APPENDIX E

PRELIMINARY ENVIRONMENTAL EXAMINATION

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PRELIMINARY ENVIRONMENTAL EXAMINATION

CHAPTER 1 GOVERNMENTAL GUIDELINES FOR INITIAL ENVIRONMENTAL EXAMINATION

1. Introduction

The NEB (National Environmental Board) Guidelines for on Environmental Examination of a development project is summarized as follows:

1.1 General Concept of IEE

(1) While it is NEB policy to require preparation of an Environmental Impact Assessment ("EIA") report for any proposal development project which might significantly affect environment, it is also NEB policy to limit this work to only such projects. Hence, at the outset in the conception and planning of any project, the question is whether or not an EIA report will be necessary, so that, if it is necessary, provision for the work can be included in the budget allocations for planning including the feasibility study.

(2) To answer this question the Initial Environmental Examination (IEE) procedure may be used. It is the purpose of these guidelines to describe this procedure, to assist in its use by all RTG implementing agencies.

1.2 Definition of IEE

(1) An IEE is essentially an initial examination of the environmental effects potentials of a proposed project, done within a very limited budget, based mostly on the preliminary information at hand or on information which can be readily obtained, and dependent to a considerable extent on the professional judgment of the individual doing the examination based on his experience in making EIA evaluations of similar projects elsewhere.

(2) The IEE is thus a "first approach" to an EIA study, which needs to be carried out at a depth only as needed to determine whether a follow-up EIA report will be required.

1.3 Parameters Included in IEE

The environmental parameters to be included in the IEE are the same as in a full-scale study, as explained in NEB's "General Guidelines for EIA Reports".

1.4 Extent of Work Needed

(1) In setting up the work plan and budget for the IEE for a particular project, it is necessary to consider the extent to which field trips may be needed, and the

extent to which outside expertise may be needed. As noted above, the objective is not to make the actual detailed evaluation for each environmental parameter, but rather to reach a decision on whether such evaluations are needed.

(2) Examples are as follows:

1) Any sizeable dam/reservoir project, any sizeable harbor project, any sizeable highway project, and sizeable projects of many other types will certainly require full-scale EIA analysis. However, for smaller projects only the preliminary IEE may suffice, depending on the findings of the IEE.

2) Another example relates to such facilities as municipal water treatment or sewage treatment plants. Often the only controversial impact involved may be those associated with the site location, so that, if an isolated location can be found, and the plant is competently designed, there may be little if any need for additional EIA work. However, if the site is located in a built-up area, or if the discharged effluent will have significant impacts on natural ecology, agricultural development, or other values, then a full-scale EIA report may be in order.

3) Usually "non-physical projects" such as projects which involve training or course instruction, will not need a full-scale EIA. Such projects may have important environmental consequences, but usually these can be handled in the IEE. Also, master planning projects, which develop proposed constraints for guiding future development, may or may not require an EIA, depending upon the environmental sensitivity of the subject concerned. Thus, for a Municipality or regional water pollution/quality control planning project, a full-scale EIA will be needed because of the profound environmental effects likely to result from implementing the comprehensive plan to be proposed.

(3) If the conclusion of the study is that an EIA is not needed, then in effect the IEE will serve as the EIA. In such cases it is important that the IEE be sufficiently complete to serve this purpose.

1.5 Organization of IEE Report

It is suggested that the IEE report include four sections, more or less as follows:

(1) **Description of Proposed Project**: A brief description should be given of the proposed project, as sufficiently as possible to give the background relating to probable environmental effects.

(2) **Discussion of Probable Environmental Effects**: Based on the available information (See Item 1.2 (1)), each environmental parameter likely to be affected by the project should be discussed and evaluated.

(3) **Tabulation of Initial Evaluations:** A tabulation should be prepared, which summarizes the results of (2) above.

(4) **Conclusions:** Conclusions should be developed and presented as to whether a full-scale EIA will be needed and (i) if not, to delineate the environmental constraints to be observed in project implementation (in this case the IEE serves as the EIA), and (ii) if needed, to present the terms of reference for the needed EIA study, including delineation of sensitive environmental aspects and an indication of the extent of work to be done and the budget which should be allocated to support the desired level of investigation.

Therefore, an environmental examination is undertaken, to cover only some important environmental aspects of each project component.

1.6 Need for IEE of This Project

Detailed or supplemental guidelines for an EIA report of a water resource project, on which the actual extent of work for an IEE is based, is not presented above. Past experience of the Consultant shows that an IEE needs adequate technical inputs from several experts in such fields as water resource, hydrology, flood prevention, water quality, forestry, land use, transportation, socio-economics, aesthetic quality, tourism, public heath, property compensation and resettlement of affected people. Sampling and analysis of certain environmental components and parameters are also needed. In general, an IEE of a water resource development project requires about 15-20 man-months of these experts and cost about 2.5-3.0 million baht.

Since the resources provided for an environmental study of this project are much less than those required for a full IEE, it is not possible to carry out an IEE study for this project. This study, called the **"Preliminary Environmental Examination"**, will summarize all related environmental impacts, and only the environmental components with moderate or significant impacts will be discussed.

CHAPTER 2 DESCRIPTION OF PROPOSED PROJECT

2.1 Project Components

The components of the Emergency Flood Prevention Planning Project for Hat Yai District and Khlong U-Taphao River Basin are obtained from the pre-feasibility study of the mentioned projects, and can be summarized as follows :

2.1.1 Flood Control Dam

Twelve dam sites were studied, and it is found that only the Upper Khlong Wa dam site is suitable for flood control in the Khlong Wa Basin. It can control the storm water of 18.6 sq.km. in the upper part of Sub-basin No. 12. It is located in Ban Plak Thing, Tambon Khlong Rang, Na Mom District, 4.3 km. upstream of Na Mom Town Area.

The peak flood at this location is estimated at 40 cms., so all the flood discharge needs to be controlled. The design peak flood discharge at Station X 174 will be reduced from 154 cms. to 128 cms. by this reservoir. The reservoir capacity of 4.7 MCM is not sufficient to reduce this peak discharge to the existing design discharge of 110 cms. The dam and reservoir features can be summarized below:

1. Dam foundation : at 43.0 m.msl.
2. Type of dam : Earth-fill
3. The required storage capacity : 5.2 MCM (Included dead storage)
4. Normal high water level (N.W.L.) : 66.0 m.msl.
5. High water level (H.W.L.) : 72.0 m.msl. to store necessary flood volume of 4.7 MCM
6. Required surcharge capacity to cope with the 2000 flood with a return period of 300 years : 9 MCM
7. Crest elevation of the dam for a 3.0 m free board: 75.0 m.msl.; Dam height : 32.0 m.
8. Crest length : 800 m.
9. Reservoir area at N.W.L : 0.6 sq.km.
10. Land to be acquired : 700 rai
11. No. of resettled households : None (only rubber plantation)

2.1.2 Retarding Basin

(1) Phru Phli Khwai Retarding Basin

1. Location : 0.5 km.north of Na Mom District
2. Drainage area to be controlled : 49 sq.km.
3. Size of area : 0.5 sq.km. of public land (Dredging of the area is required, with a depth of 4.0 m.)
4. Total Storage capacity : 2.0 MCM
5. To regulate flood peak of : 12 cms. (25-year return period.)

6. Design flood peak discharge at St. X 174 will be reduced from 154 to 142 cms.
7. River channel dredging from outlet of discharge basin :2.0 km
8. A control gate : for irrigation water supply in the dry season, such that the 2.0 MCM of stored water can be released for such purpose.

(2) Phru Mao Retarding Basin: This is an artificial retarding basin created by dike construction on both banks of the canal. But it is found to have little flood reducing capacity, and hence infeasible.

2.1.3 Integration of Flood Control Dam and Retarding Basin

The combination of the Upper Khlong Wa flood control dam and the Phru Phli Khwai retarding basin can reduce design peak discharge at St. X174 from 154 cms. to 118 cms. This is a better alternative than a flood control dam alone.

2.1.4 Improvement of Existing Channel

(1) Estimation of Discharge Capacity Required from Channel

Design discharge of Khlong Wa in Khlong U-Taphao flood mitigation plan is 110 cms. (without Khlong Rian diversion) or 160 cms. (including Khlong Rian diversion)

The integrated project of the Upper Khong Wa dam and the Phru Phli Khwai retarding basin will reduce a discharge of a 25-year return period to 118 cms. (without Khlong Rian diversion or 168 cms. with Khlong Rian diversion) at St. X.174.

The northward diversion line 1 or line 2 project will divert flood water of the Khong Rian Basin to RID 's diversion channels. The resulting flood discharge of 25-year return period in Khlong Wa at. St. X.174 is estimated at 154 cms.or 118 cms. after construction of the flood control dam and Phru Phli Khwai retarding basin.

Therefore, channel improvement of Khlong Wa is planned to meet the existing design discharge of 118 cms.

(2) Design Riverbed and High Water Level

1. Khlong U-Taphao at entrance of D1
   - Design riverbed : -0.2 m.(msl.)
   - Design high water level : 5.8 m.(msl.)
   - Crown level : 7.8 m.(msl.)

2. Khlong Wa high water level and dike crown elevation

- Design riverbed high water level and dike crown elevation of Khlong Wa at km 0.0 will be the same of those in Khlong U-Taphao.

2.1.5 Northward Diversion Channel line 3

From the existing design discharge 118 cms. on the improvement plan of existing Khlong Wa channel, the northward diversion channel line 3 is necessary to divert the excess discharge of Khlong Wa existing capacity and flood discharge over 25 year return period.

The route of the northward diversion line 3 will be started from Phru Phli Khwai retarding basin in Khlong Wa basin ,passed through Khlong Phra Wong basin and Khao Kloi before emptied to Songkhla Lake. This diversion line will reduce the peak flood in Khlong Wa of about 40 %

2.2 Other Project Components

The other project component is considered for cost comparison with the on going and existing projects, as the following details ;

2.2.1 Northward Diversion Channel line 1

The northward diversion channel line 1 will divert flood water from Khlong Rian and Khlong Ple basin to RID diversion channel D3 so the D3 channel capacity is needed to be improved to handle the additional flood amount. In this case, D4, D5 and D6 will be unnecessary.

