Ministry of Water Resources and Meteorology,
Ministry of Agriculture, Forestry and Fisheries,
The Kingdom of Cambodia

THE STUDY
ON
COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

Volume - V
Hydrological Study and Environmental Management
Basic Capacity Strengthening

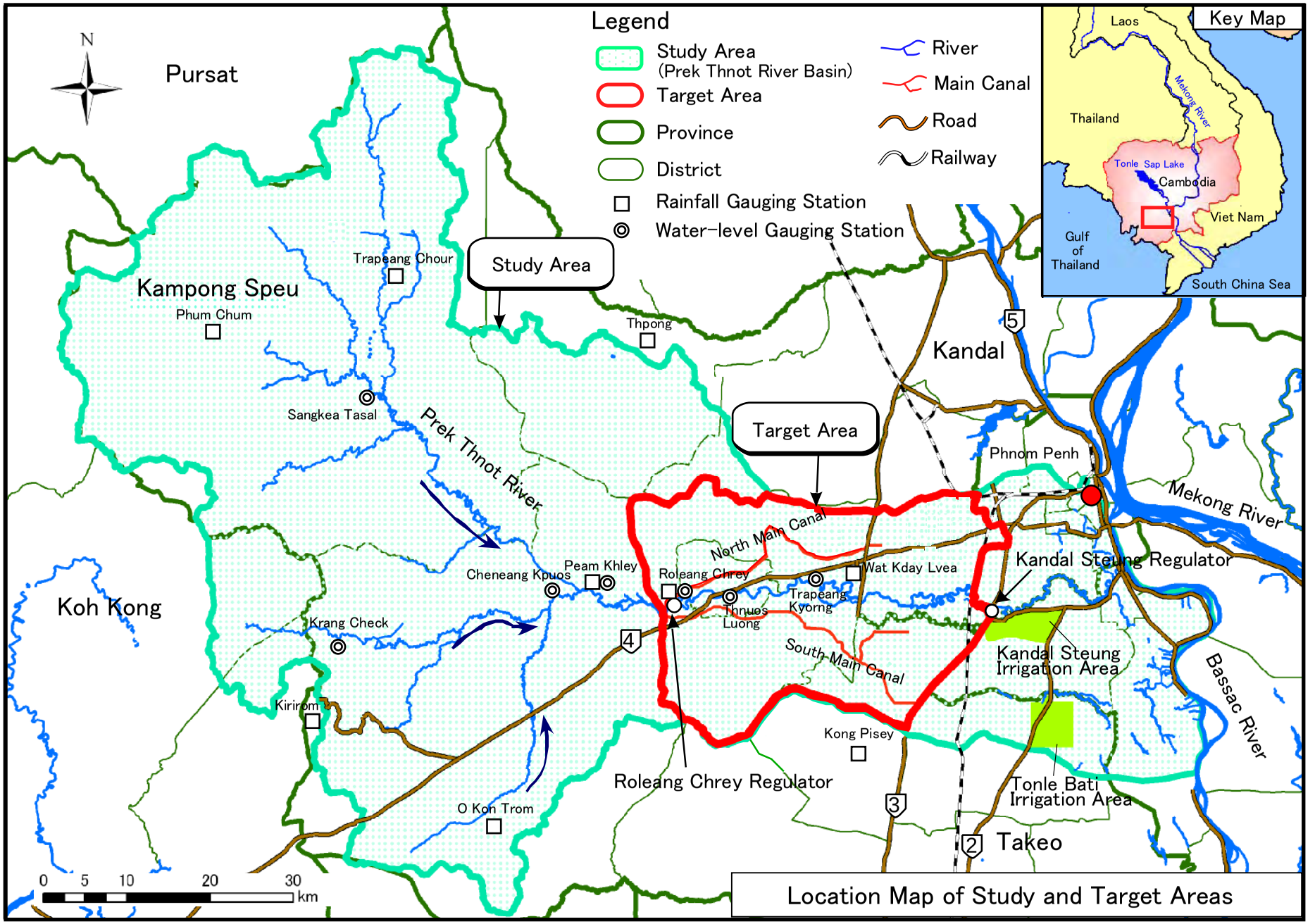
August 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

LIST OF VOLUMES

Volume-VII Appendixes for Feasibility Study for Priority/Urgent Projects


Legend
Study Area
(Prek Thnot River Basin)
Target Area
Province
District
Rainfall Gauging Station
Water-level Gauging Station
River
Main Canal
Road
Railway
N
Key Map
Laos
Thailand
Mekong River
Tonle Sap Lake
Cambodia
Viet Nam
Gulf of Thailand
South China Sea
Pursat
Kampong Speu
Phum Chum
Trapeang Chour
Sangkea Tasal
Thpong
Study Area
Target Area
Kandal
Phnom Penh
Prek Thnot River
Mekong River
North Main Canal
South Main Canal
Cheneang Kpuos
Peam Khley
Roleang Chrey
Wat Kday Lvea
Trapeang Kyorng
Thnuos Luong
Kandal Steung Regulator
Kandal Steung Irrigation Area
Bassac River
Koh Kong
Krang Check
Kirirom
Kong Pisey
Roleang Chrey Regulator
Tonle Bati Irrigation Area
O Kon Trom
Takeo
0 5 10 20 30 km
Location Map of Study and Target Areas

THE STUDY
ON
COMPREHENSIVE AGRICULTURAL DEVELOPMENT
OF
PREK THNOT RIVER BASIN
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

Volume-V: Hydrology Study and Environmental Management Basic Capacity Strengthening

Table of Contents

PART-C: ENVIRONMENTAL MANAGEMENT BASIC CAPACITY STRENGTHENING

List of Attachments

Abbreviations

CARDI	Cambodian Agricultural Research and Development Institute
CEDAC	Centre d'Etude de Development Agricole Cambodgien (NGO)
DAS	Days after Sowing
DAT	Days after Transplanting
EIA	Environmental Impact Assessment
EEM	Environmental Management and Monitoring
FWUC	Farmer Water User Community
FWUG	Farmer Water User Group
GIS	Geographic Information System
GPS	Global Positioning System
IRC	Inter-ministerial Resettlement Committee
ISF	Irrigation Service Fee
JICA	Japan International Cooperation Agency
MAFF	Ministry of Agriculture, Forestry and Fisheries
MOWRAM	Ministry of Water Resources and Meteorology
NGO	Non Government Organization
OJT	On-the-Job Training
OVI	Objectively Verifiable Indications
PDA	Provincial Department of Agriculture, MAFF
PDOWRAM	Provincial Department of Water Resources and Meteorology, MOWRAM
PDM	Project Design Matrix
PIMD	Participatory Irrigation Management and Development
SEILA	Foundation Stone in Khmer: This word is used as national rural development program to 1- Alleviate poverty and 2- Strengthen local governance and ownership of local government.
SRI	System of Rice Intensification
TOR	Terms of Reference
VDC	Village Development Committee
WUG	Water Users Group

Measurement Units

Extent

cm^2 = Square-centimeters (1.0 cm x 1.0 cm)
m^2 = Square-meters (1.0 m x 1.0 m)
km^2 = Square-kilometers (1.0 km x 1.0 km)
a = Are(100 m^2 or 0.01 ha.)
ha = Hectares (10,000 m^2)
ac = Acres (4,046.8 m^2 or 0.40468 ha.)

Length

mm = Millimeters
cm = Centimeters (cm = 10 mm)
m = Meters (m = 100 cm)
km = Kilometers (km = 1,000 m)

Power and Energy

A = Ampere
V = Volt
W = Watt
kWh = Kilowatt hour
HP = Horse power

Currency

US$ 1.0 = 3,962 Riel

Volume

cm^3 = CubiII-centimeters (1.0 cm x 1.0 cm x 1.0 cm or 1.0 m-lit.)
m^3 = CubiII-meters (1.0 m x 1.0 m x 1.0 m or 1.0 k-lit.)
lit l = Liter (1,000 cm^3)
MCM = Million Cubic Meter

Weight

gr = Grams
kg = Kilograms (1,000 gr.)
ton = Metric ton (1,000 kg)

Others

ppm = parts per million
°C = degree centigrade
% = percent

Time

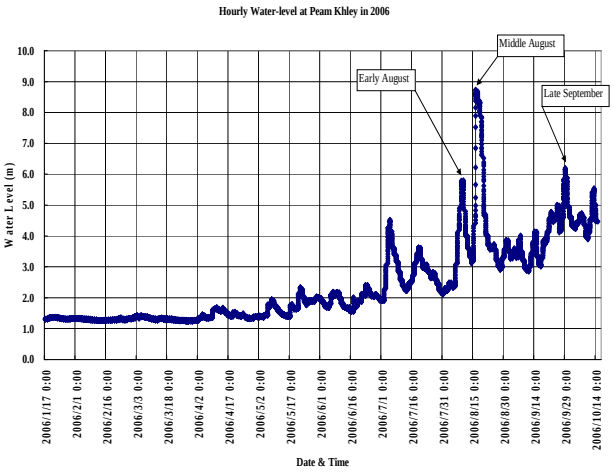
sec = Seconds

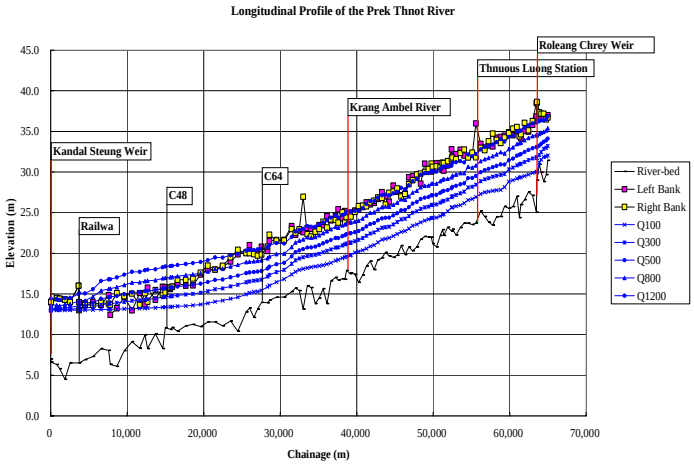
(Official Midpoint Exchange Rate as of Jan. 2007)
US$ = United State Dollars
R, Riel = Cambodian Riel

min = Minutes (60 sec.)
hr = Hours (60 min.)

PART-A

GENERAL INFORMATION





Technology Transfer about EIA (photo: left side) and Water-level at Peam Khley (fig.: right side)
Longitudinal Profile of the Prek Thnot River (fig.: left side) and EMM (photo: right side)

PART-A: GENERAL INFORMATION

Chapter A-1 Introduction

A-1.1 Authority

This Volume-V: Hydrological Study and Environmental Management Basic Capacity Strengthening is a part of final report which was prepared in accordance with the scope of work for the Study on Comprehensive Agricultural Development of Prek Thnot River Basin agreed between the Ministry of Water Resources and Meteorology, the Kingdom of Cambodia (MOWRAM) and the Japan International Cooperation Agency (JICA) on April 11, 2005.

A-1.2 Components of Final Report

The final report consists of the following volumes:

- Volume-I: Summary
- Volume-II: Master Plan
- Volume-III: Feasibility Study for Priority/Urgent Projects
- Volume-IV: Pilot Projects
- Volume-V: Hydrological Study and Environmental Management Basic Capacity Strengthening
- Volume-VI: Appendixes for Master Plan
- Volume-VII: Appendixes for Feasibility Study for Priority/Urgent Projects

This Volume-V: Hydrological Study and Environmental Management Basic Capacity Strengthening presents the results of studies conducted from July 2005 to February 2008.

A-1.3 Background

A-1.3.1 Master Plan Study

The basin of the Prek Thnot River, which flows around Phnom Penh, is one of the major paddy cultivation areas in Cambodia. However, agriculture in this basin, as well as in other areas, necessarily depends on erratic rainfall due to a limited irrigation system. This results in low and unstable crop production with some farmers in the basin not even able to cover their own consumption of rice. During the rainy season, the basin also suffers from floods overflowing the Prek Thnot River almost every year. To seek a way to improve such situations, the Master Plan Study Phase 1 was carried out for the target area (105,200 ha) in the basin from July 28, 2005 to February 28, 2006.

Based on the survey and study results, the "*Improvement of Agricultural Productivity Centering on Rice*" was selected as the strategic target of the master plan. To achieve this target, the "*Program Approach*" was elaborated in a concept of "*Well-harmonized Development of Irrigation and Drainage, Agriculture and Institutions*". There were 13 scheme-wise improvement approach programs and 14 subject-wise improvement approach programs as shown below:

Scheme-wise Improvement		
	Zone Based Projects (Zone-1),	
1	A.1(1)	Irrigated Agriculture Improvement Model Project
2	A.1(2)	Upper North Main Canal Irrigated Agriculture Improvement Project
3	A.1(3)	Upper South Main Canal Irrigated Agriculture Improvement Project
	Zone Based Projects (Zone-2)	
4	A.2(1)	Lower North Main Canal Irrigated Agriculture Improvement Project
5	A.2(2)	Lower South Main Canal Irrigated Agriculture Improvement Project

6	A.2(3)	Ou Krang Ambel Irrigated Agriculture Improvement Project
	Zone Based Project (Zone-3)	
7	A.3(1)	Water Harvesting Irrigated Agriculture Improvement Project
	Zone Based Project (Zone-4)	
8	A.4(1)	Rainfed Agriculture Improvement Project
	Zone Crosscutting Projects	
9	B.1(1)	Roleang Chrey Regulator Gates Urgent Improvement Project
10	B.1(2)	Roleang Chrey Regulator and Intakes Improvement Project
11	B.2(1)	Veterinary Services Strengthening and Livestock Raising Improvement Project
12	B.3(1)	Community Inland Fisheries Development Project
13	B.4(1)	Income Generation Projects for Marginal Farmers
Subject-wise Improvement		
14	C.1(1)	Coordination between MOWRAM and MAFF Strengthening Project
15	C.1(2)	Provincial Departments Strengthening Project
16	C.2(1)	Livestock Sub-sector Development Study
17	C.3(1)	Technical Guidelines Preparation Project
18	C.4(1)	Environmental Management Basic Capacity Development Project
19	C.4(2)	Environmental Management Applied Capacity Development Project
20	C.5(1)	Irrigated Agriculture On-Farm Technology Improvement Pilot Project
21	C.6(1)	Irrigation Facility Maintenance Capacity Strengthening Pilot Project
22	C.7(1)	Rainfed Agriculture Improvement Pilot Project
23	C.8(1)	Community Inland Fisheries Development Pilot Project
24	C.9(1)	River Basin Effective Water Use Awareness Raising Project
25	C.10(1)	Institutional and agricultural Support Services Strengthening Project
26	C.11(1)	Hydrological Observation Strengthening Project
27	C.11(2)	Flood Forecasting and Warning Study

The master plan study recognized that its implementation would contribute to self-sufficiency in rice production in the target area and would increase the farm income to about 1.5 to 2.0 times the present income. It was thus recommended that the master plan should be implemented as early as possible.

A-1.3.2 Hydrological Study

In the master plan study, one project and one study regarding hydrological aspects were proposed as subject-wise improvements. These were the: (i) Hydrological Observation Strengthening Project; and (ii) Flood Forecasting and Warning Study. As for the Hydrological Observation Strengthening project, 10 rainfall gauzing stations and 5 water level recorders were set anew in the Prek Thnot River Basin in 2005, and then observations were conducted for two years, 2005 and 2006, on a per contract basis. In this period, the Flood Forecasting and Warning Study was executed.

The works executed in the Flood Forecasting and Warning Study were the (i) finalization of runoff model; (ii) preliminary study on operation rule of major gate facilities on the Prek Thnot River; (iii) preparation of hazard map; and (iv) preparation of flood warning system.

Based on the discharge observation data which was conducted in 2005 and 2006, the draft runoff model prepared in 2005, was finalized. In the finalization of the runoff model, the hourly rainfall data and hourly water level data at Peam Khley at the flood that occurred on August 16, 2007, would be useful as cross-check data for the finalization of runoff model.

The other three works would contain the following activities:

(1) Preliminary study on operation rule of major gate facilities on the Prek Thnot River

- Identify the inundation area and confirm the inundation type.
- Arrange the basic data for establishment of inundation model and calculation of flow

capacity.

- Prepare an inundation area map.
- Prepare the operation rule of major gate facilities.

(2) Preparation of hazard map

- Execute the inundation analysis using “FLO-2D” software for model area.
- Prepare a flood hazard map for model area in a participatory manner.

(3) Preparation of flood warning system

- Select the analysis methodology well-fitted to local conditions, from single parameter correlation, multi parameters correlation of rainfall and water level, and storage function method.
- Prepare a flood warning system.

The results are detailed in Part-B of Volume-V.

A-1.3.3 Environmental Management Basic Capacity Strengthening

As mentioned above, the master plan study proposed two projects: Environmental Management Basic Capacity Development Project and Environmental Management Applied Capacity Development Project. In the study, a part of the Environmental Management Basic Capacity Development Project was executed. The executed works are as follows:

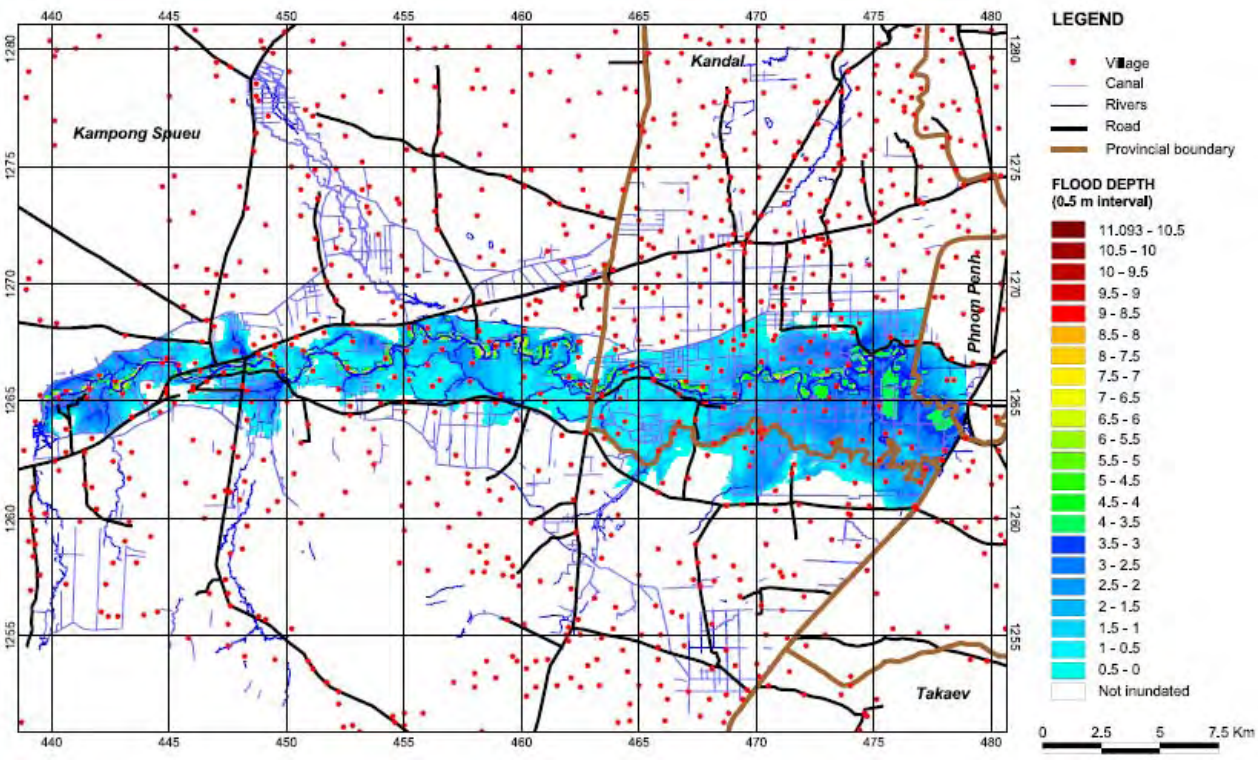
(1) Recommendation to the study items for surrounding areas for development of new water sources and the related important points

(2) Methods of environmental management and monitoring for the beneficial area after completion of water source development.

Part-C of Volume-V presents the details of executed works.

PART-B

HYDROLOGICAL STUDY



Probable Inundation Map for 10-Year Return Period of the Target Area of the Prek Thnot River Basin

PART-B: HYDROLOGICAL STUDY

As mentioned in Sub-section A-1.3.2, the hydrological study contains (a) Study on Basic Characteristics of Prek Thnot River, (b) Study on Runoff Model, (c) Preparation of Operation Rule of Major Gate Facilities, (d) Preparation of Probable Inundation Map, (e) Preparation of Flood Hazard Map, (f) Study on Flood Forecasting and Warning and (g) Hydrological Observation. Through these works, technology transfer was carried out for the counterpart personnel assigned. These works conducted are reported hereunder.

Chapter B-1 Study on Basic Characteristics of the Prek Thnot River

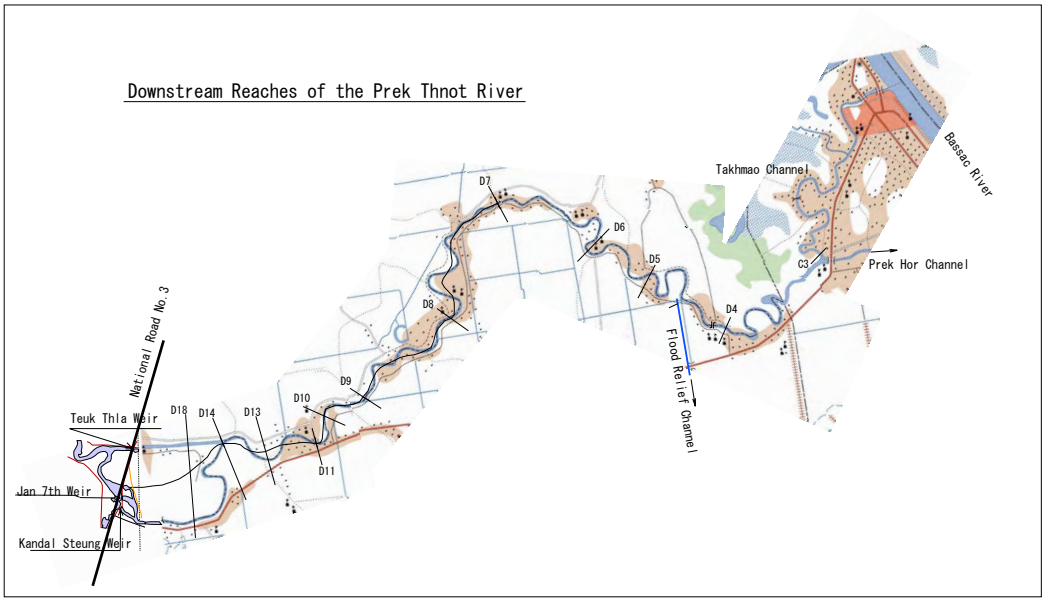
B-1.1 General

The objective of study on basic characteristics of the Prek Thnot River is to obtain the essential information and data for the preparation of probable inundation map, flood hazard map, gate operation rule, flood forecasting and warning system, and runoff model. The objective area in this study covers the region between the Roleang Chrey Regulator and the river-mouth linking the Bassac River.

B-1.2 River System of the Prek Thnot River

B-1.2.1 Downstream Reaches of National Road No.3

The Prek Thnot River downstream of national road No.3 covers the area from the river-mouth linking the Bassac River, up to the site of Teuk Thla weir, January 7th weir and Kandal Steung weir,as shown in the figure below:



The river length form the national road No.3 to the river-mouth is around 27 km. As shown in the above figure, flood embankment exists on both sides of the river, from the national road No.3 to the downstream reaches, with a length of about 16.6 km. At further downstream reaches, no flood embankment exists while a wide flood retarding area is located on the left side of the river.

Moreover, a flood relief channel exists on the right side of the river, at about 15.5 km downstream of the national road No.3. The length of the flood relief channel is around 5~6 km, which finally discharges to a swampy area.

The Prek Thnot River, in further downstream reaches, divides the Prek Ho Channel and the Takhmao Channel. The Prek Hor Channel flows to the south-east direction which branches into two channels; the one flowing to the east which discharges to the Bassac River while the other flows to the south which is presumed reaching the Vietnamese territory.

The Takhmao Channel flows to the north-east direction and discharges to the Bassac River.

The flood relief channel in the middle reaches of the channel.

