5.9 Flood Control Dam

(1) Necessity of Flood Control Dam

The diversion water at 175 m^3/s from the Kok and Ing rivers will flow into the Nan river through its sub-basins; Yot river and Yao river. In spite that the present monthly mean discharge is estimated less than 20 m^3/s at the damsite, the Yot and Yao rivers shall carry the diversion water and local flow about 195 m^3/s in wet season. Therefore the diversion water will change the flow condition of Yot and Yao rivers completely.

The flow capacity of the Yot river at the Ing-Yot tunnel outlet is estimated about 150 m^3/s and the flow capacity of the Yao river is in the range between 160 and 300 m^3/s. In order to avoid the impact by the diversion water during flood and to protect the villages downstream of the dam from flooding, it is necessary to construct a flood control dam.

(2) Proposed Damsite

The flood control damsite is recommended on the Yao river, about 3 km downstream from the confluence with the Yot river or about 2 km upstream from King Amphoe Song Khwae, Changwat Nan based on the map study on scale of 1:10,000 and 1:50,000 and site reconnaissance. The catchment area is 372 km^2. The damsite foundation consists of shale, sandstone, tuff and lapilly tuff.

The Thai side study recommended the flood control dam as zone type dam. The storage capacity was determined in relation with the improved flow capacity of the Yot and Yao rivers. They recommended the storage capacity of 14.4 MCM at the flood control level 306.3 m MSL in case of the flow capacity of the downstream at 200 m^3/s. The regulated flow of 200 m^3/s will be discharged through the river outlet under the dam. It was assumed that the diversion water would stop at a flood time and the remaining water in the Ing-Yot tunnel, about 3.8 MCM, would be stored in the reservoir. However it might not be practical operation since it is difficult to judge the timing when the flood begins and the diversion water shall stop.

The JICA Study Team recommend the flood control dam as concrete gravity dam since the reservoir water level will fluctuate frequently about 10 m in maximum. The dam foundation may

be applicable for a concrete gravity dam based on our field reconnaissance, although it is reported that there are faults along the Yao river.

(3) Flood Control Plan

a) Design Flood to be Controlled

Design flood of 20 year return period for 3 day duration is applied for the purpose of flood control. The peak flood is estimated about 250 m^3/s tentatively based on the flood records of the gauging station N.51 at the Yao river, though the estimate by the Thai side study is 520 m^3/s. Recorded annual maximum floods at the gauging station N.51 on the Yao river are as follows:

Recorded annual maximum floods at N.51 (CA 774 km^2)

No.	Year	Peak Flood (m^3/s)
1	1979	218
2	1980	191
3	1981	193
4	1982	169
5	1983	325
6	1984	380
7	1985	222
8	1986	181
9	1987	175
10	1988	320
11	1989	93
12	1990	221
13	1991	87

Source : Thai side study

b) Daily Control Plan

The flood control dam will release the diversion water and local flow at 200 m^3/s continuously in rainy season through the diversion outlet of 2.8 m in diameter. The normal water level of the reservoir to discharge 200 m^3/s is set at 302.1 m MSL and the tail race water level is estimated about 278.5 m MSL. The local flow which exceeds 25 m^3/s will be stored in the reservoir.

Flood volume is estimated at 27 MCM as shown below and will be stored in the reservoir of the flood control dam. The reservoir water level will reach at 312 m MSL in case of 20 year probable flood to store the flood volume of 27 MC

Required Flood Control Volume

Time (hrs)	Q_{in} (m^3/s)	Q'_{in} (m^3/s)	$Q_{in'}$ (m^3/s)	Storage (MCM)
0	75.62	236	36	
3	78.16	238	38	0.4
6	83.47	240	40	0.8
9	101.97	249	49	1.3
12	298.32	344	144	2.3
15	518.06	450	250	4.5
18	501.06	442	242	7.1
21	410.05	398	198	9.5
24	316.93	353	153	11.4
27	224.03	308	108	12.8
30	148	271	71	13.8
33	102.39	249	49	14.4
36	147.6	271	71	15.1
39	207.45	300	100	16.0
42	201.22	297	97	17.1
45	173.98	284	84	18.0
48	146.59	271	71	18.9
51	119.5	258	58	19.6
54	97.61	247	47	20.1
57	85.87	241	41	20.6
60	116.83	256	56	21.1
63	154.2	274	74	21.8
66	150.84	273	73	22.6
69	134.64	265	65	23.4
72	118.2	257	57	24.0
75	101.68	249	49	24.6
78	87.98	242	42	25.1
81	78.98	238	38	25.5
84	76.76	237	37	25.9
87	75.92	237	37	26.3
90	75.7	237	37	26.7
93	75.62	236	36	27.1

Q_{in} : Flood flow from residual basin into the dam estimated by the Thai side study

$Q_{in'}$: Flood flow from residual basin into the dam modified by the JICA Study Team

$Q'_{in} = Q_{in'} + 200$ (Outflow)

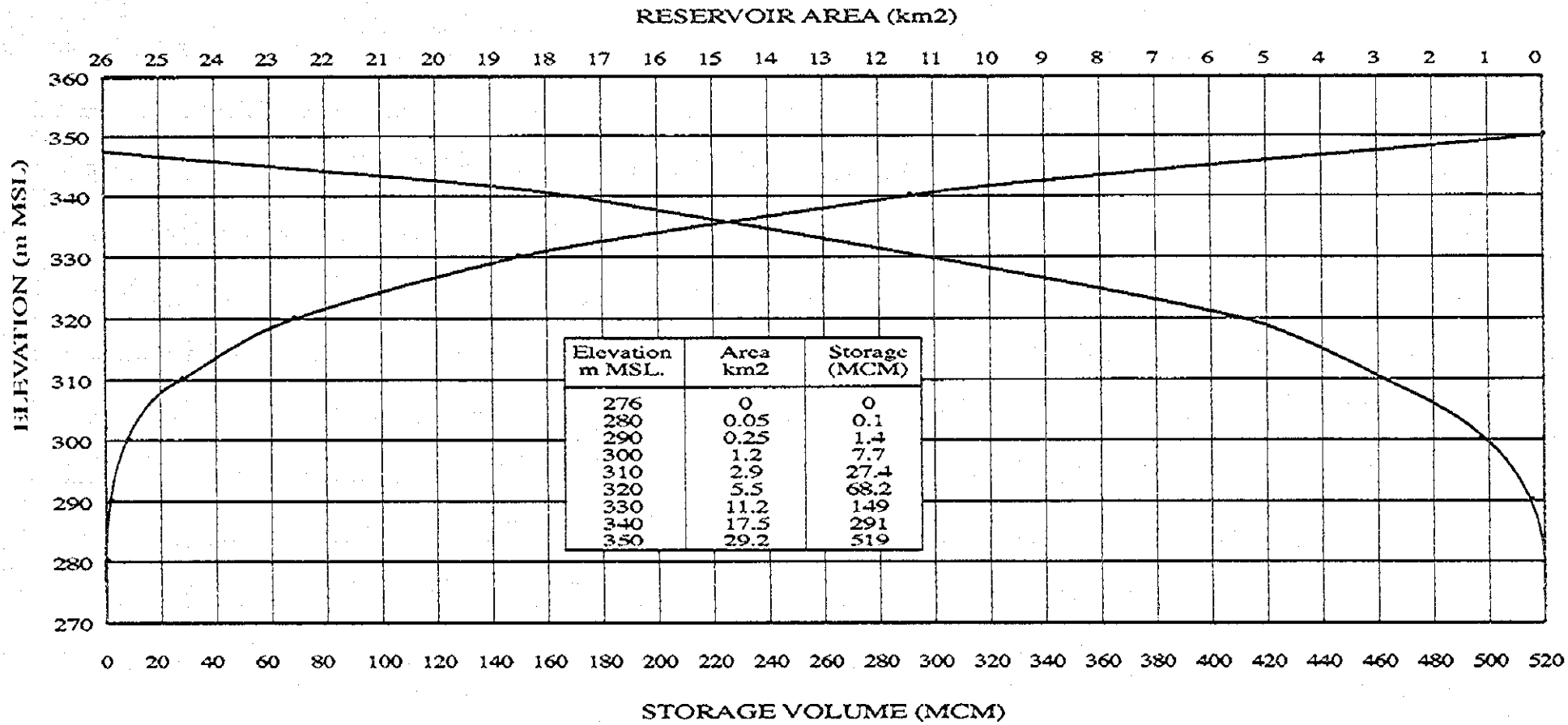
In case that there is flood in the Nan lower basin or the reservoir storage of the Sirikit dam is full, the intake gate of the Kok and Ing diversion dams will be closed to stop water diversion. Extraordinary floods from the Yot and Yao river basin will be discharged over the spillway.

(4) Dam Conceptual Layout

Conceptual layout and stage-storage-area curve of the Yao flood control dam is shown in Figures S.5.9.1 and S.5.9.2 respectively. Principal feature of the Yao flood control dam is shown in Table S.5.9.1.

Table 5.9.1 Principal Features of Yao Flood Control Dam

Principal Features	Unit	Recommended by Thai Side Study	Recommended by JICA Study Team
Reservoir			
- Peak discharge in 20 year return period	m^3/s	520	250
- Flood water level	m MSL	306.30	312.0
- Reservoir surface area at FWL	km^2	2.26	3.2
- Gross storage	MCM	14.42	35
- Flood control volume	MCM	7.10	27
- Normal (retention) water level	m MSL	302.00	302.1
- Low water level	m MSL	299.00	295.0
Dam facilities			
- Type of dam		Zone fill	Concrete gravity
- Dam crest elevation	m MSL	310.00	313.0
- River bed elevation	m MSL	275.79	276.0
- Dam height from river bed	m	34.2	37
- Crest length	m	140	120
- Crest width	m	10	6



Elevation m MSL.	Area km2	Storage (MCM)
276	0	0
280	0.05	0.1
290	0.25	1.4
300	1.2	7.7
310	2.9	27.4
320	5.5	68.2
330	11.2	149
340	17.5	291
350	29.2	519

THE STUDY ON THE KOK-ING-NAN WATER DIVERSION PROJECT	
Storage-Area Curve of Yao Flood Control Dam	Map & Drawing No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	
SANYU CONSULTANTS INC. & NIPPON KOEI CO., LTD.	

Table 7.2.A-D Construction Cost for Kok Diversion Dam

Item	Unit	Quantity	Rate	Amount (Thousand Baht)	Remark
1 Kok Diversion Weir					
Excavation	cu.m	700,000	50	35,000	Common
	cu.m	160,000	160	25,600	Weathered Rock
Embankment	cu.m	215,000	100	21,500	Compacted soil
Riprap	cu.m	5,000	200	1,000	
Concrete	cu.m	9,000	4,520	40,680	Heavy reinforced
	cu.m	500	3,250	1,625	Wall
Radial Gate	set	10	20,200,000	202,000	10 mw x 3.8 mh
PC Pile	m	3,600	1,500	5,400	600 mm dia.
Grout	m	700	5,000	3,500	Curtain
	m	400	3,000	1,200	Consolidation
Subtotal				337,505	
2 Preparatory Works					
Access & Service Road				89,000	20 % of (1+3)
Yards , Buildings					
Subtotal				89,000	
Total				**426,505**	
				426,000	
3 Intake					
Excavation	cu.m	250,000	50	12,500	
Embankment	cu.m	30,000	100	3,000	
Riprap	cu.m	24,000	200	4,800	
Concrete	cu.m	2,500	4,520	11,300	Heavy reinforced
	cu.m	450	3,250	1,463	Wall
PC Pile	m	1,250	1,500	1,875	600 mm dia.
Sluice Gate	set	3	25,048,000	75,144	10 mh x 3.8 mh
Total				**110,082**	
				110,000	
Grand Total				**536,000**	

Table 7.2.AL-C Backup Data of Construction Cost for Open Canal and Culvert in Kok-Ing Basin

