River/Area	Dam	River Improvement	Retarding Basin	Floodway
Kampar River				
Kanan	Kapoernan	x	-	-
Kiri (Sibayang)	Kiri No. 1	x	-	-
Kiri (Singingi)	Kiri No. 2	x	-	-
Kiri	Kiri No. 1&2	x	x	-
Kampar	Kiri No. 1&2	x	x	-
Indragiri River				
Kuantan-Indragiri	Kuantan	x	x	x
Payakumbuh Area	-	x	-	-
Solok Area	-	x	-	x
Sijunjung/Muara Area	Sukam	x	-	-

Note: x : Applicable - : Not Applicable

5.3.8 Identification of Flood Control Plan

The following component projects of the Overall Development Plan have been formulated on the basis of the objective areas for flood protection, as discussed in Subsection 5.3.4 and the premises and applicable alternative measures discussed in the foregoing section:

Component Project	Purpose	Note
Kampar River System		
Kampar Kanan River Improvement Works	Single	
Kampar and Kampar Kiri River Improvement Works	Multiple	Kampar Kiri No. 1 & No. 2 dams will be multipurpose dams.
Indragiri River System		
Kuantan-Indragiri River Improvement Works	Multiple	Kuantan Dam will be a multipurpose dam.
Upper Indragiri River Improvement Works		
- Payakumbuh Area	Single	
- Solok Area	Single	
- Sijunjung/Muara Area	Single	

As shown in the above table, component projects consist of single and multiple purpose projects. Optimization of multipurpose structures is described in Section 5.8, Formulation of Multipurpose Development Project, and the succeeding subsections present the optimization study of single purpose facilities for flood control.

5.3.9 Optimization of Flood Control Plan

The optimization of single purpose flood control facilities given in the table above is studied in this subsection, while the optimization of multipurpose flood control facilities is studied in Section 5.8, Formulation of Multipurpose Development Projects.

General Rule for Optimization

(1) Flood Control Dam

Application of a flood control dam and its scale are to be determined on the basis of the optimum combination of the dam and downstream river improvement. The combination with the least cost is considered as the optimum plan.

(2) Retarding Basin

Application of a retarding basin and its scale are to be determined on the basis of the optimum combination of the retarding basin and downstream river improvement. The combination with the least cost is considered as the optimum plan.

(3) Floodway

Application of a floodway and its scale are to be determined on the basis of the optimum combination of the floodway and downstream river improvement. The combination with the least cost is considered as the optimum plan.

(4) River Improvement

On the basis of the standard flood discharge with the combination of a dam, a retarding basin and a floodway, if these are applicable, design discharge distribution is determined. Optimization of river improvement is conducted for the determined design discharge as follows:

(a) Alignments and Longitudinal Profile

Case	Alignment	Longitudinal Profile
Case 1	Create shortest channel (many shortcuts)	Steep
Case 2	Shortcuts at heavily meandering points	Moderate
Case 3	Shortcuts only at extremely meandering points	Gentle

(b) Cross Section

Case	Cross Section
Case 1	Mainly with excavation
Case 2	Mainly with embankment (narrow channels with high banks)
Case 3	Mainly with embankment (intermediate of Case 2 and 4)
Case 4	Mainly with embankment (wide channels with low banks)

<u>Optimization of Kampar Kanan River Improvement Works</u>

(1) Alternative Cases

In this project, the following facilities are considered as applicable measures.

- Kapoernan flood control dam.
- River improvement of the Kampar Kanan River.

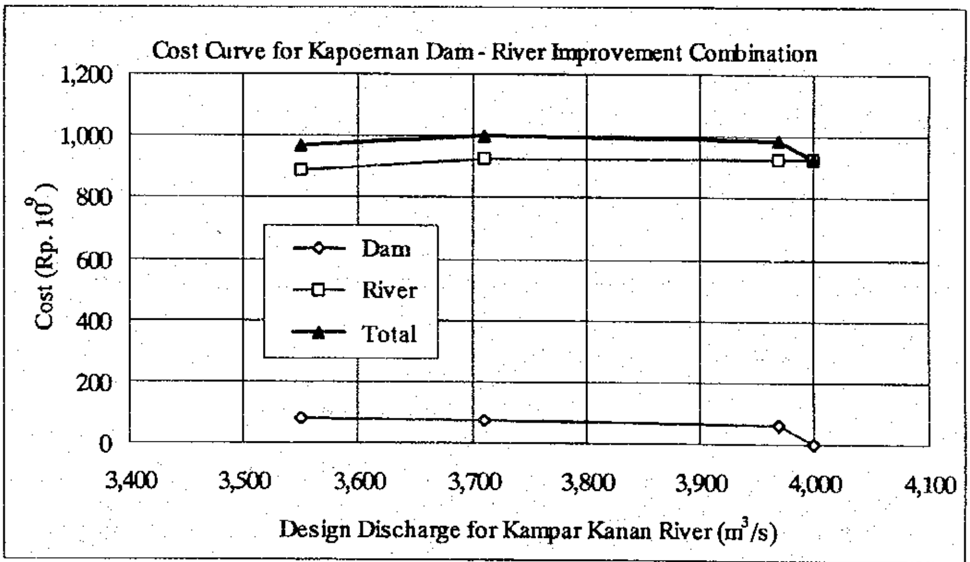
Kapoernan Dam is the only possible dam for flood control in the Kampar Kanan river basin. The damsite is located on the Kapurnangadang River at about 4.5 km upstream point from the confluence with the Kampar Kanan River. It is in the catchment area of Kotapanjang Dam. The catchment area at the Kapoernan damsite is 650 km^2. This corresponds to approximately 20% of the Kotapanjang Dam catchment area (3,337 km^2).

The alternative cases were set in combination with the flood control capacity of the Kapoernan Dam and the corresponding discharge of the Kampar Kanan River, as shown in the table below.

Flood Control Capacity of Kapoeman Dam ($10^6 m^3$)	Design Discharge of the Kampar Kanan River (m^3/s)	Peak Cut (m^3/s)
0.0	4,000	0
42.9	3,970	30
64.4	3,710	290
107.1	3,550	450

(2) Optimum Case

Costs of the dam and corresponding river improvement and the total cost are plotted as below. As shown in the figure, the minimum total cost occurs when the Kapoeman Dam is not employed. Accordingly, construction of the Kapoeman Dam is not considered.



Note: Cost is of direct construction.

(3) Design Discharge Distribution

The design discharge distribution for the Kampar Kanan River has been determined based on the standard flood discharge for 50-year return period as presented in Fig. 5.3.6. The design discharge for the Kampar Kanan River is estimated at 4,000 m^3/s.

(4) Optimization of River Improvement

(a) Alignment and Longitudinal Profile

As mentioned in the General Rule for Optimization discussed above, three alternative cases were established and compared. Among the three alternative cases, the case with shortcut at heavily meandering portions was identified as the optimum case because of the least cost. In the optimum case, the average riverbed gradient is 1/2,820 and flow velocity is 1.6 to 2.5 m/s.

(b) Cross Section

As mentioned in the General Rule for Optimization discussed above, four alternative cases were established and compared (refer to Fig. 5.3.7). Among the four alternative cases, the case that could assure flow capacity mainly by embankment, with excavation at only extremely narrow sections, is considered. The river width and height of high water level from the present land elevation of the case are 300 m and 2.6 m, respectively.

(5) Optimum Flood Control Plan

As a result of the above optimization, the optimum flood control plan for the Kampar Kanan River has been established. Plan, proposed longitudinal profiles and typical cross sections are shown in Figs. 5.3.8, 5.3.9 and 5.3.10, respectively.

Optimization of Kampar and Kampar Kiri River Improvement Works

(1) Alternative Measures

In this project, the following facilities are considered as applicable measures.

- Kampar Kiri No. 1 Multipurpose Dam
- Kampar Kiri No. 2 Multipurpose Dam
- Retarding Basin in the downstream stretch of the Kampar Kiri River
- River improvement of the Kampar and Kampar Kiri Rivers

(a) Dam

Hydropower generation is considered together with flood control purpose at the Kampar Kiri No. 1 and No. 2 dams. The optimization of dam and river improvement combination has been accordingly conducted in Section 5.8, Formulation of Multipurpose Development Projects. The capacity allocation for Kampar Kiri No. 1 and No. 2 dams has been determined, as given below.

Unit: 10^6m^3

Capacity	Kampar Kiri No. 1 Dam	Kampar Kiri No. 2 Dam
Flood Control	250	150
Hydropower Generation	646	438
Dead Storage	1,350	1,612
Gross Storage	2,246	2,200

(b) Retarding Basin

In accordance with the land use plan of REPELITA VI, the area along the Kampar Kiri River in the stretch upstream from the confluence with the Kampar Kanan River is designated as forest area. The flow capacity of the present channel in this section is very small and this area is always inundated.

The design discharges of this section can be decreased by 400-600 m^3/s, by applying this area as a retarding basin. Since the future land use in this area is forest, no benefit will be obtained even if the area is not considered as a retarding basin and protected from floods. Therefore, this area can be considered as a retarding basin.

(2) Design Discharge Distribution

As discussed before, the Kampar Kiri No. 1 and No. 2 dams and the Kampar Kiri Retarding Basin together with river improvement of Kampar and Kampar Kiri rivers have been considered as flood control measures. The design discharge distribution for the Kampar and Kampar Kiri rivers has been accordingly determined based on the standard flood discharge for 50-year return period as presented in Fig. 5.3.6 together with those for the Kampar Kanan River.

(3) Optimization of River Improvement

The following stretches are considered for river improvement.

- Sibayang River
- Singingi River
- Kampar Kiri River
- Kampar River

Since the design discharge of 500 m^3/s for the Sibayang River is almost the same as the present flow capacity, river improvement of the Sibayang River is not required. Although the design discharge of 1,200 m^3/s for the Singingi River is bigger than the present flow capacity, no improvement is considered because the area along the river is designated as forest area in the future land use plan.

The necessary improvement stretch of the Kampar Kiri River is from Kampung Dalam in the downstream end to Lipat Kain in the upstream end. As discussed for the Kampar Kanan River, improvement mainly by excavation is costly and thus, embankment is considered. In accordance with cross sections and topographical maps, the right bank area in this stretch consists of relatively high natural levees. One side bank (left bank) is thus considered for this stretch. Design high water level and crest level have been determined based on non-uniform calculation.

(a) Alignment and Longitudinal Profiles

Alignment and longitudinal profiles have been determined, as follows:

(i) Kampar Kiri River

Alignment	The present alignment has been basically maintained since wider channel can be considered by application of one side bank.
Longitudinal Profile	Basically follow the present profile.

(ii) Kampar River

Alignment	To create smoother channels by shortcut at heavily meandering points.
Longitudinal Profile	Determined on the basis of the new alignment: 1/5,500 - 1/17,000 (Average: 1/11,000).

(b) Cross Section

The following cross sections have been selected:

Kampar Kiri River	
Lipat Kain - Kampung Dalam	Left bank only
Kampar River	
Langgam - Kerinci	B = 600 m
Kerinci - downstream	Right bank only

(4) Optimum Flood Control Plan

The optimum flood control plan for the Kampar and Kampar Kiri rivers is established as a result of the above optimization. Plan, proposed longitudinal profiles and typical cross sections are shown in Figs. 5.3.8, 5.3.9 and 5.3.10, respectively.

Optimization of Flood Control Facilities for Middle and Lower Reaches of Indragiri River

The optimization of flood control facilities for the middle and lower reaches of the Indragiri River is described below.

(1) Applicable Measures

The following facilities are considered as applicable measures.

- Kuantan Dam
- Upper Sinamar Dam
- Sukam Dam

- Retarding Basin in the stretch downstream from Japura of the Indragiri River
- Gaung Floodway
- River Improvement of Kuantan and Indragiri Rivers

(a) Dam

The study revealed that flood control by the Upper Sinamar and Sukam dams is not advantageous because the peak cut effect is small. The Kuantan Dam is studied for optimization in combination with the river improvement in the downstream stretches. Since the Kuantan Dam is planned as a multipurpose dam, the optimization study is conducted in Section 5.8, Formulation of Multipurpose Development Projects. As a result, the flood control capacity of $400 \times 10^6 m^3$ is allocated to the Kuantan Dam.

(b) Retarding Basin

In accordance with the land use plan of REPELITA VI, the left bank area along the Indragiri River in the stretch downstream from Japura is designated as forest area and non-designated area. Accordingly, this area can be considered as a retarding basin. The design discharge of this section can be decreased by 500 m^3/s, by applying this area as the retarding basin.

Since the future land use in this area is forest, no benefit is obtained even if the area is not considered as a retarding basin and protected from floods. Accordingly, this retarding basin is taken into consideration.

(c) Floodway

A floodway that was planned in the Trans-Sumatra Canalization Project to divert a maximum discharge of 500 m^3/s from the Indragiri River to the Gaung River is considered for the present planning as a given condition (refer to Fig. 5.3.11).

(2) Design Discharge Distribution

The design discharge distribution for the Kuantan-Indragiri River has been accordingly determined based on the standard flood discharge for 50-year return period, as presented in Fig. 5.3.11.

(3) Optimization of River Improvement

(a) Alignment and Longitudinal Profiles

Alignment and longitudinal profiles were determined, as follows:

Alignment	To create smoother channels by shortcut at heavily meandering points.
Longitudinal Profile	Determined on the basis of the new alignment: 1/2,400 - 1/5,000 (Average: 1/3,400).

(b) Cross Section

The following cross sections have been selected.

Lubukjambi - Peranap	B = 300 m
Peranap - Japura	B = 600 m
Japura - downstream	Right bank only (Left bank is proposed as a retarding basin)

(4) Optimum Flood Control Plan

As a result of the above optimization considering the results of optimization for multipurpose structures as presented in Section 5.8, the optimum flood control plan for the middle and lower reaches of the Kuantan-Indragiri rivers has been established. Plan, proposed longitudinal profiles and typical cross sections are shown in Figs. 5.3.12, 5.3.13 and 5.3.14, respectively.

<u>Optimization of Flood Control Structure for Payakumbuh Area</u>

The following three rivers were studied in Payakumbuh Area:

- Sinamar River
- Agam River

- Lampasi River

(1) Applicable Measures

Since there is no suitable site for dams, retarding basins and floodways in the Payakumbuh area, only river improvement is the applicable measure.

(2) Design Discharge Distribution

The design discharge distribution for the Sinamar, Lampasi and Agam rivers has been determined based on the standard flood discharge for 50-year return period, as presented in Fig. 5.3.15.

(3) Optimization of River Improvement

(a) Alignment and Longitudinal Profiles

After the optimization study, the alignment was determined by basically maintaining the present channel and applying shortcuts at only the extreme meandering portions. The proposed longitudinal gradients were determined, as follows:

Sinamar River	1/450 - 1/2,050
Agam River	1/1,000
Lampasi River	1/600

(b) Cross Section

In accordance with the General Rule for Optimization discussed before, three alternative cases were established and construction costs were compared. As a result, the case that assures flow capacity by a combination of excavation and embankment was selected as the optimum case.

(4) Optimum Flood Control Plan

As a result of the above optimization, the optimum flood control plan for rivers in the Payakumbuh Area was established. Plan, proposed longitudinal profiles and typical cross sections are shown in Figs. 5.3.16, 5.3.17 and 5.3.18, respectively.

Optimization of Flood Control Structure for Solok Area

The following two rivers were studied in Solok Area:

- Lembang River
- Sumani River

(1) Applicable Measures

Since there is no suitable site for dam construction and retarding basin, river improvement and floodway were applied as alternatives. A comparative study on the construction costs of river improvement with- and without-floodway situations was carried out and the results show that river improvement without floodway is less costly than the case with floodway. Accordingly, river improvement without floodway was selected as the optimum case.

(2) Design Discharge Distribution

The design discharge distributions for the Lembang and Sumani rivers were determined based on the standard flood discharge of 50-year return period as presented in Fig. 5.3.15.

(3) Optimization of River Improvement

(a) Alignment and Longitudinal Profiles

After the optimization study, the alignment was basically determined by maintaining the present channel and applying shortcuts at only the extreme meandering portions. The proposed longitudinal gradients are given as follows:

Lembang River	1/140 - 1/1,480
Sumani River	1/800

(b) Cross Section

The excavated channel is applied to the Lembang River for the upstream stretch from the 11 km point from Singkarak Lake because it is physically and economically advantageous. For the stretch downstream from the same point, normal section with embankment and channelization as determined for the Sinamar River is applied.