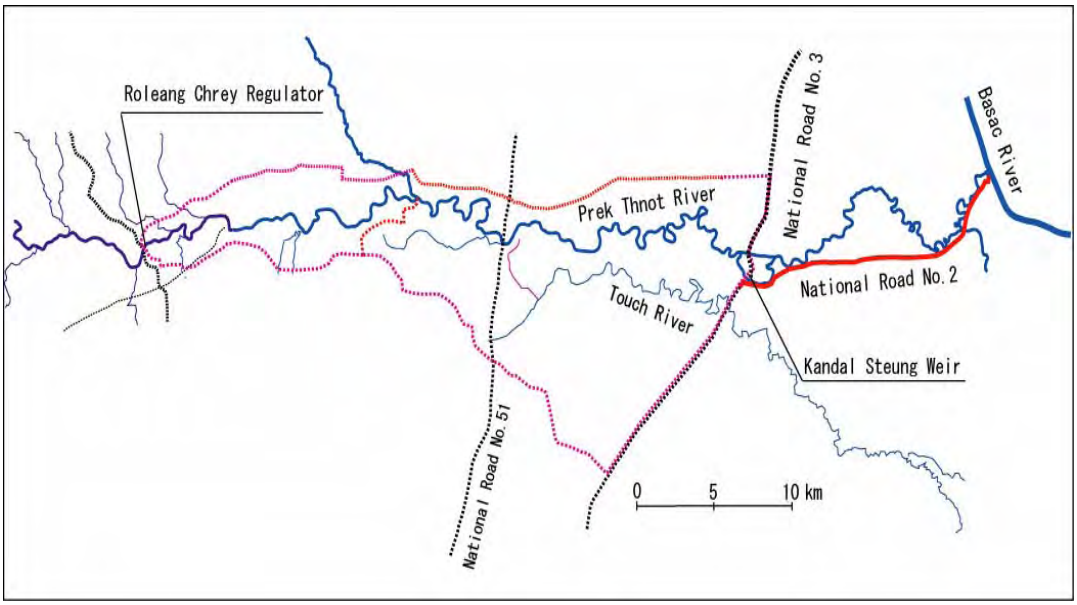
The bridge over the Prek Ho Channel at the bifurcation site

The bridge over the Takhmao Channel near its river opening to the Bassac River

The area around the river opening of the Takhmao Channel is a densely urbanized area as shown in the above photograph.

B-1.2.2 Upstream Reaches of National Road No.3

The area of the Prek Thnot River upstream of national road No.3 as shown in the figure below, covers the area from the site of Teuk Thla weir, January 7th weir and Kandal Steung weir up to the Roleang Chrey Regulator site:



The river length from the national road No.3 to the site of the Roleang Chrey Regulator is around 63.5 km. In the said reaches of the Prek Thnot River, there is no flood embankment on both sides of the river.

In the middle of the said reaches, national road No. 51 crosses the river. Near this crossing site, a small branch of Prek Thnot River known as the Touch River, branches on the right side, and flows down in the south-east direction.

Krang Ambel River joins the Prek Thnot River at about 38.7 km upstream of the national road No.3.

B-1.3 Rainfall and Water Level Gauging Station

B-1.3.1 Existing Rainfall Gauging Station

Within the vicinity of the Prek Thnot River basin one automatic and 17 ordinary rainfall gauging stations exist. The automatic gauging station has been located at Kampong Speu PDOWRAM office since year 2000. The rainfall data availability period is more than 23 years for daily data at some locations, and only 5 years at other locations. Furthermore, long term monthly rainfall records from 1901 to 1990 at Phnom Penh are available in the Reappraisal Report of the Prek Thnot Multipurpose Project, Volume 5.2 - Annex I, for the Australian Catholic Relief in December 1991. According to those rainfall data, the rainfall conditions in the basin are as follows:

- Average annual rainfall in the basin is 1,225 mm.
- The seasonal distribution is divided into rainy season from May to November, and dry season from December to April.
- The rainy season accounts for 90% of the annual rainfall.
- Frequent rain showers occur at small hyetal regions. The heaviest annual rainfall is determined in the southwest location of the Prek Thnot River Basin.

B-1.3.2 Water Level Gauging Station

As of 2005, there were 3 water level gauging stations along the Prek Thnot River. The gauging stations at Peam Khley and Thnuos Luong were installed by DHRW in 1996. The gauging station at Roleang Chrey Regulator was installed in 1999. Discharge at these gauging stations is computed from the rating curve developed by DHRW. Data of discharge measurements, data logs, rating curves, daily water stage and discharge at Peam Khley, Thnuos Luong and Roleang Chrey Regulator are available. The periods of data available vary from 5 years to 9 years by station. Daily discharge from 1997 to 2005 at Peam Khley gauging station is available.

B-1.3.3 Newly Established Rainfall and Water Level Gauging Station

As mentioned above, there have been 18 rainfalls, and three water level gauging stations exist in the Prek Thnot River basin. These stations were mainly ordinary gauging stations except for the rainfall gauging station at Kampong Speu PDOWRAM. New automatic gauging stations were established at locations within these sites, in consideration of the spatial distribution and data continuation. Based on the study, locations of the newly installed gauging stations and those replaced were identified as follows:

New Rainfall Gauging Stations

No.	Station Name	Equipment	District/Village	Location (UTM)		Remarks
				Northing	Easting	
1	Kirirom	Automatic	Phnom Sruoch	1252931	396882	Replaced
2	Wat Kdey Lvea	Automatic	Samrongtong	1268598	462114	Newly installed
3	Kong Pisey	Automatic	Kong Pisey	1247922	459627	Newly installed
4	Trapeang Chour	Automatic	Aoral	1306348	405995	Replaced
5	Thpong	Automatic	Thpong	1299115	438559	Replaced
6	Peam Khley	Automatic	Phnom Sruoch	1267566	430740	Replaced
7	Phum Chum	Automatic	Aoral	1294020	383194	Newly installed
8	Roleang Chrey	Automatic	Samrongtong	1264829	439962	Newly installed
9	Prey Kaniech	Automatic	Phnom Sruoch	1262000	409200	Newly installed
10	O Kon Trom	Automatic	Phnom Sruoch	1238125	417515	Newly installed

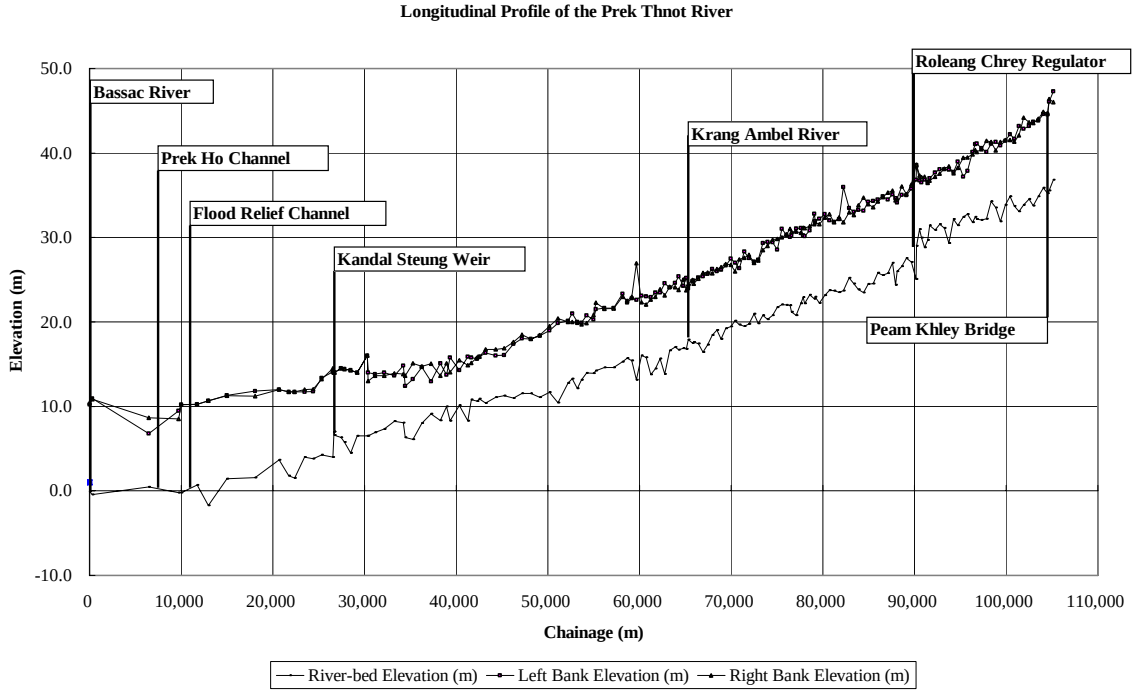
New Water Level Gauging Stations

No.	Station Name	Equipment	District/Village	Location (UTM)		Remarks
				Northing	Easting	
1	Peam Khley Bridge	S.G.	Phnom Sruoch	1266500	430871	Newly installed
2	Thnuos Luong	Logger & S.G.	Chbr Mon	1266357	446561	Replaced
3	Krang Chek	Logger & S.G.	Phnom Sruoch	1261082	402458	Newly installed
4	Cheneang Kpuos	Logger & S.G.	Phnom Sruoch	1265906	427244	Newly installed
5	Sangkea Tasal	Logger & S.G.	Aoral	1290500	405000	Replaced
6	Trapeang Kchon	Logger & S.G.	Samrongtong	1267436	458215	Newly installed
7	Roleang Chrey	S.G.	Samrongtong	1265095	440236	Newly installed
8	Prey Mean	S.G.	Aoral	1285872	406818	Newly installed

S.G. : Staff Gauge

B-1.4 Longitudinal Profile of the Prek Thnot River

The longitudinal profile of the Prek Thnot River is as shown in the figure below:



The longitudinal slope of the river is approximately as follows;

- River-opening ~ Chainage 35,000 1/5,100
- Chainage 35,000 ~ Chainage 65,000 1/4,170
- Chainage 65,000 ~ Roleang Chrey Regulator 1/2,720
- Roleang Chrey Regulator ~ Peam Khley Bridge 1/2,720

B-1.5 Manning's Roughness Coefficient

B-1.5.1 Basic Approach

The basic approach for estimating Manning's roughness coefficient of the Prek Thnot River in the downstream reaches is as follows:

- Assume values of Manning's roughness coefficient of the low-water channel as 0.027, 0.030, 0.035, 0.040, 0.045
- Estimate the Manning's roughness coefficient of the high-water channel based on the high-water channel conditions, using the estimate table of "Open Channel Hydraulics" by Ven Te Chow.
- Assume values of flood discharge as 400 m^3/s, 500 m^3/s, 600 m^3/s, 700 m^3/s, 800 m^3/s.
- Conduct non-uniform flow water-level calculation in the said reaches with the

combination of above discharge and roughness coefficient and to determine the most ideal combination of Manning's roughness coefficient and discharge, to meet the flow conditions mentioned in the detailed report of June 2003 flood (prepared by the long-term expert of Technical Service Center of the Ministry of Water Resources and Meteorology).

B-1.5.2 Flood Flow Conditions in the Report

The basic features of the June 2003 flood based on said report, which was used for estimating the Manning's roughness coefficient of the Prek Thnot River, are as follows:

- Water level of the Bassac River during the floods was around 5.0 m
- Flood water level was nearly the same with the flood embankment crown level at some locations in the downstream reaches.
- Water level at national road No.3 was close to the design flood water level of 13.0 m.
- Flow condition at Teuk Thla Weir site was considered as submerged flow.
- Flow condition at Jan 7th weir was considered submerged flow.
- Flood maximum discharge was around 700 ~ 1,000 m^3/s

B-1.5.3 Non-uniform Flow Water-level Calculation

The non-uniform flow water-level calculation was initially considered in the reaches between the estuary of the Prek Thnot River (the Takhmao Channel) and the national road No.3. However, it was found that the river reaches near the river-opening does not have sufficient capacity against flood discharge.

According to local residents in the estuary area, while they have not experienced flooding in the area for the past 40 years, floodings occurred several times in the upstream reaches.

Consequently, it is concluded that the flood discharge is significantly reduced because of the existence of flood retarding basin, located upstream of the densely urbanized region near the estuary area.

Therefore, the non-uniform flow water-level calculation is conducted between the downstream end of the river reaches, and the flood embankment at the upstream end of the flood retarding basin.

Furthermore, the starting water level at the downstream end of the non-uniform flow water-level calculation reaches is assumed to be 7.3 m based on the cross-sectional profile of the site, which is greater than the reported 5.0 m water-level of the Bassac River.

The Manning's roughness coefficient of high-water channel of the Prek Thnot River is set at 0.080 based on the present high-water channel conditions of dense bush area, in view of relevant information of "Open Channel Hydraulics"

B-1.5.4 Non-uniform Flow Water-level Calculation Results

The non-uniform flow water-level calculation has been conducted with the combination of roughness coefficient and flood discharge. Result of each calculation, as shown below, has been compared with the flow condition mentioned in the report.

Cases to fulfill the bankfull condition

n \ Q	400 m^3/s	500 m^3/s	600 m^3/s	700 m^3/s	800 m^3/s
0.027	⊗	⊗	⊗	O	O
0.030	⊗	⊗	⊗	O	⊗
0.035	⊗	⊗	⊗	O	⊗
0.040	⊗	O	O	⊗	⊗
0.045	⊗	O	O	⊗	⊗

Note: ⊗ means "No", and O means "Yes"

Cases to fulfill the submerged flow at Teuk Thla Weir

n \ Q	400 m^3/s	500 m^3/s	600 m^3/s	700 m^3/s	800 m^3/s
0.027	⊗	⊗	⊗	O	O
0.030	⊗	⊗	⊗	O	O
0.035	⊗	⊗	⊗	O	O
0.040	⊗	⊗	O	O	O
0.045	⊗	O	O	⊗	⊗

Note: ⊗ means "No", and O means "Yes"

Cases to fulfill the submerged flow at Jan 7th Weir

n \ Q	400 m^3/s	500 m^3/s	600 m^3/s	700 m^3/s	800 m^3/s
0.027	⊗	⊗	⊗	⊗	⊗
0.030	⊗	⊗	⊗	⊗	O
0.035	⊗	⊗	⊗	O	O
0.040	⊗	⊗	⊗	O	⊗
0.045	⊗	⊗	O	⊗	⊗

Note: ⊗ means "No", and O means "Yes"

Cases to fulfill all the above conditions

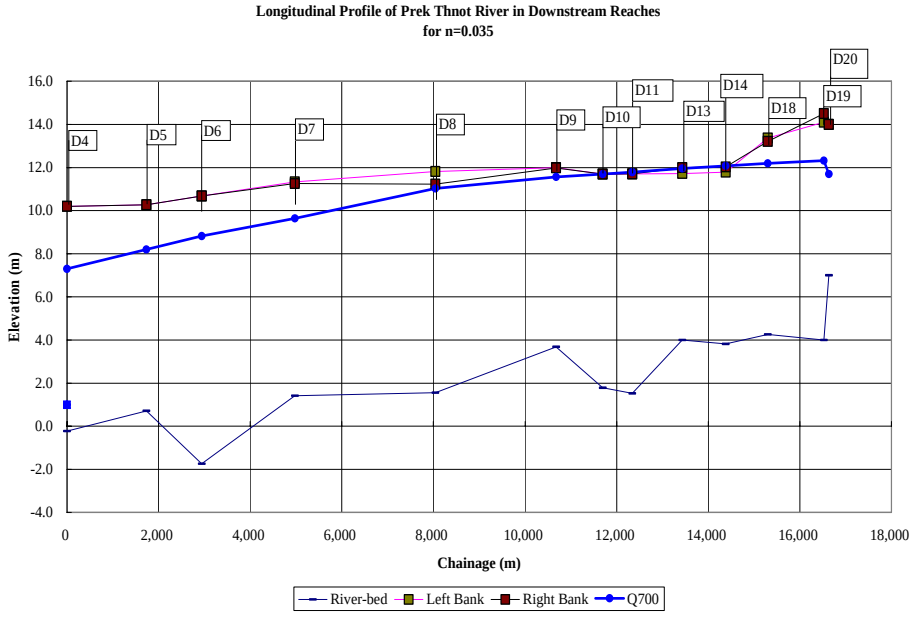
n \ Q	400 m^3/s	500 m^3/s	600 m^3/s	700 m^3/s	800 m^3/s
0.027	⊗	⊗	⊗	⊗	⊗
0.030	⊗	⊗	⊗	⊗	⊗
0.035	⊗	⊗	⊗	O	⊗
0.040	⊗	⊗	⊗	⊗	⊗
0.045	⊗	⊗	O	⊗	⊗

Note: ⊗ means "No", and O means "Yes"

B-1.5.5 Conclusions on Manning's Roughness Coefficient

Based on overall considerations given in the above table, it was concluded that the ideal Manning's roughness coefficient of the low-water channel of the Prek Thnot River in the downstream reaches was 0.035, while the discharge of the June 2003 flood was considered as 700 m^3/s.

The result of non-uniform flow water-level calculation based on these conditions is shown below:

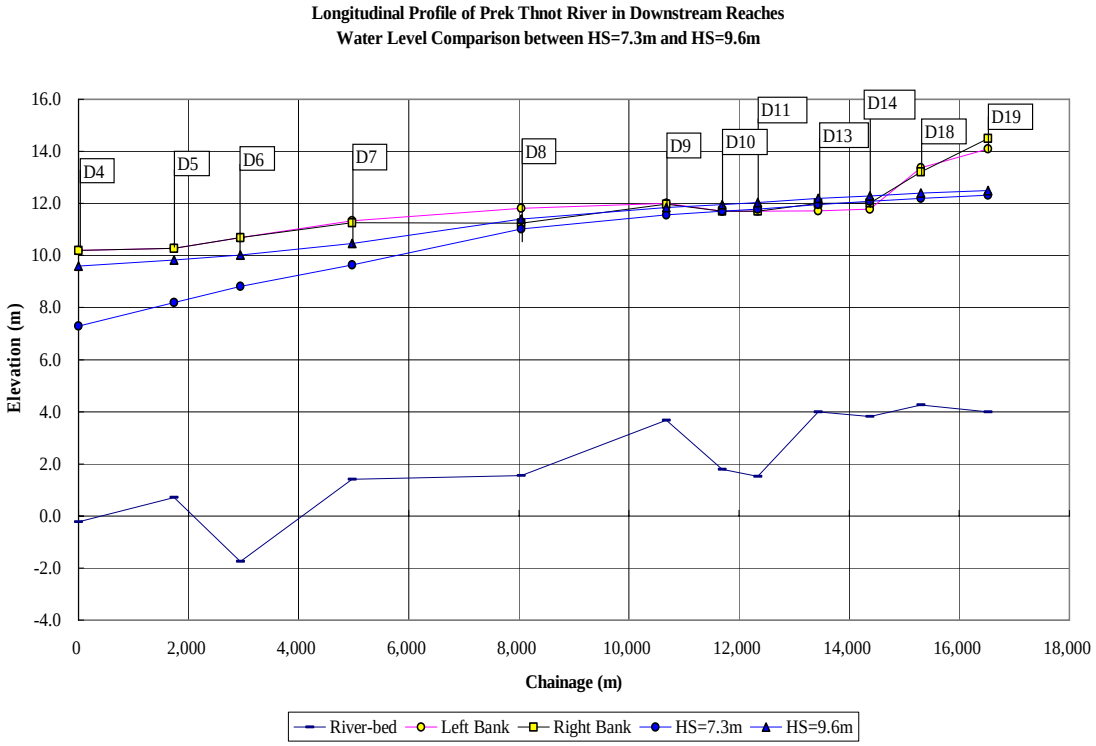


B-1.6 Influence of Backwater of the Bassac River

According to the "Prek Thnot Flood Relief Channel Hydrological Report in September 2001" of the "Emergency Flood Rehabilitation Project", the probable water-level of the Bassac River at the estuary of the Prek Thnot River is estimated as follows:

Return Period (year)	Probable Water-level of Bassac River
2	8.6 m
5	9.3 m
10	9.5 m
20	9.6 m
50	9.9 m

A non-uniform flow water-level calculation, with a starting level of 9.6 m (20-year return period) has been conducted considering discharge of 700 m^3/s in the same reaches. Based on the result, the water-level of the Prek Thnot River at the National Road No. 3 site is estimated at 11.92 m. The water-level with a starting level of 7.3 m considering the same discharge is estimated at 11.71 m. The determined difference of 21 cm does not have substantial influence during floods, to the gate operation of Teuk Thla Weir and Kandal Steung Weir at the site of National Road No.3. This means that the backwater effect of the Bassac River would not be a substantial one for the gate operation at the said site. The figure below shows the non-uniform flow water-level calculation results with different starting water level;



B-1.7 Discharge Carrying Capacity

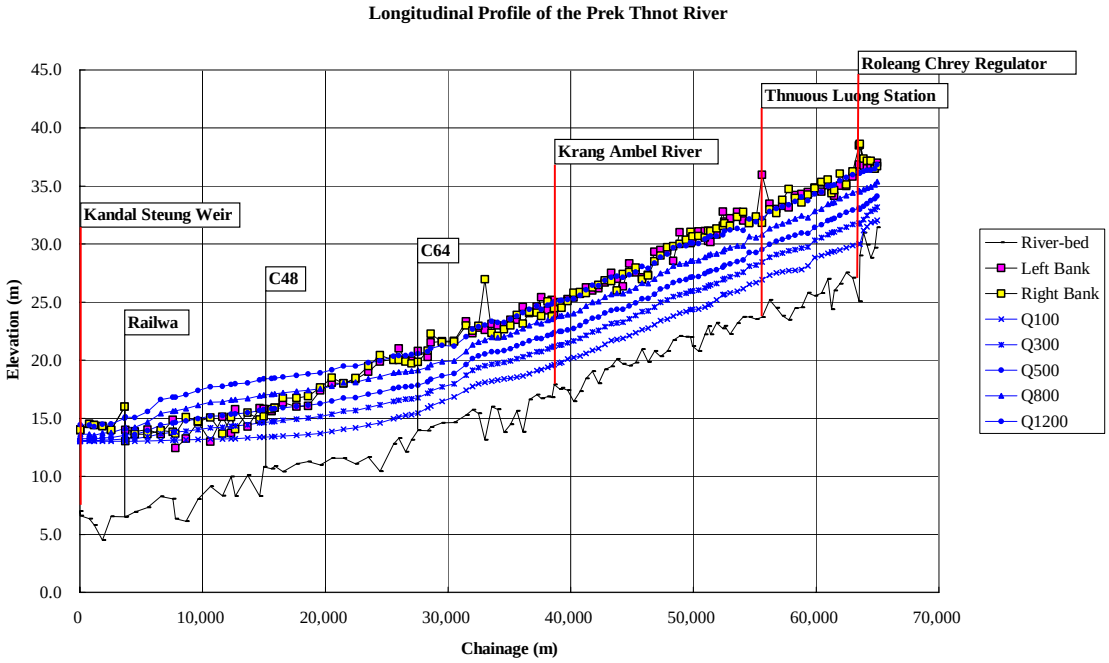
B-1.7.1 Discharge Carrying Capacity in Downstream Reaches

As discussed in the previous sections, the discharge carrying capacity of the Prek Thnot River in the downstream reaches of the national road No. 3 is estimated as 700 m^3/s. These reaches are the flood embankment, which excludes the natural flood retarding basin and the river-opening areas.

B-1.7.2 Discharge Carrying Capacity in Upstream Reaches

For examining the discharge carrying capacity in the reaches upstream of the national road No.3 up to Peam Khley bridge site, non-uniform flow water-level calculation has been conducted. In the calculation, the Manning's roughness coefficient of the low-water channel is set at 0.035, same with that in the downstream reaches in view of the present river conditions. However, the Manning's roughness coefficient of high-water channel is set at 0.055 in view of the present high-water channel conditions in the reaches. The starting water-level at the national road No.3 site is set at El. 13.00 m, which is the design flood level of Kandal Steung Weir and Teuk Thla Weir.