Item	Unit	A Route			A-R Route			B Route			B-J Route			B-P Route			Remarks
		Q'ty	Rate Baht	Amount Million B	Q'ty	Rate Baht	Amount Million B	Q'ty	Rate Baht	Amount Million B	Q'ty	Rate Baht	Amount Million B	Q'ty	Rate Baht	Amount Million B	
2 Open Canal in Kok Basin																	
2.1 Earth Canal	m	-	-	-	-	-	-	215	9.5	2.0	215	9.5	2.0	215	9.5	2.0	
2.2 Concrete Canal																	
No.1 Type (Fill)	m	2,586	26,600	68.8	-	-	-	-	-	-	-	-	-	-	-	-	
No.2 Type (Cut)	m	6,000	20,600	123.6	5,782	20,900	120.8	1163	21,500	25.0	6,372	19,800	126.2	3,885	23,000	89.4	0<H<4 m
No.3 Type (Cut)	m	5,160	31,900	164.6	9,330	35,000	326.6	12685	39,500	501.1	12,002	35,000	420.1	19,407	38,800	753.0	0<H<9 m
Subtotal		13,746		357	15,112		447.4	13848		526.1	18,374		546.3	23,292		842.4	
2.3 Syphon	m	240	160,000	38.4	240	160,000	38.4	180	160,000	28.8	420	160,000	67.2	180	160,000	28.8	
2.4 Crossing Structure	LS	1		118.6	1		145.7	1		167.1	1		184.7	1		262.0	30 %
Total				514.0			631.5			724.0			800.2			1,135.2	
(cost per meter)			(37,390 Baht/m)			(41,780 Baht/m)			(51,480 Baht/m)			(43,040 Baht/m)			(48,290 Baht/m)		
3 Culvert in Kok Basin																	
No.1 Type	m	-	-	-	-	-	-	-	-	-	200	136,100	27.2	-	-	-	H<10 m
No.2 Type	m	690	161,400	111.4	-	-	-	3,200	162,700	520.6	-	-	-	3,200	162,700	520.6	H<15 m
No.3 Type	m	-	-	-	3,011	188,900	568.8	-	-	-	1,661	182,900	303.8	656	214,600	140.8	H<20 m
No.4 Type	m	360	211,800	76.2	-	-	-	14,794	219,200	3,242.8	-	-	-	-	-	-	H<25 m
Total		1,050		187.6	3,011		568.8	17,994		3,763.4	1,861		331.0	3,856		661.4	
(cost per meter)			(178,660 Baht/m)			(188,900 Baht/m)			(209,140 Baht/m)			(177,860 Baht/m)			(171,520 Baht/m)		
8 Open Canal in Ing Basin																	
8.1 Concrete Canal																	
No.2 Type (Cut)	m	11,750	19,500	229.1	11,750	19,500	229.1	11,750	19,500	229.1	11,750	19,500	229.1	11,750	19,500	229.1	0<H<4 m
No.3 Type (Cut)	m	10,000	33,000	330.0	10,000	33,000	330.0	10,000	33,000	330.0	10,000	33,000	330.0	10,000	33,000	330.0	0<H<9 m
Subtotal		21,750		559.1	21,750		559.1	21,750		559.1	21,750		559.1	21,750		559.1	
8.2 Chek / Chek Drop	LS	1		100.0	1		100.0	1		100.0	1		100.0	1		100.0	
8.3 Crossing Structure	LS	1		263.6	1		263.6	1		263.6	1		263.6	1		263.6	40 %
Total				922.7			922.7			922.7			922.7			922.7	
(cost per meter)			(42,420 Baht/m)			(42,420 Baht/m)			(42,420 Baht/m)			(42,420 Baht/m)			(42,420 Baht/m)		

Table 7.2.AL-C(1) Backup Data of Rate/m for Open Canal and Culvet in Kok-Ing Basin

Item	Unit	Rate	A Route Q'ty	A Route Amount 1,000 Baht	A-R Route Q'ty	A-R Route Amount 1,000 Baht	B Route Q'ty	B Route Amount 1,000 Baht	B-J Route Q'ty	B-J Route Amount 1,000 Baht	B-P Route Q'ty	B-P Route Amount 1,000 Baht
2 Open Canal in Kok Basin												
2.1 Earth Canal							H=3.94 m		H=3.94 m		H=3.94 m	
Exacavation	cu.m	50	-	-	-	-	106.4	5.3	106.4	5.3	106.4	5.3
Fill	cu.m	40	-	-	-	-	7.4	0.3	7.4	0.3	7.4	0.3
Spoil Bank	cu.m	30	-	-	-	-	99.0	3.0	99.0	3.0	99.0	3.0
Others			-	-	-	-		0.9		0.9		0.9
Total			-	-	-	-		**9.5**		**9.5**		**9.5**
2.2 Concrete Canal												
No.1 Type			F=1.45m (Fill)									
Exacavation	cu.m	50	21.9	1.1	-	-	-	-	-	-	-	-
Fill	cu.m	40	261.6	10.5	-	-	-	-	-	-	-	-
Spoil Bank	cu.m	30	21.9	0.7	-	-	-	-	-	-	-	-
Lining Concrete	cu.m	1,950	5.4	10.5	-	-	-	-	-	-	-	-
Formwork	sq.m	100	14.4	1.4	-	-	-	-	-	-	-	-
Others				2.4	-	-	-	-	-	-	-	-
Total				**26.6**	-	-	-	-	-	-	-	-
No.2 Type			H=2.77 m		H=2.95 m		H=3.17 m		H=2.41 m		H=0.81 m	
Exacavation	cu.m	50	81.1	4.1	86.3	4.3	92.7	4.6	71.0	3.6	31.9	1.6
Fill	cu.m	40	43.0	1.7	37.8	1.5	31.7	1.3	54.3	2.2	115.5	4.6
Spoil Bank	cu.m	30	31.7	1.0	42.3	1.3	55.1	1.7	9.9	0.3	92.3	2.8
Lining Concrete	cu.m	1,950	5.4	10.5	5.4	10.5	5.4	10.5	5.4	10.5	5.4	10.5
Formwork	sq.m	100	14.4	1.4	14.4	1.4	14.4	1.4	14.4	1.4	14.4	1.4
Others				1.9		1.9		2.0		1.8		2.1
Total				**20.6**		**20.9**		**21.5**		**19.8**		**23.0**
No.3 Type			H=5.30 m		H=6.11 m		H=7.18 m		H=6.09 m		H=7.03 m	
Exacavation	cu.m	50	169.6	8.5	204.7	10.2	255.1	12.8	203.8	10.2	247.8	12.4
Fill	cu.m	40	19.4	0.8	19.4	0.8	19.4	0.8	19.4	0.8	19.4	0.8
Spoil Bank	cu.m	30	144.8	4.3	179.9	5.4	230.3	6.9	179.0	5.4	223.0	6.7
Lining Concrete	cu.m	1,950	7.2	14.0	7.2	14.0	7.2	14.0	7.2	14.0	7.2	14.0
Formwork	sq.m	100	14.4	1.4	14.4	1.4	14.4	1.4	14.4	1.4	14.4	1.4
Others				2.9		3.2		3.6		3.2		3.5
Total				**31.9**		**35.0**		**39.5**		**35.0**		**38.8**
3 Culvert in Kok Basin												
No.1 and 2 Type			H=14.09 m		H=17.99 m		H=14.43 m		H= 7.90 m		H=14.43 m	
Exacavation	cu.m	50	373	18.7	623	31.2	385	19.3	144	7.2	385	19.3
Backfill	cu.m	50	291	14.6	541	27.1	303	15.2	62	3.1	303	15.2
Spoil Bank	cu.m	30	82	2.5	82	2.5	82	2.5	82	2.5	82	2.5
Rein. Concrete	cu.m	1,700	32.6	55.4	32.6	55.4	32.6	55.4	32.6	55.4	32.6	55.4
Reinforcing Bar	ton	15,000	3.3	49.5	3.3	49.5	3.3	49.5	3.3	49.5	3.3	49.5
Formwork	m	6,000	1	6.0	1	6.0	1	6.0	1	6.0	1	6.0
Others				14.7		17.2		14.8		12.4		14.8
Total				**161.4**		**188.9**		**162.7**		**136.1**		**162.7**
No.3 and 4 Type			H=21.45 m				H=22.48 m		H=17.00 m		H=21.83 m	
Exacavation	cu.m	50	832	41.6			900	45.0	569	28.5	857	42.9
Backfill	cu.m	50	750	37.5			818	40.9	487	24.4	775	38.8
Spoil Bank	cu.m	30	82	2.5			82	2.5	82	2.5	82	2.5
Rein. Concrete	cu.m	1,700	32.6	55.4			32.6	55.4	32.6	55.4	32.6	55.4
Reinforcing Bar	ton	15,000	3.3	49.5			3.3	49.5	3.3	49.5	3.3	49.5
Formwork	m	6,000	1	6.0			1	6.0	1	6.0	1	6.0
Others				19.3				19.9		16.6		19.5
Total				**211.8**				**219.2**		**182.9**		**214.6**
8 Open Canal (Concrete Canal) in Ing Basin							(common to all alternativ routes)					
No.2 Type			H=2.03 m									
Exacavation	cu.m	50	53.6	2.7								
Fill	cu.m	40	67.3	2.7								
Spoil Bank	cu.m	30	13.7	0.4								
Lining Concrete	cu.m	1,950	5.4	10.5								
Formwork	sq.m	100	14.4	1.4								
Others				1.8								
Total				**19.5**								
No.3 Type			H=5.40 m									
Exacavation	cu.m	50	181.2	9.1								
Fill	cu.m	40	19.4	0.8								
Spoil Bank	cu.m	30	156.4	4.7								
Lining Concrete	cu.m	1,950	7.2	14.0								
Formwork	sq.m	100	14.4	1.4								
Others				3.0								
Total				**33.0**								

Table 7.2.A-T1 Construction Cost for Kok - Ing Tunnel

(A - T1)

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	5,800		1,164,239
1.2 Tunnel Lining	m	5,800		456,111
Subtotal				**1,620,350**
2. Associated Works				
2.1 Access Road to Temporary Potal	places	2	58,440	116,880
2.2 Permanent Drainage Works	lms.	1		19,029
2.3 Portals Works	places	2	3,240	6,480
2.4 Vertical Anchor Method	places	2	16,000	32,000
2.5 Environmental Protection Works	lms.	1		65,102
Subtotal				**239,491**
3. Depreciation for Machinery	places	2	94,380	188,760
Subtotal				**188,760**
4. Temporary Works for Construction				
4.1 Temporary Portals Facilities	lms.	1		1,316
4.2 Temporary Air Supply Facilities	lms.	1		49,620
4.3 Temporary Water Supply Facilities	lms.	1		8,047
4.4 Temporary Dranage Facilities	lms.	1		6,313
4.5 Temporary Ventilation Facilities	lms.	1		637,769
4.6 Temporary Power Facilities	lms.	1		42,891
4.7 Water Pollution Countermeasures		2	13,301	26,602
4.8 Assembling and Dismantling Works	faces	2	1,193	2,386
4.9 Plant Facilities	faces	2	1,351	2,702
4.10 Temporary Houses for Compressoor,Magazine		1		2,054
4.11 Maintenance for Temporary Works	month	56.3	1,282	72,177
4.12 Basic Power Rates and Land Rent	lms.	1		31,799
4.13 Safety Measures and Others	lms.	1		199,517
Subtotal				**1,083,192**
Total (1+2+3+4)				**3,131,793**
Total Construction Cost for Tunnel A-T1			(Rounded)	**3,131,000**
		(539,000 Bht/m)		

Table 7.2.A-T1(1) Backup Data of Cost for Kok - Ing Tunnel

(A - T1)

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type C1	m	25.0	88,385	2,209,625
Type C2	m	354.0	106,351	37,648,254
Type D1	m	732.0	165,768	121,342,176
Type D2	m	1,432.0	179,558	257,127,056
Type E1	m	1,244.0	195,330	242,990,520
Type E2	m	2,013.0	222,149	447,185,937
Type Ewr	m	(805.0)	69,237	55,735,785
Subtotal		5,800.0		1,164,239,353
1.2 Concrete Tunnel Lining				
Type C1	m	25.0	40,365	1,009,125
Type C2	m	354.0	39,052	13,824,408
Type D1	m	732.0	45,372	33,212,304
Type D2	m	1,432.0	59,929	85,818,328
Type E1	m	1,244.0	71,251	88,636,244
Type E2	m	2,013.0	116,051	233,610,663
Subtotal		5,800.0		456,111,072
Total				**1,620,350,425**

