資 料

IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

IN

THE KINGDOM OF THAILAND

INTERIM REPORT (2)

(WET SEASON)

ON

MASTER PLAN STUDY FOR THE GREATER MAE KLONG RIVER BASIN DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

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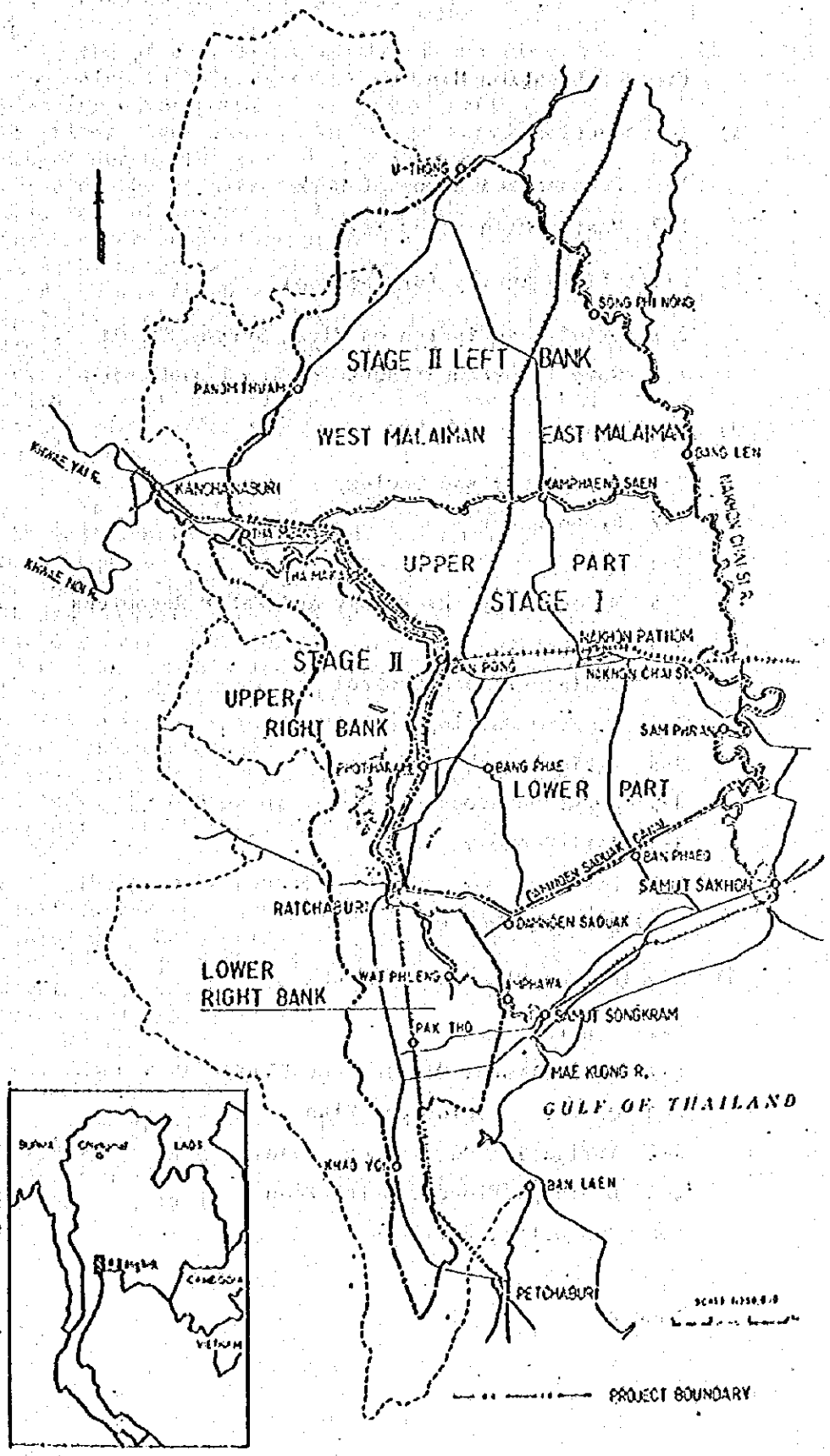
GREATER MAE KLONG PROJECT AREA



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1. INTRODUCTION

1-1. Purpose and Scope of Works

The present study is the second field survey of a series of studies to be undertaken aiming at formulation of a master plan for development of irrigated agriculture in the Greater Mae Klong River Basin. The first survey (dry season) was conducted during the period from December 1977 to March 1978, and based on the results as brought about by the first survey, this term of survey has been carried out mainly for grasping the present conditions prevailing in the area in the wet season on such aspects as agriculture, water resource utilization, land use and fresh water fishery etc. and also for further collection of data/information required for plan formulation. Another emphasis was placed on a preliminary project plan formulation for on-farm dvelopment in the Mae Klong area for which an earlier implementation is expected to realize a higher return from the investment for the irrigation project in the area.

It was on July 25, 1978 that discussions were held on the modification of scope of works for the present master plan study between the representatives from the Government of Thailand and the Government of Japan. As the results, it was mutually agreed upon with the conclusions that the field survey works for the master plan study shall be completed by the end of 1979 and the area covered by the study shall include so called Stage III area located upperstream of Stage I and II and the drainage improvement project area at the south of the Damnoen Saduak Canal. Accordingly, this term of field survey was carried out for the gross acreage of 490,000 ha including 24,000 ha of drainage improvement project area but excluding the Stage III area.

The present report is the result of the said second field survey for fact finding in the wet season and supplemental data collection with placing an emphasis on the preliminary project plan formulation especially for on-farm development which shall be finalized in the succeeding home works in Japan.

1-2. Master Plan Study Team

The study team as dispatched by the Japan International Cooperation Agency consisting of fourteen (14) experts conducted this term of field survey during a period from July 12 to October 15, 1978.

The Supervisory Committee as organized by the Japanese Government for the present master plan study dispatched its members to Thailand for a period July 15 - 25 and October 5 - 14, 1978.

The members of the Supervisory Committee and the Study Team for the master plan study are as shown in Table 1-1.

During the field survey, a close cooperation and various assistances were extended to the Study Team by Mr. Charin Atthayodhin, Deputy Director General, RID, Mr. Chari Tulyanond, Project Manager for the Greater Mae Klong Irrigation Project and many others of the Thai counterparts and of the officials in the project office in Kanchanaburi as listed in Table 1-2 in field trips, data collection and exchanging of opinions and so on. The Fishery Department assigned Mr. Kasemsant Chalayondeja to cooperate with the Fishery Expert of the Study Team, and the Electricity Generating Authority of Thailand (EGAT) extended kind cooperation in furnishing to the Study Team with the various data/information on their hydro-power development on the Khwae Yai and Khwae Noi River basins.

Table 1-1. Supervisory Committee and Study Team

Supervisory Committee

Name		Designation
Kazuya	Nakamura	Member
Takashi	Tauchi	--do--
Hideaki	Sugiura	--do--
Toshio	Yamamoto	--do--
Saburo	Fukuoka	--do--

Study Team

Name		Designation
Ikuzo	Iwamoto	Leader
Osamu	Fukuda	Irrigation
Kunio	Ohta	Drainage/Flood Control
Hideo	Hiratsuka	On-farm Development
Yasuo	Matsubara	Water Resources Development
Haruo	Hiki	Hydrology/Computor
Motoo	Okada	Power Generation
Ryoichi	Kawasaki	Geology/Ground Water
Norio	Koiwa	Soil
Yoshihiro	Takano	Agriculture
Yoshinori	Fujimoto	Sugar Industry
Tetsuo	Dokiya	Rural Development
Kiyoshi	Nemoto	Fishery
Koki	Nakamura	Agro-economy

2. FIRST FIELD SURVEY (Dry Season)

As afore-mentioned, the first field survey was conducted during the period from December 1977 to March 1978, aiming mainly at fact finding on agriculture, water resource utilization and land use etc. in the dry season and collection of basic data/information for plan formulation. As the result, the first Interim Report was prepared with the contents as summarized as follows.

2-1. Brief Description on the First Survey Results

Survey and Mapping

For the master plan study, 1/50,000 topo-maps and 1/250,000 geographic maps as published by the Royal Thai Survey (RTS) shall be used as basic maps. For planning and detailed design on the development of the Mae Klong area, 1/10,000 aero-photo maps (1 m contour interval) and thematic maps with the same scale and contour interval are presently being prepared by RID, though they are available as of date only for the left bank area, Stage II. Another maps available for the master plan study are the 1/100,000 thematic maps with 1 m contour interval which covers the whole Mae Klong Project area.

Topography/Geological Feature

The project area is located at the western end part of the Central Plain, Thailand and topographically can be divided into the following four (4) features.

Old Terrace

An old terrace is found along the western boundary line of the project area with elevations ranging from 40 m to 60 m. Residual hills formed by bedrock are existed in some places.

Residual Hill

Residual hills are found on the old terrace at the western part of the project area as either a single mountain or an isolated mountain block. With smaller scale, residual hills are formed here and there in the fan deposit area.

Fan Deposit

This is the fan-shaped part of the project area which extends from Kanchanaburi, as the rivet of the fan, to downward to east and occupies almost a half of the project area. The land slope is gentle in this fan-shaped area and has the west-east mono-slope. The area along the present river course is formed as a big natural levee.

Alluvial Plain

This is a part of the vast alluvial plain as formed by the Mae Klong and Tha Chin Rivers and so forth. Elevation of the northern part ranges from El. 2 to 4 meter and the one of the southern part from El. 1 to 2 meter, being the semi-recent tidal flat and the recent tidal flat, respectively.

Geologically, the in and around project area can also be divided into four (4) features as same with the topographical features as mentioned above.

- Bedrock: Bedrock is exposed only at a few places as residual hills on the old terrace located at the western part of the project area.

- Terrace deposits: This deposits forms the old terrace at the western part of the project area.

- Fan deposits: This is mainly of river deposits by the Mae Klong river with partial marine deposits.

- Alluvial deposits: This is mainly of marine deposits and composed of sand, silt and clay.

Soil

Though a number of surveys have been carried out on the soil and land classification in the Mae Klong project area by various agencies, the purpose of the surveys conducted and accuracy obtained are rather different each other lacking a uniformed standard of their content.

In 1962, the Ministry of Agriculture initiated a preliminary soil survey in the project area, in which landform of the project area was made with 5 topographical divisions. Major soil series and association in each division were then confirmed. Topographical divisioning as applied in this survey has been used for the various surveys undertaken thereafter. In 1963-1964, a reconnaissance level soil map was prepared by RID for the Stage II area. A detailed reconnaissance soil survey covering the southern part of the Central Plain was carried out jointly by the Land Development Department and FAO/UNDP, but the 1/100,000 soil map prepared does not cover the whole Mae Klong Project area. Further later in 1977, a soil map covering almost all of the project area was prepared as the result of the Mae Klong Integrated Rural Development Program by three (3) Universities of Kasetsart, Thammasat and Mahidol.

In this master plan study, therefore, additional soil survey data on the surrounding parts are to be put on the soil maps as prepared by three (3) Universities so as to cover the whole Mae Klong Project area.

Concerning with land classification, RID prepared a map for Stage II area in 1968 and for Stage I in 1974. Judging from the presently available soil survey results, the classification method by the Land Development Department seems to be in accordance with the one recommended by USDA and FAO and the method of RID is in accordance with the procedure recommended by U.S. Bureau of Reclamation.

Hydrology

The climate in Thailand is classified into the following four (4) seasons from the hydrological point of view:

i) The south-west monsoon season (Rainy Season)
May - October

ii) The retreating south-west monsoon season
(Transition Period)
October - November

iii) The north-east monsoon season (Cold Season)
November - February

iv) The retreating north-eash monsoon season
(Transition Period/hot Season)
March - May

In the Mae Klong River Basin, there is a little rainfall during the period from November to March and called as dry season.

Based on the data (1962) furnished by RID, hydrological features in the Mae Klong River Basin are as summarized below:

Drainage Area

1. Total Drainage Area	27,660 sq.Km
2. Drainage Area of Khwae Noi	10,640 "
3. Drainage Area of Khwae Yai	14,810 "
4. Drainage Area upstream Vajiralongkorn	25,660 "

Rivers

1. Total length of the Mae Klong	510 Km
2. River slope of the Mae Klong	
Kanchanaburi - Tha Maka	1 : 5,000
Tha Maka - Gulf	1 : 7,250

Precipitation

1. Above Kanchanaburi	1,000-1,600 mm
2. Project area	900-1,200 mm

Runoff

1. Annual runoff at Vajiralongkorn Dam	12,900 mil.cu.m/s
2. Annual peak flow at Vajiralongkorn Dam	2,400 cu.m/s
3. Maximum recorded flood (1953)	6,000 cu.m/s
4. 100-year flood	7,000 cu.m/s
5. Annual mean flow	410 cu.m/s
6. Runoff yield	15.9 l/sec./sq.Km
7. Average minimum dry season flow	50 cu.m/s
8. Extreme lowest flow	29 cu.m/s

Agriculture

Of the total cultivated land in the area, about 60% is planted to rice, 30% to upland crops and 10% to vegetables and fruit trees. In paddy rice cultivation, broadcasting is more predominant sharing 56% out of the total acreage planted to rice. While transplanting of rice is only for 37% in the wet season and 7% in the dry season. Averaged yields are estimated at about 2.1 ton/ha, 2.4 ton/ha and 2.8 ton/ha, respectively.

Broadcasting rice is the most extensive rice cultivation method being practised in the low-land area where inundation is comparatively deeper. For transplanting rice in the wet season, local sensitive variety is used in a rather extensive cultivation method, while the non-sensitive high-yielding varieties are planted in the dry season transplanting rice. In case of dry season transplanting rice, irrigation is practised by individual farmer by using pumps from the neighboring river, canal and swamp and transplanting is on March/April and harvesting is on June/July.

Sugarcane field is concentratedly located in the Stage I upper part and the west part of the Stage II left bank, totally occupying about 120,000 ha. The averaged sugarcane yield in Thailand is about 49 ton/ha, while in the Mae Klong area, the averaged yield is a little higher at 52 ton/ha. There are 17 sugarcane factories in the project area and another one is under construction. Actual capacity of 17 factories is 116,477 tons cane/day sharing about 60% of the total capacity in the country. Under the International Sugar Agreement, Thailand is allocated for 1.2 million tons quota for export, but it was only 1,02 million tons this year due to the price descalation as caused by international over-production.

In the area, beans, corn and sweet potato etc. are cultivated as upland crops. While in the flat low-land areas, small polders are constructed and vegetables and fruit trees are grown on high furrowed land in the polder dikes. Farm management is so intensive using considerable amount of fertilizer and insecticides/pesticides.

Irrigation

The Greater Mae Klong Irrigation Project is being implemented under the pashing into the Stage I and Stage II. To date, the Vajiralongkorn Diversion Dam and irrigation systems for the Stage I area have been completed and supplementary irrigation water in the wet season is supplied for the area. As to the Stage II area, construction works of the irrigation systems for the right bank area is on-going and water supply is partially practised. For the Stage II left bank area, design works are currently being undertaken.

Acreages covered and major facilities under the project are as described below:

- Unit: 1,000 ha -

Stages	Gross area	Irrigable area
Stage I	191.1	161.9
Stage II	275.0	229.4
Total	466.1	391.3

Diversion Dam : The Vajiralongkorn Diversion Dam is so designed that river water be checked up to El. 22.0 meter and divert the maximum discharge of 325.5 cu.m/s. The Dam is equipped with 8 radial gates (w 12.5 m x H 7.5 m) for the design flood discharge of 3,100 cu.m/s with the flood water level at El. 26.0 m.

Main irrigation systems:

Canals	Discharge cu.m/s	Length Km	Width m	Depth m	Slope
Left main	245.0	91.0	28.0	4.0	1/6,000
Right 1R main	66.9	122.9	15.0	3.1	1/10,000
Right 2R main	13.6	72.0	3.5	2.3	1/8,000

Water requirement for each crop is estimated based on the Penman method. Paddy field percolation is estimated at 1.0 mm/day in the dry season and 0.5 mm/day in the wet season as an average in the whole project area. Irrigation efficiency is assumed at 75% at farm level and 80% for conveyance, making the total at 60%. Canal capacity is determined by deducting effective rainfall from the peak water requirement for wet season paddy cropping. That is, a unit requirement of 0.75 l/s/ha is applied for canal designing. For future development and expansion of dry season cropping, therefore, canal capacity will be the critical factor together with the availability of stored water source in the dry season because of no rainfall expected.

Drainage

As to drainage in the project, the whole area can be divided into four (4) parts.

Stage I Upper : Most of this part is composed of fan deposits as developed by the Mae Klong River and has a west-east gentle mono-slope. In the area, drainage improvement works to rehabilitate the natural drains are being undertaken. Among all, 5 drains were formerly utilized for dual purposes of irrigation and drainage before the completion of the Diversion Dam. When the flood discharge of the Mae Klong is happened, these drains are used to divert some of the flood to the Nakhon Chai Si River. The area is inundated when flood discharge of the Mae Klong exceeds 2,500 cu.m/s level.

Stage I Lower : This part is an alluvial flat low-land as formed by the Mae Klong and Tha Chin Rivers. At the southern end, the area is bounded by the Damnoen Saduak Canal. The canal is used for draining out the excess water from the upper area to the Gulf of Thailand and for navigation and also for irrigation water supply for the neighboring areas when needed. When high flood happened in the Mae Klong River, the area is subject to serious inundation, for which a rehabilitation works to improve the drainage is undergoing.

Stage II
Right Bank: In this area, hinter-low-land of the natural levee along the Mae Klong River functions as a natural drainage. A part of flood water as flowed down from the western mountainous area inundates the lower part of the area especially when the Mae Klong River water level is high with flood discharge. When flood water in the Mae Klong River exceeds 3,100 cu.m/s the surplus water flows into this area through the breacking dike located upperstream right bank of the diversion dam. Drainage improvement is currently being undertaken by RID.

Stage II

Left Bank: A part of the discharge from the western mountainous area flows down to the Song Phi Nong River, but the rest flows down from west to east crossing the area and down to the Nakhon Chai Si River. The hinter-low-land of the natural levee along the Nakhon Chai Si functions as a regulating pond and discharge the excess water when the water level is lowered down in the Nakhon Chai Si River.

On-farm development

In the Mae Klong area, on-farm development in the manner of the Ditches and Dykes method has been undertaken for those areas where construction works for main irrigation systems were completed such as the Stage I area and the upper part of the Stage II right bank. As to the constraints on efficient water use at on-farm level, the followings can be pointed out.

a) Insufficient head due to lower situated ditches
b) Improper layout of ditches
c) Irregular ditch section/lack of maintenance
d) Insufficient ditch density
e) Lack of division facilities

Based on the data so far collected in the survey, the ditch density is about 13-14 m/ha, though the densities are 56 m/ha in Sapphaya area and 37.5 m/ha in Baromphart area where on-farm development has been completed. There found O&M roads constructed along main and lateral canals, but there is not farm roads at all to connect crop fields with the O&M roads. Main drainage system is being constructed for the Stage I area and the upper part of the Stage II right bank, however, there is no inclusion of terminal drain ditches to connect with the main systems. Construction of terminal drain facilities is of urgent necessity.

In addition to the above, the following mentioned difficulties are confirmed for water distribution for on-farm level upland field. Therefore, the utilization of irrigation water remains at low level.

a) Upland crop fields are generally situated at higher elevation than paddy fields.
b) Undulating fields
c) Incomplete drainage system
d) Different water use pattern in the paddy-upland crop mixed area
e) Farmers' inexperience in upland crop irrigation practice.

In Thailand, on-farm development projects are implemented in accordance with either the Dykes and Ditches Act or the Agricultural Land Consolidation Act. From the technical aspect, both the so called intensive method and extensive method are applied for. In planning a on-farm development project, careful attention should be paid in determining what method be applied through examining of topographic condition, farming practice, land tenure, fragmentation and economic feasibleness etc.

Some case studies on on-farm development method shall be made for a certain number of sample areas.

Rural Development

The total population in the project area is estimated at about 1,180,000 and the agricultural population at about 754,000 (64%). The density is rather bigger at 154 persons/km^2 compared with the national average of 84 persons/km^2. However, the population growth rate during the previous ten years estimated at 2.1% is rather smaller than the national average of 3.1%. Total household is about 183,000, among which 61% is shared by farming families of 117,000 household. Averaged family size is 6.4 persons and 3.9 persons are accounted for farm man power.

Farmers' group so far organized in the area are as follows:

: Farmers' group under the Department of Agriculture Extension
: Farmers' group under the Department of Cooperatives Promotion
: Farmers' group under BAAC
: Sugarcane Growers' Association
: People's Irrigation Association
: Water User's Association
: Wive's club
: 4 H Club

Agriculture cooperatives are organized under the supervision of the Department of Cooperatives Promotion. At Changwad level, cooperatives federation is organized and operated for cordination of each cooperatives. At national level, the Agriculture Cooperation Federation of Thailand (ACFT) and the Agriculture Cooperatives League of Thailand are formed for further development of cooperative business.

The Regional Office of the Department of Agriculture Extension is established at Ratchaburi and forms the extension system with having such offices in each Changwad and Amphoe. Services cover introducing of new varieties, increased application of fertilizer and pesticides and extension of improved cultivation techniques and so on.

Agricultural Economy

The major industry in the Mae Klong area is agriculture. Economic indicators to show the present conditons of the area can, therefore, be represented by such agricultural aspects.

Occupations related to agriculture are the main occupation of the people having accounted for 57% of the total. Regionally, higher proportion is in the flat lowland along the Nakhon Chai Si River at 82% of agriculture occupation. In general, rice farms are predominant in the area sharing 58% of the total followed by sugarcane farms by 14%. Buffalo and cuttle mostly for drafting purpose are raised only by 36% of total farms. 59% of farm households raise the poultry, but small in scale.

Including the landless farmers in the total farm households, about 60% of fare ownership of their land. In case of excluding the landless farmers, the figure would be 66% of owner farmers. Supposing 11% of the total farm households is landless, it seems necessary to create employment opportunity as much as possible in the rural development program.

In the area, as much as 63% of farm households were indebted in 1973. Farmers tend to get loans more from relatives (32%), merchants (18%) and neighbors (16%), and less from cooperatives (10%) and farmers' groups (13%). This suggests that strengthening of farmers' organization and systemized credit supply are of vital importance.

2-2. Some Important Issues in Plan Formulation (As of the end of the First Field Survey)

Sugarcane Production

Sugarcane production in Thailand has been remarkably increased in recent years. This holds specially true in the Mae Klong area, as the Mae Klong area produces sugarcane almost a half of the total national production. In international market, however, the sugar is suffering from over-production problem, and under the ISA, sugar export is under international control.

As this issue concerning with the sugarcane production in the Mae Klong area is closely related with the development plan formulation in the area, further exchange of opinions and highly political coordination among agencies concerned such as the MOAC and the Ministry of Industry and so on shall be fully secured.

Coordination with Development Plan of EGAT

The EGAT has conceived a power generation development plan as the Khao Laem Project on the upperstream of the Khwae Noi River. This plan has a close relation with the present Mae Klong Irrigation Project, and therefore, further comprehensive coordination with respects to power, irrigation, flood control and so on will be needed. With this concern, full coordination between RID and EGAT is of vital importance.

1/10,000 Topographic Map for Stage I Area

1/10,000 topographic map with 1 m contour interval is one of the most basic data in this master plan study. To avail the said map for plan formulation of on-farm development in the Stage I area, where main irrigation systems were completed, an early completion of mapping is vitally needed.

3. FINDINGS

3-1. Topography and Geology

During this term of field survey, on emphasis was placed on the topographic/geological features in the Khwae Noi River Basin, as the same had been conducted for the project area in the first field survey.

3-1-1. Topographic Features on the Khwae Noi River Basin

The Khwae Noi River as originated from the mountainous area in the Thailand's western border with Burma (N 15°00' E 92°50') goes down south-east-ward and turns to north-east direction at N 13 55' then meets with the Khwae Yai River at Kanchanaburi. The Mae Klong River (downstream Kanchanaburi) runs through the project area to south-east direction and empties into the Gulf of Thailand.

The upper-most basin of the Khwae Noi River is in the area with on extremely high rainfall intensity, having developed major branches of the Khwae Noi in this area. While there found only a few branches in the mid to down stream basins of the river having such branches as Huai Pilok, Huai Mae Nam Nai, Huai Bong Ti and Mae Nam Pachi on the right bank.

The river slope is quite steep at the upperstream basin before flowing into Songkhla Buri. After Thong Phu Phum, the slope becomes more gentle and there found on both banks large-scale river terrace deposits as formed in diluvial and alluvial ages. The present Khwae Noi River flows down through these deposits with a considerable meandering.

While, except these river-side banks as mentioned above, the Khwae Noi River Basin is characterized as Karstic mountainous area with having a number of Karst terraces, Karst towers, sink holes, and Karst springs, some of which are famous for tourists' spots. Furthermore, to show such high Karstic nature of the Basin from the topographical point of view, the existence of so called is pointed out.

3-1-2. Geological Features on the Khwae Noi River Basin

For the area located north of N 14° and east of E 99° in the Basin, a geological survey was conducted and 1/250,000 level geological maps were prepared by the Department of Mineral Resources. For the other part of the Basin, there have been some spot surveys conducted by EGAT or RID on or around their planned dam sites. Based on the said limited survey results and data/information as furnished by the DMR engineers who are concerned with the geological survey in the Basin, geological features in the Basin can be briefly described as follows.

Geologically, the Basin (Khwae Noi-Mae Klong) is composed of Meso-palaeo zoic and/or Protero zoic hard bedrocks, tertiary soft sedimentary rocks and quarternary deposits which covers the former two. Bedrocks include those palaeozoic rocks such as pre-cambrian, cambrian. Ordonision, Denonion, Carboniferous and permian and those granites as derived from Mesozoic. These hard rocks are found in north-west to south-west direction in narrow slope as some with the topographical feature of the Basin.

The tertiary sedimentary rocks are distributed over the comparatively flat topography along several branches of the Khwae Yai and Khwae Noi Rivers. The Quarternary deposits form large-scale river terraces and the vast fan shaped area in the Mae Klong Basin. So far as the Khwae Noi River Basin is concerned, the Permian lime stone (Sai Yok L.S) is most predominant. Considering the Triassic lime stone in the Basin, it can be said that the Khwae Noi River downstream Songkhla Buri flows down through these lime stone area.

3-1-3. Brief Description on Dam Sites so far Proposed

In the Khwae Noi River Basin, there have been a series of investigations on proposed dam sites by RID and EGAT as the Basin is favoured with an abundant water resources for development. These proposed dam sites are from the downstream to upperstream, Khao Kwang, Ban Phu Toei, Ban Soi Yok, Khao Laem and Bi Khi on the Khwae Noi main stream and Lam Pachi on the branch stream. Further in accordance with the progress in the Khao Laem project planning by EGAT, Kaeng Puan, Ban Nam Chon Yai and Ban Wang Hin sites as substitute to and/ or as regulating reservoir for Khao Laem are proposed for further investigation.

Generally in any proposed sites, foundations are of lime stone, and therefore, water leakage from the reservoir is considerrd to be the serious bottle neek in the implementation.

The followings are the summarized information on the results of those investigations as conducted by agencies concerned.

Khao Kwang Dam Site

Investigations for this dam site have been conducted by RID since 1962. From 1966 to 1970. The Austroplan, ACEC carried out topo-survey, test boring and test pit excavation. The conclusions reached in these investigations were the big risk of leakage through the Karstic lime stone in case of high dam and the insufficient storage capacity for the irrigation project downstream in case of low dam. As was the case, no succeeding investigations has been undertaken for this dam site.

At Khao Kwang site specific river banks height of the Khwae Noi are rather high, though the abutment on the right bank is lower than El. 85.0 m. It is necessary, therefore, to construct a sub-dam with a considerable crest length on the right bank, in case the storage water level would be planned higher than El. 80.0 m. At this site, the storage capacity is about 2,100 million cu.m with El. 80.0 water level and 6,600 million with El. 100.0 m having the drainage area of 6,926 km^2.

Ban Phu Toei Dam Site

This dam site was proposed by both RID and EGAT. During the period 1968-1972, the site was investigated by EGAT assisted by Japanese Experts. After this, EGAT investigated further on this site under the Khwae Noi Hydro-electric Project with the assistance by SMEC. In the second stage of this investigation, however, it was concluded not worthwhile to continue the investigation at the site, and the Khao Laem dam site was newly proposed. Reasons for this switch were some objections raised by the local people against the construction of huge size reservoir and the geological problems of secondary limestone as found at left abutment. The proposed dam site, with the drainage area of 6.558 km^2, had water storage capacities of 900 million cu.m, 4,000 million cu.m and 10,000 million cu.m with the water level at El. 80.0 m, 100.0 m and 120.0 m, respectively.

Ban Sai Yok Dam Site

In 1972, EGAT proposed this dam site, however, no substantial investigation has been made since then. As the part of the present master plan study, a survey on the river cross-section at the site was conducted by RID in 1978. Under the Khao Laem Dam Project, a site is proposed for a regulating reservoir at further downstream from Ban Sai Yok.

The topographic condition prevailed at this site is quite fari, since the Khwae Noi River crosses the Khao Wang Khoman-Khao Aru mountain range at this point. However, the crest length increases to a great extent if the elevation of crest exceeds El. 90.0 m, as the slopes of both sides abutment become so gentle above El. 90.0 m. Geologically, problems are in the faults crossing the dam axis and in the water leakage from the long and narrow ridge on the right bank. Reservoir capacity is about 600 million cu.m with water level of El. 80 m and about 7,500 million cu.m with El. 120,0 m.

Khao Laem Dam Site

This dam site was selected by EGAT/SMEC in 1973 and a reservoir is planned to be constructed under the Khao Laem Project with the main purpose of hydro-power generation. The left abutment is connected with the high cliff (specific height is about 200 m.) and the right abutment is with the mountain block of El. 600.0 m high. Foundations are Ordovision sedimentary rocks on the river bed and right abutment and lime stones are on the left abutment. The mean annual inflow is 5,499 million cu.m with the drainage area of 3,724 km2. According to the EGAT plan, the reservoir capacity is about 7,500 million cu.m with the designed water level of El. 155.0 m.

Bi Khi Dam Site

This dam site as selected by EGAT in 1973 is located at the most upperstream of the Khwae Noi River Basin. There found some advantages as a dam site because of its bedrocks of non-calcareous sedimentary rocks. However, storage efficiency is rather low due to the steep topography. The mean annual inflow is estimated at 2,348 million cu.m with the drainage area of about 878 km2. Reserv capacity is about 1,200 million cu.m with about 60 m of dam height.

Lam Pachi Dam Site

This dam site is on the Pachi River, the biggest branch of the Khwae Noi River with the drainage basin of about 2,860 km^2. There is a vast arable land in the lower basin of the Pachi River and there have been planed to develope water resources of the Pachi River. At the lower most Ban Kluai area, a comparatively bigger water storage could be expected with having about 1,600 km^2 of drainage basin, but there is no proper dam site due to its flat topography. While a dam site was selected by RID at the upper most basin of Ban Suan Phung and some geological investigations are undertaken. Though conditions are suited to a dam site geologically and topographically, catchment area is limited and reservoir capacity is also limited.

3-2. Groundwater

It can be expected that a considerable groundwater resource is existed in the Mae Klong Project area. To grasp the conditions prevailing and for preliminary fact finding on groundwater in the area, field surveys have been conducted coupled with the review on various data/references available.

The field survey covered the whole project area and mainly shallow wells were investigated with putting an emphasis on the fact finding on the followings.

a) Distribution of wells
b) Groundwater table in wet season
c) Groundwater utilization

The survey results as of date can be summarized as follows.

-Wells in the project area can be classified into three(3), shallow well, deep well and the combined type of the former two. Shallow wells are predominant in the area. The shallow well is of artesian well with the size of ϕ 0.8 - 1.0 m in a round shape. Deep wells are mostly drilled by the government agencies having ϕ 6 inches size and depth of 30 - 60 m. Recently, number of deep wells as constructed by private factories is in increasing trend. The combined type is installed with pump set, as deep well was additionally drilled on the same location of existed shallow well.

-Distribution of shallow wells is considered to be closely related with the groundwater existence. In the project area, more densities of shallow well distribution are found in those areas along the Mae Klong River and in the north-west part of the central project area. While there found no shallow wells in the northern most western-part and the flat low-land of south-east part. The former is because of no groundwater availability in the area, but the latter is attributed to abundant water source other than groundwater.

-Generally, groundwater tables are in a range from 2-3 m under the ground surface. Among the surveyed wells of 320 in total, about 50% showed that the table is in a range of 1-4 m under the ground surface. The shallowest is of spring well and the deepest revealed at 16 m under the ground surface.

-Except the stage I area, where no contour map with 1 m interval is available, the groundwater distribution is as follows:

There are groundwater ridge extending from Kanchanaburi to the south and north-east directions.

The one extending to north-east runs along the old Mae Klong River course and branched off into two after Ban Hua Wang (Amphow Song Phi Nong).

The ridge extending to south covers south-east part of the Mae Klong River up to Amphoe Photharam.

