Route Map (1/4)

(From KOK Diversion Dam to KOK-ING Tunnel)

Proposed Diversion Weir (RID)

Existing Diversion Weir (DEDP)

DEDP Project Area

Route "A" L=27,836 m

Tunnel L=5,800 m

Route "A-R" L=29,012 m

Route "B-J" L=31,339 m

Tunnel L=3,114 m

Route "B-P" L=31,563 m

Proposed Pumping Station

Nong Luan Reservoir

Route "B" L=37,563 m

Tunnel L=7,775 m (B-J)

Tunnel L=7,240 m

Tunnel L=5,506 m

Regulating Pond

N

0 1 2 3 4 5.0 km

Outline of Alternative Route

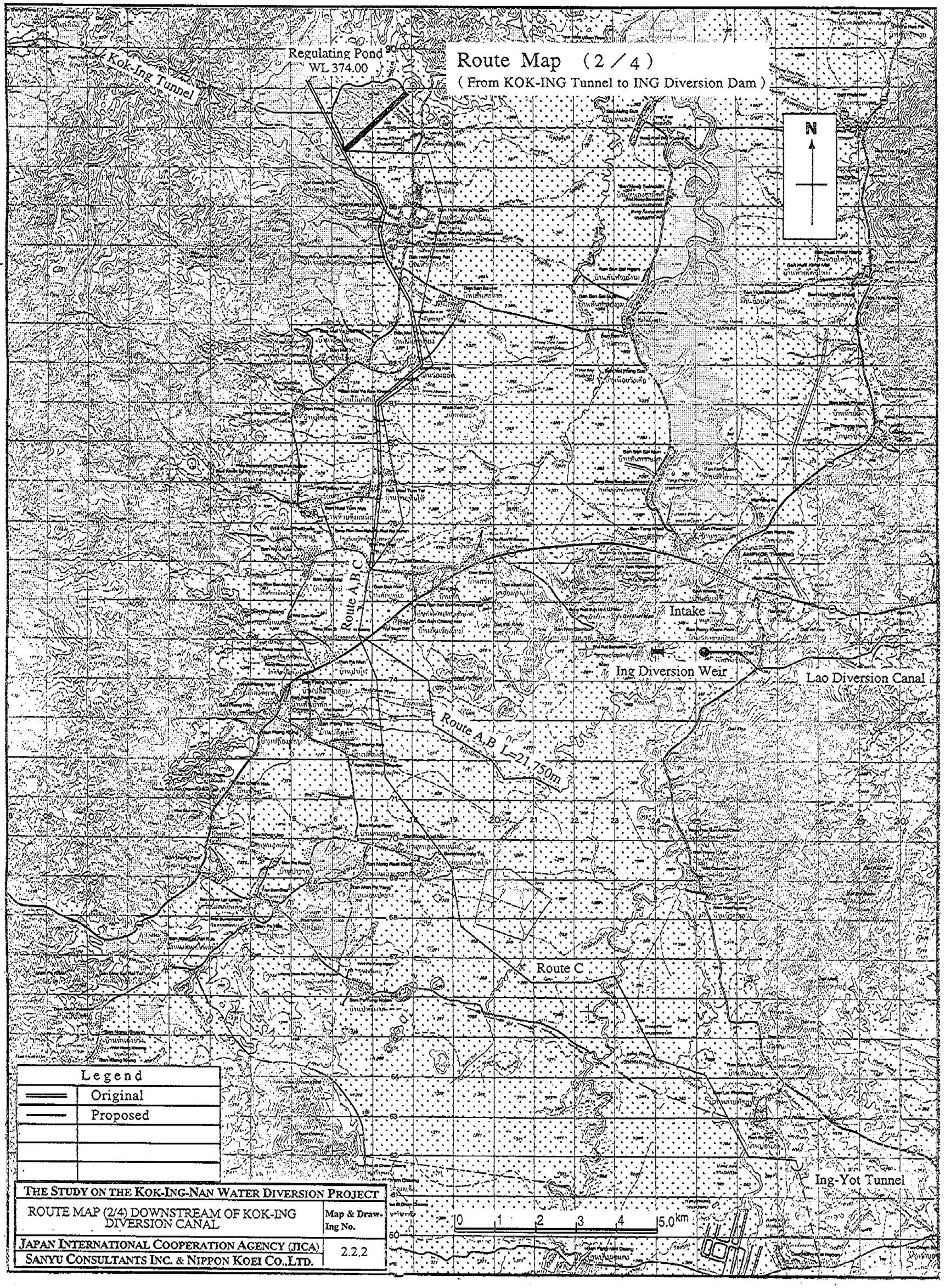
Route	Canal Length (m)				Structures		
	Open Canel	Culvert	Tunnel	Total	Syphon	Weir	Pump
A	13,746	1,050	13,040	27,836	4	1	-
A-R	15,112	3,011	10,889	29,012	4	1	-
B	14,063	17,994	5,506	37,563	2	-	-
B-J	18,589	1,861	10,889	31,339	5	-	-
B-P	23,507	3,856	4,200	31,563	2	-	1