The figure below shows the result of water-level calculation in non-uniform flow in the upstream reaches, considering various discharges;

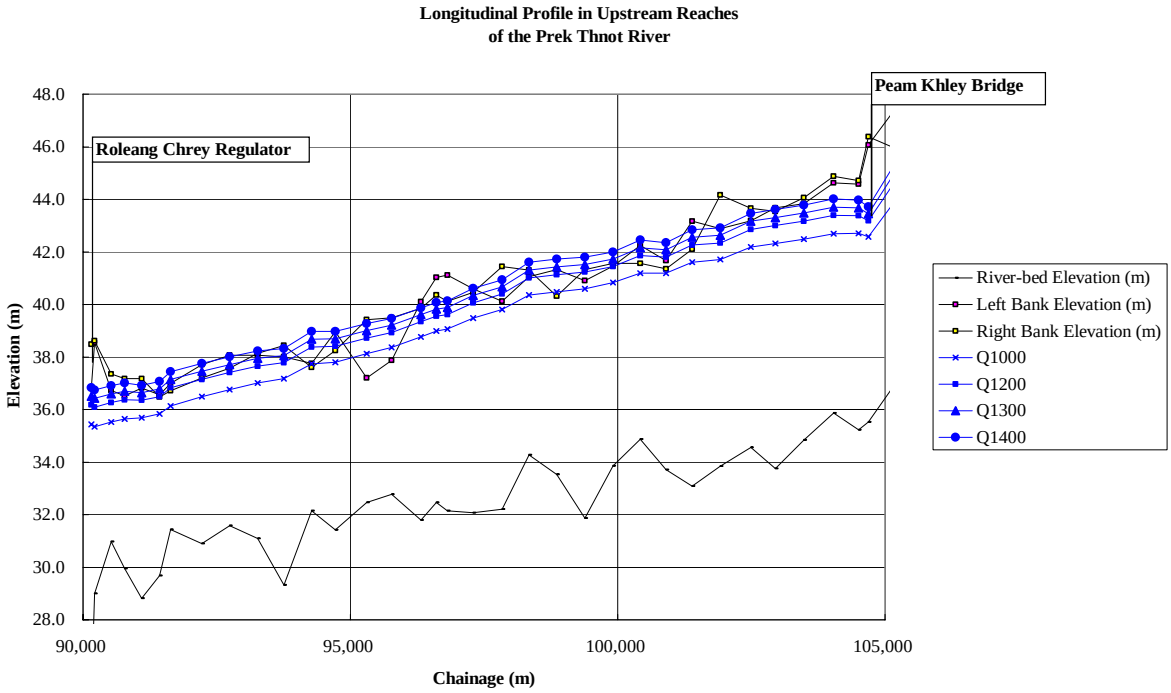


As shown in the figure above, the discharge carrying capacity of the Prek Thnot River in the upstream reaches varies in the reaches, summarized below;

Reaches	Discharge Carrying Capacity
Kandal Steung Weir ~ Railway	800 ~ 1,000 m^3/s
Railway ~ C64	300 ~ 800 m^3/s
C64 ~ Roleang Chrey Regulator	800 ~ 1,200 m^3/s

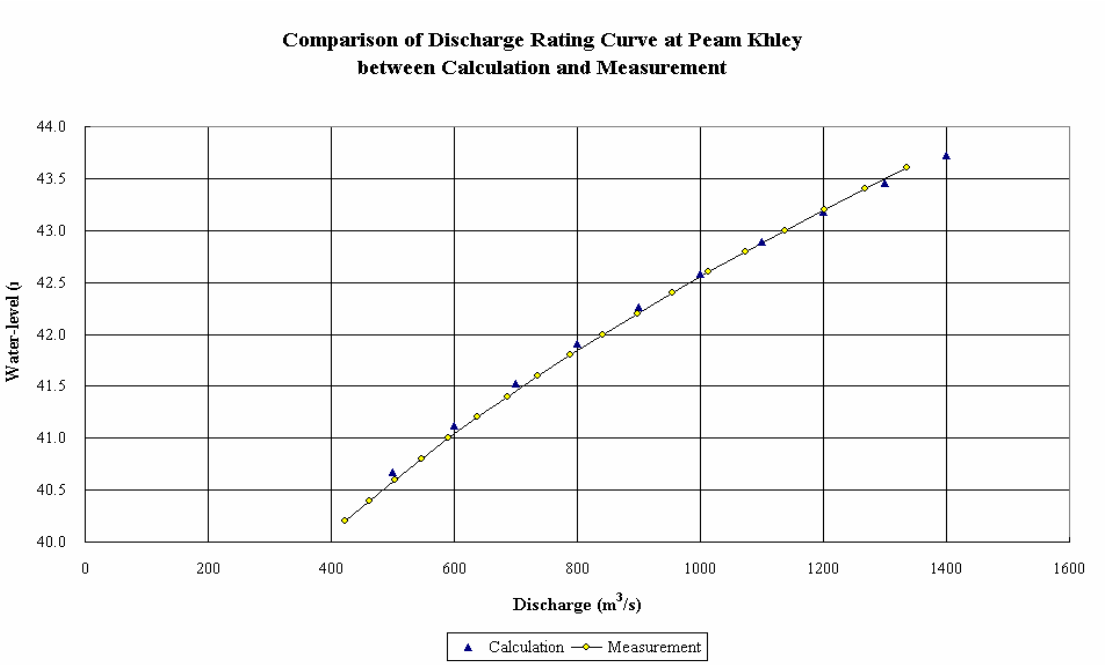
For the reaches upstream of Roleang Chrey Regulator up to Peam Khley Bridge site, the same water-level calculation has been conducted yielding results as shown below:

Reaches	Discharge Carrying Capacity
Roleang Chrey Regulator ~ Peam Khley Bridge	1,000 ~ 1,600 m^3/s



B-1.8 Discharge Rating Curve at Peam Khley Bridge Site

As mentioned above, the non-uniform flow water-level calculation has been conducted considering various discharges. Accordingly based on the calculation results, the discharge rating curve showing the relationship between the water-level and the discharge at Peam Khley bride site has been obtained. Comparatively, the discharge rating curve at same bridge site has been plotted based on discharge measurement in the field. Figure below shows the two discharge rating curves:



It is evident from the above figure that both discharge rating curves are very similar, as long as the range of flood discharge exceeds 400 m^3/s.

B-1.9 Probable Discharge

Probable discharge is estimated using the discharge at Peam Khley Bridge site. This is justified since the collected discharge data at the site is the most reliable, aside from the fact that the site is the basic point for runoff analysis, flood forecasting and warning, and probable inundation map. This was also recognized in the previous study reports.

Year	Annual Maximum Discharge (m^3/s)
1991	1,130
1996	1,380
1997	1,580
1998	1,680
1999	798
2000	1,276
2001	866
2002	132
2003	926
2004	214
2005	220
2006	1,237
2007	547

The discharge data used for the probability analysis in the present study are as follows:

In the probability analysis, the Log-Pearson Type-III Distribution is found to be the most appropriate method for determining the annual maximum discharge distribution at Peam Khley. This is in lieu of the Gumbel Distribution method that has been commonly used in the previous studies.

The probable discharges, based on the analysis, are as follows;

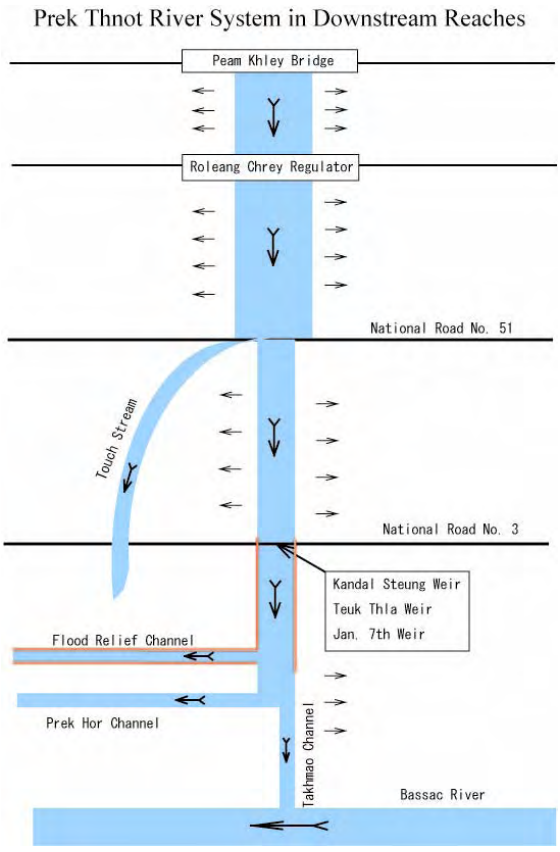
Probable discharges for return periods longer than 10 years is not shown since corresponding discharges will be unrealistically greater than the discharge carrying capacity in the upstream reaches of Peam Khley Bridge site.

Return Period (year)	Probable Discharge (m^3/s)
2	690
5	1,130
10	1,380

B-1.10 Recommendation

The characteristics of the Prek Thnot River in the reaches from the Peam Khley Bridge site to the estuary are shown in the schematic diagram below:

As shown above, the Prek Thnot River, the upstream reaches of the National Road No.3, does not basically have flood embankment. Thus, flood flows to the wide flood plain through the open banks, and spreads in the paddy field in the area. Accordingly the river channel discharge carrying capacity of the Prek Thnot River gradually decreases from the site of Peam Khley Bridge to National Road No.3. In the downstream reaches of the National Road No.3, the flood embankment is constructed on both sides of the river and up to the the bifurcation site of the flood relief channel. A wide flood retarding basin is extended on the left side of the river before discharging into the Bassac River. Accordingly the river discharge carrying capacity of the Prek Thnot River at the estuary is minimal. Thus, if the flood embankment is extended from the present downstream end to the estuary, the dense urban area would be seriously flooded. Consequently, it is recommended that the responsible government agencies carefully consider this aspect.



Chapter B-2 Study on Runoff Model

B-2.1 General

Runoff model of the Prek Thnot River is not available. Through the present Study, the runoff model is established using the storage function model. This runoff model will be a useful tool for various water resources projects in the future.

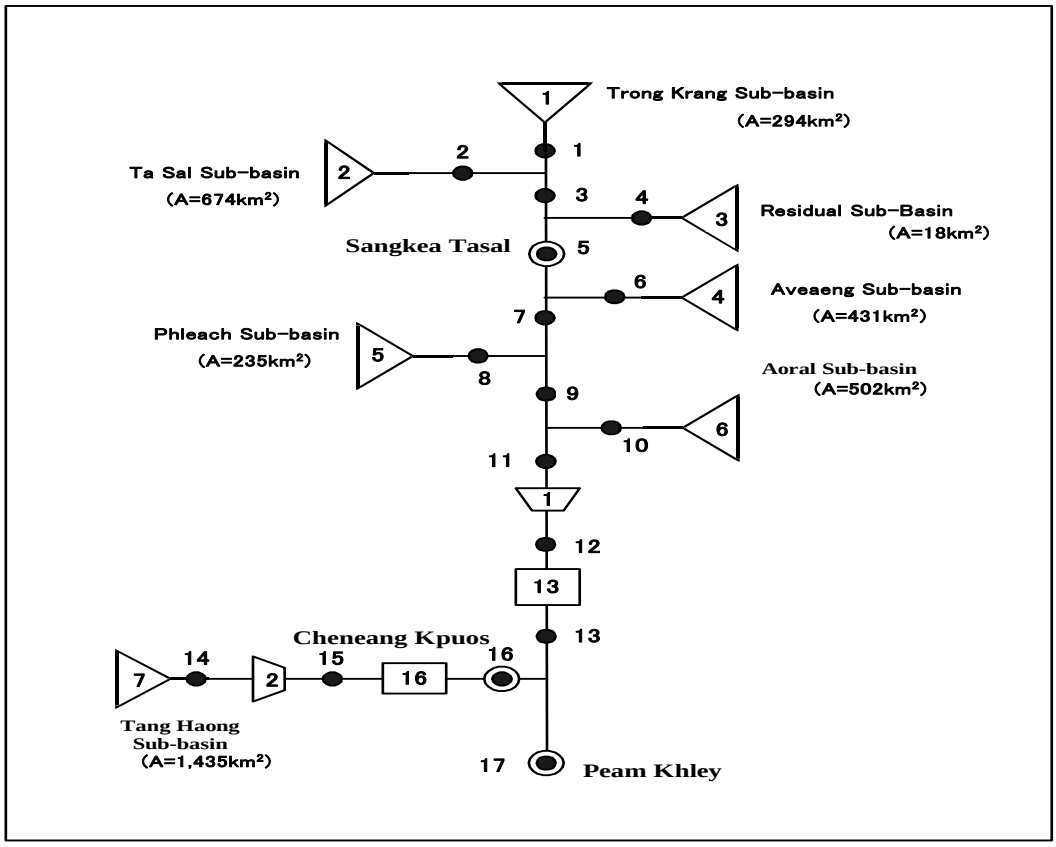
B-2.2 Runoff Datum Point

In the present Study, the target area is basically determined between the Roleang Chrey Regulator and the national road No.3. Accordingly, the Peam Khley Bridge is the most appropriate site for the runoff datum point (required for establishing the runoff model) since it is the closest water-level gauging site to the Roleang Chrey Regulator located about 14.5 km to its upstream. In addition, Peam Kley Bridge is the basic site for flood warning of the Prek Thnot River.

Accordingly Peam Khley Bridge site is decided to be the basic point for establishing the runoff model.

B-2.3 Runoff System of the Prek Thnot River

The runoff diagram of the Prek Thnot River as shown in the following figure is set up using a topographic map scaled 1/100,000:



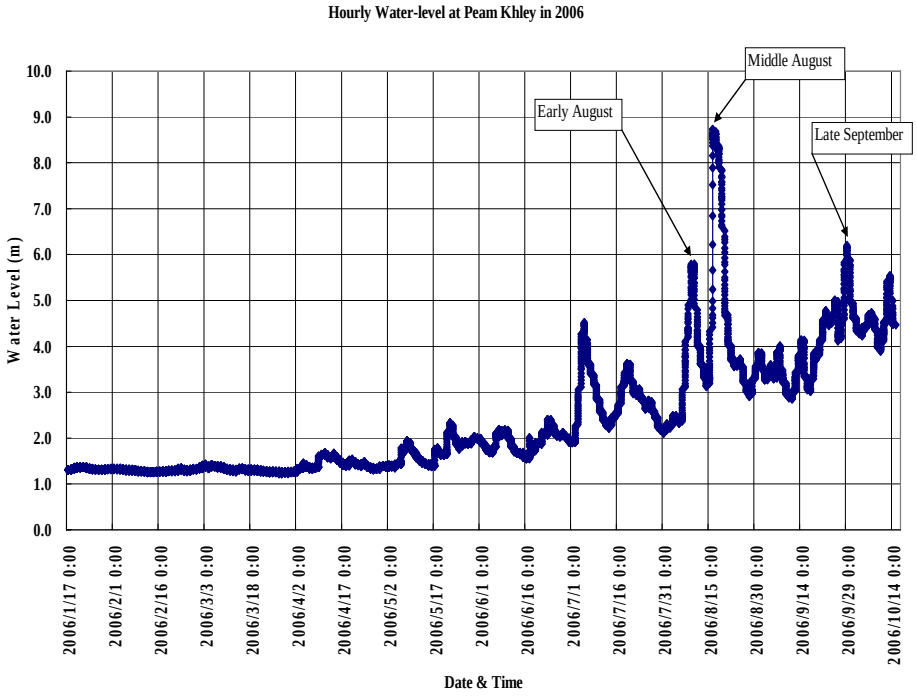
In the above figure, tow dams are incorporated even if these do not exist in the river system. This is due to the result of elaborate review of runoff recorded in the field. Without some consideration of dam effect in the river system, it is complicated to present the realistic relationship between the rainfall and runoff. It is concluded that excess runoff in the upstream basin should overflow to the river channel, and will not flow back to the channel for a short time.

B-2.4 Model Constants Verification

Actual floods that occurred in 2006, as follows, were used as constants for the model verification:

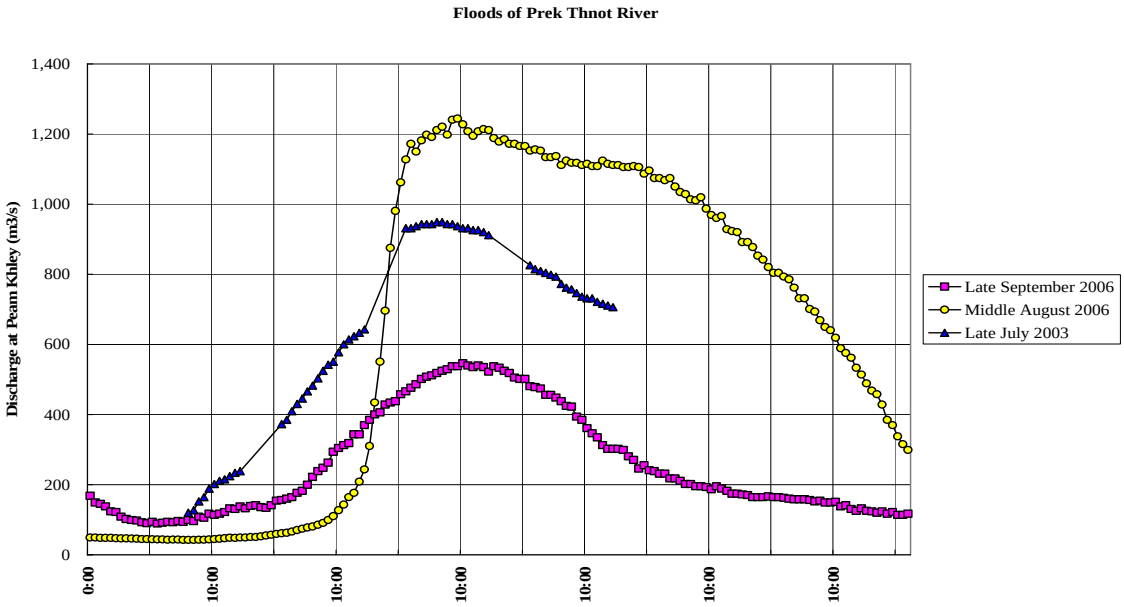
- Early August flood
- Middle August flood
- Late September flood

These floods are selected based on the hourly water-level records in 2006 shown below:



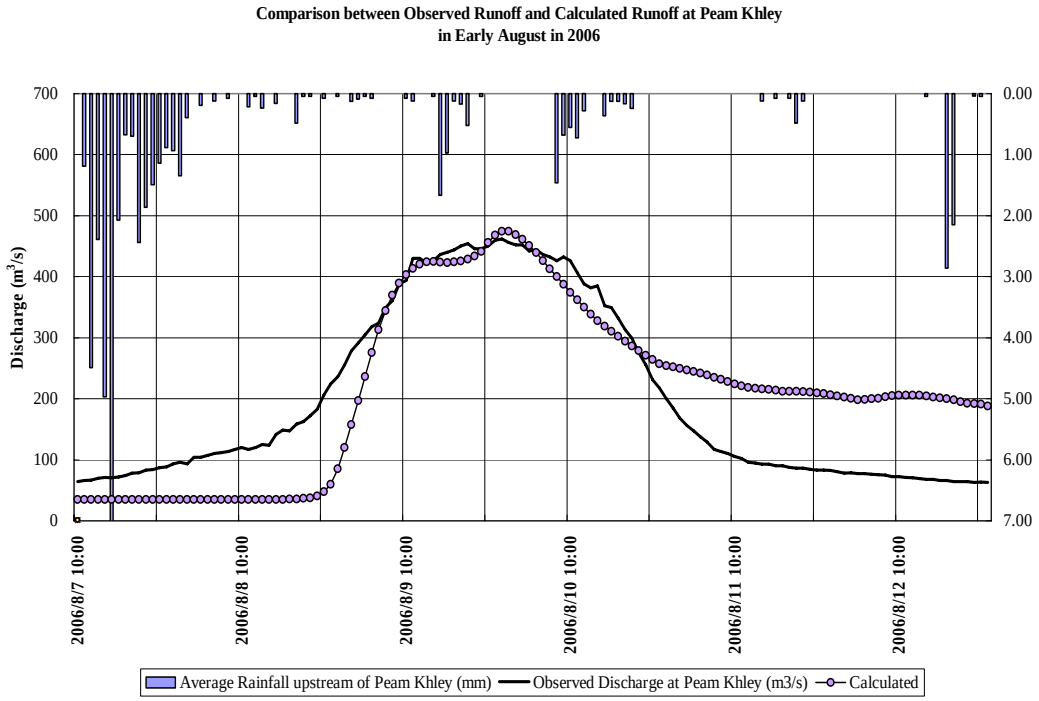
The water-level records are converted to discharge hydrograph using the discharge rating curve mentioned in the previous chapter.

The discharge hydrographs of the above three floods are as shown in the following figures:



B-2.4.1 Early August Flood

The rainfall at 11:00 hrs on August 7, 2006 caused a flood peak of 462 m^3/s at 0:00 hrs on August 10, 2006. The relationship between the basin average rainfall, the observed discharge hydrograph, and the calculated runoff hydrograph at the Peam Khley Bridge site are shown in the figure below:



The runoff model constants used for deriving the above chart are as follows:

Basin Name	K	p	Tl (hours)	F1	Area (km^2)	Rsa (mm)	Bf (m^3/s)
Tong Krang	22.8	0.3	29.7	0.8	294	100	5.0
Ta Sal	3.2	0.3	44.3	0.8	674	100	6.0
Residual	8.8	0.3	2.6	0.8	18	100	2.0
Aveaeng	26.0	0.3	44.4	0.8	431	100	5.0
Phleach	21.1	0.3	26.1	0.8	235	100	4.0
Aoral	27.3	0.3	42.4	0.8	502	50	6.0
Tang Haong	20.0	0.3	32.0	0.8	1435	100	7.0

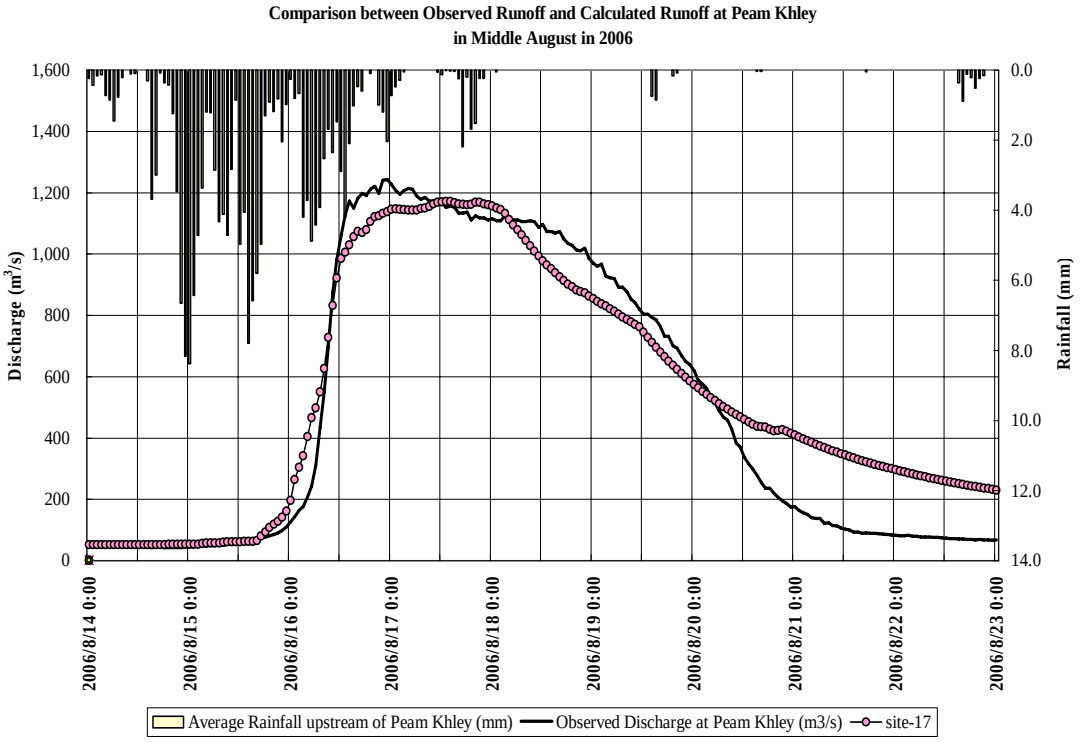
Channel No.	K	P
13	150	0.4
16	150	0.5

K, p : The basic storage function constants in the equation of $S=K*Q^p$
Tl : Time lag of runoff
F1 : Runoff coefficient to downstream
Area : Catchment area
Rsa : Rainfall loss
Bf : Base flow

B-2.4.2 Middle August Flood

The rainfall at 1:00 hrs on August 14, 2006 caused a flood peak of 1,244 m^3/s at 23:00 hrs on August 16, 2006. During this period, portion of the target area of the Project and some riverine area was seriously flooded. The relationship between basin average rainfall, the

observed discharge hydrograph, and the calculated runoff hydrograph at Peam Khley Bridge site are shown in the figure below:



The runoff model constants used for deriving the above chart are as follows:

Basin Name	K	p	Tl (hour)	F1	Area (km^2)	Rsa (mm)	Bf (m^3/s)
Tong Krang	49.4	0.5	20.2	0.8	294	100	7.5
Ta Sal	65.5	0.5	30.1	0.8	674	100	9.0
Residual	19.1	0.5	1.8	0.8	18	100	3.0
Aveaeng	56.2	0.5	30.2	0.8	431	100	7.5
Phleach	45.8	0.5	17.7	0.8	235	100	6.0
Aoral	59.2	0.5	28.8	0.8	502	50	9.0
Tang Haong	84.7	0.5	25.0	0.8	1435	100	10.5

Dam No.	Alpha	Qo
1	0.1	450
2	0.1	650

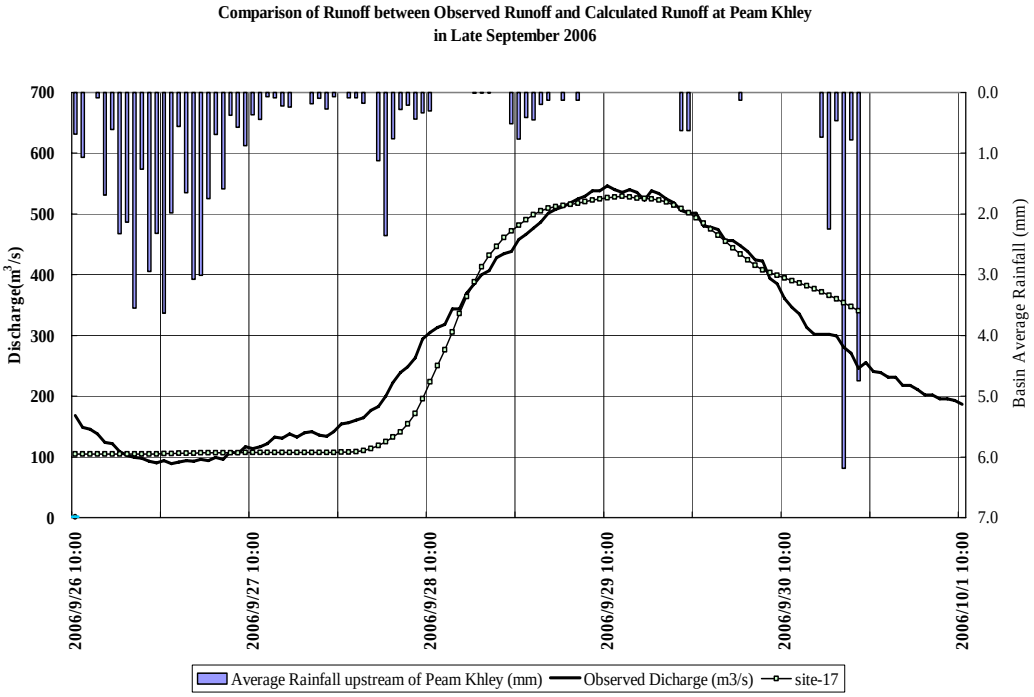
Alpha, Qo : The constants in the expression of Qout = Alpha*(Qinflow – Qo)

Qinflow : Inflow ot Dam (m^3/s)

Qo : Outflow from Dam (m^3/s)

B-2.4.3 Late September Flood

The rainfall at 10:00 hrs on September 26, 2006 caused a flood peak of 546 m^3/s at 10:00 hrs on September 29, 2006. The relationship of the basin average rainfall, the observed discharge hydrograph, and the calculated runoff hydrograph at Peam Khley Bridge site are shown in the figure on the next page:



The runoff model constants values used for the above calculation are as follows:

Basin Name	K	p	Tl (hour)	F1	Area (km^2)	Rsa (mm)	Bf (m^3/s)
Tong Krang	15.5	0.5	31.4	0.8	294	100	15.0
Ta Sal	20.5	0.5	50.6	0.8	674	100	18.0
Residual	6.0	0.5	3.5	0.8	18	100	6.0
Aveaeng	17.6	0.5	48.9	0.8	431	100	15.0
Phleach	14.3	0.5	29.7	0.8	235	100	12.0
Aoral	8.1	0.5	52.4	0.8	502	50	18.0
Tang Haong	18.0	0.7	34.0	0.8	1435	100	21.0

Channel No.	K	p
13	130	0.55
16	150	0.50

B-2.5 Recommendation

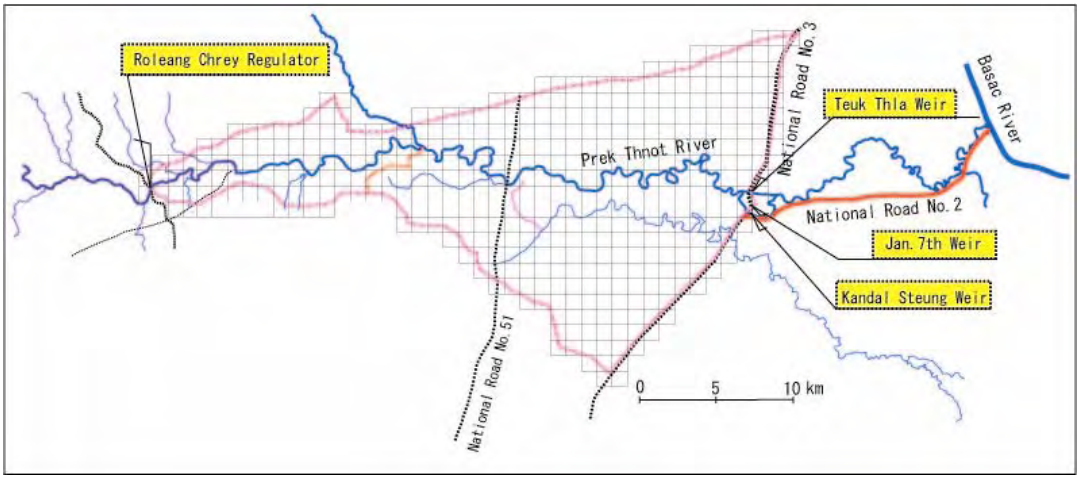
As shown above, the verification of runoff model constants has been conducted based on the actual runoffs at Peam Khley Bridge site in 2006. However, said verification was conducted considering one runoff site only, due to the limitation of availability of actual runoff data. Furthermore, the runoff data used in the verification were only those obtained in 2006. Thus, this runoff model verification remains tentative. With the accumulation of runoff records in the basin in future, further verification of runoff model is recommended.