In the west-north part of the project area, there exists a deep groundwater valley along Kanchanaburi-Suphanburi road.

3-3. Soil

3-3-1. Soils in the Project Area

The western edge of the project area is formed by terrace deposits and down to east there is a fan shaped area with a gentle slope as formed by the Mae Klong River. Those areas along the Nakhon Chai Si and Tha Chin Rivers are of marine alluvial, and further, the said areas can be divided into two with the boundary line of Nakhon Chai Si-Ratchaburi. The southern part of the line is the flat low-land which is derived from the recent deposits. The lower part of the flood area as developed by the Mae Klong River is a tidal flat.

The project area can be classified into nine (9) land forms as shown in Table B-1.

Within the project area, 50 of soil series, phase and association are confirmed. In terms of greater soil group, 52% is shared by alluvial soils, 37% by non-calcic brown soils, 10% by low humic grey soils, remaining of 1% by grey podzoic soils, regosols, rendinas and gramusols.

3-3-2. Acid Sulphate Soil

In east Malaiman area, there found a developed soils on old marine and brackish water deposits covering about 81,000 ha of land. The major component thereof are acid sulphate soils. Acid sulphate soils are distributed all over the central plain, Thailand, but the said soils in the Mae Klong project area moderately suitable for paddy cropping as compared with the one in the central plain. Acid sulphate soils found in the project area are, however, poorly suitable to upland crop cultivation. In general, these lands of acid sulphate soils are used for wet season broadcasting rice in the upper part of East Malaiman area and for the dry season transplanting rice in the lower part. Partly, however, there found some man-made ridges as prepared for only 2-3 years for wet season cropping. After 2-3 years, the ridges shall be shifted to another land due to the strong acidification of the soil.

Generally, it seems that paddy yields are vitally affected by soil acidities. Yields are higher when pH of surface soil is more than 4.5 and the paddy fields are prepared with deeper water. Ca content of the Mae Klong River water is quite high at 37.7 ppm as compared with 19.8 ppm of the national average.

It is considered, therefore, that the water quality is favorably affecting to the acid sulphate soil in the project area.

Acid sulphate soil can be improved through amelioration of soil acidity by applying limes and/or through increased phosphorus fertilizer application. As increased fertilizer application might bring a burden for farm economy, amelioration of soil reaction shall be further promoted. With this concern, marl application to the acid sulphate soil as promoted by the Land Development Department shall be further expanded. Other than the above, there is a rather passive way to protect paddy fields from being acid by keeping the field in wet condition. However, water logging may hamper smooth farming practices and moreover, roots of rice plant may have demage by strong soil reduction under the logged water and this poor activity of rice roots influences adversely to a sound growth of rice plant.

When complete irrigation and drainage systems would be provided under the Mae Klong Irrigation project, active leaching can be made by using irrigation water and through applying liming material such as marl and more phophorus fertilizer, rice yields would be increased considerately.

3-3-3. Natural Soil Fertility

A tentative evaluation was made on natural property of each series in the project area based on the chemical property such as cation exchange capacity, base saturation, organic matter content, available phosphate and soil reaction etc. Fig. B-1 shows the natural fertility of each soil series in case of paddy rice cultivation.

Natural feritlity is high in the soils of low terrace of semi-recent alluvium mainly in Khamphaen Saen and Nakhon Phathom areas and flood plains of recent alluvium in Tha Muang,Chainat and Ratchaburi, and alos the recent marine, brackish water deposit in Damnoen Saduak and Samut Songkhram.

Acid sulphate soils in Sena and Rangsit were lower eveluated due to its strong acidity, though the natural feritlity itself is high enough. Another lower evaluation was for soils in Tha Chin and Samut Prakan because of its high saline content.

Soils of low natural fertility are found in the mountainous areas in the western part of the project area, namely Nakhon Phanom Khao Yoi, Phak Tho and so on.

3-3-4. Land Classification

A semi-detailed land classification was made by RID for the Mae Klong Project area, and the results are as compiled in each report. However, no classification has been made for a limited part (7,800 ha) in the project area and for the drainage project area (24,500 ha). For the former 7,800 ha area, a field investigation was made during this field survey, and for the latter, land classification was made in accordance with the soil interpretation handbook for Thailand, using the existed soil maps as base maps.

The gross arable land area in the Mae Klong project area reveals at 438,200 ha, and the net cultivable area after deducting acreages for roads and canals out of the gross area is 391,300 ha as shown in Table B-1 and B-2.

3-3-5. Drainage Project Area

The drainage project area covers 24,500 ha of gross area. The land form can be divided into a tidal flat and former tidal flat with recent marine and brackish water deposits. In terms of soil series, the Bangkok low phase soil and the Damnoen Saduak soil shares 72% of the total. The Bangkok low phase soil is very dark grey clay with poor drainage. The natural fertility is moderately high and mainly utilized for the wet season broadcasting rice cropping. Damnoen Saduak soil is an artificial soil suitable for upland cropping as developed by ridging the banglen calcareous variant soil.

As the result of land classification, except the Damnoen Saduak Soil, it can be said that in general the soils in the area are more suited to paddy fields than upland field as negative factors for upland fields such as floods, poor drainage and salt injuries are confirmed. Soils in Tha Chin, Samut Prakan very saline phase were classified as non-arable because of the high saline content. It was then estimated that the arable area is 21,400 ha out of the gross area 24,500 ha, and the net cultivable area is 19,300 ha.

3-4. Meteorology, Hydrology and Water Resources

3-4-1. Meteorology

The Mae Klong Project area is located at the western end of the tropical savanna climate zone in Thailand and this climate can be divided into two climate seasons, dry season and wet season. The upper stream area, which is the water source of the project area, belongs also to this climate. The climate with two seasons is characterized by the two major wind systems of south-west monsoon and the north-east monsoon. The wet season is for a period from May to October and the dry season from November to April.

Meteorological stations in and around the project area are existed in the following six places.

Meteorological Station	Data Period
Suphan Buri	1951 - 1975
Uthong	1967 - 1978
Khanchanaburi	1951 - 1975
Khamphaeng Saen	1973 - 1978
Don Muang	1951 - 1975
Bangkok	1951 - 1975

The climate in Khamphaeng Saen is as shown in figure C-1.

Rainfall

Rainfall in and around the project area is of so called shower rain and passes from south to north direction with the monsoon wind and with smaller rain band mainly in afternoon to evening time. Consecutive raining hours are in an order of several hours even with the heavier rain.

Study on rainfall is based on the daily rainfall data during the period of 1952-1974 as recorded in 56 stations in the project area and 34 stations in the upper stream basin.

Annual rainfall

As shown in the Hyetograph of figure C-2, the annual rainfall in the basin varies considerably depending on the locality.

Pilok (upper most of Khwae Noi)	4,700 mm
Sangkhla Buri	2,000 mm
Kanchanaburi	1,100 mm

The mean annual rainfall in the project area is about 1,100 mm. As mentioned above, rainfall in the Mae Klong basin is extremely concentrated in the upper Khwae Noi basin. This is the reason for the bigger runoff of the Khwae Noi than the Khwae Yai though the catchment area is much bigger in the Khwae Yai River basin.

Rainfall pattern in the project area is characterized by more rainfall in the coastal area and less in inland area. The annual mean rainfall varies from the biggest of 1,300 mm at Samut Sa Khon to the smallest of 800 mm in Phanom Thuan. Based on the data of 21 selected station as indicated in figure C-4, the annual mean rainfalls in each block of the project area were calculated by the Thiessen method as follows.

Annual Rainfall in Project Area

Block	Annual Mean Rainfall	Extreme Annual Rainfall			
		Maximum		Minimum	
West Malaiman	953 mm	1,342 mm	1953	664 mm	1958
East Malaiman	1,050	1,440	1953	771	1967
Stage I Upper	1,116	1,351	1956	727	1958
Stage I Lower	1,145	1,495	1966	802	1967
Upper Right Bank	1,089	1,274	1955	684	1967
Lower Right Bank	1,176	1,413	1956	853	1967
Drainage Area	1,184	1,808	1966	845	1967
Whole Project Area	1,080	1,323	1953	748	1967

Note: computed with using data (1953-1973) at 21 representative stations

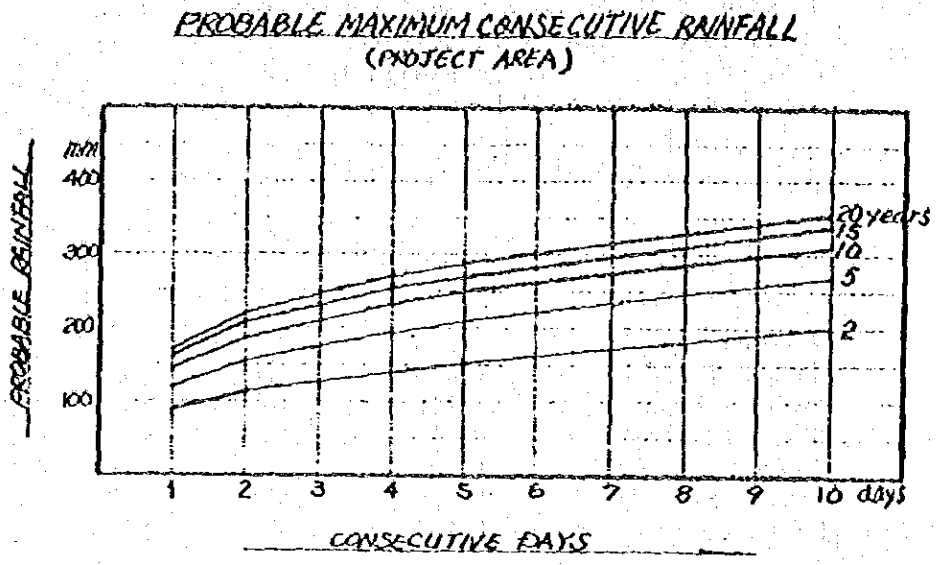
According to the historical annual rainfall as shown in figure C-3, drought years in the project area are 1958 and 1967.

Monthly mean rainfall

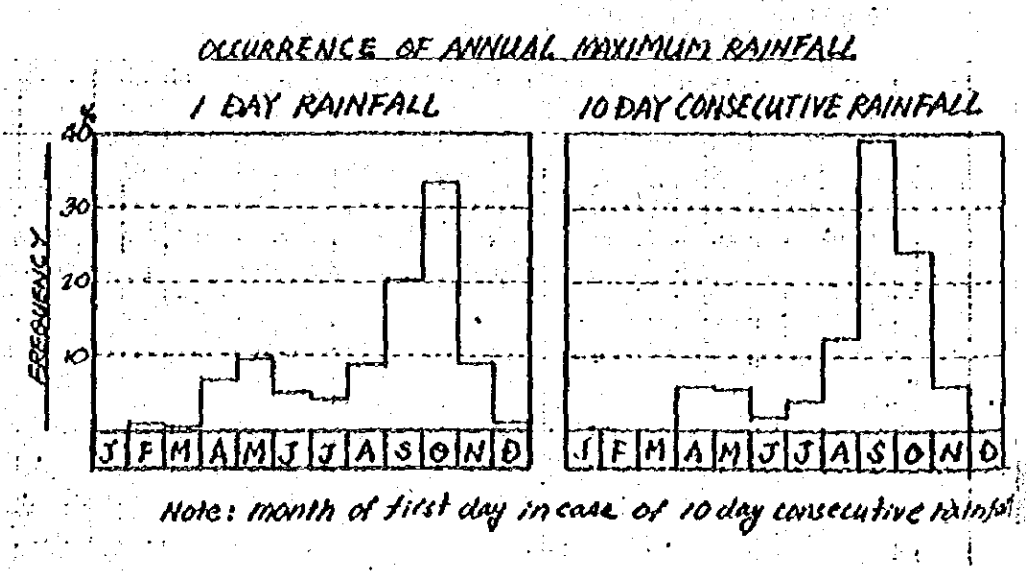
Monthly mean rainfalls in major points are as shown in table C-2 and figure C-5. As may be known in figure C-5, the maximum monthly rainfall in the upper Khwae Noi basin is recorded on July. In other basins and in the project area, the maximum monthly rainfalls are recorded on September. In the project area, 940 mm (87% of annual rainfall) is in wet season and 140 mm (13% of annual rainfall) is in dry season, where a big difference is seen.

Rainfall intensity

Annual maximum one day to 10 day consecutive rainfalls in the project area are as shown in the following figure. However, further study is necessary, as there found a big regional difference and even in between the neighboring stations, there is a considerable difference.



Further, concerning with the occurrence of annual maximum rainfall as shown in the following figure, it can be confirmed that one day rainfall occurs in October and 10 day consecutive rainfall in September.



Tropical cyclone

As stated in the paragraph for rainfall, those storms which affect the Mae Klong River basin include the local storm and tropical cyclones, one from the eastern South China Sea via Vietnam and the other from the western Bay of Bengal via Burma.

Tropical cyclones can be classified into the following three types in accordance with its maximum wind velocity (v) near center.

Depression	$v \leq 16.9$ m/sec
Tropical storm	$16.9 < v \leq 32.5$ m/sec
Typhoon	$32.5 < v$

Tropical cyclones reached to the Mae Klong River basin are mostly depressions as weakened already. There was no typhoon affected the basin during the period from 1951 to 1975. Further, there is little tropical cyclones from the Bay of Bengal as compared with the tropical cyclones from the South China Sea. According to the record it happened to be just once in May 1951, as far as the record available shows. In a period of 25 years from 1951 to 1975, 26 tropical cyclones affected the basin with a frequency of once a year. Out of the total number, 12 cyclones are happened in the month of October.

3-4-2. Hydrology

Rivers

The Mae Klong River, water source for the project area, Song Phi Nong River along the northern project boundary and the Nakhon Chaisi River running the eastern side are the three major rivers in the Mae Klong basin.

Song Phi Nong River

This river collects the discharge from the mountainous area located at the north-west of the project area and from the flat low-land of the northern project area and runs through the Song Phi Nong regulator and meets with the Nakhon Chaisi River. Song Phi Nong River is not considered as a water resource for development, since the basin belongs to comparatively dry area and the catchment area is small as same with the Lam Tapern River, a branch of the Khwae Yai River.

Nakhon Chaisi River

This river is branched off from the Chao Phya River at about 18 km upstream from Chai Nat, flows down along the eastern boundary of the project area and empties into the Gulf of Thailand This river has different names in each province which the river passes through, as Nakhamthao, Supan, Nakhon Chaisi and Tha Chin from the upper to the down stream and the total river length is about 307 km. Nakhon Chaisi River is controled by the Chai Nat Dam under the supervision by RID and utilized for supplementary water supply for the Lower Chao Phya Irrigation Project and also the river functions as a by-pass for draining excess water during the high flood at the Chao Phya River. Presently, the water balance in the Chao Phya basin is rather tight and this river can not be considered as a water source for the project area.

Mae Klong River

This river is the most important river in the basin. The catchment area is about 27,660 km^2 excluding the lower stream flood plain. The river length downstream of Kanchanaburi is about 130 km having two major branches of Khwae Yai and Khwae Noi Rivers which meet at Kanchanaburi. The mean annual runoff at the Vajiralongkorn Dam site (26,441 km^2) is about 12,200 million cu.m, out of which 10,900 cu.m (89%) is discharged during 6 months period from June to November and for the remaining 6 months from December to May, the discharge is only 1,300 cu.m (11%). As shown in figure C-7, monthly mean runoff is decreased to 50-40 cu.m/s in March - April, and it is concreased rapidly to a bigger discharge and on August the maximum of 1,100 cu.m/s is recorded.

Khwae Noi River

The Khwae Noi River has a catchment area of 10,640 km^2. As shown in figure C-2, there is a heavy rainfall area around Pilok in the north-west part of the basin and the most of the 315 km river basin is geologically formed by limestone. This river basin has the biggest water resource and discharges 7,200 million cu.m which is accounted for 59% of 12,200 million cu.m, the annual total runoff of the Mae Klong River. As it can be confirmed that high floods in the Mae Klong River are mainly caused by the discharge from the Khwae Noi River, control of Khwae Noi River is vitally important for the flood control of the entire Mae Klong River basin.

Khwae Yai River

The Khwae Yai River has a catchment area of 14,810 km^2, 380 km in river length from Umphang to the confluence with Khwae Noi River, and the river slope is rather steeper at 1:2,000 than the Khwae Noi River. Construction for water resources development in the Khwae Yai River basin initiated in 1974, and presently the Sri Nagarind Dam (total storage capacity, 17,700 million cu.m) and the lower regulating dam at Ban Tha Thung Na are under construction at about 90 km upstream and about 28 km down stream from the Sri Nagarind, respectively. The Sri Nagarind Dam started storage in 1977 and the No. 1 unit is scheduled to be inaugurated in January 1979. For Ban Tha Thung Na Dam, the scheduled completion is in 1982.

As shown in figure C-2, the annual rainfall in the Khwae Yai basin is extremely smaller than that in the Khwae Noi basin, and especially, the Lam Tapern river basin is the area with the least rainfall in the entire basin.

Annual specific discharge of the Khwae Yai River is small at 386 mm at Wang Masang (K20) point. This is less than a half as compared with the specific discharge of the Khwae Noi River. The Lam Tapern River shows the smallest figure of 96 mm in the Mae Klong River basin at Ban Wang Yai (K27).

Monthly and annual mean discharge

As shown in table C-3 and figure C-7, the mean maximum discharge of each river is occured in August, September and August for the Mae Klong River, the Khwae Yai River and the Khwae Noi River, respectively. These occurrences of maximum discharge are coincided with the rainfall pattern in each river basin as shown in figure C-5. Discharge is not increased in May when rainfall started but increased suddenly in June with one month time lag. This indicates that the rainfalls in the beginning of wet season are mostly consumed for supplementing soil moisture.

Historical fluctuation of annual discharge amount is as shown in figure C-8, in which it is known that 1954 and 1960 are drough years after 1950. In 1958 and 1967 when the project area had drought year, annual discharge amount showed average figures, for the drought year in upper stream and lower stream basin is seemed not coincided.

Annual discharge amount is closely related with the highest flood discharge (figure C-9) in the year. This indicates that the flood is the most rich in view of the water resources though it brings about damages in the lower stream area.

Floods

As shown in figure C-9, floods in the Mae Klong River occurs in a period from August to October. When flood discharge exceeds 2,500 cu.m/s, it causes over-bank flow at the lower stream of the Vajiralongkorn Diversion Dam and seriously damages the area. High floods with the discharge more than 2,500 cu.m/s occurred 15 times during 38 years from 1939 to 1976. In the recent years, such high floods happened in 1972 and 1974. Extremely high floods happened in the years as follows.

Extreme high flood

Order	Year	1-day Maximum discharge	
1	24 Aug. 1953	6,000	cms
2	28 Aug. 1961	4,330	
3	22 Sep. 1962	3,849	
4	21 Aug. 1974	3,561	
5	4 Oct. 1959	3,065	
6	19 Jul. 1972	2,939	

3-4-3. Water Resources

The relation of water resource developments and water demands in the Mae Klong River Basin has a network as shown in the following figure:

Water Resource Development

- Srinagarind Dam (Khwae Yai River)
  under construction, scheduled to be completed by Jan. 1979.
- Ban Tha Thung Na Dam (Khwae Yai River)
  under construction, scheduled to be completed by 1982.
- Khao Laem Dam
  proposed, planned to be completed by 1984.

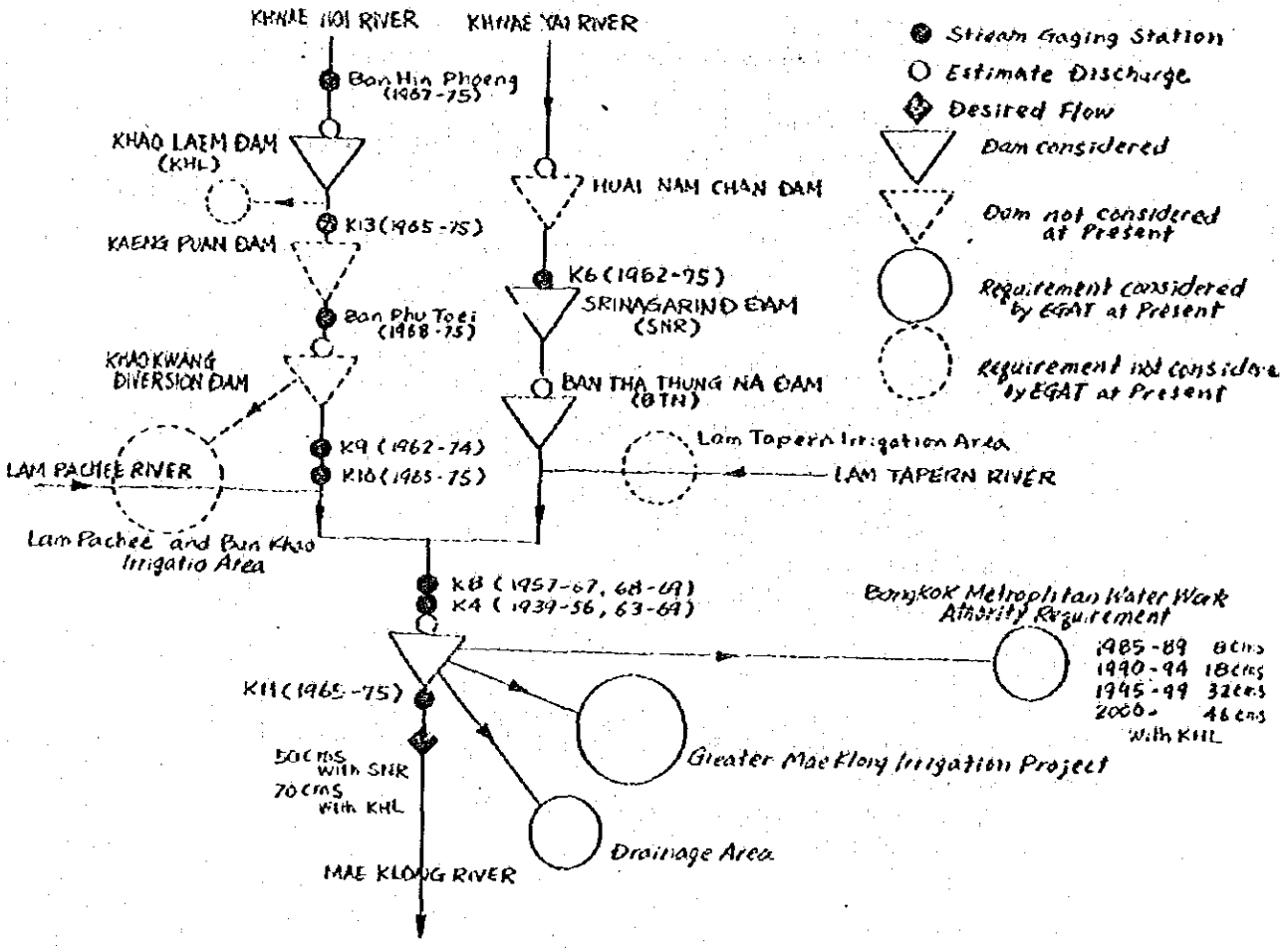
Irrigation

- Greater Mae Klong Irrigation Project, Stage I and Stage II
  under developing.
- Lam Pachee Irrigation Project and Ban Khao Irrigation Project
  under consideration at Stage III
- Lam Tapern Irrigation Project
  under consideration
- Drainage Area
  under consideration

Domestic Use

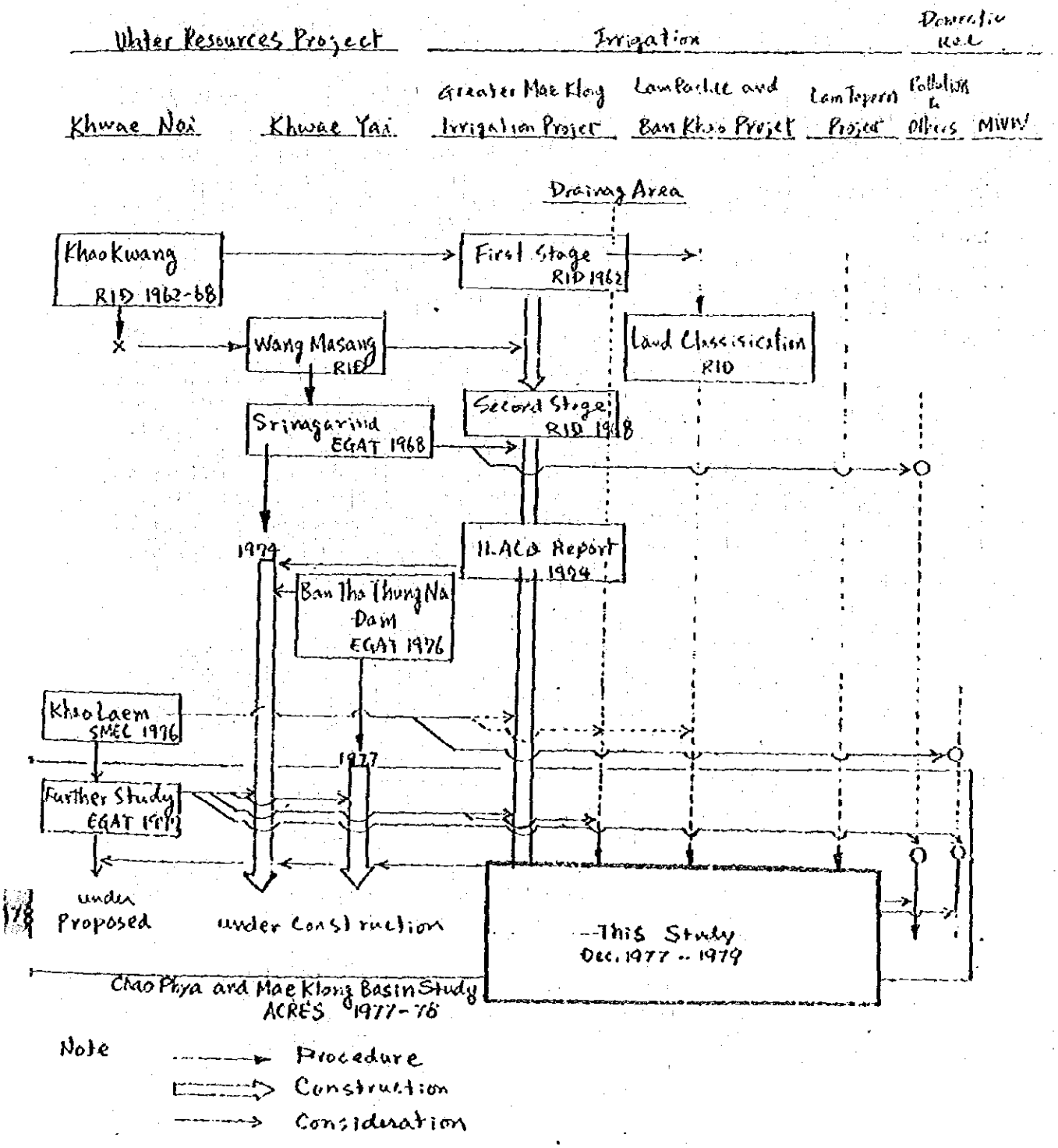
- Release water to Mae Klong River for domestic and industrial use, and for preventing polluation and salt intrusion.
- Water requirement to Bangkok Metropolitan Water Works
  under consideration.

SCHEMATIC DIAGRAM OF MAE KLONG BASIN



Note : This figure is based on the report " Benefit Derivation of Khao Laem Project, Appendix I, Dec. 1977 EGAT "

The project studies which are related to the water budget in the Mae Klong River Basin have been conducted with the following flows and particulars.



Present Status of Water Resources Development

Water resources development projects in the Mae Klong River Basin have been progressed as indicated below, and the locations and profiles of each project are as shown in figure C-6 and figure C-10, respectively.

Water Resources Development Project

	River	Construction	Administration and
Vajiralongkorn Diversion Dam	Mae Klong	1964 - 1968	RID Irrigation
Srinagarind Dam	Khwae Yai	under construction 1974 - Jan. 1979	EGAT Multipurpo
Ban Tha Thung Na Dam	Khwae Yai	under construction 1977 - 1982	EGAT Regulating
Khao Laem Dam	Khwae Noi	proposed - 1984	EGAT Multipurpo
Kaeng Puan or Khao Kwang	Khwae Noi	proposed	? Regulating Diversion

Other than the above, considerable number of dam projects have been proposed. Those proposed dams are mostly located in the upper stream area of the Khwae Yai River. Development of upper stream area of the Khwae Yai River has been mostly attained by constructing the Sri Nagarind dam, as the dam covers about 90% of 12,310 km^2, the total catchment area of the Khwae Yai River except the Lam Tapern River Basin, and further development of the Basin other than power generation prupose seems not attractive.

Sri Nagarind Dam

The Sri Nagarind dam is presently under construction and the operation inauguration for No. 1 unit is scheduled on January 1979. With the release water by the dam, irrigation water will be available for the down stream area in dry season. General description of the dam is as follows:

Catchment area	10,880	sq. km.
Annual inflow	4,600	mcm
Maximum probable flood	6,000	cms
Maximum flood	2,450	cms (20 Sep. 1962 at Kang Rieng)
Reservoir		
Storage Level		
Maximum Water Level	MSL 182.4 m	
Full Supply Level	MSL 180.0 m	
Low Water Level	MSL 159.0 m	
Top of reactive	MSL 153.0 m	

Storage Capacity

Maximum Water Level	19,200	mcm*
Full Supply Level	17,745	mcm
Low Water Level	10,225	mcm
Top of Inactive	8,700	mcm*

Installed Capacity

Initial Stage	360 mw (120mw X 3 unit)
Ultimate Stage	720 mw (Initial Stage + 180mw X 2)

Turbine (for initial stage)

Rated head	105 m (at MSL 165 m) *
Rated discharge	135 cms/unit(405cms = 135 X 3)*
Rated output	120 mw/unit(360mw = 120 X 3) *
Maximum output	135 mw/unit(MSL 176 180 m) *

Note: * in the report
"Benefit Derivation of Khao-Laem Project, Appendix I"
Dec. 1977 EGAT

Ban Tha Tung Na Dam

As the regulating dam for the Sri Nagarind dam, construction works for this dam was started in 1977 and scheduled to be completed in 1982.

With the completion of this regulating dam, the peak flow of 405 cu.m/s (135 cu.m/s x 3 unit) by power generation at Srinagarind station can be regulated and the maximum flow of 290 cu.m/s can be constantly discharged to down stream.

General description of this regulating dam is as follows:

General Description of Ban Tha Tung Na Dam

Catchment area	11,428 sq. km
Annual inflow	4,487 mcm
Maximum probable flood	3,000 cms
Reservoir	
Full Supply Level	MSL 59.7 m
Low Water Level	MSL 55.5 m
Total storage capacity(FSL)	56.3 mcm
Effective storage capacity	27.7 mcm
Installed Capacity	37 mw
Turbine	
Number of units	2 units
Rated head	15.10 m
Rated discharge	145 cms/unit (290cms = 145 x 2)
Rated Output	19 mw

Khao Laem Dam

Project study on this dam is being undertaken by EGAT as the most promising storage dam on the Khwae Noi River. It was in June 1976 the feasibility study for this project was completed by EGAT/SMEC. After that, the EGAT studied a combined operation scheme of the Khao Laem dam with the Sri Nagarind dam so as to coordinate with the water demand in the lower stream area, and the study results were reported on December, 1977.

Previous studies on development scheme of the Khwae Noi River are as follows:

Development scheme of Khwae Noi River

Dam	Investigation
Bi Khi dam	EGAT ,as upper storage dam of Ban Phu Toei.1968-76
Khao Laem dam	EGAT(SMEC),as storage dam. Nov. 1973 - Jun. 1976
Ban Wang Hin dam	EGAT(SMEC),as altanative dam site of KhaoLaem.Jun.1976
Kaeng Puan dam	EGAT(SMEC),as storage dam sifted from Ban PhuToei.Nov.1974
Ban Phu Toei dam	EGAT(Japanese experts and SMEC),as storage dam 1968-70,72-7
Khao Kwang dam	RID, as storage Dam. 1962-68

The results obtained in the above surveys and studies on the proposed dam sites are as summarized below.