Table 7.2.A-T2 Construction Cost for Kok - Ing Tunnel

(A - T2)

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	7,350		1,224,965
1.2 Tunnel Lining	m	7,350		466,695
Subtotal				**1,691,660**
2. Associated Works				
2.1 Access Road to Temporary Potal	places	2	58,440	116,880
2.2 Permanent Drainage Works	lms.	1		22,449
2.3 Portals Works	places	2	3,240	6,480
2.4 Vertical Anchor Method	places	2	16,000	32,000
2.5 Environmental Protection Works	lms.	1		67,836
Subtotal				**245,645**
3. Depreciation for Machinery	places	2	112,317	224,634
Subtotal				**224,634**
4. Temporary Works for Construction				
4.1 Temporary Portals Facilities	lms.	1		1,316
4.2 Temporary Air Supply Facilities	lms.	1		50,673
4.3 Temporary Water Supply Facilities	lms.	1		9,602
4.4 Temporary Dranage Facilities	lms.	1		8,237
4.5 Temporary Ventilation Facilities	lms.	1		759,262
4.6 Temporary Power Facilities	lms.	1		43,086
4.7 Water Pollution Countermeasures		2	15,331	30,662
4.8 Assembling and Dismantling Works	faces	2	1,193	2,386
4.9 Plant Facilities	faces	2	1,411	2,822
4.10 Temporary Houses for Compressoor,Magazine		1		2,354
4.11 Maintenance for Temporary Works	month	67.0	1,282	85,894
4.12 Basic Power Rates and Land Rent	lms.	1		36,364
4.13 Safety Measures and Others	lms.	1		229,970
Subtotal				**1,262,629**
Total (1+2+3+4)				**3,424,568**
Total Construction Cost for Tunnel A-T2			(Rounded)	**3,424,000**
		(465,000 Bht/m)		

Table 7.2.A-T2(1) Backup Data of Cost for Kok - Ing Tunnel
(A - T2)

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type C1	m	716.0	88,385	63,283,660
Type C2	m	1,790.0	106,347	190,361,130
Type D1	m	1,390.0	165,768	230,417,520
Type D2	m	1,184.0	179,558	212,596,672
Type E1	m	660.0	195,330	128,917,800
Type E2	m	1,610.0	220,668	355,275,480
Type Ewr	m	(644.0)	68,497	44,112,068
Subtotal		7,350.0		1,224,964,330
1.2 Concrete Tunnel Lining				
Type C1	m	716.0	40,365	28,901,340
Type C2	m	1,790.0	39,052	69,903,080
Type D1	m	1,390.0	45,372	63,067,080
Type D2	m	1,184.0	59,929	70,955,936
Type E1	m	660.0	71,251	47,025,660
Type E2	m	1,610.0	116,051	186,842,110
Subtotal		7,350.0		466,695,206
Total				**1,691,659,536**

Table 7.2.B-T Construction Cost for Kok - Ing Tunnel

(B)

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	5,506		1,041,428
1.2 Tunnel Lining	m	5,506		427,356
Subtotal				**1,468,784**
2. Associated Works				
2.1 Access Road to Temporary Potal	places	2	58,440	116,880
2.2 Permanent Drainage Works	lms.	1		17,710
2.3 Portals Works	places	2	3,240	6,480
2.4 Vertical Anchor Method	places	2	16,000	32,000
2.5 Environmental Protection Works	lms.	1		58,999
Subtotal				**232,069**
3. Depreciation for Machinery	places	2	88,848	177,696
Subtotal				**177,696**
4. Temporary Works for Construction				
4.1 Temporary Portals Facilities	lms.	1		1,316
4.2 Temporary Air Supply Facilities	lms.	1		49,420
4.3 Temporary Water Supply Facilities	lms.	1		7,609
4.4 Temporary Dranage Facilities	lms.	1		5,866
4.5 Temporary Ventilation Facilities	lms.	1		600,422
4.6 Temporary Power Facilities	lms.	1		42,853
4.7 Water Pollution Countermeasures		2	12,675	25,350
4.8 Assembling and Dismantling Works	faces	2	1,193	2,386
4.9 Plant Facilities	faces	2	1,333	2,665
4.10 Temporary Houses for Compressoor,Magazine		1		1,962
4.11 Maintenance for Temporary Works	month	53.0	1,282	67,946
4.12 Basic Power Rates and Land Rent	lms.	1		30,391
4.13 Safety Measures and Others	lms.	1		190,123
Subtotal				**1,028,310**
Total (1+2+3+4)				**2,906,859**
Total Construction Cost for Tunnel B-T			(Rounded)	**2,906,000**
		(527,000 Bht/m)		

Table 7.2.B-T(1) Backup Data of Cost for Kok - Ing Tunnel (B)

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type C1	m	480.0	88,385	42,424,800
Type C2	m	790.0	106,347	84,014,130
Type D1	m	620.0	165,768	102,776,160
Type D2	m	660.0	179,558	118,508,280
Type E1	m	750.0	195,330	146,497,500
Type E2	m	2,206.0	220,668	486,793,608
Type Ewr	m	(882.0)	68,497	60,414,354
Subtotal		**5,506.0**		**1,041,428,832**
1.2 Concrete Tunnel Lining				
Type C1	m	480.0	40,365	19,375,200
Type C2	m	790.0	39,052	30,851,080
Type D1	m	620.0	45,372	28,130,640
Type D2	m	660.0	59,929	39,553,140
Type E1	m	750.0	71,251	53,438,250
Type E2	m	2,206.0	116,051	256,008,506
Subtotal		**5,506.0**		**427,356,816**
Total				**1,468,785,648**

Table 7.2.B-J-T1 Construction Cost for Kok - Ing Tunnel

(B - J - T1)

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	3,114		606,368
1.2 Tunnel Lining	m	3,114		243,447
Subtotal				**849,815**
2. Associated Works				
2.1 Access Road to Temporary Potal	places	1	29,220	29,220
2.2 Permanent Drainage Works	lms.	1		10,222
2.3 Portals Works	places	1	3,240	3,240
2.4 Vertical Anchor Method	places	1	16,000	16,000
2.5 Environmental Protection Works	lms.	1		34,157
Subtotal				**92,839**
3. Depreciation for Machinery	places	1	102,259	102,259
Subtotal				**102,259**
4. Temporary Works for Construction				
4.1 Temporary Portals Facilities	lms.	1		658
4.2 Temporary Air Supply Facilities	lms.	1		26,920
4.3 Temporary Water Supply Facilities	lms.	1		2,847
4.4 Temporary Dranage Facilities	lms.	1		3,539
4.5 Temporary Ventilation Facilities	lms.	1		345,482
4.6 Temporary Power Facilities	lms.	1		21,472
4.7 Water Pollution Countermeasures		1	14,193	14,193
4.8 Assembling and Dismantling Works	faces	1	1,193	1,193
4.9 Plant Facilities	faces	1	1,377	1,377
4.10 Temporary Houses for Compressoor,Magazine		1		1,145
4.11 Maintenance for Temporary Works	month	61.0	687	41,907
4.12 Basic Power Rates and Land Rent	lms.	1		16,902
4.13 Safety Measures and Others	lms.	1		212,893
Subtotal				**690,528**
Total (1+2+3+4)				**1,735,441**
Total Construction Cost for Tunnel B-J-T1			(Rounded)	**1,735,000**
		(**557,000** Bht/m)		

Table 7.2.B-J-T1(1) Backup Data of Cost for Kok - Ing Tunnel
(B - J - T1)

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type C1	m	130.0	88,385	11,490,050
Type C2	m	340.0	106,347	36,157,980
Type D1	m	320.0	165,768	53,045,760
Type D2	m	418.0	179,558	75,055,244
Type E1	m	800.0	195,340	156,272,000
Type E2	m	1,106.0	220,678	244,069,868
Type Ewr	m	(442.0)	68,502	30,277,884
Subtotal		3,114.0		606,368,786
1.2 Concrete Tunnel Lining				
Type C1	m	130.0	40,365	5,247,450
Type C2	m	340.0	39,052	13,277,680
Type D1	m	320.0	45,372	14,519,040
Type D2	m	418.0	59,929	25,050,322
Type E1	m	800.0	71,251	57,000,800
Type E2	m	1,106.0	116,051	128,352,406
Subtotal		3,114.0		243,447,698
Total				**849,816,484**

Table 7.2.B-J-T2 Construction Cost for Kok - Ing Tunnel

(B - J - T2)

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	7,775		1,308,014
1.2 Tunnel Lining	m	7,775		503,939
Subtotal				**1,811,953**
2. Associated Works				
2.1 Access Road to Temporary Potal	places	2	58,440	116,880
2.2 Permanent Drainage Works	lms.	1		23,826
2.3 Portals Works	places	2	3,240	6,480
2.4 Vertical Anchor Method	places	2	16,000	32,000
2.5 Environmental Protection Works	lms.	1		72,670
Subtotal				**251,856**
3. Depreciation for Machinery	places	2	119,022	238,045
Subtotal				**238,045**
4. Temporary Works for Construction				
4.1 Temporary Portals Facilities	lms.	1		1,316
4.2 Temporary Air Supply Facilities	lms.	1		50,962
4.3 Temporary Water Supply Facilities	lms.	1		10,149
4.4 Temporary Dranage Facilities	lms.	1		8,869
4.5 Temporary Ventilation Facilities	lms.	1		804,578
4.6 Temporary Power Facilities	lms.	1		43,139
4.7 Water Pollution Countermeasures		2	16,090	32,180
4.8 Assembling and Dismantling Works	faces	2	1,193	2,386
4.9 Plant Facilities	faces	2	1,433	2,867
4.10 Temporary Houses for Compressoor,Magazine		1		2,466
4.11 Maintenance for Temporary Works	month	71.0	1,382	98,122
4.12 Basic Power Rates and Land Rent	lms.	1		38,071
4.13 Safety Measures and Others	lms.	1		241,357
Subtotal				**1,336,461**
Total (1+2+3+4)				**3,638,315**
Total Construction Cost for Tunnel B-J-T2			(Rounded)	**3,638,000**
		(**467,000** Bht/m)		

Table 7.2.B-J-T2(1) Backup Data of Cost for Kok - Ing Tunnel

(B - J - T2)

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type C1	**m**	**757.0**	88,385	66,907,445
Type C2	**m**	**1,893.0**	106,347	201,314,871
Type D1	**m**	**1,400.0**	165,768	232,075,200
Type D2	**m**	**1,190.0**	179,558	213,674,020
Type E1	**m**	**660.0**	195,330	128,917,800
Type E2	**m**	**1,875.0**	220,668	413,752,500
Type Ewr	**m**	**(750.0)**	68,497	51,372,750
Subtotal		**7,775.0**		**1,308,014,586**
1.2 Concrete Tunnel Lining				
Type C1	**m**	**757.0**	40,365	30,556,305
Type C2	**m**	**1,893.0**	39,052	73,925,436
Type D1	**m**	**1,400.0**	45,372	63,520,800
Type D2	**m**	**1,190.0**	59,929	71,315,510
Type E1	**m**	**660.0**	71,251	47,025,660
Type E2	**m**	**1,875.0**	116,051	217,595,625
Subtotal		**7,775.0**		**503,939,336**
Total				**1,811,953,922**

Table 7.2.B-P-T Construction Cost for Kok - Ing Tunnel
(B-P-T)

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	4,200		748,182
1.2 Tunnel Lining	m	4,200		279,180
Subtotal				**1,027,362**
2. Associated Works				
2.1 Access Road to Temporary Potal	places	1	29,220	29,220
2.2 Permanent Drainage Works	lms.	1		13,086
2.3 Portals Works	places	1	3,240	3,240
2.4 Vertical Anchor Method	places	1	16,000	16,000
2.5 Environmental Protection Works	lms.	1		41,225
Subtotal				**102,771**
3. Depreciation for Machinery	places	1	125,728	125,728
Subtotal				**125,728**
4. Temporary Works for Construction				
4.1 Temporary Portals Facilities	lms.	1		658
4.2 Temporary Air Supply Facilities	lms.	1		27,791
4.3 Temporary Water Supply Facilities	lms.	1		3,538
4.4 Temporary Dranage Facilities	lms.	1		5,088
4.5 Temporary Ventilation Facilities	lms.	1		425,013
4.6 Temporary Power Facilities	lms.	1		22,652
4.7 Water Pollution Countermeasures		1	16,849	16,849
4.8 Assembling and Dismantling Works	faces	1	1,504	1,504
4.9 Plant Facilities	faces	1	1,456	1,456
4.10 Temporary Houses for Compressoor,Magazine		1		1,341
4.11 Maintenance for Temporary Works	month	75.0	911	68,325
4.12 Basic Power Rates and Land Rent	lms.	1		19,889
4.13 Safety Measures and Others	lms.	1		252,740
Subtotal				**846,844**
Total (1+2+3+4)				**2,102,705**
Total Construction Cost for Tunnel B-P-T			(Rounded)	**2,102,000**
		(500,000 Bht/m)		

