CHAPTER IV FLOOD DAMAGE SURVEY

4.1 General

4.1.1 Methodology of Survey

The objective of this survey is to estimate the cost of average annual flood damage on Hat Yai district. The estimated damage cost is used for the economic evaluation of the proposed project as the project benefit. The cost of average annual flood damage is estimated through the following procedures.

(1) From among the flood damages experienced in the past, the typical small, medium and large floods are selected to establish the relationship between damage cost and flood magnitude (or flood frequency).

(2) Physical damage quantities of the typical floods are arranged based on the reports of the concerned agencies/organizations.

(3) Flood damage costs have been reported by various agencies/organizations immediately after the floods. However, the reports estimate only part of the damage costs or are partly duplicated each other. Damages of some items are overestimated or underestimated, or neglected. Accordingly, the damage costs are re-estimated in a unified manner to the possible extent.

(4) The damage costs are estimated for as many items of direct and indirect damages as possible. The damage costs to be estimated include following items. Among them, however, other loss of indirect damage is not estimated in monetary term although it may be very large. Its estimation is very difficult.

Damage Item	Contents
1. Direct Damage	
(1) Household Damage	House Building, Household Effects
(2) Farm Damage	Crops, Livestock
(3) Infrastructure Damage	Road, Bridge, School, Drainage System, Government Office, etc.
(4) Industrial Damage	Large Factory, Small Industry, Business Office, Hotel, Hospital, etc
2. Indirect Damage	
(1) Wage Loss	Wage Loss
(2) Tourism Revenue Loss	Revenue Loss from Tourist
(3) Other Loss	Transportation, Tele-communication, Evacuation, Secondary Business Loss etc.

(5) The damage costs reported by the concerned agencies/organizations are supplemented by the data obtained through the interview survey of this Study.

(6) The flood damage costs of the selected small, medium and large floods are estimated at 2002 price.

(7) On the other hand, return periods of the selected three (3) scale floods are estimated.

(8) Based on the results of item (6) and (7), damage cost - flood frequency curve is established.

(9) Average annual flood damage cost of Hat Yai district is estimated by integrating the above curve.

(10) The average annual flood damage cost due to the floods of Khlong Wa basin is estimated by allocating the above damage cost based on the flood share of the Khlong Wa basin.

4.1.2 Selection of Typical Floods

Hat Yai district has been damaged by floods many times. From among them, the 1998 and 1999 floods are selected as small flood, the 1988 flood as medium one and the 2000 flood as large one. The return periods of the above floods are roughly estimated based on the probability calculations of rainfall depth of the Khlong U-Taphao basin as shown below.

Flood	Small Flood		Medium Flood	Large Flood
	1998 Flood	1999 Flood	1988 Flood	2000 Flood
Return Period (year)	3	5	7	65

4.2 Estimate of Large Flood Damage (2000 Flood)

4.2.1 Flood Damage Reports of Concerned Agencies/Organizations

(1) Local Government Office, Songkhla Province

The local government office, Songkhla province reported the physical flood damage quantities on Hat Yai district as follows. However, they are limited to affected/dead/wounded persons, destructed houses, affected households, damaged crops, damaged livestock and damaged government infrastructures. Those are shown below. The damage costs estimated by the office are also shown below.

(Unit: million Baht at 2000 price)

Damage Item	Damage Quantity	Damage Cost
Affected Households	25,280	Not estimated
Affected Persons	79,130	-
Dead/Missing Persons	27	-
Wounded Persons	373	-
Destructed House (nos.)	1,088	Not estimated
Damaged Crops (rai)	28,800	32.80
Damaged Livestock (head)	31,100	10.92
Damaged Infrastructure (government)		193.56
Road (nos.)	657	57.00
Bridge (nos.)	56	21.88
Weir (nos.)	15	0.67
Drainage System (nos.)	105	2.50
Other Structures (nos.)	1,378	4.13
School (nos.)	117	90.56
Religious Building (nos.)	90	10.19
Government Office (nos.)	27	6.63

(2) Infrastructure Damage Reported by Other Agencies

The other various agencies reported the estimated damage costs on the infrastructures under their jurisdiction as follows.

(Unit: million Baht at 2000 price)

Agency	Damage Cost	Remarks
Hat Yai Municipality	1,855.00	64 Roads, 3 bridges, 3 Pumping.Stations and many other small infrastructures
Community Development Office	7.29	Community development infrastructures
Accelerated Rural Development Office	98.80	Road, water works, water resources facilities
Songkhla Highway Office	15.11	Highways
Songkhla Public Health Office	133.85	Public health service and infrastructures
Songkhla Electricity Office	32.39	Electricity supply facilities

The above damages are considered mostly duplicated with the reports of the local government, Songkhla province except electricity office's report (32.39 million Baht). The report of Hat Yai municipality is considered to be an overestimate.

(3) Songkhla Chamber of Commerce

Songkhla chamber of commerce estimated the damage costs on the private industrial factories and commercial enterprises as shown below.

(Unit: million Baht at 2000 price)

Item	Damage Quantity	Damage Cost
Large Industrial Factory	17	900
Small Scale Industries	160	900
Business Office	200	900
Hotel	50	1,000
Private Hospital/Clinic	76	640
Total		4,340

4.2.2 Interview Survey on 2000 Flood Damage

(1) General

Out of the direct damage listed in the table in Section 4.1.1, farm damage, infrastructure damage and industrial damage can be estimated from the above data with small modifications as required. However, household damage is estimated based on the interview survey since no reliable data are available. Further, some indirect damages are also estimated from the results of the interview survey.

All the damage costs obtained through the interview are shown at 2002 price.

(2) Respondents

An interview survey was made for approximately 100 people living in the flooded areas within and outside Hat Yai municipality. The respondents are classified into two (2) categories: farmer and non-farmer. They are broken down as follows.

Respondent	Within Hat Yai	Outside Hat Yai	Total
Non-farmer (person)	60	7	67
Farmer (person)	10	21	31
Total (person)	70	28	98

(3) Flooding Conditions

The year 2000 flood inundated almost all the respondents. The flooding conditions are as summarized below.

Item	Average
Flooded Respondent (%)	93
Flooded Duration (day)	4
Average Flooded Depth (cm)	127

(4) Household and Housing Conditions

The average number of household, household income, house value and house usage of the respondents are summarized below.

Item	Average
Average Nos. of Household (person)	4.18
Working at Home (person)	0.97
Working Outside (person)	1.50
Not Working (person)	1.71
Average Household Income (Baht/year)	155,347
Present Value of House (Baht/house)	391,818
Usage of House Building	
Dwelling Only (%)	48
Business Only (%)	4
Both Dwelling and Business (%)	48

(5) Damages on Household

The average property and goods damages per one (1) flooded household are estimated at about 19,500 Baht with the following breakdown.

(Unit: Baht)

Item (damage/flooded household)	Average
Damage to Finished Goods	7,138
Damage to Electrical Appliances	3,247
Damage to Vehicle	1,958
Damage to Furniture	1,651
Damage to Machinery	289
Damage to Household Utensils	467
Damage to Floor	239
Damage to Raw Materials and Inputs	262
Damage to Cloth	170
Other Damages	4,057
Total	19,478

(6) Wage Loss

The average days absent from work per one (1) household are summarized below. The man-days absent from work are calculated as shown also in the below table by using the number of working persons per household given in the above table in (4). The wage loss per one (1) household is estimated below.

This wage loss is applied not only for flooded households but also for all the households in Hat Yai district since all the offices and enterprises were closed during and after the flood.

Item	Average
Days Absent from Work Outside (day/household)	13
Days Absent from Work at Home (day/household)	18
Man-days Absent from Work Outside (man-day/household)	20
Man-days Absent from Work at Home (man-day/household)	17
Total Man-days Absent from Work (man-day/household)	37
Total Wage Loss (Baht/household)	10,360

Note: Total wage loss is estimated by assuming as 280 Baht per one (1) man-day.

(7) *Costs of Flood Preparedness and Received Relief*

The people prepared for some measures to encounter floods by themselves before flood coming. The people also received foods, medicine, cloths and other goods during and after the flood from private organization and government. The cost for the above preparedness and relieves per one (1) flooded household are as follows.

Item	Average
Flood Preparedness (Baht/flooded household)	595
Received Relief (Baht/flooded household)	146
Total (Baht/flooded household)	741

(8) Disease

Members of the flooded household suffered from the disease during the flood. The suffered ratio of disease per one (1) flooded household is summarized below. This table shows that 2.6 persons (= 4.18 x 0.62) suffered from some disease in one (1) flooded household.

Suffered Ratio (%)	Average
Foot Disease/Rot	52
Diarrhea	4
Eye Disease	1
Skin Disease	5
Total	62

For details on the interview survey, see Appendix A.

4.2.3 Estimated Flood Damage Costs

(1) Direct Damage

The direct damage includes household damage, farm damage and industrial damage. Those damages are estimated as follows. The damage costs estimated at 2000 price are converted to those at 2002 price by using the consumer's price index of 1.02.

(Unit: million Baht)

Damage Item	At 2000 Price	At 2002 Price	Remarks
1. Household Damage		918.7	
(1) Destructed House	-	426.3	1,088 destructed houses x unit house value (391,818 B)
(2) Household Effects		492.4	25,280 affected houses x unit damage (19,478 B)
2. Farm Damage	53.5	54.6	
(1) Crops	42.6	43.5	Provincial office data (32.8 mill B) + after flood cost (30%)
(2) Livestock	10.9	11.1	Provincial office data
3. Infrastructure Damage	264.7	270.0	Provincial office data (193.6 mill B) + electricity damage (32.4 mill B) + railway/ other utilities (20%: 38.7 million B)
4. Industrial Damage	4,340.0	4,426.8	Chamber of commerce data
5. Total Damage		5,670.1	

(2) Indirect Damage

(a) Wage Loss

According to the interview survey, 37 man-days per one (1) household were absent from work during and after the flood with a total wage loss of 10,360 Baht/household. This unit wage loss is applied for all the households in Hat Yai district since all the offices and enterprises were closed.

The total wage loss in Hat Yai district is 988.5 million Baht (= 95,413 households x 10,360 Baht/household) at 2002 price.

(b) Tourism Revenue Loss

According to the report of Tourism Authority of Thailand, about 4.4 million tourists visited Hat Yai district spending 27,861 million Baht (at 2000 price) in 2000. See Appendix A.

About 2,322 million Baht might have been lost in 2000 if it is assumed that no tourist visited for one (1) month during and after the flood. However, the economic revenue loss (economic benefit) is conservatively assumed to be 1,161 million Baht (50% of gross revenue loss) at 2000 price or 1,184.2 million Baht at 2002 price.

(c) Flood Preparedness and Relief Costs

The people prepared for some measures to encounter the flood before its coming and received flood relieves during and after the flood. Their cost per one (1) flooded household is estimated at 741 Baht based on the interview survey.

The total cost in Hat Yai district is estimated to be 18.7 million Baht at 2002 price.

(3) Total Damage

The total damage costs of direct and indirect damages are estimated at 7,862 million Baht at 2002 price with the following summarized breakdown.

