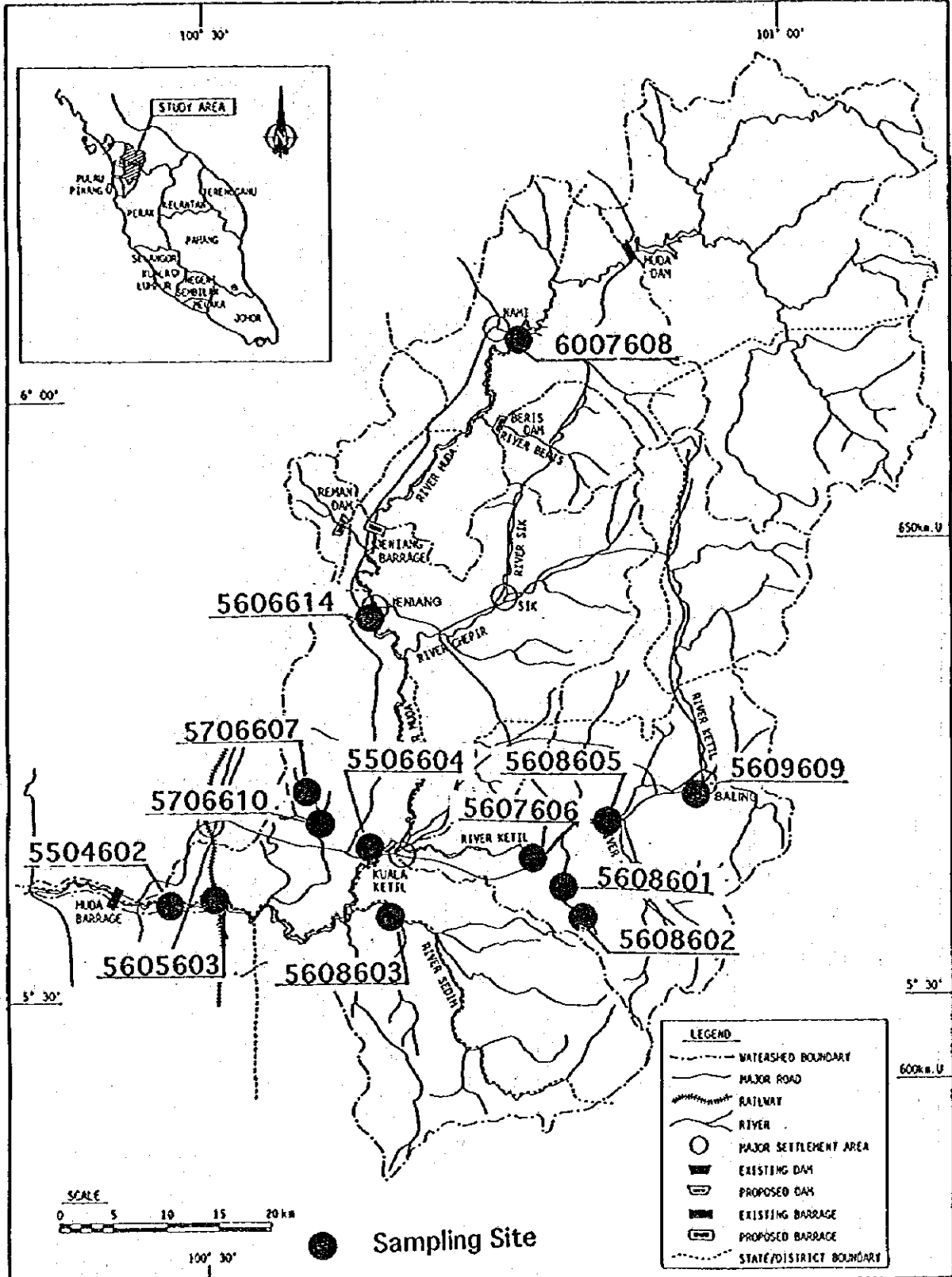


FIGURES

SECTOR IV

***RIVER ENVIRONMENTAL
MANAGEMENT PLAN***

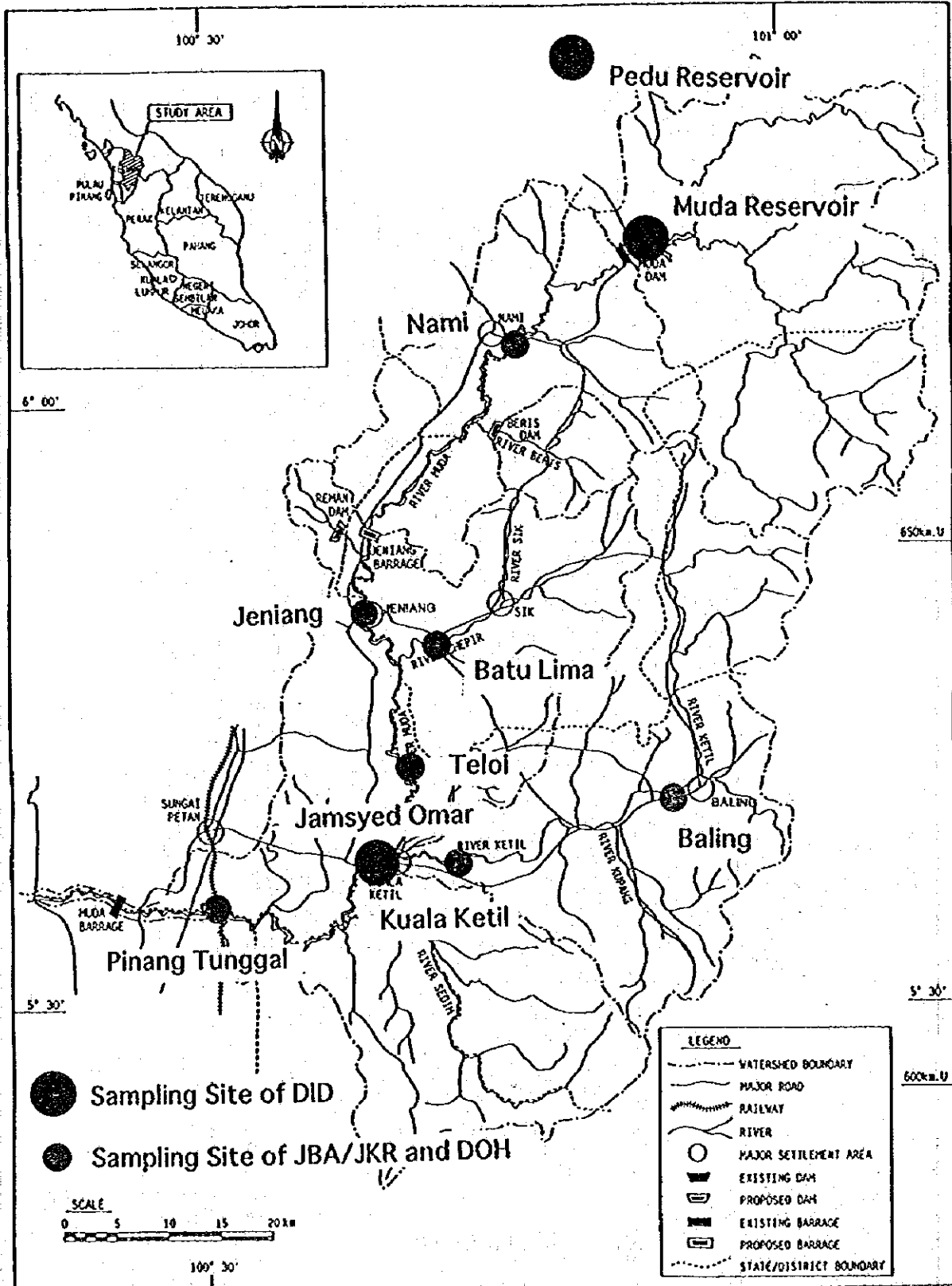


COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.1.1

WATER SAMPLING LOCATIONS OF DOE

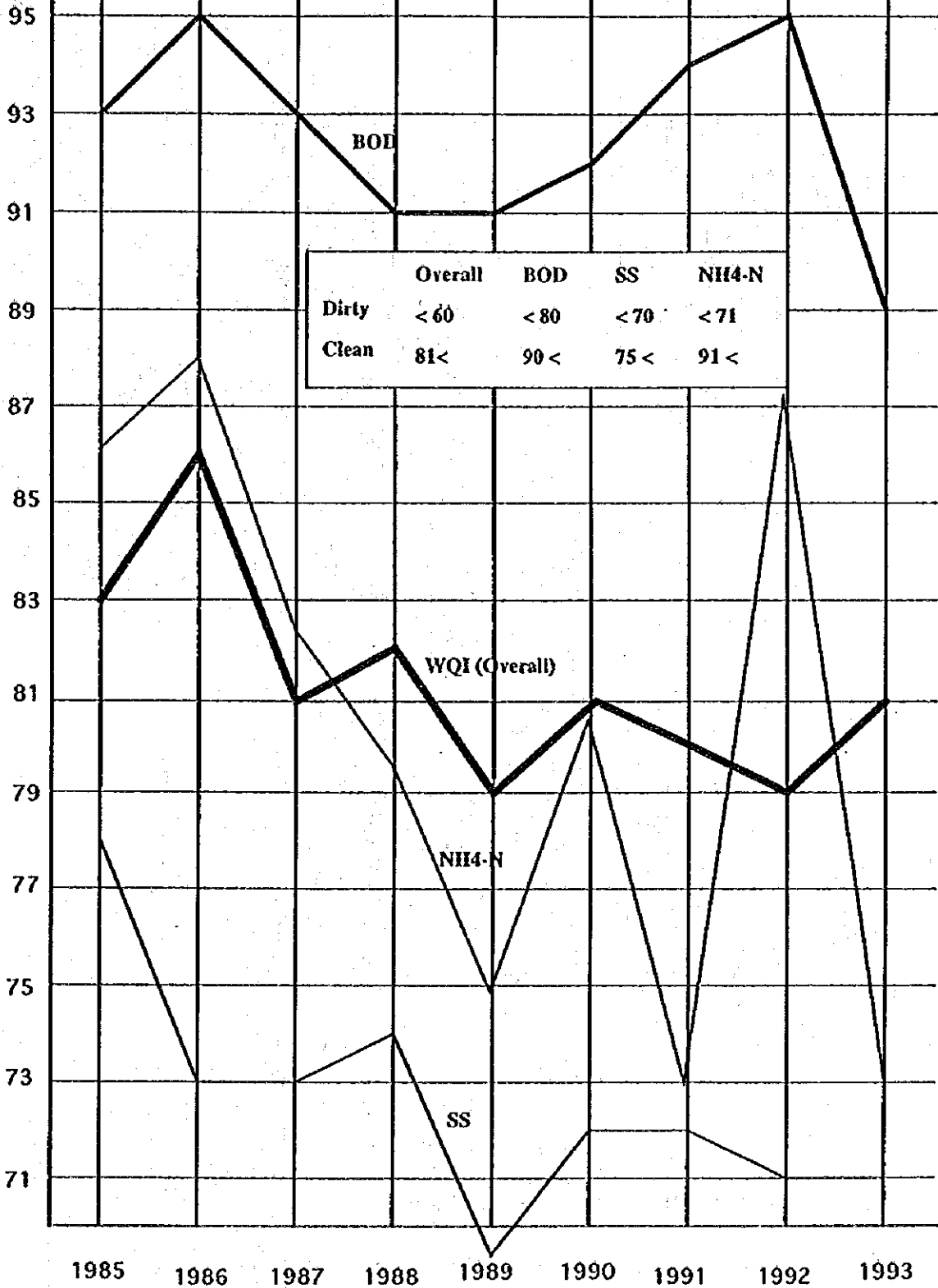


COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.1.2
WATER SAMPLING LOCATIONS
OF JBA/DOH AND DID

INDEX

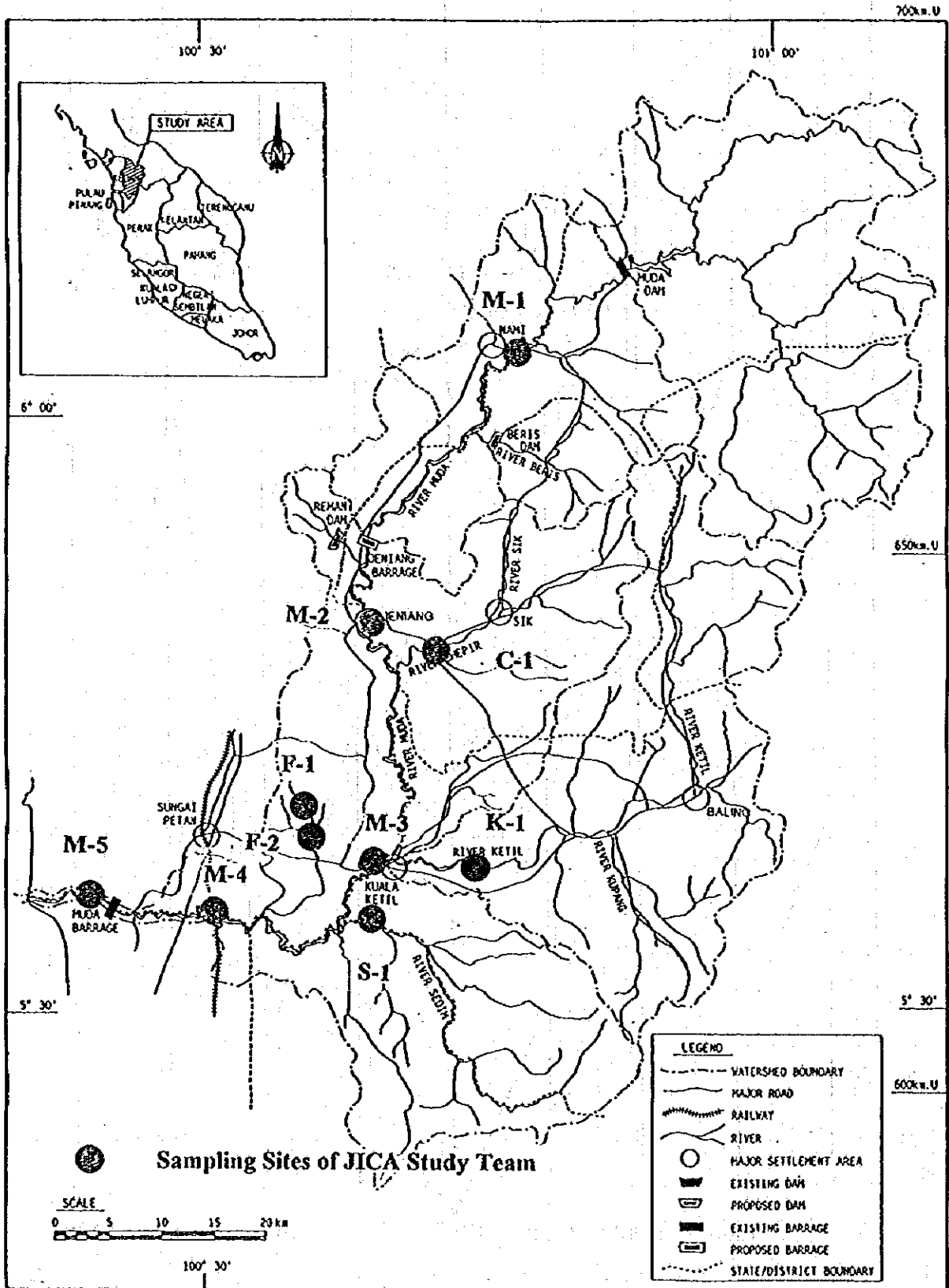


COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.1.3

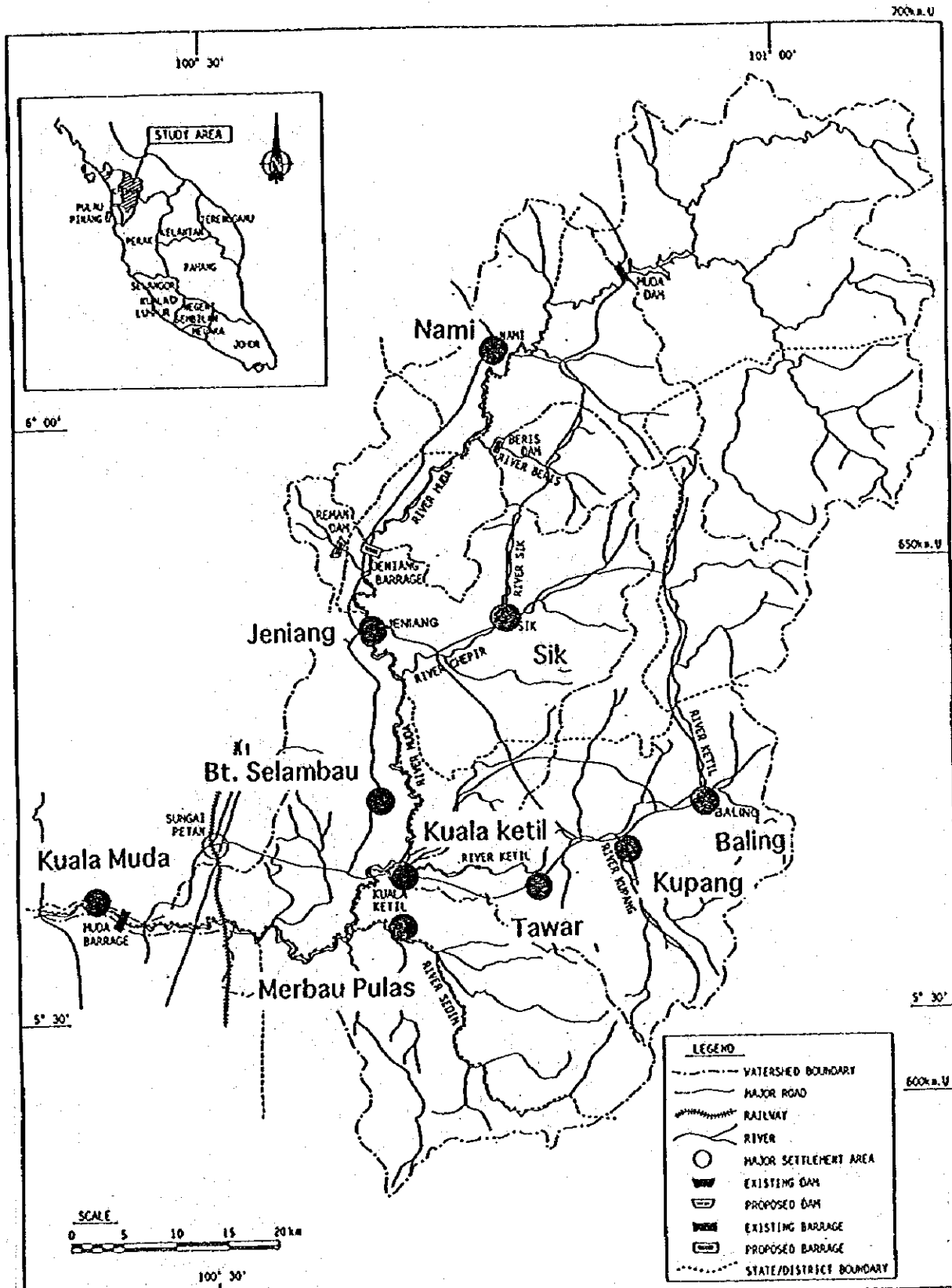
CHANGE OF WATER QUALITY INDEX OF MUDA RIVER
BY DOB CLASSIFICATION



COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

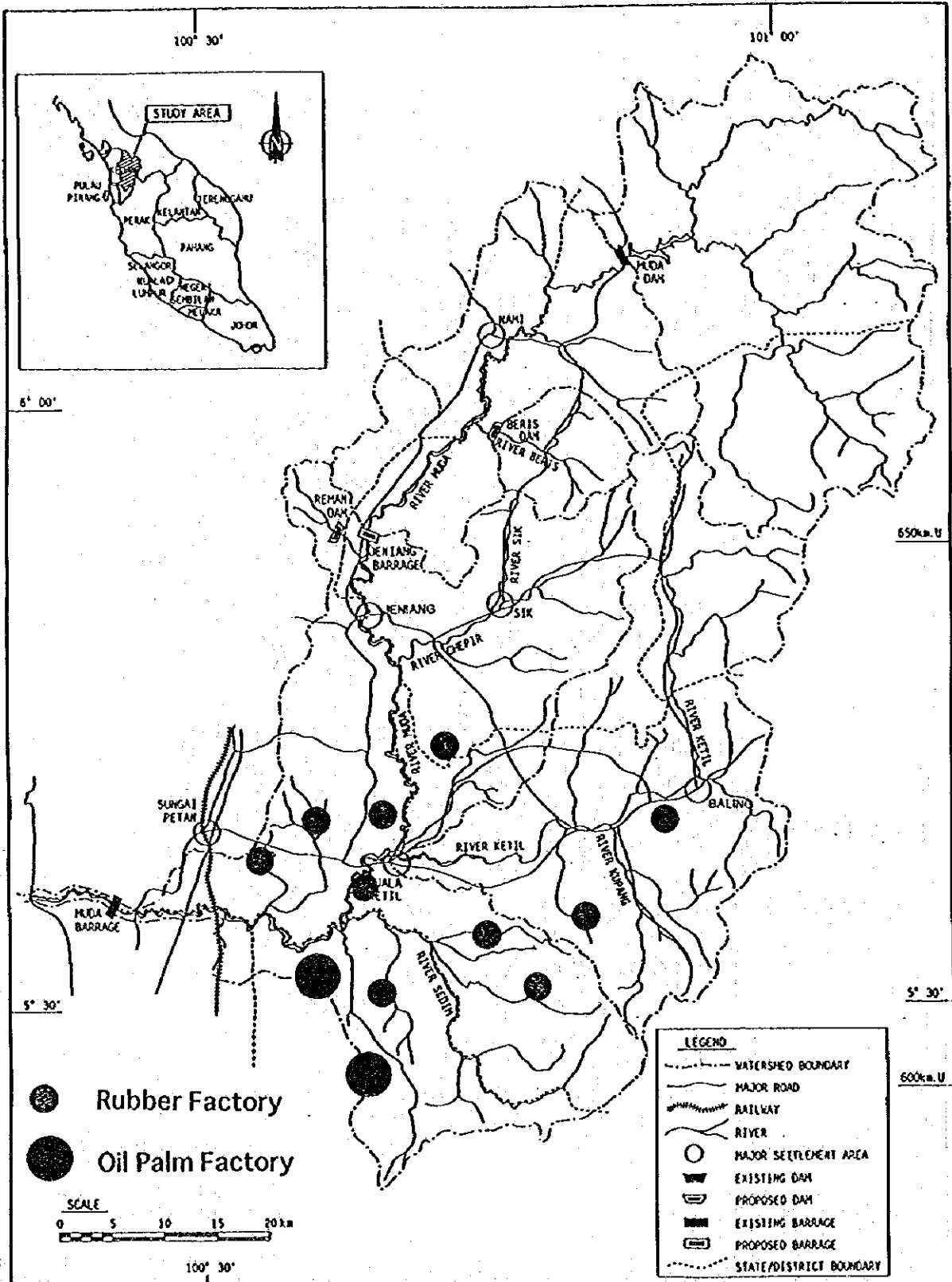
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.2.1
WATER SAMPLING LOCATIONS
JICA STUDY TEAM



COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN
 JAPAN INTERNATIONAL COOPERATION AGENCY

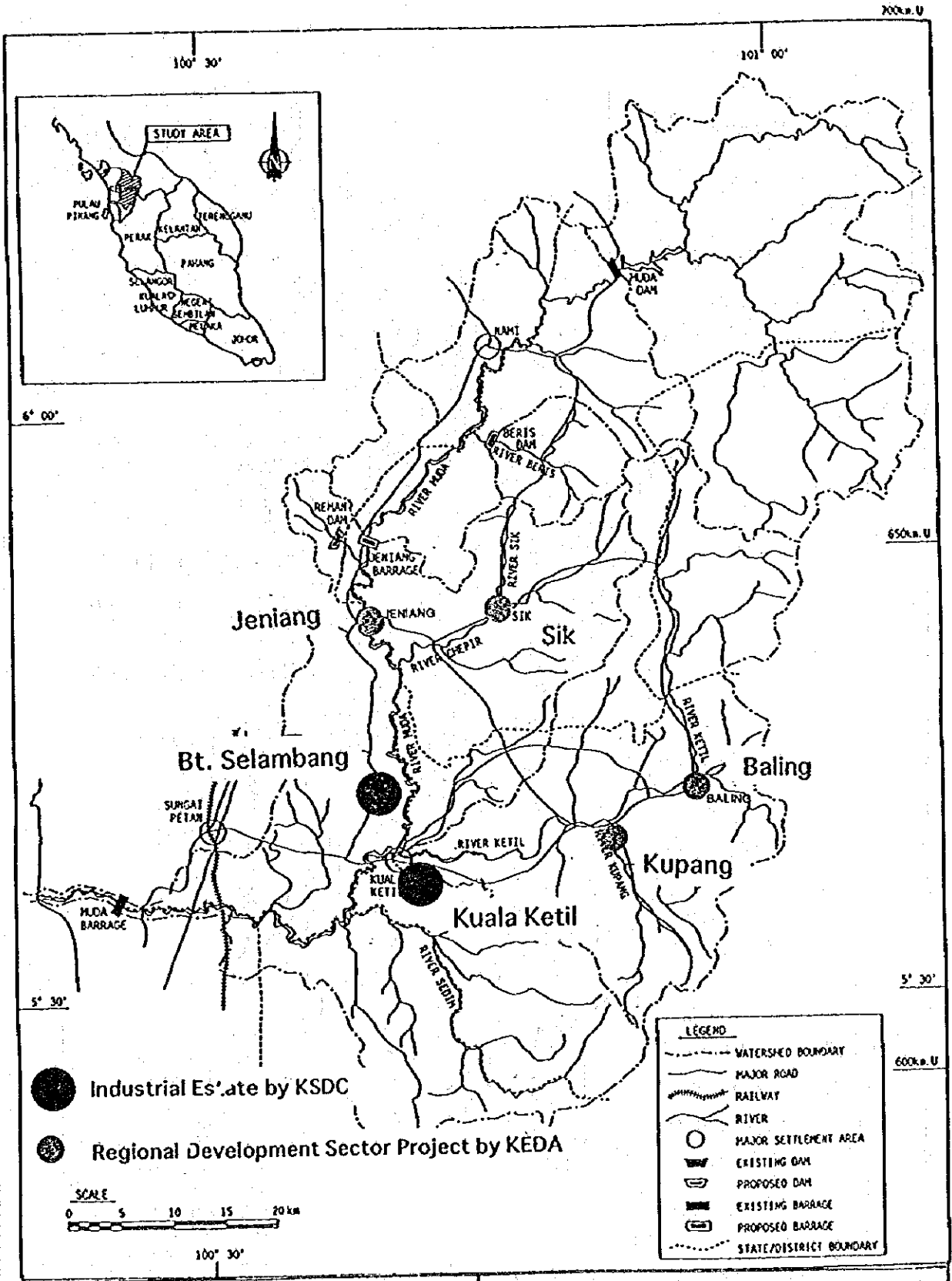
FIG. IV.1.3.1
 LOCATIONS OF MAJOR TOWNS IN THE BASIN



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.3.2 LOCATIONS OF RUBBER AND OIL-PALM FACTORIES

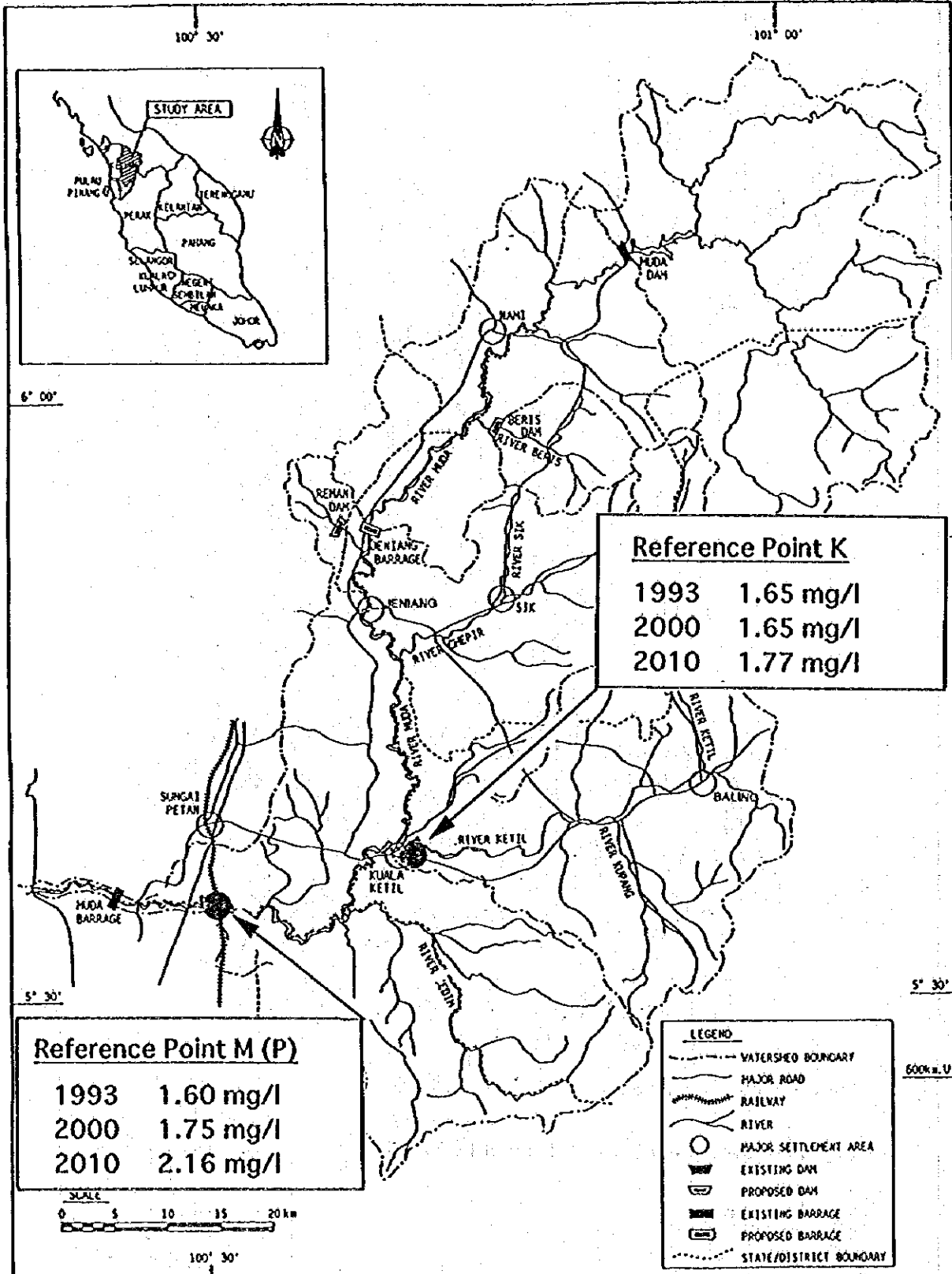


COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.3.3

LOCATIONS OF DEVELOPMENT AREAS BY KSDC AND KEDA

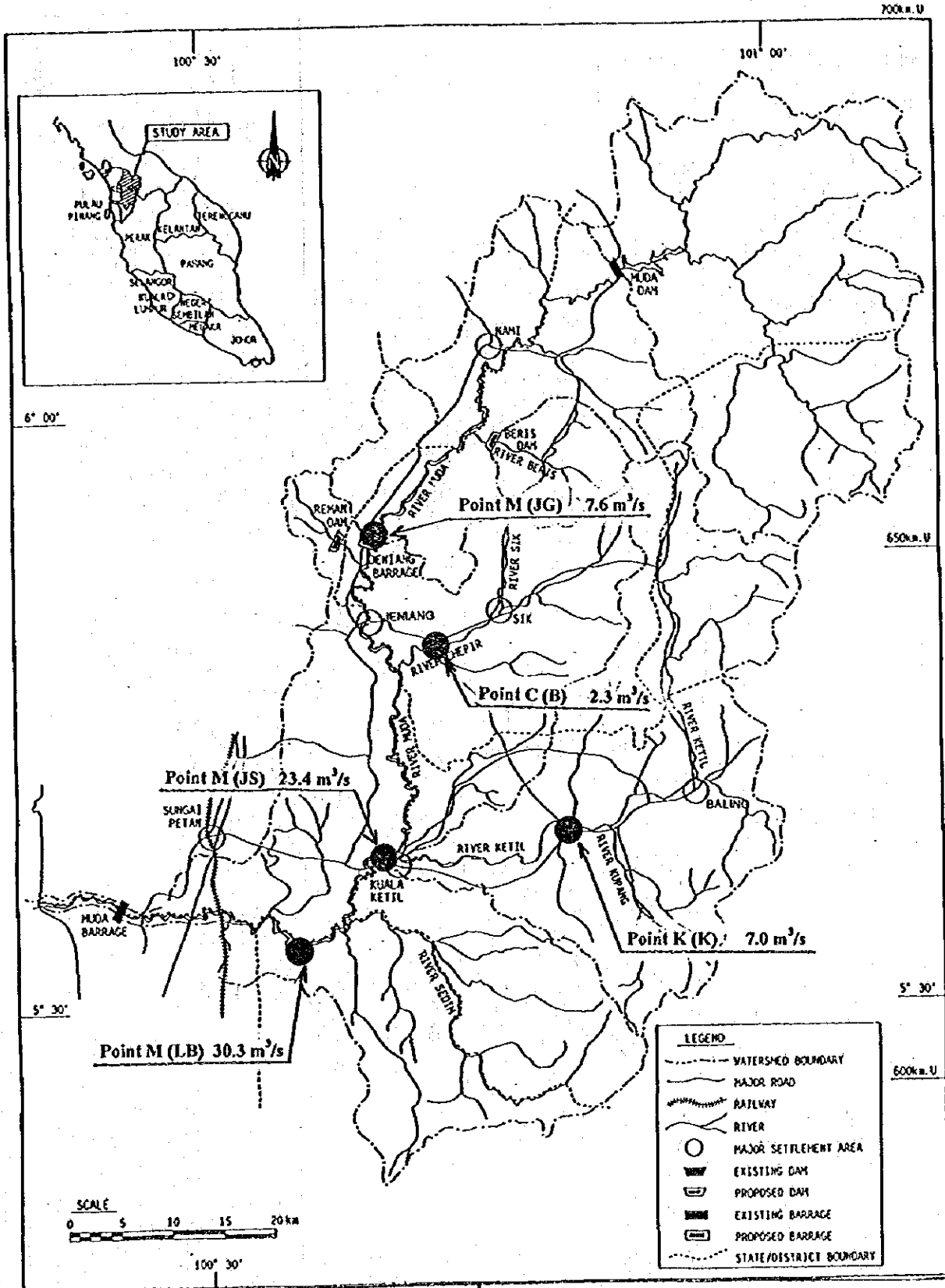


COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV.1.4.1

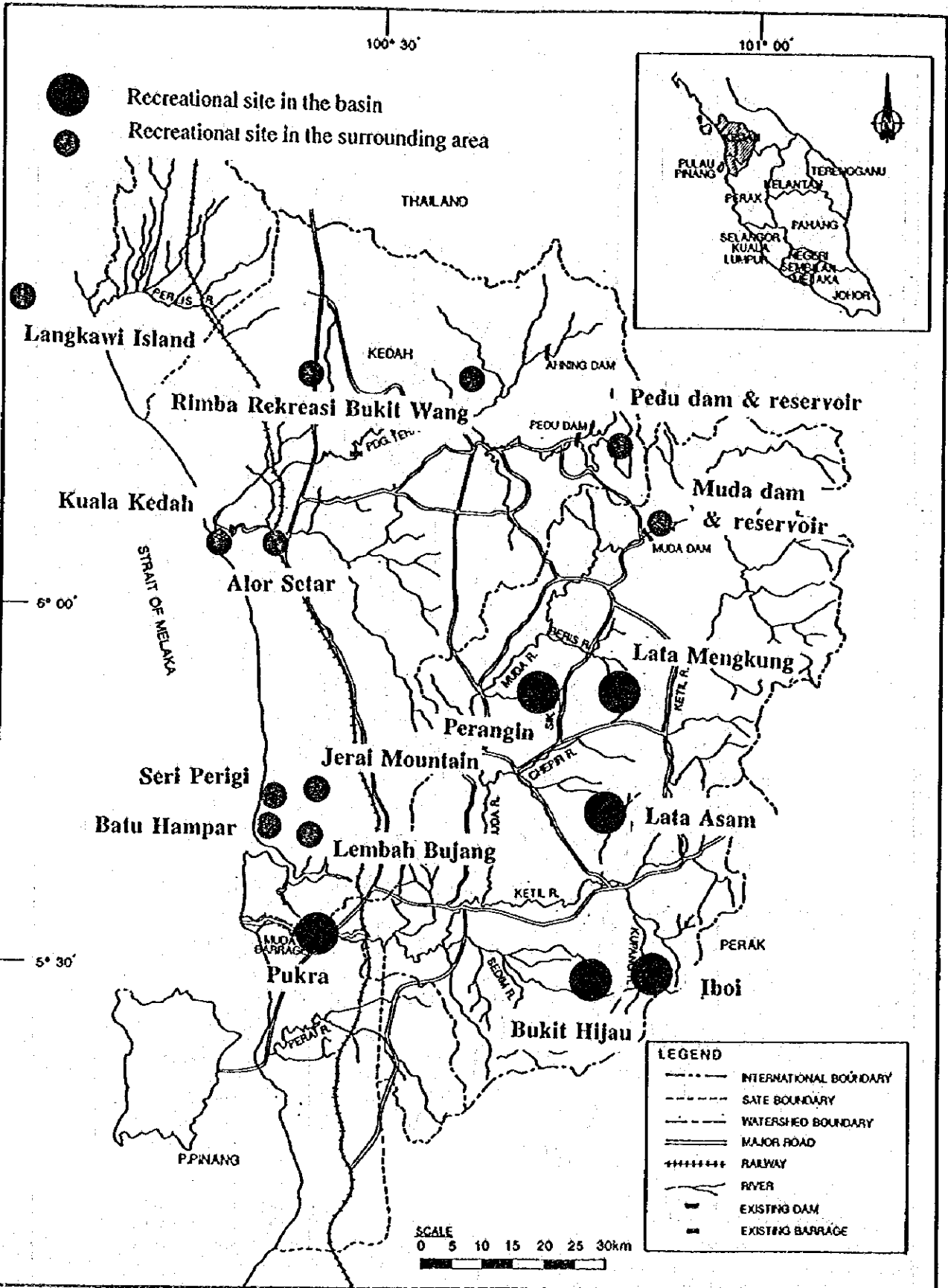
WATER QUALITY (BOD) AT REFERENCE POINTS



COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

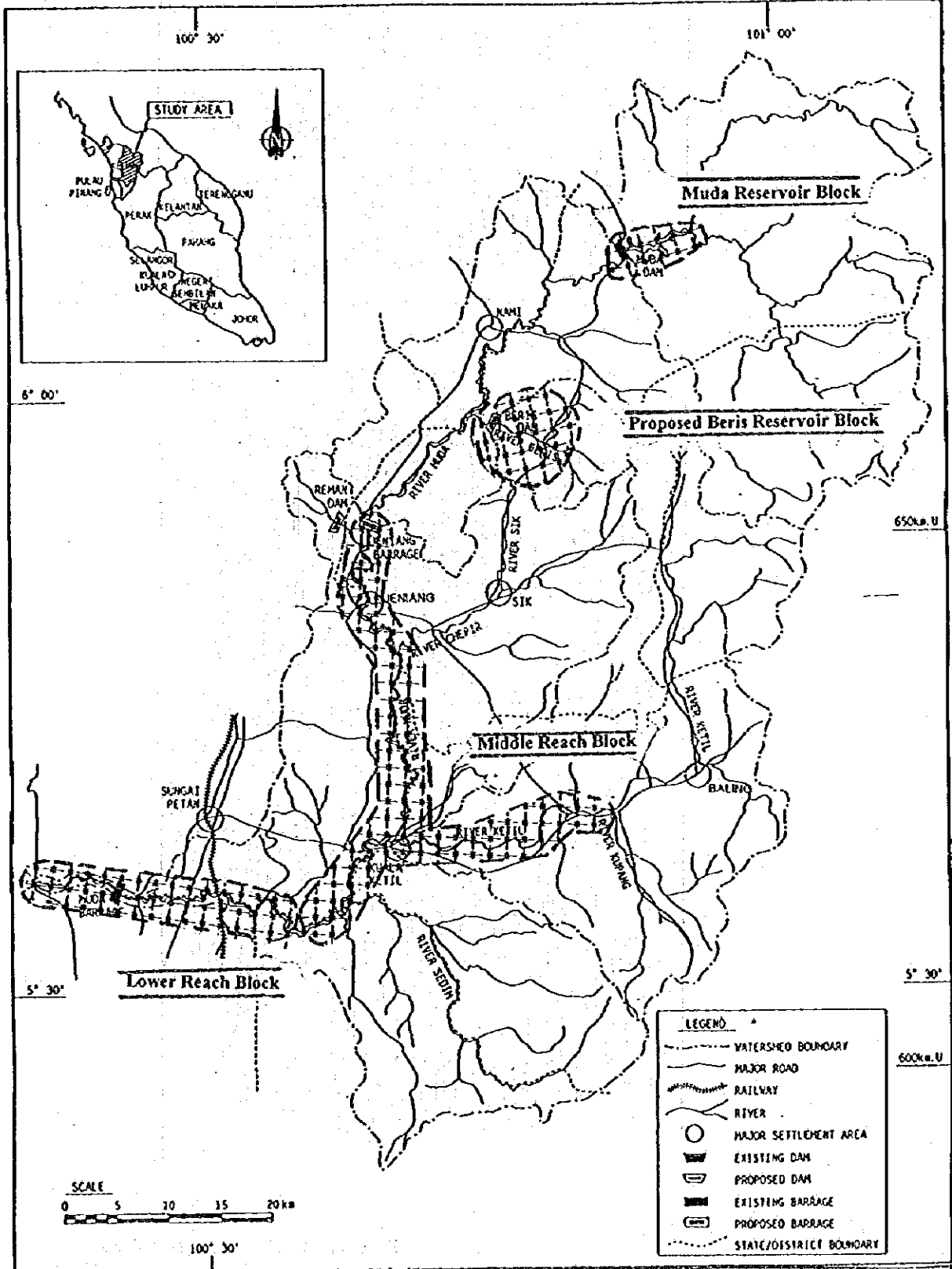
FIG. IV.2.2.1
MAINTENANCE FLOW AT REFERENCE POINTS



COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN

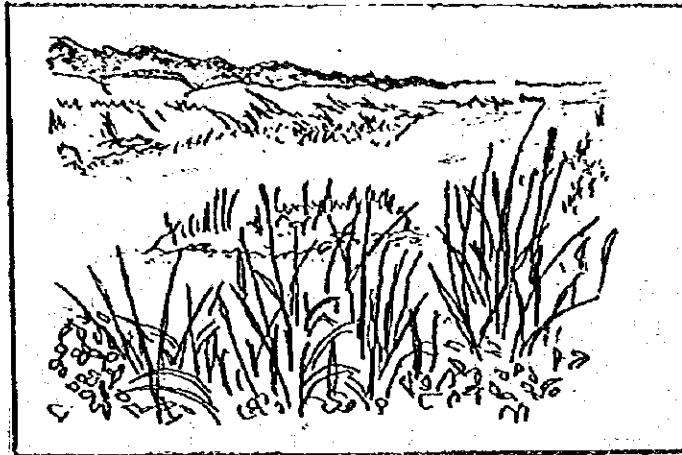