Dam	Conclusion
Bi Khi dam	-Less efficiency than Khao Laem dam to flood control. -Further study will be worthy to be undertaken when storage water level of Khao Laem shall be lower than MSL 130 m. -Combined operation with Khao Laem will be economically unfavorable than the independent operation by Khao Laem.
Khao Laem dam	-Considered to be most suitable dam site as storage dam.
Ban Wan Hin dam	-Priority is less than Khao Laem dam due to unfavourable topography.
Kaeng Puan dam	-Water level in dry season shall be lower than MSL 60m so as not to submerge the Ban Sai Yok water fall. However, this dam site is worthy to be further studied for the lower regulating dam of the Khao Laem dam.
Ban Phu Toei dam	-Unfavourable due to extensive caves of limestone.
Khao Kwang dam	-Not suitable as storage dam but it should be studied as diversion dam to Ban Khao and Lam Pachee irrigation projects

General discription on the Khao Laem dam is as follows:

General Description of Khao Laem Dam

Catchment area	3,724 sq.km
Annual inflow	5,260 mcm
Maximum probalbe flood	7,100 cms
Maximum flood	3,590 cms(Aug.1974 at Ban Phu Toei)
Reservoir	
Storage Level	
Maximum Water Level	MSL 160.4 m
Full Supply Level	MSL 155.0 m
Top of Inactive	MSL 135.0 m
Storage Capacity	
Maximum Water Level	9,500 mcm
Full Supply Level	7,450 mcm
Minimum (Top of Inactive)	2,650 mcm
Installed Capacity	290 mw(145mw x 2 units)
Turbine	
Rated head	61 m(at MSL 150 m) *
Rated discharge	251.7 cms/unit(503.4 = 251.7 x 2 units)*
Rated Output	130mw/unit(260 = 130 x 2 units) *
Maximum Output	145mw/unit(at MSL 155m)

Note: * in the report"Benefit Derivation of Khao Laem Project, Appendix I"
Dec. 1977 EGAT

Water Budget Study

Following the development of the Sri Nagarind dam and the Khao Laem dam, studies on the water demands in the lower stream areas have been progressed as follows:

Srinagarind Dam

- -Year-round irrigation water supply for the StageI and II areas of the Greater Mae Klong Irrigation Project based on the KACO Report in 1974.
- -50 cu.m/s of water release for the down stream area as the countermeasures to the public pollution and salinity problems.

Khao Laem Dam (SMEC report 1976)

- -Additional irrigation water supply to those areas which were not included as irrigable area under the Greater Mae Klong Irrigation Project and the irrigable flooded area.

-Irrigation for the drainage project area.

-Water supply to Bangkok Metropolitan Water Works Authority

-Study on irrigation for the Ban Khao and Lam Pachee areas, Stage III and upper stream Khao Laem area. However, those areas are not included as irrigation project due to lack of data.

Further study by EGAT (Dec. 1977)

-Non-commandable area in the Greater Mae Klong Irrigation Project shall not be included in the irrigation area.

-Released water (constant) shall be increased to 70 cu.m/s

Changes of irrigated area in the above studies are as shown below.

	Srinagarind Dam only		Srinagarind Dam + Khao Laem Dam			
	ILACO 1974		SMEL 1976		EGAT 1977	
	Wet	Dry	Wet	Dry	Wet	Dry
Net Irrigated Area	245	225	322	285	292	272
Non Commandable	39		9		39	
Flooded Area	77		30		30	
Outside Irrigation	27		27		27	
Cultivated Area	388		388		388	
Drainage Area			33	27	33	27
Total Irrigated Area	245	225	355	312	325	299

Important points and measures

In the present study, the land use plan for the Greater Mae Klong Irrigation Project will be further modified and the possiblity of irrigation water supply for the Lam Pachee, Ban Khao and Lam Tapern areas is to be examined.

Accordingly, the following considerations shall be taken into account in water resources plan.

- Possibility to increase the dry season flow of the Mae Klong River

Intensified land use through on-farm development and increase irrigated area can be expected. For this, possible shift of wet season release by EGAT to dry season release shall be realized. Full coordination with the operation plan for power generation shall be secured.

- Yearly fluctuation of irrigation water requirement

As stated in the section for Hydrology, rainfall amount in wet season fluctuates considerably, resulting in a considerable fluctuation of irrigation water requirement year by year. Further study is needed to clearify what effect will be given to the dam operation which is programed based on the water requirement in the average year.

- Necessity of water supply to Bangkok Metropolitan Water Works Authority.

- Examination of water release for the downstream area.

- Water resources for the upperstream irrigation project.

Upperstream irrigated areas are located at the elevation of MSL 30-80 m, higher than the river water levels of Khwae Yai and Khwae Noi Rivers.

As independent water resources, there remain the Lam Pachee and Lam Tapern River Basins. However, the water resource is only sufficient for wet season cropping and besides, there found no suitable dam sites in the basin.

3-5. Irrigation

3-5-1. Development projects in the basin

The Greater Mae Klong Irrigation Project was initiated in 1962 by the RID and the development plan for about 420,000 ha of project area was formulated. A preliminary design was made at that time for the Stage I area and irrigation operation was inaugurated in 1974 for the Stage I area. Further in 1968, RID conducted the second feasibility study on the Mae Klong area, where development plan for the Stage II area was completed together with revision of the original plan for the Stage I area. In the second feasibility study, a emphasis was placed not only for the supplementary water supply in wet season but also for the irrigation water supply for the area in dry season. To cope with the requirement for water resources, construction of Wang Masang Dam on the Khwae Yai River was proposed in this second feasibility plan. However, this dam construction plan was substituted by the Sri Nagarind Dam as proposed by the EGAT and the construction work is presently undertaken. In accordance with the report prepared by EGAT, No. 1 - No. 3 generators of the Sri Nagarind Hydropower station are to be inaugurated for operation during the period of 1979 - 1980. Another construction is going on for the regulating reservoir at some 25 km downstream from the Sri Nagarind Dam, and the scheduled completion is on August, 1982. Released water from the Sri Nagarind Dam, therefore, can be utilized for dry season irrigation for downstream areas after August, 1982.

Length and capacity of the main irrigation canal facilities in the project area are as follows.

LEFT BANK
- Left Feed Canal L=3.0 km Qmax = 245 m^3/sec
- Left Main Canal L=62.3 km Qmax = 117.7 m^3/sec
- 1L (Sub-Main Canal) L=74.0 km Qmax = 16.8 m^3/sec
- 2L (Sub-Main Canal) L=68.0 km Qmax = 110.5 m^3/sec

RIGHT BANK
- 1R Canal (Main) L=123 km Qmax = 66.9 m^3/sec
- 2R Canal (Main) L= 72 km Qmax = 13.6 m^3/sec

TOTAL 325.5 m^3/sec

3-5-2. Work accomplishment in the on-going project

The accomplishments in main canal construction under the on-going project by 1977 are as follows.

PROJECT AREA	CANAL LENGTH (PLAN)	CANAL LENGTH (COMPLETED)
Stage I	532,500 m	532,500 m (100%)
Stage II Right Bank	533,800	364,600 (68%)
Stage II Left Bank	550,000	21,500 (4%)
Total	1,616,300 m	918,600 m (57%)

Accomplishments are, therefore, 57% and 53% in terms of canal length completed and irrigation command area, respectively. According to the program by RID, all the programmed works are scheduled to be completed by 1986.

3-5-3. Irrigation facilities

Capacity of Canal

The unit water requirement as applied in designing of Canal Capacity is 0.75 l/sec/ha at each diversion site. The same unit water requirement is applied for paddy fields and upland fields, provided that a different unit water requirement is used for the Stage II Left Bank area.

0.75 l/sec/ha is the unit water requirement for the paddy cropping in wet season in the Stage I area where effective rainfall is fully taken into account.

Main Canal

Though operation is being done in favorable condition with a satisfactory flow capacity, water intake becomes difficult due to the limited number of check gates when discharge is not sufficient and water level gets lower. The loss of head is considered to be larger because of the limited cross-sectional area of gates. In general, the designed water level seems to be a little lower than the requirement.

Lateral Canal

Operation of the lateral canals is carried out in a good condition as same with the main canals. Diversion is made by gate operation from main canal to lateral canal and from lateral canal to sub-lateral canal, and the loss of head is considerable because of the limited cross section of the gate and unnecessary drop structures.

Presently, diverted discharge is measured by staff gages installed one each at upstream and downstream of the diversion facility. Measurement is practised five (5) times a day from 6:00 AM to 1:00 PM. Check structures are provided as same with main canals, however, the number is not enough and water levels fluctuate according to the discharge amount.

Diversion to farm ditch

Concrete pipe is used for diverting water to farm ditch and adjustment of flow volume is made by wood board and steel board installed upperstream side and downstream side, respectively. Operation and maintenance for this diversion facility is not satisfactory undertaken. When water is diverted directly from a big lateral canal, there found some diversion facilities which can not be effectively functioned due to the lowered water level in the lateral. (especially 5L)

3-5-4. Irrigation Conditions

Irrigation in lower area

In the low-land area of the Stage I area, where no irrigation facilities are existed, flood irrigation is practised by utilizing the water in the drainage canals. The depth of flooding water reaches at 0.5 - 1.0 m in some places in wet season.

Irrigation for sugarcane field

Mostly the sugarcane cultivation in the area is of rainfed farming, and irrigation water supply is practised only in a limited area, especially when planting and ratooning are done. Small pumps are used for supplying water to the field from farm ditches, borrow pits and drains.

Fruit trees and vegetables

In the flat low-land in the Stage I area, considerable horticulture area is existed in the small scale polder dikes where irrigation water is supplied from the neighboring drainage canals.

Non-irrigable areas with the present facilities

Based on the hearings from the RID O&M offices and checking in the field investigations, non-irrigable areas can be classified into two (2). One is those located at higher elevation than the designed water intake level in the original plan (case A). The other is those areas not equipped with required farm ditches for irrigation water distribution (case B).

Estimated non-irrigable areas as classified as mentioned above are as follows.

	Case A	Case B	Total
Stage I	16,000 ha	14,700 ha	30,700 ha
Stage II	3,000 ha	2,000 ha	5,000 ha
Total	19,000 ha	16,700 ha	35,700 ha

For the case B areas, the difficulties can be solved through the on-farm development in future, but for case A areas, some other countermeasures are required.

3-5-5. Irrigation water from drainage canals

For the area as provided with irrigation facilities irrigation water is diverted from the Vajiralongkorn Dam. On the Stage I area along the Mae Klong River, there existed some old intake facilities. These intakes are connected with the drainage canals in the project area and function not only for flood control of the Mae Klong River but also for water supply for the lower part. The Nakhon Chaisi River is also utilized for irrigation water supply for the areas along the river. Especially in the East Malaiman area where irrigation canal facilities are not constructed, water from the Nakhon Chaisi River is utilized both for wet season and dry season croppings.

3-6. Drainage/Flood Control

3-6-1. General

The area surveyed during this term of field survey includes the Greater Mae Klong Irrigation Project area and the so called drainage project area located southern part of the Project area. The gross project area of 466,100 ha is composed of the Stage I area (191,100 ha) and the Stage II area (275,000 ha) in accordance with the project phasing. The drainage project area (24,500 ha) is located at the south of the Damnoen Saduak Canal, the southern boundary line of the project area and for this area no supply of irrigation water is planned.

Stage I area

The Stage I area can be divided into the upper part (127,800 ha) and the lower part (63,300 ha). Out of the net cultivated area (106,800 ha) in the upper part, about 60 % is planted to rice and broadcasting rice shares about a half area. Elevations of the flat alluvial plains in the lower part of the Mae Klong fan deposits are in the range from El.1 to 4 meter, out of which the area lower than El. 3 m occupies 31,500 ha area (25% of the upper part). This part is not affected by the runoff from the neighboring areas, but flood water from the Mae Klong River inundate the area, being the constraint for further agricultural development in the area.

Topography of the lower part is of alluvial flat lowland and the elevation is lower than El. 2 m. The area lower than El. 1 m occupies some 35% of the lower part area. Out of the net cultivated area of 55,100 ha, 73% is planted to rice and broadcasting is applied for 32,500 ha area (80% of paddy field). The land use in this part is remarkably characterized by the horticulture for fruit trees and vegetables on the man-made ridges in the small-scale polder dikes along the Damnoen Saduak Canal. The Stage I lower part receives runoff from the upper part and the runoff is mainly drained out to the Damnoen Saduak Canal. This area also has habitual inundations as caused by the flood water from the Mae Klong River.

Stage II area

The Stage II area can be divided into the Left Bank Malaiman area (170,700 ha) and the Right Bank area (104,300 ha). About 75% of the net cultivated area in the West Malaiman (102,100 ha) is planted to sugarcane. Paddy fields are found only along the natural drainage canal in the northern part of the area, where mostly broadcasting rice is planted. This

part is affected by the runoff from the western mountainous area (119,000 ha) and the excess water is drained out to the East Malaiman area. The most part of the East Malaiman area (68,600 ha) is a low-lying area lower than El. 3 m and for 75% of the net cultivated area of 55,100 ha is planted to rice, among which 50% is of broadcasting method. The runoff from the West Malaiman area passes through this part and is drained out to the Song Phi Nong and Nakhon Chaisi Rivers.

87% of the net cultivated area (87,700 ha) in the Right Bank area is utilized as paddy fields. Broadcasting is found only the low-land paddy fields along the natural levee of the Mae Klong River. Most runoff from the western mountainous area (147,000 ha) is flooded and logged in the lower part of the area and gradually drained out to the Mae Klong River according to the lowering of water level in the River. The upper part of the Right Bank area is also a customary flood area of the Mae Klong River.

Drainage project area

The drainage project area covers 24,500 ha of tidal flat low-land with the elevation lower than El. 2 m. The area is of rectangular shape bounded by the Damnoen Saduak Canal on the north and by the tide embankments being under construction on the other three sides.

Of the net cultivated area of 19,300 ha, about 40% is planted to rice, wherein broadcasting is applied for the 5,100 ha area of lower elevation area. As same with the lower part, Stage I, horticulture for fruit threes and vegetables are practised on the man-made ridges encircled by small-scale polder dikes for the acreage covering 10,100 ha.

Excess water is drained out to Sunak Hon Canal by gate regulator as constructed for the tide embankment. With this regulator, the area is protected from saline water intrusion. The Damnoen Saduak Canal receives excess water from the upper stream area and drain out it to the drainage canals in the drainage project area. At the same time, the Damnoen Saduak Canal functions as a water source for the neighboring areas and as a nevigation canal.

3-6-2. Drainage Conditions

The major existing drainage canals in the project area are equipped with regulators at the terminal and the regulators are operated for protection of foreland water intrusion and control of inside water level. During this survey, four regulators (1 at Malaiman area, 1 at upper part of Stage I and 2 at Damnoen

Saduak Canal) were selected for study on the water level fluctuation in recent 10 years. From the water level fluctuation patterns at these regulators, drainage conditions in the project area could be fairly grasped.

Song Phi Nong regulator

This regulator is operated for irrigation water supply for the broadcasting rice in wet season in the flat low-land on both banks of the Song Phi Nong River, and the water level of the River is always kept at higher elevation than the Nakhon Chaisi River water level. In wet seasons in 1967 and 1968 when water level of the Nakhon Chaisi River was lower than the averaged year, the water level of the Song Phi Nong River was at the level of El. 2.4-2.5 m, about 1 m higher than the Nakhon Chaisi River water level for about three months period.

Higher water level in the Nakhon Chaisi River which exceeds the crest elevation of El. 2.5 m occurred in three years of 1970, 1974 and 1975 in recent 10 years. In these years, water levels in the Song Phi Nong entirely follow the fluctuation pattern in the Nakhon Chaisi River.

Chedi Bucha regulator

This regulator is equipped at the terminal point of Chedi Bucha Canal which runs along the boundary line between the upper and lower parts, Stage I area. According to the water level records at this point, fluctuation pattern of this canal can be summarized as follows.

-- The averaged pattern of water level fluctuation at the Nakhon Chaisi River is as follows:

June/July	Lowest at El. 0 - 0.4 m
August/September	Beginning for raise up
November/December	Highest at El. 1.4 - 1.6 m

-- Canal water is to be higher than river water level during June - August and suddenly reaches at the peak in August as higher than El. 1.4 m. Higher canal water level is for three (3) months period from August to October with the level at about El. 1.8 m. In November the water level goes down suddenly and then gradually lowered down according to the water level of the Nakhon Chaisi River.

Regulators with the Damnoen Saduak Canal

At the terminal points of the Damnoen Saduak Canal, Bang Nok Kwaek regulator and Bang Yang regulator at the Mae Klong River side and the Nakhon Chaisi River side, respectively. From the water level records at the both regulator points, conditions on the Damnoen Saduak Canal can be summarized as follows.

-- As for the river water levels, the Mae Klong River is higher than the Nakhon Chaisi River in wet season, and the water level is more or less same in dry season. The difference of water levels in Nakhon Chaisi River between the dry and wet seasons is quite small at only 0.6 m.

-- Canal water level is higher at the Mae Klong River side by 0.2 - 0.5 m in ordinary years excepting those high flood years of 1969, 1972 and 1974 in the Mae Klong River.

-- Canal water level at the Bang Yang regulator point is raised up to higher than El. 1.0 m after August and the water level is maintained for another 2 - 3 months at about El. 1.3 - 1.4 m to be same with the Nakhon Chaisi River water level. From November/December, the water level is lowered down and maintained at El. 0.4 - 0.6 m in dry season.

-- The canal water level at the Bang Nok Kwaek regulator point is maintained at higher than El. 0.6 m in dry season. During the flooding time of August - October, however, the water level follows the Mae Klong River water level as caused by the intrusion of flood water into the canal. After November, the level is suddenly lowered down.

From the study results as mentioned above, it can be concluded that the water levels of the major drainage canals in the project area are controled to comply with the water demand for broadcasting rice in wet season (Broadcasting: May/June, harvesting: December/January). For most cases, the water sources for broadcasting rice are unstabilized rainfall and excess water inflow from upper stream areas, and therefore, starting for land preparation and cultivated area differ year by year. Further, depending on the lowering of outer water level, drainage is delayed and makes harvesting works more difficult.

3-6-3. Flood damages

Losses as brought about by floods on the economy and people's living in the project area are such losses on facilities and products and constraints to further agricultural development in the area.

Damages

No particular report is available on the flood damages as caused by the rivers other than the Mae Klong River, since the scale is rather small.

The high floods in recent years in the Mae Klong River occurred in July, 1972 (2,980 cu.m/s) and August, 1974 (3,600 cu.m/s). According to the report on flood damages as prepared by RID, the damaged cultivated area by 1972 flood is bigger than that in 1974, though the flood itself is bigger in 1974. This can be attributed to the different stages of the crop being grown at the time of floods occurred. The cultivated area damaged in 1972 were 13,568 ha of paddy field, 488 ha of sugarcane field and 248 ha of fruit three lands, making the total at 14,304 ha. While in 1974, the damaged area was about 6,800 ha.

The repair cost for the damages on irrigation and drainage facilities and roads by 1972 flood was 240,000 Baht, and it was 6 million Baht in 1974 flood. Corresponding to the progresses attained in the Greater Mae Klong Irrigation Project, potential for damages caused by floods will be bigger year by year.

Other than the above, damages on highway, railroad and houses are reported.

Constraints for agricultural development

Frequent floods prevailed in the area lower the land use efficiency in the area. In the flat low-lands, broadcasting rice cropping is practised because of its smaller damages by floods than transplanting rice though the yields is less by broadcasting method. Flood areas of the Mae Klong River where being planted to broadcasting rice are as follows.

Acreages planted to rice in wet season
(unit: 1,000 ha)

Areas	Total acreages planted to rice	Broadcasting	Transplant
Stage I Upper	64.5	31.9	18.7
Stage I Lower	40.3	32.5	7.8
Stage II West Malaiman	20.2	15.7	4.5
Stage II East Malaiman	36.8	6.3	30.5
Total	161.8	86.4	61.5

If the flood control in the Mae Klong River can be progressed further, most of the broadcasting rice can be converted to transplanting rice, though definite confirmation cannot be made due to lack of correct information on detailed topographic conditions.

When further flood control can be attained, more effective drainage will be realized, and in and around flood areas the pattern can be converted from existing broadcasting rice to transplanting rice with higher yeilds. Rice varieties for transplanting can be harvested in a shorter time and second crop will be introduced to realize a higher land use efficiency. However, the introduction of dry season rice cropping cannot be achieved without irrigation water supply, and all the benefits cannot be attributed to the effect of improved flood control. The increase in cultivated area in dry season shall be attributed to the combined effect of both the irrigation water supply and flood control.

3-7. On-farm Development

3-7-1. On-farm development in Thailand

In Thailand, various main facilities for irrigation and drainage such as dam and main canals have been constructed and utilized not only for irrigation but also for flood control. However, the water use efficiency at farm level is rather low and not satisfactory one due to the delayed on-farm development in the country. To cope with this situation at an early date, the Agricultural Land Consolidation Act was promulgated in 1974. While since 1969, several on-farm development projects have been implemented in the country attaining some 43,800 ha area completed as of date. Compared with the total net cultivated area in the country, 43,800 ha area is so small.

3-7-2. On-farm development in the Mae Klong Project area

In Mae Klong area, terminal irrigation facilities have been constructed in accordance with the Ditch and Dike development method. The Ditch and Dike method was applied and implemented for 100% of the upper part, Stage I and for 35% area of the Stage II Right Bank, and the acreages completed for this Ditch and Dike project are rather small as compared with the total net cultivated area in Mae Klong area. On-farm facilities by the Ditch and Dike project were implemented as a measure to expand irrigation water supply for a larger area with the lower cost at an earliest possible date.

Compared with the other parts of the country, upland crop fields share a larger proportion in the Mae Klong area. Though terminal facilities for such upland fields were also implemented with the Ditch and Dike method, the facilities are not effectively utilized in many cases, as the farming practices are of traditional rainfed agriculture in these areas. Generally, upland fields are more irregular than paddy fields and an effective irrigation water utilization cannot be realized without a proper on-farm development for the areas.

3-7-3. Study on sample areas

In parallel with the field investigations as conducted during this term of field survey, five (5) sample areas were selected for various comparative studies. General information on these selected sample areas are as follows. However, no detailed data on No. 5 sample area is available, as the survey works are currently being undertaken by RID.

SAMPLE AREA NO.	LOCATION	ACREAGE	LAND USE
1	Tambol MAUNG CHUM, BANWAI Amphoe THA MUANG Changwad KANCHANABURI	500 HA	paddy
2	Tambol TAKLAMEN Amphoe THA MAKA Changwad KANCHANABURI	500	paddy
3	Tambol HONG KOB Amphoe BAN PONG Changwad RATCHABURI	1000	paddy and upland
4	Tambol KRATIP Amphoe KANPHAEN SAIN Changwad NAKHON PATHOM	170	sugar cane
5	Tambol NANG KOB Amphoe BANG PHAE Changwad RACHABURI	100	paddy

Detailed topo-maps (1/4,000) were prepared for each sample area and the followings were studied.

: Present topography (25 cm contour interval)
: Present plot size
: Farm roads
: Irrigation/drainage ditches
: Land use
: Irrigation at farm level

Results of the study can be summarized as follows.

NO. & LOCATION	TOPOGRAPHY, PLOT SIZE, LAND USE	FARM ROAD & DITCHES
No. 1 Stage II upper R.B. 1L-1R	Land slope: 1/2,000-1/3,000 comparatively gentle or flat plot size: 40 m x 40 m 50 m x 100 m, rectangular Mainly paddy fields partly sugarcane fields	Very few farm roads and drains Irrigation farm ditch for every 400 m interval. Farm roads: 8 m/ha, B=4.0 m
No. 2 Stage I upper part 3L	Comparatively flat paddy fields Slope: 1/800-1/1,000 (mono-slope) plot size: same as No. 1	Same as No.1 Farm roads: 19 m/ha, B=4.0 m
No. 3 Stage I upper part 9L	Complicated topography many depressions and swamps slope: 1/200-1/1,000 plot size: same as No. 1 land use: mixed of paddy, sugarcane and other upland crops	Farm roads: rather dense at 27 m/ha, B=4.0 m No drains at all Irrigation ditches by Ditch and Dike method
No. 4 Stage II West Malaiman	Complicated as same with No. 3 with steeper slope than No. 3 Land use is mainly for sugarcane and some for fruit trees	No irrigation ditch and drains, Farm roads are dense 50 m/ha, B=4.0 m
No. 5	Survey works being undertaken.	

Note: Sample areas No. 1 and No. 2 are the pilot farms to be implemented with the technical assistance program by the Japanese Government.

3-7-4. Approach for case study

Advantages and disadvantages were examined through applying both intensive and extensive on-farm development patterns on the selected sample areas.

In this examination, the intensive and extensive methods were defined as follows.

Intensive method

The following engineering measures and conditions shall be fully provided at the same time under this method.

-- Double cropping of rice can be cultivated in the entire area with applying the rotational irrigation method and the cropping calendar as complied with the irrigation schedule.

-- Crop diversification can be introduced for the entire area.

-- Water management can be made independently in each plot.

-- Irrigation/drainage ditch systems are rather simplified and water management technique can be easily understood by farmers.

-- The most advanced farming practices including farm mechanization and improved farm management can be introduced in the area in future.

Under the intensive method, land levelling and reparcelation shall be carried out simultaneously.

Extensive method

This method can fulfill the requirements only partially as compared with the intensive method but to be applied aiming at an earlier irrigation effect for a larger area with a limited fund and construction capability. However, the following limitations in water management and farming practices can be pointed out for this method.

-- Double cropping of rice and crop diversification cannot be perfectly carried out.

-- Water management cannot be made independently in each plot, as the irrigation method is the plot-to-plot irrigation.

-- Higher standard of water management cannot be reasonably undertaken.

-- It is difficult to practise the rotational irrigation method.

-- Only the partial areas can correspond to the more advanced farming practices and the degree of farm mechanization would be limited due to lack of farm roads.

With this method, land levelling is not executed and various types of development can be considered in the extensive method depending on the characteristics on topography and farming practices in the areas.

Estimated irrigated area in sample areas
(on the basis of ditch and dike project)

Irrigated areas in No. 2, No. 3 and No. 4 sample areas were estimated at about 70%, 45% and 60% respectively against each total irrigable area. (For No. 2 and No. 3, the ditch and dike projects were implemented. For No. 4, the irrigated area was estimated assuming the ditch layout on the same basis as No. 2 and/or No. 3)

The results indicate a necessity of earlier implementation of on-farm development in the area.

Comparison between intensive method and extensive method

In case of No. 2 sample area, the results as gained from the comparison are as follows.

-- Irrigable area	:	100% can be irrigated in both cases.
-- Drainage condition	:	100% in intensive case. About 62% in case of extensive method.
-- Rotational irrigation	:	Perfect operation can be done in case of intensive method. Operation would be very difficult in case of extensive method.
-- Ditch density	:	There is not much difference between the two cases, as the ditches cannot be laid out straight due to the existing topography in case of extensive method.

In case of No. 4 (upland field), the comparison is as follows, where an additional pattern (extensive) as same with the design for No. 2 pilot farm was also studied.

-- Irrigable area	:	Intensive	- 84%
		Extensive (No.2 pattern)	- 64%
		Extensive	- 58%
-- Drainage condition	:	Intensive -	100 %
		Other cases -	about 90 %

-- Ditch density (irrigation & drainage)	:	Intensive - 122 m/ha Other cases - 96 m/ha
-- Road density	:	Intensive - 85 m/ha Extensive (No.2 pattern) - 107 m/ha Extensive - 80 m/ha

Density is high in case of No.2 pattern because of farm roads along ditches.

3-7-5. Difficulties/problems and countermeasures

Difficulties/problems

Based on the previous experiences in the implementation of on-farm development projects and the results on the case studies of sample areas during this term of field survey, problems/difficulties to be encountered in implementation of on-farm development project can be classified into the following three (3) items.

-- Difficulties in technical aspect
-- Institutional/administrative problems
-- Constraints in farming practices

These difficulties and problems are closely related each other and constrain jointly the ultimate development, increased agricultural productivity.

Technical aspect

Both intensive and extensive methods have been undertaken to comply with the various needs in each local conditions. It can be said the intensive method may bring about the best condition for the future farming practices and water management. However, with this method the construction cost is higher and construction needs longer period. To cope with this difficulty in intensive method, so called extensive method has been applied for some areas to save the cost (more than 40%) and to bring about the benefit of on-farm development for a larger area within much shorter period. In case of applying extensive method, however, there still remains some problems on water management, drainage condition and future farm mechanization.

Institutional/administrative problems

With respect to the legal arrangement for on-farm development in the country, the Ditch and Dike Act and the Agricultural Land Consolidation Act are effective. To realize the higher land productivity through improved water management and farming practices, however, it seems that the Ditch and Dike Act cannot fulfill the needs as currently prevailed. While for the Land Consolidation Act, there found some administrative difficulties in the implementation of a project due to the limited experiences in project implementation to be carried out in compliance with the Act. Lack of farmers' understanding in the purpose of on-farm development project and measures taken in the project is also another difficulty.

For examples, the following problems are to be further studied.

--Land acquisition

In case of intensive method, common land reduction can be done rather easily through land levelling and reparcelation/ substitution. However, in case of extensive method, applying of land reduction is rather difficult though not impossible. In this connection, another measures other than the common land reduction seem to be necessary.

In the Land Consolidation Act, it is stipulated that the common land reduction exceeding 7% of the total shall be compensated by the Government. This suggest a measure to secure land acquisition for on-farm facilities by compensation to the land owners.

--Cost recovery

Though it is stipulated in the Land Consolidation Act that the beneficiaries from the on-farm development project shall bear a part of construction cost, but actually no cost recovery is practised. Presently, a program is studied by the Government to realize the cost recovery system applying the case for the Chao Phya area.

Farming practices

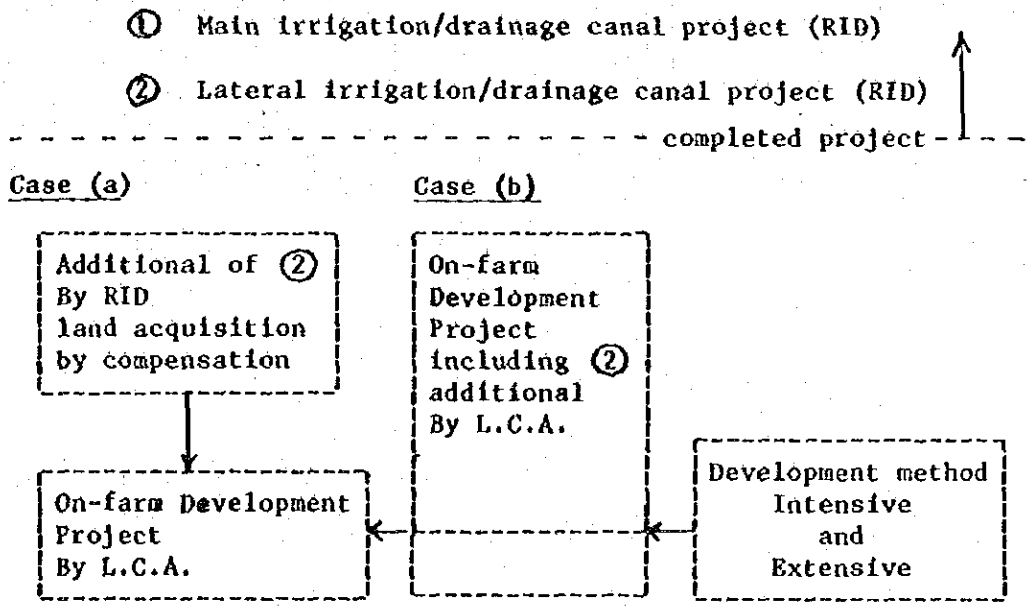
Field conditions and farming practices are closely related, viz. scheduled water management and farm operation will be more complicated in accordance with the introduction and extension of modernized farming techniques. Sometimes, farmers' cooperative works are vitally important to attain such requirement, for which technical standard of farmers shall be further levelled up.

Countermeasures

The above mentioned difficulties, problems and constraints cannot be independently solved, as they are closely related with each other.

Countermeasure for technical approach

To realize on earlier benefit of irrigation in more effective way for the vast Mae Klong project area, project implementation shall be considered in two (2) ways as it deals with a linear canal construction project and a plane on-farm development project. The following chart shows the two (2) cases of project implementation.



Note: For ②, O & M roads shall be constructed along the lateral irrigation/drainage canals. L.C.A.; Land Consolidation Act

-- Case (a)

In this case, implementations of ② additional and on-farm development do not necessary coincide with on its completion, and in most cases, implementation of ② additional be started earlier. With the completion of ② additional works, irrigation effect, improved road net work and water management can be achieved for a larger areas though the conditions are not fully satisfactory. Either after the completion of ② additional or simultaneously, on-farm development can be progressed partly and/or fully to further level up the land use efficiency of the area.

-- Case (b)

In case (b), on-farm development works and ② additional shall be simultaneously implemented under the Land Consolidation Act. With this case, a closer coordination in designing the ② additional and on-farm layout can be secured comparatively easily. While, farmers' consent is required under the Act and it needs longer time for several legal procedures and for completion of works as compared with the case (a).

The additional of lateral irrigation/drainage canals (② additional) are to be provided enough in its length and density to command each 40 ha of rotational irrigation unit. In both (a) and (b) cases, either intensive or extensive development method can be applied.

-- Countermeasures for land acquisition

There are four methods to be employed for land acquisition required for on-farm development works.

-- Common land reduction
-- Purchasing
-- Rental
-- Donation

Common reduction

This method requires all the beneficiaries to bear the total reduced land in same rate to the land holding and partial land substitution shall be necessary.

Purchasing

In this method, some particular farmers have to offer their lands though it is with pay, and there happed to be a case the field condition might be worse than before.

Rental

All the beneficiaries bear the rental according to the acreages offered for public use.

Donation

This is most predominant method practised at present where public lands are donated by owners.