(Unit: million Baht at 2002 price)

Damage Item	Damage Cost	Remarks
1. Direct Damage	5,670.1	
(1) Household Damage	918.7	
(2) Farm Damage	54.6	
(3) Infrastructure Damage	270.0	
(4) Industrial Damage	4,426.8	
2. Indirect Damage (Tangible)	2,191.4	
(1) Wage Loss	988.5	
(2) Tourism Revenue Loss	1,184.2.	
(3) Flood Preparedness and Relief Cost	18.7	
3. *Indirect Damage (Intangible)*	-	*Secondary business loss, health and sanitation problems, etc.*
4. Total	7,861.5	

The business loss to be included in direct damage (commercial goods damage, close of business, etc.) could not be estimated in detail in this Study due to the financial limitation of the interview survey. The above estimated total cost may be smaller than the real one.

On the other hand, NESDB estimated the total flood damage cost to be 17,832 million Baht at 2000 price of which breakdown is not available.

However, the above damage cost conservatively estimated by the Study Team is employed in this Report.

4.3 Estimate of Medium Flood Damage (1988 Flood)

4.3.1 Flood Damage Records

Records of the flood damage are very limited. No data are available concerning the damages of household, farm and infrastructures. Even number of affected household is not available. Only damage costs of commercial unit and losses of tourism industry are fragmentarily available. These data are not available for cost estimation of the flood damages.

However, the total cost of direct and indirect damages was reported to be 2,000 million Baht at 1988 price in a lump sum by the government.

4.3.2 Estimated Flood Damage Cost

If the same scale flood as the 1988 flood occurs this year, how much flood damage cost will it generate?

The damage potential of Hat Yai district has increased according to the economic growth during the period of 1988 to 2002. However, no significant flood prevention measures have been implemented during the above 14 years. Hence, it is considered reasonable to assume that the flood damage cost increases in proportion to the economic growth.

The damage cost of 1988 flood under the existing socio-economic situation (2002 year) is roughly estimated at 4,420 million Baht, taking into consideration to the economic growth and price escalation during the period of 1988 to 2002.

In this estimation, the multiplier of economic growth of Hat Yai district (GPP growth) during 14 years is estimated at 1.25. The multiplier for price escalation during the same period is estimated at 1.77 by taking from the consumer's price index. Accordingly, the integrated multiplier comes to 2.21.

For the GPP growth and price escalation in the past, see Appendix C.

4.4 Estimate of Small Flood Damage (1998/1999 Flood)

4.4.1 Flood Damage Records

The local government, Songkhla province reported the physical damaged quantities and damage costs of 1998 and 1999 as follows.

Damage Item	1998 Flood		1999 Flood	
	Quantity	Cost (million B at 1998 price)	Quantity	Cost (million B at 1999 price)
Affected Households	812	Not estimated	5,116	Not estimated
Affected Persons	2,685	-	22,965	-
Dead Persons	1	-	-	-
Farm Damage (Crops) (rai)	-	-	7,828	14.72
Damaged Infrastructure		2.33		6.30
Road (nos.)	29	1.88	72	3.07
Bridge (nos.)	7	0.35	-	-
Weir (nos.)	-	-	1	0.08
School (nos.)	-	-	10	-
Drainage System (nos.)	-	-	2	3.15

No other data are available.

4.4.2 Estimated Flood Damage Cost

The damage costs of 1998 and 1999floods are estimated at 2002 price based on the following assumptions.

(1) Damage cost on household effects is estimated as the product of number of affected households and unit damage cost applied for 2000 flood.

(2) For the damage costs on crops and infrastructures, the estimated costs of local government, Songkhla province are employed.

(3) Industrial damage cost is estimated on the assumption that it is proportional to the cost of household damage.

(4) Indirect damage cost is estimated on the assumption that it is also proportional to the number of affected people

(5) The socio-economic situations namely damage potential in 1998 and 1999 are almost the same as those in 2002.

(6) The multiplier for price escalation is assumed to be 1.04 from the consumer's price index (see Appendix C.) for both periods of 1998 to 2002 and 1999 to 2002.

The total damage cost of 1998 flood is estimated at 168.7 million Baht at 2002 price with the following breakdown.

(Unit: million Baht at 2002 price)

Damage Item	Damage Cost	Remarks
1. Direct Damage	94.3	
(1) Household Damage	15.8	812 affected houses x unit damage (19,478 B)
(2) Farm Damage	-	
(3) Infrastructure Damage	2.4	2.33 million B x 1.04
(4) Industrial Damage	76.1	4,426.8 million B x 15.8 million B / 918.7 million B
2. Indirect Damage (Tangible)	74.4	2,191.4 million B x 2,685 persons / 79,130 persons
3. Total	168.7	

The total damage cost of 1999 flood is estimated at 1,237.5 million Baht at 2002 price with the following breakdown.

(Unit: million Baht at 2002 price)

Damage Item	Damage Cost	Remarks
1. Direct Damage	601.4	
(1) Household Damage	99.6	5,116 affected houses x unit damage (19,478 B)
(2) Farm Damage	15.3	14.72 million Baht x 1.04
(3) Infrastructure Damage	6.6	6.3 million B x 1.04
(4) Industrial Damage	479.9	4,426.8 million B x 99.6 million B / 918.7 million B
2. Indirect Damage (Tangible)	636.0	2,191.4 million B x 22,965 persons / 79,130 persons
3. Total	1,237.4	

4.5 Average Annual Flood Damage

The targets of flood prevention areas are Hat Yai Municipality and its surrounding area, Na Mom Districts, and Kor Hong TAO. From this study, the second phrase of the project will be developed, the structures will not only prevent floods in the targeted area but also prevent floods for other areas. By this reason, the damage areas are classified into principal area, which is the originally planned targeted area as one, and supplementary area, which is extra area as another. Damages of each area is defined as follows

4.5.1 Principal Area

The principal area cover Hat Yai Municipality including Kor Hong TAO, and Na Mom District. Estimation of damages is base on following conditions.

From the analysis in Section 4.1-4.4, the flood damage costs and flood frequencies of the four (4) floods are obtained as follows.

(Unit: million Baht at 2002 price)

Item	1998 Flood	1999 Flood	1988 Flood	2000 Flood
Flood Damage Cost	168.7	1,237.4	4420.0	7,861.5
Flood Return Period (Year)	2	3	7	68

From the above table, the flood damage cost-flood frequency curve is prepared as shown in Fig. 4.5-1

The average annual flood (1.1-100 year floods) damage cost of Hat Yai district is estimated at 1,892 Million Baht/year. For the damage portion that exceeds 25 year but not more than 100 year is averaged at 220 Million Baht/year.

4.5.2 Supplementary Area

Supplementary area cover the areas of three Tambons, namely: Tambon Takham and Tambon Nam Noi, both are in Hat Yai District, and Tambon Phra Wong under Muang Songkhla District. Details are as follows:

Tambon	Takham	Nam Noi,	Phra Wong	Total
District	Hat Yai	Hat Yai	Muang Songkhla	2 Districts
Number of Village under Prevention	8	10	7	25
Population in 2000	7,500	12,085	19,235	38,820
Household	2,127	3,344	5,793	11,264

Total area of 25 villages is 90 sq. Km. or 56,250 Rai. Land uses of these villages are as follows:

Land Use	Rai	%
Paddy Land	250	35
Rubber Plantation (highlands)	215	30
Forest (mountain)	107	15
Community	36	5
Industry	36	5
Mangrove	72	10
Total	715	100

Similar to Hat Yai and Na Mom, these villages are also suffering from flood particularly paddy land, community, and industries.

For year 2000 flood damages in this area are estimated as follows.

	Million Baht	Remarks
Damage to households	285	Base on average damage of 7,341 baht per household from household survey
Damage to farms	113	Base on 2,000 baht per rai of paddy land, from household survey
Work Absence	116	About 19,410 persons absent from work for one week for one month
Total	514	

Damages cost of other years floods (years 1988 1998 and 1999) beside year 2000 are estimated by using proportionate flood damage of principal area as follows

(Unit : Million Baht at 2002 price)

Item	1998 Flood	1999 Flood	1988 Flood	2000 Flood
Flood Damage Cost in Principal Area	168.7	1,237.4	4420.0	7,861.5
Estimated Flood Damage Cost in Supplementary Area	1.0	45.5	289.0	514.0
Flood Return Period (Year)	2	3	7	68

From the above table, the flood damage cost-flood frequency curve is prepared as shown in Fig. 4.5-1

The average annual flood damage cost of supplementary area for return period of 1.1 - 50 years flood is estimated as 132.71 million baht/year

4.5.3 Future Annual Flood Damage in Principal Area

The average annual flood damage cost of principal area in the future is estimated as shown in the below table on the assumption that the damage potential will increase in proportion to the growth of Gross Provincial Product (GPP). For the future growth of GPP, see Appendix A.

(Unit: million Baht at 2002 price)

Year	Present (2002)	2005	2010	2015	2020
GPP	51,310	55,290	62,592	69,329	76,485
Future Annual Flood Damage					
1.1-100 year flood	1,892	2,039	2,308	2,556	2,820
Over 25 to 50 year flood	38	148	168	189	205

4.5.4 Future Annual Flood Damage in Supplementary Area

Similar to principal area, future annual flood damage for supplementary area are estimated as follows:

(Unit: million Baht at 2002 price)

Year	Present (2002)	2005	2010	2015	2020
GPP	51,310	55,290	62,592	69,329	76,485
Future Annual flood damage	132	142	161	178	196

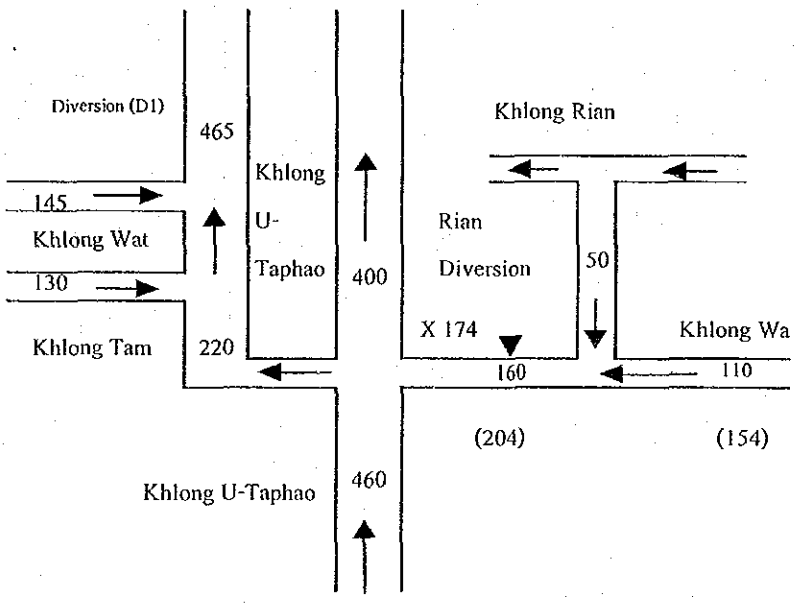
CHAPTER V FLOOD MITIGATION PROJECTS

5.1 Flood Mitigation Policy of Khlong Wa

5.1.1 Design Discharge of Khlong Wa

The ongoing flood mitigation projects of Hat Yai district were planned to meet the flood discharge with a 25-year return period. The proposed design discharges of the existing Khlong U-Taphao and new RID diversion channel (D1) are 400 cms. and 465 cms., respectively. They were determined taking into account the discharge of 160 cms. from Khlong Wa including the Rian diversion discharge of 50 cms.. The proposed Rian diversion channel joins the Khlong Wa at 4.0 km distance from the confluence with Khlong U-Taphao or immediately upstream of the water gauging station X 174 (located at 3.4 km distance).