FIG. IV. 3.1.1
 GENERAL LOCATION OF EXISTING
 RECREATIONAL SITES

JAPAN INTERNATIONAL COOPERATION AGENCY



COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN
 JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.1
 BLOCK DIVISION FOR RIVER CORRIDOR
 PLAN



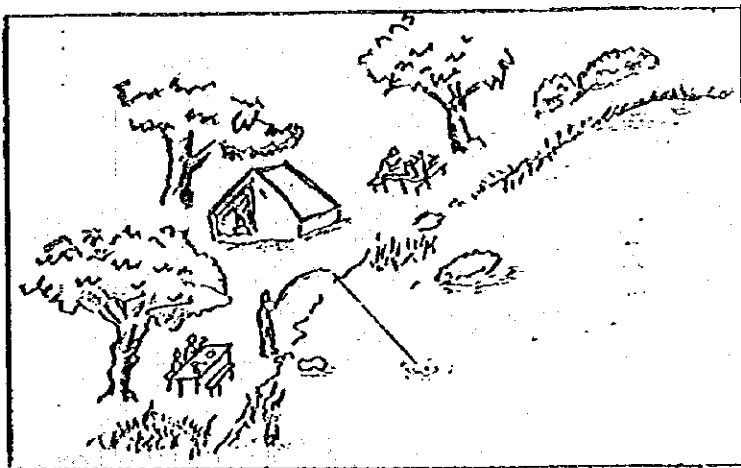
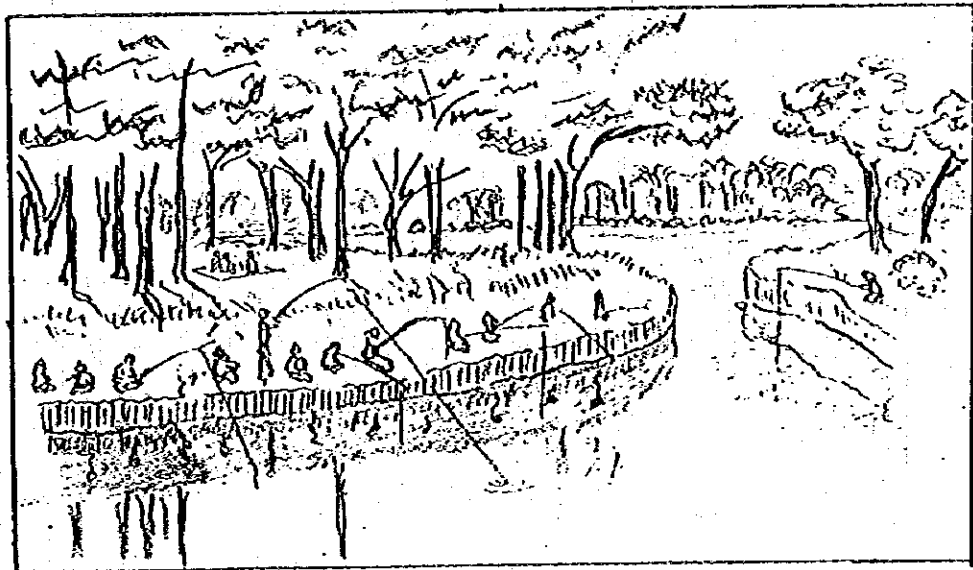
Zone type A : Natural Reserve Zone

COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.2

IMAGE SKETCH OF ZONE TYPE A
(NATURE RESERVE ZONE)



Zone Type B :

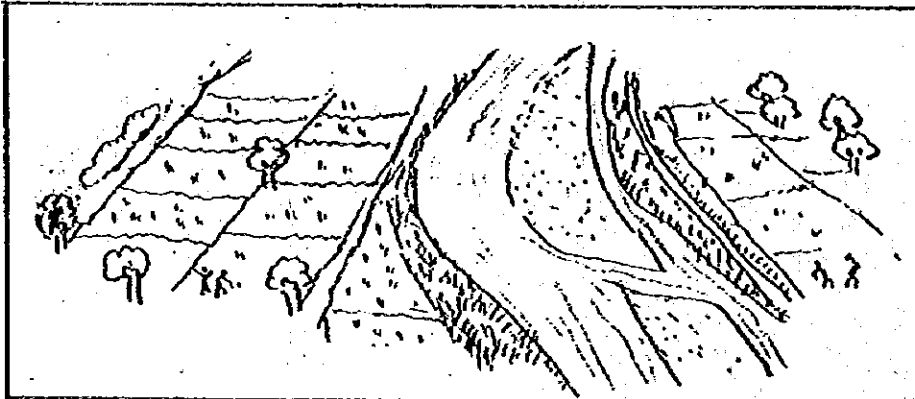
Natural Use Zone

COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.3

IMAGE SKETCH OF ZONE TYPE B
(NATURE USE ZONE)



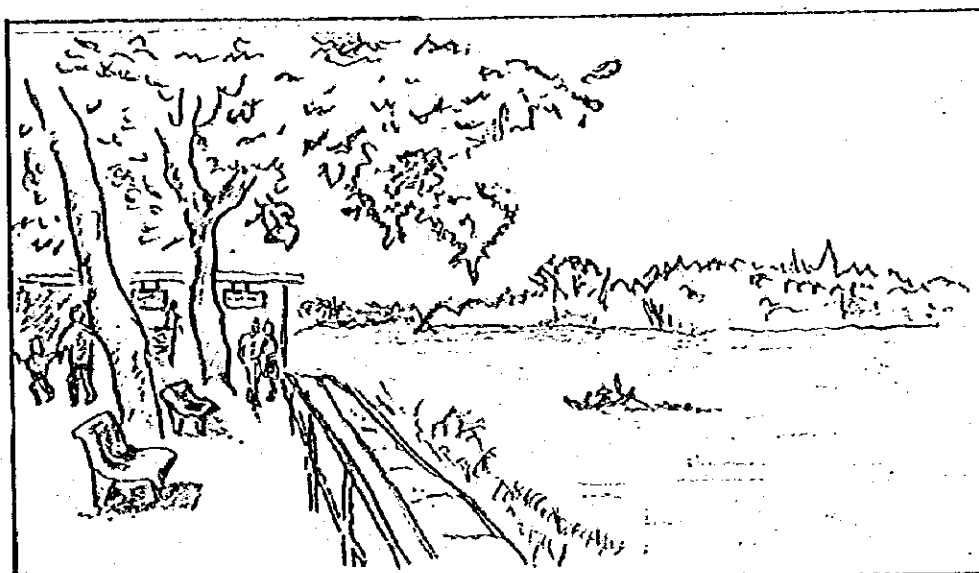
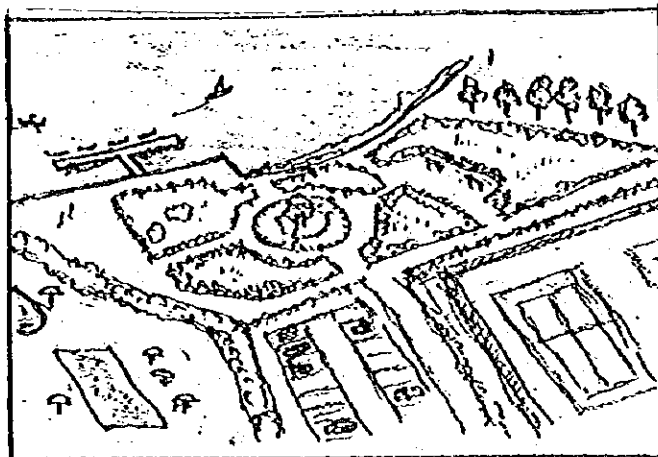
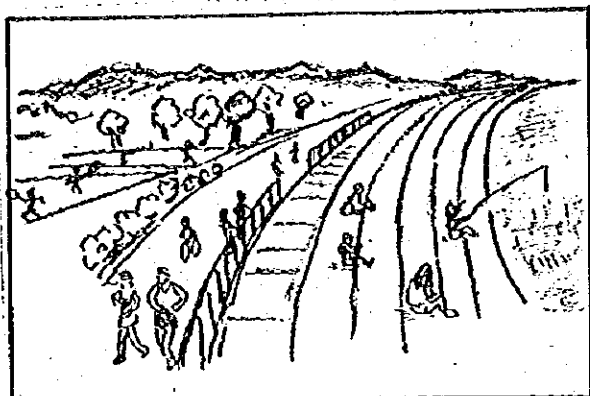
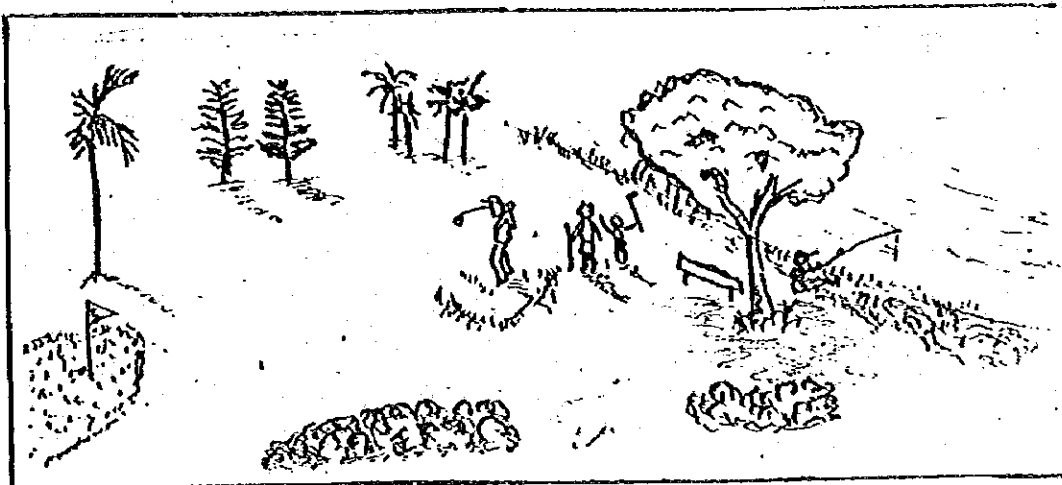
Zone Type C : Agriculture Land Zone

COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.4

IMAGE SKETCH OF ZONE TYPE C
(AGRICULTURAL LAND ZONE)



Zone Type D : Development Zone

COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.5
IMAGE SKETCH OF ZONE TYPE D
(DEVELOPMENT ZONE)

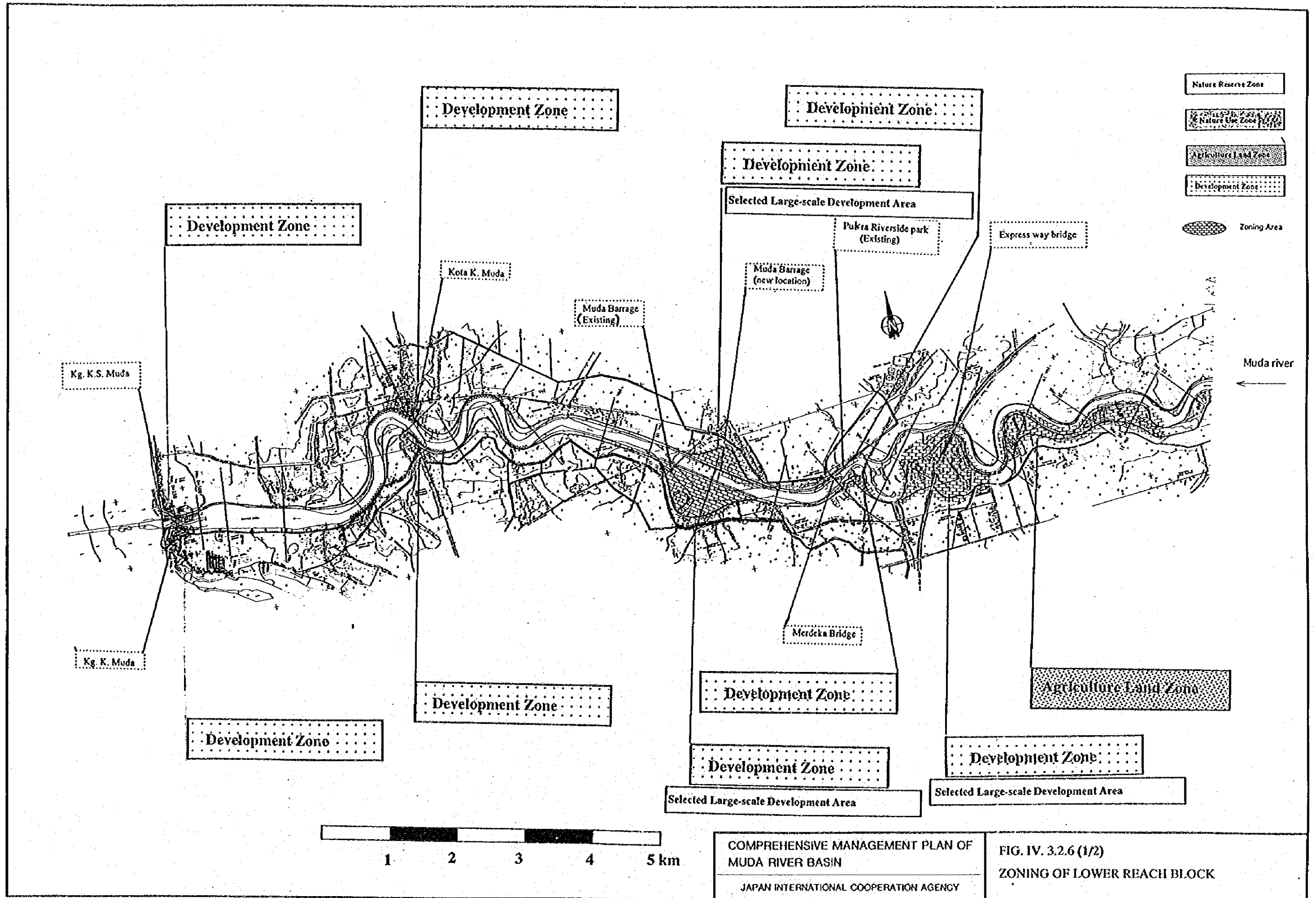
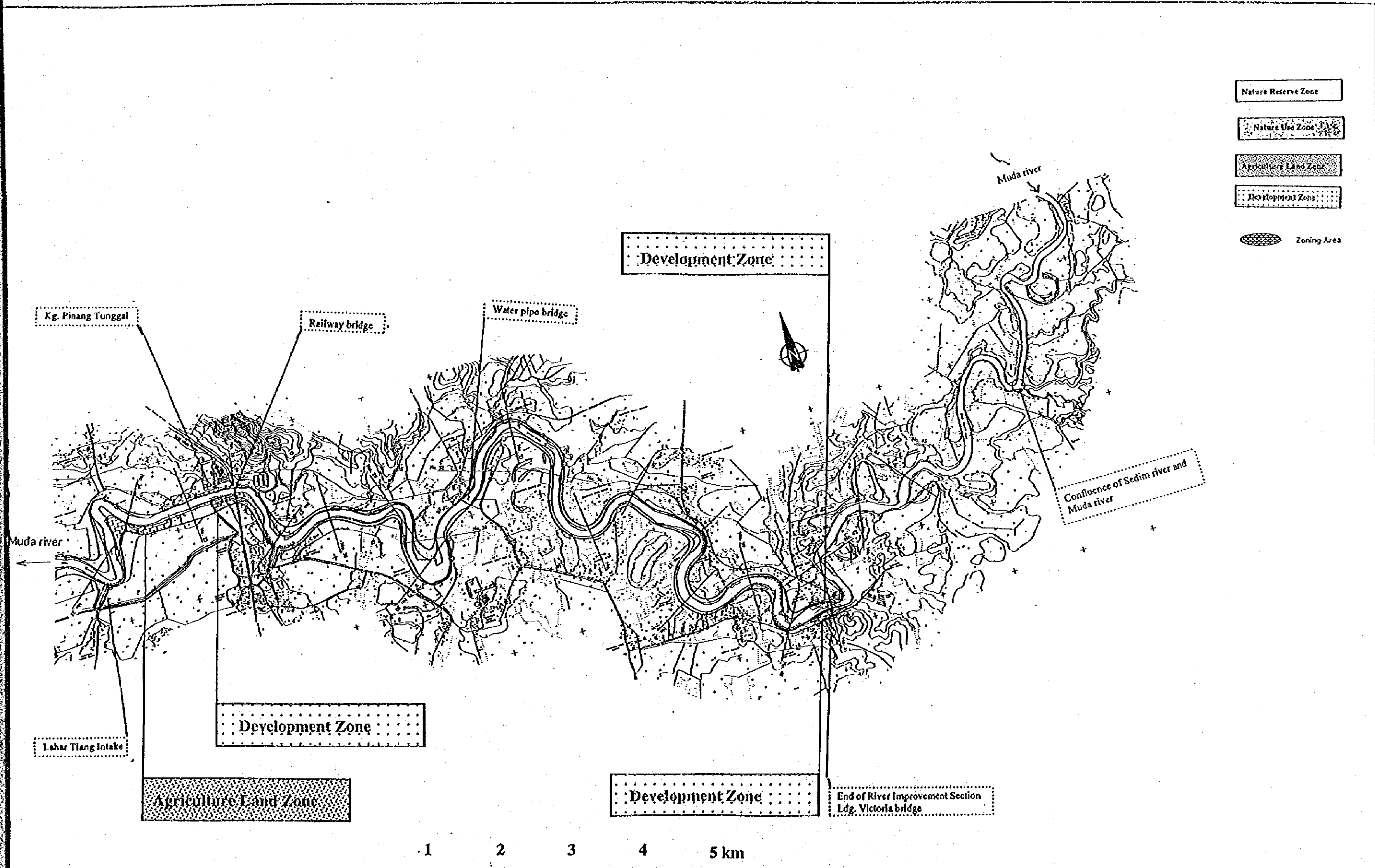
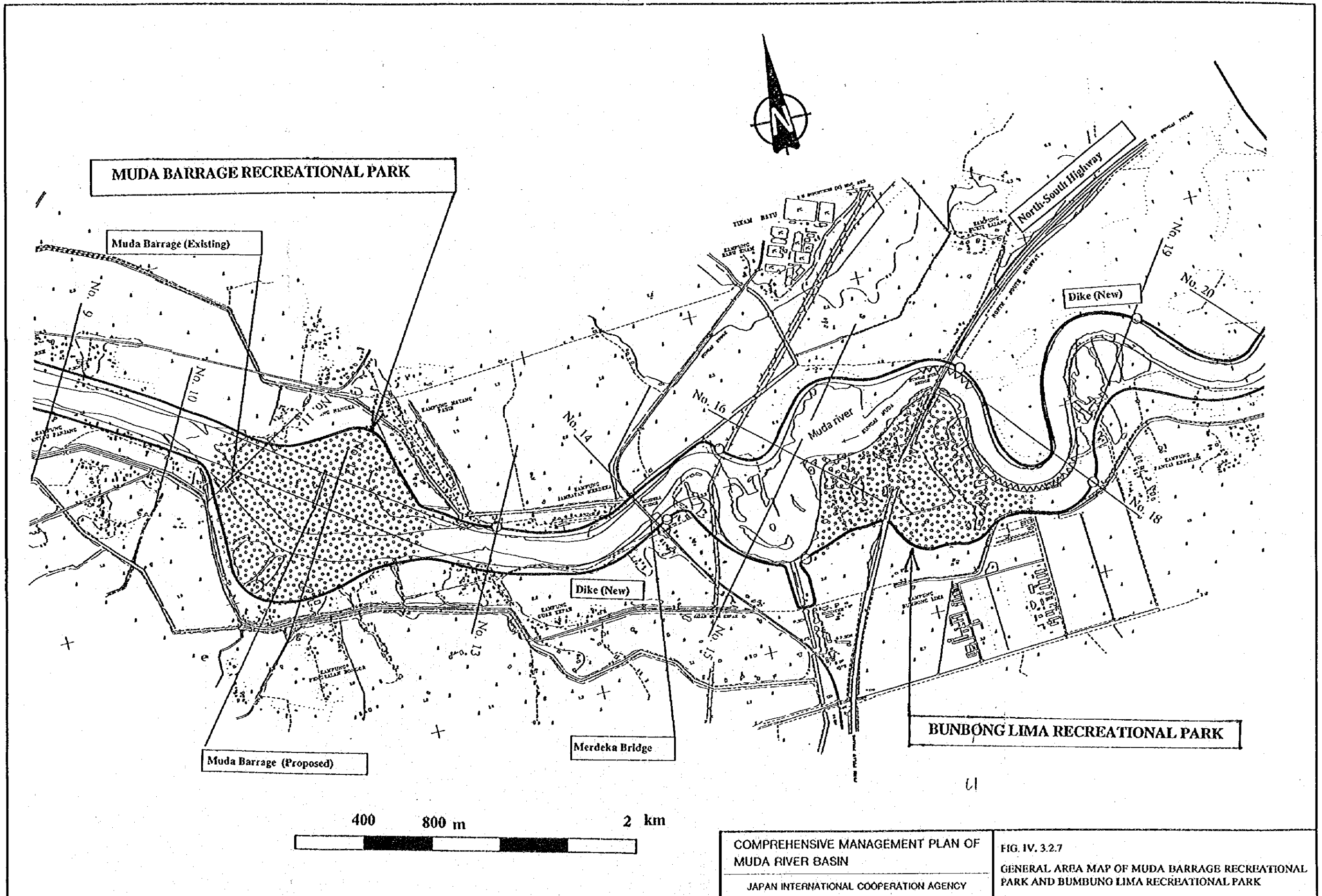


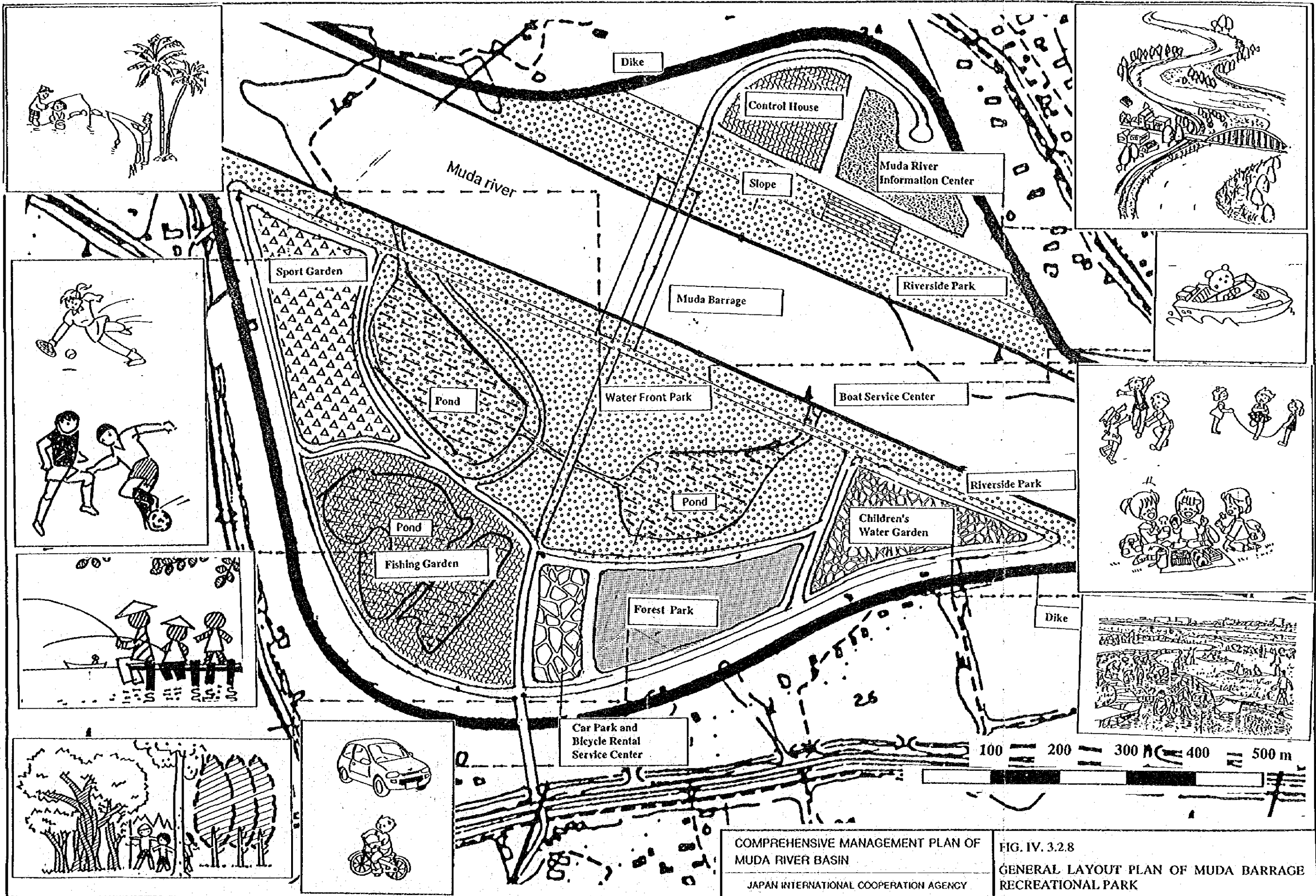
FIG. IV. 3.2.6 (1/2)
ZONING OF LOWER REACH BLOCK



COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN
 JAPAN INTERNATIONAL COOPERATION AGENCY

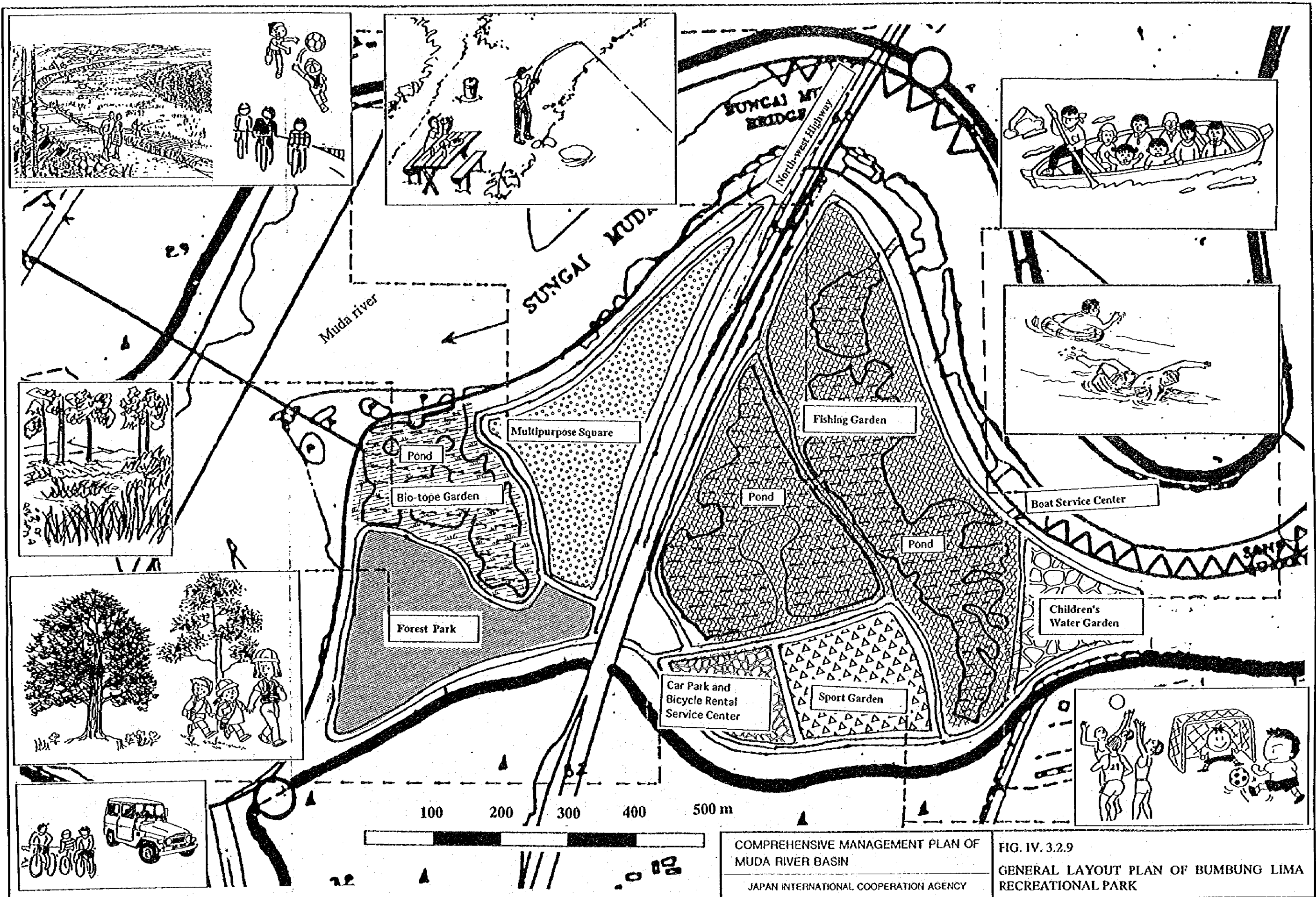
FIG. IV. 3.2.6 (2/2)
 ZONING OF LOWER REACH BLOCK





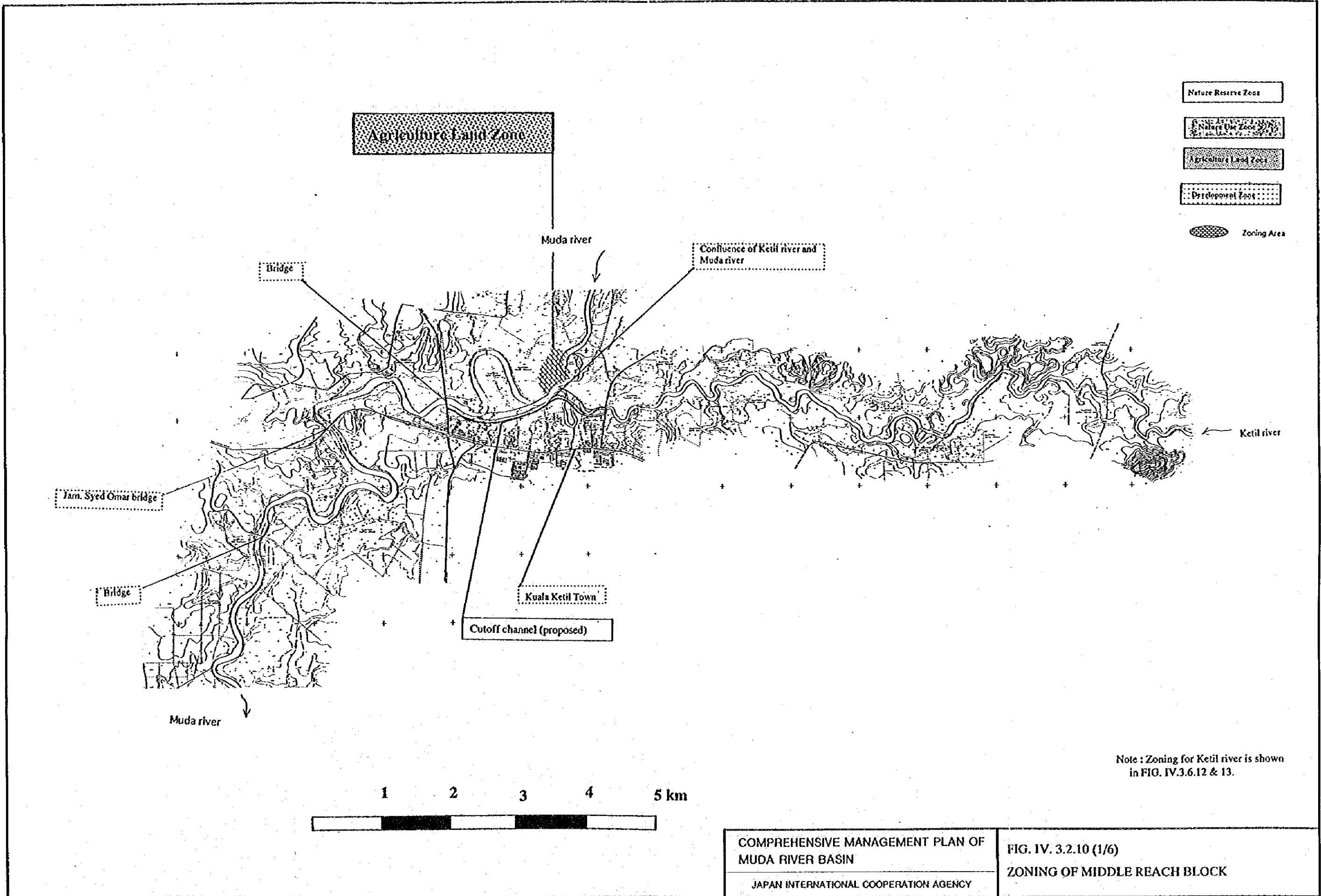
COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.8
GENERAL LAYOUT PLAN OF MUDA BARRAGE
RECREATIONAL PARK



COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

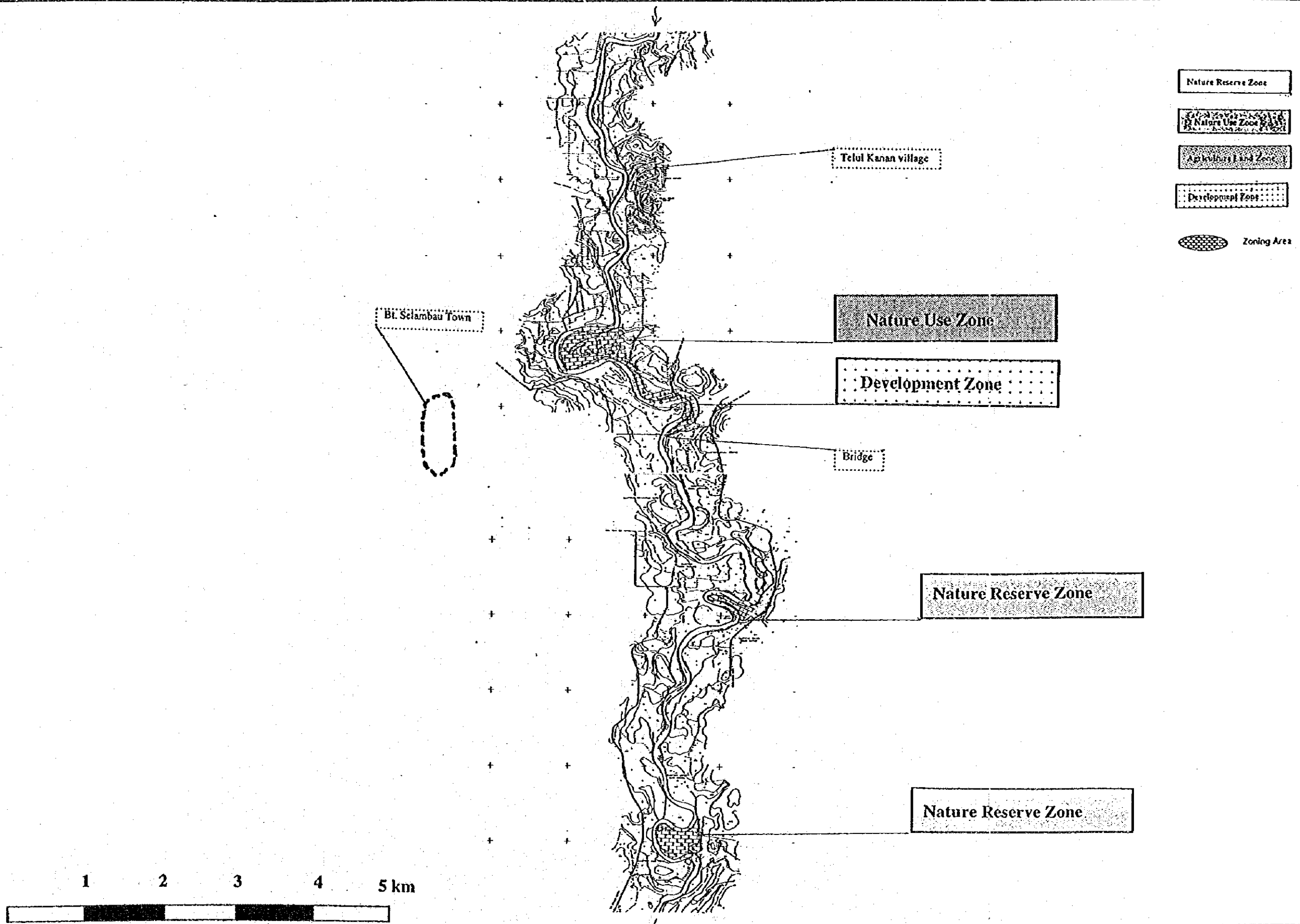
FIG. IV. 3.2.9
GENERAL LAYOUT PLAN OF BUMBUNG LIMA
RECREATIONAL PARK



Note : Zoning for Ketil river is shown in FIG. IV.3.6.12 & 13.

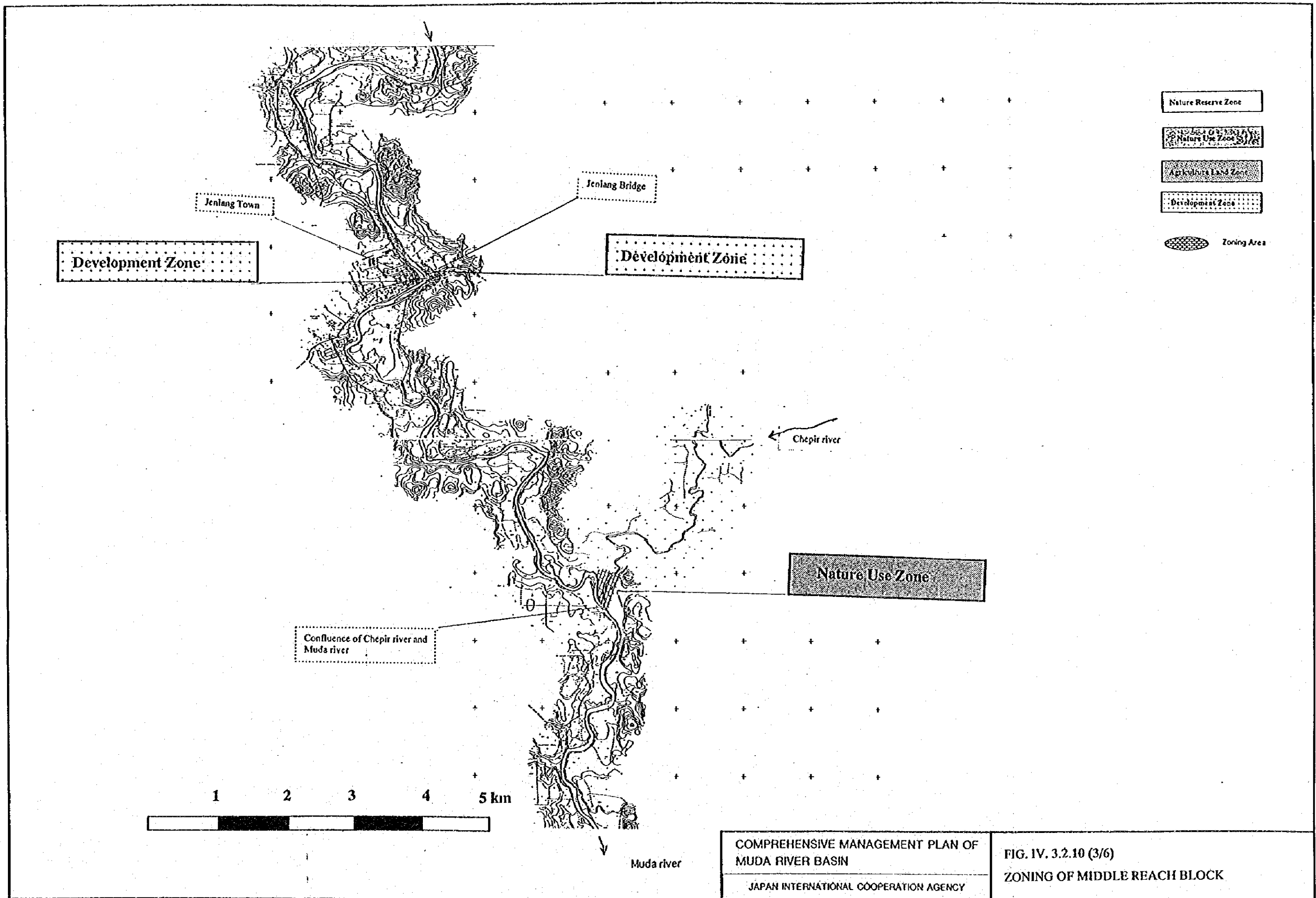
COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

