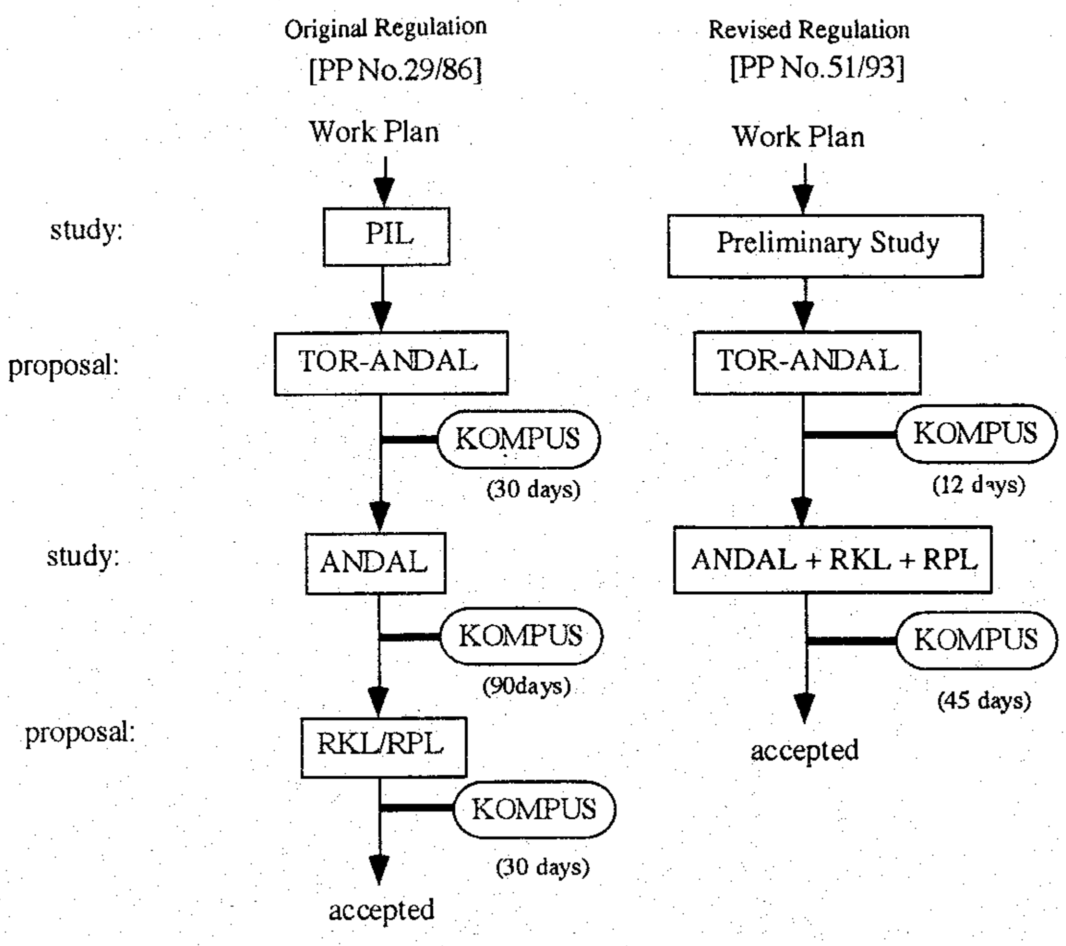
FIGURES

V ENVIRONMENTAL ANALYSIS



Note)
*PIL : Initial environmental information
*ANDAL : Environmental impact analysis
*KOMPUS : Central committee of EIA
*TOR-ANDAL: Terms of reference- Environmental impact analysis
*RKL : Environmental management plan
*RPL : Environmental monitoring plan
*AMDAL : Environmental impact assessment
*UU : a law
*PP : Government ordinance, government regulation
EIA : Environmental Impact Assessment

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. V.1.1 ORIGINAL AND REVISED AMDAL STUDY
JAPAN INTERNATIONAL COOPERATION AGENCY	

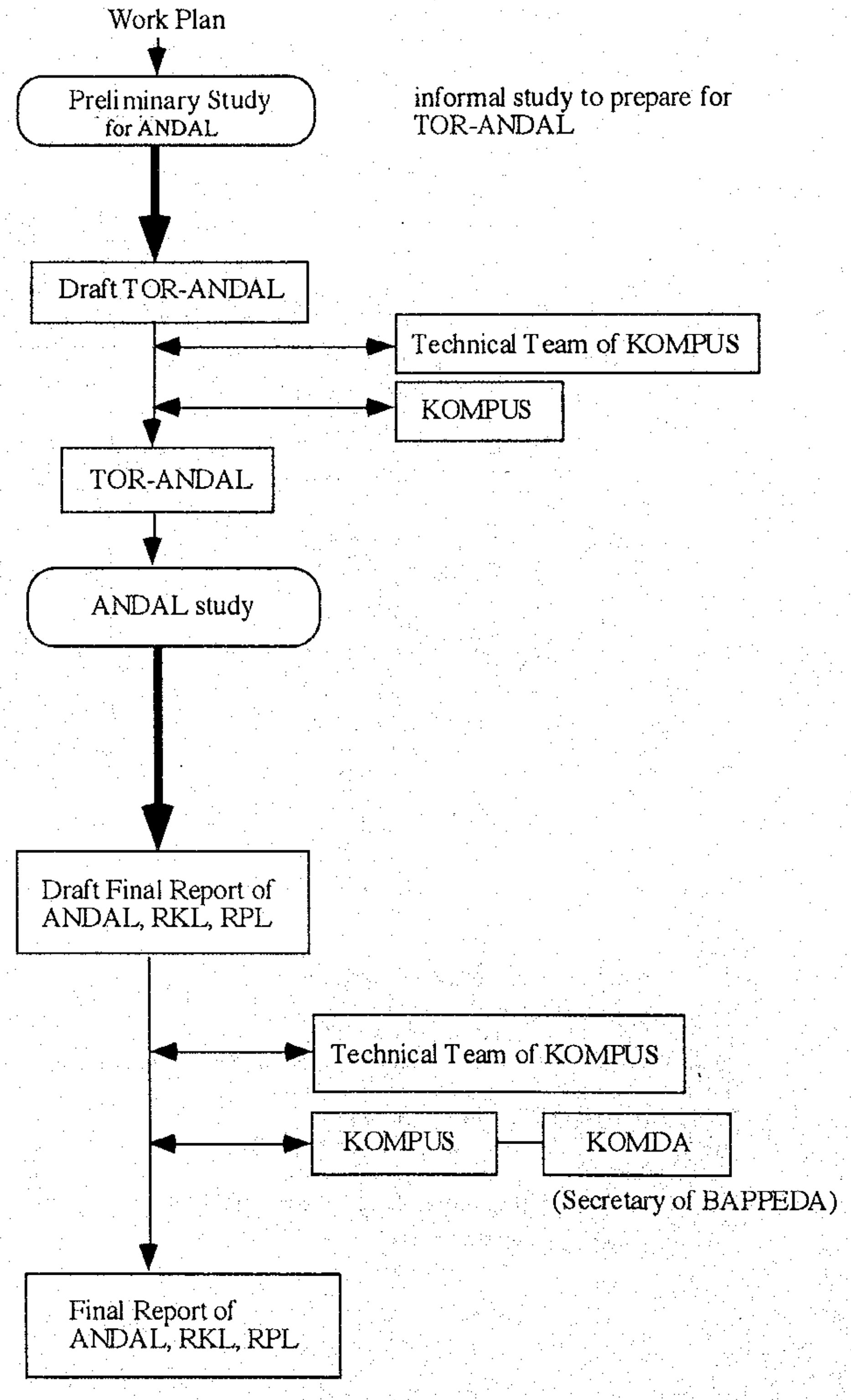


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Fig. V.1.2 REVISED PROCEDURES FOR AMDAL

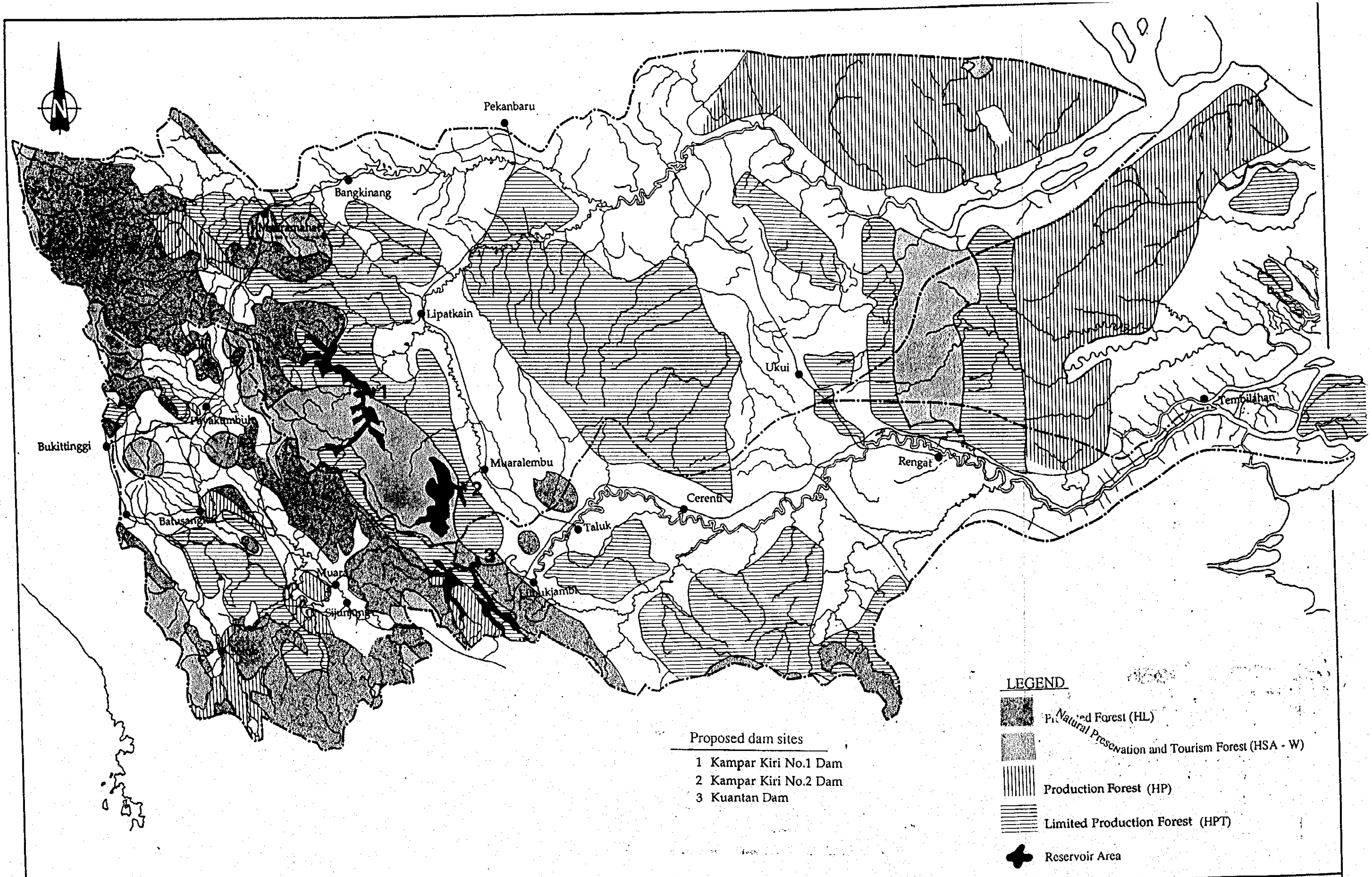

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Fig. V.2.1 DISTRIBUTION MAP OF FOREST FUNCTION FOR KAMPAR INDORAGIRI RIVER BASIN