The existing design discharge of the rivers/diversion channels around Hat Yai municipality is shown below.



However, the safety factor of the existing design discharge of Khlong Wa (110 cms.) is not enough and its return period is estimated to be approximately 10-year. The return period of the design discharge of the Khlong Wa should be graded up to 25-years to be consistent with that of the Khlong U-Taphao.

The discharge of the Khlong Wa with a 25-year return period is estimated to be 154 cms. at St. X 174 excluding the Rian diversion discharge of 50 cms. or 204 cms. including the Rian diversion discharge of 50 cms. as shown in the above figure.

However, it is considered difficult to increase the design discharge of the Khlong U-Taphao and RID diversion channel (D1) since their projects are ongoing according to the above-mentioned design discharge distribution. Hence, the discharge of 204 cms. at St. X 174 needs to be reduced to the existing design discharge of 160 cms. by regulating 44 cms. in the upper reaches of the Khlong Wa basin.

5.1.2 Structural Measures to be studied

As mentioned above, a flood discharge of 44 cms. needs to be regulated in the upper reaches of the Khlong Wa basin.

To cope with these problems, the following procedures are determined

(1) Floodwater reduction at the upstream area by construction of

- Flood Control Dam
- Retarding Basin

(2) Improvement of the existing channel to increase the discharge capacity in case of the (1) method is insufficient to reduce the floodwater amount.

(3) Water Transbasin

- Northward diversion channel line 3

In addition, the study team consider the comparison study between the on going diversion line and the proposed diversion line by this study as the following details;

- Northward diversion channel line 1 compared with RID diversion channel D4,D5,D6
- Northward diversion channel line 2 compared with RID diversion channel D6
- Southward diversion channel compared with the improvement of existing channel

For this purpose, possible regulation measures are studied in the following sections. Flood control dam in Section 5.2, retarding basin in Section 5.3, integration of flood control dam and retarding basin in Section 5.4, improvement of existing channel in section 5.5, northward diversion channel in Section 5.6 and southward diversion channel in section 5.7.

The northward diversion channel line 1 diverts the floodwater of Khlong Rian and Khao Kho Hong to the outside of Hat Yai municipality. It is an alternative of the ongoing RID diversion channels of D4, D5 and D6. The other alternative, the northward diversion channel line 2 diverts the floodwater of Khlong Rian to the middle of RID diversion channel (D5). This is an alternative of the ongoing RID diversion channel (D6). In these case, flood regulation in the upper reaches of the Khlong Wa is not necessary since the Khlong Wa receives no floodwater from the Khlong Rian.

On the other hand, the lower reaches of the Khlong Wa are habitually flooded due to the lack of discharge capacity and the backwater effects of the Khlong U-Taphao. The flood situation will become worse in the future due to the additional floodwater diverted from the Khlong Rian. However, no flood mitigation plan has been established yet for the riparian areas of the river although the polder dikes to protect only Hat Yai municipality are ongoing.

5.2 Flood Control Dam

5.2.1 Selection of Possible Dam Site

The Study Team has identified 12 dam sites based on the topographic map (scale: 1:50,000) and field survey. Their catchment area, possible storage capacity and dam heights are shown below.

No.	Name	Catchment. Area. (sq.km.)	Capacity (mcm)	Dam Height (m)
1	Khlong Ban Phli Khwai	7.1	0.5	4.0
2	Upper Khlong Muang	10.4	1.5	12.0
3	Lower Khlong Muang 1	12.4	0.1	3.1
4	Lower Khlong Muang 2	20.6	0.4	3.5
5	Upper Khlong Ban Sae	5.5	0.4	8.0
6	Lower Khlong Ban Sae	5.9	1.3	10.5
7	Lower Khlong Ko Wao	4.6	0.5	9.5
8	Upper Khlong Ko Wao	3.2	2.4	20.5
9	Lower Khlong Wa	27.8	1.5	10.5
10	Khlong Hin Dam	4.9	3.2	24.0
11	Khlong Ba	1.2	0.6	20.0
12	Upper Khlong Wa	18.6	19.3	40.0

For location of the above dam sites, see Appendix D. As evident from the above table, only No.12 Upper Khlong Wa dam site is available for flood control of the basin. Hence, feasibility of the Upper Khlong Wa dam is studied.

5.2.2 Flood Control Planning

The Upper Khlong Wa dam can control the storm water of 18.6 sq.km. in the upper part of sub-basin No.15. For location of sub-basin No.15, see Fig. 3.2-2 in Chapter III. The dam site is located at the village of Ban Plak Thing, 3.0 km upstream of Na Mom. For location of the dam site, see Fig. 5.2-1.

The elevation-storage capacity and elevation-surface area curves of the reservoir are shown in Fig. 5.2-2.

The design discharge hydrograph with a 25-year return period at the dam site is shown in Fig. 5.2-3. As shown in this figure, the flood peak discharge is estimated at 40 cms. and accordingly, all the flood discharge needs to be controlled, releasing no discharge during flood time in order to obtain a satisfactory flood peak reduction at the downstream of the Khlong Wa.

When the dam stores the entire design flood, the design flood peak discharge at St.X 174 will be reduced from 154 cms.* to 128 cms.* as shown in Fig. 5.2-4. A storage capacity of 4.9 MCM needs to be reserved for complete control of the design flood.

However, this discharge control is not sufficient to reduce the flood peak at St. X 174 to the existing design discharge of 110 cms.*.

*: The discharges at St. X 174 do not include the Rian diversion discharge (50 cms.).

5.2.3 Proposed Plan of Dam and Reservoir

(1) Required Storage Capacity

The required storage capacity and dam heights are determined based on the following assumptions.

(a) The dam foundation is assumed at 43.0 m msl..

(b) Some storage capacity for water use (water supply, irrigation and river environmental conservation) is considered in addition to the storage capacity for flood control. The required storage capacity for water use is assumed to be 5.2 mcm. (Included dead storage). Hence, the normal water level (N.W.L) for water use storage is set at 66.0 m msl.

(c) The high water level (H.W.L) is set at 72.0 m.msl. to store the necessary flood volume (4.7 mcm.)

(d) Additional surcharge capacity is provided to cope with the 2000 flood with a return period of 300 years for the safety of dam structures. The required surcharge capacity is estimated at 1.1 mcm. by assuming the emergency spillway of 20 m width. Hence, the highest high water level (H.H.W.L) is set at 73.0 m msl..

(e) The crest elevation of the dam is set at 75.0 m.msl. by assuming a freeboard of 2.0 m. Then, the required dam height comes to 32.0 m.

The elevation-storage capacity and elevation-surface area are summarized below.

Item	Elevation (m.msl)	Accumulated Storage Capacity (mcm)	Water Surface Area (sq.km.)
Dam Foundation	43.0	-	-
N.W.L	66.0	5.2	0.6
H.W.L	72.0	9.9	0.9
H.H.W.L	73.0	10.8	1.0
Dam Crest	75.0	-	-

(2) Main Features of Dam and Reservoir

The main features of the proposed dam and reservoir are shown below.

Item	Quantity
Dam Structure	
Height	32 m
Crest Length	800 m
Type	Earth-fill
Spillway crest length	20 m
Reservoir Area at Dam Crest	1.1 sq.km.
Land Acquisition	700 rai
House Resettlement	None

Layout of the proposed dam is shown in Fig. 5.2-5.

(3) Project Cost

The total project cost is estimated at 230 million Baht at 2002 prices including direct construction cost, land acquisition cost, study and survey design cost, indirect cost and physical contingency.

For details, see Appendix D.

5.3 Retarding Basin

5.3.1 Phru Phli Khwai Retarding Basin

(1) Flood Control Planning

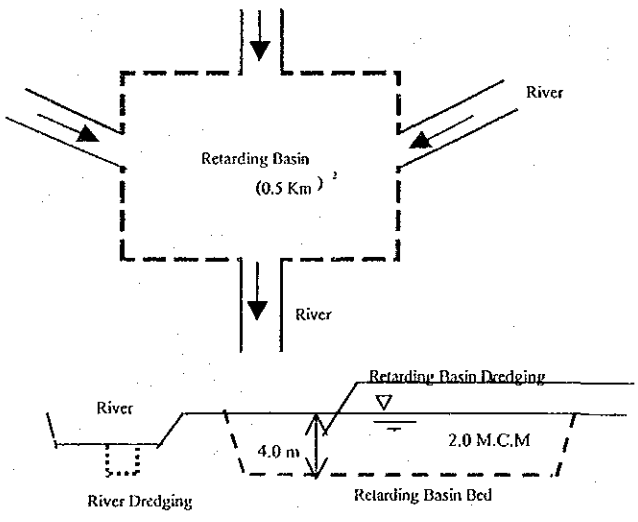
A swamp area called "Phru Phli Khwai" is located at 0.5 km north to Na Mom where four (4) major tributaries with a total drainage area of 49.3 sq.km. join. The swamp of public land covers an area of 0.5 sq.km. with the same elevation of adjacent lands (21.0 m msl.). This swamp can be converted to an artificial flood-retarding basin by dredging the land. For the location, see Fig. 5.3-1.

A retarding basin with a flood storage capacity of 2.0 mcm. is proposed by dredging the land in 4.0 m depth. The retarding basin can regulate part of the flood runoff from the upstream sub-basin of 49.3 sq.km.. It will regulate the design flood peak of 25-year return period by 19 cms. at the site. The design inflow and outflow discharge hydrographs at the site are shown in Fig. 5.3-2.

As a result, the design flood peak discharge at St. X 174 will be reduced from 154 cms. to 140 cms. as shown in Fig. 5.2-4.

On the other hand, the stored floodwater must be released immediately after the flood to meet the next coming floods. For this purpose, the existing river channel is dredged for 2.0 km from the outlet of the retarding basin.

Conceptual layout of the proposed retarding basin is illustrated below.



(2) Multiple Use of Retarding Basin

The retarding basin can store water after flood season. This storage water of 2.0 mcm can be used for the irrigation and other purposes in the surrounding areas. For this purpose, necessary control gates will be provided.

(3) Project Cost

The total project cost is estimated at 114 million Baht at 2002 prices including direct construction cost (dredging of retarding basin, dredging of river channel, spoil bank, control gate, etc.), study and survey design cost, indirect cost and physical contingency. Some land acquisitions are required and no resettlement cost is required.

For details, see Appendix D.

