KINGDOM OF THAILAND

MINISTRY OF AGRICULTURE AND COOPERATIVES

ROYAL IRRIGATION DEPARTMENT

THE EAST COAST WATER RESOURCES DEVELOPMENT PROJECT (PHASE II)

VOLUME 5-3

SECTORAL REPORT

X WATER BALANCE STUDY

XI WATER RESOURCES ENGINEERING

XII WATER CONVEYANCE ENGINEERING

XIII FLOOD MITIGATION ENGINEERING

AUGUST 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF VOLUMES

ABBREVIATIONS AND LOCAL TERMS

A. ABBREVIATION OF MEASURES

(1) Length

mm = millimetre
cm = centimetre
m = metre
km = kilometre

(2) Area

m^2 = square metre
ha = hectare = $10^4 m^2$
km^2 = square kilometre = $10^6 m^2$
rai = 0.16 ha

(3) Volume

lit, l = litre = 1,000 cm^3
kl = kilolitre = 1 m^3
m^3 = cubic metres
MCM = million cubic metres
= 1,000,000 m^3

(4) Weight

mg = milligramme
g = gramme
kg = kilogramme
t = ton = 1,000 kg
qwt = quintal = 100 kg

(5) Time

s = second
min = minute
h = hour
d = day
yr = year

(6) Money

฿ = Baht (unit of Thai currency US$ 1 = ฿ 23.0)
$ = US dollar
¥ = Japanese Yen

(7) Electric Measures

kV = kilovolt
kW = kilowatt
MW = megawatt = 1,000 kW
kWh = kilowatt hour
kVA = kilovolt Ampere

(8) Other Measures

mmho = micromho = conductance
ppm = parts per million
ppb = parts per billion
% = per cent
LCD = litre per capita per day
PS = 0.736 kW
pH = scale for acidity
° = degree
' = minute
" = second
°C = degree centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

(9) Derived Measures Based on the Same Symbols

m^3/s = cubic metre per second
ton/ha = ton per hectare
$10^6 m^3/yr$, MCM/yr = million cubic meter per year

B. OTHER ABBREVIATIONS

GDP = gross domestic product
GRP = gross regional product
El. = elevation
HWS = high water surface
SD = sanitary district
DA = development area
ESS = Eastern Seaboard Study
FOB = free on board
CIF = cost, insurance and freight
WHO = World Health Organization

C. ABBREVIATION OF ORGANIZATIONS

MOAC	Ministry of Agriculture and Cooperatives
RID	Royal Irrigation Department
DOF	Department of Fisheries
LDD	Land Development Department
NESDB	National Economic and Social Development Board
NEB	National Environment Board
NSO	National Statistical Office
MOI	Ministry of Industry
DMR	Department of Mineral Resources
DIW	Department of Industrial Works
MOC	Ministry of Communications
HD	Harbor Deparment
DHW	Department of Highways
DOH	Department of Health
RTN	Royal Thai Navy
PWWA	Public Water Works Authority
MD	Meteorology Department
DOLA	Department of Local Administration
TAT	Tourism Authority of Thailand

D. LOCAL TERMS

Changwat	:	Province
Amphoe	:	District (Township)
Tambon	:	Township (Town)
Muban	:	Village
Muang	:	Administrative Center of Province
King Amphoe	:	Sub-district
Mae Nam	:	River
Khwae	:	Main tributary of a river
Huai	:	Stream, creek or small tributary
Khlong	:	Canal
Khao	:	Mountain

SECTORAL REPORT X
WATER BALANCE STUDY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This Sectoral Report elaborates the long-term water demand and supply plan in the Study Area and integrates all the study results such as hydrology, domestic and industrial water demands, irrigation development, water resources engineering and water transmission engineering.

Water demands are classified into 3 categories in this study; that is domestic, industrial and irrigation water demands. In addition, a concept of river maintenance flow is introduced as an integral part of water demand in water resources development planning.

