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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ROYAL IRRIGATION DEPARTMENT
MINISTRY OF AGRICULTURE AND COOPERATIVES
THE KINGDOM OF THAILAND

THE STUDY
ON
THE KHLONG YAI WATER DIVERSION PROJECT
IN
THE KINGDOM OF THAILAND

FINAL REPORT

(Main Report of
Environmental Technological Assistance Study)

NOVEMBER 1989

SANYU CONSULTANTS INC.
NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a study on the Kok-Ing-Nan Water Diversion Project (Phase II) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Shoichiro Higuchi of SANYU CONSULTANTS INC. and consisted of SANYU CONSULTANTS INC. and NIPPON KOEI Co., Ltd. to Thailand, 3 times between December, 1997 and October, 1999. In addition, JICA set up an advisory committee headed by Mr. Hidetomi Oi, Development Specialist, JICA between December, 1997 and October, 1999, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Thailand and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Thailand for their close cooperation extended to the Team.

November 1999

Kimio Fujita
President
Japan International Cooperation Agency

November 24, 1999

Mr. Kimio Fujita
President,
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Mr. Fujita,

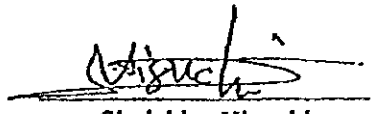
We are pleased to submit hereby the Final Report on the Feasibility Study and the Environmental Technical Assistance Study on the Kok-Ing-Nan Water Diversion Project (Phase II Study) in the Kingdom of Thailand. This report incorporates advice and suggestions of authorities concerned of the Government of Japan and your good agency as well as the comments made by the Royal Irrigation Department (RID) of the Ministry of Agriculture and Cooperatives and other responsible agencies of the Government of Thailand on the formulation of the project during technical discussions on the draft final report, which were held in Tokyo and Bangkok.

In the light of urgent importance of solving water shortage problems prevailing over the Chao Phraya basin, the Study is to supplement and strengthen the study initiated already by the Government of Thailand. Following the Conceptual Planning Study and the IEE as the Phase I Study, the Phase II Study was formulated and evaluated from both engineering and economic point of view for further implementation of the Project. The Environmental Technical Assistance Study was also conducted focusing mainly on the review of the EIA made by the Thai-side inclusive of some supplemental studies in the field of watershed management, etc.

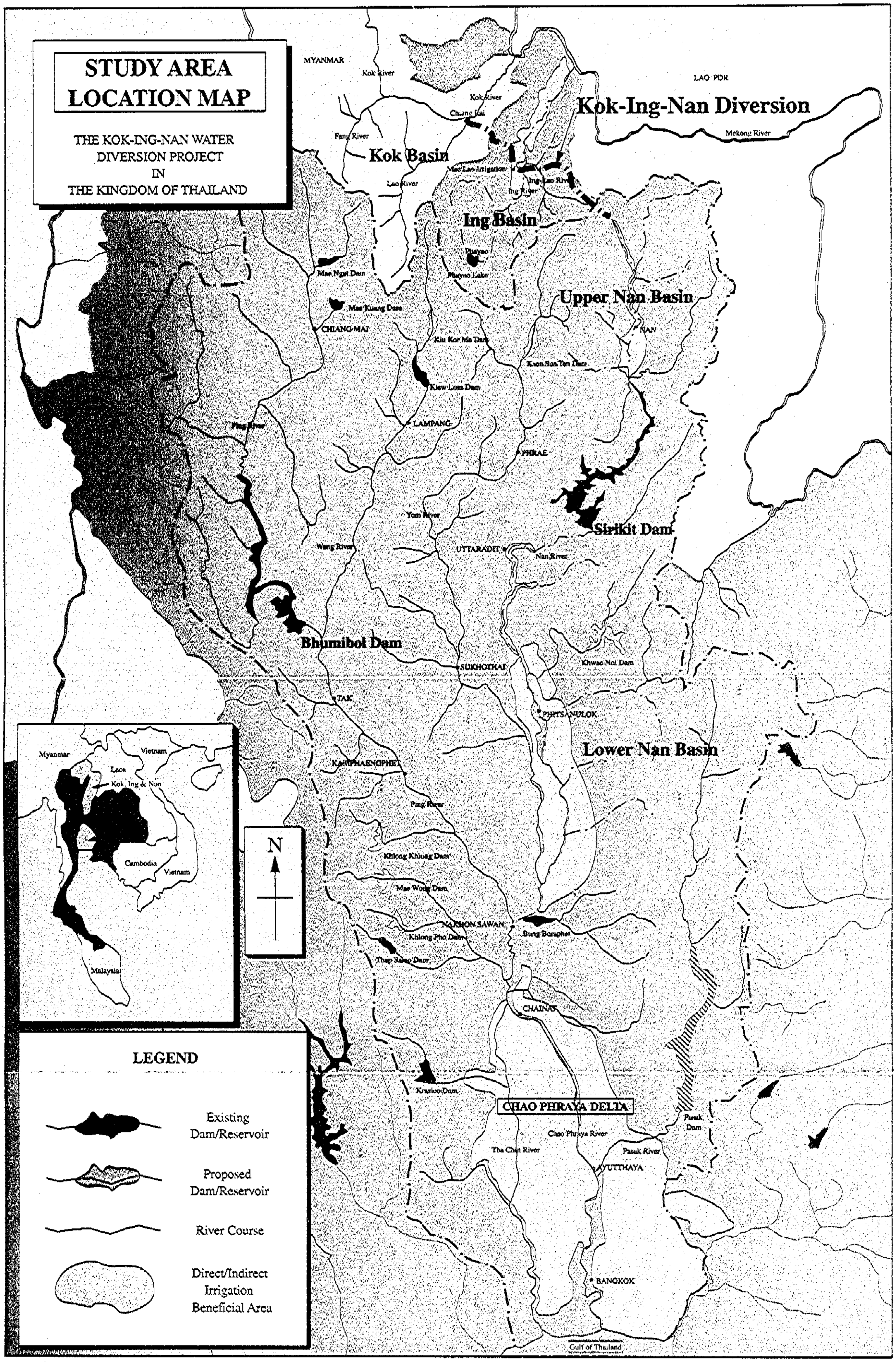
In view of critical condition of balance between demand and supply of water and of need for sustainable development of the Chao Phraya basin as a whole, water diversion as studied can be considered as one of the effective measures. The Study aims to furnish full information regarding the demand and supply of water so that the Government of Thailand can make decision for further implementation of the Project under due consideration of not only technical aspects but also economic and other situation of the country. The magnitude of influence that might be caused by Project would also be considerable, and therefore public relation activities should be executed not only in the Kok, Ing and upper Nan basins but also in the direct beneficiary areas in the lower Nan and Chao Phraya delta.

We wish to take this opportunity to express our heartfelt gratitude to your Agency and other authority concerned of the Government of Japan as well as to the RID and other agencies of the Government of Thailand for close cooperation and assistance extended to us during the course of our investigations and studies.

