4.2.3 Alternative 2-2: Diversion Channel

(1) Cost, Preliminary Design and Implementation Schedule

(a) Economic Cost and Benefit

It is possible to estimate economic cost and benefit for only the following components (refer to Table 4.2.4). The other components are difficult to be evaluated in monetary term.

Project Components	Cost (mil. Baht)	Benefit (mil. Baht)
Modification of Dam Operation Rule	40 as initial cost and 394 as annual cost	6,300/year
Distribution and Drainage System Improvement	5,633 as initial cost and 39 as annual cost	
Diversion Channel	31,402 as initial cost and 167 as annual cost	
River improvement	2,821 as initial cost and 71 as annual cost	
Others	-	-

(b) Preliminary Design and Implementation Schedule

Among the project components, preliminary design is prepared for only structural measures; i.e., the diversion channel, river improvement and distribution and drainage systems improvement.

(i) Preliminary Design

Among the project components, preliminary design is prepared for only structural measures; i.e., the diversion channel and river improvement. As for the distribution and drainage systems improvement, only the area is shown in Fig. 3.3.7 and 3.3.8.

Preliminary design of river improvement is made in the same manner as the case for agricultural area of Alternative 1.

Preliminary design of diversion channel is made in the following manner:

Alignment

The alignment of the diversion channel is set considering the following points:

- Utilization of existing channel passing through lowland area
- Minimization of house relocation

For setting the alignment, photo mosaic map with a scale of 1/50,000 is used. The total length of diversion channel is approximately 96 km. The alignment is shown in Fig. 4.2.6.

Longitudinal Profile

The longitudinal profile is set based on the ground height along the alignment. The ground height is obtained from the topographic map with a scale of 1/50,000 and 1/20,000.

Design water level at the river mouth adopt that of the Chao Phraya river, M.S.L+1.6 m, while the design water level at diversion point is MSL+3.85m. The average gradient of high water level connecting two points is 1/43,000.

Standard Cross Section

The standard cross section is set considering the following points: stability and safety of channel and economic advantage. The compound cross section type is adopted.

Current area is mainly composed from excavated channel to have enough water depth, so that river width can be minimized.

(ii) Implementation Schedule

In principle, the implementation schedule is prepared considering the following points:

- Flood damage in paddy field playing a natural retarding function can be mitigated with less cost as long as detailed study for preparation of guideline and improvement of necessary facilities are finished. Thus, high priority is given to the implementation.
- River improvement can be implemented up to the level with 10-year return period by minimizing the adverse influence to Bangkok through the utilization of effectiveness of natural retarding basin. Thus it can be given higher priority. (In case the river improvement is implemented without distribution system improvement, it is necessary to provide a fuse to minimize the adverse influence by the river improvement.)
- However, to further enhance the protection level for agricultural areas, the river improvement should be implemented under the condition that diversion channel is completed to absorb the adverse influence to the area downstream, especially BMA.
- In this connection, the implementation of river improvement to enhance the protection level from 10-year to 25-year return period should be started after the diversion channel is ready to absorb the adverse influence.
- As for the protection works for Pathum Thani and Nonthaburi by PWD, they should be undertaken considering the progress

of diversion channel Stage 1 to assure the safety level of Bangkok.

Under the above considerations, the implementation schedule is prepared, as shown in Fig. 4.2.7.

(2) Evaluation of the Master Plan

(a) Economic Evaluation

As well as Alternative 1, the economic evaluation is made only for project components that can be evaluated in monetary term based on the economic cost and benefit mentioned above. The evaluation is made in a manner of EIRR, B-C and B/C, and the results are as shown below (refer to Table 4.2.5):

- EIRR =12.0%
- B-C = 1,427 million Baht
- B/C = 1.1

As identified, the economic viability is not so high, but the EIRR value is slightly over 12%, which is regarded as the minimum of project viability.

Also, the project brings about many intangible benefits such as stabilization of people's living condition, decrease of waterborne diseases, increase of work opportunity and so on.

From the financial point of view, the project requires about 2.6 billion Baht per annum for the implementation within 20 years, which roughly corresponds to 2.7% of the total annual budget of 96.5 billion Baht for RID (44.4 billion Baht), PWD (39.8 billion Baht) and BMA (12.3 billion Baht). Although it may be difficult to designate the allowable percentage of allocation of the total budget, it seems to be still within the financial affordability of these agencies, judging from the figure (refer to Table 4.2.3).

(b) Technical Soundness and Social Acceptability

The project components are based on the conventional structural measures such as excavation and embankment. These measures do not face any technical difficulty.

On the other hand, diversion channel and river improvement may have social issues due to relocation of inhabitants in the areas where these measures are proposed. In this connection, it is natural to obtain a favorable public opinion for the decision on project implementation through meetings and seminar, so that the inhabitants can fully understand the significance and necessity of the project. By this, it seems to be possible to receive social acceptability.

(c) Environmental Sustainability

Initial Environmental Examination (IEE) has been conducted for the structural measures of project components to confirm the environmental sustainability of the Master Plan; i.e., the natural retarding basin, river improvement and diversion channel. IEE was conducted based on the customized parameters prepared in this study.

As the result, the IEE found that natural retarding basin, river improvement and diversion channel may not have significant impacts from the ecological point of view, but may have impacts on sites and the surroundings from the social point of view. Therefore, it is crucial to pay attention to soften such social impacts and it is assumed that the solution is obtainable through continuous communication with the affected people.

4.3 Selection of Project Components for the Feasibility Study

Priority projects are selected for the Feasibility Study. As shown in the implementation schedule in Figs. 4.2.4, 4.2.5 and 4.2.7, it is proposed to implement or sustain most of the project components of the Master Plan. However, in case of Alternative 2-1, heightening of flood barrier and in case of Alternative 2-2, diversion channel (Stage 1 and Stage 2) and river improvement (Stage 2) are excluded according to the urgent necessity.

Among the project components that should be promptly implemented, some are not necessary to conduct the feasibility study, because they are now under preparation stage for implementation by the Government or they should be studied in other projects judging from the project features.

Under such consideration, the following project components are selected for the Feasibility Study:

- *Nonstructural Measures:* Land use control and guidance based on flood risk map, modification of reservoir operation rule, and institution and organization.
- *Structural Measures:* River improvement (Stage 1)

Regarding the partial protection of Pathum Thani and Nonthaburi, it is proposed that PWD conduct the project in the context of the currently ongoing study.

As for distribution and drainage systems improvement, it is recommended that the local government undertake the study for the following reasons:

- The area for distribution and drainage systems improvement covers a wide area of about 6,600 km^2. In the area, the irrigation and drainage systems are composed of a tremendous number of channels and the paddy field is divided into a huge number of units.
- To further examine the effectiveness of distribution and drainage systems improvement, it is necessary to prepare a detailed topographic map including such irrigation and drainage systems.

- Furthermore, a new hydraulic calculation model to reflect such area conditions needs to be developed.
- It will take a long time to cover such works including topographic survey and development of new model, while the scheduled study period is very limited, so that enough study is hardly undertaken.
- On the other hand, the effectiveness of distribution and drainage systems improvement can be confirmed through daily practice of operation and management and development of the system can be gradually promoted confirming the effectiveness. For the purpose, the basic study by area should be conducted, but it is not included in the Feasibility Study.

4.4 Study on Possibility of Water Resources Development of Structures Proposed for Flood Mitigation

In this study, the several measures are proposed for flood damage mitigation and some of them may also be used for water resources development purposes, especially irrigation. Among the proposed measures, preservation of the natural retarding area with the capacity of 16 billion m^3 and the diversion channel have the potential for water resources development purposes. Since the stored water in the former measure, practically, is currently used for irrigation purposes, the former measure may not be considered as a new facility for water resources development, while the latter one is a newly proposed facility.

In this connection, the effectiveness of the diversion channel, when used for water resources development, is examined as follows:

(1) Storage Capacity of Diversion Channel

The storage capacity of diversion channel is roughly calculated in the following equation:

- $V_n = B_n \times L_n \times (h_{n1} + h_{n2})/2$
- $V = \Sigma V_n$

Where,

V_n , V (m^3): Storage Volume of Diversion Channel in Section (n) and the Whole Section, respectively

B_n , L_n (m): Width and Length of Diversion Channel in Section (n)

h_{n1} , h_{n2} (m): Storage Water Height at both upper and Lower Terminal End in Section (n)

According to the calculation, the proposed diversion channel can store the volume of 55 million m^3.

(2) Benefit of Water Resources Development

The above storage water volume of 55 million m^3 will provide benefit in a manner of increase of rice production as shown below:

- *Increase of Irrigation Area:* 55 million m^3/21,000 m^3/s (unit irrigation water supply volume) = 2,600 ha
- *Increase of Rice Production:* 2,600 x 5,900 Baht/ha (net benefit of rice production) = 15.3 million Baht

The benefit of 15.3 million Baht/year is expected through the water resources development using the diversion channel as the storage facility.

(3) Cost for Utilization of Diversion Channel as Storage Facility

As the major additional facility for water resources development, only the pump to extract water from diversion channel is considered. The cost of installation of the pump is estimated in the following manner:

- The required pump capacity is approximately 10 m^3/s, assuming that the volume of 55 million m^3 is extracted for 1,000 operation hours. (100 irrigation days x 10 hours/day)
- The cost of pump is about 120 million Baht, applying the unit cost of 12 million Baht/m^3.

(4) Economic Viability

Based on the above cost and benefit, EIRR is estimated to be 12%, assuming that the construction period is 2 years. Thus, the utilization of diversion channel as storage facility for water resources development is economically viable.

Tables

Table 1.3.1 HISTORICAL CHANGE IN CHAO PHRAYA RIVER BASIN

Year	General Features of the Basin	Characteristics of River Basin				Population		Major Hydro-logical Event	Construction of Major Facilities
		Forest Area	Flood Protection Area*1	Cultivated Area	Urban develop-ment*2	Bangkok	River Basin		
before 1950	The basin was in a comparatively undeveloped state the forests in the upstream were largely untouched	166,000 km^2	2,230 km^2	0.7 mil. ha	51km^2				
1950 to 1970	Basin Development had been promoted converting the forest area to agricultural land		5,700 km2	1.7 mil. ha	100 km2	2.25 million in 1960	13.47 million in 1960		Construction of Chai-nat Dam (1957) and Bhumibol dam
1970 to 1980	Agriculture development had been promoted through construction of irrigation facilities and ring levee had been constructed to protect paddy field from flood		12,900 km2		200 km2	4.23 million in 1975	17.51 million in 1970		Construction of Sirikit dam and Kiu Lom dam (1972)
1980 to 1990	Protection works for paddy field from flood had been implemented and area of traditional paddy like floating rice had been converted to high yield crops	106,000 km^2	12,900 km^2	3.5 mil. ha	389 km^2	5.72 million in 1988	22.70 million in 1980	1983 Flood, 1986/87 Drought, 1987/88 Drought	Construction of Kho Laem Dam and King's dike (1984)
to present	Urbanization as well as industrial development has been promoted	92,000 km^2	14,400 km^2		528 km^2	5.57 million in 1993	27.42 million in 1990	1992/93 Drouht 1995 Flood, 1996 Flood	

*1 : Northern and Central Regions of Thailand (Source : Chao Phraya Flood Management Review)
*2 : Bangkok area only (Source : Chao Phraya Flood Managgement Review)

Table 1.3.2 MAJOR FLOOD EVENTS

Year	Maximum Discharge at Nakhon Sawan (C.2) (m^3/s)	Maximum Discharge at Chainat (C.13) (m^3/s)	Maximum Water Level at Ayutthaya (S.5) (m^3/s)	Maximum Water Level at Memorial Bridge (C.4) * (m MSL)
1942	n.a.	n.a.	5.15	2.27
1978	3,540	3,770	4.60	1.99
1980	4,350	3,800	4.70	1.92
1983	2,290	3,290	4.54	2.04
1995	4,820	4,550	5.00	2.20
1996	3,100	3,250	4.38	2.12

* : After adjustment

Table 1.3.3 **SUMMARY OF FLOODING CONDITION**

Area	Geographical Features	Land Use	Flooding Condition In 1995	Cause of Flooding	Flood Damage in 1995
Upper Central Plain (Upstream of Nakhon Sawan)	Valley plain between hilly areas with gentle slope in the east and west.	Main land use : Paddy (Traditional varieties are dominant, but HYV is applied in Phitsanulok Irrigation Area protected by dikes) Major urban area : Uttradit, Phitsanulok, Sukhothai, Phichit	Inundation Area : 5,000 km^2 Depth : 0.5 to 3 m Duration : 2 to 3 month (in some depression areas inundation continued more than 3 months up to January next year)	• Overtopping of Yom and Nan rivers • Inland flood • Overland flow from upstream • Flash flood from upper mountainous area	Agricultural Damage More than 50% of Phitsanulok project was protected.180,000 ha of paddy field was damaged. Urban Area Damage Sukho Thai, Phitsanulok, Phichit are seriously damaged. Infrastructure Roads, bridges, irrigation facilities including regulators and canal embankment were damaged.
Nakhon Sawan Area (between Nakhon Sawan and Chainat)	Narrow valley plain with number of isolated mountains	Main land use : Paddy (Traditional varieties are dominant) Major urban area Nakhon Sawan, Uthai Thani	Inundation Area : 500 km^2 Depth : 0.5 to 3 m Duration : 1 to 2 month	• Overtopping of Chao Phraya River • Overtopping of Sakae Krang River caused by back water from Chao Phraya River • Inland flood • Overland flow from upstream	Agricultural Damage Paddy fields of 160,000 ha and 10,000 ha were damaged in Nakhon Sawan and Uthai Thani respectively. Urban Area Damage Nakhon Sawan and Uthai Thani were severely damaged. Infrastructure Damage Roads were damaged
Higher Delta in Lower Central Plain (between Chainat and Ayutthaya)	Natural levees and back marshes are well developed.	Main land use : Paddy (HYV is dominant but floating rice and deep water rice are dominant in habitually inundated area) Major urban area : Chainat, Sin Buri, Angthong, Ayutthaya, Supan Buri, Lop Buri	Inundation Area : 4,600 km^2 Depth : 0.5 to 4 m Duration : 2 to 3 month (in some depression areas inundation continued more than 3 months up to January next year)	• Overtopping and dike breaches along Chao Phraya, Nan, Lopburi, Tha Chin, Pasak rivers • Inland flood • Overland flow from upstream	Agricultural Damage Total 190,000 ha of paddy field including 50,000 ha in Maharat Project Area was damaged. Urban Area Damage Chainat, Sin Buri, Angthong, Ayutthaya and Suphan Buri are severely damaged. Infrastructure Damage Roads, bridges, irrigation facilities including regulators and canal embankments are damaged
Lower Delta in Lower Central Plain (downstream of Ayutthaya)	Very flat	Main land use : Paddy (HYV rice) is main but urban areas are expanding rapidly Major urban area : Bangkok, Pathum Thani, Nonthaburi Samut Prakan	Inundation Area : 4,700 km^2 Depth : 0.5 to 2 m Duration : 2 to 3 month	• Overtopping of Chao Phraya and Tha Chin rivers • Dike breach • Inland flood • Overland flow from upstream	Agricultural Damage 40,000 ha of paddy field and 10,000 ha of other crop fields were damaged. Urban Area Damage Pathum Thani, Nonthaburi, Samut Prakan are damaged. Infrastructure Damage Roads, irrigation facilities including regulators and canal embankments are damaged

Table 1.4.1 LIST OF PREVIOUS PLANS FOR FLOOD MITIGATION AND DRAINAGE WORKS

Study/Project on Flood Control	Contents	Agency	Year
Greater Bangkok Plan	Two perimeter canals on the east and west side of the city, Zoning to give high level of protection (Polder system), Short cut of Chao Phraya river	Lidchfield, Whiting , Bowne & Ass. Adams Howared and Greely	1960
Camp, Dresser Mckee Plan	Polder system of 460 km2 with size of polder ranging from 11 to 100 km2	Camp, Dresser Mckee	1968
City Core Project	Protection of an area of 86 km2 on the east bank of the Chao Phraya River : Major protection barrier by 100-y protection and Expected land subsidence in 5 years	Nedeco and Land Marin/Span	1984
Master Plan for Eastern Suburban-Bangkok	A polder system with pumps, diversion gates, and retention ponds for the mastar plan area of 500 km2	JICA	1985
The RID-Plan	Protection of a large area on the west side of the Chao Phraya.The system constited of the construction of dikes enclosing the area between the Chao Phraya River and Tah Chin River	RID	1985
Study on Tawee Wattana by AIT	Proteciton of the western side of the Chao Phraya River to the Tha Chin River for 500 km2. Polder dikes were proposed in line with the 1985 RID Plan	AIT	1985
Alternative Flood Control Schemes	By-pass channel with a 500 m3/s capacity along the east bank of the Chao Phraya river from Ban Mai to the sea, construction of dikes from Bangsia to river mouth and dredging from Pakkret to the esturary	AIT	1985
Chao Phraya 2	Construction of diversion Channel, eastern boundary dike, control structure at Bangsai and sea barrier structure	AIT and Austrarian Consultant	1986
Master Plan for Flood Protection and Drainage of Thonburi and Samut Prakan	Flood protection of a study area of 432 km2 on the west side of the Chao Phraya river: Construction of new or raising of existing flood barriers around the study area and construciton or rehabilitation of tegulators and flood gates in the klongs.	Nedeco and Span co, ltd.	1987
F/S for the Lower Chao Phraya West Bank Area Development Project	Sustainable development of RID West Bank projects and protection of the area by dike and drainage improvement	Team, AAC, Sanyu and AIT	1992
Chao Phraya Flood Management Review	Identification of high priority flood management projects for on-going and planned flood management initiatives and preparation of a conceptual program for basin-wide flood management.	AIT, DHI and ACRES	1996
M/P for the flood protection and Drainage system in Eastern sub-Urban Bangkok	Proteciton of the 650 km2 of BMA area between the Chao Phraya river in the west and King's dike in the east by improving the existing barriers along the Chao Phraya River and Kings's dike through the establishment of the design crest elevation.	Nedeco, Span co., ltd. and WDC co., ltd.	1997