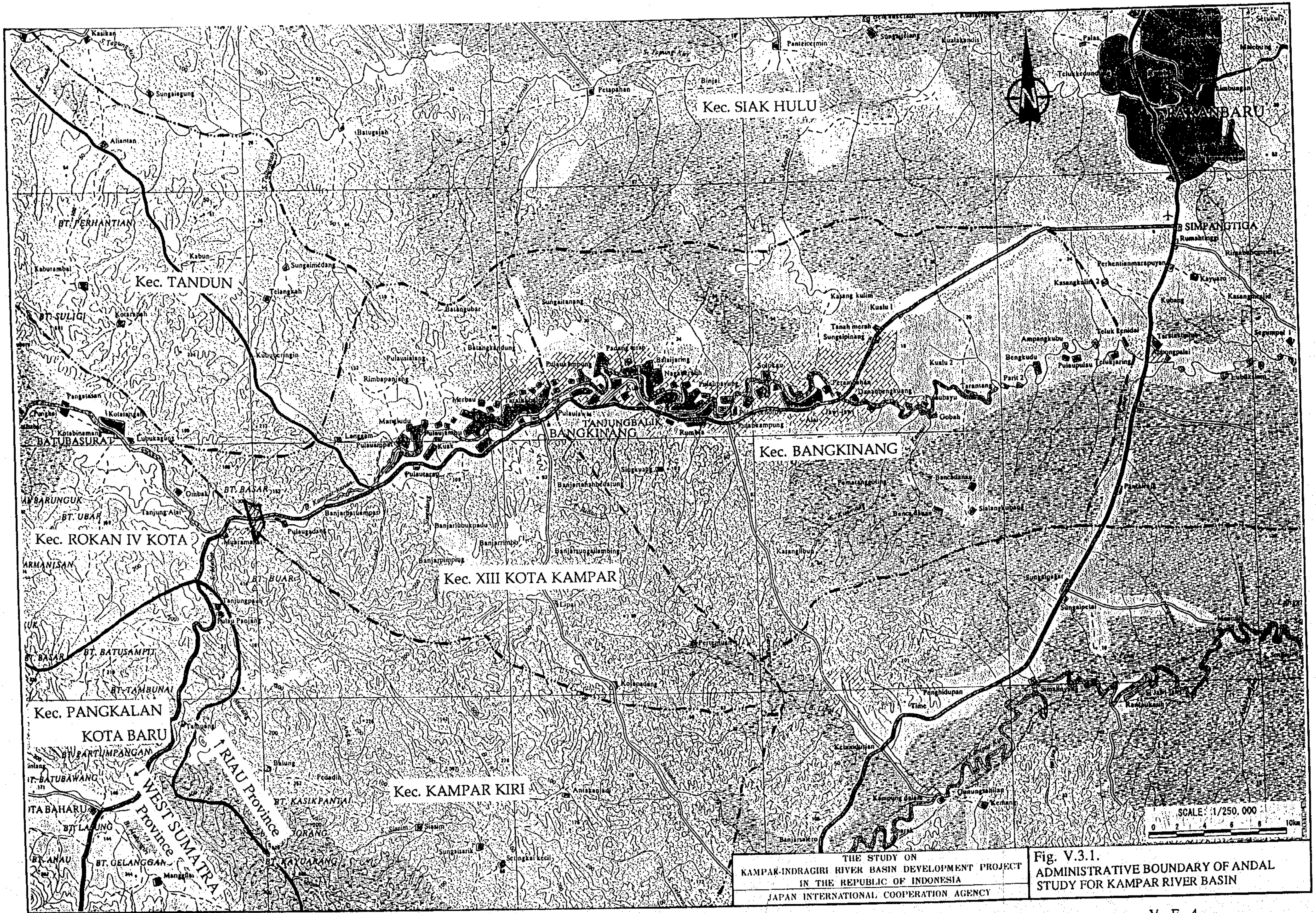

Fig. V.3.1.
ADMINISTRATIVE BOUNDARY OF ANDAL STUDY FOR KAMPAR RIVER BASIN

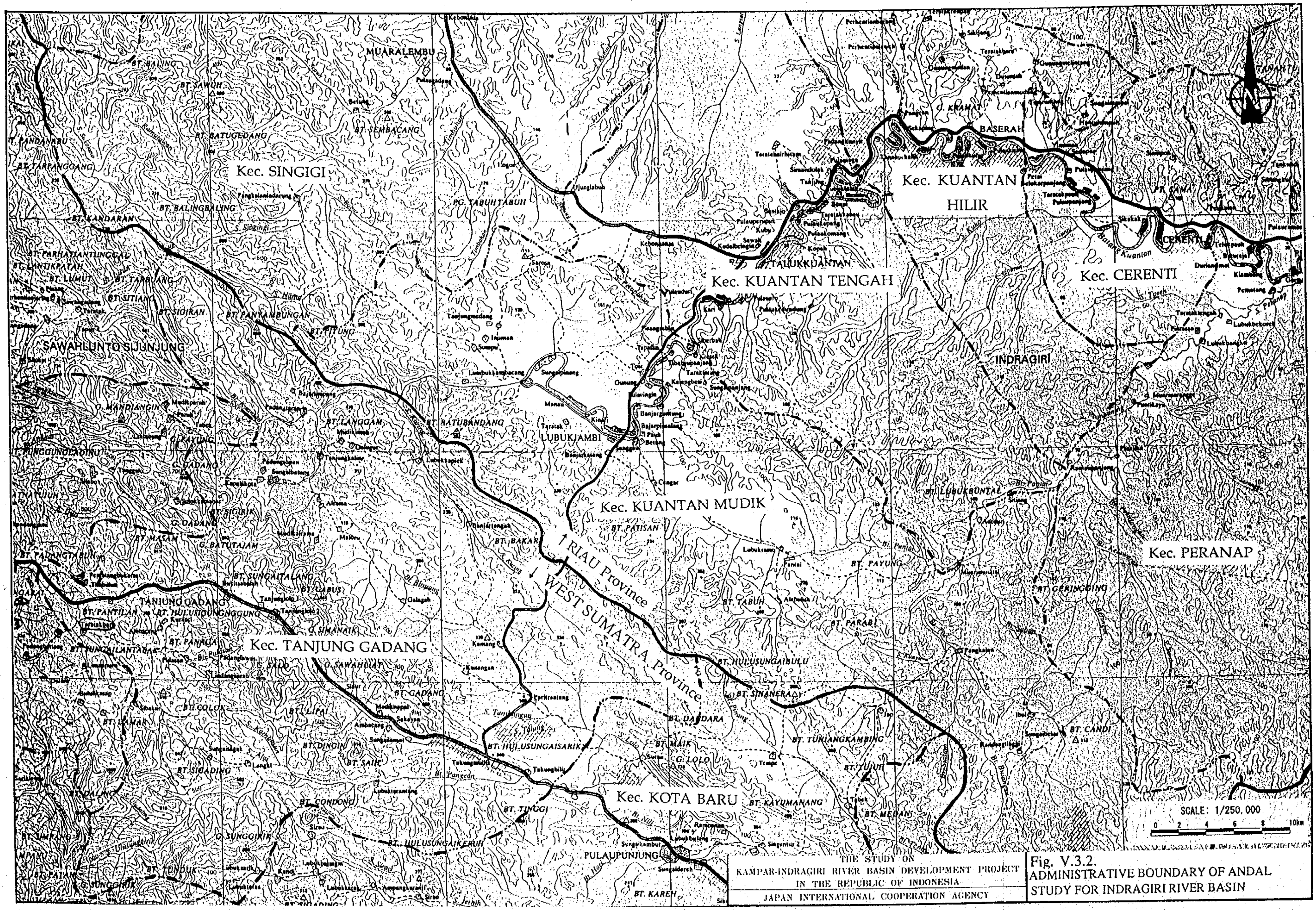

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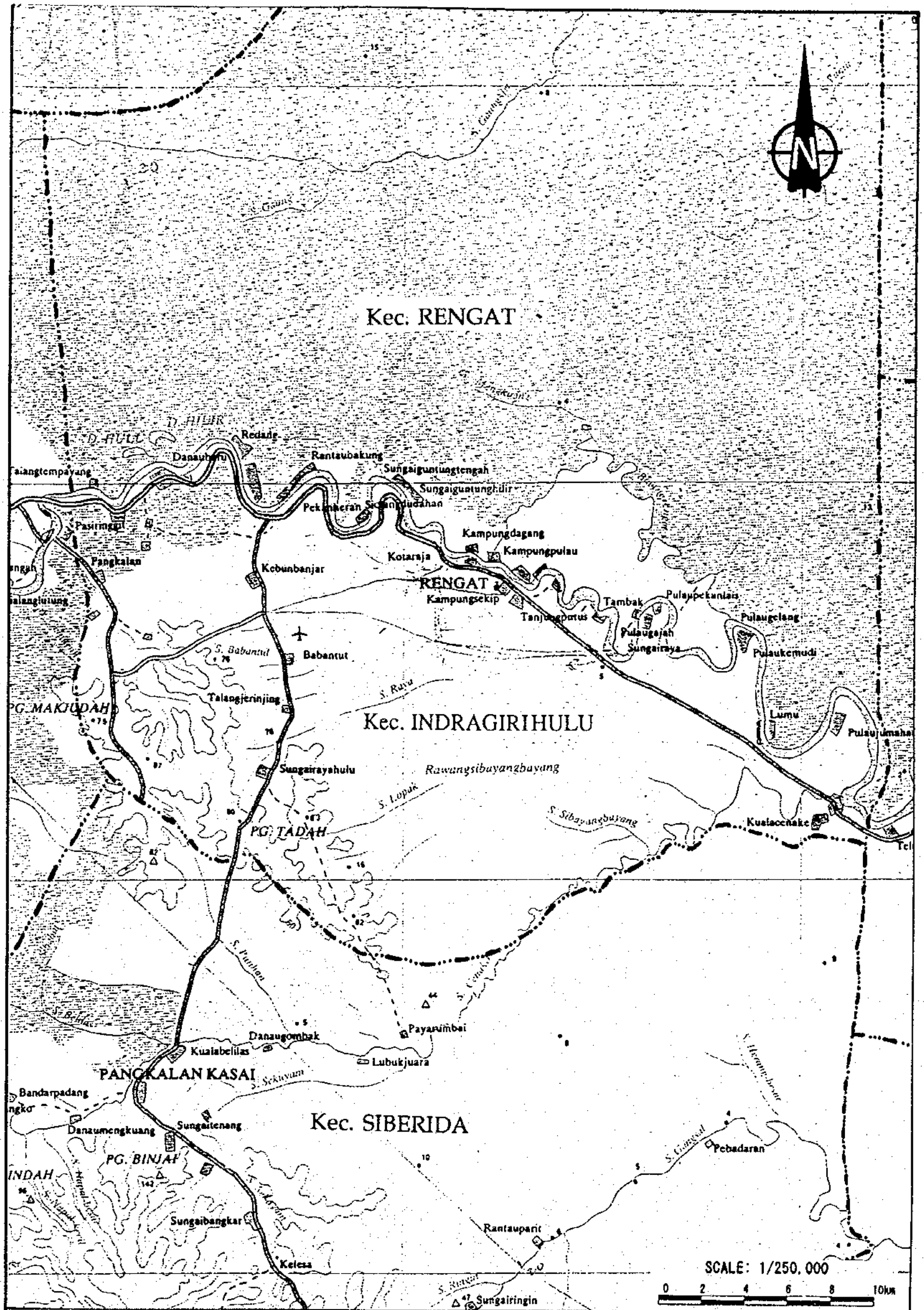
Fig. V.3.2.
ADMINISTRATIVE BOUNDARY OF ANDAL
STUDY FOR INDRAGIRI RIVER BASIN