Legend	
	Weir
	Intake
	Canal & Culvert
	Tunnel
P	Pumping Station
	Proposed Reservoir

THE STUDY ON THE KOK-ING-NAN WATER DIVERSION PROJECT	
ROUTE MAP (1/4) UPSTREAM OF KOK-ING DIVERSION CANAL	Map & Drawing No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) / SANYU CONSULTANTS INC. & NIPPON KOEI CO.,LTD.	2.2.1

Route Map (2/4)

(From KOK-ING Tunnel to ING Diversion Dam)

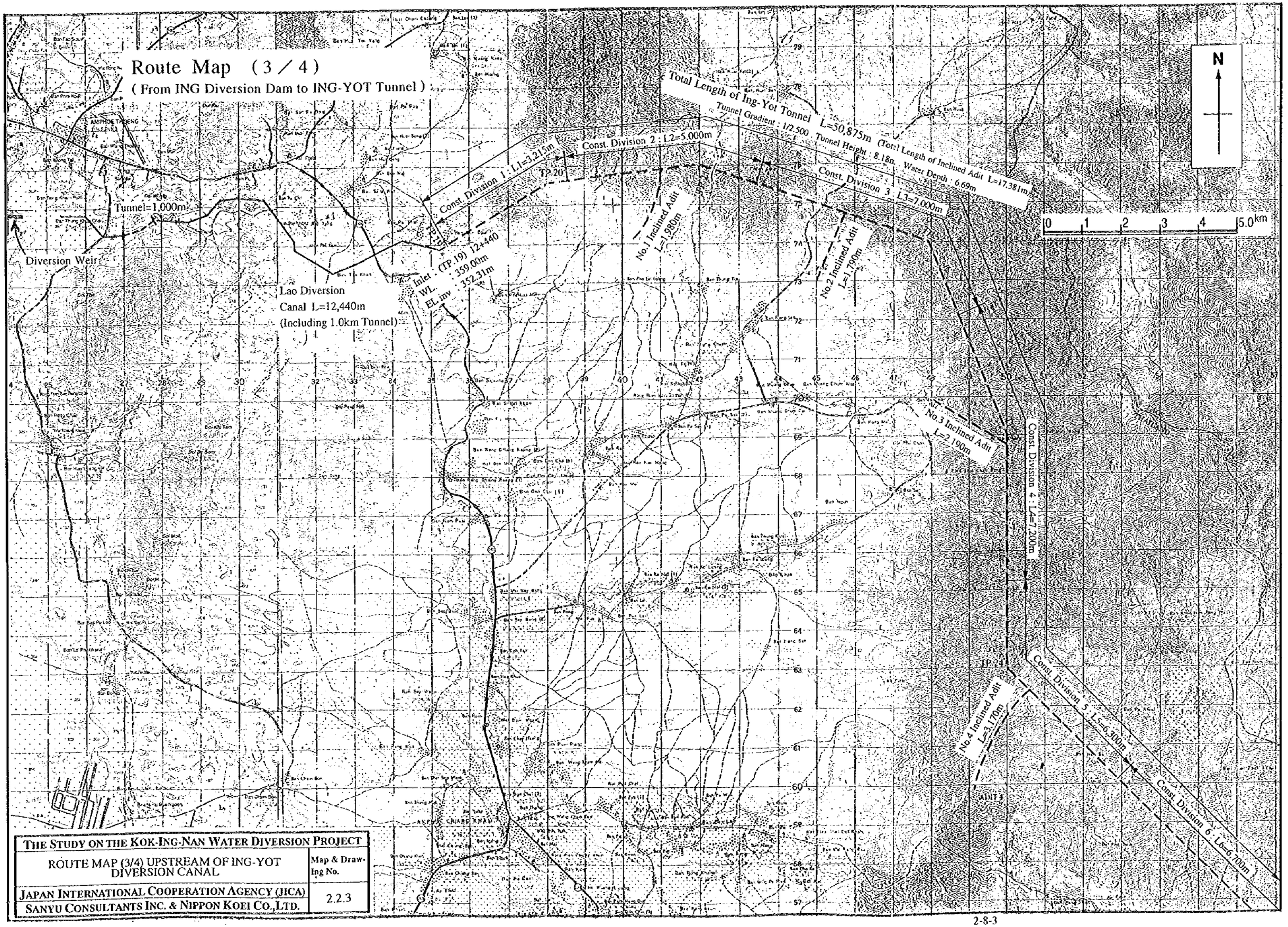


Legend	
═══	Original
———	Proposed

THE STUDY ON THE KOK-ING-NAN WATER DIVERSION PROJECT	
ROUTE MAP (2/4) DOWNSTREAM OF KOK-ING DIVERSION CANAL	Map & Drawing No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	2.2.2
SANYU CONSULTANTS INC. & NIPPON KOEI CO.,LTD.	

Route Map (3 / 4)

(From ING Diversion Dam to ING-YOT Tunnel)



THE STUDY ON THE KOK-ING-NAN WATER DIVERSION PROJECT	
ROUTE MAP (3/4) UPSTREAM OF ING-YOT DIVERSION CANAL	Map & Drawing No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	2.2.3
SANYU CONSULTANTS INC. & NIPPON KOEI CO.,LTD.	

Route Map (4 / 4)

(Outlet ING-YOT Tunnel)

LAO PEOPLE'S DEMOCRATIC REPUBLIC

THAILAND

No.5 Inclined Adit L=2,470m

No.6 Inclined Adit L=3,340m

Const. Division 7 : L7=5,800m

Total Length of Ing-Yot Tonnel L=50,875m

Tunnel Gradient : 1/2,500

Tunnel Height : 8.18m , Water Depth : 6.69m

(Total Length of Inclined Adit L=17,38[illegible])