Table 1.4.2 **MAJOR FEATURES OF THE PREVIOUS PLANS FOR FLOOD MITIGATION AND DRAINAGE WORKS**

Project	Organization	Year	Main Scheme	Project Scale = Return period of flood	Target Yea	Design Dischar	Design Water Level (m)	Crest Height, Freeboard (m)	Flood studied (year)
Greater Bangkok Plan	Litchfield, et al	1960							
Camp, Dresser, McKee Plan	Camp, Dresser and McKee	1968							
City Core Project	NEDECO, Land Marine / Span	1984		100 year			+2.27 MSL (Memorial Brdg)		
Master plan for Eastern Suburban	JICA for BMA	1985	Pump, Drainage system	100 year	2000	1500	+1.9~+2.2MSL		1942, 1980, 1983
Bangkok Flood Control Management	BPLC for NESDB	1985		100 year			+2.1 MSL (Memorial Brdg)		
RID Plan	RID	1985							1983
Tawee Wattana Study	AIT for BMA	1985		100 year			+2.2 MSL (Memorial Brdg)		1978, 1980, 1983
Alternative Flood Control Schemes	AIT for NESDB	1985	Greenbelt by-pass Loop-cut	10 year (rural) 100 year (urban)			+2.2 MSL (Memorial Brdg)	0.5 (FB)	1983
Chao Phraya 2	TAC, AIT for BMA	1986	Sea barrier, Dike and Pump	100 year	2001	3600 (Bangsai)	+2.2~+4.0 MSL	n.a.	1986
Master plan for Flood Protection and Drainage in Thonburi and Samut Prakan	NEDECO, Span for BMA	1987	Pump, Drainage system	100 year	2000, 201	n.a. (1942 flood =75 year r.p. = 3000m3/s)	+1.2~+2.3 MSL	0.3 (FB)	1983
Flood Control Bangkok and Vicinity	Sverdrup for BMA	1988	Selection of formaer schemes	n.a.	1990	n.a.	n.a.	n.a.	n.a.
Lower Chao Phraya West Bank Area Development project	Team, AIT etc. for RID/ADB	1992	Dike for rural area	10-25 year for rural area	2006	-	+2.4MSL(Non Thaburi) +4MSL(Bangsai)	0.50 (FB)	n.a.
ESUB	NEDECO for BMA	1996	Flood Proteotion Dike Drainage System	100 year and 5 year	2016	Approx. 3500	+1.90~2.75MSL (Bangkok Port~Non Thaburi)	0.50(FB) + 0.20(Land Subsidence)	n.a.
Chao Phraya Flood Management	AIT for NESDB/WB	1996	Flood Management	100 year (urban) Less than 10 years (rural)	-	-	-	-	mainly 1995

Table 1.4.3 ON-GOING FLOOD PROTECTION WORK BY BMA

Crest Elevation of Flood Barrier Under Construction (El. m)		
	NEDECO	BMA Final
Kh. Bang Khen to Krungthon Br.	3.10 - 3.20	3.00
Krungthon Br. to Memorial Br.	3.00	2.80
Memorial Br. to Taksin Br.	2.90	2.75
Taskin Br. to Rama IX Br.	2.80	
Rama IX Br. to Wat Yothin Paradit	2.60	

Discharge of Existing Pump	(m3/s)
Core City and Eastern Sub-Urban	452.22
Tomburi (West Bank)	239.80
Total	692.02

Table 1.4.4 **SUMMARY OF FLOOD PROTECTION STUDIES FOR SEVEN PROVINCES**

Location	Municipality, Sanitary District	Area (km^2)	Population	Pump Capacity (m^3/s)	Dike Elevation (MSL)	Freeboard (m)	Return Period		Construction Cost (M. B)	Implementation Year	Remarks
							Drainage	Dike			
Nakhon Sawan P. Capital	Province										
	Nakhon Sawan	28.0	109,708								
F/S Area	7-Area	136.3	-	-	-	-	-	-	4,835.60	1998-2009	
	Nakhon Sawan	124.8	145,510	-	29.0	1.0	5	100	4,394.00	1998-2009	& Vicinity
	Chumsaeng Muni.	2.4	11,690	-	-	-	-	-	90.00	2003-2004	Nan River
	Lat Yao SD	1.6	-	-	-	-	-	-	69.00	2003-2004	Far from the River
	Kao Leio SD	1.5	-	-	-	-	-	-	48.30	2003-2004	Ping River
	Krok Phra SD	2.8	-	-	-	-	-	-	48.70	2003-2004	Chao Phraya River
	Phayuha Khiri SD	1.8	-	-	-	-	-	-	48.60	2003-2004	Chao Phraya River
	Banphot Phisai SD	1.5	-	-	-	-	-	-	137.00	2006-2007	Ping River
D/D Area	Nakhon Sawan	21.0	103,400	115.5	29.0	1.0	5	100	1,687.00	1998-2002	Area No.1
Chainat P.Capital	Province										
	Chainat	6.1	15,872								
F/S Area	2-Area	88.8	39,989	12.2			5	100			
	Chainat	56.5	35,300	-	20.2~18.1	0.43~0.37	5	100	-	-	
	Watsing Muni.	32.3	4,689	-	-	-					
D/D Area	5-Area	19.6	29,012	5.0	-	-	5	100			
	Chainat	4.0	16,131	1.1					82.01		
	Ban Kluay	7.2	4,498	1.1					54.17		Chainat
	Tha Chai	3.1	2,589	1.1					63.53		Chainat
	Had Tha Sao	3.3	1,772	0.7					56.92		Chainat
	Watsing Muni.	2.0	4,022	1.0					62.43		
Sing Buri P.Capital	Province										
	Sing Buri	7.8	21,232								
F/S Area	3-Area	26.7	-	21.5			5	100	3,229.74	1998-2009	
	Sing Buri	14.9	-	15.7	13.3	0.5			2,009.76	1998-2009	
	In Buri SD	7.3	-	3.4	-	-			754.83	1999-2009	
	Phoom Buri SD	4.5	-	2.4	-	-			465.15	2002-2009	
D/D Area	Sing Buri / 4-SA	11.1	-	14.5	13.3	0.5	5	100	1,144.00	1998-2009	SA= Sub-area
Ang Thong P.Capital	Province										
	Ang Thong	6.2	11,662								
F/S Area	2-Area	50.8	-	-							
	Ang Thong	24.0	-	-	9.0	0.2	5	100	2,378.80	1999-2006	
	Pamok Muni.	26.9	17,368	25.5	-		5		2,176.11	2001-2008	
D/D Area	Ang Thong	7.0	-	24.0	9.0					1999-	
Ayuthaya P.Capital	Province										
	Ayuthaya	14.0	70,623								
F/S Area	Ayuthaya	37.0	76,576	75.5	6.5	0.5	5	100	1,564.00	-	
D/D Area	2-Area	18.4	64,228	39.5	6.5	0.5	5	100	591.91	1999-2002	
	Ko Muang	13.0	53,200	27.5	-	-	-	-	419.39	1999-2001	to Phu Kao Thong
	Ayuthaya	5.4	11,028	12.0	-	-	-	-	172.52	2001-2002	
Pathum Thani P.Capital	Pathum Thani	7.1	14,680								
F/S Area	3-Area	119.3	-	49.5	3.9	0.6	5	100	3,133.89	1999~2005	L. Sub:0.2 m
	Pathum Thani	8.8	-	16.5	-	-	-	-	434.79	1999~2000	West Bank
	Bang Pho Thai	71.1	-	51.0	-	-	-	-	1,472.88	2003~2005	West Bank
	Bang Luang	39.5	-	51.0	-	-	-	-	1,226.22	2000~2002	East Bank
Nonthaburi P.Capital	Nonthaburi	38.9	251,468								
F/S Area	2-Area					0.3	5	100		1998~2006	L. Sub. :0.2 m
	West Bank	150.0	237,000	94.5	2.85~3.35						
	East Bank	-	-	139.5	2.85~3.00						

Note; Return Period : Unit = year, SD= Sanitary District, M.B= Million Bahts, L. Sub. = Land Subsidence

Table 1.4.5 **Disbursement for Flood Protection and Drainage Region Office 3, 7, and 8**

(million Baht)

	1995 Regular	1996 Additional	Emergency	Total	(Total)
Region 3	170.8	-	-	170.8	67.3
Region 7	153.2	662	19.9	835.1	147.1
Region 8	381	156	49.8	586.8	19.3
Equipment	-	125.6	7.5	133.1	-
Total	705	943.6	77.2	1,725.80	233.6

Source: RID

Table 1.4.6 CHARACTERISTICS OF BARRAGE KM. 205 AND BARRAGE KM. 345

Item	Barrage km. 205	Barrage km. 345
River around Headwork Area	T. Phra Ngam A. Phrom Buri C. Sing Buri	T.Nam Song A. Phayuha Khiri C. Nakhon Sawan
Elevation of River Bank (m. MSL)	9-10	21-22
Elevation of River Bed (m. MSL)	-1	12.5
River Width (m)	150	200
Headwork Area		
Width of Diversion Canal (m)		
Upstream/Downstream	215/235	410/305
at Barrage Site	244	370
Flow Control Structure		
No. of Control Gates	12	20
Width of Control Gate	12.5	20
Sill Level (m. MSL)	-1	12.5
Level of Upper Edge of Sluice Gate when Closing (m. MSL)	10	22
Level of Lower Edge of Sluice Gate when Closing (m. MSL)	13	23
Drainage Capacity (m3/s)	4120	4564
Level of Roadway Bridge Surface	15.3	26.9
Width of Roadway Bridge	6	6
Max. Storage Level (m. MSL)	12.03	21.72
Storage Level (Dry/Rainy Season) (m. MSL)	9.00/8.00	21.00/20.00
Min. Downstream Water Level (m. MSL)	1.15	15.5
Max. Downstream Water Level (m. MSL)	11.9	21.5
Max. Flow (50 years return period (m3/s))	4120	4560
Designed Flow for Downstream Demand (m3/s)	80	200
Navigation Lock (number)	1	1
Width (m)	14	14
Length of Lock Chamber (m)	165	135
Downstream Sill Level (m)	-3	11
Fish Ladder (Number)	2	2
Width (m)	4	4
Slope	1:10	1:10
Hydropower Plant		
Type of Turbine	pit turbine	pit turbine
Designed Head (m)	6	4
Designed Flow (m3/s)	160	440
Installed Capacity (MW)	8.05	14.76
Average Hydropower (million units/year)	47.15	98.6
Closure Dam		
Creast Level (m. MSL)	13.5	22.8
Width of Road on the Crest (m)	6	6

Table 1.5.1 **GENERAL FEATURES OF STORAGE DAMS IN CHAO PHRAYA RIVER BABIN**

LARGE SCALE DAMS

Name of Dam	Bhumibol	Sirikit	Mae Ngat	Mae Kuang	Kiu Lom	Mae Chang	Krasieo	Pasak	Kaeng Sua Ten	Kwae Noi	Mae Wong	Kiu Kho Ma	Mae Khan	Nam Khek
Purpose	I; P; F	I; P; F	I	I	I	I	I	I; P	I; F; P	I; F; P	I	I; S	I; F	I
Under operation by	EGAT	EGAT	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID
Name of River	Ping	Nan	Ping	Ping	Wang	Ping	Chao Phraya	Pasak	Yom	Kwae Noi	Salae Krang	Wang	Mae Khan	Nam Khek
Drainage area (km2)	26,386	13,130	1,281	569	2,700	426	1,200	12,929	3,583	4,254	612	1,275	1,085	854
Active storage volume (million m3)	9,662	6,660	255	249	106	30	201	772	1,125	733	250	192	165	345
- ditto - (mm)	366	508	199	438	39	70	168	60	314	172	409	150	152	404
Existing/under constructing/proposed	E	E	E	E	E	E	E	E	P	P	P	P	P	P

Note: I = Irrigation; P = Power Generation; F = Flood Control; S = Water Supply

MEDIUM SCALE DAMS

Name of Dam	Mae Tub	Mae Yao	Mae Arb	Mae Prik	Mae Kam	Khlong Khang	Huai Head	Khlong Tron	Nam Haeng	Huai Mae Khon	Huai Mae Kon	Khlong Khayang	Khlong Prai	Nam Lai	Khlong Khlung	Mae Song
Purpose	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Under operation by	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID
River	Ping	Wang	Wang	Wang	Yom	Yom	Nan	Nan	Nan	Ping	Ping	Ping	Ping	Ping	Ping	Yom
Drainage area (km2)	126	35	35	45	59.2	28	40	265	277	34	44	20	51	74	95	305
Active storage volume (million m3)	39	3.2	7.5	3.8	9.6	9.5	2.7	52	10.2	3.7	4.85	4.6	13	15	18	53.2
- ditto - (mm)	309	91	214	84	162	339	58	196	37	109	110	230	254.9	202.7	189.5	174
Existing/under constructing/proposed	E	E	E	E	E	E	E	E	E	P	P	P	P	P	P	P

Note: I = Irrigation; P = Power Generation; F = Flood Control; S = Water Supply

SMALL SCALE DAMS

Name of Dam	Mae Tang	Huai Mae Song	Huai Ta Pae	Mae Moc	Wang Daeng	Mae Sai	Huai Suang	Mae Khong	Mae Khaning	Huai Nam Klung	Khlong Chomphu	Mae Chaery	Khlong Pho	Huai Nam Dung	Huai Kan Yao
Purpose	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Under operation by	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID
River	Yom	Yom	Yom	Yom	Yom	Yom	Yom	Yom	Nan	Nan	Nan	Nan	Sakae Krung	Sakae Krung	Sakae Krung
Drainage area (km2)	120	60	287	728	179	177	47	70	229	148.2	364	18	376	45	65
Active storage volume (million m3)	28.1	11.4	58	80	12	24.3	5.6	7.7	62	12.4	43	4.3	67.5	5	5
- ditto - (mm)	234	190	202	110	67	137	119	110	271	84	118	239	180	111	77
Existing/under constructing/proposed	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Note: I = Irrigation; P = Power Generation; F = Flood Control; S = Water Supply