Chapter B-3 Preparation of Operation Rule of Major Gate Facilities

B-3.1 General

Major gate facilities discussed herewith include Roleang Chrey Regulator, Teuk Thla Weir and Kandal Steung Weir. Although the Jan 7th weir is also one of the major weirs in the target area, it was not included in the following discussions since it is a fixed weir of overflow type with no gate operation required.

The locations of these regulators and weirs are shown in the figure below:



The rule for gate operation during floods in the target area will be discussed in the following sections.

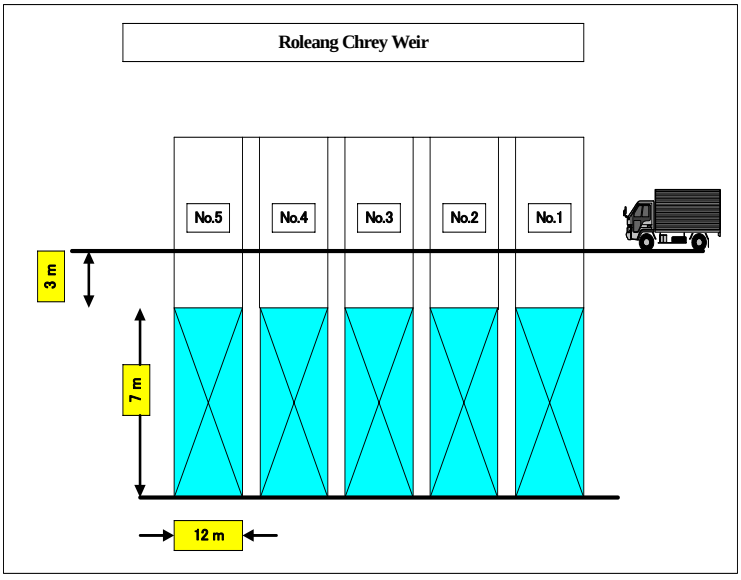
B-3.2 Present Conditions of Gates Operation

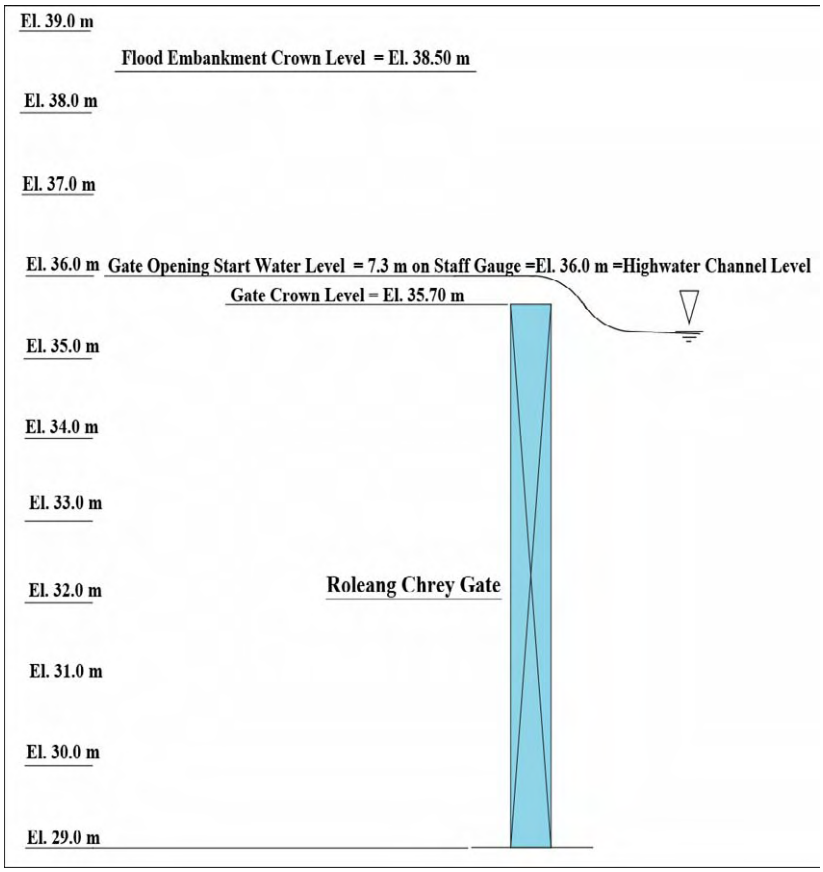
Rules for gate operation for the above mentioned major weirs are not documented. Instead, this was implemented based on usual practice adopted at the site during flooding.

B-3.2.1 Present Gate Operation of Roleang Chrey Regulator

B-3.2.1.1 Key Dimensions of Roleang Chrey Regulator

Key dimensions of Roleang Chrey Regulator are shown in the following figures:

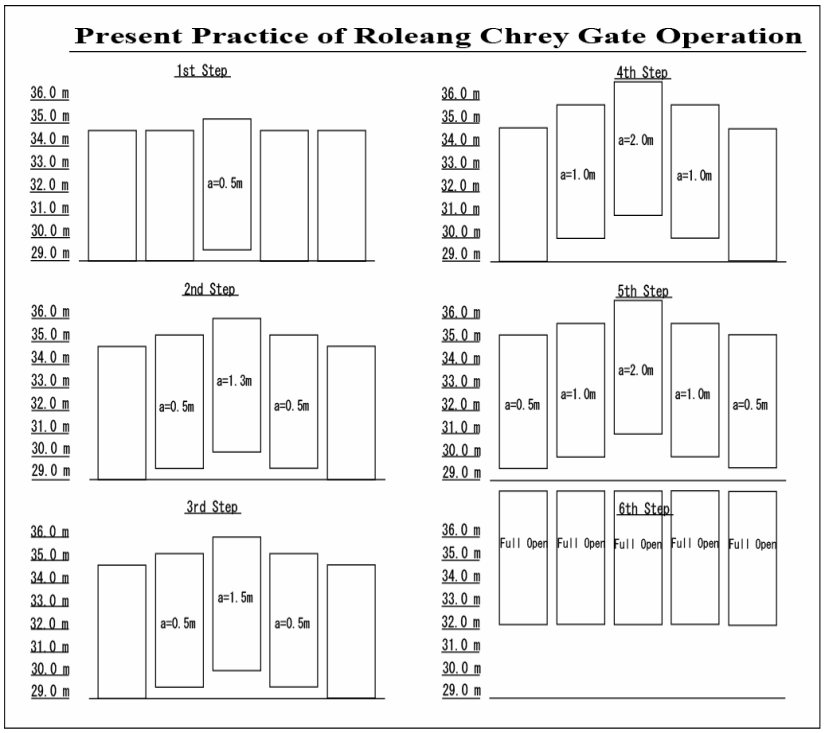




B-3.2.1.2 Present Practice of Gate Operation of Roleang Chrey Regulator

According to the gate caretaker of Roleang Chrey Regulator, the present practice for operating the gate during floods is presented in the following.

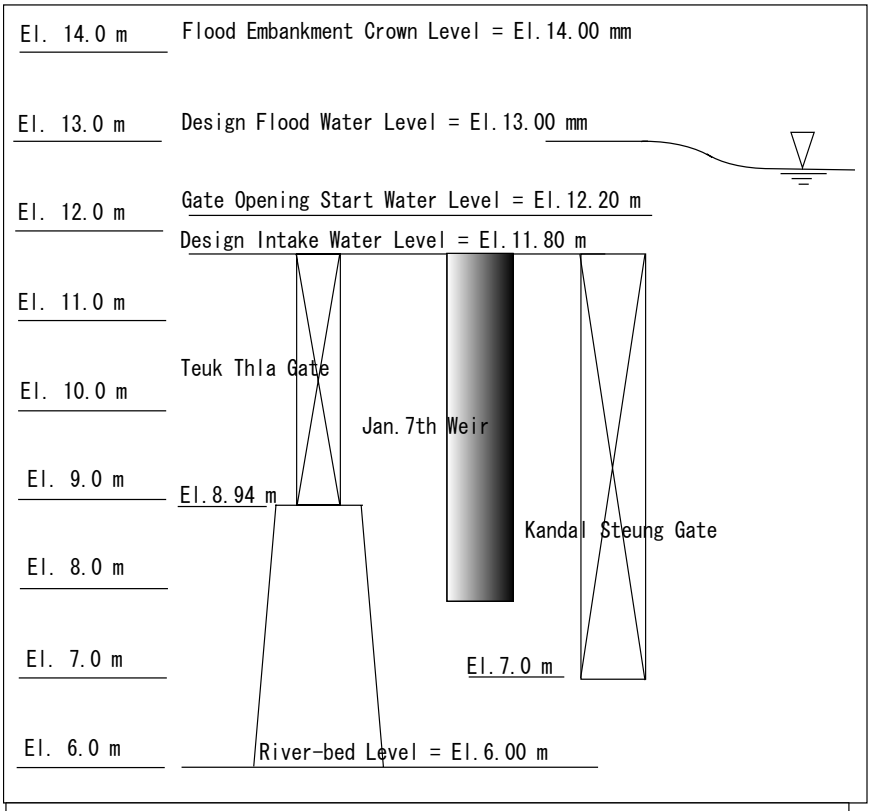
Basically, the opening of the gate commences when the water-level on the upstream side of the regulator rises higher than 7.3 m on the staff gauge, located on the upstream side of the regulator. This operation continues according to steps shown in the schematic diagram below:

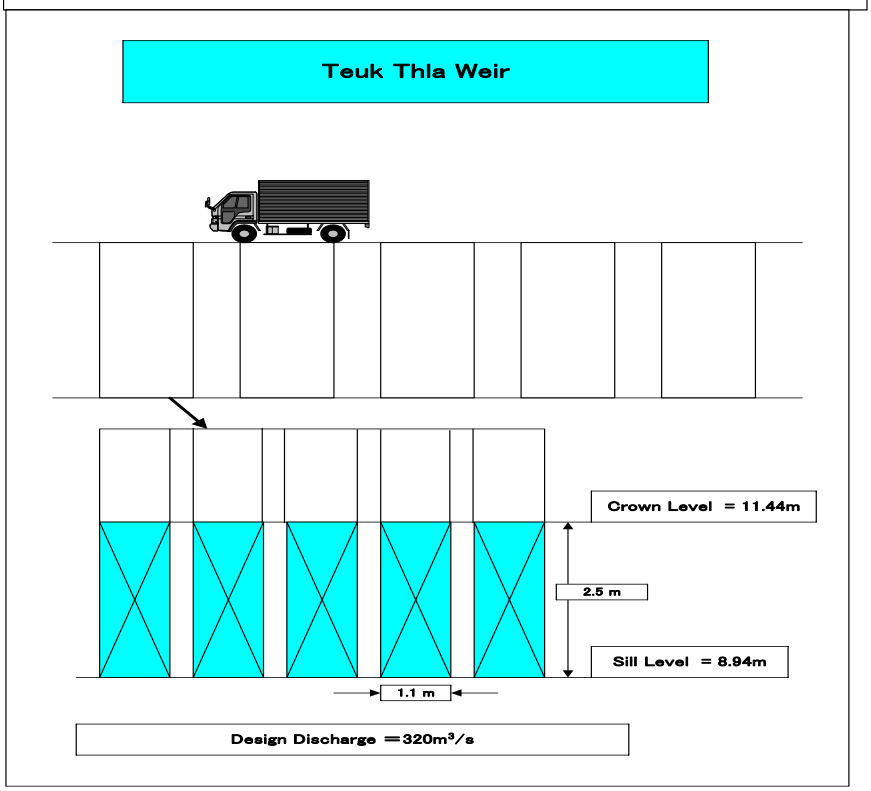


B-3.2.2 Present Gate Operation of Teuk Thla Weir

B-3.2.2.1 Key Dimensions of Teuk Thla Weir

Key dimensions of Teuk Thla Weir are shown in the following figures:



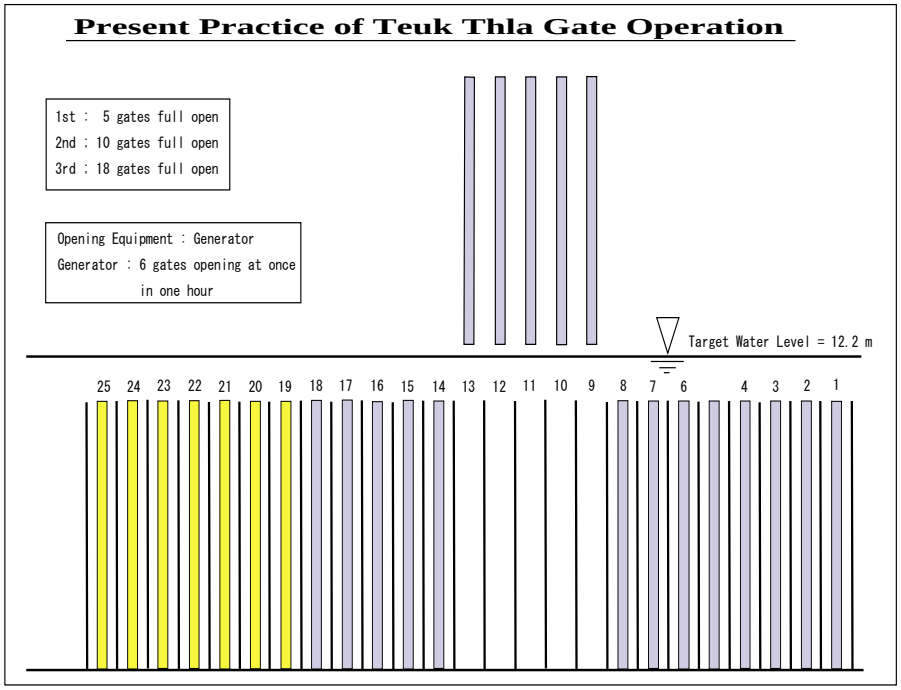


B-3.2.2.2 Present Practice of Gate Operation of Teuk Thla Weir

According to the operation and maintenance working group of Kandal Steung, the present practice of operating the gates of Teuk Thla Weir, during floods is presented in the

following.

Opening of the gate commences when the water-level on the upstream side of the weir rises higher than 12.20 m on the staff gauge, located on the upstream side of the weir. This operation continues according to steps shown in the schematic diagram below:

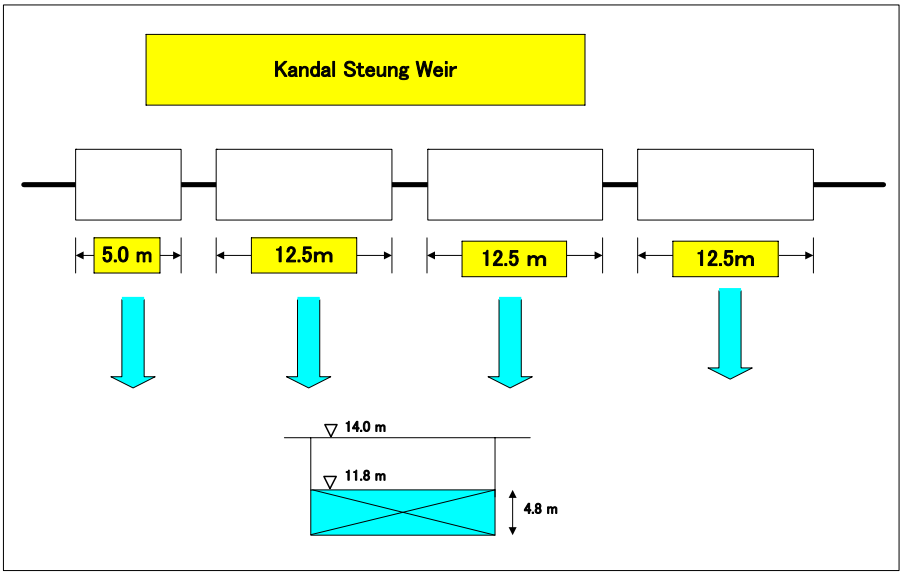


Teuk Thla Weir consists of 25 gates, where seven of which are not operational (remains in closed position) since November 2007.

B-3.2.3 Present Gate Operation of Kandal Steung Weir

B-3.2.3.1 Key Dimensions of Kandal Steung Weir

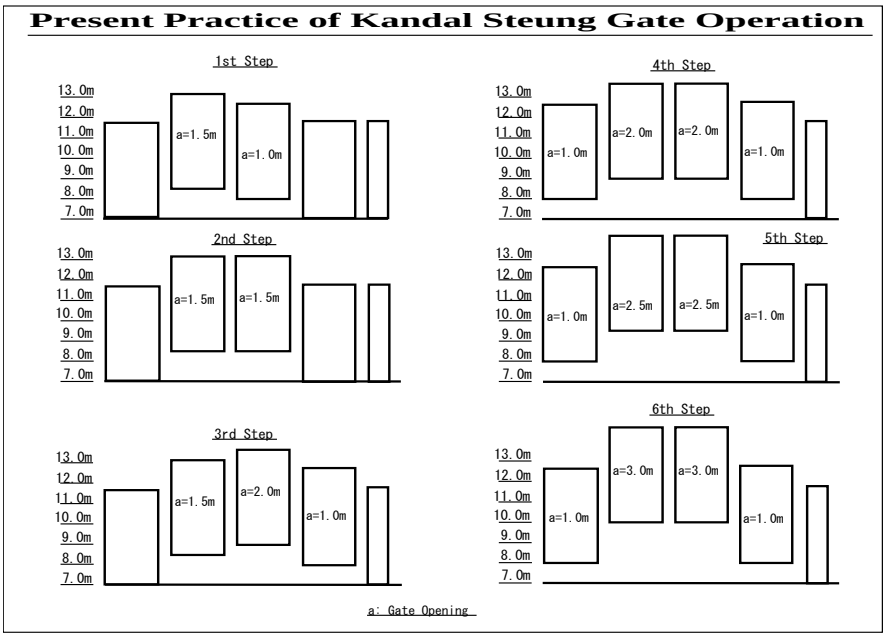
Key dimensions of Kandal Steung Weir are shown in the following figure:



B-3.2.3.2 Present Practice of Gate Operation of Kandal Steung Weir

According to the operation and maintenance working group of Kandal Steung, the present practice of operating the gates of Kandal Steung Weir during floods is presented in the following.

Basic operation of Kandal Steung weir is similar to that adopted for Teuk Thla Weir. However, steps for its gate opening is different as shown in the following figure:



B-3.3 Operation and Communication System

B-3.3.1 General

Operation and communication system is vital for smooth and appropriate operation of gates during flooding. This is presented in the following sections.

B-3.3.2 Operation System

Gates of Roleang Chrey Regulator is operated by one resident caretaker. He has been working at Roleang Chrey Regulator since 1969, excluding period from 1975 to 1978.

Gates of Teuk Thla Weir and Kandal Steung Weir is presently being operated by a resident operation and maintenance working group. The group is composed of six personnel, where two are officials from the Department of Irrigated Agriculture of MOWRAM, while four are officials from the Kandal province.

The operation system of Teuk Thla and Kandal Steung Weirs does not seem to be a problem.

For the Roleang Chrey Regulator meanwhile, operation system seems to be weak in terms of risk management. If the lone gate caretaker is suddenly unavailable during its required function, it is likely that severe damage to its gates will occur. Thus, formation of a working group at this site is more preferable.

B-3.3.3 Communication System

As mentioned in the chapter related to flood forecasting and warning, the flood information is conveyed form either the Peam Khley water-level caretaker or the gate caretaker of Roleang Chrey Regulator, to the concerned agencies, including the working group of Teuk Thla and Kandal Steung Weirs. The communication facilities include radio and/or a mobile-phone.

Presently, the information is conveyed when the discharge at said stations exceeds 600 m^3/s. According to the study result mentioned in said chapter, the traveling time of the flood from Roleang Chrey Regulator to Kandal Steung Weir site is around 13 hours. During the flood that occurred in the middle of August in 2006, in which the water-level was rising rapidly, a discharge of 90 m^3/s was observed 13 hours before exceeding the

600 m^3/s limit. Four hours later, the discharge rose to 130 m^3/s.

It takes around four hours to fully open all the gates of Teuk Thla and Kandal Steung Weirs, which were designed against a discharge of 560 m^3/s. Consideraing seven gates of Teuk Thla Weir that are presently not functioning, a discharge of 470 m^3/s can be accommodated during full opening of the other gate sites.

The flood travel time from Roleang Chrey Regulator to Kandul Steung Weir, is about 13 hours, which is sufficient enough for managing gate operations of weirs provided that communication system between gate operators is conducted efficiently. This indicates that, effective communication between the operators is vital to ensure efficient operation of the gates.

B-3.4 Observations on Gate Operation

B-3.4.1 Control Procedure of Gate Operation

As discussed above, the gate opening of all the weirs are conducted based on the water-level at the upstream side of the weir. When water-level rises higher than the maximum limit of the weir, its gates are opened to ensure that the specified limit is not exceeded.

The gate unit openings of Roleagn Chrey Regulator and Kandal Steung Weir.are either 0.5 m or 1.0 m. When specified water-level limit is exceeded only one gate is opened initially. If possible overflow still persists succeeding gates will be opened at a time until it is ensured that the specified limit is not exceeded.

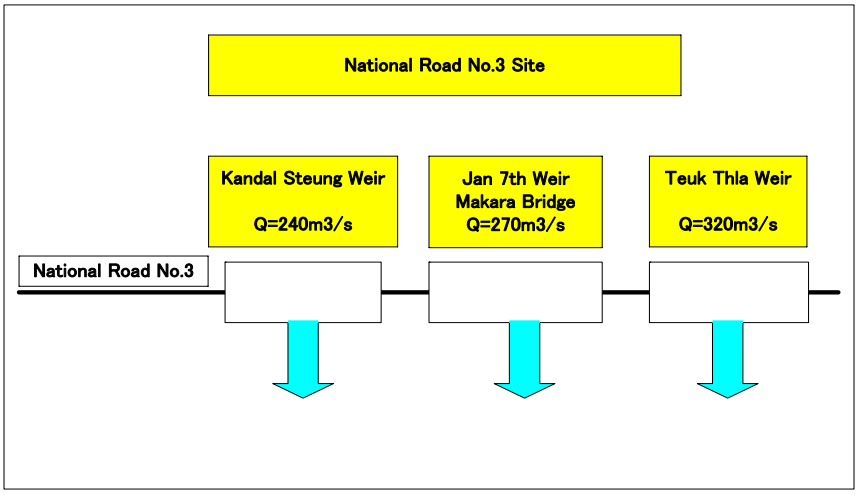
The Teuk Thla Weir, meanwhile consists of 25 gates, each with typical width of 1.1 m. The time required to fully open one gate is one hour. Since only one generator is available, only five gates can be opened simultaneously at one time. Considering this procedure, it will take more than 4 hours to full open all the gates of Teuk Thla Weir.

