Figure11.2.5-10 Location Map for Proposed Geological Investigation
(Ing-Yot No.2 Tunnel (4))

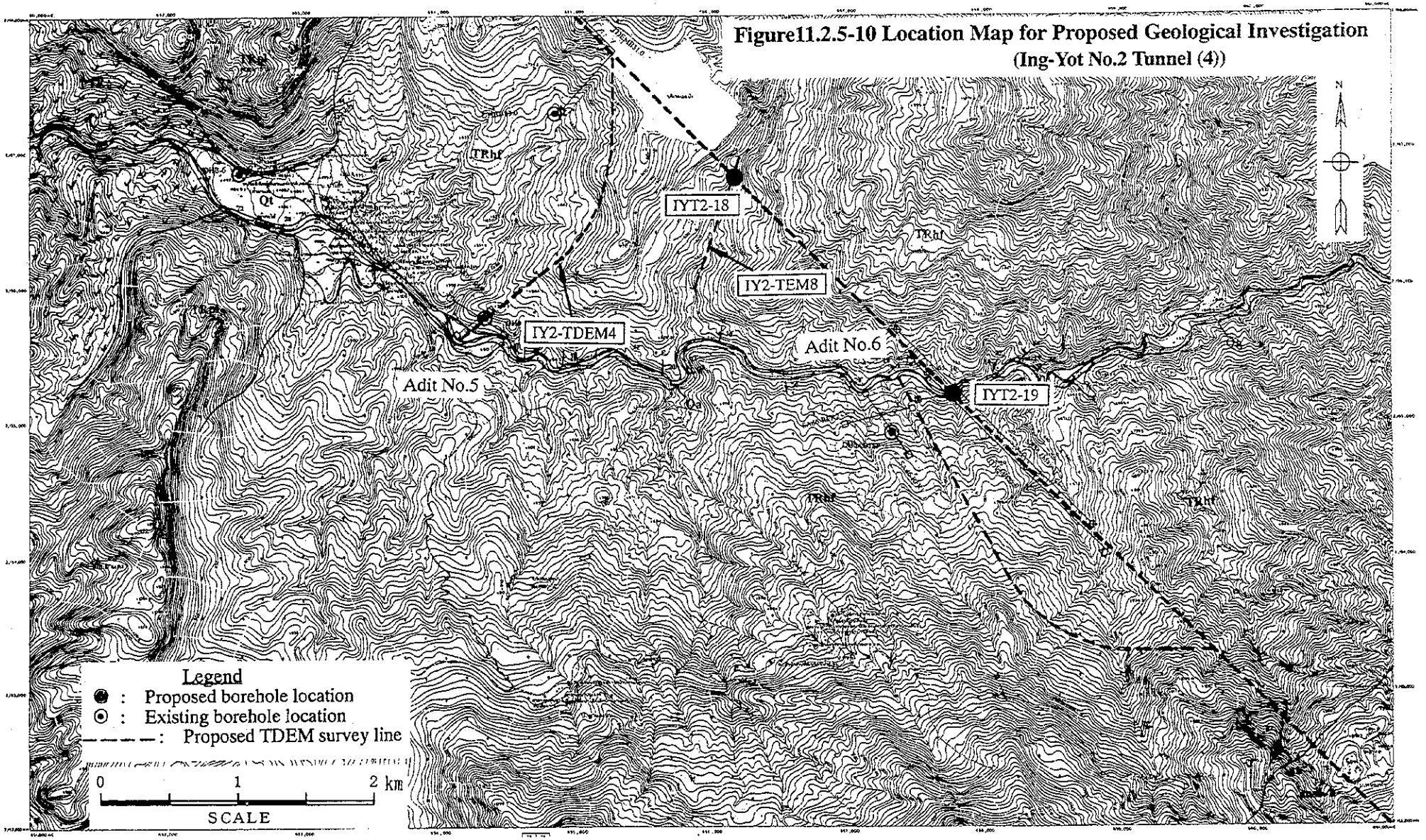
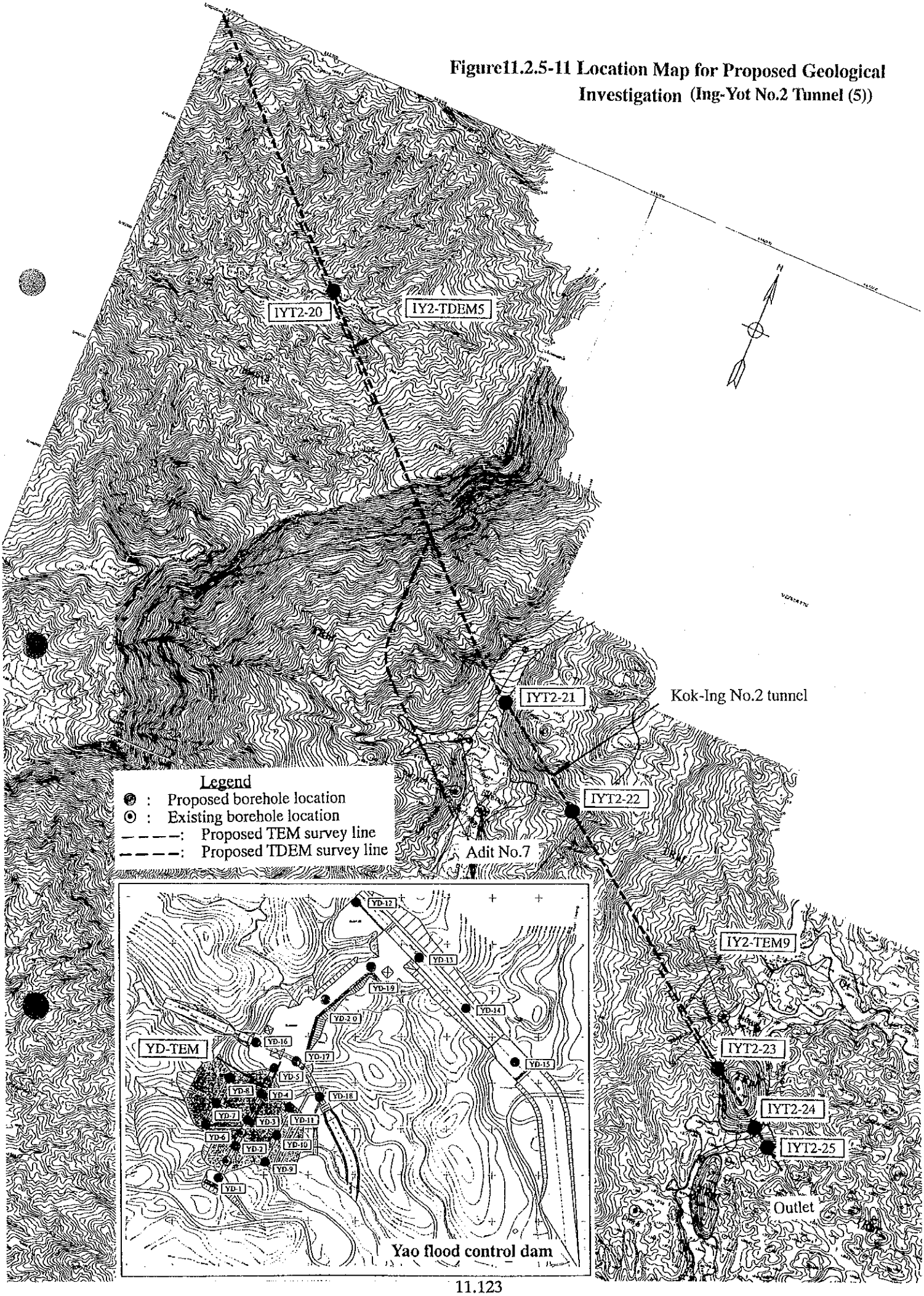


Figure11.2.5-11 Location Map for Proposed Geological Investigation (Ing-Yot No.2 Tunnel (5))



Summary of Cost Estimate for Geological Investigation

Type of Works	Unit	Quantity	Unit rate	Amount (barts)	Amount (yen)
1. Geological Investigation (Shallow Drilling, Weir, Intake and Diversion Canal)					
1.1. Mobilization and Demobilization	LS.			1,140,000	
1.2. Boring works	LS.			5,672,500	
1.3. In-situ test	LS.			4,759,000	
1.4. Laboratory test (physical test)	LS.			68,000	
1.5. Reporting	LS.			100,000	
				11,739,500	42,262,200
2. Geological Investigation (Shallow and Deep Drilling, Kok-Ing and Ing-Yot Tunnel)					
2.1. Mobilization and Demobilization	LS.			9,820,000	
2.2. Boring works	LS.			47,818,000	
2.3. In-situ test	LS.			6,520,000	
2.4. Laboratory test (rock test)	LS.			699,400	
2.5. Reporting	LS.			700,000	
Sub total				65,557,400	236,006,640
3. Geological Investigation (Yao Flood Control Dam and Yao River Training)					
3.1. Mobilization and Demobilization	LS.			2,220,000	
3.2. Boring works	LS.			8,308,000	
3.3. In-situ test	LS.			4,170,000	
3.4. Test pitting and laboratory test	LS.			2,854,000	
3.5. Reporting	LS.			500,000	
Sub total				18,052,000	64,987,200
4. Electromagnetic Survey (TEM, TDEM)					
4.1. Rental charge	LS.			4,654,500	
4.2. Labor charge	LS.			3,062,200	
4.3. Engineer for observation of TEM&TDEM	LS.			16,459,400	
4.4. Equipment for measurment	LS.			791,200	
4.5. Transportation chage (International and domestic)	LS.			818,100	
4.6. Depreciation costs of Equipment (including repair & maintenance)				5,206,700	
4.7. Reporting (including analysis)	LS.			2,083,400	
Sub total				33,075,500	119,071,800
5. Seismic Survey (Refraction Survey)					
5.1. Seismic survey (refraction survey)	LS.			400,000	
5.2. Reporting	LS.			10,000	
Sub total				410,000	1,476,000
Total				128,834,400	463,803,840
Total*1.2				154,601,280	556,564,608
VAT 10%				15,460,128	55,656,461
Grand total				170,061,408	612,221,069
			=	170,061,000	612,221,000

1. Summary of Cost Estimate for Geological Investigation (Shallow Drilling, Weir, Intake and Diversion Canal)

Type of Works	Unit	Quantity	Unit rate	Amount	
1. Mobilization and Demobilization					
1-1. Mob/demobilization to/from the site	sets	4	20,000	80,000	4 sets
1-2. Provision of access road to site	places	34	10,000	340,000	68*0.5
1-3. Setting up of contractors' camp of site	sites	4	20,000	80,000	4 sites
1-4. Additional mobilization from site to site	Nos.	64	10,000	640,000	68-4
Sub total				1,140,000	
2. Boring works					
2-1. Setting up of drilling rig	places	68	30,000	2,040,000	
2-2. Core boring (66 mm in hole diameter or equivalent size)					
2-2-1. Soil	m	1,557	1,500	2,335,500	1,730*0.9
2-2-2. Weathered rock	m	173	3,000	519,000	1,730*0.1
2-3. Core box	Nos.	433	1,200	519,600	1,730/4
2-3. Plugging holes	holes	68	800	54,400	
2-4. Top-survey, spot height leveling	Nos.	68	2,000	136,000	
2-5. Site clearance	places	68	1,000	68,000	
Sub total				5,672,500	
3. In-situ test					
3-1. Standard penetration test	times	1,644	2,000	3,288,000	1,730*0.95
3-2. Permeability test	times	198	2,000	396,000	(68-2)*3
3-3. Lugeon test	times	10	20,000	200,000	2*(30-5)/5
3-4. Lateral loading test	times	35	25,000	875,000	1,730*0.02
Sub total				4,759,000	
4. Laboratory test (physical test)					
4-1. Natural moisture content	Nos.	34	200	6,800	68/2
4-2. Spesific gravity	Nos.	34	400	13,600	
4-3. Sieving test with hydrometer	Nos.	34	1,000	34,000	
4-4. Atterberg limit	Nos.	34	400	13,600	
Sub total				68,000	
5. Reporting	LS.			100,000	
Total				11,739,500	
VAT 10 %				1,173,950	
Grand total				12,913,450	Barts
				42,262,200	Japanese yen
				24,429	cost/m (yen)