The Study Area is divided into 10 zones for the purpose of water balance study and balance point was selected in the representative river in each zone. Water deficit was calculated for each zone on 10-day basis for hydrological condition of a standard year. The standard year is a year period from May, 1979 to April, 1980, which is the driest year during a 14-year period from 1968 to 1981.

For the optimization of the combination of water resources and inter-zone water diversions, 4 alternative schemes were compared for the Target Year 2001. Their construction costs were preliminary assesed and compared each other.

Optimum development plan was selected among 4 alternatives. Development programme of the selected plan was made for 1986, 1991, 1996 and 2001. Investment requirement was also estimated in accordance with the proposed development programme.

2. FUTURE WATER DEMAND

2.1 Domestic and Industrial Water Demand

2.1.1 General

The detailed description of water demand forecast for domestic and industrial use is made in the Sectoral Report IV, Domestic and Industrial Water Demand. The figures of water demands in the Sectoral Report IV are indicated in terms of consumers' demands.

Some water losses occur between intake and consumers. Purified water losses in distribution system occupies the majority of total water losses and have been taken into account in consumers' water demands.

Other losses are raw water losses between intake and purification facilities and water losses for operation and maintenance of the purification facilities. These losses are defined as transmission losses. The quantities of transmission losses are uncertain but are assumed to be 10 % of consumers' water demands. Source water demand is defined as the consumer water demand added by the transmission losses. The water balance study was made based on the source water demand.

2.1.2 Demand Center

For the domestic water demand projection and supply plan, 13 demand centers have been identified. These centers would be populated by more than 5,000 people by the Target Year 2001. Fig. 1 shows the location of demand centers. Water demand is obtained for every five years; 1981, 1986, 1991, 1996 and 2001.

2.1.3 Urban Water Demand

Domestic water demand is divided into urban and rural water demands. Urban water demand is projected for each demand center based on the Eastern Seaboard Study and the assumptions established by the Study Team as explained in the Sectoral Report IV.

Table 1 shows the projected annual water demands in urban areas. The urban water demand reaches to 38.3 MCM/yr in 1991 and 78.2 MCM/yr in 2001.

2.1.4 Rural Water Demand

Rural water demand is projected for each zone based on the assumptions established by the Survey Team as explained in Sectoral Report IV.

The rural demand is shown in Table 2. Total water demand in rural areas is estimated to be 13.3 MCM/yr in 2001. It is assumed that 30 percent of pupulation in rural areas will be served with purified water in 2001. Other 70 percent of population will continue depending on rainfall, river water and groundwater.

2.1.5 Industrial Water Demand

Water demand for industrial use has been forecasted by ESS. These data are adopted in this study. Table 3 shows industrial water demand in each zone.

It is assumed that the water demand for Sttahip Naval Base can be met by water resources in Zone No. 7. Therefore, water demand for Sattahip Naval Base and water resources in Zone No. 7 are not considered in the water supply plan.

Water demands for commerce and light industry are included in urban water demand. Industrial water demand therefore excludes these water demands.

2.2 Irrigation Water Demand

The irrigation service areas to be included in the Study are the existing two irrigation projects, Bang Phra in Zone No. 2 and Ban Khai in Zone No. 10 and new irrigation development areas such as Khlong Luang scheme in Zone No. 1 and Khlong Thap Ma and Ban Khai extension schemes in Zone No. 10.

The irrigation areas of the Bank Phra and Ban Khai projects are 1,120 ha and 4,800 ha, respectively.

The Khlong Luang river basin embraces approximately 9,900 ha of irrigable land between the proposed Khlong Luang damsite and Phanat Nikhom. The Rayong river basin holds approximately 14,700 ha of fertile irrigable lands, of which 4,800 ha is being irrigated under Ban Khai irrigation project.

The extent of irrigation development area will be decided depending on availability of water resources. The water resources of the Khlong Luang and Rayong river basins are limited and its use shares with domestic and industrial water supply. It is, therefore, hardly attainable to develop the entire potential irrigable area.