2.2.2 Northward Diversion Channel line 2

The northward diversion channel line 2 will divert flood water from Khlong Rian basin to the middle of RID diversion channel D5. In this case, the RID diversion channel D3,D4 and D5 should be improved and D6 will be unnecessary.

2.2.3 Southward Diversion Channel

The southward diversion channel will divert flood water from Khlong Wa at about km.5+000 to upstream retarding basin of Khlong U Taphao and near highway no.43. This diversion channel will be suited if the existing condition of Khlong Wa between railway bridge at Sta. 1+470 and Kanchanavanich road at Sta.3+140 (Highway no.4) can not be improved according to the land acquisition problem.

CHAPTER 3 EXISTING ENVIRONMENTAL CONDITIONS

3.1 Introduction

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 are also collected from the agencies concerned as well as from field observations. As stated in Chapter II, 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.

3.2 Key Activities

3.2.1 Data Collection

The following data and documents have been collected and reviewed:

(1) Implementation Plans of the Hat Yai District Flood Prevention Plan Administration Sub-committee, 2001.

(2) Khlong U-Taphao Basin Flood Prevention Plan, Hat Yai District, Songkhla Province, Office for Coordination of Royal Initiated Projects and NESDB, February 2001.

(3) Civil Disaster Prevention Command Office, Emergency Flood and Storm Disaster Prevention and Relief Action Plan for Songkhla Province B.E. 2545, June 2002.

(4) Data of Songkhla Province, Songkhla Provincial Office, 2002.

(5) Statistic Reports of Songkhla Province for 2001 and 2002, Songkhla Provincial Office (two reports).

(6) Annual Report of Na Mom District, 2002.

(7) Preparation of Flood Prevention and Relief Plan for Hat Yai District in 2001, Hat Yai District Civil Disaster Prevention Command Office, 2001.

(8) Summary of Flooding in Hat Yai Municipality and Helps Given to Flood Victims in 2000, Hat Yai Municipality, 2000.

(9) Report on Public Disaster on 4 December 2000, Songkhla Provincial Office, 2000.

(10) Study, Survey and detailed Design of Flood Prevention and Drainage Projects in Hat Yai Municipal Area, Prepared for Hat Yai Municipality, Songkhla, by Water Development Consultants, Co., Ltd., August 1999.

(11) Study to Prepare City and Comprehensive Area Development Strategy for Greater Hat Yai Region, prepared by Hat Yai Municipality and Government Offices Improvement Consulting Institute, 1998.

(12) Border Town Development Project , Town Appendix: Hat Yai, prepared for Office of Social and Economic Development Board (NESDB), by Gibb Ltd. (UK) and PAL Consultants, Co., Ltd., November 1998.

3.2.2 Review of Existing Reports and Ongoing Projects

The data and documents stated in Section 3.2.1 have been reviewed, and the results of the review are presented in Sections 3.3-3.6 There are also other ongoing projects whose results have not yet been made public. Their progress reports have been collected and reviewed. Some examples of such projects are:

(1) Land Use Planning Study for Songkhla Province by PAL Consultants Co., Ltd., for the Land Development Department.

(2) Master Plan of Flood Prevention for Hat Yai Municipality, by Kasetsart University, for Committee for Coordination of Royal Initiated Projects.

3.2.3 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 to collect 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.

3.2.4 Presentation of Results

The following sections present results of data analysis and results of literature review on related environmental conditions and resources components.

3.3 Physical Resources

3.3.1 Topography

Topography in Hat Yai District and surrounding areas consists of high areas on three sides. The north-south aligned Khao Banthad Range is situated to the west between Songkhla and Satun Provinces, with a peak of 932 meters above mean sea level or m. (msl) at Khuan (mountain) Liab. The San Kalakhiri Range lies to the south, demarcating the border between Thailand and Malaysia, and has a peak of 748 m. (msl) at Khuan Lang. There is also a mountain range to the east, separating the project area and Chana, Thepha and Saba Yoi Districts.

The area gently slopes downwards to the Songkhla Lake to the north. Singha Nakhon District is situated on the sand dune which extends from Ranot District to the outlet of the Lake. Areas around the Lake's outlet is generally flat areas created by alluvial deposits along streams which discharge into the Lake. Ground levels of the area are less than 60 m. (msl)

Khlong U-Taphao originates from Khao Nam Khang. It flows through Khlong Hoi Khong District and drains to Songkhla Lake in Hat Yai District, having a total length of 95 km. Another main canal is Khlong Rattaphum which originates from the Banthad Mountain Range. This canal discharges to the Songkhla Lake in Khuan Niang District, and has a total length of 40 km.

3.3.2 Meteorology

Songkhla Province has tropical climate, consisting of two distinct seasons. The climate in the May-September period, or the dry season, is influenced by the southwest monsoon; while that in the October-January period, or the rainy season, is influenced by the northeast monsoon. The driest period in the area falls in February-April, and is influenced by the southeast monsoon.

According to the 30-year climatic record (1971-2000), the average number of rainy days in Songkhla is 153.6 days. Rainfall averages 1,994.9 mm/year, peaking at about 567.3 mm in November. The mean annual and mean maximum temperatures in the area are 28.1°C and 31.4 °C, respectively. The mean annual and mean maximum relative humidity is 77.0% and 90.0%. Local wind speed ranges from 3.7 to 7.9 knots, with the maximum of 99 knots being reported in July.

The report of the Southeast Meteorological Center shows the following climatic conditions in Songkhla in 2001:

• Number of rainy days	137	days
• Mean annual rainfall	2,119.0	mm
• Mean annual temperature	27.8	°C
• Maximum temperature	37.0	°C
• Mean annual relative humidity	77.82	%

- Mean annual pressure 1,009.7 mm
- Mean evaporation (pan) 4.85 mm/day
- Mean wind speed 5.3 knots
- Maximum wind speed 7.9 knots

3.3.3 Air Quality and Noise Pollution

(1) Air Quality

Air quality in the study area in general is good and relatively constant, particularly in areas around the outlet of the Songkhla Lake. However, there are several areas with deteriorating air quality which is below standard levels, such as in Hat Yai Municipality, the industrial zones in Hat Yai and Muang Songkhla Districts. The worst area, according to results of air quality monitoring by the Pollution Control Department, is Hat Yai Municipality where deterioration has been increasing continuously. The key air quality parameters monitored in December 1995-November 1996 are summarized in Table 3.3-1.

Table 3.3-1 Summary of Air Quality Monitoring Results in Hat Yai Municipality, during December 1995 - November 1996

Parameter	TSP ($\mu g/m^3$)	CO (ppm)	SO_2 (ppb)	NO_x (ppb)	O_3 (ppb)	Temp. (°C)	Humidity (%)	Rainfall (mm.)	Noise (dBA)
Standard	330	9*	120	170**	100**	-	-	-	70***
Dec. 1995	62.5	1.17	2.33	4.39	16.39	25.50	97.94	0.20	66.2
Mar. 1996	115.23	0.62	1.00	7.73	14.69	27.00	94.00	0.00	66.2
Apr. 1996	51.20	1.11	1.03	10.80	12.63	28.27	94.53	0.05	67.4
Oct. 1996	40.77	0.88	1.38	10.72	6.36	26.40	98.70	0.08	77.5
Nov. 1996	41.28	0.65	1.09	6.69	2.73	26.03	99.16	0.13	77.3

Source: Air Quality and Noise Monitoring Station, Phadung Phakdee, Hat Yai District, January 1997

Notes:
1. Values shown are daily averages (24 hours)
2. Standard values are those announced by PCD in 1995 (Values are in 24-hr average, except those under * are 8-hr averages and those under ** are 1-hr averages)
3. Noise level is in Leq (24 hr)
4. *** US.EPA's standard

In other areas, random sampling and analyses were carried out by Environmental Health Center 12 (Songkhla). In comparison with Ambient Air Quality Standards announced by the Ministry of Science, Technology and Environment in 1981 and those announced by the Pollution Control Department in 1995, these monitored air quality parameters did not exceed the standard levels.

For other quality parameters, particularly odor and/or smoke, there are problems in certain areas such as around fish meal plants, rubber latex processing plants, and canals with polluted water.

Visibility in the project area is generally good, except in some areas where visibility is poor due to human activities such as burning of hays, grasses or bushes along roads. Such events were frequently observed along Lopburi Ramesuan Highway.

There has been no report of risks from radioactive substances in the project area, either due to natural causes or human activities.

(2) Noise and Vibration

Under normal circumstances, there has been no report of noise levels which are hazardous to human health in the study area (report by Hat Yai Municipality, 1996). However, there are trends of increasing levels of noise and vibration in urban centers due to growth in traffic volume. The data compiled in 1996 have shown that noise levels in Hat Yai Municipality were slightly over the standard level (see Table 3.3-1). At present, responsible agencies and the Municipality have not yet installed noise barriers to mitigate effects due to high noise levels.

(3) Summary

It is found that climatic changes in the project area are within normal ranges of alterations in the local areas, and there is no definite trend of worsening. Nevertheless, air quality in certain localities, particularly noise and air pollutants, have indicated trends of increasing deterioration particularly in urban areas of Muang Songkhla and Hat Yai Districts. These situations are due to increasing traffic volumes, and the problems should be mitigated.

3.3.4 Natural Resources

(1) Geology

Geological characters of the study area are mainly characterized by loamy soils and sedimentary rocks of the Quaternary period which have accumulated in the Hat Yai and Songkhla Lake basins. They are intermixed with sedimentary locks (silty sandstone, metamorphic rocks), shale, honfell and granite. Geologic structures comprise the primary structures of terrace, and some secondary structures found in the southeast and west parts of the area. These include small and discontinued joints and faults in the NNW, NS and NNE directions. They have steep slopes, but have shown no sign of movement for a very long time. This finding is consistent with seismology of the project area because there is no focal point of earthquake in the project area.

(2) Soils

Soils in project area can be classified by landform feature into two main groups, namely lateritic areas or mountain ranges, and low-lying flat areas. Lowlying flat areas on the banks of the Songkhla Lake are coastal flats, with gentle slopes, deep soils, clayey texture, poor to relatively poor drainage

capacity, and low to medium fertility. They are used mainly for rice cultivation. At higher levels, the areas are flats or rolling flats terrains which are the major portions of the study area. Soils are deep, with fine to coarse texture, poor to good drainage, and low to very low fertility. They are mainly used for para rubber and mixed orchard plantation.

