

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ROYAL IRRIGATION DEPARTMENT

MINISTRY OF AGRICULTURE AND COOPERATIVES

THE KINGDOM OF THAILAND

THE STUDY  
ON  
THE KOK-ING-NAN WATER DIVERSION PROJECT  
IN  
THE KINGDOM OF THAILAND

MAIN REPORT

THAILAND JICA PROJECT NO. 80010001

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THE KOK-ING-NAN WATER DIVERSION PROJECT  
IN  
THE KINGDOM OF THAILAND**

**MAIN REPORT  
(Initial Environmental Examination)**

**MARCH 1997**

**SANYU CONSULTANTS INC.  
NIPPON KOEI CO., LTD.**

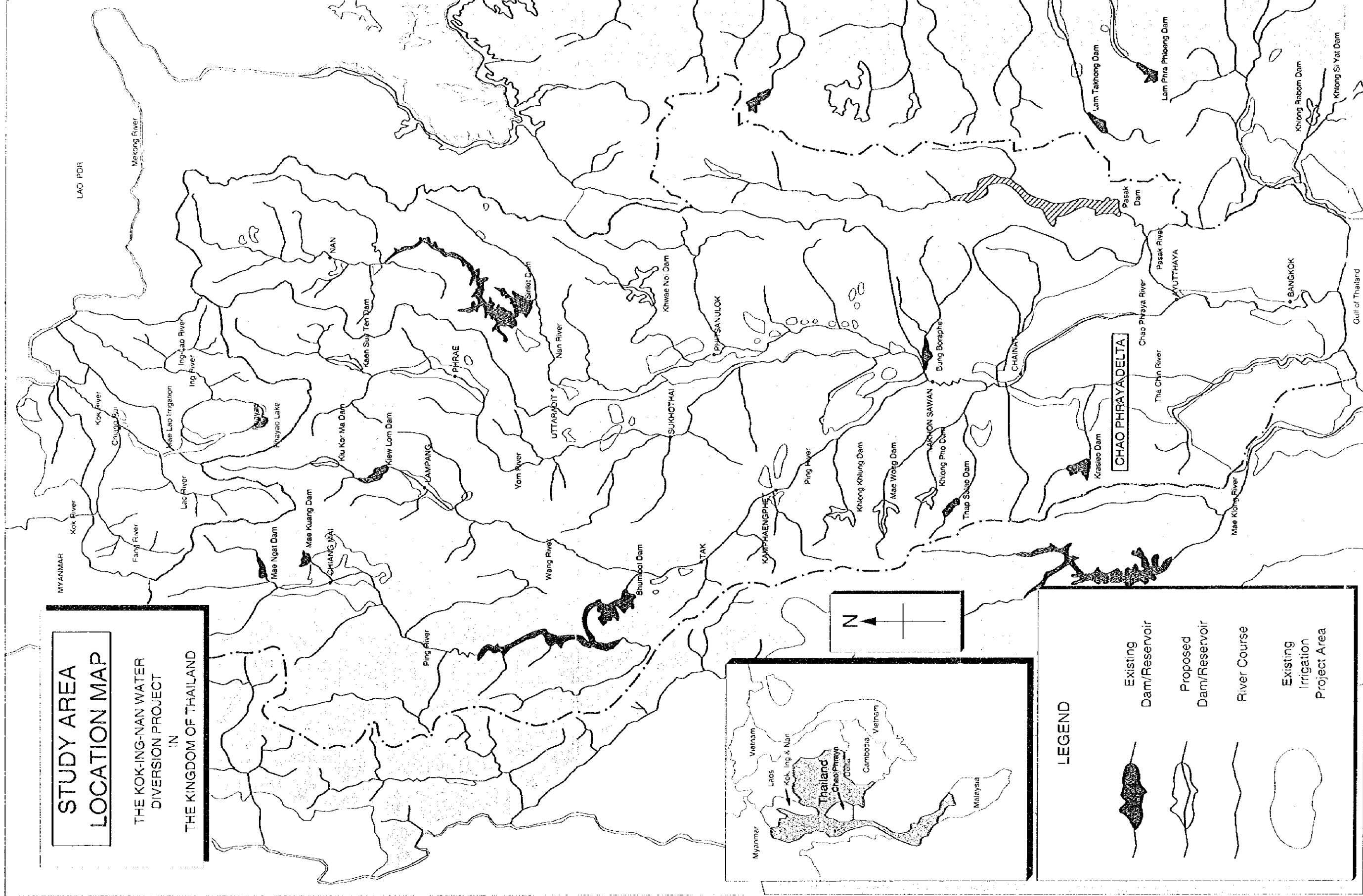


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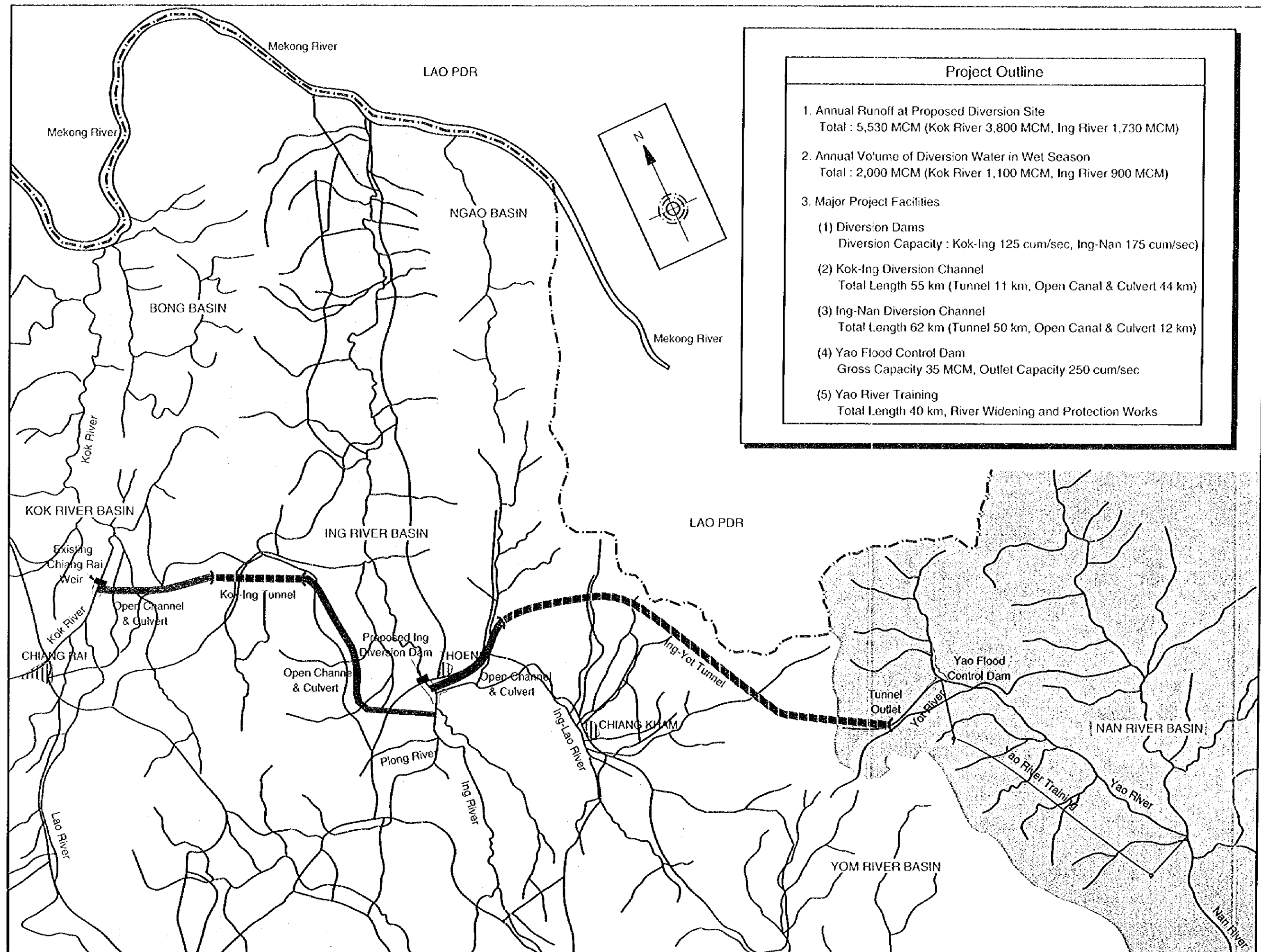
# STUDY AREA LOCATION MAP

THE KOK-ING-NAN WATER  
DIVERSION PROJECT  
IN  
THE KINGDOM OF THAILAND



## LEGEND

- Existing Dam/Reservoir
- Proposed Dam/Reservoir
- River Course
- Existing Irrigation Project Area



### Project Outline

1. Annual Runoff at Proposed Diversion Site  
Total : 5,530 MCM (Kok River 3,800 MCM, Ing River 1,730 MCM)
2. Annual Volume of Diversion Water in Wet Season  
Total : 2,000 MCM (Kok River 1,100 MCM, Ing River 900 MCM)
3. Major Project Facilities
  - (1) Diversion Dams  
Diversion Capacity : Kok-Ing 125 cum/sec, Ing-Nan 175 cum/sec)
  - (2) Kok-Ing Diversion Channel  
Total Length 55 km (Tunnel 11 km, Open Canal & Culvert 44 km)
  - (3) Ing-Nan Diversion Channel  