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. V.3.3. ADMINISTRATIVE BOUNDARY OF ANDAL STUDY FOR RENGAT AREA FLOOD PROTECTION
JAPAN INTERNATIONAL COOPERATION AGENCY	

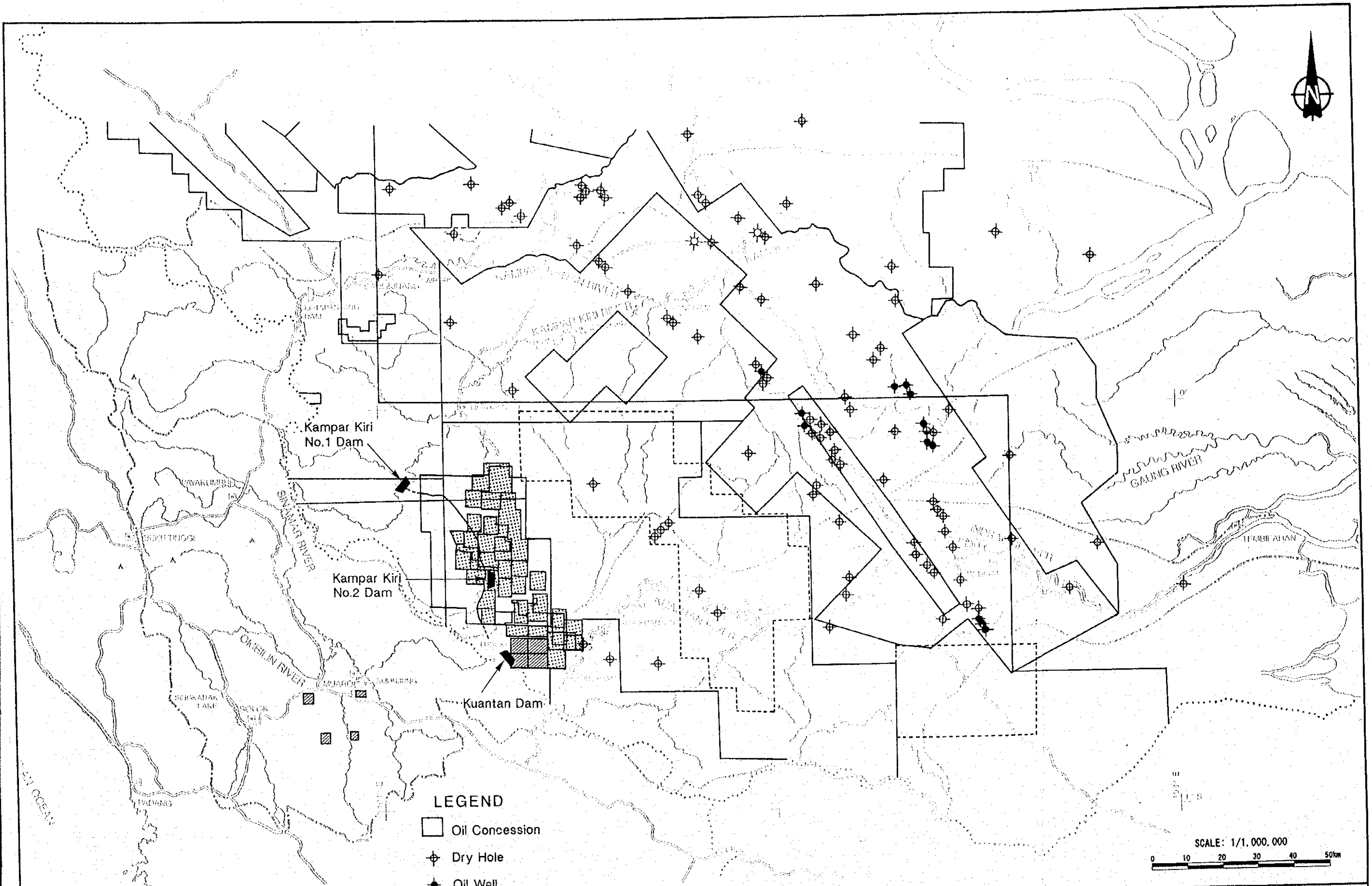


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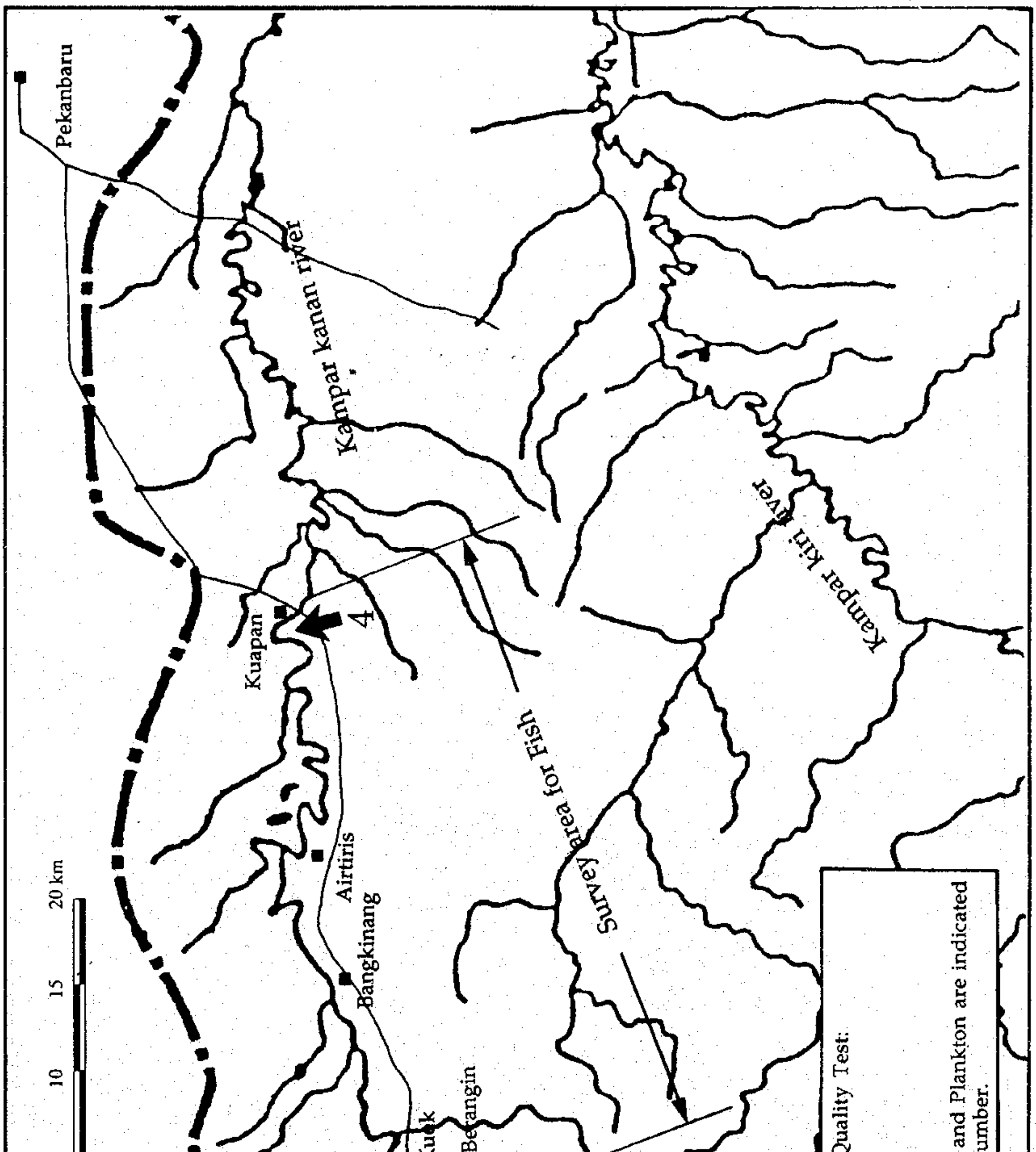
Fig. V.4.1 MINING CONCESSION IN STUDY AREA