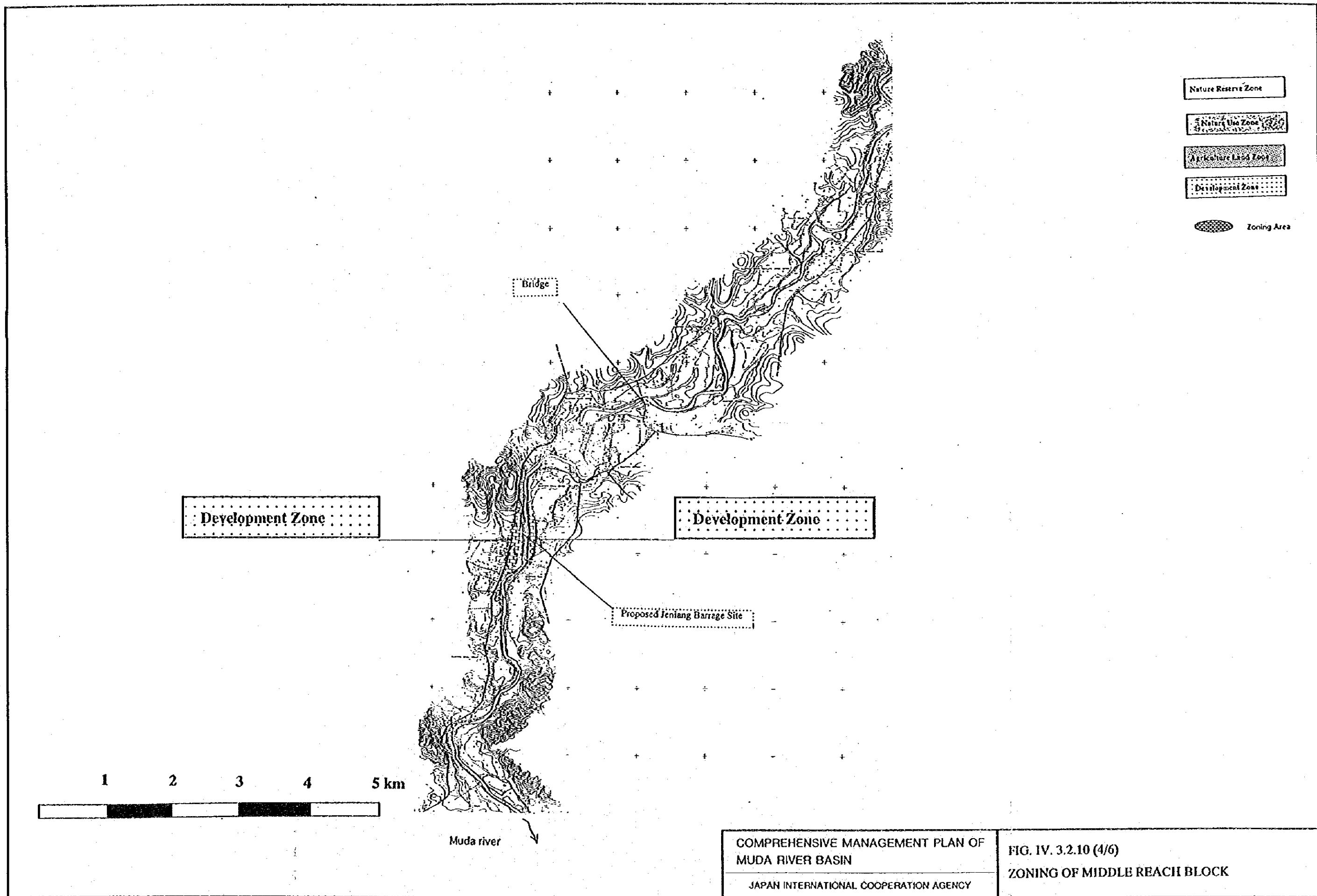
FIG. IV. 3.2.10 (1/6)
ZONING OF MIDDLE REACH BLOCK



COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN
 JAPAN INTERNATIONAL COOPERATION AGENCY

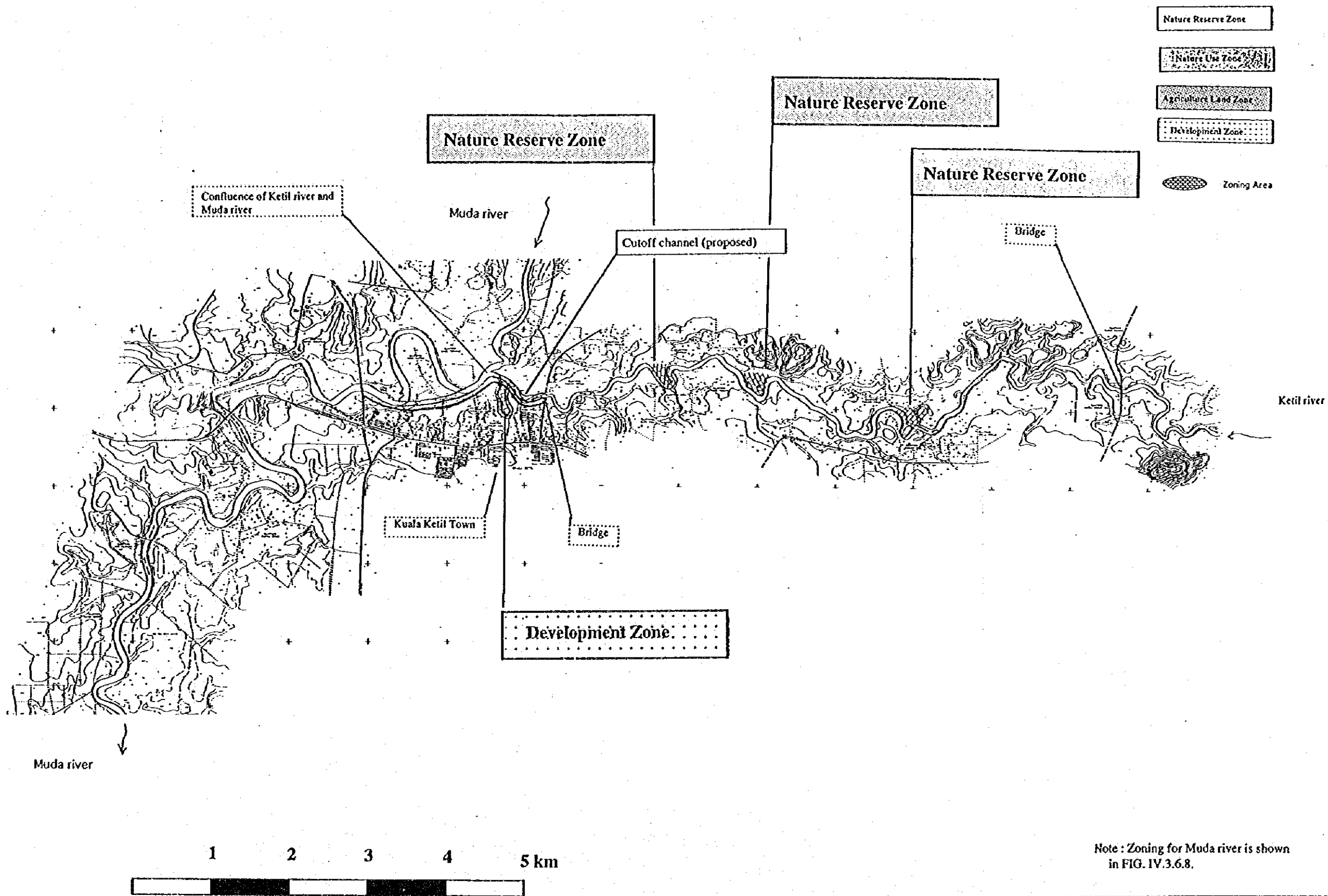
FIG. IV. 3.2.10 (2/6)
 ZONING OF MIDDLE REACH BLOCK





COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN
 JAPAN INTERNATIONAL COOPERATION AGENCY

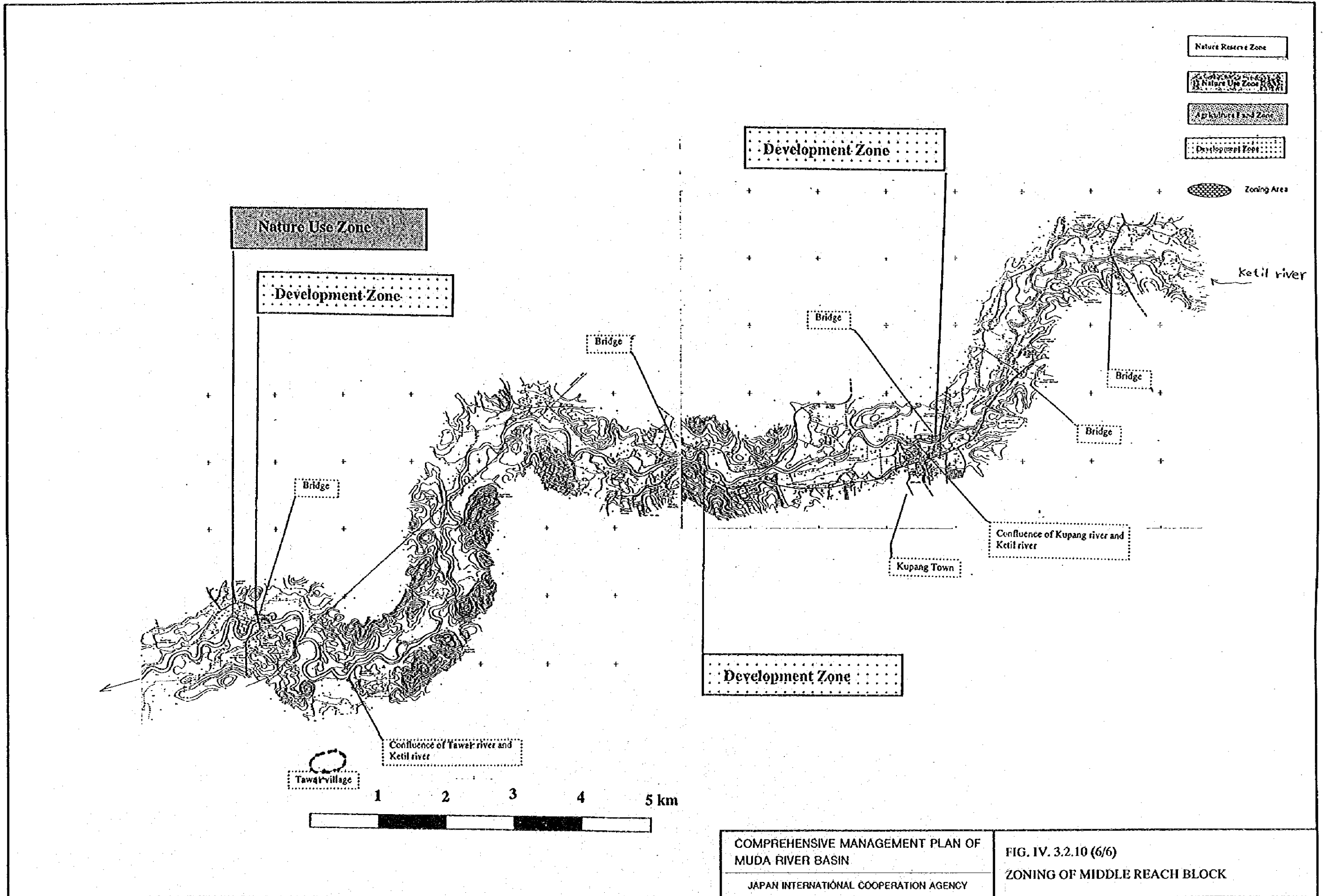
FIG. IV. 3.2.10 (4/6)
 ZONING OF MIDDLE REACH BLOCK

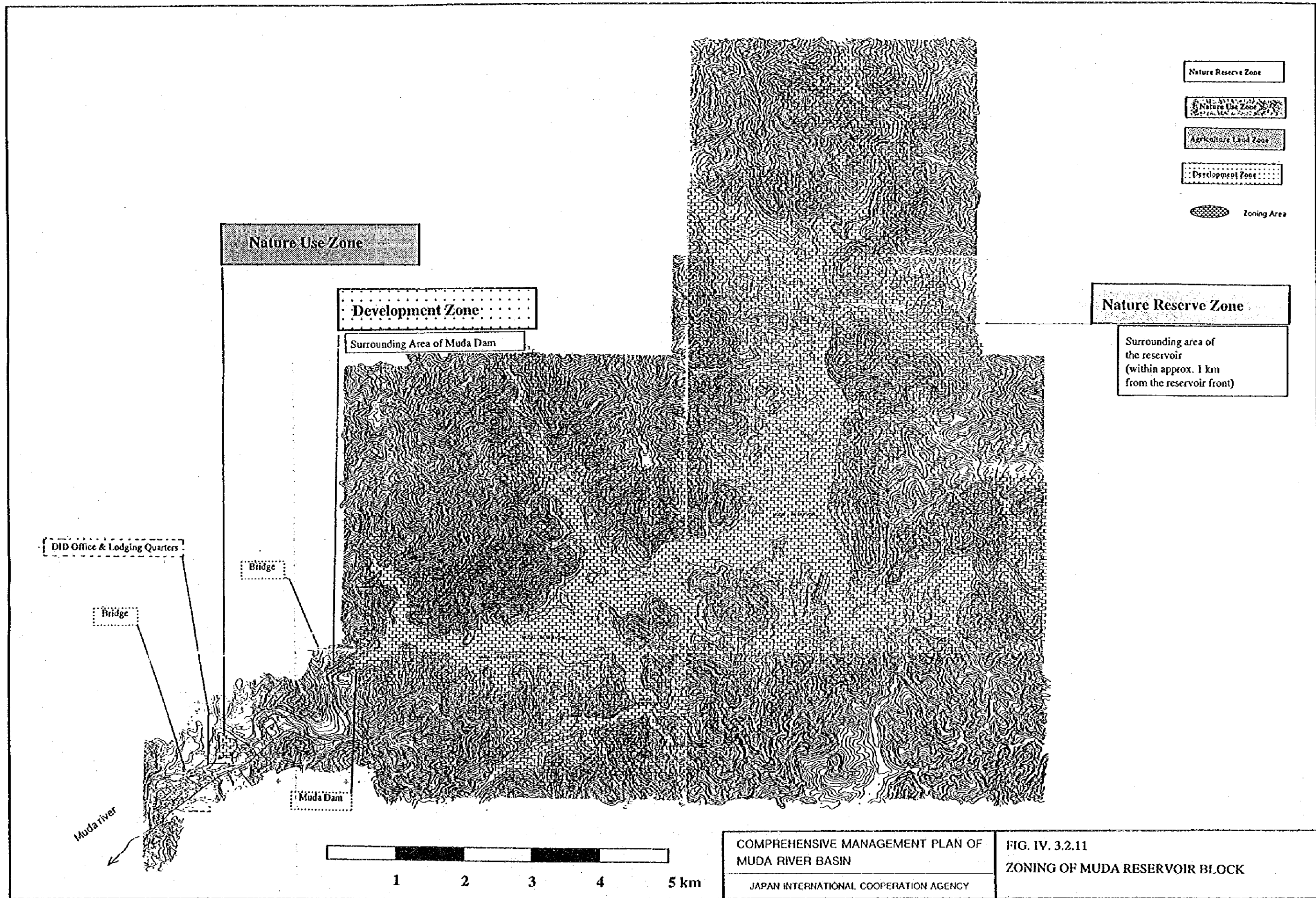


Note: Zoning for Muda river is shown in FIG. IV.3.6.8.

COMPREHENSIVE MANAGEMENT PLAN OF
MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

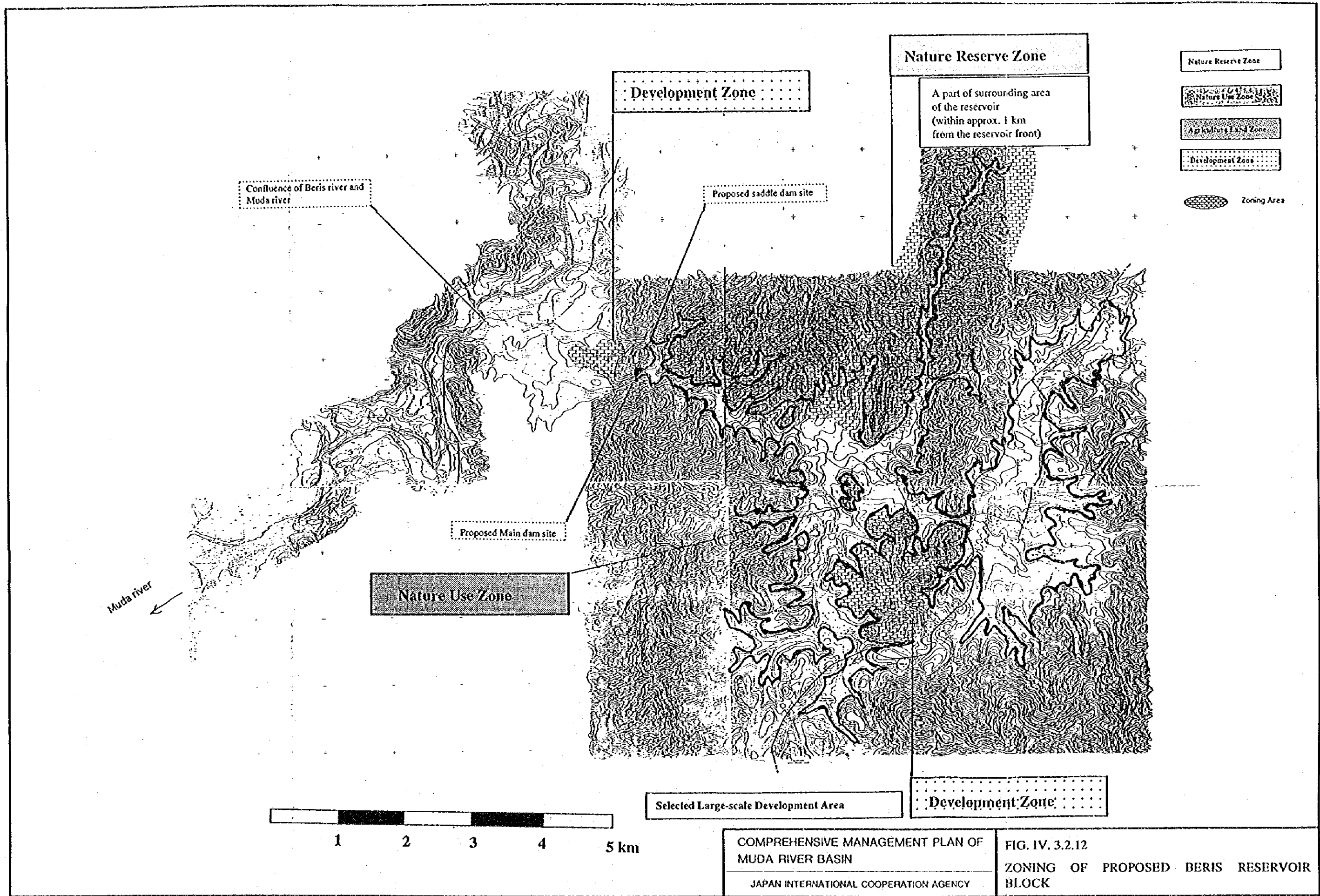
FIG. IV. 3.2.10 (5/6)
ZONING OF MIDDLE REACH BLOCK