2. Summary of Cost Estimate for Geological Investigation (Shallow and Deep Drilling, Kok-Ing and Ing-Yot Tunnel)

Type of Works	Unit	Quantity	Unit rate	Amount	
1. Mobilization and Demobilization					
1-1. Mob/demobilization to/from the site	sets	8	50,000	400,000	1set*3+25/5sets
1-2. Provision of access road to site				0	
1-2-1. Long distance for preparing road	places	9	200,000	1,800,000	
1-2-2. Semi-long distance for preparing rooad	places	16	160,000	2,560,000	150,000*0.8
1-2-3. Short distance for preparing road	places	11	140,000	1,540,000	150,000*0.6
1-3. Setting up of contractors' camp of site	sites	36	20,000	720,000	
1-4. Additional mobilization from site to site	Nos.	28	100,000	2,800,000	36-8
Sub total				9,820,000	
2. Boring works					
2-1. Setting up of drilling rig	places	36	125,000	4,500,000	
2-2. Core boring				0	
Vertical hole 0 - 50 m	m	1,560	1,900	2,964,000	1,800*1.05
50 - 100 m	m	1,200	6,100	7,320,000	5,800*1.05
100 - 150 m	m	920	7,500	6,900,000	7,100*1.05
150 - 200 m	m	690	9,200	6,348,000	8,700*1.05
200 - 250 m	m	530	11,300	5,989,000	10,700*1.05
250 - 300 m	m	340	14,000	4,760,000	13,300*1.05
300 - 350 m	m	160	17,600	2,816,000	16,700*1.05
Inclined hole 0 - 50 m	m	200	2,400	480,000	1,900/0.85
50 - 100 m	m	190	7,200	1,368,000	6,100/0.85
100 - 150 m	m	130	8,900	1,157,000	7,500/0.85
2-3. Core box	Nos.	1,480	1,200	1,776,000	5,920/4
2-3. Plugging holes	holes	36	10,000	360,000	
2-4. Top-survey, spot height leveling	Nos.	36	20,000	720,000	
2-5. Site clearance	places	36	10,000	360,000	
Sub total				47,818,000	
3. In-situ test					
3-1. Standard penetration test	times	0	2,000	0	
3-2. Permeability test	times	0	5,000	0	
3-3. Lugeon test	times	108	40,000	4,320,000	36*3
3-4. Lateral loading test	times	0	50,000	0	
3-5. Logging test	holes	22	100,000	2,200,000	
Sub total				6,520,000	
4. Laboratory test (physical test)					
4-1. Specific gravity and absorption test	Nos.	78	1,000	78,000	26*3
4-2. Unconfined compression test	Nos.	78	2,500	195,000	
4-3. Ultrasonic velocity	Nos.	78	2,500	195,000	
4-4. Tensile strength	Nos.	26	2,500	65,000	26*1
4-5. Petrologic observation	Nos.	78	1,800	140,400	26*3
4-6. X-ray diffraction analysis	Nos.	13	2,000	26,000	26/2
Sub total				699,400	
5. Reporting	LS.			700,000	
Total				65,557,400	
VAT 10 %				6,555,740	
Grand total				72,113,140	Barts
				236,006,640	Japanese yen
				39,866	cost/m (yen)

3. Summary of Cost Estimate for Geological Investigation (Yao Flood Control Dam and Yao River Training)

Type of Works	Unit	Quantity	Unit rate	Amount	
1. Mobilization and Demobilization					
1-1. Mob/demobilization to/from the site	sets	4	20,000	80,000	3(dam)+1(training)
1-2. Provision of access road to site					
1-2-1. Dam site	places	20	50,000	1,000,000	
1-2-2. River training	places	8	20,000	160,000	
1-3. Setting up of contractors' camp of site	sites	13	20,000	260,000	20/4(dam)+8(training)
1-4. Additional mobilization from site to site	Nos.	24	30,000	720,000	28-4
Sub total				2,220,000	
2. Boring works					
2-1. Setting up of drilling rig	places	28	60,000	1,680,000	
2-2. Core boring (66 mm in hole diameter or equivalent size)					
2-2-1. Soil	m	180	1,500	270,000	20*5+8*10
2-2-2. Weathered rock	m	140	3,000	420,000	20*5+8*5
2-2-3. Rock	m	880	6,100	5,368,000	1040+160-(180+140)
2-3. Core box	Nos.	300	1,200	360,000	1,200/4
2-3. Plugging holes	holes	28	1,500	42,000	
2-4. Top-survey, spot height leveling	Nos.	28	4,000	112,000	
2-5. Site clearance	places	28	2,000	56,000	
Sub total				8,308,000	
3. In-situ test					
3-1. Standard penetration test	times	235	2,000	470,000	15*5+8*20
3-2. Permeability test	times	0	2,000	0	
3-3. Lugeon test	times	160	20,000	3,200,000	(880-16*5)/5
3-4. Lateral loading test	times	20	25,000	500,000	20*1
Sub total				4,170,000	
4. Test pitting and laboratory test					
4-1. Test pitting	pits	40	4,500	180,000	
4-2. Physical test					
4-2-1. Specific gravity	Nos.	60	400	24,000	
4-2-2. Field water content	Nos.	60	200	12,000	
4-2-3. Grain size analysis (normal, including hydrometer)	Nos.	40	1,000	40,000	Core, random material
4-2-4. Grain size analysis (sieving in large scale)	Nos.	20	3,000	60,000	Rock, filter naterial
4-2-5. Liquid limit & Plastic limit	Nos.	40	400	16,000	Core, random material
4-3. Dynamic test					
4-3-1. Compaction test (small size)	Nos.	40	1,000	40,000	20*2
4-3-2. Compaction test (large size)	Nos.	20	5,000	100,000	10*2
4-3-3. Permeability test (small size)	Nos.	40	1,000	40,000	20*2
4-3-4. Permeability test (large size)	Nos.	30	6,000	180,000	10*3
4-3-5. Consolidation test (small size)	Nos.	20	2,000	40,000	10*2
4-3-6. Tri-axial compressioon test					
UU (small size) test	Nos.	10	16,000	160,000	100mm, 20/2+20/2
CU (small size) test	Nos.	10	34,000	340,000	100mm, 20/2+20/2
CU-bar (small size) test	Nos.	10	35,000	350,000	100mm, 20/2+20/2
UU (large size) test	Nos.	5	40,000	200,000	200mm, 3+2
CU (large size) test	Nos.	5	70,000	350,000	200mm, 3+2
CU-bar (large size) test	Nos.	5	80,000	400,000	200mm, 3+2
CD (large size) test	Nos.	5	50,000	250,000	200mm, 3+2
4-4. Rock test					
4-4-1. Specific gravity and absorption test	Nos.	10	1,000	10,000	
4-4-2. Unconfined compression test	Nos.	10	2,500	25,000	
4-4-3. Stability	Nos.	10	1,200	12,000	
4-4-4. Ultrasonic velocity	Nos.	10	2,500	25,000	
Sub total				2,854,000	
5. Reporting	LS.			500,000	
Total				18,052,000	
VAT 10 %				1,805,200	
Grand total				19,857,200	Barts
				64,987,200	Japanese yen

4. Summary for Cost Estimate for Electromagnetic Survey (TEM, TDEM)...Japanese yen

Type of Works	Unit	Quantity	Unit rate	Amount	
1. Rental charge					
1-1. Back hoe	day	15	18,000	270,000	TDEM, 5 points*3
1-2. Generator	day	95	21,000	1,995,000	TDEM, 95
1-3. Truck with crane	day	234	22,000	5,148,000	(93*4+95)/2
1-4. Truck with pick-up	day	467	11,000	5,137,000	93*4+95
1-5. Truck with pick-up (for topo-survey, leveling)	day	166	11,000	1,826,000	120+44
1-6. Land rental	places	17	20,000	340,000	
1-7. Site clearance	places	17	120,000	2,040,000	
Sub total				16,756,000	4,654,444
2. Labor charge					
2-1. Surveyor for topo-survey of observation line	man.day	214	8,500	1,819,000	120+36+44+14
2-2. Assitant surveyor for topo-survey of observation line	man.day	214	5,100	1,091,400	120+36+44+14
2-3. Labor for topo-survey of observation line	man.day	498	1,100	547,800	(120+44)*3
2-4. Labor for setting of observation equipment	man.day	467	1,800	840,600	93*4+95
2-5. Labor for observation of TEM&TDEM	man.day	3,736	1,800	6,724,800	(93*4+95)*8
Sub total				11,023,600	3,062,111
3. Engineer for observation of TEM&TDEM					
3-1. Engineer for observation of TEM&TDEM	man.day	196	138,500	27,146,000	Japanese(JICA-grade2), 93+95+4*2
3-2. Assitant Engineer for observation of TEM&TDEM	man.day	291	93,600	27,237,600	Japanese(JICA-grade4), 93*3+4*3
3-3. Lodging charge	man.day	487	10,000	4,870,000	196+291
Sub total				59,253,600	16,459,333
4. Equipment for measurment					
4-1. Electlic plate	sheets	1,196	500	598,000	1072+124
4-2. Cable for measurement	m	5,000	350	1,750,000	
4-3. Others	LS.			500,000	
Sub total				2,848,000	791,111
5. Transportation chage (Japan to Thailand and domestic)					
5-1. Equipment of TEM&TDEM (Japan to Thailand)	LS.			600,000	
5-2. Equipment of TEM&TDEM (Thailand to Japan)	LS.			700,000	
5-3. Equipment of TEM&TDEM (domestic)	LS.			50,000	
5-4. Engineer & assitant engeneer (fright charge)	times	5	300,000	1,500,000	
5-5. Engineer & assitant engeneer (fright charge, domestic)	times	5	15,000	75,000	
5-6. Custum clearance charge for equipment	LS.			20,000	
Sub total				2,945,000	818,056
6. Depreciation costs of Equipment (including repair & maintenance)					
6-1. TEM equipment	LS.			12,796,800	17,200,000*93*4*0.002
6-2. TDEM equipment	LS.			5,947,000	31,300,000*95*0.002
Sub total				18,743,800	5,206,611
7. Reporting					
7-1. Analysis for the results of TEM&TDEM	LS.			6,000,000	2 months
7-2. Reporting	LS.			1,500,000	including color copies
Sub total				7,500,000	2,083,333
Total				119,070,000	
VAT 10%				11,907,000	
Grand total				130,977,000	Japanese yen
				33,075,000	Barts

11.1.3 Overall Environmental Conditions

(1) Kok River

(a) Kok Intake Site

The Kok river has the mean annual runoff of 3,500 MCM corresponding to the annual mean discharge of 110 cu.m/s at the existing DEDP weir site. The maximum discharge is 950 cu.m/s and the minimum one is 30 cu.m/s at the existing weir. The Kok Ing Nan Water Diversion Project (the Project) is planned to use the existing DEDP weir for diverting the river water of the Kok river.

The existing weir has operated since 1994. The river water level at the weir sites is controlled between EL. 387 m and EL. 389 m, except during the wet season from June to November. However, since construction of the DEDP irrigation system is scheduled to be completed in February, 1999, the reservoir water level is expected to be operated at EL. 389 m even during the wet season for irrigation water supply.

The operation water level of EL. 389.0 m at the envisaged intake site has a high possibility that the backwater effect will worsen the drainage congestion in the lowland areas along the Kon river, as given in Figure 11.1.3 (1)-1. Whilst, assuming that the mentioned adverse effect is large in the lowland area and that it could not operate the Chiang Rai Reservoir at EL. 389.0, it is necessary to design the water level lower than the elevation of 389.0 m for the Project.

The intake structure is proposed at 3.5 km upstream of the aforesaid weir or about 3.0 km downstream of the Chiang Rai Bridge. Land at the proposed intake site has used for the mixed cultivation or bush area. Therefore, land acquisition will not be of the serious problem for construction of intake.

(b) Upstream of Kok Intake Site

The backwater effect reaches the existing Chiang Rai Bridge, which locates about 4.5 km upstream of the aforesaid DEDP weir. The proposed intake site is planned at 1.5 km upstream of the weir.

There are thirteen (13) private companies abstracting river sand with a license issued by the local government. While, the existing weir and reservoir have trapped the inflow sediment loads, especially bed load. Total amount of wash, suspended and bed loads flowing into the reservoir is estimated at 870 thousand cu.m/year. It is required for the Study not to change the sediment balance situation largely in the reservoir, in order to maintain the current river sand mining.

There exists the water treatment plant with pumping facility at just upstream of the Chiang Rai Bridge for municipal and industrial water supply in the city area. This plant has been operated, excavating the sediment deposited in front of the regulating pond. The reservoir sedimentation, also, has affected the maintenance of navigation route for tourism boat. The local government has asked rise of reservoir water during the dry season to the DEDP in order to keep river water depth for the navigation.