The water balance study is carried out for a hydrological condition during a year period from May 1979 to April 1980. The period is the driest year during a 14-year period from 1968 to 1981. Thus the irrigation water demand necessary for the water balance study should be computed based on the reduced irrigation area.

According to the water balance study, in the Target Year 2001, there occurs approximately 49.3 MCM/yr of water deficit in the coastal area, zone Nos. 2 to 5 under the present water resources development conditions. Most prospective measure to solve the water deficit is diversion of water from both the Khlong Luang and Rayong river basins. Assuming that the water deficit is shared by the Khlong Luang river basin and Rayong river basin in proportion of their water supply capacities, irrigation areas in the standard year would be as follows:

Irrigation Area	Potential Irrigable Area	Irrigable Area in Standard Year	Remarks
	(ha)	(ha)	
Khlong Luang	9,900	4,700	New development
Khlong Thap Ma	2,400	2,200	New development
Ban Khai	4,800	4,800	Existing
Ban Khai Extension	7,700	5,400	New development
Bang Phra	1,120	1,120	Existing

The irrigation water demand for the water balance study is calculated based on the above irrigation area and unit irrigation diversion requirement. The unit irrigation water requirement is estimated based on the proposed cropping pattern with 150 % of cropping intensity and is shown in Table 4. The annual irrigation water demand is presented in Table 5.

It should be noted that the above irrigation areas are adopted only for the water balance study. The irrigation area of the respective irrigation scheme will finally be determined through the optimum development study, which will integrate the water resources, irrigation and agricultural developments.

2.3 River Maintenance Flow

The reduction of river flow due to intensified water use will result in adverse effect to various water users, if it exceeds a certain amount. It is therefore proposed to introduce the concept of the river maintenance flow. The river maintenance flow is the minimum discharge which is able to maintain water depth, flow velocity, water quality, channel stability, aquatic ecosystem and scenery to the extent necessary for navigation, fish catch, operation and maintenance of intakes, maintenance of river facilities, sea water repulsion, prevention of estuary clogging, conservation of groundwater, preservation of riparian land and people's amenity.

The river maintenance flow may be reduced to the extent of subsistence of water use, if a severe drought takes place. This extent should be sustained under any drought by reducing water withdrawal from the river.

The river maintenance flow is the indicator of the allowable limit of water withdrawal from the river. Increase water withdrawal should not be allowed, if it is foreseen to impair the river maintenance flow frequently. The river maintenance flow should be determined for each river, based on the conditions particular to the river. The river maintenance flow may require a costly development, if its rate is set considerably high. On the other hand, the river maintenance flow should not be the same as the recorded minimum flow, which is too small to sustain the exisisting water uses and environmental quality.

In the present study, in principle, the rate of the river maintenance flow is preliminary assumed to be equal to 90% dependable monthly discharge. For Ban Bung sub-zone of Zone No.1, the river maintenance flow is broadly assessed based on the historic water supply record. The river maintenance flow is presented in Table 6.

2.4 Gross Water Demand

For the water balance study all water demands which have been mentioned hereinbefore are classified into each zone. Gross water demand in each zone is shown in Table 7.

3. WATER BALANCE STUDY

3.1 Method of Approach

3.1.1 Target Year

The ultimate target of the study is to formulate the most optimal water resources development and water supply network system in order to satisfy the domestic, industrial and irrigation water demands to be generated in the Study Area in Target Year 2001. An intermediate year has been set in 1991.

The water demand and supply balance study presented herein is elaborated for every 5-year period; 1986, 1991, 1996 and 2001, in due consideration of the period of the national five year development plan and the period of the Eastern Seaboard Development plan as well as development plan sequence of the proposed water resources and water transmission facilities.

3.1.2 Zoning and Balance Point

In principle, water resources management is carried out based on river basins. For the purpose of the water demand and supply balance study, the Study Area is divided into 10 zones as shown in Fig. 1 and summarized below.