(4) Optimum Flood Control Plan

As a result of the above optimization, the optimum flood control plan of the Lembang and Sumani rivers was established. Plan, proposed longitudinal profiles and typical cross sections are shown in Figs. 5.3.16, 5.3.17 and 5.3.18, respectively.

<u>Optimization of Flood Control Facilities for Sijunjung/Muara Area</u>

The following three rivers were studied in Sijunjung/Muara Area:

- Sukam River
- Palangki River
- Kuantan River

(1) Applicable Measures

The following works are considered as applicable for the Sijunjung/Muara areas. There is no suitable site for retarding basin and floodway.

- Sukam Dam
- River Improvement

Optimization of the dam storage capacity and river improvement with corresponding design discharge was carried out. As a result, the alternative case without Sukam Dam showed the least construction cost. Accordingly, river improvement only was applied.

(2) Design Discharge Distribution

As discussed before, dams, retarding basins and floodways are not proposed for flood control of Sijunjung/Muara Area. Accordingly, the design discharge distribution was determined based on the standard flood discharge of 50-year return period, as presented in Fig. 5.3.15.

(3) Optimization of River Improvement

The river improvement plan has been optimized in accordance with the following causes of flood.

(a) Poor Flow Capacity of Main Stream

Alignment, longitudinal profiles and cross sections have been determined following the optimization result conducted for Payakumbuh Area, since the conditions are similar.

(i) Alignment and Longitudinal Profiles

The alignment was basically determined by maintaining the present channel and applying shortcuts at only the extreme meandering portions. The proposed longitudinal gradients are as follows:

Sukam River	1/650 - 1/1,400
Palangki River	approx. 1/1,500

(ii) Cross Section

Normal section with embankment and channelization of low water channel as determined for the Sinamar River is applied.

(b) Backwater by Kuantan River

To prevent inundation by backwater from the Kuantan River, the following two alternative cases were established and construction costs were compared.

- Excavation of Kuantan River
- Backwater Levee Construction at Sukam and Palangki Rivers

As a result of the comparative study, the construction of backwater levee at the Sukam and Palangki rivers was selected as the optimum case because it is less costly.

(4) Optimum Flood Control Plan

As a result of the above optimization, the optimum flood control plan for rivers in Sijunjung/Muara Area was established. Plan, proposed longitudinal profiles and typical cross sections are shown in Figs. 5.3.16, 5.3.17 and 5.3.18, respectively.

5.4 Sediment Control Plan

5.4.1 Present Condition

The major sources of sediment in the Kampar-Indragiri river basin are:

- sheet erosion in devastated lands; and,
- bank erosion in river channels.

Of the sheet erosion, erosion in the Lampasi and Balubus rivers of the Indragiri river basin has been identified as significant through the field reconnaissance and DPU had constructed a check dam on the Balubus River. No other large sheet erosion areas have been reported.

Bank erosions are usually found along rivers especially at concave sides of meandering points. Bank erosions cause loss of land and sometimes houses.

A land cover analysis has been conducted by PUS-DATA based on the LANDSAT image. The study area was classified into 11 categories of land cover. The area and ratio of land cover are summarized below.

Land Cover	Kampar River Basin		Indragiri River Basin		Delta in Between	
	ha	%	ha	%	ha	%
High Dense Vegetation	1,100,706	44.8	623,366	38.3	976,601	92.3
Low Dense Vegetation	567,439	23.1	249,318	15.3	55,437	5.2
Bush and Shrub	162,264	6.6	130,350	8.0	8,324	0.8
Mixed Garden	302,406	12.3	253,894	15.6	1,172	0.1
Estate	149,816	6.1	150,288	9.2	113	0.0
Settlement	7	0.0	660	0.0	0	0.0
Paddy Field	37,507	1.5	70,307	4.3	4,895	0.5
Upland Cultivation	23,899	1.0	40,662	2.5	6,797	0.6
Bare Land	89,637	3.7	84,947	5.2	2,784	0.3
Transmigration	3,055	0.1	3,742	0.2	0	0.0
Water	18,066	0.7	19,266	1.2	1,877	0.2
Totals *	2,454,800	100.0	1,626,800	100.0	1,058,000	100.0

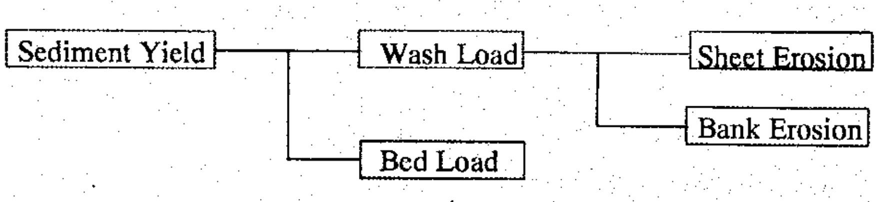
* Totals may not add up to amount indicated due to rounding.

5.4.2 Sediment Yield and Balance Analysis

Sediment yield and balance analysis have been carried out as below.

(1) Category of Sediment Yield

Sediment yield in basins can be classified into two; namely, wash load from drainage basins and bed load in river channels. Wash load is mainly produced by sheet erosion and bank erosion, and sheet erosion is a dominant source of sediment production in the study area. Sediment yield is accordingly estimated.



(2) Wash Load

As shown in the illustration above, wash load consists of sheet erosion and bank erosion. The Universal Soil Loss Equation (USLE), which is used worldwide, has been adopted for the estimation of sheet erosion in the study area. Bank erosion which is caused mainly by collapse of river bank is generally much lesser compared to sediment yield due to sheet erosion. For this study, 2% of sheet erosion is considered as bank erosion.

The yield volume of wash load has been calculated and the results are shown in the table below by sub-basin for the sediment balance analysis (refer to Fig. 5.4.1).

Unit: 1,000 m^3/year

Kampar River					
Sub-basin	K-1	K-2	K-3	K-4	Total
Wash Load	4,980	9,039	15,443	20,532	49,994
Indragiri River					
Sub-basin	I-1	I-2	I-3	I-4	Total
Wash Load	2,801	12,777	13,279	12,799	41,656

(3) Bed Load

Bed load has been calculated by the Kalinske·Brown's Formula based on the results of riverbed material survey carried out in this Study. The results of bed load calculation are summarized in the table below.

Unit: 1,000 m^3/year

Kampar River					
Sub-basin	K-1	K-2	K-3	K-4	Total
Wash Load	192	67	3,248	6,174	9,681
Indragiri River					
Sub-basin	I-1	I-2	I-3	I-4	Total
Wash Load	142	327	2695	5,116	8,280

(4) Sediment Balance Analysis

The sediment balance analysis has been carried out in accordance with the following procedure.

(a) Wash Load

The volume of wash load transport has been determined considering the delivery rate to the sheet erosion yield. The delivery rate is the ratio of wash load to be delivered to the river to the yielded sheet erosion. Wash load not delivered to the river is deposited in the basin. The delivery rate of 20% is applied to the present study referring to other similar projects in Indonesia. Wash load in the sediment balance analysis is considered not to be deposited to the downstream river channel.

(b) Bed Load

Bed load balance has been calculated as the balance of inflow of sediment produced as bed load in the upstream reaches and bed load transportability. Surplus will be deposited in the objective river channel and deficit will be taken from the channel.

The results of sediment balance analysis for both with- and without-project situations are shown in Table 5.4.1 and Fig. 5.4.2.

5.4.3 Sediment Inflow to Proposed Dams

Sediment inflow to the proposed dams have been calculated, as shown in Table 5.4.1 and summarized below.

River Basin	Location	Design Sediment Volume ($m^3/km^2/year$)
Kampar River Basin	Upper Reaches	500
Indragiri River Basin	Upper Reaches	585
	Middle Reaches	525

5.4.4 Sediment Control Plan

The sediment control plan is as described below.

(1) Collection of Basic Data

River profile and cross-section survey results shall be collected and additional survey for stretches where data are not available shall be conducted. Necessary periodical investigation surveys for whole river stretches shall also be carried out.

In addition, data for sand mining operations which are widely carried out along both Kampar and Indragiri river stretches shall be collected to serve as basic data for future control of sand mining operations.

(2) Structural Sediment Control Measures

Sediment control measures include structural and non-structural types. To prevent bank erosion, structural measures such as revetments and groins are to be provided at concave sides of meanders of river channels, and check dams or groundsills are proposed to prevent excess bed load and accordingly maintain the river gradient gentle. An example of check dam with gabion mattress which has the advantage of low cost and flexibility to riverbed variations is illustrated in Fig. 5.4.3.

(3) Non-Structural Sediment Control Measures

Non-structural sediment control measures include forest conservation or reforestation. Only non-structural measures are effective against sheet erosion which is the biggest source of sediment yield. Existing forests and plantation areas shall be conserved or maintained as reserved land and devastated areas or bare lands shall be reforested and maintained.

5.5 Irrigation Development Plan

5.5.1 Basic Concept for Planning

The Irrigation Development Plan is formulated to grasp future irrigation water demand for objective irrigation areas and to plan irrigation facilities for areas already developed as farmland but have water deficit and areas with newly established development plans but with no irrigation facilities constructed yet. Planning for new farmland development is not included in this study.

5.5.2 Agricultural Background of Study Area

The agricultural background of the study area is as presented below.

(1) Agricultural Production

At present there are about 150,000 ha of cultivated lands for paddy fields and rainfed fields in the study area. The main food crops in the study area are rice, maize, cassava, soybeans and groundnuts. Rice is an essential food crop and most cultivated areas are occupied by paddy fields. There was, however, a severe shortage of rice supply in Riau Province and about 200,000 tons of rice is bought annually from West Sumatra, North Sumatra and other provinces. Rice self-sufficiency was, therefore, a very important goal in the former Fifth Five-Year Development Plan (PELITA V) in Riau Province.

Crop production in the study area in 1992/1993 is summarized in the table below.

Summary of Crop Production in Study Area (1992/1993)

Unit: ton/ha

Crop	West Sumatra Province	Riau Province
Wetland Rice	5.4	3.8
Upland Rice	2.4	2.2
Maize	2.6	2.0
Soybean	1.4	1.2
Cassava	18.9	14.4
Sweet Potato	16.6	8.5
Groundnut	2.0	1.1
Pepper (Chili)	3.4	1.1
Cowpea	2.1	1.3
Cucumber	8.8	5.8
Eggplant	9.3	5.5
Tomato	9.4	14.4
Green Pea	1.1	1.1

(2) Transmigration Program

Transmigration from Java Island to Sumatra Island is being promoted by the national government and Riau Province in the study area is one of the destinations. The transmigration program is conducted in accordance with the basic national development plans as a means of manpower development and balanced distribution of the population aiming at promoting regional development.

Transmigration in the study area can be categorized into two: general transmigration and plantation-oriented transmigration. The former is oriented to produce food crops as its major income source with some tree crops as its secondary income source. The latter is oriented to produce tree crops as its main income source. A transmigrate under the general transmigration program is provided 2.0 ha of land per household, while a transmigrate under the plantation-oriented program is given 2.5 ha/household.

(3) Irrigation Development

(a) Cropping Conditions

Most irrigation areas in the study area in West Sumatra Province have already been developed, and even five croppings per two years are practiced locally. In the study area in Riau Province, double-cropping is dominant in the Kampar river basin while it is single-cropping in the Indragiri river basin.

(b) Irrigation System

There are three categories of irrigation system: simple, semi-technical and technical. The definition of each category is given in Table 5.5.1 and the present irrigation system in the study area is summarized in the table below.

Irrigation Projects by Irrigation System in Study Area

Unit: No.

Province	Simple Irrigation	Semi-technical Irrigation	Technical Irrigation	Total
West Sumatra	251	97	11	359
Riau	-	59	-	59
Total	251	156	11	418

Existing and future irrigable areas in the study area are as summarized below.

Irrigable Areas in Study Area

Unit: ha

Province	Government Project			Existing Village Irrigation Area	Total Future Irrigable Area
	Existing Irrigated Area	Future Irrigation Area	Total Irrigable Area		
West Sumatra	55,143	9,364	64,507	28,716	93,223
Riau	7,451	23,998	31,449	560	32,009
Total	62,594	33,362	95,956	29,276	125,232

(4) Swamp Development

Swamps are developed only in the study area in Riau Province. Swamp development is carried out both in tidal and non-tidal irrigation systems. The tidal irrigation system intake and drain river water utilizing the difference of water levels between high and low tides in areas near river mouths.

Tidal irrigation system has been developed only along the Indragiri river mouth. There is no tidal irrigation system along the Kampar river mouth. Along the Indragiri river mouth, there are 254,673 ha of potential tidal irrigation areas and about 75% of this area has been developed.

Non-tidal irrigation system means rainfed irrigation and has been developed in the swamp area in the lower reaches of both Kampar and Indragiri river basins including the in-between area. There are 6,624 ha of potential non-tidal irrigation areas and 3,006 ha have already been developed.

5.5.3 Basic Strategy of Irrigation Development

The basic strategy of irrigation development in the study area is as presented below.

(1) Irrigation Development in West Sumatra Province

In REPELITA VI, future irrigation projects in West Sumatra Province are found only in areas along the Indian Ocean outside the study area. Almost all of the study area in West Sumatra Province has already been developed as paddy field and there is no room for further development.

(2) Swamp Area

Paddy cultivation in swamp areas in Riau Province is mainly carried out during rainy season with single cropping. Irrigation water for this area is supplied by both tidal irrigation and rain. According to the interview survey in this area, additional irrigation water is not required for the swamp area. Accordingly, the swamp area is excluded from the objective area for irrigation development.

(3) Objective Area

Taking the present situation mentioned in the above items (1) and (2) into consideration, the irrigation development plan is formulated for the study area in Riau Province excluding swamp areas in the lower reaches of both Kampar and Indragiri rivers and the in-between area.

(4) Objectives of Irrigation Development

Based on the basic study on irrigation and drainage, the objectives of irrigation development are set up as follows:

- To provide a stable means of livelihood for local people and transmigrates already settled in the areas by supplying irrigation water and draining excess water;
- To contribute to regional needs by increased rice production with the aim of achieving rice self-sufficiency in Riau Province; and
- To support the program of the Government by providing irrigation and drainage facilities for local farmers and transmigrates already settled.

To realize self-sufficiency of rice in Riau Province, the following items should be increased.

- The area of paddy fields;
- The unit yield of paddy; and
- The annual cropping intensity of paddy.

5.5.4 Overall Irrigation Development Plan

As mentioned in Subsection 5.5.1, the Irrigation Development Plan is formulated for the existing irrigated areas which have irrigation water shortage and areas which have future agriculture development plans.

Selection of Existing Irrigation Development Project

The provincial government has established irrigation development projects in the study area, as shown in the table below.

Existing Irrigation Development Plans Formulated by PU in Riau

River Basin	Project Not Identified Yet		Project Already Identified	
	No. of Projects	Gross Irrigable Area (ha)	No. of Projects	Gross Irrigable Area (ha)
Kampar	3	55,000	0	0
Indragiri	6	68,000	7	42,500

Out of the existing development plans, the Rantauberangin Irrigation Development Project in the Kampar river basin (total irrigable area is 40,000 ha) and the Lubukjambi Irrigation Development Project in the Indragiri river basin (total irrigable area is 50,000 ha) were selected in this study as the objective development projects taking the following items into consideration (refer to Fig. 5.5.1).

- These areas are located downstream of the Kotapanjang Dam which is under construction and the Kuantan Dam which is proposed to be constructed.
- Many existing irrigation schemes are located within these areas, and most of the existing schemes will suffer from irrigation water deficit when they reach the target of development in the future. For proper functioning of existing irrigation schemes having water shortage problems, water sources derived from the dams to be constructed can be utilized to provide them with enough water.
- Available land for irrigation development are found in these areas, and expansion of the irrigable area is expected using abundant water sources from dams.
- Data concerning various fields in the Rantauberangin Irrigation Development Project and the Lubukjambi Irrigation Development Project required for the

irrigation development study are available and they were compared with those in other areas. They have already been arranged by the PU office in Riau and the PU branch offices in Bangkinang (the regional capital of Kampar District) and Rengat (the regional capital of the Indragiri Hulu District) which will be the managing offices for the objective irrigation development projects.