The opening sequence of the gate was determined based on consideration that the main flow is directed to the center of the river, to avoid river bank erosion in the downstream reaches.

This gate operation is not different from that of a standard gated weir. The procedure is supposed to ensure that scouring or erosion of river banks would not occur. However, the flow behavior of river during flooding is complex. Due to this, careful study should be carried out in relation to the present gate operation procedure, especially with regards to the 3rd step as shown in previous figure.

B-3.4.2 Discharge Allocation between Teuk Thla Weir and Kandal Steung Weir

The distribution of design discharges from Prek Thnot River to the weirs, near national road No. 3 is shown in the figure below:



Among above weirs, the Jan 7th weir is a fixed type without gate facilities. Thus, it will be necessary to consider the gate operation due to flood discharge distribution for both Kandal Steung Weir and Teuk Thla Weir only.

Basically it is preferable to allocate discharges at weirs in proper proportion of design flood discharge for Teuk Thala Weir and Kandal Steung Weir.

The gates of Teuk Thla Weir presently operated using a generator unit. The capacity of the generator allows simultaneous full operation of five gates at a time. Accordingly, the discharge flow with five gates fully opened is 64 m^3/s (320 m^3/s / 25 gates * 5 gates = 64 m^3/s).

The proportion of design discharge between the Teuk Thla Weir and Kandal Steung Weir, is 0.75 (250 m^3/s / 320 m^3/s = 0.75). Thus, when discharge at Teuk Thal Weir is 64 m^3/s, the discharge at Kandal Steung Weir is 48 m^3/s (64 m^3/s * 0.75 = 48 m^3/s).

The total gate opening of Kandal Steung Weir is roughly 24 m (6 m * 4 gates = 24 m), which accommodates 240 m^3/s. The estimated discharge per 1 m opening of gate is about 10 m^3/s (simplified calculation ignoring effect of hydraulic conditions).

The estimated required total opening of gates of Kandal Steung Weir to further accommodate discharge of 64 m^3/s from the Teuk Thla Weir is 4.8 m. This opening should be distributed to some gates to ensure that the flow is directed to the center of the river. The required gate opening of Kandal Steung Weir should be further adjusted based on the actual water-level on the upstream side of the weir.

B-3.4.3 Gate Opening Order between Teuk Thla Weir and Kandal Steung Weir

It takes about one hour to simultaneously open five gates of the Teuk Thla Weir, with the available generator. Meanwhile, the gate operation of Kandal Steung Weir, automated using electronic devices, is able to open a 0.5 m gate within about 20 minutes.

With the above circumstances, it is observed that the energy consumption is considerable when only the gates of the Teuk Thla Weir is operated to allow for excess discharge, while gate openings of Kandal Steung Weir is not utilized. It is therefore more preferable to simultaneously utilize operation of both weirs to optimize discharge control at the site.

Therefore, when the gates of Kandal Steung Weir are all closed, opening of gates of Teuk Thla Weir should not be conducted. The gates of Kandal Steung Weir should be opened to facilitate practical control of discharge flow through the weirs.

B-3.5 Recommendation

As stated earlier, seven of the gates of Teuk Thla Weir malfunctioned as November 2007. Furthermore, the operation of other gates was activated using a generator, with a capacity sufficient to simultaneously lift five gates in one hour. Consequently, it required more than 4 hours to open all gates and, due to floating sediments, another more than 4 hours for closing.

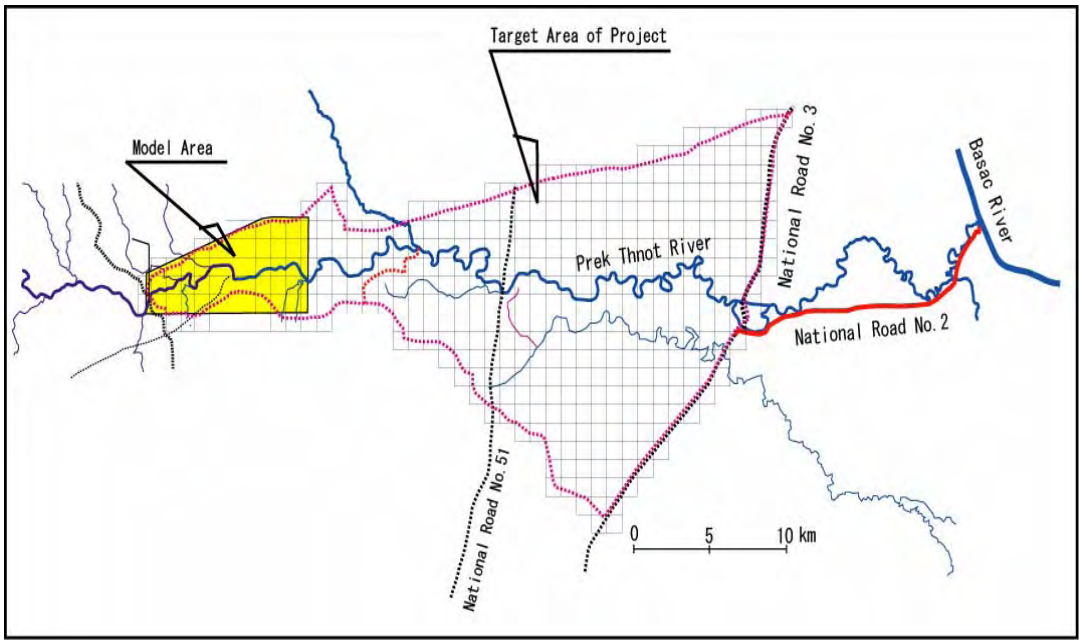
The inefficiency of the gate operations are due to the deterioration of the gates. Since Kandal Steung Weir is already constructed with electrical facilities to activate gate operation, it is therefore recommended that Teuk Thla Wier be reconstructed with the provision of similar electrical facilities for its operation. This is a more feasible measure to ensure efficient operation, rather than just implementing repairs of the malfunctioning gates.

Chapter B-4 Preparation of Probable Inundation Map

B-4.1 General

Probable inundation map of the target area of the present Project is prepared based on the non-uniform flow water-level calculation along the Prek Thnot River. This is the first step in preparing flood hazard map of the target area. The flood hazard map of the target area should be prepared in the future using an applicable computer software (similar to the one utilized for the preparation of the flood hazard map for the model area).

The following figure shows said target area and model area.



B-4.2 Methodology

Target area of the probable inundation area is divided into series of mesh scale of 250 m x 250 m. The inundation water-level is expressed as the average water-level in each mesh. The average inundation water-level in each mesh is expressed as the water-level of the Prek Thnot River at the same longitudinal location. This is because the basic inundation flow direction is from west to east. It is assumed that the water-level along the Prek Thnot River is horizontally equal in the direction north to south.

The water-level along the Prek Thnot River is determined by conducting a non-uniform flow water-level calculation.

B-4.3 Return Period

Based on earlier discussions in Chapter B-2, probable flood peak discharges at Peam Khley Bridge site are determined for return periods of 2, 5 and 10 years. This was used to calculate the non-uniform flow water-level.

B-4.4 Probable Inundation Map

Probable inundation map is prepared through the following steps:

(1) Non-uniform flow water-level calculation is conducted for each flood peak discharge of said return period

(2) Inundation water-level at each mesh is calculated with the assumption that the water-level calculated along the Prek Thnot River is the same for the north-south direction of the target area.

(3) The calculated water-level at each mesh is interpolated among meshes

(4) Thus interpolated inundation water-level at each mesh is converted to the inundation water-depth, using the average ground elevation of the mesh

(5) The meshes are colored with different shades to represent varying inundation water depth at each mesh.

(6) The probable inundation map is prepared for each return period of 2, 5 and 10 years.

The prepared probable inundation maps, shown in simplified formats, are attached with this report. The full format maps are separately prepared in A0 size sheets.

B-4.5 Recommendation

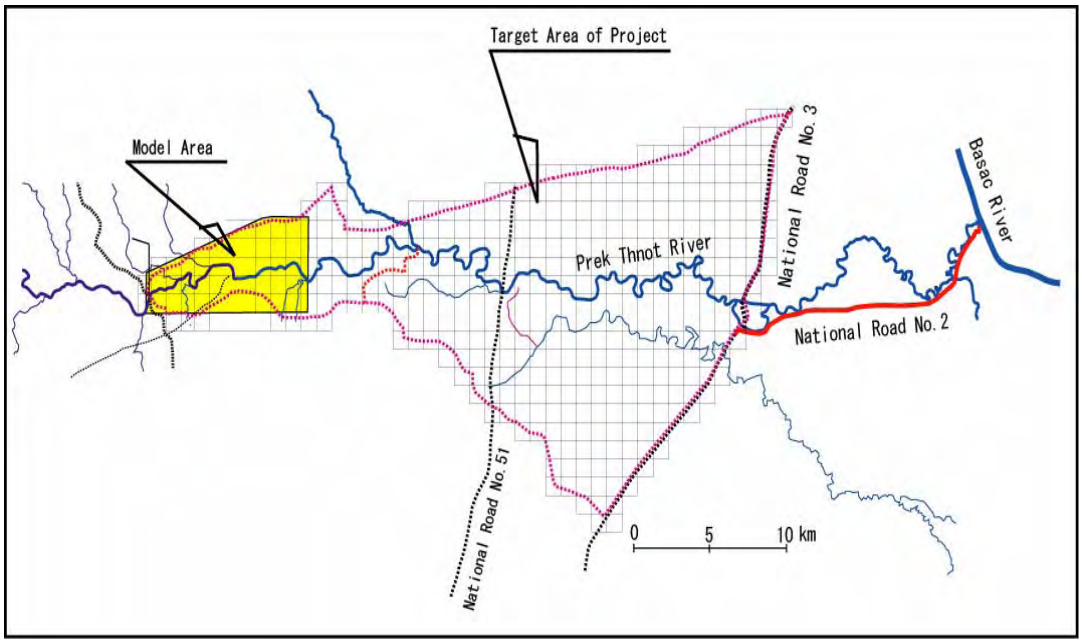
As mentioned above, the probable inundation maps in the target area of the present project have been prepared considering numerous assumptions. Hence these maps should be referred only as a general reference on the inundation in the area., Since the area is extensive for verification of the calculation results, assumptions have been adopted in the study to facilitate immediate preparation of the maps.

It is however recommended that if more accurate details are required in the future, probable inundation maps should be prepared using two-dimensional inundation calculation software, as earlier discussed.

Chapter B-5 Preparation of Flood Hazard Map

B-5.1 General

Flood hazard map is prepared for the model area in the target area. The model area is selected based on hydrological and hydraulic considerations as well as sociological considerations of the dense urban area of Kompong Speu Town. The location of the model area is indicated in figure in Chapter B-5.



B-5.2 Methodology

The inundation situation of the model area is prepared based on two-dimensional flooding calculation. The software used for the calculation is FLO-2D, one of the acceptable softwares in the United States. For the flooding calculation, the software requires that the model area be divided into series of meshes scaled 250 m x 250 m (similar to that adopted for the preparation of probable inundation maps).

The flood hazard map also considered 2-year, 5-year and 10-year return periods.

The inflow hydrograph of the said return periods for the inundation calculation are prepared based on the actual flood hydrograph recorded at Peam Khley Bridge site in 2006, with similar flood peak.

The inundation water-level is expressed as the average water-level in each mesh.

B-5.3 Calculation Conditions

For using the said FLO-2D software, the following major calculation conditions should be determined and prepared:

- Calculation area
- Mesh size in the area
- River channel characteristics
- Flood plain characteristics
- Inflow hydrograph

Details of above conditions are presented in the following sections.

B-5.3.1 Calculation Area

The calculation area filled with mesh is shown in the figure below:

B-5.3.2 Mesh Size in the Area

Each mesh is 250 m x 250 m. The number of generated meshes in the model area is 985.

B-5.3.3 River Channel Characteristics

River channel cross-sectional profiles and alignment are prepared based on the results of the river survey that was conducted in the first year of the study. Manning's roughness coefficients of river cross sections are those which were adopted in the non-uniform flow water-level calculation along the Prek Thnot River (discussed in previous chapters).

As mentioned earlier, there are many bank openings in the model area which are reflected at nearby cross-sections as low bank elevations.

B-5.3.4 Flood Plain Characteristics

The boundary of the flood plain is defined by the irrigation channel and the National Road No. 4 on the north and on the southern side, respectively. The flooding flow boundary lines meanwhile are naturally formed by the high ground elevation contour lines.

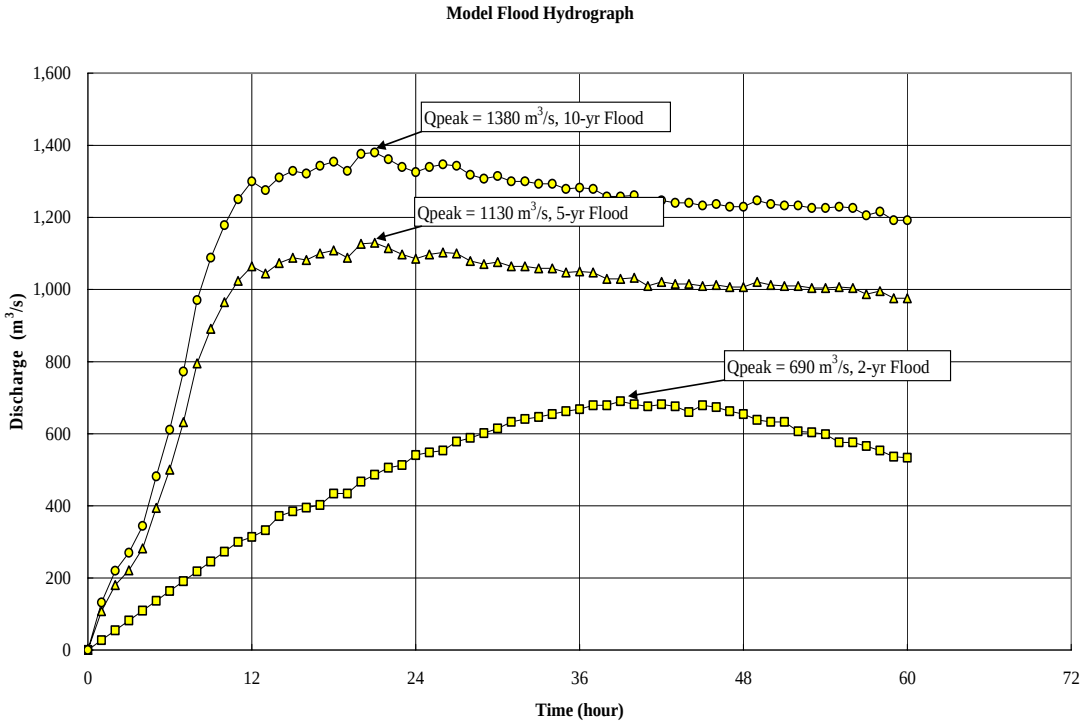
B-5.3.5 Inflow Hydrograph

Inflow hydrographs for the area are prepared for 2-year, 5-year and 10-year return periods. The inflow flood hydrographs are derived by multiplying the actual flood hydrograph recorded at Peam Khley with the ratio between the return period flood peak and actual flood peak.

It is assumed that the flood hydrograph at Peam Khley and that of the upstream end of the model area is nearly similar. This assumptioin is based on the runoff analysis of the Prek Thnot River. The following presents the plotted inflow hydrographs:

B-5.4 Calculation Results and Verification

Flooding calculations have been conducted considering the above conditions and the results corresponding to 2-year, 5-year and 10-year return periods. Since the flood in August 2006 was with a return period of between 5 and 10-years (the flood peak was 1,244 m^3/s), site reconnaissance has been conducted to verify the calculation. The inundation experiences of the residents have been collected through site interview with the residents. Though available time for verification was limited, the accuracy of calculation results was confirmed by actual experiences.



B-5.5 Flood Hazard Map

Flood hazard map should be provided at the evacuation centers and along the evacuation routes on the probable inundation map. According to experiences of the local residents, people are evacuated to nearby national road, temples, schools, public health centers, and other multi-storey houses in the neighborhood. The flood hazard maps showing only the possible evacuation centers and the evacuation routes, prepared under this project, is considered tentative. The provincial government should initiate finalization of the flood hazard maps, and identify fixed location of evacuation centers.

The results of the flood hazard map prepared under this study are shown in simplified format and attached to this report. Full format maps are prepared separately in A0 size sheets.

B-5.6 Recommendations

B-5.6.1 Evacuation Centers and Evacuation Routes

As mentioned above, the flood hazard maps prepared remains tentative and need to be finalized. It is recommended that the final decision regarding location of evacuation centers and the evacuation routes be determined through workshops with the provincial government and the local residents.

B-5.6.2 Verification

The inundation situation also needs to be further verified. Thus, it is recommended that site discussions with the residents be continued in the future during inundation situation in their area.

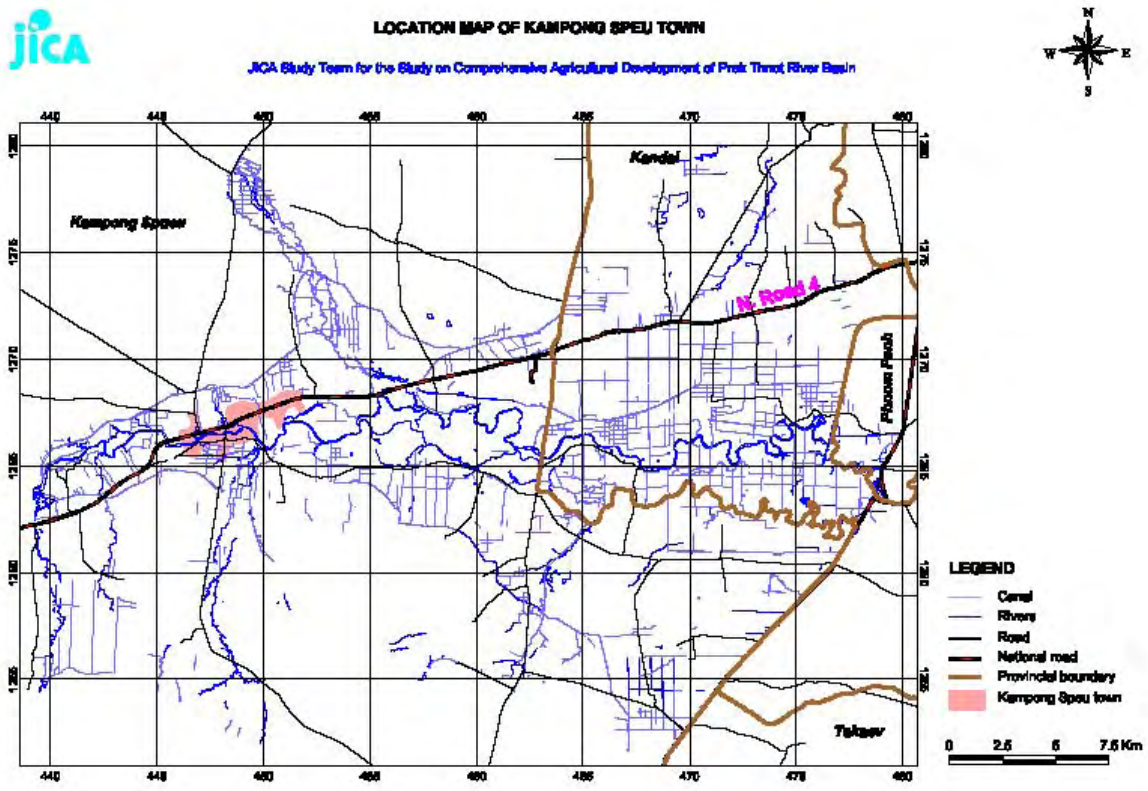
B-5.6.3 Objective Area

The flood hazard map has been prepared only for the model area of about 62 km^2. The entire target area is 1,052 km^2. It is recommended that flood hazard map for the entire target area be initiated.

Chapter B-6 Study on Flood Forecasting and Warning

B-6.1 General

The objective area of flood forecasting and warning presented in this undertaking, and shown in figure below, is Kompong Speu Town located in the western part of the target area.



B-6.2 Flood Forecasting

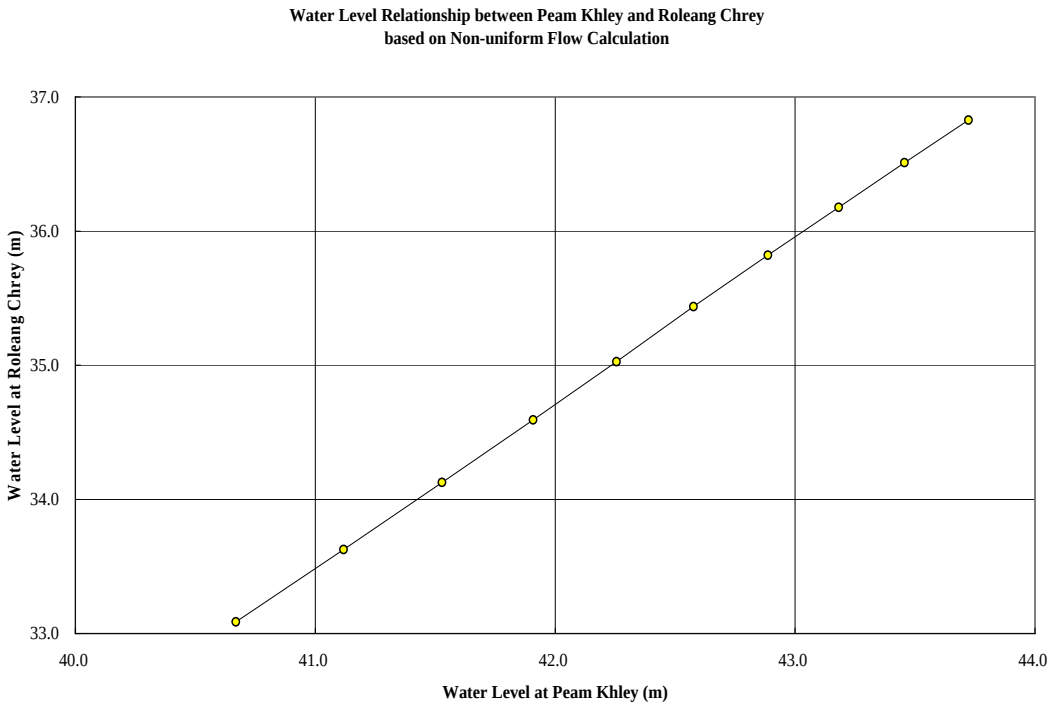
The objective area of flood forecasting; Kompong Speu Town, is located near downstream of Roleang Chrey Regulator and about 14.5 km downstream of Peam Khley Bridge.

Flood forecasting for Kompong Speu Town is conducted to cover the Roleang Chrey Regulator site.

B-6.2.1 Flood Forecasting with Water-level

Flood forecasting with water-level for Roleang Chrey Regulator is conducted considering the flood level at Peam Khley Bridge site. Other water-level gauging sites are located where major tributaries join the Prek Thnot River. The water-level correlation between gauging site and Roleang Chrey Regulator site is not satisfactory.

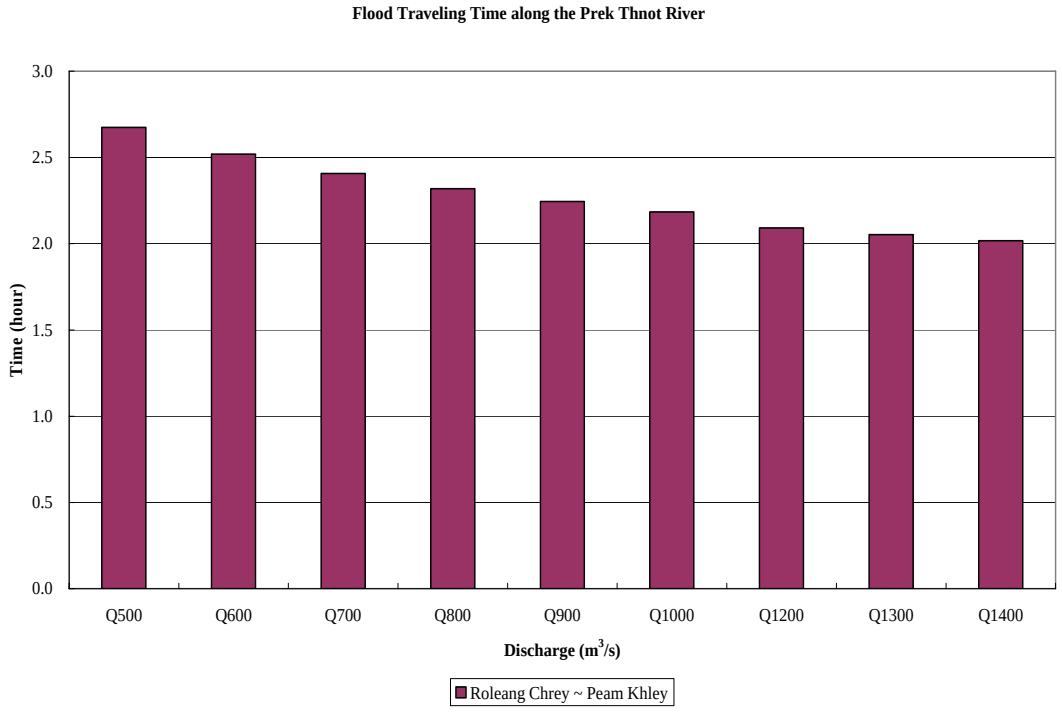
According to the non-uniform flow water-level calculation conducted in the section of river characteristics study, the water-level correlation at Peam Khley Bridge site and Roleang Chrey Regulator site is as shown in the figure on the next page;



Accordingly, the flood water-level forecasting using the flood level at Peam Khley Bridge is expected to be more accurate.