Const. Division 8 : L8=5,600m

Const. Division 9 : L9=4,000m

No.7 Inclined Adit L=2,430m

Outlet : (TP.26) 63+315

WL. : 338.65m

EL inv : 331.96m

N

0 1 2 3 4 5.0km

RESERVOIR AREA AT FWL 312M=3.2km²

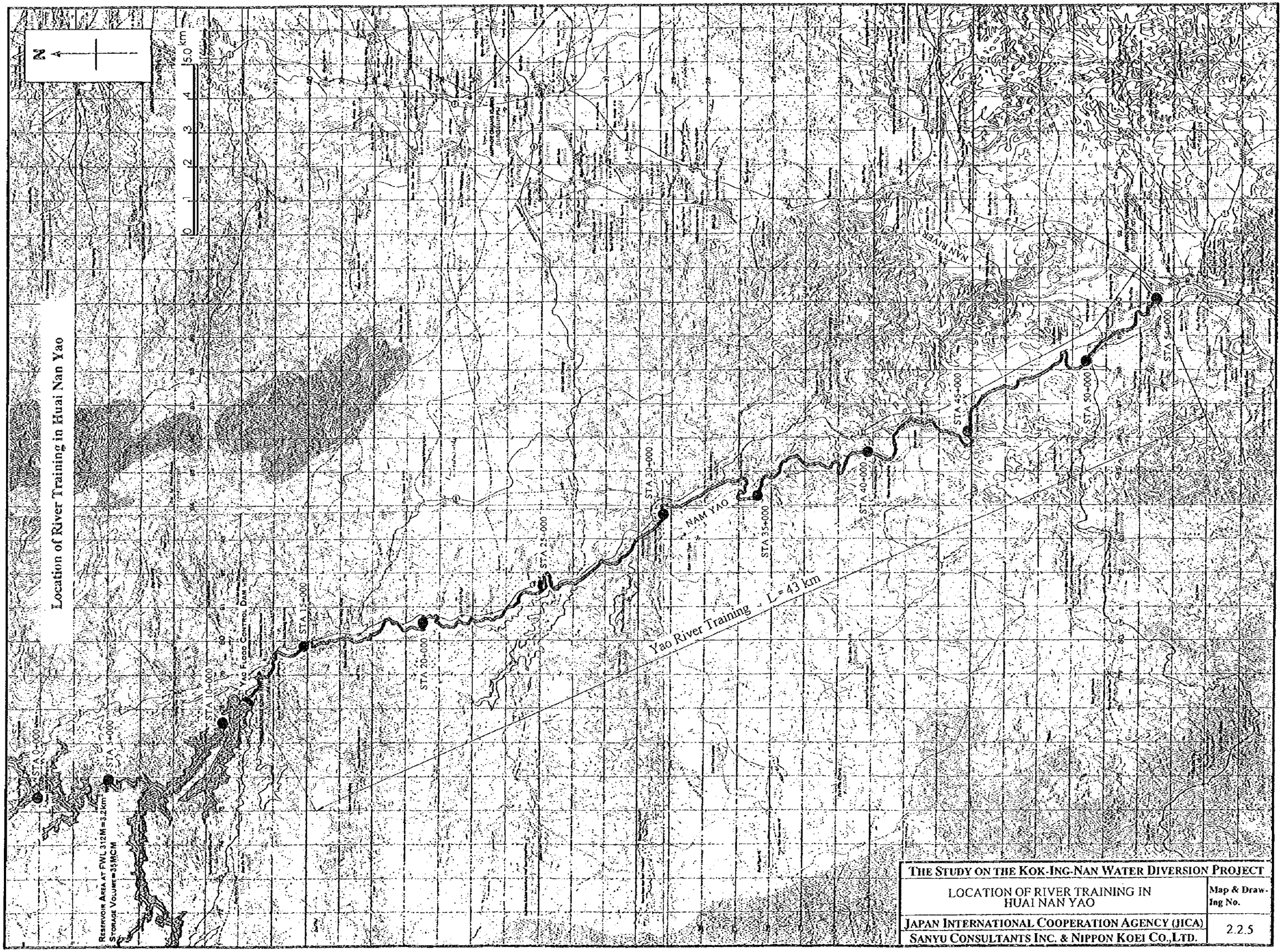
STORAGE VOLUME=35MCM

YAO FLOOD CONTROL DAM

Cordination and Distance of Turning Point

No. of Turning Point	Cordination X	Cordination Y	Distance between TP
TP.19(Inlet)	35,710	74,210	
TP.20	38,000	75,675	2,719
TP.21	42,000	76,000	4,013
TP.22	48,000	74,000	6,325
TP.23	50,000	69,000	5,385
TP.24	50,000	63,000	6,000
TP.25	65,000	48,000	21,213
TP.26(Outlet)	69,170	44,860	5,220
Total Length (m)			50,875

THE STUDY ON THE KOK-ING-NAN WATER DIVERSION PROJECT	
ROUTE MAP (4/4) DOWNSTREAM OF ING-YOT DIVERSION CANAL	Map & Drawing No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	2.2.4
SANYU CONSULTANTS INC. & NIPPON KOEI CO.,LTD.	



THE STUDY ON THE KOK-ING-NAN WATER DIVERSION PROJECT	
LOCATION OF RIVER TRAINING IN HUAI NAN YAO	Map & Drawing No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) / SANYU CONSULTANTS INC. & NIPPON KOEI CO., LTD.	2.2.5

2.3 Natural/ Social Environments

2.3.1 Aquatic ecology

In the IEE of Aquatic ecology/ Fishery section, a comprehensive study is carried out to recognize the ecological and environmental aspects in the project site and study area as well as to suggest the enhancement programs to support the project. Understanding of the present status of aquatic environment and fishery in the project site and study area requires to specify the properties in those places which belong to the tropical zone.