Table 7.2.B-P-T(1) Backup Data of Cost for Kok - Ing Tunnel (B-P-T)

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type C1	m	480.0	89,211	42,821,280
Type C2	m	790.0	107,354	84,809,660
Type D1	m	620.0	168,155	104,256,100
Type D2	m	660.0	185,843	122,656,380
Type E1	m	750.0	197,989	148,491,750
Type E2	m	900.0	241,057	216,951,300
Type Ewr	m	(360.0)	78,323	28,196,280
Subtotal		4,200.0		748,182,750
1.2 Concrete Tunnel Lining				
Type C1	m	480.0	41,111	19,733,280
Type C2	m	790.0	39,798	31,440,420
Type D1	m	620.0	46,173	28,627,260
Type D2	m	660.0	60,730	40,081,800
Type E1	m	750.0	72,108	54,081,000
Type E2	m	900.0	116,908	105,217,200
Subtotal		4,200.0		279,180,960
Total				1,027,363,710

Table 7.2.B-P-T (2) Detailed Backup Data of Cost for Kok - Ing Tunnel (B-P-T)

Grade of Ground	Type B	Type C I	Type C II	Type D I	Type D II	Type E I	Type E II	Type Ewr
Length(m) 4,200	-	480	790	620	660	750	900	
								(unit of cost:Baht)
Excavation Cost / Upper half/ m								
Labour Cost	-	13,686	16,702	18,444	19,025	19,512	22,270	50,986
Machine and Equipment	-	44,292	48,633	45,206	45,529	46,328	53,636	
Materials	-	15,198	15,709	7,867	8,015	8,319	26,065	
Subtotal	-	**73,176**	**81,044**	**71,517**	**72,569**	**74,159**	**101,971**	**50,986**
Excavation Cost / Lower half/m								
Labour Cost	-	-	-	9,222	9,513	9,756	11,135	17,737
Machine and Equipment	-	-	-	15,426	15,366	15,515	17,526	
Materials	-	-	-	2,629	2,637	2,688	6,813	
Subtotal	-	-	-	**27,277**	**27,516**	**27,959**	**35,474**	**17,737**
Steel Support	-	-	8,041	14,081	21,878	30,960	31,016	
Rockbolts	-	6,160	7,700	15,264	15,525	15,525	19,686	
Shotcrete	-	7,484	8,178	10,613	12,894	13,101	16,375	9,600
Welded net	-	-	-	1,628	1,997	2,028	2,043	
Sheeting	-	-	-	25,071	30,760	31,231	31,466	
Lin.Inv.cut	-	2,391	2,391	2,704	2,704	3,026	3,026	
Total(Excavation Works)		**89,211**	**107,354**	**168,155**	**185,843**	**197,989**	**241,057**	**78,323**
Lining.Inv.	-	12,310	12,310	15,365	15,365	18,522	18,522	
Lining.Arc.	-	28,801	27,488	30,808	30,808	36,040	36,040	
Reinfor-bar @60kg/m3	-	-	-	-	14,557	17,546	17,546	
Water Proof	-	-	-	-	-	-	44,800	
Total (Lining Works)		**41,111**	**39,798**	**46,173**	**60,730**	**72,108**	**116,908**	
Unit Cost of Type		**130,322**	**147,152**	**214,328**	**246,573**	**270,097**	**357,965**	**78,323**

Table 7.5.B-T Backup Data of Cost for Ing - Yot Tunnel

(B)

Q = 175.00 m3/sec

Item	Unit	Quantity	Rate	Amount
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type B	m	**2,680.0**	90,556	242,690,080
Type C1	m	**8,909.0**	95,278	848,831,702
Type C2	m	**14,790.0**	114,952	1,700,140,080
Type D1	m	**12,088.0**	179,059	2,164,465,192
Type D2	m	**7,810.0**	194,399	1,518,256,190
Type E1	m	**2,870.0**	211,036	605,673,320
Type E2	m	**1,728.0**	237,350	410,140,800
Type Ewr	m	**(691.0)**	72,237	49,915,767
Subtotal		**50,875.0**		**7,540,113,131**
1.2 Concrete Tunnel Lining				
Type B	m	**2,680.0**	46,456	124,502,080
Type C1	m	**8,909.0**	44,939	400,361,551
Type C2	m	**14,790.0**	43,468	642,891,720
Type D1	m	**12,088.0**	50,569	611,278,072
Type D2	m	**7,810.0**	66,999	523,262,190
Type E1	m	**2,870.0**	79,651	228,598,370
Type E2	m	**1,728.0**	124,451	215,051,328
Subtotal		**50,875.0**		**2,745,945,311**
Total				**10,286,058,442**

Table 7.5.B-T (1) Detailed Backup Data of Cost for Ing - Yot Tunnel

(B)

Q = 175.00 m3/sec

Grade of Ground	Type B	Type CI	Type CII	Type DI	Type DII	Type EI	Type EII	Type Ewr
Length(m) 50,875	2,680	8,909	14,790	12,088	7,810	2,870	1,728	(691)
								(unit of cost : Baht)
Excavation Cost / Upper half/ m								
Labour Cost	12,422	14,713	17,668	19,014	19,611	19,834	22,974	
Machine and Equipment	47,968	44,550	48,915	45,447	45,819	46,520	53,974	
Materials	17,908	17,668	18,309	9,277	9,410	9,744	9,879	
Subtotal	**78,298**	**76,931**	**84,892**	**73,738**	**74,840**	**76,098**	**86,827**	**43,414**
Excavation Cost / Lower half/m								
Labour Cost	-	-	-	9,507	9,806	9,917	11,487	
Machine and Equipment	-	-	-	15,537	15,501	15,601	17,685	
Materials	-	-	-	2,967	2,997	3,033	7,165	
Subtotal	-	-	-	**28,011**	**28,304**	**28,551**	**36,337**	**18,169**
Steel Support	-	-	9,198	15,914	20,516	34,587	34,788	
Rockbolts	4,050	6,943	8,678	16,918	17,178	17,178	20,860	
Shoterete	5,176	8,373	9,152	11,915	14,476	14,683	18,353	10,653
Welded net	-	-	-	1,828	2,236	2,268	2,282	
Sheeting	-	-	-	27,351	33,464	33,924	34,153	
Lin.Inv.cut	3,032	3,032	3,032	3,385	3,385	3,748	3,748	
Total(Excavation Works)	**90,556**	**95,279**	**114,952**	**179,060**	**194,399**	**211,037**	**237,348**	**72,236**
Lining.Inv.	13,760	13,760	13,760	17,120	17,120	20,567	20,567	
Lining.Arc.	32,696	31,179	29,709	33,450	33,450	39,300	39,300	
Reinfor-bar @60kg/m3	-	-	-	-	16,429	19,785	19,785	
Water Proof	-	-	-	-	-	-	44,800	
Total (Lining Works)	**46,456**	**44,939**	**43,469**	**50,570**	**66,999**	**79,652**	**124,452**	
Unit Cost of Type	**137,012**	**140,218**	**158,421**	**229,630**	**261,398**	**290,689**	**361,800**	**72,236**

Table 7.5.C-T Construction Cost for Ing - Yot Diversion Tunnel

(C)

Q = 175.00 m3/sec

Item	Unit	Quantity	Rate	Amount (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	52,453		10,854,362
1.2 Tunnel Lining	m	52,453		4,564,879
Subtotal				**15,419,241**
2. Inklined Adit				
2.1 Inklined Adit Exacavation	m	19,390	143,247	2,777,559
2.2 Inklined Adit Lining	m	19,390	40,455	784,422
Subtotal				**3,561,981**
3. Associated Works				
3.1 Access Road to Inclined Adit	places	13	55,420	720,460
3.2 Permanent Drainage Works	lms.	1		218,564
3.3 Portals Works	places	13	3,240	42,120
3.4 Vertical Anchor Method	places	13	16,000	208,000
3.5 Environmental Protection Works	lms.	1		616,623
Subtotal				**1,805,767**
4. Depreciation for Machinery	places	24	159,832	3,835,973
Subtotal				**3,835,973**
5. Temporary Works for Construction				
5.1 Temporary Portals Facilities	lms.	1		8,696
5.2 Temporary Air Supply Facilities	lms.	1		733,918
5.3 Temporary Water Supply Facilities	lms.	1		326,924
5.4 Temporary Dranage Facilities	lms.	1		372,570
5.5 Temporary Ventilation Facilities	lms.	1		523,944
5.6 Temporary Power Facilities	lms.	1		521,284
5.7 Water Pollution Countermeasures		13	16,166	210,158
5.8 Assembling and Dismantling Works	faces	24	1,193	28,633
5.9 Plant Facilities	faces	24	1,436	34,453
5.10 Inklined Adit Facilities	places	11	22,222	244,442
5.11 Temporary Houses for Compressoor,Magazine		1		38,076
5.12 Maintenance for Temporary Works	month	78.0	8,347	651,066
5.13 Basic Power Rates and Land Rent	lms.	1		716,156
5.14 Safety Measures and Others	lms.	1		242,493
Subtotal				**4,652,812**
Total (1+2+3+4+5)				**29,275,774**
Total Construction Cost for DiversionTunnel			(Rounded)	**29,275,000**
		(**558,000** Bht/m)		

Table 7.5.C-T (1) Backup Data of Cost for Ing - Yot Tunnel

(C)

Q = 175.00 m3/sec

Item	Unit	Quantity	Rate	Amount
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type B	m	**770.0**	90,556	69,728,120
Type C1	m	**3,850.0**	95,278	366,820,300
Type C2	m	**7,090.0**	114,952	815,009,680
Type D1	m	**5,540.0**	179,059	991,986,860
Type D2	m	**5,735.0**	194,399	1,114,878,265
Type E1	m	**6,335.0**	211,036	1,336,913,060
Type E2	m	**23,133.0**	237,350	5,490,617,550
Type Ewr	m	**(9,253.0)**	72,237	668,408,961
Subtotal		**52,453.0**		**10,854,362,796**
1.2 Concrete Tunnel Lining				
Type B	m	**770.0**	46,456	35,771,120
Type C1	m	**3,850.0**	44,939	173,015,150
Type C2	m	**7,090.0**	43,468	308,188,120
Type D1	m	**5,540.0**	50,569	280,152,260
Type D2	m	**5,735.0**	66,999	384,239,265
Type E1	m	**6,335.0**	79,651	504,589,085
Type E2	m	**23,133.0**	124,451	2,878,924,983
Subtotal		**52,453.0**		**4,564,879,983**
Total				**15,419,242,779**

Table 7.5.C-T (2) Detailed Backup Data of Cost for Ing - Yot Tunnel

(C)