Very truly yours,



Shoichiro Higuchi
Leader of the Study Team


STUDY AREA
LOCATION MAP
THE KOK-ING-NAN WATER
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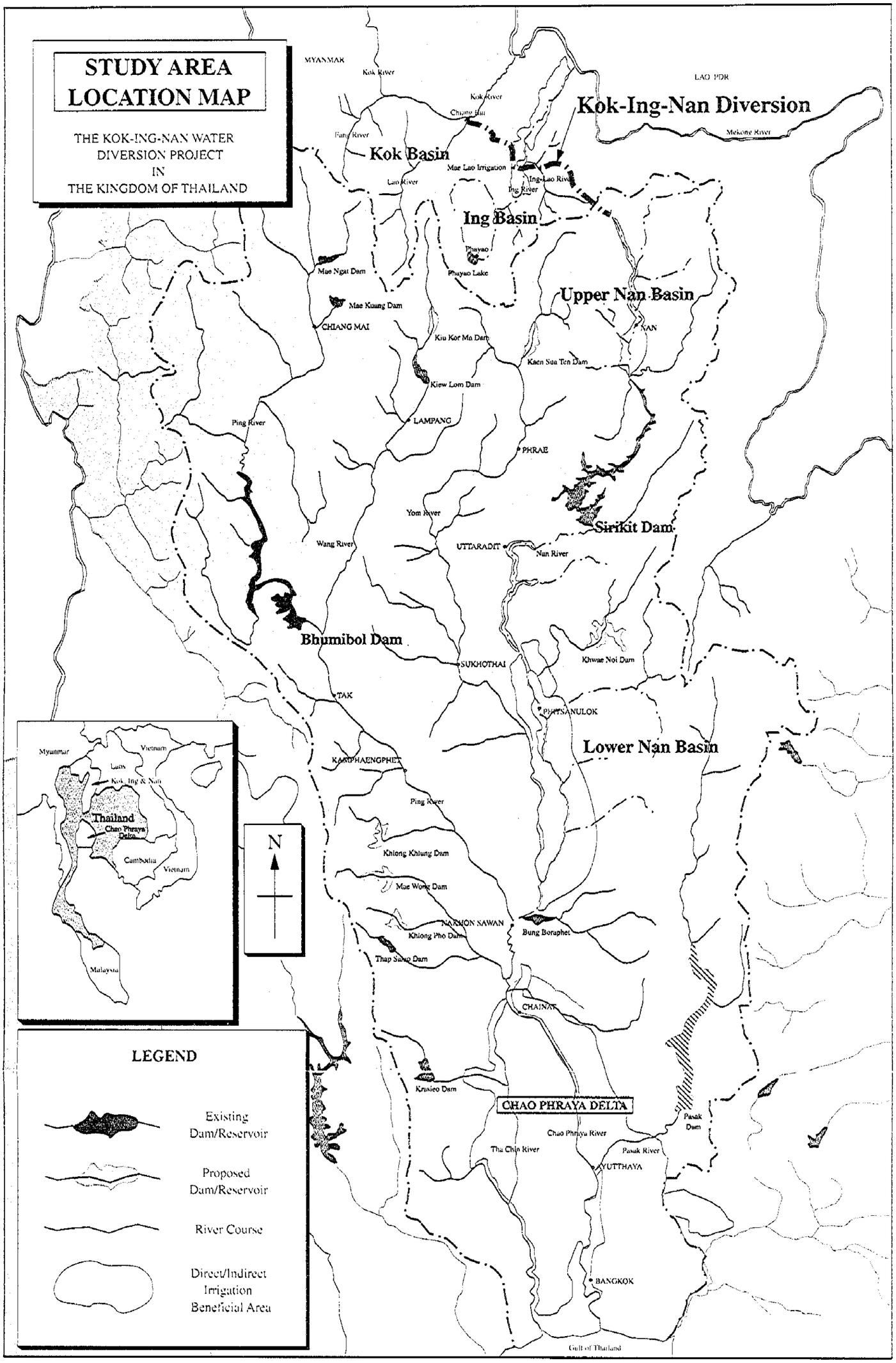
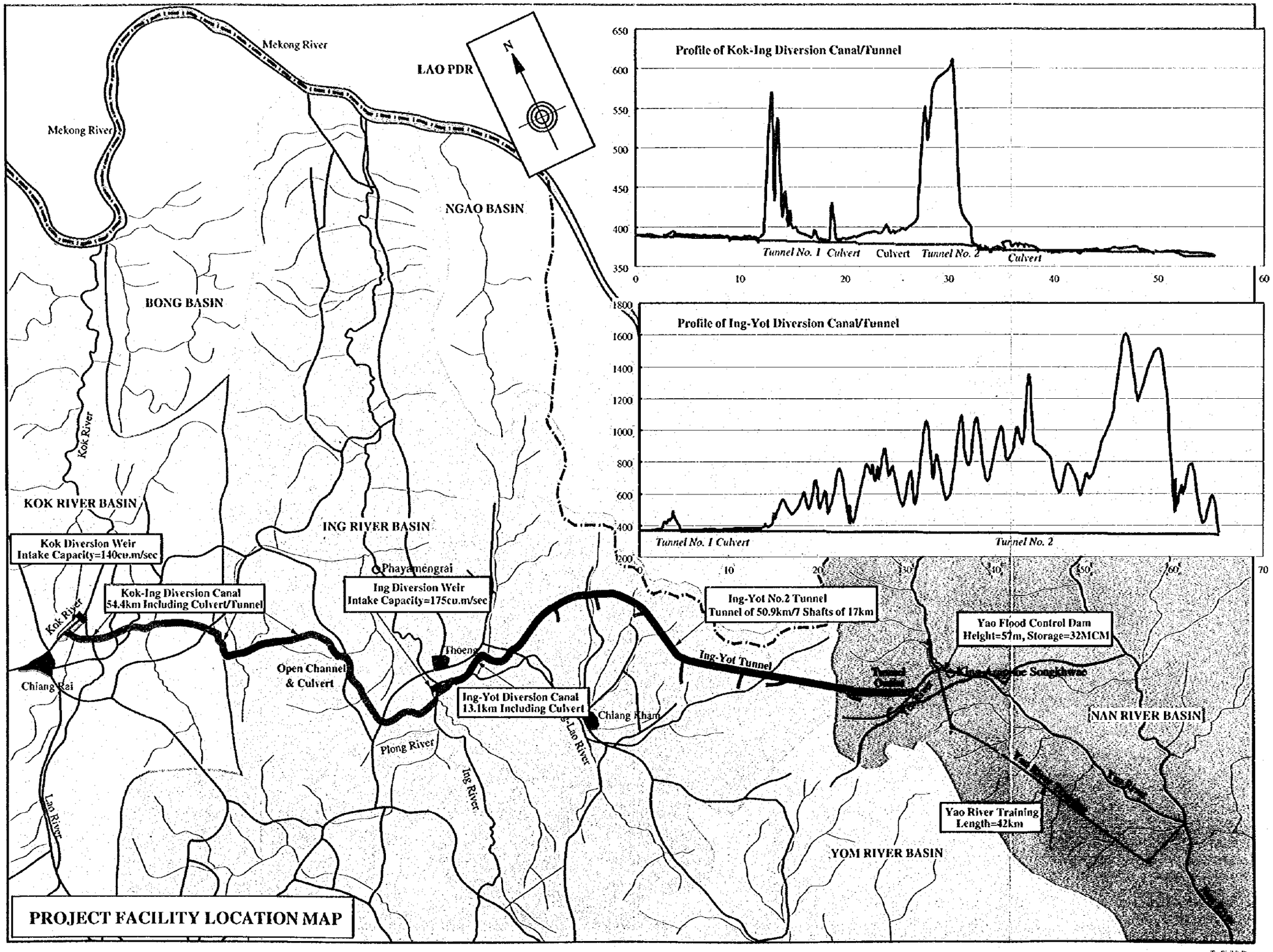
IN
THE KINGDOM OF THAILAND
MYANMAR
LAO PDR
Kok-Ing-Nan Diversion
Mekong River
Kok River
Chiang Rai
Fang River
Kok Basin
Lao River
Ing Basin
Ing River
Phayao Lake
Upper Nan Basin
NAN
Mae Ngat Dam
Mae Kuang Dam
CHIANG-MAI
Kiew Lom Dam
LAMPANG
Ping River
PHRAE
Yom River
Sirikit Dam
Wang River
UTTARADIT
Nan River
Bhumibol Dam
SUKHOTHAI
Khwae Noi Dam
TAK
PHITSANULOK
Lower Nan Basin
KAMPHAENGPHET
Ping River
Khlong Khlung Dam
Mae Wong Dam
NAKHON SAWAN
Bung Boraphet
Thap Salao Dam
CHAINAT
Krasieo Dam
CHAO PHRAYA DELTA
Chao Phraya River
Pasak Dam
The Chin River
Pasak River
AYUTTHAYA
BANGKOK
Gulf of Thailand
Myanmar
Vietnam
Laos
Kok, Ing & Nan
Cambodia
Vietnam
Malaysia
N
LEGEND
Existing Dam/Reservoir
Proposed Dam/Reservoir
River Course
Direct/Indirect Irrigation Beneficial Area

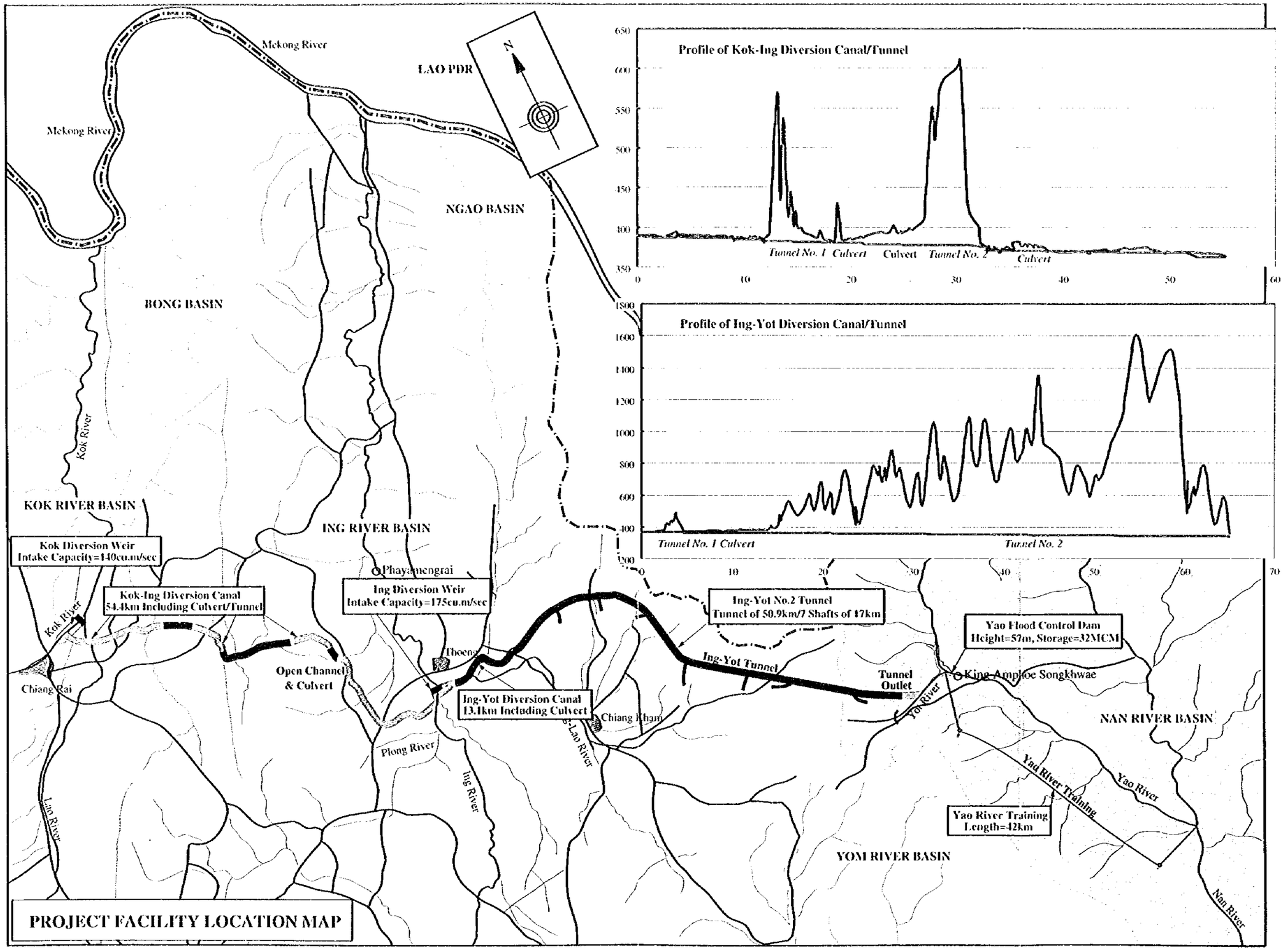
STUDY AREA LOCATION MAP

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




Mekong River
LAO PDR
Mekong River
NGAO BASIN
BONG BASIN
Kok River
KOK RIVER BASIN
ING RIVER BASIN
Kok Diversion Weir
Intake Capacity=140cu.m/sec
Kok-Ing Diversion Canal
54.4km Including Culvert/Tunnel
Kok River
Phayamengrai
Ing Diversion Weir
Intake Capacity=175cu.m/sec
Thoeng
Open Channel
& Culvert
Chiang Rai
Ing-Yot Diversion Canal
13.1km Including Culvert
Chiang Kham
Plong River
Ing River
Lao River
Ing-Yot No.2 Tunnel
Tunnel of 50.9km/7 Shafts of 17km
Ing-Yot Tunnel
Yao Flood Control Dam
Height=57m, Storage=32MCM
NAN RIVER BASIN
Yao River Training
Length=42km
YOM RIVER BASIN
PROJECT FACILITY LOCATION MAP
To Sirikit Dam
Profile of Kok-Ing Diversion Canal/Tunnel
650
600
550
500
450
400
350
0
10
20
30
40
50
60
Tunnel No. 1
Culvert
Culvert
Tunnel No. 2
Culvert
Profile of Ing-Yot Diversion Canal/Tunnel
1800
1600
1400
1200
1000
800
600
400
200
0
10
20
30
40
50
60
70
Tunnel No. 1 Culvert
Tunnel No. 2

PROJECT FACILITY LOCATION MAP



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ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ALR	Office of Agricultural Land Reform (MOAC)
amsl	above mean sea level
ARD	Office of Accelerated Rural Development (MOI)
ASDECON	ASDECON Corporation
B	*baht* (see *Local Terms*)
B.E.	Buddhist Era, with B.E. 2542 being the same as the western 1999, i.e. subtract 543 from B.E. date to obtain western date
CAO	Changwat (Provincial) Administrative Organisation
CD	Community Development
CKD	Committee of the Kok-Ing-Nan Water Diversion Project DBSDF (proposed)
DANCED	Danish Co-operation for Environment & Development
DBSDF	Donor Basin Sustainable Development Fund (proposed)
DCD	Department of Community Development (MOI)
DEDP	Department of Energy Development and Promotion (MOSTE)
DEQP	Department of Environmental Quality Promotion (MOSTE)
DLD	Department of Land Development (MOAC)
DMR	Department of Mineral Resources (MOInd)
DOAE	Department of Agricultural Economics (MOAC)
DOF	Department of Fisheries (MOAC)
DOH	Department of Health (MOPH)
DOLA	Department of Local Administration (MOI)
DPW	Department of Public Works (MOI)
EGAT	Electricity Generating Authority of Thailand (Office of Prime Minister)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
GPS	Global Positioning System
GWh	giga-Watt-hour (1000 million Watt-hours)
ha	hectare
HIV	Human Immunodeficiency Virus
JICA	Japan International Co-operation Agency
KIN	Kok-Ing-Nan Water Diversion Project (proposed)
km^2	square kilometre
kWh	kilo-Watt-hour (1000 Watt-hours)
M	million
m^3	cubic metre
MCM	million cubic metres
mm	millimetre
MOAC	Ministry of Agriculture & Co-operatives
MOC	Ministry of Commerce
MOD	Ministry of Defence
MOEd	Ministry of Education
MOF	Ministry of Finance
MOInd	Ministry of Industry
MOI	Ministry of Interior
MOLSW	Ministry of Labour & Social Welfare
MOPH	Ministry of Public Health
MOSTE	Ministry of Science, Technology & Environment
MOTC	Ministry of Transport & Communication
MOUA	Ministry of University Affairs
MRC	Mekong River Committee
MSL	mean sea level