B-6.2.1.1 Flood Traveling Time

According to the non-uniform flow water-level calculation conducted in the section of river characteristics study, the flow traveling time between Peam Khley bridge and Roleang Chrey Regulator is as shown in the following figure:



As shown above, the flood traveling time is around two hours from Peam Khley Bridge to Roleang Chrey Regulator.

B-6.2.2 Flood Forecasting with Rainfall

Since the flood traveling time from Peam Khley Bridge site to Roleang Chrey Regulator site is only two hours, the possibility of flood forecasting with rainfall has been studied.

In the Prek Thnot River basin, ten hourly rainfall automatic gauging stations have been installed with under the Study. Among these, seven stations are located in the upstream basin of Roleang Chrey Regulator. Examination of correlations between the water-level at Peam Khley and hourly rainfall at those gauging stations has been conducted. For purposes of study, three typical floods in 2006 as mentioned in the chapter for runoff model study have been used.

B-6.2.2.1 Flood Forecasting with Rainfall at Kirirom

Through the above-mentioned study, 48-hour accumulative rainfall at Kirirom rainfall gauging station has been found to have satisfactory correlation with the water-level at Peam Khley after 24 hours.

The correlation can be expressed as below:

$$Q = 200 + 4.924 \times R$$

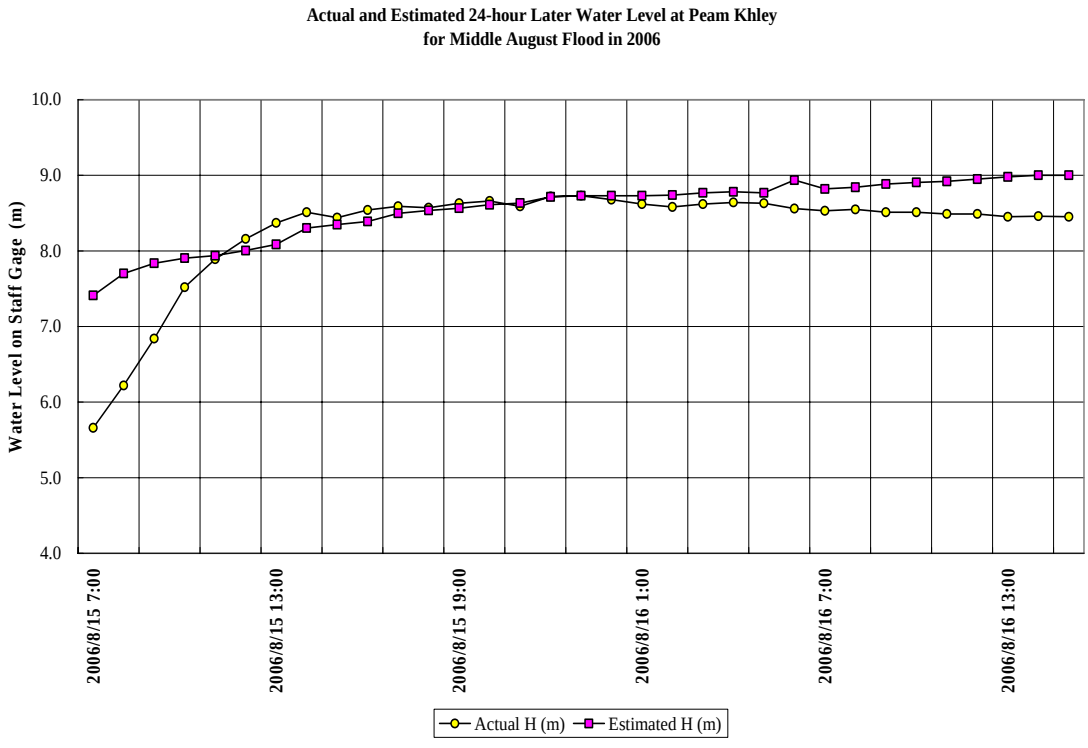
$$H = 1.227 + \sqrt{\frac{Q}{22.097}}$$

For Q > 430 m^3/s

Here, *Q: 24-hour later discharge at Peam Khley (m^3/s)*
R: 48-hour accumulative rainfall at Kirirom (mm)
H: 24-hour later water-level at Peam Khley (m)

B-6.2.2.2 Correlation of Water-level at Peam Khley and Rainfall at Kirirom

The following figure shows the relationship between the actual water-level and estimated water-level at Peam Khley. This is based on the actual flood peak of about 1,244 m^3/s that occurred in the middle of August 2006.



As shown in the above figure, the estimate error is about 10 ~ 20 cm of the flood peak time. The estimation at Peam khley Bridge site can be done 24-hours ahead. Consequently, the forecasting at Roleang Chrey Regulator site can be done about 26-hours ahead.

B-6.2.3 Flood Forecasting Network

Presently flood forecasting at Mekong, the Tonle Sap and the Bassac Rivers is conducted by the flood forecasting center of MOWRAM. Using a telemeter system, the information necessary for flood forecasting is transmitted to the center by the caretakers of water-level gauging stations along the rivers.

The flood forecasting of the Prek Thnot River will also be conducted through the said center. The flood forecasting of the Prek Thnot River is will be intended for the water-level at Peam Khley Bridge site Presently this information is reported using a mobile phone or ICOM (high frequency radio as shown in the right photo) to the chief of Kompong Speu PDOWRAM and the caretakers of Roleang Chrey Regulator and Kandal Steung Weir & Teuk Thla Weir.

High frequency radio.

This information about the water-level at Peam Khley Bridge site should also be reported to the flood forecasting center of said Ministry. In this case, no additional facilities and equipment would be needed.

When the flood forecasting of the Prek Thnot River is to be conducted based on rainfall at Kirirom, additional equipment and facilities such as telemeter device would be needed for data transmission to the flood forecasting center.

B-6.3 Flood Warning

B-6.3.1 Present Practice on Flood Warning of the Prek Thnot River

Presently, it takes three days to disseminate the forecasted water-level to related agencies and objective 40 villages. This is done through mass-media, by witnessing the height on leveling staff installed in villages.

On the Prek Thnot River meanwhile, since no flood forecasting system is established, water-level information is reported to the related personnel and agencies without any forecast information.

B-6.3.2 Basic Site of Flood Warning

The basic site of flood warning should be the Roleang Chrey Regulator located just upstream of the objective area of Kompong Speu Town. The flood water-level forecast could be conducted based on the upstream water-level or rainfall at Kirirom.

However, the flood water-level forecast and warning at each community is still not possible since the data accumulation remains insufficient. Therefore, inundation water-level at each community should be collected after each flooding event and accumulated for future analysis.

B-6.3.3 Network and Dissemination of Flood Warning

Through mobile phone or high-frequency radio, the flood information at Prek Thnot River is presently transmitted to the following agencies:

- Central Government (Cabinet, Minister, MOWRAM)
- Provincial Government (Governor, PDOWRAM)

- Disaster Management Committee
- Red Cross Committee of Province
- Police, Army
- Television and Radio stations

Food warning of the Prek Thnot River is also disseminated through the same network.

B-6.4 Recommendation on Flood Forecasting and Warning

The tentative flood forecasting and warning system presented herewith has been proposed based on the flooding history in 2006.

The upgrading of the system needs to be conducted based on a more hydrological data accumulation in the future. Continuous efforts are expected to determine better options than the proposed.

Chapter B-7 Hydrometeorological Observation Plan

B-7.1 Proposed Observation Structure

The rainfall observation in the Prek Thnot River basin has been conducted using an ordinary rainfall gauge. The water level observation has been conducted by reading twice daily (7:00 a.m. and 7:00 p.m) the water level on the staff gauge. These have been conducted by a caretaker at each gauging site. The obtained data have been reported to PDOWRAM through the district office.

Since the new rainfall and water level gauging stations with data loggers have been established in the basin, the present practice of observation and reporting is superseded. The recorded data should be downloaded on a computer as input for analysis to determine the hourly rainfall and water level data. This process which should be continued in the future, will be performed by the pivotal staff of DHRW. The collated rainfall and water level data should finally be sent to PDOWRAM in reverse.

The activity of data collection and data processing should be gradually shifted to PDOWRAM for purposes of budget preparation and their capacity building.

Meanwhile, the discharge measurement at the water level gauging station sites, were conducted by a firm sub-contracted by the study team, during the Study. This should however be conducted by PDOWRAM in the future.

B-7.2 Observation Method, Procedure and Manual

The operation methods and procedure for configuration of the data loggers and consequent downloading of recorded rainfall and water level data were provided by the equipment manufacturers. The operation and procedure for organizing the downloaded files and method of drainage measurement are all presented in the manual, submitted to MOWRAM. It is suggested that the frequency of downloading be conducted at least once in three months in consideration of data file size in the logger, and the arrangement procedure. During the rainy season, since the rainfall amount in some cases is expected to be more than 100 mm per day, it is suggested that the downloading be conducted at least once in two months. It should be kept realized that the downloading can not be done in the field during rain and or thunderstorms, thus, planning for data downloading should be considered.

Chapter B-8 Technology Transfer under the Study

B-8.1 General

Technology transfer on hydrology has been conducted to concerned staff of MOWRAM under the Project.

This was accomplished through the on-the-job-training and workshop or seminar.

The following is the detailed description on the technology transfer conducted:

B-8.2 Technology Transfer Activities

B-8.2.1 Arrangement of Rainfall Data

In the Prek Thnot River basin, automatic rainfall gauging stations have been constructed and the recorded rainfall data have been periodically downloaded to a computer. The downloaded data file however is not presented in a tabular form needed for hydrological study. The data text file is as shown below:

695
51027123752
60111165519

51028044734
51028045315
51028045738
51028050157
51028050724
51028051114
51028051515
51028051925
(to be continued)

The first line indicates the number of data recorded in the file. The second line denotes the date and time when the recording started while third line is the date and time the recording ended. The succeeding lines, indicate the rainfall data and date and time of recording the data.

As an example, the succeeding digits 51028050157 means rainfall of 0.5 mm was recorded in the year of 2005, on its 10^{th} month, 28^{th} day, at 05 o'clock, 01 minute, and 57 seconds. Sorting this data manually will take time, thus, an excel file with a Visual Basic Application Program has been prepared to facilitate organizing of the data.

The software has been prepared and submitted to counterparts of MOWRAM. Transfer of knowledge through training on how to use the software have also been conducted.

B-8.2.2 Site Reconnaissance on Flooding

Based on the cross-sectional profiles of the Prek Thnot River, it was found that the discharge carrying capacity of the Prek Thnot River near the estuary to the Bassac River is insufficient. Site reconnaissance was conducted together with the MOWRAM counterparts to identify the reason.

According to the local resident near the estuary, they had never experienced any flooding in the past. The discussions were intended to clarify the situation, since the target area is subjected flooding frequently in the past.

It was finally determined that a wide flood retarding basin is located in the upstream of the estuary urban area. Moreover, it was found that the Prek Thnot River bifurcates to the Prek Ho Channel in the reaches of the retarding basin, and that a flood relief channel had been completed in 2003, just upstream of said channel.

Future flooding situation near the downstream reaches of Prek Thnot River was also studied in detail. The land area near its upstream portion may be sold and developed. It was realized that part of the anticipated development includes construction of embankment, which will affect flood behavior and eventually cause serious flooding downstream. This anticipated situation of Prek Thnot River should also be realized by the concerned parties at this early stage.

B-8.2.3 Site Reconnaissance for Flood Hazard Map

For preparation of flood hazard map, two-dimensional flooding calculation has been conducted using FLO-2D software. Calculation results however should be verified in the field based on actual flooding experience. For this purpose, the site reconnaissance and interviews with the local residents were conducted together with the counterpart team. Other than this, evacuation centers and evacuation routes should also be surveyed in the field to finalize the flood hazard map. These activities were included in the on-the-job-training sessions for the preparation of flood hazard map.

B-8.2.4 Workshop

Presentation and discussion on the hydrological study results were conducted in the middle of December 2007, and were included in report. The following is a photo taken during the workshop.

Presentation on the Workshop

B-8.2.5 Seminar

A seminar regarding the use of FLO-2D software (two-dimensional flooding calculation) for preparation of flood hazard map was held for 3 days for the staff of related agencies of MOWRAM, at their conference room.

Due to the limited schedule of related agencies, the presentation seminar was held for only three days. Nevertheless, the basic knowledge on how to utilize the software was imparted to the participants. The original software was already submitted to the counterpart agency in MOWRAM.

Seminar on Use of FLO-2D Software

PART-C

ENVIRONMENTAL MANAGEMENT BASIC CAPACITY STRENGTHENING

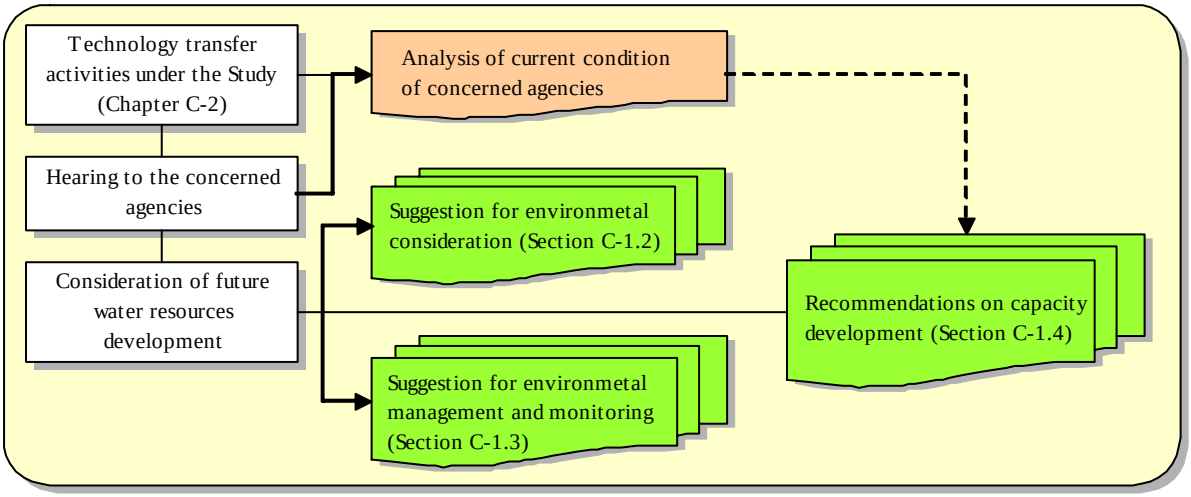
Public seminar held in Zone-1

PART-C: ENVIRONMENTAL MANAGEMENT BASIC CAPACITY STRENGTHENING

This PART-C consists of two chapters:

The Chapter C-1: ENVIRONMENTAL CONSIDERATION FOR WATER RESOURCES DEVELOPMENT describes suggestions from the environmental view point in the case of water resources development project. In planning and implementing the water resources development project in the future, it is clearly necessary to consider and implement environmental considerations, management and monitoring from the design phase up to the construction and operation phase by the executing ministries, i.e. the Ministry of Water Resources and Meteorology (MOWRAM) and the Ministry of Agriculture, Forestry, and Fisheries (MAFF). In this chapter, the noteworthy items pertaining to the following are described i) Environmental considerations for water resources development and ii) Environmental management and monitoring planning after the implementation of the water resources development project.

The Chapter C-2: TECHNOLOGY TRANSFER UNDER THE STUDY presents the records, results and evaluations of technology transfer activities which were conducted from January 2006 to July 2007 under the study. The technology transfer activities included two kinds of activities: a) technology transfer on environmental impact assessment (EIA) through workshops conducted six times with counterparts from MOWRAM and MAFF, and b) technology transfer on environmental management and monitoring (EMM) through three-day workshops, not only with counterparts from MOWRAM and MAFF, but also with counterparts from PDA and PDOWRAM of Kampong Speu Province. The description of each workshop is presented in Attachment-2 including the (i) outline of the session, (ii) participation list, and (iii) results.



Contents of PART-C

Chapter C-1 Environmental Considerations for Water Resources Development

C-1.1 General

Under the Study, the development of new water resources was not taken into account. However, current water shortages in the Prek Thnot River basin, periodical flooding and rapid population growth around the area indicated the importance of mid- and long-term planning of water resources development. In planning and implementing the water resources development project, it was necessary for the executing ministries, i.e. MOWRAM and MAFF, to consider environmental factors and to manage and monitor the relevant environmental conditions from the planning phase to construction and O&M phase. In addition, through the activities under the study, it became clear that although

environmental management, and monitoring, they have had less experience and knowledge about those so far.

As a result, it was decided to suggest the following two topics to the Cambodian government:

(1) Environmental consideration for water resources development (described in Section C-1.2)

(2) Environmental management and monitoring planning during O&M phase of water resources development (particularly for irrigation area located downstream) (described in Section C-1.3)

In addition, the result of the evaluation of their current capacities indicated the need for capacity development of the executing agencies, i.e. MOWRAM and MAFF (described in Section C-1.4).

C-1.2 Environmental Consideration for Water Resources Development

As mentioned above, environmental considerations should be given proper emphasis by the executing agencies in the planning and implementation of the new water resources development project. In this section, general suggestions for environmental considerations required for the project are discussed based on the following two issues;

- Noteworthy procedure for environmental consideration under the process of planning and implementation of water resources development project (checklist for scoping, public participation/consultation and information disclosure, mitigation measures)
- Special instructions on land acquisition/ involuntary resettlement

C-1.2.1 Environmental Consideration Procedure

Checklist for scoping of environmental consideration items

In the implementation of the water resources development project, it was important for the executing agency to identify environmental consideration items which had the potential to cause negative impacts on the social and natural environment. The impact of each item could be predicted by utilizing collected data, project design, and considered mitigation measures to be implemented.

The conceivable negative impact during the design, construction, and O&M phases of the water resources development project are shown in the table in the next page so that it can be utilized as a checklist for scoping of environmental consideration items related to the water resources development project.

The following are prior conditions for the development of the checklist for scoping:

- The project was assumed to be a water resources development project, which includes the construction of a dam, reservoir, installation of a gate in the river, and construction of canals
- The project area was assumed to be around the study area or similar environmental area of the study area. (The current condition of the environment in the study area was assumed based on the results of site visits and data collection conducted in the first and second year of the study.)

The purpose and usage of the checklist for scoping are as follows;

- To provide a tool for scoping of environmental consideration items in order to extract conceivable negative impacts and mitigate them as much as possible at the design, construction and O&M phases.

It should be noted that the checklist is a general one for water resources development projects. In order to grasp the framework of environmental items for prediction, the executing agencies should consider each of the items based on each situation and contents of the project by utilizing collected data and project designs.

Checklist for Scoping of Environmental Consideration Items

	Design	Construction	Operation
Social Environment			
Involuntary resettlement	- Land acquisition, involuntary resettlement by construction of dam, reservoirs, canals, etc	—	- Reduction in the quality of life of the affected people, or threats on their lives - No participation of the new community
Local economy (employment, etc)	—	- Limitation of agricultural/fishing activities due to the limitation of water usage from rivers/canals	- Economic disparity among the people - Change of local economic situation - Regional area disruption
Land use and utilization of local resources	—	- Land acquisition	- Deforestation
Social institutions	—	- Limitation of accessibility on social institutions like schools, markets, pagodas, and water sources due to the construction work	- Limitation of accessibility on social institutions like schools, markets, pagodas, and water sources due to the new constructed structure
Existing social infra-structures and services	—	- Limitation of accessibility on social infrastructures and services like hospitals due to the construction work	- Limitation of accessibility on social infrastructures and services like hospitals due to the new constructed structure
The poor, indigenous and ethnic people	—	—	- Reduction in the quality of life of the poor, indigenous and ethnic people or threats on their lives
Misdistribution of benefit and damage	—	—	- Economic disparity among the people
Cultural heritage	—	- Removal or relocation of cultural heritage like pagodas	—
Local conflict of interests	—	- Local conflict among farmers by improper management of the water usage	- Local conflict among farmers by improper management of the water usage
Water usage	—	- Limitation of water usage during the construction phase (ex. draining of water from canals)	- Disparity of water usage conditions among the people because of the improper management of water
Sanitation	—	- Degradation of sanitary conditions due to the inflow of construction workers	- Degradation of sanitary conditions due to population increase or relocated people
Hazards (Risk), Infectious diseases	—	- Degradation of security, increase of hazards due to the inflow of construction workers	- Spread of water-borne diseases due to the expansion of the water surface area
Natural Environment			
Topography and geographical features	—	—	- Negative impact on topography and geographical features due to the existence of constructed structures like dams and reservoirs - Slope failure
Soil erosion	—	—	- Soil erosion by change of water flow
Groundwater	—	—	—

	Design	Construction	Operation
Hydrological Situation	—	- Change of hydrological situation due to the construction work	- Change of low flow regime of the river substantially - Change of flood regime of the river substantially as a result of changes in abstractions, retention storage, reservoir releases, flood protection works, new roads, river training or surface drainage works.
Flora, Fauna and Biodiversity	—	- Negative impact on the aquatic ecosystem due to the low pH-water, turbid water caused by construction work - Negative impact on flora, fauna and ecosystem due to land change and construction work	- Change of aquatic ecosystem by flow regime change - Negative impact on the aquatic ecosystem due to the increase of water contamination caused by agricultural activities and so on
Meteorology	—	—	—
Landscape	—	—	- Change of landscape because of the constructed structures
Global Warming	—	—	—
Pollution			
Air Pollution	—	- Dust from unpaved roads by construction vehicles - Exhaust of emission gas by construction vehicles and construction machinery	—
Water Pollution	—	- Low pH-water problem triggered by the concrete works - Generation of turbid water by construction work	- Generation of turbid water by the reservoir or dam -Conversion of water temperature in the reservoir or downstream - Eutrophication and decrease of dissolved oxygen in the reservoir - Increase of nutrient load/ chemical contamination due to the increase of the fertilizers/agrochemicals in the agricultural lands
Soil Contamination	—	—	- Soil contamination due to agricultural activities (input of fertilizer, agrochemicals, etc)
Waste	—	- Disposed soil generated by excavation - Increase of water from construction workers	- Increase of water because of population increase
Noise and Vibration	—	- Noise and vibration caused by the movement of heavy equipment	—
Ground Subsidence	—	—	—
Offensive Odor	—	—	—
Bottom sediment	—	—	- Earth deposition in the reservoirs due to inflow of earth and sand - Sedimentation in the backwater section
Accidents	—	- Accidents caused by construction machinery and vehicles	—

Public Participation/Consultation and Information Disclosure

Water resources development projects have significant impacts on the local population. While the aim is to improve the welfare of the people, a lack of understanding of the people and their society may result in a development that has considerable negative consequences. More significantly, in case that the project may require land acquisition or involuntary resettlement, the executing agency should understand the real feelings of the people. If not, it may cause divergence between national economic interests and those of the local population. To prevent this, public participation/consultation in the planning process is greatly essential. On the other hand, the sub-decree on EIA does not specify the implementation of public consultations and information disclosures. In fact, there are no clear rules about how to involve the public and process of information disclosure in Cambodia so far.

Key aspects for the implementation of public participation/consultations and information disclosures are as follows;

(1) Implementation of stakeholder analysis

It is significant to grasp the range of stakeholders related to a project and its depth of relation at the beginning of the project design phase. The range of stakeholders is likely to include the local people, farmers, private sector, FWUC/FWUG/Farmers Organization, experts on local culture/society (NGOs), religious groups, and central/local government bodies.

The stakeholder analysis is a tool to identify all groups that have direct and indirect interests in the project and its potential impacts on them (magnitude of the impact) and their power of statement in the society. It is important to identify the stakeholders and the potential project impacts on them. It is also important to evaluate their concerns and needs, and their ability to understand and influence the decision-making at the project preparation stage. Moreover, the most cautious group should be identified which is significantly- impacted by the project with no power and influence to the society.

In order to conduct a stakeholder analysis, socioeconomic and cultural information should be collected. Social analysis should also be conducted in identifying stakeholders, their needs, aspirations, and concerns regarding the project by household level socioeconomic data, information on ethnic mix and interactions, cultural traditions, gender profile in socioeconomic activities, mechanisms for decision-making regarding their environment, and experience with similar projects. It is useful to rank the expectations, concerns and needs of different groups of project-affected persons. It is also important to determine how their diverse interests would impact on the project outcome.

(2) Planning and budget allocation for public participation/consultation and information disclosure

Planning a series of activities for public participation/consultation and information disclosure should be developed as a first step. Based on the developed plan, a requisite budget should be considered to be allocated. These activities require time and money.