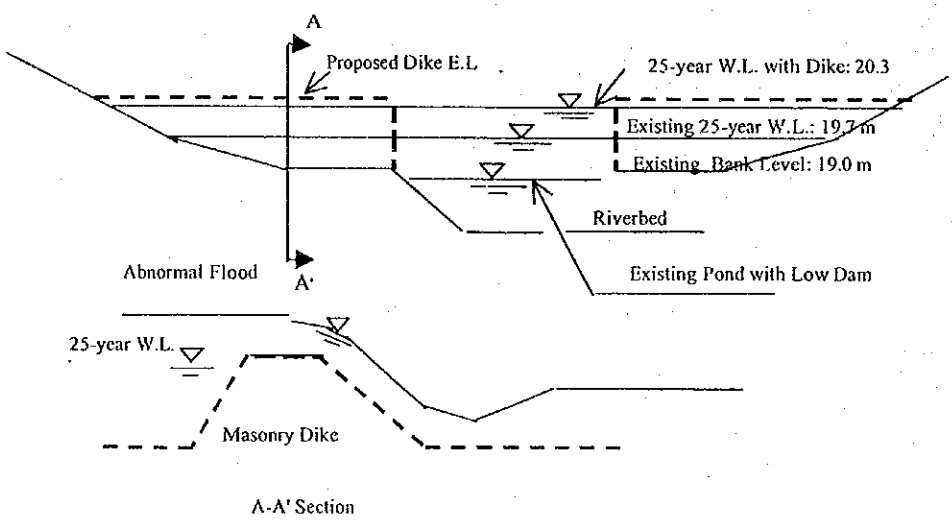
5.3.2 Phru Mao Retarding Basin

The Khlong Wa floods on both banks in the river valley of the middle reaches at a large flood time. Construction of the dikes (overflow type) intersecting the flood plain on both banks will increase the flood-retarding effect of the river valley.

An artificial retarding basin is proposed at the river section of the existing low dam of pond, which is located at 10.9 km distance or 3.0 km downstream of Na Mom district.

The high water level of the design flood (25-year return period) will rise up than the existing one, resulting in increase of the flood-retarding capacity when the dikes are constructed on both banks. The new design high water level varies depending on the height of the proposed dikes. However, the possible design high water level is limited below 20.3 m.msl. since a higher water level will affect a considerable number of houses existing in Na Mom.

The proposed dikes are shown below together with the existing and new high water level of the design flood.



A-A' Section

The proposed retarding basin will reduce the design peak discharge at the site from 152 cms. to 148 cms.. As a result, the design peak discharge at St. X 174 will be reduced from 154 cms. to 150 cms.. This project will produce only a small flood control effect and is considered infeasible.

5.4 Integration of Flood Control Dam and Retarding Basin

The design peak discharge at St. X 174 will be reduced from 154 cms. to 118 cms. by integrating the proposed Upper Khlong Wa dam and Phru Phli Kwai retarding basin. For the regulated discharge hydrograph, see Fig. 5.2-4.

5.5 Improvement of Existing Channel

5.5.1 General

As mentioned in Chapter III, the flood plains existing in the upstream reaches of St. X 174 retard the floods, resulting in decrease of the flood peak in the downstream. The total discharge regulation of the flood plains is estimated at about 24 cms. for the design flood with a 25-year return period.

The flood discharge of 25-year return period at St. X 174 will increase to 178 cms. (excluding 50 cms. of Rian diversion) from 154 cms. (discharge under the present conditions) if the flooding in the flood plains is completely removed by channel improvement.

The beneficial effects of the river channel improvement in the upper reaches are considered small. Hence, the channel improvement of the Khlong Wa will be limited to the lower reaches.

5.5.2 Existing Conditions of Channel

(1) Alignment, Profile and Cross-section

The river channel will be improved for a distance of 4.0 km between the Rian diversion outlet and the confluence to the Khlong U-Taphao. The river runs westward with small meanders for 4.0 km distance. The channel alignment is shown in Fig. 5.5-1.

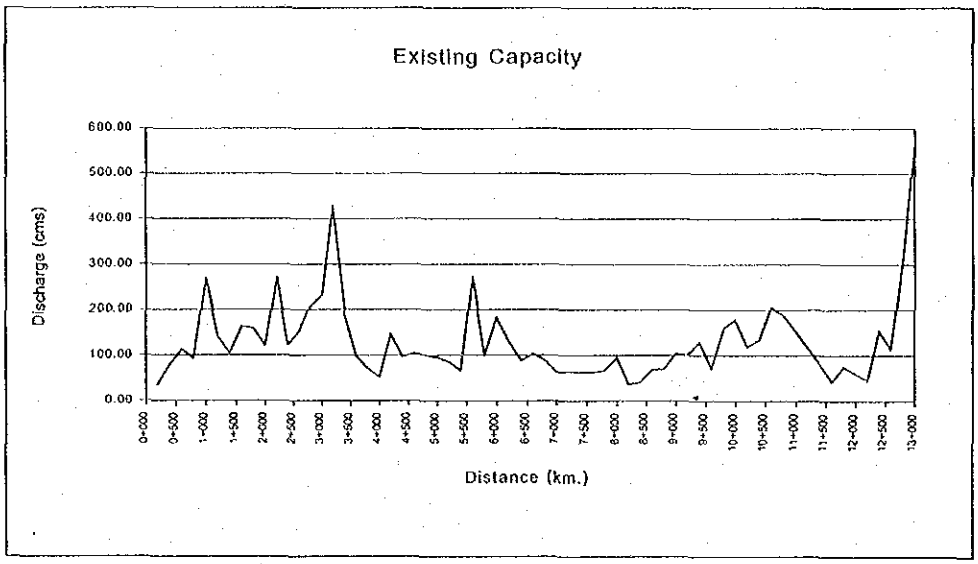
The average riverbed slope is estimated to be 1:1,500 for the lower reaches of 1.2 km distance and 1:700 for the upper reaches of 1.2 km to 4.0 km distances. Longitudinal profile of the riverbed is shown in Fig.5.5-2, along with those of both riverbanks.

The existing river channel is provided with no dikes. The existing channel is narrow and its width varies from 10.0 m to 30.0 m, averaging 20 m. The typical cross-sections of the river channel are also shown in Fig. 5.5-2.

One (1) railway-bridge and four (4) road bridges cross the channel as shown also in Fig.5.5-1.

(2) Discharge Capacity

The existing discharge capacity of the channel is calculated by assuming a uniform flow. The calculated bankful discharge is shown below.



The discharge capacity is comparatively large in the upper reaches of 1.6 km except the river sections around 2.8 km, and between 3.4 km and 4.2 km. However, the discharge capacity of the lower reaches is small. Further, the backwater of the Khlong U-Taphao affects these lower reaches.

5.5.3 Proposed Channel Improvement

(1) Design Discharge

The design discharge that proposed in the ongoing Khlong U-Taphao flood mitigation plan is 110 cms. (excluding Rian diversion discharge) or 160 cms. (including Rian diversion discharge).

On the other hand, the integrated project of the Upper Khlong Wa dam and Phru Phli Kwai retarding basin will regulate the flood discharge of 25-year return period to 118 cms. (excluding Rian diversion discharge) or 168 cms. (including Rian diversion discharge) at St. X 174.

(2) Design Riverbed and High Water Level

The design high water level is determined in due consideration to the backwater effects of the Khlong U-Taphao.

The river water level of the Khlong U-Taphao will lower after completion of the RID diversion channel (D1). The design riverbed, high water and dike crown levels at the entrance of the RID diversion channel (D1) are set at -0.2 m.msl, 5.8 m.msl. and 7.8 m.msl., respectively in the ongoing Khlong U-Taphao flood mitigation plan.

Accordingly, the design riverbed, high water and dike crown levels of the Khlong Wa are set at 0.0 m.msl., 5.8 m.msl. and 8.0 m.msl, respectively at the river section of 0.0 km distance.

The design riverbed profile is determined following the existing riverbed profiles. The design high water profile is determined based on the hydraulic calculation of a non-uniform steady flow of 168 cms. and 118 cms. The design dike elevation at each river section is determined by assuming a freeboard of 1.0 m.

The design longitudinal profiles of riverbed and high water level are proposed as shown in Fig. 5.5-3 along with the design dike level.

(3) Design Cross-section

The construction of dikes and/or riverbank dredging is proposed for the narrow river sections to carry the design discharge. Further, dikes are proposed for the lower reaches to meet the backwater of the Khlong U-Taphao. The typical design cross-section is also shown in Fig. 5.5-3.

(4) Project Cost

The total project cost is estimated at 31 million Baht at 2002 prices including direct construction cost, land acquisition cost, indirect cost and physical contingency.

For details, see Appendix D.

5.6 Northward Diversion Channel

5.6.1 General

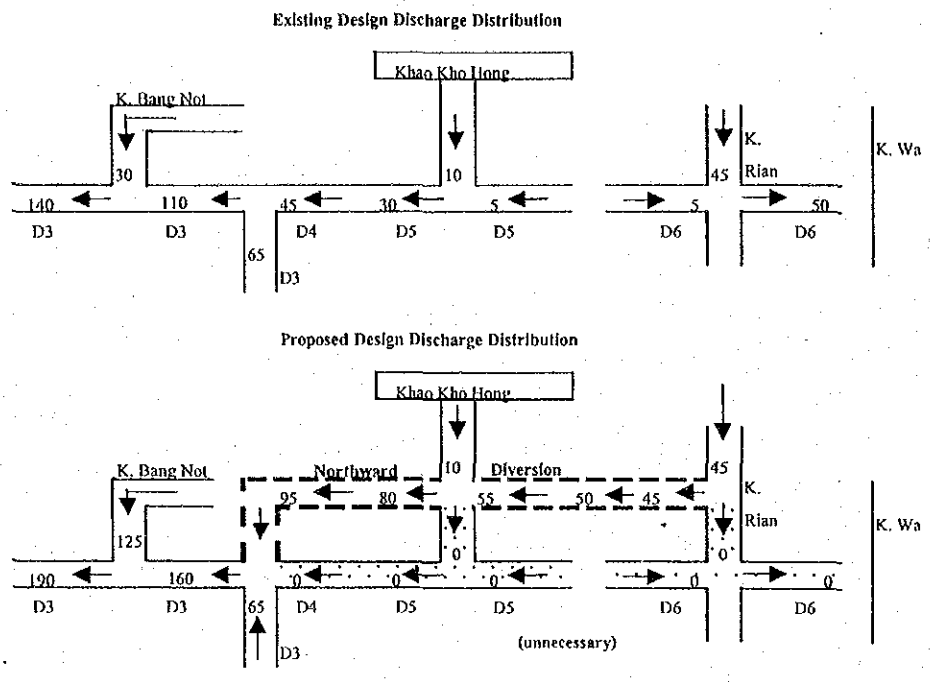
As mentioned above, the design discharge (25-year return period) of the Khlong Wa without project is estimated to be 154 cms . (excluding Rian diversion discharge of 50 cms.) at St. X 174. It is less than the design discharge distribution to the Khlong Wa (160 cms.) in the ongoing Khlong U-Taphao flood mitigation plan.

Accordingly, the ongoing RID diversion channel (D1) can be implemented with no revision if no floodwater is diverted from the Khlong Rian to the Khlong Wa.

In this study, three (3) northward diversion channels: diversion channel line (1) and line (2) are proposed as the alternatives of the on-going RID diversion channels of D6-D5-D4-D3. The northward diversion channel line (1) diverts the floodwater of the Khlong Rian and Kao Kho Hong area to the RID diversion channel (D3), while the northward diversion channel line (2) diverts the floodwater of the Khlong Rian to the middle of RID diversion channel (D5).The northward diversion channel line (3) diverts the floodwater from Phru Phli Khwai retarding basin in Na Mom District through Khong Khao Kloi and Khlong Phra Wong basin to Songkhla Lake

5.6.2 Northward Diversion Channel Line 1

The design discharge distribution of the proposed northward diversion channel line1 is determined with necessary change of the existing design discharge distribution of D6-D5-D4-D3. The total project cost is estimated at 1,391 million Baht.