Total Length 62 km (Tunnel 50 km, Open Canal & Culvert 12 km)
  - (4) Yao Flood Control Dam  
Gross Capacity 35 MCM, Outlet Capacity 250 cum/sec
  - (5) Yao River Training  
Total Length 40 km, River Widening and Protection Works



## Key Indicators Involved in the Kok-Ing-Nan Water Diversion Project

### 1. Chao Phraya Basin in Need of Water by Transbasin Water Diversion

Drainage Area	158,000 sq.km
Potential Farmland Area	5,900,000 ha
Available Water Resources	33,000 MCM/year
Specific Runoff Yield	210 mm
Water Demand	25,300 MCM (1993), 33,330 MCM (2016)
Population	22.6 million (1993), 26.7 million (2016)
GDP	1,750 billion Baht (US\$ 70 billion) in 1994
GDP per Capita	79,000 Baht (US\$ 3,200) in 1994

### 2. Water Resources in Kok and Ing Basins

Item	Kok	Ing	Total
Drainage Area at River Mouth (sq km)	10,875	7,120	17,995
Average Annual Runoff at River Mouth (MCM)	5,300	2,300	7,600
Average Annual Runoff at Diversion Site (MCM)	3,800	1,700	5,500
Planned Diversion Water in Wet Season (MCM)	1,100	900	2,000
Planned Diversion Water in Dry Season (MCM)	200	-	200

### 3. Irrigation Beneficial Area by Alternative Water Use Plans

Beneficial Area	Plan A	Plan B	Plan C
Existing Phitsanulok Area	23,100	17,000	13,000
New Phitsanulok Stage II Area	-	-	147,000
Existing Delta Area	246,900	207,000	175,000
Kok & Ing New Developed Area	32,000	32,000	32,000
Total	302,000	256,000	367,000