(c) Downstream of Kok Intake Site

There is a catchment basin with an area of 4,680 km^2 and length of river channel of 70 km between the confluence with the Mekong river and the envisaged weir site. The water amount of 1,900 million cu.m, which corresponds to 36 % of the total water amount flowing into the Mekong river, is drained out from the mentioned basin.

The Kok river along the mentioned river stretch of 70 km mainly flows down in the hilly areas utilized as fruit tree cultivation. However, the endmost river stretch with length of 10 km is affected by the river water level of the Mekong river and the lands along this stretch has suffered from inundation by the high river water level of the Mekong river.

There are many migrant fishes from the Mekong river to the Kok upstream reaches. But, the existing weir is closed the migrant way during the dry season and through a year after the completion of the irrigation system.

(3) **Ing River**

(a) Ing Weir Site

The Ing weir is proposed at 2.8 km upstream of the Thoeng Bridge on the provincial road with the code No. 1020 as given in Figure 11.1.3 (3)-1. At the weir site, the Ing river has a catchment area of 4,440 km^2 and the annual runoff amount of 1,830 million cu.m, corresponding to the annual mean discharge of 58 cu.m/s. The maximum discharge of 1,250 cu.m/s was recorded in 1994 and the minimum one is 3 cu.m/s to 5 cu.m/s.

The river flow during the wet season changes from 20 cu.m/s to 40 cu.m/s in June to 50 cu.m/s to 150 cu.m/s in August to September in the peak wet season. Since the flow discharges during the wet season in the Ing river is insufficient for satisfying the designated design discharge of 175 cu.m/s, the diversion of river water in the Kok river is necessary to supplement it.

(b) Upstream of Ing Weir Site

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.

Therefore, there are no significant resettlement problems at the proposed weir site though it is required to acquire the lands for construction of the proposed weir.

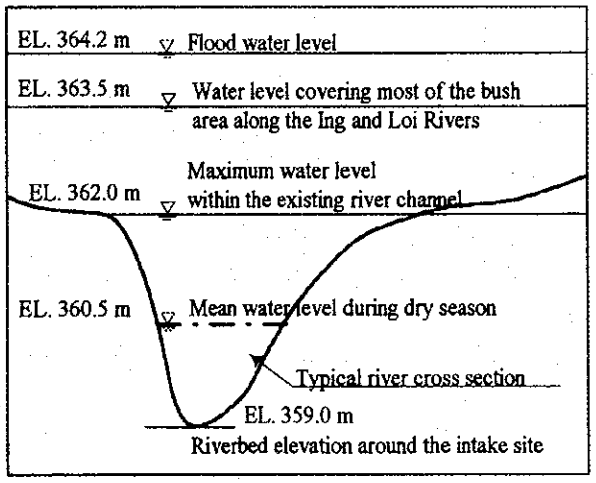


Figure 11.1.3 (3)-2Water Level and River Cross Section at the Ing Weir Site

The river water level at the intake structure site is lower than the riverbank elevation of EL. 362 m for eight (8) months from the middle of November to the middle of July. Then, for four (4) months, the river water of the Ing river covers the lowland.

There are no important or endangered species of fauna and flora in the wet lands, according to the environmental study made by the OEPP.

While, there 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 migrated fish for creating better environmental situation. Also, it is required to provide fishway at the proposed Ing diversion weir so as to make migrant fishes passing the proposed weir.

(c) Downstream of Ing Weir Site

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. Inhabitants in the mentioned river reaches have desired to mitigate flood damage and to enhance land use there.

There is a high possibility that the diversion of river water in the Ing river during the wet season will reduce the flood water level significantly in the river reaches where the backwater of the Mekong river does not reach.

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 Kok Ing Nan Water Diversion Project may be able to contribute development of land resources along the downstream river reaches.

(d) Ing-Lao River

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 630 million cu.m comprised of 630 million cu.m in the wet season and 70 million cu.m in the dry season. The mentioned river water has 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.

(6) Flood Control Dam Site

(a) Dam Site and Reservoir Area

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 million cu.m corresponding to the annual mean discharge of 5.5 cu.m/s.

The flow runoff during the wet season occupies 85 % of the annual runoff and is equivalent to the water amount of 148 million cu.m.

The following attention has been paid for the plan formulation and design of the envisaged dam as well as the topographic and natural condition at the dam site:

- Existence of villages, national park and reserved area 1A in the reservoir area,
- Existence of provincial road with a code No. 1108, running on the just downstream of the envisaged dam site,
- Possibility of occurrence of land slide or slope failure due to storing water, and
- Location of possible spoil bank

(b) Upstream of Dam Site

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 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 exist farm area of 520 rai, equivalent to 83 ha, in the reservoir area.

(7) **Yao River**

(a) Recorded Flood

Significant flood damages were caused in 1996, which is the largest flood in memory of inhabitants there. 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.

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 has 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.

According to the flood mark survey carried out by the JICA Study Team, the maximum and normal flood water level profiles are given in Figure 11.1.3 (4)-1. During the flood in 1996, rushing flood flow overtopped all the existing bridges. Also, the existing road along the Yao river was inundated at Ban Songkhwae. Duration of inundation at the upstream villages was about four (4) to five (5) hours.

The Kok Ing Nan Water Diversion Project (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 to be caused by the Project and to identify appropriate measures.

(b) Village and Farm Area along the Yao River

There are ten (10) villages along the Yao River which have suffered from the flood damages and will be affected by the Project as illustrated in Figures 11.1.3 (7)-2 to 11.1.3 (7)-5. These figures, also, illustrate the assumed inundation areas and water depth along the Yao river under 25-year probable flood.

(c) Present Water and Land Use

Figure 11.1.3 (7)-6 illustrates the land use condition in the assumed inundation areas. There exist several pumping facilities for irrigation and drinking water supply in village areas. Especially in the dry season, it is fined out that farmers provide small pump into the river to take water for supplying water to tobacco plantation.

There is no large irrigation system diverting the river water in the Yao river, since there are no wide flat land along the Yao river. Farmers have cultivated narrow land along the river course, formed by alluvial sediment.

11.1.4 Alternative Water Diversion Plan

(2) Kok Weir Site

There have been two (2) alternative weir sites. One is effective use of the existing Chiang Rai Weir. The Chiang Rai Weir was constructed by the DEDP in 1994 for irrigation water use with an area of 78,000 rais, domestic water supply to Chiang Rai City, water conservation of the Kok river and Korn river, and navigation for tourism in the upstream area of the existing weir. The other is provision of a new weir at the 3.3 km downstream of the mentioned existing weir in Ban Farm, Muang District, and Chiang Rai Province. Principal features of these alternatives are given as follows:

Table 11.1.4 (2)-1 Principal Features of Alternative Diversion Weirs

Principal Features	Unit	Alternative 1	Alternative 2
		Existing Chiang Rai Weir	New Kok Diversion Dam
Hydrology			
• Catchment Area	km^2	6,220	9,330
• Average annual runoff	MCM	3,645	
• Flood peak discharge with 100-year return period	cu.m/s	890	1,105
• Water level with 100-year return period	MMSL	390.5	386.7
Reservoir			
• Reservoir water level	m MSL	389.0	386.98
• Control water level	m MSL	389.0	385.0
• Length of reservoir			
Kok river	km	9.1	—
Kon River	km	3.1	—
• Surface area	km^2	2.77	
• Gross storage	MCM	2.95	
Dam facility			
• Type of dam	—	Concrete dam of ogee type	Concrete dam of ogee type
• Type of gate	—	Radial gate	Radial gate
• Height of steel gate pane	m	4.0	3.8
• Width of steel gate pane	m	8.0	10.0
• Numbers of steel gate	nos.	11	10
• Cut-off channel bed elevation at upstream and downstream	m MSL	384.75	381.50
• Gate sill elevation	m MSL	385.75	381.50
• Pier top elevation	m MSL	392.00	389.00
Dike			
• Crest level	m MSL	390.50	—
• Height	m	0 to 3	—
• Length	m	10.7	—

Source: Main Report (Conceptual Study), the Study on the Kok-Ing-Nan Water Diversion Project, March 1997

The Team J/V and the JICA Study Team has made comparative study in Phase I of the Study. Through the Study, the alternative 1 has advantage on no additional environmental adverse effects and reduction of the Project cost, but it requires careful monitoring about flooding in the Chiang Rai City due to operation of the existing weir during the wet season.

Whilst, the alternative 2 could use the water resources not only in the Kok river Basin but also the Lao River which is one of tributary of the Kok river and joins just downstream of the existing Chiang Rai weir. However, since it is required to align a diversion canal through a new irrigation area of the DEDP and people's irrigation system, it is possible to induce social problems due to crossing the existing canals in these irrigation areas and acquiring developed agricultural land for construction of canal. From the technical viewpoints, this alternative 2 has a disadvantage on the Project cost due to lower water head between the weir site and Ing diversion dam.

(3) Diversion Canal Route in KOK Basin

(a) Proposed Diversion Route

Two alternative routes are proposed at initial stage. The difference of route A and B plan is depending on only the route passing through the Kok and Tak basin. Both routes take the same route in the Ing basin after passing No.2 tunnel. Since the B route passes the high land the elevation of more than 390m. The culvert with long distance of 16.8 km, and deep depth of about 25 m. will be required. While the A route requires the tunnel with long distance of 5.8 km. consisting of very poor geological conditions. In accordance with the comparison study for A and B route by Thai side, the B routes was selected as the suitable one.

JICA team reviewed the above Thai side study result and the other alternative route in its conceptual plan stage, and found the new route of B-J improving the original route B route. The B-J route has fewer problems from viewpoint of a natural and social environmental and also engineering works. JICA and Thai side discussed the B-J route and selected it finally. Outline of three alternative routes including advantages for engineering works and environmental impacts is as follow.

Routes on the map are shown in Data map Fig 11.1.4(3).

A route

- A new diversion weir is proposed at 3.3 km. downstream of the existing Chaing Rai weir.
- Canal length is shortest. And open canal with the short distance crosses the agricultural land and reaches the inlet of No.1 tunnel between the Kok and Tak basin. After passing the Tak basin, the route crosses the mountains between Tak and Ing basin by No.2 tunnel.
- Two tunnels with the total length of 13.0 km. crossing the mountains between the Kok and Ing basin are formed with very poor geological condition with many fault zone requiring high construction cost.
- The open canal route in the Kok basin gives the large environmental impacts to the existing people irrigation system because the canal shall cross a number of the irrigation systems and provide a number of a small siphons to guarantee the system flow.

B route

- The existing Chiang Rai Weir is to be used as the water diversion of the project, so that the construction cost for new diversion weir is not necessary.
- An open canal passes through the agricultural area neighboring Chiang Rai urban area, thus resulting in the social environmental impacts and land acquisition cost will be higher than those of A route will.
- The route shall passe through one village and Nong Luan area by open canal or culvert and will bring about the environmental problem for Nong Luan wetland which is the most important and largest fish culture lake in Chiang Rai province.
- The culvert with long distance of 16.8 km and deep excavation of more than 25 m depth is required at the reaches between the Nong Luang lake and the Kok-Ing tunnel inlet. So

that the high construction cost is required and the large social environment impact takes place at the culvert reach and spoil bank.

- However, tunnel can pass through the mountains between the Kok and Ing basin is being by good formed by good geological condition with the short distance of 5.4 km.

B-J route

- B-J route starts at the existing Chiang Rai Weir and passes through the area between route A and B along the DEDP main canal. The area has no high land to be crossed by culvert and is formed with the flat alluvial plain.
- The route was selected as to minimize construction cost and social and natural impact.
- The route is placed at the flat plain avoiding the DEDP project area and Nong Luan wet land area.
- The route crosses Kok basin with short distance and without crossing the village.
- Two tunnels are required to cross Kok-Tak and Tak-Ing mountains, which is consist slightly poor geological conditions.

(b) Disadvantage of Route A

The project facility along the A route consists of the following structures;

- New Kok diversion weir is proposed at 3.3 km. downstream of the existing Chiang Rai weir.
- Open canal with length of 8.8 km. and the discharge capacity of 140 cum/sec. crossing the existing people irrigation system.
- No.1 tunnel with length of 5.8 km passing through the mountains between the Kok and Tak river basin.
- Open canal with length of 3.8 km in the Tak river basin.
- No.2 tunnel with length of 7.2 km crossing the mountains between the Tak and Ing river basin.

Those structures will bring about the following disadvantage for the project.