As shown in the figure above, D6, D5 and D4 become unnecessary. The design discharge of the upper part of D3 will increase from 110 cms. to 160 cms. and the lower part of D3 will increase from 140 cms. to 190 cms..

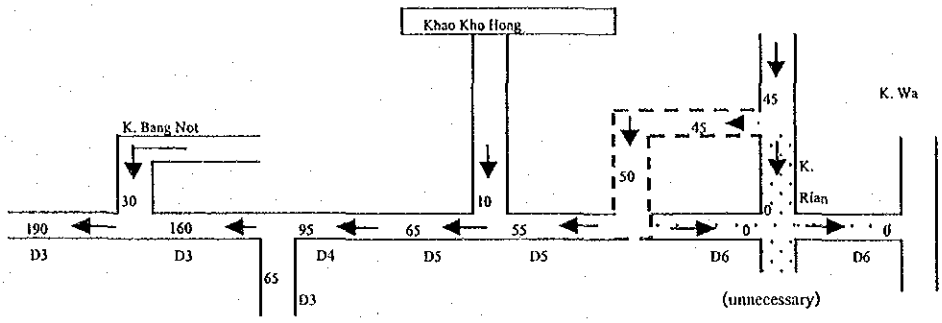
The total cost of Northward diversion channel line 1 will be much higher than RID diversion channel line D4,D5 and D6, hence it will be infeasible at this current time. However, in future when the higher flood return period than 25 years is taken in to consideration, this line might be reconsidered as one of the alternative to cope with the excess flood water amount than 25 years which is set as the present criteria.

Location, profile and main features structure are shown in Fig.5.6-1 to Fig.5.6-3

5.6.3 Northward Diversion Channel Line 2

The proposed design discharge distribution of the northward diversion channel line 2 is shown below. The RID diversion channel (D6) becomes unnecessary. Instead, the design discharge of the RID diversion channels of D5, D4 and D3 will increase by 50 cms. compared to the existing one. The total tunnel project cost is estimated at 492 million Baht or 1,073 million baht for including cost of diversion channel D5 and D4.

Proposed Design Discharge Distribution

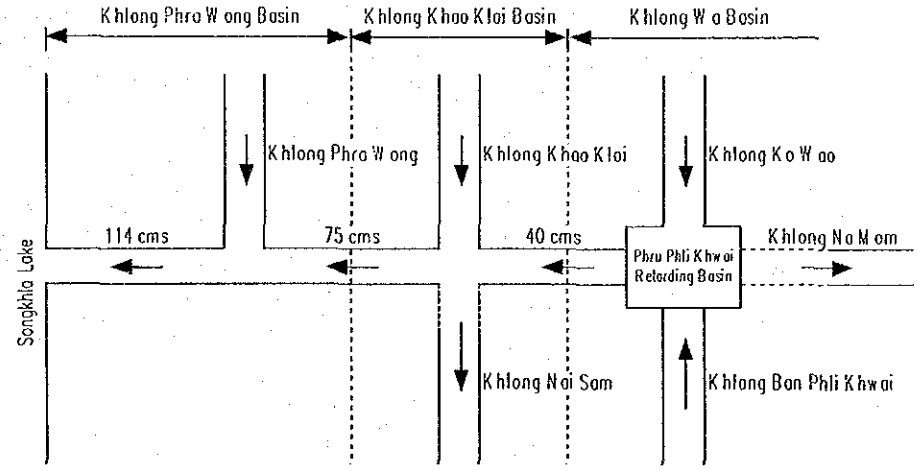


The total construction cost of Northward Diversion Line 2 will be high and it is difficult to be constructed due to limitation of discharge capacity of RID diversion channel D5 and D4 which can not be enlarged.

Location , profile and main features structures are shown in Fig. 5.6-4 and Fig.5.6-5.

5.6.4 Northward Diversion Channel Line 3

The Northward Diversion Channel Line 3 will be used for floodwater diversion from Phru Phli Khwai through Khlong Wa river basin (drainage area 49.3 sq.km.) and flow northward emptily to Songkhla Lake. The total length is about 21.8 km. This route will pass through Khlong Khao Kloi and Khlong Phra Wong river basin. The diversion water amount is vary from 40 cms. at Khlong Wa river basin and increase to 75 cms. when collect water from Khlong Khao Kloi river basin. Finally it will receive water from Khlong Phra Wong river basin and its discharge will be about 114 cms.. The proposed design discharge distribution of the northward diversion channel line 3 is shown below. The total project cost is estimated at 1,445 million Baht.

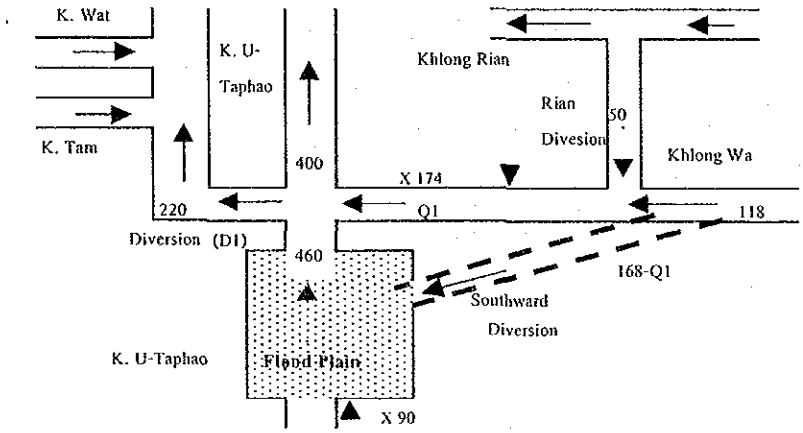


Even the Northward Diversion Channel Line 3 has high construction cost, however this project can reduce flood amount that flow from Khlong Wa basin to Khlong U-Taphao more than 40% especially in case of excess flood amount that is higher than 25 years return period which make serious impact on Hat Yai Municipality. In addition, flood in Khlong Bang Not or Khlong Ban Nam Noi can be reduced of about 50 % that will alleviate the frequent flood problem in Ban Nam Noi community area. This channel also can be used as one of the reserved water resource for agricultural land along the channel line.

Location, profiles and main feature structure are shown in Fig.5.6-6 and Fig.5.6-7

5.7 Southward Diversion Channel

This is an alternative of the existing channel improvement of the Khlong Wa. Construction of a new channel can be considered to divert part of the design discharge of the Khlong Wa from the location of 5.0 km distance (1.0 km upstream of the Rian diversion outlet) to the flood plain of the Khlong U-Taphao located between St. X 90 and Highway No.43 as shown below. Out of the design discharge of the Khlong Wa (168 cms.), the existing bankful discharge (Q1) is discharged through the existing channel and excessive discharge (168 – Q1) is diverted.



However, the southward diversion cannot reduce the flood discharge of the lower Khlong U-Taphao and diversion channel (D1). The southward diversion will lower the water level at the confluence of the Khlong U-Taphao and Khlong Wa, causing increase of the discharge from the upstream flood plain. As a result, the flood discharge or water level at the confluence will not change from the existing one. Hence, the southward diversion is only a structural alternative for the improvement of the existing Khlong Wa channel.

The bankful discharge of the Khlong Wa is very small in the lower reaches of 1.6 km distance. However, this river reaches are affected by the backwater of the Khlong U-Taphao and accordingly, the southward diversion cannot lower the floodwater level in the lower reaches. While, the river sections in the upper reaches of 1.6 km distance have mostly a sufficient discharge capacity to carry the design discharge of 168 cms. except a few river sections around 2.8 km distance and 3.4 - 4.2 km river distance.

On the other hand, the southward diversion requires construction of a new channel of approximately 3.6 km with two (2) highway crossings and one (1) railway crossing. For route

of the southward diversion, see Appendix D. The construction cost only is 165 million baht (excluded land acquisition)

As evident from the above discussions, the southward diversion is infeasible. However, the southward diversion line shall be possibly done in case of the improvement of Khlong Wa channel at Km.1+470 Padang Besa railway to Km.3+140 Kanchanavanich road can not be expanded Location , profile and main feature structures are shown in Fig. 5.7-1 and Fig.5.7-2.

5.8 Flood Mitigation Plan

The structural measures in this study can be considered as 2 phases as first phase and second phase plan. The first phase plan will be composed of Construction of flood control dam, Phru Phli Khwai retarding basin and Khlong Wa improvement. Total construction period will be 7 years. The first phase plan will be started from the first year to the fourth year and the second phase plan will be started from the third year to the seventh year. The construction period of the first phase plan and second phase plan are depicted as table belows.

First Phase Plan	Operation period (year)			
	1	2	3	4
Flood Control Dam				
- Study ,survey and detail design				
- Land Acquisition				
- Construction				
Phru Phli Khwai retarding basin				
- Study, survey and detail design				
- Land Acquisition				
- Construction				
Improvement of Existing Channel				
- Study, survey and detail design				
- Land Acquisition				
- Construction				

Second Phase Plan	Operation period (year)				
	3	4	5	6	7
Northward Diversion Channel Line 3					
- Study, survey and detail design					
- Land Acquisition					
- Construction					

Construction costs of the northward diversion line 1 and line 2 are higher compared with the RID diversion channel D4, D5 and D6. However, the northward diversion line 1 will cause least impact to dwelling people especially when taking the RID diversion channel D4, D5 and D6 into consideration. According to the socio-economic condition, this northward diversion line 1 can be possibly constructed instead of the RID diversion channel D4, D5 and D6. The Study, survey and detail design compose of the Feasibility study, Environmental impact study on IEE, Survey for Topographic condition, geology and foundation, construction material, Detail design and Cost estimation. These works should be carried out by RID in future.

CHAPTER VI PROJECT EVALUATION

6.1 Other Benefits

Other benefits are miscellaneous benefits additional to Emergency Flood Prevention Planning for Hat Yai District in Khlong U-Taphao River Basin. With existence of two reservoirs built to retard flows of Khlong Wa, at the same time the water can be used for domestic water supply for ten villages of four Tambons within proximity of five Kms. from the reservoirs. Besides it can be used to irrigate the paddy land and orchards can be developed from abandoned paddy land and old rubber-plantation areas. Each benefit is estimated as follows.

6.1.1 Water Supply

The two reservoirs can supply the water to ten villages of four Tambons located near the reservoirs in Na Mom District. At present, they depend on deep well and shallow well as sources of domestic water. The water from the reservoir is better alternative to replace the conventional sources.

Detail of the benefit from water supply is shown in Appendix C.