Though each method has advantages with disadvantages, the common reduction is most reasonable and practical among all. In this common reduction, procedures are rater complicated and time-consuming, however, this method shall be promoted for future sake as coupled with possible simplification of procedures. Purchasing method will be most applicable specially for major lateral canal facilities, taking into account the design and future O & M works. Combination of the above four methods is also another practical method in some cases.

Constraints in farming practices

In the future water management and modernized farming practices, farmers' cooperative works shall be necessary, for which strengthened farmers' organization shall be established. For levelling up of farming techniques, training of farmers will also be necessary. For this sake, effective demonstrations at the pilot farm scheduled for earlier implementation and implementation of more systematic training programs through the said organization are to be realized.

-- Cost recovery

Taking into account the following advantages, cost recovery program is to be implemented at an early date as far as the collection of charges might not adversely affect the farm economies.

-- Through paying the project cost, farmers may acknowledge more that the project is implemented for the benefit of farmers.

-- With having such rotational funds, on-farm development can be further expanded to the larger areas.

While it can be foreseen that farmers consent on the project implementation will become difficult because of the cost to be borne by farmers. As mentioned above, this issue is rather difficult problem, for which further comprehensive studies are needed.

3-8. Agriculture

3-8-1. General

The project area is located at the south-western part of the Central Plain, Thailand and paddy and sugarcane are the two(2) major crops in the area having the cultivated land of 251,100 ha (2.7% of the nation's total) and 118,700 ha (26.7% of the nation's total), respectively. Rapid increase in acreages planted to sugarcane is the most characteristic change of the agriculture in the area in recent years, and sugarcane farms are suffering from the over production problem. With respect to paddy, there observed a change in the cropping pattern specially in those areas where main irrigation systems have been completed.

3-8-2. Land Use

Present land use in the project area is as shown block by block in Table 3-8-a. The composition of areal characteristics can be summarized as follows.

Stage I upper	Sugarcane, sugarcane & paddy mixed, paddy
Stage I lower	Paddy, polder horticulture
Stage II east Malaiman	Paddy, sugarcane
Stage II west Malaiman	Paddy, sugarcane
Stage II right bank	Paddy

3-8-3. Cropping Pattern

Present cropping pattern and each corresponding acreages in each block are as shown in the Table 3-8-b. There are five(5) patterns for paddy cropping in the area as affected by different conditions in irrigation water supply and introducing of non-sensitive rice varieties.

i) Broadcasting
ii) Transplanting in wet season
iii) Transplanting in dry season
iv) Double cropping (two paddy a year)
v) Dry season upland + wet season rice

As for sugarcane, new planting is made once every three years and no irrigation water is supplied for sugarcane fields in most cases.

In the Stage I lower block, the cropping pattern is getting more complicated owing to the availability of irrigation water through completed main and lateral canals though the supply is still not sufficient. Another reason is to be attributed to the stabilized water supply in the Nakhon Chai Si River as brought about by the completion of dam construction at the upper Chao Phya areas. While, breeding and promotion of new non-sensitive rice varieties play a conclusive role in changes of cropping pattern. In the other blocks, the cropping patterns are comparatively simple except East Malaiman.

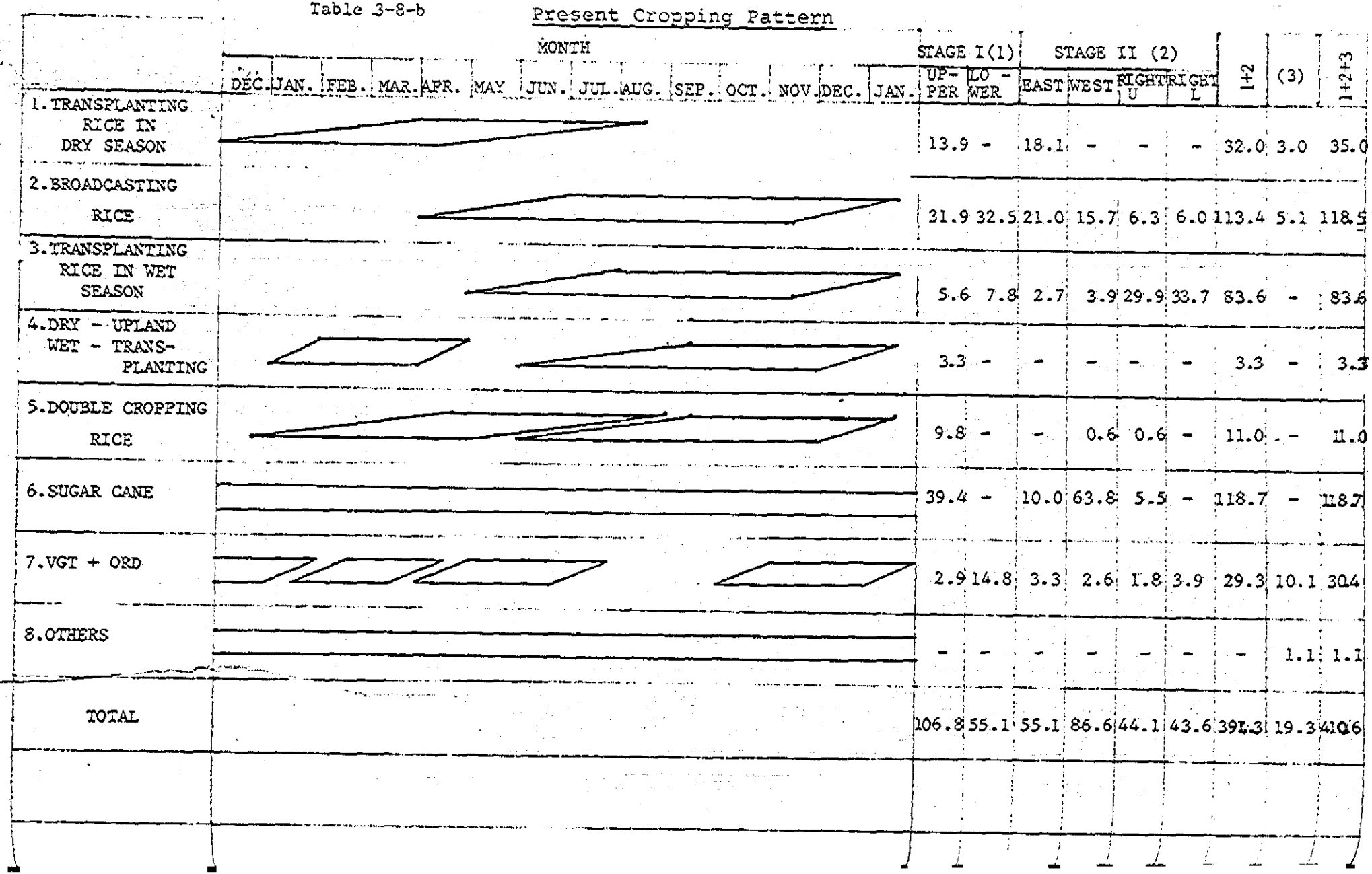
Table 3-8-a Present Land Use (Units: 10^3 x ha)

	Total Cultivable Land	Paddy Field	Upland	Tree crops and Vegetable	Others
Stage I					
Upper part	106.8	64.5	39.4	2.9	
Lower part	55.1	40.3	-	14.8	
Total	161.9	104.8	39.4	17.7	
Stage II					
East	55.1	41.8	10.0	3.3	
West	86.6	20.2	63.8	2.6	
Upper Right Bank	44.1	36.8	5.5	1.8	
Lower Right Bank	43.6	39.7	-	3.9	
Total	229.4	138.5	79.3	11.6	
Stage I + Stage II	391.3	243.3	118.7	29.3	
Drainage Project Area	19.3	8.1	-	10.1	1.1*
Grand Total	410.6	251.4	118.7	30.4	1.1*

* Nipa Palm Plantation, Salt Field and Etcs.

Table 3-8-b

Present Cropping Pattern



	STAGE I (1)		STAGE II (2)				1+2	(3)	1+2+3
	UP-PER	LO-WER	EAST	WEST	RIGHT U	RIGHT L			
1. TRANSPLANTING RICE IN DRY SEASON	13.9	-	18.1	-	-	-	32.0	3.0	35.0
2. BROADCASTING RICE	31.9	32.5	21.0	15.7	6.3	6.0	113.4	5.1	118.5
3. TRANSPLANTING RICE IN WET SEASON	5.6	7.8	2.7	3.9	29.9	33.7	83.6	-	83.6
4. DRY - UPLAND WET - TRANS-PLANTING	3.3	-	-	-	-	-	3.3	-	3.3
5. DOUBLE CROPPING RICE	9.8	-	-	0.6	0.6	-	11.0	-	11.0
6. SUGAR CANE	39.4	-	10.0	63.8	5.5	-	118.7	-	118.7
7. VGT + ORD	2.9	14.8	3.3	2.6	1.8	3.9	29.3	10.1	30.4
8. OTHERS	-	-	-	-	-	-	-	1.1	1.1
TOTAL	106.8	55.1	55.1	86.6	44.1	43.6	391.3	19.3	410.6

Table 3-8-c

PRESENT CULTIVATED AREA BY EACH CROP

unit: 10^3 x ha

	TOTAL CULTIVABLE AREA	WET SEASON					DRY SEASON				
		PADDY RICE	SUGAR CANE	UPLAND CROP	ORCHARD AND VEGETABLE	TOTAL	PADDY RICE	SUGAR CANE	UPLAND CROP	ORCHARD AND VEGETABLE	TOTAL
Stage I											
Upper	106.8	50.6	39.4	-	2.9	92.9	23.7	39.4	3.3	2.9	69.3
Lower	55.1	40.3	-	-	14.8	55.1	-	-	-	14.8	14.8
Total	161.9	90.9	39.4	-	17.7	148.0	23.7	39.4	3.3	17.7	84.1
Stage II											
East	55.1	23.7	10.0	-	3.3	37.0	18.1	10.0	-	3.3	31.4
West	86.6	20.2	63.8	-	2.6	86.6	0.6	63.8	-	2.6	67.0
Upper Right	44.1	36.8	5.5	-	1.8	44.1	0.6	5.5	-	1.8	7.9
Lower Right	43.6	39.7	-	-	3.9	43.6	-	-	-	3.9	3.9
Total	229.4	120.4	79.3	-	11.6	211.3	19.3	79.3	-	11.6	110.2
Stage I+Stage II	391.3	211.3	118.7	-	29.3	359.3	43.0	118.7	3.3	29.3	194.3
Drainage Project Area	19.3	5.1	-	-	10.1	15.2	3.0	-	-	10.1	13.1
Whole Area	410.6	216.4	118.7	-	39.4	374.5	46.0	118.7	3.3	39.4	207.4

Traditional paddy rice cultivation has been practised in a form of broadcasting/transplanting in wet season. Transplanting in dry season has been developed in the area where broadcasting was formerly practised and presently irrigation water is available in dry season. Double cropping is found in the areas where irrigation water is available in dry season and transplanting rice can be grown in wet season. The double cropping pattern area has shown a rapid expansion in recent years, though places are not definite and there are a lot to be technically further improved. In the pattern of combined rice and upland crop, in many cases, mung bean is planted in dry season.

3-8-4. Acreage Cultivated and Cropping Intensity

Acreages Cultivated

Table 3-8-c shows acreages cultivated to each crop in dry and wet season. As for paddy, the difference in cultivated area in dry season and wet season is much less in Stage I area as compared with Stage II area. This is simply because of completed main irrigation systems in Stage I area.

Cropping Intensity

Cropping intensities by all the crops planted are as shown in Table 3-8-d. For the whole project area, the intensities are 91.4% in wet season and 50.8% in dry season, making the average for a year at 71.1%. Excluding the sugarcane of year-round cropping and polder horticulture from the Table 3-8-d, cropping intensity of paddy only can be shown as in Table 3-8-e. The intensities are 86.1% and 18.3% in wet season and dry season, respectively. Referring to the dry season cropping only, the figures are 13.9% in Stage II and 22.6% in Stage I. 13.9% in Stage II is mainly because of the conversion from 40% of wet season broadcasting to the dry season transplanting.

3-8-5. Yields and Production

Present yields in the project area are as estimated as follows.

Rice	
Broadcasting	1.6 t/ha
Transplanting in wet season	2.2
Transplanting in dry season	2.8
Sugarcane	50.0
Upland crops	0.8
Vegetables	10.0

These low yields prevailed in the area are mainly due to inadequate infra-structures for agricultural production especially to the lack of on-farm facilities. Absence of appropriate supporting services is another negative factor for higher productivity. Agricultural production in the area is as shown in Table 3-8-f.

TABLE 3-8-d

PRESENT CULTIVATED AREA BY EACH SEASON

UNIT: 10^3 x ha

( ): %

	TOTAL CULTIVABLE LAND	CULTIVATED LAND		
		WET SEASON	DRY SEASON	AVERAGE
STAGE I				
UPPER	106.8	92.9 (87.0)	69.3 (64.9)	(75.9)
LOWER	55.1	55.1 (100.0)	14.8 (30.4)	(63.4)
TOTAL	161.9	148.0 (91.4)	84.1 (51.9)	(71.1)
STAGE II				
EAST	55.1	37.0 (67.2)	31.4 (57.0)	(62.1)
WEST	86.6	86.6 (100)	67.0 (77.4)	(88.7)
UPPER RIGHT	44.1	44.1 (100)	7.9 (17.9)	(59.0)
LOWER RIGHT	43.6	43.6 (100)	3.9 (8.9)	(54.5)
TOTAL	229.4	211.3 (92.1)	110.2 (48.0)	(70.1)
STAGE I + STAGE II	391.3	359.3 (91.8)	194.3 (49.7)	(70.7)
DRAINAGE PROJECT AREA	19.3	16.3 (84.5)	14.2 (73.6)	(79.0)
GRAND TOTAL	410.6	375.6 (91.4)	208.5 (50.8)	(71.1)

Table 3-8-e

PRESENT CULTIVATED AREA BY RICE

unit: 10^3 x ha

( ): Cultivated Area/Total Paddy Field x 100

	TOTAL PADDY FIELD	CULTIVATED LAND		
		WET SEASON	DRY SEASON	AVERAGE
STAGE I				
UPPER	64.5	50.6(78.4)	23.7(36.7)	74.3(57.6)
LOWER	40.3	40.3(100.0)	- (0)	40.3(50.0)
TOTAL	104.8	90.0(86.7)	23.7(22.6)	114.6(54.7)
STAGE II				
EAST	41.8	23.7(56.7)	18.1(43.3)	41.8(50.0)
WEST	20.2	20.2(100.0)	0.6(0.3)	20.8(51.5)
UPPER RIGHT	36.8	36.8(100.0)	0.6(1.6)	37.4(50.8)
LOWER RIGHT	39.7	39.7(100.0)	- (0)	39.7(50.0)
TOTAL	138.5	120.4(86.9)	19.3(13.9)	139.7(50.4)
STAGE I + STAGE II	243.3	211.3(86.8)	43.0(17.7)	254.3(523)
DRAINAGE PROJECT	8.1	5.1(63.0)	3.0(37.0)	8.1(50.0)
WHOLE AREA	251.4	216.4(86.1)	46.0(18.3)	262.4(52.2)

TABLE 3-8-f

Present Agricultural Productions in the Project Area

unit: 10^3 x t

BLOCK / CROPS	STAGE I			STAGE II					STAGE I + II	DRAINAGE PROJECT AREA	GRAND TOTAL
	UPPER	LOWER	TOTAL	EAST	WEST	UPPER RIGHT BANK	LOWER RIGHT BANK	TOTAL			
RICE											
BROADCASTING	51.0	52.0	103.0	33.6	25.1	10.1	9.6	78.4	181.4	8.2	189.6
WET TRANS.	41.1	17.1	58.2	5.9	9.9	67.1	74.1	157.0	215.2	-	215.2
DRY TRANS.	66.5	-	66.5	50.7	1.7	1.7	-	54.1	120.6	8.4	129.0
TOTAL	158.6	69.1	227.7	90.2	36.7	78.9	83.7	289.5	517.2	16.6	533.8
UPLAND CROP	2.6										2.6
SUGAR CANE	1,970.0	-	1,970.0	500.0	3,190.0	275.0	-	3,965.0	5,935.0	-	5,935.0
VEGETABLE AND ORCHARD	870.0	440.0	1,310.0	99.0	78.0	54.0	117.0	348.0	1,658.0	303.0	1,961.0

Major items are :

Paddy rice	533,800	ton/year
Sugarcane	5,935,000	
Vegetables	1,961,000	

3-8-6. Sugar Cane

In the project area, seventeen number of factories are located along the Mae Klong River. Transportation distance from fields to factories are close so that sugar cane growers has some advantages for marketing comparing with other area. But due to over-production of sugar in international market, production control of sugar cane has been started on the world-wide basis. Sugar cane cultivation in Thailand has been developed after the Second World War, especially its expansion has been remarkable for the recent several years after oil crisis. At present, cane cultivation faces with rather more difficulties being encountered on over-production.

Cultivation

Sugar cane fields has invaded into relatively higher area where upland or non-arable have existed without irrigation water supply. Sugar cane is replanted after continuous growing for 3 years. Land preparation is commonly done by contractors with tractors and harvesting is taken care by seasonal labours from northeast, Thailand. Other major farming practices are fertilizer application and pest control, which is being done only in a minor part. Crop rotation with other crops and application of organic matter and compost are scarcely adopted to improve soil physical condition and soil fertility. In Khampaen Saeng, a sugar cane experimental station established by Sugar Institute, Ministry of Industry, has supplied to farmers from extension farms multipling recommendable varieties. But systematical renew of cane varieties and unification of varieties are not advanced so much.

Marketing of Product

Quota men collect and transport sugar cane from each farmer's field to sugar cane milling factories by their own trucks. They are mostly merchants, heads of muban and Tambon, and large scale farmers. Quota men belong to Sugar Cane Growers Association, which offers information about purchasing prices of cane by each milling factory. They carry the cane to factories which can buy with higher price than the other factories in accordance with indication from the Sugar Cane Growers Association. In Mae Klong Basin area, the cane price of ex-farm gate is mostly based on weight, so farmers don't pay much attention on cane quality

Sugar production from one ton of sugar cane counts to 85 kg in Thailand, on the other hand, sugar production in Australia reaches at 135 kg per one ton of sugar cane. In order to grade up production efficiency and benefits for farmers, milling factories and other persons concerned, rational collecting and purchasing system on cane should be established.

Production Control

In May 8th, 1978, the Ministry of Agriculture has decided total cane production amount at 21 million ton from 3 million rai of sugar cane fields with approval of the Cabinets. Every province has been allocated with acreage to be planted to sugar cane, also indicated each factory its quota. Anticipated harvesting area in 78 - 79 crop year is expected to exceed the acreage decided by the Government. Practical guideline of production control will be formulated by the working committee as organized by the Department of Agriculture Extension, MOAC. From replanting season in April 1979, production control will function at farm level. At present, the comittee decided two major actions; one is nation-wide socio-economic survey on individual farmer by questionaire prepared by the Division of Agriculture Economics, M.O.A.C., through the Ministry of Interior since October. Second one is to provide loan amounting to one million baht to farmers intending to convert sugar cane cultivation to other crops with five % per annum interest.

3-9. Rural Development

3-9-1. Transportation

Concerning with the construction and maintenance of roads in Thailand, the Highway Department is responsible for the main road networks and the Public and Municipal Works Department is for the provincial roads. The Office of the Accelerated Rural Development is undertaking roads construction in the areas neighboring the national boundaries. Other than the above, RID constructs and takes care of maintenance for the feeder roads needed for farming practices and O & M roads along main irrigation canals.

Changes in traffic volume of the main roads in the project area during the period from 1972 to 1976 are mostly increasing trend except the Route 4 between Ratchaburi and Petchaburi. Traffic volume was impressively increased on the Route 323 (108 km) of Bang Pong - Kanchanaburi. Traffic volume in 1976 was 2.4 times of that in 1972 on this Route.

The Damnoen Saduak canal is most highly utilized among the major navigation systems in the project area and in 1977, 54,947 vessels passed Bang Yang navigation lock and 37,046 vessels at Bang Nokwack lock. However, the figures are 42% and 19% less than that in 1973. In other navigation systems too, the tendency is decreasing trend. Especially in Chedi Bucha Canal which runs parallel with the Route 4, the vessels utilized the system was only 120 in 1977 as compared with 3,270 vessels in 1973.

3-9-2. Vocational School

With respect to the vocational schooling in Thailand, enrolment has been increased to some extent in recent years. However some problems have been pointed out, viz. there was a shortage in supplying equipment and materials for education/training, and in some courses no demand for the graduates of the courses was existed in the man-power market. To cope with this, under the fourth five year plan, the government is going to develop further the vocational school as one of the social services by the government, putting an emphasis in agriculture, technology and industry. Under the program, enrolment will be increased yearly by 8% for vocational secondary schools and by 15% for higher vocational schools.

In the Mae Klong project area, an agricultural vocational school is being implemented at Amphoe Potharam Changwad Ratchaburi. To attain the projected benefit of irrigated agriculture in the 391,300 ha of farm lands, not only leveling up of farmers' farming technique, but also promotion of a number of experts/engineers on agriculture, irrigation, farmmachineries and processing of agricultural products and so forth are to be necessary. Considering such requirements in the Mae Klong area, it is considered benefitable to expand and improve such vocational school establishments in the area.

3-9-3. Supporting Services

Extension Services

An extension office is established in each Amphoe. One extension agent takes care of 2,500 - 4,000 ha area though it differs Amphoe by Amphoe. In terms of number of farm households, 2,800 - 3,300 households are taken care of by one agent. Extension service is generally being practised in Tambol unit, while in some areas, service is extended to the farmers' groups as formed by the extension office in accordance with the crops cultivated. Major items included in the present extension service are as follows:

a) Improvement of farming technique.
b) Assistance in group organization specially for intensive irrigated agriculture.
c) Assistance in marketing of products and reporting to MOAC and related experimental stations.
d) Organization of farmers' group.

With the National Agricultural Extension Project, the government is implementing an improvement program of extension services covering 72 Changwad and about 4.6 million farm households. In the Mae Klong area,three provinces of Suphanburi, Ratchaburi and Nakhon Pathom are included in the project. Under the project, extension staff will be increased and improved extension method will be introduced and expanded. Training will be extensively conducted for extension workers and it is aimed to have one extension worker for 1,000 farm households as the target.

Agricultural Cooperatives

Agricultural Cooperatives activities are promoted by the 3-15 of Cooperative League's staff and 1-3 of official staff of the Amphoe offices as established by the Cooperatives Promotion Department, MOAC. Annual budget of 8,000 - 20,000 Bahts is officially provided and the others are derived from the sales profit and interests from farm credit. Major activities by the cooperatives are such credit supply, marketing, materials supply and processing for the member farmers.

Organization for Water Management

The Mae Klong project area is divided into several sub-projects and RID established an O & M office for each sub-projects. Under the present organizational set-up there is a project engineer for each O & M office, a water master for each 100,000 rai area, a zone-man for each 10,000 rai area, and a common irrigator for each 1,000 rai area. For example in the Kamphaeng Saen O & M Office with the acreage of 265,300 rai and total canal length of 254 km, 3 water masters and 24 zone-men are working for the O & M works as similar to the rule. However common irrigators are not sufficient with having only 14 persons at work.

For further development of irrigated agriculture in the area, water management as closely coordinated with the improved cropping pattern shall be established, for which organizational establishment for O & M works shall be further strengthened.

3-9-4. Mae Klong Integrated Rural Development Project

Phase I and II of this project, which has been jointly undertaken by the three universities of Kasetsart, Thamasart and Mahidol, has been completed as of date and rather concrete problems and relates issues for agricultural development in the area were cleared up, and studies were made on more effective development method as the countermeasures for the constraints prevailed. It is scheduled to go on Phase III program after 1977. Under the Phase III program, sub-project as formulated based on the previous study results is to be implemented for the selected 5 pilot zones. With the progress of the Mae Klong Irrigation Project, further accomplishment under the Phase III program in a form of pilot project would bring a fruitful result for the overall development in the Mae Klong River Basin.

3-10. Agri-economy

Population, land tenurs system,farm economy and credits as prevailed in the project area are the major items studied during this term of field survey. References used are the report on Socio Economic Survey which was conducted in 1975-1977 by RID (published in Thai, June 1978) and the Agricultural Land Tenure Survey Report (1974-1976) by the Land Development Department, MOAC.

3-10-1.Population

Total Population and Density

According to the scio-economic survey by RID, the total population in the project area is about 1,018,000 in 1976. As the gross project area is about 4,660 km^2, the density is 219 persons/km^2. This is more than two times of 74.5, the national average excluding Bangkok-Thonburi area, and of 93.1, the density of Central plain, Thailand.

There are 28 Amphoes related in the project area and there found a considerable difference in population density among the 28 places as shown below.

Population Density and Number of Amphoes Corresponded

Density (person/km^2)	Number of Amphoe	
less than 50	2	
50 - 150	6	
151 - 250	10	(Average: 219)
251 - 350	7	
351 - 450	2	
more than 450		
Total	28	

Population Grwoth Rate

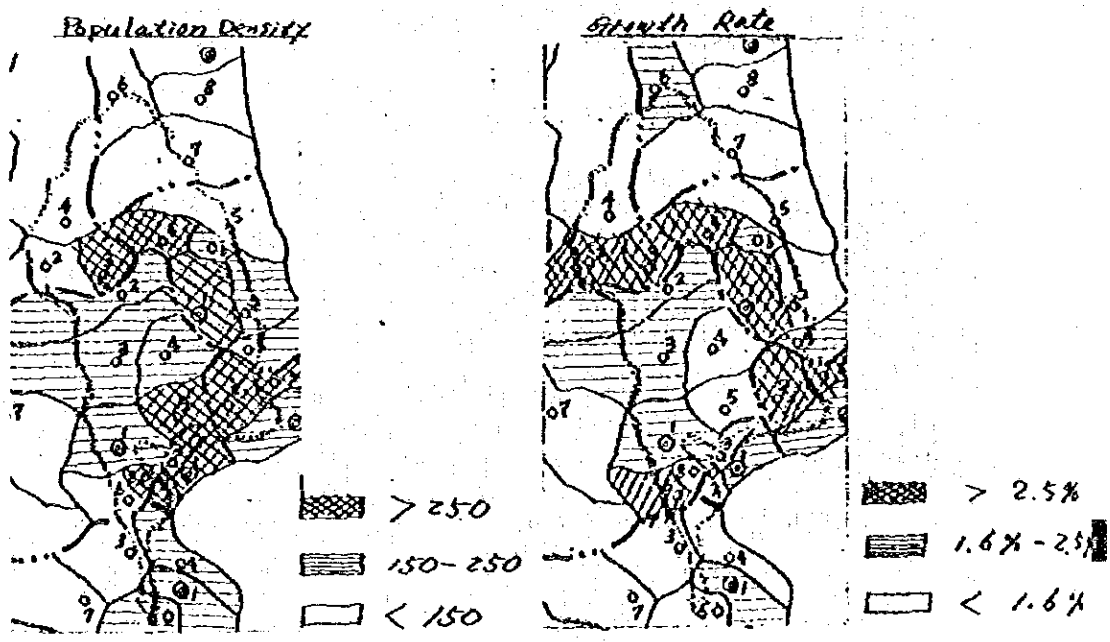
Averaged annual population growth rate (1966-1975) in the 28 Amphoes revealed at 1.86%. This is considerately lower than the national average of 3.11% during the same period (excluding Bangkok and Thonburi area) and even lower than the averaged figure of 2.38% in the seven provinces related to the project.

As same with the population density, there found a considerable difference in the growth rate too among 28 Amphoes as shown below.

Population Growth Rate	Number of Amphoe	
lower than 0.5%	4	
0.5 - 1.0%	3	
1.0 - 1.5%	3	
1.5 - 2.0	5	(Average: 1.86)
2.0 - 2.5	6	
2.5 - 3.0	4	
Higher than 3.0	3	
Total	28	

Combination of Population Density and Growth Rate

The densities and rates mentioned above were classified into three(3) levels as high, moderate and low and illustrated as a figure below. There are three(3)types found in the project area, viz. High density with high growth rate, high density with low growth rate and low density with low growth rate.



Farm Labor power

Number of farm households, non-farm households and labor power population in the project area in 1976 are as follows.

	Urbanized Area		Rural Area		Total		
	Farm	Non-farm	Farm	Non-farm	Farm	Non-farm	Total
Population	24,300	97,200	571,402	325,452	595,702	422,652	1,018,354
No. of household	4,440	17,760	88,727	50,536	93,167	68,296	161,463
Labor power pop.	14,519	58,075	340,712	194,058	355,231	252,133	607,364

3-10-2. Farm Size

With the total cultivated land area of 391,300 ha (2,446,000 rai) and 93,167 farm households in the project area, the averaged farm size is come out at 4.2 ha (26.2 rai) per a household.

The Land Tenure Survey as conducted by the Land Development Department covers the largest area and number of households surveyed, and based on this, the relation among farm size, number of households and acreages shared are shown as follows:

Farm Size	Number of Households	Acreages Shared
smaller than 10 rai	27 %	7 %
10 - 20	24	4
20 - 30	18	16
30 - 40	11	14
40 - 50	8	13
bigger than 50 rai	12	36
Total	100 %	100 %

According to the above table, about half (51%) households of smaller farm size (samller than 20 rai) operate farming only for 11% of total cultivated land. In the contrary, 19% households of bigger farm size (bigger than 40 rai) operate for almost half (49%) of the total cultivated area.

The remainings of 29% in number of households and 30% in acreages are shared by the averaged farm households of 20-40 rai farm size. As is the case, it can be said that the differentiation of farm size is being accelerated.

3-10-3. Land Tenure System

Based on the data derived from the Scio Economic Survey by RID, the land tenure system in the project area was classified into seven(7)patterns as follows:

	Stage I	Stage II	Whole Area
Owner only	51 %	50 %	51 %
Owner Tenant	32	28	30
Owner & Others *	4	8	6
Owner Tenant & Others	2	6	4
Tenant only	6	4	5
Tenent & Others	3	3	3
Others only	2	2	2
Total	100%	100 %	100 %

* rented from relatives and neighbours without paying rent fee.

The above table shows that the tenent farmers are quite limited as owner only shares 51% and 41% by Owner Tenant, Owner & Others and Owner Tenant & Others. Tenant lands are operated mostly by Owner Tenent farmers.

3-10-4. Tenant Lands and Rent Rate

According to the Land Tenure Survey, tenant lands share only 17% of the total cultivated land in the project area. However there found a considerable difference among Amphoes and in Amphoe Bang Len the tenent lands are accounted for about 40% of the total as shown below.

Amphoe	Changwad	% of tenant lands	Amphoe	Changwad	% of tenant lands
Bang Len	(N.P)	39	Tha Maka	(Kan)	10
Nakho Chaisi	(N.P)	34	Kamphaeng Saen	(N.P)	9
Samphran	(N.P)	33	Muang Samut Songkhram	(Son)	9
Ban Phaeo	(Sak)	24	Muang Samut Sakhorn	(Sak)	9
Amphawa	(Son)	24	Don Tum	(N.P)	6
Song Phi Nong	(Sup)	19	Tha Muang	(Kan)	5
Muang Nakhon Pathom	(N.P)	17	U-Thong	(Sup)	5
Bang Khonthi	(Son)	14	Phanom Thuang	(Kan)	4

Socio Economic Survey confirmed the higher share of tenant lands in Nakhon Pathom area and in the lower part of the project area.

Land Holding by Landlord

According to the Land Tenure Survey, landlords (All or a part of his holding are rented to the others.) owns about 19% of total agricultural land in the project area. As tenant lands shares 17% of the total agricultural land in the area, it can be said that 90% of the total owned by landlords is rented to the others for tenant farming. Scale of holding by land lords is as tabulated below.

	Number of Landlords	Acreages
Less than 50 rai	85 %	50 %
50 - 100	10	24
100 - 150	3	10
150 - 200	1	5
More than 200	1	11
Total	100 %	100 %

Note: Survey was conducted for 14,709 landlords covering the area of 471,313 rai.

The above table says most of landlords(85%)owns less than 50 rai agricultural land and only 5% of landlords in number occupies 26% of total holdings by landlords.

Rent Rate

As per the Socio Economic Survey, 42% of total household operates farming on tenant lands. The sources of tenant lands are by relatives, neighbourers, merchants and others, 43%, 38%, 18% and 1%,respectively.

In case of paddy cropping, the rent rate is paid more in kind and less in cash. Other than the paddy, rent rate is paid in cash.

Rent rates per rai for each crop and source of tenant land are as shown in the following table.

Land Owner	Paddy				Other Crop	
	In Kind		In Cash		In Cash	
	No.	Rate (kg.)	No.	Rate (baht)	No.	Rate
Cousin	100	81	22	118	32	122
Neighbor	86	80	23	141	30	131
Merchant	30	74	13	101	18	148
Others	-	-	-	-	4	115
Total(Ave.)	216	(80)	58	(123)	84	(130)

As the table indicates, rent rate is higher for upland fields and lower for paddy fields. In case of rent rate paid in kind for paddy field, the average is 80 kg. paddy per rai.