(3) Consideration of participation method and its level

One of the important matters of public participation activities is that stakeholders can feel themselves as the main players of the project in cooperation with the executing agency. Therefore, when public participation activities are planned, the participation method and its level have to be considered in advance by the executing agency and social experts.

The participation method includes the time/venue of the public meeting, process of invitation, method of communication, collection of public comments, and consensus building method among the public and the executing agency. In addition, participation level means the decision by public consensus is reflected in the project design. These

kinds of matters have to be decided in advance by the executing agency and social experts.

(4) Invitation to environmental NGOs

There has been an enormous increase in the number of environmental NGOs throughout the world. Such organizations often bring environmental issues to the attention of the local press. However, this should not deter participation with the process of public participation/consultation. It should be open and positive with the aim of making improvements. Relevant NGOs should be identified at first and they should be invited in the process of public participation/consultation in order that their experience and technical capacity be put to good use.

Consideration of Mitigation Measures

It is quite important for the executing agency to consider mitigation measures in order to avoid/mitigate negative impacts on the environment at the design phase. Getting anticipated impacts into mind, each impact should be mitigated by proper measures as much as possible. However, sometimes the costs for the protection of the environment by the mitigation measures might involve a huge amount. The value itself and balance between the costs and magnitude of negative impact on environment should be taken into consideration when practical actions for mitigation are considered.

The following table shows the assumed mitigation measures towards the potential impacts during the design and construction phases of the water resources development project.

Potential Impacts and Possible Mitigation Measures

Potential Impacts	Impact cause/ severity	Assumed mitigation measures/ Monitoring method	Action time*
Involuntary resettlement	- Land acquisition, involuntary resettlement caused by the construction of dams, reservoirs, canals, etc	- Design of the project in order to minimize involuntary resettlement as much as possible. - Cooperation with the Inter-ministerial Resettlement Committee (IRC) and identification and compensation evaluation of the entitled property affected adequately - Complete socioeconomic surveys and census of people affected early in the project design phase - Relocation and compensation of all affected people - Follow-up program for enhancement of living standards	Des
Limitation of water usage for domestic	- Limitation of water usage (by draining of water from canals, etc)	- Stakeholder meetings at the design phase in order to discuss and obtain consensus of construction schedule and methods. - Construction at dry season (avoidance of rainy season because of paddy season) - Regular public meetings.	Des, Cons
Limitation of economic activities	- Limitation of agricultural activities - Limitation of fishery due to the limitation of water usage	- Stakeholder meetings at the design phase in order to discuss and obtain consensus of construction schedule and methods. - Construction during the dry season (avoidance of rainy season because of paddy season) - Decide construction schedule in consideration of egg production of the species and fishery timing (avoidance of rainy season) - Regular public meetings.	Des, Cons
Decline of accessibility	- Decline of accessibility to schools, hospitals, markets, pagodas, water sources and so on	- Installment of temporary bridge based on people's request. - Regular public meetings.	Des

Potential Impacts	Impact cause/ severity	Assumed mitigation measures/ Monitoring method	Action time*
Impact on cultural heritage	- Removal or relocation of cultural heritage like pagodas	- Consideration of project design in order to avoid cultural heritage areas as much as possible	Des
Deterioration of sanitation condition, increase of risk of diseases	- Degradation of sanitation conditions and increase of risk of diseases due to the inflow of construction workers - Spread of infection due to the inflow of workers	- Improvement of sanitary conditions of workers (accommodation, toilet, water supply, etc). - Implementation of an educational program for workers. - Periodical patrol	Cons
Impact on ecosystem	- Negative impact on the aquatic ecosystem by low pH-water, turbid water due to the construction work	- Consideration of project design in order to avoid the significant seed/gregarious plants - Transplanting the significant seed/gregarious plants for conservation, and replanting to the original position after construction phase	Des, Cons
	- Negative impact on flora, fauna and ecosystem due to land change and construction work	- Consideration of project design in order to avoid the significant seed/gregarious plants - Transplanting the significant seed/gregarious plants for conservation	Des, Cons
Air pollution	- Dust from unpaved roads by construction vehicles	- Regular watering for unpaved road - Regular washing of vehicle tires	Cons
	- Exhaust of emission gas by construction vehicles and construction machinery	- Prevention of intensive construction - Stop idling at useless time	Des, Cons
Water pollution	- Low pH-water problem triggered by the concrete works	- Installation of adequate treatment system for alkalified water (ex. installation of water tank collecting water from concrete work for neutralization)	Cons
	- Generation of turbid water due to the construction work	- Installation of grid tank at dam body, construction of roads, relevant facilities, etc	Cons
Generation of construction waste	- Disposed soil generated by excavation	- Effective utilization of surplus soil in and around the project area. - Establishment of soil disposal site far from residence area or river.	Cons
	- Increase of water from construction workers	- Educate construction workers	Cons
Noise and vibration	- Noise and vibration caused by movement of heavy equipment	- Limitation of construction time. (e.g. at daytime only) - Prevention of intensive construction - Public meetings to obtain consensus about the construction time with surrounding people.	Cons
Increase of accident	- Accidents caused by construction machinery and vehicles	- Appropriate maintenance of machinery and vehicles - Imposition of disciplines for safety operation. - Periodical check	Cons

Note) Des; Designing Phase, Cons; Construction Phase*

C-1.2.2 Land Acquisition/ Involuntary Resettlement

As described in the above checklist, water resources development projects have the potential to make negative impacts on the environment. Under these potential impacts during both the design and construction phases, noteworthy topics which should be paid close attention by the executing agency are chosen for suggestions. These topics are land acquisition and involuntary resettlement.

Water resources development projects that might change patterns of use of land, water, and other natural resources will cause a range of land acquisition and/or involuntary resettlement. Productive assets including land, income sources and livelihoods will be lost.

Cultural identity and potential for mutual help may be diminished. Loss of resources for subsistence and income may lead to exploitation of fragile ecosystems, hardships and impoverishment. To ensure that some people are not disadvantaged in the process of development, it is necessary to avoid or minimize resettlement effects at first. If resettlement is unavoidable, the executing agency of the project should help restore the quality of life and livelihoods of those affected. There may also be opportunities to improve the quality of life, particularly for vulnerable groups. During the resettlement process, great sensitivity should be conducted very carefully from the design phase.

Nowadays, any resettlement policy or guideline had not been enacted in Cambodia yet. The draft national policy and guidelines are being prepared as a consultative document under ADB assistance. According to ADB, the policy is in line with the ADB Guidelines on resettlement and affirms that affected people will be fully compensated for all assets lost as a result of the projects, regardless of whether affected people have formal title to the land which they occupy and use. On the other hand, Inter-Ministerial Resettlement Committee (IRC) was established on ad-hoc basis in 1997. IRC is responsible for the determination of entitlements, land values and appropriate compensations through detailed surveys and public consultations. The members of IRC are composed of the Ministry of Economy and Finance as a chairperson, the executing agency and other concerned ministries. When the project requires land acquisition or involuntary resettlement, the executing agency, which is the first responsible agency dealing with compensation and resettlement matters, will cooperate with IRC to conduct all the processes of resettlement appropriately. In the case of a water resources development project, the resettlement unit of MOWRAM might take initiative for land acquisition and resettlement in cooperation with IRC and other relevant organizations.

Here, abstracted key aspects for implementation of land acquisition and involuntary resettlement are described as suggestions related to water resources development as follows:

(1) Formulation of land acquisition/resettlement plan in cooperation with IRC and other relevant organizations

Regardless of the magnitude of the land acquisition/resettlement plan, it was recommended that a land acquisition/resettlement plan be formulated in cooperation with IRC at the beginning of the design phase in order to consider the strategy of the resettlement and grasp the whole framework of the plan. It was also beneficial for the ordering of activities to be conducted and consensus building among the relevant organizations.

Conceivable contents of the resettlement plan for water resources development is shown below:

Conceivable Contents of Resettlement Plan

Topics	Contents
Introduction	- Description of the project with map; Objectives of the project - Objectives of the resettlement plan
Land acquisition and resettlement	- Scope of land acquisition and resettlement - Purpose and objectives of land acquisition and resettlement. - Consideration of avoidance/mitigation of land acquisition and resettlement
Socioeconomic characteristics	- Socioeconomic situation in and around the project area - Identification of affected people and their socioeconomic situation (Census and baseline survey, household size, age-sex ratio, household vulnerability and poverty, household income, employment, land tenure, minority group, etc)
Impact of the project	- Project benefit - All losses for people affected by land acquisition and any common property resources - Specification of how project will impact on the poor, indigenous people and other vulnerable groups, including women, and any special measures needed to restore fully, or enhance, their economic and social base - Mitigation measures
Policy, eligibility and entitlement	- Key national and local land, compensation and resettlement policies, laws and guidelines - Principles of resettlement - Eligibility, legal entitlement of project affected people, entitlements matrix, losses (land price, agricultural assets, etc)
Participation, consultation and information	- Identification of project stakeholders, local institutions or organizations to support people affected and NGOs - Strategy for stakeholder participation in planning, management, monitoring and evaluation - Review potential role of NGOs - Procedure of consultation of the affected people - Grievance process (grievance rights, functions, steps involved, formulation of grievance committee)
Relocation of housing and settlements	- Identification of options for relocation of housing and other structures, including replacement housing, replacement cash compensation, and self selection. - Measures to assist with transfer Wand establishment at new sites. - Layout, design, and social infrastructure for each site. - Measures for planned integration with host communities, safeguarding income and livelihoods. - Gender issue, vulnerable groups - Environmental risks and its management and monitoring plan
Follow-up and income restoration strategy	- Identification of follow-up program contents for income restoration through beneficiary consultation and through market and financial feasibility analysis - Specification of job opportunities in a job creation plan - Special assistance to the poor, vulnerable groups and indigenous people - Provision of public service (hospital, school, pagoda, etc) - Identification of any environmental risks and show how these will be managed and monitored.
Institutional framework	- Relevant institutions for resettlement and its framework (main tasks, responsibilities) - Resettlement and rehabilitation capacity in the executing agency - Role of NGOs
Resettlement budget and financing	- Identification of land acquisition and resettlement costs. - Preparation of an annual budget and specification of the timing for release of funds. - Specification of sources of funding for all land acquisition and resettlement activities.
Monitoring, evaluation and feedback	- Monitoring method of resettlement targets - Evaluation plan - Public participation in monitoring and evaluation activities
Implementation schedule	- Detailed time schedule of the project and resettlement (start and finish dates for major resettlement tasks)
Budget and finance plan	- Cost estimation for the plan - Budget allocation plan, procedures for flow of funds

(2) Time scheduling and budgeting for resettlement

Resettlement needs sufficient time and budget in order to proceed properly from the beginning of the project design phase. The executing agency should consider these items and establish a time line for all activities from project preparation to completion in consideration of the resettlement-related activities schedule. Moreover, if the resettlement process might be late due to more time spent for consensus building with the affected people, the time schedule of the project should be modified in respective cases.

In addition, it is necessary to prepare the itemized budget for not only compensation and relocation, but also census and survey of the affected people, public consultation activities and follow-up programs for income restoration. The executing agency should allocate the budget from government or donors based on the time schedule of the resettlement plan. Conceivable costs for resettlement are as shown below;

Conceivable Resettlement Cost

Category	Cost Items
Resettlement preparation and compensation	- Census and survey of affected people and inventory of assets - Collection of information and consultation - Compensation for assets lost (land, structures, etc.) - Preparation of replacement land and farmland
Relocation and transfer	- Moving and transporting movable items - Replacement housing - Site and infrastructure development and services - Subsistence allowances during transition - Replacement businesses and downtime
Follow-up programs	- Cost estimates for follow-up programs including income restoration (e.g., survey, planning, training, subsidization, monitoring) - Incremental services (extension, health, education) - Environmental enhancement packages (forestry, soil conservation, grazing land, etc.)
Administrative matters	- Physical facilities (office space, staff housing, etc.) - Transport/vehicles, materials - Operation staff (managerial, technical), and support staff - Training and monitoring - Technical assistance - Evaluation by independent agency

Reference: Handbook on Resettlement - A Guide to Good Practice -, ADB, 1998

(3) Consideration of implementation of follow-up program and monitoring

A follow-up program toward the affected people, including income restoration, is an important component of resettlement where the affected people have lost their productive base, businesses, jobs, or other income sources, regardless of whether they have also lost their houses. They may face the risk of becoming worse-off, impoverishment and alienation, which might result in joblessness, food insecurity, and so on. The executing agency should take account of the links between relocation and follow-up for income generation.

The following are suggested steps for consideration for a proper follow-up program

- To analyze the economic activities of all affected people to assess their needs.
- To identify follow-up program contents for income restoration through beneficiary consultation and through market and financial feasibility analysis
- To plan a follow-up program for short-term (immediate assistance during relocation) and long-term (after 3-5 years) and allocate a satisfactory budget
- To conduct follow-up program to the affected people
  - Training on technical skills for income generation (agriculture, livestock

production, etc)
  - Subsidization of input or agricultural, fisheries, and livestock production for the first two or three years or until income levels are restored
  - Provision of temporary or short-term employment in civil construction activities at the resettlement or project construction sites
  - Special assistance to the poor, vulnerable groups and indigenous people
  - Provision of public service (hospital, school, pagoda, etc)
- To monitor their living situation periodically through site visits and questionnaire surveys
- To evaluate the program and provide additional technical assistance, if required

Box 1: Affected People by Prek Thnot Multipurpose Project

There was the Prek Thnot Multipurpose Project, development for dam and reservoirs for irrigation, power generation and flood control in the lower Prek Thnot River basin, which was located in the middle reaches of the Prek Thnot River. The construction of the project started in 1969, but was suspended in 1973 because of unstable security conditions in the project sites.

After 20 years, the environmental study for the project was conducted in order to provide technical advice on the environmental aspects of the project. The study examined the people affected by the project. In total, 43 villages with 3,660 households would be affected directly by the project. According to the contemporary population statistics, the total number of people who will eventually be affected was estimated to be about 17,700. In the study, a questionnaire survey was also conducted for the selected 10 villages (100 households) in and around the reservoir area to obtain the present socio-economic data on the affected people. The results of the survey showed that i) almost all heads of the sampled households (97%) were engaged in farming; ii) the average size of land owned was 3.6 hectares per household, of which 3.0 hectares were for cultivation and; iii) the average household cash income was about Riel 727,000 including wood cutting, livestock selling and charcoal making, while the average expenditure was only Riel 115,000. In addition to that, most of sampled people (94%) answered favorably on the project under proper compensation, which were preferred to be paid in cash (59%) and to have both new land and cash (41%). Most of them (94%) preferred to live close to the reservoir area or in neighboring villages. Moreover, most (81%) preferred to continue farming activities in the resettlement sites. Taking the examined situation into consideration, the study examined possible resettlement sites near their home town and indicated the cost of site preparation for resettlement, which amounted to a total US$28.9 million.

Reference: Prek Thnot Multipurpose Project Environment Study Report, August 1994, Nippon Koei Co., LTD in association with Snowy Mountains Engineering Corporation

C-1.3 Environmental Management and Monitoring Planning for Water Resources Development

As mentioned above, in planning and implementing water resources development projects, environmental considerations should be made in parallel in order to mitigate/minimize negative impacts toward the environment as much as possible. In addition, after the project will be implemented (constructed), it is necessary to manage and monitor the relevant environmental conditions properly and periodically, because there is no doubt that changes in society and environment by the project will influence sustainability of the society, water resources usage, and the environment after the project. Furthermore, unexpected environmental problems might occur after the project implementation.

In this Section C-1.3, noteworthy items of environmental management and monitoring (EMM) activities after implementation of water resources development project were considered.

As a result, the following issues are described as suggestions.

- Checklist for EMM planning related to water resources development project (considerable items)

- Four noteworthy items which requires particular attention (water quality monitoring, management of agricultural activities, monitoring of people's life and watershed management)

C-1.3.1 Checklist for EMM Planning

In order to plan EMM, it is essential for the executing agency to identify the environmental items to be managed and monitored. After that, they should develop the EMM plan by each item as a first step. This time, accordingly, general checklist for EMM planning related to water resources development project was developed as shown in the below table.

The following are assumptions for the development of the checklist;

- The project is assumed to be water resources development, which includes construction of dams, reservoir creations, installation of gates in the river and construction of canals
- The project area is assumed to be around the study area or similar environmental area of the study area. (Current condition of environment in the study area is assumed based on results of site visits and data collections in the first and second year of the Study.)

The purpose and usage of the checklist are as follows;

- To provide a tool for screening of environmental items to be managed and monitored
- To provide a tool for consideration of framework of EMM as a first step

It should be noted that because its checklist is a general one for a water resources development project in order to grasp framework of management activities, the executing agencies should consider each method on environmental management and monitoring based on each situation and contents of the development project using collected data and assessment of environmental impact.

Checklist for EMM Planning

Items	Impact by the Project*			Consideration of EMM contents
	Plan-ning	Const-ruction	Opera-tion	
Social Environment				
Involuntary resettlement	--/A	*	=/B	- Affected people's lives (life, economic situation, participation of the community, agricultural activities, etc) by interviewing them or through a questionnaire survey
Local economy (employment, etc)	*	=/B	=/C	- Local economic condition by statistical data or questionnaire survey - Economic disparity among the people by questionnaire survey or interview of the people - Impact on people's activities by regional area disruption
Land use and utilization of local resources	*	--/B	=/B	- Change of land use condition including forests by site exploration or air photo if available
Social institutions	*	--/B	=/B	- Accessibility of social institutions by questionnaire survey, interview of the people or site exploration
Existing social infra- structures and services	*	--/C	=/B	- Accessibility of social infrastructure and services by questionnaire survey, interview of the people or site exploration
The poor, indigenous and ethnic people	*	*	=/C	- Life condition of the poor, indigenous and ethnic people by interviewing them or questionnaire survey

Items	Impact by the Project*			Consideration of EMM contents
	Plan-ning	Const-ruction	Opera-tion	
Misdistribution of benefit and damage	∗	∗	=/B	- Economic disparity among the people by questionnaire survey or interview of the people
Cultural heritage	∗	--/C	∗	—
Local conflict of interests	∗	=/C	=/B	- Community condition and conflict (likely) to happen through interview of the village chief, community representative, FWUC members, or farmers
Water Usage	∗	--/B	=/A	- Water usage situation among the people through interview or questionnaire survey - Operational condition of FWUC through interview of the members
Sanitation	∗	--/B	=/B	- Change of sanitation conditions through interview of the village chief, provincial department of sanitation
Hazards (Risk), Infectious diseases	∗	--/B	--/B	- Spread of water-borne diseases through interviews conducted in village hospitals/clinics
Natural Environment				
Topography and geographical features	∗	∗	--/C	—
Soil erosion	∗	∗	--/B	- To observe the place where danger is prospective periodically
Groundwater	∗	∗	∗	—
Hydrological situation	∗	--/B	--/A	- Change of hydrological regime through data collection of flow condition
Flora, fauna and biodiversity	∗	--/B	--/B	- To confirm transplanting/planting condition
Meteorology	∗	∗	∗	—
Landscape	∗	∗	--/C	—
Global Warming	∗	∗	∗	—
Pollution				
Air Pollution	∗	--/B	∗	—
Water Pollution	∗	--/B	--/B	- Water quality monitoring in and around the project area
Soil Contamination	∗	∗	--/B	- Agricultural activities (input of fertilizer, agrochemicals, etc) at agricultural field through interview of the farmers or questionnaire survey - Soil quality monitoring in and around the project area
Waste	∗	--/B	--/B	- Waste disposal condition by site exploration
Noise and vibration	∗	--/B	∗	—
Ground subsidence	∗	∗	∗	—
Offensive Odor	∗	∗	∗	—
Bottom sediment	∗	∗	--/C	- Bottom sediment condition of reservoirs/canals by field survey - Condition of earth deposition in the reservoirs by field survey
Accidents	∗	--/B	∗	—

Note) Impact by the project shows possibility of the impact and its magnitude caused by the water resources development project.*

--/B: Left-hand side of each cell represents a direction of impact;, right-hand side represents a magnitude of impact.

++:Positive impact --:Negative Impact =:Neutral Impact, A: relatively significant impact, B: relatively medium-size impact, C: relative small impact, D: unknown as of now, ∗:No impact or no corresponding impact

C-1.3.2 Noteworthy Topics for EMM

C-1.3.2.1 Water Quality Monitoring

Increased irrigation area by enhancement of water availability in the field might increase the use of irrigation water, which results in greater amounts of water draining through irrigation systems and back into drainage canals and rivers. In addition, increased irrigation areas might encourage farmers to use higher levels of agrichemicals and fertilizers due to the reduction of crop risk when water is assured. In fact, the socio-economic survey results conducted in 2006 indicated that more than half of households wanted to use more fertilizers for improvement of rice productivity than that time. This situation might result in the increase of load or chemical contamination in the water. In addition, people living downstream of the Prek Thnot River are taking canal water for both drinking and domestic use at the moment. Therefore, there are some risks of water pollution and eventually health hazards.

In this connection, several key elements which have to be managed and monitored water quality are described hereunder. It is noted that the framework of the water quality monitoring should be finalized based on the project design and current situation of the project area.

Planning of Water Quality Monitoring

Items	Main Contents	Executing Agencies	Location	Time/ Period
Items to be managed	- Protection of water for domestic use - Protection of water quality of river and reservoirs/canals - Setting up water quality criteria and standards as a management goal/target - Management of affected areas for the appropriate development of fisheries - Management of agricultural activities (fertilizer/agrichemical use)	MOWRAM/ PDOWRAM	―	―
Items to be monitored	- Temperature of air/water, flow rate, color, odor, appearance - Physico-chemical properties (pH, EC, TSS, BOD, COD, DO) - Organo-chemical substances (NH4-N, NO2-N, NO3-N, T-N, T-P) - Micro-organisms (bacteria, coliform group) - Inorganic ions (Na, Mn, Fe, Zn, Cu, Cl) - Land use conditions and vegetation coverage around the reservoir area	MOWRAM/ PDOWRAM	- Reservoirs - Relevant river basin (Prek Thnot, Tonle Bati River) - Canals etc	Periodical implementation (ex. once a month)
Data analysis/ evaluation	Monitored values should be evaluated with reference to the related standards (WHO standard for drinking water, RGC water quality standard in public water areas).	MOWRAM/ PDOWRAM	―	Monitoring time
Ways of coping	- Analysis of pollution and establishment of the cause. - Consideration of prevention method - Information disclosure - In case the contaminated water is used for drinking,, people should be informed of the dangers of drinking it - To remove the pathogens from the water	MOWRAM/ PDOWRAM	Polluted area	When pollution was confirmed

Items	Main Contents	Executing Agencies	Location	Time/ Period
Supportive activities	- Program for the establishment of quality standards and water quality conservation plans - Program for data collection and analysis of water quality	MOWRAM/ PDOWRAM	MOWRAM/ PDOWRAM/ MOE	－

Note; Related regulation; Sub-decree on Water Pollution Control (April 6, 1999); Water quality standard in public water areas for bio-diversity conservation (pH, BOD, TSS, DO, T o Total coliform, TN, TP), Water quality standard in public water areas for public health protection (DDT, Cadmium, Lead, and so on)

C-1.3.2.2 Management of Agricultural Activities

As mentioned above, water resources development might increase the irrigation area and, in some cases, irrigation frequency. An increased irrigation area might result in the increase in the total amount of agricultural input like water, fertilizer and agrochemicals in the agricultural area. Some farmers might use higher levels of agrochemicals/fertilizers after assurance of water by the project.

According to the socio-economic survey conducted in the target area by the JICA study team in 2006, the current condition of fertilizer usage was relatively low and agrochemicals were seldom used (70kg/ha of Urea, 60kg/ha of DAP and 1,800kg/ha of manure/compost to paddy field on average). However, there might be a risk of contamination with the increase of the use of agricultural chemicals. In fact, Cambodia had no rules for agrochemicals. Highly toxic agrochemicals such as DDT, banned in many other countries, were easily available in Cambodia.

The following four issues have the potential to become serious problems at the O&M phase without the proper management of agricultural activities.

(1) Water quantity and quality

- Water contamination by outflow of agrochemicals, N, P and Urea because of inadequate usage of fertilizer and agrochemicals
- Inequity of water usage among the people

(2) Effects on ecosystem/ biodiversity

- Negative impact on the aquatic ecosystem

(3) Effects on the local economy

- Impact on rice productivity because of poor soil by inadequate usage of fertilizers and agrochemicals
- Impact on fisheries production because of water contamination/water shortage

(4) Effects on peoples' lives

- Impact on humans by drinking/using contaminated water
- Spread of infectious or water-borne infections like diarrhea, cholera, amoebic dysentery, Hepatitis A and parasites by drinking or washing in contaminated water

For the reasons mentioned above, it is so important to manage the farmers' agricultural activities at the O&M phase in order to prevent the negative impact on both social and ecological conditions. The following table shows the framework of management of agricultural activities.