6.1.2 Dry Season Rice Crop Production

About 1,500 Rai of paddy rice areas locating partly in Na Mom District is presently planting wet season rice only. With the water supply from reservoirs, about 500 Rai can be used for planting dry season paddy rice. Benefits from this can be estimated as the following table and details are shown in Appendix C

(Unit: Baht per Rai)

	Financial Value	Economic Value
Total Expenditure	1,415	1,206
Product 500 Kg.	2,400	2,506
Net Return per Rai	685	1,104
per 500 Rai	342,500	552,200

6.1.3 Orchard Production

Without water supply, many areas such as paddy land, old rubber plantation area, and unclassified land are left idle. With water supply, these lands can be developed into orchard. Many kinds of fruit trees can be planted. However, for the study, orchard farm model would be three common fruits: rambutan, durian and longong. Among these fruits, rambutan requires least investment, whereas longong returns best income but highest risks due to short marketing life; it can not be preserved in any form. Durian requires moderate investment and returns good incomes.

Of 1,000 Rai of lands that can be developed for orchard, for this study, aggregate farm

models will be 300 Rai for rambutan, 350 Rai each for durian and longong respectively. The details of financial and economic benefits of rambutan, durian and longong are shown in Appendix C and summary of benefits from orchard is shown as follows

(Unit: Million Baht)

Year	300 Rai of Rambutan (Million Baht)	350 Rai of Durian (Million Baht)	350 Rai of Longong (Million Baht)	Total 1000 Rai orchard (Million Baht)
1	-0.51	-0.87	-0.85	-2.23
2	-0.29	-0.62	-0.54	-1.45
3	-0.31	-0.71	-0.57	-1.60
4	0.89	-0.90	-0.70	-0.71
5	1.06	-0.21	5.40	6.24
6	1.18	3.12	8.80	13.10
7	1.51	5.47	9.84	16.83
8	1.89	10.68	10.93	23.50
9	2.28	12.58	13.30	28.16
10	2.79	14.66	16.87	34.32
11	4.01	14.66	16.87	35.54
12	4.01	14.66	16.87	35.54
13	4.01	14.66	16.87	35.54
14	4.01	14.66	16.87	35.54
15	4.01	14.66	16.87	35.54
16~25	6.49	14.66	16.87	38.02
ENPV	15.12	47.29	61.57	123.99
Annual Equivalent	1.93	6.03	7.85	15.81

6.2 Economic Evaluation

Economic analysis is made to measure the feasibility of the project. The indicators used for measurement here are Net Present Value (NPV), B/C (Benefit/Cost) ratio, and internal rate of returns (IRR). NPV is defined as the product of subtraction of Present Value of Benefits over Present Value of Costs. The project that is considered feasible must return the positive value of subtraction product, or, in other words, present value of cost must be less than present value of benefits base on a given interest rate or opportunity cost of investment capital. Interest rate as generally adopted for development project s in Thailand is 12% per annum. B/C ratio is the ratio between Present Value of Benefits over Present Value of Costs base on a given interest rate. If the ratio is 1 : 1 or more, then the project will be considered feasible. IRR is the rate, when apply, will make the present value of both costs and benefits equal. The rate would indicate the maximum opportunity cost of capital investment the project might sustain viably.

Period of the survey design study and project construction is same as the structural plan as shown in item 5.8. Period of analysis for this project is 50 years after project completion, without replacement cost during the period.

6.2.1 Conversion Factor

Conversion factor is coefficient used for converting both cost and benefits from financial or market value into economic value. Economic value or actual value of goods and services is assumed or shadowed under such condition that, with perfect

market competition and without taxation, what the value of those goods and services would be. Each particular goods and services has its' own conversion factor since each of them is different in aspects of extent of competition and rate of taxes levied on them. For project assessment, economic value of both cost and benefit will be used to reflect the actual condition. Conversion factors of different items as calculated by the World Bank are as follows

Particulars	Conversion Factor
Standard Conversion Factor	0.94
Specific Conversion Factors for followings:	
Consumers' goods	0.95
Labour	0.94
Electricity	0.90
Intermediate goods	0.94
Capital goods	0.84
Margin for traders	0.69
Fertilizer	0.92
Pesticide	0.88
Construction material	0.80
Seeds	0.94
Transportation	0.87
Fuel oil and lubricant	0.70
Steel	0.83
Cement	0.91
Timber	0.92
Farm machinery	0.70
Agricultural chemicals	0.94
Civil work	0.92
Building	0.84
Road	0.80

Source: Thailand/Indochina Division, East Asia and Pacific Programs Dept., the World Bank, "Shadow Price For Economic Appraisal of Projects and Application to Thailand" 1983

6.2.2 Development Costs

The project is two phrases. Phrase 1 consists of flood control dam, Phru Phli Kwai and existing channel improvement. Development period of the project spreads from year 1 to year 4. Phrase 2 is to develop further the Northward Diversion Line 3. Development of this phase start from year 3 to year 7 (five years).

Financial and economic costs of the project including land acquisition and O&M cost can be estimated as follows, see datials in Appendix C

Unit: Million Baht

	Financial Cost	Economic Cost
Phrase 1		
Flood Control Dam	230.00	176.72
Study,Survey, Design	25.00	23.50
Land Acquisition	42.00	-
Construction	163.00	153.22
O&M	3.26	3.07
Phru Phli Kwai Retarding Basin	114	73.32
Study,Survey, Design	15	14.10
Land Acquisition	36	-
Construction	63	5.22
O&M	1.26	1.18
Existing Channel Improvement	31	15.98
Survey, Design	1	0.94
Land Acquisition	14	-
Construction	16	15.04
O&M	0.32	0.30
Total in Phase 1	375	266.02
Study,Survey, Design	41	38.54
Land Acquisition Cost	92	-
Construction	242	227.48
O&M	4.84	4.55
Phrase 2		
Northward Diversion Channel Line 3	1,455	1,295.32
Study,Survey, Design	35	32.90
Land Acquisition	77	-
Construction	1,343	1,262.42
O&M	26.86	25.25
TOTAL 2 PHRASES	1,830	1,561.34
Study,Survey, Design	76	71.44
Land Acquisition	169	-
Construction	1,585	1,489.90
O&M	31.70	29.80

Note : Standard conversion factor of financial : economic is 1: 0.94

6.2.3 Flood Damage Cost

From flood damage cost of principal area in item 4.5, the average annual flood damage of 25 to 50 years return period is 138 million baht/year. This benefit cost is occurred from the development of project phase 1 and it will be obtained the full benefit when the development of project phase 2 is completed, so that the principal area as 30% for phase 1 of project and 70% for phase 2 of project are determined.

The average annual flood damage cost of principal and supplementary areas for the project development can be estimated as follows

(Unit: Million Baths/year)

	Financial Cost	Economic Cost
Annual Flood Damage Cost for		
-Principal area (25-50 yr. return period)	138.00	129.72
-Supplementary area. (1-50 yr. return period)	132.71	124.75
Development of Project Phase 1		
- 30 % of annual flood damage of principal area	41.40	38.92
Development of Projects Phase 2		
- 70 % of annual flood damage of principal area	96.60	90.80
- 100 % of annual flood damage of supplementary area	132.71	124.75

Note: Standard conversion factor of financial: economic is 1: 0.94

6.2.4 Economic Evaluation of Proposed Project

When compare the cost of the project and the total benefits in each development of projects, the results are as shown on table Benefit/cost comparison and derivation of economic indicators. Summaries of the results are shown below.

(1) Development of project in Phase 1: The project is feasible, the Net Present Value (NPV) of 63.33 Million Baht is achieved whereas the B/C Ratio is 1.30:1 and IRR is 15.33 % per annum. These indicators further improved to be more favorable if the level of contribution will be more.

(2) Development of project in Phase 2 only: The project is feasible, the Net Present Value (NPV) of 80.50 Million Baht is achieved whereas the B/C Ratio is 1.09:1 and IRR is 13.09 % per annum.

(3) For all projects, there will be highly feasible, the Net Present Value (NPV) of 127.51 Million Baht is achieved whereas the B/C Ratio is 1.13:1 and IRR is 13.65 % per annum.

Economic Benefit / Cost Comparison and Derivation of Economic Indicators

(Unit : Million Baht)

Project Year	Operation Year	Development Project in Phase 1							Development Project in Phase 2 only					Total 2 Phases		
		Total Cost	Flood Damage in Principal Area*	Water Works	Dry Sea. Paddy	Orchard	Total Benefit	Net Benefit	Total Cost	Flood Damage in Principal Area*	Flood Damage in Supplementary Area**	Total Benefit	Net Benefit	Total Cost	Total Benefit	Net Benefit
1		29.14					0.00	-29.14						29.14	0.00	-29.14
2		36.66					0.00	-36.66						36.66	0.00	-36.66
3		99.00					0.00	-99.00	18.80			0.00	-18.80	117.80	0.00	-117.80
4		101.82					0.00	-101.82	14.10			0.00	-14.10	115.92	0.00	-115.92
5	1	4.55	38.92	0.29	0.11	3.16	42.48	37.93	134.42			0.00	-134.42	138.97	42.48	-96.49
6	2	4.55	38.92	0.30	0.28	7.90	47.40	42.85	752.00			0.00	-752.00	756.55	47.40	-709.15
7	3	4.55	38.92	0.30	0.39	11.07	50.68	46.13	376.00			0.00	-376.00	380.55	50.68	-329.87
8	4	4.55	38.92	0.30	0.44	12.65	52.31	47.76	25.25	90.80	124.75	215.55	190.30	29.80	267.86	238.06
9	5	4.55	38.92	0.31	0.50	14.23	53.96	49.41	25.25	90.80	124.75	215.55	190.30	29.80	269.51	239.71
10	6	4.55	38.92	0.31	0.55	15.81	55.59	51.04	25.25	90.80	124.75	215.55	190.30	29.80	271.14	241.34
11	7	4.55	38.92	0.32	0.55	15.81	55.60	51.05	25.25	90.80	124.75	215.55	190.30	29.80	271.15	241.35
12	8	4.55	38.92	0.32	0.55	15.81	55.60	51.05	25.25	90.80	124.75	215.55	190.30	29.80	271.15	241.35
13	9	4.55	38.92	0.32	0.55	15.81	55.60	51.05	25.25	90.80	124.75	215.55	190.30	29.80	271.15	241.35
14	10	4.55	38.92	0.33	0.55	15.81	55.61	51.06	25.25	90.80	124.75	215.55	190.30	29.80	271.16	241.36
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	15	4.55	38.92	0.35	0.55	15.81	55.63	51.08	25.25	90.80	124.75	215.55	190.30	29.80	271.18	241.38
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	20	4.55	38.92	0.37	0.55	15.81	55.65	51.10	25.25	90.80	124.75	215.55	190.30	29.80	271.20	241.40
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	25	4.55	38.92	0.39	0.55	15.81	55.67	51.12	25.25	90.80	124.75	215.55	190.30	29.80	271.22	241.42
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	30	4.55	38.92	0.40	0.55	15.81	55.68	51.13	25.25	90.80	124.75	215.55	190.30	29.80	271.23	241.43
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	35	4.55	38.92	0.42	0.55	15.81	55.70	51.15	25.25	90.80	124.75	215.55	190.30	29.80	271.25	241.45
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	40	4.55	38.92	0.45	0.55	15.81	55.73	51.18	25.25	90.80	124.75	215.55	190.30	29.80	271.28	241.48
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	45	4.55	38.92	0.47	0.55	15.81	55.75	51.20	25.25	90.80	124.75	215.55	190.30	29.80	271.30	241.50
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	50	4.55	38.92	0.50	0.55	15.81	55.78	51.23	25.25	90.80	124.75	215.55	190.30	29.80	271.33	241.53
Present Value		214.43	323.21	2.69	3.75	107.42	277.76	63.33	933.78	752.99	1,034.53	1,014.29	80.50	958.84	1,086.35	127.51
NPV								63.33					80.50			127.51
B/C ratio (:1)								1.30					1.09			1.13
IRR/Year								15.33%					13.09%			13.65%

Note : * Flood damage in Principal Area of 25 - 50 years return period are estimated as 30% for Phase 1 and 70% for Phase 2.