As the Northern Thailand is categorized in tropical zone, it is necessary to recognize that the present project site and the study area put ecological or environmental impacts on the organisms in a different manner from the temperate zone. The volume of water discharges in rivers and other water bodies limits the distribution and abundance of aquatic organisms, so that activity of fishing and aquaculture are impeded due to the shortage of water supply in narrow land area. Villagers along the rivers and streams harvest only less quantity of fish and aquatic organisms to sustain their lives in a dry season.

The enhancement programs related to and supported by the project will contribute to improve their living standard through people participation, so that the project itself will be well understood.

2.3.1.1 Habitat of aquatic organisms

The pattern of nutrient cycling in the tropical zone is, in several aspect, different from that in the temperate zone. In the tropical zone, much larger percentage of nutrients is in the biomass and is recycled within the organic structure system. In tropical freshwater ecosystem found in the project site, the biological diversity is higher than in the temperate zone. The community structure shows that the larger total organic matter is in terms of organisms, the lower community production or yield is. As the structure of the food chain in the tropical zone are weblike and dominated by detritus, the role of detritus in nutrient regeneration between organisms is more critical to the organisms. Ecological stability against external perturbation, is higher in the tropical zone than in temperate zone due to lower nutrient exchange rate between organisms and the environment, but net community production or yield is lower than in temperate zone.