### 4. Increasing Municipal and Industrial Water in Lower Nan and Delta Area

Increasing Amount from 1993 to 2016 = 1,240 MCM/year (620 MCM in dry season)

### 5. Project Facility

(1) Kok Diversion Dam	Intake Capacity 125 cu.m/sec
(2) Kok-Ing Diversion Channel	55 km including open canal, culvert and tunnel
(3) Ing Diversion Dam	Intake capacity 175 cu.m/sec
(4) Lao Diversion Canal	12.4 km consisting of culvert and tunnel
(5) Ing-Yot Diversion Tunnel	Tunnel of 50 km and shafts of 17 km
(6) Yao Flood Control Dam	Dam Height of 37 m, storage of 35 MCM
(7) Yao River Training	Length of 40 km

### 6. Project Cost

47,600 million Baht for water use plans A and B  
55,600 million Baht for water use plan C

### 7. Project Evaluation

Item	Plan A	Plan B	Plan C
(1) Incremental Benefit (10% Baht)			
Irrigated Agriculture	6,261	4,312	5,435
Municipal & Industrial Water of 1,240 MCM/year	4,024	4,024	4,024
Hydro-power Generation	328	328	328
Total	10,613	8,664	9,787
(2) EIRR (%)	15.1	13.2	12.7



## LIST OF ABBREVIATIONS

AIT	Asian Institute of Technology
ALRO	Agricultural Land Reform Office
ARD	Accelerated Rural Development, MOI
ASDECON	ASDECON Corporation
BMA	Bangkok Metropolitan Administration
CPD	Cooperatives Promotion Department, MOAC
DEDP	Department of Energy Development and Promotion
DLD	Department of Land Development, MOAC
DMR	Department of Mineral Resources, Ministry of Industry
DOF	Department of Fishery
DOH	Department of Health, Ministry of Public Health
DPW	Department of Public Works
DTEC	Department of Technical and Economic Cooperation
EGAT	Electricity Generating Authority of Thailand
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
IEAT	Industrial Estate Authority of Thailand
JICA	Japan International Cooperation Agency
KINWDP	Kok-Ing-Nan Water Diversion Project
MD	Meteorological Department, Ministry of Communications
MOAC	Ministry of Agriculture and Cooperatives
MOI	Ministry of Interior
MOSTE	Ministry of Science, Technology and Environment
MWA	Metropolitan Waterworks Authority
NEA	National Energy Administration
NEB	National Environmental Board
NESDB	National Economic and Social Development Board of Thailand
NRDC	National Rural Development Committee
NSC	National Security Command
NWRC	National Water Resources Committee
NWRB	National Water Resources Board
OECF	Overseas Economic Cooperation Fund
OEPP	Office of Environmental Policy and Planning
PANYA	PANYA Consultants
PAO	Provincial Administration Organization
PPD	Project Planning Division, RID
PWA	Provincial Waterworks Authority
PWD	Public Works Department, MOAC
RID	Royal Irrigation Department, MOAC
RDPB	Royal Development Project Board
RFD	Royal Forestry Department
TDRI	Thailand Development Research Institute
TEAM	TEAM Consultants
SCT	Sanyu Consultants (Thailand) Inc.
WHO	World Health Organization
WMO	World Meteorological Organization



# KOK-ING-NAN RIVER DIVERSION PROJECT

## Initial Environmental Examination

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## I. Executive Summary

The prime objective of an Initial Environmental Examination (IEE) is to reach a decision on whether a full-scale examination of environmental impacts, i.e., an Environmental Impact Assessment (EIA), is required or not. The purpose of conducting the IEE for the Kok-Ing-Nan Water Diversion Project is to identify various environmental parameters affected by a project implementation for the proposed alternatives. The impact on these environmental parameters for the selected optimum water diversion route will be reviewed and carefully examined in the next stage of the EIA.

The preparation of an IEE is an iterative assessment process that begins at the earliest phase of a project development and, running concurrently with project development, constitutes an integrated feedback loop with project planning, implementation, and operation.

The impact assessment, whether it is IEE or EIA, should be regarded as an iterative assessment process that retains its importance in project authorization ( or denial ) but also becomes a central tool for (1) monitoring and managing predicted impacts from the time of land acquisition and the management process through construction, operational, and maintenance phases; and (2) refining project development on discovery of impacts previously overlooked or changes in project design that may be required during the actual implementation.

The objective of the Project is to divert surplus water available in the Kok and Ing rivers flowing in the Northern Thailand, both of them being tributaries of the Mekong River, through several facilities such as open canal, culvert, tunnel, etc., to the Nan river and finally to the Sirikit Dam to meet the water demand in the Chao Phraya Delta. The volume of the diverted water is estimated at about 2 billion m<sup>3</sup> per annum, which corresponds to 175 m<sup>3</sup>/sec, mainly used for agriculture, industrial and domestic purposes.

In light of the development concept focusing on the human resources development addressed in the 8th National Economic and Social Development Plan (1997-2001), the following points are stressed;

- (1) The people should benefit the most from the development plan,
- (2) Sustainable environmental development to support the improvement of quality of life, and participation of people in the national development plan,
- (3) Adjustment of the administration of the government to such as environment where NGOs, private sector, community and people are allowed to participate more in the national

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- (2) Sustainable environmental development to support the improvement of quality of life, and participation of people in the national development plan,
- (3) Adjustment of the administration of the government to such as environment where NGOs, private sector, community and people are allowed to participate more in the national

development plan, even in an initial stage of determining a strategic development plan and in a later stage of monitoring and evaluation.