Q = 175.00 m3/sec

Grade of Ground	Type B	Type CI	Type CII	Type DI	Type DII	Type EI	Type EII	Type Ewr
Length(m) 52,453	770	3,850	7,090	5,540	5,735	6,335	23,133	(9,253)
								(unit of cost : Baht)
Excavation Cost / Upper half/ m								
Labour Cost	12,422	14,713	17,668	19,014	19,611	19,834	22,974	
Machine and Equipment	47,968	44,550	48,915	45,447	45,819	46,520	53,974	
Materials	17,908	17,668	18,309	9,277	9,410	9,744	9,879	
Subtotal	**78,298**	**76,931**	**84,892**	**73,738**	**74,840**	**76,098**	**86,827**	**43,414**
Excavation Cost / Lower half/m								
Labour Cost	-	-	-	9,507	9,806	9,917	11,487	
Machine and Equipment	-	-	-	15,537	15,501	15,601	17,685	
Materials	-	-	-	2,967	2,997	3,033	7,165	
Subtotal	-	-	-	**28,011**	**28,304**	**28,551**	**36,337**	**18,169**
Steel Support	-	-	9,198	15,914	20,516	34,587	34,788	
Rockbolts	4,050	6,943	8,678	16,918	17,178	17,178	20,860	
Shotcrete	5,176	8,373	9,152	11,915	14,476	14,683	18,353	10,653
Welded net	-	-	-	1,828	2,236	2,268	2,282	
Sheeting	-	-	-	27,351	33,464	33,924	34,153	
Lin.Inv.cut	3,032	3,032	3,032	3,385	3,385	3,748	3,748	
Total(Excavation Works)	**90,556**	**95,279**	**114,952**	**179,060**	**194,399**	**211,037**	**237,348**	**72,236**
Lining.Inv.	13,760	13,760	13,760	17,120	17,120	20,567	20,567	
Lining.Arc.	32,696	31,179	29,709	33,450	33,450	39,300	39,300	
Reinfor-bar @60kg/m3	-	-	-	-	16,429	19,785	19,785	
Water Proof	-	-	-	-	-	-	44,800	
Total (Lining Works)	**46,456**	**44,939**	**43,469**	**50,570**	**66,999**	**79,652**	**124,452**	
Unit Cost of Type	**137,012**	**140,218**	**158,421**	**229,630**	**261,398**	**290,689**	**361,800**	**72,236**

Table 7.5.B-T(150) Construction Cost for Ing - Yot Tunnel

(B)

Q = 150.00 m3/sec

Item	Unit	Quantity	Rate	Cost (Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	50,875		7,163,510
1.2 Tunnel Lining	m	50,875		2,613,710
Subtotal				**9,777,220**
2. Inklined Adit				
2.1 Inklined Adit Exacavation	m	17,381	136,732	2,376,538
2.2 Inklined Adit Lining	m	17,381	38,444	668,195
Subtotal				**3,044,733**
3. Associated Works				
3.1 Access Road to Inclined Adit	places	9	55,420	498,780
3.2 Permanent Drainage Works	lms.	1		190,354
3.3 Portals Works	places	9	3,240	29,160
3.4 Vertical Anchor Method	places	9	16,000	144,000
3.5 Environmental Protection Works	lms.	1		390,939
Subtotal				**1,253,233**
4. Depreciation for Machinery	places	16	159,832	2,557,316
Subtotal				**2,557,316**
5. Temporary Works for Construction				
5.1 Temporary Portals Facilities	lms.	1		5,980
5.2 Temporary Air Supply Facilities	lms.	1		507,451
5.3 Temporary Water Supply Facilities	lms.	1		168,442
5.4 Temporary Dranage Facilities	lms.	1		349,779
5.5 Temporary Ventilation Facilities	lms.	1		375,042
5.6 Temporary Power Facilities	lms.	1		347,522
5.7 Water Pollution Countermeasures		9	16,166	145,494
5.8 Assembling and Dismantling Works	faces	16	1,193	19,089
5.9 Plant Facilities	faces	16	1,436	22,969
5.10 Inklined Adit Facilities	places	7	22,222	155,554
5.11 Temporary Houses for Compressoor,Magazine		1		25,418
5.12 Maintenance for Temporary Works	month	78.0	5,864	457,392
5.13 Basic Power Rates and Land Rent	lms.	1		478,733
5.14 Safety Measures and Others	lms.	1		242,493
Subtotal				**3,301,360**
6. Total (1+2+3+4+5)				**19,933,862**
Total Construction Cost for Tunnel			(Rounded)	**19,933,000**
		(391,000 Bht/m)		

Table 7.5.B-T(150)(1) Backup Data of Cost for Ing - Yot Tunnel

(B)

Q = 150.00 m3/sec

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type B	m	2,680.0	83,925	224,919,000
Type C1	m	8,909.0	89,517	797,506,953
Type C2	m	14,790.0	108,303	1,601,801,370
Type D1	m	12,088.0	170,915	2,066,020,520
Type D2	m	7,810.0	185,774	1,450,894,940
Type E1	m	2,870.0	202,028	579,820,360
Type E2	m	1,728.0	228,055	394,079,040
Type Ewr	m	(691.0)	70,143	48,468,813
Subtotal		50,875.0		7,163,510,996
1.2 Concrete Tunnel Lining				
Type B	m	2,680.0	44,191	118,431,880
Type C1	m	8,909.0	42,742	380,788,478
Type C2	m	14,790.0	41,340	611,418,600
Type D1	m	12,088.0	48,055	580,888,840
Type D2	m	7,810.0	63,625	496,911,250
Type E1	m	2,870.0	75,654	217,126,980
Type E2	m	1,728.0	120,454	208,144,512
Subtotal		50,875.0		2,613,710,540
Total				9,777,221,536

Table 7.5.B-T(150)(2) Detailed Backup Data of Cost for Ing - Yot Tunnel (B)

Q = 150.00 m3/sec

(unit of cost : Baht)

Grade of Ground	Type B	Type C I	Type C II	Type D I	Type D II	Type E I	Type E II	Type E wr
Length(m) 50,875	2,680	8,909	14,790	12,088	7,810	2,870	1,728	(691)
Excavation Cost / Upper half/ m								
Labour Cost	11,740	14,100	17,023	18,608	19,198	19,428	22,524	
Machine and Equipment	44,266	41,699	46,036	43,447	43,842	44,580	51,916	
Materials	16,626	16,578	17,159	8,617	8,750	9,084	9,174	
Subtotal	72,632	72,377	80,218	70,672	71,790	73,092	83,614	41,807
Excavation Cost / Lower half/m								
Labour Cost	-	-	-	9,304	9,599	9,714	11,262	
Machine and Equipment	-	-	-	15,025	14,995	15,122	17,063	
Materials	-	-	-	2,847	2,862	2,898	7,038	
Subtotal	-	-	-	27,176	27,456	27,734	35,363	17,682
Steel Support	-	-	8,564	14,986	19,379	33,016	33,225	
Rockbolts	3,757	6,551	8,189	16,091	16,352	16,352	20,273	
Shotcrete	4,941	7,993	8,736	11,355	13,797	14,005	17,504	10,653
Welded net	-	-	-	1,736	2,134	2,166	2,180	
Sheeting	-	-	-	25,973	31,941	32,398	32,628	
Lin.Inv.cut	2,595	2,595	2,595	2,926	2,926	3,267	3,267	
Total(Excavation Works)	83,925	89,516	108,302	170,915	185,775	202,030	228,054	70,142
Lining.Inv.	12,880	12,880	12,880	16,059	16,059	19,337	19,337	
Lining.Arc.	31,311	29,862	28,460	31,997	31,997	37,561	37,561	
Reinfor-bar @60kg/m3	-	-	-	-	15,570	18,755	18,755	
Water Proof	-	-	-	-	-	-	44,800	
Total (Lining Works)	44,191	42,742	41,340	48,056	63,626	75,653	120,453	
Unit Cost of Type	128,116	132,258	149,642	218,971	249,401	277,683	348,507	70,142

Table 7.5.B-T(200) Construction Cost for Ing - Yot Tunnel

(B)

Q = 200.00 m3/sec

Item	Unit	Quantity	Rate	Cost
				(Thousand Baht)
1. Main Tunnel				
1.1 Tunnel Exacavation	m	50,875		7,955,177
1.2 Tunnel Lining	m	50,875		2,859,832
Subtotal				**10,815,009**
2. Inklined Adit				
2.1 Inklined Adit Exacavation	m	17,381	149,920	2,605,759
2.2 Inklined Adit Lining	m	17,381	42,137	732,383
Subtotal				**3,338,142**
3. Associated Works				
3.1 Access Road to Inclined Adit	places	9	55,420	498,780
3.2 Permanent Drainage Works	lms.	1		190,354
3.3 Portals Works	places	9	3,240	29,160
3.4 Vertical Anchor Method	places	9	16,000	144,000
3.5 Environmental Protection Works	lms.	1		432,071
Subtotal				**1,294,365**
4. Depreciation for Machinery	places	16	159,832	2,557,316
Subtotal				**2,557,316**
5. Temporary Works for Construction				
5.1 Temporary Portals Facilities	lms.	1		6,060
5.2 Temporary Air Supply Facilities	lms.	1		507,451
5.3 Temporary Water Supply Facilities	lms.	1		168,442
5.4 Temporary Dranage Facilities	lms.	1		349,779
5.5 Temporary Ventilation Facilities	lms.	1		375,042
5.6 Temporary Power Facilities	lms.	1		347,522
5.7 Water Pollution Countermeasures		9	16,166	145,494
5.8 Assembling and Dismantling Works	faces	16	1,193	19,089
5.9 Plant Facilities	faces	16	1,436	22,969
5.10 Inklined Adit Facilities	places	7	22,222	155,554
5.11 Temporary Houses for Compressoor,Magazine		1		25,418
5.12 Maintenance for Temporary Works	month	78.0	5,864	457,392
5.13 Basic Power Rates and Land Rent	lms.	1		478,733
5.14 Safety Measures and Others	lms.	1		242,493
Subtotal				**3,301,440**
6. Total (1+2+3+4+5)				**21,306,272**
Total Construction Cost for Tunnel			(Rounded)	**21,306,000**
		(418,000 Bht/m)		

Table 7.5.B-T(200)(1) Backup Data of Cost for Ing - Yot Tunnel

(B)

Q = 200.00 m3/sec

Item	Unit	Quantity	Rate	Cost
1. Direct Tunnel Construction Cost				
1.1 Tunnel Exacavation				
Type B	m	2,680.0	98,275	263,377,000
Type C1	m	8,909.0	102,208	910,571,072
Type C2	m	14,790.0	122,254	1,808,136,660
Type D1	m	12,088.0	187,400	2,265,291,200
Type D2	m	7,810.0	203,606	1,590,162,860
Type E1	m	2,870.0	221,465	635,604,550
Type E2	m	1,728.0	249,051	430,360,128
Type Ewr	m	(691.0)	74,781	51,673,671
Subtotal		50,875.0		7,955,177,141
1.2 Concrete Tunnel Lining				
Type B	m	2,680.0	48,432	129,797,760
Type C1	m	8,909.0	46,830	417,208,470
Type C2	m	14,790.0	45,273	669,587,670
Type D1	m	12,088.0	52,671	636,687,048
Type D2	m	7,810.0	69,975	546,504,750
Type E1	m	2,870.0	83,217	238,832,790
Type E2	m	1,728.0	128,017	221,213,376
Subtotal		50,875.0		2,859,831,864
Total				**10,815,009,005**

Table 7.5.B-T(200)(2) Detailed Backup Data of Cost for Ing - Yot Tunnel (B)

Q = 200.00 m3/sec

(unit of cost : Baht)

Grade of Ground	Type B	Type C I	Type C II	Type D I	Type D II	Type E I	Type E II	Type E wr
Length(m) 50,875	2,680	8,909	14,790	12,088	7,810	2,870	1,728	(691)
Excavation Cost / Upper half/ m								
Labour Cost	13,259	15,562	18,465	19,471	20,062	20,342	23,481	
Machine and Equipment	52,656	48,353	52,656	47,469	47,754	48,592	56,100	
Materials	19,558	19,118	19,847	9,982	10,115	10,464	10,599	
Subtotal	**85,473**	**83,033**	**90,968**	**76,922**	**77,931**	**79,398**	**90,180**	**45,090**
Excavation Cost / Lower half/m								
Labour Cost	-	-	-	9,736	10,031	10,171	11,740	
Machine and Equipment	-	-	-	16,601	16,502	16,645	18,906	
Materials	-	-	-	3,244	3,259	3,303	7,428	
Subtotal	-	-	-	**29,581**	**29,792**	**30,119**	**38,074**	**19,037**
Steel Support	-	-	9,451	16,539	21,399	36,392	36,604	
Rockbolts	4,344	7,334	9,167	17,744	18,005	18,005	22,513	
Shotcrete	5,479	8,863	9,689	12,619	15,335	15,543	19,427	10,653
Welded net	-	-	-	1,920	2,368	2,399	2,414	
Sheeting	-	-	-	28,731	35,434	35,893	36,123	
Lin.Inv.cut	2,978	2,978	2,978	3,343	3,343	3,717	3,717	
Total(Excavation Works)	**98,274**	**102,208**	**122,253**	**187,399**	**203,607**	**221,466**	**249,052**	**74,780**
Lining.Inv.	14,255	14,255	14,255	17,743	17,743	21,333	21,333	
Lining.Arc.	34,177	32,574	31,018	34,929	34,929	41,058	41,058	
Reinfor-bar @60kg/m3	-	-	-	-	17,304	20,825	20,825	
Water Proof	-	-	-	-	-	-	44,800	
Total (Lining Works)	**48,432**	**46,829**	**45,273**	**52,672**	**69,976**	**83,216**	**128,016**	
Unit Cost of Type	**146,706**	**149,037**	**167,526**	**240,071**	**273,583**	**304,682**	**377,068**	**74,780**

9.3 Economic Evaluation

(1) 4 Types of Project Benefits

There are 4 types of benefits to be realized as a result of project implementation of which the foremost is agricultural benefit.

