding to roughly two-third of national average (5,610 Bahts). The area suffers also from the instability in annual income which fluctuates largely year by year. Such poor economic situation of the area is mainly derived from low productivity of agriculture which is definitely ascribed to lack of assured irrigation system coupled with the shortage of available water.

Paddy cultivation is a mainstay in the Sakae Krang river basin. It is surely suited to the area in economic-social-histrical-cultural-physical context. The area is endowed with good soils and climate (except rainfall) suitable for paddy cultivation and the farmers are accustomed to paddy cultivation. Farmers heavily rely on paddy production economically. It however gives them only unstable results of yield due to irregular water availability. The most important sole constraint to rural development in this area is again shortage of available water.

It is generally recognized among the government officials that for increase of paddy production, more attention will be given to the improvement of unit yield per rai because expansion of paddy field has become rather difficult in the country, and the priority is given to the improvement of unit yield in the existing paddy fields of the Central and Northern Regions where exploitable water resources still remain. The Sakae Krang river basin is one of the areas endowed with such exploitable water resources.

In the Sakae Krang river basin, the irrigated paddy field is mostly located along the upstream of each river, and the rainfed paddy fields extend over the downstream areas. There is clear difference in crop yield and therefore in farm income between irrigated area and rainfed areas. It is reported that serious disputes for river water are often occured between farmers in upstream areas and those in the downstream areas. This causes some social tensions in the area.

The Sakae Krang river basin is a considerably matured area for agricultural production, where numerous irrigation systems have been implemented and the presently available water is fully utilized with almost fixed cropping system. There is no water available for vast rainfed fields. Under these conditions, significant changes in agricultural production will not be expected unless new water resources are exploited.

Considering all these, basic strategies for development in the Sakae Krang river basin are considered as follows:

(1) The current poor economic position of the area should be improved through full utilization of the endowed resources for increase of paddy production.

(2) The present rural living standard should be uplifted with particular emphasis on improvement of present income disparity in the area.

These basic principles are exactly conformed to the government policy given in the Fifth National Development Plan. With these in mind, the basic development concept for the Sakae Krang river basin is conceived as in the following. Major items of the basic concept are (1) exploitation of new water resources by means of dam construction, (2) full utilization of existing irrigation systems and improvement of existing facilities, and (3) expansion of irrigated paddy field.

These measures will significantly contribute to the realization of the above basic requirement for rural development in the Sakae Krang river basin. In order to realize these measures and attain the prospective goals, more precise guidelines for formulation of development plan will be required. The proposed guidelines for development planning in the fields of agriculture, water resources development and irrigation/drainage are given in the following sub-sections.

3.5.1 Agricultural development

The agricultural development plan should be formulated on the basis of the following basic concepts:

(1) Cultivation of rainy season paddy should be stabilized through optimum utilization of newly exploited water resources.

(2) Unit yield of rainy season paddy should be maximized through proper supplemental irrigation and improved farming practices.

(3) Supplemental irrigation area for rainy season paddy should be maximized with full use of the limited exploitable water resources; however, first priority should be given to the existing irrigation areas. If water would still remain after supplying sufficient water to the existing irrigation area, the rainfed areas should be benefited within economically reasonable range.

(4) Special attention should be paid to the rainfed areas, in connection with further studies on possibility of groundwater exploitation.

(5) Dry season cropping should be considered as secondary importance; if water is still available during the dry season, irrigation for dry season cropping should be considered to a possible maximum extent. In order to save the water consumption and to use the limited water resources more effectively, some upland crops other than paddy should be considered as second crop in the dry season.

3.5.2 Water resources development

It is estimated from the runoff analysis for 29 years that the average annual discharges at upstream watershed of the Sakae Krang basin are about 0.32 MCM/sq.km. for the Mae Wong river, 0.20 MCM/sq.km. for the Khlong Pho river and 0.23 MCM/sq.km. for the Thap Salao and the Khok Khuwai rivers.

With this substantial quantity of water available in the basin, these rivers appear to have reliable potentials for water resources development. The significant annual fluctuation of the streamflow and long period of low flow for about successive 8 months from December to July give rise to the necessity of the construction of dams and reservoir to control and regulate the streamflows for optimum utilization. Potential watershed area for the storage reservoir is limited topographically only along the western hilly regions which is about 30% of the total drainage area of the basin. It will be hardly sufficient to meet existing and future water requirements of the basin. It is considered that the first priority should be given to exploit the dams and reservoirs at their maximum extent of storage.

As for the groundwater exploitation, it appears to have large potential productivity in the downstream basin. Small scale groundwater development will be accelerated under the technical assistance of RID and financial support of BAAC. However, the observation and study on the groundwater balance and quality analysis should be required prior to the exploitation of large scale groundwater development. It is considered necessary to continue the observation to clarify the effects of reservoir construction at upstream and irrigation development at downstream in future.

3.5.3 Irrigation and drainage development

In order to realize the concepts for agricultureal development, the following basic concepts for irrigation and drainage development are envisaged in conformity with the concepts for water resources development:

a) First priority for irrigation development would be given to the supplemental irrigation for wet season paddy in the existing irrigation areas.

b) Possible further extension of irrigable area would be examined taking the topographic and soil condition into consideration. If the exploited water resources are available, either the supplemental irrigation for the wet season paddy in the above extension area or the irrigation for dry season crop in the existing irrigation area would be considered.

c) Even under full utilization of surface water in the basin, the downstream area of the basin would remain under rainfed condition. Possibility of groundwater irrigation in the above area would be examined based on the data presently available.

d) In principle, the irrigation facilities in the existing irrigation areas would be incorporated into the project as far as possible to minimize the project cost. From viewpoints of water management, rehabilitation, improvement or integrated plan of the existing facilities would be considered, if necessary.

e) Basin-wise water management organization and method would be recommended to timely and fairly to distribute the exploited water to each irrigation scheme. Establishment of water users' organization would also be recommended for proper water management at farm level.

f) The natural streams in the basin would used for drainage as many as possible. The collector drains would be provided for proper drainage in each scheme.

3.5.4 Other consideration

(1) Flood control

Flood control in the project is not considered primary, however, it is realized that incidental flood control could be attained from the operation of the reservoir especially from floods occuring in the early part of wet season. The study will be conducted to clarify the effects of incidental flood control based on the result of flood hydrograph analysis.

(2) Hydropower

Source of electric power supply in northern Thailand where the Sakae Krang River Basin Project is located is composed fo three kinds of power plant, i.e. hydroelectric, thermal and diesel power plants. Bhumipol power plant of 553 MW and Sirikit power plant of 500 MW are considerable as large scale existing hydro power plants in the region, while Mae Moh power plant 375 MW is counted as large scale existing thermal power plant.

Supply pattern in the region where 230 kv trnasmission line network extends centering the Nakhon Sawan province, Chainat province and Uthai Thani province are that the base load is coped with by Mae Moh thermal plant while the peak load is supplied by both Bhumipol and Sirikit power plants. However, since power demand is not large in the region around Nakhon Sawan, Chainat and Uthai Thani, most of the electric power generated at Bhumipol and Sirikit power plant is conveyed by 230 kv long distance transmission line to Bangkok area, via Nakhon Sawan substation, which consumes very large amount to power rising up to about 60% of total demand in Thailand.

Three units of 150 MW are at present under construction in Mae Moe thermal plant. The electricity generated in such large scale units is planned to be transmitted Bangkok area by EHV transmission line.

Power demand in Thailand is rapidly increasing as its economy grows sharply, and the trend is considered to continue in the future. Although any remarkable large demand is not seen at present in the northern area where agriculture and commerce are predominant, increase of demand mainly for residential use is expected in near future upon consideration of present large expansion of electrification in the country.

According to daily load curves at several s/s in the region, peak of demand takes place in the morning and evening, each of which has one band of peak time lasting for about 1 hour in the morning and for 4 to 5 hours in the evening.

Summarising the facts mentioned above, the followings can be said. Future increase of power demand is surely expected in the northern area where the Sakae Krang river basin is located. Upon construction of additional units in Mae Moh thermal plant, power plant providing supplementary function in power supply are needed.

Consequently, although details should be clarified through precise study of hydropower development potential, the projected plant should be developed for mainly peak load and partially base load as well as for supply to adjacent area in cooperation with other power sources under planning in northern area.

(3) Inland fishery

In the present state of fishery activities in Thailand are divided into marine and inland fisheries. Production of marine fishery has had the overwholming majority of the total production (more than 95% of total production of 2 million tons), but production is on a declining trend due to exececssive marine fishing which has caused a deterioration in marine resources, and due to the expnasion of the 200 mile economic zone of neighbouring countries creating a restriction in Thailand's fishing ground.

On the other hand, inland fishery, through its production is not so large, has played an important role for providing the rich protain food to people, especially those who line in the depressed rural areas. Furthermore, the development of inland raising fishery has drown the attention from the view point of utilization of water resources.

The latest Fifth National Development Plan states that "speed up the production of fresh-water fishes and release them to multiply in natural water reservoirs and various irrigation project in order to provide a source of protain".

From the fact above mentioned, it is strongly expected that due consideration be paid for utilizing the proposed reservoir as an aquacultural fishery pond, and the another feasibility study be required for this purpose, at appropriate stage, in cooperation with the Department of Fishery, MOAC.

3.6 RIVER BASIN DEVELOPMENT PLAN

3.6.1 Possible projects

The project aims at irrigation development of potential areas in the Sakae Krang river basin including the existing irrigated areas. RID primarily proposed six dam schemes for this purpose. JICA study team proposed to investigate two additional dam schemes. Hence, the following eight dam schemes were identified.

Upper Mae Wong	:	proposed by EGAT
Lower Mae Wong	:	proposed by RID
Khlong Pho	:	proposed by RID
Thap Salao	:	proposed by RID
Upper Huai Rang	:	proposed by RID
Lower Huai Rang	:	proposed by JICA study team as an alternative of Upper Huai Rang
Upper Khun Kaew	:	proposed by JICA study team as an alternative of Lower Khun Kaew
Lower Khun Kaew	:	proposed by RID

The Thap Salao dam scheme among above proposed dam schemes had already been decided to be implemented in the near future. Then, the Thap Salao dam scheme was excluded from the study on selection of high priority projects.

As for the both Huai Rang dam schemes, an investigation was made laying an emphasis on the topographical, geological and hydrological conditions for both proposed dam sites. It was found through the investigation that the Lower Huai Rang dam was more attractive for irrigation development than the Upper Huai Rang dam. Because, both dams are almost same in foundation conditions, dam height and dam length, while the possible reservoir capacities for both dams are much different in the Lower Huai Rang of 18 MCM and the Upper Huai Rang of 10 MCM, respectively. Thus, the Upper Huai Rang dam scheme was also excluded from the study.

3.6.2 Selection of high priority projects

In order to select the high priority projects out of the identified projects mentioned above, an overall river basin development study including the water balance study was carried on the basis of the following conditions:

(1) The water resources endowed in the sub-river basins would be developed by constructing storage dam to the maximum extent, and

(2) To evaluate all identified projects at the same level, the irrigation development scale would be determined under the supplemental irrigation for the wet season paddy (cropping intensity of 100%).

Through the overall river basin development study, the major dimensions of possible projects were determined on a preliminary basis as shown in Table 3.6.1. For selection of high priority projects, a preliminary evaluation was made on the possible projects by using several indicators like reservoir performance, incremental irrigable area and dam construction cost which were calculated on the basis of the said major dimensions. The indicators used for evaluation are summarized below:

Item		Mae Wong Upper	Mae Wong Lower	Khlong Pho	Huai Rang	Khun Kaew Upper	Khun Kaew Lower
1. Reservoir Performance							
Irr. Area/Eff. Storage	ha/MCM	213	153	260	111	342	292
Embk. Vol/Eff. Storage	10^3m^3/MCM	14.8	1.1	7.7	46.1	34.7	40.4
2. Irrigation							
Irrigation Area	10^3 ha	49.0	53.5	25.0	2.0	13.0	14.9
Incremental Irr. Area	10^3 ha	25.4	29.9	18.0	-	4.7	6.6
Irr. Area/Eff. Storage	ha/MCM	110	85	187	-	124	129
3. Dam Construction Cost							
Direct Const. Cost	M฿	1,148	620	567	195	403	545
Cost/Eff. Storage	M฿/MCM	4.9	1.8	5.9	10.8	10.6	10.7
Cost/Embk. Vol.	฿/m^3	326	1,140	497	235	305	265
Construction Period	Yr	5	5	5	4.5	5	5
4. Resettlement							
House	No	40	520	365	218	30	105
Land	km^2	19.5	68.0	32.0	2.2	2.2	7.3
Compensation	@0.2 M฿/House, @0.6 M฿/km^2 M฿	19.7	144.8	92.2	44.9	7.3	25.4

Based on the evaluation on these four components, the Upper Mae Wong, the Lower Mae Wong and the Khlong Pho projects were selected as high priority projects.

3.6.3 Consideration on other possible projects

(1) Upper Khun Kaew project

As stated in the previous sub-section, the high priority projects were selected based on mainly such engineering viewpoints as the size of possible irrigable area and the dam construction efficiency on exploitation of water resource. However, it is also important for the projects to evaluate the difficulties foreseen in the resettlement program from the political and social viewpoints.

Among six identified possible projects, the Upper Mae Wong and Upper Khun Kaew projects have less number of household in the reservoir areas to be created than the other projects. Even if the Upper Khun Kaew project would not gain the higher economical performance in the project evaluation, it has the following merits:

- The smallest investment cost among the identified possible project except the Huai Rang project,
- Less resettlement problem, and
- Suitable geological formation for dam construction.

Considering the above merits, it is recommended that the further investigation on the hydrological, topographical and geological aspects should be carried out by RID for future development of the Upper Khun Kaew project.

(2) Groundwater development project

The downstream area of the Sakae Krang river is a part of vast flood plain of the Chao Phraya river. The area is formed by the alluvial deposits which consist of loose to unconsolidated layers of sand, gravel, silt and clay. Average thickness of the alluvial deposits is approximately 50 m on foundation rock. The sand and gravel layers of alluvial deposits are potential aquifer of groundwater.

A preliminary study on the productive capacity of the groundwater in the whole basin was made based on the data of test wells and experimental bore holes conducted by RID during the period from 1973 to 1978 (see ANNEX I). Through the study, the potential productivity of groundwater was roughly estimated at 2.8 to 7.4 MCM/km^2.

To meet with this large potential productivity in the downstream basin, the following undertaking by RID are recommended:

- The present small scale groundwater development should be accelerated under technical assistance of RID and financial support of BAAC,

- The exploitation of large scale groundwater resources should be concentrated to the downstream areas in the Sakae Krang river basin, where the surface water resources development could not be expected,

- Prior to the exploitation of large scale groundwater resources, the investigation and study on the groundwater balance and quality analysis should be required, and

- The present observation of groundwater should be continued for future development, particularly on the effects of reservoir exploitation at upstream and irrigation development at downstream in future.

3.6.4 Overall river basin development plan

Through the above study, the overall irrigation development plan in the Sakae Krang river basin is envisaged as follows:

(a) Mae Wong river basin :

irrigation development based on exploitation of surface water resources by the Upper Mae Wong or Lower Mae Wong dam.

(b) Khlong Pho river basin :

irrigation development based on exploitation of surface water resources by the Khlong Pho dam.

(c) Thap Salao river basin :

irrigation development based on exploitation of surface water resources by the Thap Salao dam.

(d) Khok Khuai river basin :

irrigation development based on exploitation of surface water resources by the Upper Khun Kaew dam.

(e) Downstream basin of the Sakae Krang river :

irrigation development based on exploitation of large scale groundwater resources.

(1) Mae Wong river basin

As stated hereinafter, this river basin is given first priority for irrigation development of the Sakae Krang river basin and would be defined as a large scale irrigation project. The development area was determined at about 299,000 rai (47,800 ha) through the optimization study. Prior to the consturction works, the detailed design including loan arrangement would be carried out for two years. The construction period would be about five years.

(2) Khlong Pho river basin

The Khlong Pho river basin development was selected as a high priority project. According to the results of pre-feasibility study, the Internal Rate of Return (IRR) was estimated at 11.5%. The economic viability is rather low but still feasible. The project would be implemented as a large scale irrigation project. The development area was determined at 112,000 rai (17,900 ha) on the optimization study. After completion of the Mae Wong river basin development, the project would be implemented. Prior to the construction works, the feasibility study, detailed design and loan arrangement would be carried out for three years.

(3) Thap Salao river basin

The implementation of the Thap Salao dam scheme had already approved by the Government. The construction works would be started in very near future. After completion of this scheme, the area of about 110,000 rai (17,600 ha) would be irrigated by the scheme.

(4) Khok Khwai river basin

The existing small scale irrigation projects almost covers the irrigable areas along the Khok Khwai river. The Upper Khun Kaew dam would be contructed to mainly supply the stable irrigation water for the wet season paddy to these existing irrigation areas. The supplemental irrigation water for wet season paddy could be supplied for the areas of about 81,000 rai (13,000 ha). The Upper Khum Kaew dam scheme would be defined as a medium scale irrigation project.

According to the results of present water balance study, the irrigation ratio of existing irrigation areas of about 76,000 rai (12,200 ha) in the basin is estimated at about 60%. The existing irrigation areas of about 40% suffer from serious irrigation water shortage. As soon as completion of the Mae Wong river basin irrigation development, the construction of this dam scheme would be commenced. About three years are necessary for making the feasibility study, detailed design and financial arrangement, prior to the construction.

(5) Downstream basin of the Sakae Krang river

There exist potential areas of about 219,000 rai (35,000 ha) for irrigation development in the downstream basin of the Sakae Krang river. Most of these areas are categorized as the rainfed paddy fields. The basin would be developed on the basis of groundwater exploitation due to limited surface water resources despite of high potential of groundwater resources in the basin.