The Kok-Ing-Nan Water Diversion Plan should be really a strategic development plan. Therefore, the Project should be planned and implemented to meet the above development concepts, that is, to maximise the benefit of the people affected/people related and facilitate people's participation in the whole project cycle of planning, implementation, monitoring and evaluation. Furthermore, to secure the sustainable environmental development, the co-operation /collaboration among government agencies concerned and provincial governments will be strongly required and be indispensable.

The statistical data on

- Annual average income distribution
- Planting rate and water resources in a dry season
- Land utilization rate
- Working location and period, and
- Immigration rate and type of work

have clearly indicated that most social problems in the rural communities are closely related to wage and job opportunities. Judging from the correlation among three significant indicators such as household income, land utilization rate and emigration rate, a vicious circle of the problems is found, which the rural communities are now facing.

The vicious circle is represented as follows;

Water shortage → Low rate of land utilization → Low income →  
Emmigration to urban area, due to lack of job opportunities in rural  
community → Socio-economic problems

In this respect, the provision of irrigation water in a dry season by the Project and its associated projects will be expected to contribute to sever this vicious cycle. In due consideration of the national development principles and the problems faced by the rural communities, the matters seemingly vital to the project implementation are discussed below in association with the environmental study, but not limited to environmental problems.

The Project is designed to utilize efficiently and effectively the existing facility of "Sirikit Dam" to store the diverted water of 2 billion m<sup>3</sup>. Therefore, no significant resettlement/relocation will take place in spite of the storage of water as large as 2 billion m<sup>3</sup> and the diversion route running over a length of about 160 km, because any large-scale dam is not required. However, a regulating dam with a height of about 35 m is required to be constructed on the upstream Yao river, for regulating the diverted water,



protecting the downstream villages from flooding and supplying the stored water to the surrounding villages for agricultural purposes. In association with constructing the regulating dam, any resettlement/relocation is not envisaged.

The Project has to be planned to minimize relocation of local communities as much as possible, especially in selecting the diversion route which inevitably passes through the village communities. However, about 20 households will be required to be relocated in the route near the Kok diversion dam. In addition to the resettlement problem, more attention should be paid to the issue of People's Irrigation, called "Muang Fai", representing the traditional irrigation system in Northern Thailand. It will be unavoidable for the diversion route to pass, more or less, through the canal network of People's Irrigation. This issue may be vital to the implementation of the project, because this area is a starting point of the Project. In this respect, the activities of public relations should be concentrated on this matter with a full support of Chiang Rai Province at the beginning of the next stage of the study.

The Ing Diversion Dam, which is planned to be constructed 2 km upstream of the Thoeng road bridge, consists of concrete weir and polder dyke with a height of 5 m. The roles of and impacts by the Dam, such as influence on wetland, effect of flood mitigation, availability of irrigation water in the dry season, etc. should be well informed to and discussed with the village community when more concrete plan on this scheme be clarified. In this connection, people's participation, from the planning stage, in rural development will be highly recommended to be promoted under the initiative of village community with a full support of Chiang Rai Province.

In the preliminary study, of two (2) routes for Ing - Yot tunnel selected for comparison, the northern route has been judged to be more advantageous than the southern route, based on the past consultant's experiences, in taking into account engineering factors such as topographical and geological conditions and construction cost estimated for tunnel. According to the preliminary engineering study, the cost of tunnel construction for the southern route has been estimated at about 30,400 million Baht which is about 1.4 times as high as 21,100 million Baht for the northern route.

The tunnel runs underground in the mountain/conservation areas mostly represented by National Forest Reserve (C)/National Park under establishment and designated as "Watershed Classification (1A)" as well. According to the regulation set up by OEPP, no development activities are allowed in the forest areas classified as Watershed Classification (1A). In association with the tunnel construction, tunnel shafts are planned to be located at seven places along the route. In order to avoid the environmental impact, the entrance, exit and all the inlet portions of shafts are located outside of the Watershed Classification (1A).

From the ecological viewpoints of forest conservation, any significantly adverse impacts of the tunnel construction on forest resources may not be expected. There exist some projects planned/implemented in the area designated as Watershed Classification (1A), one of which was that an

underground headrace tunnel had been planned, in part, under the designated area (1A) for the "LAMTAKONG Hydroelectric Power Project".

However, the prior permission to proceed to the next study should be obtained through discussion/ consultation among RID, RFD and OEPP. In addition, their joint site inspection is highly advised to be carried out at the earliest possible date to clarify the present situation of the inlet and the outlet portions of the tunnel and the shafts, focusing on the forest resources, the watershed conservation, the access road (reinstatement after the operation and/or proper protection measures to prevent illegal logging), impacts of portals on slope stability, social environment of the surrounding villages, etc..

In addition, in association with the tunnel construction which is estimated to produce quarried rock of around 7 - 8 million m<sup>3</sup>, much attention should be paid to safety of construction, and disposal /efficient utilization of such a huge amount of quarried rock. On this matter, sufficient discussion be highly recommended to be made about construction contracts, including unit price of quarried rock and designated disposal area, among RID, RFD and Chiang Rai/Phayao Provinces.

Finally, in order to flow the diverted water of 175 m<sup>3</sup>/sec., the Yao river will be inevitably required to be improved along the river stream stretching over a length of 40 km. Along the river, thirteen (13) villages, consisting of about 1,700 households equal to about 7,000 population, are distributed. The social impacts on these 13 villages should be discussed among RID, Nan Province, affected village communities (chief of villages, chief of women's association, etc.), environmental experts of the third party (NGOs included). The ecological impacts should be examined as well.