The water to be newly available after the project is completed will be used for an expansion of irrigated area in the study area, which will increase agricultural production. The increased agricultural production is eventually converted to economic benefit. Secondly, a part of the newly available water will be destined for urban water use. This urban water, which is used in households, industry and tourism is converted to economic benefit. Thirdly, the newly available water will be used for electricity generation. This newly generated electricity is used for domestic, industrial and agricultural purposes. It is converted to economic benefit. Lastly, the project is going to substantially increase the stored water level of the Sirikit Dam reservoirs. It means that regulating capacity of the Dam in time of flood will go up. That is to say, the project will contribute to the mitigation and control of floods. In economic terms the project will reduce flood damage to crops, houses and infrastructure. This reduction of flood damage is economic benefit.

Out of these 4 types of benefits, the first three were quantitatively evaluated. The last one was excluded from quantitative evaluation due to a lack of immediately available data and information.

(2) Proposed Allocation of Water

(a) Water Allocation for Irrigation

The total volume of water to be newly available by the project is estimated at 2,400 MCM per annum. Out of it, 600 MCM will be allocated for urban water use. And the remaining 1,800 MCM will be destined for irrigating the farm land of the Chao Phraya Basin. Regarding the allocation of this 1,800 MCM for various crops and fish culture, three alternatives are proposed.

In Plan A, taking account of the profitability, the existing cropped/cultured

area, water requirements per ha and market trend, this volume of water was allocated for upland crops comprised of maize, soybean, peanut and sugar cane, orchards including mango and pomelo, vegetables such as shallot, onion and garlic and inland fisheries, i.e. the culture of fish and prawn in the manner as shown in Table 9.3.1(1). Rice was excluded from consideration in compliance to the recent governmental policy of the restructuring of agricultural land use towards increased diversification of production, using rice growing land for other crops. The total area to be newly irrigated/used will come to 270,000 ha. Area-wise, 1,647 MCM will be allotted for Chao Phraya Delta area to irrigate 247,000 ha, and the balance of 153 MCM for the Phitsanulok area to irrigate 23,000 ha.

In Plan B, a part of the newly available water will be used for the second rice, taking into consideration a comparatively high productivity of the crop and a traditional preference for the growing of the crop. In total 910 MCM will be allocated to irrigate 91,000 ha of dry paddy fields. Area-wise, the Chao Phraya Delta and Phitsanulok areas will get 850 MCM and 60 MCM for the irrigation of 85,000 ha and 6,000 ha respectively. By so doing, the cropping intensity of 40% will be attained for the crop in both areas. The balance of 890 MCM will be used for upland crops, vegetables, orchards and fisheries, covering 133,000 ha in the manner as proposed in Plan A. (Refer to Table 9.3.2(1).) The total area to be newly irrigated /used will come to 224,000 ha.

In Plan C, a part of the newly available water will be used for the irrigation of the left bank area of the Nan River which was to be irrigated under the Phitsanulok Project Stage II, but left unirrigated. 240 MCM will be allotted for supplementary irrigation of 120,000 ha of rainfed wet paddy fields. In addition, 120 MCM will be used for the irrigation of 12,000 ha of dry paddy fields in the same area. Besides, 250 MCM will be earmarked for the irrigation of 25,000 ha of the dry paddy fields in the Chao Phraya Delta area. In total 610 MCM will be used for the irrigation of 157,000 ha of wet and dry paddy fields. The balance of 1,190 MCM will be used for the upland crops, vegetables, fruit trees and fish, covering 178,000 ha in the manner as proposed in Plan A. (Refer to Table 9.3.3(1).) The total area to be newly irrigated/used will come to 335,000 ha.

For the project area, it is proposed that 32,000 ha will be newly developed for

irrigation and fish culture. The recommended types of crops are upland crops comprised of maize, soybean and peanut, orchards and vegetables. The allocations of area for these crops and fisheries are shown in Table 9.3.1(2). The total annual water requirements work out to around 200 MCM.

(b) Water Allocation for Urban Water and Water for Power Generation

It is estimated that the water amounting to 1,200 MCM will be additionally required per annum to cater for the urban water needs of the Chao Phraya Basin in 2016. It is assumed that this volume of water will be met by the project. In the dry season, 600 MCM will be earmarked for this purpose out of 2,400 MCM. For the electric power generation, 2,000 MCM will be newly available per annum.

(3) Methodology for Estimation of Economic Benefits and Cost

(a) Estimation of Economic Benefits

In arriving at agricultural benefit, the volume of water to be newly available for irrigation will be converted to cropped area for each of the crops concerned through crop-wise requirements of water per ha. Yields per ha and economic price per kg are estimated by crop. The economic price is derived from the financial price. When the former is multiplied by the latter, one will get economic gross benefit per ha. Economic input cost per ha is estimated by crop. When one subtracts economic input cost per ha from economic gross benefit per ha, one will get economic net benefit per ha. Finally, cropped area is multiplied by economic net benefit per ha by crop. Thus, one will get economic net benefit for each crop. It is added together to arrive at agricultural benefit. It is to be noted that water requirements per ha, yields per ha, economic price and economic input cost per ha for various crops/fish are all essentially based on the existing conditions especially in the Chao Phraya Basin.

Also, it might be necessary for the Project Area to estimate the agricultural benefit in the without and with cases separately because yields per ha, economic input cost per ha, etc. could be different in the two cases. The study is now at the conceptual planning stage. Therefore, one could be unaffordable to delve into an in-depth theoretical estimations and assumptions. It would be more important to

consolidate the foothold first.

It is expected to take some time for the farmers to be accustomed to the irrigated farming. It is therefore assumed that the realization of the benefits after the project is implemented will be 60% in the first year, 80% in the second year and 100% from the third year onward for the area other than the Phitsanulok Stage II area. Regarding the latter area, since it will be newly developed, the realization of the benefits after the project implementation is assumed to be 20% in the 1st year, 40% in the 2nd year, 60% in the 3rd year, 80% in the 4th year and 100% from the 5th year onward.

The incremental volume of water allocated for urban water use will be converted to economic benefit through the opportunity cost of the unit volume of urban water. The opportunity cost of the unit volume of urban water was estimated based on the cost of ground water in the Western Water Supply Project.

In arriving at the economic benefit of electricity generation, the incremental volume of water will be converted to the volume of electricity to be generated through water requirement to generate unit volume of electricity. This volume of electricity will be converted to economic benefit through the opportunity cost of the unit volume of electricity. The opportunity cost of the unit volume of water is the price of power paid by the Electric Generating Authority of Thailand to the private sector.

(b) Estimation of Economic Cost

To convert capital cost to economic one, the conversion factor was estimated and applied for each of the capital cost items. Then, the capital cost for each item worked out in this way was added together. The annual operation and maintenance cost (O & M cost) was assumed to be 0.5% of the capital cost. To convert O & M cost to economic one, the standard conversion factor of 0.92 was used.

On-farm cost is considered in calculating benefits, since it is included in the economic input cost. Replacement cost is not taken into account because the facilities to be constructed are mostly civil engineering structures except some gate-

related structures.

(4) Results of Estimation of Benefits and Cost and Economic Analysis

(a) Results of Estimation of Benefits and Cost

Plan A Unit: baht million

Item	Annual Economic Benefit	Economic Capital Cost	Economic O/M Cost
Agriculture	6,261	-	-
Urban Water	4,024	-	-
Power Generation	328	-	-
Total	10,613	40,558	219

As shown in the above table, the economic cost totaling Baht 40,558 million will be invested to implement the project and the economic cost of Baht 219 million will be annually incurred to operate and maintain the facilities. As a result, the project is estimated to generate the economic benefit amounting to Baht 10,613 million every year.

Plan B Unit: baht million

Item	Annual Economic Benefit	Economic Capital Cost	Economic O/M Cost
Agriculture	4,312	-	-
Urban Water	4,024	-	-
Power Generation	328	-	-
Total	8,664	40,558	219

Agricultural benefit is lower than in Plan A. It is because the cultivation of the second rice is proposed in this alternative and it requires more water per ha than most of other crops and it is not efficient in terms of productivity per unit volume of water used.

Plan C Unit: baht million

Item	Annual Economic Benefit	Economic Capital Cost	Economic O/M Cost
Agriculture	5,435	-	-
Urban Water	4,024	-	-
Power Generation	328	-	-
Total	9,787	47,420	256

The level of agricultural benefit is between Plan A and Plan B. It is because no water is allocated for the dry paddy in Plan A and less water is allocated for the dry paddy in Plan C than in Plan B.

(b) Results of Economic Analysis

In making economic analysis, it was assumed that the project implementation period will be 8 years and that the progress rates of works will be 5% in the 1st year, 10% in 2nd year, 15% in the 3rd to 7th year and 10% in the 8th year. Opportunity cost of capital was assumed to be 12%. The results of economic analysis are shown below by alternative:

Alternative	NPV (million Baht)	B/C	EIRR (%)
A	9,391	1.38	15.1
B	3,260	1.13	13.2
C	2,246	1.08	12.7

Table 9.3.1(1) Estimation of Benefits for Plan A

A. Plan A

1. Agricultural Benefit (Annual)

(1) Chao Phraya Basin

a) Relationship between Area to be Newly Irrigated and Water Requirements

Crops/Fish	Area to be Newly Irrigated (ha)	Water Requirements per ha (m3/ha)	Water Requirements (MCM)
	A	B	C=AxB/1E6
1. Upland Crops			
Maize	70,000	4,000	280
Soybean	60,000	5,000	300
Peanut	20,000	4,000	80
Sugar Cane	40,000	7,000	280
Sub-Total	190,000		940
2. Orchards	40,000	11,000	440
3. Vegetables	10,000	6,000	60
4 Fish	30,000	12,000	360
Total	270,000		1,800

Source: JICA

b) Economic Net Benefit per ha

Crops/Fish	Yields per ha (kg/ha)	Financial Price (baht/kg)	Economic Price (baht/kg)	Economic Gross Benefit per ha (baht/ha)
	A		B	C=AxB
1. Upland Crops				
Maize	3,500	2.9	3.0	10,500
Soybean	2,000	8.0	8.3	16,600
Peanut	1,800	9.1	11.4	20,520
Sugar Cane	43,300	0.44	0.46	19,918
Sub-Total				
2. Orchards	5,000	15.0	16.5	82,500
3. Vegetables	10,000	8.0	9.1	91,000
4. Fish	4,000	25.0	27.0	108,000
Total				

Crops/Fish	Economic Input Cost per ha (baht/ha)	Economic Net Benefit per ha (baht/ha)
	D	E=C-D
1. Upland Crops		
Maize	6,195	4,305
Soybean	7,624	8,976
Peanut	9,410	11,110
Sugar Cane	12,078	7,840
Sub-Total		
2. Orchards	37,120	45,380
3. Vegetables	33,600	57,400
4. Fish	47,250	60,750
Total		

Source: Agricultural Statistics of Thailand Crop Year 1994/95, Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