MW	mega-Watt (million Watts)
MWA	Metropolitan Waterworks Authority (MOI)
NEB	National Environment Board (Office of Prime Minister)
NESDB	National Economic & Social Development Board (Office of Prime Minister)
NGO	Non-governmental Organisation
NRDDC	National Rural Development & Decentralisation Committee (Office of Prime Minister)
NWRC	National Water Resources Committee (Office of Prime Minister)
OECF	Overseas Economic Co-operation Fund (of Japan)
OEPP	Office of Environmental Policy & Planning (MOSTE)
OKD	Office of the Kok-Ing-Nan Water Diversion Project DBSDF (proposed)
O/M	Operation and Maintenance
p.a.	per annum
PANYA	PANYA Consultants
PCD	Pollution Control Department (MOSTE)
PIS	People's Irrigation System, *Muang Fai*
PRA	Participatory Rural Appraisal
PWA	Provincial Waterworks Authority (MOI)
RBC	River Basin Committee
RF	Reserve Forest
RFD	Royal Forestry Department (MOAC)
RID	Royal Irrigation Department (MOAC)
ROW	right of way
RTG	Royal Thai Government
SCT	Sanyu Consultants (Thailand) Inc.
SIF	Social Investment Fund (World Bank)
SIP	Social Investment Project (World Bank)
SWC	soil and water conservation
T&CP	town and country planning
TAO	Tambon Administrative Organisation, *Aboto*
TAT	Tourism Authority of Thailand (Office of Prime Minister)
TCPD	Town & Country Planning Department (MOI)
TEAM	TEAM Consultants
TEAM/JV	TEAM Joint Venture, comprising TEAM, PANYA, ASDECON and SCT
WCIC	Watershed Conservation & Information Centre (proposed)
WMD	Watershed Management Division
WSC	Watershed Class
WUA	Water Users Association
WUC	Water Users Co-operative
WUG	Water Users Group
WUO	Water Users Organisation

LOCAL TERMS

Aboto	*Tambon* Administrative Organisation
amphoe	district
baht	currency unit, approximately 36 baht per United States dollar (January 1999)
ban	village
changwat	province
fai	weir
kae fai	weir chief, head of *muang fai*
kae muang	canal chief
kamnan	head of *tambon*
king amphoe	sub-district
muang	city
Muang Fai	People's Irrigation System
muu-baan, mu-ban	village
naiyok thetsamontrii	mayor
nakhon	metropolis
phuu yai baan	village headman
rai	area unit, 0.16 hectare, i.e. approximately one sixth of a hectare
stang	currency unit, one hundredth of a baht
sukhaaphibaan	sanitary district
tambon	commune or township
tang	weight unit, approximately nine kilograms
thetsabaan	municipality
wat	temple

1. *Introduction*

1 INTRODUCTION

RID has employed the Thai consultant group "Team J/V" (Thai Consultant) comprising Team Consulting Engineers Co. LTD, Asdecon Corporation LTD, Panya Consultants CO. LTD and Sanyu Consultants (Thailand) LTD to conduct a feasibility study and an environmental impact assessment (EIA) of the Project. The Study was commenced at March 1996 and completed a May 1999 and its draft final report was submitted to RID at May 1999.

As for the EIA study, Team Consulting Engineers CO. LTD has carried out with responsibility
JICA environmental team had reviewed the Initial Environmental Report prepared by Thai Consultants from August 1996 to March 1997 in Phase I study and its report was submitted to RID on March 1997.

JICA environmental team also had carried out the following environmental technical assistant study from January 1998 to August 1999 in Phase II in parallel with the feasibility study of the Project.

Stage 1 Review of Term of Reference for EIA, January to February 1998

Stage 2
(1) Supplementary Study for Environment, October 1998 to February 1996
(2) Review of EIA report prepared by Thai Consultants
(3) Preparation of the final report for the environmental technical assistant study, July to August 1999.

The Environmental Technical Assistant Report prepared by JICA Environmental Team is composed of the following component.

(1) Review and Supplement of EIA Report

JICA team had review the EIA report prepared by Thai Consultants and studied the feasibility study report by JICA F/S Team from viewpoint of environmental assessment and prepared the supplemental items.

(2) Supplementary Study for Environmental Assessment

The following Supplementary. Study to broaden and strengthen the environmental assessment carried out by Thai Consultants was performed by JICA Environmental Team in accordance with the study result of I.E.E. Report and Term of Reference for E.I.A. used by Thai Consultants.

- Socio-economic survey in the Lower Ing basin aiming to present an alternative approach to sustainable rural development and to confirm the socio-economic conditions in the basin which will be influenced largely by the Project.

- Watershed management in the basins related to the Project to assess the existing deteriorated watershed by using the satellite image analysis.

- Inventory survey of People Irrigation System in the Kok and Ing basins which will be influenced by the Kok-Ing water diversion canal.

- Study on fisheries, aquatic ecology and freshwater biodiversity because the Kok and Ing basins are the famous wetland in the country and the impact study for those items by the Project is very important.

- Spoil utilization study in order to use huge spoil materials of about 13 million cu.m in the Kok-Ing canal, Yao dam and Yao training, as well as about 9 million cu.m in tunnel excavation.

- Study on the donor basin sustainable development fund because the beneficial area in the Chao Phraya will get a large benefits by the transbasin project as compared with the environmental impact and small benefit for the donor basin by the Project.

The JICA supplementary studies are founded on principles defined in key Thai government policy statements, and particularly on the King's land and agricultural management initiative ('New Theory'), as illustrated by His Majesty's speech on a community-based on self-sufficient economy: "It is not important for Thailand to become an economic tiger. The important thing is that Thais should live a life that leaves them enough to eat, and that they should rely on their own economy". The approach taken by this JICA study also reflects elements of OEPP's overall policy on natural resources:

- To enhance administration and management of natural resources by systematic decentralisation of power and authority from central offices to regional offices, in addition to strengthening relationships among government agencies, the private sector, NGOs and local people.

- To amend the legal and regulatory framework enabling support for more effective administration and management of natural resources, and recognition of rights and responsibilities of local people to demonstrate ownership of resources.

The above-mentioned policy-related matters, critical to a project as large as the Kok-Ing-Nan Project, were reflected in part in OEPP's comments on the IEE report prepared by the JICA study team. Among others the following were considered of particular importance:

- Consideration should be given to ecological impacts and impacts on water users within the donor basins. Provision of water to the population of the donor basins should be the first priority; and

- Given the scale of the project and its wide-ranging impacts, people should be allowed to participate in various stages of project implementation, including the environmental study, so as to avoid conflict between the project and the local population.

The idea of greater public participation is promoted by the new Constitution, the current *National Economic and Social Development Plan* and other policy documents, all of which encourage greater involvement of local communities, particularly through the empowerment of Tambon Administrative Organisations.

In light of these recent policy trends, which place greater importance on local community participation in resource control and environmental management, the JICA supplementary studies will be utilized to strengthen the RID environmental study (EIA) placing more importance on social aspects and people's participation. As a result, it is found indispensable to conduct further participatory rural appraisals in the donor basins, in close collaboration with DCD (Department of Community Development, MOI) in order to promote rural development of the donor basins in the future.

2. *SUMMARY OF PROJECT FEATURE*

2 SUMMARY OF PROJECT FEATURE

The Kok-Ing-Nan Water Diversion Project is the transbasin water resources development Project to cope with the chronic shortage of water prevailing in the Chao Phraya basin. The following description is the summary of the project features discussed in detail in the Feasibility Study.

(1) Water Resources of the Diversion Plan

The water resources of the diversion plan are the Kok and Ing rivers presenting an abundant annual runoff of 5,500 MCM and 2,500 MCM respectively. The future potential irrigation area is estimated at about 1.0 million rai in both basins, which would consume water of some 2,000 MCM including water uses for non-agricultural sectors. About 6,000 MCM of water will be still available for the proposed water diversion project. Available water resources at the proposed intake site of the Kok and Ing rivers are estimated at about 4,000 MCM.

(2) Method and Amount of Water Diversion

The proposed diversion plan intends to divert about 2,000 MCM in average of water during the wet season. The Kok water is diverted with the maximum capacity of 140 cm.m/sec through the Kok-Ing canal, regulated at the Ing weir site together with the Ing water and conveyed to the Nan basin with the maximum capacity of 175 cu.m/sec through the Ing-Yot long tunnel.

The diverted water in the Nan basin flows into the Sirikit reservoir where water is stored to recover the deficit reservoir inflow in the wet season and released to the downstream in the dry season. Total length of the water diversion route from the Kok intake to the end of the Yao river, tributary of the Nan river is about 150 km.

(3) Increased Water Demand and Decreased Resources in the Upper Chao Phraya Basin

The upper Chao Phraya basin having a catchment area of 124,000 sq.km has contributed to supply the water to the lower Chao Phraya delta. A vast farmland of exceeding 24.0 million rai extends in the basin populated with 9.5 million farmers. The existing irrigation area in the basin however, is 6.6 million rai or equivalent to 28% of the total farmland area and has used irrigation water of 10,500 MCM. Irrigation projects will be expanded more and more in future to stabilize agriculture in the basin by increasing the irrigated area. The future irrigation area and water demand are assumed to be 12.0 million rai and 20,000 MCM respectively, both are twice as much as the existing figures. It is assumed that the dry season water of 1,900 MCM will be deficit at the Chai Nat barrage site due to increasing irrigation projects at the upper basin in future.

(4) Increasing Water Demand in the Chao Phraya Delta

The Chao Phraya delta area holds the Bangkok Metropolis and a large expansion of industrial zone as well as the existing irrigated agriculture area of 7.3 million rai, and has supported the economic development and fool security in the country. Accordingly the water consumption in the delta reaches the highest amount in the country.

The water required in the delta has been supplied mostly by the Chai Nat barrage which controls the water in whole upper Chao Phraya basin. The existing available water at the Chai Nat barrage in the dry season is 6,000 MCM of which 2,000 MCM is released downstream to meet the demands for domestic and industrial water supply, navigation and river maintenance. The remaining 4,000 MCM is allocated to irrigated agriculture area of 7.3 million rai.