At present, the small scale groundwater development by farmers is prevailing in the basin. The present small scale groundwater development should be accelerated under technical assistance by RID and financial assistance by BAAC.

The large scale groundwater development would be implemented dividing into several packages of about 31,200 rai (5,000 ha). The implementation period of one package is assumed at four years including one year for investigation, studies and design of facilities.

An overall implementation schedule of possible projects is tentatively made as shown Fig. 3.6.1. The location map of development area for the possible projects is shown in Fig. 3.6.2.

After implementation of overall river basin development plan in the Sakae Krang river basin, the irrigation area of 821,000 rai (131,000 ha) would be developed, corresponding with about 96% of existing paddy field of 869,000 rai (139,000 ha).

CHAPTER IV PROSPECTIVE DEVELOPMENT PLAN FOR HIGH PRIORITY PROJECT

4.1 ASSESSMENT OF WATER RESOURCES

4.1.1 Annual Inflow

Applying the simulated tank models and rainfall data, the streamflow generation was conducted. The average annual runoff at each gaging station was estimated from the observed runoff records and generated stream flow for 29 years from 1954 to 1982. The results are summarized as follows.

Station	River	Average Annual Railfall mm/year	Average Annual Runoff MCM/km²/year	Average Runoff Rate %
CT-5A	Mae Wong River	1,294.6	0.316	24
CT-7	Khlong Pho River	1,283.5	0.217	17

The average runoff rate for the Khlong Pho river shows lower than one for the Mae Wong river. The Mae Wong river is known to be an effluent stream which continues to flow even during extremely dry periods.

Based on the results of streamflow generation, annual inflow to the proposed reservoir is estimated as follows.

Dam	Applied Model	Drainage Area (km²)	Average Annual Inflow (MCM)
Upper Mae Wong	CT-5A	612	193
Lower Mae Wong	CT-5A	930	294
Khlong Pho	CT-7	394	85

4.1.2 Possible maximum exploitable water resources

In order to obtain an approximate assessment on the water resources, the possible maximum reservoir capacity was assumed for each proposed dam on the following assumptions:

(a) Effective storage Ve

$$Ve = \text{Average annual inflow} \times C$$

(b) Dead storage Vd

$$Vd = \text{Annual sediment inflow} \times 100 \text{ years}$$

Coefficient C is assumed at 1.2 for the Mae Wong and 1.1 for the Khlong Pro rivers, respectively, as their drainage areas are relatively large. As for the annual sediment inflow, it was assumed at 300 cum/km^2/year for the Mae Wong river and 350 cum/km^2/year for the Khlong Pho river, evaluating from the ground coverage of watershed. The maximum reservoir storage was assumed as follows.

Dam	Drainage Area (sq.km)	Average Inflow (MCM/year)	Effective Storage (MCM)	Dead Storage (MCM)	Total Storage (MCM)
1. Upper Mae Wong	612	193	230	20	250
2. Lower Mae Wong	930	294	350	30	380
3. Khlong Pho	394	85	96	14	110

4.2 IRRIGATION WATER REQUIREMENT

4.2.1 Calculation procedures

The calculation of irrigation water requirements was made on monthly basis through the following procedures:

a) Estimation of consumptive use of water by crop,

b) Estimation of percolation rate for paddy crop,

c) Estimation of water requirement for nursery and land preparation for paddy crop,

d) Estimation of effective rainfall, and

e) Estimation of diversion irrigation water requirement based on the overall irrigation efficiency.

4.2.2 Irrigation water requirements

The irrigation water requirements were estimated on the proposed cropping pattern shown in Fig. 4.5.1.

Irrigation Water Requirements (mm)		Remarks
Wet Season	Dry Season	
700	785	Average for 28 years from 1954 to 1981

The peak unit irrigation water requirement varies from 0.547 ℓ/sec/ha to 1.080 ℓ/sec/ha. The peak unit irrigation water requirement with 5 years return period was estimated at 0.9 ℓ/sec/ha. The unit design irrigation requirement was determined at 1.0 ℓ/sec/ha taking an allowance of 10%.

4.3 WATER BALANCE STUDY

4.3.1 Objectives

The main purpose of this study is to clarify the optimal scale of the dam and irrigable area. The water balance study was made on 10 day-basis for 28 years period from 1954 to 1981 using the runoff data estimated through the hydrologic studies for the Mae Wong river and the Khlong Pho river and the irrigation water demand data estimated on the proposed cropping pattern, and cropping intensity.

4.3.2 Alternative plans for development

The following alternative development plans for high priority projects were made for optimization of development scale and consequently selection of first priority project among high priority projects.

(1) Alternative development plan for optimization of dam scale

Alternative D-1: supplemental irrigation to the existing irrigation area for wet season paddy

Alternative D-2: supplemental irrigation to the possible maximum irrigable area in each river basin for wet season paddy

Alternative D-3: supplemental irrigation to the possible maximum irrigable area in each basin for wet season paddy and dry season crop

(2) Alternative development plan for optimization of irrigable area and cropping intensity

Alternative I-1: supplemental irrigation to the existing irrigation area

Alternative I-2: supplemental irrigation to the possible maximum irrigable area in each river basin

4.3.3 Methodology of water balance study

(1) Layout of irrigation water supply system

The systematic layouts of irrigation water supply system for both the Mae Wong and Khlong Pho river basins are shown in Fig. 4.3.1 and Fig. 4.3.2, respectively. The irrigation water for the Wang Rom Klao on the Sakae Krang river, an existing medium scale irrigation project, has been planned to supply mainly from the Khlong Pho river. Accordingly, the Wang Rom Klao Project is included in the Khlong Pho river basin.

(2) Calculation step

The water balance calculations are divided into the following two steps.

Step 1: The water balance is calculated at each diversion point to irrigation area based on river runoff and irrigation water demand. Through this calculation, required water amount to be released from the proposed storage dam is estimated.

Step 2: The reservoir operation is carried out to determine the possible irrigable area and reservoir capacity of dam by trial and error method based on the released water amount for irrigation estimated through Step 1 and given reservoir capacity.

A basic balance for Step 1 is simply expressed as follows:

If Runoff > Diversion Requirement

Surplus = Runoff - Diversion Requirement

If Runoff < Diversion Requirement

Deficit = Diversion Requirement - Runoff

where,

Runoff: Natural runoff at the diversion point to irrigation block including return flows and excess water of rainfall from upstream

Diversion Requirement: Irrigation water requirement at the diversion point to irrigation block

Deficit: Required water amount to be released from the storage dam.

A flow chart for water balance calculation is shown in Fig. 4.3.3.

A reservoir operation is calculated based on the following formula.

$$Se = Sb + I - Or - E - Os$$

where, Se: Reservoir storage of the end of the period

Sb: Reservoir storage at the beginning of the period

I: Inflow to the reservoir during the period

Or: Outflow from the reservoir during the period, this is equal to the release water for irrigation estimated through the water balance calculation downstream of the proposed dam in Step 1.

E: Evaporation from the reservoir surface during the period

Os: Spillout discharge during the period, if any. Because the storage at the end of the period is limited to the storage at the full supply water level in the maximum, the excess water is defined as spillout discharge.

A flow chart of reservoir operation is shown in Fig. 4.3.4.

(3) Definitions

(a) Simulation period and calculation interval

Water balance and reservoir operation calculations are carried out for 28 years period from 1954 to 1981 on the basis of runoff data and irrigation water demand. The calculations are made on 10 day-basis.

(b) Return flow

The derivation of effective return flow is given as follows:

Irrigation efficiency 55%

Effective return flow = (1 - 0.55) x Return Flow Factor

= (1 - 0.55) x 0.60

= 0.27 of diversion requirement

(c) Excess water of rainfall from paddy field

Excess water of rainfall = 0.2 x Rainfall

(d) Determination of possible irrigable area

Possible irrigable area is determined through the reservoir operation calculation in Step 2 on conditions that reservoir is completely depleted five times at least for the 28 years period, or in other words, drought damage recurs by 5 years return.

4.3.4 Results of water balance study

The results of the water balance study for each alternative plan are shown as follows:

Dam	Alternative plan	Reservoir Capacity (MCM)	Possible Irrigable Area Existing (ha)	Potential (ha)	Total (ha)	Intensity (%)
Upper Mae Wong	D-1	115	36,800	-	36,800	100
	D-2	205	36,800	11,000	47,800	100
	D-3	230	36,800	11,000	47,800	105
	I-1	230	36,800	-	36,800	130
	I-2	230	36,800	11,000	47,800	105
Lower Mae Wong	D-1	115	36,800	-	36,800	100
	D-2	235	36,800	11,000	47,800	100
	D-3	350	36,800	11,000	47,800	115
	I-1	350	36,800	-	36,800	140
	I-2	350	36,800	11,000	47,800	115
Khlong Pho	D-1	25	10,600	-	10,600	100
	D-2	45	10,600	7,300	17,900	100
	D-3	96	10,600	7,300	17,900	140
	I-1	96	10,600	-	10,600	190
	I-2	96	10,600	7,300	17,900	140

Note: Cropping Pattern = Paddy + Mung Bean

From the above table, the relationship curve between the irrigable area and cropping intensity on the maximum reservoir capacity of dam were made for each high priority project as shown in Fig. 4.3.5.

4.3.5 Optimum scale of development area

A comparison study of all alternative development plans was made on the basis of the Internal Rate of Return (IRR). The study was carried out dividing i) optimization of dam scale and ii) optimization of irrigable area and cropping intensity (See ANNEX X).

(1) Optimization of dam scale

The economic construction cost, benefit and IRR for each alternative development plan are shown below:

High Priority Project	Alternative	Construction Cost (10^6฿)	Benefit (10^6฿)	IRR (%)
Upper Mae Wong	D-1	1,794.3	308.0	11.8
	D-2	2,385.0	445.7	12.9
	D-3	2,453.4	461.3	13.0
Lower Mae Wong	D-1	1,521.1	308.0	13.0
	D-2	1,984.6	445.7	14.4
	D-3	1,989.0	492.4	15.2
Khlong Pho	D-1	867.7	79.2	6.5
	D-2	1,247.7	170.6	9.5
	D-3	1,271.4	217.2	11.5

From the above table, it can be obviously said that the alternative plan of D-3 is the most economical development plan for each high priority project. Accordingly, the maximum development of endowed water resources is recommended for each high priority project as far as the topographic and geologic conditions are allowable.

(2) Optimization of irrigable area and cropping intensity

The economic construction cost, benefit and IRR for each alternative development plan are shown as follows:

High Priority Project	Alternative	Construction Cost (10^6฿)	Benefit (10^6฿)	IRR (%)
Upper Mae Wong	I-1	2,025.4	380.0	13.0
	I-2	2,453.7	461.3	13.0
Lower Mae Wong	I-1	1,565.7	403.9	15.4
	I-2	1,989.0	492.4	15.2
Khlong Pho	I-1	963.6	141.4	10.3
	I-2	1,271.4	217.2	11.5

Taking basic concept on irrigation development stipulated in Section 3.5 and equalization of development impact into consideration, the alternative I-2 was selected as the irrigation development plan in the basin, though the evaluation indicator in the above table shows almost same in IRR.

Through the above optimization studies, the strategies on irrigation development in the basin was concluded as follows:

- The water resources in the basin would be exploited to their maximum extent by constructing the storage dam,
- The possible irrigable area would be developed to its maximum extent in the basin, and
- The dry season crop would be introduced, if the exploited water resources are further available for development.

4.4 DELINEATION OF IRRIGATION DEVELOPMENT AREAS

4.4.1 Mae Wong river basin

There exist small and medium scale irrigation projects along the Mae Wong river, which cover the irrigation service area of 230,000 rai (36,800 ha) in total. Most of existing irrigation areas have an intake weir or regulator and irrigation canal system constructed by farmers. These irrigation areas would be incorporated into the development plan. Other than the existing irrigation areas, there are following three potential areas, where the paddy cultivation is being made under rainfed condition:

(a) Potential area of 30,000 rai (4,800 ha) on the right bank in the upstream reach of the Mae Wong river

(b) Potential area of 20,000 rai (3,200 ha) on the right bank in the middle to downstream reach of the Mae Wong river, and

(c) Potential area of 18,750 rai (3,000 ha) on the left bank in downstream reach of the Mae Wong river.

Total development area is tabulated as follows:

Existing Irrigation Area	Rainfed Area	Total
230,000 rai (36,800 ha)	68,750 rai (11,000 ha)	298,750 rai (47,800 ha)

The location map of delineated irrigation development area in the Mae Wong river basin is shown in Fig. 4.4.1.

4.4.2 Khlong Pho river basin

There exist small scale irrigation projects in the Khlong Pho river basin, which have the irrigation service areas of 53,800 rai (8,600 ha) in total. Other than these existing irrigation projects, a medium scale irrigation project, the Wang Rom Klao, is located at just downstream of the confluence of the Mae Wong river and the Khlong Pho river. The Wang Rom Klao has the irrigation service area of 12,500 rai (2,000 ha) and is originally irrigated by using the water from the Khlong Pho, because no available water from the Mae Wong can be expected. Accordingly, the Wang Rom Kao would be incorporated into the irrigation development plan for the Khlong Pho river basin.

The Khlong Pho river basin has the following potential areas, where farmers enjoy the rainfed paddy cultivation:

(a) Potential area of 18,750 rai (3,000 ha), which extends on both banks in the upstream reach of the Khlong Pho river,

(b) Potential area of 12,500 rai (2,000 ha) on the left bank in the middle reach of the Khlong Pho river, and

(c) Potential area of 14,400 rai (2,300 ha) on the right bank in the downstream reach of the Khlong Pho river.

Total development area is summarized below:

Existing Irrigation Area	Rainfed Area	Total
56,300 rai (10,600 ha)	45,650 rai (7,300 ha)	101,950 rai (17,900 ha)

The location of delineated irrigation development area in the Khlong Pho river basin is shown in Fig. 4.4.1.

4.5 AGRICULTURAL DEVELOPMENT PLAN

4.5.1 General

The objectives of the pre-feasibility study in the field of agriculture and agricultural economy, at the present stage, are to measure the possible changes in agricultural production between the future conditions with and without the projects and to estimate the project benefits for priority ranking of the high priority projects.

The selected high priority projects areas are considerably matured for agricultural production, where numerous irrigation systems have been implemented and the available water is fully utilized with almost fixed cropping systems. There is no water available at present for the existing rainfed paddy fields. Under such conditions, significant changes in agricultural production will not be expected unless new water resources are exploited. With this in view, future condition without the project is considered same as the present condition. In the long run, the production techniques such as new varieties and efficient use of farm input and agricultural engineering investment are always changing and progressing and will certainly lead to some changes of agricultural production even if no project is realized. These factors will, however, be neglected in the estimate of possible changes attributed to the project partly because these will have influences on both with and without the project and partly because the effects of these factors are considered insignificant.

4.5.2 Changes in land use

The potential irrigation areas are delineated within the existing paddy fields. Paddy cultivation is a mainstay in these areas and its importance in rural economy will increasingly continue. The drastic changes in land use will not be occurred under such condition.

The existing paddy fields are classified into three (3) categories, depending on the degree of irrigation; (1) irrigated, (2) semi-irrigated and (3) rainfed fields. The "irrigated" means the paddy fields equipped with irrigation facilities and full supplemental irrigation for wet season paddy is guaranteed, and the "semi-irrigated" means those covered with irrigation facilities but not actually irrigated due to shortage of available water. The "rainfed" means those without the irrigation facilities.

After completion of the projects, all these paddy fields will be converted into the irrigated paddy fields.

Project	Categories	Without Project	With Project
Upper Mae Wong	irrigated	23,600	47,800
	semi-irrigated	13,200	-
	rainfed	11,000	-
	Total	47,800	47,800
Lower Mae Wong	irrigated	23,600	47,800
	semi-irrigated	13,200	-
	rainfed	11,000	-
	Total	47,800	47,800
Khlong Pho	irrigated	8,900	17,900
	semi-irrigated	1,700	-
	rainfed	7,300	-
	Total	17,900	17,900

4.5.3 Proposed cropping pattern

Paddy and mung beans are selected as main crops in the priority projects areas. Paddy will be cultivated in the wet season and mung beans will be grown after harvest of wet season paddy in the dry season.

Paddy is Thailand's most important crop. It is the main staple for domestic consumption and is also the major source of foreign exchange earnings. Thailand produces about 14 to 17 million tons of paddy annually. Its production fluctuates largely depending on the weather, especially seasonal patterns and amounts of rainfall. About two-thirds of production is consumed domestically and the rest is exported. In recent years, world rice production amounted to around 410 million tons, while only about 13 million tons or about 3.2% of production were internationally traded. Thailand's export accounts for about one-fourth of the total trade.

In January 1985, the Government of Thailand announced that about 19-21 million tons of paddy would be produced in the 1984/85 crop season and in anticipation of over-production problems, the Government would change its policy for rice and seek the possibility of a reduction in local paddy production by encouraging rice farmers to grow other cash crops yielding parallel income. The Government accorded its priority to sorghum and mung beans as substitute crops.

The farmers in the projects areas, however, have long experience for rice cultivation and also have strong desire to grow rice even in the dry season if irrigation is provided. Drastic crop diversification from rice to other cash crops is not realistic, particularly in the wet season cropping.

Mung bean is one of the prospective crops since its demand in the world market is high. Thailand is one of the major producers and exporters of mung beans. Thailand produces about 10% of the world output and exports a value of over one (1) billion bahts annually (about 133,000 tons).