On mountainous areas or mountain ranges, soils are primarily shallow, with occurrence of rocks at depths less than 1.00 m. In areas of rocks formed by silty clays or granite, weathered rocks generally exist, together with sandy loam and clayey loam, and have good drainage. Headwaters of streams are present at higher elevations while forests on hillslopes and low hills with less slopes have usually been cleared for rubber plantations or are left as scrub forests.

Soils in the project area generally have medium to good bearing capacity, except in lowlying areas, ponded areas, swamps and areas around the Lake which are suitable for crop cultivation. For example, the areas between urban centers in Hat Yai and Muang Songkhla Districts have low to medium fertility and are suitable for rubber plantation, according to the Land Development Department.

(3) Surface Water Resources

The project area is a part of the Songkhla Lake Basin, and comprises several sub-areas. The sub-areas within the project area include the Lower Songkhla Lake sub-area which connects to the Gulf of Thailand. In this sub-area, there are several streams such as Khlong U-Taphao, Khlong Toei, Khlong Thon Samroang, Khlong Nam Noi (Hat Yai), Khlong Nam Krachai, Khlong Phra Wong and Khlong Samroang (Muang Songkhla). These are perennial streams except Khlong Phra Wong and Khlong Samroang which are silted and become shallow, and may have flows in the rainy season only.

There are two a main river basins in the study area and its vicinity, the Khlong U-Taphao Basin and Khlong Rattaphum Basin. The catchment areas of these basins are 2,480 sq.km.. and 420 sq.km. respectively. They have average annual flows of 1,056.0 and 236.0 million cubic meters (MCM) per year, totaling 1,292 MCM/year. Only 85.02 MCM of the water in these basins is impounded in reservoirs, amounting to only 6.58% of the total.

3.3.5 Groundwater Resource

The Hat Yai aquifer is located in sedimentary rock with a thickness of 50 m and an average yield of 100 cu.m/hour. Groundwater quality is generally good for different usage, except in some areas where iron content is high. The layer of the aquifer where water has high risk of health hazards is the Hat Yai aquifer which is an unconfined aquifer. Large amounts of groundwater are pumped out for use everyday. However, results of groundwater quality monitoring have not shown water quality with serous pollution problems.

In the urban centers of Hat Yai and Muang Songkhla Districts, both quantity and quality of groundwater are expected to change in the future. Due to large amount of water abstraction every year, the cone of depression has spread while water table has progressively decreased. Over pumpage of groundwater out of the unconfined aquifer will lead to salinity intrusion problems, as well as groundwater pollution due to leachate from sanitary landfills, and wastewater.

3.3.6 Water Quality

Water in the Songkhla Lake is usually saline or brackish, and is still suitable for fisheries and aquaculture. Water in natural streams is normally freshwater and has moderate to good water quality, except in some sections of Khlong U-Taphao, Khlong Toei (Hat Yai) and Khlong Samroang (Muang Songkhla) where water is polluted and cannot be used. The sections of streams where water is polluted to an extent which can be harmful to human health are as follows:

(1) **Khlong Toei**: It receives wastewater draining from communities and industries in Hat Yai Municipality, which causes the Khlong water to be polluted. Low flows exists in this canal in the dry season, and sewage discharging from the urban center of Hat Yai causes water ponding, heavy pollution and objectionable odor. Water hyacinth infests heavily in some sections of the canal. Such effect results in health hazards and unsightliness.

(2) **At Pumping Station in Khlong U-Taphao**: This is the point from which raw water for the Songkhla and Hat Yai water supply systems is withdrawn. In the dry season, low flows and wastewater cause heavy pollution (from communities and industries), and this has severe effects on the municipal water treatment plant.

(3) **Khlong U-Taphao downstream of Khlong Toei**: This section is within the Hat Yai municipal area and is also heavily polluted, with higher concentration of fecal coliform than the standard level. Pollution is also caused by communities and industries, adversely affecting domestic water supply, fishery and aquaculture around the outlet of the Lake.

(4) **At Hat Yai Railway Station, Railway Overpass and in front of Waterworks Office**: This is where water quality is of Type 4, which cannot be used for domestic water supply unless after treatment using special treatment methods followed by disinfecting.

(5) **Villages along Coastline of Songkhla Lake**: From these villages, wastewater discharges directly to the Lake, thus polluting the Lake water and affecting fish culture in cages and polluting raw water source of the water supply systems in that vicinity.

Table 3.3-2 presents water quality monitored in 1995-1996 in the project area and in its vicinity.

Table 3.3-2 Results of Surface Water Quality in Vicinity of Project Area 1995-1996

Sampling Station	May 1995		September 1995		January 1996	
	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
1. Outlet of Songkhla Lake	0.6	13	1.20	46	1.46	41
2. Ko Yo	1.0	42	2.19	46	1.75	20
3. Khao Daeng	1.1	58	0.94	49	1.17	38
4. Fishing Port	0.4	50	1.25	50	1.27	32
5. Outlet of Khlong Phra Wong	10	44	7.37	24	9.38	19
6. Outlet of Khlong U-Taphao	7.1	9	4.28	55	2.32	15
7. Outlet of Khlong Khwang	21	49	40.8	44	105	38
8. Outlet of Khlong Samroang	13	93	13.3	40	7.08	34

Notes: Sampling by Southern Environment Office, and Analyzing by Environmental Management Establishment Project, Prince of Songkhla University, 1995-1996.

(6) **Wastewater Treatment**: Wastewater treatment plants were being constructed in 1996. If these treatment plants are operated successfully, together with water resource rehabilitation, an improvement trend of surface water quality should result. But if they fail, more deterioration of water quality will be inevitable. Water quality in the Lake will also further deteriorate due to communities and activities which encroach upon conservation zones around the Lake.

(7) **Summary**: In comparison with the standards of the Ministry of Science, Technology and Environment (1996), water in Khlong Toei, Khlong U-Taphao and Khlong Samroang was worse than the standards. BOD and SS were higher than the standard levels, particularly surface water quality near river outlets in Hat Yai District.

In May and September 1995 and January 1996, BOD_5 contents were found to be significantly above the standard level of 4 mg/l. The exception was found at the outlet of Khlong U-Taphao where BOD_5 content was 2.32 mg/l (which is still too high for general uses). Suspended solids (SS) contents were also higher than the standard level in urban areas, especially at the outlet of Khlong Khwang and Khlong Samroang.

3.4 Biological Resources

3.4.1 Forests

In the study area and its vicinity, there are 26 forests with 923,193 rai of area in total. They comprise 22 national forest reserves with a total area of 660,556 rai. The remainders are conserved forests such as Ton Nga Chang Waterfall Wildlife Sanctuary (13,750 rai), Khao Nam Khang National Park (137,500 rai), Boriphat Waterfall Botanical Garden (10,937 rai) and Phru Khang Khao Non-hunting Area (450 rai). The main parts of forest reserves have been encroached upon and

severely damaged; hence the total area of true or climax or healthy forests is much less than that officially reported.

3.4.2 Habitats and Sensitive Ecological Areas

Important wildlife habitats and sensitive ecological areas in Songkhla comprise national forest reserves, botanical gardens, and healthy or climax forests. In the vicinity of the project area, there are the Hua Khao area west of Ko Yo, Khao Roop Chang area, in Muang Songkhla District and a public park in Hat Yai District. However, they are less important than Ton Nga Chang Waterfall Wildlife Sanctuary, mangrove forests, peat swamps and wetlands around the Songkhla Lake between Hat Yai and Muang Songkhla Districts. They include ponded areas on both sides of Phetchkasem and Lopburi Ramesuan Highways.

3.4.3 Natural Vegetation

Important plant species found in the area include Yang (Dipterocarpus tuberculatus), Daeng (Xylia xylocarpa), Saya Daeng (Shorea curtisii), and Saya Khao (Shorea assamica). Plants which are ubiquitous consist of ferns, bamboos, palms, wild banana, climbers and water-sorbent plants. However, nowadays these plants have commonly been replaced by para rubber tree plantations. In wetlands, important plant species commonly found include Samae (Avicennia sp.), Kong Kang (Rhizophora sp.) and Samed (Melaleuca leucadendra Linn). In addition Krajude (Typha bispinosa) has become an economic plant for communities around the Songkhla Lake (for producing handicrafts). Again these plants, particularly in Melaleuca areas, have gradually been replaced by para rubber tree plantations or converted into rice paddies. In most swamps or pounded areas, Kok (Cyperus imbricatus Retz.), Thoop Rusi (Typha angustifolia Linn.), Phak Bung (Impomoea aquatica Forsk.), etc. are found.

3.4.4 Wildlife

Many species of wildlife have been reported to be found or exist in the project area, including birds, amphibians, reptiles and mammals. Some important or frequently found species include Krajong (Barking deer, or Tragulus spp)., Ngu Luam (Phython, or Phython recticulus), Nok Khamin Dam Hua Lek (Oriolus xanthonotus) and Ngu Kapa (Askitrodon rhodostoma). Wildlife are commonly found in natural forests in Songkhla Province. Wetlands around the Lower Songkhla Lake (Thale Sap Songkhla) are habitats of many species of wildlife such as waterfowls, snakes, and amphibians, and are spawning and rearing areas of juvenile aquatic faunas such as shrimps and prawns, Pla Kra Phong (Lates calcarifer) and Pla Kao (Chinese carp) which are important economic faunas in Songkhla. However, these faunas, particularly black tiger prawn (Penaeus monodon) can be cultured in ponds in other areas particularly in mangrove forests.

3.4.5 Rare Wildlife and Plants

There has been no report of the presence of rare or threatened wildlife or plant species in the study area which consist of agricultural areas, communities and residential areas. Neither have these rare species been reported to be found in wetlands in the study areas. However, there are important waterfowl habitats in the upper part of the Songkhla Lake system such as in Khu Khud Waterfowl Sanctuary and Thale Noi Waterfowl Sanctuary which are very far to the north of the project area.

