

A SUMMARY REPORT  
OF  
ENVIRONMENTAL IMPACT ASSESSMENT  
OF  
BANG PAKONG DIVERSION DAM

1. BACKGROUND AND PROJECT FEATURES

The Bang Pakong Diversion Dam Construction Project is a project to construct a diversion dam across the stream flow in the Bang Pakong River. This diversion dam is a multi-purpose one, aiming to raise the water level and thus raising the water storage capacity to 30.00 million cubic meters which will be utilized during the dry season. The higher water storage capacity will be available for agricultural activities, to repel saline water, to be used in aquaculture, and for water works as well. In the rainy season excess water above storage level will be released to orchard farms, paddy fields, and other areas along the irrigation canal such as the Bang Pakong Left Bank irrigation area of 65,000 rai which has an annual agricultural water requirement of 243.5 million cubic meters : 12.8 million cu.m. for 4,000 rai of brackish water fishery and 2,500 rai of freshwater fishery ; 15.1 million cu. m. of domestic water supply for rural and urban communities in Amphoe Muang, Bang Khla, Ban Pho, and Bang Pakong ; as well as 144 million cu.m. of industrial water supply both for industrial areas in Bang Pakong and other industrial-related activities in Amphoe Muang, Bang Khla, Ban Pho, and Bang Pakong.

The proposed project involves construction that will obstruct stream flow, resulting in higher water level upstream from the diversion dam. The maximum external water level will be +1.80 m MSL higher than the original water level of +2.00 m MSL. The higher water level will lead to overflow in some areas especially those in the damsite vicinity and

decreasing towards the Amphoe Bang Khla's administrative building. The most important effect will be that of prolonged overflow with excess water seeping into both sides of the river banks resulting in perpetual water-saturated soil.

The construction of an obstruction such as the Bang Pakong Diversion Dam, however, will reduce the effect of sea water tides not to be beyond the damsite. This situation will provide the perfect diversion of saline water from fresh water even though saline water was previously reported to have penetrated as far upstream as Changwat Nakhon Nayok. However, fresh water from the Bang Pakong Diversion Dam will be released continuously regardless of the season. Therefore, brackish and fresh water will still exist from downstream of the damsite to the mouth of the Bang Pakong River.

Because of the meandering nature of the Bang Pakong River, a suitable site for the construction of the diversion dam was selected by JICA survey team in 1990 outside of the meandering river course at Ban Phai Sawek and Ban Laem Phraya Chak, Tambon Bang Kaew, Amphoe Muang. The damsite is located between Chachoengsao provincial seat and Amphoe Bang Khla, 70 km. from the Bang Pakong River mouth. A diversion channel of 1.6 km. will be excavated to connect both bends of the river with the diversion dam at the mid-point. The closure dam will later be constructed to seal off the river at a width of 250 m. and 8 to 10 m. deep. Furthermore, an area of 430 rai is required for the construction of office buildings, residential buildings, and other buildings amounting to 793 rai of total land requirement for the project. This area is mostly orchards, rice fields, and residences which will be expropriated and compensated for no less than 65 households. Such loss must be assessed physically, socially and economically.

Construction of the proposed diversion dam will result in unique features which can be summarized as follows.

1) Freshwater ecology will be abruptly separated from marine ecology. After completion of the project saline-water intrusion upstream from the damsite is unlikely. The dam itself will not only block the travel route of aquatic animals and water navigation but will also change both freshwater and marine and brackishwater ecology of both animals and plants all through the Bang Pakong River.

2) Not only the loss of orchards, rice fields, and residential areas but also the loss of other local properties-physically, economically, and socially, which will be greatly felt.

3) Water storage upstream from the damsite with water level of +1.8 m. MSL higher than previous level will lead to water seepage into both banks. Such seepage is seen as directly affected on plants, buildings, as well as the mangrove forest at the mouth of the Bang Pakong River. To facilitate water storage, it is necessary to construct a higher embankment on the Bang Pakong left bank.