The proposed cropping patterns is shown in Fig. 4.5.1. Two kinds of paddy varieties will be introduced; i.e., (1) high yielding varieties (H.Y.V.), and (2) improved local varieties. High yielding varieties will be cultivated mainly for export and improved local varieties will mainly be for home consumption.

4.5.4 Cropping intensity

The irrigation areas under the projects will possibly vary with the cropping intensity; the lower cropping intensity makes the irrigation areas larger, and on the other the higher cropping intensity smaller irrigation areas. The selected combinations of irrigation areas and cropping intensity are as follows:

Project	Irrigation Area (ha)	Cropping Intensity (%)
Upper Mae Wong	47,800	105
Lower Mae Wong	47,800	115
Khlong Pho	17,800	140

The cropping intensity mentioned above means 100% of wet season paddy and the rest of percentage allocated for mung beans cultivation in the dry season.

4.5.5 Proposed farming practices

After the proposed projects are realized, the existing paddy fields will be fully irrigated and new production techniques will be gradually introduced to the areas. The recommendable farming practices will be those developed by the Chainat Rice Experimental Station and the Field Crop Research Institute. The labour and farm inputs requirements for the proposed farming practices are estimated in monetary term and included in the estimate of crop production costs under the future condition with the project.

4.5.6 Anticipated crop yield and production

Crop yields under the present condition vary place by place and year by year, depending on the degree of irrigation water supplies. The present crop yields are estimated through field observations and interview with local farmers:

Wet season paddy	
irrigated	400 kg/rai (2.5 ton/ha)
semi-irrigated	250 kg/rai (1.6 ton/ha)
rainfed	200 kg/rai (1.2 ton/ha)
Dry season paddy	600 kg/rai (3.7 ton/ha)
Mung beans	100 kg/rai (0.6 ton/ha)

Crop yields will be substantially increased after completion of the project with introduction of improved farming practices under assured irrigation system. The anticipated crop yields under the condition with the project are estimated as follows:

Paddy	
H.Y.V.	820 kg/rai (4.5 ton/ha)
Local	640 kg/rai (4.0 ton/ha)
Mung Beans	190 kg/rai (1.2 ton/ha)

Crop yields and production under future condition without project are considered same as those of present condition. The incremental crop production attributed to the project is estimated as follows (for details, see Table 4.5.1):

Projects	Crops	Without Project (ton)	With Project (ton)	Increment (ton)
Upper Mao Wong	Paddy	95,210	203,150	107,940
	Mung Beans	920	2,870	1,950
Lower Mae Wong	Paddy	95,210	203,150	107,940
	Mung Beans	920	8,600	7,680
Khlong Pho	Paddy	34,430	76,080	41,650
		340	8,590	8,250

4.5.7 Marketing and price prospects

Production surplus of rice in the year of 1995, when full development of the project is attained, is estimated as follows:

Item	Mae Wong Upper	Mae Wong Lower	Khlong Pho
Population in 1980	65,000	65,000	25,000
Population Growth Rate (%)	5.2	5.2	2.4
Population in 1995	139,000	139,000	36,000
Rice Consumption per Capita (Kg)	150	150	150
Total Consumption in 1995 (ton)	20,900	20,900	5,400
Total Paddy Production in 1995	203,150	203,150	76,080
Total Production of Milled Rice in 1995	132,000	132,000	49,500
Surplus	111,100	111,100	44,100

Anticipated surplus of rice in 1995 will be significant in and around the projects areas. These surplus will be transported to the outside of the provinces particularly to the Bangkok market.

Present production of mung beans in the priority areas is about 1,260 tons in total. About a half of the products are consumed in the area and the surplus is directly sold at the local markets or to Bangkok through local merchants. After completion of the Projects, the incremental production of mung beans will be remarkable, ranging from 1,950 tons to 16,740 tons. All these surplus will be marketed to Bangkok for export.

For making preliminary evaluation of the priority projects, economic prices of paddy and mung beans of farm gate are estimated as follows (for details, see Table 4.5.2):

Paddy : ฿5,200 per ton

Mung Beans : ฿8,700 per ton

These prices are estimated on the basis of the projected international market prices forecasted by IBRD for the year of 1990.

4.5.8 Crop production cost

Crop production costs under "without Project" condition are estimated on the basis of farm economy survey carried out by the Office of Agricultural Economics. Detailed estimates are given in Table 4.5.3. Those under "with Project" condition are also estimated on the basis of farm inputs and labour requirement for recommendable farming practices. In the estimates of crop production costs, economic prices of inputs and labour are used. These estimates are shown in Table 4.5.4. Unit production costs per ha thus estimated are:

Without Project

- Wet Season Paddy

irrigated	:	Ø4,640/ha
semi-irrigated	:	Ø4,000/ha
rainfed	:	Ø3,160/ha

- Dry Season Paddy : Ø6,110/ha
- Mung Beans : Ø2,190/ha

With Projects

- Paddy : Ø6,510/ha
- Mung Beans : Ø3,920/ha

4.5.9 Gross and net crop production values

Gross and net production values under conditions with and without the project are estimated as shown in Table 4.5.5. The net incremental crop production values which will be taken as the primary project benefit, are derived from the difference in net production values under the conditions with and without the project. They are:

Projects	Without Project (Ø Million)	With Project (Ø Million)	Increment (Ø Million)
1. Upper Mae Wong	299.5	760.8	461.3
2. Lower Mae Wong	299.5	791.9	492.4
3. Khlong Pho	108.5	325.7	217.2

4.6 IRRIGATION DEVELOPMENT PLAN

4.6.1 Proposed irrigation systems

The general features of each high priority project are to irrigate the area of 298,750 rai (47,800 ha) for the Lower Mae Wong and Upper Mae Wong Projects and the area of 101,950 rai (17,900 ha) for the Khlong Pho Project. The proposed irrigation works for each high priority project consist of the following:

(a) Construction of new facilities for diverting irrigation water to the existing and potential areas,

(b) Rehabilitation and improvement of the existing irrigation facilities, and

(c) Expansion of irrigation facilities to the potential areas (existing rainfed areas) which are proposed to be irrigated in the project.

A layout planning of main canal and lateral is made for both the Mae Wong and Khlong Pho river basins by using the topographic maps on a scale of 1/50,000. However, the scale and contour interval of the topographic map used for the layout planning are not sufficient to estimate the construction cost of irrigation facilities. Consequently, the rainfed area located in the upstream reach of the Mae Wong river, which is covered by the topographic maps on a scale of 1/10,000 with 1.0 contour interval was selected as a model area for preliminary design of irrigation facilities.

Fig. 4.6.1 shows the layout of proposed irrigation system for the model area. The overall layout of irrigation system for the Mae Wong and Khlong Pho river basins is shown in Fig. 4.6.2.

4.6.2 Drainage requirement and proposed drainage system

The drainage water requirement is estimated in accordance with the following design standard which is generally applied to drainage plan in the humid Asian countries such as Thailand, Philippines, Malaysia and Indonesia:

(a) Return period of design rainfall is five years,

(b) Design rainfall is of three days - consecutive rainfall,

(c) Design rainfall shall be drained off for three days, and

(d) On-field storage of an average surchage of 75 mm.

Design rainfall with return period of five years is determined at 170 mm based on the daily rainfall records at Thap Than.

Unit drainage water requirement is calculated by using the following formula.

$$q = \frac{(R-h) \times 10^{-3} \times 10{,}000 \times 10^{3}}{86{,}400 \times d}$$

where,
- q : unit drainage water requirement (ℓ/sec/ha)
- R : design rainfall (mm)
- h : on-field storage of an average surchage (75 mm)
- d : allowable duration of inundation (3 days)

Unit drainage water requirement is determined at 3.67 ℓ/sec/ha.

There exist many existing small rivers and streams. These rivers and streams would be used for drainage purpose as many as possible. Only collector drain would be provided in the model area so as to drain the excess water of rainfall to the existing rivers and streams (See Fig. 4.6.1 and Fig. 4.6.2).

4.7 HYDRO POWER DEVELOPMENT PLAN

4.7.1 Electric power demand forecast

Although there were some years in which the growth of power demand in Thailand became stagnant due to the oil crisises in the 1970's, power demand during the same period shows an average annual growth rate of more than 13%, which seems to be very high. During the 1980's such increase was forced to be oppressed because of the energy-saving policies of the Thai Government and hike in electricity tariffs. Despite this situation, increases in power demand in 1980 and subsequent years was recorded at 6% or more on the average per annum. The power demand is still on the rapid increase in Thailand in correspondence to acceleration of her economic development, and this tendency is considered to continue in the future.

In northern Thailand where agriculture and commerce are dominant, remarkable demand for electric power is hardly observed whereas power demand for residential use is estimated to further grow with the progress of the rural electrification programs currently being implemented.

The electric power demand forecast adopted in this report has been worked out by the "Load Forecast Working Group for Power Tariff Study Sub-Committee" composed of representatives of EGAT, MEA, PEA, NEA and NESDB.

Figures mentioned in the above-mentioned forecast used to be revised every year based on actual records in the past. Accordingly, this forecast fully reflects possible increase in power demand to a considerably accurate extent and is judged to be reliable (refer to Fig. 4.7.1).

4.7.2 Present situation of power supply in the project area and adjacent places

Electric power sources in northern Thailand, where the site of the Sakae Krang River Basin Irrigation Project is located, are composed of three (3) categories of power plants; hydro, thermal and diesel-engine generating power plants.

There exist two (2) major hydro power plants; Bumipol Power Plant with an installed capacity of 553 MW and Sirikit Power Plant having an installed power capacity of 500 MW. On the other hand, there is Mae Mo Thermal Power Plant with an installed capacity of 375 MW in this region.

Electric power is supplied to Nakon Sawan, Chainat and Uthai Thani Provinces in this region through 230 kV transmission lines. In these provinces, base load is provided by

Mae Mo Thermal Power Plant while Bhumipol and Sirikit Hydro Power Plants respond to peak demand in the said provinces.

4.7.3 Hydro power development programs

EGAT has formulated its power supply programs up to the year of 1996 in accordance with the results of such Power Demand Forecast (See Fig. 4.7.2 for details). Among the gradiose hydro power plants incorporated in the said programs are included Khao Laem Power Plant with an installed capacity of 300 MW and Chrew Larn Power Plant with that of 240 MW which are now under construction and the proposed Upper Quai Yai Project (580 MW). Nevertheless, any large scale projects other than those mentioned above are yet to be planned. Miscellaneous hydro power plants having a total installed capacity of 700 MW at 11 sites for the years from 1990 to 1996 are proposed.

The Sakae Krang River Basin Irrigation Project has been planned mainly for irrigation purposes, and dam schemes on the respective tributaries of the Mae Wong, Khlong Pho, Huai Rang and Khun Kaew rivers have also been proposed for such purposes.

The hydro power development scheme is based on the utilization of irrigation water to be released from those dams by means of heads to be obtained after completion of the said dams (refer to Table 4.7.1).

CHAPTER V PROPOSED WORKS FOR HIGH PRIORITY PROJECTS

5.1 DAM AND RESERVOIR

5.1.1 Dam

(1) General

The effective storage capacity was determined below through the water balance study for proposed dams in order to exploit the available annual inflow to its maximum extent.

Dam	Effective Storage	Dead Storage	Total Storage
	MCM	MCM	MCM
Upper Mae Wong	230	20	250
Lower Mae Wong	350	30	380
Khlong Pho	96	14	110

The design of these dams was conducted at the pre-feasibility level which aimed to define the major dimensions of dams and related structures. Most of design values on the earthfill materials and foundation conditions are based on the estimates obtained from the site investigations.

Summary of dam and reservoir dimensions is shown in Table 5.1.1.

(2) Upper Mae Wong dam

The Upper Mae Wong dam site is located at about 17 km upstream of the Lower Mae Wong dam where the Mae Wong river emerges on the flood plain from the mountain ranges of the Mt. Khao Mokochun.

Valley shape is relatively wide about 400 m at river bed and about 800 m at around the dam crest. The foundation of dam is formed by massive hard rocks bearable for construction of all types of high dam.

In the selection of dam type, the concrete dam type is considered disadvantageous because of wide valley shape which will result in higher construction cost. Large volume of sutiable earthfil materials is also not obtainable in the vicinity of dam site. Rockfill type is preferable in all aspects such as material availability, suitability for high dam and economical construction. Rockfill dam with center-core was then selected for the Upper Mae Wong Dam. Designed major dimentions of dam body are summarized as follows.

Height m	Crest Elevation m	Crest Width m	Slope		Free Board m
			Upstream	Downstream	
62.0	222.0	10	1:1.7	1:1.6	2.5

The designed typical cross section is shown in Fig. 5.1.1.

As for the foundation treatment, open cracks are developed on the left side abutment and weathering is noticed but not deep, on the surface rocks at right side abutment. The principle purpose of foundation treatment for this dam is to decrease the seapage flow through dam foundation. Cement grouting is adopted for this purpose, consisting of blanket grout, main and supplemental curtain grouts. Grout line and grout hole spaces were designed to be 3.0 m and 3.5 m respectively.

Ungated side channel type was selected for the service spillway which was designed to locate at right side abutment. Spillway alignment was selected to release smoothly the flooding water spilt over the weir into the existing river channel through chute and stilling pool. The main features of the service spillway are as given below.

Design Discharge m^3/sec	Crest Length m	Surcharge Head m	Chute	
			Width m	Depth m
1,770	165	3.0	25	(max) 22

Intake structures consist of drop inlet structure and intake tunnel which will be initially constructed for the river diversion during embankment period. The hydraulic energy of impounded reservoir can be utilized at the outlet of intake tunnel for the possible hydro-electric power generation. The design discharge for diversion tunnel was determined at 700 m^3/sec equivalent to the flood of 5-year return period. Designed dimensions for intake (diversion) tunnel are as follows.

Design Discharge m^3/sec	Tunnel Diameter m	Tunnel Length m	Intake Discharge m^3/sec
700	9	190	35

(3) Lower Mae Wong dam

The Lower Mae Wong dam site is located at about 3 km upstream of the RID gauging station CT-5A, where the Mae Wong river runs through the narrow valley of the Khao Chonkan mountains. The valley shape is steep and river width is narrow about 60 m, which is considered fairly suitable for dam construction. On the left abutment, Mesozoic conglomerates and sandstone are exposed on the surface. The right abutment is thickly covered by talus deposit of about 4 m. Weathering of foundation rocks seems remarkable. A structural fault is indicated by the geological map of the Royal Thai Survey Department at about 400 m upstream of the proposed dam axis. Evaluating from these charactoristics, the dam site will be suitable for fill type dam but not advantageous for high concrete dam construction. Based on the availability of embankment material, center core zone type earthfill dam was determined. Designed major dimensions of dam body are summarized as follows, and the typical cross section is shown in Fig. 5.1.2.

Height m	Crest Elevation m	Crest Width m	Slope		Free Board m
			Uostream	Downstream	
38.1	143.1	9.0	1:2.0	1:2.5	2.6

Cement groutings were adopted for the foundation treatment. Groutings are formed by curtain grout lines in the center, supplemental curtain grout lines on both sides and blanket grout lines. As the foundation is considered to be soft rock formation, the spaces for the grout line and hole are selected at 2.0 m and 2.5 m narrower than in the case of the Upper Mae Wong dam.

Considering the topographic condition and utility of excavated materials for embankment, the location of service spillway was selected at right side abutment. Design flood for spillway is 2,600 m^3/sec which will make the scale of spillway structure excessively large compared with the size of dam body. Designed dimensions are summarized below.

Design Discharge m^3/sec	Crest Length m	Surcharge Head m	Chute	
			Width m	Depth m
2,600	155	4.0	30	(max) 23

In case of the Lower Mae Wong dam, the valley shape is narrow so that all construction works should be commenced after the diversion of river water through tunnel. The design flood scale for diversion tunnel was determined at 1,240 m^3/sec equivalent to the flood scale of 10-year return period. With this design flood, two diversion tunnels are necessary to keep the tunnel diameter not excessively large. The tunnel was designed at both sides of the river. Intake structure of drop inlet type was designed to be located at left side tunnel as it is short in tunnel length.

Location	Design Discharge m^3/sec	Diameter m	Length m	Intake Discharge m^3/sec
Left abutment	620	8.5	266	36
Right abutment	620	8.5	565	-

(4) Khlong Pho dam

The proposed dam site is located at the southern end of Khao Chonkan mountain ranges, where the river runs through the high terrace of the plain. Exploitation of large reservoir with high dam will be difficult as the valley is wide and shallow and the geological condition at dam site is not suitable for large dam construction. The valley width is about 1,500 m and the valley height is about 20 m from the river bed.

The dam site foundation is composed of diluvial sand layers which had been deposited in the old eroded valley. Rock meterials are not obtainable around the dam site, the earthfill type dam is preferable.
In order to utilize the sandy silt materials distributed abundantly near the dam site, inclined core type was selected. Major dimensions of dam body are given below.

The designed typical cross section is shown in Fig. 5.1.3.

Height m	Crest Elevation m	Crest Width m	Slope		Free Board m
			Upstream	Downstream	
20.9	104.9	8	1:2.0	1:2.0 to 1:2.5	2.6

Cement grouting was planned for both abutments as their foundation was considered consolidated. These grouts are composed fo 3 lines of main curtain grout, 2 lines of supplemental grout and 2 lines of blanket grout lines having line space at 2 m and grout hole space at 2.5 m.

In order to treat the loose diluvial deposit left unexcavated in the buried valley portion, chemical grouting was preferred. Considering that the permeability of foundation was estimated about $1x10^{-4}$cm/sec, the grout line space was determined at 1.0 m and grout hole space at 1.5 m.