Table 1.5.2 PRINCIPAL FEATURES OF EXISTING/PROPORSED LARGE DAM

Project Name	(unit)	Bhumibol	Sirikit	Mae Ngat	Mae Kuang	Kiu Lom	Mae Chang	Thap Salao	Pasak	Kaeng SuaTen	Kwae Noi	Mae Wong	Kiu Kho Ma	Mae Khan
Purpose		I; P; F	I; P; F	I	I	I	I	I	I; P	I; F; P	I; F; P	I	I; S	I; F
Under operation by		EGAT	EGAT	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID	RID
Location														
Local Community		A Sam Ngao,C Tak	A Tha Pla,C Uttaradit	A Mae Taeng,C C Chiang Mai	A Doi Saket,C C Chiang Mai	A Muang,C Lampang	A Mae Moh,C Lampang	A Lan Sak,C Uthai Thanee	A.Phattana Nikhom ,o Lopburi	A.Song,C Phrae	A.Wat Bot,C Phitsanulok	A.Ladyao, o Nakorn Sawan	A.Chai Ham Lampang	A.san Pa Tong C Chiang Mai
River		Ping	Nan	Mae Ngat	Ping	Wang	Mae Chang	Sakae Krang	Pasak	Yom	Kwae Noi	Salao Krang	Wang	Mae Khan
Latitude	(M)	17-14-31	17-16-05	19-09-45	18-56-32	18-31-19	18-18-14							
Longitude	(E)	98-58-31	100-33-15	99-02-35	99-07-11	99-37-34	99-48-42							
Hydrology														
Drainage area	(km2)	26,386	13,130	1,281	569	2,700	426	534	12,929	3,583	4,254	615	1,275	1,085
Annual inflow	(MCM)	5,256	5,600	293	206	588	54.3	202	2,100	933	1,449	221	265	181
	(mm)	199.2	427.5	228.9	362.0	217.8	190.5	378.3	162.4	260.4	340.6	361.1	207.8	166.8
Reservoir														
Max. water level	(m M.S.L)	260.0	166.0	400.0	385.0	285.0	354.0	159.0	43.3	261.0	130.0	207.5		381.8
Normal water level	(m M.S.L)	260.0	162.0	396.0	385.0	285.0	352.0	157.0		258.0		204.5	352.0	380.0
Min. water level	(m M.S.L)	213.0	128.0	360.0	350.0	263.0	340.0	142.0	32.5	210.0	90.0	180.0		328.8
power operation		213.0	128.0	-	-	-	-	-						
irrigation		202.5	105.75	360.0	350.0	263.0	340.0	142.0	32.5	210.0	90.0	180		328.8
Storage														
max. water level	(MCM)	13,462	10,508	325	263	112	-	198						
normal water level	(MCM)	13,462	9,510	265	263	112	109	160	785	1,175	769	250	192	75
min. water level	(MCM)	3,800	2,850	22	14	4	16	8	13	50	36	20	12	4
Active storage volume	(MCM)	9,662	6,660	255	249	106	30	152	772	1,125	733	230	180	71
	(mm)	366.2	508.4	199.1	437.6	39.3	70.4	284.7	59.7	314	172.3	375.8	141.1	152.1
Surface area	(km2)	316.0	260.0	16.0	12.0	16.0	12.3	19.0	148.8	65.0	40.5	17.6		13.0
Dam														
Type		Gravity arch	Earthfill	Earthfill	Earthfill	Gravity	Rockfill	Earthfill	Earthfill	Concrete	Rockfill	Rockfill	Rockfill	Earthfill
Height	(m)	154.0	113.6	59.0	61.0	26.5	40.0	26.8		83.0	80.0	57.0	47.0	65.0
Crest elevation	(m M.S.L)	261.0	169.0	404.0	400.0	286.5	356.0		46.2	263.7	135.0	211.0		385.0
Crest length	(m)	486.0	800.0						70.0	545.0	2630.0			
Spillway														
Type		Tunnel type	2 Tunnels,						over flow	over flow	over flow			
Crest elevation	(m M.S.L)	242.9	150.5	393.8	-	-	347.0		35.0	258.0	118.5			380.0
Control gate		Radial Gate	Radial Gate								Radial G.			
		11.0m(w)*	11.85m(w)*								13.0m (W)			
		17.4m(h)*4	15.0m(h)*2								*12.0m *5			
Design flood peak inflow	(m3/s)		10,500	3,174	1,470	2,900	1,056		2,967	5,600	8,252	1,770		
Design flood volume	(MCM)	7,670	4,643	261	-	-	-	-						
Max. discharge capacity	(m3/S)	6,000	3,250	1,035		3,000	440		3,497	3,300	7,046		2,385	1,619
Intake structure														
Intake gate		Fixed Wheel	Fixed Wheel											
Gate size		4.2m(w)*	6.0m(w)*								Fixed Wheel			
		6.7m(h)*7	8.5m(h)*1								5.0m (W)*			
Base elevation of inlet		201.0	105.75								5.5m (h) * 1			
Power station										200.0	90.0			
Installed capacity		70MW*6	125MW*4											
		+128MW								48MW*1	19MW*2			
Discharge of power outlet														
- At max. head	(m3/s/UNIT)	75.8	194.3											
- At nor. head	(m3/s/UNIT)	69.5	175.0							107.0	44.0			
- At min. head	(m3/s/UNIT)	61.0												
Produced Annual Energy	(GWh)	1,560	1,200						47	94	150			

Note: I = Irrigation; P = Power Generation; F = Flood Control
Source: RID

Table 1.5.3 **DAM RESERVOIR VOLUME IN THE CHAO PHARAYA RIVER BASIN**

River Basin	Drainage Area of River Basin	Number of Dam Reservoirs in	Total Dam Redervoir Volume (MCM)	Total Dam Redervoir Volume/Drainage
Ping	39,880	5 (13)	10,268 (10,853)	257.4 (272.1)
Yom	23,550	2(12)	13 (248)	0.6 (10.5)
Wang	11,240	4 (5)	123 (313)	10.9 (27.8)
Nan	31,830	4 (9)	6,693 (7,482)	210.3 (235.1)
Pask	18,200	0 (1)	0 (875)	0 (43.0)
Chao Phraya	16,200	16 (45)	17,298 (19,989)	106.7(123.3)

Note: value in parentheses is total value of exiteing and proposed dam reservoirs

Table 1.5.4 FORECAST OF FUTURE WATER DIVERSION REQUIREMENT (MCM) IN 2016

	Present 1996	NESDB/WB Best	NESDB/WB Safe	NESDB/RID /JICA	Combination of Maximum
Domestic	1,482	1,282	1,282	1,236	1,282
Industry	273	581	581		581
Agriculture	21,916	(-)6,336	0	2,760	2,760
Total	23,671	(-)4,473	1,863	3,996	4,623

Source: NESDB/World Bank in 1997 and NESDB/RID/JICA in 1996

Table 2.2.1 **THE TARGET COMPLETION YEAR OF CURRENT RELATED DEVELOPMENT PROJECTS**

Sector	Project	Target Year
Flood Mitigation Plan	Chao Phraya Flood Management Review	2016
	Flood Protection and Drainage in Eastern Suburban	2006 for Flood Protection and 2016 for Drainage
	Flood Protection of 7 towns in Chao Phraya Basin	2016
	National Flood Protection Master Plan	2016
Water Resources Development, etc.	Chao Phraya Basin Water Management Strategy	2006, 2016, 2026
	Kok-Ing-Nan Water Diversion Project	2016
	Bangkok Environmental Improvement Program	2012

Table 2.2.2 **EXISTING AND PLANNED DRAINAGE PUMP CAPACITY FROM URBAN AREAS**

-CHAO PHRAYA RIVER-

Province	Protection Area			Pump Capacity (m^3/s)			S. Capacity	Population	Remarks
	Name	km^2	Population	Existing	Planned	Total	($m^3/s/km^2$)	Density	
Sukhothai	Sukhothai	3.5	21,712	0.3**	1.7*	2	0.70	6,203	
	Sawankalok	6.5	19,345	None	5*	5	0.70	2,976	
Phitsanulok	Phitsanulok	18.3	78,469	None	13*	13	0.70	4,297	
Phichit	Phichit	12.0	24,832	None	8*	8	0.65	2,069	
	Taphan Hin	5.2	22,066	None	4*	4	0.70	4,243	
	Bang Mun Nak	2.5	10,258	None	2*	2	0.70	4,103	
Nakhon Sawan	Nakhon Sawan	124.8	145,510	3.0**	131.7	134.7	1.08	1,166	
	Chumsaeng	2.4	11,690	None	2*	2	0.70	4,871	
	Krok Phra	2.8	-	None	2*	2	0.70	-	
	Phayuha Khiri	1.8	-	None	1*	1	0.70	-	
Chainat	Chainat	56.5	35,300	None	15*	15	0.26	625	
	Watsing	32.3	4,689	None	6*	6	0.20	145	
Sing Buri	Sing Buri	14.9	21,232	0.3**	15.7	16	1.07	-	
	In Buri	7.3	-	None	3.0	3	0.41	-	
	Phrom Buri	4.5	-	None	2.0	2	0.44	-	
Ang Thong	Ang Thong	24.0	11,662	None	29.0	29	1.21	-	
	Pamok	26.9	17,368	None	26.0	26	0.97	647	
Ayuthaya	Ayuthaya	37.0	76,576	None	76.0	76	2.05	2,070	
Pathum Thani	Pathum Thani	8.8	14,680	None	17.0	17	1.94	-	
	Bang Pho Thai	71.1	-	None	51.0	51	0.72	-	
	Bang Luang	39.5	-	None	51.0	51	1.29	-	
Nonthaburi	East Bank	89.0	390,335	None	140.0	140	1.57	4,386	
	West Bank	150.0	237,000	None	95.0	95	0.63	1,580	
Bangkok	East Bank	650.0	-	452.2	101.0	553	0.85		
	West Bank	240.0	-	221.8	70.0	292	1.29		
				18.0	0.0	18			Drained to the Sea
Samut Prakan	East Bank	236.0		55#	0	55	0.28	-	#12m^3/s pumps under const. are included
				12.0	0	12			Drained to the Sea
	West Bank	124.0		59#	0	59	0.48	-	#16m^3/s pumps under const. are included
Total (Chao Phraya River)				791.6	868.1	1,659			

-THA CHIN RIVER-

Province	Protection Area			Pump Capacity (m^3/s)			S. Capacity	Population	Remarks
	Name	km^2	Population	Existing	Planned	Total	($m^3/s/km^2$)	Density	
Supanburi	Supanburi	9.0	27,788	None	6*	6	0.70	3,084	
	Songpeenong	10.4	12,848	None	5*	5	0.50	1,235	
Samutsakorn	Samutsakorn	10.3	54,335	0.1*	7.2*	7.3	0.70	5,275	
	Katumban	2.2	14,677	None	1.5*	1.5	0.70	6,671	
	Aomnoy	30.0	29,882	None	15*	15.0	0.50	996	
Total (Tha Chin River)				0.1	34.7	35			

-PASAK RIVER-

Province	Protection Area			Pump Capacity (m^3/s)			S. Capacity	Population	Remarks
	Name	km^2	Population	Existing	Planned	Total	($m^3/s/km^2$)	Density	
Saraburi	Saraburi	20.1	57,410	None	14*	14	0.70	2,856	
	Phaphuttabat	29.6	36,021	None	15*	15	0.50	1,217	
	Nongkhea	5.0	8,769	None	3*	3	0.62	1,754	
	Keangkoy	4.1	13,648	None	3*	3	0.70	3,329	
Total (Pasak River)				0.1	34.7	35			

Note; S. Capacity = Specific Capacity, Population Density = Capita per square kilometer, *= Pump capacity estimated from Specific capacity - Population density Curve, ** = Pump capacity estimated from pump's diameter

Table 2.2.3 SIMULATION CASE FOR IDENTIFICATION OF INFLUENCE BY FUTURE DEVELOPMENT

Case	Basin Condition							Simulation Results (1995 Flood)					Remarks
	Present Condition	Urban Development	Change of Agricultural Cultivation	Land Subsidence	Dam		Loop Cut	Flood Discharege at Nakon Sawan (m3/s)	Flood Discharge at Bang Sai (m3/s)	Water Level at Samsen (C.12) (MSL+m)	Water Level at Memorial Bridge (C.4) (MSL+m)	Total Inundation Volume (billion m3)	
					Existing	Planned							
Reappearance of Present Condition	○							4,600	4,150	2.32	2.20	15.9	
Influence by Urban Development (Providing Ring Levee with Drainage Pump)		○			○			4,430	4,070	2.80	2.57	16.0	
Influence by Change of Agricultural Cultivation (in combination with Urban Development)		○	○		○			4,430	4,070	2.81	2.57	16.1	
Influence by Land Subsidence (in combination with Urban Development and Change of Agricultutal Cultivation)		○	○	○	○			4,430	4,070	2.81	2.56	16.2	
Influence by Construction of Dam(in combination with Urban Development and Change of Agricultutal Cultivation)		○	○	○	◎	○		4,110	4,000	2.77	2.53	14.7	
Influence by Construction of Loop Cut (in combination with Urban Development, Change of Agricultural Cultivation and Construction of Dam)		○	○	○	◎	○	○	4,110	3,980	2.62	2.45	14.1	Future Basin Condition
Influence by Large Scale of Agricultural Development (in combination with Urban Development)		○	○		○			4,430	4,570	3.13	2.83	15.9	

◎ : Actual outflow is applied for Bhumipol Dam, but Sirikit Dam outflow is assumed to be regulated with a conduit newly added after the 1995 flood accrding to the current operation rulr, resulting in no spillage.

Table 2.3.1 CONCEIVABLE MEASURES

Area	Geographical Features	Land Use	Flood Damage in 1995	Conceivable Measures	
				Structural Measure	Non-structural Measure
Upper Central Plain (Upstream of Nakhon Sawan)	Valley plain between hilly areas with gentle slope in the east and west.	Main land use : Paddy (Traditional varieties are dominant, but HYV is applied in Phitsanulok Irrigation Area protected by dikes) Major urban area : Uttradit, Phitsanulok, Sukhothai, Phichit	Agricultural Damage More than 50% of Phitsanulok project was protected.40,000 ha of paddy field was damaged. Urban Area Damage Sukho Thai, Phitsanulok, Phichit are seriously damaged. Infrastructure Roads, bridges, irrigation facilities including regulators and canal embankment were damaged.	For agricultural area River Training For urban area Ring Levee	Flood Plain Management (Strengthening of Control and Guidance, Flood Disaster Response and Financial Response) Watershed Management Institution and Organization Modification of Reservoir Operation Rule
Nakhon Sawan Area (between Nakhon Sawan and Chainat)	Narrow valley plain with number of isolated mountains	Main land use : Paddy (Traditional varieties are dominant) Major urban area Nakhon Sawan, Uthai Thani	Agricultural Damage Paddy field of about 30,000 ha was damaged in this area. Urban Area Damage Nakhon Sawan and Uthai Thani were severely damaged. Infrastructure Damage Roads were damaged	For agricultural area River Training For uraban area Ring Levee	Flood Plain Management (Strengthening of Control and Guidance, Flood Disaster Response and Financial Response) Institution and Organization Modification of Reservoir Operation Rule
Higher Delta in Lower Central Plain (between Chainat and Ayutthaya)	Natural levees and back marshes are well developed.	Main land use : Paddy (HYV is dominant but floating rice and deep water rice are planted in habitually inundated area) Major urban area : Chainat, Sin Buri, Angthong, Ayutthaya, Supan Buri, Lop Buri	Agricultural Damage Total 190,000 ha of paddy field including 50,000 ha in Maharat Project Area was damaged. Urban Area Damage Chainat, Sin Buri, Angthong, Ayutthaya and Suphan Buri are severely damaged. Infrastructure Damage Roads, bridges, irrigation facilities including regulators and canal embankments are damaged	For agiricultural area River Training Retarding Basin Diversion Channel For urban area Ring Levee	Flood Plain Management (Strengthening of Control and Guidance, Flood Disaster Response and Financial Response) Institution and Organization
Lower Delta in Lower Central Plain (downstream of Ayutthaya)	Very flat	Main land use : Paddy (HYV rice) is main but urban areas are expanding rapidly Major urban area : Bangkok, Pathum Thani, Nonthaburi Samut Prakan	Agricultural Damage 40,000 ha of paddy field and 10,000 ha of other crop fields were damaged. Urban Area Damage Pathum Thani, Nonthaburi, Samut Prakan are damaged. Infrastructure Damage Roads, irrigation facilities including regulators and canal embankments are damaged	For aguricultural area River Training Retarding Basin For a bigger-scale Flood Ring Levee Diversion Channel Tidal Barrage with Pump	Flood Plain Management (Strengthening of Control and Guidance, Flood Disaster Response and Financial Response) Institution and Organization

Table 2.4.1 **CUSTOMIZED IEE PARAMETERS**

Changes expected in		Diversion Channel	Retarding Basin	River Training
Physical Resources	Surface water Quantities (hydrology)	X	X	
	Surface water Quality	X	X	
	Ground water	X	X	
	Soil Fertility	X	X	
	Geology / Seismology			
	Sediments and Erosion	X	X	
	Climate			
Ecological Resources	Agriculture	X	X	
	Fisheries	X	X	
	Aquatic Biology	X	X	X
	Wildlife (Terrestrial Fauna)	X	X	
	Forests			
	Reservoir Ecology			
Human Use Values	Water Supply	X	X	
	Aquaculture			
	Navigation	X	X	X
	Flood Control			
	Mineral Development			
	Highways/ Railways	X	X	
	Land Uses	X	X	
Quality of Life Values	Socio-Economics	X	X	
	Resettlement	X	X	
	Public Health	X	X	
	Nutrition			
	Recreation and Aesthetics			X
	Archaeology and Historical Treasures	X	X	

Note: X is parameter to be examined.