In this discussion, the situation of the river before and after the implementation of the Project should be precisely and schematically explained so as to make village chiefs easily understand the merits and demerits. In addition to that, the enhancement programs in which the water available due to this project may be used for the villages' economic activities, should be accelerated under people's participation in rural development with a positive support of Nan Province and other governmental agencies.

Major items including the above-mentioned matters, revealed by this study of IEE, are described as below, that is, "Overall Impacts"(A - E) and "Individual Impacts"(1 - 15).

## **II. Overall Impacts**

### **A. Change in Run-off in the Rivers**

The project is planned to divert surplus water estimated at 2.0 billion m<sup>3</sup> available in total, 1.1 billion m<sup>3</sup> in the Kok river and 0.9 billion m<sup>3</sup> in the Ing river, to the Nan river in the other basin, as shown on Chart 1.

The surplus water, principally taken in the wet season, will contribute to mitigation of flood-induced disaster in the paddy field spreading in the lower Kok and Ing rivers. Especially, the Ing Diversion dam planned on the Ing river will contribute to flood mitigation in Amphoe Thoeng and the paddy field occurring in the lower basin of the Ing river. The diverted water flowing in the open canal and temporarily stored in the regulating pond/Ing Diversion Dam could be used for agricultural purpose through pumping-up by the surrounding villages and be supplied as well to Nong Luang Wetland on the way.

The change in water volume in the lower basins of Kok and Ing rivers will be alleviated to some extent due to inflow of back-water from the Mekong River.

#### **B. Impacts on Ecosystem in the Mekong**

The amount of diverted water from the Kok and Ing rivers is estimated at 1 to 3% of the average runoff of 129,370 MCM at Chiang Khong as shown on Chart 2. The reduction of this volume itself has, more or less, some impacts on the Mekong river, but seems to be not significant. Supposing that, similar projects which reduce the runoff in the Mekong river, be implemented in near future at random or even in order in riparian countries in the Mekong basin, the impacts of the Project on the ecosystem in the Mekong basin might be not small.

Each individual project results in direct and indirect impacts. Cumulative impacts are the aggregates of direct and indirect impacts resulting from two or more projects in the same area or region. Assessment of cumulative impact is important, considering the impact on the future ecosystem of the Mekong, whereas relatively small amount of water taken from the tributary of the Mekong may not be environmentally significant on a per project basis, the cumulative amount of water taken in the future may be highly significant.

Generally, environmental impact assessment has focused on those impacts that result from single projects. However, the growing concern for the global environment is likely to underscore the importance of assessing impacts in terms of whole developmental programs as well as individual projects. In this respect, the Project should be regarded as a part of the whole developmental programs associated with the watershed development of the Mekong River Basin, with which the riparian countries as well as international institutions/organization are concerned.

The Kok-Ing-Nan Water Diversion Project could be, in other terms, a pilot project which has, more or less, some impacts on the ecosystem in the Mekong basin. Taking this opportunity, the RID will be advised to carry out some study or collect data concerning the cumulative impact of the Project. The location for this study is recommended to be "Nongbongkai Wildlife Restriction Area (NWRA) near

Chiang Saen, which was declared as a Non-Hunting Area in 1985. The river or stream originated in NWRA is connected to the Ing river about 10 km from the river mouth to the Mekong River.

The tentative items for monitoring in a dry season and a wet season are as follows;

- Observation of bio-diversity
- Water level in NWRA
- Rice productivity, fish capture, cultivation area
- Population density
- Meteorological data
- Observation of aquatic plant, including weed
- Type and population of wildlife
- pH, BOD, SS and water level at the mouth of the Ing river
- pH, BOD, SS and water level in the center of the swamp

C. Back-water from Mekong River

The water level of the Mekong River at the mouth of the Ing river is recorded at 350 m max. and 340 m min., indicating that the fluctuation of water be ranged within 10 m around. The highest water level is observed in October to November and the lowest in April. The river gradient of the Ing river is very gentle, being approximately 1/5,000, from Thoeng to the mouth to the Mekong, so that the back-water comes up to about 50 km upstream from the mouth, but not to Amphoe Thoeng.

D. Impacts on Aquatic Ecology from One Watershed to Other Watershed

The impacts on aquatic ecology from one watershed to other watershed have been examined based on captured species for Kok, Ing, Nan rivers and concerned tributaries. At this preliminary stage, it has been concluded that the impacts on distribution of fish from one watershed to other watershed is expected to be low because the preliminary result of the study (RID study) indicated that there are minor differences in families and species of fish found in each watershed.

This conclusion should be reconfirmed by more samplings/analyses and more precise examination in the subsequent study. And the impact analysis will be required to be continuously made in the monitoring stage after the implementation of the project.

E. Public Health

In Thailand, diarrhea is by far the highest cause of morbidity. Diarrhea and food poisoning have not been reduced due to lack of water supply, hygienic latrine and food sanitation.

The implementation of water resources development project could cause both positive or negative health impacts. Therefore, it is necessary to study the present public health condition before project implementation, so that careful analysis of causes and problems could be done in the next study.

The RID (TEAM J/V) study showed that important water-related disease found in the study was malaria whereas encephalitis and hemorrhagic fever were not present in the record. But encephalitis is reported to have occurred in the Project Area. Common malnutrition problems were goitre and anemia. Particularly in the construction stage, the main problem is likely to be the outbreak of malaria among labors and communities in areas around the tunnel outlet and shaft construction sites. Besides, the spread of AIDS and diarrhea might be possibly found among workers.