COMPREHENSIVE MANAGEMENT PLAN OF
 MUDA RIVER BASIN
 JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.11
 ZONING OF MUDA RESERVOIR BLOCK



Confluence of Beris river and Muda river

Development Zone

Nature Reserve Zone

A part of surrounding area of the reservoir (within approx. 1 km from the reservoir front)

Proposed saddle dam site

Proposed Main dam site

Nature Use Zone

Nature Reserve Zone

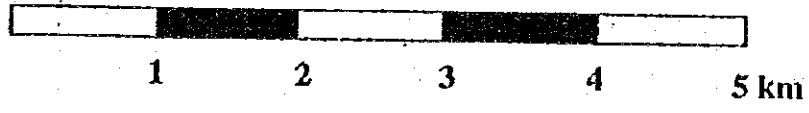
Nature Use Zone

Agriculture Land Zone

Development Zone

Zoning Area

Muda river

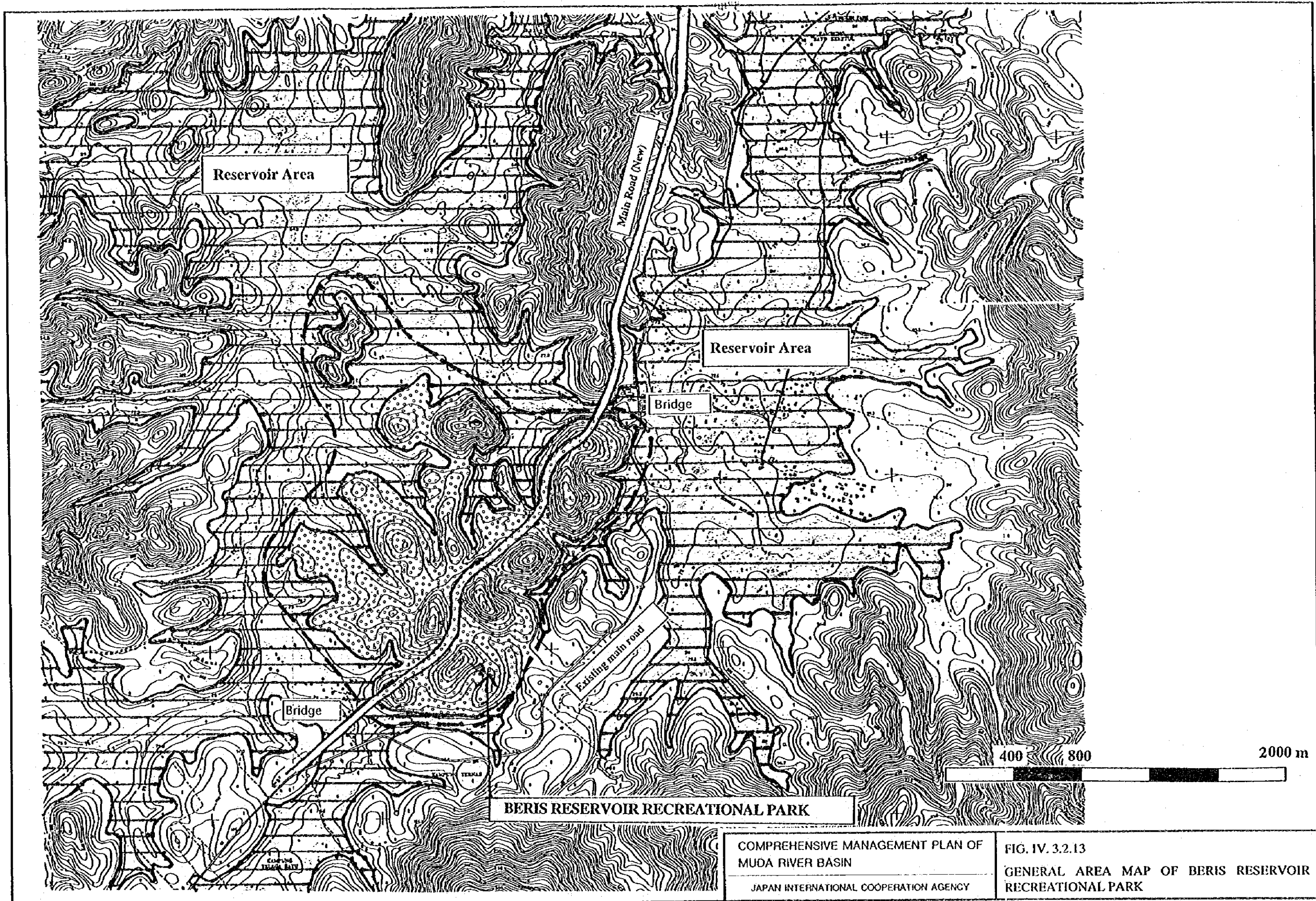


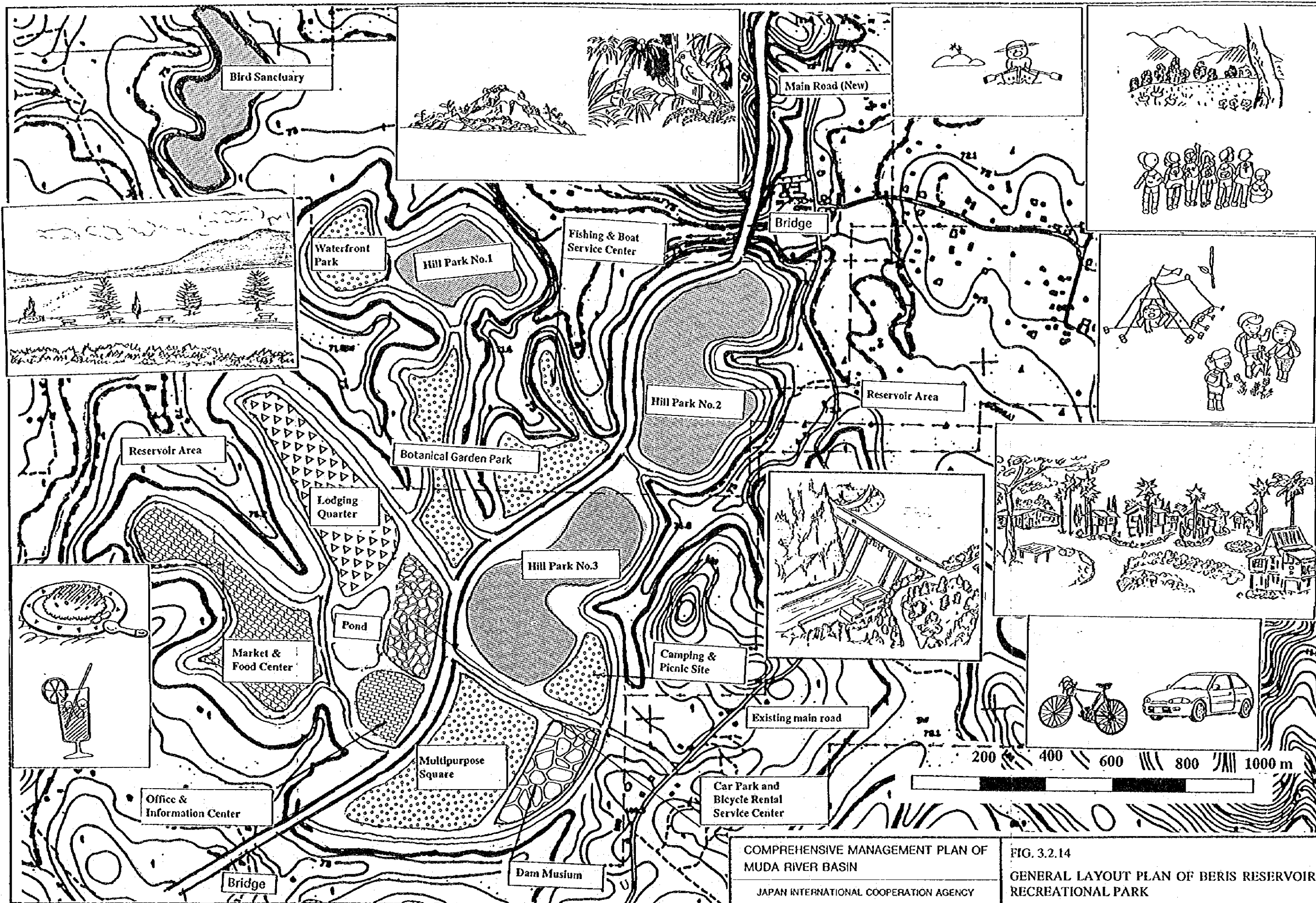
Selected Large-scale Development Area

Development Zone

COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. IV. 3.2.12
ZONING OF PROPOSED BERIS RESERVOIR BLOCK





SECTOR V

***WATERSHED MANAGEMENT
AND MONITORING PLAN***

**SECTOR V
WATERSHED MANAGEMENT AND MONITORING PLAN**

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1. GENERAL

Government agencies and/or private firms are taking various basin development activities such as urban, agricultural and industrial development in the Muda river basin. These basin developments are closely related to the river management works, and possibly cause adverse effects on the river functions as enumerated below, unless appropriate coordination is made between the basin development and the river management works.

- (a) Increment of basin flood runoff discharge and increment of properties in probable flood inundation areas that could increase flood damage potential;
- (b) Aggravation of low flow regime and excessive growth of water demand inducing unstable water supply from the river;
- (c) River water pollution caused by increment of pollutant sources in the basin affecting fauna and flora and other river environments;

To minimize the above adverse effects, monitoring and management works are required for both the river and the basin with the following objectives:

- (a) For River: Hydrology (river water level and discharge), morphology (river channel meandering, erosion and sedimentation), biology (fauna and flora), water quality, and scenery.
- (b) For Basin: Structural development (urban and industrial development), agricultural activities, mining activities in and around the river channel, and logging activities

Reviewed in this Sectoral Report are the ongoing basin development plans by the year 2010. The review clarifies major issues on river management works, and the zoning plan for the monitoring and management is proposed to ensure a well-balanced basin development and river management conditions. River basin monitoring and management objectives are further prepared for each of the proposed zones. In addition, a hydrological and water quality monitoring network is proposed to facilitate river basin monitoring works.

2. PHYSICAL FEATURES OF MUDA RIVER BASIN

2.1 Catchment Area and River System

Muda River with a catchment area of 4,150 km² is located in the northwestern part of Peninsular Malaysia. The main stream originates in the north mountainous area in Kedah State and flows down toward the south. It changes its course towards the west coast after passing the confluence of the main stream and its tributary, Ketil River. The total length of the main stream is about 180 km. In terms of administrative

boundary, the upper and middle reaches belong to the State of Kedah, while the river downstream with a length of about 30 km forms the boundary between the states of Kedah and Pulau Pinang.

Muda Dam exists on the main stream about 130 km upstream from the river mouth. The dam catchment area and active storage capacity is 984 km² and 160 million m³, respectively. The dam stores almost all of the basin runoff discharge conveying it into the adjacent Pedu Dam that has an active storage capacity of 1,049 million m³ in the upper reaches of the Kedah River. Thus, the catchment area of Muda Dam is a part of the Muda river basin in terms of topography but it belongs to the Kedah river basin in terms of hydrology.

There are three (3) major tributaries in the Muda river system; namely, Ketil River with a catchment area of 868 km², Sedim River with 626 km², and Chepir River with 335 km². Among them, Ketil River is the largest tributary including its secondary tributary of Kupan River that has a catchment area of 147 km².

2.2 Topography, Geography and Soils

Almost all of the northeastern half of the Muda river basin is mountainous fringed with hilly land at altitudes of more than EL 76 m (250 feet), as shown in Fig. V.2.1.1. The mountainous area is composed of two mountain ranges. One mountain range stretches along the northern half centerline of the basin starting from Mt. Tek Bidan (842 m) in the middle reaches until Mt. Bt. Pakir Terbang (EL 574 m) at the northern end of the basin. This range includes the mountains with altitudes of EL 500 to EL 900 m. The other is called "Bintang Range" stretching from the highest Mt. G. Bintang (EL 1,862 m) in the southeastern end until the northeastern end of the basin. This range includes many high mountains of more than EL 1,000 m in altitude forming the national boundary between Malaysia and Thailand.

The geographic features of the above mountainous area are represented by the granites developed in the period of orogenesis after late Carboniferous. The plain area in the middle reaches is mainly composed of complex argillaceous rocks, cherts and interbeds of sandstone. As for the middle reaches of Ketil River around Baling, however, the geographic features show a complex of shales/slates, quartzites/hornfels and limestone that are often crystallized.

The soils of the basin are composed of the alluvial soil, the sedentary soil and the lithosols. The alluvial soil spreads out in the lower reaches from the confluence of the main stream and Ketil River, where the land is fertile and used as paddy production area. The plain area in the middle and upper reaches is covered with sedentary soils where rubber plantation is extensively developed. In the upper mountainous area, the dominant soil is lithosols which is little fertile and not suitable for agricultural production.

3. BASIN DEVELOPMENT CONDITION AND SOCIOECONOMIC TARGETS IN 2010

3.1 Agricultural Development

About 1,780 km² or 42% of Muda river basin has been developed as agricultural land and the remaining area of about 2,400 km² is mostly kept as forest/shrub area. Settlement area covers only 0.05% of the entire basin (refer to Table V.3.1.1 and Fig. V.3.1.1).

Agricultural lands extend particularly in the lower and middle reaches along Muda River and its tributaries. A greater part of the agricultural land is used as rubber plantation area occupying about 33% of the basin. The remaining area consists of mixed horticulture area (4%), paddy area (3%), and oil palm area (2%). The mixed horticulture areas are usually located near settlement areas and tend to be unevenly distributed on the riverside areas.

The dominant water use of Muda River is irrigation for paddy areas of 6,584 ha which are under the management of DID and divided into 27 irrigation schemes in the basin. The water of Muda River is also used for external irrigation schemes outside the basin which are managed by MADA and DID covering about 104,000 ha in total. Thus, as far as the irrigation areas relying on Muda river are concerned, the irrigation area located outside the basin is far wider than the area within the basin.

The share of the agricultural sector in the Kedah State Economy has been gradually declining; i.e., from 54.2% share in 1980 and 37.5% in 1990. This declining tendency is attributed to the transfer of labor to non-agricultural activities. It is, however noted that a specific national policy emphasizes a target to secure a minimum self-sufficiency level of 65% for rice production by the year 2010. Due to this national policy, the future rice production will not be drastically reduced as compared with the present rice production.

In parallel with the declining of agricultural GDP, the expansion of agricultural land has been minimal. In fact, the year 1982-1990 recorded the overall development area of only about 2.5% over eight years or 0.3% annual growth. In view of this tendency, Kedah State EPU projected the minimal annual growth of the entire state agricultural land by the year 2000 as below.

Future Agricultural Land in Muda River Basin

Item	Year 1990	Year 2000	Growth Rate
Paddy	135 ha	131 ha	0.3%/year
Rubber	1,274 ha	1,393 ha	-0.9%/year
Oil Palm	104 ha	76 ha	3.2%/year

Source: Kedah Development Action Plan, 1990-2000

In this Study, the above projected annual growth rate is justified, and farther expansion of the agricultural area is assumed to be nil in the Muda river basin by the year of 2010.

3.2 Forest Reserve

The present forest area spreads out in the upper reaches of Muda River, and this area is delineated as forest reserve under the control of the Forest Department (refer to Fig. V.3.2.1). The total area of the forest reserve area is 2,361 km² or 56% of the Muda river basin (refer to Table V.3.1.1). The delineated forest reservation is herein classified into the following three (3) categories:

- (a) Non-logging area of 25 km² which is composed of the virgin forest area, the research area for forest development, and the recreation area;
- (b) Protective area for Muda dam reservoir of 155 km² which is delineated as "catchment area" where logging work is conditionally allowed as long as logging will not affect the water quality and quantity for the reservoir; and
- (c) Logging area of 2,181 km² which is subject to the acquisition of logging license issued by the Forest Department.

A majority of the delineated forest reserve area is employed as either protected area (item b) or logging area (item c); therefore, logging could be made in most parts of the present forest area. This situation may be attributed to the fact that logging is the second biggest source of revenue for the State of Kedah.

The logging schedule/volume could not be clarified due to insufficiency of basic information. However, it was confirmed through the latest aerial photographs as well as the field reconnaissance that the catchment area of the proposed Reman dam site has been entirely cleared, and used as rubber plantation, which will possibly aggravate the quality of water in the reservoir. Furthermore, due to lack of coordination, there is no assurance that the existing Muda dam reservoir will be well protected by the delineated forest reserve.

3.3 Population Density and Urban Development

3.3.1 Population Density

The population in Muda river basin is herein clarified according to the population projection for each *Mukim* in the State of Kedah as studied in Sector VII, Socio-Economy. Muda river basin covers 28 mukims in the State of Kedah, occupying about 44% of the State of Kedah. The population in the State of Kedah is, however, unevenly distributed to the low-lying coastal area, and Muda river basin which is mostly located in the inland area is less populated; the total population of the basin is less than 30% of the state total (refer to Table V.3.1.1).