Table 3.1.1 THE OUTLINE OF THE ALTERNATIVE ROUTES OF DIVERSION

Case	Diversion	Beginning Point	Ending Point	Distance (km)	Water level at Diversion Point (MSL+m)	Bed Eleva-tion at the Mouth (MSL+m)	Bed Slope (i=1/I)
1	Tachin River Div.	Chainat	Tha Chin	Mouth to 319	17.581	-6	I=119,000, 9,500*
2	Chainat-Pasak-Raphipat-Sea Div.	Chainat	near Khlong Dan	Mouth to 260	18.00 at Chainat	-6	13,500, 16,700**
3	Chainat-Pasak-Raphipat-Ban Pakong Div.	Chainat	Ban Pakong	Mouth to 362	18.00 at Chainat	-6	163,000, 13,500, 16,700***
4	Pasak-Raphipat-Sea Div.	RamaVI Barrage	near Khlong Dan	Mouth to 127	9.5 at Pasak	-6	13,500
5	Pasak-Raphipat-Ban Pakong Div.	RamaVI Barrage	Ban Pakong	Mouth to 229	9.5 at Pasak	-6	163,000, 13500
6	Ayutaya - West Bank - Sea Div.	Sena	near Khlong Samaedam	Mouth to 105	4	-6	46,000
7	Ayuthaya- West Bank - Tha Chin Div.	Sena	Tha Chin	Mouth to 160	4	-6	119,000 46,000
8	Ayutthaya-East Bank-sea Div.	Bang-Pa-Ing	near Khlong Ban Thai	Mouth to 94	3.81	-6	45,000
9	Chaophraya II Div.	Pathum Thani	Chao Phraya	Mouth to 57	2.73	-6	56,000
10	Green Belt Div.	Pathum Thani	near Khlong Ban Thai	Mouth to 78	2.73	-6	76,000

*: Slope from mouth to 180 km (1/119,000) and upstream from 180 km (1/9,500)
**: Slope from mouth to Pasak (1/13,500) and Pask to Chainat (1/16,700)
***:Slope from mouth to Nakhon Nayok (1/163,000) and Nakhon Nayok to pasak (13,500)

Table 3.1.2 (1/3) COST AND BENEFIT OF ALTERNATIVE FLOOD DIVERSION CHANNEL (1,500m3/s)

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Diversion	Thachin River Diversion	Chainat-Pasak-Raphipat -Sea Diversion	Chainat-Pasak-Raphipat -Ban Pakong Diversion	Pasak-Raphipat-Sea Diversion	Raphipat-Ban Pakong Diversion	Ayuthaya-West-Sea Diversion	Ayuthaya-West-Tha Chin Diversion	Ayuthaya-East-Sea Diversion	Chaophraya-II Diversion	Greenbelt Diversion
Distance (km)	319	260	362	127	229	105	160	96	57	78
Order	9	8	10	5	7	4	6	3	1	2
Expropriation Area (m^2)	30,771,810	54,837,921	76,092,941	27,042,690	48,297,710	32,685,300	32,595,400	29,850,588	18,534,750	30,236,328
Order	5	9	10	2	8	7	6	3	1	4
Ratio of Expropriation Cost *1	0.83	1.00	1.06	0.51	0.57	0.99	0.82	1.06	1.40	1.80
Order	4	6	7	1	2	5	3	7	8	9
Excavation Volume (m3)	344,390,580	229,587,521	560,900,581	117,601,110	448,914,170	216,145,050	313,890,300	172,428,603	138,181,860	193,420,045
Order	8	6	10	1	9	5	7	3	2	4
Embankment Volume (m3)	21,598,200	24,289,185	32,810,595	13,086,640	21,608,050	2,808,700	12,512,200	4,009,455	754,830	2,692,605
Order	7	9	10	6	8	3	5	4	1	2
Number of House Relocation	6,500	2,400	3,000	1,400	2,000	3,200	3,600	1,600	11,000	2,500
Order	9	4	6	1	3	7	8	2	10	5
Water Height in Diversion from Mean Ground Level (m)	0 ~2.0	1.5~2.5	0.5~2.5	2.0~2.5	0.5~2.5	1.0~2.0	1.0~2.0	1.0~2.0	0 ~2.0	0 ~2.0
Order	1	4	3	5	3	2	2	2	1	1
Beneficial People (B) *2	9,305,000	9,305,000	9,305,000	8,450,000	8,450,000	7,751,000	7,751,000	7,751,000	7,239,000	7,239,000
Order	1	1	1	2	2	3	3	3	4	4
Assumed Water Quality *4	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-7	BOD 1-7
Order	1	1	1	1	1	1	1	1	2	2
Construction Cost *3 (Million Baht) (C)	81,210	88,244	98,500	44,121	77,527	71,734	81,533	59,060	77,375	91,098
Order	6	8	10	1	5	3	7	2	4	9
Possible Water Volume for Use (MCM)	226	148	330	60	260	77	158	70	46	72
Order	3	5	1	10	2	6	4	8	9	7
(C) / (B) (Baht)	8,728	9,484	10,586	5,221	9,175	9,255	10,519	7,620	10,689	12,584
Order	3	5	10	1	8	4	7	2	6	9

*1 : (Chainat-Pasak) = 1.0
*2 : Source; Statistical Yearbook Thailand, 1995
*3 : Inclusive of Land Expropriation Cost and House Resettlement (Refer to Table.3.1.3) . Exclusive of Price Contingency
*4 : Information from "Draft Final Report of Feasibility Study of Damming Chao Phraya and Nan Rivers for Improvement of Navigation"

Table 3.1.2 (2/3) COST AND BENEFIT OF ALTERNATIVE FLOOD DIVERSION CHANNEL (1,000m3/s)

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Diversion	Thachin River Diversion	Chainat-Pasak-Raphipat -Sea Diversion	Chainat-Pasak-Raphipat -Ban Pakong Diversion	Pasak-Raphipat-Sea Diversion	Raphipat-Ban Pakong Diversion	Ayuthaya-West-Sea Diversion	Ayuthaya-West-Tha Chin Diversion	Ayuthaya-East-Sea Diversion	Chaophraya-II Diversion	Greenbelt Diversion
Distance (km)	319	260	362	127	229	105	160	96	57	78
Order	9	8	10	5	7	4	6	3	1	2
Expropriation Area (m^2)	18,825,550	36,818,494	49,172,974	19,981,490	32,335,970	23,118,700	20,905,900	21,233,088	12,903,150	21,287,303
Order	2	9	10	3	8	7	4	5	1	6
Ratio of Expropriation Cost *1	0.67	1.00	1.00	0.55	0.55	1.05	0.69	1.12	1.47	2.01
Order	2	4	4	1	1	5	3	6	7	8
Excavation Volume (m3)	196,327,460	149,364,751	368,696,791	79,907,500	299,239,540	147,605,950	192,265,100	116,911,285	94,193,410	131,070,050
Order	8	6	10	1	9	5	7	3	2	4
Embankment Volume (m3)	25,288,190	24,787,433	30,636,823	13,086,640	18,936,030	2,808,700	14,709,900	4,009,455	754,830	2,692,605
Order	9	8	10	5	7	3	6	4	1	2
Number of House Relocation	4,000	2,200	2,800	1,200	1,900	2,900	2,500	1,500	8,000	2,300
Order	9	4	7	1	3	8	6	2	10	5
Water Height in Diversion from Mean Ground Level (m)	0 ~2.0	1.5~2.5	0.5~2.5	2.0~2.5	0.5~2.5	1.0~2.0	1.0~2.0	1.0~2.0	0 ~2.0	0 ~2.0
Order	1	4	3	5	3	2	2	2	1	1
Beneficial People (B) *2	9,305,000	9,305,000	9,305,000	8,450,000	8,450,000	7,751,000	7,751,000	7,751,000	7,239,000	7,239,000
Order	1	1	1	2	2	3	3	3	4	4
Assumed Water Quality *4	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-7	BOD 1-7
Order	1	1	1	1	1	1	1	1	2	2
Construction Cost *3 (Million Baht) (C)	42,151	45,012	65,495	22,538	44,013	39,254	40,081	34,479	40,471	50,216
Order	6	8	10	1	7	3	4	2	5	9
Possible Water Volume for Use (MCM)	137	103	235	48	190	53	109	48	31	50
	3	5	1	8	2	6	4	8	9	7
(C) / (B) (Baht)	4,530	4,837	7,039	2,667	5,209	5,064	5,171	4,448	5,591	6,937
Order	3	4	10	1	7	5	6	2	8	9

*1 : (Chainat-Pasak) = 1.0
*2 : Source; Statistical Yearbook Thailand, 1995
*3 : Inclusive of Land Expropriation Cost and House Resettlement (Refer to Table.3.1.3) . Exclusive of Price Contingency
*4 : Information from "Draft Final Report of Feasibility Study of Damming Chao Phraya and Nan Rivers for Improvement of Navigation

Table 3.1.2 (3/3) COST AND BENEFIT OF ALTERNATIVE FLOOD DIVERSION CHANNEL (500m3/s)

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Diversion	Thachin River Diversion	Chainat-Pasak-Raphipat -Sea Diversion	Chainat-Pasak-Raphipat -Ban Pakong Diversion	Pasak-Raphipat-Sea Diversion	Raphipat-Ban Pakong Diversion	Ayuthaya-West-Sea Diversion	Ayuthaya-West-Tha Chin Diversion	Ayuthaya-East-Sea Diversion	Chaophraya-II Diversion	Greenbelt Diversion
Distance (km)	319	260	362	127	229	105	160	96	57	78
Order	9	8	10	5	7	4	6	3	1	2
Expropriation Area (m^2)	8,352,120	18,855,053	24,118,833	12,818,690	18,082,470	13,774,900	10,488,100	12,587,813	7,225,610	12,299,403
Order	2	8	9	6	5	7	3	5	1	4
Ratio of Expropriation Cost *1	0.63	1.00	0.94	0.66	0.60	1.26	0.63	1.31	1.64	2.35
Order	2	5	4	3	1	6	2	7	8	9
Excavation Volume (m3)	57,064,000	68,739,296	191,304,186	41,933,300	164,498,190	78,219,800	78,370,900	61,272,883	49,848,290	68,359,330
Order	3	6	10	1	9	7	8	4	2	5
Embankment Volume (m3)	28,312,090	24,787,433	31,412,433	13,086,640	19,711,640	2,808,700	18,664,400	4,009,455	754,830	2,692,605
Order	9	8	10	5	7	3	6	4	1	2
Number of House Relocation	1,500	1,700	2,000	1,000	1,300	2,200	1,500	1,400	5,700	2,300
Order	4	5	6	1	2	7	4	3	9	8
Water Height in Diversion from Mean Ground Level (m)	0 ~2.0	1.5~2.5	0.5~2.5	2.0~2.5	0.5~2.5	1.0~2.0	1.0~2.0	1.0~2.0	0 ~2.0	0 ~2.0
Order	1	4	3	5	3	2	2	2	1	1
Beneficial People (B) *2	9,305,000	9,305,000	9,305,000	8,450,000	8,450,000	7,751,000	7,751,000	7,751,000	7,239,000	7,239,000
Order	1	1	1	2	2	3	3	3	4	4
Assumed Water Quality *4	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-3	BOD 1-7	BOD 1-7
Order	1	1	1	1	1	1	1	1	2	2
Construction Cost *3 (Million Baht) (C)	20,093	26,492	37,597	14,501	26,980	24,269	27,717	18,781	24,511	30,847
Order	3	6	10	1	7	5	8	2	4	9
Possible Water Volume for Use (MCM)	80	56	158	22	133	28	61	26	17	26
Order	3	5	1	8	2	6	4	7	9	7
(C) / (B) (Baht)	2,159	2,847	4,040	1,716	3,193	3,131	3,576	2,423	3,386	4,261
Order	2	4	9	1	6	5	8	3	7	10

*1 : (Chainat-Pasak) = 1.0
*2 : Source; Statistical Yearbook Thailand, 1995
*3 : Inclusive of Land Expropriation Cost and House Resettlement (Refer to Table.3.1.3) . Exclusive of Price Contingency
*4 : Information from "Draft Final Report of Feasibility Study of Damming Chao Phraya and Nan Rivers for Improvement of Navigation

Table 3.1.3 (1/3) FINANCIAL CONSTRUCTION COST IN CASE OF 1,500M3/S

Ayutthaya-East-Sea-Diversion 2 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	7	10	79	56	106	158
Excavation		m3	116,856,660	161	373	945	2,375	2,025	5,456
Embankment		m3	2,772,420	4	1	2	15	7	35
Land Surface Smoothing		m2	19,486,600	54	18	18	139	60	314
Land Surface Smoothing		m2	2,176,300	11	22	12	15	7	32
Diversion Point Weir		piece	1	26	26	616	51	1,232	616
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	18	18	580	54	725	529
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	8						
	Medium	piece	17						
	Small	piece	29	75	38	1,580	113	1,128	827
OTHERS									
Miscellaneous	2%	L.S.	1	7	10	80	57	108	161
Temporary Work	10%	L.S.	1	37	52	410	289	552	822
Subtotal				410	577	4,512	3,181	6,075	9,044
Resettlement			1,480	570					
Land Price		m2	22,278,640	16,041					
Total (1)				25,291				15,119	
Tax (VAT) 10%				2,529				1,512	
Total (2)				27,820				16,631	
Sale of Soil			29,473,292						
Grand Total				27,820				16,631	

Table 3.1.3 (2/3) FINANCIAL CONSTRUCTION COST IN CASE OF 1,000M3/S

Ayutthaya-East-Sea-Diversion 2 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	5	7	56	38	75	108
Excavation		m3	79,217,560	109	253	641	1,610	1,373	3,699
Embankment		m3	2,772,420	4	1	2	15	7	35
Land Surface Smoothing		m2	13,661,900	38	13	13	97	42	220
Land Surface Smoothing		m2	2,176,300	11	22	12	15	7	32
Diversion Point Weir		piece	1	18	18	435	36	869	435
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	13	13	409	38	511	294
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	8						
	Medium	piece	17						
	Small	piece	29	53	27	1,115	80	797	584
OTHERS									
Miscellaneous	2%	L.S.	1	5	7	57	39	76	110
Temporary Work	10%	L.S.	1	27	37	293	199	388	561
Subtotal				292	406	3,222	2,185	4,268	6,170
Resettlement			1,397	539					
Land Price		m2	16,413,520	12,565					
Total (1)				19,209				10,438	
Tax (VAT) 10%				1,921				1,044	
Total (2)				21,129				11,482	
Sale of Soil			21,169,094						
Grand Total				21,129				11,482	

Table 3.1.3 (3/3) FINANCIAL CONSTRUCTION COST IN CASE OF 500M3/S

Ayutthaya-East-Sea-Diversion 2 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	3	4	34	21	43	149
Excavation		m3	41,456,960	57	132	335	842	718	1,936
Embankment		m3	2,772,420	4	1	2	15	7	35
Land Surface Smoothing		m2	7,785,400	22	7	7	56	24	126
Land Surface Smoothing		m2	2,176,300	11	22	12	15	7	32
Diversion Point Weir		piece	1	11	11	255	21	510	255
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	8	8	240	23	300	173
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	8						
	Medium	piece	17						
	Small	piece	29	31	15	651	46	465	341
OTHERS									
Miscellaneous	2%	L.S.	1	3	4	35	21	44	63
Temporary Work	10%	L.S.	1	16	21	176	108	224	320
Subtotal				173	235	1,936	1,185	2,466	3,522
Resettlement			1,310	510					
Land Price		m2	9,704,720	6,895					
Total (1)				10,933				5,988	
Tax (VAT) 10%				1,093				599	
Total (2)				12,027				6,587	
Sale of Soil			11,452,686						
Grand Total				12,027				6,587	