Table 9.3.1(2) Estimation of Benefits for Plan A

c) Economic Net Benefit

Crops/Fish	Area to be Newly Irrigated (ha)	Economic Net Benefit per ha (baht/ha)	Economic Net Benefit (baht million)
	A	B	C=AxB/1E6
1. Upland Crops			
Maize	70,000	4,305	301
Soybean	60,000	8,976	539
Peanut	20,000	11,110	222
Sugar Cane	40,000	7,840	314
Sub-Total	190,000		1,376
2. Orchards	40,000	45,380	1,815
3. Vegetables	10,000	57,400	574
4. Fish	30,000	60,750	1,823
Total	270,000		5,588

Source: JICA

(2) Project Area

a) Relationship between Area to be Newly Irrigated and Water Requirements

Crops/Fish	Area to be Newly Irrigated (ha)	Water Requirements per ha (m3/ha)	Water Requirements (MCM)
	A	B	C=AxB/1E6
1. Upland Crops			
Maize	10,000	4,000	40
Soybean	6,000	5,000	30
Peanut	6,000	4,000	24
Sub-Total	22,000		94
2. Orchards	6,000	11,000	66
3. Vegetables	2,000	6,000	12
4. Fish	2,000	12,000	24
Total	32,000		196

Source: JICA

b) Economic Net Benefit per ha

Crops/Fish	Yields per ha (kg/ha)	Economic Price (baht/kg)	Economic Gross Benefit per ha (baht/ha)	Economic Input Cost per ha (baht/ha)	Economic Net Benefit per ha (baht/ha)
	A	B	C=AxB	D	E=C-D
1. Upland Crops					
Maize	3,500	3.0	10,500	6,195	4,305
Soybean	2,000	8.3	16,600	7,624	8,976
Peanut	1,800	11.4	20,520	9,410	11,110
Sub-Total					
2. Orchards	5,000	16.5	82,500	37,120	45,380
3. Vegetables	10,000	9.1	91,000	33,600	57,400
4. Fish	4,000	27.0	108,000	47,250	60,750
Total					

Source: Agricultural Statistics of Thailand Crop Year 1994/95, Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

Table 9.3.1(3) Estimation of Benefits for Plan A

c) Economic Net Benefit

Crops/Fish	Area to be Newly Irrigated (ha)	Economic Net Benefit per ha (baht/ha)	Economic Net Benefit (baht million)
1. Upland Crops			
Maize	10,000	4,305	43
Soybean	6,000	8,976	54
Peanut	6,000	11,110	67
Sub-Total	22,000		164
2. Orchards	6,000	45,380	272
3. Vegetables	2,000	57,400	115
4. Fish	2,000	60,750	122
Total	32,000		673

Source: JICA

(1) + (2) = 5,588 + 673 = 6,261 (baht million)

Note: It will take some time for farmers to be accustomed to the irrigated farming. So, it is assumed that the realization rate of the benefits after the project is implemented will be 60% in the first year, 80% in the second year and 100% from the third year onward.

2. Benefit of More Urban Water (Annual)

Water to be Newly Available (MCM)	Opportunity Cost of Urban Water Production (baht/m3)	Transmission Loss Coefficient	Economic Benefit (baht million)
A	B	C	D=AxBxC
1,200	4.79	0.7	4,024

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

3. Benefit of More Electricity (Annual)

Water to be Newly Available (MCM)	Water Required to Generate 1 kwh of Electricity (m3/kwh)	Opportunity Cost of Electricity Generation (baht/kwh)	Transmission Loss Coefficient	Economic Benefit (baht million)
A	B	C	D	E=A/BxCxD
2,000	5.8	1.12	0.85	328

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

1. + 2.+ 3. = 6,261 + 4,024 + 328 = 10,613 (baht million)

Table 9.3.2(1) Estimation of Benefits for Plan B

B. Plan B

1. Agricultural Benefit (Annual)

(1) Chao Phraya Basin

a) Relationship between Area to be Newly Irrigated and Water Requirements

Crops/Fish	Area to be Newly Irrigated (ha)	Water Requirements per ha (m3/ha)	Water Requirements (MCM)
	A	B	C=AxB/1E6
1. Dry Paddy	91,000	10,000	910
2. Upland Crops			
Maize	35,000	4,000	140
Soybean	30,000	5,000	150
Peanut	9,000	4,000	36
Sugar Cane	20,000	7,000	140
Sub-Total	94,000		466
3. Orchards	20,000	11,000	220
4. Vegetables	4,000	6,000	24
5 Fish	15,000	12,000	180
Total	224,000		1,800

Source: JICA

b) Economic Net Benefit per ha

Crops/Fish	Yields per ha (kg/ha)	Financial Price (baht/kg)	Economic Price (baht/kg)	Economic Gross Benefit per ha (baht/ha)	Economic Input Cost per ha (baht/ha)	Economic Net Benefit per ha (baht/ha)
	A		B	C=AxB	D	E=C-D
1. Dry Paddy	4,500	4.0	4.3	19,350	9,320	10,030
2. Upland Crops						
Maize	3,500	2.9	3.0	10,500	6,195	4,305
Soybean	2,000	8.0	8.3	16,600	7,624	8,976
Peanut	1,800	9.1	11.4	20,520	9,410	11,110
Sugar Cane	43,300	0.44	0.46	19,918	12,078	7,840
Sub-Total						
3. Orchards	5,000	15.0	16.5	82,500	37,120	45,380
4. Vegetables	10,000	8.0	9.1	91,000	33,600	57,400
5. Fish	4,000	25.0	27.0	108,000	47,250	60,750
Total						

Source: Agricultural Statistics of Thailand Crop Year 1994/95, Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

Table 9.3.2(2) Estimation of Benefits for Plan B

c) Economic Net Benefit

Crops/Fish	Area to be Newly Irrigated (ha)	Economic Net Benefit per ha (baht/ha)	Economic Net Benefit (baht million)
	A	B	C=AxB/1E6
1. Dry Paddy	91,000	10,030	913
2. Upland Crops			
Maize	35,000	4,305	151
Soybean	30,000	8,976	269
Peanut	9,000	11,110	100
Sugar Cane	20,000	7,840	157
Sub-Total	94,000		677
3. Orchards	20,000	45,380	908
4. Vegetables	4,000	57,400	230
5. Fish	15,000	60,750	911
Total	224,000		3,639

Source: JICA

(2) Project Area

a) Relationship between Area to be Newly Irrigated and Water Requirements

Crops/Fish	Area to be Newly Irrigated (ha)	Water Requirements per ha (m3/ha)	Water Requirements (MCM)
	A	B	C=AxB/1E6
1. Upland Crops			
Maize	10,000	4,000	40
Soybean	6,000	5,000	30
Peanut	6,000	4,000	24
Sub-Total	22,000		94
2. Orchards	6,000	11,000	66
3. Vegetables	2,000	6,000	12
4. Fish	2,000	12,000	24
Total	32,000		196

Source: JICA

b) Economic Net Benefit per ha

Crops/Fish	Yields per ha (kg/ha)	Economic Price (baht/kg)	Economic Gross Benefit per ha (baht/ha)	Economic Input Cost per ha (baht/ha)	Economic Net Benefit per ha (baht/ha)
	A	B	C=AxB	D	E=C-D
1. Upland Crops					
Maize	3,500	3.0	10,500	6,195	4,305
Soybean	2,000	8.3	16,600	7,624	8,976
Peanut	1,800	11.4	20,520	9,410	11,110
Sub-Total					
2. Orchards	5,000	16.5	82,500	37,120	45,380
3. Vegetables	10,000	9.1	91,000	33,600	57,400
4. Fish	4,000	27.0	108,000	47,250	60,750
Total					

Source: Agricultural Statistics of Thailand Crop Year 1994/95, Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

Table 9.3.2(3) Estimation of Benefits for Plan B

c) Economic Net Benefit

Crops/Fish	Area to be Newly Irrigated (ha)	Economic Net Benefit per ha (baht/ha)	Economic Net Benefit (baht million)
1. Upland Crops			
Maize	10,000	4,305	43
Soybean	6,000	8,976	54
Peanut	6,000	11,110	67
Sub-Total	22,000		164
2. Orchards	6,000	45,380	272
3. Vegetables	2,000	57,400	115
4. Fish	2,000	60,750	122
Total	32,000		673

Source: JICA

(1) + (2) = 3,639 + 673 = 4,312 (baht million)

Note: It will take some time for farmers to be accustomed to the irrigated farming. So, it is assumed that the realization rate of the benefits after the project is implemented will be 60% in the first year, 80% in the second year and 100% from the third year onward.

2. Benefit of More Urban Water (Annual)

Water to be Newly Available (MCM)	Opportunity Cost of Urban Water Production (baht/m3)	Transmission Loss Coefficient	Economic Benefit (baht million)
A	B	C	D=AxBxC
1,200	4.79	0.7	4,024

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

3. Benefit of More Electricity (Annual)

Water to be Newly Available (MCM)	Water Required to Generate 1 kwh of Electricity (m3/kwh)	Opportunity Cost of Electricity Generation (baht/kwh)	Transmission Loss Coefficient	Economic Benefit (baht million)
A	B	C	D	E=A/BxCxD
2,000	5.8	1.12	0.85	328

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

1. + 2.+ 3. = 4,312 + 4,024 + 328 = 8,664 (baht million)

Table 9.3.3.(1) Estimation of Benefits for Plan C

C. Plan C

1. Agricultural Benefit (Annual)

(1) Chao Phraya Basin

a) Relationship between Area to be Newly Irrigated and Water Requirements

Crops/Fish	Area to be Newly Irrigated (ha)	Water Requirements per ha (m3/ha)	Water Requirements (MCM)
	A	B	C=AxB/1E6
1. Wet Paddy	120,000	2,000	240
2. Dry Paddy	37,000	10,000	370
3. Upland Crops			
Maize	46,000	4,000	184
Soybean	39,000	5,000	195
Peanut	13,000	4,000	52
Sugar Cane	26,000	7,000	182
Sub-Total	124,000		613
4. Orchards	26,000	11,000	286
5. Vegetables	8,000	6,000	48
6 Fish	20,000	12,000	240
Total	335,000		1,797

Source: JICA

b) Economic Net Benefit per ha

Crops/Fish	Yields per ha (kg/ha)	Financial Price (baht/kg)	Economic Price (baht/kg)	Economic Gross Benefit per ha (baht/ha)	Economic Input Cost per ha (baht/ha)	Economic Net Benefit per ha (baht/ha)
	A		B	C=AxB	D	E=C-D
1. Wet Paddy	1,800*	3.7	4.0	7,200	1,860*	5,340
2. Dry Paddy	4,500	4.0	4.3	19,350	9,320	10,030
3. Upland Crops						
Maize	3,500	2.9	3.0	10,500	6,195	4,305
Soybean	2,000	8.0	8.3	16,600	7,624	8,976
Peanut	1,800	9.1	11.4	20,520	9,410	11,110
Sugar Cane	43,300	0.44	0.46	19,918	12,078	7,840
Sub-Total						
4. Orchards	5,000	15.0	16.5	82,500	37,120	45,380
5. Vegetables	10,000	8.0	9.1	91,000	33,600	57,400
6. Fish	4,000	25.0	27.0	108,000	47,250	60,750
Total						

Note: *=(Irrigated) - (Rainfed)

Source: Agricultural Statistics of Thailand Crop Year 1994/95, Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

Table 9.3.3(2) Estimation of Benefits for Plan C

c) Economic Net Benefit

Crops/Fish	Area to be Newly Irrigated (ha)	Economic Net Benefit per ha (baht/ha)	Economic Net Benefit (baht million)
	A	B	C=AxB/1E6
1. Wet Paddy	120,000	5,340	641
2. Dry Paddy	37,000	10,030	371
3. Upland Crops			
Maize	46,000	4,305	198
Soybean	39,000	8,976	350
Peanut	13,000	11,110	144
Sugar Cane	26,000	7,840	204
Sub-Total	124,000		896
4. Orchards	26,000	45,380	1,180
5. Vegetables	8,000	57,400	459
6. Fish	20,000	60,750	1,215
Total	335,000		4,762

Source: JICA

(2) Project Area

a) Relationship between Area to be Newly Irrigated and Water Requirements

Crops/Fish	Area to be Newly Irrigated (ha)	Water Requirements per ha (m3/ha)	Water Requirements (MCM)
	A	B	C=AxB/1E6
1. Upland Crops			
Maize	10,000	4,000	40
Soybean	6,000	5,000	30
Peanut	6,000	4,000	24
Sub-Total	22,000		94
2. Orchards	6,000	11,000	66
3. Vegetables	2,000	6,000	12
4. Fish	2,000	12,000	24
Total	32,000		196