Zone No.	Name of Basin	Area (km^2)	Representative River
1	Khlong Luang	2,118	Khlong Luang
2	Chon Buri	168	Khlong Yai Cheng
3	Bang Phra	128	Huai Sukhrip
4	Laem Chabang	361	Khlong Bang Lamung
5	Pattaya	142	Huai Nong Pru
6	Huai Yai	135	Huai Yai
7	Sattahip	422	Khlong Bang Phai
8	Ban Chang	109	Khlong Phayun
9	Map Ta Phut	120	Khlong Huai Yai
10	Rayong	1,776	Rayong

Each zone consists of a single river basin or a few river basins.

Zone Nos. 1 and 10 embrace Sub-zone No. 1-1 (Ban Bung) and Sub-zone No. 10-1 (Thap Ma) respectively.

The balance point was selected in the representative river of each zone, except Zone No. 7, to calculate the water deficit. It was broadly assumed that water resources available in Zone No. 7 would be exclusively used for Sattahip Naval Base. The water demand by civil life in Zone No. 7 will therefore be met by the planned Dok Krai pipeline project.

Zone No.	Representative Rivers	Balance Point	Catchment Area (km^2)
1	Khlong Luang	Khlong Luang damsite	526
1-1	Khlong Ban Bung	Ban Bung dam	51.2
2	Khlong Yai Cheng	Estuary	30.1
3	Bang Phra	Bang Phra dam	123
4	Khlong Bang Lamung	Estuary	301
5	Huai Nong Pru	Map Prachan dam	37.9
6	Huai Yai	Estuary	119
7	Khlong Bang Phai	-	-
8	Khlong Phayun	Estuary	31.8
9	Khlong Huai Yai	Estuary	120
10	Rayong	Ban Khai weir	1,143
10-1	Khlong Thap Ma	Thap Ma damsite	158

The balance point was set up at the lowest intake site basically. If not, it was set up at the estuary.

The water resources in catchment area upstream from the balance point can be used for water supply. The water resources in the other area is used partially as local water resources if available.

3.1.3 Standard Year

In order to determine the water resources development requirement and the inter-zone diversion requirement, water deficit at balance point was calculated for each basin based on hydrological condition of a standard year. The standard year is a year period from May 1979 to April 1980, which was the driest year during a 14-year period from 1968 to 1981 in terms of hydrologic year.

The water deficit was calculated on 10-day basis for 1986, 1991, 1996 and 2001. The 10-day discharge in the standard year is shown in Table 8.

3.2 Available Local Water Resources

The field investigation of water resources has been carried out. As a result of the investigation it is found that water resources described hereinafter are utilized at present.

Water works in operation for domestic use are as shown in Tables 9 and 10. If the water resources of the water work are located out of the upper catchment area from the balance point, it is taken into account as an available local water resources.

Groundwater is also utilized for domestic and industrial use as shown in Table 11. A number of tube wells were utilized but recently abandoned because of salt water intrusion from the sea. One-third of existing shallow-wells become dryness in the dry season. For the water balance study, groundwater only for industrial use was adopted as available local water resources though the amount is a little compared with the water demand.

The available local water has been taken into account in Zone Nos. 1, 1-1 (Bang Bung Sub-zone), 8 and 9. These quantities are shown in Table 12.

3.3 Water Withdrawal

Water withdrawal is a river discharge at a balance point requested by the water demands which are deducted by the available local water resources. The water withdrawal is calculated at each balance point of each zone as presented in Table 13. The water withdrawal for the whole Study Area is also shown in Table 13.

3.4 Water Deficit

The water deficit is defined as balance between the water withdrawal and the natural run-off at the balance point. If the water withdrawal deducted by the natural run-off is positive, water deficit comes out. It negative, remainder of natural run-off runs into the sea. The water deficit is an indicator in determining the water resources development requirement.