The additional water demand of 2,050 MCM will be expected to be required in the delta in future taking into account the increasing population and commercial/industrial development in the delta as well as the stabilizing diversified agriculture at the existing large irrigation project areas.

(5) Necessity of Transbasin Water Diversion Project

The dry season water to be required additionally in future will reach about 4,000 MCM consisting of 1,900 MCM in the upper Chao Phraya basin and 2,050 MCM in the Chao Phraya delta.

It is very difficult to generate this order of dry season water within the Chao Phraya basin by developing new water resources and by achieving water saving in term of water management. Accordingly Thai government has studied various water diversion projects by transbasin from the Mekong and Salaween rivers since 1980s. It was judged from the feasibility study that the Kok-Ing-Nan water diversion project would be technically and economically possible with less environmental impacts as compared with the other transbasin projects already studied. The proposed Project could supply about 2,800 MCM of dry season water at the Sirikit dam when the diversion water of 2,000 MCM from the Kok and Ing rivers is combined with improvement of the Sirikit reservoir operation.

(6) Allocation of Dry Season Water Developed by Project

The dry season water of 2,800 MCM could be developed by the Project and will be used for irrigation, and domestic and industrial water supply in beneficial areas located downstream of the reservoir such as the lower Nan basin and the Chao Phraya delta. Among various alternative plans of water allocation, it will be judged to be suitable to allocate 825 MCM to the domestic and industrial water in the delta and 1,985 MCM to the irrigation in the lower Nan and Chao Phraya delta.

(7) Irrigated Agriculture in the Kok, Ing and upper Nan Basins

The Kok and Ing basins are the donor basin to supply water to the Chao Phraya basin and the lower Nan basin is the incommoded basin, where a large amount of water only flows in the wet season.

The following irrigation projects identified by JICA Team in cooperation with Thai Consultants accordingly will be implemented in advance or in parallel with the water diversion Project in order to obtain and promote the cooperation and participation of t he people in the basins.

- New irrigation projects which covers about 1.0 million rai in the Kok and Ing basin and 300,000 rai in the upper Nan basin consisting of a number of medium and small scale projects and pumping projects.

- Associate irrigation projects of about 200,000 rai in the Kok and Ing basin developed by the Kok-Ing canal water and 50,000 in the upper Nan basin developed by the Yao reservoir water. Those projects are identified and proposed by JICA Team on preliminary basis.

(8) Project Facility Plan

The diversion canals and tunnels of about 150 km long, consisting of the following facilities, are required by the Projected.

- Kok Intake — At the intake structure to be constructed immediate upstream of the existing Chiang Rai weir, water is diverted from the Kok river with water levels raised by the Chiang Rai weir.

- Kok to Ing Diversion Canal — A series of open canal, siphon, tunnel and culvert with a total length of 54.4 km and a capacity of 150 cu.m/sec to link the Kok intake and the Ing diversion weir.
- Ing Diversion Weir — A rubber-type weir constructed on the Ing river near Amphoe Thoeng to divert 175 cu.m/sec of water from the Ing river together with the water diverted from the Kok river.
- Lao Diversion Canal — Diversion canal of 11.1 km long and 175 cu.m/sec capacity to connect the Ing diversion weir and the Ing to Yot tunnel, consisting of open canal, siphon, tunnel and culvert.
- Ing-Yot Tunnel — The diversion tunnel of 52.9 km long and 175 cu.m/sec capacity with 7 adits of 17.4 km long in total is planned to transport the water from the Ing basin to the Nan basin connecting the outlet of the Lao diversion canal and the Yot river, a tributary of the Yao river.
- Yao Flood Control Dam — This works to control a peak flood during wet season from the upstream reaches of the Yao river and to provide in dry season irrigation water to the beneficiary areas situated along the Yao and Nan rivers.
- Yao River Training Works — Improvement works of Yao river channel extending over 41.9 km to let the 200 cu.m/sec at most of discharge flow smoothly.

(9) Project Cost

Total project cost is estimated at 59,563 million Baht Classifying into the Kok-Ing-Nan water diversion project of 43,386 million and the other costs of 31,416 million Baht for associate irrigation project, environmental impact mitigation measures and development of beneficial areas in the lower Nan and the Chao Phraya delta area.

(10) Project Evaluation

Incremental project benefit is estimated as follows;

Domestic and industrial water supply	3,766	million Baht
Diversified agriculture	10,918	million Baht
Hydropower generation	406	million Baht
Total	14,090	million Baht

3. *Review Basin Characteristics*

3 RIVER BASIN CHARACTERISTICS

The proposed Kok-Ing-Nan Water Diversion Project has implications for several major river basins. Water from the Kok and Ing Rivers would be diverted to the Chao Phraya via the Nan River and Sirikit Dam. The Kok and Ing Rivers drain an area of 18,000 km^2 of Northern Thailand, on the borders of Myanmar and Lao PDR, into the Mekong River. The Chao Phraya basin may be examined most usefully as two sub-basins: the Upper and Lower Chao Phraya, with basin areas of 124,200 km^2 and 33,800 km^2, respectively.

The Upper Chao Phraya basin has significant water resources, supplying water for irrigation, domestic, industrial and commercial use within the basin, and supplying water for various users in the Lower Chao Phraya basin. The Lower Chao Phraya includes the river's Delta, with its large irrigated area (7.5 million rai or 1.3 million ha) and significant commercial and industrial areas, the most economically important area in the whole of Thailand. The Lower Chao Phraya Basin is the intended beneficiary of the proposed Kok-Ing-Nan Project. This section presents the characteristics of these five river basins: Mekong, Kok, Ing, Upper Chao Phraya and Lower Chao Phraya.

The climate in the Chao Phraya, Kok and Ing basins is characterised by distinct wet and dry seasons created by the air movements of the Northeast and Southwest Monsoon. The dry season lasts from November to May when the Northeast Monsoon brings dry stable airflow. March to April is the hottest period with temperatures over 30 Celsius. In June the Southwest Monsoon is established with the prevailing winds bringing in unstable moist air streams, resulting in long periods of rainfall. As the wet season progresses, rainfall becomes more intensive and prolonged till July, August and September, which are the months with highest rainfall. Due to the cyclic nature of the trade winds, about 70-80% of annual rainfall occurs in the wet season.

3.1 Mekong Basin

The Mekong River originates in the eastern part of the Tibetan plateau, in Chinese territory. It is an international river, flowing down through Myanmar, Lao PDR, Thailand, Cambodia, Vietnam and into the South China Sea. The Mekong is one of the largest river systems in the world.

The total area of the basin is 790,500 km^2. The average annual flow at Chiang Saen, at the confluence of the Mekong and Kok rivers, (basin area 204,000 km^2) is about 85,290 MCM (1962-1995). Flows from the Kok basin (5,460 MCM, 1974-1996) and the Ing basin (2,500 MCM, 1974-1996) contribute about 6% and 3% to the Mekong flow at their confluence points, respectively.

The total potential water resource of the Kok and Ing rivers combined is about 8,000MCM. The project will divert about 25% of this potential resource, i.e. the average annual flow of the Mekong at the Ing/Mekong confluence will be reduced by about 2%.

About 80% of Mekong, Kok and Ing river flows are in the wet season, and the project will divert about 3% of the wet season flow. The diversion of the Kok and Ing flood discharge into the Nan basin in the wet season will reduce the flood discharge in the Mekong.

3.2 Kok Basin

The source of the Kok River originates in densely forested mountains (over 1,500 m amsl) in Myanmar. The area of the Kok basin is 10,880 km^2, including 2,980 km^2 in Myanmar. After its confluence with the Fang River (470 m amsl) at the border town Ban Tha Don, the Kok flows through a deep valley and eventually into a wide flood plain (380-420 m amsl) at Amphoe Muang Chiang Rai. The Kok River joins the Kok-Lao River at Chiang Rai Weir and, continuing north, eventually discharges into the Mekong River at Ban Sop Kok (360-380 m) near Chiang Saen. North of Chiang Rai the meanders are more pronounced and

the river slope is only about 1/3,000. At its confluence with the Mekong the Kok River's flow is subject to the 10-m level range of the Mekong, 350 m amsl in the dry season and 360 m in the wet season.

The upper reaches of the Fang and Kok-Lao Rivers also drain densely forested mountainous areas, 1,000 to 1,300 m amsl. Farmland is scarce and scattered in small plots in the narrow strips of alluvial land along the rivers, however, the majority of the basin's 800,000 population (1995) work in agriculture.

In the Lower Kok basin, a large proportion of the flat agricultural land is subject to inundation and the backwater effect of the Mekong in the wet season. Wetlands and ponds have formed in many of the depressions in the landscape, most notably the Nong Luang Lake.

Much of the Kok basin is covered by forest, totalling about 2.2 million rai (340,000 ha or 44% of basin area). Agricultural land covers about 1.2 million rai (200,000 ha or 25% of basin area). Most of the agricultural land is found in the Kok-Lao basin and in the alluvial plain along the main river downstream of Chiang Rai.

The average annual flow at Chiang Rai Bridge (draining an area of 6,063 km^2) is 3,260 MCM, with 2,570 MCM (79%) and 690 MCM (21%) in the wet and dry seasons, respectively. The flow at Ban Tha Kok (drainage area 10,300 km^2) is 4,800 MCM, 3,820 MCM (80%) and 980 MCM (20%) in the wet and dry seasons, respectively. Chiang Rai Weir, constructed by DEDP in 1994 irrigates 78,000 rai of farmland and to supplies municipal water to Amphoe Muang Chiang Rai.

3.3 Ing Basin

The Ing basin is slightly smaller than the Kok, at about 7,120 km^2. The Ing River originates in the southern plateau (400 to 550 m amsl) of Changwat Phayao, flows into Phayao Lake (380 m amsl) and joins the Phung River (375 m amsl). In its northward course it collects water from smaller tributaries. At Amphoe Thoeng it is joined by the Ing-Lao, the largest tributary. The Ing-Lao River (with a basin of 1,260 km^2) originates in the eastern mountains (1,000-1,500 m).

Large area of wetlands such as Nong Leng Sai and Phayao Lake are found in the alluvial plain. Most of the wetlands and swamps are dry in the dry season when there is little rainfall or runoff. Phayao Lake, located in the upper basin, is used for aquaculture and irrigation. The flat alluvial plain, 6 to 8 km wide and 70 km long (350 to 450 m amsl), is utilised for rain-fed paddy cultivation in the wet season.

The river slope is about 1/5,000 at Amphoe Thoeng. The slope becomes gentler further downstream, at about 1/8,500, as the river flows through a series of meanders. At the confluence with the Mekong, the river is also subject to the same 10-m level range of the Mekong, at 340 m amsl and 350 m amsl. in dry and wet seasons, respectively.

Agricultural land totals about 1.2 million rai (190,000 ha or 27% of basin area), mainly in the flat alluvial plain along the river. Most of the 700,000 people (1995) living in the basin are farmers. Forest totals about 1.7 million rai (270,000 ha or 38% of basin area), and is found mainly in the Ing-Lao basin and upper reaches of the tributaries.

Average annual flows are 1,840 MCM at Amphoe Thoeng (basin area 5,700 km^2) and 2,400 MCM at the confluence with the Mekong. Since most of the rain water is impounded in paddy fields and therefore does not manifest itself in main channel flow, the runoff of the Ing river basin is less than that of the Kok river.