The objective development areas selected include existing developed areas with irrigation water shortage. Supplemental water supply for these areas were studied and incorporated into the future irrigation water demand.

Assessment of New Irrigation Development Areas

The selected new irrigation development areas have been assessed in terms of the following factors. As a result of assessment, these areas were identified to be suitable areas for paddy cultivation.

- Agroclimatic conditions;
- Water availability;
- Land and suitable soils;
- Farmer's motivation and farming skill;
- Crop productivity;
- Labor force availability;
- Farm input availability; and
- Accessibility to the scheme areas.

Features of New Irrigation Development Projects

(1) Rantauberangin Irrigation Development Project

The proposed project is situated at either banks of the Kampar Kanan River which runs through the center of Bangkinang, the regional capital of Kampar District. Both banks are comparatively flat areas, extending from the skirt of the hills at Rantauberangin Town to the confluence of the Kampar Kanan and Kampar Kiri rivers. The elevation of the area ranges from around EL 40 m to EL 10 m.

Among the total area of about 40,000 ha, the existing governmental irrigation schemes (10 schemes: 5,171 ha in the left bank area, and 12 schemes: 4,338 ha in the right bank area), and the existing drainage and swamp development schemes (4 schemes: 2,975 ha in the left bank area) are incorporated in the objective project formulation, taking topographic and soil conditions into consideration (refer to Table 5.5.2).

(2) Lubukjambi Irrigation Development Project

The proposed project is situated at either bank of the Indragiri River. Both banks are comparatively flat, extending from the skirts of the hills at Lubukkambacang Town to Japura. The elevation of the area ranges from around EL 40 m to EL 5 m.

Among the total area of about 50,000 ha, the existing governmental irrigation schemes (12 existing schemes: 4,142 ha in the left bank area, and 8 existing schemes: 2,230 ha in the right bank area) are incorporated in the objective project formulation, taking topographic and soil conditions into consideration (refer to Table 5.5.2).

Establishment of Irrigation Development Plan

(1) Rantauberangin Irrigation Development Project

(a) Objective Irrigable Areas

Identification of the objective irrigable areas was made from broad and comprehensive viewpoints paying attention to factors such as water sources available for irrigation, agricultural conditions, land use, soil and land suitability, influence of flood, and drainage conditions (refer to Fig. 5.5.2).

(i) Existing Irrigation Schemes

Left Bank Area	5,171 ha
Right Bank Area	4,338 ha
Total Irrigable Area	9,509 ha

(ii) Net Additional Area (including existing drainage and swamp development schemes)

Left Bank Area	10,517 ha
Right Bank Area	277 ha
Total Area	10,794 ha

(iii) Total Irrigable Area

Left Bank Area	15,688 ha
Right Bank Area	4,615 ha
Total Area	20,303 ha

(b) Intake Weir

At the upstream end of the Rantauberangin project area on the Kampar River, the Kuok Intake Weir is proposed to regulate water released from the Kotapanjang Dam and to intake water to main canals on both banks. The crest elevation of the Kuok Intake Weir is set at EL 40 m taking the tailrace water level of the Kotapanjang Dam of EL 41 m and the elevation of the Rantauberangin irrigation area into consideration (refer to Fig. 5.5.2).

(c) Main Irrigation Canals

Main irrigation canals with gravity command are proposed on both riverbanks. The alignment of main canals is shown in Fig. 5.5.2, and lengths are as follows:

Left Bank Main Canal	84 km
Right Bank Main Canal	40 km
Total Length	124 km

(2) Lubukjambi Irrigation Development Project

(a) Objective Irrigation Areas (refer to Table 5.5.2 and Fig. 5.5.3)

(i) Existing Irrigation Schemes

Left Bank Area	4,142 ha
Right Bank Area	2,230 ha
Total Irrigable Area	6,372 ha

(ii) Net Additional Area

Left Bank Area	12,875 ha
Right Bank Area	10,902 ha
Total Area	23,777 ha

(iii) Total Irrigation Area

Left Bank Area	17,017 ha
Right Bank Area	13,132 ha
Total Area	30,149 ha

(b) Intake Weir

At the downstream of the proposed Kuantan Dam and the upstream end of the Lubukjambi irrigation area near Lubukkambacang village, the Lubukjambi Intake Weir is proposed on the Indragiri River. The crest elevation of the Lubukjambi Intake Weir is set at EL 60 m, taking the elevation of the Lubukjambi irrigation area into consideration (refer to Fig. 5.5.3).

(c) Main Irrigation Canals

Main irrigation canals with gravity command are proposed on both riverbanks. The alignment of primary canals is shown in Fig. 5.5.3, and lengths are as follows:

Left Bank Primary Canal	119 km
Right Bank Primary Canal	123 km
Total Length	242 km

5.5.5 Irrigation Water Requirement

Cropping Pattern

Following cases were established for the study on optimization of cropping pattern.

Starting Dates of Land Preparation by Case

Study Cases	Rantauberangin Irrigation Development Project		Lubukjambi Irrigation Development Project	
	1st Crop	2nd Crop	1st Crop	2nd Crop
Case 1	Feb. 16	Sep. 1	Feb. 16	Sep. 1
Case 2	Jan. 1	Jul. 16	Jan. 1	Jul. 16
Case 3	Jan. 16	Aug. 1	Jan. 16	Aug. 1
Case 4	Feb. 1	Aug. 16	Feb. 1	Aug. 16
Case 5	Mar. 1	Sep. 16	Mar. 1	Sep. 16
Case 6	Mar. 16	Oct. 1	Mar. 16	Oct. 1
Case 7	Apr. 1	Oct. 16	Apr. 1	Oct. 16
Case 8	Apr. 16	Nov. 1	-	-

Note: In the case of Lubukjambi Irrigation Development Project, Case 8 was not studied because optimum cropping pattern appeared in Case 6.

Unit Water Requirement

Irrigation water requirements were estimated using the meteorological data at Pasar Kampar Station (Kampar river basin) and Sentajo Station (Indragiri river basin) which are located close to the center of the irrigation development project areas in each basin. Since data were not available at Sentajo throughout the whole observation period, the data at Peranal Station were used to supplement the unavailable data.

The unit water requirement was calculated based on the following factors:

- Effective rainfall
- Percolation
- Evapotranspiration
- Crop coefficient
- Water requirement for land preparation
- Irrigation water requirement during land preparation

- Water layer replacement
- Consumptive use
- Irrigation efficiency
- Base year

The calculation results of unit water requirement for each case are shown in Table 5.5.3.

Calculation of Water Requirement

Based on the following assumptions and unit water requirements, the water requirement of each case was calculated, as shown in Table 5.5.4.

- The irrigation area (refer to Table 5.5.2).
- The percolation rate is assumed to be 3 mm/day for future condition.
- Double-cropping is employed for both Kampar and Indragiri river basins.
- The starting date of land preparation.

Optimum Cropping Pattern and Water Requirement

The study cases with the minimum water requirement in Table 5.5.5 were identified as the optimum cropping pattern in both the Rantauberangin and Lubukjambi development plans. The identified optimum cropping patterns and water requirements are summarized below.

Development Plan	Study Case	Water Requirement (m^3/s)	
		Left Bank Area	Right Bank Area
Rantauberangin Irrigation Development Plan	Case 7	20.69	4.80
Lubukjambi Irrigation Development Plan	Case 6	19.31	17.62

5.5.6 Selection of Irrigation Area for Priority Projects

Priority projects to be urgently implemented have been selected from the Overall Development Plan. Two irrigation areas were selected for the priority projects in consideration of the following items:

- Early realization of existing irrigation schemes;

- Accessibility to project area in consideration of construction and marketing of the products;
- Population increase impact within the target year;
- Existence of some water user's associations in the existing irrigation schemes; and
- Higher economic viability.

The priority project areas which have higher economic viability were selected, as shown in Figs. 5.5.4 and 5.5.5 and summarized as follows:

- Either bank area from Kuok Intake Weir to Danau Bingkuang Bridge in the Rantauberangin Irrigation Development Project; and
- The left bank area from Lubukjambi Intake Weir to Kampung Baru in the Lubukjambi Irrigation Development Project.

<u>Priority Projects for Rantauberangin Irrigation Development Project</u>

The priority projects for Rantauberangin Irrigation Development Project are summarized below. Irrigation areas and primary canal lengths are given in Table 5.5.6.

(1) Existing Irrigation Schemes

Left Bank Area	5,171 ha (10 schemes)
Right Bank Area	4,338 ha (12 schemes)
Total Irrigable Area	9,509 ha (22 schemes)

(2) Net Additional Area (including existing drainage and swamp development schemes)

Left Bank Area	4,429 ha
Right Bank Area	277 ha
Irrigable Area	4,706 ha

(3) Total Irrigable Area

Left Bank Area	9,600 ha
Right Bank Area	4,615 ha
Irrigable Area	14,215 ha

Priority Projects for Lubukjambi Irrigation Development Project

The priority projects for Lubukjambi Irrigation Development Project are summarized below. Irrigation areas and primary canal lengths are given in Table 5.5.5.

(1) Existing Irrigation Schemes

Left Bank Area	4,142 ha (12 schemes)
Right Bank Area	- ha (- schemes)
Total Irrigable Area	4,142 ha (12 schemes)

(2) Net Additional Area

Left Bank Area	5,234 ha
Right Bank Area	- ha
Total Irrigable Area	5,234 ha

(3) Total Irrigable Area

Left Bank Area	9,376 ha
Right Bank Area	- ha
Total Irrigable Area	9,376 ha

5.6 Water Resources Development Plan

5.6.1 Study Area for Water Resources Development Plan

Study Area

The study area consists of two river basins, the Kampar river basin with a catchment area of 24,548 km^2 and the Indragiri river basin with 16,268 km^2, as shown in Fig. 5.6.1. In addition, a delta zone extending between the Kampar and Indragiri river basins with a catchment area of 10,580 km^2 will be included in the study area if the study is related to the zone. The study area belongs to the Riau and West Sumatra provinces and is divided by province as follows:

Unit: km^2

River Basin	West Sumatra Province	Riau Province	Total
Kampar	3,462	21,086	24,548
Indragiri	7,459	8,809	16,268
In-between Area	0	10,580	10,580
Total	10,921	40,475	51,396

Pekanbaru City, the capital of Riau Province, is included in the study area for water supply, although it is located outside the both river basins, because Pekanbaru City has a plan to take water for domestic and urban flashing uses from the Kampar River in the near future.

Administrative Division

The study area administratively belongs to the two provinces of Riau and West Sumatra, or the nine regencies (Kabupaten) and six municipalities (Kotamadya), as shown in Fig. 5.6.1.

Area and Population Shares

To estimate the water demand of the river basins and sub-basins based on administrative statistical data, an area share and a population share are introduced, as presented in Table 5.6.1.

Present and Future Population

The present and future population of Riau and West Sumatra provinces are summarized as follows:

Province	1994	2019	Growth Rate
Riau	3,833,000	8,747,000	3.36%/year
West Sumatra	4,404,000	6,279,000	1.43%/year

The future populations of the Kampar and Indragiri river basins are estimated based on the respective regencies and municipalities dividing them into rural and urban areas. The population forecast in the study area is summarized by area, river basin and province as below:

Unit: 1,000 persons

River Basin	Area	1994	1999	2004	2009	2014	2019
Kampar	Rural	493.1	551.5	609.5	672.7	733.7	792.8
	Urban	29.0	45.0	64.1	87.3	114.2	145.1
	Total	522.1	596.5	673.6	760.0	847.9	937.9
Indragiri	Rural	1,888.6	2,040.0	2,186.6	2,356.3	2,515.0	2,677.5
	Urban	322.5	382.4	448.4	528.6	614.4	710.3
	Total	2,211.1	2,422.4	2,635.0	2,884.9	3,129.4	3,387.8
Pekanbaru City	Rural	64.0	70.7	76.4	78.2	71.7	54.1
	Urban	432.8	578.6	782.4	1,057.5	1,395.1	1,818.0
	Total	496.8	649.3	858.8	1,135.7	1,466.8	1,872.1
Study Area	Total	3,230.0	3,668.2	4,167.4	4,780.6	5,444.1	6,197.8

Unit: 1,000 persons

Province	River Basin	1994	1999	2004	2009	2014	2019
Riau	Kampar	924.7	1,145.6	1,426.8	1,782.3	2,194.3	2,682.6
	Indragiri	711.3	813.2	921.4	1,037.7	1,156.3	1,282.4
	Total	1,635.0	1,958.8	2,348.2	2,820.0	3,350.6	3,965.0
West Sumatra	Kampar	94.3	100.2	105.5	113.4	120.4	127.4
	Indragiri	1,499.9	1,609.2	1,713.6	1,847.2	1,973.1	2,105.4
	Total	1,594.2	1,709.4	1,819.1	1,960.6	2,093.5	2,232.8
Study Area	Total	3,230.0	3,668.2	4,167.4	4,780.6	5,444.1	6,197.8

The average annual growth rate of the Kampar river basin is 2.4%, while that of the Indragiri river basin is 1.7%. Pekanbaru City has a higher growth rate of 5.4%.

5.6.2 Possible Water Supply Sources and Potential Water Resources

Possible Water Supply Sources

River water, groundwater, spring water and lake water in the study area are considered as the four water supply sources, and they are evaluated as follows:

(1) River Water

River water is the main water source and has the greatest potential of development among the water sources. It is usable for almost all purposes in most of the study area.

(2) Groundwater

Groundwater has been used a little in the study area because of its small potential compared with river water. The groundwater is utilized for domestic water in the lower basins of the Kampar and Indragiri rivers in Riau Province where piped water supply is difficult. However, water quality is not good for domestic use. No room exists for the substantial and economical development of groundwater.

(3) Spring Water

Spring water is abundant in West Sumatra Province and fully used for domestic water because water quality is good for domestic use and treatment cost is low. However, no room exists for the substantial development of spring water for other purposes.

(4) Lake Water

There are two natural lakes in the Indragiri river basin. One is the Singkarak Lake with a surface area of 130.11 km^2. It has a great storage capacity, but will be almost fully utilized for the Singkarak Hydropower Project after completion. No room for further development exist unless the present hydropower generation plan is altered. The other is Dibaruh Lake with surface area of 14.00 km^2. It is located upstream from Singkarak Lake and at the uppermost reach of the Indragiri River. No room for substantial development exists due to the small catchment area.

After completion of the Kotapanjang Dam for hydropower on the Kampar River, a huge reservoir will be created and flow of the Kampar River will be almost completely regulated. The water regulated is suitable for water supply for irrigation, domestic water of Pekanbaru City, etc. Accordingly, the river water should be considered as water source to be developed in this study.

Potential Water Resources

Among the water supply sources discussed above, the potential amount of river water and groundwater was estimated because these two sources represent the water resources.

(1) River Water

According to the hydrological analysis, the average discharges at major points of the Kampar and Indragiri rivers from 1981 to 1992 are tabulated as follows:

River Basin	Point	Catchment Area (km^2)	Ave. Discharge (m^3/sec)
Kampar	Kotapanjang Damsite	3,337	186.6
	Langgam	7,053	352.1
	River Mouth	24,548	1,010.4
Indragiri	Lubukjambi	7,453	260.9
	Air-Molek	12,320	462.2
	River Mouth	16,268	590.5

The annual river water potential volume and available water volume of both river basins are calculated from the above table, as presented below.

River Basin	Surface Water Potential ($10^9 m^3/year$)	Available Water ($10^9 m^3/year$)	Specific Discharge ($m^3/sec/100\ km^2$)
Kampar	31.9	22.3	4.12
Indragiri	18.6	13.0	3.63

Note: Available water is assumed to be 70% of the surface water potential.

(2) Groundwater

Groundwater use in the study area is not high because of abundant surface water, so that its potential has not yet been investigated in detail.

According to the study on "Water Resources and Potentially Irrigable Land of Riau" (Binnie & Partners Ltd. with Hunting Technical Service Ltd., July 1981), the groundwater potential areas (aquifer) in Riau Province come to 1,470 km^2 in Kampar river basin and 740 km^2 in Indragiri river basin.

On the other hand, the groundwater potential areas in West Sumatra Province was estimated, assuming that a recharge rate through potential area is 30% of effective rainfall in the area concerned. The results are as summarized below.