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig.V.5.1. SAMPLING STATIONS FOR WATER QUALITY TEST IN KAMPAR RIVER
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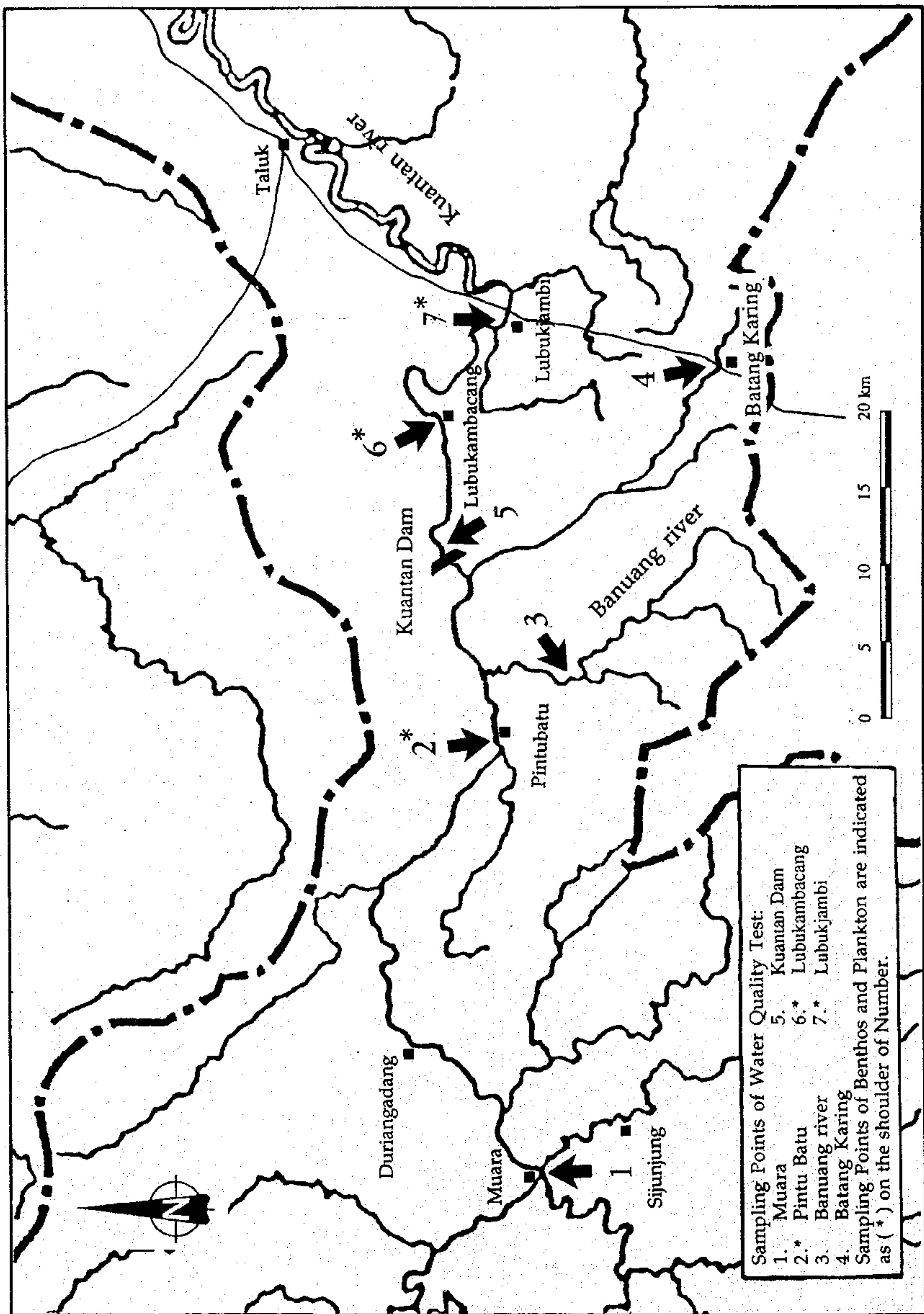
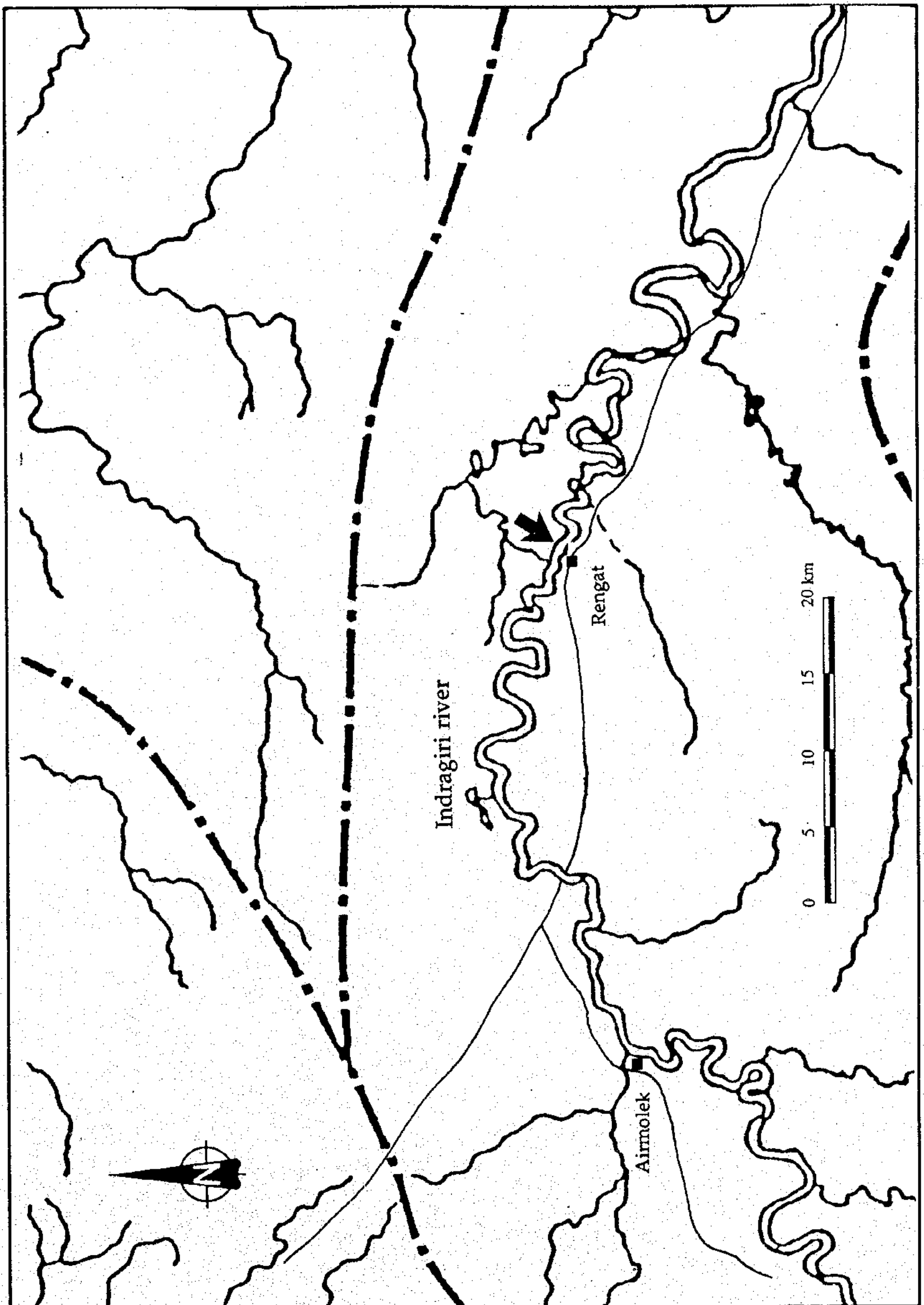


THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. V.5.2 (1/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	SAMPLING STATIONS FOR WATER QUALITY TEST IN INDRAGIRI RIVER



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. V.5.2 (2/2) SAMPLING STATIONS FOR WATER QUALITY TEST IN INDRAGIRI RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	

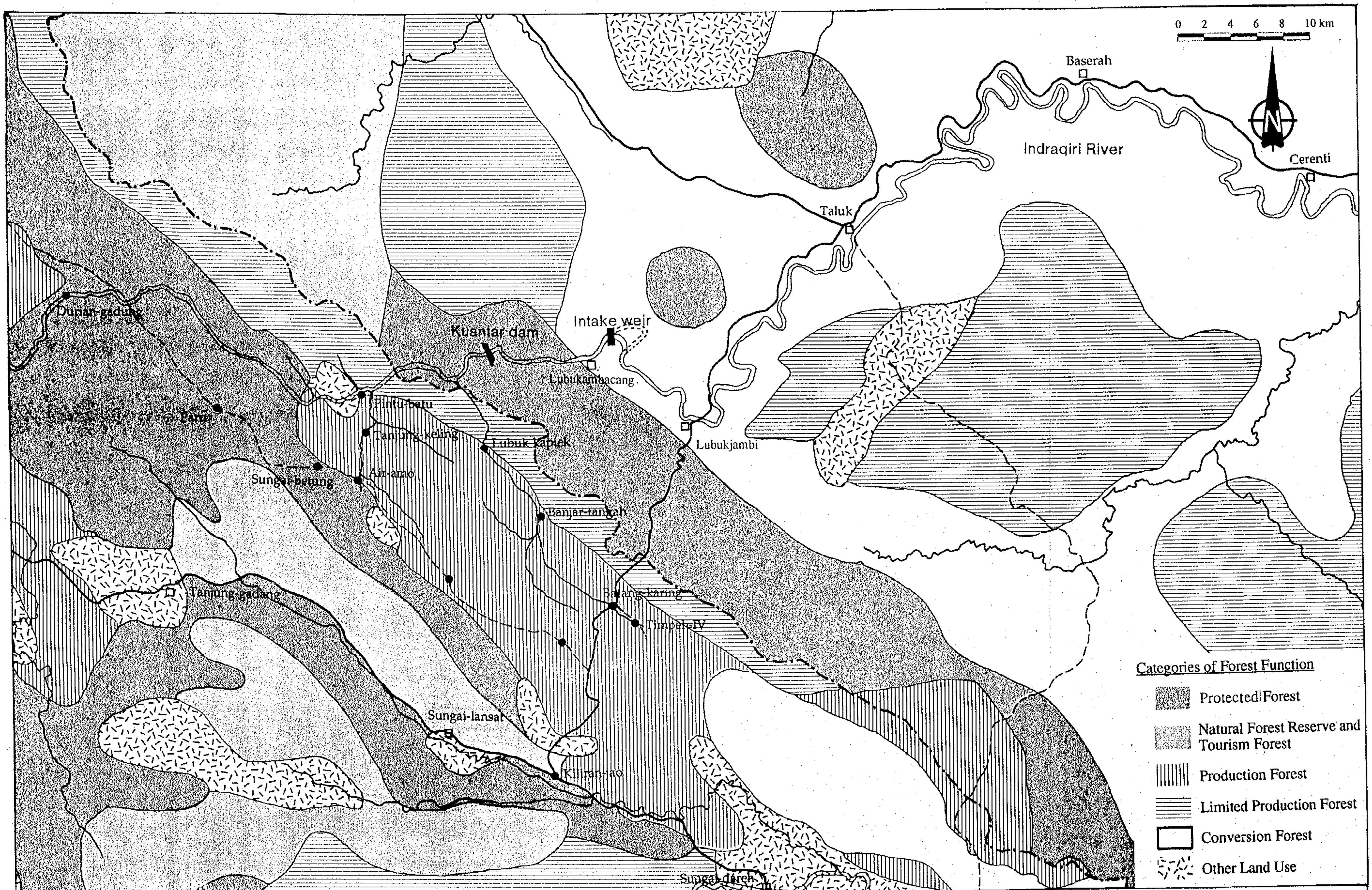


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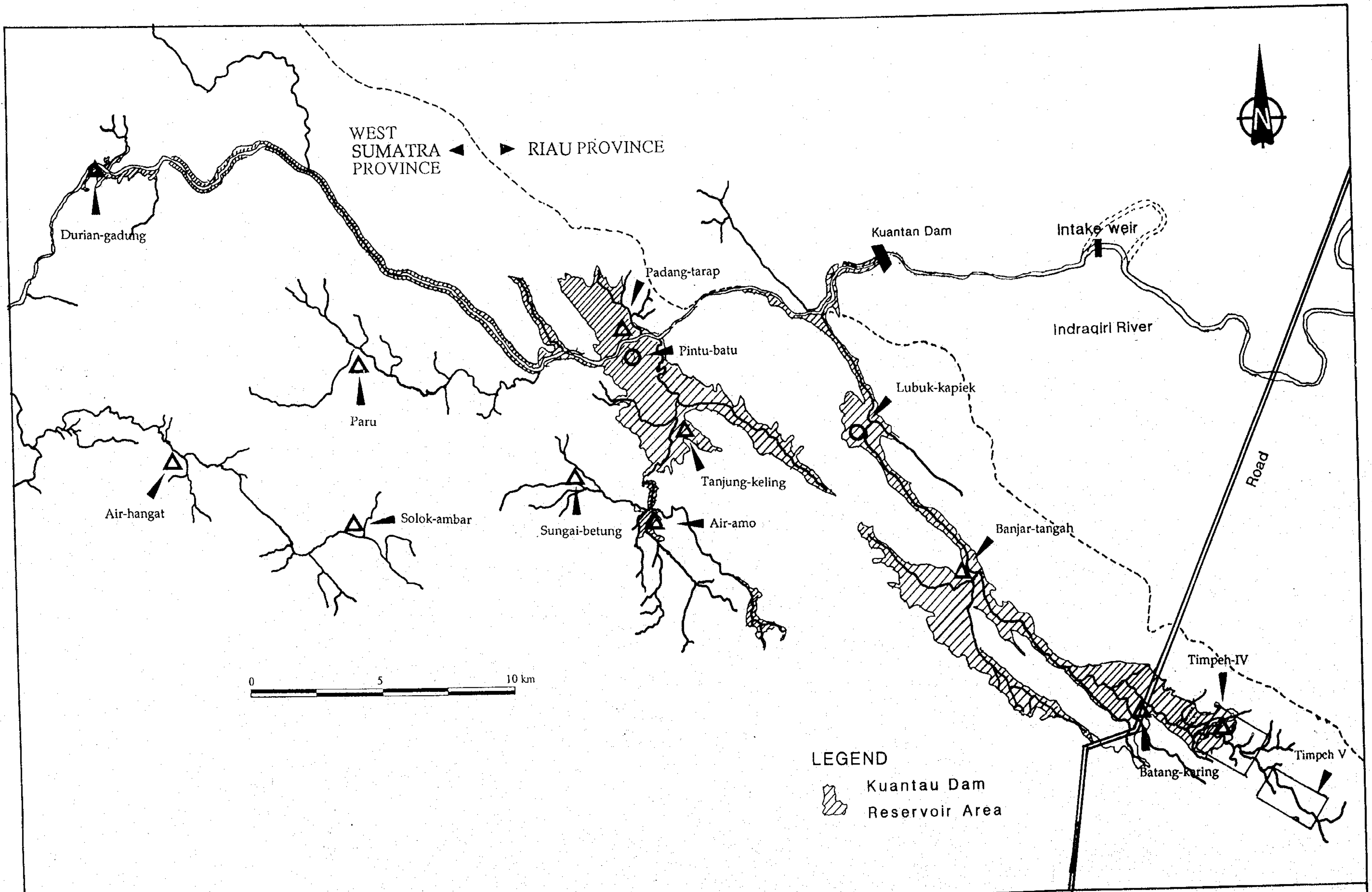
Fig. V.6.1
DISTRIBUTION MAP OF FOREST FUNCTION IN THE AREA OF KUANTAN DAM AND LUBUKJAMBI IRRIGATION