Table 3.3.1 EFFECTIVENESS OF MEASURES WHEN SOLELY APPLIED

Type	Alternative Measures		Discharge at Nakhon Sawan*1 in 1995 Flood (m3/s)	Discharge at Bang Sai in 1995 Flood (m3/s)	Water Level at Samsen (C.12) in 1995Flood (m MSL)	Water Level at Mem. Bridge (C.4) in 1995Flood (m MSL)	Total Inundation Volume in 1995 (billion m3)	Flood Damage in 1995 (mil. Baht)	Decrease of Damage in 1995 (mil. Baht)	Cost*2 (mil.Baht)	Decrease of Damage in 1995 by Cost
Future Basin Condition in 2018 (Without Project)			4,110	3,980	2.62	2.45	14.1	143,535	-	-	-
Non-structure	Modification of Dam Operation Rule	Case1: Flood Control Capacity of 4,400 mil. m^3	4,020	3,960	2.59	2.43	13.7	132,829	10,706	minimum	infinite
		Case2: Flood Control Capacity of 6,700 mil. m^3	3,890	3,950	2.58	2.42	13.4	125,467	18,068	185*3	97.66
		Case3: Flood Control Capacity of 9,100 mil. m^3	3,820	3,920	2.57	2.41	13.1	112,987	30,548	1,853*3	16.49
Structure	River Improvement from Nan and Yom to Pathum Thani	Case1: 2-year Return Period	4,250	4,570	2.97	2.97	13.2	540,234	-396,699	10,430	-38.03
		Case1: 3-year Return Period	4,290	5,200	3.33	3.33	13.9	1,543,899	-1,400,364	15,240	-91.89
		Case3: 5-year Return Period	4,350	5,400	3.46	3.46	13.7	2,034,769	-1,891,234	21,710	-87.11
	River Improvement from Chainat to Pathum Thani	Case1: 5-year Return Period	4,110	4,350	3.01	2.52	13.8	398,755	-255,220	3,490	-73.13
		Case2: 10-year Return Period	4,110	4,690	3.11	2.67	13.9	874,567	-731,032	4,170	-175.31
		Case3: 25-year Return Period	4,110	4,860	3.12	2.75	14.3	1,093,588	-950,053	4,850	-195.89
	Pasak-Raphipat-Sea Diversion	Case1: Q= 500 m3/s	4,110	3,750	2.47	2.33	13.5	89,651	53,884	19,100	2.82
		Case2: Q=1,000 m3/s	4,110	3,450	2.39	2.32	13.4	53,465	90,651	32,000	2.83
		Case3: Q= 1,500 m3/s	4,110	3,320	2.39	2.32	13.3	52,258	91,538	45,000	2.03
	Chainat-Pasak-Raphipat-Sea Diversion	Case1: Q= 500 m3/s	4,110	3,790	2.51	2.35	12.9	98,527	45,008	33,000	1.36
		Case2: Q=1,000 m3/s	4,110	3,540	2.38	2.24	11.9	46,397	97,138	60,000	1.62
		Case3: Q= 1,500 m3/s	4,110	3,170	2.18	2.13	10.9	43,049	100,486	88,000	1.14
	Ayutthaya-East-Sea Diversion	Case1: Q= 500 m3/s	4,110	3,550	2.38	2.31	13.7	51,543	91,992	19,700	4.67
		Case2: Q=1,000 m3/s	4,110	3,130	2.22	2.19	13.4	45,359	98,100	31,400	3.06
		Case3: Q= 1,500 m3/s	4,110	2,670	2.10	2.10	13.3	41,254	101,414	49,000	2.07

*1: C.2 Station

*2: Financial Capital Cost (exclusive of price contingency)

*3: Net Present Value of Annual Financial Cost

Table 3.3.2 SIMULATION RESULT FOR TYPICAL RIVER TRAINING IN 1995 FLOOD

Case	Maximum Discharge (m^3/s)		Maximum Water Level in Bangkok*
	Nakhon Sawan C.2	Bang Sai	
Full Confinement in River	4,850	6,420	3.87
20 cm Dike Heightening	4,110	4,180	2.70

*:RID Samsen Station C.12

Table 3.3.3 DIKE HEIGHTENING COST FOR BANGKOK

Heightening Height (m)	Cost (Million Baht)	Running Cost (mil.Baht/year)
0.1	128	3
0.3	261	5
0.5	359	6
1.0	946	16
2.0	2,059	34

Table 3.3.4 EFFECT OF DISTRIBUTION SYSTEM IMPROVEMENT (1995 FLOOD)

NO. of Blocks	Area(km2)	Area with Inundation				Area without Inundation*		Effectiveness			
		Area(km^2)	Major Cultivation of Paddy Field	Present Inundation Volume(mil. m^3)	Present Inundation Damage (mil. Baht)	Area(km^2)	Major Cultivation in Paddy Field	Possible Distributed Water Volume (mil. m^3)	① Damage Reduced (mil. Baht)	② Damage Increased (mil. Baht)	②-① Balance(mil. Baht)
1	1875	705	GTV	1,089	735	300	HYV	0.0	0.0	0.0	0.0
2	502	1,163	GTV	2,878	974	0	-	0.0	0.0	0.0	0.0
3	328	1,553	GTV	317	34	0	-	0.0	0.0	0.0	0.0
4	1053	266	HYV	570	19	250	HYV	50.0	3.6	2.5	-1.1
5	620	624	HYV	458	23	0	HYV	0.0	0.0	0.0	0.0
6	635	305	DR	693	91	125	HYV	25.0	4.0	3.3	-0.7
7	969	533	DR,FR	1,035	148	50	HYV	10.0	0.6	0.3	-0.3
8	773	376	FR	749	53	50	HYV	10.0	4.0	3.0	-1.0
9	1691	1,424	DR,FR	3,447	723	0	-	0.0	0.0	0.0	0.0
10	836	230	HYV	567	20	0	-	0.0	0.0	0.0	0.0
11	774	500	HYV	283	82	0	-	0.0	0.0	0.0	0.0
12	1360	663	HYV	767	184	0	-	0.0	0.0	0.0	0.0
13	225	225	HYV	292	90	0	-	0.0	0.0	0.0	0.0
14	387	367	HYV	209	27	0	-	0.0	0.0	0.0	0.0
15	806	671	HYV	153	6	0	-	0.0	0.0	0.0	0.0
16	360	51	-	26	14	0	-	0.0	0.0	0.0	0.0
17	699	291	-	308	174	0	-	0.0	0.0	0.0	0.0
18	418	337	HYV	236	6	0	-	0.0	0.0	0.0	0.0
TOTAL1	14,311	10,283		14,078	3,402	775		95.0	12.2	9.1	-3.1
TOTAL2	6,577	3,758		7,519	1,077	475		95.0	12.2	9.1	-3.1

TOTAL1 (Block NO.1-NO.18)
TOTAL2 (Block NO.4-NO.10)
*Area, where the inundation water is possibly distributed from the inundation area

Table 3.3.5 **DISTRIBUTION OF INYNDATION WATER IN PADDY FIELD**

YEAR	VOLUME (mil.m^3)	DAMAGE (mil.Bhat)	Minimum DAMAGE (mil.Bhat)	DAMAGE REDUCED (mil.Bhat)	RATE (%)
1952	3,040	1,621	687	934	57.6
1953	2,774	1,447	365	1,082	74.8
1954	4,932	3,033	2,979	54	1.8
1955	3,054	1,643	705	938	57.1
1956	4,169	2,589	2,055	534	20.6
1957	5,501	4,089	3,668	421	10.3
1958	2,988	1,590	624	966	60.7
1959	5,488	4,080	3,653	427	10.5
1960	2,525	1,318	201	1,117	84.8
1961	3,485	1,727	1,227	500	29.0
1962	5,592	4,076	3,779	297	7.3
1963	4,149	3,189	2,031	1,158	36.3
1964	5,751	4,043	3,972	71	1.8
1965	2,250	861	61	800	92.9
1966	3,778	2,161	1,581	580	26.8
1967	2,542	1,247	210	1,037	83.2
1968	1,335	300	0	300	100.0
1969	3,944	2,137	1,783	354	16.6
1970	4,407	2,362	2,343	19	0.8
1971	2,878	1,545	491	1,054	68.2
1972	3,040	1,950	687	1,263	64.8
1973	3,039	720	687	33	4.6
1974	3,169	2,062	844	1,218	59.1
1975	5,167	3,458	3,264	194	5.6
1976	3,784	2,083	1,589	494	23.7
1977	2,446	1,104	161	943	85.4
1978	6,123	4,630	4,421	209	4.5
1979	1,860	0	0	0	-
1980	5,432	3,593	3,585	8	0.2
1981	2,860	635	469	166	26.1
1982	2,300	894	86	808	90.3
1983	5,415	4,825	3,564	1,261	26.1
1984	1,906	223	0	223	100.0
1985	3,174	1,551	850	701	45.2
1986	1,813	0	0	0	-
1987	3,270	1,615	966	649	40.2
1988	3,684	2,015	1,468	547	27.1
1989	2,216	1,125	44	1,081	96.1
1990	3,061	1,824	713	1,111	60.9
1991	1,926	0	0	0	-
1992	2,617	1,362	247	1,115	81.8
1993	1,590	0	0	0	-
1994	3,230	1,546	918	628	40.6
1995	6,659	5,851	5,277	574	9.8
1996	4,379	3,751	2,309	1,442	38.4
AVERAGE	3,528	2,042	1,435	607	29.7

Table 3.3.6 EFFECTIVENESS OF DRAINAGE CHANNEL IMPROVEMENT

(1) East Bank

Case	Decrease of Inundation Volume			Decrease of Inundation Duration			Decrease of Flood Damage			Cost (mil.Baht)	Ratio of Decreased Damage by Cost
	Average Vol.*1 (mil. m3)	Decreased Vol. (mil.m3)	Rate of Decrease (%)	Average Duration*2 (day)	Decreased Period (day)	(%)	Average Damage (mil.baht)	Decreased Damage (mil.Baht)	(%)		
Future Basin Condition	663	-	-	100	-	-	7,076	-	-	-	-
Case A-1	468	195	29	77	23	23	5,387	1,690	24	4,040	0.418
Case A-2	380	283	43	50	50	50	3,810	3,266	46	12,230	0.267
Case A-3	327	336	51	32	68	68	2,819	4,258	60	20,580	0.207
Case B-1	569	94	14	95	5	5	5,245	1,832	26	3,020	0.607
Case B-2	550	113	17	90	10	10	4,598	2,478	35	5,840	0.424
Case B-3	534	129	20	85	15	15	4,336	2,741	39	8,860	0.309

* 1 : Average inundation volume for three years, 1983, 1995 and 1996

* 2 : Average inundation period of three points for three years, 1983, 1995 and 1996

(2) West Bank

Case	Decrease of Inundation Volume			Decrease of Inundation Duration *			Decrease of Flood Damage *			Cost (mil.Baht)	Ratio of Decreased Damage by Cost
	Average Vol.*1 (mil. m3)	Decreased Vol. (mil.m3)	Rate of Decrease (%)	Average Duration*2 (day)	Decreased Period (day)	(%)	Average Damage (mil.baht)	Decreased Damage (mil.Baht)	(%)		
Future Basin Condition	726	-	-	120	-	-	7,437	-	-	-	-
Case A-1	303	423	58	56	64	53	3,045	4,391	59	10,400	0.422
Case A-2	197	529	73	29	91	76	1,925	5,512	74	24,500	0.225
Case A-3	147	579	80	13	107	89	1,357	6,079	82	38,280	0.159
Case B-1	474	252	35	83	37	31	5,181	2,256	30	3,100	0.728
Case B-2	442	284	39	79	41	34	4,603	2,834	38	5,900	0.480
Case B-3	413	313	43	75	45	38	3,909	3,528	47	9,020	0.391

* 1 : Average inundation volume for three years, 1983, 1995 and 1996

* 2 : Average inundation period of three points for three years, 1983, 1995 and 1996

Table 3.3.7 CONSTURUCTION COST OF DISTRIBUTION
OF INUNDATION WATER

Item	unit	Quantity	unit cost (million baht)	Cost (million baht)
Connection Canal Expansion of Main Canal	km	40	0.8	32
Gate	place	5	18	90
Regulator (Small Sluice)	place	15	3	45
Siphon	place	3	20	60
Administration	L.S.			3
Engineering	L.S.			18
Physical Contingency	L.S.			11
Price Contingency	%			26
Total				285

Table 3.3.8 PROJECT COST OF DRAINAGE IMPROVEMENT

UNIT of PROJECT COST

Range		Method	Unit Cost	Unit
East Bank	0 ~ 120 m2	Minor	0.1	million baht/m2/km
	120 ~ 300m2	Major	0.5	including all.
	over 300 m2	New Canal	0.7	(tax, profit, etc.)
Lower of West Bank	0 ~ 120 m2	Minor	0.1	
	80 ~ 300m2	Major	0.5	
	over 300 m2	New Canal	0.7	

Note : Unit costs are quoted from similar projects of agency concerned.

CONSTRUCTION COST

Case	Area	Stretch *1	Distance (km)	Reqired Canal Area Minor (m2)	Major (m2)	Minor Improvement (miilion baht)	Major Improvement (miilion baht)	Total (miilion baht)
B1	East Bank	A	25	120	45	300	563	863
		B	30	120	120	360	1,800	2,160
	Subtotal(1)							3,023
	West Bank	A	40	80	55	320	1,100	1,420
		B	40	120	60	480	1,200	1,680
	Subtotal(2)							3,100
Total								6,123
Price Contingency								612
Grand Total								6,735

Note: *1 Refer to Sector I "Hydrology" regarding A and B

Table 3.3.9 CONSTRUCTION COST OF ARTIFICIAL RETARDING BASIN

Case-1 3,000km2

Enclosure Dike Construction						
No.	Distance (m)	Improvement Length (m)	Type	Heightening Height (m)	Unit Cost (Bart / m)	Cost (million baht)
1	40,000	2,500	A1	3	15,700	39
2	10,000	10,000	A2	1	6,000	60
3	25,500	25,500	A1	3	15,700	400
4	7,500	7,500	C1	1	5,200	39
5	29,000	29,000	C1	1	5,200	151
6	54,000	54,000	C1	1	5,200	281
7	27,500	27,500	C1	1	5,200	143
8	13,500	13,500	C1	1	5,200	70
9	8,500	8,500	C1	1	5,200	44
Total	215,500					1,228
Small Sluice Gate	2m x2m x2 x 10			1.0	million baht/m2	80
Pumping Station	5m3/s x 10			12	million baht/m3	600
Over Flow Weir	2km wide x 2m high x 2places					6,400
Road Improvement	42km x 112 x 0.6m heightening x 6m wide					22,109
House Relocation	3,000km2 x 35 house/km2			0.25	mill. baht/house	26,250
Total						56,666 million baht
Running Cost					million baht / year	620

Case-2 2,000km2

Enclosure Dike Construction						
No.	Distance (m)	Improvement Length (m)	Type	Heightening Height (m)	Unit Cost (Bart / m)	Cost (million baht)
1	9,000	9,000	C1	1	5,200	47
2	7,500	7,500	C1	1	5,200	39
3	29,000	29,000	C1	1	5,200	151
4	54,000	54,000	C1	1	5,200	281
5	27,500	27,500	C1	1	5,200	143
6	11,500	11,500	C1	1	5,200	60
7	19,000	19,000	C1	1	5,200	99
Total	157,500					819
Small Sluice Gate	2m x2m x2 x 7			1.0 million baht/m2		56 million baht
Pumping Station	5m3/s x 7			12 million baht / m3		420
Overflow Weir	1km wide x 2m high x 2 places					3,200
Road Improvement	42km x 50 x 0.6m heightening x 6m wide					9,870
House Relocation	2,000km2 x 35 house/km2			0.25	mill. baht/house	17,500
Total						31,865 million baht
Running Cost					million baht / year	290

Case-3 1,000km2

Enclosure Dike Construction						
No.	Distance (m)	Improvement Length (m)	Type	Heightening Height (m)	Unit Cost (Bart / m)	Cost (million baht)
1	20,500	20,500	C1	0.5	3,100	64
Total	20,500					64
Small Sluice Gate	2m x2m x2 x 5			1.0 million baht/m2		40 million baht
Pumping Station	5m3/s x 5			12 million baht / m3		300
Overflow Weir	1km wide x 2m high x 1 places					1,600
Road Improvement	42km x 35 x 0.6m heightening x 6m wide					6,909
House Relocation	1,000km2 x 35 house/km2			0.25	mill. baht/house	8,750
Total						17,663 million baht
Running Cost					million baht / year	150

Note 1 : Aforementioned Cost is Financial Cost.
2 : Exclusive of Price Contingency

Table 3.4.1 MAJOR ISSUES AND POINT TO SELECT SUITABLE MEASURES

Area divided	Contents of Major Flood Issue	Features of Flood Condition	Major points to select suitable measures	Conceivable Measures	
				Non-structural Measures	Structural Measures
Higher Central Plain	Damage to urban area	Protection works for urban area will not bring about severe influence to downstream.	To follow the protection works for urban area by PWD.	Flood plain management/ watershed management/ Institution and Organization/ Modification of Reservoir Operation Rule	Ring levee with drainage pump by PWD
	Damage to agricultural area	Protection for agricultural aera may cuase adverse influence to down stream	To seek for measures to mitigate flood damage to agricultural area but not to cause the adverse influenc to downstream.	- do -	River Training
Nakon Swan Area	Damage to urban area	Protection works for urban area will not bring about severe influence to downstream.	To follow the protection works for urban area by PWD.	- do -	Ring levee with drainage pump by PWD
	Damage to agricultural area	Protection for agricultural aera may cuase adverse influence to down stream.	To seek for measures to mitigate flood damage to agricultural area but not to cause the adverse influenc to downstream.	- do -	River Training
Higher delta in lower Central Plain	Damage to urban area	Protection works for urban area will not bring about severe influence to downstream.	To control and guide the change of land use condition. /To follow the protection works for urban area by PWD.	- do -	Ring levee with drainage pump by PWD
	Damage to agricultural area/ Change of land use/ Reservation of retarding effect	Protection for agricultural aera may cuase adverse influence to down stream./ Change of land use results in increase of flood damage and reduction of natural retarding effect.	To control and guide the change of land use condition./ To seek for measures to mitiagate the flood damage in paddy field maintaing the natural retarding effect.	- do -	River Training and natural retarding basin with damage mitigation in agricultural area and diversion (Ayuthaya-E.Bank-Sea route)
Lower delta in lower Central Plain	Damage to urban area/ expantion of urban area	Protection woks for urban area will bring about severe influence to down stream, Bangkok./ Expansion of urban area will results in increase of flood damage.	To seek the measures to cope with the adverse influence./ To control and guide the change of land use condition.	Control of ground water extraction in addition to the above non-structural measures	Ring levee with drainnage pump by PWD/ Diversion Channel/ other option (Heightening)
	Damage to agricultural area/ Change of land use/ Reservation of retarding effect	Protection for agricultural aera may cuase adverse influence to down stream/ Change of land use results in increase of flood damage and reduction of natural retarding effect.	To control and guide the change of land use condition./ To seek measures to mitigate flood damage in paddy field maintaing the natural retarding effect.	Control of ground water extraction in addition to the above non-structural measures	Nnatural retarding basin with damage mitigation in agricultural areas and Diversion(Ayuthaya-E.Bank-Sea route)