4) Upstream water storage will result in a very slow water flow or no flow. Wastewater discharge from residential areas, livestock farms, manufacturing plants, and from other activities, directly into stagnant water body may cause lower water quality. This situation will be compounded should the volume of wastewater discharge be increased.

5) The Bang Pakong Diversion Dam Project will lead to several other projects such as road construction, resettlement and compensation scheme, irrigation scheme, soil and water conservation, and forest and wildlife conservation, and so on so forth.

## 2. EXISTING ENVIRONMENTAL CONDITIONS

Environmental conditions stipulated by the National Environmental Board to be studied in the environmental impact assessment of various construction projects consist of four groups : physical resources; ecological resources; human use values; and quality of life values. In principle, each group contains more detail and specific methodology as well as findings which are fully described in the Final Report. In this report, only major findings on important issues are presented.

### 2.1 PHYSICAL RESOURCES

The general climatic condition of the project area and its vicinity is sub-equatorial with temperature ranging from 19 to 36 degrees celsius. April is the hottest month while January is the coolest. Mean annual relative humidity is as high as 71 percent with normal wind velocity between 4 to 10 kilometers per hour. Annual rainfall is between 869 to 2,176 millimeters. And annual evaporation is 1,699.7 millimeters.

Analysis of 26 year record of annual stream flow at the proposed damsite reveals an average of 6,828.8 million cu.m., or ranging between 3,599.1 to 10,470.3 million cu.m. That of the mouth of the Bang Pakong River is between 3,653.1 to 11,427.6 million cu.m., or an average of 7,241.5 million cu.m. It is clear that the proposed project has carefully considered management of water upstream from the damsite at an elevation of +1.80 to -1.50 m. MSL with storage volume of 30 million cu.m. Such threshold is to prevent saline water intrusion. In the rainy season water will be released downstream at all times.

Surface water quality of Bang Pakong River is normal with high turbidity in the rainy season and lower in the dry season. Similarly its

chemical properties are also normal with heavy metal and toxic contamination below the standard values, whereas the BOD is between 0.1 to 2.5 mg./l. In contrast, its biological quality is below standard, with coliform bacteria between 460 to 92,000 MPN/100 ml. Coliform bacteria is especially high in densely populated areas. Quality of water in canals draining into Bang Pakong River is lower than that of the Bang Pakong itself. Despite the low quality the water can be utilized for every purpose. On the contrary, groundwater quality found at a very deep level and only in small quantity (1 to 4 cu.m. per hour) has very high chloride content ranging from 400 to 2,000 ppm. Therefore, it is not suitable for utilization except in areas of higher elevation such as at Amphoe Ratchasan where groundwater could be developed for utilization.

Soil property in the project area is suitable for sustainable agriculture but is usually water-logged during the growing season, hence suitable for rice and fruit tree cultivation. Irrigation area has similar conditions. Only small pockets of land has saline soil problem which tends to be serious.

It should be pointed out that soil on both banks of the Bang Pakong River, which has been formed by sedimentation as high as one to two meters, is mainly soft clay. Quantity of the sediment is approximately 974,233.8 tons per year, or an equivalent of annual surface soil erosion of 1.6 millimeter with sedimentation during storage from December to April of 17,564.3 tons. Such an amount is considered higher than normal resulting in high water turbidity especially in the rainy season. Soil erosion from both banks of the Bang Pakong is not evident indicating that water turbidity is due to soil erosion in the upper part of the watershed.

## 2.2 ECOLOGICAL RESOURCES

Analysis of primary produces in the Bang Pakong River reveals that phytoplankton ranges from  $545 \times 10^3$  to  $5,121 \times 10^3$  per cu.m. Water turbidity directly influences the quantity of phytoplankton. That is, if water turbidity is high, phytoplankton will be low in quantity. Chlorophyta was found more than other species of phytoplankton. Bluegreen algae which can be used as an indicator of water deterioration was found at almost every observation point both in the Bang Pakong itself and in its tributaries. Surface animals were found in only small numbers, both in types and in quantity such as *Sesaphuta* and *Brotia* sp. Aquatic insects larvae and red worms (Chiromonid larvae) were also found. Water hyacinth was profuse during low tides.