3.4.6 Future Trend

In the future, terrestrial ecological resources in the project area are anticipated to progressively degrade. The main cause of such degradation is the gradual expansion of urban areas and it is expected that the comprehensive area of Muang Songkhla and Hat Yai Districts will extend to join each other and become one big comprehensive area. In addition, wetlands around the Lake are expected to further deteriorate from the present conditions due to expansion of communities, housing projects, tourist places and other economic developments. In particular, aquacultural areas have expanded extensively around the Songkhla Lake including swamps and pounded areas along Phetchkasem and Petchburi Ramet Highways.

3.5 Human Uses Values

3.5.1 Transportation System

Songkhla is the main center of land, water and air transportation of southern Thailand. There are an international airport in Hat Yai District, a deep-sea port for cargo transport in Singha Nakhon District, a fishing port in Muang Songkhla District, and a southern railway junction in Hat Yai Municipality. However, roads and highways in Hat Yai and Muang Songkhla Districts are not yet enough to support steady population and economic growth of these areas. Within the Muang Songkhla and Hat Yai comprehensive planning areas, the total road surface amounts to 879 and 192 rai or about 0.92% and 0.12% of the total area, respectively. Between Muang Songkhla and Hat Yai, there is an old railway track which has not been used for a long time.

3.5.2 Highways

The study area is the connecting point between the highway along the coastline of the Gulf of Thailand with the highway along the coastline of the Andaman Sea and the southern highways which connect with highways and an expressway in Malaysia. The major highways in the study area and in the vicinity comprise:

(1) **Highway 4 (Phetchkasem):** This is the main highway which links southern Thailand with other regions of the country. It enters Songkhla in Rattaphum District, extends through Hat Yai District to meet the N-S expressway in

Malaysia at Ban Khlong Phruan, Sadao District. The section from Ban Khlong Phruan to Hat Yai is a divided highway, with 4 lanes on each side.

(2) **Highway 42**: This highway branches from Highway 4 at Ban Khlong Ngae, Sadao District, passing through Pattani Province and ending at Muang Narathiwas District. This highway connects the Taba or Padang Besar border post with Highway 3 which runs along the east coast and extends to Kalantan State of Malaysia.

(3) **Highway 43**: Branching from Highway 4 at Rattaphum District, this highway passes through Bang Klam, Hat Yai and Na Mom Districts and meets with Highway 42 in Muang Pattani District. It is a divided highway with 4 lanes on each side from Rattaphum District to Chana District.

(4) **Highway 406**: This highway branches from Highway 4 in Rattaphum District and then extends to Satun Province. There is a highway which connects Highway 4 with the capital of Peris State in Malaysia.

(5) **Highway 408**: This is the highway along the eastern coastline from Nakhon Sri Thammarat, passing through Muang Songkhla District and connecting with Highway 3 of Malaysia at Chana District.

3.5.3 Railways

The southern railway track enters Songkhla in Khuan Niang District, passing through Bang Klam District. At Hat Yai, it branches out into 3 directions. The first one extends to Muang Songkhla District, but this track has not been used at all for a very long time. The second track extends to Pattani, Yala then Narathiwas Provinces, and connects with the Thai-Malaysia railway at Sungai-kolok at Padang Besar.

3.5.4 Air Transport

Hat Yai international airport has a runway 45 m x 3,050 m in size, which can accommodate large passenger planes such as Boeing 737 and Airbus 300. The passenger terminal has a throughput capacity of 300 domestic passengers/hour and 800 foreign passengers/hour. It connects with Bangkok and other airports in southern Thailand. Internationally, it connects with Singapore, Malaysia and Hong Kong.

3.6 Quality of Life Values

3.6.1 Human Settlements and Population

(1) Human Settlements

In the project area, there are two main community centers, Hat Yai District and Na Mom District. In 2001, these two districts have a combined total

population of 348,215, or about 27.8% of the total population in Songkhla Province. Administratively, there are 3 municipalities, and 12 Tambons in Hat Yai District, while Na Mom District has 4 Tambons, without any municipality.

The three municipalities in Hat Yai District comprise Hat Yai Municipality (population of 157,806 in 2001), Tambon Ban Phru Municipality (population of 16,941) and Tambon Phatong Municipality (population of 6,674).

(2) **Population**

Population data in Songkhla from 1997-2001, particularly in Hat Yai and Na Mom Districts, are summarized in Table 3.6-1. In 2001, the total population in Songkhla was 1.49 million people, while the populations in Hat Yai and Na Mom Districts were 327,934 and 20,279, respectively. The average population density in the province, Hat Yai and Na Mom Districts was 169, 385 and 219 people/sq.km., in that order. The population density in Hat Yai Municipality is very high, averaging 7,514 people/sq.km., followed by that in Phatong Municipality, with 199 people/sq.km.. At the Tambon level, the population density in 12 Tambons of Hat Yai District in 2001 was in the range of 45-845 people/sq.km.. The density in 4 Tambons of Na Mom District ranged from 157 to 256 people/sq.km.. Tambon Na Mom had the highest density (256 people/sq.km.).

The provincial population had an average increasing rate of 1.22% per year. Hat Yai population growth rate averaged at 1.85% per year, while the average growth rate in Na Mom was somewhat lower, at 0.48% per year. For municipal areas, Tambon Ban Phru Municipality had the highest population growth rate of 2.79% per year, whereas the average growth rate in Hat Yai Municipality, was only 0.29% per year. As for Phatong Municipality, which was established in 2002, the population data are too short to compute a growth rate.

(3) **Human Settlement Problems**: Results of interviews with representatives of Tambon Administrative Organizations (TAO) in the project area concerning problems relative to these human settlements can be summarized. The problem which most TAOs wanted to solve was poor conditions of roads linking among Tambons and villages, followed by inadequate health services due to insufficient public health staff, diseases of intestinal track, narcotic problems which can lead to crimes, and problems related to life and property security of local people. There are also land rights and land tenurial problems and, problems due to solid waste and wastewater.

3.6.2 Land Use

The study area and its vicinity have distinctly different land uses. The central business district (CBD) of Hat Yai Municipality has expanded in every direction, while Songkhla Municipality has a limited CBD expansion. Community and commercial areas of the latter Municipality gradually extend along the highways

Table 3.6-1 Population, Population Density and Population Changes in Hat Yai and Na Mom Districts and in Songkhla Province, 1992-2001

Area		Population			Population Density in 2001 (people / sq.km.)	Growth Rate (% pa)
		1992	1997	2001		
1.	**Hat Yai District**	273,332	305,260	327,936	385	1.85
1.1	Hat Yai Municipality	124,295	155,949	157,806	7,514	0.29
1.2	TM. Ban Phru	13,762	15,236	16,941	942	2.79
1.3	TM. Phatong	-	-	6,674	999	-
1.4	T. Khuan Lang	28,175	24,545	30,688	460	6.25
1.5	T. Khu Tao	8,974	9,563	10,122	298	1.46
1.6	T. Kho Hong	30,398	24,373	29,967	845	5.73
1.7	T. Khlong Hae	11,963	16,313	20,091	820	5.78
1.8	T. Khlong U-Taphao	1,896	2,010	2,150	317	1.74
1.9	T. Cha Loong	4,862	5,560	6,042	45	2.17
1.10	T. Thung Yai	3,916	4,042	4,211	109	1.04
1.11	T. Thung Tam Sao	11,778	12,861	13,723	120	1.67
1.12	T. Tha Kham	6,802	7,177	7,593	224	1.45
1.13	T. Nam Noi	11,687	12,056	12,153	257	0.30
1.14	T. Ban Phru	3,397	3,779	4,338	58	3.69
1.15	T. Phatong	11,427	11,796	5,437	51	-13.47
2.	**Na Mom District**	18,182	19,893	20,279	219	0.48
2.1	T. Na Mom	-	6,904	7,146	256	0.87
2.2	T. Phichit	-	4,145	4,211	220	0.39
2.3	T. Thung Kamint	-	4,605	4,724	214	0.64
2.4	T. Khlong Rang	-	3,780	3,812	157	0.21
3.	**Songkhla Province**	1,130,073	1,191,233	1,249,402	169	1.22

Source: Registration Administration Bureau, Department of Local Administration

Note: T. = Tambon or group of villages

TM. = Tambon Municipality

which lead to Hat Yai. Industrial developments also spread within Songkhla and Hat Yai Municipality, including those on both sides of the Songkhla-Hat Yai section of Kanchanavanich Highway and in the Southern Industrial Estates in Hat Yai. Land use for mining, which used to be very important in the past, has become much less important at present.

Agricultural land uses consist mainly of para rubber plantations, followed by plantations of fruit trees and coconut, areas for vegetable growing and livestock raising. In the Lower Songkhla Lake, fish raising in cages such as Pla Krapong (Lates calcarifer) and Pla Kao (Chinese carps) is a significant business. Shrimp farming is also very common, and its total coverage area is next only to that of para rubber plantations. Low-lying areas in the southeast part of Hat Yai District and those adjacent to the western side of the Lake consist mainly of agricultural areas.

There are several areas which are tourist sites and recreational areas, particularly the natural type of tourist places. They are located mainly in Muang Songkhla District.

Table 3.6-2 shows land use patterns in Hat Yai Municipality in 1997.

Table 3.6-2 Land Use Patterns in Hat Yai Municipality in 1997

Land Use Type	Area (sq.km.)	%
1. Residential Area	9.264	30.74
2. Commercial Area	1.691	5.61
3. Industrial Area and Warehouses	0.445	1.48
4. Rural and Agricultural Areas	15.142	50.26
5. Recreation Area and Sports Arenas	0.168	0.56
6. Educational Institutes	0.452	1.50
7. Religious Institutes	0.188	0.62
8. Government Institutes and Infrastructure	0.442	1.47
9. Roads/Highways	1.793	5.95
10. Water Bodies	0.545	1.81
Total	30.13	100.00

Source: Obtained by measurement of land use map of Hat Yai Municipality (scale 1:50,000) prepared by Department of Town and Country Planning together with aerial photo interpretation and ground checks.

Surprisingly, rural and agricultural areas accounted for the large coverage of 50.3% of the total area in the Municipality. Residential area was second (30.7%), followed by roads and highways (5.15%) and commercial areas (5.6%).

CHAPTER 4 ENIRONMENTAL IMPACT ASSESSMENT

4.1 Introduction

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 in to 4 major groups, namely Physical Resources, Biological Resources, Human Uses Values and Quality of Life Values. Such impacts are summarized in Table 4-1, 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. Impacts of each project component are described in the following sections.