3.4 Upper Chao Phraya Basin

The Upper Chao Phraya basin comprises six main sub-basins: the Ping, Wang, Yom, Nan, Pasak and Sakae Krang. All bar the Sakae Krang originate in the northern mountain ranges. The Ping, Wang, Yom and

Nan converge at Nakhon Sawan to form the Chao Phraya River. The Sakae Krang flows into the Chao Phraya downstream of Nakhon Sawan. The Pasak joins the Chao Phraya at Ayutthaya.

Thirty-one percent of the basin's area is agricultural land (23.8 million rai or 3.8 million ha) and 40% is forested (31 million rai or 5 million ha). The population of the Upper Chao Phraya basin is estimated at 9.5 million (1995), of whom about 8.5 million live in rural areas, dependent on agricultural activities for a living.

The average annual flow of the Ping, Wang, Yom and Nan at Nakhon Sawan in recent years (1985-1996) is about 17,500 MCM, with 11,900 MCM (68%) of flow occurring during the wet season (June to November). The average annual flows of the Pasak (with a basin area of 16,290 km^2) and Sakae Krang (5,190km^2) are 2,540 MCM and 1,050 MCM, respectively.

The Nan basin includes Sirikit reservoir, the intended storage area for water diverted by the project. The Nan Basin may be divided into two sub-basins by Sirikit Dam: the Upper Nan (12,980km^2) and the Lower Nan (21,350km^2).

(1) Upper Nan basin

The Nan River originates in high mountains (1,000-1,500 m) on the border with Lao PDR. After converging with the Huai Yao river it passes through Amphoe Muang Nan and discharges into the Sirikit reservoir. The basin is slender in shape, about 200 km long and 60-70 km wide, with many tributaries in deep valleys. The Huai Yao tributary is vital to the proposed project as it would convey water from the diversion tunnel to the Nan River, with a flood control dam being built in its upper reaches.

The Upper Nan basin is mainly mountainous with steep slopes. About 41% (3.4 million rai or 540,000ha) is covered with dense forest. Agricultural land is concentrated in the narrow strip of alluvial plain along the main channel and tributaries, totalling only 1.1million rai (180,000ha) or 14% of the basin area.

The population in the Upper Nan basin is about 580,000. The population density of 45 people/km^2, is the lowest among the main sub-basins in the Upper Chao Phraya basin.

Average annual flow from the basin at Sirikit Dam (basin area 13,130 km^2) is 4,750 MCM, over the period 1985-1996. The average annual runoff, 360 mm, is the highest in the Upper Chao Phraya basin. The high runoff percentage is the result of higher rainfall and denser forest. However, due to the distinct dry and wet season, seasonal flow variations are large: 4,090 MCM (86%) in the wet season and 660 MCM (14%) in the dry season. Runoff in the dry season can be as low as 30-50 mm.

(2) Lower Nan Basin

The Lower Nan basin expands on the alluvial plain downstream of the Sirikit Dam. With the exception of the area to the east of the river, where the land is hilly and mountainous and rises to over 1000 m, most of the plain is about 100-300 m in elevation. The Nan River joins with the Yom River before converging with the Ping at Nakhon Sawan.

Naresuan Barrage, about 25 km to the north of Amphoe Muang Phitsanulok, was constructed across the mainstream of the Nan river in 1983 to irrigate the Phitsanulok Irrigation Project (110,000 ha); it diverts water released from the Sirikit Dam. Major tributaries, such as the Khwae Noi (4,680 km^2) and Wang Thong (2,300 km^2) discharge substantial flows in the wet season. Dry season flows are negligible because of agricultural water demand combined with low rainfall.

Agricultural land in the Lower Nan basin, totalling about 5.7 million rai (910,000 ha) or 43% of the area, is mainly cropped as wet season paddy. Forest is limited, at about 3 million rai (480,00 ha) or 23% of the area.

(3) Other Main Sub-Basins

The other main sub-basins - the Ping, Wang, Yom, Pasak and Sakae Krang - in the Upper Chao Phraya Basin all have no direct influence on the Kok-Ing-Nan project. All of these rivers supply water for irrigation and domestic consumption within the basins before flowing into the Chao Phraya. The outflows from these rivers are used to supply water for irrigation, as well as for domestic and industrial use in the Delta. Only the Ping has a dry-season flow that is not heavily utilised.

3.5 Lower Chao Phraya

The Lower Chao Phraya basin (33,800 km^2) comprises the basin of the Chao Phraya River (20,125 km^2) and its tributaries. It includes the large alluvial plains of Nakhon Sawan province, the main Chao Phraya and tributaries such as the Lopburi, Noi and Tha Chin (13,682 km^2). The Delta is extremely flat, with elevations of 0 to 8 m. Bangkok and the associated urban centres are all located in the Delta.

Out of 12.3 million rai (2 million ha or 58% of basin area) of agricultural land, about 8 million rai (1.3 million ha or 65%) is irrigated. Forest is scarce, covering only 2.1 million rai (340,000 ha or 10% of basin area). The population of the basin is 12.5 million, with 6.7 million urban dwellers and 5.8 million living in rural areas.

The Delta in the Lower Chao Phraya basin is the potential beneficiary area of the Kok-Ing-Nan project. The Delta, located downstream of the Chainat Barrage, is divided into the east and west banks by the Chao Phraya. The east bank area is served by the Chai Nat-Pasak canal system, while the west bank by the Noi and Tha Chin. The Pasak and Lopburi flow into the Chao Phraya at Ayutthaya. The Pasak divides the east bank into two; the upper east bank area is irrigated by an extensive canal system, whereas the lower east bank area is a conservation area. The Tha Chin canal conveys water diverted from the Chao Phraya at the head regulator located upstream of Chainat Barrage, and supplies irrigation water to the west bank area before emptying into the Gulf of Thailand. Water demand in the Delta is met primarily by water diverted at the head regulators located upstream of Chainat Barrage. The Chainat Barrage regulates all waters from the Upper Chao Phraya Basin.

The average annual flow at Chainat Barrage in the period 1985 to 1996 was 20,000 MCM, with 14,160 MCM (71%) in the wet season and 5,840 MCM (29%) in the dry season. These flows may be compared with 26,510 MCM (19,310 MCM wet season/ 7,200 MCM dry season) in the period 1974 to 1984. This decrease has resulted in a chronic water shortage in the Delta, especially in the dry season. The decrease is a result of a reduction in rainfall and an increase in the irrigated area in the Upper Chao Phraya basin.

The main characteristics of the main basins are summarised in Table 2.1.

Table 3.1. Summary Characteristics of the "Donor Basins" and the Beneficiary Basin

Parameter	Unit	Kok and Ing Basins	Upper Chao Phraya	Lower Chao Phraya	Upper and Lower Chao Phraya
Total Area	thousand km^2	15.0	124.3	33.7	158.0
Population (1993)	thousand people	1,460	9,480	12,430	21,910
Land Use (1993)					
• Farmland	million rai (%)	2.4 (26)	23.8 (31)	12.3 (58)	36.1 (37)
• Forest	million rai (%)	3.8 (40)	31.0 (40)	2.1 (10)	33.0 (33)
• Other	million rai (%)	3.2 (34)	22.9 (29)	6.7 (32)	29.7 (30)
• Total	million rai (%)	9.4 (100)	77.7 (100)	21.1 (100)	98.8 (100)
Farmland Use (1993)					
• Paddy	million rai (%)	1.6 (65)	11.9 (50)	7.7 (63)	19.6 (54)
• Field Crops	million rai (%)	0.3 (14)	8.8 (37)	3.2 (26)	12.0 (33)
• Fruit & Vegetable	million rai (%)	0.2 (9)	1.8 (8)	0.9 (7)	2.7 (7)
• Other	million rai (%)	0.3 (13)	1.3 (5)	0.5 (4)	1.8 (5)
• Total	million rai (%)	2.4 (100)	23.8 (100)	12.3 (100)	36.1 (100)
Irrigation					
• Present Area, wet/dry	million rai	1.0/0.1	6.6/1.5	8.0/3.2	14.6/4.5
• Present Intensity, wet/dry	%	42/4	28/6	65/24	40/12
Paddy Harvested (1991-96)					
• Area, wet season	million rai	1.0	8.7	5.9	14.6
• Area, dry season	million rai	-	0.9	2.1	3.0
• Product, wet season	million tonne	0.5	3.6	2.8	6.4
• Product, dry season	million tonne	-	0.7	1.5	2.2
Gross Basin Product (1994)					
• Total	billion baht	25.3	237	1,505	1,742
• Per Capita	thousand baht	17.4	25.1	122.1	78.0

4. *Review and Supplement for EIA Report*

4. REVIEW AND SUPPLEMENT FOR EIA REPORT

4.1 Review of EIA Study

The EIA report prepared by Thai Side consists of the following Seven Chapters.

Chapter 1	Introduction
Chapter 2	Project Feature
Chapter 3	Existing Environmental Conditions
Chapter 4	Environmental Impact Assessment
Chapter 5	Mitigation Measures
Chapter 6	Monitoring Program
Chapter 7	Public Relation

This EIA study is conducted based on the Terms of Reference for EIA prepared by Faculty of Engineering and Faculty of Science, Chulalong Korn University.

The report content is Chapter 3 Existing Environmental Conditions covers sufficiently the conditions of the physical resources, ecological resources, human use values and quality of life in three basins of Kok, Ing and upper Nan where the Project site is located.

The contents in Chapter 4 Environmental Impact Assessment and Chapter 5 Mitigation Measures describe the environment impact by the Project and its mitigation measures. Though the contents address many important issues for the impact, some supplements are necessary to promote the Project implementation successfully and smoothly.

The contents in Chapter 6 and 7 also are well prepared. However, it is necessary to recommend strongly to continue the further monitoring and public relation work by government based on the issues mentioned in Feasibility Report and EIA Report in order to maintain the better environmental conditions in the basins and obtain the people participation.

4.2 Supplement for Existing Environmental Conditions

In order to be able to understand clearly and judge properly the existing environmental conditions in the basins and the Project area, it is desirable to supplement the following items.

4.2.1 Physical Resources

(1) Geological Conditions

(a) Diversion Canal Route

- Foundation along the canal route in the Kok, Tak and Ing basins is formed with thick alluvial plain with high permeability, where bulk drainage operations are planned during canal construction with deep excavation depth. The existing paddy area along the canal route will be suffered from the lowing of ground water level.

(b) Tunnel Route

In accordance with geological investigation result carried by JICA and Thai Consultants, the following items shall be supplemental for geological conditions in tunnel.

- Rock formations along the tunnel route except entrances of runnel and inclined adit and fault zones show generally low permeability with Lugeon value of less than 20 which indicates no or less leakage through tunnel.
- Entrances of tunnel and adit are formed with weathered and shallow rock formation with relatively high permeability and will require some protection works for leakage during tunnel construction.
- Leakagae at fault zones will be judged to be small by the investigation result because the tunnel position is placed at very deep depth of more than 100 m from the ground surface.
- Rock materials along the tunnel route are consisting of sandstone, shell, slate, tuff, limestone, etc. and their compression strength except limestone material is relatively low as 400 to 500 km/cm2, which could be easily excavated by tunnel excavation equipment without blasting method by dynamite. However the excavated materials will become sandy powder and could not be used for construction materials such as aggregate and riprap. The excavated materials of limestone and some tuff will be available for construction materials.