Thirty-seven types of aquatic animals were found, almost all were freshwater fish and only one of them was brackish water fish. Both marine and brackish water animals increased in numbers in the proximity of the river mouth. Migrations of aquatic animals occurred in the eight-month period: from November to June. The rest would take place during the wet season. It is clear that the freshwater saline water watershed is at Amphoe Bang Khla. Freshwater animals would migrate from an area upstream from Bang Khla to saline water area during the wet season. Similarly, marine animals would migrate upstream from Bang Khla with the intrusion of saline water. Such migration was due to aquatic animals' feeding behavior. Egg-layings would take place within each animal's territory, with an exception of *Macrbrachium rosenbergii* that usually lay their eggs near the river mouth and would mature upstream. The project construction site is therefore quite clearly a boundary of freshwater and marine animals.

Freshwater aquaculture covers an area as large as 34,620 rai. Their water requirement was 524,696 cu.m. Marine aquaculture covers 21,671 rai but required as much as 1,024,100 cu.m. of water.

Mangrove forest was found at the Bang Pakong River mouth where *Nipa fruticosa* and *Bruguiera* sp. were found at the density of 86 and 12 per hectare, respectively.

The diversion dam construction site requires the clearing of 793 rai of various orchards, mainly areca palms, mangoes, coconuts, and bananas totaling 60,017 trees or a density of 473 trees per hectare.

Wildlife found in the project area totaled 167 species, most of which were birds, followed by reptiles and amphibians. The most prolific mammals were bats. These wildlife species were found throughout the project area.

### 2.3 HUMAN USE VALUES

In 1990, Changwat Chachoengsao had a water supply requirement for all activities of 17.956 million cu.m. From an estimate for 1995, 2000, and 2005 water demand would be 28.639, 38.409, and 50.991 million cu.m. per annum. That is, water demand would rise every year. Industrial water demand would be the highest, followed by domestic use, livestock farming, and aquaculture, respectively. Water requirement for government offices ranked last and would increase only minimally.

Chachoengsao has 10 national highways passing through, providing decent land transportation. There are also several rural roads in the form of dikes, village roads, and tambon roads. It is estimated that by the year 1995, all road surface within this changwat will be adequate for land transportation demand.

Water transportation is very important to the proposed project. The study of water transportation by passenger boats revealed a frequency of 30 boats per day. These boats service areas between Amphoe Muang and Bang

Khla, passing near the project area. From Chachoengsao Bridge regular service, both upstream and downstream, is available : 56 boats per day in the upstream direction ; but as many as 115 boats per day for downstream transportation.

Chachoengsao has 262 manufacturing plants, most of which are agricultural produce fabrication and preservation. An increase in the number of manufacturing plants will take place in the future but will be located within industrial estates. But they will still be agricultural-related industries. These manufacturing plants have high water demand as pointed out earlier. But more important is their wastewater discharge in terms of BOD which will rise continually. At present, wastewater discharge analysis revealed that the BOD value for Bang Khla was 17.24 kg./day, 112.33 kg./day in Amphoe Muang, 6.63 kg./day in Amphoe Ban Pho, and 2.90 kg./day in Amphoe Bang Pakong. In general, wastewater discharge in terms of BOD was still low. The Bang Pakong River has a potential to cleanse itself at the present rate. However, the ever increasing wastewater discharge would eventually lead to water pollution problems.

#### 2.4 QUALITY OF LIFE VALUE

After completion of the diversion dam construction the Bang Pakong Left Bank irrigation area will cover 98 villages, 90 percent of which are agricultural land. Extended family is the norm, with 5 to 6 members each of whom has the compulsory education. Most of the population are approaching the working age-group. Because this area is relatively fertile agricultural productivity is high, resulting in an average annual family income of 105,550 baht which is higher than those with and without irrigation water in other area.