Table 4.1.1 EFECTIVENESS OF THE DIVERSION FOR AGRICULTURAL AREA

Diversion Route	Ayutthaya-East-Sea
Flow Capacity	300 m3/s
Financial Initial Cost (million baht)	11,525
Financial O/M Cost (million baht/year)	106
Economic Initial Cost (million baht)	9,230
Economic O/M Cost (million baht/year)	101
Benefit (million baht/year)	314
Net Present Value (12% discount rate)	-2,840
B/C (12% discount rate)	0.16
EIRR (%)	0.68

Table 4.1.2 COST COMPARISON BETWEEN CHAINAT-PASAK-SEA DIVERSIONAND RIVER IMPROVEMENT

	Chainat-Pasak-Sea Diversion	River Improvement
Required Capacity	800 m3/s	10-year
Equipment and Financial Cost (exclusive of O&M cost) (million baht)	26,000	1,425

Table 4.1.3 COMPARISON OF OPTION TO MITIGATE FLOOD DAMAGE

Option	Safety Level		Description	Advantage and Disadvantage
	Bangkok	Pathum Thani and Nontha Buri		
(1)To maintain the present condition of Pathum Thani and Nontha Buri	125-year return period	2-3 year return period	Suspension of planned protection works by PWD	From technical, economical and environmental point of view, there may be no issues. From social point of view, inhabitants in urban areas, Pathum Thani and Nonthaburi, will not accept to maintain the present safety level in the future. The option can not cope with the situation to enhance the protection level of agricultural area in the upstream in the future.
(2) To enhance the safety level up to the allowable level	100	5	The safety level of Bangkok can be enhanced more than 100-year return period by loop cut at port. Therefore there is a room to enhance the safety level of Pathum Thani and Nontha Buri for that part.	From technical, economical and environmental point of view, there may be no issues. From social point of view, inhabitants in urban areas, Pathum Thani and Nonthaburi, will not accept to maintain the present safety level in the future. The option can not cope with the situation to enhance the protection level of agricultural area in the upstream in the future.
(3) To lower the safety level at Bangkok	50	7	The safety level of Bangkok will be reduced to 50-year return period for example, while those of Pathun Thani and Nontha Buri be enhanced to 7 year return period for example.	From technical, economical and environmental point of view, there may be no issues. From social point of view, inhabitants in urban areas, Pathum Thani and Nonthaburi, will not accept to maintain the present safety level in the future. The option can not cope with the situation to enhance the protection level of agricultural area in the upstream in the future.
(4) To narrow the protection area of Pathum Thani and Nontha Buri	100	100, and 2-3	The protection area of Pathum Thani and Nontha Buri is narrowed down to the extent, in which adverse influence to Bangkok is not severe.	From technical, economical and environmental point of view, there may be no issues. From social point of view, inhabitants in urban areas may oppose delineation of protected and not protected areas in the same municipality level in the future. The option can not cope with the situation to enhance the protection level of agricultural area in the upstream in the future.
(5) To heighten the flood barrier at Bangkok	100	100	To further heighten the flood barrier at Bangkok from ongoing project.	From the technical and economical point of view, the works will not involve serious issues. From environmental and social points of view, this option will cause serious issues. The option can not cope with the situation to enhance the protection level of agricultural area in the upstream in the future.
(6) To provide diversion channel	100	100	To provide diversion channel to absorb the adverse influence.	From the technical point of view, the works will not involve serious issues. From the environmental point of view, issues derived from the option will be solved. From economical point of view, this works will require a huge burden to the country. From social point of view, this option will cause issues for land acquisition and house evacuation. This option can be used for enhancement of the safety level of agricultural areas.

Table 4.1.4 REQUIRED CAPACITY OF AYUTTHAYA-EAST-SEA DIVERSION

Capaciy of AES Diversion (m3/s)	Combination of Applicable Measures			Discharge at Nakhon Sawan*1 in 1995 (m3/s)	Discharge at Bang Sai in 1995 (m3/s)	Water Level at Samsen (C.12) in 1995 (m MSL)	Water Level at Memorial Bridge (C.4) in 1995 (m MSL)	Total Inundation Volume in 1995 (billion m3)
	Dam	Retarding	River Improvement					
800 m3/s	14,600 mil. M3	5,600 km2	10yr (Chainat to Pathum Thani)	3,820	3,230	2.26	2.20	12.4
1,100 m3/s	14,600 mil. M3	5,600 km2	25yr (Chainat to Pathum Thani)	3,820	3,490	2.32	2.18	11.6

Note : The required capacity has been estimated so that the water levels at Samsen and the Memorial Bridge could be lowered below the actual levels in 1995, namely 2.32 and 2.20 m MSL respectively.

Table 4.1.5 (1/3) MEASURES SELECTED FOR MASTER PLAN

Alternative-1

Areas	Major Flood Problems	Conceivable Measures		Proposed Measures		Remarks
		Structural Measures	Non-structural Measures	Structural Measures	Non-structural Measures	
Upper Central Plain	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement	Land use control and guidance, modification of reservoir operation and others	Not applicable	Land use control and guidance, modification of reservoir operation and others	(2 ~ 10-year)
Nakon Sawan Area	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement	Land use control and guidance, modification of reservoir operation and others	Not applicable	Land use control and guidance, modification of reservoir operation and others	(2 ~ 10-year)
Higher Delta in Lower Central Plain (Chainat-Ayuthaya)	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement, distribution system improvement* and diversion channel	Land use control and guidance, modification of reservoir operation and others	River improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	10-year
Lower Delta in Lower Central Plain (Down stream of Ayuthaya)	- Flood damage in urban Areas and Bangkok	Ring levee with drainage pump, diversion channel and heightening of flood barrier at Bangkok	Land use control and guidance, modification of reservoir operation and others	Parcial protection of Nonthaburi and Pathum thani by ring levee with drainage pump and Ring levee with drainage pump of other PWD and BMA	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year) and BMA Plan
	- Flood damage in agricultural areas	River improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	River improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	10-year

*: Damage mitigation measures in agriculutral area are included.

Table 4.1.5 (2/3) MEASURES SELECTED FOR MASTER PLAN

Alternative-2-1

Areas	Major Flood Problems	Conceivable Measures		Proposed Measures		Remarks
		Structural Measures	Non-structural Measures	Structural Measures	Non-structural Measures	
Upper Central Plain	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement	Land use control and guidance, modification of reservoir operation and others	Not applicable	Land use control and guidance, modification of reservoir operation and others	(2 ~ 10-year)
Nakon Sawan Area	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement	Land use control and guidance, modification of reservoir operation and others	Not applicable	Land use control and guidance, modification of reservoir operation and others	(2 ~ 10-year)
Higher Delta in Lower Central Plain (Chainat-Ayuthaya)	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement, distribution system improvement* and diversion channel	Land use control and guidance, modification of reservoir operation and others	River Improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	10-year
Lower Delta in Lower Central Plain (Down stream of Ayuthaya)	- Flood damage in urban Areas and Bangkok	Ring levee with drainage pump, diversion channel and heightening of flood barrier at Bangkok	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump and heightening of flood barrier at Bangkok	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year) and BMA Plan
	- Flood damage in agricultural areas	River improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	River improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	10-year

*: Damage mitigation measures in agriculutral area are included.

Table 4.1.5 (3/3) MEASURES SELECTED FOR MASTER PLAN
Alternative-2-2

Areas	Major Flood Problems	Conceivable Measures		Proposed Measures		Remarks
		Structural Measures	Non-structural Measures	Structural Measures	Non-structural Measures	
Upper Central Plain	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement	Land use control and guidance, modification of reservoir operation and others	Not applicable	Land use control and guidance, modification of reservoir operation and others	(2 ~ 10-year)
Nakon Sawan Area	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement	Land use control and guidance, modification of reservoir operation and others	Not applicable	Land use control and guidance, modification of reservoir operation and others	(2 ~ 10-year)
Higher Delta in Lower Central Plain (Chainat-Ayuthaya)	- Flood damage in urban Areas	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year)
	- Flood damage in agricultural areas	River improvement, distribution system improvement* and diversion channel	Land use control and guidance, modification of reservoir operation and others	River Improvement, distribution system improvement* and diversion channel	Land use control and guidance, modification of reservoir operation and others	First stage: 10-year, Second Stage: 25-year
Lower Delta in Lower Central Plain (Down stream of Ayuthaya)	- Flood damage in urban Areas and Bangkok	Ring levee with drainage pump, diversion channel and heightening of flood barrier at	Land use control and guidance, modification of reservoir operation and others	Ring levee with drainage pump and diversion channel	Land use control and guidance, modification of reservoir operation and others	Based on PWD Plan (100-year) and BMA plan
	- Flood damage in agricultural areas	River improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	River Improvement and distribution system improvement*	Land use control and guidance, modification of reservoir operation and others	First stage: 10-year, Second Stage: 25-year

*: Damage mitigation measures in agriculutral area are included.

Table 4.1.6 (1/3) FEATURES OF SELECTED MEASURES FOR MASTER PLAN

(Altenative-1)

Measures	Location of Measures	Dimension	Cost (million bahts) *3	
			Initial	O & M
Modification of Reservoir Operation	Five dams	14,600 mil. m3 of storage capacity for flood control	Economic Cost	Economic Cost
	Bumipol	5,500 mil. m3	40	394
	Sirikit	6,500 mil. m3	Financial Cost	Financial Cost
	Pasak	772 mil. m3		
	Kwae Noi	733 mil. m3	46	451
	Kaeng Sua Teng	1,125 mil. m3		
River Training	Main Stretch between Phatum Thani and Chainat	400 km in total with 10-year return period	Economic Cost	Economic Cost
	Chao Phraya River (between Pathumthani and Chainat)	180 km	1,234	31
	Lop Buri River	100 km		
	Noi River (between Bang Sai and Pakhai)	30 km	Financial Cost	Financial Cost
	Pasak River (between Ayutthaya and Rama VI)	50 km	1,425	34
	Bang Bal Canal	15 km		
	Bang Luang Canal	15 km		
	Bang Keao Canal	15 km		
Distribution and Drainage System Improvement including Damage Mitigation Measures	Flood pron area in higher delta in lower central plain	5,600 km2 of paddy field with drainage channels*1 improvement of 75 m3/s each in total capacity and 80 km of stretch in west bank and 55 km of it in east bank	Economic Cost 5,632 Financial Cost 7,020	Economic Cost 39 Financial Cost 44
Parcial Protection by Ring Levee	Nanthaburi and Pathum Thani	Parcial protection by ring levee with drainage pump	-	-
Protection of Urban Area	Major urban areas: BMA, 12 provincial capitals and 16 municipalities exclusive of Nonthaburi and Pathum Thani	Ring levee with drainage pump to cope with 100-year return period flood in Chao Phraya River	-	-

*1 : Drainage channels are provided in lower delta in lower central plain both of east and west.

*2 : Apply the existing operation rule

Table 4.1.6 (2/3) FEATURES OF SELECTED MEASURES FOR MASTER PLAN

(Altenative-2-1)

Measures	Location of Measures	Dimension	Cost (million bahts) *3	
			Initial	O & M
Modification of Reservoir Operation	Five dams	14,600 mil. m3 of storage capacity for flood control	Economic Cost	Economic Cost
	Bumipol	5,500 mil. m3	40	394
	Sirikit	6,500 mil. m3	Financial Cost	Financial Cost
	Pasak	772 mil. m3		
	Kwae Noi	733 mil. m3	46	451
	Kaeng Sua Teng	1,125 mil. m3		
River Training	Main Stretch between Phatum Thani and Chainat	400 km in total with 10-year return period	Economic Cost	Economic Cost
	Chao Phraya River (between Pathumthani and Chainat)	180 km	1,234	31
	Lop Buri River	100 km		
	Noi River (between Bang Sai and Pakhai)	30 km	Financial Cost	Financial Cost
	Pasak River (between Ayutthaya and Rama VI)	50 km	1,425	34
	Bang Bal Canal	15 km		
	Bang Luang Canal	15 km		
	Bang Keao Canal	15 km		
Distribution and Drainage System Improvement including Damage Mitigation Measures	Flood pron area in higher delta in lower central plain	5,600 km2 of paddy field with drainage channels*1 improvement of 75 m3/s each in total capacity and 80 km of stretch in west bank and 55 km of it in east bank	Economic Cost 5,632 Financial Cost 7,020	Economic Cost 39 Financial Cost 44
Heightening of Flood Barrier	Bankok Metropolitan Area	Heightening of flood barrier with 30 cm on an average	EC 1,492 FC 1,840	EC 31 FC 34
Protection of Urban Area	Major urban areas: BMA, 14 provincial capitals and 18 municipalities	Ring levee with drainage pump to cope with 100-year return period flood in Chao Phraya River	-	-

*1 : Drainage channels are provided in lower delta in lower central plain both of east and west.

*2 : Apply the existing operation rule

Table 4.1.6 (3/3) FEATURES OF SELECTED MEASURES FOR MASTER PLAN

(Altenative-2-2)

Measures	Location of Measures	Dimension	Cost (million bahts) *3	
			Initial	O & M
Modification of Reservoir Operation	Five dams	14,600 mil. m3 of storage capacity for flood control	Economic Cost	Economic Cost
	Bumipol	5,500 mil. m3	40	394
	Sirikit	6,500 mil. m3	Financial Cost	Financial Cost
	Pasak	772 mil. m3		
	Kwae Noi	733 mil. m3	46	451
	Kaeng Sua Teng	1,125 mil. m3		
River Training (Stage-1)	Main Stretch between Phatum Thani and Chainat	400 km in total with 10-year return period	Economic Cost	Economic Cost
	Chao Phraya River (between Pathumthani and Chainat)	180 km	1,234	31
	Lop Buri River	100 km		
	Noi River (between Bang Sai and Pakhai)	30 km	Financial Cost	Financial Cost
	Pasak River (between Ayutthaya and Rama VI)	50 km	1,425	34
	Bang Bal Canal	15 km		
	Bang Luang Canal	15 km		
	Bang Keao Canal	15 km		
River Training (Stage-2)	Main Stretch between Phatum Thani and Chainat	400 km in total with 25-year return period	Economic Cost	Economic Cost
	Chao Phraya River (between Pathumthani and Chainat)	180 km	1,588	40
	Lop Buri River	100 km		
	Noi River (between Bang Sai and Pakhai)	30 km	Financial Cost	Financial Cost
	Pasak River (between Ayutthaya and Rama VI)	50 km	1,834	44
	Bang Bal Canal	15 km		
	Bang Luang Canal	15 km		
	Bang Keao Canal	15 km		
Distribution and Drainage System Improvement including Damage Mitigation Measures	Flood pron area in higher delta in lower central plain	5,600 km2 of paddy field with drainage channels*1 improvement of 75 m3/s each in total capacity and 80 km of stretch in west bank and 55 km of it in east bank	Economic Cost 5,632 Financial Cost 7,020	Economic Cost 39 Financial Cost 44
Diversion Channel (Stage-1)	Ayuthaya-East Bank-Sea	800 m3/s of flow capacity with the stretch of 95 km	EC 24,989 FC 33,684	EC 127 FC 141
Diversion Channel (Stage-2)	Ayuthaya-East Bank-Sea	Increase of flow capacity from 800 m3/s to 300 m3/s with the stretch of 95 km	EC 6,143 FC 8,645	EC 40 FC 45
Protection of Urban Area	Major urban areas: BMA, 14 provincial capitals and 18 municipalities	Ring levee with drainage pump to cope with 100-year return period flood in Chao Phraya River	-	-

*1 : Drainage channels are provided in lower delta in lower central plain both of east and west.