Source: JICA

b) Economic Net Benefit per ha

Crops/Fish	Yields per ha (kg/ha)	Economic Price (baht/kg)	Economic Gross Benefit per ha (baht/ha)	Economic Input Cost per ha (baht/ha)	Economic Net Benefit per ha (baht/ha)
	A	B	C=AxB	D	E=C-D
1. Upland Crops					
Maize	3,500	3.0	10,500	6,195	4,305
Soybean	2,000	8.3	16,600	7,624	8,976
Peanut	1,800	11.4	20,520	9,410	11,110
Sub-Total					
2. Orchards	5,000	16.5	82,500	37,120	45,380
3. Vegetables	10,000	9.1	91,000	33,600	57,400
4. Fish	4,000	27.0	108,000	47,250	60,750
Total					

Source: Agricultural Statistics of Thailand Crop Year 1994/95, Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

Table 9.3.3(3) Estimation of Benefits for Plan C

c) Economic Net Benefit

Crops/Fish	Area to be Newly Irrigated (ha)	Economic Net Benefit per ha (baht/ha)	Economic Net Benefit (baht million)
1. Upland Crops			
Maize	10,000	4,305	43
Soybean	6,000	8,976	54
Peanut	6,000	11,110	67
Sub-Total	22,000		164
2. Orchards	6,000	45,380	272
3. Vegetables	2,000	57,400	115
4. Fish	2,000	60,750	122
Total	32,000		673

Source: JICA

(1) + (2) = 4,762 + 673 = 5,435 (baht million)

Note: It will take some time for farmers to be accustomed to the irrigated farming. So, it is assumed that the realization rate of the benefits after the project is implemented will be 60% in the first year, 80% in the second year and 100% from the third year onward for the area other than the Phitsanulok Stage II area. Regarding the Phitsanulok Stage II area, since it will be newly developed the realization rate of the benefits after project implementation is assumed to be 20% in the first year, 40% in the second year, 60% in the third year, 80% in the fourth year and 100% from the fifth year onward.

2. Benefit of More Urban Water (Annual)

Water to be Newly Available (MCM)	Opportunity Cost of Urban Water Production (baht/m3)	Transmission Loss Coefficient	Economic Benefit (baht million)
A	B	C	D=AxBxC
1,200	4.79	0.7	4,024

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

3. Benefit of More Electricity (Annual)

Water to be Newly Available (MCM)	Water Required to Generate 1 kwh of Electricity (m3/kwh)	Opportunity Cost of Electricity Generation (baht/kwh)	Transmission Loss Coefficient	Economic Benefit (baht million)
A	B	C	D	E=A/BxCxD
2,000	5.8	1.12	0.85	328

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

1. + 2.+ 3. = 5,435 + 4,024 + 328 = 9,787 (baht million)

Table 9.3.4(1) Estimation of Cost

A. Plan A

1. Estimation of Economic Capital Cost

Unit: baht million

Item	Financial Capital Cost	Conversion Factor	Economic Capital Cost
1) Construction Cost	40,708	0.85	34,602
2) Engineering Fee	3,257	0.85	2,768
3) Administration Fee	2,035	0.94	1,913
4) Land Acquisition	1,000	0.94	940
5) O/M Equipment	106	0.85	90
6) Environmental Mitigation	500	0.49	245
Total	47,606		40,558

Source: JICA

2. Estimation of Economic O & M Cost

Unit: baht million

Financial Capital Cost	Financial O & M Cost	Economic O & M Cost
A	B=Ax0.005	C=Bx0.92
47,606	238	219

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

3. Implementation Period and Progress Rates of Works

(1) Implementation Period: 8 years

(2) Progress Rates of Works

1st year	5%
2nd year	10%
3rd year	15%
4th year	15%
5th year	15%
6th year	15%
7th year	15%
8th year	10%

B. Plan B

Same as Plan A

Table 9.3.4(2) Estimation of Cost

C. Plan C

1. Estimation of Economic Capital Cost

Unit: baht million

Item	Financial Capital Cost	Conversion Factor	Economic Capital Cost
1) Construction Cost	47,608	0.85	40,467
2) Engineering Fee	3,809	0.85	3,238
3) Administration Fee	2,380	0.94	2,237
4) Land Acquisition	1,200	0.94	1,128
5) O/M Equipment	124	0.85	105
6) Environmental Mitigation	500	0.49	245
Total	55,621		47,420

Source: JICA

2. Estimation of Economic O & M Cost

Unit: baht million

Financial Capital Cost	Financial O & M Cost	Economic O & M Cost
A	B=Ax0.005	C=Bx0.92
55,621	278	256

Source: Conceptual Planning Report of Kok Ing Nan Water Diversion Project and JICA

3. Implementation Period and Progress Rates of Works

(1) Implementation Period: 8 years

(2) Progress Rates of Works

1st year	5%
2nd year	10%
3rd year	15%
4th year	15%
5th year	15%
6th year	15%
7th year	15%
8th year	10%

Table 9.3.5(1) Cost Benefit Streams

A. Plan A

Legend: CC=Capital Cost; OM=O & M Cost; CS=Cost; BF=Benefits; CF= Cash Flow (=BF-CS)

Unit: baht million

Nth Year	CC	OM	CS	BF	CF
1	2,028	0	2,028	0	-2,028
2	4,056	0	4,056	0	-4,056
3	6,084	0	6,084	0	-6,084
4	6,084	0	6,084	0	-6,084
5	6,084	0	6,084	0	-6,084
6	6,084	0	6,084	0	-6,084
7	6,084	0	6,084	0	-6,084
8	4,056	0	4,056	0	-4,056
9		219	219	8,109	7,890
10		219	219	9,361	9,142
11		219	219	10,613	10,394
12		219	219	10,613	10,394
13		219	219	10,613	10,394
14		219	219	10,613	10,394
15		219	219	10,613	10,394
16		219	219	10,613	10,394
17		219	219	10,613	10,394
18		219	219	10,613	10,394
19		219	219	10,613	10,394
20		219	219	10,613	10,394
21		219	219	10,613	10,394
22		219	219	10,613	10,394
23		219	219	10,613	10,394
24		219	219	10,613	10,394
25		219	219	10,613	10,394
26		219	219	10,613	10,394
27		219	219	10,613	10,394
28		219	219	10,613	10,394
29		219	219	10,613	10,394
30		219	219	10,613	10,394
31		219	219	10,613	10,394
32		219	219	10,613	10,394
33		219	219	10,613	10,394
34		219	219	10,613	10,394
35		219	219	10,613	10,394
36		219	219	10,613	10,394
37		219	219	10,613	10,394
38		219	219	10,613	10,394
39		219	219	10,613	10,394
40		219	219	10,613	10,394
41		219	219	10,613	10,394
42		219	219	10,613	10,394
43		219	219	10,613	10,394
44		219	219	10,613	10,394
45		219	219	10,613	10,394
46		219	219	10,613	10,394
47		219	219	10,613	10,394
48		219	219	10,613	10,394
49		219	219	10,613	10,394
50		219	219	10,613	10,394
51		219	219	10,613	10,394
52		219	219	10,613	10,394
53		219	219	10,613	10,394
54		219	219	10,613	10,394
55		219	219	10,613	10,394
56		219	219	10,613	10,394
57		219	219	10,613	10,394
58		219	219	10,613	10,394

Source: JICA

Table 9.3.5(2) Cost Benefit Streams

B. Plan B

Legend: CC=Capital Cost; OM=O & M Cost; CS=Cost; BF=Benefits; CF= Cash Flow (=BF-CS)

Unit: baht million

Nth Year	CC	OM	CS	BF	CF
1	2,028	0	2,028	0	-2,028
2	4,056	0	4,056	0	-4,056
3	6,084	0	6,084	0	-6,084
4	6,084	0	6,084	0	-6,084
5	6,084	0	6,084	0	-6,084
6	6,084	0	6,084	0	-6,084
7	6,084	0	6,084	0	-6,084
8	4,056	0	4,056	0	-4,056
9		219	219	8,664	6,720
10		219	219	8,664	7,583
11		219	219	8,664	8,445
12		219	219	8,664	8,445
13		219	219	8,664	8,445
14		219	219	8,664	8,445
15		219	219	8,664	8,445
16		219	219	8,664	8,445
17		219	219	8,664	8,445
18		219	219	8,664	8,445
19		219	219	8,664	8,445
20		219	219	8,664	8,445
21		219	219	8,664	8,445
22		219	219	8,664	8,445
23		219	219	8,664	8,445
24		219	219	8,664	8,445
25		219	219	8,664	8,445
26		219	219	8,664	8,445
27		219	219	8,664	8,445
28		219	219	8,664	8,445
29		219	219	8,664	8,445
30		219	219	8,664	8,445
31		219	219	8,664	8,445
32		219	219	8,664	8,445
33		219	219	8,664	8,445
34		219	219	8,664	8,445
35		219	219	8,664	8,445
36		219	219	8,664	8,445
37		219	219	8,664	8,445
38		219	219	8,664	8,445
39		219	219	8,664	8,445
40		219	219	8,664	8,445
41		219	219	8,664	8,445
42		219	219	8,664	8,445
43		219	219	8,661	8,445
44		219	219	8,664	8,445
45		219	219	8,664	8,445
46		219	219	8,664	8,445
47		219	219	8,664	8,445
48		219	219	8,664	8,445
49		219	219	8,664	8,445
50		219	219	8,664	8,445
51		219	219	8,664	8,445
52		219	219	8,664	8,445
53		219	219	8,664	8,445
54		219	219	8,664	8,445
55		219	219	8,664	8,445
56		219	219	8,664	8,445
57		219	219	8,664	8,445
58		219	219	8,664	8,445

Source: JICA

Table 9.3.5(3) Cost Benefit Streams

C. Plan C

Legend: CC=Capital Cost; OM=O & M Cost; CS=Cost; BF=Benefits; CF= Cash Flow (=BF-CS)

Unit: baht million

Nth Year	CC	OM	CS	BF	CF
1	2,371	0	2,371	0	-2,371
2	4,742	0	4,742	0	-4,742
3	7,113	0	7,113	0	-7,113
4	7,113	0	7,113	0	-7,113
5	7,113	0	7,113	0	-7,113
6	7,113	0	7,113	0	-7,113
7	7,113	0	7,113	0	-7,113
8	4,742	0	4,742	0	-4,742
9		256	256	7,309	7,053
10		256	256	8,396	8,140
11		256	256	9,483	9,227
12		256	256	9,635	9,379
13		256	256	9,787	9,531
14		256	256	9,787	9,531
15		256	256	9,787	9,531
16		256	256	9,787	9,531
17		256	256	9,787	9,531
18		256	256	9,787	9,531
19		256	256	9,787	9,531
20		256	256	9,787	9,531
21		256	256	9,787	9,531
22		256	256	9,787	9,531
23		256	256	9,787	9,531
24		256	256	9,787	9,531
25		256	256	9,787	9,531
26		256	256	9,787	9,531
27		256	256	9,787	9,531
28		256	256	9,787	9,531
29		256	256	9,787	9,531
30		256	256	9,787	9,531
31		256	256	9,787	9,531
32		256	256	9,787	9,531
33		256	256	9,787	9,531
34		256	256	9,787	9,531
35		256	256	9,787	9,531
36		256	256	9,787	9,531
37		256	256	9,787	9,531
38		256	256	9,787	9,531
39		256	256	9,787	9,531
40		256	256	9,787	9,531
41		256	256	9,787	9,531
42		256	256	9,787	9,531
43		256	256	9,787	9,531
44		256	256	9,787	9,531
45		256	256	9,787	9,531
46		256	256	9,787	9,531
47		256	256	9,787	9,531
48		256	256	9,787	9,531
49		256	256	9,787	9,531
50		256	256	9,787	9,531
51		256	256	9,787	9,531
52		256	256	9,787	9,531
53		256	256	9,787	9,531
54		256	256	9,787	9,531
55		256	256	9,787	9,531
56		256	256	9,787	9,531
57		256	256	9,787	9,531
58		256	256	9,787	9,531

Source: JICA