Within the project area of 793 rai, the estimated compensation will be 581,062,783 baht for the 98 plots of land with ownership certificate.



Sixty-five houses will have to be compensated financially without further resettlement scheme.

It should be noted that the population within the project area have a relatively good health. Those who will have their land expropriated show signs of high stress. Those who settle upstream from the proposed damsite are anxious about the effect of floods. Whereas those downstream are were concerned with a longer period of saline water intrusion. Malnutrition was found at a low level. Other health problems include food poisoning, diarrhoea, and dysentery.

Recreational activities are not outstanding. Most of the recreation areas are cultural, religious, and archaeological sites. It is expected that commercial tourism would increase after completion of the diversion dam.

### 3. ENVIRONMENTAL IMPACT

#### 3.1 PHYSICAL RESOURCES

##### 3.1.1 SURFACE WATER HYDROLOGY

The Bang Pakong Diversion Dam Construction Project would result in freshwater storage during the dry season of 30.00 million cu.m., creating a barrier between freshwater and brackish water. Brackish and saline water will no longer intrude upstream, but at the same time freshwater will not flow downstream as before. This condition would lessen saline water seepage. However, water storage will be adequate to satisfy all water demand which is expected to increase from 17.96 million cu.m. in 1990 to 50.90 million cu.m. in 2005.

### 3.1.2 SURFACE WATER QUALITY

There will be no change in surface water quality physically but turbidity will increase during construction. The chemical water quality is expected to worsen: it is highly likely that water pollution will increase due to stagnant stored water. Moreover, effluent discharge from livestock farm has rapidly increased. The value of BOD was found to be between 1.05 to 2.05 mg./l. and will certainly increase in the near future. Downstream from the damsite will have the problem of higher salinity and prolonged water pollution caused by no freshwater from upstream. Nevertheless, the impact towards marine animal raising is too low to be assessed.

### 3.1.3 GROUNDWATER HYDROLOGY

It is certain that groundwater at the depth of 10 m. upstream from the proposed damsite will have or slightly higher quality because of the freshwater storage volume. The maldistribution of groundwater at 10 m. depth will impede further improvement of water quality. Downstream from the damsite will definitely be more saline with the exception of groundwater at the 50 m. depth level which will not be affected. In short, the impact on groundwater hydrology is expected to be minimal.

### 3.1.4 SOIL RESOURCES

The proposed project will greatly affect agricultural activities and irrigation. Land will be used intensively especially for agricultural purposes which will result in a good maintenance of land. Therefore, soil resources are not expected to change or affected.

### 3.1.5 EROSION AND SEDIMENTATION

The study reveals a 1.60 mm. sedimentation which is considered to be very high when compared to the natural standard reported by UNESCO in 1958 at the annual rate of 0.20 mm. in the upper part of the watershed. Erosion and sedimentation of both banks of the Bang Pakong are not clearly evident because of thick vegetation cover on the banks themselves. Future water transportation is not expected to greatly increase therefore its impact towards erosion and sedimentation is negligible.

## 3.2 ECOLOGICAL RESOURCES

### 3.2.1 AQUATIC BIOLOGY

The freshwater storage will result in the lowering of water turbidity, increasing translucence which is expected to have a positive effect upon the member of phytoplankton. As a result, previously low fertility should improve. During construction, however, the negative impact upon fertility of the Bang Pakong River is inevitable.

### 3.2.2 FISHERIES AND AQUACULTURE

As mentioned above, freshwater storage would lead to higher fertility. It is therefore reasonable to expect an increase in fishery activities. Aquaculture should also benefit from the readily available water.

Although the diversion dam will separate the habitat of freshwater animal from that of brackish water animal as well as the freshwater storage during the dry season, nevertheless water will be released all through the rainy season. Therefore migration and movement of aquatic animal and the laying of their eggs should not be impeded, invalidating the necessity to construct the fish ladder.