(c) Yao Damsite

- Medium scale fault zones are existing at the left abutment of damsite, where spillway is proposed. The careful geological investigation will be required for the fault zone in order to confirm the dam foundation stability for dam embankment and spillway structures.
- Land sliding in the reservoir area will not be caused by rapid fluctuation of reservoir water level in the flood control operation because of consolidated geological conditions of the reservoir area.

(2) Groundwater

It is necessary in future to survey and study the groundwater in the lower Ing basin which locates between the Ing weir site and river mouth because the lower area along the river has been inundated always in the wet season by the Ing flood and the Mekong backwater and may preserve the groundwater with shallow depth which could be developed for domestic and irrigation use.

(3) Surface Water

Though the surface water study for the Kok, Ing and Nan rivers is well prepared in EIA Report showing the flow diagram of three rivers and monthly runoff fluctuation, it is desirable to supplement the following items.

(a) Observation of River Flow

It is necessary urgently to install the gaging stations and observe the water level and discharge at the following sites which have no observation data at present.

- The downstream of Ing-Lao river, which has brought about the large flood and sedimentation into the Ing river.
- The lower Ing river, where the water level is largely fluctuated in the wet season by the Mekong backwater (Three sites where JICA proposed the weirs to store the water in river channel and use it for irrigation and fish culture in the dry season)
- The proposed Yao damsite to observe and evaluate the peak flood discharge at the damsite.

(b) Surplus Water in Kok and Ing River

It is desirable to describe the surplus runoff at the downstream rivers of Chiang Rai weir site in the Kok and Ing weir site in the Ing river in order to proof the sufficient surplus runoff in the wet season.

- The existing surplus water at the downstream of the Kok and Ing river is estimated as follows;

Unit MCM

River	Catchment Area (km^2)	Wet Season	Dry Season	Total
(1) Kok River				
At Chiang Rai Weir Site	6,050	2,510	710	3,220
At GN1, Chan Chiang	10,300	3,870	940	4,810
At River Month	10,880	4,170	1,020	5,190
(2) Ing River				
At Ing Weir Site	4,240	1,100	110	1,210
At In at Thoeng	5,700	1,670	170	1,840
At River Month	7,120	2,180	230	2,410

Remark; The above runoff is mean value in the recent year 1985-96.

- Since the average diversion water amount of the Project in the wet season is estimated at 1,200 MCM in the Kok river and 900 MCM in the Ing river, the Kok and Ing has the runoff allowance of about 3,000 MCM and 1,000 MCM respectively at the river month after reducing the diversion water of the Project.
- The Kok river has the surplus water of about 1,000 MCM in the dry season in the river mouth and could supply a part of dry season runoff to the irrigation in the lower Ing basin being suffered from chronic water shortage in the dry season.

(c) Backwater Influence of Mekong River

Since the Mekong river has a large water level fluctuation of 10 to 12 m at the Kok and Ing river mouth, the downstream river reach of 30 km from the Kok river mouth and 90 km from the Ing river mouth will be influenced by the backwater of the Mekong river in the wet season, because the river slope is very gentle as 1/3,000 in the Kok downstream and 1/9,000 in the Ing. Namely the downstream river reach of both rivers will not be influenced by the diversion water in the Project.

(4) Soil Resources

It is required to carry out the further detailed survey and study for the soil resources in the lower Ing basin, where a vast farmland is existing and will be developed in future by irrigation water supply from the Kok-Ing diversion canal.

(5) Erosion and Sedimentation

- The river flow at the upper basin of the Ing river has not convey a large sediment in flood season because rain water in the basin flows into the Ing river passing through a vast and flat paddy field area which could mitigate naturally the flood and sedimentation, while the large sediment has been brought from the Ing-Lao river because its basin is formed with steep mountains and devastated forest area.

4.2.2 Ecological Resources

(1) Aquatic Ecology and Fishery Resources

- The lower basin of the Kok and Ing forms the wetland adjoining to the Mekong river and forms the very important basin for aquatic ecology and fishery resources. However, the lower Ing basin is dried up in the dry season and has brought the large impact to fishery resources.
- There are existing a number of weirs constructed by farmers in the tributary and main river of the Kok-Lao and the upper Ing. Those weirs have obstructed fish migrant to the upstream river.
- The existing Chiang Rai Weir is operated by opening the gates to release flood downstream the river but closing the gate to take the irrigation water. The weir has not provided the fish ladder and obstructed fish migrant in the dry season.

(2) Forest Resources

- Forest resources in three watershed have been deteriorated by slush-burn cultivation and tree cutting by mountain tribes as shown in the watershed conditions analyzed by the satellite image in JICA survey.
- The mountain areas along the tunnel route is mostly covered with the national park and reserved forest of 1A and 1B. Particular care shall be required for selection of tunnel route and entrance position of tunnel and adit.
- There are cool climate, clean water in tributaries and beautiful landscape in the mountain forest area along the tunnel route. Those forest areas will become the eco-tourism area in future which is going to be promoted by RFD.

(3) Wildlife Resources

No supplement by JICA.

(4) Watershed Management

The detailed supplementary study for the watershed management is carried out by JICA and described in Chapter 4.

4.2.3 Human Use Values

(1) Land Use

(a) Land Use in the Lower Kok Basin

There are no existing farmland at the lowland area along the Kok downstream because the low land is always inundated in the wet season by the Mekong backwater. Accordingly the water diversion will not give influence for the water use in the downstream river.

(b) Land Use in Lower Ing Basin

The detailed land use survey and study will be required for the farmland in the lower Ing basin because the basin has a large potential for irrigated agriculture to be developed by the diversion water of the Kon-Ing canal in the Project. The land use study will be carried out in future together with the feasibility study for the associate irrigation project in the lower Ing basin.

(c) Land Use in Spoil Bank

JICA F/S team selects the proposed spoil bank area along the Kok-Ing diversion canal route and at the site near the inclined adits along the tunnel route. Those spoil bank area would be used for the agro-tourism area planting special vegetable and fruit and opening to urban people visiting site and/or public recreation land for village people. Accordingly the land use at the spoil bank site will be survey and studied in future taking into account the possibility mentioned in the above.

(2) Agriculture

(a) Crop Cultivation

It is necessary to describe the increased crop diversification program in the Kok and Ing as well as the upper Nan basin because the crop diversification is the most important program to create jobs and generate income for farmers living in the basins. In accordance with the data of JICA F/S, the cropping area for fruits and vegetable increases remarkably as shown in the following table.

Unit 10^3 rai

Basin	Paddy		Fruit		Field Crop		Vegetable	
	1981	1993	1981	1993	1981	1993	1981	1993
Kok	861	809	40.0	92.9	196	125	5.7	19.5
Ing	841	773	27.0	84.3	187	205	8.7	39.4
Upper Nan	379	364	39.4	114.5	342	543	0.3	9.0

(b) Livestock Breeding

The plateau areas are expanding at the left bank of the In-Lao river and scattering at the area near the entrances of the proposed adit tunnel. The cattle breeding will be promoted in future in those plateau which could be converted to grasslands.

(3) Water Use/Irrigation

(a) Irrigation Area along the Kok-Ing Diversion Canal

EIA Report describes that there are existing the irrigation area of 45,800 rai along the Kok-Ing diversion canal and this area will be irrigated by pump from the diversion canal.

In accordance with JICA F/S Report, those existing large irrigation area in the Ing basin could be irrigated by gravity system operating regulators and turnouts installed in the canal and providing new irrigation canal to connect the diversion canal.

Since the Kok river has sufficient surplus runoff even in the dry season, those irrigation area could be irrigated in the dry season by the diverting the Kok dry season water.

- A part of diversion water is released to the Tak river at the end of culvert canal connecting to No. 1 Kok-Ing tunnel outlet and conveyed through the Tak river. This diversion water will be used for the existing farm area being suffered from water shortage at the Tak basin.
- The water will be supplied by existing weirs crossing the Tak river and new pumping facility in the river.
- The surplus water in the Tak, Ing and Ing-Lao river flows down in the lower Ing river and empties into the Mekong river. Those surplus waters are stored in the river channel by

constructing new weirs crossing the lower Ing river and used for irrigation at the area along both banks of the lower Ing river.

(4) Transportation

No supplement by JICA.

4.2.4 Quality of Life Value

As for the quality of life value, EIA Report describes ① compensation and resettlement, ② Socio-economic study based on Ko Cho Cho 2 Ko, ③ Public Health and Nutrition, ④ Archaeology and History and ⑤ Aesthetics and tourism.

No supplement for those items by JICA.

4.3 Supplement for EIA by Project and Mitigation Measures

Supplement for EIA by the Project and its mitigation measures is studied mainly based on JICA feasibility study report after reviewing EIA report by Thai Consultants.

Supplement by JICA study are summarized based on the Term of Reference prepared by Chulalong Kom University and used by Thai Consultants for this EIA study.

4.3.1 Important Area to Concentrate the Study on the Impact of the Project

The important areas to assess the impact of the Project are the lower Kok and lower Ing bsins located at the downstream of the water diversion route and the upper Nan basin, especially the Yao river basin. The supplements for the impact of the Project and its mitigation measures are as follows;

(1) Lower Kok Basin

The water diversion at the existing Chiang Rai weir site in the Kok river will not give the significant impact to the lower Kok basin with the following reasons;

- As mentioned in 3.2.1 (3) "Surface Water", the lower Kok river being located downstream the Chiang Rai weir has sufficient surplus runoff in wet and dry season which will not be used in the lower basin due to few farmland and could be used for the diversion water of the Project.
- Since the sufficient surplus water of 3,000 MCM in wet season flows into the Mekong river through the lower basin after diverting the water of 1,200 MCM in the Project, the water diversion will not give influence for fish migrant in the wet season. However the water diversion in dry season to supply the irrigation water for the lower Ing basin will bring about some influence for fish migrant due to small surplus water of 1,000 MCM in dry season. The water diversion control in the dry season shall be carefully studied in future taking into account fish species and fish migrant status in the dry season.
- The inundation problem at the lower area along the lower Kok river in the wet season could not be solved by the water diversion because of problem caused by the Mekong backwater.
- Due consideration to PIS (see JICA Supplemental Study)

(2) Lower Ing Basin

- The lower land area along the Ing river lying on the upstream of the proposed Ing weir site has faced vast inundation problem every year because the flood water level at the area is rised up by a narrow river section at the Thoeng bridge being located at 3 km downstream the proposed Ing weir site. This inundation problem could be mitigated by diversion water of 175 cu.m/sec to the Nan basin during flood season at the Ing weir site.