More comprehensive public health survey is desirable to understand existing problems and to foresee health impact which will be brought by the water resources development project. Especially, the study on present situation of sanitation and hygiene such as types of drinking water and latrine is necessary in the 13 villages along the Yao river, the area of the Ing Diversion Dam and the vicinity of Nong Luang wetland.

Most of the health impact studies show that improved access to water in terms of quantity, not quality, brought a significant reduction in diarrheal disease. Furthermore, the health education for people in communities is useful to change inadequate health behavior. In this connection, it is recommended that in the early stage of the project, the health education programs be applied to these areas as a part of enhancement programs of the Project, to ensure that the available water is fully used for hygienic purposes, and to minimize fecal contamination of the environment.

Individual impacts along the diversion route from the starting point of the intake site in the Kok river are summarized below. The summary is shown on Chart 3 covering the whole route and the precise impacts on several alternative routes limited to the area between the intake in the Kok river and the Ing Diversion Dam is shown on Chart 4.

### **III. Individual Impacts along the Diversion Route**

#### **1. Intake from the Kok River**

As an intake site, two alternatives are proposed, an upstream one and a downstream one of the existing diversion dam administered by DEDP. The downstream one ( A route ) is that a new intake facility is planned to be constructed about 4 km downstream of the Kok Diversion Dam ( existing ). In this case, the RID is able to administer the water under his control, but the canal will inevitably pass, in most parts, through the irrigation canal network under the DEDP control. On the other hand, the

upstream one ( B route ) is planned to take directly the water at the location about 2 km upstream of the existing dam, but is not able to administer the water under his control.

In any case, mutual understanding and close co-operation between RID and DEDP will be highly required to promote the project. It should be noted by both governmental agencies through the process of site selection that the project be implemented to contribute to the economic development in the local community, in which the role the Chiang Rai Province is expected to play is not small, but rather large and vital to the project implementation.

## 2. Land Acquisition and People's Irrigation

The Kok Diversion Dam (existing) and the subsequent canal route are the starting point of the Project. The land acquisition for these areas located within the economic zone of Chiang Rai city, may be more sensitive than that for other areas.

The Project has to be planned to minimize resettlement/relocation of local communities as much as possible, especially in selecting the diversion route which inevitably passes through the village communities, resulting in that about 20 households be required to be relocated in the route near the Kok diversion dam. In addition to the resettlement problem, more attention should be paid to the issue of People's Irrigation, called " Muang Fai ", representing the traditional irrigation system in Northern Thailand.

The traditional People's Irrigation system, called as " Muang Fai ", not only controls the rivers and streams but defines the social fabric of thousands villages, welding communities together to share resources to ensure mutual prosperity. However, now village cohesion is weakening, and with it the willingness to co-operate. One of the reasons is that the new settlers refuse to pay for the water; old farmers, seeing the newcomers receiving free water, become reluctant to pay, resulting in most distressing to "Muang Fai administrators". Particularly, when water supplies are scarce during the dry season, the potential for conflict escalates and the problem becomes more serious.

It will be unavoidable for the diversion route to pass, more or less, through the canal network of People's Irrigation. This issue may be vital to the implementation of the project, because this area is the starting point of the Project. In this respect, the activities of public relations and the social study on People's Irrigation should be concentrated on this matter with a full support of Chiang Rai Province in the next stage of the study.

In case of Route A, about 20 households will be required to be relocated as mentioned above. On the other hand, in case of Route B, no resettlement problems may be expected to take place at this moment, but some households may be possibly affected in the future due to expansion of the urban development in Chiang Rai city. Furthermore, in the route selection, it will be necessary to take into consideration the hike of land price with progress of urbanization.

### 3. Ecosystem of Wetland (Nong Luang) for Routes "B" and "B-P"

The wetland of Nong Luang is dried up in a dry season. The wetland presently plays an important role not only in feeding and breeding for birds and wildlife but also in aquaculture in the rural economy.

The canal route is to pass through Nong Luang, resulting in, more or less, having some adverse effects on the wetland ecosystem. However, the introduction of water from the canal in a dry season into the wetland is expected to contribute more to the rural economy, in meeting the needs of local communities. In this respect, the conservation of the wetland in Nong Luang, or more positive utilization of the wetland, is closely related to enhancement programs under people's participation to be recommended with a full support of RID, RFD and DOF.

Despite the wide ranges of resources and services provided through wetlands in the region, they have not likely been properly protected or managed on a sustainable basis. In Southeast Asia, major threats come from mining, and unsustainable forestry conversion to agricultural or urban land. If these systems are to continue to support the region's biodiversity and the people who depend upon their resources, urgent attention needs to be given to improving their management. Governments and non-governmental organizations (NGOs) have been paying increasing attention to this issue in recent years, and Vietnam and Indonesia both joined the Ramsar Convention in the late 1980s.

Before that, understanding of wetlands, that is, understanding the full value of wetland ecosystems and the role that their sustainable use can play in achieving social and economic goals, needs to be built at all levels of society, firstly among government departments concerned such as RID, DOF, RFD, provincial government, etc..

### 4. Deep Excavation in Culvert (Route "B")

The canal passes through a paddy field and a small hill after coming out of the Nong Luang, and again run through a paddy field along which several villages, namely Ban Thung Khong and Ban Mua Luk, are situated several hundred meters away, and finally comes to a regulating pond planned with an area of 200 ha. The pond plays a role in regulating diverted water temporarily, from which the diversion main canal goes out and another canal goes out as well to supply the water to the area on the left bank of the Hong Khua river, a tributary of the Ing river.