The water deficit was firstly calculated under with-dam condition; outflows from the catchment areas of the existing, under construction and planned dams are not taken into account for the convenience of study. The calculation was made for each 10-day period for each zone for 1986, 1991, 1996 and 2001. The natural run-off of the standard year are incorporated in the calculation. The results of the calculation are shown in Tables 14 to 25.

The resultant water deficit was modified. The water supply capacity of Ban Bung, Bang Phra, Nong Kho, Map Prachan, Dok Krai and Nong Pla Lai dams is deducted from the water deficit calculated as above. The annual water deficit of each zone and the Study Area is shown in Table 13. Figs. 2 to 14 present a relationship between water demand, natural run-off and water supply capacity of dam.

It should be noted that the water deficit in each zone was computed only at the balance point and it indicates an overall balance in the zone. There may be a case that river flow is in deficit in some section upstream of the balance point, if there exists a large water demand.

4. WATER SUPPLY PLAN OVER STUDY AREA

4.1 Potential Damsites

The water deficit in each zone should be met by either development of the water resources in the zone or diversion of water from other zones. The source of water is entirely dependent on surface water resources, since groundwater development potential is nil.

The construction of dam is the most conventional way of water resources development. Dam retains water in the flood period, so far as the storage capacity is available. The stored water can be released at any time to meet the water demand.

Sectoral Report XI, Water Resources Engineering has identified 9 potential damsites in the Study Area as under-listed and as shown in Fig. 15.

Potential Damsites	Zone No.	River	Catchment Area (km^2)
Khlong Luang	1	Khlong Luang	526
Pa Daeng	1	Huai Pa Daeng	53.8
Huai Bung	4	Huai Bung	68.5
Huai Takhian Tia	4	Huai Takhian Tia	33.0
Khlong Na Klua	5	Khlong Na Klua	22.3
Huai Chak Nok	6	Huai Chak Nok	18.1
Huai Yai	6	Huai Yai	65.9
Khlong Yai	10	Khlong Yai	218
Khlong Thap Ma	10	Khlong Thap Ma	158

The economic characteristics of the potential damsites have been studied in Sectoral Report XI and is indicated in terms of unit cost of water for the sequence of priority. Most prospective development scale of each potential damsite is also determined from the viewpoint of unit cost of water and is shown in Table 26 .

Water supply capacity of the existing, under construction and planned dams has also been revealed through draft analysis as presented in Sectoral Report XI and is shown in Table 27.

4.2 Water Resources Development and Inter-zone Water Diversion Alternatives

4.2.1 Basic Strategy

The water resources development and inter-zone water diversion alternatives have been set up in line with the following basic strategy.

(1) The water resources development and inter-zone water diversion plan will initially be formulated for the Target Year 2001. The proposed plan will be implemented in a stage-wise development. It is therefore, considered that a plan for the Intermediate Year 1991 is an integral part of the proposed plan for 2001 and must be consistent with concept of the proposed plan for 2001. The plan for 1991 will accordingly be established based on the proposed plan for 2001.

(2) Dok Krai pipeline system should be completed earlier as possible to satisfy the immediate industrial water demand in Zone No. 9 which has no alternative source of water supply. The water demand in Zone No. 9 reaches to 33.9 MCM in 1986.

(3) The extension of Dok Krai pipeline system needs to be realized to supply the domestic and industrial water demand in Zone Nos.7 and 8. Both zones are hardly blessed with water resources development potentials. The existing Phulta Luang and Khlong Bang Phai dams are used exclusively for Sattahip Naval Base.

(4) The Nong Pla Lai dam should be completed in 1986 at the latest to take over function of Dok Krai dam. The Dok Krai dam alters its main function to the domestic and industrial water supply. Delay in completion of Nong Pla Lai dam will create a serious water shortage problem in Ban Khai and Ban Khai Extension irrigation areas.

(5) In the Target Year 2001, quantity of water deficit in the coastal area (Zone Nos. 2 through 5) reaches to 49.3 MCM/yr. The water deficit should be met by either the development of a number of potential dams in the coastal area or the diversion of water from the Khlong Luang and/or Rayong river basin.