3-10-5. Farm Economy

Cash Flow Balance

Though it is necessary to study further the values of products paid in kind and depreciation cost and so forth, in this term of field survey, a cash flow balance was tentatively prepared for a averaged farm size as follows.

	Stage I	Stage II	Whole Area
Cash inflow			
Agriculture	38,665	27,472	32,884
Farming	31,798	23,841	27,688
Livestock	6,867	3,631	5,196
Non-agriculture	6,148	5,807	5,972
Total	44,813	33,279	38,853
Cash outflow			
Farming	19,880	14,768	17,240
Livestock	4,565	1,341	2,901
Total	24,447	16,109	20,142
Balance	20,369	17,170	18,714

The above table indicates the fact that the income from agriculture is higher in Stage I owing to the completion of main irrigation systems and in Stage II it is lower without irrigation facilities though the acreage operated is bigger than Stage I.

3-10-6. Farm Credit

Among the 850 farm households surveyed, 35% were indebted in Stage I area and 38% in Stage II.

Amount Indebted and Repayment

Amount indebted and repayment per a household in 1976 are as follows.

	Stage I	Stage II	Average for Whole Area
Credit	6,104	5,687	5,888
Before 1976	1,490	1,347	1,416
1976	4,614	4,340	4,472
Interest	712	633	691
For the previous year	305	219	312
For 1976	409	314	359
Repayment	1,895	3,145	2,514
For principal	1,183	2,512	1,870
For interest	712	633	671
Balance	4,921	3,175	4,018

This survey covers only a single year of 1976, and there is no data surveyed on yearly changes. The table shows, however, that in 1976 all the principal as carried over from the previous years and 10% in the current year were repaid within the year. Baht 2,541, the total amount repaid and Baht 691, repayment for interest as the averages in the whole area are equal to 13.6% and 3.6% of Baht 18,714, the averaged balance of farm economy. Out of the total amount of credit, 63% was used for agricultural production in Stage I and 83% in Stage II.

Source of Credit

Farmers get credits from various sources with the proportions and interest rates as follows.

	Number	Amount	Interest Rate
Merchants	20 %	24 %	24.0
Relatives	17	12	16.4
Neighbourers	20	13	22.9
Cooperatives	19	13	12.0
Banks	23	36	13.7
Others	2	2	18.3
Total	100	100	17.8

As per the above table, farmers tend to get loans more from Banks because of the lower interest rate. Combining the loans from Banks with the cooperatives, the share would be 42% in number and 39% in the amount with the average interest rate of 15.46% per a year.

3-11. Fishery

3-11-1. Present Conditions of Fishery in the Project Area

Fisheries in the Mae Klong River Basin area are mainly for home consumption as same with the other regions of Thailand. So called flooding fishery is predominant in the area and the daily fish catch shares higher percentage in the total fish catch. In accordance with the progress in flood control in the Basin the flooding fishery is partially disused.

Water Quality

Water quality in the Basin is of weak alkaline and favorable for fish habitance though nutrient salts are not sufficient. The lower the stream is the higher the nutrient content of the water in the basin.

Fishes

There are 104 natural fish species in the Mae Klong area (700 fresh water fish species in Thailand). Out of 104 species, 37 are edible. Out of 37 species., 18 are more important than the others. Carps are most predominant with 48 species including those economically important fishes such as Probalous. Cat fish is only clarias b. No natural Tillapia is found in the area, though snake head fish are catched in a considerable volume. Climbing perch and Giant gramy in paddy fields are ponds are rather improtant. Seput Siam is rare however. Feather back and swamp eel are distributed to a considerable extent in the seven(7) provinces within the project area. Macrobrachium is found in any part of the Mae Klong River.

Fish Catches

Fish catches (fresh water) in seven(7) provinces in 1976 reveals at about 20,000 tons and the culture fisheries (fresh water) produced 13,000 tons of fishes, sharing 13% and 43% respectively in the national total. Suphanburi province is the most important among seven provinces with shares of 60% in fish catch and 56T in culture fisheries. Fish catches was the maximum in 1973 and there often tend to decrease. Major fishes catched are cat fish, Snake head fish, local carp and swamp eel, with the volume of 5,800 ton, 5,200 ton, 1,690 ton and 1,600 ton, respectively.

Fishing Gear and Fishing Method

As same with the other regions of Thailand there are various fishing gears and methods to cope with fish species, fish sizes and locations. Giel net, throwing net and dip net are the main and this tendency might not be changed.

Inland Waters Fishery

Recently, inland waters fishery has been promoted/developed in Thailand. In the seven(7)provinces, however, insufficient water supply, too dense culture and diseases caused decreased production of culture fisheries. Those cultured fishes are cat fish, snake head fish and four species of Carp and recently Giant gourami has been introduced for culture fishery in fish ponds.

Cage fish culutre in stream water was rare in the area due to the big fluctuations of the velocities and discharges of the Mae Klong River.

After the improvement of the river discharge, however, bildge part of the river with a smaller velocity will be increased, for which development of culture fish in stream water can be expected.

In Suphanburi province, where fish pond culture is very popular, cat fish culture is predominant. Tillapia and carps are cultured in the lower stream fish ponds utilizing ditch water. Culture fishery in paddy fields are practised for Tillapia scattering over the lower stream paddy field area. So called combining culture with livestocks is for the above-mentioned fish species and also for the Indian Majer ((Carp).

Big production of cat fish is because of the taste as favored by the people and the advantages in storage as fresh fish.

Processing and Marketing

Compared with the other regions, fresh fish consumption is extremely high in the Mae Klong area with the share of 80% of the total. 10-11% is for salted/dried fish and 6.1-7.5% is for smoked fish. Outside of the urban areas, consumptions of fish and shellfishes are bigger than that of meats, indicating the importance of fish and shellfishes as the source of animal protein.

Self-sufficiency is attained in fish and shellfishes in the Mae Klong River Basin area, and the self-caught natural fishes can answer for the fresh fish demend in the beginning of the dry season. In the urban areas, consumption of cultured fish is on the peak demand when the catch of natural fishes decreases in the dry season. Fishery in this area can take some advantages from its location as located neighboring to Metropolitan Bangkok and marketing system is well established. Averaged fresh fish price in Bangkok is always higher than marine fishes. In recent 2-3 years, the price has been in a range 14.57 baht/kg.-15.4 baht/kg. The difference between the prices of fresh water fish and marine fish tends to be larger.

3-11-2. Policy and Administration

Under the fourth five(5)years plan (1977-1981), 3.4% per annum of growth rate is the target as combined by marine fish with fresh water fish. In principe maintaining of production level in inland waters fishery and further promotion of cultured fishery are stressed as the policy.

In Thailand, fishery administration is centralized in the Central Government, and under the Department of Fishery, offices/agencies at province, Amphoe and municipality levels are established. In Kanchanaburi, an experimental statation on inland waters fishery is existed and takes care for technical guidance for the region as directed by the Department of Fishery. Further, there is a fishery experimemtal station under construction at Suphanburi, and it is planned to set up a branch office of the Kanchanaburi station at the Sri Nagarind Dam site.

3-11-3. Forecast for Inland Waters Fishery in the Mae Klong Basin

The Vajiralongkorn Diversion Dam is completed on the Mae Klong River and the Sri Nagarind is under construction on the Khwae Yai River. While on the Khwae Noi River, the Khao Laem Project is planned for inplementation. Such constuction of big structures on the rivers of the basin, specieally for fishes.

Difference of water temperatures between just before and after the outlet facilities of the Sir Nagarind Dam was about 5 c according to the actual measurement. Temperature difference to this extent does not affect much on fish growing. The Sri Nagarind Dam buried the existed forests and entrophy is being progressed to some extent.

The discharged water from the Dam is to be oxidated by air and shows higher D.O than the water stored in the Dam. D.O becomes lower when water flows down to lower stream.

Cut-off of river flow by dam structure may result in no more spawning, feeding and migration by Probarbus j. and Macrobrachium r. Probarbus j. as caught in recent years are getting smaller showing limited chances for spawning, decreased fish resources and over fishing. With a dam structure constructed, stream flow changes to static flow and formation and volume of fish species varies considerably in and around the reservoir. Quantitatively, it is difficult to forecast the variation, but it can be said that rivering species will be decreased and clarias b. etc. will be increased. In 4-5 years period the reservoir will be fully nourished, but the size of Tort, Probarbus j., oxyeleotric of Carp family will be getting smaller than before.

3-11-4. Countermeasures

It is foreseen that a sound development of fisheries based on natural fish resources will be considerable hampered by water resources development in the Basin. To cope with this, it seems necessary to take active measures for development of fish resource potential in each part of the Basin. Measures include seedling production for liberation and promotion of cultured fishery which is suited to the natural conditions of the Basin as summarized below.

-Liberation shall be made for the upper stream of the Khwae Yai and Khwae Noi Rivers where population density is low. For the lower stream, cage culture in stream water and fish pond culture shall be promoted.

-Seedling is for local Carp, Common Carp, big head Carp, Indian majer, Probabus j., pangacius Sutehi, Tleapia n. and three of Chinese Carp.

-Cage culture in stream water shall be promoted. Fluctuation of Mae Klong River discharge will be less and this type of culture would be possible especially at the bilge of river. The bilge section just downstream of the Vajiralongkorn Dam would be a model area for this type of culture.

-Other than the above, so called combining culture with livestocks shall be further promoted. Utilization of water stored along canals is also possible.

-To conserve juveniles, fish shalter shall be provided in the reservoir and also some measures be taken for protection of juveniles from flowing down through the dam inlet.

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3-12. Electric Power
3-12. Electric Power

3-12-1. Present Status of Electric Power in Thailand
3-12-1. Present Status of Electric Power in Thailand

In the existing network of power supply in Thailand, the Electricity Generating Authority of Thailand (EGAT) is in charge of power generation, the Metropolitan Electricity Authority (MEA) is for power distribution in Metropolitan (Bangkok and Thonburi area, and the Provincial Electricity Authority (PEA) for the rural areas not covered by MEA. Direct supply of electric power is made by EGAT in some exceptional cases, but the electric power generated by EGAT is mainly for whole-sale to MEA and PEA.

The installed capacity as operated by EGAT in 1977 is 2,742,3 The installed capacity as operated by EGAT in 1977 is, 2,742,350 kw. as the total of 7 hydro electric power stations, 5 thermal power plants, 5 gas-turbine power plants and 5 diesel power plants. Among the above; 2 thermal power plants of North Bangkok and South Bangkok and 2 hydro electric power plants of Bhumibol and Sirikit are the major plants/stations with the total output of 2,332,500 KW. sharing 85% of EGATs' total output.

Demand and Supply of Electric Power
Demand and Supply of Electric Power

Electric power demand in Thailand showed a high growth rate of 20-4 Electric power demand in Thailand showed a high growth rate of 20-40% per annum till the year of 1969 under the extensive public industrialization program of the government, improvement of public infrastructures in and around Bangkok and Bangkok and modernization of home electrical appliances. After 70 thorisis, the growth rate was slowed down (5% in 1974) even After 1975, however, the growth rate is on an increasing trend.

The maximum power generated uring the fiscal year 1977 (Oct. 1 The maximum power generated uring the fiscal year 1977 (Oct 1 1976 - Sept 1977) was 1,873.4 MW and the peak demand. In usually occurs at 19:00-20:00 hours with the evening load. In terms of load fluctuation pattern, there is little seasonal zone. Variation observed in Thailand is located in the tropical zone. Maximum load in Sundays is about 85% of the maximum load in weekdays and it goes down to 50% only in midnight. Daily load factor is a little higher than 70% and annual load factor is comparatively high at 65-66%.

Operation Pattern
Operation Pattern

Most of the dams for hydro power generation is for multi-purpose Most of the dams for hydro power generation is for multi-purpose uses and operated as much as possible to comply with the requirements from irrigation purpose. The Reservoir capacity is equal to the annual inflow or bigger than, that or Aiming at irrigation water supply in the dry season, water storage is made achieved during the wet season, and therefore, energy output tends to be bigger in the dry season and smaller in the wet season.

Thermal power plants are operated mainly for base load and hydro power, gas-turbine and diesel power stations plants are for peak load, which is ideal pattern from the viewpoint of overall power plant operation. However, hydro-power generation can not be completely stopped in midnight, since the reservoir shall discharge some for irrigation requirement.

3-12-2. Demand Forecast of Electric Power

In December 1977, EGAT made a demand forecast of electric power till the end of 1990, where growth rates are estimated to be 10-12% in the former half period and 7-9% in the latter half during the period. As compared with the maximum demand of 1,873 MW and annual energy production of 10,950 MKWH in 1977, it is estimated that the figures will be about 6,196 MW and 34,774 MKWH in 1990.

At present, the annual load factor is comparatively high at 66%, but it will remain at some 64% even in 1990.

3-12-3. Electric Power Development Plans

To comply with the above mentioned demand in future, additional capacity of 2,300 MW by 1984 and 4,750 MW by 1990 are needed including some reserves. 4,750 MW in 1990 is equivalent to 170 % of 2,743 MW, installed capacity at present, and to fulfill this requirement, new development of installed capacity by 360 MW per a year has to be attained. Plans and progress in electric power development by EGAT are as briefly described below.

On-going Projects

-Mae Moh power plant: This is a thermal power plant being constructed in Northern Thai. It is scheduled to start No. 1 unit (75 MW) in 1978 and No. 2 unit (75 MW) will be completed in October, 1978.

-Sri Nagarind Hydroelectric Project:
A multi-purpose dam is under construction on the Khwae Yai River, a branch of the Mae Klong River to serve for annual energy output of 1,200 MKWH, irrigation, flood control, domestic/industrial water supply, navigation and salinity control. 3 units of generators (120 MW) are geing installed at present and in future another 2 units (180 MW) are to be added, making the total at 720 MW.

-Pattani Hydroelectric Project:
This is a multi-purpose project being implemented in Southern Thailand. The maximum output is 72 MW and scheduled completion is in 1981.

Plans Scheduled to be Implemented

In the fourth five year developemtn plan, the lower Khwae Yai Hydroelectric Project, Upper Khwae Yai Hydroelectric Project and other 8 projects are to be further progressed. There are investigations undertaken for 6 projects to be implemented after the fourth five year development plan.

According to the plans mentioned above, in 1984 total of 2,655 MW will be added 850 MW by hydro power, 1,685 MW by thermal power, 120 MW by purchasing. Further, by 1990, another total of 1,635 MW will be added , 535 MW, 500 MW and 600 MW by hydro, thermal and atomic power, respectively.

9-12-4. Development of Mae Klong River Basin and Power Facilities

Electric power facilities which are related to the project area for this master plan can be divided into two: one is those power generation facilities to be developed by EGAT on the Khwae Yai and Khwae Noi Rivers and the other is the distribution network by PEA. PEA is implementing an expansion program in the area including unification/abolition of such small-scale diesel power plants in the area. Expansion of distribtuion network can be completed within shorter time and any revision/intensification to cope with the future demand can also be undertaken rather easily. Therefore, study was concentrated on the hydro power generation program in the Mae Klong River Basin.

Sri Nagarind Hydroelectric Project:

Utilizing the reservoir to be completed on the Khwae Yai River (total storage capacity, 17,745 million cu.m, effective storage capacity, 7,470 million cu.m.), the maximum energy output of 360 MW (generators 3 units) and annual energy production of 1,160 MKWH are expected under the 1st phase program. Water discharge is 133 cu.m/s per a unit and totally 399 cu.m/s for 3 units. This hydro power station has the third largest maximum output next to the Bhumibol and Sirikit stations and the second largest next to the Bhumibol in terms of annual energy production.

For this reservoir, water storage was commenced in 1977 and the water level reached at El. 117.0 m as of August 15, 1978. Generators can be operated with the maximum energy output when water level is higher than El. 152.5 m. According to the schedule as set forth by EGAT, operation of No. 1-No. 3 units are to be inaugurated during the period from September 1979 to April 1980. El. 152.5 m is lower than the high water level of El. 180.0 m by 27.5 m and 6.5 m less in effective draw-down as compared with the ordinary case of 21 m depth.

Lower Khwae YAi Hydroelectric Project

At about 25 Km downstream from the Sri Nagarind Dam, a regulating reservoir is to be constructed with the total storage capacity of 56,300 cu.m, effective storage capacity of 27,700 cu.m and the high water level at El. 59.7 m. This regulating reservoir is for relieving big fluctuation of discharge as released from the Sri Nagarind Dam and for power generation (Maximum energy output, 38 MW, annual energy production, 150 MKWH) by utilizing the water released from Sri Nagarind through generators. Moreover, the regulating reservoir will serve as the lower stream reservoir when oepration of pumping-up power plant will be started under the phase 2 program.

After completion of this regulating reservoir(August, 1982 scheduled), discharge fluctuation at down stream in one day operation of the Sri Nagarind station can be fully protected. Further, a controled water release can be done for downstream irrigation use in one week interval if well programmed operation rule is established, even the Sri Nagarind station generate more in high demend weekdays and stop operation in low demand sundays.

Those hydro power development projects being implemented are as mentioned above, while those on the planning stage are as described below.

Khao Laem Hydroelectric Project

The project is a multi-purpose dam to be constructed on the Khwae Noi River for hydro power, flood control and city water supply with the total storage capacity of 9,500 million cu.m and the effective storage capacity of 4,800 million cu.m. Ordinary high water level is El. 155 m and 20 m of drawdown water depth can be available. Generators with the maximum energe output of 290 MW are to be installed for annual energy production of 806 MKWH.

Effective storage capacity of the reservoir is equivalent to 87% of the mean annual inflow.

A little smaller than the other reservoirs in Thailand. As the utilized water depth is rather bigger in proportion to the limited effective head, operation with the highest efficiecy does not always mean the operation for the maximum energy output.

Feasibility study for the project has been completed by EGAT and the complementation is scheduled to be in 1984. By that time, operation of the Lower Khwae Yai will also have been started and on overall operation plan of those stations in the Basin shall be established.

Upper Khwae Yai Hydroelectric Project

At the location of the Khwae Yai River Basin about 135 KM upstream from the Sri Nagarind, a multi-purpose reservoir with the total storage capacity of 5,380 million cu.m and effective storage capacity of 2,680 million cu.m will be constructed under this project for power generation and flood control. In the initial stage 2 units of generators will be installed for the maximum energy output of 300 MW and annual energy production of 1,158 MKWH. This scale of power development is almost same with the Sri Nagarind Dam.

According to the program by EGAT, the project will be started under the fourth five year development plan and be completed by October 1987. With this reservoir, flood control on the Khwae Yai River will be more effectively realized and more effective water resource utilization would be attained through due coordination with the Sri Nagarind Dam.

Sri Nagarind Hydroelectric Project, STAGE II

Under this project, two additional generators (180 MW each) will be installed for the Sri Nagarind Hydro Power Station to double the capacity at 720 MW. For those additional facilities, reversible pump turbine are to be installed and 6 million cu.m of stored water in the Lower Khwae Yai reservoir will be pumped up by surplus power in midnight.

4. DEVELOPMENT PLAN FORMULATION

4-1. General

During this term of field survey conducted succeeding to the first field survey (March, 1978), further development plans for irrigated agriculture in the Greater Mae Klong Irrigation Project area and the Drainage Project area were provisionally formulated on the following items.

- Agricultural development
- On-farm development
- Irrigation
- Drainage / flood control
- Supporting services

The agricultural development plan as the basis for an overall development plan was formulated on the necessary conditions in future that the water resources development on the Khwae Yai and Khwae Noi Rivers could be fully achieved and the flood control in the Mae Klong River Basin would be attained, and the most effective land use plan was proposed on such conditions.

On-farm development shall play a major role to carry the proposed land use plan to a success. In conceiving the on-farm development plan, case studies were made on the selected sample areas so as to represent various requirements in the project area as derived from various conditions prevailing in the area. Further, discussions were made on the problems/contraints and the measures to be taken in the fields of irrigation drainage/ flood control and supporting services to support the on-farm development in the area.

4-2. Agricultural Development Plan

Agriculture in the project area is to be converted from the existing rainfed/incomplete irrigated agriculture to a complete irrigated agriculture through attaining on-farm development in the area. In parallel with the technical measures, various supporting services shall be fully arranged. When the above two conditions will be fulfilled, the agriculture in the area shall attain the followings.

- Full conversion from broadcasting rice to transplanting rice
- Maximum expansion of double cropping of rice
- Introducing of HYV RD varieties
- Irrigated sugarcane farming
- Practice of improved modern farming
- Strengthened marketing oriented farming to increase farm income

Land Use Plan

Assuming the full development condition at the time of project works completed, a land use plan is proposed as shown in Table 4-1. In principle, no conversion of present land category was considered in this land use plan. While the followings were taken into consideration in the planning.

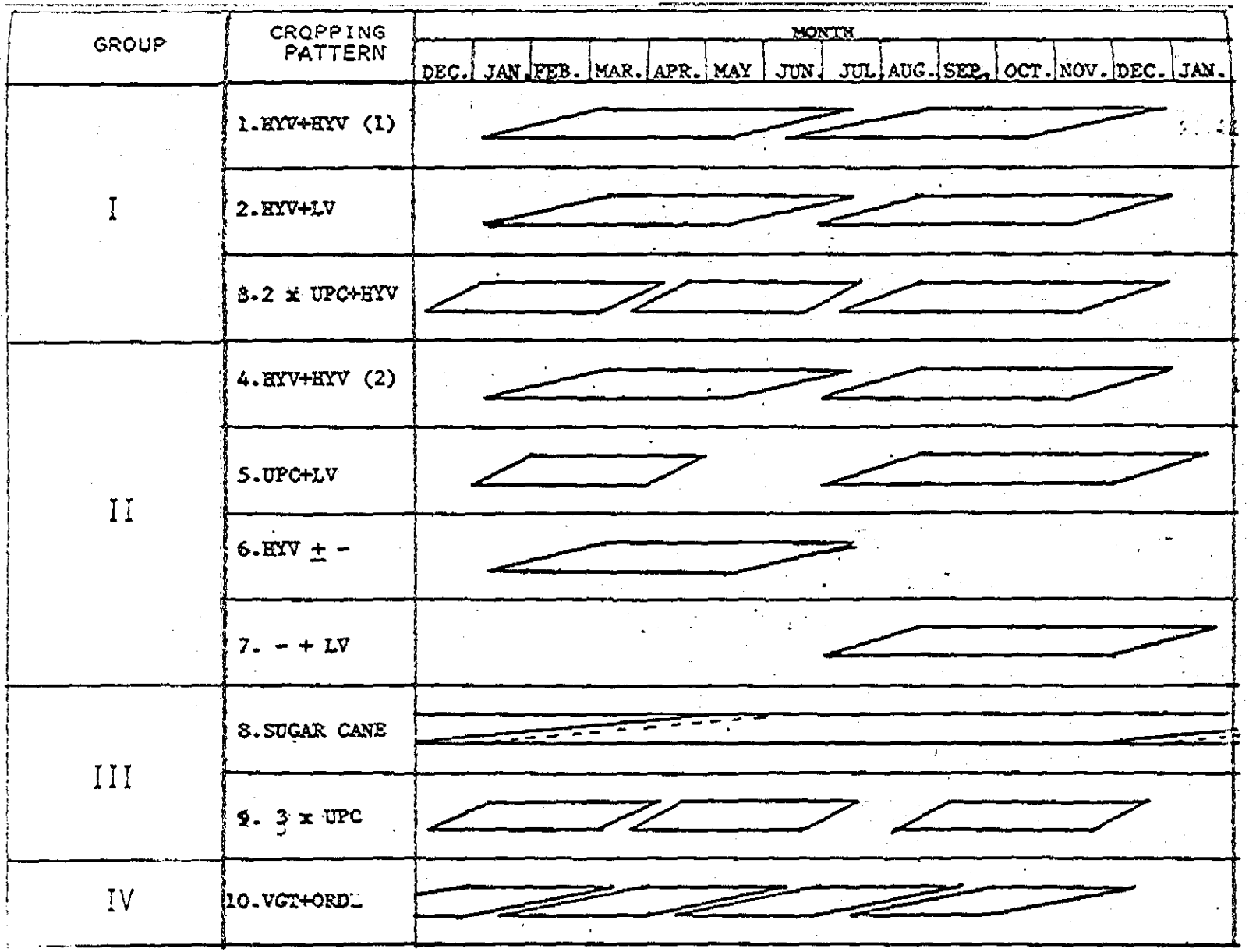
- To raise up the land use efficiency
- Promotion of crop diversification
- Increment net income for farmers
- To accelerate the effect of on-farm development

Table 4-1 Proposed Land Use

	TOTAL CULTIVABLE LAND	PADDY FIELD	UPLAND	TREE CROPS AND VEGETABLE	OTHERS
Stage I					
Upper Part	106.8	64.5	39.4	2.9	
Lower Part	55.1	40.3	-	14.8	
Total	161.9	104.8	39.4	17.7	
Stage II					
East	55.1	41.8	10.0	3.3	
West	86.6	20.2	63.8	2.6	
Upper Right Bank	44.1	36.8	5.5	1.8	
Lower Right Bank	43.6	39.7	-	3.9	
Total	229.4	138.5	79.3	11.6	
Stage I + Stage II	391.3	243.3	118.7	29.3	
Drainage Project Area	19.3	8.1	-	10.1	1.1 *
Grand Total	410.6	251.4	118.7	30.4	1.1 *

Cropping Pattern

Any cropping patterns to be planned are characterized mainly by irrigation condition. In the present report, cropping patterns are worked out on the conditions that required irrigation water can be fully supplied for the project area and the drainage conditions will be improved to the level as planned in the development plan for drainage/flood control in this report. The proposed cropping pattern is as follows.


GROUP
CROPPING PATTERN
MONTH
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
I
1.HYV+HYV (1)
2.HYV+LV
3.2 x UPC+HYV
II
4.HYV+HYV (2)
5.UPC+LV
6.HYV ± -
7. - + LV
III
8.SUGAR CANE
9. 3 x UPC
IV
10.VGT+ORD

Group 1

This cropping pattern is introduced for the areas with a favorable conditions in irrigation and drainage.

Dry + Wet		
1. HYV + HYV (1)	-	The yield will be the highest with this pattern.
2. HYV + LV	-	Local varieties in wet season will remain because of consumer's taste even after the on-farm development.
3. 2 X UPC + HYV	-	This pattern may promote crop diversification.

Group 2

This pattern is introduced for the areas where irrigation water can be supplied at any time though drainage condition is not fully improved as the Group 1 area.

4. HYV + HYV (2)	-	HYV in dry season is an ordinary RD variety. For wet season, BKN 6986-66-2,etc. which will be released by the Rice Division in 1978 will be planted.
5. UPC + LV	-	This combination is for the area where inundation water can be drained out at an early stage in dry season. Irrigation water can be supplied for upland crops too.
6. HYV + —	-	This is an alternative to the pattern 7 and no cultivation can be done in wet season.
7. — + LV	-	This is for a deep inundation area, and broadcasting variety is transplanted for easier weed control.

Group 3

This pattern is for the present sugarcane area. Some part shall be converted to other upland crops depending on the demand in the world market.

8. Sugarcane	-	Irrigation water can be supplied
9. 3 X UPC	-	Crop diversification is to be practised in the present sugarcane area where transportation condition is fair and hired labor is avail[illegible]

Group 4

This pattern is for the present horticulture area in the polder dikes. Irrigation water can be sufficiently supplied.

4-3. On-farm Development Plan

Basic concept

On-farm development plan for the irrigated agriculture in the Greater Mae Klong River Basin was provisionaly formulated as follows based on the proposed agricultural development plan and study results on the rural conditions and topographic conditions in the area.

With respect to the technical measures to be applied, so called intensive method shall be necessary in future. Considering the limited fund and implementation capacity at present and necessity to bring about the irrigation benefit for the larger area at the earliest possible date, however, advantages are also found in the extensive development method, with which the construction cost is much smaller than the intensive method. Attention is, therefore, to be paid on such layouts of main facilities under the extensive method where succeeding intensive development in future may be well suited to the original extensive development.

Outline of plan

From the viewpoint of on-farm development method, the entire project area can be classified into the following four (4) categories.

: Paddy field
  - Flat low-land paddy field
  - Paddy field in a comparatively complicated topography

: Mixed area of upland field with paddy field (Paddy field in upland area)

: Upland field (Sugarcane)

: Horticulture area (Polder area)

Following the above categories, development method to be applied for each area are shown as follows.

Categories	Method	Location
Flat low-land	Extensive	Stage I lower and East Malaiman Low yields with lower standard of farming practices
Complicated topography with considerable slope	Intensive	Areas in Stage I and II where main irrigation facilities are completed Farming level is comparatively high.
Mixed area	Intensive	Upper part of Stage I area with complicated topographic conditions
Sugarcane area	Extensive	Stage II left bank
Horticulture area	Extensive	Polder area in the lower part of Nakhon Pathom and Nakhon Chum

More detailed descriptions on the development plans for each categories are as follows.

Paddy fields

Flat low-land paddy fields are existed in the lower part of Stage I and the part of East Malaiman, Stage II left bank.

In these areas, following conditions are prevailed and constrain further development of irrigated agriculture.

-- Absence of main irrigation canal facilities.

-- Broadcasting is predominant because of poor drainage and un-stabilized irrigation water supply.

Aiming at realizing earlier benefit of on-farm development for a larger area, the extensive method shall be employed for these areas. Irrigation and drainage canals and road facilities are provided. In the layout of major facilities of canals and roads, attention shall be paid on the suitable design for the future intensive development in the areas.

While for some areas where provided with main canals mostly completed, the intensive method shall be applied. Generally, the level of farming practices in these areas are comparatively higher owing to the completed major facilities. Stabilized and increased agricultural production shall be, therefore, achieved in these areas by making the field conditions suitable to double cropping of rice by implementing the intensive method.

Mixed area

Generally, the areas belonging to this category are in rather complicated topography with considerable slope. Because of the different requirements between paddy and sugarcane croppings, there have been conflicts over the water distribution problems. To solve such problems and to enable more effective conversion of crops cultivated depending on the market situation, the intensive method shall be applied for the area.

Sugarcane area

In implementing an on-farm development for the sugarcane area, more improved farming and production are to be attained with providing enough farm roads network and ditches for irrigation water supply. In this case, two (2) types of development are planned, viz. one is to minimize the cost by utilizing as much as possible the existing farm roads and plot boundaries and the other is to level up the land use efficiency by increasing the densities of farm roads and ditches.

Horticulture area

Horticulture area in small-scale polder dikes are existed in the flat low-land of Nakhon Pathom, Nakhon Chum and Ratchaburi left bank. The polder dikes are utilized for protecting excess water intrusion in wet season and for securing water supply in dry season. Present land use pattern and plot size will not be changed under the proposed plan, and only measures for irrigation water supply and drainage improvement are to be implemented including farm roads networks.

Zoning of the Project area

The whole project area was divided into 6 blocks under the on-going project. In this term of field survey, the same was further divided into 13 zones considering the optimum size of project implementation for on-farm development. 13 zones are composed of 5 zones from Stage I area, 2 zones from Stage II Right Bank and 6 zones from Stage II Left Bank.

In determining the zoning, attention was paid on the present and future irrigation/drainage networks, land use and the O & M offices' responsible areas. Composition of zoning with each acreages are as shown in Table 4-3. It is considered necessary to review the zoning from the viewpoints of the on-farm development method applied, estimated cost, construction capacity and available funds and so on.

4-4. Irrigation Development Plan

Acreages

During this term of field survey, acreages on the gross project, gross arable and net cultivable areas and so forth of the Greater Mae Klong Irrigation Project including the Drainage project area were confirmed and fixed as follows.

	Acreage (1,000 ha)					
	Gross Project Area	Non Arable Area	Gross Arable Area	Net Cultivable Area	Non Commandable Area	Commandable Area
Greater Mae Klong Irrigation Project						
Stage I						
Upper Part	127.8	7.4	120.4	106.8	15.3	91.5
Lower Part	63.3	1.2	62.1	55.1	0.9	54.2
Total	191.1	8.6	182.5	161.9	16.2	145.7
Stage II						
East Malaiman	68.6	4.5	64.1	55.1	4.3	50.8
West Malaiman	102.1	1.7	100.4	86.6	6.8	79.8
Upper Right Bank	50.4	4.5	45.9	44.1	2.0	42.1
Lower Right Bank	53.9	8.6	45.3	43.6	1.0	42.6
Total	275.0	19.3	255.7	229.4	14.1	215.3
TOTAL	466.1	27.9	438.2	391.3	30.3	361.0
Drainage Area	24.5			19.3		

Note:
1. Acreages on the East Malaiman and West Malaiman, Stage II are based on the information furnished by the Design Division, RID.
2. Non-irrigable areas due to the lack of farm ditches are included in the commandable area as those area can be irrigated after on-farm development.
3. Non-commandable areas are those higher lands which cannot be irrigated by gravity system.

Development Plan

For the constraints for further development of irrigated agriculture in the area, the following counter-measures are considered.

Unit water requirement and insufficient canal capacity

All of the major irrigation canals for the Stage I area and the Stage II Right Bank area was designed and constructed/ under construction based on the unit water requirement of 0.75 l/sec/ha. Thia unit water requirement is a diversion requirement for wet season rice (effective rainfall is taken into account) as computed on the basis of maximum water requirement which was confirmed in the Sam Chok Agricultural Experimental Station. The unit water requirement of 0.75 l/sec/ha is, therefore, not sufficient for dry season rice cropping.