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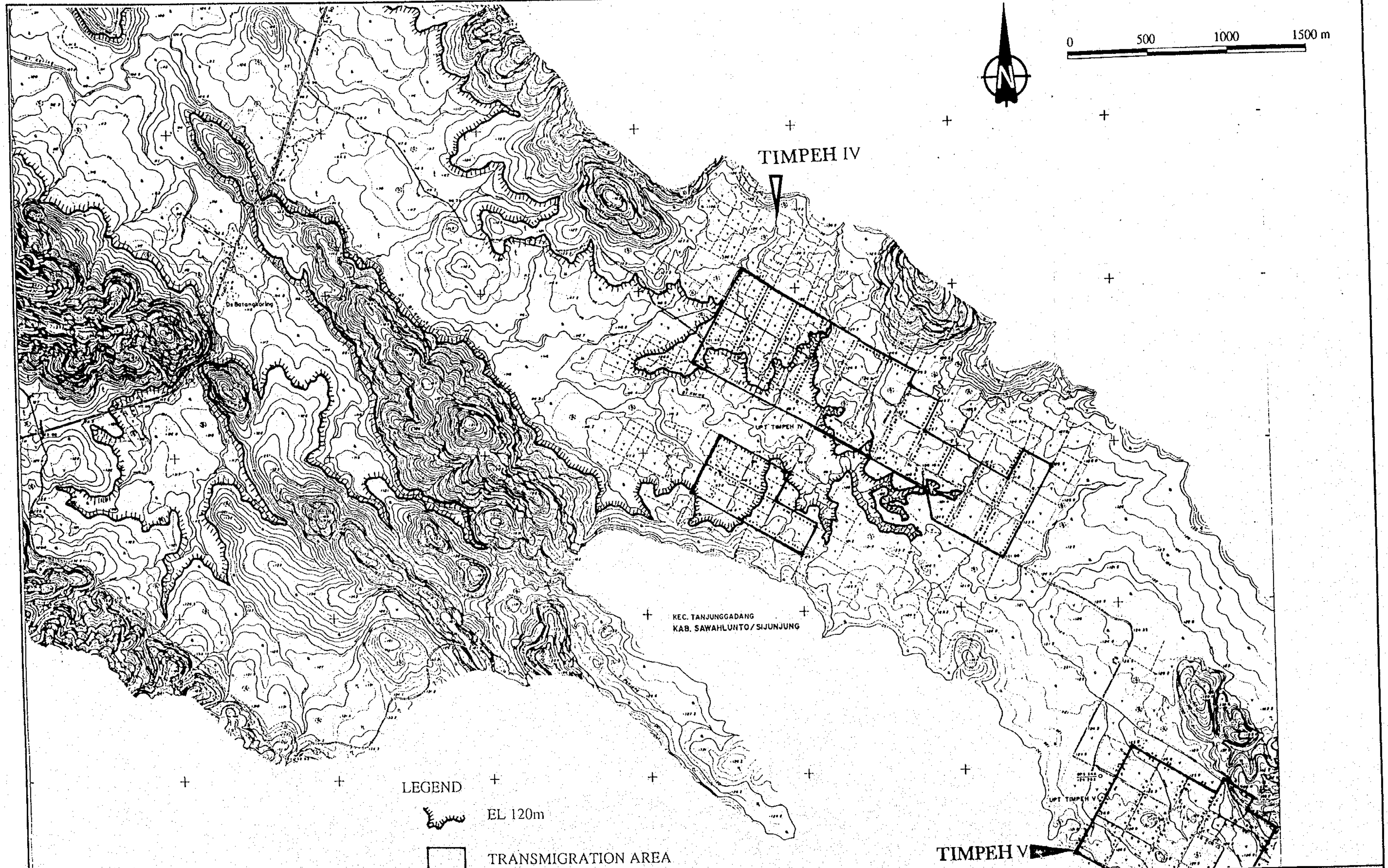
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. V.7.1 RESERVOIR AREA OF KUANTAN DAM AND VILLAGES TO BE SUBMERGED



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. V.7.2	AREA OF UTP TIMPEH IV (TRANSMIGRATION VILLAGE) TO BE SUBMERGED BY KUANTAN DAM
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VI FLOOD CONTROL PLAN

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FLOOD CONTROL PLAN

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CHAPTER 1 PRESENT RIVER CONDITION

1.1 Whole Basin

The Kampar and Indragiri river basins lie in 0°40'N to 1°05'S latitude and 100°10'E to 103°30'E longitude. The river length and catchment area of the Kampar and Indragiri rivers and the deltaic area near the sea in-between the two rivers are given as follows:

Particulars	Kampar River	Delta In-between	Indragiri River	Total
River Length (km)	580	193*	706	-
Catchment Area (km^2)				
Riau Province	21,086	10,580	8,809	40,475
West Sumatra Province	3,462	0	7,459	10,921
Total	24,548	10,580	16,268	51,396

* River length of the Gaung River.

Both Kampar and Indragiri rivers administratively belong to West Sumatra Province in the upper and middle reaches and to Riau Province in the lower reaches. Pekanbaru, the capital of Riau Province, is outside the river basin on the north of the Kampar river basin.

The mountains in the upper and middle reaches belong to the Barisan Mountains (Pegunungan Barisan), the mountain ranges that form the backbone of Sumatra Island. In the west part of the mountain ranges there is a narrow, flat land between the mountain ranges and the Indian Ocean where Padang City is located. The east part of the mountain ranges is a vast hilly to flat lands of more than 250 km wide to the Strait of Malacca.

Fig. VI.1.1 illustrates the river system and Fig. VI.1.2 shows the longitudinal profiles of the Kampar and Indragiri rivers, respectively. Flow capacity of the present river channels are presented in Fig. VI.1.3. Present conditions of the rivers in the Kampar-Indragiri river basin are described below.

1.2 Kampar River System

The Kampar River System is composed of rivers as described below.

(1) Kampar Kanan - Kampar Rivers

The Kampar Kanan River (a left bank tributary) and the Kampar Kiri River (a right bank tributary) join at Langgam approximately 40 km southeast of Pekanbaru. The name of the river in the downstream part from this point is the Kampar River.

The Kampar Kanan River originates at Mt. Gadang (EL. 2,060.3 m) at 0°10'North latitude and 100°19'East longitude. It has a catchment area of 5,231 km^2. The river flows north in the steep mountains, then gradually turns to the east. After joining the Kapurnangadang River, a right bank tributary, at the 480 km point from the mouth, the river flows in a gently inclined valley around Batubersurat until it joins the Mahat River, a right bank tributary at the 436 km point. The river then flows east in mountains for 15 km to the flood plain. Kotapanjang Dam is under construction for hydropower development by PLN at the 426 km point.

After flowing out to the floodplain, the Kampar Kanan River flows generally to the east in a heavily meandered channel passing Bangkinang, the capital of Kab. Kampar and Airtiris, the capital of Kec. Kampar. The width of the meandering in this stretch is approximately 2 km. The river then flows generally to the east south of Pekanbaru and to the southeast to join the Kampar Kiri River at Langgam. In upper reaches near Bangkinang the width of the river channel is approximately 100 to 150 m, and the flow capacity is about 1,000 m^3/s (refer to Fig. VI.1.3) with gradients of about 1/1,200. In the lower reaches between Danaubingkuang and Teratakbuluh, flow capacity is much smaller at about 700 m^3/s with the width of 100-150 m and gradient of about 1/4,900.

The Kampar River, after the confluence with the Kampar Kiri River, generally flows east in a heavily and gently meandered channel with a meandering width of more than 4.0 km. The Nilo River, a right bank tributary, joins at Kerinci. The highway that connects Pekanbaru with Airmolek crosses by a bridge at just the downstream part of the Nilo River confluence. After this point, the river penetrates swamp forests to the east with a gently curved channel of less meandering. The width of the river exceeds 1.0 km from around the 100 km point and it is 7.0 km at the mouth.

(2) Sibayang - Kampar Kiri Rivers

The Kampar Kiri River, the largest right bank tributary of the Kampar River, originates in 1,000 to 1,300 m high mountains (Mt. Ngalautinggi - Mt. Solokjanjaang-Mt. Paninjauannanelok) of the Barisan Mountains at latitudes near 0°10'S in the border of the Riau and West Sumatra provinces. It has a catchment area of 7,053 km^2. The upper reaches consist of two tributaries, namely, the Sibayang and Singingi rivers.

The Sibayang River which has a catchment area of 1,606 km^2 flows southeastward in the upper reaches then turns to the north to join the Biobio River at the 442 km point. The Biobio River originates in the same mountains and flows generally to the east in the north of the Sibayang river catchment. The Sibayang River, after joining the Biobio River, flows generally to the northeast with a slope of 1/1,000 and gentler, and joins the Singingi River, a right bank tributary. The river then flows in the floodplain in a heavily meandering channel like the Kampar Kanan River at Bangkinang, and generally flows to the northeast joining many tributaries, e.g., the Teso River, to Langgam to join the Kampar Kanan River.

The Singingi River has a catchment area of 1,678 km^2. It is a right bank tributary of the Kampar Kiri River and called the Sukojano River in the upper reaches. The Sukojano River flows southeasterly in the mountains of Riau and West Sumatra bordering in latitudes of about 0°25'S almost parallel to the Lisun River, a tributary of the Kuantan-Indragiri River, with a distance of approximately 6.0 km. The Singingi River, after approaching a short distance of about 4.0 km to the Sukojano River, flows east and north, and then north to northwest from Muaralembu with a gradient of 1/2,000 and gentler in hilly to flat land to join the Sibayang River.

Flow capacity of the Kampar Kiri River is especially small at about 200-400 m^3/s in the downstream stretch from the junction with the Teso River (refer to Fig. VI.1.3). The river upstream from this point and the Sibayang River has a capacity of about 1,000 m^3/s.

(3) Other Tributaries of Kampar Kiri and Kampar Rivers

Right bank tributaries of the Kampar Kiri and Kampar rivers, namely, the Teso River, the Nilo River, etc., originate in hilly areas with the elevation of less than 100 m. The hilly areas are located approximately 5 to 10 km north of the Kuantan River for the stretch from Telukkuantan down to Airmolek. Accordingly, these right bank tributaries have no high mountains in the catchments. They flow in hilly to flat land. In the case of the Nilo River, about 2/3 of the whole stretch is in the lowlands.

1.3 Indragiri River System

The Indragiri River System is composed of rivers as described below.

(1) Lembang - Ombilin River (Upper Reaches of Kuantan-Indragiri River)

The Lembang and Ombilin rivers are considered as the main stream in the upper reaches of the Kuantan-Indragiri River, although the total river stretch is shorter than the Sinamar River, a left bank tributary of the Ombilin River. The Lembang River originates from the Dibaruh Lake (Lake Water Level of approximately EL 1,450 m) which is located approximately 40 km east of Padang. The river generally flows NNW, joining the Sumani River, a left bank tributary. From this point, the river heavily meanders. After passing Solok City at the downstream part of the confluence with the Sumani River, the river flows 12 km to Singkarak Lake. Singkarak Lake has a water area of about 130 km^2 and an average water level of approximately EL 360 m.

The Lembang River frequently causes floods at Solok City. The cause of the flood is insufficient channel capacity of about 400 m^3/s (refer to Fig. VI.1.3) near Solok City where the river heavily meanders. There is a longitudinal bottleneck at about the 11 km point from Singkarak Lake and this seems to be causing a rise in riverbeds resulting in small flow capacity in the upstream reaches from this point.