4.2 Impact Assessment Related to Upper Khlong Wa Flood Control Dam

4.2.1 Physical Resources

(1) Geology and Seismology: There would be some minor effects relative to local geology and seismology when a dam and reservoir are built in the proposed site. The area is within a zone of low seismic incidences, and some precautions have to be taken in the foundation design such that dam safety provision is made adequately. In addition, foundation treatment at the dam site has to be investigated in more details during the detailed design phase so that safety of the dam is secured. The reservoir is relatively steep, and there are chances that erosion at certain soft spots would occur.

(2) Water Hydrology: Flood prevention is the main purpose of the entire project, so water retention in the reservoir in the rainy season would cause downstream streamflow to change. However the changes would be beneficial as far as flood control and prevention is considered. Higher flows due to release from the reservoir would be beneficial concerning more water supply for domestic and irrigation purposes. Level and flow fluctuations in the canals would not have a serious impact because the flows would be controlled.

(3) Surface Water Quality

Water storage in the reservoir would generally cause considerable beneficial effects on water quality. There would be settling of sediments contained in the reservoir inflows. Clearer water released downstream of the dam in the dry season would be beneficial if the water is withdrawn from the canal and used as raw water source for domestic water supply. Water treatment cost to remove suspended solids would be lower because suspended solids contents in the stream would be lower than normal. If trees, shrubs and other vegetation are left unclear in the reservoir, their anaerobic decomposition would cause significant water pollution in the reservoir in the initial phase of impoundment

Table 4-1 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/Sedementation	Fisherics	Aquatic Ecology	Forestry	Wildlife	Agriculture	Irrigation	Water Use	Flood Prevention	Industry	Mining	Transportation	Land Use	Socio-economics	Propcity 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

(about 3-5 years). Thus, efforts should be made to clear such vegetative covers before the reservoir is impounded.

There would be some adverse impacts on water quality during the construction period because soil and rock dumping to construct the dam would cause increases in water turbidity and suspended solids, thus affecting use of water for domestic purposes. But the construction will be carried out during the dry season and construction periods will relatively short, so such impacts would be short-lived and not significant.

(4) Ground Water Hydrology and Groundwater Quality

Construction of this project commenting would not adversely affect groundwater hydrology a groundwater quality. The impoundment of water in the reservoir would have some beneficial affects, however. Downstream of the dam site, water recharge to the aquifer would make groundwater table to rise. So, there would be more groundwater from deep wells and shallow wells in downstream areas. Their water quality would also improve due to settling of sediments in the reservoir.

(5) Soils

The reservoir would flood 1.1 sq.km. (700 rai) of agricultural areas, mostly rubber plantations. Soils in such areas are relatively suitable for planting of para rubber and fruit trees. The loss of such land would be irreversible, and this adverse impact is regarded as considerable.

(6) Erosion and Sedimentation

In the construction phase, earth filling process for dam construction and earth movement near the riverbed would cause sedimentation in the canals. In addition, construction sites would be subjected to erosion of soil surface. Good treatment of the cleared construction sites should be carried out after the construction has been completed to reduce such effects.

Sedimentation would occur in the reservoir in the operation phase, and it is estimated that, in 50 years after use, the amount of cumulating sediments would be about 0.014 MCM, causing the reservoir bottom to rise by 0.004 m., to less than +44 m.(msl.). This would amount to 0.3 % of the total reservoir capacity at the N.W.L, and is considered a minor effect. The reservoir outlet pipe is set at +48m.(msl.) which is above this level. Erosion of reservoir bank could occur at some soft and steep spots, but it is not anticipated to be a significant effect.

4.2.2 Biological Resources

(1) Aquatic Ecology and Fisheries

Construction activities would have some adverse impacts on aquatic ecology. These impacts are closely related to the effects on water quality as stated above, and would affect downstream subsistence fisheries.

Impounding of the reservoir would cause settling of sediments which leads to clearer water in the upper water layer. This, together with supply of natural nutrients contained in inflowing water, would cause water to be more productive and bring about higher concentrations of plankton and benthic organisms, the lower forms of lives in the reservoir's food chain. Fish population is expected to flourish, especially in the first 5-10 years. It is projected that the fish production in the reservoir would be about 5,000 kg per year, and this would support local subsistence fisheries. With good management, sustainable fish yields would result. Aquatic weeds could also infest the reservoir, and regular control of the weeds is necessary.

(2) Forestry and Watershed

During the construction phase, forest in the construction areas would not be affected. Access to the construction site consists of paved roads and laterite roads which do not pass through any forest.

The reservoir area is not located within a Class 1A watershed, and hence there is no prohibition of construction of the dam at that site. There is no forest is the reservoir area, except some shrubs, so effects of the reservoir on forest would be nil. However, about 700 rai of para rubber plantations would be flooded. Even though rubber plantations are not regarded as forests, they have some ecological and hydrological characteristics similar to those of forests. The loss of such plantations thus represents some minor loss of forest.

(3) Wildlife

The construction of the dam would have some effects on wildlife in the nearby rubber plantations, due to the presence of construction equipment and camps. Hunting of wildlife by construction workers could occur, and control of such hunting is required. However, the only main types of wildlife found in the reservoir area consist of birds and they are accustomed to the presence of villages, people and vehicles used in the area. Thus, the impacts on wildlife would be minor.

Flooding of rubber plantations would cause loss of habitats of local wildlife, mainly birds. These rubber plantations do not represent a healthy wildlife habitat. In addition, there are lots of rubber plantations and forests nearby. Birds can move to such places and much further, thus reducing these adverse effects.

4.2.3 Human Uses Values

(1) Agriculture

Construction activities would have minor impacts on agricultural areas along the access road and in the construction site. However, the loss of 700 rai of rubber plantations to flooding in the reservoir represents a considerable adverse effect. To compensate for such a loss, the use of water stored in the reservoir for dry-season irrigation of 5,000 rai of cropped area of would be a beneficial effect concerning agriculture. However, the losers and the beneficiaries are not the same group of people.

(2) Irrigation

Construction activities of this dam would not affect any irrigation area. But as stated above, about 5,000 rai of agricultural area would be irrigated as a result of use of irrigation water for dry-season cropping of rice, fruit trees, etc. The estimated yield would be 400 tones of rice and 3,500 tones of fruits per year.

(3) Water Use

Water use in the project area would not be affected during the construction phase. In the operation phase, however considerable benefits would be gained from impounding of the water in the reservoir. One benefit would be the irrigation use of water, as stated above. As for domestic water supply, about 0.3 MCM. of water could be used for this purpose, thus benefiting about 7,000 people in the dry season. These benefits are regarded as considerable.

(4) Flood Prevention

Flood prevention is the main goal of this project. The proposed reservoir would reduce flood peak (25-year return period) in Khlong Wa (St. X.174) from 154 cms. to 128 cms. Although beneficial, such control is not sufficient to reduce flood peak at St. X174 to the existing design discharge of 110 cms..

(5) Transportation

During the construction of the dam, traffic flows on the access road and connecting roads would be affected. The access road is a narrow 2-lane road, so there could be inconvenience to the local people to some extent. Good traffic management by the RID and the contractor will be required in order to reduce effects on traffic, accidents and disturbance to local residents due to noise and dust caused by construction-related vehicles.

During the construction phase, the access road would be improved to facilitate the construction-related transport. After the construction has been completed, this access road would also be properly maintained by the RID. Hence, it

would provide a better means of transportation and convenience to the local people.

(6) Land Use

Land use in the project area would not be adversely affected, except at the construction site and reservoir area where significant land use changes would occur. The main impact would be the change from rubber plantations to water body. The area around the headwork of the dam would also be developed. These would cause considerable adverse changes.

In the operation phases, the improved access road would induce community development. Land use along this road is expected to be developed at certain sections, mainly development of houses and perhaps some tourist facilities. Consequently, land price in such area would increase. These changes are regarded as significant, and proper control is required.

(7) Socio-economics

During the construction phase, local economy would gain from commercial businesses centered around construction material sale and construction activities. Where the construction camp is located, local trading would increase (food, household necessities, etc.), depending on the size of the labor force involved. At the same time, local social conditions may be affected including greater population density, more crimes, more drug abuse, gambling, etc. Accordingly, proper control of such social impacts is needed.

About 700 rai of rubber plantations and other types of land use would be flooded, but no household would be resettled. For those affected, socio-economic impacts would be significant. Therefore, fair compensation and adequate assistances for their relocation and rehabilitation would be very necessary.

(8) Property Compensation and Resettlement

As stated in (7) above, 700 rai of rubber plantation and other types of land use would be affected by the project reservoir. The total compensation cost is estimated at 42.0 million Baht. It is recommended that fair compensation for these properties should be made by RID or the agencies concerned, in order to minimize socio-economic impacts on these people.

No household would be evacuated due to flooding of the reservoir area. Therefore, evacuation and resettlement of people will not be necessary.

(9) Public Health

The construction area and the reservoir area are not infested by vectors of dangerous epidemic diseases. Thus, health of construction workers would not

be threatened. But, due attention should be made to reduce normal diseases and sanitation problems in the construction camp and to minimize accidents due to construction-related transport and construction activities.

In the operation phase, there would be no important diseases which would be induced by the reservoir. However, the better access road would lead to more use of vehicles and more accidents, and attention should be paid to reduce them.

The water stored in the reservoir would be used in part for domestic water supply. As far as public health of local people is concerned, such benefit is considered significant.

(10) Tourism

The project construction activities would not adversely affect tourism in the project area because there is no important tourist site nearby. If traffic flows on the access road are affected, traffic management should be organized with assistance of local traffic policemen.

The new reservoir would create a new local tourist site. It would not be a significant one at the provincial level, but could serve local people.

4.3 Assessment of Impacts Related to Phru Phli Khwai Retarding Basin

4.3.1 Impacts of This Project Component Alone

This retarding basin would cover an area of only about 0.5 sq.km.. The retarding basin would be dredged to a depth of 4.0 m in order to obtain a storage capacity of 2.0 MCM. The downstream channel (2.0 km.) would be dredged so as to facilitate draining of the water from this retarding basin and from the flood control dam in Section 4.2, in order to prevent overbank flows. This retarding basin can store 2.0 MCM of flood water during the flood season, and in the dry season, the stored water can be used for irrigation and other purposes in the surrounding areas.