- New Kok diversion weir requires the additional construction cost and gives the new environmental impacts to the area.
- The open canal route is to be placed at the existing people irrigation area with the elevation of 386 to 382 m M.S.L, which is mostly same as the hydraulic water level of open canal. Accordingly the canal shall be designed with embankment type and as a result, numbers of existing people irrigation canals shall cross the diversion canal by siphon with the length of more than 100 meters instead of aqueduct crossing over the open canal. Siphon with the long length and small discharge capacity will bring about many problems such as the large hydraulic losses, high construction cost, maintenance difficulty such as removal of sediment deposit. DEDP supplying the Kok river water to the areas by the Chiang Rai weir and the canal, and irrigation groups in the area do not

agree with the proposed open canal in route A alternative. Open canal in A route shall cross village area at Ban San Sarit and will require its resettlement.

- No.1 tunnel in A alternative shall pass through the mountains consisting of very poor geological conditions being covered with shallow overburden and having many fault zones. And this will require a high construction cost of more than 400,000 Baht per meter, as compared with the ordinary tunnel cost of 350,000 Bahts per meter for the Kok-Ing tunnel. In addition, No.1 tunnel is designed with the long distance of 5.8 km as compared with the tunnel length of 3.1 km in B-J plan.
- No.2 tunnel between the Tak and Ing river basin will require a longer length of 7.2 km than the length of 5.4 km in the new B-J tunnel. The large and worst fault zone with the length of about 1.0 km is existing at the middle part of the tunnel alignment. The construction cost of No.2 accordingly will be higher than that of the tunnel in the new B-J.

(c) Disadvantage of "B" route

The project facility in the "B" route is composed of the following structures under the condition that existing Chiang Rai weir would be utilized.

- The intake structure to take the Kok water of 140 cu.m/sec at 3.3 km upstream site of the Chiang Rai weir.
- The open canal and culvert with the length of 14 km from the Kok intake to the Nong Luang wet land.
- The culvert canal with the length of 16.7 km, which passes through the Nong Luang wet land and the high land area and reaches the No.1 tunnel inlet.
- No.1 tunnel with the length of 5.4 km passing through mountains between Tak and Ing river basin. The diversion canal in the B route will cause following disadvantage from engineering and environmental aspects.
- The open canal and culvert starting off the Kok intake and reaching the Nong Luang wet land shall pass through the area with the higher elevation of 390 to 392 m M.S.L than the canal water level of 388 to 383 m M.S.L. And canal will be designed with deep excavation of 7 m to15 m, which produces a huge excavation volume of 4.6 million cu.m. It is rather difficult to provide spoil bank area required treating the huge excavation volume at the area along the canal route. Because the canal passes through the productive paddy land area where the irrigation water from the Lao river is available and the semi urban area with the higher land cost being close to Chiang Rai city area. A part of canal route shall pass through the semi urban area requiring higher land acquisition cost.
- The diversion canal in B route shall pass the Nong Luang wet land which is the very important inhabited area of fishes, birds, aquatics, animals and vegetables, and placed at the water level between 390 to 393 m M.S.L. The diversion canal with water level of 383 at the end of the open canal shall pass the Nong Luang by culvert. The culvert construction in the Nong Luang will bring about a considerable impacts such as water contamination by excavation and concrete works, and spoil bank of excavation material,

etc. It shall be prohibited any construction works in the Nong Luang from environmental aspect for the wet land.

- The diversion canal shall pass through the high land area with elevation of 395 to 400 m M.S.L after the Nong Luang and require the culvert to be constructed by deep excavation with the depth of 15 to 25 m. The culvert excavation with such depth shall be carried out for the long distance of 16.7 km to reach No.2 tunnel inlet and produce the huge excavation volume of 12.2 million cu.m requiring the large spoil bank. In addition, the culvert construction will cause a serious impact on the existing paddy field, plantation area, people irrigation system including pond, provincial and village roads, transportation of rural inhabitant and agricultural product, etc.
- Inclined adits to access the culvert shall be required for construction and maintenance after construction, because of the culvert with the long distance of 16.7 km.
- The construction cost of B route reaches at the cost of 7,800 million Baht as compared with the cost of 6,200 million Baht in A and 5,200 million Baht in B-J route, because of the higher construction cost for the culvert works.

(d) Advantage and disadvantage of B-J Alignment

The project facility in the B-J route proposed by JICA in the conceptual plan stage is composed of the following structures with advantages but less impacts to environment as compared with those in A and B alignment.

- The open canal with the length of 11.8 km from the Kok intake to No.1 tunnel inlet.
- No.1 tunnel with length of 3.1 km crossing the mountains between the Kok and Tak river basin.
- The open canal and culvert with the length of 6.2 km passing through paddy field and high land in the Tak river basin.
- No.2 tunnel with the length of 7.8 km between the Tak and Ing river basins.
- The open canal route from the Kok intake to No.1 tunnel is placed at a little upstream of the DEDP canal route in order to avoid the existing people irrigation area. Accordingly the open canal in the project will give less impact to the people irrigation area. DEDP also agrees to use the Chiang Rai weir for project and proposed canal route which does not bring about any trouble in the DEDP project area.
- The proposed open canal crosses in flat paddy field area with elevation of 390 to 385 m M.S.L that is a slightly higher than the canal water level of 388 to385 m M.S.L. Therefor, the open canal is designed without any deep excavation, while the existing people irrigation canals starting from the Lao river could cross the diversion open canal by aqueduct type instead of the siphon type.
- The open canal route is selected so as not to encounter villages and houses to be resettled and runs through only in the paddy field area, though the canal crosses with some rivers and highway or provincial roads.
- No.1 tunnel is planned with a shorter distance of 3.1 km as compared with the length of

5.8 km in A route, though the tunnel passes through the mountains with a little poor geological condition.

Outline of route A,B and B-J from Kok intake to outlet of No.2 tunnel is shown in Table 11.1.4(3)-2.

Table 11.1.4 (3)-2 Outline of Route A,B and B-J from Kok Intake to Outlet of No.2 Tunnel

Item	Route A	Route B	Route B-J	Advantage
Diversion Weir	New	Existing	Existing	B,B-J
Total canal length(m)	26,300	35,000	29,100	B-J
Open canal length (Ing)	8,800	12,800	12,000	A
(Tak)	3,800	--	4,900	
Culvert length (Ing)	300	16,800	--	
(Tak)	400	--	1,300	A
Tunnel(No.1)	5,800	--	3,100	B
Tunnel(No.2)	7,200	5,400	7,800	B
Construction cost(MB)	6,200	7,800	5,200	B-J
Environmental impact				
Land acquisition (ha)	140	150	180	A
Resettlement	Existing a little	Existing a little	No existing	B-J
Existing canal	Drainage Culvert	Over chute type	Over chute type	B,B-J
DEDP project area	Crossing	No crossing	No crossing	B,B-J
Kok new diversion weir	Necessary	--	--	B,B-J
Major canal type	Open canal	Culvert	Open canal	A
Tunnel geology	Poor	Good	Medium	B

Note; Construction cost and land acquisition area are shown in Table 11.1.4(3)-4 and 11.1.4(3)-5.

The route of the open canal crossing the Tak basin in B-J plan proposed by JICA is improved slightly by the study together with Thai side in this stage of PhaseII taking into account, geological and environment conditions along the route including No.2 tunnel. Those considerations are carefully studied based on the map with scale of 1 to10, 000 newly prepared by RID and geological investigation by TDEM and core drilling.

The open canal is in principle applied for flat and low area with elevation of 390 m M.S.L in Tak river basin, while the culvert for the area with the elevation of more than 390 m M.S.L along the tributary of the Tak river. The length of culvert in new B-J requiring the high construction cost is about 5.5 km which is more than that of 4.2 km in the B-J route. However, farmers living along the canal route did not agree to loose the paddy area by the open canal, as a result the culvert system is forced to apply for the route.

(e) Environmental Impact

As mentioned previously, project facilities will give environmental impacts to nature and human life, especially in case of open canal and culvert. Environmental impacts in each route are listed up as follows.

Crossing of Nong Luan wet land in route B and crossing of village and people irrigation area in route A will give large impacts. Other impacts would be not large and be solved by the mitigation measures against the project impacts.

Environmental impact of route A,B and B-J is shown in Table 11.1.4 (3)-3.

Table 11.1.4 (3)-3 Environmental Impact in Route A,B and B-J

Items	Description	Route			Remarks
		A	B	B-J	
Resettlement	Village crossing	● Ban San Salit	● Ban Chai Narai	-	
Land acquisition	Urban area, cost	△	●	△	
Agriculture	Farm land area (Open canal & culvert Length)	△ Shortest	▲ Longest	△	
	Crossing of DEDP canal	▲	-	-	
	Existing irrigation & drainage canal	▲	▲	▲	
		Almost same condition but Route B in Nong Luan area is more serious due to deep and long open canal and culvert. Route A in Kok basin crosses existing canals by drain culvert mostly.			
	Drop of under ground water	▲	△	△	
	Access to farm area	▲	▲	▲	
New Kok river Intake	Flood protection	▲	-	-	
	Deposited sand / Dredging	▲	-	-	
	Water management	▲	-	-	
Tunnel	Geological	●	△	▲	
Fishery, irrigation	Fish pond	○	○	○	
Existing road and River	Crossing of big river (Nos.)	△(3)	△(2)	▲(4)	
	Crossing of highway (Nos.)	△(3)	▲(4)	▲(4)	
Regional area Disruption	Communication	▲	▲	▲	
Influence to land Transportation	Increase of traffic & dusty	▲	▲	▲	
		Almost same condition. Route B is neighboring of urban area			
Damage to water Right	Quantity and Quality of water	▲	▲	▲	
		Almost same condition			
Damage to natural, Cultural assets	Nong Luan Wetland	-	●	-	
Excavation and Spoil Bank volume	Canal & culvert	△	▲	△	-
Tunnel		● Longest	△	▲	
Slope failure, soil Erosion		△	▲ Deepest	△	
		Route B-J is passing through small hill with deep cut and near private pond			
Water supply	To Kok & Tak basin by gravity	○	▲	○	

Notes;○ Good impact △ Rather better than other Route ▲ Unavoidable impact ● Biggest

Table 11.1.4 (3) -4 Consrtuction Cost of Alternative Routes

Kok-Ing Diversion Canal

Canal	Cost	Unit Price Length	Unit Price U.price	Route-A Length	Route-A Cost	Route-B Length	Route-B Cost	Route-B-J Length	Route-B-J Cost	Route New B-J Length	Route New B-J Cost	Remarks
	1000'B	km	B/m	m	1000'B	m	1000'B	m	1000'B	m	1000'B	
1.Open canal												
Kok	570,000	11.692	48,750	8,800	430,000	12,800	620,000	12,000	590,000	12,000	590,000	
Tak	294,000	5.36	54,850	3,800	210,000	--	--	4,900	270,000	5,400	300,000	
2.Culvert Tak	1,757,000	5.459	321,850	700	230,000	16,800	5,410,000	1,300	420,000	5,500	1,770,000	
3.No.1 tunnel	1,062,000	3.039	349,460	5,800	2,430,000	--	--	3,100	1,080,000	3,100	1,080,000	
4.No.2 tunnel	1,802,000	5.419	332,530	7,200	2,870,000	5,400	1,800,000	7,800	2,850,000	5,400	1,800,000	
Total	5,485,000			26,300	6,170,000	35,000	7,830,000	29,100	5,210,000	31,400	5,540,000	

Notes ; Additional unit price ratio of No1 and No.2 tunnel

	Route A	Route B	Route B-J	Route new B-J
No.1 tunnel	1.20	--	1.00	1.00
No.2 tunnel	1.20	1.00	1.10	1.00

Ing-Yot Diversion Canal

				Route-A		Route-B		Route-C	
1.Open canal	65,000	1.827	35,580	2,000	70,000	2,500	90,000	1,800	60,000
2.Clvert	2,870,000	9.637	297,810	10,000	2,980,000	10,000	2,980,000	9,600	2,860,000
3.No.1 tunnel	595,000	2.008	296,310	--	--	1,000	300,000	2,000	590,000
Total	3,530,000			12,000	3,050,000	13,500	3,370,000	13,400	3,510,000

Table 11.1.4(3)-5 Land Acquisition Area of Alternative Routes

Kok-Ing Diversion Canal

Canal	U.area B/m	Route-A Length m	Route-A Area ha	Route-B Length m	Route-B Area ha	Route-B-J Length m	Route-B-J Area ha	Route New B-J Length m	Route New B-J Area ha	Remarks
1.Open canal										
Kok	100	8,800	88	12,800	128	12,000	120	12,000	120	
Tak	130	3,800	49	--	--	4,900	60	5,400	70	
2.Culvert Tak	15	700	1	16,800	25	1,300	0	5,500	8	
3.No.1 tunnel	0	5,800	0	--	--	3,100	0	3,100	0	
4.No.2 tunnel	0	7,200	0	5,400	0	7,800	0	5,400	0	
Total		26,300	138	35,000	153	29,100	180	31,400	198	

Ing-Yot Diversion Canal

		Route-A		Route-B		Route-C	
1.Open canal	130	2,000	26	2,500	33	1,800	23
2.Culvert	15	10,000	15	10,000	15	9,600	14
Total		12,000	41	12,500	48	11,400	37

(4) Diversion Canal Route from Tak to Ing

Diversion canal in Tak basin

(a) Proposed Diversion Route

The route B-J of diversion canal from Kok to Tak is passing through mountains or hilly area with tunnel, after crossed through the Tak basin with shortest distance by open canal and/or culvert.