Side spillway was planned to be located at right abutment where the foundation layer was expected to be consolidated well. The designed spillway dimensions are as follows.

Design Discharge m /sec	Crest Length m	Surcharge Head m	Chute	
			Width m	Depth m
1,190	200	2.0	30	(max) 13.4

Incase of the Khlong Pho dam, most of the embankment works can be progressed without effect from river flow. River diversion is not necessary except for the last enclosure of the dam site.

Maximum intake capacity for irrigation is 10.0 m^3/sec. Therefore, the river diversion will be made as follows through intake tunnel which is to be located at right side.

Tunnel Diameter m	Intake Discharge m^3/sec	Tunnel Length m	Intake Type
1.8	10	300	Drop Inlet

5.1.2 Reservoir

Reservoir dimensions were determined below from the topographical maps on a scale 1/50,000 for the Upper Mae Wong dam and the Khlong Pho dam and 1/10,000 for the Lower Mae Wong dam.

Reservoir Dimension		Upper Mae Wong	Lower Mae Wong	Khlong Pho
Catchment area	km^2	612	930	394
Effective storage	MCM	230	350	96
Dead storage	MCM	20	30	14
Total storage	MCM	250	380	110
Water level				
Full storage	ELm	216	136	100
Dead storage	ELm	189	124	95
Flood water	ELm	219	140	102
Reservoir area				
Full storage	km^2	17.0	54.0	30.0
Flood water	km^2	19.5	68.0	36.0

5.2 IRRIGATION AND DRAINAGE FACILITIES FOR MODEL AREA

5.2.1 General

The general feature for each high priority project is to supply irrigation water to the proposed irrigation areas which consist of the existing irrigation area and the potential areas (rainfed paddy fields). The facilities required for each high priority project include the intake facilities, irrigation and drainage canals and their related structures.

As stated in Section 4.6, since the existing topographic maps were not sufficient for making the proper layout planning of irrigation and drainage systems, the model area of 46,000 rai (7,360 ha) was selected for preliminary design of irrigation and drainage facilities, and consequently construction cost estimate. The general features of irrigation and drainage facilities for the model area are shown in Table 5.2.1.

5.2.2 Intake facilities

An intake weir of ogee type would be constructed for the model area to divert the irrigation water to the area. The weir would be 4.5 m high and 35 m long including the scouring sluice portion. In the right end of the weir, a scouring sluice with 2 sets of gate, 2.0 m wide and 2.0 m high, would be provided so that the deposited sand can be flashed down. The scouring gate would be operated by man power.

An intake structure would be constructed on the right bank of the Mae Wong river. The intake gates would consist of 3 sets of slide gate, each 2.0 m wide and 1.8 m high, which would be operated by man power. The intake discharge is estimated at 7.4 m^3/sec in maximum.

5.2.3 Irrigation canals

The major irrigation canal system for the model area consists of a main canal and four laterals. The total lengths of main canal and laterals including sub-laterals are 12.7 km and 97.6 km, respectively. All the existing irrigation canal systems in the model area would be rehabilitated and improved for incorporating into the project as many as possible.

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

(a) Turnout with check structures for diversion of irrigation water from main canal or lateral to lateral or tertiary canal,

(b) Syphon structures for conveyance of irrigation water crossing over the existing rivers and streams,

(c) Culvert structures for conveyance of irrigation water under the road, and

(d) Sidespillway structures for wasting excessive water in the canal.

The related structures of 81 in number are required for the model area.

5.2.4 Drainage canals

The existing rivers and streams in the model area are proposed to be used as the main and lateral drains with minor rehabilitation and imporvement works. To collect and drain the excess water by irrigation and rainfall, new collector drain of 4 km is proposed.

5.2.5 Inspection roads

For proper operation and maintenance of project facilities, well arranged inspection roads are of vital importance.

(1) Main inspection road

The main inspection road is required for inspection operation and maintenance of main canal. Considering the future increase of vehicles for the inspection and operation and heavy construction to be required for the canal maintenance and repair, all the main inspection road is so designed as to have an effective width of 5 m and to be laterite-paved. The road is also used for transportation of agricultural products and equipment.

(2) Lateral inspection road

The lateral inspection roads are mainly provided alongside the lateral canal. All these roads have a width of 4 m.

5.3 CONSTRUCTION PLAN

5.3.1 Construction planning

(1) Dam construction

(a) Upper Mae Wong Dam

Rock zone of the dam embankment is to be obtained from the quarry site proposed at left side upstream hill in the distance about 1.5 km from the dam site. Hard rocks excavated by dynamite blasting will be applied for rock zone embankment. Estimated construction equipments are 3.2 m^3tractor shovel and 32 t dump track assisted by 21 t bulldozers at quarry site and embankment yard.

Core material is to be obtained from the borrow area proposed at downstream right side terrace about 1.5 km from the dam site. It is assumed that about 70% of excavation will be adoptable for core zone embankment. Materials for transition zone will be obtained mainly from service spillway excavation, river diversion channel excavation and quarry site. For the embankment of transition zone, excavated materials except quarry will be once for stockpiled for adjustment of embankment schedule with the progress of other zones such as rock and core zones. Weathered rock and smaller size rocks obtained from quarry site will be directly transported to the transition zone. The expected diversion rate of excavated materials suitable for transition zone will be 20% of quarry excavation, 80% of river diversion channel excavation and also 80% of spillway excavation. Filter zone materials will be obtained from river sand excavation but about 50% suitable for proposed sand grading.

(b) Lower Mae Wong Dam

The design of the dam body for Lower Mae Wong dam is so made that the most of excavated materials from the service spillway should be utilized for the embankment of the dam. The earth moving plan is made according to this design concept. The diversion rate is estimated from the site investigations on the soil mechanical and geological conditions that 70% of spillway excavation can be used for the random zone, semi-pervious zone and back fill of structures. And about 10% can be used for rock zone. Out of total excavation volume of 800,000 m^3 from service spillway, all embankment volumes for rock zone, random zone and semi-pervious zone are supplied but about 310,000 m^3 will be disposed. Core materials are obtained from borrow area located at downstream of dam. Filter material will be produced from river sand. All materials for embankment from spillway excavation should be once stockpiled in order to adjust the embankment speeds of different zones. Dynamite plasting for excavation will be limited only for hard rock with small quantity.

(c) Khlong Pho Dam

In case of the Khlong Pho dam, available materials near the dam site is expected only applicable for random zone. Core materials should be borrowed in far distance about 5 km from dam site near the foot hill of the Khao Chonkan mountains. Filter zone will be supplied from the river sand but grade adjustment will be required. As for the riprap material, it is planned to find the suitable quarry site around the dam site. In this design, the quarry site was assumed to exist within 5 km distance. If there is no quarry site available, the rock material for riprap should be purchaced.

(2) Construction of irrigation facilities

(a) Excavation and filling

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

The excavated materials excessive of filling requirement would be transported to a spoil area. In case of lacking of materials for filling, the materials would be supplemented from borrow area selected near the working site. Spreading of filling materials would be mainly made by bull-dozer and supplementally by manpower. Materials for laterite pavement would be transported from a borrow area, spreaded by bulldozer, and compacted by compactor.

(b) Concrete lining

Main canals would be lined with 10-cm thick concrete. After completion of earth works, concrete lining works would be started. Concrete would be produced by portable concrete mixer, and placed by manpower. Simple sliding concrete form removed by manpower would be used for the lining. Three or four sets of the slide forms would be required for making continuous lining works every day.

(c) Related strucutres

Earth works for canal related structures would be done by manpower. The structures are mainly made by reinforced concrete. The concrete would be mixed by portable mixer and placed by manpower.
The structures are not so simple compared with canal lining that wooden forms would be used for these structures.

5.3.2 Implementation schedule

(1) Detailed design works

Prior to the construction works, the detailed design for the project will be carried out for about two years. Loan arrangement will also be included in this period.

(2) Preparatory works

The construction office and quarters will be constructed prior to the major construction works. The access road for construction of dam and temporary access road for canal construction will be provided for smooth construction works. The land acquisition for the dam and canal system will be completed before start of the construction works. Resettlement and compensation will be also included in the preparatory works.

These works will be started from mid-2nd year and completed by mid-3rd year.

(3) Construction works for dam and irrigation facilities

The construction works for dam will be started from the 3rd year and completed within five years. Since the existing irrigation areas have the intake weir and intake facilities, the rehabilitation or improvement works should be started as early as possible in order to gain the benefits in possiblely early stage. The construction works for irrigation facilities will be commenced from the 4th year and completed within four years, at the same time of completion of dam construction.

The implementation schedule is shown in Fig. 5.3.1.

5.4 PRELIMINARY COST ESTIMATE

5.4.1 Assumptions

The construction cost is estimated based on the following assumptions.

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

US$1.0 = ฿ 27 = ¥ 240 (end-1984 level)

(2) Civil works are to be carried out on the international contract basis using contractor's own heavy construction machinery and equipment.

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

(4) The construction cost comprises foreign and local currency portions. The cost estimate is made based on the price level in November, 1984. The classification of foreign and local portions is shown below:

Foreign currency portion:

- large gates for dam and intake weir,
- depreciation costs for heavy construction machinery and equipment,
- engineering services cost of foreign consultant, and
- contractor's general expenses and profit.

Local currency portion:

- labor forces,
- sand, gravel and wooden materials,
- cement,
- reinforcement bar and other structural steel,
- fuel, oil, etc.,
- inland transportation costs,
- resettlement and compensation costs,

- administration costs,
- engineering services costs of local consultant, and
- contractor's general expenses and profit.

(5) The physical contingency, 15% of direct construction cost is included in the construction cost in view of the preliminary nature of the estimate.

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

5.4.2 Project costs

The total project cost for each high priority project is estimated as follows:

(Unit: 10^6 ฿)

High Priority Project	Foreign Currency	Local Currency	Total
Upper Mae Wong	1,812.4	2,100.2	3,912.6
Lower Mae Wong	1,085.8	2,009.0	3,094.8
Khlong Pho	727.4	1,267.4	1,994.8

The summaries of cost estimate for high priority projects are shown in Table 5.4.1 to Table 5.4.3. The annual disbursement schedule is worked out as shown in Table 5.4.4 to 5.4.6 based on the implementation schedule.

5.4.3 Operation and maintenance cost

The annual operation and maintenance costs include the salaries of the operation and maintenance office staff, the materials and labor costs reparing and maintenance of project facilities and running cost of project facilities. The operation and maintenance costs are estimated based on the following assumptions:

Dam	:	0.5% of direct construction cost
Irrigation facilities	:	2.5% of direct construction cost

The annual operation and maintenance costs for high priority projects are estimated as follows:

Upper Mae Wong	27.6×10^6 ฿
Lower Mae Wong	30.2×10^6 ฿
Khlong Pho	13.9×10^6 ฿

CHAPTER VI PRELIMINARY ECONOMIC EVALUATION

6.1 GENERAL

The economic evaluations were made for comparison of the high priority projects. The development scale of each project was determined through alternative studies before final comparison of the projects would be made. The proposed scale of each project for economic comparison would be, in conclusion, the potential maximum scale of dam and reservoir coupled with the potential maximum irrigation development in area.

The economic evaluations were made in terms of internal rate of return (IRR). The sensitivity analysis was also made for several cases, considering the possible future changes in the economic assumptions. The sensitivity was also examined for uncertainty in number of household in the prospective reservoir areas.

The financial aspects of the projects have not been studied at the present stage of the pre-feasibility study, mainly due to lack of reliable economic data for analysis. These will be made during the next stage of the feasibility study for the first priority project which will be selected at the present stage through economic and overall comparison of the high priority projects.

The main features of the high priority projects determined for economic comparison are summarized as follows:

Item		Unit	Mae Wong		Khlong Pho
			Upper	Lower	
	Dam & Reservoir				
a.	Effective Storage	MCM	230	350	96
b.	Reservoir Area	km^2	19.5	68.0	32.0
c.	Dam Height	m	62.0	38.1	20.9
d.	Crest Length	m	780.0	240.0	1,555.0
e.	Embankment	MCM	3.40	0.38	0.74
	Irrigation				
a.	Without Project				
	- irrigated	ha	23,600	23,600	8,900
	- semi-irrigated	ha	13,200	13,200	1,700
	- rainfed	ha	11,000	11,000	7,300
	Total	ha	(47,800)	(47,800)	(17,900)
b.	With Project				
	- irrigated	ha	47,800	47,800	17,900
	- cropping intensity	%	105	115	140

6.2 PRELIMINARY ECONOMIC EVALUATION

6.2.1 Economic costs

The project cost broadly comprises (1) cost for preparatory works, (2) construction cost for project facilities including the contractor's overhead cost, profit and contract tax, (3) cost for land acquisition and compensation, (4) administration expenses, (5) expenses for engineering services, (6) physical contingencies and (7) price contingencies. These cost estimates are made on a financial basis as given in Section 5.4. All the costs except the contractor's profit, contract tax and price contingencies, are generally regarded as net capital cost. The net capital cost is further converted into the economic project cost by applying the construction conversion factor (CCF) of 0.9.

In addition to the above, the cost for on-farm development is included in the economic project cost. The on-farm development is to be executed by the farmers themselves.

The economic project cost and its annual disbursement are estimated as follows:

Year	Mae Wong Upper (10^6 ฿)	Mae Wong Lower (10^6 ฿)	Khlong Pho (10^6 ฿)
1st year	55.8	41.2	26.9
2nd year	112.6	160.5	120.0
3rd year	85.5	305.4	112.1
4th year	404.0	292.0	163.9
5th year	725.1	464.8	371.2
6th year	725.1	464.8	342.3
7th year	345.6	260.3	135.0
Total	2,453.7	1,989.0	1,271.4

The annual O & M cost is roughly estimated at 2.5% of the economic direct cost for irrigation facilities and 0.5% for economic direct dam construction cost.

6.2.2 Project benefits

The project benefits will primarily accrue from the increased crop production attributable to the projects. These benefits are estimated as the difference of the annual net production values under future with and without project conditions.

The project benefits will gradually increase year by year as follows:

Year	Mae Wong Upper (10^6 ฿)	Mae Wong Lower (10^6 ฿)	Khlong Pho (10^6 ฿)
6th year	46.1	46.1	21.7
7th year	92.3	92.3	43.4
8th year	276.8	295.4	130.3
9th year	322.9	344.7	152.0
10th year	369.0	393.4	173.8
11th year	415.2	443.2	195.5
12th year	461.3	492.4	217.2
.	.	.	.
.	.	.	.
.	.	.	.
50th year	461.3	492.4	217.2
Total	19,513.0	20,818.7	9,187.5

6.2.3 Internal rate of return (IRR)

The internal rate of return is calculated on the following assumptions:

(1) The economic useful life of the projects will be 50 years,

(2) Only the agricultural benefit is counted in the evaluations, and any indirect or intangible benefits are not taken into account in calculation of IRR,

(3) The construction periods will be seven (7) years including two years for detailed design and preparatory works,

(4) The benefit will initially accrue from rehabilitation of existing irrigation facilities in 6th year by 10% of full incremental benefit and 20% in seventh (7th) year, and after completion of dam construction, the annual benefit will increase gradually during the build-up period of 5 years from 60% in 8th year to 100% in 12th year,

(5) The cost for resettlement and compensation is estimated on the basis of the officially reported number of household, using the unit prices of 0.2 million Bahts per household for houses and 0.6 million Bahts per sq. km for land,

(6) The economic costs and benefits are used in the evaluation, and

(7) The prevailing exchange rate of US$1.00=฿27.0=¥240 is used in the project cost estimate.

Using the costs and benefit estimated in the above, the internal rate of return (IRR) are calculated as follows:

	Mae Wong		
	Upper	Lower	Khlong Pho
IRR (%)	13.0	15.2	11.5

6.3 SENSITIVITY ANALYSIS

In order to evaluate further the economic soundness of the projects under the possible changes in the economic assumptions, the sensitivity analysis is made for the following four (4) cases;

(a) Case-1 10% cost increase and benefit as schedule,

(b) Case-2 20% cost increase and benefit as schedule,

(c) Case-3 10% benefit decrease and cost as schedule, and

(d) Case-4 10% benefit decrease and 20% cost increase.

The following shows the results of sensitivity analysis:

	Mae Wong		
Case	Upper	Lower	Khlong Pho
Case-1	12.1	14.2	10.7
Case-2	11.2	13.3	10.0
Case-3	11.8	13.9	10.4
Case-4	10.2	12.2	8.9

From the above calculated results, it can be said that both of the Upper and Lower Mae Wong Projects will be still economically viable even in the worst case and on the other, the Khlong Pho Project will become questionable in economic feasibility.

The sensitivity analysis is also made for uncertainty in number of household in the prospective reservoir area. Although the official report indicates that there are 40 households living in the Upper Mae Wong reservoir area, 520 in the Lower Mae Wong and 365 in the Khlong Pro, it is generally believed that more number of households are actually living in the respective reservoir areas, particularly in the Lower Mae Wong and Khlong Pro reservoir areas. The economic evaluations mentioned above were made on the assumption that the official report gives collect number of households. If the actual number of households is different from the official report, the IRR will be changed. The interview with the farmers indicates that about 2,500 households are living in the Lower Mae Wong area and about 2,000 in the Khlong Pho area. Number of household in the Upper Mae Wong area is not significant, ranging from 40 to 80.

The following figure shows the results of sensitivity analysis for number of households in the reservoir areas. The results indicate that the economic viability of the projects, in case of Lower Mae Wong and Khlong Pho, will drastically decrease with the increased number of household in the reservoir areas.