This is a relatively small project, therefore its adverse impacts or benefits would be minor and of a limited scale and extent.

(1) As shown in Table 4-1, minor impacts are expected concerning the following resource and environment: surface hydrology, surface water quality aquatic ecology and fisheries, irrigation, water use, land use, socio-economics, public health and tourism.

Flood flows would be regulated to some extent by the retarding basin. Water retained in the basin would have better quality due to settling of sediment and the impounded water can be used for domestic purposes by 100 households living around the basin and can irrigate 1,000 rai of mixed orchard crops in such an area in the dry season. Shallow water together with better water

quality would make the water relatively productive. The resultant good aquatic ecological conditions would lead to moderate to high fish production, and it is expected that about 3,000 kg.of fish can be harvested annually. This production will benefit local subsistence fishermen. However, shallow water would also be suitable for infestation of aquatic weeds including macrophytic algae and floating weeds such as water hyacinth. Good control of these weeds is thus required. Land use around the retarding basin is expected to be developed to some extent. This basin of about 300-350 rai surface is sizeable, so recreation areas or small parks can be developed on the edge of the basin and serve recreational and tourism purposes for local residents. One good aspect of this site is that it is a public land, so no property compensation is needed.

(2) As for flood control and prevention, this project component would induce considerable benefits, by reducing the flood peak (25-year return period) at St. X174 from 154 cms. to 140 cms., a 9% reduction. Integrated with the Upper Khlong Wa flood control dam, this retarding basin would make the reservoir more feasible.

4.3.2 Integration of Upper Khlong Wa Flood Control Dam and Phru Phli Khwai Retarding Basin.

The reservoir is a rather large project component compared with the much smaller retarding basin. The integration of the two project components is analyzed, and it is found that certain impacts and benefits would become more evident. As shown in Table 4-1, when integrated, the following benefits due to the two project components would become moderate:

- Surface hydrology, aquatic ecology and fisheries agriculture, irrigation water use, flood control, land use, socio-economics, public health and tourism (affected mainly by the reservoir)
- Considerable adverse impacts would be related to loss of soils due to flooding and property compensation.

As for flood control, the integrated project would reduce design peak discharge at Sta.X174 from 154 cms. to 118 cms. (or 23.4% reduction). The flood control dam alone would reduce the said peak discharge to 128 cms. (or 16.9%). In other words, the retarding basin would help increase the reduction by 6.5%, and this would make the integrated project more feasible.

4.4 Impact Assessment Related to Flood Water Diversion Channel

4.4.1 Alternative Diversion Routes

(1) **Diversion Route 1 (Northward Diversion Channel line 1):** This route consists mainly of a diversion tunnel, which diverts water from Khlong Rain at retarding pond through Khlong Ple, runs beneath Khao Kho Hong, is then changed to a dredged canal which discharges to the drainage canal D3.

(2) **Diversion Route 2 (Northward Diversion Channel line 2):** This route will divert water from Khlong Rian at retarding pond to the RID channel D5 near it's middle length.

(3) **Diversion Route 3 (Northward Diversion Channel line 3):** This route will divert flood water from the Phru Phli Khwai retarding basin near Na Mom District Office and discharge it to the Songkhla Lake at Khlong Phra Wong. So, this is a new channel which has to be dredged and some section will be designed as tunnel.

(4) **Southward Diversion Channel:** This route would divert flood water from Khlong Wa through Ban Phru Municipality to Khlong U-Taphao upstream of Highway No. 43. Some sections will be laid along the road in this municipality. This open channel will have a ROW 20-30 m wide, while the section laid under the road will be a box culvert or tunnel.

The analysis and comparison of these alternative routes has shown that Diversion Route 1 and 3 or the Northward Diversion Channel line 1 and line 3 are the two feasible alternatives (with a discharge capacity of 35-60 cms.).

4.4.2 Environmental Impact Assessment

(1) Diversion Route 1

(a) The most desirable benefit of this alternative is flood control. This route would make RID diversion channel D4, D5 and D6 unnecessary. The design discharge in the upper part of D3 would increase from 110 cms. to 160 cms.. On the other hand, the discharge in the lower part of D3 would increase from 140 cms. to 190 cms..

(b) Socio-economic benefits of this route would be moderate. On the beneficial side, flood water diversion away from Hat Yai Municipality would significantly prevent or reduce losses of lives and properties, minimize disruption of traffic/communication/normal way of life, and minimize economic losses of commercial and industrial enterprises. On the adverse side, however, the construction works of this alternative route would require land acquisition, property demolition and relocation of people. Such undertakings would cause significant socio-economic impacts on the affected people.

(c) Like Diversion Route 1, flood prevention/reduction in Hat Yai District would induce moderate beneficial impacts on transportation, industry and tourism in this district particularly in Hat Yai Municipality. Some adverse effects on these aspects would occur during the construction periods, and mitigation measures need to be taken.

(d) Minor adverse effects of this alternative route would be related to erosion/sedimentation, aquatic ecology/fisheries and public health. Dredging of a long channel would also affect traffic at the points where the channel intersects the existing roads. To minimize such an effect,

detour roads and temporary bridges would be needed during the construction period. As for fisheries and aquatic ecology, the existing water ponds caused by regular annual flood would be drained, thus adversely affecting local fish production.

(2) Diversion Route 3

1) The comparison between the two feasible routes shows that Diversion Route seems to be more advantageous, having moderate benefits in the following aspects:

   (a) Agriculture, irrigation and water uses: Water in the canal can be used for these purposes as well as for domestic water use. About 1,900 households is expected to benefit from use of water for domestic purposes, while 1,000 rai of mixed orchard crops can be irrigated.
   (b) Land use and socio-economics: Land use development along this route is possible, while socio-economic benefits of the project due to flood reduction would be moderate.
   (c) Flood control (highest level of benefit): The design flood peak at St. X.174 in Khlong Wa would be reduced from 154 cms.. to 128 cms.. by this diversion channel.
   (d) Moderate benefits are also expected from transportation, industrial development and tourism improvement when flooding in Hat Yai Municipality is avoided or minimized. Minors adverse impacts on these aspects would occur during the construction period.
   (e) However, moderate adverse impacts of this route would be property compensation and resettlement of people. The affected area would be 630 rai, and number of the affected/relocated households would be 150. This would be the relatively serious impact of this route. The total compensation cost is estimated at 36 million baht if the buy-out compensation concept is adopted.
   (f) Other minor adverse impacts of this alternative route would be sedimentation of sediment in the diversion channel and adverse impact on aquatic ecology and fisheries. Regular dredging to remove such sediment would be required.

4.5 Impact Assessment Related to Channel Improvement by Dredging

4.5.1 Project Feature

When the canal receives diversion water, its drainage capacity would be affected. Therefore, there is a need to improve its capacity by dredging such that it can accommodate the diverted flood flow. As for Khlong Wa, which would receive water released from the upper flood control dam, the retarding basin and Khlong Rian diverted discharge, and the required discharge capacity is 160 cms. (for a 25-year return period). One section which should be dredged is from the outlet of Khlong Wa to drainage canal D6. Another section is from the diversion point or

Khlong Wa to Khlong U-Taphao, while other sections with inadequate depth would be depend by dredging. The design riverbed, high water and dike crown levels of Khlong Wa are set at 0.0 m.msl., 5.8 m.msl. and 8.0 m.msl, respectively at km 0.0 of the canal. A freeboard for the dike is assumed to be 2.0 m. The construction of dikes and/or riverbank dredging is proposed for the narrow canal sections to be able to carry the above design discharge.

4.5.2 Environmental Impact Assessment

(1) From Table 4-1, it can be seen that flood control by this project component would induce a moderate benefit for this project component because it would certainly help the canal to accommodate the design flood discharge which includes the Khlong Rian diverted flow. The bankful discharge of Khlong Wa is very small in the lower reach of 1.6 km distance. However, these river reaches are affected by backwater flow of the Khlong U-Taphao, and hence the southward diversion route cannot lower the floodwater level in the lower reaches. On the other hand, most river sections in the upper reaches of 1.6 km distance have a sufficient bankful discharge to carry the design flood discharge of 160 cms..

(2) The minor benefits of this alternative would include Socio-economic benefit due to flood control and beneficial effects on aquatic ecology/fisheries.

(3) On the other hand, minor adverse impacts are expected on loss of land due to river bank dredging, erosion and sedimentation due to dredging, impacts on agriculture/water use/irrigation (because the channel is deepened, and the water which would otherwise be stored in ponds in low-lying areas, is totally drained).

CHAPTER 5 RECOMMENDED IMPACT MITIGATION MEASURES

5.1 Introduction

In this chapter, environmental impact mitigation measures will be recommended for alleviating adverse impacts assessed in Chapter IV which are summarized in Table 4-1. The mitigation measures will be 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 will be specifically discussed.

5.2 Recommended Mitigation Measures Concerning Physical Resources

5.2.1 Geology and Seismology

(1) In Construction Period

Certain adverse impacts relative to geology/seismology and geotechnical aspects are expected concerning the construction the Upper Khlong Wa flood control dam and the diversion tunnel. In the detailed design of these project components, detailed geological and geotechnical surveys should be carried out to assess the foundation engineering aspects of these components, and well as to assess seismic precaution requirements. The designs of their foundations should be carried out carefully, with adequate geotechnical and seismological provision to achieve sturdy foundation of each project component, particularly the one for heavy structure such as the dam, the tunnel and the diversion channel.

In case the diversion tunnel is selected, it is important to find appropriate sites for dumping the rocks excavated from the Northward diversion route. Large quantity of the excavated rocks would be dumped, so adequate area for dumping is required. The site should be sufficiently far from the Hat Yai urban center and has low potential for forest plantation and agricultural development. A good alternative is to sell the excavated rocks to several local quarry owners, to be used for concrete aggregate production or other types of uses. In addition, good traffic management will be required for transport of the excavated rocks to the dump sites.

At every material borrow site, site rehabilitation should be undertaken after it is no longer used. Mitigation of soil erosion and anesthetic effects should be planned and carried out carefully.