** Flood damage in Supplementary Area of 1 - 50 years return period for Phase 2.

6.3 Preliminary Environmental Evaluation

6.3.1 General

Existing environmental conditions to be presented herein are based on review of existing reports on engineering and environmental studies in Songkhla, Hat Yai District and Hat Yai Municipality. Additional data is also collected from the agencies concerned as well as from field observations. This environmental study will not be a full IEE (Initial Environmental Examination) Study. Rather, it covers certain environmental and resource components, which are considered important for the individual project components, proposed.
The Key activities are composed of data collection, review of existing reports and ongoing projects and fieldwork

6.3.2 Field Work and Survey

The Environmentalist made a trip to the project site on 11 March 2002. Visits were made to Khlong U-Taphao, Khlong Wa, Khlong Rian, Khlong Tam and Khlong Toei as well as areas in the basins of these canals. Environmental conditions were observed, such as general environmental settings of the basins, land use along the canals including forests and agricultural areas, communities along right-of-ways (ROWs) of the canals, illegal intrusion of the ROWs of the canals, stream flows and water levels, as well as appearance of water pollution in the canals. Some sections of the routes of the proposed flood diversion canals were also observed.
In July and August 2002, the Land Use Expert, the Compensation Expert, and an assistant environmental expert made a few separate trips to the project area. They collected additional reports and information on related matters including environmental conditions, potential compensation and relocation issues in the areas to be covered by or to be affected by the proposed project components. Field observations of environmental conditions at different sites were also made.

6.3.3 Environmental Impact Assessment

Environmental impacts of the proposed project components have been assessed at a very preliminary level, based on basic data available and on project features obtained at the pre-feasibility study level. The resources and environmental components subject to assessment are divided into 4 major groups, namely *Physical Resources, Biological Resources, Human Uses Values* and *Quality of Life Values*. Such impacts are summarized in table on the next page, which shows different levels of beneficial impacts and adverse impacts. Numbers +1, +2 and +3 represent low level, medium level and high level of beneficial impacts respectively, while –1, –2 and –3 represent the different levels of impacts in the opposite direction.

6.3.4 Recommended Impact Mitigation Measures

Environmental impact mitigation measures have been recommended for alleviating adverse impacts assessed. The mitigation measures are discussed by type of resource and environmental component rather than by project component. However, if recommendations for a given project component are needed, specific recommendations for such project component are specifically discussed. The

measures to be considered are divided into 2 phases namely construction period and operation period. The details of recommended mitigation measures concerning various resources and environment components can be seen in Appendix E, Chapter V. Measures concerning Irrigation water use, Agriculture, Flood control and Prevention are described as follow.

(1) Irrigation Water Use and Agriculture

Since benefits relating to these aspects would occur in the operation phase, efforts should be made to increase such benefits to a suitable extent.

For the Upper Khlong Wa flood control dam and the Phru Phli Khwai retarding basin, amounts of stored water are limited. Hence, an appropriate water-allocating scheme should be established such that fair water allocation can be made for all key types of usage such as domestic uses, irrigated agriculture, and subsistence fisheries/aqua-culture. Industrial development and tourism promotion should also get some water supply, but their priorities are lower than that usage just mentioned above

(2) Flood Control and Prevention

Flood control and prevention in Hat Yai District is the main objective of this project. Therefore, efforts should be made to maximize flood control benefits. However, due to several related constraints including adverse environmental impacts in achieving the maximum benefits, only the feasible flood control alternatives with due consideration of other adverse impacts and benefits will be selected for further implementation.

Summary of Environmental Impacts Anticipated to be caused by Implementation of Emergency Flood Prevention Plan in Khlong Wa Basin

Resources/ Environmental Values / Project Components	Physical Resources								Biological Resources				Human Use Values								Quality of Life Values				
	Geology/Seismology	Surface Hydrology	Surface Water Quality	Groundwater Hydrology	Groundwater Quality	Meteorology	Soils	Erosion/Sedimentation	Fisheries	Aquatic Ecology	Forestry	Wildlife	Agriculture	Irrigation	Water Use	Flood Prevention	Industry	Mining	Transportation	Land Use	Socio-economics	Property Compensation/Resettlement	History/Archaeology	Public Health	Tourism
1. Upper Khlong Wa Dam	-1	+1	+2	+1	+1	0	-2	-1	+2	+2	-1	-1	+1	+1	+1	+2	+1	0	+1	+2	+2	-2	0	+2	+2
2. Phru Phli Khwai Retarding *Basin*	0	+1	+1	+1	0	0	0	+1	+1	+1	0	0	+1	+1	+1	+2	0	0	0	+1	+1	0	0	+1	+1
3. Integration of 1 and 2	-1	+2	+2	+1	+1	0	-2	-1	+2	+2	-1	-1	+2	+2	+2	+2	0	0	0	+2	+2	-2	0	+2	+2
4. Northward Diversion Channel																									
- Route 1	0	+1	+1	0	0	0	0	-1	-1	-1	0	0	+2	+2	+2	+3	+2	0	+2	+2	+2	-2	0	+1	+2
- Route 2	-1	+1	-1	0	0	0	0	-1	-1	-1	0	0	0	0	0	+3	+2	0	+2	0	+2	0	0	+1	+2
- Route 3	0	+1	0	0	0	0	0	-1	0	-1	0	0	0	0	0	+1	+1	0	+1	0	+1	0	0	0	+1
5. Channel Improvement	0	-1	0	0	0	0	-1	-1	+1	+1	0	0	-1	-1	-1	+2	0	0	0	0	+1	0	0	+1	+1

Notes:
+3 High level of beneficial impact or benefit,
+2 Medium level of beneficial impact or benefit,
+1 Low level of beneficial impact or benefit,
-1 Low level of impact or benefit
-2 Medium level of adverse impact
-3 High level of adverse impact

6.3.5 Preliminary Environmental Examination Conclusions

By reviewing the data concerned, engineering analysis and economic evaluation of each proposed project component, the following conclusions can be reached:

(1) The Upper Khlong Wa flood control dam is engineeringly and economically feasible. Its main benefits would be related to flood prevention and control, socio-economic improvement, land use development, water quality/public health improvement and tourism development. On the other hand, its significant impacts would be caused by property compensation, relocation of affected people and adverse socio-economic impact on these people. Other adverse impacts would be of minor significance, none of which cannot be solved. So, fair compensation for the lost and affected properties is necessary.

(2) The Phru Phli Khwai retarding basin is a good project component. It is engineeringly, environmentally and economically feasible. Flood reduction would be its important benefit. Another desirable asset of this project component is that it is located in a public land, so land and property compensation cost is considered as about half area to be compensated. No serious environmental impact of this project component is anticipated.

The integration of the Upper Khlong Wa flood control dam and the Phru Phli Khwai retarding basin is the best choice compared with each project component alone. More flood control benefit would be achieved. And, again, no insurmountable adverse environmental impact of this integrated alternative is anticipated.

As for the further environmental study required for the approval of these project components, an official IEE is needed, based on the size of the project and its location in a protected forest reserve.

(3) Four flood water diversion routes are considered and the Northward Diversion Channel line 1 and 3 are found to be the good diversion line in this study, with respect to flood reduction, socio-economic/transportation/ tourism benefits. All adverse effects are of a minor importance. These project components are feasible based on engineering, environmental and economic aspects.

(4) The Khlong Wa channel improvement project component is desirable because it would prevent overbank flows after Khlong Wa has received water from the Upper Khlong Wa dam, the Phru Phli Khwai retarding basin and the Khlong Rian diversion discharge. No important adverse environmental impact is anticipated. Actually, there is no need for a further environmental study for this project component.

The conclusions discussed above can be summarized in table below.

Project Component	Feasibility Assessment			Further Environmental Study Required
	Engineering	Environmental	Economic	
1. Upper Khlong Wa Flood Control Reservoir	✓✓	✓	✓	IEE
2. Phru Phli Khwai Retarding Basin	✓✓✓	✓✓✓	✓	-
3. Integration of 1 and 2	✓✓	✓✓	✓✓	IEE
4. Northward Flood Diversion Channel line 3	✓✓	✓✓	✓	IEE for Selected Line
5. Khlong Wa Channel Improvement	✓✓✓	✓✓✓	✓✓	-
6. Integration of 3, 4 and 5	✓✓	✓✓	✓✓	IEE for all Project components

Note: ✓ Feasible; ✓✓ Moderately feasible; ✓✓✓ Highly feasible.

6.3.6 *Recommendations*

Based on the conclusions summarized above, the following recommendations are made concerning the project implementation.

(1) The integration of the following project components should be implemented:

1. Upper Khlong Wa flood control dam
2. Phru Phli Khwai retarding basin
3. Khlong Wa channel improvement
4. Northward flood diversion channel line 3

(2) An IEE study should be carried out for these project components.

CHAPTER VII COMPREHENSIVE FLOOD MANAGEMENT

7.1 Necessity of Comprehensive Flood Management

7.1.1 Necessity of Non-structural Measures

(1) General

As mentioned in Chapter II, Section 2.4, the government has prepared a structural plan consisting of various sub-projects for the flood prevention of Hat Yai district. However, the capacity of the structural plan is limited and it can meet only the floods smaller than that of 25-year return period. The existing channels and new diversion channels will overflow when a larger floods than 25-year one occurs, damaging Hat Yai district. Further, disorderly land development of the flood plains will increase flood peak in the downstream, resulting in decrease of the safety factor of the structural plan.

To cope with these problems, the structural plan should be supplemented by non-structural measures to the possible extent. The major and effective non-structural measures for Hat Yai district are considered to be (i) establishment of flood forecasting and warning system and (ii) land use control in flood plain.

(2) Flood Forecasting and Warning System

According to the interviews to the people living within and around Hat Yai municipality on the year 2000 flood, 75% of the respondents were not aware of the coming flood hazard. Approximately 20% were aware of it before less than 12 hours. Hence, about 80% of the respondents could not prepare for necessary measures to cope with the flood hazard in advance.

The respondents said that almost no official flood warning was given to them and most of them (about 90% of the respondents) forecast flood hazard by themselves from the weather situation of the region.

For details of the interviews, see Appendix C.

The government has already recognized the urgent necessity of establishment of flood forecasting and warning system. The flood forecasting and warning system is being studied for the entire Khlong U-Taphao basin (including Khlong Wa basin) by the study team of Kasetsart University.

(3) Land Use Control in Flood Plain

There are many large flood plains along the Khlong U-Taphao from Sadao municipality to Highway No.43 (located immediately upstream of Hat Yai municipality). They retard floods, decreasing the flood peak in the downstream. The flood plains play an important role in mitigation of the flood disaster on Hat Yai District Hence, the land use of the flood plains should be well controlled in due consideration to the adverse effects on the downstream.