River Basin	Groundwater Potential (10^9m^3/Year)	Available Water (10^9m^3/Year)	Specific Discharge (m^3/sec/100 km^2)
Kampar	0.6	0.4	0.07
Indragiri	0.9	0.6	0.17

Note: Available water is assumed to be 70% of the surface water potential.

5.6.3 Present and Future Water Demand

Water Demands Subject to Study

The present and future water demands in the study area are studied for the following ten sectors.

- Irrigation
- Domestic Water
- Industry
- Inland Fishery
- Livestock
- Tourism
- Urban Area Flushing
- Hydropower Generation
- River Navigation
- River Maintenance Flow

The target year for water demand forecast is 2019. The analysis of historical data, estimation of present water demand and forecast of future water demand of the respective sectors are described hereinafter.

Irrigation

(1) Present Water Demand

The present water demand was estimated based on the existing irrigation areas identified in Section 5.5. The proposed irrigation development projects are Rantauberangin Irrigation Development Project in the Kampar river basin and Lubukjambi Irrigation Development Project in the Indragiri river basin.

In calculating the present irrigation water demand, double-cropping and single cropping were applied for the Kampar and Indragiri river basins, respectively. The present water demand estimated is summarized below.

River Basin	Existing Irrigation Area (ha)	Water Demand (m^3/sec)	
		Peak	Average
Kampar	7,557	12.09	3.26
Indragiri	84,313	147.77	38.84

(2) Future Water Demand

The future water demand has been estimated as the sum of water supply for new development areas and supplemental water supply for the existing irrigation areas in the Rantauberangin and Lubukjambi irrigation development projects. The future water demand has been estimated based on the assumption of double-cropping, as summarized below.

Unit: m^3/sec

River Basin	1994	1999	2004	2009	2014	2019	Average Annual Growth Rate (%)
Kampar							
Peak	12.09	22.57	31.68	40.79	9.90	59.01	6.5
Average	3.26	6.97	9.78	12.59	15.41	18.22	7.1
Indragiri							
Peak	147.77	122.73	131.80	140.87	149.94	159.01	0.3
Average	38.84	54.80	58.08	61.36	64.63	67.91	2.3

Note: Kampar River Basin - Base year 1988
Indragiri River Basin - Base year 1986

Domestic Water

(1) Present Water Demand

The present water demand was represented by the amount of services provided by water supply companies in the study area [called PDAM (Perusahaan Daera Air Minum)] and the demand of the area not served by PDAM. The latter was estimated based on the population and the assumption of water consumption rate of 30 ltr/capita/day. The results of estimation are as given below.

Present Water Supply by PDAM (1994)

River Basin	Service Population (person)	Water Supply (m^3/sec)
Kampar	137,100	0.25
Indragiri	264,800	0.49

Water Demand Areas not Served by PDAM (1994)

River Basin	Non-PDAM Population (person)	Water Demand (m^3/sec)
Kampar	881,800	0.31
Indragiri	1,946,400	0.68

(2) Future Water Demand

The future domestic water demand is forecasted dividing areas into PDAM service areas and other rural areas not served by PDAM as mentioned before.

(a) PDAM Demand Forecast

The future water demand of PDAM is forecasted based on the future population, the guideline of water supply planning of PU given in Table 5.6.2 and the REPELITA VI Program (1994/95-1999/2000) of the respective PDAMs. The criteria applied for the forecast of future water demand of PDAM are as follows:

- Service population is to be constantly increased at the same rate as stipulated in REPELITA VI.
- Operation hour is to be 24 hours.
- Loss rate is to be reduced down to 20% of production volume by 2019.
- Unit consumption per capita is to reach the government guideline by 2019.

(b) Non-PDAM Demand Forecast

The future water demand of the rural area not served by PDAM is forecasted assuming that unit water consumption per capita increases from 30 ltr/capita/day in 1994 to 40 ltr/capita/day in 2019.

(c) Future Water Demand

The future domestic water demand of the Kampar and Indragiri river basins is estimated based on the forecasted water demand of each PDAM and regency by the population share mentioned before. The results of estimation are summarized below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	1.00	1.50	2.15	3.18	4.55
Indragiri	1.66	2.22	2.67	3.30	3.85

Industry

(1) Present Water Demand

The production of existing industrial establishments in the study area was investigated using statistical data. The present water demand was estimated by multiplying the unit water consumption by the production amount. The unit water consumption was assumed as tabulated below.

Industry	Unit Water Consumption
Rubber Remilling	40 m^3/t
Pulp and Paper	170 m^3/t
Mineral Water	2 m^3/m^3
Crum Rubber	40 m^3/t
Plywood	2.8 m^3/m^3
Ice	2 m^3/m^3
Sawmill	2.8 m^3/m^3

Industry	Unit Water Consumption
Tapioka	60 m^3/t
Textile	150 m^3/t
Coal Mining	15.8 m^3/t
Fly Oil	6 m^3/t
Coconut Oil	6 m^3/t
Palm Flour	60 m^3/t

The present water demand estimated is summarized below.

River Basin	Water Demand (m^3/sec)
Kampar	0.23
Indragiri	0.74

(2) Future Water Demand

Since the future industrial development program in the study area has not been fixed yet in the Riau and West Sumatra provinces, the future water demand for industrial use is forecasted by future production of the existing major industries forecasted by regency based on the historical trend. The same unit water requirement rate as the present ones were applied.

Besides the above, water demand of the Ombilin Coal-Fired Steam Power Station (200 MW) which is scheduled to be commissioned in 1997 was taken into account. The water demand is 0.3 m^3/sec. The results of estimation are as given below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	0.34	0.46	0.58	0.68	0.81
Indragiri	0.78	1.22	1.62	2.03	2.35

Inland Fishery

(1) Present Water Demand

Based on statistical data, the present fishpond areas in the Kampar and Indragiri river basins have been estimated at 1,000 ha and 1,490 ha, respectively.

The unit water consumption of fishpond was assumed to be 7 mm/day/ha or 0.81 ltr/sec/ha with reference to the Study on Planning of Integrated Water Resources Development (DGWRD, Ministry of Public Works, 1991). The water demand of inland fishery is obtained by multiplying fishpond area by unit water consumption. The water demands of inland fishery of both river basins are estimated as below.

River Basin	Fishpond Area (ha)	Water Demand (m^3/sec)
Kampar	1,000	0.81
Indragiri	1,490	1.21

(2) Future Water Demand

The future growth of fishpond area was forecasted based on the past trend. The unit water consumption is taken as 0.81 ltr/sec/ha as mentioned above. The future water demand of inland fishery in each river basin is as given below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	0.99	1.11	1.23	1.35	1.47
Indragiri	1.37	1.51	1.65	1.80	1.94

Livestock

(1) Present Water Demand

Six typical kinds of livestock were selected for the study: the cow, the buffalo, the pig, the chicken, the duck and the goat/sheep. The livestock populations of the Kampar and Indragiri river basins in 1994 are estimated by the area share, as shown below.

Unit: head

River Basin	Cow	Buffalo	Pig	Chicken	Duck	Goat/Sheep
Kampar	46,600	28,300	280	1,673,500	60,600	39,600
Indragiri	102,700	63,100	340	2,457,200	364,600	96,500

The unit water consumption rate by each animal is as given below.

Kind	Cow	Buffalo	Pig	Chicken	Duck	Goat/Sheep
U.W.C	40	40	6	0.3	0.3	5

Note: U.W.C. = Unit water consumption rate in ltr/head/day .

By multiplying the number of livestock with the unit water consumption, the present livestock water demand of each river basin in 1994 was estimated as below.

River Basin	Water Demand (m^3/sec)
Kampar	0.05
Indragiri	0.11

(2) Future Water Demand

The future livestock population was estimated by extending the past trend. The future water demand was calculated by multiplying the future population with the unit water consumption at present. The results are as given below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	0.06	0.08	0.09	0.11	0.12
Indragiri	0.12	0.14	0.16	0.18	0.20

Tourism

(1) Present Water Demand

The water use for tourism is water consumption at tourism spots and recreation sites. Tourists are basically divided into domestic and foreign tourists.

The number of foreign tourists was obtained from statistical data, while no data on domestic tourists is available.. Therefore, the number of domestic tourists is assumed to be two times the foreign tourists in Pekanbaru City and 30% in regencies according to the information from Dinas Pariwisata (Provincial Office of Tourism).

The estimated number of tourists in the Kampar river basin in 1994 is 129,800 persons and in Indragiri river basin, 304,700 persons.

The unit water consumption per capita is assumed to be 10 ltr/capita/day and the average touring days 30 days/capita/year. Based on the above figures, the present water demand of tourism is estimated by river basin as below.

River Basin	Number of Tourists (person)	Water Demand (m^3/sec)
Kampar	129,800	0.001
Indragiri	304,700	0.002

(2) Future Water Demand

The future number of tourists was estimated by extending the past trend. The future water demand was estimated by multiplying the future number of tourists with the unit water consumption at present. The results are as given below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	0.002	0.005	0.006	0.008	0.011
Indragiri	0.005	0.007	0.011	0.015	0.019

Urban Area Flushing

(1) Present Water Demand

No flushing is being carried out in the study area. Therefore, the present water use for urban area flushing in the study area is nil.

(2) Future Water Demand

No criteria and standards for flushing are presently available in Indonesia. Also, no concrete flushing plan or program has been prepared yet in the study area. Therefore, the future water demand of urban area flushing is estimated by urban area population and per capita flushing water requirement, referring to the Study on Planning of Integrated Water Resources Development (DGWRD, Ministry of Public Works, 1991) in which the following figures are presented. The less requirement in 2016 to 2020 is due to the expected provision of sewerage system.

Year	Per Capita Water Requirement
1990 - 2000	330 ltr/capita/day
2001 - 2015	360 ltr/capita/day
2016 - 2020	300 ltr/capita/day

The results of estimation are as shown below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	2.38	3.52	4.76	6.28	6.80
Indragiri	1.46	1.87	2.20	2.56	2.47

Hydropower

(1) Present Water Demand

The existing hydropower stations located in the study area are Agam Station with installed capacity of 10,500 kW on the Agam River in Limapuluh Kota regency and a mini-hydropower station with 3 kW on the Sumani River in Solok regency. Both stations belong to Sumatra Province. Since they do not consume any water, no water demand for hydropower use exists at present.

(2) Future Water Demand

In the study area, two big hydropower projects related to the study are under construction in the Riau and West Sumatra provinces. They are:

- Kotapanjang Hydropower Project (Installed Capacity: 114 MW)
- Singkarak Hydropower Project (Installed Capacity: 175 MW)

The Kotapanjang Hydropower Project will be completed in 1997 and the Singkarak Hydropower Project, in 1998. They will affect the water balance in the study area.

The water released from the Kotapanjang Hydropower Station will be discharged to the downstream of the dam on the Kampar Kanan River. Therefore, no water will be consumed by hydropower generation. On the other hand, the water released from the Singkarak Hydropower Station will be diverted to the Anai River situated outside the Indragiri river basin. Therefore, diversion discharge of 43.7 m^3/s will be consumed.

The future water demand of hydropower is summarized as below.

Unit: m^3/sec

River Basin	1999	2004	2009	2014	2019
Kampar	0	0	0	0	0
Indragiri	43.7	43.7	43.7	43.7	43.7

River Navigation

(1) Present Water Demand

In the lower reaches of the Kampar and Indragiri rivers, river navigation is an important means of transportation at present because of the poor road network in the lower areas. However, this role will be reduced with the improvement and extension of road networks.

The navigation reaches in the Indragiri River extends from the river mouth to Peranap, about 350 km long. On the other hand, the navigation reaches of the Kampar River extends from Penyalai to Pangkalan Baru, about 300 km long. The water demand of river navigation is the present river discharge.

(2) Future Water Demand

Considering the present use of both rivers and the information from the Regional Office of the Ministry of Transportation, no significant increase of river navigation in both rivers is expected in the future. Therefore, it can be said that the water demand of river navigation is preferably to keep or improve the present river condition in the dry season. In this study, the average annual minimum monthly mean discharge is taken as the future water demand as far as no obstacle appears in the study, and it coincides with the river maintenance flow discussed below.

River Maintenance Flow

(1) Present Water Demand

Neither the Kampar River nor the Indragiri River has river structures to control river flow. Both rivers have been utilized under natural conditions so far. The river maintenance flow is important for water use in the downstream reaches such as river navigation, hindrance of sea water intrusion, irrigation, etc.

The river maintenance flow is usually set at an average annual minimum flow and represented by a specific discharge. The average annual minimum monthly mean discharges at major points are as follows:

River Basin	Point	Catchment Area (km^2)	Min. Discharge (m^3/sec)
Kampar	Kotapanjang Damsite	3,337	48.9
	Langgam	7,053	95.5
	River Mouth	24,548	275.6
Indragiri	Lubukjambi	7,453	65.1
	Air Morek	12,320	126.8
	River Mouth	16,268	165.4

The specific discharges of each river are summarized as follows:

Unit: $m^3/sec/100\ km^2$

River Basin	Maximum	Minimum	Average
Kampar	1.46	0.62	1.20
Indragiri (*)	1.03	0.70	0.92

* Excluding Sinkarak Lake basin.

(2) Future Water Demand

To maintain the present conditions of the Kampar and Indragiri rivers as much as possible in the future, the river maintenance flow in the future for the present water resources development study is set at almost average of the annual minimum monthly mean discharge from 1981 to 1992, that is, 1.2 $m^3/sec/100\ km^2$ in specific discharge for the Kampar river basin and 0.9 $m^3/sec/100\ km^2$ for the Indragiri river basin.

The future water demands of river maintenance flow of both rivers are given in specific discharge as below. The river maintenance flow at river mouth is 294.6 m^3/sec on the Kampar River and 146.4 m^3/sec on the Indragiri River, excluding the Singkarak Lake basin.

Summary of Future Water Demand

The future peak water demands forecasted by sector are summarized below. The average annual growth rate of total water demand excluding the river maintenance flow is 7.6% in the Kampar river basin and 3.2% in the Indragiri river basin.

Unit: m^3/sec

River Basin	1994	1999	2004	2009	2014	2019
Kampar	308.32 (13.74)	321.92 (27.34)	332.94 (38.36)	344.19 (49.61)	356.10 (61.52)	367.35 (72.77)
Indragiri	297.34 (150.93)	318.24 (171.83)	328.88 (182.47)	339.29 (192.88)	349.94 (203.53)	359.95 (213.54)

Note: Figures in parentheses indicate water demand excluding river maintenance flow.

5.6.4 Water Balance Analysis

Basin Division

For the water balance analysis, the Kampar and Indragiri river basins are divided into 11 sub-basins referring to the basin division for hydrological analysis shown in Fig. 5.6.2.

Water Balance Calculation

Water balance calculation is performed for the Kampar and Indragiri river basins following the criteria for water balance calculation given below. The calculation manner is schematically shown in Fig. 5.6.3.

Basin Runoff

The runoff of each sub-basin to be used for water balance analysis is given by hydrological analysis in CHAPTER 4, HYDROLOGICAL ANALYSIS. The period of runoff data is 12 years from 1981 to 1992.

The runoff data of the Kampar and Indragiri river basins are prepared for two cases each to cope with the implementation of the ongoing hydropower projects, Kotapanjang and Singkarak hydropower stations.

Water Demand

The water demand obtained in the previous subsection by administrative division are distributed to each sub-basin by areal ratio or population ratio. The future water demand of each basin is presented in Fig. 5.6.4.

Criteria for Water Balance Calculation

The water balance calculation is made based on the following criteria.

(1) Simulation Period: 12 years from 1981 to 1992.

(2) Calculation Interval: 5 days interval, in principle.

(3) Water Demand Case: Demand in 2019 is to be used for determination of project scale.

(4) Return Flow: Return flow is to be taken into account at the following rates.

Irrigation Water	30%
Domestic Water	40%
Industrial Water	40%
Urban Area Flushing Water	40%

(5) Effect of Ongoing Hydropower Projects

As mentioned before, the Kotapanjang Hydropower Project in the Kampar river basin and Singkarak Hydropower Project in the Indragiri river basin are under construction. They will be completed in 1997 and 1998, respectively. The effect of these projects to the study is to be taken into account in the form of change of basin runoff as mentioned before.