(2) In Operation Period

Monitoring of water leakage from the reservoir, conditions of foundation and sturdiness of the important project components should be carried out regularly, particularly in the first 5 years in the operation period.

5.2.2 Surface Hydrology

During the construction period, efforts should be made to get rid of stream flow obstacles in each canal, which could otherwise be caused by construction activities. Such obstacles, including sediment, rocks or earth can cause overbank flows and consequential flood damages. The Contractor should be supervised carefully and be advised to use acceptable methods of construction material handling and good management of construction site and related areas.

5.2.3 Surface Water Quality

(1) In Construction Period

Appropriate construction methods as stated in (2) above should be adopted in order to reduce impacts of construction on surface water quality. The recommended measures are:

1) Dredging of drainage channels, dumping of earth-fill materials for the dam and related construction activities should be carried out in the dry season because impacts on water quality in that season would be less than those in the rainy season.
2) Construction material borrowing operations should be undertaken carefully and preferably in the dry season, to minimize surface erosion and effects of storm runoff through the borrow sites which can cause adverse impact on water quality. Where appropriate, settling basins should be build to collect sediments from each site.
3) Construction material stockpiling (sand, earth, concrete aggregates) should be handled with adequate precautions, in order to minimize the chance that the sites would be washed by rainwater, thus alleviating adverse effects on surface water quality.
4) Prior to commencement of initial impoundment of the reservoir, trees, shrubs and other vegetative covers in the reservoir area should be cleared and burned in order to minimize serious water pollution in the reservoir in the first-10 years.
5) Water quality in Khlong Wa, Khlong Rian, Khlong U-Taphao and the Songkhla Lake (downstream of construction sites) should be monitored three times per year during the construction period in order to assess the actual impacts. If found to be necessary, appropriate mitigation measures can be implemented to reduce adverse impacts on surface water quality.

(2) In Operation Period

1) All construction sites should be treated properly after the construction has been completed, with site leveling, surface compaction and sodding (if necessary), to minimize soil erosion which would affect surface water quality.
2) Quality of the water stored in the reservoir and in all the project canals and the diversion channel should be monitored three times a year, with adequate sampling sites (See Figure 5-1) in order to assess impacts of

project operation and to find better measures to mitigate adverse impacts if it is found that impacts are still considerable or serious. The monitoring should be carried out annually for at least 5 years before a decision can be made whether that program should be terminated.

(3 *Soils*

Fertile soils in the reservoir area would be lost due to flooding, and that adverse impact cannot be avoided if the dam has to be constructed. In other areas, where land and soils would be affected by the construction, rehabilitation of the construction sites should be undertaken properly so that the rehabilitated sites can be used in accordance with the soil suitability.

5.2.4 Erosion and Sedimentation

(1) In Construction Phase

1) At each site, good and practical construction methods should be adopted by the Contractor such that erosion and sedimentation are minimized. Some recommended precaution measures to minimize impacts on water quality have been discussed, as stated in (3) above.
2) In channel dredging and tunnel excavation, appropriate efforts should be made to minimize erosion of the construction sites and subsequential sedimentation. Where construction involves steep slopes, or if steep slopes would be left after the construction, slope protection will be required such as the use of concrete-lined surfaces, RC retaining walls and support columns, depending on location and slope conditions. Sodding should be used on areas of moderate and mild slopes.
3) During the construction phase, regular monitoring of erosion and sedimentation at each construction site should be carried out. If serious problems are found, appropriate mitigation measures should be implemented.

(2) In Operation Phase

1) The monitoring of erosion and sedimentation at each construction site as stated above should also be carried out in the operation phase. Proper site rehabilitation should be performed if erosion is still found to be serious, such as additional compaction of soil surface, additional sodding and use of concrete-lined RC surfaces in seriously-affected areas where such surfaces do not exist.
2) Sedimentation in the reservoir should be monitored in every 5 years to determine effects of the sedimentation on the design dead storage, and to take necessary actions if there is a serious threat on the dead storage and on the active storage capacity of the reservoir.
3) Monitoring of sedimentation and erosion of every diversion channel should be carried out to determine whether any mitigation measure is required. If sedimentation problem is found to be significant, a suitable mitigation

measure is maintenance dredging of the diversion channel and other flood discharge canals.

5.3 Recommended Measures Concerning Biological Resources

5.3.1 Aquatic Ecology and Fisheries

(1) In Construction Phase

1) Mitigation measures for water quality as described previously will also reduce effects on aquatic biology and fisheries.
2) In the Songkhla Lake downstream of the diversion channel construction site, there are both fisheries and fish aquaculture. If, in some periods, it is predicted that some important impacts on water quality would occur, which would accordingly affect fisheries and aquaculture in that area the concerned fishermen and owners of aquaculture business should be notified well in advance such that timely preparation can be made to avoid or minimize such effects.
3) When water quality is monitored in the construction phase, monitoring of aquatic biology should also be performed at the same stations to assess the actual effects and to determine suitable mitigation measures.

(2) In Operation Phase

1) Aquatic biology and fisheries in each diversion channel should be monitored in the operation phase, along with the surface water quality monitoring. Remaining adverse impacts should be further mitigated. On the other hand, if the diversion channel is found to have good potential for fisheries enhancement, promotion of subsistence fisheries should be promoted. Adequate attention should also be given to effects of salinity intrusion into the diversion channel and its impact on fisheries and aquaculture in the Songkhla Lake.
2) For the flood control reservoir and the retarding basin, where fisheries potential is relatively high, monitoring of aquatic ecology and fisheries in these water bodies should be carried out. Prevention of adverse impacts such as water pollution and excessive fishing should be controlled. Subsistence fishing or limited fish firming should be promoted if found to have adequate potential.

5.3.2 Forest and Wildlife

(1) In Construction Period

1) If forest or vegetative covers have to be cleared for construction of any project component, the cleared areas should be kept to the minimum requirement.
2) If possible, the construction camps should be located far from forests. The RID and the Contractor should prohibit uses of wood and trees from the

nearby forests by construction workers. Hunting of wildlife in areas around the camps should also be prohibited. Local authorities and police force should be asked to provide necessary helps for these purposes.

3) Prior to initial impounding of the reservoir, all large trees, shrubs and vegetative covers should be cleared and burned, in order to minimize serious water pollution in the reservoir in the first 5-10 years.
4) The forest clearing in Item 3) above should begin from the lowest part of reservoir area near the riverbed, then gradually move to higher elevations while impounding is taking place. This is a means to drive wildlife away from the lower areas to the higher areas to avoid being trapped in the reservoir during the impounding period. If wildlife are found to be left trapped in that manner, rescue efforts should be made.

(2) Operation Phase

1) Impact of reduction of wildlife habit due to flooding or riverbank dredging of should be monitored in the nearby forests. If necessary, a rehabilitation program or a mitigation program for such wildlife should be undertaken.
2) Side effects of the presence of the reservoir and the better access road on the nearby forests should be monitored. If the effects are found to be considerable, suitable measures should be undertaken such as establishing a new forest and wildlife protection unit, which should be provided with adequate patrol staff, vehicles and budget, such that forests and wildlife can be effectively protected.

5.4 Quality of Life Values

5.4.1 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, subsistence fisheries/aqua-culture. Industrial development and tourism promotion should also get some water supply, but their priorities are lower than those usage just mentioned above.

5.4.2 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.

5.4.3 Transportation

(1) In Construction Period

1) Traffic on all roads used frequently by the project's construction-related transport should be managed and controlled, in order to reduce impacts on other types of traffic and to reduce accidents. Local police forces should be asked to help on that matter, while the RID and the Contractor should also undertake to control the situation.
2) The access road to the construction site should be properly and regularly maintained to serve the following purposes : to reduce road accidents, and reduce disturbance to local communities due to noise and dust. If dust problem is found to be significant, intermittent water spraying of the access road and traffic surface in the construction site should be carried out. Speed limit should be imposed, and effects should be controlled in order to minimize accidents due to transport of construction material and equipment.

(2) In Operation Phase

1) The access road should be regularly maintained in the operation phase. Additionally, proper control and management of the project-related traffic and transport should be maintained. Such undertakings would minimize road accidents and lead to good relationship between the RID and the local communities.
2) The related agencies and the RID should monitor effects of drainage channels under all highways and railways in the project areas on flood flow discharging. If their drainage capacity is found to be still inadequate, improvement should be made by the concerned agencies.

5.4.4 Land Use

(1) In Construction Phase

The project components should be planned and designed properly, taking into due consideration of the present and future land uses in Hat Yai District, particularly in Hat Yai Municipality. In the construction phase, such plan should be maintained so that land uses in very area are not improperly altered by the project components.

(2) In Operation Phase

The Hat Yai comprehensive area improvement plan of the Town and Country Planning Department and the land use plan for rural areas of Land Development Department should be prepared with close coordination between the two agencies and with other related local agencies. The goal is to obtain the suitable and coordinated land use plans in rural and urban areas with due

consideration of flood prevention and flood relief in this district in the future. It is recommended the two departments impose regulations such that such land these plans are stringently followed by the concerned agencies and the private sector. Besides, they should maintain regular monitoring of actual land use changes in each responsible area and, if necessary these land use plans should be modified in every 5 years, in order to be in agreement with the actual current land uses. If such changes require consistent modifications to the already established flood prevention master plan of Hat Yai District, the concerned agencies should be informed such that necessary modifications to the flood prevention plan can be considered, planned and implemented.

5.5 Recommended Measures Concerning Quality of Life Values

5.5.1 Socio-economics, Tourism and Public Health

In both construction and operation phases, Socio-economic conditions of the people affected by the construction and the operation of each project component should be monitored particularly those impacted by compensation and relocation. Necessary helps should be made to the seriously-affected people. In the operation phase, monitoring of socio-economic conditions and altitudes of residents in each important flooded area should be carried out in order to assess the performance and achievement of the flood prevention components with respect to Socio-economic improvements of the affected people. Their attitudes and opinions should also be assessed in order identify the proper ways to effectively improve the flood prevention master plan. After that the improvement should be made accordingly.

In the monitoring program described above, benefits or impacts of the project components on tourism development and public health of residents in each area should also be included. The program should be used in improving the flood prevention master plan in order to improve these aspects as well.