Planning of Management of Agricultural Activities

Items	Main Contents	Executing agencies	Location	Time/ Period
Items to be managed	- Usage of fertilizers, agrochemicals and pesticides in the agricultural field - Water usage condition	MAFF/PDA/ MOWRAM/ PDOWRAM	At the agricultural field (in and around the project area)	Periodic implementation in agricultural season
Items to be monitored	- Farmers' activities for input of fertilizer, agrochemical and pesticide /water usage condition through interviews, site visits, questionnaires - FWUC's activities through interviews - Analysis of water quality monitoring	MAFF/PDA/ MOWRAM/ PDOWRAM	At the agricultural field (in and around the project area)	Periodic implementation (ex. once a month)
Data analysis/ evaluation	- Identification of farmers' activities (proper usage of fertilizers, agrochemicals and pesticides) - Inequity of water usage among the people	MAFF/PDA/ MOWRAM/ PDOWRAM	—	At monitoring time
Ways of coping	- To train farmers on appropriate agricultural management - To conduct public meetings among the farmers to share and solve the problems - To consult FWUC about their roles and works	MAFF/PDA/ MOWRAM/ PDOWRAM	At the agricultural field (in and around the project area)	—
Supportive activities	- Training of farmers - Establishment/enhancement of FWUC/FWUG - To conduct a support program regarding appropriate agricultural management - To introduce composting activities to the farmers - To introduce check systems among the FWUC members regarding agricultural management	MAFF/PDA/ MOWRAM/ PDOWRAM	At the agricultural field (in and around the project area)	—

C-1.3.2.3Monitoring of Peoples' Lives

Water resources development projects often require land acquisition and involuntary resettlement because of the creation of reservoirs in the new areas. In addition, the project directly influences the peoples' lives because of the change in water usage, land usage, and social structures at the O&M phase. The people who resettled on the new land might find it hard to keep their lives because of lack of skills in new works such as agriculture or they could not adapt to the new community. Sometimes community conflicts might occur in the water usage among the farmers.

The following four issues have the potential to become serious problems at the O&M phase.

(1) Involuntary resettlement / Land acquisition

- Can not adapt to the new life in the relocation area (relocated people)
- To become poorer than before (affected people, relocated people, people who acquired land)

- Can not adapt to the new community of relocated people
- Disparity between local people and relocated people
- Community conflict among local and relocated people

(2) Change of community, economic condition, women's role

- Economic/political change
- Decrease of social harmony and individual well-being
- Change in the general levels of employment and income
- Change in the provision of local infrastructure and amenities
- Change in the relative distribution of income, property value and project benefits (including access to irrigation water)
- Change in the demand of labor and skills
- Change in the status and roles of women in relation to social standing, work load, access to income, heritage, and marital right

(3) Water usage/ local conflict by water use

- Inefficient water usage
- No/inefficient system for water usage among the local people
- Community conflict caused by inequality of water usage
- Disparity of water usage among the people (water shortage for the poor, indigenous and ethnic people)

(4) Infectious diseases/sanitation/public health

- Change in sanitation conditions of water and surrounding areas
- Spread of infectious or water-borne infections like diarrhea, cholera, amoebic dysentery, Hepatitis A and parasites by drinking or washing in contaminated water
- Spread of water-breeding insect vectors such as mosquitoes carry malaria, dengue fever and yellow fever

For these reasons mentioned above, it was crucial to monitor the peoples' lives and their communities at the O&M phase. The following table shows the framework of the monitoring of peoples' lives.

Planning of Monitoring of Peoples' lives

Items	Main Contents	Executing agencies	Location	Time/ Period
Items to be managed	- People's economic condition/life condition/women's condition (affected people/ in and around the project area) - Community - Water usage situation - Local economy - Sanitation condition/Public health	MAFF/PDA/ MOWRAM/ PDOWRAM	In and around the project area	Periodical implementation
Items to be monitored	- People's economic condition/life condition/women's condition through interviews or questionnaire surveys - Community condition/ sanitation through interviews of the local chief and visits - Water usage situation through interviews of FWUC members - Statistical data of diseases from local hospitals - Statistical data of economy - Water quality	MAFF/PDA/ MOWRAM/ PDOWRAM	In and around the project area (sampling)	Periodical implementation (ex. annual, for five years)

Items	Main Contents	Executing agencies	Location	Time/ Period
Data analysis/ evaluation	- Data comparison between before and after - Inequity among the people - Decrease of people's life level - Investigation of cause of conflict	MAFF/PDA/ MOWRAM/ PDOWRAM	—	At monitoring time
Ways of coping	- To interview the affected people in order to grasp the problems and conduct supportive activities - To consult FWUC's role and their work - To conduct public meetings among the local people to share and solve the community's problems	MAFF/PDA/ MOWRAM/ PDOWRAM	In and around the project area	—
Supportive activities	- - To conduct follow-up program toward affected/ local people - To establish FWUC/ enhance FWUC's role and work - To provide job training for the people	MAFF/PDA/ MOWRAM/ PDOWRAM	In and around the project area	—

C-1.3.2.4Watershed Management

Watershed management is the most important factor in attaining sustainable use of water resources by the project and in protecting forest and wildlife resources in the catchment area.

As for the current condition of the Prek Thnot River basin, the catchment area and the length are about 4,650 km^2 and 232 km at the confluence with the Bassac River, respectively. There is the Aural Wildlife Sanctuaries as a national protected area, of which the area is about 2,540 km^2 upstream of the River. However there are no available data about the forest condition and the transition of the catchment area of the Prek Thnot River.

The following issues have the potential to become serious problems at the O&M phase without proper watershed management. It could be easily imagined that watershed management covers a wide range of environment around the river.

- Deforestation and land cover changes, increase of agricultural land instead of forest
- Impact on ecology and biodiversity
- Increase of soil loss and erosion
- Increase of sedimentation in downstream river channels.
- Change of hydrological regime
- Significant impact on the rate of erosion by extensive farm-level land-use practices
- Impact on human activities and their economy
- Deterioration of water quality (by Intensive agriculture, inappropriate application of fertilizers and pesticides, factory along the river, cattle feedlots, sewage water from residential area, etc), Eutrophication by excess amounts of nutrient (mainly nitrogen and phosphorus) from human activities

For that reason, watershed management is very important at the O&M phase in order to prevent negative impact on both social and ecological conditions. The following table shows the framework of watershed management. The cooperation of all stakeholders, not only of relevant ministries but also the local people and the private sector, is essential for effective watershed management.

Planning of Watershed Management

Items	Main Contents	Executing agencies	Location	Time/ Period
Items to be managed	- Conservation of forest resources from uncontrolled deforestation and encroachment of forest reserves - Protection of wildlife in the catchment area - Control on stakeholders' activities related to the river (people, farmer, private sectors, etc) - Land use control	MOWRAM/ PDOWRAM/ MAFF/PDA (forestry)	Catchment area	Periodic implementation
Items to be monitored	- Land use condition and vegetation coverage in the catchment area - Forestry activities such as logging, production, and conditions of shifting cultivation - Flood situation	MOWRAM/ PDOWRAM/ MAFF/PDA	Catchment area	Periodic implementation (ex. once a year) by interpreting the Landsat imagery and patrolling.
Data analysis/ evaluation	- Change of land use condition and flood condition - Situation of forestry activities	MOWRAM/ PDOWRAM/ MAFF/PDA	―	At monitoring time
Ways of coping	- To conduct community forest activities - To set protected area for forest	MOWRAM/ PDOWRAM/ MAFF/PDA	Catchment area	―
Supportive activities	- To map land use and forest classification - To prepare forest inventory, zoning of protection areas and long-term watershed management plan	MOWRAM/ PDOWRAM/ MAFF/PDA	Catchment area	―

C-1.3.3 Conclusion

Water resources development would have direct impact, either positively or negatively, on both human activities and natural environment. In addition, environmental management and monitoring after the project implementation is furthermore deeply linked with them for their sustainability. Even if the results of the EIA study conclude that the proposed project is acceptable from the environmental viewpoints, it is not possible to eliminate all uncertainties of negative impacts to environment. Therefore, the environmental management and monitoring activities are keenly required to ensure the sustainability of the society, water resources usage and environment. It is important to plan proper EMM, at first, among relevant ministries and organizations in order to clarify environmental aspects to be managed and monitored, and to delineate a framework of the EMM plan from institutional, technical, and financial viewpoints based on the results of assessment.

In this section, the checklist for the EMM planning and four topic-wise suggestions were explained in order to be utilized for planning and implementation of the EMM. However, as a practical matter, the executing agency should consider the EMM plan carefully in consideration of practical situation of the society, results of EIA study and own capabilities.

C-1.4 Recommendations on Capacity Development

C-1.4.1 Current Condition of Relevant Institution

C-1.4.1.1MOWRAM

MOWRAM had not set up any units or departments for environmental management and/or EIA. Moreover, no staff had been assigned in charge of the environmental management. In fact, MOWRAM had not implemented any projects which require EIA study under the Sub-decree on Environmental Impact Assessment Process (1999).

On the other hand, MOWRAM had the resettlement unit which had been supported by ADB since it's inception in 2001. Currently the resettlement unit has four staff members The resettlement unit had been engaged in the Stung Chinit Irrigation and Rural Infrastructure Project supported by ADB and conducted resettlement together with a series of compensation programs.

According to the Strategic Development Plan (2006-2010) of MOWRAM, one of its institutional development goals was to strengthen comprehensive capacity to develop and apply procedures for social and environmental impact assessment and mitigation. Under the plan, they aim to establish a Social and Environmental Impact Management (S&EIM) unit with appropriate training to the staff in MOWRAM and PDOWRAM.

In the provincial level, there was no unit/staff in charge of environmental management in PDOWRAM of Kampong Speu Province and Kandal Province. Moreover, PDOWRAM had few experiences related to environmental management in the field. Nowadays they are interested in the environmental management activities in their field. For example, PDOWRAM of Kampong Speu Province plans to conduct several environmental activities like water quality observation in order to study its polluted source.

C-1.4.1.2MAFF

The MAFF has two departments and their provincial equivalents which are in charge of environmental monitoring and management, and one office for EIA.

The former two departments are the Department of Forestry and Wildlife and the Department of Fisheries. At the provincial level, these are the Forestry and Wildlife Service and the Fisheries Service of the Provincial Departments of Agriculture, Forestry and Fisheries (PDA). The Department of Forestry and Wildlife is responsible for managing wildlife and wildlife habitat within the forested areas and for declaring and managing forestry and wildlife reserves. On the other hand, the Department of Fisheries and its provincial services have legislative jurisdiction over all water bodies that are fisheries resources and covers protection of species and habitat, the management of the resources, monitoring of catch and upgrading and enhancement activities.

The latter one, the EIA office under the Department of Planning and Statistics, was established in 1999 with the support of ADB under the Institutional Strengthening and Expanding EIA Capacity in Cambodia project in 1997-1999. Though there were seven staff members assigned at the moment, currently, two staff members are working at the EIA office. According to the EIA Office, it had not experienced any EIA related activities including preparation of terms of refernce, supervision, review and monitoring of EIA activities for seven years since the office was set up. They had undergone several trainings including the 6-week training of trainers about EIA under the project of ADB (Institutional Strengthening and Expanding EIA Capacity in Cambodia project). However, they expressed insufficient practical experience and practical skill to carry out the EIA study as the executing agency. In addition, it was noted that there had been no relation and cooperation between the EIA office and other technical units so far.

At the provincial level, there was no unit/staff in charge of environmental management in the PDA of Kampong Speu Province and Kandal Province. Some activities like fish pond

conservation and integrated pest management had been conducted by the PDA in cooperation with FAO, DANIDA, etc. The PDA staff of Kampong Speu Province expressed their interests in acquiring knowledge and practical experience in environmental management. In fact, PDA answered that they had planned environmental management activities including chemical substance of agricultural management, fish conservation, natural fish pond conservation and pesticide management. In addition, three staff members will be assigned as environmental experts.

C-1.4.2 Recommendations

C-1.4.2.1MOWRAM

Institutional Structure

Under the Sub-decree on Environmental Impact Assessment Process, MOWRAM was requested to conduct an EIA study for an irrigation infrastructure project with an area of over 5,000 hectares. In fact, one of the projects under the master plan, The Lower South Main Canal Irrigation Agricultural Improvement Project required an EIA study because the project covered more than 5,000 hectares.

In line with the plan to build up a responsible unit for environmental and social impact management under the Strategic Development Plan (2006-2010), MOWRAM should pursue the plan of establishment of the unit as a first step. At least a few staff should be assigned as environmental specialists even if they may also hold other posts initially. It was suggested that the counterpart of environment in MOWRAM under the study should be involved in the unit at launching period primarily because he had participated in almost all activities related to the environment under the study, so that he became familiar with the environmental approach gradually through a series of discussions and workshops.

Capacity Development

In addition to the strengthening of the institutional structure, in parallel, the capability of the relevant staff on environmental issues should be strengthened as laid-out in the Environmental Management Capacity Development Project under the master plan. When MOWRAM conducts new development projects, they should make environmental considerations from the beginning of the planning phase up to the O&M phase. Moreover, when a project requires an EIA study under the sub-decree on EIA, the executing agency should conduct the EIA study to follow the sub-decree on EIA as supervisor. Therefore, the knowledge and skills to consider, supervise and monitor the EIA study should be obtained by the staff of the new unit of environmental and social impact management under the MOWRAM.

C-1.4.2.2MAFF

Institutional Structure

At the moment, it can be said that the EIA office of MAFF had not been utilized practically. Moreover, the MAFF does not have any strategic plans related to the EIA Office. In addition, coordination between the EIA office and other relevant technical departments had not yet been established.

In consideration of the current situation of the EIA office, the following three points are suggested;

- MAFF should clarify the mission and job responsibility of the EIA office and share them among management levels of staff of MAFF. In addition, MAFF should reconsider strategic plans for the effective utilization of the EIA office.
- The EIA office, together with the Department of Planning and Statistics, should prepare an annual and mid-term action plan. Based on the annual action plan, the EIA office should request budgets for environmental activities.

- The EIA office should build cooperative ties with other technical departments including the Department of Forestry and Wildlife and the Department of Fisheries. One of the means at the beginning is to hold sharing meetings among them in order to share knowledge and experience related to environmental management and EIA. Through the sharing meetings, the EIA office should consider its own coordination structure.

Capacity Development

At the individual level, the staff of the EIA office have insufficient knowledge of the practical implementation of the EIA study. Similar to MOWRAM, MAFF would also be the executing agency of a development project which would need environmental consideration, and in some cases would require the EIA study under the sub-decree on EIA. Therefore, it was suggested that the capability of preparation of terms of reference for the EIA study, supervision, monitoring of the EIA study and review of the EIA report should be strengthened as shown in the Environmental Management Capacity Development Project under the master plan. As described above, several kinds of training related to EIA had already been provided to them by other donors and organizations. In order to strengthen their practical capability much further, the training conducted should focus on case study work and practical work.

C-1.4.2.3Project Organization

As proposed in the priority/urgent projects for the feasibility study (F/S) under the study, when large-scale projects related to water resources development is planned, it is proposed to formulate a project organization focusing on the close coordination between MOWRAM and MAFF. If the project is predicted to have some significant negative impact on the environment and social community, an environmental staff or adviser should be assigned under the project organization in order to make environmental considerations properly. The environmental staff should be assigned for the implementation of resettlement procedures, supervision of the EIA study, and/or management of the public consultation activities properly, according to the project design and process.

It should be noted that even though the project does not formulate the project organization, coordination between MOWRAM and MAFF for environmental activities is highly important in order to make environmental considerations more effectively.

Chapter C-2 Technology Transfer under the Study

C-2.1 General

One of the objectives of the study was technology transfer toward the staff of MOWRAM and MAFF. Technology transfer for them had been carried out mainly by means of the "On-the-job training (OJT)" through the study activities. In terms of environmental considerations, in addition to the OJT, a series of workshops and discussions were conducted for the staff members concerned as technology transfer activities.

On the other hand, the draft master plan for comprehensive agricultural development, which included 27 projects/studies, was formulated in Phase I. One of the 27 projects/studies was the "Environmental Management Basic Capacity Development Project", which contained implementation of training/workshop in order to strengthen basic capabilities of the relevant staff of MOWRAM and MAFF regarding EIA and environmental management in 2006-2007. A series of workshops conducted under the study covered some parts of the project. However, because of the limited input and time, project contents and implementation methods were changed and some parts of activities under the proposed project had not been conducted so far.

C-2.2 Overall Activities for Technology Transfer under the Study

Two kinds of activities for technology transfer were conducted: a) technology transfer related to environmental impact assessment (EIA); and b) technology transfer related to environmental management and monitoring (EMM) as follows.

Framework of Technology Transfer Activities

Activities	Technology transfer related to EIA	Technology transfer related to EMM
Target Staff	- Counterpart from MOWRAM - Counterpart from MAFF	- Counterpart from MOWRAM - Counterpart from MAFF - Staff of PDA and PDOWRAM, Kampong Speu Province
Method	- Discussion meetings - six times workshops	- Three-day workshop
Contents	- Basic information of the study - Environmental impact assessment (EIA) - Initial Environmental Examination (IEE) toward the draft Master Plans - Environmental assessment toward the Feasibility Study Projects - Field visit - Topics for discussion, etc	- Basic concept of EMM - Topics for discussion (water quality monitoring, watershed management, management of agricultural activities, monitoring of people's life) , etc

Basically, technology transfer related to EIA was conducted through every step of the study procedure. During the study activities, several discussions and workshops were carried out in order to explain the progress of the study and environmental consideration, discuss initial environmental examinations of the draft master plan, and environmental assessment of the project in the feasibility study. MOWRAM and the EIA Office of MAFF each sent one staff member as participants in these activities.

On the other hand, as for technology transfer related to EMM, a three-day workshop was conducted in 2007. The reason the workshop was conducted was that it became clear that both MOWRAM and MAFF were interested in the knowledge and skills of EMM through the activities of the study though they had few experiences about that at that time. The target of the three-day workshop was not only the counterpart personnel of the environment but also the staff from PDA and PDOWRAM of Kampong Speu Province who had responsibility of management in their field.

C-2.2.1 Technology Transfer about EIA

The following activities for technology transfer related to EIA were conducted under the Study.

Technology Transfer related to EIA

Date	Contents of the Activities	Technology Transfer
January 23-31, 2006	Review of the current condition - Interview of Ministry of Environment (MOE), Department of EIA - Interview of Provincial Office of Environment (PDE) in Kampong Speu - Interview of PDE in Kandal - Exploration of the target area - Interview of resettlement unit, MOWRAM	- Collected relevant data and information about environmental aspects through interview of concerned organizations - Observed the Target Area in order to grasp the current condition of environment.
February 6, 2006	First workshop - Explanation of the JICA study by the JICA study team - Explanation of overview of EIA and EIA procedure in Cambodia by the JICA study team - Discussion on draft master plan related to environmental management. - Discussion on future activities under the study	- Discussed environmental items to be checked - Discussed draft master plan related to environmental management in consideration of each organizational condition. - Discussed necessity of capacity development
February 9. 2006	Second workshop - Screening of the draft master plan - Practice of initial environmental examination (IEE) toward the selected projects from the draft master plan - Presentation of the IEE result by each counterpart	- Discussed screening of the master plan - Discussed IEE toward selected projects (rehabilitation of canal project and community inland fishery project) - Presented the result of IEE - Discussed mitigation measures toward prospective negative impacts
February 14, 2006	Meeting - Practice of presentation for coming seminar.	- Developed presentation material for coming seminar
January 23-24, 2007	Kick off meeting - Explanation of the activities in the second year of the project by the JICA study team - Explanation of the F/S projects by the JICA study team	Discussed prospective impact by F/S projects
January 26, 2007	Third workshop (Field survey) - Explanation of construction method of F/S projects by the JICA study team - Discussion on consideration of check points in the field - Field survey - Summarization	- Discussed environmental items to be checked in the field - Consideration of prospective impact during the construction phase - Observed the project area to grasp the current condition of the environment.
February 5, 2007	Fourth workshop - Discussion on data analysis collected by field survey and a series of research under the Study - Consideration of environmental/social impact - Consideration of mitigation and monitoring/management measure - Conclusion	- Reviewed initial environmental examination toward F/S projects - Presented the result of IEE - Proposed mitigation measures toward negative impacts - Discussed environmental management and monitoring measure

Date	Contents of the Activities	Technology Transfer
February 13, 2007	Fifth workshop - Explanation of "terms of reference (TOR)" by JICA Study Team - Explanation of steps of preparation of TOR by JICA study team - Discussion on next activities - Conclusion	- Learned about "TOR" and their roles - Discussed necessity of capacity development training
July 16, 2007	Sixth workshop - Environmental consideration for water resources development	- Reviewed EIA process in Cambodia - Considered prospective negative impacts by water resources development project and its mitigation measures

As a whole, counterparts from both MOWRAM and MAFF took part actively in all the aforementioned activities. In spite of the limited time, the fundamental concepts on EIA and its procedures were studied through the discussions and workshops. In order to provide the counterparts with an opportunity to think and practice environmental consideration by themselves, two field visits, exercises and discussion time were secured during a series of workshops. Through these activities, they practiced each procedure of environmental consideration including field observation and data collection, prediction of negative impacts toward the environment, evaluation of the impact and consideration of mitigation measures through the case study of two priority/urgent projects of proposed master plan, i.e. Roleang Chrey Regulator and Intakes Improvement Project, and Irrigated Agriculture Improvement Model Project.

Detailed results of each workshop are presented in Attachment-3 consisting of (i) outline of the session, (ii) attendance list and (iii) results.

Consideration of negative impact by the project at the workshop

Field visit (North Main Canal) and discussion with gate operator

C-2.2.2 Technology Transfer about EMM

Technology transfer on Environmental management and monitoring (EMM) was conducted through a three-day workshop held on July 4, 6, 9, 2007. The PDA and PDOWRAM staff of Kampong Speu province were also invited to attend at this workshop so that they would become familiar with the EMM activities which were to be conducted at their field. Accordingly, a total of 9 staff members from PDOWRAM and 3 staff members from PDA actively participated in the workshop in addition to the counterparts from both MOWRAM and MAFF.

The main objectives of this workshop were i) to understand the basic concept of EMM for water resources development and ii) to acquire the fundamental knowledge about planning of EMM activities for water resources development. Because there was limited time and the participants were not familiar with the environment, this workshop was considered as a first step to provide the basic concept of EMM for the participants.

Three-day Workshop on EMM

Date	Contents
July 4, 2007	- Introduction, self-introduction (all participants) - Explanation of the overview of the workshop, objectives, goals, schedules - Questionnaire - Overview of the environmental management and monitoring - Clarification of items to be managed and monitored (in case of water resources development)
July 6, 2007	- Introduction of the day - Study on monitoring of water quality - Study on watershed management - Field study on water sampling/water quality checking
July 9, 2007	- Introduction of the day - Study on management of agricultural activities (fertilizer use, water use, etc) - Study on monitoring of people's life (resettlement, health, community, etc) - Summary of the workshop

Almost all participants, except the counterpart from MAFF and one staff member of PDA, have had no experience in any environmental work so far. According to the results of the questionnaire asked in the beginning of the workshop, most participants had little knowledge about EMM and EIA at the moment. Moreover, some participants had never heard the term itself. However, active participation from both PDOWRAM and PDA indicated that field staff members were interested in EMM which could be put to practical use at their work field.

The three-day workshop started from the explanation about "what is the environment?" and EMM followed by the discussion about prospective negative impacts caused by water resources development projects, which were divided into physical environment, ecological environment and social environment, and its mitigation measures. At the second and third day, topic wise contents were explained and discussed. As for monitoring of water quality, a field study was also conducted in order to demonstrate water sampling and water quality checking by the simple method.

During the workshop, participants actively listened to the facilitator's explanation and had an exchange of opinions. They also asked questions during the workshop, which included the negative impact of polluted water on the human body, solution for polluted water in the well and canals, and the simple method of checking the water quality without any equipment. On the other hand, the participants also expressed that they were facing insufficient support for EMM. They voiced-out problems such as the lack of budget for monitoring, lack of monitoring equipment and tools, and lack of office facility.

In the evaluation questionnaire, all participants answered that they were satisfied with the three-day workshop contents. Most participants indicated their requests that they undergo more workshops regarding EMM in greater detail. They signified their intention to learn more about the environment including such topics as environmental pollution caused by agricultural waste and health management by water canal quality.

The detailed results of the three-day workshop are presented in Attachment-3 covering i) outline of the session, ii) attendance list, and iii) results.

Discussion among the participants

Field study of water quality checking

C-2.3 Result and Evaluation

As a whole, counterparts from both MOWRAM and MAFF participated actively in all the activities of technology transfer. Though the participants from MOWRAM were not experts on the environment, they learned the basic procedure of environmental consideration including field observation and data collection, impact analysis, and consideration of mitigation measures through the technology transfer activities. They answered that they had understood a large part of the environmental consideration and the EIA procedure in the survey conducted in February 2007. In addition, the relation between MOWRAM and MAFF on environment was developed through the activities so that they would utilize their relationship in future environmental work especially in the implementation of EIA. On the other hand, they expressed their desire to undergo more training for EIA and environmental management. In addition, the participant from MAFF requested that the knowledge acquired through the trainings be applied to the actual work. In fact, there had been few fields for them to work on the environment till now.

In conclusion, the capacity development at the individual levels should be continued. However, taking into consideration the current situation of both MOWRAM and MAFF, it should be important to consider institutional levels of capacity development as a first step. It means that MOWRAM and MAFF should establish an institutional structure in order to deal with environmental consideration issues as the executing agency and put the environmental staff to practical use for their actual work.

As for the provincial office, it became clear that the provincial level of staff had a lot of interest in environment. When they go to their work areas, they encounter problems related to environment, which include the usage of fertilizer, water quality management and its impact to the human body. Therefore their knowledge of environmental management, which can be applied in their work field, had been expanded. Because of lack of time available under the study, enough knowledge and skills related to environmental management could not be provided. It is recommended that more structural and practical training be conducted for the provincial office and consult planning of daily environmental management activities.