Description of major ecological habitats in the project site focuses on five typical water bodies including river, swamp, reservoir, ditch and pond.

(1) River

Running water bodies of the river and stream have remarkable characeristics in the following three aspects, compared to the stagnant water bodies such as the swamp and pond.

(1) current is much more of a mojor controlling and limiting factor in the biological production.
(2) land - water interchange is relatively more extensive, resulting in a more open ecosystem.
(3) oxygen tension is more uniform and there is little or no thermal or chemical stratification.

Rivers and streams show prominent longitudinal zonation of the organisms. Changes of the zone are pronounced in the upper part of streams because the gradient, volume of flow, and chemical composition change significantly. In the longitudinal distribution of fish in streams, headwater species generally exhibit wide tolerances and are found throughout the length of the stream, whereas other species occurs in successive sections of the stream.

Rivers and streams are in general represented by two major zones. Firstly, the rapid zone has shallow water where the velocity of the current is high enough to keep the bottom free of silt and other loose materials, thus providing a firm bottom. This zone is occupied largely by specialized benthic or periphytic organisms which become firmly attached or climbing to a firm substrate, and strong swimmers such as darters of fish. Secondly, the pool zone has deeper water where the velocity of the current is low to medium and silt and other loose materials tend to settle to the bottom, thus providing a soft bottom, unfavorable for surface benthos but favorable for burrowing forms, fish, and, in some cases, plankton.

Unfavorable environment of the water bodies bring the lower standing crop and production of the organisms. Higher swimming ability allows fish to migrate upstream and other water bodies to acquire the opportunities of growing and spawning.

(2) Swamp

Water bodies are managed by municipal authorities where the water is drawn out downstream by gate operation. They have some deep bottom forming stratified physical characteristics which limit the production and distribution of the organisms. The level and circulation of water bodies depend on the inundation and discharge from the upper streams. In spite of the seasonal fluctuation due to river water discharge, the water level changes within less than few meters which doesn't affects the stable community structure.

Most of coasts are covered with spermatophytes from the surface to bottom being limited by the light penetration. Trophic status reveals mesophilic from the surface water color with showing pale green as the dominance with green algae of phytoplankton. Surrounding villagers take the opportunity aquaculture by applying the local waste materials to promote and stabilize fish production but the biomass and the productivity are not so high because of higher diversity than other water bodies.

Major swamps in the Northern Thailand are located as follows :

Chiang Saen Basin,	Chiang Rai Province,	10,000 ha
Nong Luang,	Chiang Rai Province,	2,000 ha
Nong Hang,	Chiang Rai Province,	740 ha
Nong Leng Sai,	Phayao Province,	1,050 ha
Kwan Phayao,	Phayao Province,	2,300 ha

(3) Reservoir

Direct continuous discharge from the upper streams keep the reservoif full of water, often forming the euphotic zone . Coastal lines are covered with the spermatophyte community of bushes. The plants contribute to build the shelter for the fragile stage of smaller organisms to escape from their predators and also nursery during the initial period of their life cycle. Decayed plant material is attacked by the microbial degradation through which nutritious food source for the organisms be reformed by the fermentation to the detritus as organic fragments. Trophic status of water bodies are classified in oligo- or mesophylic. No effort of water enrichment is required to be made, such as provision of fertilizers due to natural constant supply of detritus after decaying plant material in the coastal bushes. The diversity and standing crop of organisms are declined from the coast to offshore with water depth. Fish harvest and fry releasing are managed by the villagers under the instruction and assistance of the municipal authorities.

Major reservoirs in the Northern Thailand are located as follows;

Huaisuk Reservoir,	Chiang Rai Prov
Mepun Reservoir,	Phayao Province
Nan Tun Reservoir,	Nan Province
Huai Hat Reservoir,	Nan Province
Nam Mae Kum Luang	
Nam Mae Sao	

Nam Mae Mao

Hual Mae Phong

Sirikit Reservoir, Nan Province

(4) Ditch

Along the paddy fields, smaller water bodies are scattered to draw the water from the river or swamp by connecting with pipes or due to inundation. A few or several meters of the depth enable villagers to promise the irrigation in a dry season. Although the productivity and standing crop of the fish are not so high, villagers can enjoy harvesting them for the daily cooking. Trophic status of the water body reveals mesophylic or moderate eutrophic, the surface of which shows pale green color.