### 3.2.3 FORESTRY

The forest area involved in the proposed project is confined to the mouth of the Bang Pakong River and its banks. Water blackage only in the dry season should not affect the mangrove forest. Water release from time to time during the dry season is expected to lessen the impact.

### 3.2.4 WILDLIFE

Because of the small area of the dams site (793 rai) wildlife found in the area was both limited in numbers and species. Most of the wildlife were mobile while the rest is expected to be slightly affected during construction.

## 3.3 HUMAN USE VALUES

### 3.3.1 WATER DEMAND

The proposed project will provide adequate water supply for all purposes : domestic consumption ; industrial use ; livestock ; aquaculture as well as agricultural utilization. On the other hand, downstream from the dams site will inevitably be under a stronger influence of saline water while freshwater shortage will also be more pronounced. Sever water shortage in the downstream area will be faced by the communities, manufacturing plants, aquaculture farms, agricultural land, and other activities especially during the dry season.

### 3.3.2 LAND AND WATER TRANSPORTAION

At present, transportation in Changvat Chachaengsao is at a normal condition similar to other provinces. Both land and water transportation is well regulated. It is reasonable to expect no problems in the near future.

Moreover, there will be road improvement either by reconstruction of existing roads or construction of several new routes. Water transportation has been previously anticipated to increase only slightly. The proposed project will cause negligible impact, if it all. Should the diversion dam be constructed the raft services both upstream and downstream should also be made available which would be adequate for passenger transfers.

### 3.3.3 LIVESTOCK AND MANUFACTURING INDUSTRY

The diversion dam construction project will not only make available an adequate amount of freshwater supply for livestock farms but will also result in the increasing number of these farms. Consequently water pollution from wastewater discharge especially the BOD value will increase from the normal level.

Analysis of water quality from manufacturing plants reveals that existing water pollution is not too severe to be utilized. Both BOD and toxicity are not above the standard even though the number of manufacturing plants will gradually increase. These plants are mainly agro-industry. The Government has also supported the industrial estate projects which would strengthen better pollution control.

It is anticipated that there will be sedimentation of toxic substance at the dam face. Such sedimentation will gradually increase. Therefore periodic release of sediments from dam bottom in the downstream diversion should more or less lower the toxicity.

### 3.3.4 LAND USE

The proposed project is for the construction of a diversion dam which involves the excavation of a diversion channel to divert the stream flow of the Bang Pakong River. The proposed construction site will cover

an area of 793 rai all of which are prime agricultural land. The length of the new diversion channel will be 1.60 kilometers with a 280.0 m. diversion dam at +2.00 m. MSL. Maximum water level will be +1.80 m. MSL. and the minimum level will be -1.50 m. MSL. both upstream and downstream. The operation of the diversion dam will allow continuous water flow throughout the rainy season with dry season storage volume of 30.0 million cu.m.

The dry season water shortage will waste an overflow and will flood parts of the irrigation area in Amphoe Bang Khla along the banks of the Bang Pakong for 13.00 kilometers. Downstream from the damsite the flood will mainly occur on the left bank to Highway 304 for 15.00 kilometers, covering an area of 21.6125 square kilometers. At the same time the area on the Bang Pakong right bank will be inundated by saline water especially in Amphoe Muang, covering an area of 16.2 square Kilometers.

### 3.4 QUALITY OF LIFE

The proposed project will involve construction in a prime agricultural area where agricultural produce could earn as much as 7 million baht for the land together with the creation of 1,088 jobs resulting from the project, the previous occupants will have to move out of the area. Some of them might have health problems-either physical or mental-that would need time for adjustment.

Water storage upstream from the damsite may lead to water pollution and may affect the breeding of mosquitoes and other disease agents. As a result, health conditions of the population along the banks of the river and their vicinity might be endangered.