The canal passing near the above-mentioned villages, is designed to be of culvert type. The excavation is, in some parts, down to a depth of 20-30 m from the ground. Therefore, the open space during construction is as wide as 100 m or more in the deepest section. Besides disposal of large amount of excavated soils, estimated at 18 million m<sup>3</sup>, this might possibly induce several safety problems such as accidents during construction, safety hazards to small children, etc.. The design of such a deep excavation is



strongly advised to be reviewed. If it is unavoidable, the construction will be required to take the following measures in due consideration of anticipated adverse impacts on the environment;

- Safety measures against excavated slope collapse and slope sliding during construction,
- Safety measure against access to the excavated open space during construction (setting up the fence along the shoulder of the open space, preventing village people from approaching the site),
- Proper treatment of dewatering during the excavation work,
- Proper treatment of excavated materials (utilization of organic top soil and disposal of 18 million m<sup>3</sup> excavated soils), and
- Correct information about the construction to the local community.

##### 5. Ing Diversion Dam

The construction of the polder dyke will contribute to close off a paddy field from the flood and to alleviate potential damage to infrastructure. On the other hand, farmers will lose a benefit from the fertilizing role of the flood when the water recedes, but the benefits of the flood are not altogether lost. Generally, the dry season drawdown speeds up aerobic decomposition of accumulated organic matter, releasing nutrients that, on reflooding, support a wet-season bloom in productivity. The life histories of many organisms are intimately coupled to this periodicity. The volume of water discharges in rivers and other water bodies such as swamp and pond, principally dominates the distribution and the abundance of aquatic organisms. Therefore, the shortage of water supply has a significant influence on the activities of fishing and aquaculture.

The change of environment after the construction of the dykes is represented by longer periods of flood condition, 3 to 4 months, compared with the current flood, 2 to 3 weeks. It should be noted that the fluctuation in water level caused by change in water discharge after the project implementation is less than that due to seasonal change, a dry season and a wet season. Therefore, the impacts of the Project on the aquatic ecology are rather small. Plants and wildlife living there may adapt themselves to such environmental change of alternate periods of longer flooding and shorter drying.

In maintaining the function of the wetland, the periodicity of flow pattern is quite important. Although the flood pattern itself is to be changed by the Project, the periodicity will be secured. Therefore, productivity in aquaculture, growth cycle in aquatic plant and habitat/migration for wildlife will be less affected.

Here, it should be noted that the reservoir formed by the dyke helps farmers living there to utilize water even in a dry season for paddy/crop cultivation and aquaculture. Available water of 300 MCM in a dry season will be used for associated projects, that is, Lower Ing Irrigation project (5,000 ha), upper Ing Irrigation project (3,000 ha) and Inland Fishery project (2,000 ha in water surface area).

Principally, at each stage of the project implementation, such as planning, construction and operation, intensive and frequent consultation among local communities, representatives of Theong, RFD, RID, etc. will be advisable to be held for mutual understanding in the next stage of the study.

## **6. Tunnel Under Watershed Classification and National Forest Reserves**

Although the impacts on forest resources are expected to be of low magnitude, there are important issues about environment-related regulations to be clarified before proceeding to the next stage of the study, that is, Watershed Classification and National Forest Reserves. According to the regulation set up by OEPP, no development activities are allowed in the forest areas classified as Watershed Classification (1A).

A major objective of watershed classification is to formulate land use plan for conservation of natural resources, in particular, water and forest resource from the viewpoint of their sustainable use. From the ecological viewpoints of forest conservation, any significantly adverse impacts of the tunnel construction on forest resources may not be expected. However, the prior permission to proceed to the next study should be obtained through discussion/ consultation among RID, RFD and OEPP at the earliest possible date.

In addition, no data on the vegetation around the Phu Sang Waterfall in the National Park are available. So, the survey on vegetation will be required to be made in the next stage of the study.

In the tunnel construction, the major issues related to watershed conservation will be the behavior of the groundwater/the surface water which may affect, more or less, the vegetation and forest resources occurring on the surface above the tunnel/shafts. The longitudinal sections of the tunnel/shafts are shown on Database Map. From the watershed conservation aspects, the investigation items are provisionally listed in Chart - 5 for the impacts likely induced by tunnel construction.

## **7. Safety Measures in Tunnel Construction**

The tunnel construction will be required to take the following measures in due consideration of anticipated adverse impacts on the environment;

- Safty measures against the collapse of the wall and the ceiling,
- Proper treatment of polluted water,
- Proper treatment of excavated rock, and
- Reforestation of the areas affected such as inlet and outlet portions of tunnel and shafts, and access road from existing roads to the shafts.

## **8. Reforestation Plan in the Inlet Portions of Shafts and along the Access Road**

Some forest resources will be inevitably affected by construction of the tunnel shafts and the access roads. As mitigation measures, adequate reforestation plans are advised to be established under the "Village Reforestation" concept. Seedles for forest planting should be provided from RFD' Seedling Centre. Principally, the area for reforestation should be more than that affected by the construction. In the preparation stage of the reforestation plan, the co-operation/ collaboration among RID,RFD and village communities will be indispensable.

## 9. Utilization of Quarried Rock from Tunnel Construction

In connection to the proper treatment of excavated rock, it will be well advised to prepare the plan for utilizing the quarried rock from the tunnel excavation, the volume of which is estimated to be as large as 6 to 7 million m<sup>3</sup> in-situ.