Water Balance in Sub-basin

Water balance was calculated in accordance with the manner of water balance calculation mentioned above and the water deficit of each sub-basin is obtained by the independent water balance calculation in the subject sub-basin. Table 5.6.3 presents the annual deficits in 2019 by sub-basin in the Kampar and Indragiri river basins excluding river maintenance flow which is subject to further study. The maximum annual deficits in the simulation period from 1981 to 1992 are summarized below. The sub-basins not given in the table have no water deficit.

Unit: $10^6 m^3$

Kampar River Basin		Indragiri River Basin	
Sub-basin	Max. Annual Deficit Volume	Sub-basin	Max. Annual Deficit Volume
K-2	89.1	I-1	57.2
		I-2	13.1
		I-3	13.3
		I-5	11.0
		I-6	272.8

5.6.5 Overall Water Resources Development Plan

Kampar River Basin

(1) Major Water Demand Areas

Major water demand areas were identified at the Rantauberangin Irrigation Development Project area which requires a maximum of 25.49 m^3/s in 2019 and Pekanbaru City which requires 10.90 m^3/s in 2019, as indicated in Fig. 5.6.5. No water deficits appear in the other sub-basins.

(2) Possible Damsites

Development of river water by construction of dams was proposed for water resources development. Three possible damsites were identified in the Kampar river basin. Their locations are as shown in Fig. 5.6.5 and their main features are as given below. Since the reservoir capacity of the Kapoernan

Dam is too small, the dam was excluded from the study on water resources development.

Damsite	Catchment Area (km^2)	Max. Effective Storage (10^6m^3)
Kampar Kiri No. 1	1,187	2,289 (El. 130 m)
Kampar Kiri No. 2	552	3,189 (El. 150 m)
Kapoernan	650	107 (El. 125 m)

Note: Figures in parentheses indicate possible maximum water levels.

(3) Formulation of Water Resources Development Plan

Since the major demand areas of Rantauberangin Irrigation Development Project and Pekanbaru City are situated downstream of the Kotapanjang Dam which is presently under construction, water released from the dam could be utilized for water supply to these areas by construction of an intake weir on the Kampar Kanan River at the uppermost reaches of the Rantauberangin area.

On the other hand, it is difficult to use the Kampar Kiri No. 1 and No. 2 dams for water supply to the above water demand areas due to their far location. Therefore, they should be independently developed. The expected benefits by these dams are of flood control and hydropower generation since the water demands downstream from these dams are as small as less than 1 m^3/s.

Consequently, the water resources development plans in the Kampar river basin are formulated as follows:

Water Resources Development Plan	Purpose
Kampar Kanan Water Supply Project	Irrigation water supply to Rantauberangin Irrigation Project and supply of domestic water, etc., to Pekanbaru City.
Kampar Kiri No. 1 Dam Construction Works	Flood control and hydropower generation.
Kampar Kiri No. 2 Dam Construction Works	Flood control and hydropower generation.

The location of each plan is as shown in Fig. 5.6.5.

(4) Optimization of Plans

Among the three water resources development projects mentioned above, projects (b) and (c) are multipurpose development projects and their optimization was studied in Section 5.8, Formulation of Multipurpose Development Projects. Only Project (a) of single purpose, Kampar Kanan Water Supply Project, is studied here.

As mentioned before, Kuok Intake Weir is proposed to be constructed to regulate the released water from Kotapanjang Dam and to divert water to the Rantauberangin irrigation area and Pekanbaru City. The diversion requirements at peak are as shown below.

Rantauberangin Project	25.49 m^3/s (*)
Pekanbaru City	10.90 m^3/s
Total	36.39 m^3/s

* For 5-year probable drought.

Indragiri River Basin

(1) Major Water Demand Area

The major water demand area was identified at Lubukjambi Irrigation Development Project area which requires a maximum of 48.03 m^3/s in 2019.

(2) Possible Damsites

Three possible damsites were identified in the Indragiri river basin. Their locations are as shown in Fig. 5.6.5, and their main features are as follows:

Damsite	Catchment Area (km^2)	Max. Effective Storage ($10^6 m^3$)
Kuantan	7,453	1,765 (EL 125 m)
Upper Sinamar	1,580	104 (EL 485 m)
Sukam	360	674 (EL 240 m)

Note: Figures in parentheses indicate possible maximum water levels.

(3) Formulation of Water Resources Development Plan

Since only the Kuantan Dam has enough reservoir capacity for water supply to the Lubukjambi Irrigation Development Project area and the maintenance flow for the downstream of the dam, the other dams were excluded from the study on water resources development in the Indragiri river basin.

Since the flood control and water resources development plans were however formulated as multipurpose projects, two other smaller dams were studied as alternative cases for flood control purpose in combination with the Kuantan Dam.

The optimum scales of multipurpose development projects were studied in Section 5.8, Formulation of Multipurpose Development Projects. As a result of the comparative study for 31 alternative cases, only the Kuantan Dam was employed for the Overall Development Plan and the other two dams, Upper Sinamar and Sukam dams, were not employed.

The optimum storage capacity and allocation for each purpose were determined as follows:

Flood Control	$400 \times 10^6 m^3$
Hydropower Generation	$415 \times 10^6 m^3$
Irrigation	$117 \times 10^6 m^3$
River Maintenance Flow	$213 \times 10^6 m^3$
Dead Storage	$425 \times 10^6 m^3$
Total	$1,570 \times 10^6 m^3$

5.7 Hydropower Development Plan

5.7.1 Basic Planning Concept

Indonesia's energy policy is to efficiently mobilize hydropower potential to save exportable resources such as oil, natural gas and coal, contributing to maximization of the country's foreign exchange earnings. In this sense, whenever dams are planned in development projects, the possibility of hydropower development are taken into account.

Since dam construction is employed in this study, the hydropower generation plan is formulated to use the residual capacity of the planned dam reservoirs or discharge flow released from dams for water supply. A single purpose dam of hydropower generation is not primarily studied, and the study on the hydropower generation plan does not aim to satisfy the future electricity demand but aims at supplemental supply.

The possible dams selected to be studied here are as below:

- Kampar Kiri No. 1 Dam (Kampar River Basin)
- Kampar Kiri No. 2 Dam (Kampar River Basin)
- Upper Sinamar Dam (Indragiri River Basin)
- Sukam Dam (Indragiri River Basin)
- Kuantan Dam (Indragiri River Basin)

5.7.2 Present Condition of Electric Power Supply and Use in Study Area

Existing Electric Power Facilities

Electric power in Indonesia is supplied by PLN and private sectors. West Sumatra and Riau provinces where the study area is situated belong to Region III of PLN. The power generating capacity of PLN Region III is summarized below.

Type	Hydro-power	Gas Turbine Power	Diesel Power	Total
Installed Capacity (kW)	79,100	42,700	142,300	264,100
Share (%)	30	16	54	100

The power generating capacity in West Sumatra and Riau provinces by private sectors is as tabulated below.

Province	Capacity	Remarks
West Sumatra	32,216 kW	including Padang Cement
Riau	103,212 kW	including Pertamina, but excluding Caltex
Total	135,428 kW	

PLN Transmission and Distribution System

PLN has two transmission systems in Region III: Maninjau System (150 kV, 228 km long) and Batangagam System (20 kV, 151 km long). Power distribution in Region III is made at the 20 kV level and low voltage of 380/220 volts, 50 Hz standard.

Present Electric Power Demand and Supply

The power generation and sales of PLN Region III Office in the year 1993/1994 are given as follows:

Item	Unit	1993/94
(1) Generation and Sales		
(a) Sales	GWh	891
(b) Losses of Transmission and Distribution	GWh	188
(Loss Ratio to Energy Production)	(%)	(17.0)
(c) Sent-out Energy	GWh	1,079
(d) Plant Use for Energy Production	%	2.5
(e) Energy Production	GWh	1,107
(f) Peak Load	MW	206.2
(g) Load Factor	%	61.3
(2) Type of Generation		
(a) Mini-Hydroelectric Power	MW	0.6
(b) Hydroelectric Power	MW	78.5
(c) Gas Turbine Power	MW	42.7
(d) Diesel Power	MW	142.3
Total	MW	264.1

The annual growth rate of sales is 13.4% in the period 1989/1990 to 1993/94. The share of energy consumption by area in the region in 1993/94 was as tabulated below:

Area	Padang	Bukittinggi	Solok	Pekanbaru	Dumai	Tj. Pinang	Total
Share (%)	48.8	9.2	2.7	22.2	7.6	9.5	100

The share of energy consumption by customer type in 1993/94 is as tabulated below.

Customer Type	Residential Use	Industrial Use	Others	Total
Share (%)	42.1	41.4	16.5	100

The PLN is pushing through the electrification of towns and villages as one of the important goals in social and economic development. The rural electrification rate in Region III as of 1994 is as follows:

Region	Total No. of Villages	Electricity Supplied Villages (No.)	Electrification Rate (%)	No. of Houses	Electrification Rate (%)
West Sumatra	2,011	1,453	72.25	147,850	20.62
Riau	983	277	28.18	66,458	11.66
Kerinci	246	169	68.70	16,258	29.48
Total			58.61		17.45

5.7.3 Expansion Program of Electric Power Facilities in Region III

PLN Generating Capacity Expansion Program

PLN has three major power generation projects in Region III which are under construction. Project features are as given below.

(1) Kotapanjang Hydropower Project

Location	Desa Merangin, Kec. Bangkinang, Kab. Kampar, Riau Province, 20 km from Bangkinang, 85 km from Pekanbaru, Riau Province
Water Source	Kampar Kanan River
Installed Capacity	114 MW (3 × 38 MW)
Annual Generation	542 GWh
Completion Year	1997/98

(2) Singkarak Hydropower Project

Location	Desa Tapakis, Kec. Lubukalung, Kab. Pariaman, West Sumatra Province, 32 km from Padang City
Water Source	Singkarak Lake
Installed Capacity	175 MW (4 × 43.75 MW)
Annual Generation	986 GWh
Completion Year	1998/99

(3) Ombilin Thermal Power Project

Location	Desa Sijantang, Kec. Talawi, Kab. Sawahlunto/Sijunjung, West Sumatra Province
Energy Source	Coal
Installed Capacity	200 MW (2 × 100 MW)
Completion Year	1997/98

Power System Interconnection Program

PLN is constructing transmission and substation facilities in Region III, which connect the existing system and newly constructed power stations at the capacity of 150 kV.

PLN also has a plan to connect the transmission in Sumatra Island aiming to achieve a better inter-cultural relationship, to reduce power reserve requirements and to improve network operations (refer to Fig. 5.7.1).

As a further long term plan, PLN is expecting networks with 500 kV extra high voltage transmission systems to interconnect with Java Island, as shown in Fig. 5.7.2.

5.7.4 Electric Power Demand Forecast

PLN's power demand forecast in Region III until 2008/09 is as tabulated below.

Fiscal Year	Energy Consumption (GWh)	Generation (GWh)	Peak Load (MW)
1993/94	891.2	1,107.1	206.2
1998/99	2,157.9	2,599.8	452.6
2003/04	3,383.7	4,076.7	738.4
2008/09	5,000.8	5,953.4	1,112.5
2013/14	7,313.9	8,707.1	1,672.8
2018/19	10,696.9	12,734.4	2,515.3

The growth rates of power generation capacity up to the year 2018/2019 are estimated as below:

Fiscal Year	Generation (%)	Peak Load (%)
1993/94 - 1998/99	18.6	17.0
1998/99 - 2003/04	9.4	10.2
2003/04 - 2008/09	7.9	8.5
2008/09 - 2013/14	7.9	8.5
2013/14 - 2018/19	7.9	8.5

Power demand and supply in Region III is presented in Table 5.7.1.

5.7.5 Necessity of Electric Power Development in Study Area

Presently, the power supply capacity cannot meet the demand in Region III, especially Pekanbaru City. Even though PLN is constructing three major power stations in the study area, demand will exceed the supply capacity in 2005, as shown in Table 5.7.1. After 2005, the additional demand shall have to be met from other regions through interconnection network. To reduce power supply from other regions, development of a power generation plan for the region is necessary.

5.7.6 Overall Development Plan of Hydropower Generation

Proposed Hydropower Stations

The following six dams are selected as possible dams for flood control and water resources development:

- Kampar Kiri No. 1 Dam (Kampar River Basin)
- Kampar Kiri No. 2 Dam (Kampar River Basin)
- Kapoeman Dam (Kampar River Basin)
- Upper Sinamar Dam (Indragiri River Basin)
- Sukam Dam (Indragiri River Basin)
- Kuantan Dam (Indragiri River Basin)

Since the Kapoeman Dam has a small reservoir capacity, it is studied for flood control purposes only. Kampar Kiri No. 1 and Kampar Kiri No. 2 power stations are optimized for power generation use since the dam reservoir capacities are huge and no interventions occur in storage allocation.

On the other hand, Kuantan Dam has a huge storage capacity but effective storage is limited, so that the installed capacity of Kuantan Power Station is to be determined as a part of multipurpose development for flood control and water supply.

Since Upper Sinamar and Sukam dams have small storage capacities, they are considered to supplement the Kuantan Dam. No exclusive storage for power generation use is considered.

Criteria for Reservoir Operation

For the hydropower generation calculation, the following criteria for reservoir operation are established.

(1) Power Generation Pattern

The power generation pattern of each power station is set as shown in Fig. 5.7.3 for the comparative study taking into account annual runoff, discharge for water supply, river maintenance flow, etc.

The simulated reservoir water level shall be returned to Normal Water Level (NWL) at least once every 5 years.

(2) Power and Energy Calculation

The outputs of power and energy are calculated by the following equations.

$$P = 9.8 \times h \times Q \times He$$

where, P : power output (kW)
h : combined efficiency (0.85)
Q : turbine discharge (m^3/s)
He : effective head (m)

$$E = P \times T$$

where, E : energy output (kWh)
P : power output (kW)
T : time (hours)

(3) Rated Water Level and Tail Water Level

The rated water level is set at the level of two-thirds of the water depth for effective storage. Tail water level is given by the uniform flow calculation.

(4) Installed Capacity

The installed capacity for comparative study is taken as the capacity given by turbine discharge of three times the assumed firm discharge and head for rated water level.

(5) Available Water for Power Generation

The water available for hydropower generation is, in principle, the water released for water supply. However, when excess water is spilled out from dams, peak power generation is extended to utilize the excess water for power generation as much as possible.

(6) Head Loss

Head loss in waterway to determine an effective head is approximated in the simulation study by the following equation:

$$H_L = \{ L/200 + 0.5 + \alpha \} (Q/Q_{max})^2$$

where,

H_L	:	head loss (m)
L	:	length of waterway (m)
α	:	0 to 0.5 m
Q_{max}	:	maximum turbine discharge (m^3/sec)
Q	:	discharge at power generation (m^3/sec)

Therefore, the effective head He is calculated as follows:

$$He = RWL - TWL - H_L$$

where,

He	:	effective head (m)

RWL : reservoir water level (EL m)

TWL : tail water level (EL m)

H_L : head loss (m)

Optimization of Installed Capacity

The optimization study for Kampar Kiri No. 1 and No. 2 power stations have been conducted.

The optimum installed capacity of power station is in principle defined as the one which gives maximum net present value (B-C) and benefit cost ratio (B/C) in comparative study. The benefit and cost of hydropower generation is represented by the benefit and cost of thermal power generation.

The benefit of hydropower generation consists of power benefit and energy benefit of thermal power generation. The power benefit is obtained by multiplying kW-value by 90% dependable power output and the energy benefit is obtained by multiplying kWh-value by annual energy output. The kW-value and kWh-value of thermal power generation applied are as summarized below.

kW-value	US$391.66/kW (< 50 MW) or US$318.14/kW (> 50 MW)
kWh-value	US$0.0178/kWh

(1) Kampar Kiri No. 1 Power Station

The alternative cases set by normal water levels (NWL)and corresponding installed capacities were established and the cost (C) and benefit (B) of each case were calculated.

The net present value (B-C) and benefit-cost ratio (B/C) were obtained as shown in the table below. Among the alternative cases, Case A.8 which has the maximum B-C and B/C was selected as the optimum case.