*2 : Apply the existing operation rule

Table 4.2.1 FINANCIAL AND ECONOMIC COST AND BEENFIT OF ALTERNATIVE-1

Benefit (million baht/yeawr)

General	Agriculture	Total
1,997	196	2,193

excluding benefit of Dam

Cost Evaluation (Unit : baht 1,000,000)

Distribution System Improvement :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	101	123	224
1) Material and Equipment	86	123	208
2)Skilled Labor	4	0	4
3)Unskilled Labor	11	0	11
2 Land acquisition & House R	3	0	3
3 Administration	3	0	3
4 1)Engineering serviceD/D	1	5	6
2)Engineering serviceS/V	1	11	13
5 Phisical contingency	4	7	11
Sub-total	113	146	259
6 Price Contingency	12	14	26
Grand total	125	160	285
OM Cost			2

Distribution System Improvement :Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	88	112	199
1) Material and Equipment	75	112	186
2)Skilled Labor	4	0	4
3)Unskilled Labor	10	0	10
2 Land acquisition & House Reloc	2	0	2
3 Administration	2	0	2
4 1)Engineering serviceD/D	0	5	5
2)Engineering serviceS/V	1	10	12
5 Phisical contingency	4	6	10
Sub-total	98	133	231
6 Price Contingency	0	0	0
Grand total	98	133	231
OM Cost			2

Drainage Improvement :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	2,112	2,327	4,439
1) Material and Equipment	1,837	2,327	4,163
2)Skilled Labor	92	0	92
3)Unskilled Labor	184	0	184
2 Land acquisition & House R	612	0	612
3 Administration	61	0	61
4 1)Engineering serviceD/D	31	122	153
2)Engineering serviceS/V	61	306	367
5 Phisical contingency	245	245	490
Sub-total	3,122	3,000	6,123
6 Price Contingency	312	300	612
Grand total	3,435	3,300	6,735
OM Cost			42

Drainage Improvement : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	1,838	2,117	3,955
1) Material and Equipment	1,603	2,117	3,721
2)Skilled Labor	80	0	80
3)Unskilled Labor	155	0	155
2 Land acquisition & House Reloc	486	0	486
3 Administration	53	0	53
4 1)Engineering serviceD/D	27	111	138
2)Engineering serviceS/V	53	279	332
5 Phisical contingency	214	223	437
Sub-total	2,671	2,730	5,401
6 Price Contingency	0	0	0
Grand total	2,671	2,730	5,401
OM Cost			37

River Improvement 10-year (Chainat~Pathum Thani : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	507	602	1,109
1) Material and Equipment	432	602	1,034
2)(a) Skilled Labor	40		40
(b) Unskilled Labor	35		35
2 Land acquisition	20		20
3 Administration	22		22
4 1)Engineering service D/D	8	59	66
2)Engineering service S/V	6	56	62
5 Physical contingency	45	60	105
Sub-total	607	776	1,384
6 Price Contingency	18	23	41
Grand total	625	800	1,425
OM Cost			34

River Improvement 10-year (Chainat~Pathum Thani : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	441	548	989
1) Material and Equipment	377	548	925
2)(a) Skilled Labor	35	0	35
(b) Unskilled Labor	29	0	29
2 Land acquisition	16	0	16
3 Administration	19	0	19
4 1)Engineering service D/D	7	53	60
2)Engineering service S/V	5	51	56
5 Physical contingency	39	55	94
Sub-total	528	707	1,234
6 Price Contingency	0	0	0
Grand total	528	707	1,234
OM Cost		31	31

Dam Compensation Cost : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	0	0	0
1) Material and Equipment	0	0	0
2)(a) Skilled Labor	0	0	0
(b) Unskilled Labor	0	0	0
2 Land acquisition	0	0	0
3 Administration	0	0	0
4 Engineering service	0	0	0
5 Physical contingency	46	0	46
Sub-total	46	0	46
6 Price Contingency	0	0	0
Grand total	46	0	46
OM Cost	451	0	451

Dam Compensation : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	0	0	0
1) Material and Equipment	0	0	0
2)(a) Skilled Labor	0	0	0
(b) Unskilled Labor	0	0	0
2 Land acquisition	0	0	0
3 Administration	0	0	0
4 Engineering service	0	0	0
5 Physical contingency	40	0	40
Sub-total	40	0	40
6 Price Contingency	0	0	0
Grand total	40	0	40
OM Cost	394	0	394

Note : Physical contingency of Dam means initial cost of necessary expences for preparation.

Table 4.2.2 PROJECT EVALUATION OF ALTERNATIVE 1

Alt-1 (excluding Dams)

Unit: million baht

		Economic cost			Economic benefit			
Year		Construction (A)	O&M (B)	Total (C)	General, etc. (D)	Agri. (E)	Total Economic Benefit (F)	(F)-(C) Benefit-Cost (G)
1	1998	1	0	1	0	0	0	-1
2	1999	56	0	56	0	0	0	-56
3	2000	87	0	87	0	0	0	-87
4	2001	99	0	99	0	0	0	-99
5	2002	627	0	627	0	0	0	-627
6	2003	1,199	0	1,199	0	0	0	-1,199
7	2004	1,939	0	1,939	0	0	0	-1,939
8	2005	1,602	2	1,604	78	15	93	-1,511
9	2006	765	33	798	969	49	1,018	220
10	2007	479	33	512	969	49	1,018	506
11	2008	0	70	70	1,997	177	2,174	2,104
12	2009	0	70	70	1,997	177	2,174	2,104
13	2010	0	70	70	1,997	177	2,174	2,104
14	2011	0	70	70	1,997	177	2,174	2,104
15	2012	0	70	70	1,997	177	2,174	2,104
16	2013	0	70	70	1,997	196	2,193	2,123
17	2014	0	70	70	1,997	196	2,193	2,123
18	2015	0	70	70	1,997	196	2,193	2,123
19	2016	0	70	70	1,997	196	2,193	2,123
20	2017	0	70	70	1,997	196	2,193	2,123
21	2018	0	70	70	1,997	196	2,193	2,123
22	2019	0	70	70	1,997	196	2,193	2,123
23	2020	0	70	70	1,997	196	2,193	2,123
24	2021	0	70	70	1,997	196	2,193	2,123
25	2022	0	70	70	1,997	196	2,193	2,123
26	2023	0	70	70	1,997	196	2,193	2,123
27	2024	0	70	70	1,997	196	2,193	2,123
28	2025	0	70	70	1,997	196	2,193	2,123
29	2026	0	70	70	1,997	196	2,193	2,123
30	2027	0	70	70	1,997	196	2,193	2,123
31	2028	0	70	70	1,997	196	2,193	2,123
32	2029	0	70	70	1,997	196	2,193	2,123
33	2030	0	70	70	1,997	196	2,193	2,123
34	2031	0	70	70	1,997	196	2,193	2,123
35	2032	0	70	70	1,997	196	2,193	2,123
36	2033	0	70	70	1,997	196	2,193	2,123
37	2034	0	70	70	1,997	196	2,193	2,123
38	2035	0	70	70	1,997	196	2,193	2,123
39	2036	0	70	70	1,997	196	2,193	2,123
40	2037	0	70	70	1,997	196	2,193	2,123
41	2038	0	70	70	1,997	196	2,193	2,123
42	2039	0	70	70	1,997	196	2,193	2,123
43	2040	0	70	70	1,997	196	2,193	2,123
44	2041	0	70	70	1,997	196	2,193	2,123
45	2042	0	70	70	1,997	196	2,193	2,123
46	2043	0	70	70	1,997	196	2,193	2,123
47	2044	0	70	70	1,997	196	2,193	2,123
48	2045	0	70	70	1,997	196	2,193	2,123
49	2046	0	70	70	1,997	196	2,193	2,123
50	2047	0	70	70	1,997	196	2,193	2,123
51	2048	0	70	70	1,997	196	2,193	2,123
52	2049	0	70	70	1,997	196	2,193	2,123
53	2050	0	70	70	1,997	196	2,193	2,123
54	2051	0	70	70	1,997	196	2,193	2,123
55	2052	0	70	70	1,997	196	2,193	2,123
56	2053	0	70	70	1,997	196	2,193	2,123
57	2054	0	70	70	1,997	196	2,193	2,123
58	2055	0	70	70	1,997	196	2,193	2,123
59	2056	0	70	70	1,997	196	2,193	2,123
60	2057	0	70	70	1,997	196	2,193	2,123
61	2058	0	70	70	1,997	196	2,193	2,123
62	2059	0	70	70	1,997	196	2,193	2,123
63	2060	0	70	70	1,997	196	2,193	2,123
64	2061	0	70	70	1,997	196	2,193	2,123
65	2062	0	70	70	1,997	196	2,193	2,123
66	2063	0	70	70	1,997	196	2,193	2,123
67	2064	0	70	70	1,997	196	2,193	2,123
68	2065	0	70	70	1,997	196	2,193	2,123
69	2066	0	70	70	1,997	196	2,193	2,123
70	2067	0	70	70	1,997	196	2,193	2,123
71	2068	0	70	70	1,997	196	2,193	2,123
		6,853	4,332	11,185	123,833	11,957	135,790	124,605
	EIRR		21.10%					

		PV		
Discount rate(%)	B/C	Cost	Benefit	NPV
15	1.54	2,708	4,169	1,461
12	2.00	3,298	6,588	3,291
10	2.44	3,793	9,269	5,476
5	4.71	5,700	26,845	21,145
3	6.66	7,049	46,972	39,923

Table 4.2.3 FINANCIAL CONSIDERATION

Unit : million baht

Item	Amount	Remark
I. Budget :		
Gov.Thailand	984,000	
Ministry of Agriculture and Cooperative		
RID	44,436	
Ministry of Interior		
PWD	39,813	
BMA	12,264	
Other Related Agency		
HD (Harbour Dept.)	2,301	
DOH (Dept. of Highway)	78127	
(1) Total of RID, PWD and BMA	96,513	
(1)' Total of (1), HD and DOH	176,941	
II. Cost :		
(a) Cost Requirement (Alternative-1)		
Distrubution System Improvement	14	285/20=14
Drainage System Improvement	337	6,735/20=337
River Improvement	71	1425/20=71
Modification of Dam Operation Rule	*453*	40/20+451=453
(2) Total Cost requirement/year	875	
(2) / (1) %	0.9	
(2) / (1)' %	0.5	
(b) Cost Requirement (Alternative 2-1)		
Distrubution System Improvement	14	285/20=14
Drainage System Improvement	337	6,735/20=337
Heightening of Flood Barrier	92	1,840/20=92
River Improvement	71	1,425/20=71
Modification of Dam Operation Rule	*453*	40/20+451=453
(3) Total Cost requirement/year	967	
(3) / (1) %	1.0	
(3) / (1)' %	0.5	
(b) Cost Requirement (Alternative 2-2)	2,992	
Distrubution System Improvement	14	285/20=14
Drainage System Improvement	337	6,735/20=337
Diversion Channel	2,116	42,329/20=2116
River Improvement	71	1,425/20=71
Modification of Dam Operation Rule	*453*	40/20+451=453
(4) Total Cost requirement/year	2,992	
(4) / (1) %	3.1	
(4) / (1)' %	1.7	

Note : Budget for 1997 from the source of Statiatical Yearbook Thailand,1996.

Table 4.2.4 FINANCIAL AND ECONOMIC COST AND BENEFIT OF ALTERNATIVE-2-1

Benefit (million baht/yeawr)

General	Agriculture	Total
3,568	196	3,764

exeluding benefit of Dam

Cost Evaluation (Unit : baht 1,000,000)

Distribution System Improvement :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	101	123	224
1) Material and Equipment	86	123	208
2)Skilled Labor	4	0	4
3)Unskilled Labor	11	0	11
2 Land acquisition & House R	3	0	3
3 Administration	3	0	3
4 1)Engineering serviceD/D	1	5	6
2)Engineering serviceS/V	1	11	13
5 Phisical contingency	4	7	11
Sub-total	113	146	259
6 Price Contingency	12	14	26
Grand total	125	160	285
OM Cost			2

Distribution System Improvement :Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	88	112	199
1) Material and Equipment	75	112	186
2)Skilled Labor	4	0	4
3)Unskilled Labor	10	0	10
2 Land acquisition & House Relo	2	0	2
3 Administration	2	0	2
4 1)Engineering serviceD/D	0	5	5
2)Engineering serviceS/V	1	10	12
5 Phisical contingency	4	6	10
Sub-total	98	133	231
6 Price Contingency	0	0	0
Grand total	98	133	231
OM Cost			2

Drainage Improvement :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	2,112	2,327	4,439
1) Material and Equipment	1,837	2,327	4,163
2)Skilled Labor	92	0	92
3)Unskilled Labor	184	0	184
2 Land acquisition & House R	612	0	612
3 Administration	61	0	61
4 1)Engineering serviceD/D	31	122	153
2)Engineering serviceS/V	61	306	367
5 Phisical contingency	245	245	490
Sub-total	3,122	3,000	6,123
6 Price Contingency	312	300	612
Grand total	3,435	3,300	6,735
OM Cost			42

Drainage Improvement : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	1,838	2,117	3,955
1) Material and Equipment	1,603	2,117	3,721
2)Skilled Labor	80	0	80
3)Unskilled Labor	155	0	155
2 Land acquisition & House Relo	486	0	486
3 Administration	53	0	53
4 1)Engineering serviceD/D	27	111	138
2)Engineering serviceS/V	53	279	332
5 Phisical contingency	214	223	437
Sub-total	2,671	2,730	5,401
6 Price Contingency	0	0	0
Grand total	2,671	2,730	5,401
OM Cost			37

Bangkok Dike along Chao Phraya River (Heightening=0.3m): Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	653	791	1,445
1) Material and Equipment	552	791	1,344
2)Skilled Labor	28	0	28
3)Unskilled Labor	74	0	74
2 Land acquisition & House R	18	0	18
3 Administration	18	0	18
4 1)Engineering serviceD/D	4	33	37
2)Engineering serviceS/V	9	74	83
5 Phisical contingency	28	44	72
Sub-total	731	942	1,673
6 Price Contingency	75	92	167
Grand total	806	1,034	1,840
OM Cost			13

Bangkok Dike along Chao Phraya River (Heightening=0.3m): Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	568	720	1,288
1) Material and Equipment	482	720	1,202
2)Skilled Labor	24	0	24
3)Unskilled Labor	62	0	62
2 Land acquisition & House Relo	15	0	15
3 Administration	16	0	16
4 1)Engineering serviceD/D	3	30	33
2)Engineering serviceS/V	8	67	75
5 Phisical contingency	24	40	64
Sub-total	634	858	1,492
6 Price Contingency	0	0	0
Grand total	634	858	1,492
OM Cost			12

River Improvement 10-year (Chainat-Pathum Thani : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	507	602	1,109
1) Material and Equipment	432	602	1,034
2)(a) Skilled Labor	40		40
(b) Unskilled Labor	35		35
2 Land acquisition	20		20
3 Administration	22		22
4 1)Engineering service D/D	8	59	66
2)Engineering service S/V	6	56	62
5 Physical contingency	45	60	105
Sub-total	607	776	1,384
6 Price Contingency	18	23	41
Grand total	625	800	1,425
OM Cost			34

River Improvement 10-year (Chainat-Pathum Thani : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	441	548	989
1) Material and Equipment	377	548	925
2)(a) Skilled Labor	35	0	35
(b) Unskilled Labor	29	0	29
2 Land acquisition	16	0	16
3 Administration	19	0	19
4 1)Engineering service D/D	7	53	60
2)Engineering service S/V	5	51	56
5 Physical contingency	39	55	94
Sub-total	528	707	1,234
6 Price Contingency	0	0	0
Grand total	528	707	1,234
OM Cost		31	31

Dam Compensation Cost : Thai (Financial)

Dam Compensation Cost : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	0	0	0
1) Material and Equipment	0	0	0
2)(a) Skilled Labor	0	0	0
(b) Unskilled Labor	0	0	0
2 Land acquisition	0	0	0
3 Administration	0	0	0
4 Engineering service	0	0	0
5 Physical contingency	46	0	46
Sub-total	46	0	46
6 Price Contingency	0	0	0
Grand total	46	0	46
OM Cost	451	0	451

Dam Compensation : Thai (Economic)

Dam Compensation : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	0	0	0
1) Material and Equipment	0	0	0
2)(a) Skilled Labor	0	0	0
(b) Unskilled Labor	0	0	0
2 Land acquisition	0	0	0
3 Administration	0	0	0
4 Engineering service	0	0	0
5 Physical contingency	40	0	40
Sub-total	40	0	40
6 Price Contingency	0	0	0
Grand total	40	0	40
OM Cost	394	0	394

Note : Physical contingency of Dam means initial cost of necessary expences for preparation.