The average population density of Muda river basin is estimated at about 86 persons/km² in 1991 and 146 persons/km² in 2010 which are less than the average of the entire Kedah State (138 persons/km² in 1991 and 215 persons/km² in 2010). There is, however, a large spatial variation of the basin population density, which is roughly divided into the following three groups (refer to Table V.3.3.2 and Fig. V.3.3.1):

(1) High Population Density in Lower Reaches of Muda River

The population density is about 443 persons/km² in 1991 (3 times the state average) increasing to 1,020 persons/km² in 2010 (5 times the state average). Such high population density is due to the fact that the lower reaches is adjacent to the major urban area of Sungai Petani in the State of Kedah and Butterworth in the State of Pulau Pinang.

(2) Middle Population Density in Lower Reaches of Ketil

The population density is about 132 persons/km² in 1991 and 165 persons/km² in 2010 which are almost equivalent to the average total. The lower reaches of Ketil River is rather populated particularly in and around the existing major settlement areas of Kuala Ketil, Kupang and Baling.

(3) Low Population Density in Middle/Upper Reaches of Muda River

The population density is about 11 person/km² in 1991 and 21 person/km² in 2010 which are around 10% of the state average. Such extremely low population density is attributed to hilly topography and poor soil associated with insufficient infrastructures such as irrigation facilities, water supply system and road transportation network. Most of the basin belong to this area of low population density; therefore, the basin average population density falls below the state average.

3.3.2 Urban Development

There are eight (8) major urban areas with a population of more than 10,000 in the State of Kedah. The total population of these urban areas is about 425,000, corresponding to 33% of the state total. All of these urban areas are, however, located in the low-lying coastal area and out of the Muda river basin.

To redress the partial concentration of population in the coastal area, the Kedah Regional Development Authority (KEDA) has proposed to develop 30 urban centers in the inland area by the year 2000. Among these 30 urban centers, six centers are located in the Muda river basin, and KEDA projected the following population for the six centers in 2000 assuming the annual population growth of 3.5% (refer to Fig. V.3.3.2):

Projected Population in Six Urban Centers in Muda River Basin

Name of Town	Population in 1991	Population in 2000
(1) Baling	6,500	9,200
(2) Kuala Ketil	4,800	6,800
(3) Kupang	3,000	4,200
(4) Bukit Selambau	2,900	4,100
(5) Jeniang	2,500	3,500
(6) Sik	2,200	3,100
Total	21,900	30,900

In parallel with the population growth of the above urban centers the future population of the entire Muda river basin is estimated to increase from about 358,000 to about 449,000 in 2000 and 607,000 in 2010 (refer to Table V.3.3.2). The corresponding annual average population growth of the basin is 2.60% from 1991 to 2000 and 3.06% from 2000 to 2010.

3.4 Industrial Development

3.4.1 Present Industrial Area

As shown in Table V.3.4.1, an industrial area of about 1,800 ha has been developed, and out of the developed area, about 1,500 ha is now in operation in the states of Kedah and Pulau Pinang. Thus, the occupancy rate of the industrial development area (i.e., the ratio of industrial area in operation to the industrial development area) is estimated at about 80%.

The present industrial area in the State of Kedah has been developed either by the Kedah State Economic Corporation (KSDC) or the Kedah Regional Development Authority (KEDA). The area developed by KSDC is mostly for large and medium scale industries being biased in the coastal area and taking an overwhelming share of about 97% of the state total. On the other hand, the area by KEDA is for small and medium scale industries mainly developed in the inland area.

There are three industrial areas located in Muda river basin; namely, Baling, Sik, and Jeniang, all of which were developed by KEDA. However, these industrial areas in the basin cover only 14.52 ha in total, which corresponds to 2.2% of the state total.

The industrial areas in the State of Pulau Pinang are mainly developed by Pinang Development Corporation (PDC). Such industrial areas concentrate in and around Butterworth in Seberang Perai and Bayang Lepas in Pinang Island due to convenient use of the international seaports and airports. About 70% of water demand in these industrial areas are supplied from Muda River.

3.4.2 Increment of Future Industrial Area

The accumulated industrial development area is projected by the state government to be about 2,832 ha in the State of Kedah and about 2,869 ha in the State of Pulau Pinang by the year 2000 (refer to Table V.3.4.2). However, these industrial development areas will not be fully operated as mentioned in Subsection 3.4.1 that the present actual industrial area in operation is about 80% of the developed area. From this viewpoint, an attempt was made to estimate the future industrial area in operation assuming that the present industrial area in operation will increase according to average annual growth of GDP in the industrial sector.

The state governments of Kedah and Pulau Pinang had projected the average annual growth rates of GDP in the industrial sector by the year of 2000. In this Study, the average annual growth rate of GDP in the industrial sector for 2000-2010 is further estimated from the actual and projected values from 1980 to 2000, as below.

Average Annual Growth Rate of GDP in Industrial Sector
(Unit: %/year)

State	1980-1990 (Actual)	1990-2000 (Projected)	2000-2010 (Estimated by this Study)
Kedah	12.3	12.3	11.0
P. Pinang	6.3	8.0	10.0

Note: The growth rate for 2000-2010 in the State of Kedah is assumed to slightly decrease compared with the growth rates for 1980-1990 and 1990-2000 because of the limited labor force to be engaged in the industrial sector.

The future industrial area is assumed to increase according to the above average annual growth, and herein estimated as below:

Future Industrial Area in Operation
(Unit: ha)

State	Year 1993	Year 2000	Year 2010
Kedah	663	1,465	4,158
P. Pinang	881	1,535	3,980
Total	1,544	3,000	8,138

As estimated above, the industrial area in operation will be 3,000 ha by the year 2000, which corresponds to 53% of the accumulated industrial development area (i.e., 5,700 ha). Furthermore, the industrial area in operation will increase to 8,139 ha in the year 2010, which will be about 1.4 times the accumulated industrial development area in the year 2000.

3.4.3 Distribution of Future Industrial Area in Operation

It is assumed that the above state total of future industrial areas in operation both for the years 2000 and 2010 will be distributed in proportion to the projected land development size by the year 2000. Thus, the distribution of the future industry areas in operation is estimated as below.

Distribution of Future Industrial Area
(Unit: ha)

State	Area	Industrial Area				
		Developed		In Operation		
		1993	2000	1993	2000	2010
Kedah	(1) In Muda River Basin	62	1,006	47	534	1,517
	(2) Out of Muda Basin					
	- North Kedah	96	689	73	453	1,285
	- South and Central Kedah	652	1,137	543	478	1,357
	Sub-Total	809	2,832	663	1,465	4,159
P. Pinang	(1) Perai North and Central	757	2,020	651	986	2,558
	(2) Perai South	0	587	0	286	743
	(3) Penang Island	230	262	230	262	680
	Sub-Total	987	2,869	881	1,535	3,980
Grand Total		1,796	5,701	1,544	3,000	8,139

There are 39 industrial development areas projected in the year 2000. Out of these industrial areas, 6 areas are located in Muda river basin; namely, Kuala Ketil, Baling, Sik, Jeniang, Tikam Batu and Bukit Selambau. All of these sites are to develop as a part of the aforesaid urban centers except Tikam Batu. Particularly, Kuala Ketil (Location No. 10 in Fig. V.3.4.1) will have a noteworthy growth due to easy access to the present intensive industrial areas in and around Sungai Petani, Kulim and Butterworth. There is no industrial area in Kuala Ketil but in the year 2000, about 740 ha will be developed as industrial area along Ketil River (refer to Table V.3.4.2 and Fig. V.3.4.2). In this connection, appropriate monitoring and coordination of the industrial development will be required to avoid the adverse effects on the river environment.

3.5 Major Issues on Ongoing Basin Development

By reviewing the aforesaid ongoing basin development, the following items are given as the major issues to harmonize the basin development activities with the appropriate river management works.

3.5.1 Major Issues on Agricultural Development

The largest water user of Muda River as water source is the agricultural land in and around the Muda river basin, and chronic water deficit occurs even in the present agricultural water demand as described in SECTOR III, Water Resources Management Plan. However, the future spatial expansion of the agricultural development is predicted to be nil; therefore, the minimal increment of future water demand is estimated. Moreover, proposed to be constructed by the year 2010 are water resources development facilities such as Beris Dam, Reman Dam, Naok Dam and Jeniang Diversion so as to increase the water supply capacity. The proposed water resources development facilities will guarantee the full water supply level for the projected water demand in the design drought level of 10-year return period, provided that the following issues on the river basin monitoring and management are satisfied:

- (a) To establish the integrated river monitoring system that could collect the information on the river flow regime and the water intake volume for Muda River; and
- (b) To establish the institutional setup to facilitate river monitoring works and water allocation as proposed in SECTOR III.

In addition to the above issues related to water supply, particular attention is given to the water quality possibly aggravated by agricultural activities in the catchment of the proposed Beris and Remand dams. The whole catchment area of Remand Dam and about 30% of the catchment area of Beris Dam have been developed as agricultural land. Unless appropriate monitoring and management works are given to the agricultural activities, the water quality as well as the morphology of the dam reservoirs could be seriously affected by the agricultural activities.

3.5.2 Major Issues on Forest Reserve

The present delineated forest reserve area of 2,361 km² or 56% of the Muda river basin is regarded as a principal part of water resource area of the basin dominating the basin runoff and sediment yield conditions. However, all information on logging activities and/or land development in the forest reserve area are handled as confidential matter and none of them are reflected in the river management works.

In this connection, it is indispensable to establish an appropriate monitoring network to relate the logging activities and/or land development with the river management works, particularly, in the aspect of control of basin runoff discharge and sediment yield.

3.5.3 Major Issues on Urban and Industrial Development

All proposed urban centers as well as the industrial development area are to be placed adjacent to the river channel, so that aggravation of river functions may locally occur, particularly, in the aspect of river water quality and/or flood damage potential in and around the development area.

Among the development areas, the industrial area of about 740 ha in Kuala Ketil will be placed along the left bank of Muda river main stream between the confluence of Ketil River and Sedim River, and the probable flood inundation area of 100-year return period overlaps with a part of the proposed industrial area, as shown in Fig. V.3.4.2. Thus, the proposed industrial area in Kuala Ketil contains a high flood damage risk, and certain coordination will be required between the industrial development and the river management for flood mitigation. The river water quality also will be possibly aggravated by wastewater from the developed industrial areas unless appropriate treatment is provided.

4. PRESENT RIVER BASIN MANAGEMENT AND MONITORING SYSTEM

4.1 Overall System

The present monitoring system for Muda River cover three (3) territories which are independently managed by the State of Kedah, the State of Pulau Pinang and MADA (refer to Table V.4.1.1 and Fig. V.4.1.1). Monitoring by the State of Kedah and the State of Pulau Pinang is respectively made within the limits of each state boundary. The catchment area of Muda Dam is, however, not included in the monitoring coverage of the State of Kedah although the area is located in the state. Instead, the catchment is under the monitoring of MADA for the sake of irrigation supply from Muda Dam to the Muda irrigation area. The details of the existing monitoring system in the State of Kedah, the State of Pulau Pinang and MADA are described in the following sections.

4.2 The System Controlled by the State of Kedah

The major monitoring items are water level and rainfall for flood forecasting and warning. There are ten (10) water level monitoring stations, out of which three (3) stations are for common use of rainfall monitoring. All monitored data are transmitted on real time base through VSB system to the State DID Office which is located at Alor Setar. It is, however, scheduled that the data transmission system from six (6) monitoring points is improved to a telemetering system in 1994.

River channel erosion and/or sedimentation are also monitored by DID through periodical on-site inspection. Furthermore, the water quality of Muda River is monitored by DOE at 17 sampling points. In addition to the DOE's sampling point, PWD also monitors the water quality at its 17 intake points and sends the results of monitoring to DOE.

Low flow water level is monitored by DID at its 28 irrigation intake points and also by DOE at its 17 intake points for domestic and industrial water. The monitored data are, however, sent to their head offices on non-real time base. Furthermore, the schedule of water intake is independently made in accordance with the low flow data monitored at each intake point. Thus, nobody knows the integrated water intake volume from the entire river stretch, and the monitored data are not substantially reflected to the comprehensive control of low flow regime as well as water allocation for each intake point of Muda River.

4.3 The System Controlled by MADA

The monitoring system under MADA was developed to rationalize water allocation for the Muda irrigation area using local rainfall and the runoff discharge from the catchment area of Muda Dam as the water source. There are 70 rainfall monitoring stations consisting of 39 manual gauging stations and 31 telemetry gauging stations. Among the telemetry gauging stations, 26 stations are commonly used by water level gauging stations at key locations along Kedah River and at the inlet point of the conveyance tunnel from Muda Dam to Pedu Dam. Water quality is also monitored at the reservoir of Pedu and Muda dams. All monitored data could be transmitted to the head office of MADA located in the suburbs of Alor Setar on real time base. Thus, monitoring on the catchment area of Muda Dam is independently made by MADA, and rather isolated from monitoring on the lower reaches of the dam.

4.4 The System Controlled by the State of Pulau Pinang

There are two (2) water level gauging stations along the downstream of Muda River. These gauging stations are used, in principle, for flood forecasting and warning, as well as monitoring of low water level of the downstream stretch of Muda River within the State of Pulau Pinang. The water level monitored by the State of Kedah at two stations (Jeniang and Jam Shed Omar) are also transmitted to the State of Pulau Pinang for the sake of flood forecasting and warning. Thus, as far as flood forecasting and warning is concerned, interstate monitoring is made, although it is still in a preliminary level.

4.5 Major Issues on Existing River Basin Management and Monitoring System

The major issues on the existing river management and monitoring system are classified into two items; namely, (1) to build up the existing monitoring system, and (2) to integrate the monitoring data controlled by the various government agencies so as to facilitate the comprehensive and consistent management and monitoring system. The details of these issues are described below.

4.5.1 Issues on Buildup of Existing Monitoring System

The existing system is available to monitor river hydrology including rainfall, water level, flow discharge and water quality, but the number of hydrological monitoring stations is not necessarily sufficient as described in Section 6.2.

Furthermore, the existing system is not available to monitor sediment load, the indispensable information to control river channel erosion caused by the present excessive sand mining operations. Moreover, there exist no system to monitor the river environments such as fauna and flora, river scenery, navigation and also to monitor the land development conditions as well as the forest reserve conditions that are the dominant factors on the basin runoff conditions and the basin sediment yield.

Thus, one of the main issues will be the build-up of the existing hydrological monitoring network and expansion of the monitoring items including sediment load, river environmental conditions and land development conditions.

4.5.2 Issues on Integration of Monitoring System

The present monitoring of Muda River is separately managed by the State of Kedah, MADA (under the Federal Government) and the State of Pulau Pinang, and the information monitored by them is seldom exchanged. Only the flood water level monitored by the State of Kedah is sent to the State of Pulau Pinang.

Furthermore, there are various government agencies in charge of monitoring under the state governments but most of the information monitored by each agency is not integrated and/or centralized under a representative agency. These separate and independent management systems will be a great hindrance to carrying out comprehensive river management, and need to be integrated into an interstate system.

5. PROPOSED ZONING PLAN FOR WATERSHED MANAGEMENT AND MONITORING WORKS

5.1 Overall Zoning Plan

The zoning plan is necessary to specify the boundary for jurisdiction of river basin management and monitoring. In this Report, the proposed zoning is divided into the three (3) major classifications; namely, (a) water source reserve area, (b) river reserve area, and (c) potential land development area.

The water source reserve area aims at basin-wide preservation, in particular, to the upper reaches of Muda River that play a major role of river water source. On the other hand, the river reserve area focuses on preservation of the river and its surrounding river corridor. The potential land development area is defined as the area other than the above reserved areas where land development and/or activities are not subject to monitoring. The extent, purpose and required management activities for each classified zone are as shown in Tables V.5.1.1 and V.5.1.2 and in Fig. V.5.1.1.

A gazette on the above river reserve area has been proposed by DID for years but not successfully executed for Muda river basin. In contrast with the river reserve area, the water source reserve area is newly delineated in this Study in due consideration of the necessity to reserve the basin runoff condition.

As mentioned in SECTOR VIII, an integrated river management body is proposed with a three tier structure composed of the Muda Council at the top supported by a Technical Committee at the second level and a Technical Secretariat at the third level. All river basin management and monitoring will be undertaken by the council. On the premise of this integrated river management body, detailed management and monitoring works for each reserve area proposed are as described in the following sections.

5.2 Water Source Reserve Area

5.2.1 Zoning Purpose of Water Source Reserve Area

The proposed Beris and Reman dam reservoirs are surrounded by considerable agricultural land, and could be in danger of serious aggravation by polluted water and sediment load produced from the agricultural land.

Aside from these agricultural lands, the upper reaches of Muda River is now mostly delineated as forest reserve area. The management of the forest reserve area is, however, solely made by the Department of Forest and the excessive logging may aggravate the basin runoff conditions and the water quality of the river flow and/or dam reservoir.

In due consideration of the above conditions, the actual logging as well as agricultural activities in the water source reserve area are proposed to be monitored and to relate them with the river hydrology, biology, water quality and morphology. The major purposes of the water resource reserve area are enumerated as below:

- (a) To preserve the appropriate basin runoff discharge and sediment load;
- (b) To restrain polluted water loads flowing out from the basin; and
- (c) To protect the morphology of the dam reservoir from the undesirable activities along the lakeshore.