Dry season water storage will create larger area of water surface which could be utilized for recreational purposes. Hence, a potential for commercial tourism development.

#### 4. MITIGATION PLANS

Should the proposed diversion dam be approved for construction, it is inevitable that some environmental impacts will take place. Therefore, it is necessary that the mitigation plan be set up. However, the price and the operational budget are still under consideration and fluctuating it is only appropriate to present the mitigation plan for the most pressing issues which need to be carried out.

##### 4.1 SOCIAL ADJUSTMENT PLAN

Land expropriation of 793 rai involving 65 households has already created tension among the potential evacuees. These people are under duress, calling for timely social adjustment plan. Such plan should be carried out by the the provincial agencies as soon as possible and must be before the start of the project.

##### 4.2 MITIGATION AND IMPROVEMENT PLAN FOR SURFACE WATER QUALITY

It is evident that livestock farming and manufacturing industry are the two major water polluters. To prevent wastewater discharge into the Bang Pakong River upstream from the damsite it is recommended that all canals that are now receiving wastewater discharge from livestock farms and manufacturing plants be sealed. The canals are Chukkachoe Bon, Sadao, Ban Mai, and Song Phi Nong. A drainage canal should then be constructed to receive natural stream flow which will be discharged into the Bang Pakong River downstream from the damsite along the line proposed by JICA with the total length of 20 kilometers. A budget of 12 million baht will be needed for the construction of this drainage canal and necessary irrigation control building but will not cover the land appropriation.

#### 4.3 FLOOD MITIGATION PLAN

Higher water level resulting from water storage volume will in turn create an overflow on the left bank of the Bang Pakong River. It is therefore necessary to construct a dike upstream from the diversion dam along the river bank to the district seat of Amphoe Bang Khla, a distance of 13.00 kilometers. Downstream from the diversion dam a dike should also be constructed for a distance of 15 kilometers from the damsite along the river bank to Highway 304. The construction cost of the 28 kilometers dike is approximately 35 million baht which will cover the construction of irrigation control building but not adequate for land appropriate as well.

#### 4.4 UPSTREAM AND DOWNSTREAM JETTY CONSTRUCTION PLAN

After completion of the diversion dam and the diversion channel it is expected that water transportation will resume and may moderately increased. The passenger volume is not expected to sharply rise therefore passenger transfer upstream and downstream could be effectively handled by allowing them to walk across the dam crest. But to enounce greater security and facilitate effective control it is recommended that jetties be constructed both upstream and downstream of the damsite to be the landing sites.

#### 4.5 MANGROVE FOREST PROTECTION AND REFORESTATION PLAN

For better protection of brackish water animals it is imperative to have mangrove forest reforestation along the banks of the Bang Pakong for a total distance of 20 kilometers from downstream of the damsite to the mouth of the river. Reforestation area must be at least 75 m. deep from the river banks which will total 2.8 square kilometers or 1,750 rai. The proposed budget for mangrove reforestation is 7 million baht.



#### 4.6 AGRICULTURAL DEVELOPMENT PLAN

One of the objectives of the proposed project is to supply agricultural water. Therefore it is necessary to create an agricultural development plan with an emphasis on water user organization and agricultural technology.

#### 5. RECOMMENDATIONS

1) Before the diversion dam can be designed in full detailed it is recommended that the hydrological impact of the Bang Pakong River be re-assessed. This could be carried by the hydraulic simulation analysis as proposed by JICA in 1990.