The following three (3) measures can be considered for this constraint.

-- Increase of canal capacity

i) Heightening of canal embankment
ii) Enlargement of canal width

However, there remains a problem of limited capacity of Vajiralongkorn Dam for i) and land acquisition problem for ii).

-- Provision of different canal network

i) Considering the network from the Vajiralongkorn Diversion Dam, land acquisition problem would be more serious than enlargement of canal width.

ii) In the case of constructing another diversion dam on the Mae Klong River, possible increase of irrigated area will be the key factor as the construction cost would be rather higher.

-- Restriction in land use

Unit water requirement can be fixed at lower amount with a limited land use in dry season. This is the most passive measure in view of the development strategy.

Irrigation plan for non-commandable area

Heightening of existing canal embankment and pumping up method can be considered for this problem. By heightening, with level can be lifted of only to some extent though such non-commandable areas scattered over the area can be converted to commandable area with rather low cost.

While in the case of pumping up method, the difference in elevation would not be any problems if the area is of a certain large acreage. However, irrigation for those scattered areas with smaller acreages cannot be easily irrigated.

Irrigation method for the lower part, Stage I

The lower part, Stage I occupies 54,200 ha of commandable area with the elevation mostly lower than El. 2.0 m and quite flat topography. The flood water from the Mae Klong River affects much to this area. Irrigation plan for this area is to be formulated based on the following conditions.

- No more flood water intrusion owing to the dam constructed on the Khwae Noi River.
- Topographic condition is flat low-land.
- Unit water requirement of 0.75 l/sec/ha is secured.
- Highly intensive land use is practised in a considerable extent for fruit trees and vegetables on individual basis.
- Irrigation plan for this area is closely related with the development method for the neighboring drainage project area, south of the Damnoen Saduak Canal.

With the conditions as described above, the development methods are considered as follows.

- Water level of the Damnoen Saduak Canal shall be lowered down to improve the drainage conditions.
- Irrigation method
  : Separated system of irrigation and drainage canals

    This system can be applied for any areas in various topographic conditions.

  : Dual-purpose canal system

    This can be applied only where topographic condition is extremely flat. Dual-purpose canal is only for main system, and on-farm level, the separated system shall be provided. In this case, pump facilities are needed.

Development method for the drainage project area

The drainage project area occupies 24,500 ha of gross area as bounded by the National highway along the Gulf of Thailand and the Damnoen Saduak Canal. The natural and social conditions prevailed in this area are similar to the Stage I lower part area with only some different conditions as follows.

- No irrigation water source is secured for the area. Therefore, inundation irrigation is practised in wet season by utilizing the excess water from the Stage I area. In dry season, transplanting rice is cultivated for about 5,000 ha area with irrigation water supply mainly by pumps.

- Being close to the sea, sea dikes are completed around the area as the measure for salt injury, and excess water is drained out to the Gulf of Thailand through regulators.

Development method to be applied for this area could be quite similar to that for the lower situated areas of the Stage I lower part.

4-5. Drainage/Flood Control Plan

Excess water in the project area is drained out to rivers and/or outer area through natural drains and irrigation/drainage dual purpose canals. However, almost none of drains are existed at on-farm and inter-farm level. In the flat low-land areas, controlled flood water is used for broadcasting rice cropping and in the upper part, transplanting rice of local varieties is practised. Those varieties presently used are of inundation-proof rice varieties. Rice cultivation is practised in such conditions and no drainage control is carried out at on-farm and inter-farm level.

Drainage problems in the area can be classified into the following four (4) cased in accordance with the cause.

I) Lack of drainage system.
II) Sometimes, outer water level is higher than inner water level.
III) Runoff intrusion from the higher part.
IV) Inundation in depressions.

Case I) can be found in any part of the project area, for which the drainage improvement project is on-going by RID and further improvement can be achieved through implementation of on-farm development project.

Case II) is happened in the Stage II Right Bank area and the areas along Song Phi Nong and Nakhon Chaisi Rivers. To lower the river water level in the Mae Klong, a river improvement plan was studied by RID, but due to the problems on cost and disposal of dredged soil, the plan was abandoned. The most effective way is to control floods by reservoir operation on the Mae Klong River so as to lower the river water level. In other words, drainage improvement can not be effectively done in the Mae Klong Right Bank area without lowering of the river water by relieving the floods on the Mae Klong River.

Runoff condition in the Nakhon Chaisi River has been considerably improved after the completion of the Bhumibol and the Sirikit Dams.

The Right Bank and Malaiman areas receive runoff from the western mountainous areas and the Stage I lower part from its upper areas. In the Right Bank area, construction works for main drainage system are going on, and the runoff may be drained out to the Mae Klong River without flooding the area when the flood relieving can be attained in future. For Malaiman area, it seems necessary

to construct a catch canal along the foot of the mountainous area so as to drain out the runoff from Song Phi Nong River to Nakhon Chaisi River.

For the purpose of water supply for wet season broadcasting rice in the both banks (Right bank-Mae Klong, Left Bank-Chao Phya), river water level is checked up in the Song Phi Nong River. After the completion of irrigation system, irrigation water supply for the Right Bank can be done through this system, though check up of river water level shall be necessary for the Left Bank area. In this case, to raise up the land use efficiency in the Right Bank area, the existing provincial road located in parallel with the River can be heightened by utilizing the embankment materials as obtained from irrigation canal excavation, so that the Right Bank area can be protected from flood water (artificially controlled) intrusion. Outside area of the embankment has to be planted to broadcasting rice. For inside area, excess water can be drained out to the Nakhon Chaisi River at lower than the Song Phi Nong Regulator through the new drainage system.

Runoff from the upper part to the lower part, Stage I, are checked up in the main drainage canals in the lower part and utilized for broadcasting rice. In this area, flood damage occurs when there is a flood water intrusion from the Mae Klong River. Irrigation water supply for this flat low-land, Stage I is included in the Greater Mae Klong Irrigation Project, though no construction of irrigation canal is undertaken as the area is a customary flood area of the Mae Klong River. However when the area is equipped with an irrigation system, irrigation water is secured, and check-up of water in drainage canals in wet season will not be necessary when water level of Damnoen Saduak canal in wet season can be lowered down, drainage conditions in this area would be consideably improved.

Local depression areas scattered over the project area and the lower areas along natural levees are usually inundated with excess water from the other areas. For these areas, drainage canals have to be independently excavated to drain out the water to rivers or to outside of the project area. However, these depressions have a function as flood storage basin and it may adversely affect the drainage condition in the lower part, unless a proper drainage system be designed. Generally, in designing drainage system in paddy field area, it is necessary to take into account the flood storage function of paddy field itself and the fact that rice plant can stand with the inundation depth to some extent.

In the drainage project area located at the south of the Damnoen Saduak Canal, the canal and the branches are utilized for dual purpose of irrigation and drainage. Lower parts in the area

get water from the canal by gravity in wet season and cultivate broadcasting rice, while in the upper part water is supplied by pumping up and fruit trees and vegetables are cultivated with higher productivity. Under the present condition in which water source is not secured, water level has to be maintained as high as possible and the lower part shall be encircled by polder dikes. Further, pumps is needed for draining out of excess water. In order to make the land use efficiency higher in this area, water source shall be secrued first and be distributed with higher water level. On the other hand, drainage can be done through the existing canal and regulators to the Gulf of Thailand and maintain the water level in the canal as low as possible. In this case, however, difficulties can be pointed out in the high cost and technical problems caused by a construction of canal with high water level in this flat low-land. Though water management shall be made by using pumps, it seems that water management oan be done quite reasonably in the dual prupose canal. In this case, drainage condition not only in the drainage project area but also the lower part, Stage I would be improved because of no need for maintaining water level in the Damnoen Saduak Canal, though water source shall be fully secured.

Drainage problems in the project area are mostly for those areas along the Mae Klong River. For this, the most effective measure can be achieved when the floods on the Mae Klong River can be relieved. The EGAT is implementing the Sri Nagarind Dam on the Khwae Yai River and a plan was prepared by EGAT to construct the Khao Laem Multi-purpose Dam on the Khwae Noi River, another main source of flood in the Mae Klong River Basin. According to these development plans, owing to the flood control by the Sri Nagarind and the Khao Laem Dams, the flood in the Mae Klong River can be controled to be less than 3,000 cu.m/s and 4,050 cu.m/s with the return period of 20 years and 100 yeas, respectively.

4-6. Supporting Services

After the completion of various agricultural infrastructures, e.g. water resources, irrigation and drainage improvements and on-farm development, the supporting services classified as follows shall be provided for the farmers to realize the modern improved agriculture based mainly on the double cropping of rice (HYV) in the project area.

- Development of new farming technology
- Breeding of new varieties
- Extension of new farming technology
- Multiplication and distribution of new varieties
- Practice of rational and effective water usage
- Training for farmers
- Agriculture education
- Establishment of systematic agricultural statistic arrangement
- Supply of farm input
- Establishment of improved marketing system for the agricultural products
- Credit supply
- Farmers' organization

In Thailand, the above-mentioned items belong to the responsibilities of many government agencies, and sometime services for specific field duplicate in some plural organizations. Therefore, there are various difficulties in integrating each supporting services. But, farmers' self-consciousness, self-support and mutual cooperation will become more important in achieving agricultural development through overcoming various difficulties in the present situations. Supporting services are being undertaken mainly by the government offices, and the Government should implement each item according to the priority with limited funds, taking into consideration the farmers' requests. After due consideration on previous reports on supporting services, insufficient facilities and inadequate functions will have to be improved to comply with future needs with on-farm development.

Lower income farm management due to low yielding under reinfed condition will turn into advantageous one under irrigated agriculture. Inevitably, farm management will become complicated, and new farming knowledges will be necessary to comply with the advanced agriculture production systems. From the viewpoint of the above all, it can be said that agriculture education for youth who will take responsibilities in future agriculture sector will be very important so as to change the traditional self-sufficient agriculture to marketing oriented one.

In order to introduce double cropping of rice, it seems necessary that irrigation water be distributed systematically in accordance with the crop rotation. To achieve an improved water management, an establishment of new organization in which representatives from various government agencies join together might be necessary.

Further, introduction of post-harvesting facilities for harvesting during wet season has been examined. By the next survey in 1979, stage development plan for supporting services is to be proposed to eliminate those restrictive factors for modernized agriculture with higher productivity.

ANNEXES

ANNEXES

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TABLE: B-1 ACREAGE OF MAJOR SOIL SERIES IN THE PROJECT AREA (unit: 1,000 ha.)

1.	Tidal flat	7.0
	Samut Song Khram	5.6
	(Tha Chin, Samut Prakan, very soilin phase...)	1.4
2.	Former tidal flat with recent marine and brackish water deposits	82.3
	Bang Len	26.1
	Dumnoen Saduak	14.2
	Bang Phae	9.9
	Bangkok	9.5
	Samut Prakan	4.8
	Bang Len, Calcareous	4.3
	(Bang Len,overwash phase.Thon Buri,Hua Hin,Phan Thong....)	13.5
3.	Former tidal flat with old marine and brackish water deposits	81.2
	Ayutthaya	40.9
	Sena	21.9
	Bang Khen	16.6
	(Rangsit, Tha Khwang.....)	2.1
4.	Flood plains of recent river alluvium	59.4
	ChaiNat, calcareous/Ratchaburi, mildly alkaline	18.9
	Ratchaburi, mildly alkaline	12.4
	Bang Pa - in	7.5
	(Sing Buri.Sing Buri,acid substratum.Tha Muang, calcareous. Tha Muang/Chai Nat.....)	20.6
5.	Low terraces of semi - recent river alluvium	190.9
	Kamphaen Saen/Nakhon Pathom	106.7
	Kamphaen Saen	39.4
	Nakhon Pathom	14.1
	Sara Buri,Sara Buri,acid substratum & marine substration	13.1
	Petchaburi	9.4
	Nakhon Phanom,brown mottle/Nakhon Phanom	6.8
	(Soil series is not clear)	1.4
6.	Low terraces of old alluvium	41.9
	Khao Yoi/Pak Tho	35.3
	(Tha Phanom concretionary Variant/Khao Yoi/Phak Tho.Renu/Khao Yoi)	6.6
7.	High terraces of old alluvium	1.9
	(Yang Talat.Don Rai.Yang Talat,mottled variant...)	1.9
8.	Erosion terraces and foot - hills	0.9
	(Takhli. Colluvial complex...)	0.9
9.	Hills	0.6
	Total:	466.1

NOTE: 1. Acreage of each soil series were measured by plainmeter using 1:250,000 scale soil map provided for M/P study.

2. Acreage of parentheses include minor soil series and undefined soil series area.

TABLE B-2 GROSS AREA BY THE BLOCK IN THE MAE KLONG PROJECT AREA

(UNIT: 1,000 HA)

Landclass groups	STAGE I			STAGE II							Total
				Mae Klong Left Bank			Mae Klong Right Bank			Sub Total	
	Upper	Lower	Sub Total	East Malai-man	West Malai-man	Sub Total	Upper	Lower	Sub Total		
Project Gross	127.8	63.3	191.1	68.6	102.1	170.7	50.4	53.9	104.3	275.0	466.1
Non Arable	7.4	1.2	8.6	4.5	1.7	6.2	4.5	8.6	13.1	19.3	27.9
Arable Gross	120.4	62.1	182.5	64.1	100.4	164.5	45.9	45.3	91.2	255.7	438.2

Note: Non-arable Land means Unsuitable Land for the Production of Crops (Class 6)

TABLE B-3 NET CULTIVABLE AREA AND LAND CLASS GROUP BY THE BLOCK IN THE MAE KLONG PROJECT AREA

(UNIT: 1,000 HA)

Landclass groups	STAGE I			STAGE II							Total
				Mae Klong Left Bank			Mae Klong Right Bank				
	Upper	Lower	Sub Total	East Malai-man	West Malai-man	Sub Total	Upper	Lower	Sub Total	Sub Total	
U 1	22.1	-	22.1	2.7	41.7	44.4	1.2	1.7	2.9	47.3	69.4
U 2	1.2	-	1.2	3.5	10.3	13.8	3.5	2.2	5.7	19.5	20.7
U 3	1.1	-	1.1	-	1.7	1.7	-	1.1	1.1	2.8	3.9
U 2/R 2	21.3	0.4	21.7	2.4	6.6	9.0	6.6	3.3	9.9	18.9	40.6
R 1	46.0	38.8	84.8	6.7	24.1	30.8	23.4	25.9	49.3	80.1	164.9
R 2	15.1	15.9	31.0	39.8	2.2	42.0	9.4	9.4	18.8	60.8	91.8
Total Net Cultivable	106.8	55.1	161.9	55.1	86.6	141.7	44.1	43.6	87.7	229.4	391.3
U 1 + U 2	23.3	-	23.3	6.2	52.0	58.2	4.7	3.9	8.6	66.8	90.1
U 2 / R 2	21.3	0.4	21.7	2.4	6.6	9.0	6.6	3.3	9.9	18.9	40.6
R 1 + R 2	61.1	54.7	115.8	46.5	26.3	72.8	32.8	35.3	68.1	140.9	256.7

Note: Net cultivable area = Arable gross areas minus roads, water courses, etc.

Table B-4

SOIL SERIES AND SOIL SUITABILITY IN THE DRAINAGE PROJECT AREA

SOIL SERIES	SUITABILITY		ACREAGE
	UPLAND FIELD	PADDY FIELD	(10^3ha)
Bangkok	U-IVf	P-I	2.0
Bangkok,low phase	U-IVd	P-I	9.6
Bang Nam Prieo	U-IVf	P-IIa	0.2
Samut Prakan	U-Vd	P-IIIx	0.8
Dammoen Saduak	U-IIIt	P-Vt	8.1
Samut Songkhram	U-Vt	P-Vt	0.7
Tha Chin	U-Vx	P-Vx	2.2
Samut Prakan, very saline phase	U-Vx	P-Vx	0.9
Total			24.5

Table B-5

SUMMARY OF LANDCLASSIFICATION

	ARABLE GROSS	NET CULTIVABLE
P-I	11.6	10.44
P-II	0.2	0.18
P-III	0.8	0.72
Subtotal	12.6	11.34
U-III	8.1	7.29
U-V/P-V	0.7	0.63
Total	21.4	19.3
Unsuitable	3.1	
Project Gross	24.5	

Note: Net Cultivable Area = Arable Gross Areas Minus Roads, Water Courses,etc.

TABLE 6.1 CLIMATOLOGICAL DATA

STATION	LOCATION LATITUDE	LONGITUDE	ELEVATION OF STATION MSL m.	HEIGHT OF WIND VANE ABOVE GROUND m	DATA PERIOD	
Suphan Buri	14 30'N	100 10'E	7.00	15.8	1951 - 1975	*-1
Uthong	14 23'N	99 54'E			1967 - 1978	*-2
Khanchanaburi	14 01'N	99 32'E	28.00	11.40	1951 - 1975	*-1
Khamphaeng Saen	14 00'N	99 59'E			1973 - 1978	*-2
Don Muang	13 55'N	100 36'E	12.00	18.80	1951 - 1975	*-1
Bangkok	13 44'N	100 30'E	2.30	23.38	1951 - 1975	*-1

Monthly Mean Temperature (c)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Suphan Buri	26.1	28.5	30.5	31.8	30.7	29.9	29.2	28.9	28.4	28.0	27.0	25.6	28.7
Uthong	24.4	26.9	29.2	30.6	29.8	29.3	28.9	28.7	28.0	27.1	25.5	24.6	27.8
Khanchanaburi	25.5	28.1	30.2	31.4	29.9	28.7	28.2	28.1	27.9	27.1	26.1	24.8	28.0
Khamphaeng Saen	24.8	26.4	28.8	30.3	29.0	28.6	28.2	28.0	27.6	26.9	24.6	23.1	27.2
Don Muang	26.0	27.4	28.9	29.8	29.3	28.7	28.2	28.0	28.2	28.1	27.4	25.6	28.0
Bangkok	25.5	27.1	28.6	29.5	29.0	28.5	28.0	27.8	27.5	27.4	26.6	25.3	27.6

Monthly Mean Relative Humidity (%)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Suphan Buri	64	65	63	63	69	71	73	75	80	80	75	68	70
Uthong	65	63	63	63	69	70	71	71	76	79	75	68	69
Khanchanaburi	63	60	58	60	70	73	74	74	78	80	75	67	69
Khamphaeng Saen	69	67	65	65	72	72	72	74	77	78	77	72	72
Don Muang	67	70	70	71	74	74	75	80	78	77	74	69	73
Bangkok	73	76	77	77	80	80	81	82	84	83	79	74	79

Monthly Mean Wind Velocity (m/sec)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Suphan Buri	3.0	3.0	3.6	3.6	3.5	3.9	3.9	3.8	3.1	3.1	3.6	3.5	3.5
Uthong	2.3	2.5	3.4	3.2	3.3	4.0	3.8	3.6	2.0	2.1	3.4	3.3	3.1
Khanchanaburi	1.8	2.0	2.2	2.3	2.2	2.2	2.4	2.4	2.0	1.7	1.9	2.0	2.1
Khamphaeng Saen	1.8	1.8	2.3	2.2	1.8	2.3	2.2	2.2	1.4	1.6	2.4	2.8	2.1
Don Muang	3.0	3.8	4.1	4.0	3.8	3.7	3.5	3.7	3.4	3.1	3.1	2.0	3.4
Bangkok	2.0	2.7	3.0	2.9	2.4	2.5	2.4	2.4	2.0	1.8	1.9	1.8	2.3

Monthly Mean Sunshaine Hours Duration (hours/day)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR	
Suphan Buri				(NO OBSERVATION)										
Uthong	7.71	8.11	7.95	8.39	6.79	5.04	4.16	3.75	5.14	6.25	7.60	6.99	6.49	*-2
Khanchanaburi				(NO OBSERVATION)										
Khamphaeng Saen	7.75	8.03	7.85	8.35	6.37	5.67	5.00	4.24	5.32	6.44	7.60	8.24	6.74	*-2
Don Muang				(NO OBSERVATION)										
Bangkok	9.11	8.95	8.79	8.68	7.27	6.49	5.46	5.34	5.18	6.69	8.28	8.23	7.41	*-2

Monthly Mean Evaporation (Pan-A class, mm/month)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Suphan Buri	131.2	134.1	178.4	198.9	186.8	166.4	158.7	156.1	137.2	115.6	123.2	126.3	1,812.9
Uthong	149	158	230	237	230	208	209	202	156	163	149	158	2,249
Khanchanaburi				(NO OBSERVATION)									
Khamphaeng Saen	153	164	226	246	189	192	177	174	147	141	143	162	2,114
Don Muang				(NO OBSERVATION)									
Bangkok	132.8	139.2	179.8	182.6	162.6	145.8	141.6	140.3	126.2	120.7	118.8	123.9	1,714.3

Data Source: *-1: Climatological Data of Thailand 25 year period (1951-1975) Meteorological Department.
*-2: Agrometeorological Division, Meteorological Department.

TABLE C-2 MONTHLY MEAN RAINFALL

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Khwae Noi River Basin													
Pilok	7	9	22	64	393	898	1,129	1,180	773	211	22	8	4,716
Sangkhla Buri	4	12	31	75	244	427	499	441	379	168	27	3	2,310
Thong Pha Phum	4	17	35	74	173	268	357	311	215	122	21	2	1,599
Sai Yok	3	25	50	95	170	113	127	164	204	181	49	3	1,184
Khwae Yai River Basin													
Umphang	9	10	28	81	140	175	231	261	262	141	30	6	1,374
Si Sawat	7	39	38	98	144	97	109	112	191	174	38	6	1,053
Lam Tapern River Basin													
Bo Pholoi	4	13	50	81	122	63	88	123	216	188	38	5	991
Lam Pachee River Basin													
Chom Bung	3	15	21	77	164	116	153	175	285	277	98	10	1,393
Kanchanaburi	2	10	31	75	146	88	99	102	234	220	62	8	1,077
Project Area	3	11	18	46	132	112	118	139	227	210	56	8	1,080

Note: Rainfall only in project area is computed by useing data at 21 representative stations

Table: C-3

ANNUAL DISCHARGE IN MAE KLONG RIVER BASIN

Main River	Khwae Yai	Khwae Noi	Mae Klong
Chatchment Area(1)	14,810 sq.km	10,640 sq.km	27,660 sq.km
Length	380 km	315 km	130 km

Tributary	Lam Tapern	Huai Mae Nam Noi	Lam Pachee
Chatchment Area(2)	2,500 sq.km		2,660 sq.km
Length			

Gaging Station	K6	K20	K27	K12	K13	K9	K10	K22	K22A	K17	K8	K4	K11	K1
Record Period	57-67	66-76	68-76	65-76	65-76	62-74	65-77	66-69	69-76	66-77	57-69	43-69	65-76	60-67
C.A.(sq.km)(3)	10,802	11,184	1,191	2,340	4,047	6,902	7,008	312	321	1,355	26,421	26,441	26,449	-
(3)/(1)or(2)(%)	73	76	48	94	38	65	66	-	-	51	96	96	96	-
Mean Annual Discharge														
(CMS)	146	137	3.6	3.0	173	200	200	6.0	10.1	6.9	368	377	353	396
(MCM)	4,600	4,320	114	95	5,460	6,310	6,310	189	319	218	11,600	11,900	11,100	12,500
Annual Specific Runoff														
(4)/(3)X 10^3(mm)	390	386	96	41	1,349	914	900	606	994	161	439	450	420	-

Note: Discharge at k11 is less than acctual discharge of Mae Klong River, because of intake at Vajiralongkorn Diversion Dam.

TABLE C-4 MONTHLY AND ANNUAL DISCHARGE IN MAE KLONG RIVER BASIN

	MONTHLY MEAN DISCHARGE (CMS)												ANNUAL	
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	(CMS)	(MCM)
Khwae Yai River *-2	53.3	39.9	33.1	29.2	44.5	86.0	182.7	352.5	422.6	400.8	160.9	81.6	158.0	4,983
Kang Kieng (K6)	44.6	32.8	25.4	23.2	35.5	74.3	170.5	308.5	424.7	411.0	128.1	68.8	145.6	4,580
Srinagarind Dam *-1	49.0	36.7	30.4	26.8	40.9	79.0	167.9	324.0	388.4	368.4	147.9	75.0	145.2	4,579
Wang Masang (K20)	50.0	35.9	29.1	28.3	41.1	83.4	167.8	314.5	362.2	308.0	147.7	76.9	137.1	4,324
Khwae Noi River *-3	42.3	25.6	18.7	14.7	34.6	173.2	477.4	763.8	593.5	381.7	222.8	70.2	228.2	7,197
Khao Laem Dam *-1	24.9	14.9	10.5	8.9	22.9	133.4	335.9	585.0	442.6	278.5	84.1	44.8	166.7	5,258
Tha Khanun (K13)	26.8	18.4	14.5	12.9	30.7	175.8	402.6	591.0	436.7	234.2	85.9	43.7	172.8	5,449
Wang Pho (K9)	35.3	25.6	20.3	17.7	31.4	157.0	439.5	642.5	545.2	326.7	100.3	53.5	199.6	6,295
Lum Sum (K10)	38.7	27.7	22.6	19.3	36.8	204.1	425.3	634.1	506.0	303.8	120.9	59.9	199.9	6,304
Mae Klong River *-1	95.6	65.5	51.8	43.9	79.1	259.2	660.1	1116.3	1016.1	782.5	283.7	151.8	386.2	12,180
Ban Tham (K8)	97.7	70.0	54.3	46.4	69.0	211.6	532.6	932.2	1049.5	897.9	303.2	155.6	368.3	11,615
Tha Muang (K4)	115.5	86.5	69.4	67.0	93.8	239.5	511.5	1003.7	962.4	818.5	376.6	179.1	377.0	11,889
Ban Wang (K11)	103.5	73.1	54.9	49.4	75.7	293.0	556.5	955.7	875.5	701.2	334.1	167.2	353.3	11,142
Lam Tapern River (K21)	0.9	0.3	1.0	0.4	0.4	0.3	0.1	0.2	6.6	20.4	8.7	3.5	3.6	113
Lam Pachee River (K17)	1.9	1.0	0.8	1.1	2.3	3.7	2.2	4.7	7.8	28.5	21.4	7.7	6.9	218

Note: *-1 Estimated by EGAT 1952-1975 (report: Benefit Derivation of Khao-Laem Project, Dec. 1977 EGAT)

*-2 Estimated with following formula:

$$Qy = \frac{Ay}{As} \cdot d \cdot Qs = \frac{14,800}{10,880} \times 0.8 \cdot Qs = 1.088\ Qs$$

Qy = Runoff of Khwae Yai River at the confluence with Khwae Noi River. (cms)
Ay = Catchment area of Khwae Yai River at the confluence. 14,800 sq.km.
As = Catchment area of Srinagarind Dam. 10,880 sq.km.
d = Specific runoff ratio.
Qs = Runoff at Srinagarind Dam site. (cms)

(reffered report: Feasibility Report Khwae Yai No.1 Hydroelectric Project, Volume 1, Mar. 1968, EPDC)

*-3 Estimated with following formula:

$$Qn = Qm - Qy$$

Qn = Runoff of Khwae Noi River at the confluence with Khwae Yai River (cms)
Qm = Runoff of Mae Klong River at Tha Muang (Vajiralongkorn Dam) (cms)
Qy = Runoff of Khwae Yai River at the confluence with Khwae Noi River (cms)

K4 - K21 : based on observed records

TABLE C-5

WATER RESOURCES DEVELOPMENT IN MAE KLONG RIVER BASIN

WATER RESOURCES DEVELOPMENT	RIVER	LOCATION	CONSTRUCTION PERIOD	ADMINISTRATION	AIM
Vajiralongkorn Diversion Dam	Mae Klong	Tha Muang	-	RID	Irrigation for Greater Mae Klong Irrigation Project
Srinagarind Dam	Khwae Yai	km upstream of Khanchanaburi	under Construction 1974 - Jan. 1979	EGAT	Multipurpose - Power generation - Irrigation especially for dry season - Flood control - Control of salt intrusion - Others
Ban Tha Thung Na Dam	Khwae Yai	28 km downstream of Srinagarind Dam	under Construction 1977 - 1982	EGAT	Regulating Dam - Regulating of peak flow from Srinagarind Dam - Power Generation
Khao Laem Dam	Khwae Noi	150 km upstream of Khanchanaburi	proposed ? - 1984	EGAT	Multipurpose - Power generation - Flood control - Irrigation - Water supply to Bangkok - Domestic Water, Pollution and Salt Control
Reregulating Dam	Khwae Noi	Kaeng Puan or Khao Kwang	proposed ? - ?	?	Regulating Dam - Regulating of peak flow from Khao Laem Dam - Irrigation especially for Stage III zone

Table F-1

ZONE ACREAGE ON THE PROJECT AREA

(unit: 1,000 ha)

STAGE & BLOCK	NET CULTIVABLE AREA	ZONE	NET CULTIVABLE AREA	REMARKS
STAGE I				
Upper Part	106.8	I-1	37.4	Paddy 64.5
		I-2	34.2	Sugarcane 39.4
		I-3	35.2	Tree Crop &
Sub-total	106.8		106.8	Vegetable 2.9
Lower Part	55.1	I-4	29.2	Paddy 40.3
		I-5	25.9	Sugarcane --
Sub-total	55.1		55.1	Tree Crop &
Total	161.9		161.9	Vegetable 14.8
STAGE II				
Upper Right Bank	44.1	II-1	44.1	Paddy 36.8 Sugarcane 5.5 Tree Crop & Vegetable 1.8
Lower Right Bank	43.6	II-2	43.6	Paddy 39.7 Sugarcane -- Tree Crop &
Sub-total	87.7		87.7	Vegetable 3.9
STAGE II				Paddy 41.8 Sugarcane 10.0
East Malaiman	55.1	II-3	28.1	Tree Crop &
		II-4	27.0	Vegetable 3.3
West Malaiman	86.6	II-5	22.5	Paddy 20.2
		II-6	23.4	Sugarcane 63.8
		II-7	19.9	Tree Crop &
		II-8	20.8	Vegetable 2.6
Sub-total	141.7		141.7	
Total	229.4		229.4	Paddy 243.3 Sugarcane 118.7
Grand Total	391.3		391.3	Tree Crop & Vegetable 29.3

Table K-1

TRAFFIC VOLUMES FOR FIVE YEARS (1972-1976)

Route No. (station, km)	Termination	1972	1973	1974	1975	1976
4	Bangkok - Nakhon Pathom	12,878	12,460	14,193	15,512	17,913
(41.5)	(Ratio)	(100)	(97)	(110)	(120)	(139)
	% of Truck, Bus	52	49	54	54	53
4	Nakhon Pathom - Ratcha Buri	7,156	6,110	5,970	7,812	8,300
(80.0)	(Ratio)	(100)	(85)	(83)	(109)	(116)
	% of Truck, Bus	60	66	73	73	73
4	Ratcha Buri - Petcha Buri	3,836	3.283	2,677	3,159	3,533
(119.5)	(Ratio)	(100)	(86)	(70)	(82)	(92)
	% of Truck, Bus	60	68	70	71	74
35	Thonburi - Pak Tho	-	3,439	4,114	5,193	7,067
(30.7)	(Ratio)	-	(100)	(120)	(151)	(205)
	% of Truck, Bus	-	47	49	55	52
321	U-Thong - Nakhon Pathom	1,616	1,977	1,782	2,582	2,545
(111.0)	(Ratio)	(100)	(122)	(110)	(160)	(157)
	% of Truck, Bus	57	63	67	62	85
323	Bang Pong - Kanchana Buri	2,732	3,911	3,381	4,350	6,469
(108.3)	(Ratio)	(100)	(143)	(124)	(159)	(237)
	% of Truck, Bus	65	70	69	62	74
324	Bang Pong - U-Thong	913	1,011	1,068	1,400	1,363
(12.0)	(Ratio)	(100)	(111)	(117)	(153)	(149)
	% of Truck, Bus	80	82	82	81	85
325	Bang Phae - Samut Songkram	1,647	2,032	1,813	1,892	2,111
(3.3)	(Ratio)	(100)	(123)	(110)	(115)	(128)
	% of Truck, Bus	60	58	64	62	54

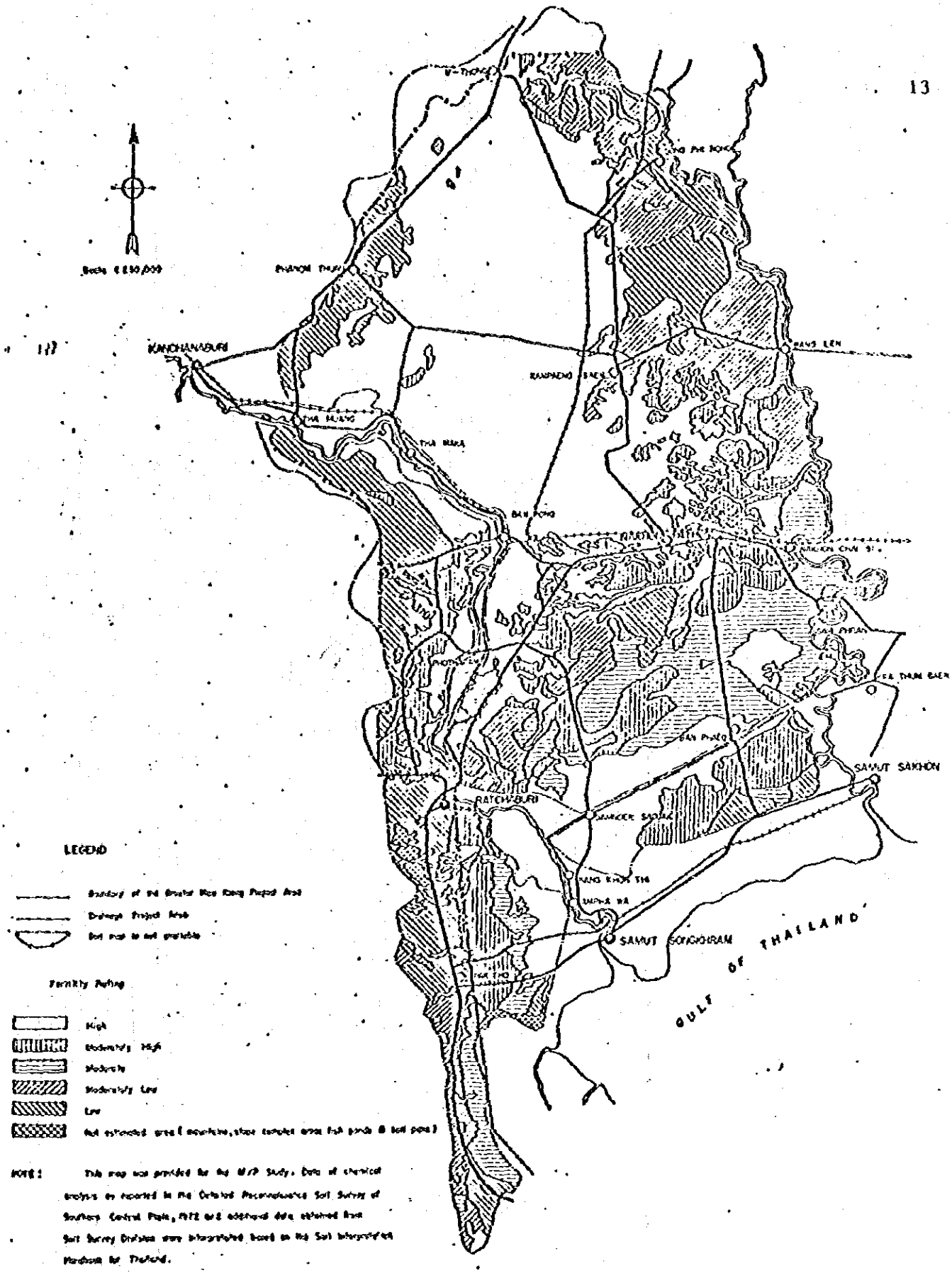
Source: Planning Division, Department of Highway, Ministry of Communications.