Table 4.2.5 PROJECT EVALUATION OF ALTERNATIVE 2-1

Alt-2-1 (excluding Dams)　　Unit: million baht

		Economic cost			Economic benefit			
Year		Construction (A)	O&M (B)	Total (C)	General, etc. (D)	Agri. (E)	Total Economic Benefit (F)	(F)-(C) Benefit-Cost (G)
1	1998	1	0	1	0	0	0	-1
2	1999	56	0	56	0	0	0	-56
3	2000	87	0	87	0	0	0	-87
4	2001	103	0	103	0	0	0	-103
5	2002	640	0	640	0	0	0	-640
6	2003	1,216	0	1,216	0	0	0	-1,216
7	2004	2,097	0	2,097	0	0	0	-2,097
8	2005	2,109	2	2,111	78	15	93	-2,018
9	2006	1,270	33	1,303	285	48	333	-970
10	2007	768	33	801	285	48	333	-468
11	2008	0	82	82	3,037	177	3,214	3,132
12	2009	0	82	82	3,446	177	3,624	3,542
13	2010	0	82	82	3,446	177	3,624	3,542
14	2011	0	82	82	3,446	177	3,624	3,542
15	2012	0	82	82	3,446	177	3,624	3,542
16	2013	0	82	82	3,568	196	3,764	3,682
17	2014	0	82	82	3,568	196	3,764	3,682
18	2015	0	82	82	3,568	196	3,764	3,682
19	2016	0	82	82	3,568	196	3,764	3,682
20	2017	0	82	82	3,568	196	3,764	3,682
21	2018	0	82	82	3,568	196	3,764	3,682
22	2019	0	82	82	3,568	196	3,764	3,682
23	2020	0	82	82	3,568	196	3,764	3,682
24	2021	0	82	82	3,568	196	3,764	3,682
25	2022	0	82	82	3,568	196	3,764	3,682
26	2023	0	82	82	3,568	196	3,764	3,682
27	2024	0	82	82	3,568	196	3,764	3,682
28	2025	0	82	82	3,568	196	3,764	3,682
29	2026	0	82	82	3,568	196	3,764	3,682
30	2027	0	82	82	3,568	196	3,764	3,682
31	2028	0	82	82	3,568	196	3,764	3,682
32	2029	0	82	82	3,568	196	3,764	3,682
33	2030	0	82	82	3,568	196	3,764	3,682
34	2031	0	82	82	3,568	196	3,764	3,682
35	2032	0	82	82	3,568	196	3,764	3,682
36	2033	0	82	82	3,568	196	3,764	3,682
37	2034	0	82	82	3,568	196	3,764	3,682
38	2035	0	82	82	3,568	196	3,764	3,682
39	2036	0	82	82	3,568	196	3,764	3,682
40	2037	0	82	82	3,568	196	3,764	3,682
41	2038	0	82	82	3,568	196	3,764	3,682
42	2039	0	82	82	3,568	196	3,764	3,682
43	2040	0	82	82	3,568	196	3,764	3,682
44	2041	0	82	82	3,568	196	3,764	3,682
45	2042	0	82	82	3,568	196	3,764	3,682
46	2043	0	82	82	3,568	196	3,764	3,682
47	2044	0	82	82	3,568	196	3,764	3,682
48	2045	0	82	82	3,568	196	3,764	3,682
49	2046	0	82	82	3,568	196	3,764	3,682
50	2047	0	82	82	3,568	196	3,764	3,682
51	2048	0	82	82	3,568	196	3,764	3,682
52	2049	0	82	82	3,568	196	3,764	3,682
53	2050	0	82	82	3,568	196	3,764	3,682
54	2051	0	82	82	3,568	196	3,764	3,682
55	2052	0	82	82	3,568	196	3,764	3,682
56	2053	0	82	82	3,568	196	3,764	3,682
57	2054	0	82	82	3,568	196	3,764	3,682
58	2055	0	82	82	3,568	196	3,764	3,682
59	2056	0	82	82	3,568	196	3,764	3,682
60	2057	0	82	82	3,568	196	3,764	3,682
61	2058	0	82	82	3,568	196	3,764	3,682
62	2059	0	82	82	3,568	196	3,764	3,682
63	2060	0	82	82	3,568	196	3,764	3,682
64	2061	0	82	82	3,568	196	3,764	3,682
65	2062	0	82	82	3,568	196	3,764	3,682
66	2063	0	82	82	3,568	196	3,764	3,682
67	2064	0	82	82	3,568	196	3,764	3,682
68	2065	0	82	82	3,568	196	3,764	3,682
69	2066	0	82	82	3,568	196	3,764	3,682
70	2067	0	82	82	3,568	196	3,764	3,682
71	2068	0	82	82	3,568	196	3,764	3,682
		8,346	5,064	13,410	217,278	11,955	229,233	215,823
	EIRR		24.02%					

		PV		
Discount rate(%)	B/C	Cost	Benefit	NPV
15	1.95	3,184	6,204	3,020
12	2.58	3,900	10,073	6,173
10	3.20	4,503	14,432	9,929
5	6.41	6,825	43,725	36,901
3	9.20	8,457	77,771	69,313

Table 4.2.6 FINANCIAL AND ECONOMIC COST AND BENEFIT OF ALTERNATIVE-2-2

Cost Evaluation (Unit : baht 1,000,000)

Ayuthaya-East-Sea-2 Diversion(1,100m3/s) :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	7,152	12,289	19,441
1) Material and Equipment	6,335	12,289	18,624
2)Skilled Labor	341	0	341
3)Unskilled Labor	476	0	476
2 Land acquisition & House F	15,186	0	15,186
3 Administration	759	0	759
4 1)Engineering serviceD-D	10	87	97
2)Engineering serviceS/V	97	875	972
5 Phisical contingency	130	223	353
Sub-total	23,334	13,474	36,808
6 Price Contingency	3,500	2,021	5,521
Grand total	26 834	15,495	42,329
OM Cost			186

Ayuthaya-East-Sea Diversion(1,100m3/s) : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Construction cost	6,219	11,183	17,412
1) Material and Equipment	5,531	11,183	16,714
2)Skilled Labor	298	0	298
3)Unskilled Labor	400	0	400
2 Land acquisition & House Relo	12,013	0	12,013
3 Administration	663	0	663
4 1)Engineering serviceD/D	8	80	88
2)Engineering serviceS/V	85	796	881
5 Phisical contingency	113	203	316
Sub-total	19,141	12,262	31,402
6 Price Contingency	0	0	0
Grand total	19,141	12,262	31,402
OM Cost			167

Benefit (million baht/yeawr)

General	Agriculture	Total
3,568	196	3,764

excluding benefit of Dam

Distribution System Improvement :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Construction cost	101	123	224
1) Material and Equipment	86	123	208
2)Skilled Labor	4	0	4
3)Unskilled Labor	11	0	11
2 Land acquisition & House F	3	0	3
3 Administration	3	0	3
4 1)Engineering serviceD/D	1	5	6
2)Engineering serviceS/V	1	11	13
5 Phisical contingency	4	7	11
Sub-total	113	146	259
6 Price Contingency	12	14	26
Grand total	125	160	285
OM Cost			2

Distribution System Improvement :Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	88	112	199
1) Material and Equipment	75	112	186
2)Skilled Labor	4	0	4
3)Unskilled Labor	10	0	10
2 Land acquisition & House Relo	2	0	2
3 Administration	2	0	2
4 1)Engineering serviceD/D	0	5	5
2)Engineering serviceS/V	1	10	12
5 Phisical contingency	4	6	10
Sub-total	98	133	231
6 Price Contingency	0	0	0
Grand total	98	133	231
OM Cost			2

Drainage Improvement :Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Construction cost	2,112	2,327	4,439
1) Material and Equipment	1,837	2,327	4,163
2)Skilled Labor	92	0	92
3)Unskilled Labor	184	0	184
2 Land acquisition & House F	612	0	612
3 Administration	61	0	61
4 1)Engineering serviceD/D	31	122	153
2)Engineering serviceS/V	61	306	367
5 Phisical contingency	245	245	490
Sub-total	3,122	3,000	6,123
6 Price Contingency	312	300	612
Grand total	3,435	3,300	6,735
OM Cost			42

Drainage Improvement : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	1,838	2,117	3,955
1) Material and Equipment	1,603	2,117	3,721
2)Skilled Labor	80	0	80
3)Unskilled Labor	155	0	155
2 Land acquisition & House Relo	486	0	486
3 Administration	53	0	53
4 1)Engineering serviceD/D	27	111	138
2)Engineering serviceS/V	53	279	332
5 Phisical contingency	214	223	437
Sub-total	2,671	2,730	5,401
6 Price Contingency	0	0	0
Grand total	2,671	2,730	5,401
OM Cost			37

River Improvement 10-year (Chainat~Pathum Thani : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	507	602	1,109
1) Material and Equipment	432	602	1,034
2)(a) Skilled Labor	40		40
(b) Unskilled Labor	35		35
2 Land acquisition	20		20
3 Administration	22		22
4 1)Engineering service D/D	8	59	66
2)Engineering service S/V	6	56	62
5 Physical contingency	45	60	105
Sub-total	607	776	1,384
6 Price Contingency	18	23	41
Grand total	625	800	1,425
OM Cost			34

River Improvement 10-year (Chainat~Pathum Thani : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	441	548	989
1) Material and Equipment	377	548	925
2)(a) Skilled Labor	35	0	35
(b) Unskilled Labor	29	0	29
2 Land acquisition	16	0	16
3 Administration	19	0	19
4 1)Engineering service D/D	7	53	60
2)Engineering service S/V	5	51	56
5 Physical contingency	39	55	94
Sub-total	528	707	1,234
6 Price Contingency	0	0	0
Grand total	528	707	1,234
OM Cost		31	31

River Improvement 25-year (Chainat~Pathum Thani : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	652	775	1,427
1) Material and Equipment	556	775	1,330
2)(a) Skilled Labor	52	0	52
(b) Unskilled Labor	45	0	45
2 Land acquisition	26	0	26
3 Administration	28	0	28
4 1)Engineering service D/D	10	75	85
2)Engineering service S/V	8	71	79
5 Physical contingency	58	78	135
Sub-total	782	999	1,781
6 Price Contingency	23	30	53
Grand total	805	1,029	1,834
OM Cost			44

River Improvement 25-year (Chainat~Pathum Thani : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	568	705	1,273
1) Material and Equipment	485	705	1,190
2)(a) Skilled Labor	45	0	45
(b) Unskilled Labor	38	0	38
2 Land acquisition	20	0	20
3 Administration	25	0	25
4 1)Engineering service D/D	9	69	77
2)Engineering service S/V	7	65	72
5 Physical contingency	51	71	121
Sub-total	679	909	1,588
6 Price Contingency	0	0	0
Grand total	679	909	1,588
OM Cost		39	40

Dam Compensation Cost : Thai (Financial)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	0	0	0
1) Material and Equipment	0	0	0
2)(a) Skilled Labor	0	0	0
(b) Unskilled Labor	0	0	0
2 Land acquisition	0	0	0
3 Administration	0	0	0
4 Engineering service	0	0	0
5 Physical contingency	46	0	46
Sub-total	46	0	46
6 Price Contingency	0	0	0
Grand total	46	0	46
OM Cost	451	0	451

Dam Compensation : Thai (Economic)

Classification of cost	L.C.	F.C	Total
1 Constructioin cost	0	0	0
1) Material and Equipment	0	0	0
2)(a) Skilled Labor	0	0	0
(b) Unskilled Labor	0	0	0
2 Land acquisition	0	0	0
3 Administration	0	0	0
4 Engineering service	0	0	0
5 Physical contingency	40	0	40
Sub-total	40	0	40
6 Price Contingency	0	0	0
Grand total	40	0	40
OM Cost	391	0	391

Note : Physical contingency of Dam means initial cost of necessary expences for preparation.

Table 4.2.7 PROJECT EVALUATION OF ALTERNATIVE 2-2

Alt-2-2 (excluding Dams)

Unit: million baht

		Economic cost			Economic benefit			
Year		Construction (A)	O&M (B)	Total (C)	General, etc. (D)	Agri. (E)	Tot Economic Benefit (F)	(F)-(C) Benefit-Cost (G)
1	1998	1	0	1	0	0	0	-1
2	1999	56	0	56	0	0	0	-56
3	2000	87	0	87	0	0	0	-87
4	2001	104	0	104	0	0	0	-104
5	2002	653	0	653	0	0	0	-653
6	2003	1,225	0	1,225	0	0	0	-1,225
7	2004	1,948	0	1,948	0	0	0	-1,948
8	2005	2,636	2	2,638	78	15	93	-2,545
9	2006	1,799	33	1,832	285	48	333	-1,499
10	2007	1,513	33	1,546	285	48	333	-1,213
11	2008	1,034	70	1,104	1,313	232	1,545	441
12	2009	2,245	70	2,315	1,313	232	1,545	-770
13	2010	2,422	70	2,492	1,313	232	1,545	-947
14	2011	4,169	70	4,239	1,313	232	1,545	-2,694
15	2012	6,120	70	6,190	1,313	232	1,545	-4,645
16	2013	6,109	70	6,178	1,313	232	1,545	-4,633
17	2014	2,303	70	2,373	4,634	201	4,835	2,462
18	2015	1,955	70	2,025	4,634	201	4,835	2,810
19	2016	2,193	70	2,263	4,634	201	4,835	2,572
20	2017	399	237	636	5,529	224	5,752	5,116
21	2018	133	237	370	5,863	229	6,092	5,722
22	2019	0	280	280	5,851	227	6,078	5,798
23	2020	0	280	280	5,851	227	6,078	5,798
24	2021	0	280	280	5,851	227	6,078	5,798
25	2022	0	280	280	5,851	227	6,078	5,798
26	2023	0	280	280	5,851	227	6,078	5,798
27	2024	0	280	280	5,851	227	6,078	5,798
28	2025	0	280	280	5,851	227	6,078	5,798
29	2026	0	280	280	5,851	227	6,078	5,798
30	2027	0	280	280	5,851	227	6,078	5,798
31	2028	0	280	280	5,851	227	6,078	5,798
32	2029	0	280	280	5,851	227	6,078	5,798
33	2030	0	280	280	5,851	227	6,078	5,798
34	2031	0	280	280	5,851	227	6,078	5,798
35	2032	0	280	280	5,851	227	6,078	5,798
36	2033	0	280	280	5,851	227	6,078	5,798
37	2034	0	280	280	5,851	227	6,078	5,798
38	2035	0	280	280	5,851	227	6,078	5,798
39	2036	0	280	280	5,851	227	6,078	5,798
40	2037	0	280	280	5,851	227	6,078	5,798
41	2038	0	280	280	5,851	227	6,078	5,798
42	2039	0	280	280	5,851	227	6,078	5,798
43	2040	0	280	280	5,851	227	6,078	5,798
44	2041	0	280	280	5,851	227	6,078	5,798
45	2042	0	280	280	5,851	227	6,078	5,798
46	2043	0	280	280	5,851	227	6,078	5,798
47	2044	0	280	280	5,851	227	6,078	5,798
48	2045	0	280	280	5,851	227	6,078	5,798
49	2046	0	280	280	5,851	227	6,078	5,798
50	2047	0	280	280	5,851	227	6,078	5,798
51	2048	0	280	280	5,851	227	6,078	5,798
52	2049	0	280	280	5,851	227	6,078	5,798
53	2050	0	280	280	5,851	227	6,078	5,798
54	2051	0	280	280	5,851	227	6,078	5,798
55	2052	0	280	280	5,851	227	6,078	5,798
56	2053	0	280	280	5,851	227	6,078	5,798
57	2054	0	280	280	5,851	227	6,078	5,798
58	2055	0	280	280	5,851	227	6,078	5,798
59	2056	0	280	280	5,851	227	6,078	5,798
60	2057	0	280	280	5,851	227	6,078	5,798
61	2058	0	280	280	5,851	227	6,078	5,798
62	2059	0	280	280	5,851	227	6,078	5,798
63	2060	0	280	280	5,851	227	6,078	5,798
64	2061	0	280	280	5,851	227	6,078	5,798
65	2062	0	280	280	5,851	227	6,078	5,798
66	2063	0	280	280	5,851	227	6,078	5,798
67	2064	0	280	280	5,851	227	6,078	5,798
68	2065	0	280	280	5,851	227	6,078	5,798
69	2066	0	280	280	5,851	227	6,078	5,798
70	2067	0	280	280	5,851	227	6,078	5,798
71	2068	0	280	280	5,851	227	6,078	5,798
		39,103	15,166	54,268	326,370	13,908	340,277	286,009
	EIRR		12.10%					

		PV		
Discount rate(%)	B/C	Cost	Benefit	NPV
15	0.77	7,306	5,658	-1,648
12	1.01	9,944	10,036	92
10	1.24	12,395	15,345	2,950
5	2.40	23,120	55,511	32,390
3	3.40	31,116	105,851	74,735