The geological conditions of No.2 tunnel route between Tak and Ing basin in route B are judged to be poor including a large fault zone in accordance with the investigation result of JICA TDEM and RID core drilling. It is proposed there for, to replace the No.2 tunnel route at the consolidated mountain being formed with basalt formation. The route of New B-J is proposed to upstream of Tak river and connect to the original route B tunnel with short distance and good geological conditions.

The project facility in the new B-J route, which is slightly improved for the B-J route, is composed of the following structures.

- No.1 tunnel with length of 3.1 km. crossing the mountains between the Kok and Tak river basin.
- The open canal and culvert with the length of 10.9 km. passing through paddy field and high land in the Tak river basin.
- No.2 tunnel with length of 5.4 km. between the Tak and Ing river basin.

The route of the open canal at the Tak basin in B-J plan is improved slightly by the study together with Thai side in the stage of Phase II taking into account geological and environment conditions along the route including No.2 tunnel.

(b) Advantage and Disadvantage of New B-J

- No.2 tunnel route consist of the short length and good geological conditions as compared with B-J route which has the large fault zone.
- The route is placed at the high land, so that the open canal and culvert requires the long and deep excavation depth.

Outline of B-J and New B-J Route from Tak basin to outlet of No.2 tunnel is shown in Table 11.1.4 (4)-2.

Table 11.1.4 (4)-2 Outline of B-J and New B-J Route from Tak Basin to Outlet of No.2 tunnel

Item	Route B-J	New Route B-J	Remarks(Advantage)
Total canal length(m)	14,000	16,300	B-J(Short)
Open canal length	4,900	5,400	B-J(Short)
Culvert length	1,300	5,500	B-J(Short)
Tunnel	7,800	5,400	New B-J(Short)
Construction cost (M.Bahtt)	5,200	5,500	B(Cheep)
Environmental impact			
Land acquisition (ha)	180, Difficult	200, Medium	B-J(Less)
Resettlement	Nothing	Nothing	
Crossing of Tak River	Over canal	Under canal	New B-J (Safety for flood)
Existing canal	Drainage Culvert	Overchute type	New B-J(Good for O/M)
Major canal type	Open canal	Culvert	B-J(Cost & construction) New B-J(after completion)
Tunnel geology, Length	Poor , Long	Good, Short	New B-J(Cost & construction)
Spoil bank Volume	1.5 MCM	2.2 MCM	B-J(Less)

(c) Environmental Impact

Environmental impact of B-J and New B-J route is shown in Table 11.1.4 (4)-3.

Table 11.1.4 (4)-3 Environmental Impact in Route B-J and New B-J

Items	Description	Route		Remarks
		B-J	New B-J	
Resettlement	Village crossing	-	-	
Agriculture land area	Open canal &culvert Length	△Short	▲Long	
	Existing irrigation & drainage canal Drop of under ground water	△	▲	
		New B-J is more serious due to deep and long open canal and culvert.		
	Land acquisition	Developing	△(much)	
Tunnel	Geological	▲	○	
Fishery	Fish pond	○		
Existing road and river	Crossing of big river(Nos.)	▲(1)	○(1)	
	Crossing of highway(Nos.)	▲(1)	▲(1)	
Regional area disruption	Communication	▲	▲	
		Almost same condition. Route B-J is Neighboring of Village extension area		
Influence to land Transportation	Increase of traffic & dusty	▲	▲	
		Almost same condition. Route B-J is Neighboring of Village extension area		
Damage to water right	Quantity and Quality of water	▲	▲	
Damage to natural, Cultural assets		-	▲ Near remarry	- -
Excavation and Spoil Bank volume	Canal & culvert	△	▲Deep	
	Tunnel	▲Longest	△	
Slope failure and soil Erosion		△	▲Deep	
Water supply to Kok & Tak basin by gravity		○	△	

Notes; ○ Good impact △ Rather better than other rout ▲ Unavoidable impact ● Biggest

Diversion canal at Ing basin

(a) Proposed Diversion Route

The diversion canal route at Ing basin starts off from outlet of No.2 tunnel, and reaches to Loi river, a tributary of Ing river. The canal type is planned mostly by the open type based on topographic condition. No alternative route is existing in the route. The canal is composed following structures.

- The open canal with the length of 22. km from No.2 tunnel outlet.
- No.1 drop structure with 3.2 m.drop is placed 3.2 km downstream of No.2 tunnel outlet to dissipate excess energy.
- The culvert with the length of 1.3 km passes through hilly area with orchard near to Ban Si Chun to avoid village area. After passing the Huai Kang riverbed, canal will change to

open type.

- Open canal with length of 15.7 km runs through Ing basin being covered with paddy field from culvert and reaches the Loi river, where the drop structure with 5.0 m. head is required.

(b) Environmental impact

The canal will give the large impact at Ban Si Chun site, where the culvert will be constructed at the orchard area, teak plantation, etc. and also placed at the site near village.

(5) Ing Weir Site

Two (2) alternative weir sites have been studied in accordance with the alternative alignment of Ing-Yot diversion canal and tunnel; namely, 1) lower site which locates 2.8 km upstream of the Thoeng Bridge; and 2) upper site which is lied out in the Ing River 3.5 km southwest of Ban Huai Luang.

The lower site is set up for the alternative water diversion routes A and B, and the upper site is for the route C. The alternative study on the weir sites were carried out together with the alternative water diversion routes. As a result, the lower site is selected as a preferable option since the tunnel geology for the route C is rather poor and needs larger amount of the Project cost than other alternative routes A and B.

(6) Ing-Yot Diversion Canal

Three alternative routes from Ing intake to Ing-Lao siphon are planed under the condition of Kok intake water level, topographic features and environmental impact, that are consisting of north route along Lao river (A), south route with tunnel (C) and mid-route of both (B). From Ing-Lao river to inlet of No.2 tunnel, routes passes through paddy field in rolling hilly area or flat paddy field by culvert. Route C with rather high cost but without resettlement, river troubles and less environment impact to villagers is finally proposed. Details are described and/or shown in Supporting Repot 11.1.4 (6) and in Data Map in 1.1.4 (3)

Outline of each Route at Ing-Lao Diversion Canal is shown in Table 11.1.4 (6)-1.

Route A (Ing-Lao river course)

The route running parallel with Ing-Lao river or under riverbed may cause many troubles of river maintenance of diversion canal, river maintenance, flood damage and river water quantity during construction stage etc. Route passes through flat paddy field but crosses highway No.1121 and one village.

Route B (Village crossing and tunnel course)

The route crosses provincial road and Ing-Lao mountain by culvert and tunnel, which has a shortest length of one (1) km but poor geological conditions cleared by JICA and/or RID geological investigation. The route is forced to crosses one village located at inlet of tunnel.

Route C (Tunnel course)

Location of tunnel with length of two (2) km is situated south of village. After passing though Lao river, the route crosses through paddy field in rolling hilly area as same as Route B with culvert. Environment impact to villager is less than other route.

Table 11.1.4. (6)-1 Outline of each Route at Ing-Lao Diversion Canal

Item	Route A	Route B	Route C	Advantage
Total canal length(m)	12,000	13,500	13,100	
Open canal length	2,000	2,500	1,500	A
Culvert length	10,000	10.000	9,600	C
Tunnel	--	1,000	2,000	A
Construction cost(MB)	3,100	3.400	3,500	A
Environmental impact				
Land Acquisition (ha)	40	50	40	A,C
Resettlement	Existing a little	Existing a little	No existing	C
Lao River work	Difficult	--	--	B,C
Existing canal	Over chute type	Over chute type	Over chute type	B,B-J
Major canal type	Culvert	Culvert	Culvert	
Tunnel geology	--	Poor	Medium	C

Lao diversion canal with capacity of 175 cu.m/s starts off at the Ing intake and reaches to the inlet of the Ing-Yot tunnel. The canal is crossing through Ing right basin, river and Ing-Lao river basin with high ground elevation, and it consists of open canal, long and deep culverts, tunnel and siphon.

(a) Proposed Water Diversion Plan

The routes are roughly divided into two courses to cross the hilly area between Ing and Ing-Lao river siphon. One is detour route from hilly area along Lao river and the other is tunnel route. In case of tunnel plans, two alternatives are studied. The down steam route from siphon is restricted by topographic and environmental conditions such as village location.

Ing river course (Alternative route A)

- The open canal to convey the water to be diverted at the intake of the Ing weir is planned along the right bank of the Ing river. The open canal length along the right bank is about 2.0 km.
- The culvert canal with the water level of 362.0 to 360 m M.S.L is placed at the flat area with the elevation of 365 to 370 m M.S.L along the Lao river, which is located at north of Doi Wiang.
- The Lao river is formed by many meandering shapes at the mouth connecting with the Ing river. This meandering river reaches is about 5 km and shall be improved when the culvert canal is proposed. The excavation for the culvert canal along the river could be easily carried out because the excavation material is mostly composed of earth and fine sand.
- Bypass canal of Lao river and small regulating pond are required to release the Loa flood

discharge and to regulate flood water. This Lao food basin surrounded by low mountains and highway is narrow and good fertilized farm planted corn and tobacco. Construction of culvert is restricted to only dry season to prevent flood of Lao river. Land acquisition for thus reason may be not allowed. Big impact is supposed to give farmers.

- The culvert with the length of 5 km shall pass through the hilly area with the high elevation of 375 to 380 m M.S.L after placing at the flat area along the Lao river. The hilly area is mostly formed with the weathered rock formation where excavation is slightly difficult.

Tunnel route-1 (Alternative route B)

- The end point of open canal is slightly sifted to south at Wat for aiming shortest tunnel with low cost. Open canal condition and culvert along hilly area are same as alternative Route A.
- The route is passing very closely through an existing Wat and residential area at inlet of culvert and tunnels which is located at south of Doi Wiang. Wall and some property of Wat should be removed; otherwise some house should be replaced
- The proposed short tunnel route at the mountain on the right bank of the Ing diversion weir site is confirmed with very poor geological condition being formed with crushed tuff formation which could not allow the tunnel works without applying the special construction method for the works. The tunnel route therefore shall be changed to the mountain being formed with more consolidated rock formation but the length of tunnel reaches the long distance of 2 km. (Long Tunnel course---alternative route C)
- The culvert case, proposed by Thai side at initial stage, passing through hilly area with deep excavation depth is mostly composed of the shallow overburden depth and deep weathered rock formation, which requires the high excavation cost based on the geological investigation result by core drilling. The culvert construction also requires the high cost as compared with the original cost estimated in the conceptual plan.

Tunnel course-2 (Alternative route C)

- The end point of open canal is slightly sifted to south beyond Wat not, cause to draw environmental problems. Open canal condition and culvert along hilly area are same as alternative Route B
- The route is passing through Ing right flood basin, provincial road and between Wat and crematory, reaches inlet of tunnel.
- The proposed tunnel route at the mountain on the right bank of the Ing diversion weir site is confirmed with a little good geological condition compared with short tunnel case.
- Location of Lao siphon is slightly sifted to upstream of original's one caused by tunnel outlet condition.

Canal length from Ing intake to Lao Siphon is shown in Table 11.1.4 (6)-2

Table 11.1.4 (6)-2 Canal Length from Ing Intake to Lao Siphon

Item	Route A	Route B	Route C	Remarks
Total canal length(m)	12,000	13,500	13,460	
Open canal length	2,000	2,500	1,830	
Culvert length	9,820	9,820	9,450	
Siphon	180	180	180	
Tunnel	-	1,000	2,000	
Land acquisition	Difficult	Difficult	Medium	
Construction cost	Higher	Low	Highest	
Environmental				
Farm	More seriously	Seriously	Seriously	
Wat & Village		Seriously		
Lao river	Seriously	-	-	
Tunnel geology	-	Poor	Good	

Route C is finally selected taking into consideration of geological and environmental conditions.