Case	NWL (EL m)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh/year)	B-C (Rp. 10^9)	B/C
A.1	115.0	98.6	95.3	355.6	27.10	1.52
A.2	115.0	113.6	102.3	349.9	29.29	1.53
A.3	115.0	119.3	99.8	340.9	26.68	1.48
A.4	120.0	105.8	101.5	378.4	28.78	1.51
A.5	120.0	122.1	111.4	373.3	31.73	1.53
A.6	120.0	128.2	107.2	373.3	27.76	1.46
A.7	125.0	112.7	110.2	401.7	30.62	1.50
A.8	125.0	130.9	121.2	398.5	35.99	1.57
A.9	125.0	137.3	115.8	388.8	28.70	1.43

NWL: Normal Water Level

The main features of Case A.8 are as summarized below.

Dam Height	103 m
NWL	EL 125 m
Necessary Storage Capacity for Hydropower Generation	$646 \times 10^6 m^3$
Installed Capacity	131 MW

(2) Kampar Kiri No. 2 Power Station

The alternative cases, B-C and B of the Kampar Kiri No. 2 Power Station are given in the table below.

Case	NWL (EL m)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh/year)	B-C (Rp. 10^9)	B/C
B.1	125.0	34.7	33.1	114.3	9.12	1.39
B.2	125.0	37.5	33.9	115.5	9.74	1.41
B.3	125.0	39.1	31.8	116.1	7.77	1.33
B.4	135.0	39.9	38.2	128.3	10.30	1.38
B.5	135.0	42.8	38.9	131.2	10.91	1.40
B.6	135.0	45.2	37.6	132.8	9.54	1.35
B.7	147.0	45.9	44.1	143.9	9.16	1.27
B.8	147.0	49.4	45.0	149.2	9.60	1.28
B.9	147.0	52.5	44.5	152.9	9.11	1.26

NWL: Normal Water Level

Among the alternative cases, Case B.5 gave the maximum B-C. However, the reservoir water level does not recover to NWL within five years. Therefore, Case B.4 which shows the second maximum B-C and B/C was selected as the optimum case.

The main features of Case B.4 are as summarized below.

Dam Height	95 m
NWL	EL 135 m
Necessary Storage Capacity for Hydropower Generation	$438 \times 10^6 m^3$
Installed Capacity	40 MW

(3) Kuantan Dam, Upper Sinamar Dam and Sukam Dam

Kuantan Dam is proposed to be developed as a multipurpose dam for flood control and water resources development. Therefore, the optimization study has been conducted in Section 5.8, Formulation of Multipurpose Development Projects, together with the Upper Sinamar and Sukam dams.

In total, 31 alternative cases were established for the optimization study in Section 5.8, as shown in Table 5.7.2. Among the alternative cases, Case K.19 was selected as the optimum case.

The main features of Case K.19 are as summarized below.

Surcharge Water Level (SWL)	EL 120.00 m
Normal Water level (NWL)	EL 115.20 m
Low Water Level (LWL)	EL 102.00 m
Effective Storage Available for Hydropower	$527 \times 10^6 m^3$
Installed Capacity	114.0 MW
90% Dependable Power	103.6 MW
Annual Energy Output	657.0 GWh/year

In the above optimum case, the Upper Sinamar and Sukam dams were not included. Accordingly, the Kuantan Dam only was employed for the Overall Development Plan in the Indragiri river basin.

5.8 Formulation of Multipurpose Development Projects

5.8.1 Project Components

The Overall Development Plan has five project components, three in the Kampar River System and two in the Indragiri River System. The projects consist of three single purpose and two multipurpose projects of flood control and water resources development as shown in the table below (refer to Fig. 5.8.1). Single purpose projects of flood control and water resources development are discussed in Section 5.3 and 5.6, respectively.

Name of Project	Purpose	Optimization Study
Kampar River System		
(1) Kampar Kanan Water Supply Project	Single	Section 5.6
(2) Kampar Kanan River Improvement Project	Single	Section 5.3
(3) Kampar and Kampar Kiri River Development Project	Multiple	This Section
Indragiri River System		
(4) Indragiri River Development Project	Multiple	This Section
(5) Upper Indragiri River Improvement Project	Single	Section 5.3

As shown in the table above, the following two projects are multipurpose development projects of flood control and water resources development.

- Kampar and Kampar Kiri River Development Project
- Indragiri River Development Project

5.8.2 Optimization for Kampar and Kampar Kiri River Development Project

Optimization for Kampar and Kampar Kiri River Development Project has been carried out as discussed below.

Basic Conditions

The following items were taken into consideration as basic conditions for the optimization study.

(1) Purposes of the Project

- Flood control of Kampar and Kampar Kiri rivers; and

- Hydropower generation at Kampar Kiri No. 1 and No. 2 dams.

(2) Hydropower Generation

Two damsites in the Kampar Kiri river basin are proposed respectively for Kampar Kiri No. 1 and No. 2 dams which may be used for both flood control and water resources development. Since the future water supply for Kampar river basin and Pekanbaru City is possible through the water released from Kotapanjang Dam which is under construction by PLN, water resources development at the above two dams focuses on hydropower generation only. The optimum reservoir capacity of the Kampar Kiri No. 1 and No. 2 dams is discussed in detail in Section 5.7, Hydropower Development Plan.

(3) Alternative Flood Control Measures

River improvement works, dams and natural retarding basin at the downstream of the Kampar Kiri River are taken into consideration as alternative flood control measures (refer to Section 5.3, Flood Control Plan). Floodway is not considered as an alternative due to topographic reasons.

(4) Dam Operation

Non-gated control was considered for both the Kampar Kiri No. 1 and No. 2 dams taking easier operation into account.

(5) Planning Criteria

(a) Design Scale for Flood Control

Final Phase: Urban Rural	50-year return period 50-year return period
Initial Phase	No project

(b) Standard Flood Discharge at Damsite

Standard flood discharges were set as below in accordance with the results of flood runoff analysis.

Damsite	Standard Flood Discharge (50-year Return Period)
Kampar Kiri No. 1 Dam	1,630 m^3/s
Kampar Kiri No. 2 Dam	1,240 m^3/s

(c) Flood Control Method at Dam

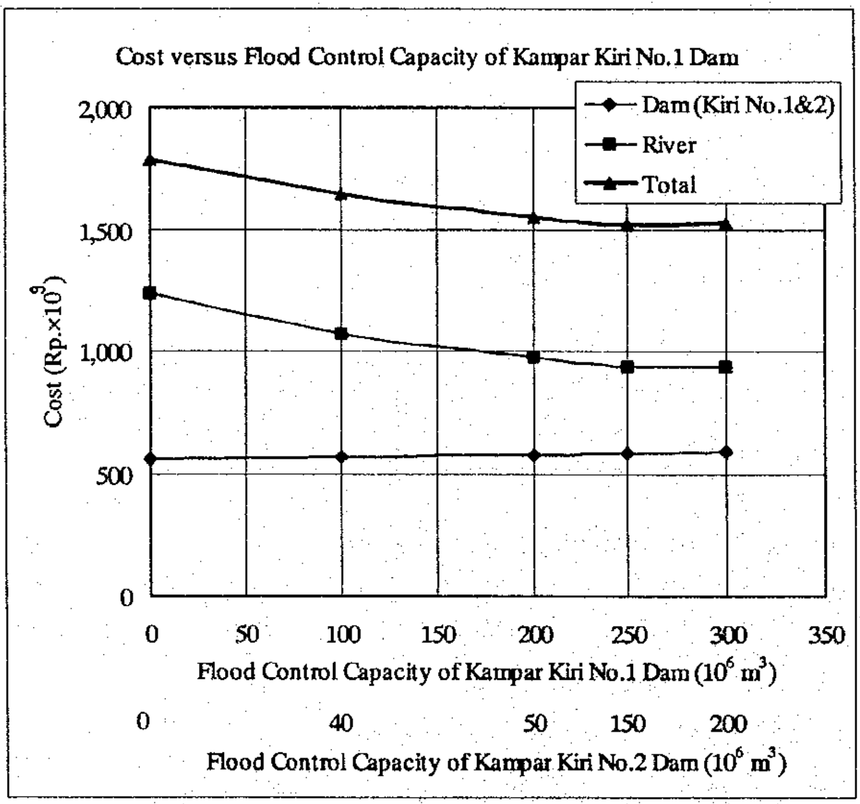
Non-gated control is considered for both Kampar Kiri No. 1 and No. 2 dams taking easier operation into account.

Alternative Cases

Alternative cases were established by the combination of reservoir capacity of the two dams and the design discharges for the improvement of the Kampar and Kampar Kiri rivers. The alternative cases established are presented in Table 5.8.1. A natural retarding basin at the downstream of Kampar Kiri River was taken into consideration in all alternative cases.

Cost Comparison

The costs versus flood control capacities of Kampar Kiri No.1 Dam are plotted as below:



As shown in the above illustration, the total cost is minimum when Kampar Kiri No. 1 Dam has the flood control capacity of $250 \times 10^6 m^3$ and Kampar Kiri No. 2 Dam has $150 \times 10^6 m^3$. As shown by the study results, although both dams can physically provide more flood control capacity, the design discharge of 1,450 m^3/s at Lipat Kain is the minimum value because of the existence of a residual catchment area between the dams and Lipat Kain.

Optimum Plan

Costs for dam construction and river improvement of the alternative cases presented above were estimated and a comparative study was made among total costs. The alternative case in which the Kampar Kiri No. 1 and No. 2 dams have the reservoir capacity of $2{,}246 \times 10^6 m^3$ and $2{,}200 \times 10^6 m^3$, respectively, was identified to have the minimum cost.

The major features of the optimum plan are summarized below.

(1) Kampar Kiri No. 1 Dam	
(a) Capacity Allocation	
Flood Control	$250 \times 10^6 m^3$
Hydropower Generation	$646 \times 10^6 m^3$
Dead Storage	$1{,}350 \times 10^6 m^3$
Total	$2{,}246 \times 10^6 m^3$
(b) Water Level	
Surcharge Water Level	EL 128.5 m
Normal Water Level	EL 125.0 m
Low Water Level	EL 113.9 m
(c) Flood Control	
Control Method	Non-gated Control
(2) Kampar Kiri No. 2 Dam	
(a) Capacity Allocation	
Flood Control	$150 \times 10^6 m^3$
Hydropower Generation	$438 \times 10^6 m^3$
Dead Storage	$1{,}612 \times 10^6 m^3$
Total	$2{,}200 \times 10^6 m^3$
(b) Water Level	
Surcharge Water Level	EL 136.9 m
Normal Water Level	EL 135.0 m
Low Water Level	EL 128.0 m
(c) Flood Control	
Control Method	Non-gated Control
(3) Design Discharge	
(a) Kampar Kiri River	
Lipat Kain	1,450 m^3/s
(b) Kampar River	
Langgam - Kerinci	4,850 m^3/s
Kerinci - River Mouth	5,100 m^3/s

5.8.3 Optimization for Indragiri River Development Project

The optimization for Indragiri River Development Project is as discussed below.

Basic Conditions

The following items were taken into consideration in the optimization study.

(1) Purposes of the Project

- Flood control of the middle and lower reaches of the Kuantan-Indragiri River;
- Irrigation water supply to Lubukjambi Irrigation Project; and
- Hydropower generation at proposed dams.

(2) Proposed Dams

In the Indragiri river basin, three possible damsites are proposed for dams which may be used for both flood control and water resources development. The proposed dams are the Kuantan, Upper Sinamar and Sukam dams.

(3) Applicable Measures and Structures

To achieve the project purposes mentioned above, the following measures and structures are taken into consideration.

(a) Flood Control

- Kuantan Dam
- Upper Sinamar Dam
- Sukam Dam
- Indragiri River Improvement Works
- Gaung Floodway
- Indragiri Retarding Basin

Gaung Floodway was planned under the Trans-Sumatra Canalization Project and it is incorporated into the project with the capacity of 500 m^3/s as a given condition.

(b) Water Supply for Irrigation and Maintenance Flow

- Kuantan Dam
- Upper Sinamar Dam
- Sukam Dam
- Lubukjambi Intake Weir

(c) Hydropower Generation

- Kuantan Dam
- Upper Sinamar Dam
- Sukam Dam

(4) Dam Operation

Operation of the Kuantan and Upper Sinamar dams is controlled by gates, because it is difficult to control flood discharge at these dams without the gates due to the small reservoir capacities. On the other hand, Sukam Dam was studied as a non-gated control operation because of the possibility of controlling flood discharge without gates and the operation is easier.

(5) Planning Criteria and Premises

(a) Design Scale for Flood Control

Final Phase	
Urban	50-year return period
Rural	50-year return period
Initial Phase	
Urban	10-year return period
Rural	5-year return period

(b) Standard Flood Discharge at Kuantan Dam

50-year Return Period	6,550 m^3/s
5-year Return Period	3,900 m^3/s

(c) Irrigation Water Requirement

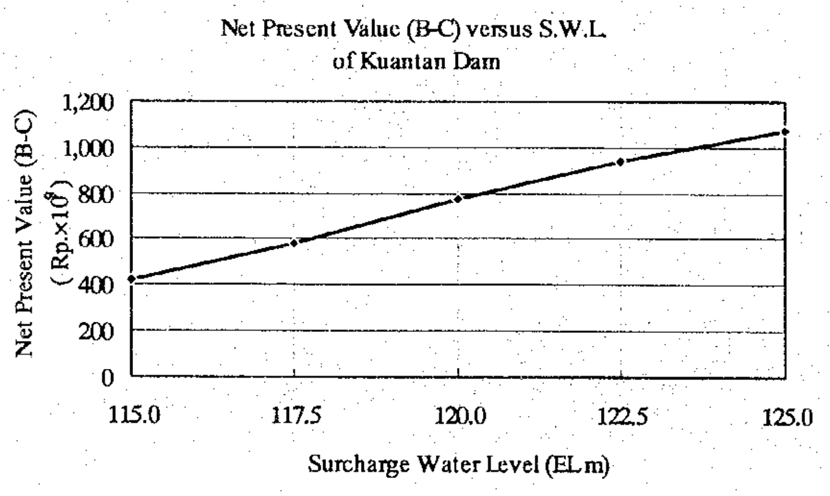
Irrigation water requirements were calculated for 5-year return period through simulation for 12 years from 1981-92.

Alternative Cases

Alternative cases were established by the combination of reservoir capacity of the three dams proposed and design discharges for the Indragiri River. In allocating the reservoir capacity of the three dams for flood control, water resources development and hydropower generation, the Upper Sinamar and Sukam dams were not allocated any flood control capacity because of the little effect of flood control by their small catchment areas and reservoir capacities. The Kuantan Dam only was allocated a flood control capacity. The alternative cases established are presented in Table 5.8.2.

Cost (C) and Benefit (B) Comparison

Net Present Value (B-C) and Benefit Cost Ratio (B/C) were calculated accordingly, as shown in Table 5.8.3. Alternative Case No. K-1-6 shows the highest Net Present Value. This case uses Kuantan Dam only with SWL of EL 125.0 m and flood control and hydropower generation capacities of 400 and $945 \times 10^6 m^3$, respectively. The highest Net Present Value in each case of Surcharge Water Level was plotted as illustrated below.



Optimum Plan

The alternative case where the Kuantan Dam has the surcharge water level (SWL) of EL 125.0 m showed the highest Net Present Value (B-C). However, this case has the social problem of submergence of transmigration areas located in the southern part of the Kuantan Reservoir.

After due consideration of the above situation, the other alternative case in which the Kuantan Dam has the SWL. of EL 120.0 m is selected as the optimum plan. Though the selected plan shows a smaller Net Present Value, the number of houses to be submerged is much less than the case with SWL. of EL 125.0 m.

The number of houses to be submerged is as summarized below.

Surcharge Water Level	Number of Houses to be Submerged
EL 115.0 m	0
EL 120.0 m	92
EL 125.0 m	525

The major features of the Optimum Plan are as summarized below.