6.4 SOCIO-ECONOMIC IMPACTS

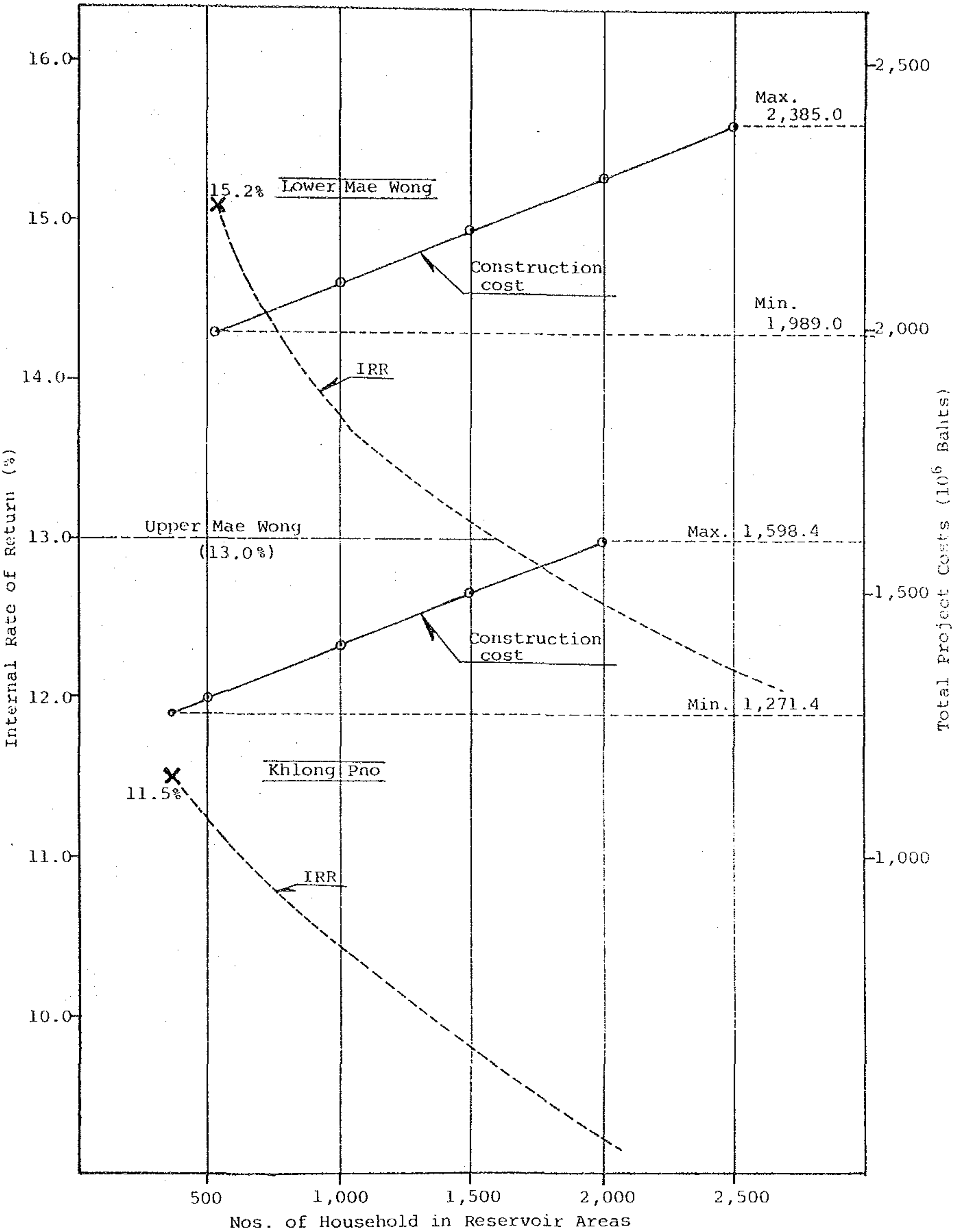
In addition to the direct project benefits counted in the economic evaluation, various secondary and intangible benefits and/or favourable socio-economic impacts are expected from the implementation of the projects. The major socio-economic impacts are described hereunder.

(1) Possibility of hydropower generation

The proposed storage dams, especially for the Upper Mae Wong dam, provide a possibility of hydropower development. According to the preliminary study results, about 13,700 MWH of annual energy output will be produced with an installed capacity of 5,000 kW at the Upper Mae Wong dam. The hydropower development potential for the Lower Mae Wong and Khlong Pho dams is rather small compared with the Upper Mae Wong dam. the annual energy outputs estimated for these dams are about 5,300 MWH for Lower Mae Wong dam and 600 MWH for Khlong Pho dam.

(2) Increase of potential fish production

After creation of the reservoirs, the potential fish production will be increased to a great extent, and it would be made possible for the farmers to manage stable aquaculture of valuable fishes. This possibility will be studied during the next stage of the feasibility study.


Lower Mae Wong
15.2%
Construction cost
IRR
Max. 2,385.0
Min. 1,989.0
Upper Mae Wong
(13.0%)
Max. 1,598.4
Min. 1,271.4
Construction cost
Khlong Pno
11.5%
IRR
16.0
15.0
14.0
13.0
12.0
11.0
10.0
2,500
2,000
1,500
1,000
500
1,000
1,500
2,000
2,500
Internal Rate of Return (%)
Total Project Costs (10^6 Bahts)
Nos. of Household in Reservoir Areas

(3) Foreign exchange earning

After completion of the projects, significant increase in crop production is expected. With the increased production, the marketable surplus of paddy and mung beans will also be increased. The estimated marketable surplus would be:

Surplus for export	Mae Wong Upper (ton)	Mae Wong Lower (ton)	Khlong Pho (ton)
a. Paddy	111,000	111,000	44,000
b. Mung Beans	1,400	4,300	4,300

These surplus would increase the annual amount of exports, resulting in the foreign exchange earning equivalent to around 1,072 million Bahts per annum for Upper Mae Wong, 1,109 million Bahts for Lower Mae Wong and 471 million Bahts for Khlong Pho project.

(4) Increase of employment opportunity

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

(5) Improvement of local transportation

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

(6) Mitigation of flood damages

Flood control is not considered primary in the projects. However, incidental flood control could be realized to some extent by the operation of reservoirs, expecially in eary part of the wet season.

CHAPTER VII. ENVIRONMENTAL CONSIDERATIONS

7.1 ENVIRONMENTAL STUDY

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

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

a.	Effective storage	:	100 MCM
b.	Reservoir area	:	15 Km^2
c.	Irrigation area	:	80,000 Rai

All the proposed high priority projects are larger than the above guideline in scale and therefore the detailed EIS will be required.

The environmental study required by NEB comprises manifold items of environmental impact evaluations. They are classified into four (4) categories (Table 7.1.1, to be referred) as follows:

(1) Physical resources

- i Surface water hydrology
- ii Surface water quality
- iii Groundwater hydrology
- iv Groundwater quality
- v Soils
- vi Geology/Seismology
- vii Erosion/Sedimentation
- viii Climate

(2) Ecological resources

- i Fisheries
- ii Aquatic biology
- iii Wildlife
- iv Forests

(3) Human use values

i Agriculture/Irrigation
ii Aquaculture
iii Water supplies
iv Navigation
v Recreation
vi Power
vii Flood control
viii Dedicated area uses
ix Industry
x Agro-industry
xi Mineral development
xii Highway/Railway
xiii Land use

(4) Quality of Life values

i Socio-economic
ii Resettlement
iii Cultural/Historical
iv Aesthetic
v Archaeological
vi Public health
vii Nutrition

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

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

7.2 PRESENT ENVIRONEMNTAL PROBLEMS

The proposed dam and reservoir sites in the Sakae Kran river basin are recognized to have some environmental problems at present.

(1) Illigal migration

Inspite of forest reserve declaration on the upstream watershed, villagers trespassed and settled down in the reserved area illigally. As the upstream area was turned into the farmland, more people used more water than earlier, so the people living downstream had to suffer from the water shortage for cultivation.

(2) Depletion of forest reserve

Within the watershed of the basin, many numbers of the forest reserve areas of Forestry Department are located. The proposed reservoir/dam sites are included in the forest reserve area except Huai Rang Dam.
A wildlife conservation area (Huai Ka Kaeng) exists in west of Thap Salao river. These forest reserves have been encroached by those illegal settlers for logging and cultivation. Using the areal photos and landsat image, the Forestry Department investigated the arer of encroachment in the Mae Wong, Mae Poen Forest Reserves. The investigation estimated that the encroached area increased from 7% of total reserve area in 1963 to 43% in 1982.

Year	Encroached Area		%	Investigation Method
	rai	ha		
1963	78,594	12,600	7	areal photo
1975	210,860	33,700	20	landsat image
1982	459,532	73,500	43	landsat image

(Total area is 1,080,725 rais or 172,900 ha.)

7.3 PRELIMINARY ASSESSMENT ON ENVIRONMENTAL IMPACTS

The anticipated environmental impacts affected by the projects are roughly studies with the present small knowledge obtained through the limited time of the pre-feasibility study.

7.3.1 Physical resources

(1) By the operation of the proposed dam, the pattern of river flow will be remarkably changed in the downstream of the dam site. However, the irrigation water from the dam is once released to the river channel and taken at the downstream diversion weirs to the irrigation areas. Thus, it is expected that the future river flow will become more steady than the present natural river flow and contribute to maintenance of river channel fisheries, local navigation, domestic water use, etc. The situation of the present river water quality will not be turned worse.

(2) Exploitation of water resources by a storage dam and irrigation development will increase the potential of groundwater in the whole basin, particularly in the downstream area of the Sakae Krang river. The present observation of grounwater in the area should be continued for future development.

(3) A storage dam on a river will change the transportation mechanism of sediment in the river system. In the upstream of the dam, sediment will be trapped in the reservoir and the channel bed of rivers flowing into the reservoir will be elevated because of back sand at the edge of the reservoir. The elevation of river bed will cause flooding in the riparian area at the reservoir edge. The compensation of the land to be damaged will be a possible solution. In the dam design, it is planned that the lands of reservoir rim whose altitude is lower than the dam crest elevation (2 to 4 m higher than the full water level) are to be compensated, and the cost was counted in the project cost.

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

(4) The proposed projects have been formulated and designed on the basis of technical assessement on present condition of soils and geology in order to minimize the environmental impacts in future. Serious impacts are not therefore anticipated.

7.3.2 Ecological resources

In general, some impacts to fauna and flora are conceivable. It is however quite difficult to assess such impacts, because there have not been any studies of fauna and flora in the relevant river basins. The areas to be submerged by the dams, particularly the Lower Mae Wong and Khlong Pho, mostly consist of the cultivated lands, scrub and artificial forests. The respective reservoir areas of 68 km^2 and 32 km^2 for Lower Mae Wong dam and Khlong Pho dam are rather small as compared with their total catchment areas of 950 km^2 and 394 km^2, and therefore serious impacts to fauna and flora are not anticipated. On the other, the reservoir area of the Upper Mae Wong dam is mostly covered by artificial and partially virgin forests, and some effects to wild animal would be conceivable. Further study may be required in this region. Actually, however, the anticipated impacts are negligible since the reservoir area of 19.5 km^2 is extremely small compared with the total catchment area of 612 km^2.

7.3.3 Human use value

(1) Irrigation will improve the present low land productivity and increase crop production in the Sakae Krang river basin. The increased crop production may accelerate the further development of agro-industries and marketing activities in the area. It will also increase the employment opportunity.

(2) The dam construction will increase the potential of aguaculture particularly in the downstream due to improved water flow during the dry season, and will also provide a new possibility of sizable aquaculture in the reservoir.

(3) The proposed dam will create the possibility of hydropower development. The estimated annual energy outputs are about 13,700 MWH for the Upper Mae Wong dam, about 5,300 MWH for the Lower Mae Wong dam and about 600 KWH for the Khlong Pho dam. The hydropower generation will contribute to rural electrification.

(4) Although the proposed plan does not include flood control in its purpose, dams will reduce the peak discharges to a some extent and will mitigate the flood damages to crops and rural life.

(5) The regulated water flow resulting from the dam construction will improve the water supplies for domestic uses. Rehabilitation of the existing canal system will also improve the situation. New construction of irrigation canals in the rain-fed area will provide the farmers with easy access to domestic water.

(6) The inspection roads which will be constructed along the irrigation canals, will enhance the economic activities in the area. The improvement of road network will give favourable impacts to socio-economic aspects of the area.

(7) No significant impacts will be anticipated in other aspects of human use value.

7.3.4 Quality of life values

(1) Resettlement problems are considered most serious, particularly for the Lower Mae Wong dam and Khlong Pro dam as their reservoir areas are occupied by villagers. As shown in Table 7.3.1, it is officially reported that there are 520 households in Lower Mae Wong and 365 households in Khlong Pro area. It seems, however, that more than those number of households are living in the reservoir areas. It is generally believed by the local people that there are about 2,500 households in Lower Mae Wong and about 2,000 household in the Khlong Pho area. A part of these villagers have land ownership called Sor Tor Kor, which is subject to compensation. Moreover this, the resettlement area is not easily found in the vicinity of proposed reservoir unless the reserved forest area is to be sacrificed.

(2) The proposed projects will largely contibute to the improvement of rural economy and also uplift the rural living standard. The construction of dam and reservoir will provide the rural communities with new recreation areas. The cultural/historical heritages and archaeological treasures in the reservoir areas, will be checked.

CHAPTER VIII RECOMMENDATION

8.1 SELECTION OF FIRST PRIORITY PROJECT

For selection of the first priority project, the overall results of the pre-feasibility study on the high priority projects are summarized in the following table.

As seen from the table, there is a clear difference among three projects in terms of internal rate of return (IRR). The Khlong Pho project is rather small in development scale, having smaller irrigation area, smaller number of project-benefited farmers and minor hydropower potential. The economic viability of the Khlong Pho project is also low, as indicated by comparatively low IRR of 11.5%. The Khlong Pho project also involves the problems of resettlement and compensation because a large number of villagers are living in the reservoir area. Considering all these, the Khlong Pho project should be given the lowest priority among three projects.

Comparison between two other projects indicates that the Lower Mae Wong project seems to be more attractive in both technical and economic aspects, showing higher IRR of 15.2% against that of 13.0% for the Upper Mae Wong project. However, the Lower Mae Wong project has the following economic and social difficulties which will be induced by the resettlement of and compensation to a large number of villagers in its reservoir area:

(1) Uncertainty is involved in the estimate of the project cost due to lack of reliable data on resettlement and compensation costs as well as uncertain number of household in the reservoir area, and if the number of household in the reservoir area is more than 1,600, its economic viavility will become lower than that of the Upper Mae Wong project. Such case could be foreseen with rather high probability.

(2) Large land area will be required for resettlement program. The land requirement will range from 850 ha to 4,000 ha, depending on the number of household. The potential agricultural land resources are already almost fully utilized in the Sakae Krang river basin and therefore new land development for resettlement program will be difficult.

(3) It may take several years to completely settle the problems of resettlement and compensation. The case of the Thap Salao dam project gives an idea how the problems should be settled. Peaceful settlement of the problems will require untiring

efforts over several years. It may affect the construction schedule adversely and the completion of the project may be delayed.

(4) The problem of social tensions which may be induced by resettlement of a large number of household, is also foreseen, and can not be neglected.

(5) The reservoir area is largest among those of other projects. There exist large farmlands and forest reserve. If the project is realized, large negative benefits for these will surely arise.

A kind of political consideration may be required for the judgement on the socio-economic difficulties mentioned above.

The study team would, however, give the first priority to the Upper Mae Wong project on the following reasons:

(1) The Upper Mae Wong project is economically feasible and technically sound, with same development scale as the Lower Mae Wong.

(2) The socio-economic difficulties of the Lower Mae Wong project could not be neglected and might seriously affect the project costs and construction schedule.

(3) The Upper Mae Wong project has no such socio-economic difficulties and will possibly be realized in a shortest time.

(4) The Upper Mae Wong project has higher hydropower development potential.

8.2 ADDITIONAL SURVEY AND INVESTIGATION REQUIREMENTS FOR FIRST PRIORITY PROJECT

The feasibility study for the first priority project (Part C Study) is scheduled to be commenced from June, 1985. Prior to start of the feasiblity study, the additional survey and investigation on the first priority project are requested to be carried out by RID. It is requested that the above survey and investigation will be completed by beginning of June, 1985. The detailed scope of works for the additional survey and investigation of the first priority project is shown in ATTACHMENT-4.