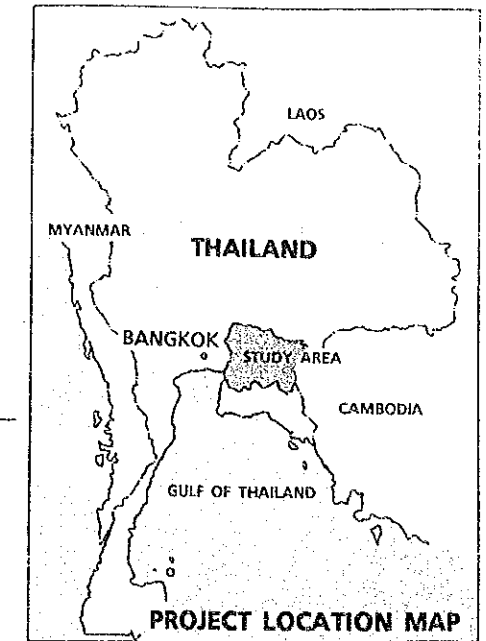
2) It is imperative that a drainage canal be constructed to receive contaminated water from natural canals caused by wastewater discharge from livestock farms, manufacturing plants, and the communities. This canal will divert the contaminated discharge into the Bang Pakong River downstream from the damsite.

3) Public relations campaigns should be organized to promote better understanding among the people in the project area and its vicinity concerning the nature, objectives, advantages and disadvantages of the project.

4) A working committee to help ease the potential evacuees of their tension should be set up as soon as possible.

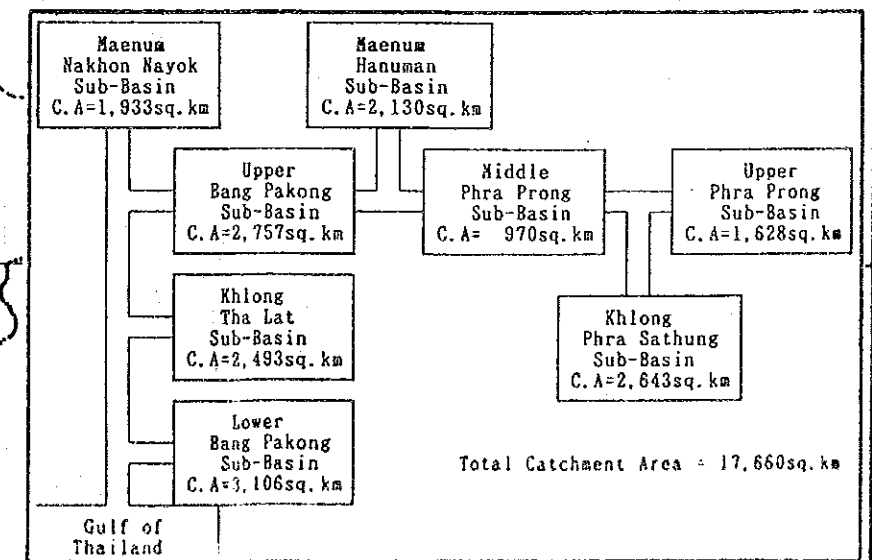
5) A regulating gate or a drainage pipe that can regulate or drain bottom layer water should be constructed at the closure dam. This regulating gate must be capable of draining wastewater, organic matters, as well as sediments from the bottom layer during the rainy season.

# GENERAL LOCATION MAP



- EXISTING IRRIGATION PROJECT
- AREA NEWLY DEVELOPED
- PROPOSED DAM/RESERVOIR

Sub-Basin	Irrigation Area (ha)	Water Requirement in MCM		
		Crop	Effect Rain	Diversion
Upper Phra prong	62,400	377.830	211.933	310.179
Khlong Phra Sathung	43,000	261.950	146.077	218.740
Middle Phra Prong	25,000	159.574	94.342	118.959
Maenum Hanuman	39,600	230.404	128.192	191.662
Upper Bang Pakong	87,900	1,485.396	732.863	1,350.028
Maenum Nakhon Nayok	207,400	766.108	423.962	575.036
Khlong Tha Lat	8,700	54.923	19.995	64.567
Lower Bang Pakong	104,000	742.186	306.755	779.703
Whole River Basin	578,000	4,078.369	2,064.115	3,606.873



0 5 10 15 km  
SCALE

# THA LAT RIVER BASIN DEVELOPMENT PROJECT

SCALE 1 : 250,000