- The lowland area along the lower Ing river with the long river length of 140 km between the Ing weir and the river mouth also has faced inundation problem during flood season. The inundation problem at the upper river reach of 70 to 80 km could be mitigated by the diverting water of 175 cu.m/sec at the Ing weir. It is difficult however to mitigate the problem at the lower river reach of 60 to 70 km near the river mouth due to invasion of backwater of the Mekong river to the lower Ing river from tributaries and backwater of the Mekong river.
- The lower Ing river has no or very scarce runoff in the dry season, because the upper Ing basin has used fully the dry season runoff for irrigated agriculture. There are accordingly no irrigated agriculture and no fish migrant in the dry season in the lower Ing basin.
- JICA feasibility report proposes three weirs along the lower Ing river to store the wet season surplus water at the river channel with very gentle slope of 1 to 9,000 to 10,000 and to regulate the dry season water from the Ing-Lao, Ing return flow and the Kok river by diversion canal of the Project. When this weir project will be implemented together with the water diversion canal project, the irrigated agriculture could be promoted at the lowland area along the lower Ing river and fish culture at the channel reservoir in the dry season also will be possible.
- Socio-economic survey in the lower Ing Basin (See JICA Supplemental Study)

(3) Yao River Basin

- The Yao river basin is the incommoded basin receives the large impact by the Project because the bulk diversion water of 175 cu.m/sec has to be released through the river with small discharge capacity and steep slope. The flood control dam to control the peak flood at the Yao basin and the diversion water of 175 cu.m/sec and the river training to release the diversion water and discharge at the Yao own basin shall be provided. There are existing upland farm area to be submerged in the Yao reservoir and a number of villages along the Yao river which will be suffered from the bulk water release in the wet season.
- The diversion water of 175 cu.m/sec will not give significant impact to the upper Nan river, because the upper Nan river has the large discharge capacity of about 1,500 cu.m/sec at the conjunction point of the Yao and Nan rivers and 2,500 cu.m/sec at Nan city.

4.3.2 Location of Diversion Points

In the Kok river, the existing Chiang Rai weir site and the new site 3 km downstream the above existing weir are studied, while three weir sites in the Ing river at the Thoeng site and upstream and downstream sites of the Thoeng are studied. Finally the existing Chiang Rai weir and the new Ing weir at Thoeng are selected as the most suitable site taking into account not only engineering viewpoint but also environmental aspects. The environmental impact caused by the project facilities and mitigation measures studied by JICA Feasibility Study Team are summarized as follows;

(1) Existing Chiang Rai Weir

Since the fixed type weir is constructed with the crest elevation of 385.79 m, which is 1.2 m higher than the original river bed elevation, the scouring at the river bed at the weir downstream will be accelerated in future by flood energy, while the flood water level of the Kok river at the Chiang Rai urban area located at 6 km upstream of the weir will be slightly rised up.

The Chang Rai weir has not fishway to migrate from the Mekong river to the upstream of the Kok river.

Several weirs also are constructed in the Kok-Lao river which joins at the downstream of the Chiang Rai weir but have no provision of fishways. The following mitigation measures for the above environmental impact will be required;

- River bed reinforcement at the downstream of the Chiang Rai weir to prevent the scoring

- Provision of fishway which will be proposed at the route from the Lao river mouth connecting with the Kok river at the downstream of Chiang Rai weir to the right bank of the weir. This proposed route is the original course of the Kok river before construction of the weir. Fishes being obstructed by the existing weirs in the Lao river could migrate to the Kok upstream from the Mekong river through the above route.
- The existing intake water level of 389 m at Chiang Rai weir is mainly designed to divert the Kok water in the dry season to the people irrigation area. If the water level of 389 m is maintained in the flood season, its back water will bring about inundation problem at the upstream Chiang Rai area. The operation water level at the weir in the flood season shall be carefully reviewed.

(2) Kok Intake

The Kok intake is proposed at 3.5 km upstream right bank of the Chiang Rai weir. At the Kok river has a possibility at the proposed intake site to rise up the flood water level and to bring about a large sediment materials, so that the following mitigation measures will be required.

- The Kok intake water level will be set up below 389 m to avoid the inundation problem at the upstream area.
- Flood protection dike with elevation of more than 389 m will be necessary at the Kok intake site.
- A large sediment pond with area of more than 2.0 ha shall be provided in front of the Kok intake structure.
- The sediment materials deposited in the pond shall be handed over to the private dredging company having a license to get the materials because the sediment materials are mostly fine sands which have been dredged and used for construction materials at present by many companies along the Kok river.
- The intake site including a large sediment area will be selected at the site under the public land without land acquisition cost, if possible.

4.3.3 Diversion Canal Route and Ing Weir Site

The environmental impact and mitigation measures for the diversion canal route from the Kok to the Ing and from the Ing to Ing-Yot tunnel as well as the new Ing weir site are summarized as follows;

(1) Kok-Ing Diversion Canal Route

The water diverted from the Kok river at the Kok intake is conveyed to the Ing basin through the Kok and Tak basins. These basins are formed with the flat alluvial plain with the elevation of 390 to 360 m. M.S.L where the wet season paddy cultivation has been dominant. The people irrigation system is existing also in the Kok, Tak and Ing basins. The mountains with the low elevation of 500 to 600 m. M.S.L are lying between the Kok-Tak and Tak-Ing. These mountains do not belong to the national park and waterland classification I.A., so that No. 1 and No. 2 tunnels could be proposed there without significant environmental impact and mitigation measures. Following are the environmental issues studied for the Project facilities.

- Resettlement, land acquisition and compensation along the canal route
- Sufficient number of bridges to cross the diversion canal is necessary in order to facilitate the smooth communication between villages along the canal route.
- Proper crossing structures at the open canal route such as siphons, culverts, overchutes, aqueducts etc. to maintain the existing flow in the rivers, people irrigation canals and drainage canals.
- Possibility of irrigation and fishpond water supply from the diversion open canal to the beneficiaries at the project site.
- Safety measures for deep excavation at the culvert constructions site.
- Spoil bank for excavation materials and borrow area for fill materials taking into account the place, volume and treatment method.

- Disposal of excavated materials from canal construction.
- Operation and maintenance road along the diversion canal route, which will have sufficient road width and could be used for tourism.
- Prevention for slope and land sliding at the canal construction site with deep excavation depth.

(2) Ing Weir

The Ing weir is proposed at 2.8 km upstream of the Thoeng bridge on the provincial road with the code No. 1020. At the weir site, the Ing river has a catchment area of 4,440 km^2 and the annual runoff amount of 1,830 MCM.

The river flow during the wet season changes from 30 cu.m/sec in June to 100 cu.m/sec in August to September in the peak wet season on an average. Since the flow discharges during the wet season in the Ing river is insufficient to satisfy the design discharge of 175 cu.m/sec, the diversion water from the Kok river is necessary to supplement it.

The lowland with an area of 500 ha spreads widely at the Ing weir site and in the upstream reaches. The elevation of the lowlands ranges between EL. 362.0 m and EL. 363.5 m.

This area is covered with bush or reed and there are no villages developed in this lowland. There are no important or endangered species of fauna and flora in this area.

There, however, are many kinds of migrant fishes from the Mekong river to the upstream of the Ing river.

Taking into account that there are no sufficient river water or water body during the dry season, it is worthy to provide water for migrant fishes for creating better water environmental situation during the dry season. It also is required to provide fish-way at the proposed Ing diversion weir so as to make migrant fishes passing the proposed weir.

The wide flood prone areas spread along the Ing river from the downstream of the proposed weir site to the confluence with the Mekong river. These areas have suffered from the inundation with a long duration through the wet season due to insufficient flow capacity and the back-water effect of the Mekong river. There is a high possibility that the diversion of river water in the Ing river during the peak wet season will reduce the flood water level significantly in the river reaches.

While, during the dry season, the Ing river has no significant water for cultivating the aforesaid flood prone areas located along the downstream reaches of the Ing river. The Project may be able to contribute development of land resources along the downstream river reaches.

The Lao river with a catchment area of 1,260 km^2, the largest tributary of the Ing river, joins at the just downstream of the proposed weir site. Flood discharge in the Lao river comes into the wide lowland area and spreads widely there.

The mean annual runoff of the Lao river is about 640 MCM comprised of 570 MCM in the wet season and 70 MCM in the dry season. The mentioned river water has been utilized in the downstream area as a water source for irrigation and drinking water, especially in the dry season. Therefore, the runoff in the Lao river is planned not to be diverted to the Nan river.

(3) Ing-Yot Diversion Canal Route

The Ing-Yot diversion canal is proposed to convey the water regulated in the Ing reservoir from the intake in the Ing weir to the inlet of Ing-Yot No. 2 tunnel. The canal however shall pass through the very complicated and difficult area for construction such as the Ing flood plain, the area near village and temple,

right bank mountain with poor geological condition, the Lao river with meandering shape, the high land at the right bank of the Lao river, etc.

The following environmental impact shall be carefully studied;

(a) Canal Route from Ing Intake to Ing-Yot No. 1 Tunnel

The canal shall pass through at first the Ing flood plain with the open canal. Since the flood water level in the Ing basin is largely changed from 363 m to 367 m, the open canal with design water level of 363.5 m shall be protected by the flood protection dike with the crest elevation of more than 367 m. The canal shall cross the existing provincial road by culvert structure before connection with the Ing-Yot No. 1 tunnel.

(b) Ing-Yot No. 1 Tunnel

The canal shall cross the right bank mountain with the Ing-Yot No. 1 tunnel to convey the water released from the culvert. The tunnel route shall be selected avoiding the existing village and temple and so as to access easily to the Lao river where the canal shall cross with the siphon. The particular care shall be paid for the poor geological condition in the tunnel route.

(c) Alternative Route instead of Tunnel Route

In order to avoid the tunnel construction at the mountain with the poor geological condition, the alternative route to access the Lao river by the open canal and culvert along the existing provincial road will be studied. It will be necessary however to get the consent of village peoples to select this alternative route because the route requires a large farmland acquisition and changes of the Lao river course, where the river water have been used for irrigation by village peoples.

(d) Crossing Siphon at Lao River

The diversion canal shall cross the Lao river by siphon to convey the water released from the Ing-Yot No. 1 tunnel. The water level of the diversion canal at the river crossing point is mostly same as the river bed elevation of the Lao. Accordingly temporary works to change the river course during construction period will be carefully studied taking into account the impact for the water use of village peoples, farmland acquisition for the river course to be changed, flood capacity, etc.

(e) Culvert Canal between Lao Siphon and Inlet of Ing-Yot No. 2

The route between the Lao siphon and the inlet of the Ing-Yot No. 2 tunnel passes through hilly area being covered with bushes and paddy field without any resettlement. The culvert structure will be required for this canal route because hilly area is formed with high elevation of 370 to 380 m against the water level of 360 m in the culvert canal.

The culvert reach between the highway No. 1121 and the inlet of No. 2 tunnel is formed with paddy field with the high elevation of 380 to 390 m so that the particular measure for environment impact by the deep excavation such as drainage method, land sliding protection method, etc. in the culvert shall be studied. The compensation of paddy area by the culvert construction also shall be considered.

4.3.4 Tunnel Route

The No. 1 and No. 2 tunnels at the water diversion route between the Kok and Ing basin is designed with the discharge capacity of 140 cu.m/s, while the No. 1 and No. 2 tunnels between the Ing and Yot basin with discharge of 175 cu.m/s.

Although the Kok-Ing No. 1 and No. 2, and the Ing-Yot No. 1 tunnels are proposed at the mountainous area out of the national park and the watershed classification 1A, while the Ing-Yot No. 2 long tunnel passes through the high mountain area with the elevation of 600 to 1,600 m which is belonging to the national park and the watershed classification 1A.

Accordingly the tunnel shall be planned and designed taking into account the following safety and mitigation measures for the environment impact along the tunnel route.