In case that the water diversion is needed from both the Khlong Luang and Rayong river basins, both river basins bear their share in water diversion in proportion of availability of water resources and their runoff coefficients.

4.2.2 Water Resources Development and Inter-zone Diversion Alternatives

Four alternatives are open to balance the water demand and supply for the Target Year 2001. They are illustrated in Figs. 16 through 19 and their characteristics are described hereunder.

The water balance study has been repeated to work out the water demand and supply of each alternative. The water deficit was calculated assuming that there is no outflow from the catchment area of the proposed damsite. This is to compare the water deficit to the water supply capacity by the proposed dams. Tables 28 to 36 present the refined water deficit for each alternative.

ALTERNATIVE I:

Four dams are newly developed. They are the Khlong Luang and new Ban Bung dams in Zone No. 1 and Khlong Thap Ma and Khlong Yai dams in Zone No. 10.

The domestic and industrial water demand in Zone Nos. 7 through 9 is satisfied by water diversion from Dok Krai dam through Dok Krai pipeline system.

The water deficit in the coastal area, Zones 2 to 5, 49.3 MCM/yr is met by water diversion from both the Khlong Luang and Rayong river basins. The Khlong Luang river basin diverts 18.0 MCM/yr of water, consisting of 7.0 MCM/yr by new Ban Bung dam and 11.0 MCM/yr by Khlong Luang dam, and the Rayong river 31.3 MCM/yr.

ALTERNATIVE II:

This is quite similar to ALTERNATIVE I. The Huai Bung dam is proposed in lieu of new Ban Bung dam.

As same as ALTERNATIVE I, the domestic and industrial water in Zone Nos. 7 through 9 is supplied by water diversion from Dok Krai dam through Dok Krai pipeline system.

The Huai Bung dam produces 16.0 MCM/yr of regulated flow. The Khlong Luang and Rayong river basins divert 11.0 MCM/yr and 31.3 MCM/yr, respectively, to remedy further water deficit in the east coast. The Khlong Luang dam supplies the domestic and industrial water required in Bang Bung sub-zone.

ALTERNATIVE III:

The water diversion from the Rayong river basin is not included in this alternative plan. Dams to be developed are, therefore, Khlong Luang and new Ban Bung dams in Zone No. 1, Huai Bung, Huai Takian Tia dams in Zone No. 4, Khlong Na Klua dam in Zone No. 5, Huai Yai dam in Zone No. 6 and Khlong Thap Ma and Khlong Yai dams in Zone No. 10.

The water supply to Zone Nos. 7 through 9 is attained by water diversion from Dok Krai dam through Dok Krai pipeline system. Since no water diversion is made from the Rayong river basin to the east coast, development scale of the Khlong Yai dam is reduced to such extent as to meet the water deficit properly in Zone No. 10.

As same as ALTERNATIVE I, the Khlong Luang river basin bears 18.0 MCM/yr, out of 55.8 MCM/yr of water deficit in the east coast. The rest of the water deficit in the east coast, 37.8 MCM/yr is covered by construction of 4 small dams; Huai Bung, Huai Takhian Tia and Khlong Na Klua and Huai Yai dams.

ALTERNATIVE IV:

This is a case contrary to ALTERNATIVE III. No water diversion is made from the Khlong Luang Dam. The Khlong Luang dam is developed with reduced scale aiming mainly at supplying the irrigation water.

The new Ban Bung dam sustains the water use in Zone 10, including Ban Bung sub-zone.

The Dok Krai dam feeds Zone Nos. 7 through 9 with the domestic and industrial water through Dok Krai pipeline system.

The quantity of the water diversion from the Rayong river basin is 31.3 MCM/yr. The Huai Bung and Huai Takhian Tia dams are developed to overcome the further water deficit of 21.4 MCM/yr.

4.2.3 Rough Cost Estimate

The cost of the water resources development and inter-zone water diversion plan comprises the construction cost of the water resources facilities and the construction cost of the water transmission system. The construction cost of the irrigation development is not included and is common for the alternatives established.