The quarried rock can be used for several purposes, not only for the project but also for other purposes, depending on weathering degree.

For the project, and associated projects	coarse aggregates for concrete, rock material for river bank protection and construction materials for dam and dyke
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For other purposes	coarse aggregates for local sale and construction materials for local sale
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Particularly, in association with utilisation of quarried rock related to the tunnel construction, it is advised that not only the provincial government, under the initiative of community villages, participate positively in the development project, but also private sectors will be invited to join the project in a more positive manner.

For instance, a special purpose company in which a private sector and an affiliated entity of the provincial government take an equity participation, will be possibly established to produce and sell construction materials such as concrete aggregates, etc., in using quarried rock from tunnel excavation. The location for the spoil bank where the above excavated materials be disposed, shall be designated by the provincial government. In case of disposing such excavated materials at the designated site, the contractor shall pay at the price agreed among the parties concerned to the provincial government. First of all, it is necessary to formulate a framework in which all the parties concerned, fairly and equally, share together the benefits and the risks coming from the Project.

In the background of this concept, the destruction of forest resources could be avoided in other areas where the quarried rock is necessitated for rural development purposes.

## 10. Aquatic Ecology and Fish Migration in Tunnel

Concerning the migration of fishes through the tunnel with a length of 50 km, most of the fishes have enough swimming capability so that no significant impacts are expected to be envisaged. But at the inlet portion of the tunnel, some measures are recommended to be considered for reducing the flow velocity, for instance, installing a resting place.

The lack of oxygen in the tunnel will be avoided, because the oxygen will be supplied into the water as far as the movement of atmospheric air occurs and the steady flow is present even under no sunlight condition like the night time. Furthermore, the temperature of the underground, about 1,000 m below the ground

surface at the deepest, is almost the same as the annual average temperature of the atmosphere in the respective region, so that the difference in temperature is expected to be minor throughout the tunnel. Fishes could adapt themselves to change in temperature in the tunnel.

#### 11. Ethnic Hilltribe

Villages of hilltribe (Yao tribe) are scattered around the entrance of Tunnel No. 4 shaft. Thus this area would need more attention than other areas, before and during the construction. And the Public Relation activities will have to be executed ( for instance, at the time when the route of an access road be clarified.) in a close collaboration with NGOs for this special region earlier than the other regions.

#### 12. Regulating Dam in the Yao River

The regulating dam is planned to be located out of the National Forest Reserve but its reservoir enters in parts into the National Forest Reserve covered with degraded forests. Any village is not directly affected, but pasture will be affected at limited places. The regulating dam will play a very important role not only in preventing the villages scattered along the Yao river from being flooded in a wet season, but also in providing the paddy field with stored water in a dry season. The water stored in the reservoir can be also used, for example, for nursery bed of valuable trees, medical plant, fishery, etc. In this connection, the enhancement programs are recommended to be promoted for the rural development under people's participation.

#### 13. Yao River Training

In order to flow the diverted water of 175 m<sup>3</sup>/sec., the Yao river will be inevitably required to be improved along the river stream stretching over a length of 40 km. Along the river, thirteen (13) villages, consisting of about 1,700 households equal to about 7,000 population, are distributed as shown on Chart 6. The social impacts on these 13 villages should be examined/discussed among RID, Nan Province, affected village communities (chief of villages, chief of women's association, etc.), environmental experts of the third party (NGOs included). The ecological impacts should be examined as well.

The plan should have a minimal impact upon river flow, and minimize the affects of agricultural, fishery and pastoral activities, and minimize loss of biological diversity. However, if the plan is unavoidable, all efforts should be made not only to minimise loss of biological diversity but also to create more of biological diversity than its loss. The following programs are recommended to be implemented;

- create moderate slope of banks for the aquatic plant growth, which will contribute to produce natural detritus food for the fish,
- plant riparian vegetation along the water's edge to conserve and create biological diversity, and
- pay attention to the habitat for wildlife and the morphology of the river

Vegetation can stabilize shorelines by reducing the energy of waves, currents or other erosive forces. At the same time, the roots of plants hold the bottom sediment in place, preventing the erosion of the river bank.

In this connection, taking the opportunities to utilise water available in a dry season, rural development projects are strongly recommended to be promoted for the dry season cultivation eagerly needed in the Yao river basin. In addition, the Lower Yao Irrigation project (2,000 ha) is planned as associated project. These projects should be implemented at the tambon level under the initiative of village people. There, village people themselves assess the present conditions of livelihood and resources potential such as land use, labour force, credit/fund sources, and propose their development plan to the Tambon Council, which undertakes coordination, cooperation and information dissemination.

#### **14. Impact on the Sirikit Dam**

The volume of diverted water of 2,000 MCM will be stored additionally in the Sirikit Dam, which is the final destination of the Project.

This raises and keeps the water level of the Sirikit reservoir to H.W.L. in a wet season, which eventually has some environmental impacts on the ecosystems of the reservoir in a different manner from the case without project.

- Riparian habitat and riparian vegetation
- Aquatic habitat and aquatic plant/aquatic organisms
- Fish nursery and spawning
- Siltation
- Eutrophication
- Weed habitat
- Freshwater aquaculture and fishing

#### **15. Minor Impacts on Wildlife**

Only small size wildlife such as rat, snake, lizard, frog, etc. is present in most of the project area. The small size wildlife moves only within 50 m of his habitat. Most of the wildlife species present in the project area can adapt themselves to the change of the environment caused by the project. Most of the mid-size wildlife such as deer, wild pig, etc. have gone to the forest area. So the impacts on the mid-size wildlife appears to be minor.