Water of Singkarak Lake flows out to the Ombilin River at a distance of 640 km from the mouth. The Ombilin River flows generally to the east in the mountainous to hilly areas with a longitudinal gradient of 1/300 to 1/780. It sharply changes its direction at two points, joins the left bank tributary, the Sinamar River, at the 571 km point, and reaches Muara Town. From this point (550 km point), the river changes its name to the Kuantan River. No flood has been reported along the Ombilin River.

(2) Sinamar - Lampasi - Agam River

The Sinamar River is a left bank tributary of the Ombilin River and originates at Mt. Putus (EL. 1,930 m) at about the 717 km point from the mouth. The northern slope of this mountain drains water to the Kampar Kanan River. The gradient of the river becomes gentler at near Suliki Town and both banks are flood-prone areas from this place. The river gradient at Suliki Town is about 1/720. Meandering also starts around this point.

The river joins the Lampasi River, a right bank tributary, and after flowing 2.3 km from this point, it joins the Agam River at an elevation of about EL. 480 m. Around this point the gradient is about 1/1,200 and the river flows in a flat valley.

Flow capacity of the Sinamar River is small at about 200 m^3/s in the upstream reaches from the confluence of the Agam River and about 400 m^3/s in the lower reaches from this point (refer to Fig. VI.1.3).

River floods occur frequently in this area. The trunk road connecting Padang-Bukittinggi-Pekanbaru crosses the river at this area. After passing this area, the river enters mountainous to hilly areas of the foot of Mt. Malitang and flows generally southeastward. The gradient becomes steeper at about 1/100 in average for the stretch of 23 km from EL. 425 to 200 m. The Sinamar River finally pours into the Ombilin River at the 571 km point.

The Lampasi River, a right bank tributary of the Sinamar River, originates in 1,500 m class mountains. Steeper southern slopes of the mountains belong to the Agam river basin, but the Lampasi River catchment consists of gentler slopes. In the stretches from EL. 525 m, paddy fields extend on both banks.

One of the major problems of the Lampasi River is the production of sediment in the upper reaches. In the middle and lower reaches, sediment is deposited in the river channel and reduces the flow capacity. Flow capacity is extremely small at about 100 m^3/s or less in 5-14 km stretches from the confluence with the Sinamar River. DPU had constructed a check dam on the river at about the 662 km point. The area near Kotobaru Town and the area near the confluence with the Sinamar River are flood-prone areas.

The Agam River, a right bank tributary of the Sinamar River originates in the Bukittinggi City area. The river then flows in the foot of Mt. Marapi with a gentle slope collecting water of the north to northeast slope of the mountain. The river then collects water from the northwest slope of Mt. Malintang. From the elevation of about EL 500 m, located on both banks of the river is

Payakumbuh Town. The town itself is in a relatively higher place; it has never been inundated. A fixed concrete weir was constructed on the river at Payakumbuh City in the 1930s. Flow capacity is about 400 m^3/s for about 13 km stretches from the confluence with the Sinamar River.

Three and two intake weirs for irrigation exist on the Lampasi and the Agam rivers, respectively. There is no intake weir on the Sinamar River.

(3) Palangki and Sukam River

The Palangki and Sukam rivers are right bank tributaries of the Ombilin River. They flow to the Ombilin River near Muara Town. At this point, the Ombilin River changes its name to the Kuantan River. The Palangki River originates in 1,800 m class mountains of the Barisan Mountains and generally flows north in mountainous areas until it reaches a flat valley near Padangsibusuk Tengah. The river then passes south of Muara Town in a heavily meandered channel. The area in the south of Muara Town is frequently flooded due to backwater by a bottleneck in the Kuantan River.

The Sukam river basin lies in the east side of the Palangki river basin. The river rises at relatively lower mountains of 1,000 m class. After flowing in mountainous to hilly terrain, the river flows northwest along the provincial road from the 673 km point and finally joins to the Ombilin River at the 554 km point. Near Sijunjung Town, the river heavily meanders in a flat area causing inundation on both banks. Flow capacity in this area is about 200 m^3/s.

(4) Kuantan River (Muara-Lubukkambacang)

From Muara until around Airmolek, the river is called the Kuantan River. The Kuantan River from Muara to Lubukkambacang flows generally east in mountainous areas. Access to the river in this stretch is very difficult.

In accordance with the 1/50,000 maps, the river profile in the upper part of this stretch is almost flat, although the field investigation gives a different impression. The result of river survey for the Sukam River and the aerial photographing maps developed for the reservoir area of the Kuantan Dam revealed, however, that the 1/50,000 map is not correct. In accordance with these materials, the gradient of the Kuantan River for about 14 km in the downstream stretch from Muara Town to is about 1/630.

(5) Kuantan River (Lubukkambacang - Japura)

The Kuantan River flows out from mountainous areas at Lubukkambacang (441 km point) with an elevation of about EL 50 m. In this stretch of about 220 km from Lubukkambacang to Japura, the river flows in hilly areas of altitude less than 100 m forming a floodplain of 2 to 3 km wide in the upper reaches and 7 to 8 km wide in the lower reaches. The river channel in this stretch heavily meanders with meandering widths of 2 to 3 km and in some locations, 5 km.

In the meandered channel, the river flows generally to the east with the gradient of 1/3,500 to 1/6,000. Flow capacity of the river in this stretch is about 1,200 to 1,500 m^3/s. Bank erosions due to the progress of meandering occur at many locations. The erosion gives serious damage to houses because towns exist along the river.

(6) Indragiri River (Japura - River Mouth)

After passing Japura, the river flows in a vast lowland. The left bank generally consists of wetlands (rawa in Indonesian term) and the right bank generally consists of forests. Rengat Town is located on the right bank of the river at around the 174 km point. Tidal influence exist up to about the 100 km point. The mouth of the river is a river mouth delta formation. Tembilahan Town is on the left bank of the river at about the 57 km point.

1.4 Other Rivers in between Kampar and Indragiri Rivers

There are rivers in-between the Kampar and Indragiri river basins that pour directly into the Strait of Malacca. The major ones are, from the north, the Guntung, the Kateman, the Gaung, the Simpang and the Anakserku. The basins of these rivers consist of a vast wetland forest. A forest reserve is located in the westernmost part of this area. In the eastern part, there is a large transmigration area.

CHAPTER 2 FLOOD DAMAGE CONDITION

Flood-prone areas in the basins mainly exist along the rivers as shown in Fig. VI.2.1. As shown in the illustration, flooding problems in the basins can be divided broadly into two, namely, local problems in the upper reaches and general problems in the middle and lower reaches.

The local problems in the upper reaches are in West Sumatra Province. These are in Solok, Payakumbuh and Sijunjung/Muara areas. The maximum areas of inundation are approximately 5, 10 and 25 km^2, respectively.

The inundation areas in the middle and lower reaches are along the rivers of Kampar Kanan, Sibayang, Singingi, Kampar Kiri and Kampar rivers in the Kampar river basin, and along the Kuantan-Indragiri River and the Cenako River in the Indragiri river basin. The inundation areas of the Kampar and Indragiri rivers are about 1,800 and 900 km^2, respectively. These are all storage type inundation.

2.1 Middle and Lower Reaches

(1) Flow Capacity of Present River Channel

The present flow capacity in this stretch is estimated as follows (refer to Fig. VI.1.3):

River	Flow Capacity (m^3/s)
Kampar Kanan River	
Bangkinang Area	750 - 1,000
Lower Reaches	700 - 800
Kampar Kiri River	
Sibayang	500
Upper Reaches of Kampar Kiri River	600
Lower Reaches of Kampar Kiri River	200
Kampar River	around 1,200
Indragiri River	around 1,200

As the flood-prone area map shows (refer to Fig. VI.2.1), areas along the rivers are flood plain and easily inundated by normal floods. Floods occur almost every year and once these occur, inundation continues for 7 to 10 days in the lower areas.

(2) Historical Major Floods

Field interview survey revealed the following notable floods in recent years:

- January 1995
- November 1993 (Upper reaches of the Indragiri River)

- December 1991 to January 1992
- January 1991
- January 1989
- February 1988
- January 1986
- 1978
- 1964 (the historical largest flood)

Inundation is most serious in residential areas, namely, Bangkinang and Airtiris along the Kampar Kanan River, and the towns between Telukkuantan to Airmolek and Rengat along the Kuantan-Indragiri River. Agricultural lands also suffer from flooding.

(3) Outline of January 1995 Flooding in Kampar River Basin

The condition of the flooding in January, 1995 in the Kampar river basin is as follows:

(a) Date of Flooding

- January 6-8, 1995

(b) Rainfall, River Discharge and Water Level

- Rainfall: Approx. 140 mm/day
- River Discharge: Approx. 1,900 m^3/s at Kotapanjang Dam (less than 2-year return period)
- Water Level: The highest water level at Kotapanjang Dam Site is approx. EL 52.0 m

(c) Affected

- Inundation Area: 897.5 ha in Kab. Kampar, Riau
- Villages: Inundation of 59 villages in 9 Kecamatans
- Irrigation Facilities: Inundation of 11 irrigation areas
- Roads: Inundation for 8.8 km of Pekanbaru-West Sumatra National Road and interception of transportation between Riau and West Sumatra for 17 hours
- Total Damage: not yet summarized

(4) Outline of January 1995 Flooding in Indragiri River Basin

The condition of the flooding in January, 1995 in the Indragiri river basin is as follows:

(a) Date of Flooding

- starting in January 7, 1995 and last for two weeks

(b) Rainfall, River Discharge and Water Level

- Rainfall: Approx. 156 mm/day
- River Discharge: Approx. 2,500 m^3/s at Japura, Indragiri River (approximately 10-year return period)
- Water Level: The highest water level at the Pier of Rengat City is EL 6.744 m in January 14-15, 1995

(c) Affected

- Death: 3 persons
- Inundation Area: 45,000 ha in Kab. Indragiri Hulu, Riau
- Villages: Inundation of 164 villages in 8 Kecamatans
- Houses: Heavy damage: 2,045 houses (as of Jan. 17)
Light damage: 15,223 houses (as of Jan. 17)
- Irrigation facilities: Inundation of 31 irrigation areas
- Roads: A total of 157.4 km segment of roads is affected.
- Total Damage: Rp.11.55 billion (as of Jan. 17, estimated by Kab. Indragiri Hulu)

2.2 Upper Reaches

Flooding conditions in the upper reaches, namely, Solok, Payakumbuh and Sijunjung/Muara areas are as described below.

(1) Payakumbuh Area

Northeast of Payakumbuh City, the Lampasi and Agam rivers join the Sinamar River in a relatively flat terrain. Areas near the junctions and along these rivers are flood-prone. The most serious flooding area is located around the Lampasi River junction. This flood-prone area is approximately 4.0 km^2. The road connecting Padang and Pekanbaru via Bukittinggi passes this area and suffers from frequent inundation.

A detailed design for the improvement of the Sinamar-Lampasi River has been completed by DPU and the implementation is scheduled to be undertaken from 1994/95 onward. A more detailed information is given in CHAPTER 3.

One of the causes of flooding in this area is the much sediment production in the upper reaches of the Lampasi river basin. The flow capacity of the channel of the Lampasi River in the flat land to the northwest and north of Payakumbuh is rather small due to sediment deposition in the riverbed. DPU constructed a check dam on the Lampasi River as one of countermeasures to solve this problem. A more detailed information is given in CHAPTER 4.

(2) Solok Area

Solok Town is situated approximately 15 km to the southeast from the southern tip of Singkarak Lake. The flood-prone area is a stretch of 4.0 km in direct distance with an area of about 5.0 km^2 in the downstream part of the confluence of the Lembang and the Sumani rivers. Floods occur more than once a year with the maximum water depth of 1.5 m.