MAIN FEATURES OF HIGH PRIORITY PROJECTS

Item	Unit	Upper Mae Wong	Lower Mae Wong	Khlong Pho
1. Dam & Reservoir				
a. Effective Storage	MCM	230	350	96
b. Reservoir Area	Km^2	19.5	68.0	32.0
c. Dam Height	m	62.0	38.1	20.9
d. Crest Length	m	775	225	1,555
e. Embankment	MCM	3.40	0.38	0.74
2. Irrigation				
a. Without Project				
- irrigated	ha	23,600	23,600	8,900
- semi-irrigated	ha	13,200	13,200	1,700
- rainfed	ha	11,000	11,000	7,300
(Total)	ha	(47,800)	(47,800)	(17,900)
b. With project				
- irrigated	ha	47,800	47,800	17,900
- cropping intensity	%	105	115	140
3. Reservoir Performance				
a. Eff. Storage/ Irri. Area	m^3/ha	4,812	7,322	5,363
b. Embk. Vol./ Eff. Storage	m^3/MCM	14,800	1,100	7,700
c. Irri. Area/ Eff. Storage	ha/MCM	208	137	186
4. Economic Project Cost				
a. Dam	M฿	1,123.5	628.1	579.1
b. Irrigation	M฿	944.9	944.9	424.1
c. Resettlement	M฿	19.7	144.8	92.2
d. Others	M฿	365.6	271.2	176.0
(Total)	M฿	(2,453.4)	(1,989.0)	(1,271.4)
e. Unit Cost	฿/ha	51,300	41,600	71,000
5. Annual Benefit				
a. Total	M฿	461.3	492.4	217.2
b. Unit	฿/ha	9,600	10,300	12,100
6. Internal Rate of Return (IRR)	%	13.0	15.2	11.5
7. Resettlement & Compensation				
a. House	No.	40 - (80)	520 - (2,500)	365 - (2,000)
b. Land	Km^2	19.5	68.0	32.0
c. Cost	M฿	19.7 - (27.7)	144.8 - (540.8)	92.2 - (419.2)
d. Sensitivity to IRR	%	13.0 - (12.9)	15.2 - (12.3)	11.5 - (9.2)
8. Crop Production				
a. Without Project				
- Paddy	ton	95,200	95,200	34,400
- Mung Bean	ton	900	900	300
b. With Project				
- Paddy	ton	203,200	203,200	76,100
- Mung Bean	ton	2,900	8,600	8,600
c. Increment				
- Paddy	ton	108,000	108,000	41,700
- Mung Bean	ton	2,000	7,700	8,300
9. Financial Project Cost				
a. Dam	M฿	1,194.8	666.5	614.3
b. Irrigation	M฿	978.4	978.4	441.2
c. Resettlement	M฿	19.7	144.8	92.2
d. Others	M฿	1,719.7	1,305.1	847.1
(Total)	M฿	(3,912.6)	(3,094.8)	(1,994.8)
e. Unit Cost	฿/ha	81,800	64,700	111,400
f. F/C Portion	M฿	1,812.4	1,085.8	727.4
g. L/C Portion	M฿	2,100.2	2,009.0	1,267.4
10. Hydropower Potential				
a. Intake Level	EL.m	207.9	131.2	98.3
b. Tail Water Level	EL.m	162.5	116.8	91.0
c. Gross Head	m	45.4	14.4	7.3
d. Rate Net Head	m	43.1	12.4	6.1
e. Max. Discharge	m^3/sec	14.2	17.6	3.9
f. Installed Capacity	KW	5,000	1,500	170
g. Energy Production	MWH	13,718	5,289	571
h. Construction Cost	M฿	173	109	60
11. Land Acquisition				
a. Dam	ha	20	10	25
b. Reservoir	Km^2	19.5	68.0	32.0
c. Irrigation Facilities	ha	830	830	550
d. Resettlement Area	ha	60 - (130)	830 - (4,000)	590 - (3,200)
12. Technical Soundness of Dam				
a. Dam Site Embankment Materials		Good Hard Rock	Good but Weathered rock	Poor
b. Foundation Treatment		No Problem	No Problem	Difficult
c. Overall Construction Difficulty		Moderate	Moderate	Difficult
13. Socio-economic Impacts				
a. Foreign Exchange Earning Surplus for Export				
- Paddy	ton	111,000	111,000	44,000
	M฿	1,055.6	1,055.6	418.4
- Mung Bean	ton	1,400	4,300	4,300
	M฿	17.2	52.9	52.9
b. Employment Opportunity		high	rather high	moderate
c. Inland Fishery Potential		low	high	rather high
d. Effect of Flood Control		rather high	high	low

TABLES

Table 3.2.1 METEOROLOGICAL DATA FOR THE PERIOD 1951-1980 AT NAKHON SAWAN

Lat 15-48 N
Long 100-10 E

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (°C)													
Mean	25.6	28.3	30.7	31.9	30.6	29.6	29.0	28.5	28.0	27.9	26.7	25.2	28.5
Mean Max	32.2	34.5	36.7	37.9	36.1	34.5	33.8	33.1	32.2	32.0	31.5	31.1	33.8
Mean Min	17.7	21.0	23.7	25.3	25.1	24.7	24.3	24.1	23.9	23.5	21.0	18.2	22.7
Ext Max	37.0	39.8	41.2	42.5	42.7	41.0	38.9	37.8	36.3	35.9	35.7	35.8	42.7
Ext Min	6.1	12.0	14.2	17.0	20.3	21.4	20.9	20.9	20.4	18.4	11.9	8.2	6.1
Relative Humidity (%)													
Mean	63.0	62.0	61.0	61.0	70.0	74.0	75.0	78.0	82.0	80.0	73.0	67.0	70.0
Mean Max	87.3	86.9	87.3	86.5	89.1	90.5	91.5	92.9	95.5	94.7	92.4	89.9	90.4
Mean Min	41.3	40.3	39.1	40.8	51.2	56.6	58.4	62.0	66.4	63.3	53.9	45.9	51.6
Dew-Point (°C)													
Mean	17.1	19.3	21.2	22.7	23.8	23.9	23.8	24.0	24.4	23.7	20.8	17.9	21.9
Evaporation (mm)													
Mean - Pan	150.6	174.9	232.8	260.3	218.9	184.1	174.3	153.2	127.7	138.8	132.8	140.5	2088.9
Wind (knots)													
Previaling wind	E	S	S	S	S	S	S	S	S	S	E	N	-
Mean wind speed	3.7	4.8	6.3	6.4	5.4	5.5	5.0	4.4	3.2	3.0	3.4	3.5	-
Max wind speed	33NE	58S	62N	60N	70S	50S	52S	45SSW	65N	54NE	27NW	27E	70S
Sunshine Duration (hr)													
Mean	264.1	242.9	249.0	259.2	243.0	186.2	174.2	169.0	158.7	228.6	256.8	275.5	2707.2
Cloundiness (0-8)													
Mean	3.0	3.3	3.3	4.0	5.6	6.4	6.7	6.9	6.6	5.4	4.2	3.4	4.9

Table 3.2.2 METEOROLOGICAL DATA AT CT5-A , CT-7 and CT-9

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (° C)													
Mean													
CT-5A(1969～1983)	20.6	22.3	24.9	27.0	26.9	26.1	26.3	25.9	25.5	24.8	22.9	21.0	24.5
CT-7 (1975～1983)	21.5	24.3	27.8	29.0	30.3	28.0	27.8	27.3	26.9	25.6	22.7	20.8	26.0
CT-9 (1977～1983)	22.1	24.2	26.4	29.1	28.3	27.5	27.5	27.1	26.4	24.9	23.3	21.2	25.7
Wind (km/hr)													
Mean Wind Speed													
CT-5A(1973～1983)	1.08	1.46	1.67	2.00	1.91	1.43	1.30	1.06	0.98	0.90	0.83	0.96	1.30
CT-7 (1975～1983)	0.75	0.87	1.44	1.74	1.95	1.12	1.32	1.21	0.79	0.58	0.55	0.62	1.08
CT-9 (1977～1983)	0.97	1.37	1.85	2.11	2.60	1.51	1.93	2.01	1.15	0.85	0.79	0.91	1.50
Evaporation (mm)													
Mean - Pan													
CT-5A(1973～1983)	83.7	89.5	117.3	130.8	120.3	93.4	91.8	75.4	80.7	79.8	75.6	79.2	1,117.5
CT-7 (1975～1983)	77.8	89.0	120.8	136.4	127.9	107.8	122.1	103.5	91.8	88.2	76.6	73.8	1,215.7
CT-9 (1977～1983)	80.1	90.9	124.4	131.9	136.8	90.3	95.6	84.8	70.4	67.5	65.1	74.1	1,111.9

Table 3.2.3 (1) MONTHLY RUNOFF RECORD AT CT-5A, D.A. 936 km^2

(Unit : cum/s)

Water Year	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1969	14.89	20.86	45.02	60.82	246.08	760.50	591.00	670.28	117.26	46.59	19.89	14.86	2,608.05
1970	17.34	158.05	285.05	124.53	499.04	574.74	1456.00	666.84	608.41	137.32	61.96	40.48	4,629.76
1971	34.08	98.05	148.21	207.80	352.89	746.68	1181.60	547.60	126.33	70.24	35.09	26.02	3,574.59
1972	13.24	9.20	8.68	45.90	63.14	781.05	1683.00	942.69	509.24	165.29	74.70	63.84	4,359.97
1973	34.80	39.64	364.32	218.88	203.14	867.94	1390.00	461.88	214.60	120.38	69.56	61.98	4,101.12
1974	122.42	143.90	101.07	96.32	345.96	186.33	2406.00	1081.00	216.98	190.10	90.22	58.08	6,714.35
1975	44.04	169.93	253.98	150.93	163.88	861.00	1440.00	645.00	222.88	121.40	61.87	46.72	4,181.63
1976	32.70	177.42	51.17	56.75	249.63	955.00	1038.00	1167.89	120.06	60.56	24.29	15.09	3,948.56
1977	25.58	48.77	21.42	37.76	63.17	302.74	286.88	102.06	37.98	21.34	15.40	15.80	978.90
1978	15.45	94.83	68.46	389.37	288.42	973.82	1729.82	255.98	98.09	48.01	20.59	13.84	3,966.68
1979	16.05	54.93	311.04	77.99	85.51	1119.71	601.80	92.87	42.70	25.05	13.60	8.00	2,449.25
1980	14.20	831.37	-	251.90	290.65	945.00	2386.59	329.80	101.45	59.70	43.75	36.75	-
1981	53.15	170.95	218.10	203.10	301.40	639.40	1044.25	-	266.95	69.85	32.10	23.60	-
1982	25.28	104.10	178.69	148.64	199.05	292.00	669.90	158.94	85.75	59.05	40.79	38.67	2,000.86
Mean	33.02	155.43	158.09	147.91	239.43	834.49	1278.92	545.60	197.76	85.35	43.13	33.12	3,626.14

Note: - : Missing Data

Table 3.2.3 (2) MONTHLY RUNOFF RECORD AT CT-7 AND CT-9

CT-7 D.A. 403 km^2

(Unit : cum/s)

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1975	6.58	13.85	34.89	39.51	47.48	234.78	625.84	250.63	34.39	13.40	6.67	3.82	1,311.84
1976	1.76	15.12	2.99	2.13	11.10	328.12	193.43	240.16	6.33	2.31	0.78	0.04	804.27
1977	2.81	3.32	2.91	0.39	0	6.45	13.09	7.94	2.40	0.18	0	0	39.49
1978	0	75.81	32.30	141.15	30.22	208.48	826.36	57.54	16.24	7.30	3.42	0.28	1,399.11
1979	0	2.44	241.64	1.24	0.89	1157.91	149.64	27.71	15.78	10.59	7.81	8.41	1,624.06
1980	0	68.32	262.51	208.27	116.70	439.05	1072.66	182.85	62.19	40.50	29.97	28.44	2,511.46
1981	4.25	58.65	43.50	107.55	53.35	189.25	336.22	-	124.95	66.20	43.40	39.30	-
1982	1.73	12.87	41.40	12.38	10.55	27.45	194.80	62.08	35.76	12.83	4.82	1.11	417.78
Mean	2.14	31.30	82.77	64.08	33.79	323.94	426.51	118.42	37.26	19.16	12.11	10.18	1,158.29

CT-9 D.A. 541km^2

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1977	8.11	10.24	6.81	6.40	9.03	40.54	67.28	19.50	6.84	4.33	4.10	3.56	186.74
1978	3.14	74.87	62.50	266.18	73.89	245.85	459.16	68.14	21.98	9.24	5.46	3.38	1293.79
1979	5.01	7.40	44.04	21.80	13.00	209.29	95.51	12.09	4.88	3.03	2.47	2.17	420.69
1980	2.10	133.62	394.79	73.50	97.73	271.99	1094.46	177.39	43.25	20.62	11.91	12.50	2333.86
1981	6.19	42.38	57.02	65.22	32.61	315.28	480.81	1237.77	169.38	61.38	29.89	25.75	2523.68
1982	17.67	32.64	44.50	20.22	20.24	51.11	261.63	100.04	35.99	18.80	10.53	7.17	620.54
Mean	7.03	50.19	101.61	75.55	41.08	189.01	409.81	269.16	47.05	19.57	10.73	9.09	1229.88

Note :- Missing Data

Table 3.2.4 RESULTS OF WATER QUALITY ANALIYSIS

Sample No.	Location	Date	B	NO_2	PH	EC×10^6 at 25°C	Irrigation	Milliequivalent per litre (Lower figure in ppm)									SSP	SAR	RSC	Fe (Iron)	
			ppm	ppm			class	Ca	Mg	Na	K	CO_3	HCO_3	CI	SO_4	NO_3			meg./l	Total	Dissolved
1	Upper Mae Wong Dam	17,12 1984	0	0	7,9	79	C1 - S1	0.41 8	0.09 1	0.25 6	<0.01 < 1	0	0.75 46	0.07 2	0.02 1	<0.01 0.24	33	0.5	0.25	< 0.01 0.05	0 0
2	Lower Mae Wong Dam	〃	0	0	7.7	100	C1 - S1	0.43 9	0.21 2	0.29 7	0.01 < 1	0	0.91 55	0.05 2	0.03 1	0.01 0.38	31	0.5	0.27	0.02 0.30	< 0.01 0.05
3	Khlong Pho Dam	〃	0	0.77	7.7	260	C2 - S1	1.19 24	0.57 7	0.80 18	0.10 4	0	2.41 147	0.12 4	0.09 4	<0.01 0.24	31	0.8	0.65	0.02 0.40	0 0
4	Upper Huai Rang Dam	〃	0	0.02	7.4	70	C1 - S1	0.16 3	0.06 1	0.40 9	0.04 2	0	0.52 32	0.08 3	0.08 4	0.01 0.40	64	1.2	0.30	0.02 0.30	0.01 0.15
5	Lower Huai Rang Dam	〃	0	0.01	7.7	75	C1 - S1	0.21 4	0.09 1	0.45 10	0.06 2	0	0.64 39	0.08 3	0.03 1	0.01 0.41	60	1.2	0.34	0.02 0.45	0.01 0.25
6	Upper Khun Keaw Dam	〃	0	0	7.5	55	C1 - S1	0.15 3	0.04 < 1	0.40 9	0.04 2	0	0.48 29	0.07 2	0.03 1	<0.01 0.14	68	1.3	0.29	< 0.01 0.05	0 0
7	Lower Khun Keaw Dam	〃	0	0.01	7.5	140	C1 - S1	0.56 11	0.40 5	0.40 9	0.04 2	0	1.32 80	0.07 2	0.02 1	0.01 0.62	29	0.6	0.36	0.04 0.80	0.02 0.40
8	Changwat NakhonSawan	〃	0	0.01	7.1	170	C1 - S1	0.62 12	0,39 5	0.68 16	0.08 3	0	1.70 104	0.12 4	0.03 1	<0.01 0.17	40	1.0	0.69	0.03 0.50	< 0.01 0.05
9	Sawang Arom	〃	0	0.01	7.5	160	C1 - S1	0.60 12	0.32 4	0.70 16	0.15 6	0	1.38 84	0.23 8	0.06 3	<0.01 0.18	43	1.0	0.46	0.03 0.50	< 0.01 0.10
10	Nong Chang	〃	0	0.27	7.2	170	C1 - S1	0.58 12	0.39 5	0.83 19	0.08 3	0	1.61 98	0.10 3	0.06 3	0.01 0.54	46	1.2	0.64	0.04 0.80	0.02 0.40

Table 3.2.5 CHRONOLOGY

Symbol	Era	Period	Epoch/Series	Name	Remarks
Q	Cenozeic	Quaternary	Recent	Alluvial	flood plain alluvials, sand, silts develops at along rivers and back swamp
Q1			Pleistocen	Diluvial	old flood deposits of gravel, sand, silt and laterite
	(Unconformity)				
Gr				Igneous Rocks	granite, grano-diorite, diorite & quartz
rh	Mesozoic				rhyolite, andesite
Mz		Jurassic	Khao Chonkan Formation		mainly red sand stone, shales, minor conglomerates and volcanic conglome
	(Unconformity)				
P		Permian	Ratbri Group		massive, grey limestones with fusulinids, minor shale, chert and conglomerate
C	Paleozoic	Caboniferous	Takli Sand Stones		intercalation of red shale sandstone, quartz sand stone; intersified conglomerates and reddish grey shale and sandstone
			(Unconformity)		
SDc		Devorian	Kao Gob cherts		mainly chertbeds and thinly interbedded tuff and shale
SDm		Silurian	Kao Mano Marble		mainly grey to white, massive to poorly beeded marble
SDt			Kao Luang Tuff		mainly quartz, fields pathic tuff, green schist and greywake
SD					undifferentiated sequences of quartzite, phyllite; greywake chert bed and local conglomerates
			(Unconformity)		
O		Ordovician	Thung Song Group		
Eo		Canbro-Ordovician	Phubon Marble		micaschist, contorted marble and minor calc-silicate rock
E		Cambrian	Huai Wai Quartz		quartzite, phyllite and quartz biotite schist
			(Unconformity)		
Pe	Proterzoic	Precambrian	Uthai Thani Complexes		

TABLE 3.2.6 SPECIFICATION FOR SEMI-DETAILED LAND CLASSIFICATION

Classification Characteristics	Upland			Rice-Land		
	U1	U2	U3	R1	R2	R3
SOIL						
Soil texture	SL-fri. CL	LS-p. C LS<30 cm	LS-sp. C LS<60 cm	CL-vsp. C CL<30 cm	SL-VSP. C SL<15 cm L < 30 cm CL>30 cm	LS-vsp. C LS<15 cm
Depth of soil	150 cm	120 cm	90 cm	90 cm	60 cm	30 cm
pH (paste)	5.5 - 8.0	5.0 - 8.5	4.5 - 8.5	5.0 - 8.0	4.5 - 8.5	4.0 - 8.5
Salinity $EC_e \times 10^3$	<4	<6	<8	<4	<6	<8
Exchangeable sodium meq/100 gm	<2	<2	<3	<3	<4	<4
Water-holding capacity in 120 cm depth	15 cm	11 cm	8 cm	Not applicable	Not applicable	Not applicable
TOPOGRAPHY						
Relief	Smooth	Uneven	Rough	Smooth	Uneven	Rough
Slope	<2%	<4%	<6%	<2%	<4%	>4%
Leveling requirement	Low	Medium	High	Low	Low	Medium
Gravel or rock	Few	Few	Some but tillable	Few	Few	Some but tillable
Rock removal	None	None	Some	None	None	Some
Trees or brush cover	Slight clearing	Moderate clearing	Heavy clearing	Slight clearing	Moderate clearing	Heavy clearing
DRAINAGE						
Surface	Good	Good-fair	Fair-poor	Good	Good-fair	Fair-poor
Sub-surface	Good	Good-fair	Fair-poor	Poor	Good-fair	Good
Flood	None	None	Occasional	Infrequent damaging floods	Periodic damaging floods	Annual damaging floods

Class 6: Non-arable lands - includes all lands which do not meet the minimal requirements for class 1, 2 and 3.