(b) Environmental Impact

Construction of diversion canal gives environmental impacts to nature and human life, especially in case of open canal and culvert. Environmental impacts in each route are listed up as follows. Resettlement of Wat or inhabitants in Route B and culvert of Ing –Lao flood basin in route A shall affect big impact to villagers.

Environmental impact in Ing-Yot diversion canal is shown in Table 11.1.4 (6)-3

Table 11.1.4 (6)-3 Environmental Impact in Ing-Yot Diversion Canal

Items	Description	Route			Remarks
		A	B	C	
Resettlement	Village crossing	-	●	-	
Agriculture	Farm area (Open canal &culvert Length)	●	▲	△ Shortest	
	Existing irrigation & Drainage canal	△	△	△	
		Almost same condition but culvert of route A at flood farm is more serious due to deep and long culvert even if no irrigation systems.			
	Drop of under ground Water level	▲	△	△	
	Access to farm area	▲	▲	▲	
Flood for river work	Flood protection	▲	-	-	
	Deposited sand	▲	-	-	
	Water management	▲	-	-	
Tunnel	Geological	-	●	△	
Existing road and river	Crossing of big river Crossing of highway	Same condition			
Regional area disruption	Communication				
Influence to land Transportation	Increase of traffic & dusty				
Damage to water	Quantity and Quality	Almost same condition			
Excavation and Spoil Bank volume	Canal & culvert	▲	▲	△	-
	Tunnel	-	△	●Longest	

Note ; ○ Good impact, △ Rather fair, ▲ Unavoidable impact, ● Biggest impact

(7) Ing-Yot No.2 Tunnel

(a) General Conditions

Ing-Yot No.2 tunnel is planned with the length of about 51 km passing underneath high and steep mountain area along the national borderline between Thailand and Laos. Topographical and geological conditions around the proposed tunnel route are different from each other at, and these are briefly summarized as stated in Geological Condition of this supporting report.

(b) Selection of Ing-Yot No.2 Tunnel Route

As for the Ing-Yot tunnel to divert the water from the Ing diversion weir to the Yao river, which is the tributary of the Nan river, the following three alternative routes are selected for the study at first in the Ing-Lao basin.

- A tunnel route to pass through the Ing-Lao alluvial plain area (located in the direction of northeast from Chiang Kham) with the elevation of about 400 to 500 m. and under cultivation of paddy.

  This tunnel route is planned with the shortest length of 19 km. as compared with the length of about 25 km. in B and C route.

- B tunnel route which is placed at the northern mountain area with the high elevation of 600 to 1000 m. and being covered with deep forest.

  This tunnel route requires the long length of 25 km. to pass the mountain because the tunnel is placed with curve along the high mountain consisting of consolidated rock formation.

- C tunnel route which is planned at the southern hilly and mountain area with the elevation of 400 to 600 m. and being covered with field crops and bushes.

  This tunnel also requires the long length of 25 km. and consists of the poor geological condition slightly as compared with that of tunnel B route.

The study for three alternative routes was carried out in the conceptual plan on the reconnaissance level by using the topographical map with scale of 1 to 10,000 prepared by RID and geological map of 1 to 250,000 and field survey of tunnel expert and geologist of JICA Study Team.

The study result is summarized as follow and as the study result the B tunnel route is selected as the most suitable one.

(c) Alternative Tunnel Route - A

A tunnel route shall cross the large alluvial plain in the Ing-Lao basin, where many farm areas are spread along the tributaries of the Lao. If tunnel route is selected in this plain, the tunnel shall pass through the area with the shallow overburden depth of about 50 m. and below and consisting of complete weathered rock formation with many crushed fault zones along the tributaries of the Lao river.

The tunnel works in the alluvial plain accordingly will face difficult problems such as large

water leakage, many rock falls, etc. and require the huge construction cost in order to apply the following tunnel construction method.

- In the tunnel excavation at the site with large water leakage, the pre-grouting works to consolidate the excavation body and prevent the water leakage will be carried out before excavation.
- In order to prevent the rock falls at the tunnel section formed with the large weathered rock formations and fault zones consisting of many crushed rocks, the strong steel support to be placed with short interval of less than 1.0 m., a number of rock bolt, thick sprayed concrete for primary lining to cover the rock surface immediately after excavation, reinforced in situ concrete for secondary lining, etc. shall be required for tunnel works.
- Large scale drainage system in the tunnel including drainage pumps and pipes as well as emergency electrical facility shall be required to drain the bulk leakage water from the excavation place to the tunnel outlet.

The tunnel works passing through the alluvial plain will give the large impact for water resources in tributaries, irrigated water in paddy field, drinking water provided by wells, ground surface by caving which are mostly caused by the water leakage in the tunnel.

Tunnel construction passing through the alluvial plain and very weathered rock formation will be carried out by the shield method instead of NATM and require very high construction cost.

The plan for A tunnel route therefore is not adopted in the project and its further study is canceled.

(d) Alternative Tunnel Route - C

C tunnel route is planned to pass through the southern hilly and mountain area. This tunnel route was carefully studied on the same level as the B tunnel route plan in the conceptual plan stage.

However the tunnel route C plan requires the very large construction cost of 29,275 million Baht as compared with the cost of 20,604 million in the B tunnel plan due to the following reason :

- The beginning portion of the C tunnel route with the length of 19 km. shall pass through under the low hill, terrace and alluvial plain with the ground elevation of 400 to 450 m., so that the overburden depth above tunnel route is as shallow as less than 60 m.
- The geological condition near the tunnel elevation of 350 to 340 m. is formed with weathered shale and sandstone which is easily changed to clayey material by water absorption. The compression strength of rock is only 100 kg/cm^2 according to the result of uniaxial compression test. The large water leakage will take place during construction through the above tunnel length of 19 km. and require the large scale pumping drainage system and operation during the construction.

In accordance with the above poor geological conditions in the C tunnel route, the tunnel length of about 35 km. out of the total length of 52 km. shall be designed with the structure type D_2 and E which requires the strong steel support of H-200, installation interval of 1.0 m. for steel support, sprayed concrete for primary lining thickness of 20 cm. and reinforced in situ concrete

lining for the secondary lining with the large thickness of 50 to 60 cm. as compared with the E type length of only 12.4 km. in the B route tunnel.

(e) Alternative Tunnel Route - B

B tunnel route is placed at the northern high mountain area consisting of consolidated and firm rock formation and deep overburden depth of 200 to 1300 m. above the tunnel route except the tunnel inlet and fault zone consisting of weathered and crushed rock formation.

The comparison of grade of ground in B and C tunnel route is shown in the following Table 11.1.4-(7)-1.

Table 11.1.4.(7)-1 Comparative Table of Grade of Ground in B and C Tunnel Route

Grade of Ground	B Tunnel Route (m.)	C Tunnel Route (m.)
Type B	2,680	770
Type C1	8,910	3,850
Type C2	14,790	7,030
Type D1	12,090	5,540
Type D2	7,810 ⎫	5,740 ⎫
Type E1	2,870 ⎬12,400	6,330 ⎬ 35,200
Type E2	1,730 ⎭	23,130 ⎭
Total	**50,880**	**52,450**

It can be judged in the above figure that the B tunnel route is superior than the C tunnel.

(f) Alternative Tunnel Route - Lower B

The lower B tunnel route also was studied in the conceptual plan stage on the desk plan by topographical map of 1/10,000 and geological map of 1 to 250,000 as well as the field survey by JICA tunnel expert and geologist.

The route of the lower B tunnel is summarized as follows ;

- The water diversion canal starting at the outlet of No 2 tunnel to cross the mountain between the Kok and Ing basin is connected to the site near Ban Nong Bua with the shortest distance of 11 km. instead of the canal with the length of 21 km. connecting to the Thoeng diversion weir site in the B plan.
- This canal with the length of 11 km., however requires the drops to dissipate the water head of 375 m. at the No 2 tunnel outlet because the Ing basin where the canal passes through and reaches the Ban Nong Bua site is lying on the lower elevation of 367 to 362 m.
- The lower Ing diversion weir will be proposed at the Ing river near the Ban Nong Bua site and its retention water level is designed with 362 m. to regulate the Ing and Kok water and divert to the Ing-Yot tunnel.
- This diversion weir however has the following disadvantage as compared with the Ing

diversion weir in the original plan in the new BJ route.

- The regulating reservoir capacity at the weir is very small as less than 1.0 MCM because there is no large wet land at the upstream of the weir site.
- The existing villages of Ban Nong Bua near the weir site and two large villages at the upstream weir will be resettled, otherwise those villages will be inundated by the operation of weir gates.
- Additional open diversion canal of 4 km. shall be placed at the right bank area in the Ing basin to divert the water taken at the Ing weir intake to the Ing-Yot tunnel.
- The inlet of the Ing-Yot tunnel is planed to be placed at the site near Ban Huai Pong being located in the mountain foot of the right bank in the Ing river. The Ing-Yot tunnel route is placed so as to connect from the Ban Huai Pong inlet to T.P. 22 station proposed in the original B plan.
- Tunnel length between the inlet and T.P. 22 station reaches to the long distance of 22.5 km. which is 9.5 km. longer than the length of 13 km. in the original B plan, though the original B plan additional culvert length of 10 km. along the Lao river.
- The Lower B tunnel route shall cross the Nam Muang river before reaching T.P. 22 station. The Nam Muang river is one of the large tributaries emptying into the Lao river in the Ing basin and will be composed of the large fault zone with the long length of 1.0 to 1.5 km. The overburden depth above the route formed with the fault zone also is as shallow as 40 to 50 m. and consists of alluvial layers.
- Tunnel construction through the fault zone in the Muang river is judged to be very difficult without the special method of the pre-grouting at the excavation place and provision of the large scale drainage system and operation to drain the bulk leakage water through tunnel.
- The farm area and wells for domestic water above the tunnel route and along the Muban river will be completely dried up by the water leakage through the large scale fault zone.
- According to above long tunnel length and the large scale fault zone, the study on the lower tunnel route is canceled.

Therefore, a reconnaissance survey has been made on the above mentioned northern B route decided in Phase I study including the above mentioned 7 inclined adits with careful consideration to various conditions inclusive of the topographic features of wide range of areas surrounding the planned route, geological conditions, environment, village location and road condition for using access road for construction.

During the reconnaissance survey and the initial TDEM method survey, following significant points have been found out at the area of two places named Phu Sang Park and Doi Pha Dam, respectively.

The proposed tunnel route passes through several limestone area, where, it is important to confirm the position of limestone bottom. These details are also studied using the results of TDEM survey. Moreover, it is noted that the most significant factor in tunneling at the limestone area is removal of groundwater, however, owing to the lack of hydrogeological data (hydrogeological characteristics of

limestone), a definite conclusion must be reserved at this stage, leaving this point to be further studied in detail in the detail design stage.

(8) Flood Control Plan in the Yao River

(a) Hydrological and hydraulic change to be induced by the Project

The large amount of water of about two (2) billion planned to be conveyed to the Yot and Yao rivers and finally stored in the Sirikit reservoir during the wet season. The maximum diverted discharge is planned to 175 m^3/s corresponding to 100-year probable flood at the confluence of the connection channel and the Yot river and normal flood peak discharges with a return period of less than 2 years along the Yao River.

The hydrological features in the Yao River will be drastically changed by water diversion. For example, those at the existing water level and discharge gauging station with a code number of N51 is summarized as follows:

Table 11.1.4 (8)-1 Hydrological Features with and without the Project

Features	Without the Project	With the Project
(1)Catchment Area (km^2)	774	774
(2)Mean discharge during wet season (m^3/s)	82	243 (3.0)
(3)Water depth in terms of item (2) (EL. m)	233.3	234.4
(4)25-year Probable Flood Peak Discharge (m^3/s)	650	830 (1.3)
(5)Riverbed load transport capacity (thousands m^3/year)	to be studied based on the riverbed material survey	

The Nan River, which is the main stream of the Yao river, will be expected to pass the diverted water safely to the Sirikit Reservoir under the normal flow condition as well as discharges drained out from the own catchment area, taking into account the flow discharge capacity of 400 cu.m/s to more than 2000 cu.m/s.

When flood with a return period of more than 2 years occurs in the Nan river basin, lowland places will be inundated even without the diverted water. However, flooding along the Nan river has a retarding effect to the downstream area and therefore, river training works along the Nan river will have a large adverse effect. Taking into account the mentioned, the Project will stop the water diversion in case that the flooding is predicted to occur in the downstream reaches of the Nan river by the proposed flood forecasting and management system.