Among them; the lowermost flood plain located between St. X 90 and highway No.43 is the largest one. This lowermost flood plain is subject to urban development due to

easy access to the center of Hat Yai municipality. In fact, the existing comprehensive town planning of Hat Yai district shows the land use zoning of residential, commercial and industrial purposes for the eastern part of the flood plain (see Fig. 2.2-2).

The flood plains are also subject to urban development due to easy access to the center of Hat Yai municipality. The urban development of the flood plain will not only increase flood damage potential but also increase the flood peak to the Hat Yai district. Hence, land use in the flood plains should be also well controlled.

According to the interviews to the people living within and around Hat Yai municipality, about 60% of the respondents recognize necessity of the land use control of flood plain or other flood prone area. However, the remaining people are not willing to the land use control mainly due to that compulsory land use control will restrict their development activities in the future.

For details of the interviews, see Appendix C.

7.1.2 Necessity of Participatory Flood Management

According to the above interviews, very few people know about the ongoing flood prevention project. Even the people, who know the project, their knowledge is very limited. They listed up only pump station as project component and RID as concerned agency.

After being briefed on the ongoing projects, most of them expressed their agreement with the projects. They listed up various kinds of flood prevention measures when they were asked for their opinion on the flood prevention measures during the interview. However, the listed measures are mostly fragmentary since their knowledge on flood management of the Khlong U-Taphao basin is limited.

The ongoing structural projects require a large land acquisition and compensation. Cooperation of the concerned people is essentially necessary for smooth implementation of the projects. According to the above interviews, about 40% of the respondents are willing to offer the land at market price and 20% are willing to cooperate even at official price. However, the others are not willing to cooperate with the projects mainly due to (i) they have only a small piece of land and (ii) they have no other land than the project land.

For details of the interviews, see Appendix C.

As evident from the above interview survey, more intensive public relations may be necessary for the smooth implementation of the projects.

7.1.3 Necessity of Coordination among Concerned Agencies

The ongoing structural and non-structural measures are being implemented by many concerned agencies. The involved major works of the respective agencies are summarized below.

Agency	Major Involved Works
1. National Economic and Social Development Board (NESDB)	Coordination of Flood Prevention Plan Administration
2. Royal Irrigation Department (RID)	Dredging of Existing Channel, Construction. of Diversion Channel, Study and construction of Reservoir, Installation of Flood Forecasting and Warning System
3. Hat Yai Municipality (HYM)	Urban Drainage, Related Flood Management
4. Department of Highways (DOH)	Construction of Related Bridge
5. Public Works Department (PWD)	Construction of Related Bridge
6. Department of Accelerated Rural Development (ARD)	Construction of Related Bridge
7. State Railways of Thailand (SRT)	Construction. of Related Bridge
8. Department of Town and Country Planning (DTCP)	Hat Yai City Planning
9. Land Development Department (LDD)	Land Use Planning of Basin
10. Meteorological Department (MET)	Installation of Meteorological Observatories
11. Royal Forest Department (RFD)	Watershed Management
12. Governor Office of Songkhla Province	General Administration of Flood Management Project

All the works should be timely implemented to attain the target of the Hat Yai flood prevention as scheduled. For this purpose, strong coordination among the concerned agencies is necessary.

7.2 Coordination Committees of Existing Flood Management Plan

7.2.1 General

The government established Hat Yai District Flood Prevention Plan Administration Sub-committee (HYFP Sub-committee) in July 2001 under the Specific and Cities Development Coordination Committee (SACDEC) to coordinate the flood management plan of Hat Yai district and its implementation. The government further established six (6) sub-committees for specific subjects under HYFP Sub-committee.

The six (6) sub-committees include:

(1) Public Relations Public Understanding Sub-committee (PR Sub-committee)

(2) Land Acquisition Sub-committee (LA Sub-committee)

(3) Construction Coordination Sub-committee (CC Sub-committee)

(4) City Planning Sub-committee (CP Sub-committee)

(5) Sub-committee for Career Promotion and Land Allocation to Resettle

(CPLA Sub committee)

(6) Project Monitoring and Evaluation Sub-committee (PM Sub-committee)

7.2.2 Hat Yai District Flood Prevention Plan Administration Sub-committee (HYFP Sub-committee)

HYFP Sub-committee consists of 26 members of concerned agencies with the deputy Prime Minister as chairman and deputy secretary-general of NESDB as secretary. Further, Hat Yai District Flood Prevention Plan Administration Coordination Center (HYFPCC) was established within the Office of NESDB to serve as the secretariat of HYFP Sub-committee.

The major duties of HYFP Sub-committee are summarized below.

(1) Propose policies, measures and programs/projects for the flood prevention.

(2) Consider, scrutinize and approve implementation plans and budget framework for the six (6) specific sub-committees.

(3) Coordinate administration, supervision, monitoring and evaluation of the six (6) specific sub-committees.

HYFP Sub-committee holds a meeting every two (2) months or more meetings as requested by the chairman. In each meeting, the six (6) specific sub-committees report their work progress to HYFP Sub-committee.

The six (6) specific sub-committees must establish their own action plans, administration mechanism and budgets, that are to be submitted to HYFP Sub-committee for consideration and approval.

7.2.3 Specific Sub-committee

The six (6) specific sub-committees were established under HYFP Sub-committee to take precise actions in every step of work and to achieve quick and effective results. The key members and major duties of the six (6) sub-committees are summarized below.

Sub-committee	Key Member	Major Duties
Public Relations and Public Understanding	Chairman: Governor, Songkhla Province Secretary: Chief, PR Office, Songkhla	1) Prepare public relations action plans to facilitate people's understanding on flood prevention and management. 2) Coordinate public relation activities. 3) Disseminate official information on progress of flood prevention, solution to flood problems as well as on relocation of people.
Land Acquisition	Chairman: Governor, Songkhla Province Secretary: Chief, Land Office, Songkhla	1) Prepare action plans and budget for land acquisition. 2) Control and coordinate land acquisition activities. 3) Monitor and supervise land acquisition activities, and solve related problems.
Construction Coordination	Chairman: Director General, RID Secretary: Director, The office of Water Resources Development 5, RID	1) Prepare work plan and budget for construction of the projects 2) Control and coordinate to expedite construction work according to the master plan. 3) Monitor and supervise construction activities and solve related problems.
City Planning Coordination	Chairman: Director General, DTCP Secretary: Director, Town Planning Bureau, DTCP	1) Study on land use planning and improvement of urban development plan of Hat Yai City 2) Control and coordinate the enforcement of city plan and land use plan
Career Promotion and Land Allocation to Resettle	Chairman: Deputy Permanent Secretary of MOAC Secretary: Director, Planning and Special Project Division, MOAC	1) Prepare career promotion plan for resettled people. 2) Control and coordinate related agencies 3) Monitor and expedite career promotion and land allocation
Project Monitoring and Evaluation	Chairman: Governor, Songkhla Province Secretary: Chief, Songkhla Provincial Office	1) Monitor and expedite activities of related agencies. 2) Coordinate activities of flood hazard relief 3) Report results of monitoring and promotion of activities of Flood Prevention Plan to SACDEC

MOAC: Ministry of Agriculture and Cooperative

CHAPTER VIII RECOMMENDATION

8.1 Structural Measures

The ongoing structural measures including the dredging of the downstream reaches of the Khlong U-Taphao, construction of the RID diversion channels (D1, D3, D4, D5 and D6), polder dikes, urban drainage and construction of the related bridges will be successfully implemented under the strong coordination of the existing related committees.

Several flood control dams (reservoirs) in the upper Khlong U-Taphao basin are being studied by RID. The proposed dam/reservoir plan and responsible agency for the implementation may be finalized through the existing coordination system.

Improvement of the existing channel, construction of a retarding basin ,a flood control dam and diversion channels are proposed for the Khlong Wa basin by this Study. The proposed project plan and responsible agency for the implementation may be finalized through the existing coordination system after the feasibility studies are completed.

No special coordination system may be necessary for the planning and implementation of the above structural measures.

However, public hearing or public consultation on the proposed project plan will be made by the concerned agencies (agency that conducts the feasibility study together with local government/organization) before finalization of the project plan.

8.2 Non-structural Measures

(1) Flood Forecasting and Warning

A flood forecasting and warning system covering the whole basin of the Khlong U-Taphao (including the Khlong Wa basin) is being studied by the study team of Kasetsart University entrusted by RID. The system will include installation of necessary hydrologic observatories and telemeter system.

The flood forecasting and warning will be achieved through three (3) steps of activities: (i) forecasting of river water level by flood forecasting center, (ii) transmission of forecast water level to flood warning center, (iii) issuing of warning for evacuation/flood fighting/flood relief to the concerned agencies and organizations.

The organizational systems for the above three (3) steps will be recommended by the ongoing flood forecasting and warning study.

(2) Land Use Control in Flood Plain

The existing land use zoning of the lowermost flood plain of the Khlong U-Taphao (located between St. X 90 and highway No.43) should be immediately reviewed. Land filling of the flood plain or reduction of the flooding area by encroachment will change the existing flood behavior in a complicated manner. The land use zoning of this flood plain should be reviewed based on detailed hydraulic simulation in the channels and flood plains.

As mentioned in Section 7.1, land use in the flood plains of the Khlong Wa should be well controlled by the government since they are also subject to urban development due to easy access to the center of Hat Yai municipality.

According to the existing coordination system, the Land Development Department is responsible for planning the optimum land use of the entire basin of the Khlong U-Taphao including the Khlong Wa basin. On the other hand, Department of Town and Country Planning is responsible for preparation of the urban development plan of Hat Yai and its surrounding area. Those plans should be prepared in due consideration to the necessary land use control of the flood plains.

However, strong coordination may be necessary between the urban development and flood management plans.

The coordination will be made in the existing City Planning Coordination Sub-committee, based on the following studies and analyses.

(a) Preparation of flood hazard map of the flood plains and Hat Yai District,

(b) Flood risk estimation of the proposed urban development area in the flood plain,

(c) Evaluation of the adverse effects (increase of flood peak) of the urban development on the downstream,

(d) Delineation of the reserved area for flood retarding where land filling and building of permanent structures will be restricted,

Generally, restriction of private land use by law/regulation is not easy. However, private sector may not be able to conduct a large land development without provision of infrastructures by the government. Opening to the public of the flood hazard map and land use zoning of the flood plain is considered important. It will guide the people not to conduct disorderly land development in the flood plain with a high risk.

8.3 Public Participation

In this Study, construction of Upper Khlong Wa dam and Phru Phli Kwai retarding basin is proposed for flood prevention of Hat Yai district. This flood control plan will produce little benefits on the people of Na Mom district although a large land is lost. Hence, the two (2) projects should be planned to produce benefits on both areas of Hat Yai and Na Mom districts to the possible extent.

For this purpose, the proposed dam and retarding basin are planned for multiple uses including flood control, water supply, irrigation and other uses. The water use plan should be determined through discussions with the local government/organization and the representatives of the concerned communities.

Further, technical information on the project plans should be open to the public to obtain the people's understanding on the projects before finalization of the project plan.

The public participation in the project planning will be conducted in the stage of feasibility study.