(1) Kuantan Dam

Capacity Allocation	
Flood Control	$400 \times 10^6 m^3$
Hydropower Generation	$415 \times 10^6 m^3$
Irrigation	$117 \times 10^6 m^3$
River Maintenance	$213 \times 10^6 m^3$
Dead Storage	$425 \times 10^6 m^3$
Gross Storage	$1,570 \times 10^6 m^3$
Water Level	
Surcharge Water Level	EL 120.0 m
Normal Water Level	EL 115.2 m
Low Water Level	EL 102.0 m
Flood Control	
Control Method	Constant Rate Discharging Method
Control Starting Discharge	$500 m^3/s$
Constant Rate	0.440

(2) Design Discharge of Indragiri River

Kuantan Dam - Peranap	3,200 m^3/s
Peranap - Japura	5,400 m^3/s
Japura - River Mouth	5,050 m^3/s (Indragiri Retarding Basin and Gaung Floodway are considered)

5.9 Possible Maximum Development Amount of Water Resources

The governments of both Indonesia and Singapore executed a Memorandum of Understanding in August 1990 on the export of water from Indonesia to Singapore. The export amount agreed so far is as follows:

- 31.25 m^3/s from Riau Province by the year 2010.
- 52.6 m^3/s from Sumatra by the year 2090.

Three dams are proposed in the Overall Development Plan in this study, as follows:

- Kampar Kiri No. 1 Dam (Kampar River Basin)
- Kampar Kiri No. 2 Dam (Kampar River Basin)
- Kuantan Dam (Indragiri River Basin)

To study the possibility of water export to Singapore from the study area, the possible maximum development amount of water resources was estimated by employing the above three dams together with the Kotapanjang Dam which is presently under construction. The results of estimation shows that 103 m^3/s of the possible maximum development amount of water resources is expected from the study area. Of the 103 m^3/s from the study area, 81 m^3/s is expected from the Kampar river basin, and 22 m^3/s in the Indragiri river basin.

As mentioned before, six possible damsites have been identified in this study and the three dams mentioned above were taken up for the Overall Development Plan of the study area from the economical point of view. However, if economical, environmental and social matters are put aside, about 25 m^3/s could be additionally obtained although the development cost may be high.

5.10 Dam Engineering

5.10.1 General

As discussed in Section 5.2, Selection of Possible Damsites, the following six dams are selected as possible dams for the Overall Development Plan, as shown in Fig. 5.10.1.

- Kapoernan Dam
- Kampar Kiri No. 1 Dam
- Kampar Kiri No. 2 Dam
- Upper Sinamar Dam
- Sukam Dam
- Kuantan Dam

5.10.2 Geology at Possible Damsites

The geology at possible damsites is as described below.

(1) Kapoernan Damsite

The rocks exposed in this area belong to the Miocene Telisa and Shapas formations. Folds and faults with a NW-SE trend cross the area.

At the damsite the bedrock consists of conglomerate sandstone with siltstone intercalations, slightly soft. The rock outcrops are scarce and the slopes are covered by weathering soil, with loose boulders. Under the soil cover the rock is probably weathered. The depth of weathering shall be investigated in further study stage.

From the structural point of view, the damsite is located on the NE limb of a wide anticline. The dip direction of the beds is accordingly NE.

In the reservoir area, both the Sihapas and the Telisa formations are found. The Telisa formation consists of calcareous siltstones and limestones.

(2) Kampar Kiri No. 1 Damsite

The oldest rocks are the limestones of the Kuantan formation, around the village of Gema. These limestones have been strongly affected by dissolution. They appear now as loose, rounded blocks, surrounded by reddish soil. The limestones occur only downstream of the damsite.

The predominant rocks are those of the upper member of the Kuantan formation, with a heterogeneous lithology. The rocks are generally harder downstream of the damsite and rather soft in the reservoir area. The Kuantan formation is covered unconformaly by the Tertiary Telisa and Palembang formations. The former is exposed SE from Tanjungbelit and the latter, NE from it. Downstream from Tanjungbelit, the river is bordered by a Quaternary alluvial plain.

(3) Kampar Kiri No. 2 Damsite

This area consists of predominantly "softer" rocks, as reflected by the gentle and low topography along the Singingi (Kampar Kiri) river. Such rocks belong to the Tertiary formations, claystones and uncemented sandstones, and to the older Kuantan formation. The contact between the former two and the Kuantan formation is unconformity.

"Harder" rocks do exist in the area of the Sembacang Mountain, east of the tributary river Sepuh. According to a geological map these rocks should belong to the Tuhur formation: slates, silicified shales, etc. The rocks encountered during the field investigation do not correspond to the above description, but look rather similar to the sandstones and quartzites of the Kuantan formation.

(4) Upper Sinamar Damsite

In the downstream area, the Permo-Carboniferous limestone of the Kuantan formation spreads out widely. It is often bordered by the "shale member" which crops out only in the riverbed. ,The exposed rocks look different from the typical Kuantan formation and rather similar to the rocks of the Tuhur formation. ,They are mostly dark-gray shale and slate and in the vicinity of the Kalo-Kalo village, black, silicified shale. The origin of rocks shall be investigated in further study stage.

The area upstream which are now covered by paddy fields consists of the lahar deposits of the Malintang Volcano. These deposits extend only along the right riverbank. The hills on the left riverbank consist of rocks of the Kuantan formation and weathered granite.

(5) Sukam Damsite

The oldest exposed rocks are the Cretaceous granites, unconformaly covered by the Tertiary Ombilin formation. Only the lower and upper members of this formation are exposed. The upper member consists of "softer" rocks, while the lower member is harder. The rocks exposed at the damsite seem to belong to the lower member, massive sandstone/quartzite, and not to the upper member, as represented on the official geological map (Solok 1/250,000). This matter has to be checked in further study stage.

(6) Kuantan Damsite

Most of the subject area is covered by the Kuantan formation, divided into three members. It appears that sedimentation of the limestone occurred simultaneously with the sedimentation of quartzite and later also shale. This means that quartzite, limestone and shale can interpose and the age relationship between them is complex.

The limestone for example, is the middle member and usually lies on the quartzite (lower member) but locally also under the quartzite. Therefore, the alternating pattern of rocks along the Kuantan River is not entirely the result of folding but it is also due to the interference of the different facies (lithologies).

The rocks of the Kuantan formation have been slightly affected by metamorphism. All gradations from shale to slate phyllite and from sandstone to quartzite are found. The term " shales" used in this context includes low to non-metamorphic mudstones and siltstones. A more adequate designation would be "meta-pellite".

During the Cretaceous, the Paleozoic rocks have been intruded by granites as a result of the activity along the Great Sumatran Fault. Younger rocks belong to the Tertiary Telisa formation exposed at Lubukambacang, which covers the Kuantan formation unconformaly. Downstream from Lubukambacang the alluvial plain of the Kuantan river consists of unconsolidated sediments.

5.10.3 Planning Criteria for Structural Layout

The planning criteria for the structural layout are spelled out as below.

(1) Type of Dam

Two types of dam, concrete gravity and rockfill with center core, are adopted. Selection of type is based on the following considerations.

- Topographical and geological conditions at damsite;
- Availability of construction material in and around the damsite; and
- Construction cost.

The upstream and downstream slopes of dam are empirically determined as follows:

Dam Type	Upstream Slope	Downstream Slope
Concrete Gravity	1 : 0.15	1 : 0.8
Rockfill	1 : 2.3	1 : 1.8

Based on the above planning criteria, dam type of the six possible dams are determined as below.

Name of Dam	Dam Type
Kapoernan Dam	Concrete gravity
Kampar Kiri No. 1 Dam	Rockfill
Kampar Kiri No. 2 Dam	Concrete gravity
Upper Sinamar Dam	Rockfill
Sukam Dam	Concrete gravity
Kuantan Dam	Concrete gravity

(2) Type of Spillway

Two types of spillway, ordinary and emergency, are employed for each dam, as given below.

(a) Ordinary Spillway

Ordinary spillway shall be provided to regulate outflow discharge for flood control of up to a 50-year return period flood.

(b) Emergency Spillway

Emergency spillway shall be provided to discharge extraordinary floods of more than 50-year return period to ensure dam safety.

(3) Design Discharge

Design discharges for the diversion tunnel and emergency spillway shall be as follows:

Dam Type	Design Discharge
Diversion Tunnel	
Concrete Gravity Dam	2-year return period flood
Rockfill Dam	20-year return period flood
Spillway (Emergency)	
Concrete Gravity Dam	1,000-year return period flood
Rockfill Dam	Probable maximum flood

(4) Sedimentation

Sedimentation shall assume the following sediment volumes studied in Section 5.4, Sediment Control Plan, and a 100-year sedimentation.

River Basin	Specific Sediment Volume
Kampar River Basin	500 $m^3/km^2/yr$
Kuantan River Basin	
Sinamar River	585 $m^3/km^2/yr$
Kuantan and Sukam Rivers	525 $m^3/km^2/yr$

5.10.4 Structural Layout

In accordance with the planning criteria presented in the previous subsection, the structural layout of possible dams are planned, as shown in Fig. 5.10.2. The main features of planned possible dams are summarized below.

Name of Dam	Dam Type	Dam Height (m)	Crest Length (m)	Gross Storage Capacity ($10^6 m^3$)	Effective Storage Capacity ($10^6 m^3$)
Kapoernan	Concrete Gravity	34.5	197.0	140	84
Kampar Kiri No. 1	Rockfill	103.0	495.0	2,300	902
Kampar Kiri No. 2	Concrete Gravity	95.0	385.0	2,250	579
Upper Sinamar	Rockfill	132.5	650.0	165	68
Sukam	Concrete Gravity	66.5	330.0	230	203
Kuantan	Concrete Gravity	73.0	294.0	1,570	1,145

5.11 Riparian Structure Engineering

5.11.1 Present Condition of Flood Control and Water Supply Facilities

Kampar River Basin

Except Kotapanjang Dam and some bridges spanning the Kampar river system, only a few riparian structures exist in the Kampar river basin. The Kotapanjang Dam is presently being constructed on the Kampar Kanan River for hydropower purpose by PLN and is expected to be completed in 1997/1998.

Indragiri River Basin

(1) Upper Reaches

The existing riparian structures are a sabo dam at the upstream of the Sinamar River, some small scale intake weirs and pumping stations for irrigation, and a number of bridges.

(2) Middle Reaches

A few hundred meters of concrete revetments supported by concrete piles are provided to protect banks at major towns along the river such as Telukkuantan, Simandolak, Baserah and Rengat. Concrete pile type groins which have a length of 25 m and a width of 2 m were constructed together with revetments at Rengat and Baserah. Construction of revetments and groins is being continuously implemented.

(3) Lower Reaches

Along the lower reaches from Rengat to the river mouth, there are many intake canals for tidal irrigation, some port facilities for inland waterways (especially two big ports, Tembilahan near the estuary and Kualacenake located 20 km downstream from Rengat or 125 km upstream from the estuary), ferry facilities located 110 km upstream from the estuary, and some drinking water intake facilities.

5.11.2 Structure Planning for Overall Development Plan

The structural layout plan for flood control and water development facilities are discussed in Sections 5.3, 5.5 and 5.6. The planned facilities are summarized below except dams. Dam planning is independently discussed in Section 5.10.

<u>Flood Control Facilities</u>

The following structures are employed for flood control or protection purposes in the Kampar and Indragiri river systems:

(1) River Improvement Works
- Construction of dike
- Existing channel excavation
- Shortcut

(2) Revetment;
(3) Groin;
(4) Sluice;

(5) Drainage pump; and

(6) Reconstruction of existing bridges.

The layout plan of the above structures are discussed in Section 5.3 and shown in Fig. 5.11.1.

Water Resources Development Facilities

The following structures are employed for water development facilities in the Kampar and Indragiri river systems:

(1) Intake Weir

- Kuok Intake Weir (Kampar Kanan River)
- Lubukjambi Intake Weir (Kuantan River)

(2) Irrigation Canal

- Rantauberangin Irrigation Canal (Kampar Kanan River Basin)
- Lubukjambi Irrigation Canal (Kuantan River Basin)

The layout plan of the above structures are discussed in Sections 5.5 and 5.6 and shown in Figs. 5.11.2 and 5.11.3.

5.11.3 Soil Mechanical and Geological Condition at Proposed Major Structures

Field investigations, collected data and results of drilling works have revealed soil mechanical and geological conditions of riparian structures in the study area.

Kampar River System

(1) Kuok Intake Weir

Drilling works at three points on the weir site were made. The geological cross section at the weir site based on the drillings is presented in Fig. 5.11.4. At the weir site, river sediment is thin, 10 m deep, and base rock with claystone exist below the river sediment.

The general geological features of the weir site are summarized below.

River Sediment	Sand, 3 m thick only on the right bank; gravel, 3.5 m thick in the river banks, 1 m thick in the river channel.
Residual Soil	Silt or clayey sand 4-7 m thick, absent on the right river bank.
Bedrock	Claystone with thin sandstone intercalations, covered by 3 m completely weathered rock on the left riverbank.

The standard penetration tests show a N-value > 50 blows for the whole length of boreholes (refer to Fig. 5.11.4). Accordingly, the bearing strength of the foundation is considered to be sufficient, whether it is placed on the residual soil or on weak, weathered claystone.

(2) Area Downstream from Kuok Intake Weir

Downstream from the weir site, the thickness of the river sediment increases progressively toward downstream, from 12 m to 18 m. The bedrock has been encountered only in one drillhole at EL 24 m.

The upper layer consists of fine non-cohesive material, sand and silt, in average 5 m thick. The N-value is generally more than 10 blows. According to Terzaghi, the angle of friction is estimated to be 26°. The cohesion value is 0 kg/cm^2.

The lower sediment layer consists of gravel, underlain by organic clay. The gravel is well graded, with a poor content in fines. Such gravels are generally characterized by high permeability, angles of friction close to 35°, sufficient bearing strength. The organic clay has been found only in hole SB-2. The Standard Penetration Test values exceed 50 blows, indicating a very stiff, over-consolidated material.

Indragiri River System

(1) Lubukjambi Intake Weir

The alluvial plain is underlain by Tertiary rock formations. In the vicinity of Lubukambacang there are outcrops of the so-called Telisa formation which consist of clayey marl and glauconitic sandstone, nodular, containing concretions. At the weir site, river sediments are thin. The bedrock has been encountered at 9 m deep from the ground surface (WL-3-95), at EL 51.7 m.

The results of drilling investigation are summarized in Fig. 5.11.5. The figure represents a cross section along the axis of the proposed weir. The subsurface consists of two distinctive and continuous layers:

River Sediment	9 to 10.5 m thick
Bedrock	claystone/siltstone with thin sandstone intercalations, minimal 20 m thick.

As shown in Fig. 5.11.5, the subsurface consists of three continuous layers. The two upper layers are river sediments, 10 m thick. Under the sediments there is weak bedrock. In case of a shallow foundation, less than 10 m from the ground surface, the foundation bed will be sand or gravel.

The bearing strength of the sand bed can be estimated from the Standard Penetration Test values by Terzaghi's formula. The N-value is usually 4 blows. Accordingly, the internal angle of friction is 20°. The cohesion value is estimated to be 0.3 kg/cm^2.

(2) Rengat Area

The Rengat area is an area of flat, low topography, EL 0 to 7 m. The water table is close to the surface and swamps cover a significant part of the land surface, on the right riverbank. The results of the drilling investigation are summarized in Fig. 5.11.6.

Fig. 5.11.6 is a profile along the planned ring dike structure. Vertically and laterally, the different beds are discontinuous. Roughly, two zones can be distinguished as follows:

Zone I	Between the river and main road (holes SR-3, SR-4 and LR-6 to LR-8).
Zone II	South of the main road (holes LR-9 and LR-10).

In Zone I, the subsurface consists of two main layers, as follows:

Upper Layer	Alternation of anorganic and organic fine soils, 3.5 to more than 7 m thick.
Lower Layer	Fine river sands, minimum 8 m thick.

The subsurface of Zone II consists of only one layer of fine, organic sediments, minimum 10 m thick.

5.11.4 Criteria for Structural Design

Basic Guidelines, Standards and Criteria

To plan and design the structures for flood control and water resources development except dams, the following guidelines, standards and criteria were applied.

- Flood Control Manual, Vol. I, II and III , DGWRD DPU, 1993
- Irrigation Design Standards, DGWRD DPU, 1986
- Bridge Design Code, BINA MARGA, DPU 1992
- River and Sabo Technical Standard (Draft), Ministry of Construction of Japan

Criteria for Preliminary Design

The main criteria for the preliminary design of proposed structures were set in accordance with the above standards.

(1) Freeboard for Dike and Bridge

The table below shows freeboards to be adopted in the Project, corresponding to the magnitude of design discharges. Crest elevations of dikes are determined by adding freeboard onto a design high water level. Additional 0.3 m of freeboard shall be further provided along critical reaches where dikes are higher than 3.5 m.