Possible changes or adverse effects along the Yot and Yao rivers are; 1) increase of flooding, 2) widening of inundation area, 3) prolongation of inundation period, and 4) development of river bank and bed erosion at meandering portions, bridge piers, confluence with tributaries, and so on.

(b) Mitigation and improvement measures for possible impacts

The Yot, Yao and finally Nan rivers will receive the large amount of diverted water through the proposed water conveyance system. As a result of operation of the Project, its frequency and magnitude of flooding in the aforesaid villages will be worsened by the Project.

In order to mitigate flooding problems along the villages, there are several measures; 1) provision of flood control dam; 2) improvement of the existing river channel; and 3) combination of the mentioned measures.

In order to examine the appropriate measures, the following concept has been applied for the Study:

1) to identify a reservoir or reservoirs which have no significant resettlement problems,

2) to identify river improvement measures which needs no significant change on social life and nature along the river course of the Yot, Yao and Nan Rivers, and to establish a mitigation and improvement plan against the diverted water and probable flood with a probability of once in 25 years corresponding to the recorded maximum flood in the Yao River basin.

(c) Alternative Sites of Flood Control Dam

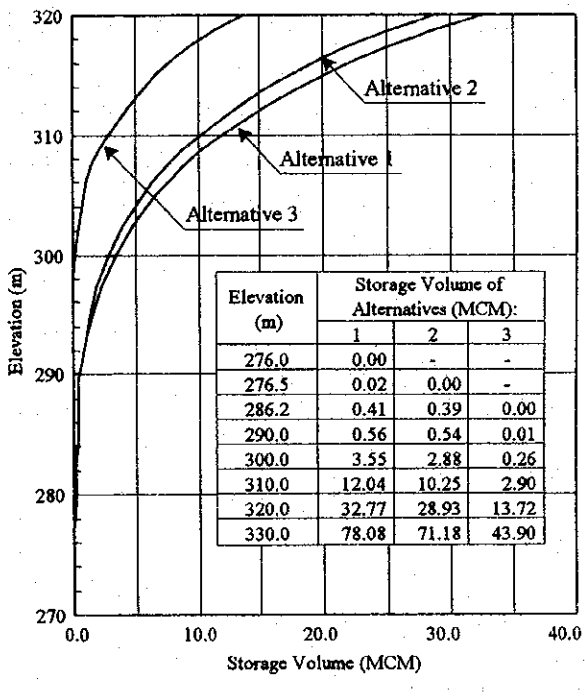
There have been identified three (3) sites in the upstream of Ban Songkhwae and one or two sites in the downstream reaches from the said village. In order to construct a reservoir at the downstream sites, several villages are necessary to be inundated. Therefore, the downstream possible sites are excluded from the Study.

The upstream sites have an advantage on no resettlement in case that the reservoir water level is lower than EL. 320 m. There are several villages such as Ban Huai Lao and Nam Lu over the altitude of EL. 320 m as shown in Figure 11.1.4.(8)-1.

One site is located at the 200 m upstream of the existing road bridge, where the riverbed elevation is EL. 276 m. Other upstream two (2) sites are 0.7 km and 2.6 km far from this site, respectively. The storage volumes of these possible dams enable to reduce flood peak discharge of 570 cu.m/s to 100 cu.m/s (alternative 1), 120 cu.m/s (alternative 2) and 200 cu.m/s (alternative 3), assuming the constant release from each alternative dam.

Whilst, the dam sites of alternatives 2 and 3 are judged to be lied on two fault lines along the Yao River and small tributary joining from the right bank through the geological investigation, and effectiveness for flood retention is less than the alternative 1.

Consequently, the dam site in the alternative 1 is further investigated in the feasibility study stage as the optimum dam site, taking into account the geological condition and effectiveness for flood control.



Elevation (m)	Storage Volume of Alternatives (MCM):		
	1	2	3
276.0	0.00	-	-
276.5	0.02	0.00	-
286.2	0.41	0.39	0.00
290.0	0.56	0.54	0.01
300.0	3.55	2.88	0.26
310.0	12.04	10.25	2.90
320.0	32.77	28.93	13.72
330.0	78.08	71.18	43.90

Figure 11.1.4.(8)-2 Storage Volume of the Alternative Dam Sites

(d) Yao River Training

The Team J/V has established the planning concept for Yao River Training Works through the social study and discussion with the inhabitants in the riverine villages.

The concept describes that the present river water level should not be changed even if the river water in the Kok and Ing Rivers are diverted by the Project and adverse effects be mitigated.

Flooding situation would not be improved by the Project though the diverted water will flow down to the downstream reaches.

Based on the mentioned concept, the Team J/V proposes that the river training comprises provision of drop structures for stabilizing the present riverbed and wide and deep river channel excavation for maintain the water level under the present river as illustrated below:

Large excavation work due to widening and deepening of the river banks and bed will give large land loss and social problems, since the inhabitants are living on the narrow and habitual flood plain to be excavated by the Project.

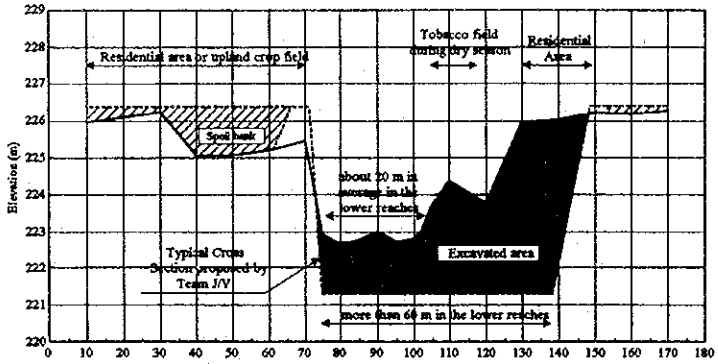


Figure 11.1.4 (8)-3 Typical Cross Section Proposed by Team J/V

It is judged to be necessary to establish an alternative concept on the river training works, which enable to minimize the land loss by the Project and to mitigate the habitual inundation by flooding in the Yao River. From the viewpoints, the study on the river training works is carried out.

(e) Design Discharges along the Yao River

Design discharge distribution has been studied by using frequency analysis based on the annual maximum instantaneous discharge series for 13 years from 1979 to 1991. However, since observation period of 13 years is judged to be insufficient for the feasibility study, the specific flood peak discharge curves are established for the Nan River basin including the Yao River.

Further study on the flood discharge distribution is made by means of unit hydrograph method for generating flood runoff and Mike 11 for converting the estimated flood discharges to water level along the Yao River.

Under the present river condition, the Yot and Yao Rivers drain the flood discharge with the peak discharges of 280 m^3/s and 270 m^3/s to the proposed reservoir under the probability of once in 25 years.

These floods join and form a flood discharge hydrograph with a peak discharge of 570 m^3/s and duration of 3 days.

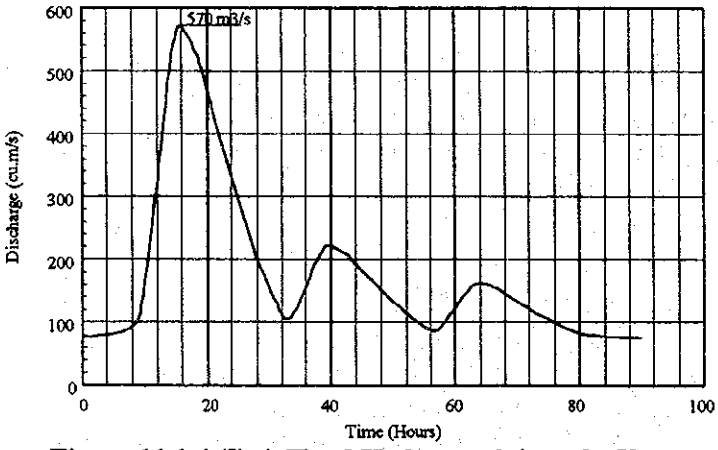


Figure 11.1.4 (8)-4 Flood Hydrograph into the Yao Reservoir

Reservoir operation method for regulating the flood peak discharges is examined by applying two (2) method; 1) one is the constant release, and 2) the other is flexible release. These methods

reduces the released discharge according to the inflow discharge into the reservoir as illustrated as follows:

In the option 1, it is planned to reduce the released discharge when the flow discharge in the downstream reaches of the dam is forecasted to increase. Several constant flows are examined and as a result, 100 cu.m/s is judged to be the optimum one corresponding to the storage capacity of about thirty two (32) million cu.m.

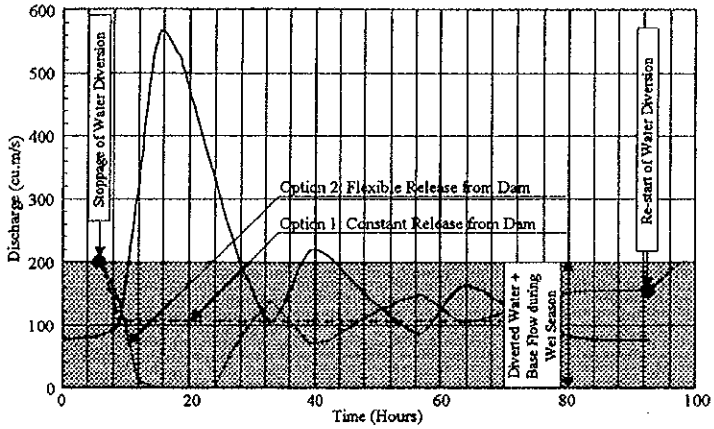


Figure 11.1.4 (8)-5 Concept of Reservoir Operation Method

The option 2 is examined under the assumption that the discharges and water level along the Yao and Nan Rivers are monitored by the proposed monitoring system in real time and that the water conveyance system could be operated based on the monitored information. The released discharges of 200 m^3/s comprised of the diverted water and base flow during the wet season, will be decreased by subtracting part of the predicted inflow discharge to the proposed reservoir from 200 m^3/s as given as follows:

[Released Discharge] = [200 m3/s] – [Deduction Rate] x [Inflow Discharge to the Reservoir]

Through a simulation study, the deduction rate of 0.6 could be the maximum one under the proposed storage capacity of the Yao dam. As a result, the following design discharges with a probability of once in 25 years are proposed for flood control plan in the Yao River:

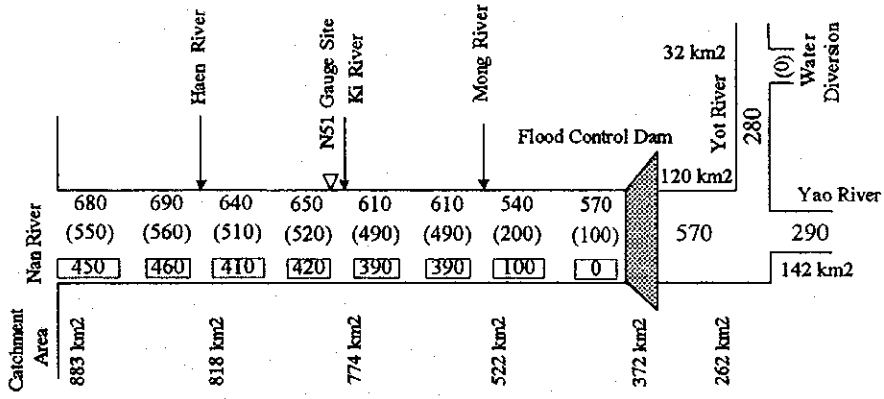


Figure 11.1.4 (8)-6 Proposed Flood Discharge Distribution

The proposed Yao flood control dam has a capacity for reducing the flood peak discharges under present condition within a extent from 350 cu.m/s in the upstream reaches to 230 cu.m/s in the downstream reaches along the course of the Yao River in case of the option 2. But, the option 1 is effective only for the upstream reaches.

Flood control plan under the regulating flood peak discharges under the option 2 is proposed through the above-mentioned study. The proposed work in the plan is; 1) provision of the flood control dam, and 2) river training works along the Yao River, based on the proposed design discharges.

11.2 Preliminary Design

11.2.1 Kok Intake

(1) Design Concept and Criteria

The design of intake structure has been made under the concept; 1) less impact on the current natural and social condition as much as possible, 2) less resettlement and compensation to be induced by construction works of the Project, and 3) less project cost, as well as engineering viability for structural design.