The Lembang River in this stretch heavily meanders and the flow capacity of the channel is very small. In addition, there is an approximately 3.0 km long bottleneck with channel width of 10 to 20 m in between Solok City and Singkarak Lake.

DPU is presently implementing an improvement project of the Lembang River that includes enlargement of the bottleneck channel, embankment and channelization of the river, etc. Details are presented in CHAPTER 3.

(3) Sijunjung/Muara Area

Northeast of Muara Town, two right bank tributaries, namely the Palangki and Sukam rivers join to the Ombilin River. From this point down, the river is called the Kuantan River. Flow capacity of the Kuantan River is relatively small in this stretch. During floods, backwaters extend to the upper reaches and inundation occurs in the area along the Palangki and Sukam rivers. It is said that landslides occurred in the banks of the Kuantan River at just the downstream point of Muara Town and caused clogging of the flow. DPU removed debris in this area to smoothen the flow, but it was not a permanent solution.

Sijunjung Town and the area along the Sukam River are frequently inundated due to the small flow capacity of the channel. The flood-prone area extends in a 9.0 km stretch with an average width of 1.0 km. The area is inundated more than once a year.

2.3 Area between Kampar and Indragiri Rivers

Areas near the river mouth delta suffer from flooding mainly of tidal influence. These areas are along the Guntung, the Kateman, the Gaung and the Anakserku rivers, and the upstream area of Tembilahan along the Tuaka River.

CHAPTER 3 RELATED PROJECTS

Existing projects related to flood control, sediment control, river maintenance, etc., are described below. Fig. VI.3.1 shows the location of these projects.

3.1 Completed and Ongoing Projects

Projects already implemented and under construction in the Kampar-Indragiri river basin are as follows:

(1) Radio Communication/Warning System (Kampar & Kuantan-Indragiri Rivers)

Radio communication/warning system stations have been installed at nine locations, four locations along the Kampar River and five locations along the Kuantan-Indragiri River. These stations are under the control of the River Improvement and Flood Control Project Office of KANWIL PU Riau in Pekanbaru.

(2) Kotapanjang Hydropower Project (Kampar Kanan River)

Kotapanjang Dam is under construction by PLN on the Kampar Kanan River at about the 426 km point from the mouth. The dam is planned for the single purpose of hydropower generation and does not have a flood control capacity.

The effect of flood peak cut by Kotapanjang Dam is studied in Subsection 5.2.1.

(3) Lembang River Improvement Project (Upper Indragiri River Basin)

The project is proposed for flood protection of Solok City. The outline of the river improvement plan is given in Table VI.3.1. Major works include the following:

- Normalization and embankment of the channel
- Enlargement of a bottleneck in the downstream stretch
- Short-cut of the channel

The implementation of the project started in 1992/93 and is scheduled to continue in 1994/95 onward.

(4) Sinamar-Lampasi River Improvement Project (Upper Indragiri River Basin)

The detailed design of this project was completed in 1990/91 with the major features as given in Table VI.3.1.

The project aims to reduce flooding in the area and also include the control of sediment discharge in the Lampasi river basin. In 1992/93 and 1993/94, budget was allocated for the construction of a check dam on the Balubus

River, a left bank tributary of the Lampasi River. A total of 250,000 m^3 concrete was used for the construction of the check dam with a total construction cost of Rp. 800 million. It was completed by the end of 1993.

The improvement to be implemented continuously includes construction of check dams, river bank protection, construction of dike, normalization of river channel, construction of rubber dam for irrigation water intake, etc.

(5) Muara Area River Improvement Project (Upper Indragiri River Basin)

This project was implemented with the 1992/93 and 1993/94 budget. No study or detailed design for the determination of design discharge has been conducted, and the design discharge of Q=2,200 m^3/s has been applied considering the actually observed flood in December 1991. The works include the following:

- Removal of landslide debris on the Kuantan River.
- Shortcut for the channel of the Palangki River south of Muara Town to protect Muara Town.

(6) Singkarak Hydropower Project

The project uses water and its head in Singkarak Lake for hydropower generation. Water in Singkarak Lake will be diverted to the Anai River that is located to the west of the lake and outside the Indragiri river basin. This project is being implemented by PLN. Detailed information on the project is given in SUPPORTING REPORT IX HYDROPOWER GENERATION PLAN and the points to be considered are as follows:

- Effect of lowering of the lake water level and resultant steepened water surface gradient of the Lembang River.
- Effect of decrease in discharge of the Ombilin River; maintenance flow of 2 and 6 m^3/s, respectively, in normal and extremely dry period is proposed to be released from the Ombilin Weir.

(7) River Works in Middle and Lower Reaches

DPU has conducted riverine works in the Kuantan-Indragiri River, as shown in Fig. VI.3.1. The works have been implemented giving priority to serious damage areas. No overall study, however, has been implemented and the works are mainly of river bank protection for water colliding front of meandering.

3.2 Projects under Planning and Designing

The following projects are under planning and designing:

(1) Canalization for the Lower Kampar-Indragiri Delta

An impact assessment study has been conducted by DGWRD for the canalization to improve inter-delta communication and transportation and to contribute to the alleviation of widespread flooding especially near the town of Rengat and local drainage constraints. The following master plan and feasibility studies have been accordingly conducted.

(a) Survey, Hydrological Analysis and Topographical Mapping for General Planning of Canalization in East Coast of Sumatra

This is a master plan level hydrological analysis and topographical mapping for the canalization in the east coast of Sumatra. The report concludes as follows:

The entire canal is proposed between the Way Seputih River, Lampung Province and the Asahan River, North Sumatra Province. The study was conducted in the zone between Kampar River and Batang Hari River for hydraulic and topographic aspects, and the report concluded that the project is feasible.

From the aspect of economic growth in the area of Kampar-Batang Hari, the canal constitutes one of the major important investment to reduce ICOR (Incremental Capital Output Ratio). It means that the canal will realize a high economic growth with relatively low capital.

(b) Survey and Mapping for Flood Control and Drainage for Gaung and Kateman Rivers in the Indragiri River Basin/Feasibility Study of Canalization Development for Waterborne Transportation, Flood Control and Swamp Land Reclamation for Plantation in Riau (Kampar-Indragiri Zone), March 1994, DPU

This is a feasibility study and survey for the Kampar-Indragiri Zone for the canalization in the east coast of Sumatra. It includes studies for waterborne transportation, flood control and swamp land reclamation. A basic policy for the development is established considering the important role of Riau Province as a constituent of SIJORI (Singapore-Johor-Riau).

Major contents of flood control and drainage improvement are summarized below:

(i) Floodway and Canal

General layout of the floodway and a related canal is as shown in Fig. VI.3.2.

- Floodway Location: from Redang Village on the left bank of the Indragiri River to the Gaung River
- Length:

Floodway:	19 km
Gaung-Kateman Canal:	18 km

- Capacity:

Floodway:	500 m^3/s
Gaung-Kateman Canal:	300 m^3/s
Gaung River:	200 m^3/s

(ii) Drainage Improvement

After an alternative study, the study report concluded that the flood water (inland water) in the study area should be drained by two channels; namely, the Kateman River and the Gaung River.

(2) Projects Included in REPELITA VI, Riau Province

River improvement works for the Kampar and Indragiri rivers are proposed as shown in Fig. VI.3.1.

(3) Projects Included in REPELITA VI, West Sumatra Province

The activity of river-related projects in the stage of REPELITA VI is stressed on continuity of what have been done in the previous years. The projects described previously will be implemented accordingly. The project that is not included in the previous description is the Agam River Improvement Project.

The Agam River, a right bank tributary of the Sinamar River, functions as the main drainage of Bukittinggi City and at the same time is used to supply water to 13 irrigation systems with a total area of 1,250 ha. Since the intake weirs are not maintained well, these cause clogging of the river. The project includes normalization of the channel, construction of dikes, improvement of 13 intake weirs, etc.

(4) Outline of Rengat Area Detailed City Layout Plan

Detailed City Layout Plan for Rengat has been prepared in January 1988 by Riau Province Stratified Spatial Arrangement Project (Proyek Peningkatan Penataan Ruang Riau), KANWIL Riau, PU. The plan is developed following the local development policy of Indragiri Hulu Regency that follows the basic pattern of Provincial development as well as national development policy.

In spatial policy of Riau Province, Rengat City is included into Development Area IV consisting of all regions of Indragiri Hulu and Indragiri Hilir regencies with Rengat as the center of the development. In accordance with the City Layout Plan, Rengat City is divided into three city section areas (BWK: Bagian Wilayah Kota) with major functions as follows (refer to Fig. VI.3.3):

- Central City Area: Central business district of Rengat City
- Eastern Part of Rengat City: Settlement areas fully oriented to the Central City Area
- Western Part of Rengat City: Center of government offices of Indragiri Hulu Regency and for settlements

CHAPTER 4 OBJECTIVE FLOOD PROTECTION AREAS

Objective flood protection areas for the present overall plan are identified as follows (refer to Fig. VI.4.1) in due consideration of the present flood damage conditions and related projects as discussed in the previous chapters as well as the proposed land use plan under REPELITA VI.

(1) Kampar River Basin

- Bangkinang-Airtiris area along the Kampar Kanan River
- Proposed agricultural lands in lower reaches of the Kampar Kanan River
- Areas along the Sibayang River
- Areas along the upper reaches of the Kampar Kiri River
- Existing and proposed agricultural lands along the Kampar River

(2) Kuantan-Indragiri River Basin

- Towns and agricultural areas in the upstream reaches, namely, Payakumbuh, Solok and Sijunjung/Muara areas
- Towns in the lower reaches from Telukkuantan to Airmolek
- Rengat area
- Existing and proposed agricultural lands along the middle and lower reaches of the Kuantan-Indragiri River

CHAPTER 5 OVERALL DEVELOPMENT PLAN

5.1 Planning Criteria for Overall Development Plan

5.1.1 Target Year

The target year for the flood control planning refers to the year whose conditions serve as the basis for determining the design scale of the Project. For this project the target year is set at 2019.

5.1.2 Design Scale

The design scale, namely the return period of the design rainfall for the flood control planning, is decided at 50-year for the final phase of the overall development plan and 5 to 10-year for the initial phase in due consideration of the following:

(1) Flood Control Criteria

The following return periods are recommended as minimum value for flood control projects in the "Flood Control Manual, CIDA-DPU, June 1993".

Conveyance System	Project Type *1	Return Period (year)	
		Initial Phase	Final Phase
River	Emergency Project *3	5	10
	New Project *4	10	25
	Updating Project *5 - For Rural and/or Urban with P<2,000,000 *2	25	50
	- For Urban with P≥2,000,000 *2	25	100

Note: *1 Higher design flood standard shall be applied if economic analysis indicates that it is desirable, or if flooding is a significant risk to human life.

*2 P: Total Urban Population

*3 Emergency Project: Emergency Projects are developed without preliminary engineering and economic feasibility studies at sites where flooding is excessive and flooding problems present a significant risk to human life.

*4 New Project: New Projects include flood control projects where no previous flood control projects have been developed or where emergency projects have been developed.

*5 Updating Project: Updating Projects include rehabilitation projects and improvements to existing projects. Most river basin development projects are considered as updating projects.

(2) Design Scale in Other Projects

Protection levels in other river projects in Indonesia are referred to as shown in Table VI.5.1. From this table, 50-year return period for the final phase and 5 to 10-year return period for the initial phase are deemed reasonable.

(3) This Project

In due consideration of the criteria and actually applied levels in other projects, design scales for this project have been determined as follows:

Particulars	Initial Phase (Urban/Rural)	Final Phase
Kampar River System		
Kampar Kanan River	5 / 5	50
Kampar Kiri River	-	50
Kampar River after confluence	-	50
Indragiri River System		
Sinamar/Lampasi/Agam Rivers	10 / 10	50
Lembang River	10 / 10	50
Sukam/Palangki Rivers	10 / 10	50
Kuantan-Indragiri River	10 / 5	50

5.1.3 Standard Flood Discharge

Standard flood discharges which correspond to the design scales as determined above are as follows (calculation is conducted in SECTOR I METEOROLOGY AND HYDROLOGY).