Table 3.2.7 RESULTS OF LAND CLASSIFICATION

(Unit: km^2)

Land Class Group	Land Classe	Sub-basin											
		Mae Wong		Khlong Pho		Thap Salao		Khok Khwai		Sakae Krang		Total	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
R1	U3sd/R1	74	3.4	41	3.4	154	12.3	-	-	39	7.0	308	4.9
R2	U3sd/R2s	292	13.5	132	10.9	48	3.8	54	4.9	204	36.5	730	11.6
U2/R2	U2sd/R2s	67	3.1	13	1.1	32	2.6	70	6.3	17	3.1	199	3.2
	U2s/R2s	51	2.3	26	2.1	70	5.6	30	2.7	95	17.1	272	4.3
U1	U1/R2s	-	-	-	-	-	-	76	6.9	-	-	76	1.2
U2	U2s/R3s	247	11.4	161	13.3	151	12.1	145	13.1	12	2.2	716	11.4
U3/R3	U3st/R3st	802	36.9	637	52.6	297	23.7	407	36.7	101	18.1	2,244	35.6
6		638	29.4	201	16.6	501	39.9	326	29.4	89	16.0	1,755	27.8
Total		2,171	100.0	1,211	100.0	1,253	100.0	1,108	100.0	557	100.0	6,300	100.0

Table 3.3.1 NUMBER OF FARM HOUSEHOLDS BY SIZE OF HOLDING (ESTIMATE)

Province & district	Number of Holding	Size of Holding (Rai) Under 2	2 ~ 5.9	6 ~ 14.9	15 ~ 24.9	25 ~ 39.9	40 ~ 59.9	60 ~ 99.9	100 ~ 139.9	140 and Over
Uthai Thani	(29,057)									
(1) Uthai Thani	3,255	13	146	342	641	1,110	656	277	49	21
(2) Thap Than	4,669	19	210	490	920	1,592	943	397	70	28
(3) Swang Arom	3,573	14	161	375	704	1,218	722	304	54	21
(4) Nong Khayyang	2,137	9	96	224	421	729	432	182	32	12
(5) Nong Chang	5,094	20	229	535	1,004	1,737	1,029	433	76	31
(6) Ban Rai	2,322	9	104	244	457	792	469	197	35	15
Nakhon Sawan	(90,598)									
Lat Yao	21,152	85	1,354	2,686	3,744	5,161	4,167	2,961	698	296
Khampheng Phet	(57,533)									
(1) Khanu Waralaksaburi	797	2	45	125	170	209	145	78	15	8
(2) Khong Khlung	144	-	8	22	31	38	26	14	3	2
Chai Nat	(36,018)									
Wat Sing	653	1	69	147	148	150	86	40	9	3
T o t a l	43,766 100.0%	172 0.4	2,422 5.5	5,190 11.9	8,240 18.8	12,736 29.1	8,657 19.8	4,883 11.1	1,041 2.4	437 1.0

Source: 1978 Agricultural Census Report. Office of Prime Minister
Population & Housing Census 1980. Office of Prime Minister

Table 3.6.1 SUMMARY OF PROJECT DIMENSION FOR SELECTION OF HIGH PRIORITY PROJECTS

Item		Mae Wong River		Khlong	Thap Salao River		Khok Khwai River	
		Upper	Lower	Pho	Thap Salao	Huai Rang	Upper Khun Kaew	Lower Khun Kaew
1. Watershed								
Drainage Area	km^2	612	930	394	534	76	162	219
Ave. Ann, Inflow	MCM	193	294	80	125	18	38	51
Ave. Ann. Rainfall	mm	1,293	1,293	1,284	1,347	1,347	1,347	1,347
2. Reservoir								
Effective Storage	MCM	230	350	96	160	18	38	51
Dead Storage	MCM	20	30	14	8	3	6	8
Total Storage	MCM	250	380	110	168	21	44	59
Reservoir Area								
Full Storage	km^2	17.0	54.0	30.0	18.2	2.0	2.0	6.7
High Water	km^2	19.5	68.0	32.0	20.3	2.2	2.2	7.3
3. Dam								
Type		RF	ZEF	EF	EF	ZEF	RF	EF
Height	m	62.0	38.1	20.9	28.2	30.5	49.5	32.0
Crest Length	m	780	240	1,555	4,270	1,470	570	2,500
Embankment	MCM	3.40	0.38	0.74	5.1	0.83	1.32	2.06
Design Flood	cum/s	1,770	2,600	1,190	952	260	530	690
4. Irrigation Area								
Existing Area 1/	ha	36,800	36,800	10,600 3/	25,900	25,900	10,300	10,300
Irrigated Area 2/	ha	23,600	23,600	7,000	13,100	13,100	8,300	8,300
Irrigated Area	ha	49,000	53,500	25,000	23,500	2,000	13,000	14,900
5. Reservoir Operation	(Annual Mean)							
Evapo. Loss	MCM/yr	12	37	25	13	1	2	6
Spillout	MCM/yr	30	16	19	2	5	12	12

1/ Estimated from water balance for the present condition.
2/ Estimated from water balance for with-project condition of wet season paddy.
3/ Include the Wang Rom Klao fo 2,000 ha.

TABLE 4.5.1 INCREMENTAL CROP PRODUCTION

		Without Project			With Project			Increment
Projects	Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production (ton)	Cultivated Area (ha)	Unit Yield (ton/ha)	Production (ton)	Production (ton)
Upper Mae Wong								
	Paddy							
	-West Season							
	irrigated	23,600	2.5	59,000	47,800	4.25	203,150	107,940
	semi-irrigated	13,200	1.6	21,120	-	-	-	-
	rainfed	11,000	1.2	13,200	-	-	-	-
	-Dry Season	510	3.7	1,890	-	-	-	-
	Total	48,310	1.97	95,210	47,800	4.25	203,150	107,940
	Mung Beans	1,530	0.6	920	2,390	1.20	2,870	1,950
Lower Mae Wong								
	Paddy							
	-West Season							
	irrigated	23,600	2.5	59,000	47,800	4.25	203,150	107,940
	semi-irrigated	13,200	1.6	21,120	-	-	-	-
	rainfed	11,000	1.2	13,200	-	-	-	-
	-Dry Season	510	3.7	1,890	-	-	-	-
	Total	48,310	1.97	95,210	47,800	4.25	203,150	107,940
	Mung Beans	1,530	0.6	920	7,170	1.20	8,600	7,680
Khlong Pho								
	Paddy							
	-West season							
	irrigated	8,900	2.5	22,250	17,900	4.25	76,080	41,650
	semi-irrigated	1,700	1.6	2,720	-	-	-	-
	rainfed	7,300	1.2	8,760	-	-	-	-
	-Dry Season	190	3.7	700	-	-	-	-
	Total	18,090	1.97	34,430	17,900	4.25	76,080	41,650
	Mung Beans	570	0.6	340	7,160	1.20	8,590	8,250

Table 4.5.2 ECONOMIC PRICE OF PADDY AND MUNGBEANS

Item	Paddy		Mung beans	
	฿/ton	Balance	฿/ton	Balance
FOB Bangkok	9,150 /1		12,300 /2	
Storage Loss	450	8,700	850	11,450
Warehouse Cost	60	8,640	60	11,390
Transportation Cost (Nakhon Sawan-Bangkok)	320	8,320	350	11,040
Milling Charge	200	8,120	1,530 /3	9,510
Ex-mill price of rice	8,120		-	
Price of Paddy at Mill	5,280		-	
Local Storage Loss	-		700	8,810
Local Transportation Cost	80	5,200	85	8,725
Farm-gate Price	5,200		8,725 ≑ 8,700	

/1 : Price in 1990 forecasted by IBRD, "Price Prospects for Major Primary Commodities", Dec. 1983.

/2 : Price in 1990 forcasted by using the export prices at Bangkok in the past and adjusted by using international market price index by IBRD, Dec. 1983.

/3 : Including cost of bags.

Table 4.5.3 CROP PRODUCTION COST UNDER "WITHOUT PROJECT" CONDITION

(UNIT: BAHT/HA)

Items	Unit Price	Wet Season Paddy						Dry Season Paddy		Mungbeans	
		Rain-fed		Semi-Irrigated		Irrigated					
	(Economic)	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Farm Input											
1. Seed - Local Variety (Paddy)	5.7/kg	35 kg	199.5	35 kg	199.5	18 kg	102.6	-		-	-
- High Yield Variety (Paddy)	6.3/kg	-	-	-	-	17 kg	107.1	35 kg	220.5	-	-
- Mungbeans	8.7/kg	-	-	-	-	-	-	-		40 kg	348.0
2. Fertilizer											
- Urea	8.8/kg	-	-	-	-	24 kg	211.2	60 kg	528.0	-	-
- Compound fertilizer	10.3/kg	-	-	48 kg	494.4	48 kg	494.4	100 kg	1,030.0	-	-
3. Agro-chemical											
- Insecticides	264/ℓ	-	-	-	-	0.21 ℓ	52.0	1 ℓ	264.0	-	-
- Fungicides	220/ℓ	-	-	-	-	-	-	0.4 ℓ	88.0	-	-
4. Land Preparation											
- Hand Tractor	84/day	6.25 day	525.0	6.25 day	525.0	6.25 day	525.0	6.25 day	525.0	6.25 day	525.0
5. Thresing-Machine	84/day	1.6 day	134.0	1.8 day	151.0	2.0 day	168.0	2.2 day	184.0	-	-
(A) Sub-Total			859		1,370		1,661		2,840		873
Labour Requirement											
1. Nursery Preparation	40/day	1.5 day	60.0	1.5 day	60.0	1.5 day	60.0	1.5 day	60.0	-	-
2. Land Preparation	40/day	6.25 day	250.0	6.25 day	250.0	6.25 day	250.0	6.25 day	250.0	6.25 day	250.0
3. Transplanting or Sowing	40/day	20.0 day	800.0	22.0 day	880.0	22.0 day	880.0	22.0 day	880.0	1.5 day	60.0
4. Weeding	40/day	-	-	-	-	2.0 day	80.0	2.0 day	80.0	-	-
5. Fertilizer Application	30/day	-	-	1.5 day	45.0	2.0 day	60.0	3.0 day	90.0	-	-
6. Chemical Application	40/day	-	-	-	-	1.0 day	40.0	1.5 day	60.0	-	-
7. Harvesting	40/day	18.0 day	720.0	20.0 day	800.0	21.0 day	880.0	22.0 day	880.0	1.5 day	600.0
8. Thresing, drying & winnowing	30/day	8.0 day	240.0	9.0 day	270.0	10.0 day	300.0	14.0 day	420.0	7 day	210.0
9. Water management	30/day	-	-	1.0 day	30.0	3.0 day	90.0	3.0 day	90.0	-	-
(B) Sub-Total		53.75 day	2,070	61.25 day	2,335	70.75 day	2,640	71.25 day	2,810	29.75 day	1,120
Miscellaneous Cost	8% of (A+B)		231		295		344		460		197
Grand-Total			3,160		4,000		4,645		6,110		2,190

Table 4.5.4 CROP PRODUCTION COST UNDER "WITH PROJECT" CONDITION

(UNIT: BAHT/HA)

Items	Unit Price (Economic)	Paddy		Mungbeans	
		Quantity	Value	Quantity	Value
Farm Input					
1. Seed - Local Variety (Paddy)	5.7/kg	18 kg	102.6	-	-
- High Yield Variety (Paddy)	6.3/kg	17 kg	107.1	-	-
- Mungbeans	8.7/kg	-	-	40 kg	348.0
2. Fertilizer					
- Urea	8.8/kg	60 kg	528.0		
- Compound fertilizer	10.3/kg	120 kg	1,236.0	62.5 kg	643.8
3. Agro-chemical					
- Insecticides	264/ℓ	1 ℓ	264.0	1.2 ℓ	316.8
- Fungicides	220/ℓ	0.5 ℓ	110.0	0.5 ℓ	110.0
4. Land Preparation					
- Hand Tractor	84/day	6.25 day	525.0	6.25 day	525.0
5. Thresing-Machine	84/day	3.0 day	252.0	-	-
(A) Sub-Total			3,125		1,944
Labour Requirement					
1. Nursery Preparation	40/day	1.5 day	60.0	-	
2. Land Preparation	40/day	6.25 day	250.0	6.25 day	250.0
3. Transplanting or Sowing	40/day	22.0 day	880.0	1.5 day	60.0
4. Weeding	40/day	2.0 day	80.0	6.25 day	250.0
5. Fertilizer Application	30/day	3.0 day	90.0	0.6 day	18.0
6. Chemical Application	40/day	2.0 day	80.0	1.5 day	60.0
7. Harresting	40/day	23.0 day	920.0	17.0 day	680.0
8. Threshing, drying & winnowing	30/day	15.0 day	450.0	9.0 day	270.0
9. Water management	30/day	3.0 day	90.0	1.0 day	30.0
(B) Sub-Total		77.75 day	2,900	43.1 day	1,618
Miscellaneous Cost	8% of (A+B)		485		358
Grand-Total			6,510		3,920

Table 4.5.5 (1) GROSS AND NET CROP PRODUCTION VALUES UNDER "WITHOUT PROJECT" CONDITION (1/2)

(1) Existing Irrigation Areas

Project	Crops	Cultivated Area (ha)	Unit Yield (Ton/ha)	Total Production (ton)	Unit Price (฿/ton)	Gross Production Value (฿/Million)	Unit Production Cost (฿/ha)	Total Production Cost (฿/Million)	Net Production Cost (฿/Million)
1. Upper Mae Wong	Wet Season Paddy	36,800	2.2	80,120	5,200	416.6	4,410	162.3	254.3
	irrigated	23,600	2.5	59,000	5,200	306.8	4,640	109.5	197.3
	semi-irrigated	13,200	1.6	21,120	5,200	109.8	4,000	52.8	57.0
	rainfed	-	-	-	-	-	-	-	-
	Dry Season Paddy	510	3.7	1,890	5,200	9.9	6,110	3.1	6.8
	Mung Beans	1,530	0.6	920	8,700	8.0	2,190	3.4	4.6
	Total					434.5		168.8	265.7
2. Lower Mae Wong	Wet Season Paddy	36,800	2.2	80,120	5,200	416.6	4,410	162.3	254.3
	irrigated	23,600	2.5	59,000	5,200	306.8	4,640	109.5	197.3
	semi-irrigated	13,200	1.6	21,120	5,200	109.8	4,000	52.8	57.0
	rainfed	-	-	-	-	-	-	-	-
	Dry Season Paddy	510	3.7	1,890	5,200	9.9	6,110	3.1	6.8
	Mung Beans	1,530	0.6	920	8,700	8.0	2,190	3.4	4.6
	Total					434.5		168.8	265.7
3. Khlong Pho	Wet Season Paddy	10,600	2.4	24,970	5,200	129.9	4,540	48.1	81.8
	irrigated	8,900	2.5	22,250	5,200	115.8	4,640	41.3	74.5
	semi-irrigated	1,700	1.6	2,720	5,200	14.1	4,000	6.8	7.3
	rainfed	-	-	-	-	-	-	-	-
	Dry Season Paddy	190	3.7	700	5,200	3.6	6,100	1.1	2.5
	Mung Beans	570	0.6	340	8,700	3.0	2,190	1.2	1.8
	Total					136.5		50.4	86.1

Table 4.5.5 (2) GROSS AND NET CROP PRODUCTION VALUES UNDER "WITHOUT PROJECT" CONDITION

(1) Existing Irrigation Areas

Project	Crops	Cultivated Area (ha)	Unit Yield (Ton/ha)	Total Production (ton)	Unit Price (₿/ton)	Gross Production Value (₿/Million)	Unit Production Cost (₿/ha)	Total Production Cost (₿/Million	Net Production Cost (₿/Million)
1. Upper Mae Wong	Paddy	36,800	4.25	156,400	5,200	813.3	6,510	239.6	573.7
	Mung Beans (30%)	11,040	1.20	13,250	8,700	115.3	3,920	43.3	72.0
	Total					928.6		282.9	645.7
2. Lower Mae Wong	Paddy	36,800	4.25	156,400	5,200	813.3	6,510	239.6	573.7
	Mung Beans (40%)	14,720	1.20	17,660	8,700	153.6	3,920	75.7	95.9
	Total					966.9		297.3	669.6
3. Khlong Pho	Paddy	10,600	4.25	45,050	5,200	234.3	6,510	69.0	165.3
	Mung Beans (90%)	9,540	1.20	11,450	8,700	99.6	3,920	37.4	62.2
	Total					333.9		106.4	227.5