Design Discharge (m^3/s)	Freeboard (m)
Less than 200	0.5
200 to less than 500	0.8
500 to less than 2,000	1.0
2,000 to less than 5,000	1.2
5,000 to less than 10,000	1.5

(2) Dike Crown Width

The following widths shall be applied in the Project, depending on the magnitude of design discharges.

Design Discharge (m^3/s)	Crown Width (m)
Less than 500	3.0
500 to less than 2,000	4.0
2,000 to less than 5,000	5.0
5,000 to less than 10,000	6.0

(3) Side Slope of Dike

The following slopes and berms shall be applied for dike side slope.

Location	Slope Gradient (V:H)	Berm
Landside Slope	1 : 2 for top slope; 1 : 3 for slopes below	Every 4 m in height with 3 m in width
Riverside Slope	1 : 2 for all slopes	Every 6 m in height with 3 m in width

(4) Slope Protection Works

Slope protection works are proposed along river channel banks subjected to direct attack of the river flow and along dike slopes for protection against scouring and wave wash.

(a) Locations to be Provided

Revetments shall be provided:

- at concave side of meander bends of river; and
- at both downstream and upstream of structures such as intake weirs, outlets, , bridges, etc., where turbulent flow usually occurs.

(b) Height

Crown elevation of slope protection works is set at the same level as the design high water level.

(5) Groin

Groins are proposed to prevent scouring and to accelerate sedimentation near banks. Permeable groins are selected considering flow velocity with gentle gradient at proposed areas.

Angle	right angle to dike
Length	less than 10% of river channel width
Spacing	between two to six times of the length

(6) Design Discharge of Intake Weir

Kuok Intake Weir	4,000 m^3/s
Lubukjambi Intake Weir	3,000 m^3/s

(7) Irrigation Channel

Design discharges of the irrigation channels are as follows:

Unit: m^3/s

Location	Initial Phase	Final Phase
Rantauberangin Irrigation Channel		
Left Bank	11.31	20.69
Right Bank	4.80	4.80
Lubukjambi Irrigation Channel		
Left Bank	7.85	19.31
Right Bank	-	17.62

Other structural criteria for irrigation channels shall follow the Irrigation Design Standard, DGWRD, DPU.

(8) Bridge

The structural criteria for bridge design shall follow the Bridge Design Code, Bina Marga, DPU.

5.11.5 Design of Proposed Riparian Structure

Riparian structures applied in flood control and water resources plans for the Kampar and Indragiri rivers are summarized below.

(1) Kampar River Basin

River	Dike	Shortcut/ Excavation	Slope Protection	Groin	Sluice	Intake	Bridge
Kampar	Y	Y	Y	-	Y	-	Y
Kampar Kanan	Y	Y	Y	Y	Y	Y	Y
Kampar Kiri	Y	Y	Y	-	Y	-	-

(2) Indragiri River Basin

River	Dike	Shortcut/ Excavation	Slope Protection	Groin	Sluice	Intake	Bridge
Indragiri	Y	Y	Y	Y	-	Y	Y
Sinamar	Y	Y	Y	-	Y	-	Y
Lampasi	Y	Y	Y	-	Y	-	Y
Agam	Y	Y	Y	-	Y	-	Y
Lembang	Y	Y	Y	-	Y	-	Y
Sumani	Y	Y	Y	-	-	-	Y
Sukam	Y	Y	Y	-	Y	-	Y
Palangki	Y	Y	Y	-	Y	-	Y

In accordance with the criteria described in Subsection 5.11.4, major structures were designed as mentioned below.

(1) Dike

Structural features of typical dike sections proposed for the projects are shown in Fig. 5.11.7.

(2) Slope Protection Works

In principle, wet stone masonry type with a side slope of 1 : 2 (V : H) embedded into the riverbed against the toe scour is applicable for both lower channel (banks) and high water channel (dikes). On the other hand, combination type consisting of reinforced concrete piles, reinforced concrete panels, and stone masonry will be one of the alternatives in view of easy construction of lower channel slope protection works in case of deep normal water in the lower and middle Kampar and Indragiri rivers. The former is applied to the rivers in the upper reaches of the Indragiri River, while the latter is applied to the middle and lower reaches of both Kampar and Indragiri rivers. Fig. 5.11.8 shows a typical high water channel and low water channel revetments.

(3) Groin

Groins are proposed in the lower and middle reaches of the Kampar and Indragiri rivers. Fig. 5.11.9 shows a typical groin applicable. Length of groin is 21 m which is equivalent to 10% of the average river width, and interval of groins is 3 times of length (60 m). Riprap for pile permeable groins should be considered against local scouring.

(4) Sluice

In accordance with the size of inland drainage areas measured on the topographical map with a scale of 1 : 50,000, the required sluices are classified into 8 types. Fig. 5.11.10 shows typical structural sections. Sluices are designed as reinforced concrete structures with steel gates.

(5) Bridge

As an example for bridges to be reconstructed, a typical steel truss bridge designed on the basis of existing structural profiles is shown in Fig. 5.11.11.

(6) Intake Weir

Intake weir with Watergate is applied instead of the fixed type intake weir to avoid obstruction of flood discharge. The preliminary design of both intake weirs is discussed in Sections 7.2 and 7.4.

(7) Main Irrigation Canal

Main irrigation canals which carry water from proposed weirs to target areas are designed with composite lining consisting of heavy masonry foundation with 10 cm thick concrete lining to prevent canal side slope erosion and compacted earth bottom, as shown in Fig. 5.11.12. The dimensions were determined assuming that the longitudinal slope of canal is 1/3,000 based on the 1/50,000 topographic maps. A 3.0 m wide gravel metaled inspection road will be provided beside the canal.

5.12 Construction Plan and Project Cost Estimate

5.12.1 Construction Plan

General

The Overall Development Plan consists of five major projects, three of which are located in the Kampar river basin and the other two are in the Indragiri river basin. These major projects involve the construction of various facilities such as two intake weirs, two irrigation systems, three dams and ten river improvement works. Itemized below are the five major projects.

(1) Kampar Kanan Water Supply Project
(2) Kampar Kanan River Improvement Project
(3) Kampar and Kampar Kiri River Development Project
(4) Indragiri River Development Project
(5) Upper Indragiri River Improvement Project

Basic Considerations in Construction Planning and Schedule

(1) Workable Days

The number of workable days is estimated based on rainfall data recorded in the vicinity of each project site. Sundays, national holidays and religious events are considered as non-workable days.

The criteria to estimate non-workable days are as follows:

Daily Rainfall (mm)	Suspended Day	
	Concrete Works	Earthworks
0-4	0	0
5-14	Rainy Day × 1	Rainy Day × 1
15-29	Rainy Day × 2	Rainy Day × 2
> 30	Rainy Day × 2	Rainy Day × 4

In accordance with the above criteria, workable days are estimated as below.

Items of Work	Workable Days
Concrete Works	250
Embankment Works	
Embankment of Rockfill Dam	200
Dike Embankment	220

(2) Daily Working Hours and Work Shift

All construction works will be implemented under a single shift of 9-hour labor including 2 hours of overtime per day.

(3) Mode of Construction

Construction works will be carried out by the contract system. International and local competitive bidding for prequalified contractors will be carried out following the guidelines and regulations of the government, DPU, and financing agencies. The DPU will manage and administer the implementation of the project, while the DPU of Riau Province will supervise the construction works in collaboration with a consultant. Upon completion, the operation and maintenance will be handled by the DPU of Riau Province.

(4) Cement

PT. Semen Padang (Padang Cement Company), a state-owned company, is the major source of supply in and around the study area. The plant is located at Indarung, Padang City, West Sumatra Province, about 13 km from the seaport, Teluk Bayur of Padang. The maximum annual production capacity of the plant is 3,300,000 tons and the average is 2,650,000 tons. The relation between supply and demand is generally balance in recent years.

(5) Port of Disembarkation

In Riau Province, there are four major ports for waterborne transportation as follows:

- Dumai Port
- Pekanbaru Port
- Rengat Port
- Tembilahan Port

Implementation Schedule

Based on the above considerations, the implementation schedule was established. The implementation schedule of each project of the Overall Development Plan is presented in Figs. 5.12.1 to 5.12.6.

5.12.2 Project Cost Estimate

General

The construction cost estimate for the Overall Development Plan is based on the preliminary design and construction schedule. Basic unit costs, labor wages, construction materials and heavy equipment were surveyed in Pekanbaru, adjacent construction sites and some manufacturers near the study area. The project cost required for the implementation of the Overall Development Plan was estimated, as described below.

Conditions for Cost Estimate

Project cost was estimated based on the following concept:

(1) All unit costs are based on the price level as of July 1994.

(2) Currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90 as of July 1994.

(3) Project cost is composed of construction base cost, compensation cost, administration cost, engineering cost, price contingency, physical contingency and value added tax. The calculation was carried out as follows:

(a) Construction Base Cost = Work Quantity × Unit Price

(b) Compensation Cost = Area of Land and/or Number of Houses × Unit Price

(c) Administration Cost = 5 % of [(a) + (b)]

(d) Engineering Cost = 10% of (a)

(e) Price Contingency (Financial Cost only): Annual escalation rate of foreign currency portion is 3% and local portion, 8%.

(f) Physical Contingency = 10% of [(a) + (b) + (d) + (e)]

(g) Value Added Tax (Financial Cost only) = 10% of [(a) + (b) + (c) + (d) + (e) + (f)]

(4) Unit Prices of Construction Materials

Unit prices of construction materials available in the local market and those that have to be imported are based on current market prices (refer to Table 5.12.1).

(5) Labor Wages

Labor wages were carefully examined and determined and the results are shown in Table 5.12.2.

(6) Unit Prices of Heavy Equipment

The unit prices of heavy equipment are given in Table 5.12.3.

(7) Compensation for House Evacuation and Land Acquisition

Referring to the available data mainly provided by the Provincial Public Works of Riau and West Sumatra provinces and through discussions with the officials concerned, the unit costs of compensation for house evacuation and land acquisition were determined and are summarized in Table 5.12.4.

(8) Foreign Currency and Local Currency Portions

Project cost consists of the foreign currency portion (F.C.) and the local currency portion (L.C.). The components of major items are as given below.

Item	F.C. (%)	L.C. (%)
(1) Labor Cost	0	100
(2) Owning Cost of Heavy Equipment	100	0
(3) Material Unit Cost		
- Cement	50	50
- Aggregate	0	100
- Fuel	50	50
- Oil	50	50
- Reinforced Bar	80	20
- Structural Steel	80	20
(4) Compensation Cost	0	100
(5) Administration Cost	0	100

(9) Financial and Economic Costs

Financial costs are estimated as real expenses of the project owner; whereas, project cost in economic evaluation is reckoned in terms of usage of real sources. Contractor's profit, price contingency and value added tax are, therefore, not considered in the economic costs. Hence, market prices are converted to economic prices in the economic evaluation. Conversion factors for economic prices are described in Section 5.14, Economic Evaluation.

Project Cost

The financial costs of project components were worked out, as shown in Tables 5.12.5 to 5.12.19. Tabulated below is the summary of financial cost for the five major projects broken down into foreign and local currency portions.

Unit: Rp. 10^6

Project	F.C.	L.C.	Total
(1) Kampar Kanan Water Supply Project	155,256	127,068	282,324
1-1 Kuok Intake Weir/Rantauberangin Irrigation System Construction Works (Initial Phase)	107,874	87,942	195,816
1-2 Rantauberangin Irrigation System Construction Works (Final Phase)	47,382	39,126	86,508

(2) Kampar Kanan River Improvement Project	444,751	423,859	868,610
2-1 Bangkinang Area River Improvement Works (Initial Phase)	126,915	120,397	247,312
2-2 Bangkinang Area River Improvement Works (Final Phase)	45,135	59,125	104,260
2-3 Lower Kampar Kanan River Improvement Works (Initial Phase)	216,755	181,406	398,161
2-4 Lower Kampar Kanan River Improvement Works (Final Phase)	55,946	62,931	118,877
(3) Kampar and Kampar Kiri River Development Project	1,018,100	793,692	1,811,792
3-1 Kampar Kiri No. 1 Dam Construction Works	379,796	274,195	653,991
3-2 Kampar Kiri No. 2 Dam Construction Works	158,568	143,113	301,681
3-3 Kampar Kiri River Improvement Works	50,113	33,800	83,913
3-4 Kampar River Improvement Works	429,623	342,584	772,207
(4) Indragiri River Development Project	1,328,732	1,172,919	2,501,651
4-1 Kuantan River Multipurpose Development Project	503,705	422,283	925,988
4-1-1 Kuantan Dam Construction Works	256,976	210,292	467,268
4-1-2 Lubukjambi Intake Weir / Irrigation System Construction Works (Initial Phase)	100,591	85,693	186,284
4-1-3 Lubukjambi Intake Weir / Irrigation System Construction Works (Final Phase)	146,138	126,298	272,436
4-2 Kuantan-Indragiri River Improvement Project	825,027	750,636	1,575,663
4-2-1 Lubukjambi-Peranap Area River Improvement Works	275,053	290,878	565,931
4-2-2 Peranap-Japura Area River Improvement Works	338,925	304,315	643,240
4-2-3 Rengat Area Flood Protection Works (Initial Phase)	21,704	17,932	39,636
4-2-4 Rengat Area Flood Protection Works (Final Phase)	189,345	137,511	326,856

(5) Upper Indragiri River Improvement Project	360,022	307,215	667,237
5-1 Payakumbuh Area River Improvement Works (Initial Phase)	131,335	99,581	230,916
5-2 Payakumbuh Area River Improvement Works (Final Phase)	63,799	63,523	127,322
5-3 Solok Area River Improvement Works (Initial Phase)	52,499	41,410	93,909
5-4 Solok Area River Improvement Works (Final Phase)	16,793	26,489	43,282
5-5 Sijunjung/Muara Area River Improvement Works (Initial Phase)	72,077	54,586	126,663
5-6 Sijunjung/Muara Area River Improvement Works (Final Phase)	23,519	21,626	45,145
Grand Total	3,306,861	2,824,753	6,131,614

Note: Price Contingency is not included.

Operation and Maintenance Cost

The annual operation and maintenance costs include the salaries of project administrative and operation staff, the material and labor costs for operation, repair and maintenance of O&M equipment, and the running costs for the project facilities. The annual O&M costs were estimated to be 0.5% of the total construction base cost except for the Kampar Water Supply Project (Kuok Intake Weir and Rantauberangin Irrigation Project) and the Lubukjambi Intake Weir and Irrigation Project. Annual O&M cost for the Kampar Water Supply Project is estimated at Rp. 813×10^6 and the Lubukjambi Intake Weir and Irrigation Project, Rp. $1{,}206 \times 10^6$.

Replacement Cost

Some of the facilities, especially mechanical and electrical equipment, have shorter useful life than the civil works. However, only the rubber gates for the Kuok Intake Weir are to be replaced after 25 years upon its completion and the other costs could be met by the O&M costs.

<u>Annual Disbursement Schedule</u>

The annual disbursement of investment costs was estimated on the basis of the implementation schedule. The financial disbursement schedule is given in Tables 5.12.20 to 5.12.24.

5.13 Implementation Schedule

Based on the construction schedule of each project, the implementation schedule of the Overall Development Plan was prepared, as shown in Fig. 5.13.1, by placing higher priority on projects which satisfy the following conditions:

- Urgency in implementation to mitigate flood damage;
- Higher economic efficiency and less negative social impact to be expected with the implementation; and
- Contribution to existing or other ongoing projects of the Indonesian Government.

The implementation period is 24 years from 1996 until 2019 which is the target year of the Overall Development Plan. The implementation schedule includes detailed design, land acquisition and house evacuation, prequalification and tendering, and construction activities.

5.14 Economic Evaluation

5.14.1 Basic Conditions for Evaluation

<u>Flood Control Plan</u>

The basic conditions for the economic evaluation of the Flood Control Plan are as follows:

(1) Design scale is 50-year return period.

(2) Annual average benefit or potential flood damage is calculated by the mesh unit based on LANDSATanalysis data;

(3) Final completion year is fixed at the year 2019 which is the final year of the Second Long Term Development Plan (PJP II), and project life is assumed