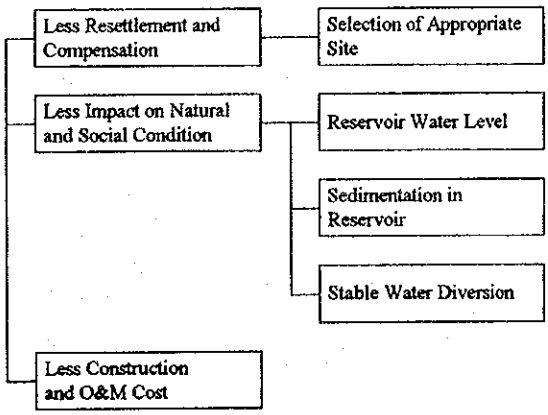


Figure 11.2.1-1 Design Concept and Criteria

(a) Weir and Intake Site

It is proposed to utilize the existing Chiang Rai weir of the DEDP as the water diversion weir. The intake structure locates in the upstream reaches of the existing weir as shown in Figure 11.2.1-2. Therefore, the main features of the intake structure are designed taking into account the operation of the existing weir during the wet season.

In the upstream reaches of the existing Chiang Rai weir constructed by the DEDP, the intake structure for the irrigation system of DEDP is under construction at about 1 km upstream of the weir. Chiang Rai City has been developed along the river reaches 5 km upstream of this intake. In order to minimize the impacts on social and natural impacts not only for the Chiang Rai City but also the irrigation system, the structure site is studied for the river reaches between the irrigation intake of the DEDP and Chiang Rai City area.

As a result, the intake structure is proposed at about 3 km upstream of the existing Chiang Rai weir. The Kon river, a small tributary of the Kok river, joins to the Kok river in this area where the land use is categorized mainly to mixed cultivation area or bush.

(b) Operation of the Existing Weir and Design Water Level

The existing irrigation weir of the DEDP has been operated within the maximum controlled water level of EL. 389 m during the dry season and fully opened during the wet season in order not to induce flooding along the upstream river stretch in Chiang Rai City.

In this river stretch, there are a few low elevation areas with the altitude of less than 389 m as shown in Figure 11.2.1-2. These areas are uncultivated lands and some locations are utilized as a temporary ferry terminal for tourism boats navigating from Chiang Rai City to the border with the Laos during the dry season.

The design water level for the proposed intake structure of the Project has been studied under the currently applied operation rule of the existing weir of the DEDP. Namely, the eleven (11) gates of the existing weir have to be fully opened during the peak wet season from August to October when the Project would divert the river water of 140 cu.m/s to the Sirikit reservoir.

Whilst, the beginning and end of the wet season, June, July and November, it is necessary for stable diversion of the river water to control the certain river water stage. Figure 11.2.1-3 indicates the water level hydrograph at the proposed intake site on the Kok river during the wet season. The design water level of EL. 389 m, which is proposed by the Team JV Study, needs fully control the river water level even through the wet season. It results in reduction of safety level against the flood.

Taking into account the above-mentioned, the design water level is suggested to be EL. 388 m, which requires the control of the river water level for two (2) months of July and November and no operation during other four (4) months in the wet season from August to November.

(c) Mitigation Measure of Impact on the Sedimentation in the Existing Reservoir

It is necessary to maintain the sediment balance at the existing reservoir, since there are many sand mining companies with a license issued by the local government.

In order to achieve mentioned objective, the silting basin with a length of 180 m and the sill elevation of 386 m is designed to trap the river sand in the basin. The mentioned sill elevation is almost same as the sill level of gates provided at the existing Chiang Rai weir.

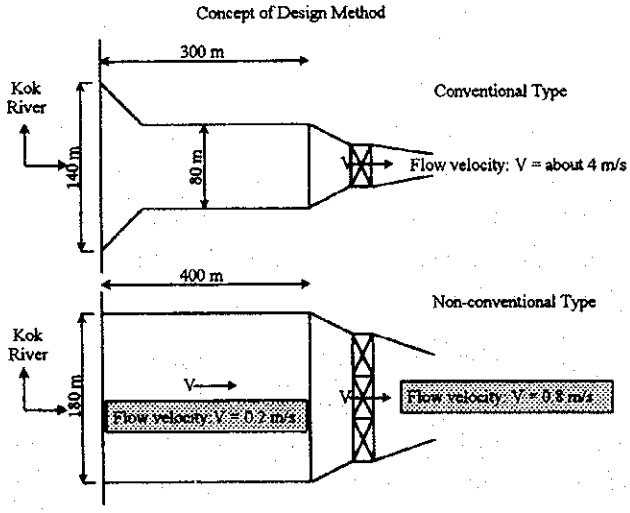


Figure 11.2.1-4 Type of Intake Facility

In the proposed silting basin, the current river sand mining is expected to dredge deposit sand, instead of provision of sand flushing facility for removal of deposited sand in operation and maintenance of the intake facility.

In order to make the proposed wide silting basin more effective, sufficient number of gates are proposed to reduce the flow velocity passing the gate to 0.8 m/s in order not to convey the significant size of sediment.

(d) Layout and conditions of intake structures

The proposed intake structures comprises; 1) a silting basin, 2) an intake tower and gate(s), 3) flood embankment surrounding intake tower, and 4) river structures such as revetment and riverbed protection works.

Currently, many local companies for supplying construction material execute river sand mining along the up-and downstream reaches of the existing weir. Whilst, the proposed intake structure possibly change the sediment balance around the structure.

A silting basin is planned to be provided between the existing river channel of the Kok and the intake tower, in order to mitigate the possible change of the sediment flow and to avoid adverse effects on the river sand mining.

The sill elevation of the proposed intake gate is designed to be higher than the sill level of EL. 385.95 m of the existing gates at the DEDP weir so as not to take the riverbed sand to the diversion canal as possible. Also, its length and width is determined enough to deposit the riverbed material conveyed by the diverted water.

The river water stage of the Kok river fluctuates time by time during the wet season, especially from August to October and the proposed gates are required to strictly control the amount of the diverted water according to fluctuating river water level. Therefore, a fixed wheel gate type is selected as intake gate(s) because of an advantage on accurate operation comparing with the tender-gate type.

Design flood water level of EL 391.91 m is proposed based on hydraulic analysis for the design flood discharge of 1,090 cu.m/s with a probability of once in 100 years. The crest elevation of flood embankment is set at EL. 393.41 m, adding free board of 1.5 m to the aforesaid design flood water level.

Such river structures as revetment and riverbed protection works are planned to provide at inlet portion of the silting basin and in front of the intake tower.

(2) Review of Structural Design Made by the Team J/V

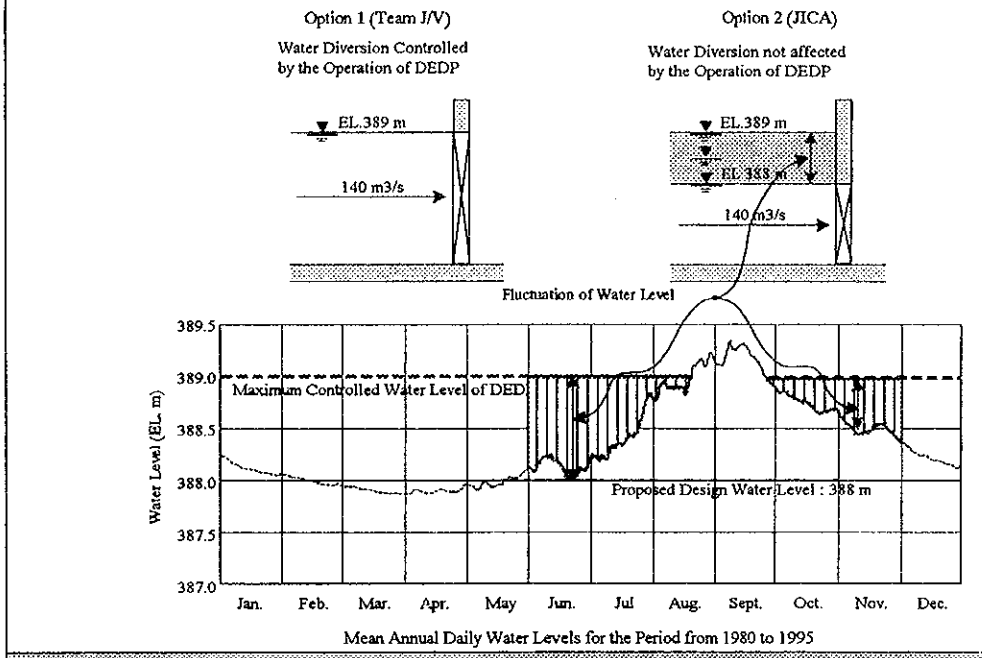
The following are the comparison of the design issues made by the Team J/V and JICA Study Team and significant discussion has been made on these points by the both sides of the study team with the Project Planning Division and Design Division of the RID:

Table 11.2.1-1 Comparison of the Main Features between Team J/V and JICA Study Team

Main Features	Team J/V	JICA Study Team
Intake structure site	3 km upstream of the DEDP weir	Same location
Design Water Level of Intake Gates	Reservoir WL : EL.389.0m Intake gates : EL.389.0 m	No proposal EL. 388.0 m
DFWL	EL. 391.0 m	EL. 391.91 m (1,090 m3/s)
Width of silting basin	50 m with a length of 500 m	180 m with a length of 400 m
Width of Intake	26 m	114 m
Gate type	Roller gate	Fixed wheel gate
No. of gates	6 m @ 4 nos.	5 m @ 2 nos., 10 m @ 7 nos. and 12 m @ 1 nos.
Height of gates	3.4 m	2 m

Design water levels of intake gates are further examined about the advantage and disadvantages or merit and demerit of these designs. Results are as given as follows:

Table 11.2.1-2 Options for Decision of Design Water Level

Team J/V	JICA Study Team
Design water level for Gate Structure	
 Mean Annual Daily Water Levels for the Period from 1980 to 1995	
Stable water diversion against fluctuation of reservoir water level	
Maximum water diversion needs to control the reservoir water level at EL.389 m.	No control of reservoir water level is required.
Risk of inundation along the Kok and Kon Rivers	
Low land area will be inundated. Drainage condition in part of Chiang Rai City will be worsened due to high river water level.	— (No Relationship)
Sedimentation in the Reservoir	
Sediment carrying capacity will be decreased and sedimentation situation will be changed in a some extent	Water diversion possibly affects sedimentation, but proper measures and design and management are able to mitigate impacts.
Close coordination for operation of reservoir water level between RID and DEDP	
Highly required, specially for reservoir water level operation as well as irrigation water demand	Irrigation water demands are necessary to be informed from DEDP to RID.

The design water level of EL. 389.0 m is based on the applied elevation of the existing DEDP weir and proposed by the Team J/V.

The studies on the DEDP irrigation Project also recommended to provide the flood dykes along Chiang Rai City, but the proposed dyke has not been constructed due to difficulties of land acquisition in the urban area of Chiang Rai City. Without the appropriate dyke system including drainage facilities, the proposed elevation of 389 m has high possibility to worsen the drainage situation in the lowland areas along the Kok and Kon rivers and drainage canal in the urban area.

The JICA Study Team concludes that the water level of EL. 388.0 m is appropriate option for design of intake gate so as to avoid the adverse effect of the Project.

Regarding the design flood water level of intake structures, both sides suggests that it should be estimated under the flow condition that the both bank areas are protected by flood dyke since the current urbanization in Chiang Rai City will require such infrastructures in near future.

It is recognized through the discussion that such different points as an applied flow velocity at gate and silting basin related to sedimentation are subject to further studies and designs based on the significant investigations and surveys in the next stage of the Project.

(3) Design by JICA Team

Preliminary design is made on the basis of the mentioned methods under the following design conditions, focusing required number of gates in the conventional method, and flow velocity in the non-conventional method:

- Catchment area 6,220 km^2
- Design flood discharge 1,090 m^3/s with a probability of once in 100 years
- Flood water level 391.91 m
- Design water level for intake gate 388.0 m
- Design discharge 140 m^3/s

To avoid impact on sediment flow situation, it is designed to keep flow velocity of 0.2 m/s in the silting basin and 0.8 m/s at the gates. Figures 11.2.1-5 and -6 show the result of design and main features are given as follows:

- Width of intake : 114 m
- Width of silting basin : 180 m
- Sill elevation : 386.0 m
- Gate type : Fixed wheel gate
- Gate size : 1 no. with 12.0 m (width) and 2.0 m (height)
  7 nos. with 10.0 m (width) and 2.0 m (height)
  2 nos. with 5.0 m (width) and 2.0 m (height)

The total of 10 leaves of gates is required to mitigate the impact on sedimentation, since the change of sedimentation situation at the existing Chiang Rai reservoir is one of serious problems for the private companies with a license of river sand mining.