- Tunnel alignment shall consist of the consolidated rock formation, where tunnel construction could be safely carried out.
- The tunnel inlet and outlet, adit portals as well as muck disposal area are selected at the locations outside the national park and watershed classification 1A and 1B.
- And the tunnel route is designed at the location more than 100 m deeper from the ground surface in order to avoid any impact on the forest area of the national park and watershed classification 1A and 1B.
- Countermeasures to prevent the leakage through poor geological formation at the inlet and outlet of the tunnel as well as the inlet of adits in order to preserve the existing forest area above the entrance of the tunnel and adits.
- Safety measures for the tunnel construction such as electrical, lighting, ventilating, drainage and water supply inside tunnel.
- Treatment facility and proper operation for the polluted drainage water brought from tunnel.
- Tunnel construction method using tunnel excavation machine instead of dynamite blasting method is adopted after due consideration given to the environmental conditions in mountain area.
- Spoil bank of the tunnel excavation materials taking into account quantity and quality of the materials, spoil bank area, treatment method of the materials using method of the spoil are, etc.
- Spoil utilization (see JICA Supplemental Study)

4.3.5 Flood Control Dam Site

The flood control dam is proposed at 1.5 km upstream of the village named as King Amphoe Song Khwae. The dam site has a catchment area of 372 km^2 and the mean annual runoff of 175 MCM. The flow runoff during the wet season occupies 85% of the annual runoff.

In the upstream of the mentioned dam site, there are several village areas along the Yao river, namely, 1) Ban Sop Phang, 2) Ban Wang Sao, 3) Ban Huai Lao, and 4) Ban Nam Pan. Among these villages, the lowest riverbed elevation at the village area is about EL. 320 m in Ban Huai Lao. Therefore, the maximum reservoir water level is possible to be set at the above mentioned elevation.

Applying the reservoir water level of EL. 320 m, there is no villages, national park and reserved areas in the reservoir area, though there exists farm area of 520 rai, or equivalent to 83 ha in the reservoir area, which requires land acquisition.

4.3.6 Yao River

According to hearing survey about flooding in the past to village people, lowland of Ban Na Nung and Song has suffered from flood damage every year due to backwater effect of the Nan river. Downstream part of Ban Songkhwae was damaged four times in 1989, 1994, 1995 and 1996 by the flood in the last decade. In other villages, they have not experienced flooding, excluding in 1995 and 1996. Significant flood damages were caused in 1996. Especially, in Ban Na Nun and Song, village people had to evacuate to neighboring elementary school for three (3) weeks during flooding. Also, the flood with high flow velocity in 1996 washed out several houses in Ban Songkhwae and Ban Hang Thung.

The Project will convey the large amount of water during the wet season to the Yao river, which has flood problems even under the present flow condition. It is necessary to carefully study the impacts on

hydraulic and hydrological change and to identify appropriate measures, as well as to mitigate flood damages along the Yao river.

The potential impacts are discussed in the JICA Supplemental Study.

4.3.7 Specific Physical Environment

(1) Geological Conditions and Faults

The detailed geological conditions and faults are described in the Feasibility Report consisting of the Main, Supplement and Data base Reports. Accordingly no supplement for those items.

(2) Quality of Water

JICA has no supplement for the quality of water, which has studied well by the Thai Consultants.

(3) Characteristics of Water from One River to Another

The Project is the transbasin project, which the water in the Kok and Ing is conveyed to the Nan river. The Phsio-chemical properties of the water in both basins are mostly same in accordance with Thai consultants study. This matter is discussed in detail in the JICA Supplemental Study.

(4) Impact on Flooded River Bank

The inundation area by flood at the middle and lower Ing river could be mitigated by the diversion water of 175 cu.m/sec which is reduced from the existing flood in the Ing river.

(5) Mitigation to Drought Conditions in Dry Season

People irrigation area along the proposed diversion canal route in the Kok, Tak and Ing basin and the lower Ing basin located downstream the Ing Weir site have been suffered from water shortage ever year in dry season due to no rainfall and less runoff in the river. Those drought conditions will be remarkably improved by supplying the dry season water from the water diversion canal of the Project and the proposed associate irrigation project.

4.3.8 Construction Period

The impact to the construction activity, contamination of surface water, spoil bank, etc. and their mitigation measures are studied and as a result the preliminary design and cost estimation for the Project facility is carried out.

4.3.9 Bio-Diversity and Biological Aspects

The caption items are mostly well studied by the Thai Consultants.

The matter is briefly discussed in the JICA Supplement Study.

4.3.10 Settlement

The caption items also are studied well by Thai Consultants and JICA has no supplement except the following items.

(1) Benefits to Local People

Associate irrigation project developed by the water to be supplied by the Kok-Ing canal and released from the Yao reservoir in the dry season will create the new irrigation area of 200,000 rai in the Kok and Ing basin and 50,000 rai in the upper Nan basin.

(2) Expansion of Local Economy

The local economy will be expanding by the following activities by the Project.

- Promotion of irrigated and diversified agriculture including cattle breeding at the high land and fish culture in the river and ponds.
-
- Development of agro-tourism and eco-tourism by providing orchard and vegetable gardens and green parks for urban peoples and facilitating recreation camps at the sites with beautiful landscape and clean water along the tunnel route.

4.4 Summary of Environmental Consideration in Project Facilities Alternative Study

As for the route and site of the Project facility, various alternative plans are studied taking into account not only the engineering works but also the environmental impact of the Project and mitigation measure as mentioned in the above 4.3.

The summary of alternative study result is shown the following Table 4.4.1

Table 4.4.1 Environmental Considerations in Project Facilities Alternative Study

Project Component	Alternatives considered	Environmental aspects considered	Advantages of selected alternative from environmental viewpoint	Remarks
Kok diversion weir site	Two alternative sites	Flooding problem; river dredging difficulty; avoidance of sedimentation in the main canal.	Existing Chiang Rai weir to be used; new intake 2 km upstream of the weir site; flood control achieved; no impact on on-going river dredging works; sedimentation in main canal countered by appropriate intake design with a sediment Pond.	Appropriate intake design with sediment pond being studied.
Kok-Ing diversion canal				
Diversion canal in Kok basin	Three alternative routes	Social impacts on resettlement and impact on PIS; impacts on wetlands; avoidance of deep excavation. Lowering groundwater level in deep excavation of canal.	Impact on PIS minimised; appropriate crossing structures to be provided; open canal design without any deep excavation; avoided urban/ peri-urban area and resettlement.	Additional studies on PIS being conducted to clarify impacts and propose measures; productive irrigated paddy land may be lost - need for adequate compensation; adequacy of various crossing structures being studied.

Project Component	Alternatives considered	Environmental aspects considered	Advantages of selected alternative from environmental viewpoint	Remarks
Diversion canal from Kok to Tak - No.1 Tunnel, Open and Culvert canal in Tak basin, No.2 Tunnel	Two alternative routes	Avoid watershed class 1A, 1B and national parks and wildlife sanctuaries completely; avoid conservation forest area, and prime agricultural areas; avoid or minimise impacts on PIS and resettlement; avoid deep excavation as far as possible.	Important Nong Luang area avoided; deep excavation culvert length reduced; mountainous areas with poor geological conditions avoided.	Land use, resettlement, forest cover and wildlife aspects are being studied in detail at all project facility locations, along proposed route and construction access roads; deep excavation areas – appropriate drainage system, slope protection works being studied.
Diversion canal in Ing basin				
Culvert canal at Ban Huai Kang Rat and open canal in the Ing basin	Three alternative routes	Avoid watershed class 1A, 1B and national parks and wildlife sanctuaries completely; avoid conservation forest area, and prime agricultural area; avoid or minimise impacts on PIS and resettlement; avoid deep excavation as far as possible.	Regulation pond requiring large farm area to control fluctuation in discharge not necessary. The culverted canal at Ban Huai Kang Rat will not experience problems with landslides, high volumes of seepage water, etc., in the deep excavation works. The open concrete-lined canal in the Ing basin to be designed with adequate balance of excavated and fill volume to reduce spoil-bank area and borrow area requirements.	Deep excavation areas – the balance of excavation and fill volume, appropriate drainage systems, slope protection works, spoil bank and borrow area characteristics are all being studied in detail. Crossing structures such as syphons, culverted drains, aqueducts, bridges, etc., are all being surveyed and studied. The adequacy of Mae Loi river for diverting water to the weir site is being studied.
Ing diversion weir and intake site	Two alternative sites	Avoid any impacts on temple in Amphoe Thoeng; preserve current river flood control regulation function as well as existing natural environmental condition.	Diversion dam site selected 2 km upstream from temple; intake structure planned 100 m upstream of proposed dam axis on the right bank.	Diversion dam with rubber gate proposed to retain flood control regulation and existing natural environmental conditions; detailed study of fish migration being carried out.
Lao diversion canal route: open canal along right bank of river, culvert along Lao river, culvert through hilly area	Three alternative routes	Avoid tunnels in areas with poor geological conditions; avoid or minimise deep excavation; minimise impact on Lao river; avoid resettlement and impact on important temple.	Excavation for culvert canals along river canal easy to carry out as excavation material is mostly earth and fine sand; tunnels not required in difficult areas.	The culvert route along the Lao river and hilly area is very complicated and excavation works are rather difficult. This route is being studied in detail taking into account river training of Lao and suitable construction method for deep excavation.

Project Component	Alternatives considered	Environmental aspects considered	Advantages of selected alternative from environmental viewpoint	Remarks
Ing-Yot long tunnel	Northern and southern routes: both in turn including two alternative routes; thus in all four alternative routes	Avoidance of areas of watershed class 1A & 1B, national parks and wildlife sanctuaries; avoidance of conservation forest area, and prime agricultural areas. Avoidance or minimisation of impacts on PIS and resettlement. Avoidance of deep excavation as far as possible. Avoidance or minimisation of impacts of resettlement and farming activities; road condition to minimise construction of new roads in mountain areas; avoidance of impacts on tourist areas; avoidance of tunnel construction in alluvial plains and in areas of poor geological conditions; minimise impacts on existing roads, villages, and streams.	Tunnel route placed in northern high mountain area consisting of consolidated and firm rock foundation; tunnel entrance, exit and adit locations avoid 1A watershed areas.	Land use, forest cover, wildlife aspects are being studied in detail at tunnel inlet and outlet locations, adit locations, access road areas, and tunnel spoil disposal areas; proposed tunnel route passes through several limestone rock formation areas where important issue is removal of groundwater/ spring water. Impact on Phu Sang waterfall and spring also needs to be assessed.
Yao Flood control dam	Two alternative sites	Flood protection of communities in the watershed; avoid or minimise resettlement.	No resettlement is involved; proposed inundation area has poor vegetation cover.	Upstream basin of Yao river is completely degraded with hardly any tree cover; peak flood from basin is being analysed.
River training works in Yao river	Various inter-related river training works	Minimise resettlement; provide flood protection; safety considerations; minimise impact on infrastructure.	Improved flood protection.	Various components of river-training works being studied, e.g. waterway facility, provision of drop structure, river-channel excavation, provision of flood dikes, provision of revetment work for improved river channel, replacement or upgrading of bridges and other crossing structures; project's impacts on natural environment and human settlements significant; socio-economic situation of affected population being studied.