Table K-2

Navigation Lock: Data for Five Years (1973 - 1977)

	1973	1974	1975	1976	1977
(1) Krathum Ban					
Rowing boat (vessels)	-	59,174	57,095	48,850	34,873
Launch (vessels)	-	6,697	7,465	8,133	6,235
Sub-Total	75,767	65,871	64,560	56,983	41,108
Ratio	100	87	85	75	54
Raft (sq.m.)	(1,540)	(1,492)	(470)	(1,174)	(430)
(2) Bang Yang					
Rowing boat (vessels)	-	69,200	62,012	54,882	43,761
Launch (vessels)	-	12,657	12,431	13,303	11,186
Sub-Total	93,790	81,857	74,443	68,185	54,947
Ratio	100	87	79	73	58
Raft (sq.m.)	(1,734)	(848)	(1,142)	(1,580)	(856)
(3) Bang Nokkwaek					
Rowing boat (vessels)	-	38,729	40,432	35,254	30,989
Launch (vessels)	-	5,642	5,761	5,332	6,057
Sub-Total	45,714	44,371	46,193	40,586	37,046
Ratio	100	97	101	88	81
Raft (sq.m.)	(9,804)	(4,886)	(2,394)	(2,358)	(2,348)
(4) Chedi Bucha					
Rowing boat (vessels)	-	894	29	-	75
Launch (vessels)	-	277	51	2	45
Sub-Total	3,270	1,171	80	2	120
Ratio	100	35.8	2.4	0.06	3.6
Raft (sq.m.)	(-)	(-)	(-)	(-)	(-)
(5) Vajiralongkorn					
Rowing boat (vessels)	-	205	110	55	6
Launch (vessels)	-	1,158	1,158	944	45
Sub-Total	1,921	1,363	1,268	999	51
Ratio	100	70.9	66	52	2.6
Raft	(442,908)	(296,944)	(308,030)	(218,790)	(10,414)

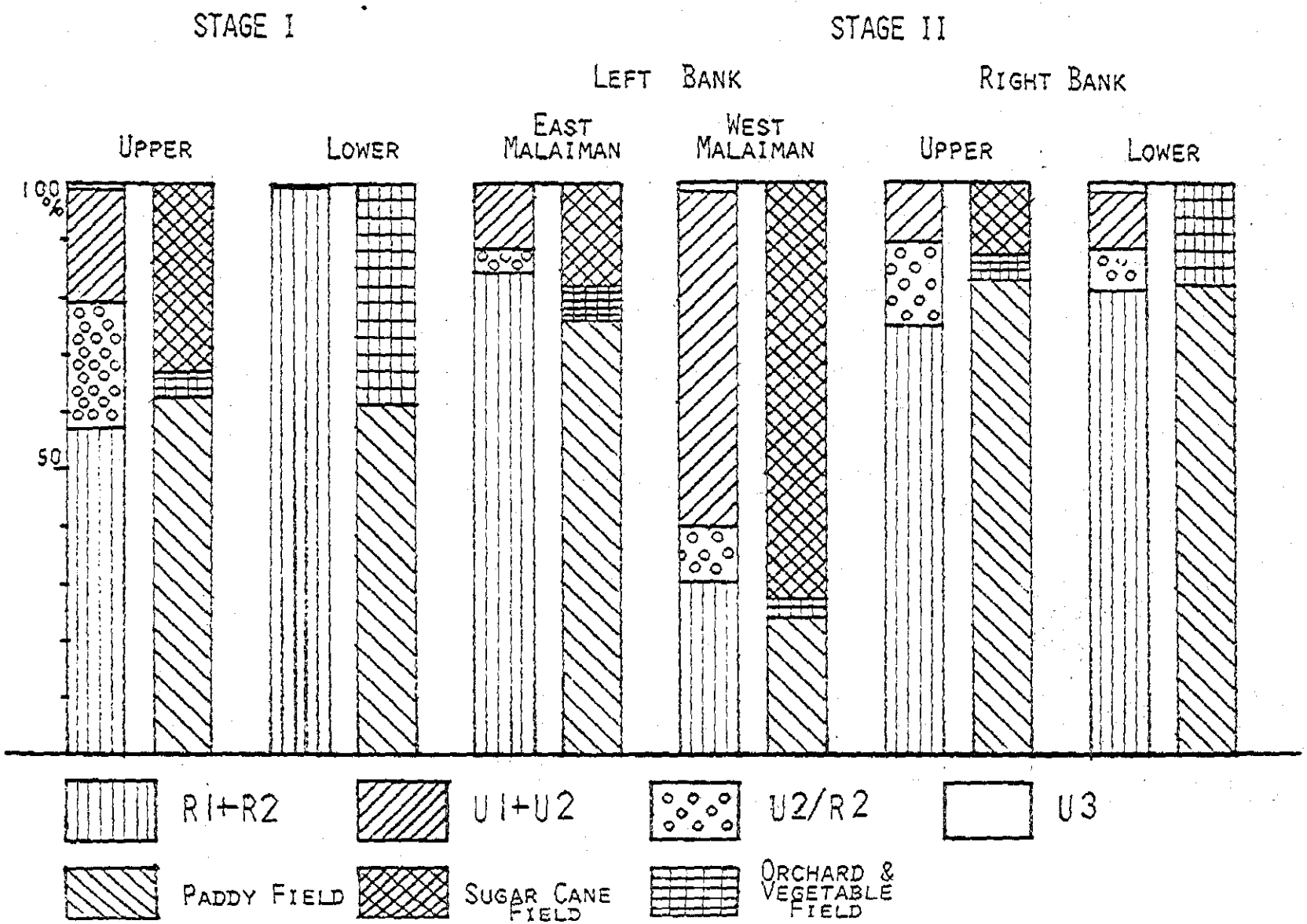
Source: Division of Operation and Maintenance, RID.

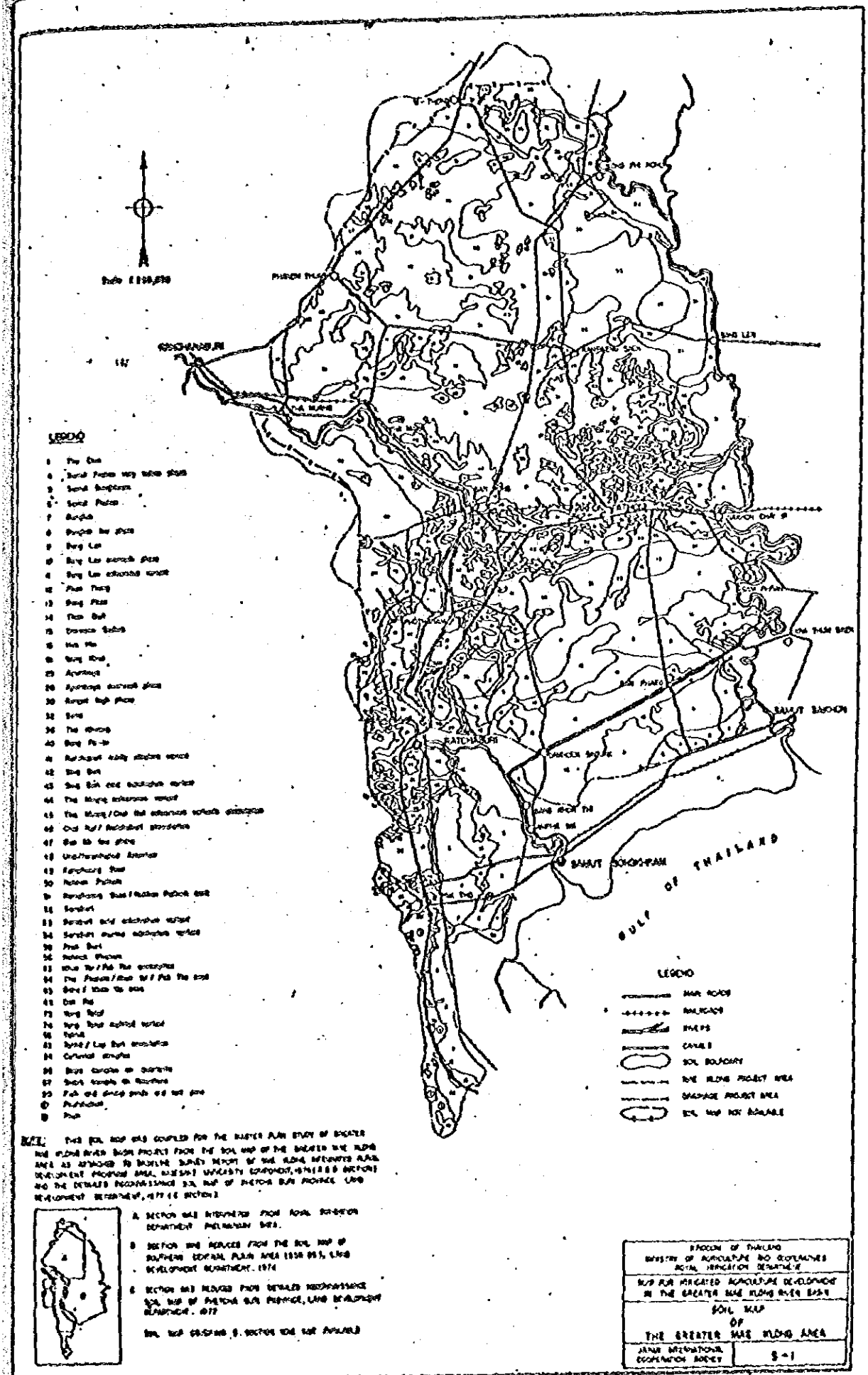


NOTE: This map was provided for the M/P Study. Data of chemical analysis as reported in the Detailed Reconnaissance Soil Survey of Southern Central Plain, 1972 and additional data obtained from Soil Survey Division were interpolated based on the Soil Interpretation Handbook for Thailand.

FIG.B-1 MAP SHOWING ESTIMATED NATURAL FERTILITY FOR PADDY RICE

FIG. B-2 COMPARISON BETWEEN THE OCCUPANCY BY EACH LAND CLASS GROUP AND THE PRESENT LAND USE IN EACH BLOCK





NOTE: THIS SOIL MAP WAS COMPILED FOR THE MASTER PLAN STUDY OF GREATER MAE KLONG RIVER BASIN PROJECT FROM THE SOIL MAP OF THE GREATER MAE KLONG AREA AS ATTACHED TO BASELINE SURVEY REPORT OF MAE KLONG IRRIGATED AREA DEVELOPMENT PROJECT AREA, KASETSART UNIVERSITY (KAMPHAENG SAEN), 1974 AND THE DETAILED RECONNAISSANCE SOIL MAP OF PHETCHA BURI PROVINCE, LAND DEVELOPMENT DEPARTMENT, 1977 (5 SHEETS).

A SECTION WAS INTERPRETED FROM ROYAL IRRIGATION DEPARTMENT PRELIMINARY DATA.

B SECTION WAS REDRAWN FROM THE SOIL MAP OF SOUTHERN CENTRAL PLAIN AREA (1:50,000), LAND DEVELOPMENT DEPARTMENT, 1974

C SECTION WAS REDRAWN FROM DETAILED RECONNAISSANCE SOIL MAP OF PHETCHA BURI PROVINCE, LAND DEVELOPMENT DEPARTMENT, 1977

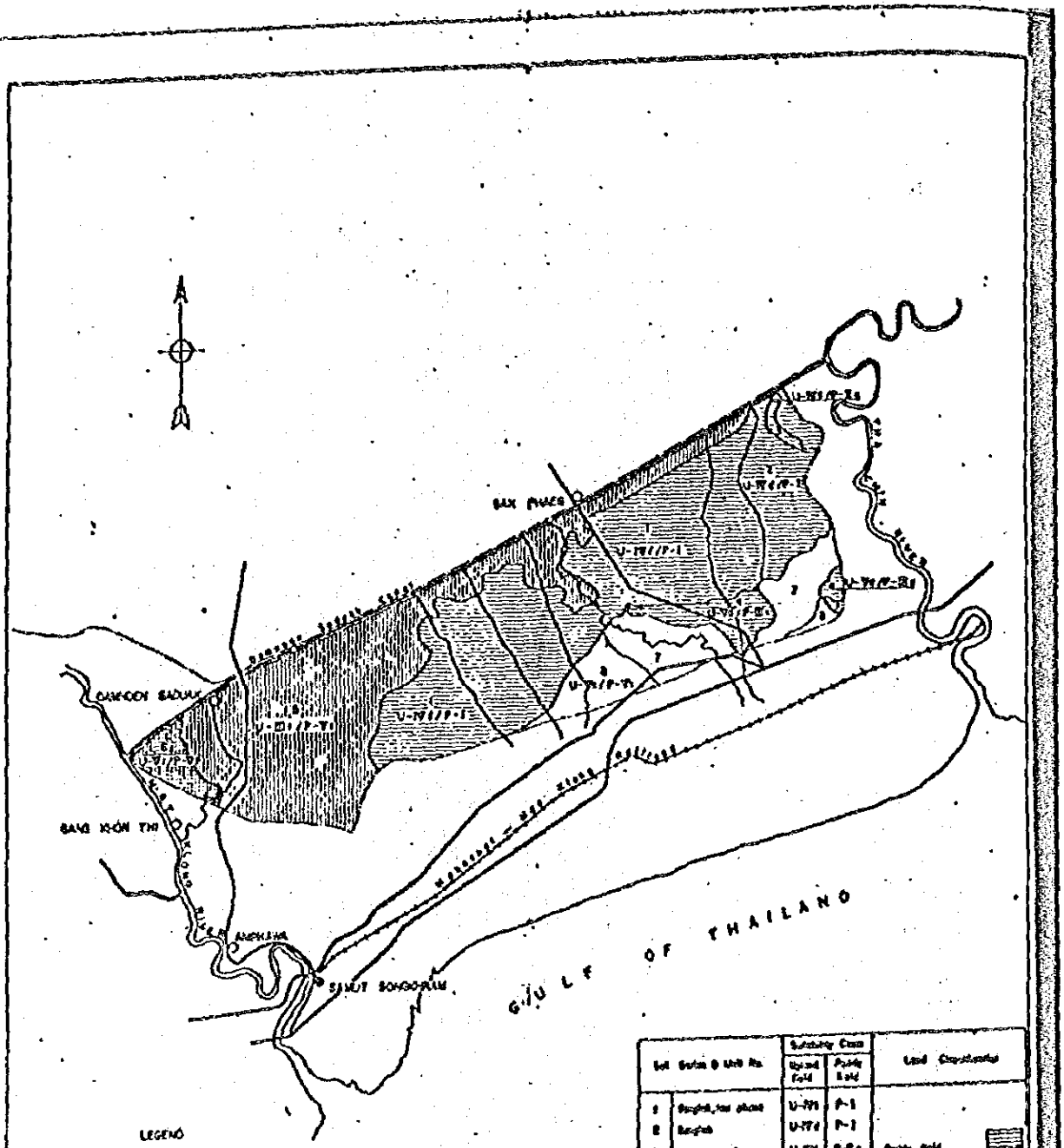
SOIL MAP OF SECTION C AND D NOT AVAILABLE

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

MASTER PLAN FOR IRRIGATED AGRICULTURE DEVELOPMENT IN THE GREATER MAE KLONG RIVER BASIN

SOIL MAP
OF
THE GREATER MAE KLONG AREA

JAPAN INTERNATIONAL COOPERATION AGENCY | S-1



Soil Series & Unit No.		Suitability Class: Upland Soil	Suitability Class: Paddy Soil	Land Classification
1	Bangkok, low phase	U-IV1	P-1	Paddy field
2	Bangkok	U-IV2	P-1	
3	Bang Nam Phrik	U-IV1	P-2	
4	Samut Prakan	U-IV2	P-2	
5	Ratchaburi Association	U-III	P-III	Upland field
6	Samut Songkhram	U-IV	P-IV	Paddy/upland field
7	Thai Phra	U-V1	P-V1	Uncultivable
8	Samut Prakan w/ Bolero phase	U-V1	P-V1	

LEGEND

- BOUNDARY OF GREATER BANGKOK FLOOD PROTECTION PROJECT
- BOUNDARY OF DRAINAGE PROJECT
- MAIN ROADS
- RAILROAD
- SOIL SERIES BOUNDARY
- CANAL
- RIVER

NOTE: 1. THIS LAND CLASSIFICATION MAP WAS PREPARED FOR THE STUDY OF DRAINAGE PROJECT AREA. THE PROCESS OF THIS LAND CLASSIFICATION WAS BASED ON SOIL RECONNAISSANCE PROCEDURE FOR THAILAND, MINISTRY OF AGRICULTURE, 1978 (PROVISIONAL) AND MAP OF THE DETAILED RECONNAISSANCE SOIL MAP OF THE SOUTHERN CENTRAL PLAIN, 1968 & 1970.

2. THE UPLAND FIELDS ARE DIVIDED MAINLY ON RAIN-FED BASIS (SOME AREAS HAVE BEEN CONSTRUCTED FROM NATURAL AND FROM DRAINAGE DITCHES)

1:100,000

KILOMETERS

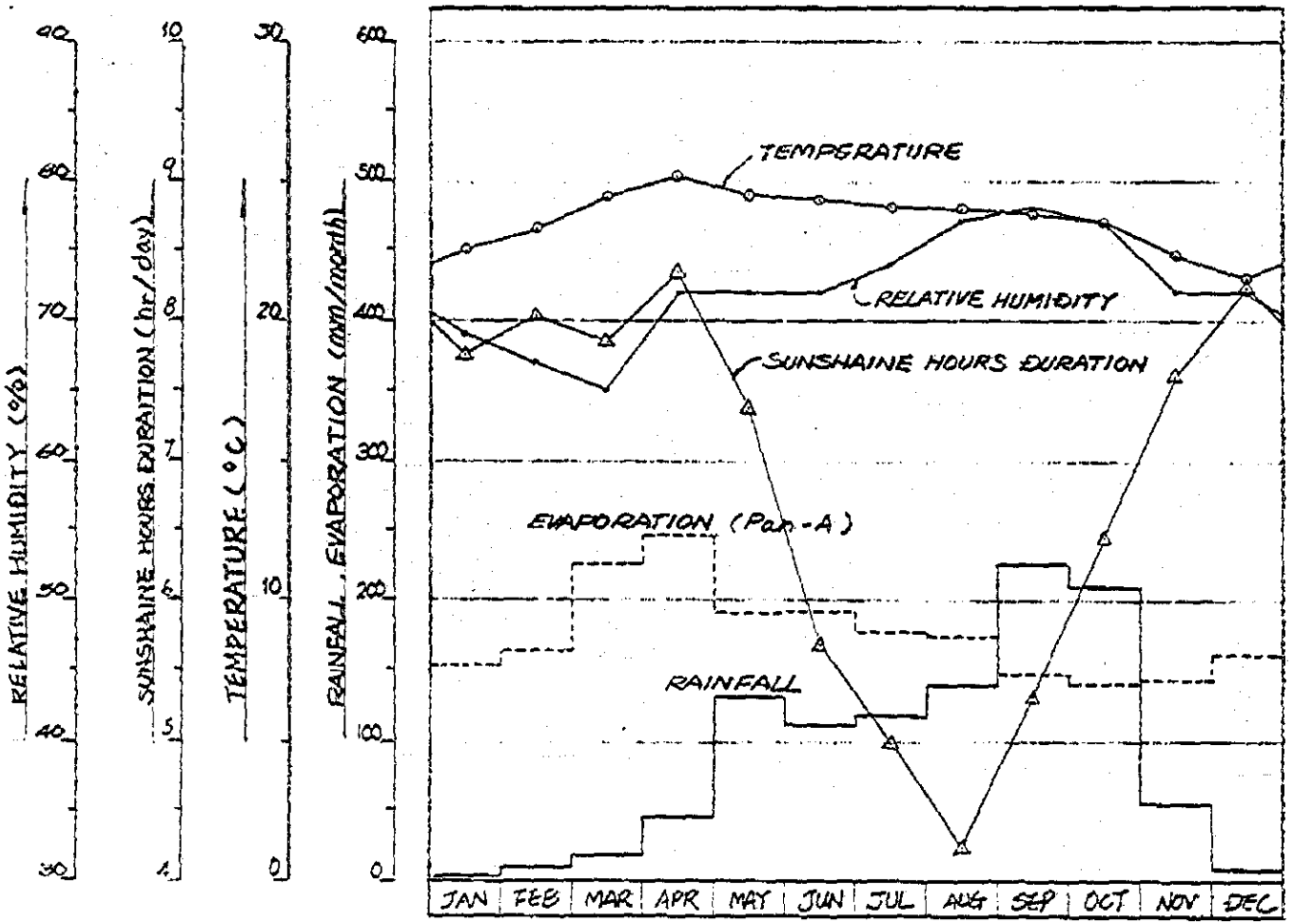
KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

MAP FOR DETAILED AGRICULTURE DEVELOPMENT IN THE GREATER BANGKOK FLOOD PROTECTION AREA

LAND CLASSIFICATION MAP OF DRAINAGE PROJECT AREA

JAPAN INTERNATIONAL COOPERATION AGENCY | S-3

Figure: C-1 Monthly Mean Meteorological Data



Note: All data except rainfall are showing records at Khamphaeng Saen. Rainfall shows weighted average of 21 representative stations.

FIGURE C-2

HYETOGRAPH OF ANNUAL RAINFALL IN MAE KLONG RIVER BASIN
(1952 - 1974)

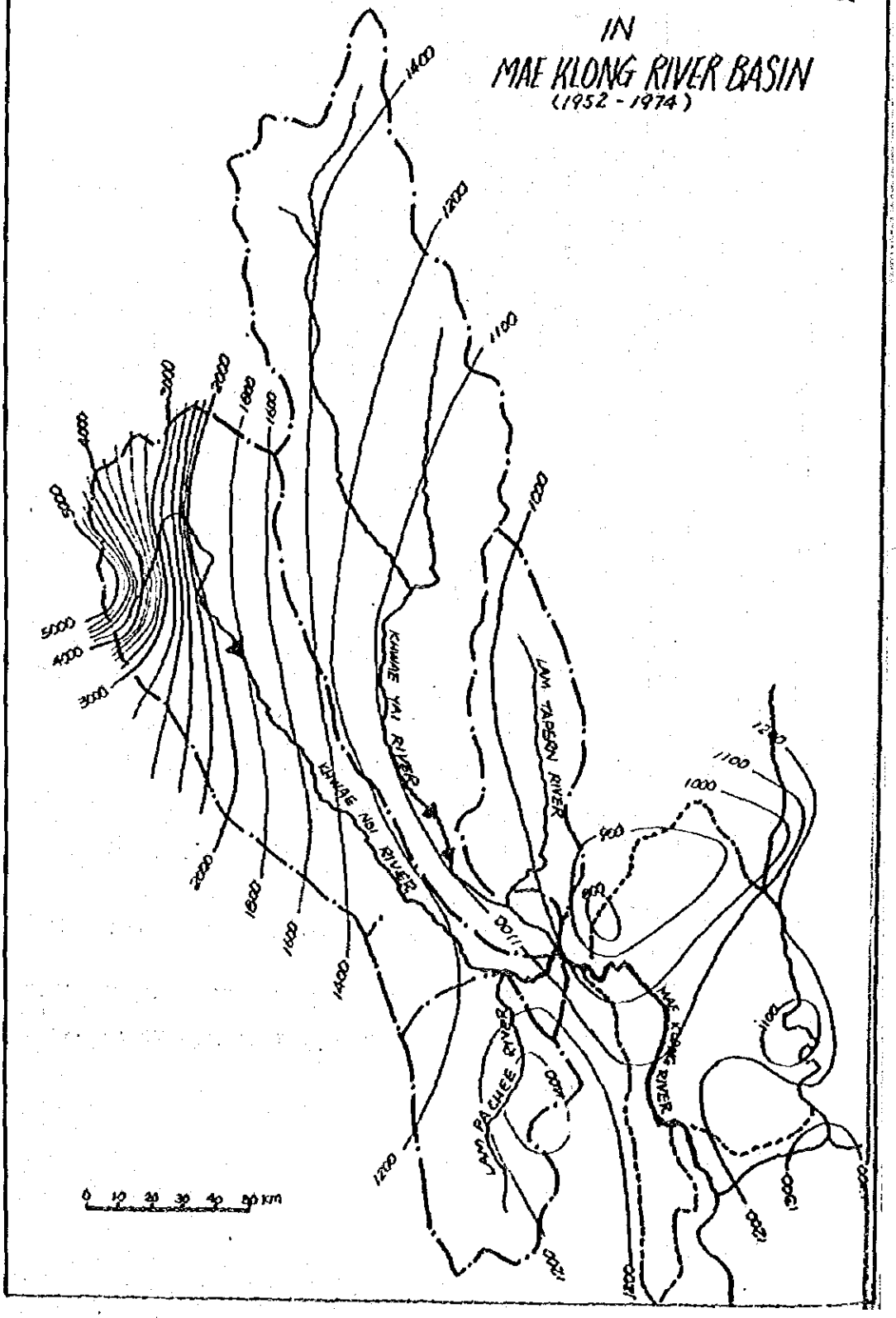


FIGURE C-3 HISTORICAL ANNUAL RAINFALL IN PROJECT AREA

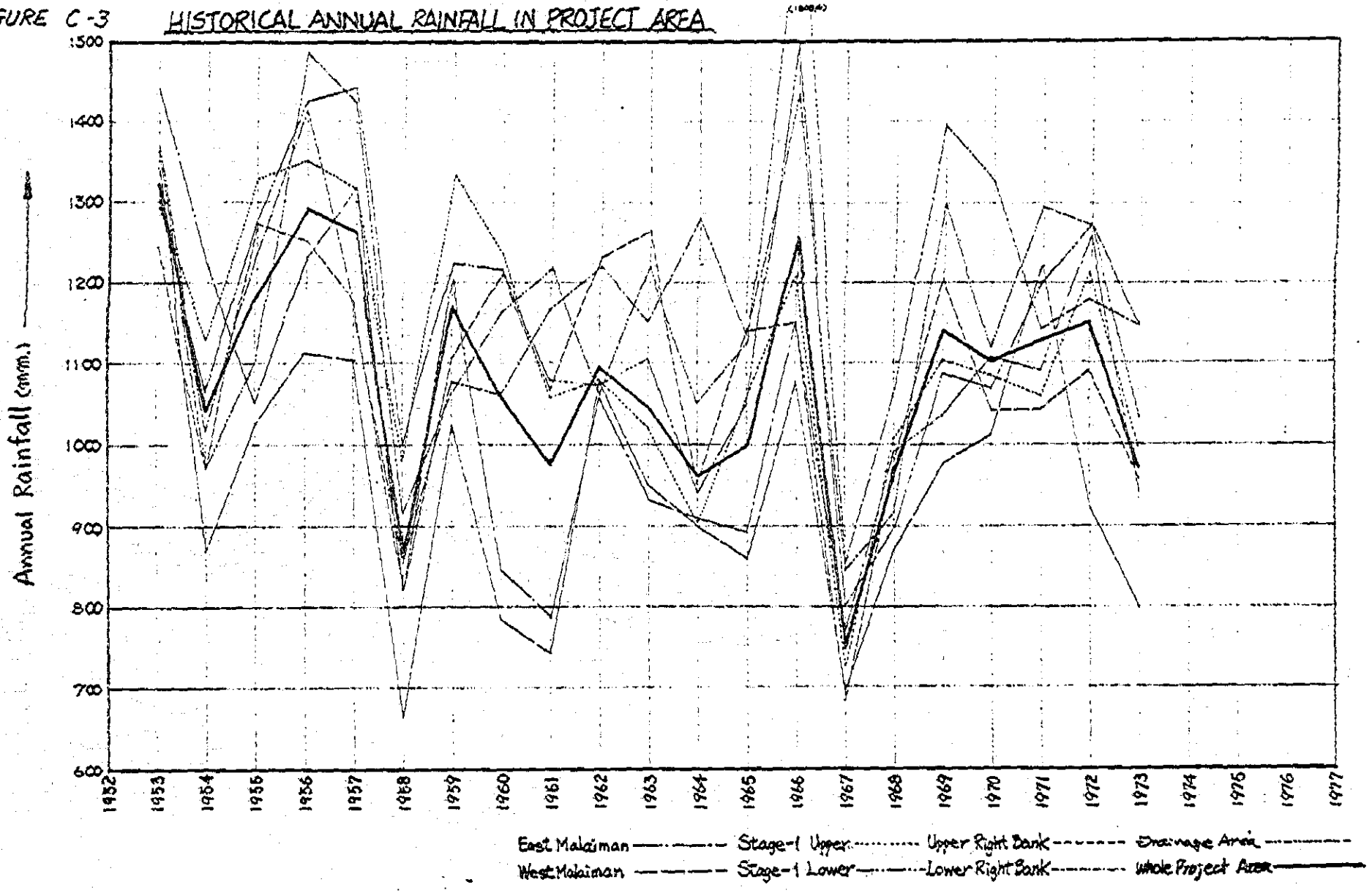


FIGURE C-4

HYETOGRAPH OF ANNUAL RAINFALL IN PROJECT AREA

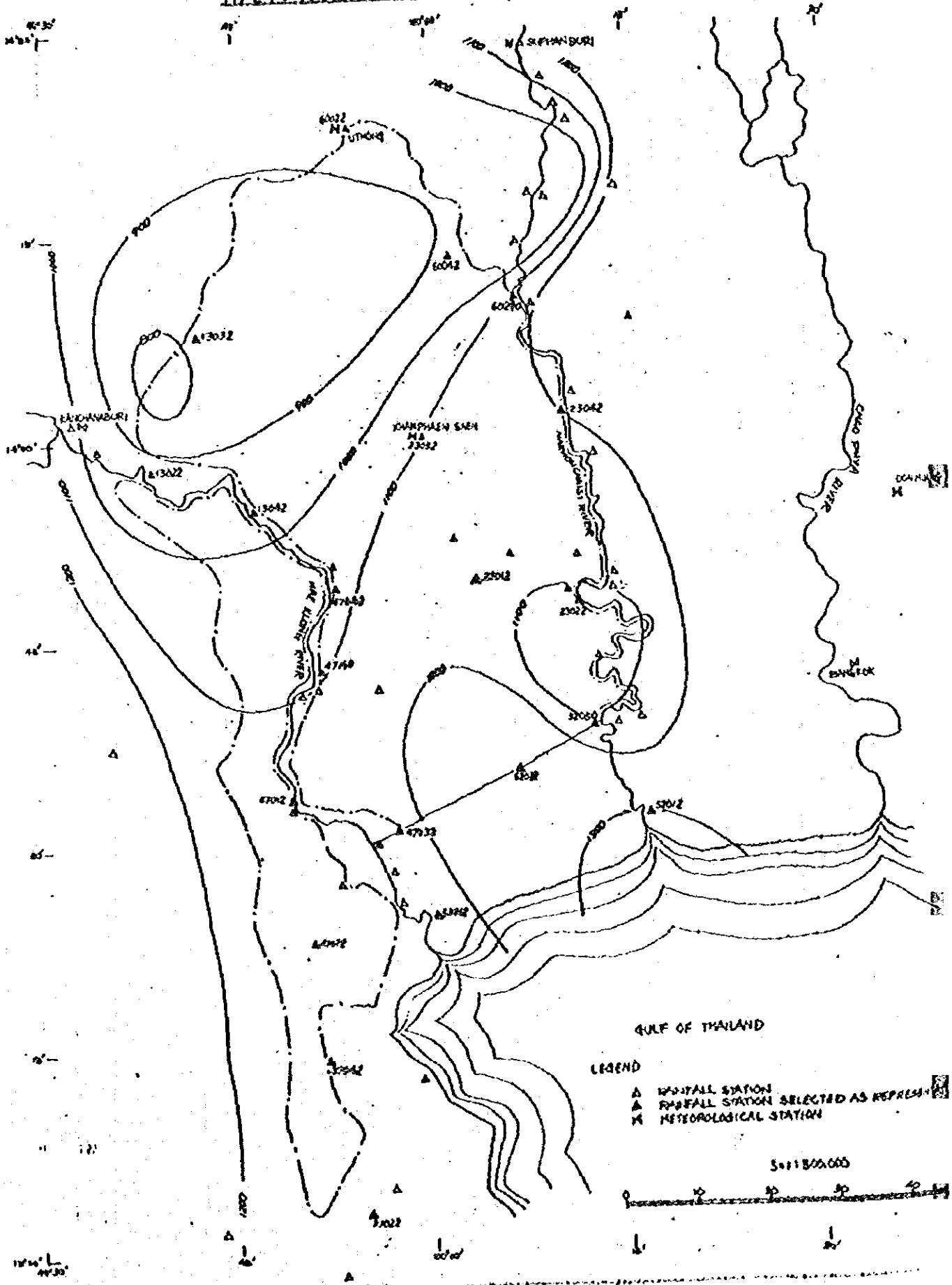
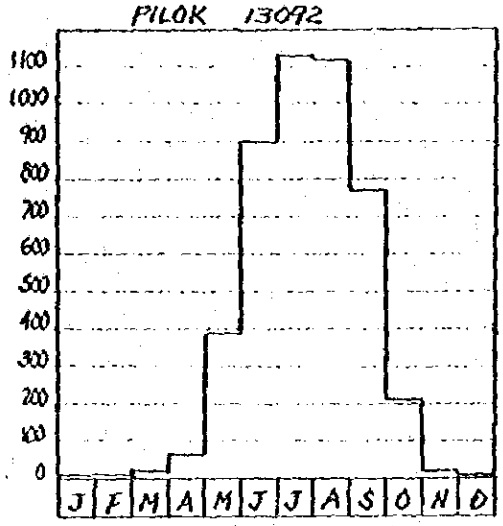