The construction cost of the water resources development facilities has been estimated at preliminary level as reported in Sectoral Report XI. Table 37 presents the preliminary cost estimate of the water resources facilities for each alternative.

The construction cost of the water transmission system is estimated based on rough layout. Main features of the water transmission system are given in Table 38 and Figs. 16 through 19 for each alternative. This layout is tentatively used only for the purpose of comparison of the alternatives and is drawn up without paying an attention to development sequence. The stage-wise development plan is worked out only for the proposed plan. The estimate of construction cost of the water transmission system is reported in more detail in Sectoral Report XII. Table 37 shows the estimated cost of the water transmission system for each alternative.

The total construction cost, comprising the construction cost of the water resources facilities and the construction cost of the water transmission system, is estimated as shown in Table 37 for each alternative plan and is summarized below.

Alternatives	Construction Cost (฿ 10^6)		
	Water resources facilities	Water transmission system	Total
I	3,735.5	3,437.5	7,173.0
II	3,845.5	3,545.6	7,391.1
III	5,582.6	2,118.8	7,701.4
IV	4,534.5	3,281.9	7,816.4

4.3 Selection of Proposed Plan

In selecting the proposed water resources development and inter-zone water diversion plan, three basic criteria have been set forth as described below.

Firstly, the proposed plan should be that can be realized at the minimum cost. Since all the alternatives are set up for the same objective, the selected plan results in maximum economic return.

Secondarily, the raw water transmission facilities must be flexible for their implementation plan, since they would be expanded progressively in accordance with the increasing water demand.

Thirdly, it is intimated that the proposed plan is founded on the development of water resources facilities located in the inland area. The development of small damsites in the coastal plain is expressed to be hardly attainable, because of resettlement problems of inhabitants in impounding area.

All the alternatives were carefully evaluated from the viewpoint of construction cost and technical soundness. As the result, ALTERNATIVE I was selected as the selected plan.

4.4 Development Programme

The water resources development and inter-zone diversion plan would be implemented progressively in a stage-wise development. Thus the selected plan must be refined taking into account the development sequence during a study period. In the light of such circumstances, development programme was worked out for every 5-year period; 1986, 1991, 1996 and 2001 and was elaborated based on the preliminary selected plan and water deficit of the respective year.

The proposed development programmes are illustrated in Figs. 16 and 20 to 22 and are shown in Table 39.

The main features of the water resources facilities and raw water transmission facilities are shown in Table 26 and Table 40 , respectively.

4.5 Investment Requirement

The construction cost estimate was carried out for the proposed development programme. The cost was estimated separately for the water resources facilities and for the raw water transmission facilities. Table 41 shows the preliminary cost of the water resources facilities and the raw water transmission facilities.

The total cost for the proposed water resources development and inter-zone water diversion plan is estimated at ฿7,568.3x10^6 as tabulated below.

Year	Construction Cost (฿ 10^6)			Accumulation (฿ 10^6)
	Water Resources Facilities	Raw Water Transmission Facilities	Total	
1986	542.6	1,011.0	1,553.6	1,553.6
1991	2,471.9	971.6	3,443.5	4,997.1
1996	721.0	879.8	1,600.8	6,597.9
2001	-	970.4	970.4	7,568.3
Total	3,735.5	3,832.8	7,568.3	7,568.3

REFERENCES

1. EASTERN SEABOARD STUDY FOR THE NATIONAL ECONOMIC & SOCIAL DEVELOPMENT BOARD, INTERIM REPORT ; COOPERS & ASSOCIATES, JUL. 1982.

2. THE FIFTH NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN, (1982 - 1986) : NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD

3. EAST COAST WATER RESOURCES DEVELOPMENT PROJECT : JICA, MAR. 1982.

4. HANDBOOK OF APPLIED HYDROLOGY ; V.T. CHOW ; McGRAW-HILL BOOK CO., INC., 1964