River	Catchment Area (km^2)	Initial Phase		Final Phase	
		Return Period (Year)	Standard Flood Discharge (m^3/s)	Return Period (Year)	Standard Flood Discharge (m^3/s)
Kampar River System					
Kampar River at Bangkinang	3,337	5	2,800	50	4,000
Sibayang River	1,187	5	1,050	50	1,650
Singingi River	552	5	550	50	950
Kampar Kiri River	3,284	-	-	50	3,100
Kampar River at Langgam	12,284	-	-	50	6,800
Indragiri River System					
Kuantan River at Lubukjambi	7,453	5	3,900	50	6,550
Kuantan River at Peranap	10,885	5	4,300	50	6,800
Kuantan River at Japura	12,320	5	4,500	50	7,000
Sinamar River	1,278	10	1,550	50	2,100
Lembang River	359	10	500	50	1,000
Sukam River	360	10	700	50	1,050
Kuantan River at Muara	6,169	10	3,950	50	5,450

5.1.4 Design Criteria

The design criteria considered for flood control planning are as follows:

(1) River Improvement

(a) High Water Level

The design high water levels are maintained as low as possible.

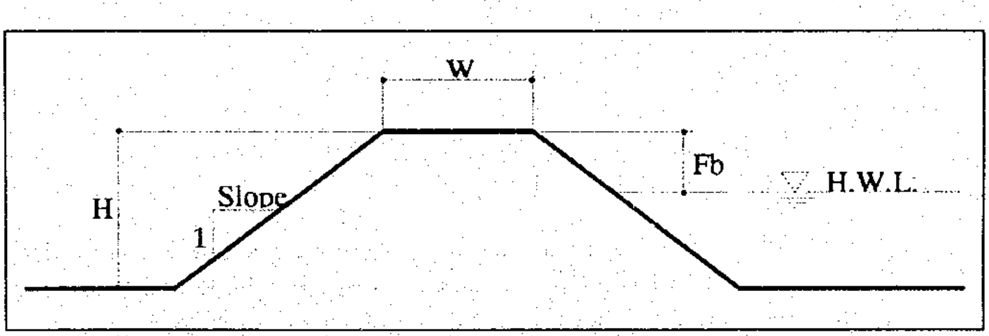
(b) Channel Alignment and Longitudinal Profile

The alignment of the improved river channel basically follows the present alignment. Although comparison of construction cost is carried out, the following principles are considered. Continuous shortcuts are basically avoided in order to maintain the present river regime. However, extreme meandering portions are to be shortcut to realize smooth flow during floods and to minimize improvement cost. Rough cost comparison revealed that if shortcut length is shorter than 1/2.5 of the original channel, shortcut cost is smaller than the embankment cost for the original channel.

The longitudinal profiles will be determined based on a new channel alignment. Extreme shortcuts make the profile steeper and destroy the river regime.

(c) Cross Section

Basically, compound cross sections will be adopted. Dike dimensions will be determined based on the Flood Control Manual as follows:



W:		Q <	500	m^3/s	:	3 m
	500 ≤	Q <	2,000	m^3/s	:	4 m
	2,000 ≤	Q <	5,000	m^3/s	:	5 m
	5,000 ≤	Q <	10,000	m^3/s	:	6 m

where, Q: Design Discharge

Fb:	$Q <$	200	m^3/s	:	0.5 m
	$200 \leq Q <$	500	m^3/s	:	0.8 m
	$500 \leq Q <$	2,000	m^3/s	:	1.0 m
	$2{,}000 \leq Q <$	5,000	m^3/s	:	1.2 m
	$5{,}000 \leq Q <$	10,000	m^3/s	:	1.5 m

(+0.3 m for Critical Areas or dike H>3.5 m)

where, Q: Design Discharge

Slope: 1 : 2 (minimum)

(2) Flood Control Dam

Dams will be basically planned as multipurpose dams.

(a) Regulation Type

Natural regulation (non-gated) will be adopted if physical conditions and the function of the dam allow.

(b) Capacity

Optimum scales of dams will be determined through optimization study with river improvement considering reservoir capacity allocation with other purposes.

5.2 Premises and Applicable Alternative Measures

5.2.1 Premises for Flood Control Planning

The following premises are considered for flood control planning:

(1) Flood Control Effect of Kotapanjang Dam

Kotapanjang Dam (scheduled to be completed in 1997) does not have a flood control capacity as shown in Fig. VI.5.1.

During the detailed design stage, PLN compared cost and benefit reduction in the case of using 10.8×10^6 m^3 capacity from EL. 84.0 to 85.0 m for flood control and concluded that it was not beneficial as follows:

- Flood Peak Discharge: 8,000 m^3/s → 6,400 m3/s (200-year return period)
- Cost Reduction: US$153,700/year (Spillway, gates, etc.)
- Benefit Reduction: US$618,140/year (-2,000 kW, -11.2 GWh)

Accordingly, if floods occur when the reservoir water level is in High Water Level (EL. 85.0 m), then INFLOW=OUTFLOW.

However, the reservoir operation simulation reveals the following fact. The reservoir generally becomes empty at the end of the dry season in September to October. The reservoir is then recovered to full, High Water Level, at the end of the rainy season, namely, in April to May. In due consideration of the fact that high discharges and flooding generally occur in the months of November to January, there may be a flood control effect as a result.

Annual maximum daily average discharges with and without the Kotapanjang reservoir were accordingly compared.

Dam operation rule is as follows:

- February to October : 174.0 m^3/s release
- November to January : 215.6 m^3/s release
- Annual Average Discharge : 184.4 m^3/s

As the results show (refer to Table VI.5.2 and Fig VI.5.2), probable daily discharge of with or without the reservoir is about 80% on average. In some years, the with/without ratio is 1.0, namely, the annual maximum flood occurred when the reservoir water level is in high water of EL. 85.0.

Accordingly, peak discharge reduction has not been considered for the flood control planning of the Kampar Kanan River.

(2) Indragiri-Gaung Floodway

As explained in CHAPTER 3, DPU had conducted a feasibility study for the Kampar-Indragiri Zone for the canalization in the east coast of Sumatra. The floodway is proposed in this plan to divert a maximum discharge of 500 m^3/s from the Indragiri River to the Gaung River. Detail design has also been started for this floodway. Accordingly, this floodway is considered as a prerequisite for the present study.

5.2.2 Applicable Alternative Measures

Applicable countermeasures are consist of structural and non-structural measures. Non-structural measures, e.g., flood risk mapping and land use regulation are not taken into consideration as alternatives, however, because the effect is uncountable.

For flood control, the following four measures are considered as applicable countermeasures:

- Construction of flood control dam;
- Improvement of existing river channel;
- Establishment of retarding basins; and,
- Construction of floodways.

Applicable alternative structural measures for each river are identified considering the natural conditions as follows (refer to Fig. VI.5.3).

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	-	-

x : Applicable -: Not Applicable

5.3 Formulation of Component Project of Overall Plan

The following component projects of the overall plan have been formulated on the basis of the objective areas for flood protection as discussed in CHAPTER 4 as well as 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 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 SECTOR XI, MULTIPURPOSE DEVELOPMENT PLAN, and the subsequent sections present the optimization study of single purpose structures for flood control.

5.4 General Rule for Optimization of Flood Control Structure

Alternative plans of optimization for single purpose flood control structures and general rule for optimization include the following:

(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 Profiles

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)

5.5 Optimization of Flood Control Structure for Kampar Kanan River

The optimization of flood control structures for the Kampar Kanan River is presented in this section.

As discussed in applicable alternative measures, the following structures are applicable for the flood control of the Kampar Kanan River.

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

5.5.1 Major Characteristics for Flood Control Planning

Present conditions of the Kampar Kanan River are described in CHAPTER 1. Characteristics related to flood control planning are summarized as follows:

- Flow capacity of the present channel of the Kampar Kanan River is small at 750-1,000 m3/s compared to the design discharge of 4,000 m3/s (without Kapoernan Dam).
- This flow capacity is less than a 2-year return period and floods occur almost every year.
- The flood inundation area, namely, the area to be protected, is long and narrow along the river. The width of the area is about 5 to 10 km.
- The river forms a heavily meandering channel. The width of the meandering is about 1.5 to 2 km. This means that if the improved channel is formed to comprehend the meandering channel, many portions of the area to be protected will be included in the river channel.
- The development of meandering is not so rapid.

Optimization study is conducted as described below on the basis of the above mentioned major characteristics.

5.5.2 Dam

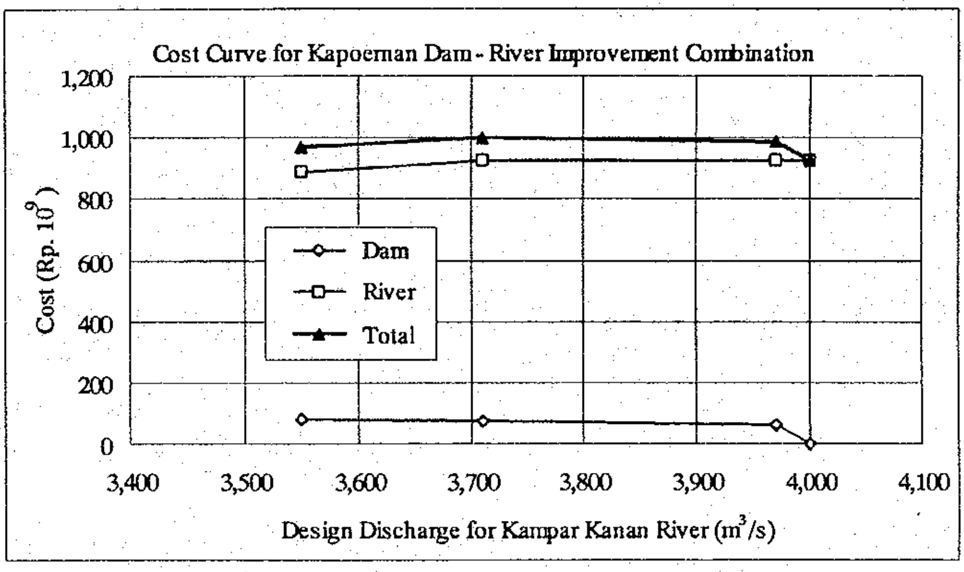
Kapoernan Dam is the only possible dam for flood control in the Kampar Kanan river basin. The damsite is located on the Kapurnangadang River at about 4.5 km upstream point from the confluence with the Kampar Kanan River. It is in the catchment area of Kotapanjang Dam. The catchment area at the Kapoernan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

As discussed in Section 5.2, Kotapanjang Dam has no flood control effect although it is located at the upstream end of the objective flood control area along the Kampar Kanan River. If Kapoernan Dam is constructed, the peak of flood hydrograph at Kotapanjang Dam will be cut. This will result in the reduction of design discharge in the Kampar Kanan River.

The relation of the flood control capacity of Kapoernan Dam and the design discharge of the Kampar Kanan River is obtained as tabulated as follows:

Flood Control Capacity of Kapoernan Dam ($10^6 m^3$)	Design Discharge of 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

Costs for 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 Kapoernan Dam is not employed. Accordingly, construction of the Kapoernan Dam has not been considered.



Note: Cost is of direct construction.

5.5.3 Other Alternative Measures

In the Kampar Kanan river basin, there are no realistic sites for retarding basins and floodways.

5.5.4 Design Discharge Distribution

As discussed in the previous sub-sections, dams, retarding basins and floodways have not been proposed for flood control of the Kampar Kanan River. Accordingly, 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. VI.5.4.