FIGURE C-5 DISTRIBUTION PATTERN OF MANTHLY RAINFALL

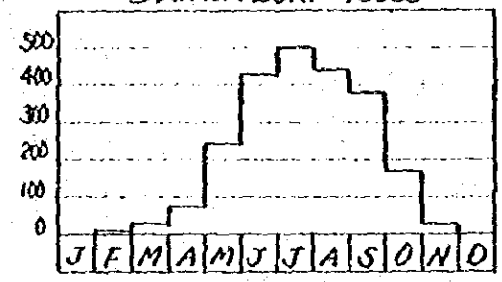
(Unit : mm)

KHWAE NOI RIVER BASIN

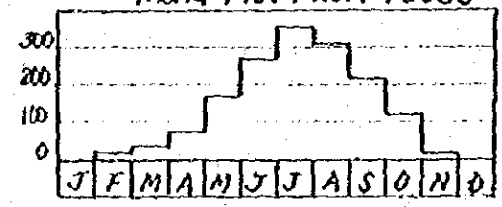
PILOK 13092



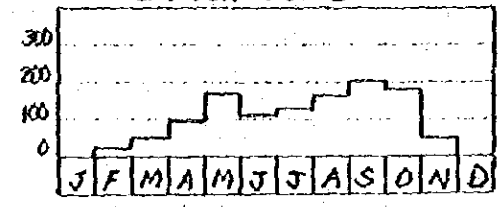
SANKHLA BURI 13063



THONG PHA PHUM 13053

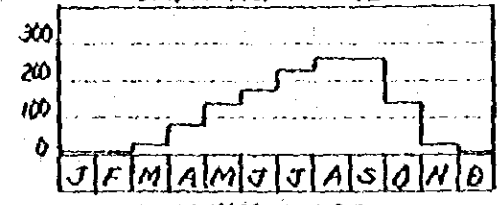


SAI YOK 13073

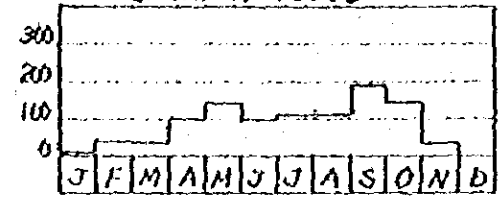


KHWAE YAI RIVER BASIN

UMPHANG 63042

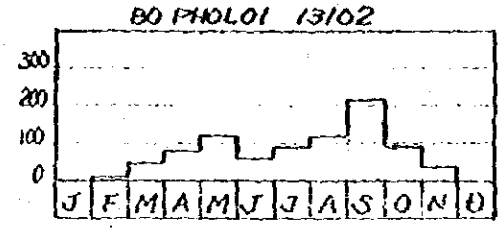


SI SAWAT 13083



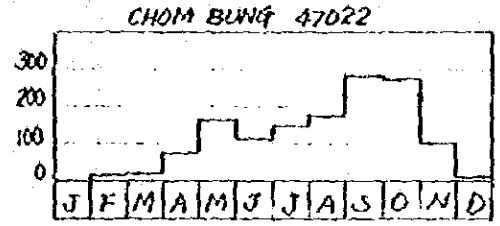
LAM TAPERN RIVER BASIN

BO PHOLOI 13102



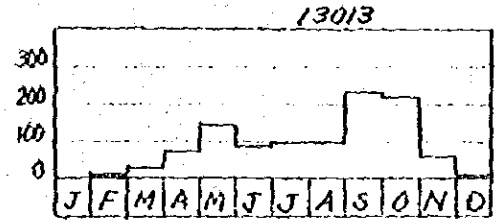
LAM PACHEE RIVER BASIN

CHOM BUNG 47022



KANCHANABURI

13013



PROJECT AREA

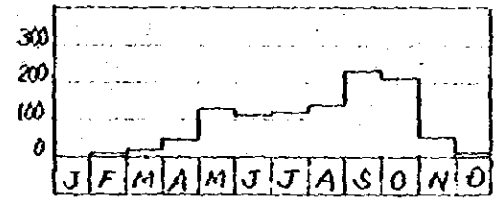


FIGURE C-6 RIVERS AND OBSERVATION NETWORKS

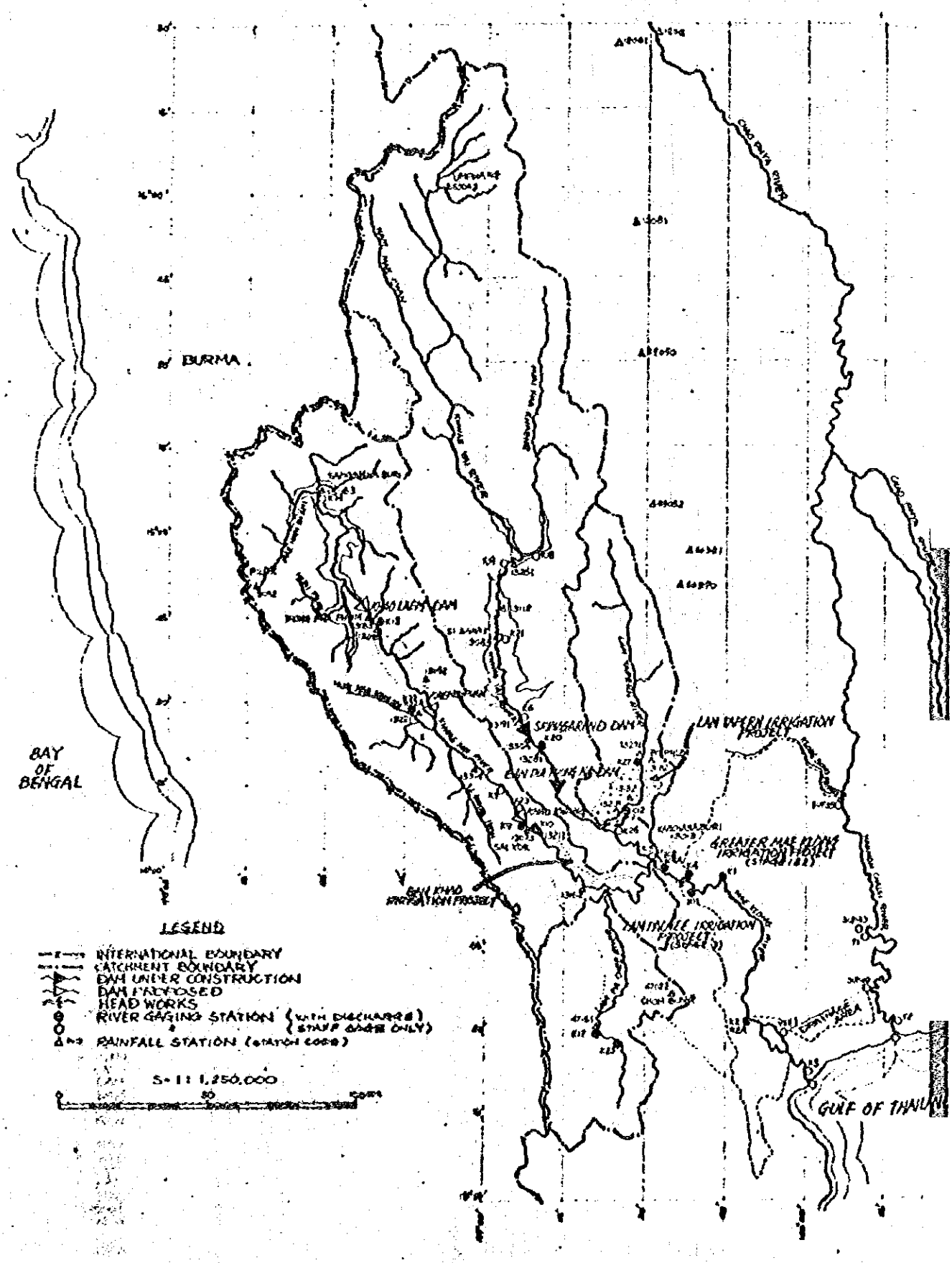
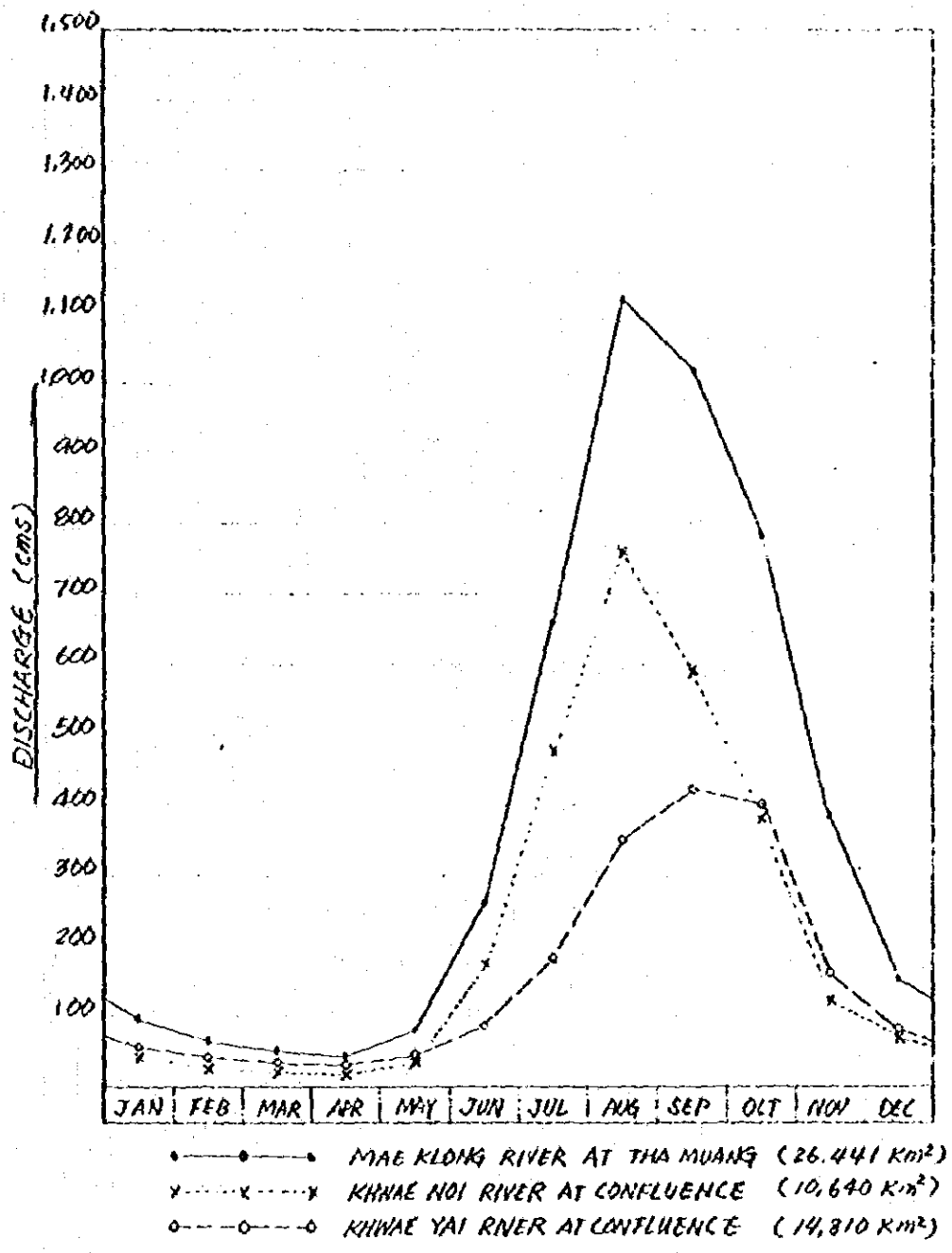


FIGURE C- 7

MONTHLY MEAN DISCHARGE IN MAE KLONG RIVER BASIN

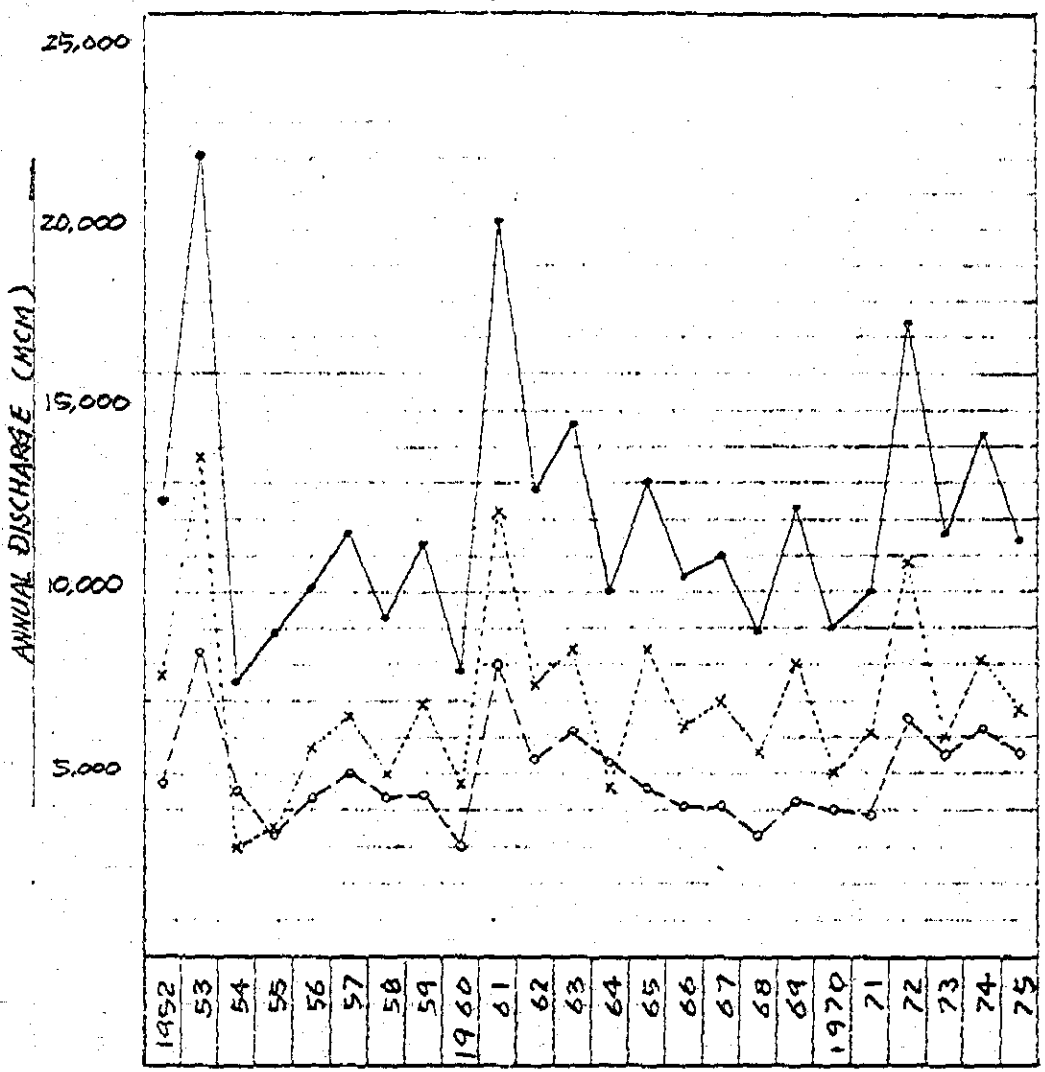


Note: Details are in TABLE C-3

FIGURE C-8 HISTORICAL ANNUAL DISCHARGE OF MAE KLONG RIVER

(UNIT MCM)

YEAR	MAE KLONG RIVER ACTUAL RECORD AT K8, K4, K11		MAE KLONG RIVER ESTIMATION BY EGAT	KHWAE YAI	KHWAE NOI
1952	13,266	K4	12,497	4,737	7,760
53	21,295	"	22,118	8,342	13,776
54	7,114	"	7,502	4,471	3,031
55	—		6,860	3,333	3,527
56	—		10,116	4,360	5,756
57	11,558	K8	11,629	5,007	6,622
58	9,909	"	9,268	4,312	4,956
59	10,746	"	11,321	4,445	6,876
1960	7,725	"	7,824	3,055	4,769
61	20,083	"	20,237	8,041	12,196
62	13,036	"	12,827	5,392	7,435
63	14,993	K4	14,627	6,165	8,462
64	10,946	"	10,016	5,317	4,699
65	12,281	"	13,090	4,610	8,480
66	9,476	"	10,412	4,103	6,309
67	10,460	"	11,057	4,079	6,978
68	8,207	"	8,919	3,339	5,580
69	12,437	K11	12,351	4,257	8,094
1970	8,988	"	9,058	4,038	5,020
71	9,892	"	10,058	3,869	6,189
72	16,289	"	17,394	6,573	10,821
73	11,615	"	17,394 *1	5,585	6,050 *2
74	14,367	"	14,335	6,230	8,105
75	10,496	"	11,409	5,577	5,832
MEAN	12,054		12,180	4,967	6,972
S.D.	3,542		3,805	1,234	2,486



Data Source : Benefit Derivation of Khao-Laem Project Appendix I Dec. 1977 EGAT

Note : Discharges of Khwae Yai and Khwae Noi rivers are estimated by the same formulas mentioned in Table C-3

*-1 Data mistake in the report.

URE C-9 ANNUAL MAXIMUM DISCHARGE IN MAE KLONG RIVER BASIN

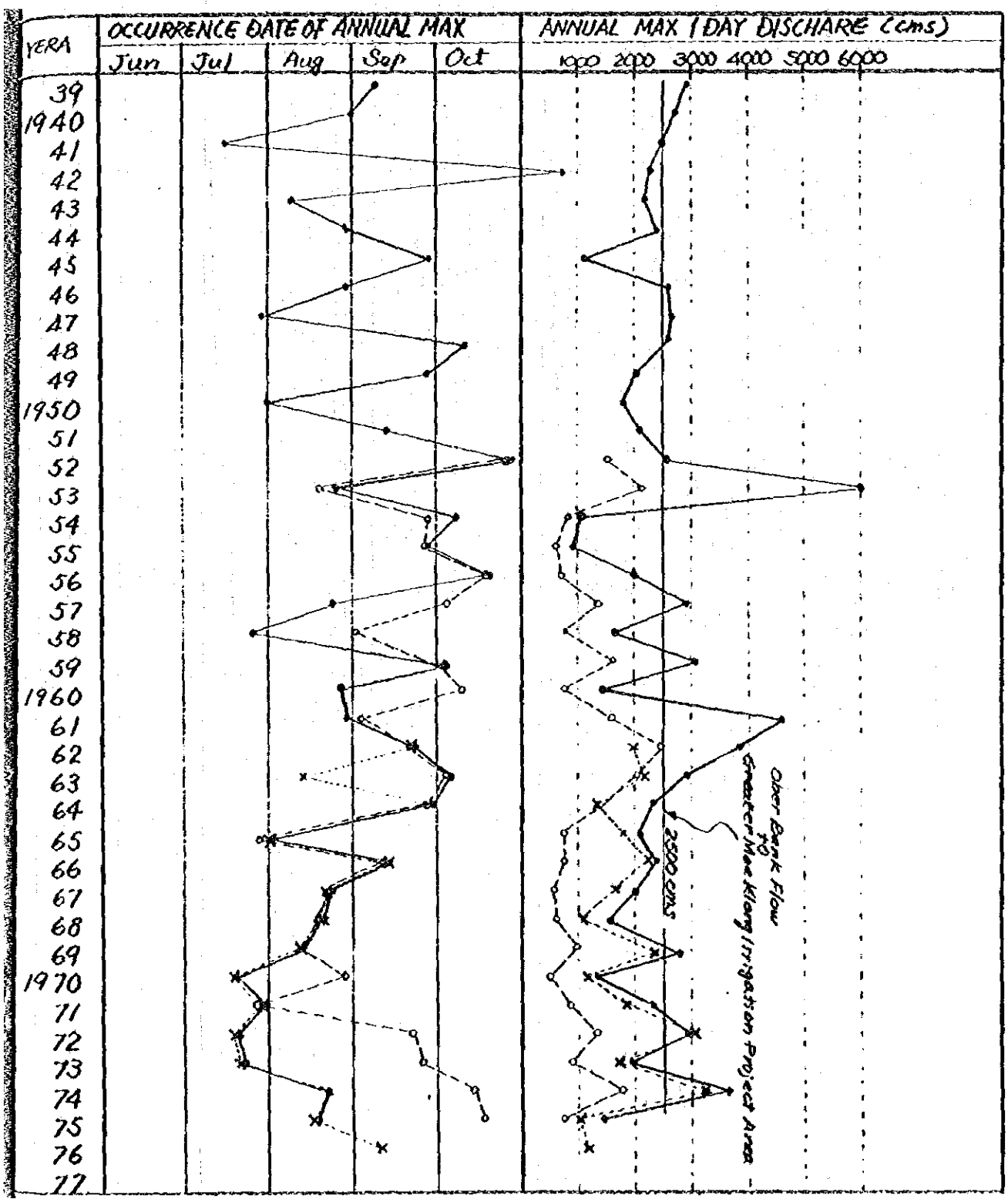
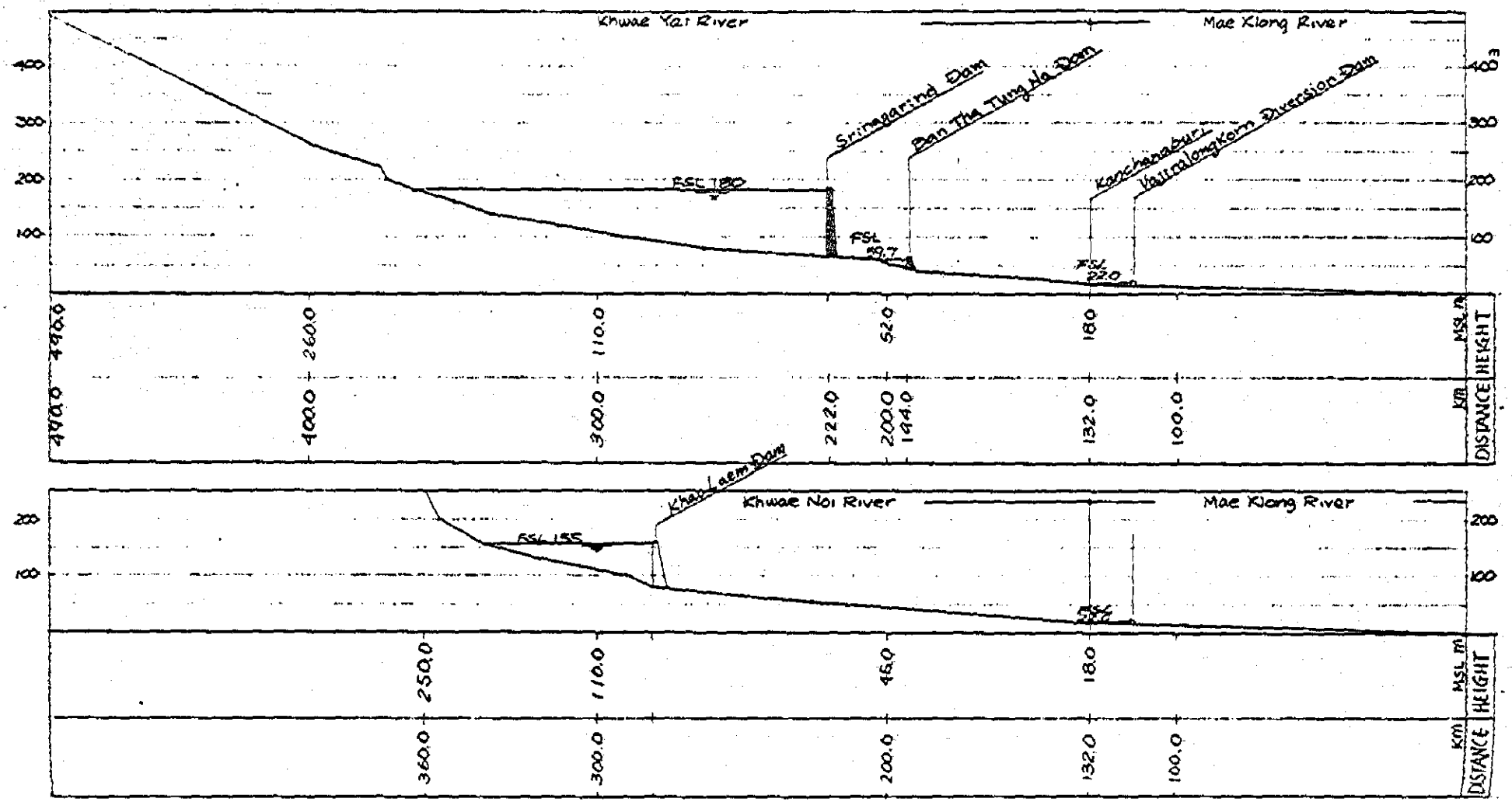


FIGURE C-10

PROFILE OF MAE KLONG RIVER



LIST OF REPORTS AND MAPS

GENERAL REPORTS

	TITLE	REMARKS
1.	Preliminary Phase Reports	
	Chao Phraya - Mae Klong Basin Study Executive Summary	ACRES August 1977
2.	Interim Feasibility Reports	
	Khao Laem Project Volume 1, 2, 2A, 3	EGAT SMEC June 1976
3.	Khwae Noi Project A Reconnaissance Survey of Agriculture, Land, Soils and General Conditions	RID Srerdrup & Parcel and Associates September 1970
4.	Khwae Noi Greater Mae Klong Project Land Classification Report	RID Srerdrup & Parcel and Associates September 1972

SOIL

1) The Study on Advance in Rice Production by Soil Management. Under the Cooperation Research Work Program between Thailand and Japan, 1973.
S. Motomuro

2) The Study on Fertility of Upland Soil in Thailand. Under the Cooperation Research Work Program between Thailand and Japan, 1975.
K. Ogawa, Samnao Phetchawee, etal.

3) Report on Soil Chemistry and Fertility No. 4 (Fertility of Acid Sulphate Soils in the Bangkok Plain) 1977.
Laboratory of Soil Chemistry and Fertility. Department of Agriculture.

4) Simple Experiment of Marl on Acid Sulphate Soil.
Land Conservation Division, Department of Land Development.

HYDROLOGY

1) Tracks of Tropical Cyclones over Thailand and Neighbouring Areas during 25 year period from 1951 - 1975
Meteorological Department, Jan. 1977

(WATER RESOURCES IN KHWAE YAI RIVER)

2) Feasibility Report Khwae Yai No. 1 Hydroelectric Project
EPDC Mar. 1968

3) Supplementary Study on Design Flood and Spillway Capacity
EGAT Jul. 1973

4) Ban Chao Nen Hydroelectric Project, Implementation Report
EGAT Aug. 1973

5) Feasibility Report on Lower Khwae Yai Regulating Dam Project
JICA Oct. 1976

6) Report on Second Study/1977 on Planning for Water Release during filling Ban Chao Nen Reservoir
Note: written in Thai
EGAT May 1977

(WATER RESOURCES IN KHWAE NOI RIVER)

7) Summary Report on Khwae Noi River Basin Project No. 841-2004
Note: written in Thai
EGAT Apr. 1977

8) Benefit Derivation of Khao Laem Project, Appendix I

EGAT Dec. 1977

LAND CONSOLIDATION

1)	Spot Elevation Maps	1/4,000	Sample Area	No. 1	RID
2)	Aero-photograph	1/10,000	Sample Area	No. 3	RID
3)	Topographic Maps and Aero-photo	1/10,000	Sample Area	No. 4	RID
4)	Land Use Maps		Sample Area	No. 3	RID

FISHERY

1) Statistic of Fresh Water Fish Farm Product
   Fishery Department, MOAC
   1974

2) A Report on Giant Fresh Water Prawn, Inacrobacium r, De Man in Thailand Its Distribution and Abundance
   Fishery Department, MOAC
   1974

3) The Fisheries of Ubolratana Reservoir in the First 10 years of Impoundment
   Fishery Department, MOAC
   1976

4) Research of Production and Marketing of Fresh Water Fish of Rural Development of Mae Klong Basin
   Prayong Netayarak
   1977

5) Preliminary Environmental Study of Upper Khwae Noi Basin
   Applied Scientific Research Corporation of Thailand
   1976

6) Check List of Fresh Water Funda in the N.I.F.I. Museum
   National Inland Fisheries Institute
   1978

7) Annual Report
   Fisheries Research Unit 1968 - 76
   MOAC

RURAL DEVELOPMENT

1) Water User Association Rule
RID 1974

2) The Papers Concerning Water Management and On-farm Development Works in Irrigation Project in Thailand
RID 1976

3) Information of Irrigation School in RID 1976
RID 1976

4) Information and Practical Instructions on the Field of Plant Protection
DTEC

5) Translation the Cooperative Societies Act BE 2511
By-laws of the Agricultural Cooperatives Limited
The Cooperative Movement
A Brief Report of the Cooperative Marketing and Purchasing Federation
MOAC

6) Traffic Volumes and Flow Maps
Highway Department,
Ministry of Communications, 1972-1976

7) Fourteenth Compendium of Technical Assistant to Thailand 1977
DTEC

8) Vocational and Technical Education
Ministry of Education 1976

9) Fact Book on Population and Manpower of Thailand
National Economical and Social Development Board 1977

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1975/76 RID

2) Monthly Bulletin, Bank of Thailand, Feb. Apr. May, 1978

3) Gross Provincial Product, 1973-1976, NESDB

4) Gross Regional Product, 1973-1976, NESDB

5) Gross Provincial Product, Per Capita GPP, 1973-1977, NESDB

6) Gross Provincial Product, 1977-1981, NESDB