(2) Potential Maximum Irrigation Areas

Project	Crops	Cultivated Area (ha)	Unit Yield (Ton/ha)	Total Production (ton)	Unit Price (₿/ton)	Gross Production Value (₿/Million)	Unit Production Cost (₿/ha)	Total Production Cost (₿/Million	Net Production Cost (₿/Million)
1. Upper Mae Wong	Paddy	47,800	4.25	203,150	5,200	1,056.4	6,510	311.2	745.2
	Mung Beans (5%)	2,390	1.20	2,870	8,700	25.0	3,920	9.4	15.6
	Total					1,081.4		320.6	760.8
2. Lower Mae Wong	Paddy	47,800	4.25	203,150	5,200	1,056.4	6,510	311.2	745.2
	Mung Beans (15%)	7,170	1.20	8,600	8,700	74.8	3,920	28.1	46.7
	Total					1,131.2		339.3	791.9
3. Khlong Pho	Paddy	17,900	4.25	76,080	5,200	395.6	6,510	116.5	279.1
	Mung Beans (40%)	7,160	1.20	8,590	8,700	74.7	3,920	28.1	46.6
	Total					470.3		144.6	325.7

Table 4.7.1 PRINCIPAL FEATURE OF PROPOSED DAM SCHEMES

Name of Dam		Upper Mae Wong	Lower Mae Wong	Khlong Pho	Lower Huai Rang	Upper Khun Kaew	Lower Khun Kaew
River System		Mae Wong	Mae Wong	Khlong Pho	Huai Rang	Khun Kaew	Khun Kaew
1. Hydrology							
Catchment area	km^2	612	930	394	76	162	219
Annual in flow	$10^6 m^3$	193	294	80	18	38	51
2. Reservoir							
Flood water surface	El.m						
High water surface	El.m	216	136	100	150	177.5	130.5
Low water surface	El.m	189	124	95	141	147	119
Drawdown	m	27	12	5	9	30.5	11.5
Gross storage	$10^6 m^3$	250	380	110	21	44	59
Dead storage	$10^6 m^3$	20	30	14	3	6	8
Active storage	$10^6 m^3$	230	350	96	18	38	51
Surface area	km^2						
3. Dam							
Type		RF	ZEF	EF	ZEF	RF	EF
Crest elevation	El.m	222	143.1	103.9	153.5	181.5	135
Height	m	62	38.1	19.9	30.5	49.5	29
Crest length	m	780	262	1,580	1,470	570	2,500
Volume	$10^6 m^3$	3.4	0.43	0.71	0.83	1.32	2.06
Design flood	m^3/s	1,770	2,600	1,190	260	530	690
4. Power Facilities							
Maximum discharge	m^3/s	14.2	17.6	3.9	0.8	1.6	2.2
Rated net head	m	43.1	12.4	6.1	20.9	31.8	17.7
Installed capacity	kW	5,000	1,500	170	120	360	270
Energy production	MWH	13,718	5,289	571	357	1,072	804
5. * Construction Cost	10^6 ฿	173	109	60	40	49	44
6. * Annual Benefit	10^6 ฿	13.7	5.3	0.6	0.4	1.07	0.8
7. * Annual Cost	10^6 ฿	3.5	2.2	1.2	0.8	1	0.9
8. * B/C Ratio		3.9	2.4	0.5	0.5	1.07	0.9

The items indicated with * are related only to "Power".

RF: Rock fill type
ZEF: Zone type earth fill type
EF: Earth type

Table 5.1.1 SUMMARY OF RESERVOIR AND DAM

Item		Upper Mae Wong	Lower Mae Wong	Khlong Pho
1. Reservoir				
Catchment area	km^2	612	930	394
Effective storage	MCM	230	350	96
Dead storage	MCM	20	30	14
Total storage	MCM	250	380	110
Water level				
Full storage	Elm	216	136	100
High water	Elm	219	140	102
Dead storage	Elm	189	124	95
Reservoir area				
Full storage	km^2	17.0	54.0	30.0
High water	km^2	19.5	68.0	36.0
2. Dam				
Type		RF	ZEF	EF
Height	m	62.0	38.1	20.9
Crest level	Elm	222	143.1	104.9
Foundation level	Elm	160	105	84
Crest length	m	775	225	1,555
Embankment	MCM	3.40	0.38	0.74
3. Spillway				
Design flood	m^3/s	1,770	2,600	1,190
Crest length	m	165	155	200
Total Length	m	525	465	850
4. Diversion tunnel				
Design discharge	m^3/s	700	1,240	10
Tunnel diameter	m	9.0	8.5	1.8
Tunnel length	m	190	831 *	300
5. Intake structure				
Type		DI	DI	DI
Intake discharge	m^3/s	35.0	36.0	10

RF : Rockfill type
ZEF: Zone type earthfill
EF : Earthfill type
DI : Drop Inlet type

* : Right side tunnel 565 m
Left side tunnel 266 m

Table 5.2.1 MAIN FEATURES OF IRRIGATION MODEL AREA

1. Head Works

1.1 Intake Weir

Type of weir	Ogee type
Weir height	4.5 m
Weir length	28.6 m

1.2 Scouring Sluice

Gate type	Slide gate
Size of gate (B x H x No.)	2.0 m x 2.0 m x 2 nos

1.3 Intake Structure

Intake discharge	7.36 m^3/sec
Gate type	Slide gate
Size of gate (B x H x No.)	2.0 m x 1.8 m x 3 nos

2. Irrigation System

Irrigation service area	7,360 ha
Main canal (concrete linning)	12.7 km
Lateral (concrete linning)	52.7 km
Sub-lateral	44.8 km
Related structures	
Turnout with Check	48 nos
Syphon	7 nos
Culvert	24 nos
Side Spillway	2 nos

3. Drainage System

Lateral drain	4 km

Table 5.4.1 SUMMARY OF CONSTRUCTION COST
UPPER MAE WONG PROJECT

(10^6 ฿)

Work Item	Total	Foreign Currency	Local Currency
1. Direct Construction Cost	2,173.2	1,056.6	1,116.6
1.1 Dam Construction	1,147.8	752.9	394.9
1.2 Irrigation Facilities	978.4	303.7	674.7
1.3 Office & Quarters	47.0	-	47.0
2. Resettlement & Compensation	19.7	-	19.7
3. Administration	108.6	-	108.6
4. Engineering Services	257.0	190.0	67.0
Total	2,558.5	1,246.6	1,311.9
5. Physical Contingency	326.0	158.5	167.5
Total	2,884.5	1,405.1	1,479.4
6. Price Contingency	1,028.1	407.3	620.8
Grand Total	3,912.6	1,812.4	2,100.2

Table 5.4.2 SUMMARY OF CONSTRUCTION COST
LOWER MAE WONG PROJECT

(10^6 ฿)

Work Item	Total	Foreign Currency	Local Currency
1. Direct Construction Cost	1,644.9	624.5	1,020.4
1.1 Dam Construction	619.5	320.8	298.7
1.2 Irrigation Facilities	978.4	303.7	674.7
1.3 Office & Quarters	47.0	-	47.0
2. Resettlement & Compensation	144.8	-	144.8
3. Administration	82.2	-	82.2
4. Engineering Services	189.0	138.0	51.0
Total	2,060.9	762.5	1,298.4
5. Physical Contingency	246.8	93.7	153.1
Total	2,307.7	856.2	1,451.5
6. Price Contingency	787.1	229.6	557.5
Grand Total	3,094.8	1,085.8	2,009.0

Table 5.4.3 SUMMARY OF CONSTRUCTION COST
KHLONG PHO PROJECT

(10^6 ฿)

Work Item	Total	Foreign Currency	Local Currency
1. Direct Construction Cost	1,055.5	414.2	641.3
1.1 Dam Construction	567.3	279.6	287.7
1.2 Irrigation Facilities	441.2	134.6	306.6
1.3 Office & Quarters	47.0	-	47.0
2. Resettlement & Compensation	92.2	-	92.2
3. Administration	52.8	-	52.8
4. Engineering Services	123.2	91.1	32.1
Total	1,323.7	505.3	818.4
5. Physical Contingency	158.3	62.1	96.2
Total	1,482.0	567.4	914.6
6. Price Contingency	512.8	160.0	352.8
Grand Total	1,994.8	727.4	1,267.4

Table 5.4.4 ANNUAL DISBURSEMENT SCHEDULE, UPPER MAE WONG

(Unit: 10^6 ฿)

Item	Total		1st Year		2nd Year		3rd Year		4th Year		5th Year		6th Year		7th Year	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
I. Direct Construction Cost																
1. Dam Construction	752.9	394.9	-	-	-	-	37.6	19.7	150.6	79.0	225.9	118.5	225.9	118.5	112.9	59.2
2. Irrigation System	303.7	674.7	-	-	-	-	-	-	45.6	101.3	106.3	236.1	106.3	236.1	45.5	101.2
3. Office & Quarters	-	47.0	-	-	-	47.0	-	-	-	-	-	-	-	-	-	-
Sub-Total	1,056.6	1,116.6	-	-	-	47.0	37.6	19.7	196.2	180.3	332.2	354.6	332.2	354.6	158.4	160.4
II. Resettlement & Compensation	-	19.7	-	-	-	9.9	-	9.8	-	-	-	-	-	-	-	-
III. Administration	-	108.6	-	10.9	-	10.9	-	17.4	-	17.4	-	17.4	-	17.3	-	17.3
IV. Engineering Services	190.0	67.0	33.3	11.7	33.3	11.7	4.4	1.0	22.9	7.3	38.8	14.5	38.8	14.5	18.5	6.3
V. Physical Contingency	158.5	167.5	-	-	-	7.1	5.6	3.0	29.4	27.0	49.8	53.2	49.8	53.2	23.9	24.0
Sub-Total	348.5	362.8	33.3	22.6	33.3	39.6	10.0	31.2	52.3	51.7	88.6	85.1	88.6	85.0	42.4	47.6
Total	1,405.1	1,479.4	33.3	22.6	33.3	86.6	47.6	50.9	248.5	232.0	420.8	439.7	420.8	439.6	200.8	208.0
VI. Price Contingency	407.3	620.8	1.7	1.6	3.4	12.5	7.5	11.5	53.6	72.1	116.3	177.0	143.1	220.1	81.7	126.0
Grand Total	1,812.4	2,100.2	35.0	24.2	36.7	99.1	55.1	62.4	302.1	304.1	537.1	616.7	563.9	659.7	282.5	334.0

Table 5.4.5 ANNUAL DISBURSEMENT SCHEDULE, LOWER MAE WONG

(Unit: 10^6 ฿)

Item	Total		1st Year		2nd Year		3rd Year		4th Year		5th Year		6th Year		7th Year	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
I. Direct Construction Cost																
1. Dam Construction	320.8	298.7	-	-	-	-	112.3	104.5	64.2	59.7	48.1	44.9	48.1	44.8	48.1	44.8
2. Irrigation System	303.7	674.7	-	-	-	-	-	-	45.6	101.3	106.3	236.1	106.3	236.1	45.5	101.2
3. Office & Quarters	-	47.0	-	-	-	47.0	-	-	-	-	-	-	-	-	-	-
Sub-Total	624.5	1,020.4	-	-	-	47.0	112.3	104.5	109.8	161.0	154.4	281.0	154.4	280.9	93.6	146.0
II. Resettlement & Compensation	-	144.8	-	-	-	72.4	-	72.4	-	-	-	-	-	-	-	-
III. Administration	-	82.2	-	8.2	-	8.2	-	13.2	-	13.2	-	13.2	-	13.1	-	13.1
IV. Engineering Services	138.0	51.0	24.2	8.9	24.2	8.9	16.1	3.6	15.8	5.5	22.2	9.6	22.2	9.6	13.3	4.9
V. Physical Contingency	93.7	153.1	-	-	-	7.1	16.8	15.7	16.5	24.2	23.2	42.2	23.2	42.1	14.0	21.8
Sub-Total	231.7	431.1	24.2	17.1	24.2	96.6	32.9	104.9	32.3	42.9	45.4	65.0	45.4	64.8	27.3	39.8
Total	856.2	1,451.5	24.2	17.1	24.2	143.6	145.2	209.4	142.1	203.9	199.8	346.0	199.8	345.7	120.9	185.8
VI. Price Contingency	229.6	557.5	1.2	1.2	2.5	20.8	22.9	47.1	30.6	63.4	55.2	139.3	68.0	173.1	49.2	112.6
Grand Total	1,085.8	2,009.0	25.4	18.3	26.7	164.4	168.1	256.5	172.7	267.3	255.0	485.3	267.8	518.8	170.1	298.4

Table 5.4.6 ANNUAL DISBURSEMENT SCHEDULE, KHLONG PHO

(Unit: 10^6 ฿)

Item	Total		1st Year		2nd Year		3rd Year		4th Year		5th Year		6th Year		7th Year	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
I. Direct Construction Cost																
1. Dam Construction	279.6	287.7	-	-	-	-	28.0	28.8	41.9	43.2	97.9	100.7	83.9	86.3	27.9	28.7
2. Irrigation System	134.6	306.6	-	-	-	-	-	-	20.2	46.0	47.1	107.3	47.1	107.3	20.2	46.0
3. Office & Quarters	-	47.0	-	-	-	47.0	-	-	-	-	-	-	-	-	-	-
Sub-Total	414.2	641.3	-	-	-	47.0	28.0	28.8	62.1	89.2	145.0	208.0	131.0	193.6	48.1	74.7
II. Resettlement & Compensation	-	92.2	-	-	-	46.1	-	46.1	-	-	-	-	-	-	-	-
III. Administration	-	52.8	-	5.3	-	5.3	-	8.4	-	8.4	-	8.4	-	8.5	-	8.5
IV. Engineering Services	91.1	32.1	15.9	5.6	15.9	5.6	4.0	1.0	8.9	3.1	20.8	7.3	18.8	6.8	6.8	2.7
V. Physical Contingency	62.1	96.2	-	-	-	7.1	4.2	4.3	9.3	13.4	21.8	31.2	19.7	29.0	7.1	11.2
Sub-Total	153.2	273.3	15.9	10.9	15.9	64.1	8.2	59.8	18.2	24.9	42.6	46.9	38.5	44.3	13.9	22.4
Total	567.4	914.6	15.9	10.9	15.9	111.1	36.2	88.6	80.3	114.1	187.6	254.9	169.5	237.9	62.0	97.1
VI. Price Contingency	160.0	352.8	0.8	0.8	1.6	16.1	5.7	19.9	17.3	35.5	51.8	102.6	57.6	119.1	25.2	58.8
Grand Total	727.4	1,267.4	16.7	11.7	17.5	127.2	41.9	108.5	97.6	149.6	239.4	357.5	227.1	357.0	87.2	155.9

Table 7.1.1 ENVIRONMENTAL PARAMETERS FOR ANALYSIS OF DAM AND RESERVOIR PROJECTS (INCLUDING IRRIGATION AND HYDROELECTRIC SUB-PROJECTS)

Environmental Resource / Project Component		Physical Resources							Ecological Resources					Human Use Values													Quality of Life Values						
		Surface Water Hydrology	Surface Water Quality	Ground Water Hydrology	Ground Water Quality	Soils	Geology/Seismology	Erosion/Sedimentation	Climate	Fisheries	Aquatic Biology	Terrestrial Wildlife	Forests	Agriculture/Irrigation (if applicable)	Aquaculture	Water Supply	Navigation	Recreation	Power (if applicable)	Flood Control	Dedicated Area Uses	Industry	Agro-Industry	Mineral Development	Highways/Railways	Land Use	Socio-Economic	Resettlement	Cultural/Historical	Aesthetic	Archaeological	Public Health	Nutrition
Dam and	A	3	2	2	1	-	-	3	1	((3))	((3))	((3))	2	(3)	(3)	(3)	(2)	(3)	(3)	(3)	3	-	-	(2)	((2))	3	(3)	3	1	((3))	1	((2))	(3)
Reservoir	B	3	-	3	-	2	3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	3	-	-	-	1	-
Irrigation	A	1	3	2	-	3	-	2	-	(3)	(3)	1	-	(3)	(3)	(3)	-	(1)	-	-	-	(2)	(2)	-	1	3	(3)	-	-	-	-	(2)	(3)
System	B	2	3	3	1	3	3	3	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Hydroelectric Power and	A	-	-	-	-	-	-	1	-	-	-	1	3	1	-	-	-	-	3	-	-	3	2	-	-	3	(3)	-	-	2	-	-	-
Transmission	B	1	-	1	1	2	2	1	-	-	1	1	3	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-

NOTES: (a) (A) means significant impact of project on environmental resources, whereas (B) means impact of the environment on the project.

(b) Numerical value of 3 means probable major impact, 2 means intermediate, and 1 means significant but relatively minor.

(c) Numbers in parentheses indicate effects are mostly enhancement of environmental.
Numbers in double parentheses represent combination of adverse and beneficial effects.
Numbers without parentheses represent either adverse or beneficial effects.

Table 7.3.1 INVENTORY OF COMPENSATION FOR EACH RESERVOIR

No.	Reservoir	Household	Land Ownership	School	Temple
1	Upper Mae Wong	40 (80)	(Sor Tor Kor)	0 (0)	0 (1)
2	Lower Mae Wong	520 (2,460)	Sor Tor Kor	8 (11)	5 (13)
3	Khlong Pho	365 (1,967)	Sor Tor Kor	3 (+)	4 (+)
4	Huai Rang	218 (930)	(Por Bor Tor 5)	(+)	(+)
5	Khun Kaew	105 (83)	(Por Bor Tor 5)	1 (+)	0 (0)

* Data in parethesis were given by local people's interviews.
Other data are official data by responsible agencies.
(+) means more than 1.