(5) Pond

Small pipes are facilitated to induce river water to the isolated space where enclosed with earthen dikes with the square or rectangle shape. The working depth of less than two meters can satisfy the fish to propagate themselves in such closed circumstances. The commercialization of fish culture can be introduced to broadcast several kinds of feed including dry chicken dug, chemical fertilizer, food processed wastes, domestic cooking wastes, dry pellets and so on. The dry season often prevent pond owners from promoting the fish production because of water depletion. The water color shows that the tropic status of the water body must be eutrophic. Some of the water in the ponds appears to be judging from the color of green, yellow or orange, because the owners do an excess feeding for higher production. The higher productivity with lower diversity is caused by the single or few species of fish stock.

2.3.1.2 Ecological component

Description of major ecological components in the study area is focuses on five major types, consisting of phytoplankton, zooplankton, benthos, fish and macrophyte. These components of organisms have not been studied completely in the area although the community of the organisms are to be affected more or less in the implementation stage of the project.

(1) Phytoplankton

Five phyla of phytoplankton are found in the project site, represented by *Chlorophyta* (green algae), *Bacillariophyta* (diatom), *Cyanophyta* (blue-green algae), *Pyrrophyta* (dinoflagellata), and *Euglenophyta* (euglenoida).

The standing crop depends mainly on the degree of the fertility in the water, so that gradient of increase is observed to be less in the river and dense in the ponds.

In the contribution of the food supply to upper ecological pyramid as the producer, they are in less importance compared to the detritus in the tropical zone for the fatal oligotrophic water body. They are partly food of the primary consumer of zooplankton and benthos although most of them are to be changed to the detritus attacked by microbial destruction.

(2) Zooplankton

Three phyla of invertebrates are found in the project site, represented by including *Protozoa* (protozoan), *Trochelminthes* (rotifer), and *Arthropoda* (copepoda)

Those primary consumers take in suspended particles in the water, such as phytoplankton and organic aggregates of detritus, both depending on the particle size to fit their mouths not on the preference or type of food organisms. Protozoan directly consume bacteria and fungi which attack the organic material originated in plant and animals, so that biodegradation and nutrient recycle work and keep the vegetable growth of microbial population. Rotifer and copepoda take in larger size of particles including protozoan to maintain effective potentiality of nutrient recycling by the same manner as in the protozoan. Zooplankton are regarded as a prey to their consumer of fish and benthos.

(3) Benthos

Five classes in three phyla are found in the project site, represented by *Oligochaeta* (fishworm), *Gastropoda* (snail), *Pelecypoda* (bivalve), *Decapoda* (shrimp and crab), and *Insecta* (insect).

The feeding mechanisms are classified into two types, the filter feeding and the grazing, based on the species. The food habit are classified into three types, the herbivore, carnivore and omnivore, based on the same case in the feeding mechanism. The standing crop of them depends mainly on the vegetation and

biomass of macrophyte and phytoplankton. Most of macrophyte contribute to their feed both in the fresh and in the decayed as the detritus. Some of these macro- and megarobenthos are utilized as the local special products which are consumed in fresh or after processed with some ingredients such as the crab pastes and aquatic bugs.

(4) Fish

More than 200 species are exploited in the study area. Among those species, approximate fifty are of some or primary economic importance. The main species are divided into the four groups as follows :

Group (1) : species which are mainly associated with the larger streams/main river, but undertake spawning migrations between these and the flooded areas in the season.

They are mainly cyprinids, Schibeidae, Suiluridae and Notopteridae. Several of these species undertake both lateral and longitudinal migrations.

Group (2) : species which are able to survive under more adverse and varied environmental conditions such as the low oxygen level, some acidity, some salinity, and which can stay in the swamps and plains all year around.

Members of this group are in most cases carnivores or detritus feeders, some are able to migrate over land and several species posses auxiliary organs for oxygen uptake from atmospheric air. This group includes members of the families Claridae, Ophicephalidae, Bargridae and Anabantidae.

Group (3) : smller, fast growing and prolific species as opportunists, which are able to utilize the flood for prolific reproduction and growth. The group consists mainly of cyprinids. Due to their biology they can exhibit very high abundance in a distinct seasonal pattern.

Group (4) : shrimps and giant freshwater prawn. Shrimps are in the canals and flooded areas.

(5) Machrophyte

Aquatic spermatophytes are classified in three types as emerging type of rooted plants, submerged type of benthic plants, and floating type of periphyton.