5.5.2 Property Compensation and Resettlement

(1) In Construction Phase

It has been recommended that the by-out method, rather than the resettlement method, will be adopted where relocation of people from right-of-ways (ROW) of a project component is necessary. Therefore, no resettlement scheme will be planned and implemented. As a consequence, it is recommended that fair compensation rates have to be set for land and properties affected with the ROWs. And in case relocation is necessary, other provisions such as evacuation costs and relocation costs should be provided in the compensation rates such that, after relocation, the affected people will have adequate money to buy new lands for living and for making a living and to be able to resettle and rehabilitate themselves.

(2) In Operation Phase

When the socio-economic monitoring program is undertaken in each affected or flood-protected area in the operation phase, it is advisable to find a sample group which represents those affected by compensation and relocation. The results of impact analysis and attitude survey of this sample group should then be used in identifying the assistance they need and in providing appropriate assistances to these people if they are found to be seriously impacted at that time.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The foregoing chapters have presented a review of the features of the proposed project components, existing environmental conditions in the project area, environmental impact assessment and recommended environmental impact mitigation measures. By reviewing the above presentations, 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 impact 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 is considered to be required only half area. 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 Line 1 and 3 is found to be the best, with respect to flood reduction, socio-economic/transportation/tourism benefits. All adverse effects are of a minor importance. This project component is 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 6-1.

Table 6-1 Summary of Feasibility Assessment of the Proposed Project Components and the Environmental Studies Required

Project Component	Cost	Feasibility Assessment			Further Environmental Study Required
	(Million Baht)	Engineering	Environmental	Economic	
1. Upper Khlong Wa Flood Control Reservoir	230	✓✓	✓	✓	IEE
2. Phru Phli Khwai Retarding Basin	114	✓✓✓	✓✓✓	✓	-
3. Integration of 1 and 2	344	✓✓	✓✓	✓✓	IEE
4. Northward Flood Diversion Channel Line 3	1,445	✓✓	✓✓	✓	IEE for Selected - Line
5. Khlong Wa Channel Improvement	31	✓✓✓	✓✓✓	✓✓	-
6. Integration of 3, 4 and 5	1,820	✓✓	✓✓	✓✓	IEE for all project components

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

6.2 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. Northward flood diversion channel
4. Khlong Wa channel improvement line 3

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

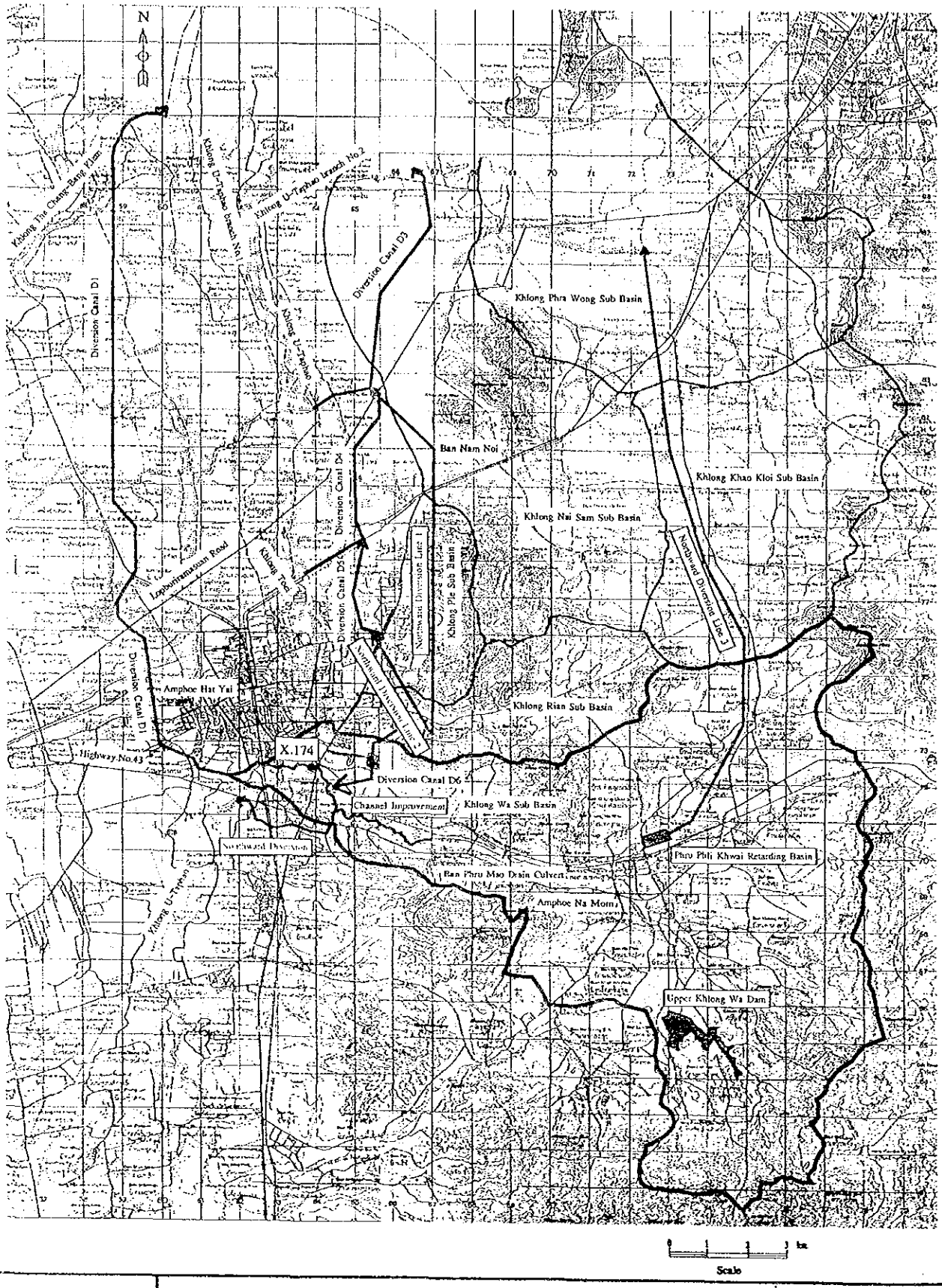

Fig. 2-1 Proposed Project Components of Emergency Flood Prevention Planning for Hat Yai District in Khlong U-Taphao River Basin

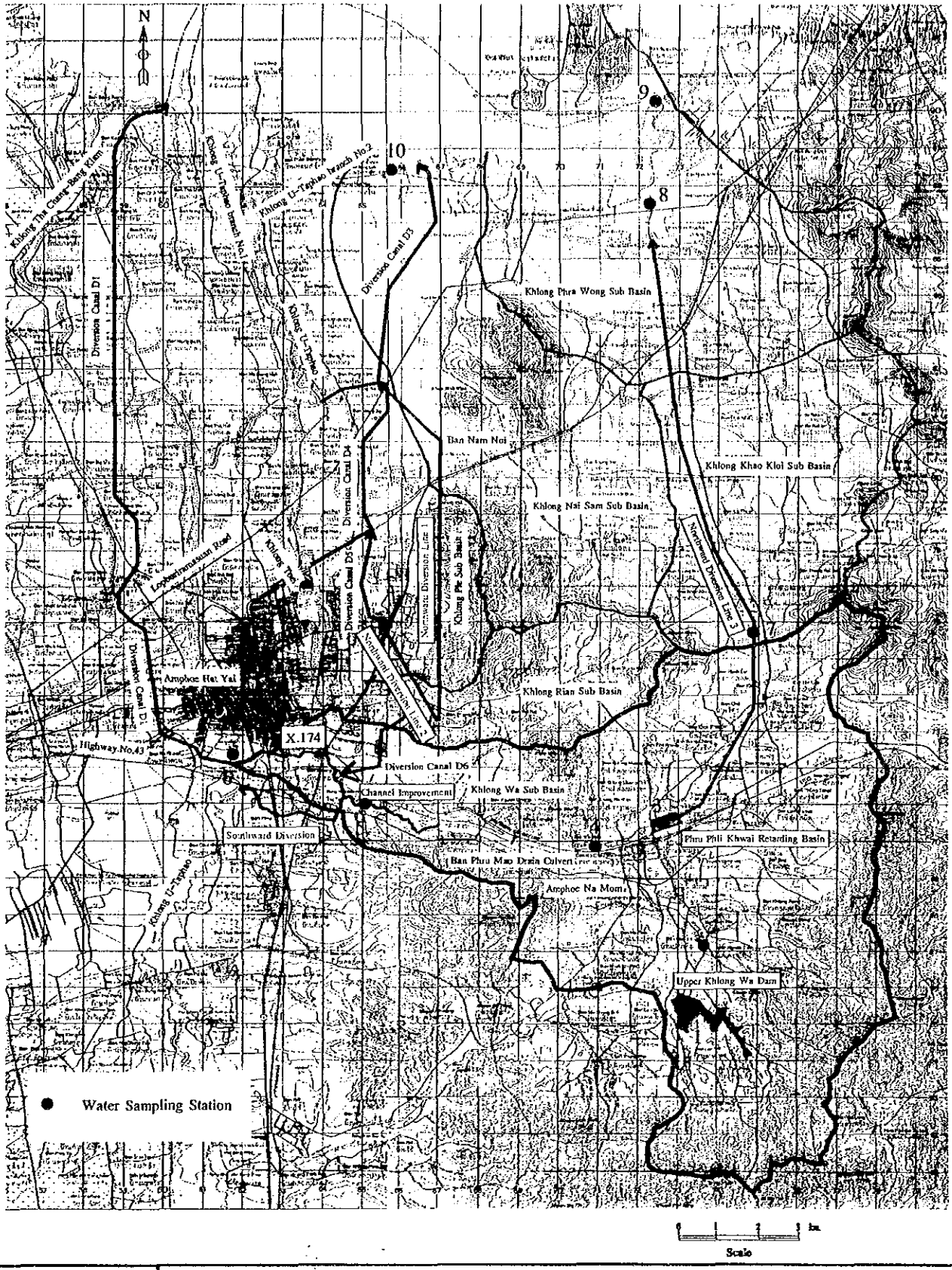

Fig. 5-1	Proposed Water Sampling Stations for Water Quality Monitoring in Construction and Operation Phases, Hat Yai District Flood Prevention Plan