Paddy

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cropping Calendar	Main-Season			Off-season						Main-season		
Planted Area (%)	100	50		50	100			100	50	50	100	100

Tobacco

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cropping Calendar	Season-II											Season-II
	Season-I										Season-I	
Total Planted Area (%)	100	85		70						30	65	100

Flood Frequency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(%)	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	72.1

Source : "Paddy Production and Area",KADA
"Basic Agriculture Statistics", Agriculture Department of Kelantan
"Kelantan Development Statictics, Nov.1987"
"Kelantan Tobacco Statictics, 1987", National Tobacco Board

Note : Percentage of planted area for seasons I and II to total tobacco planted area are 30% and 70%, respectively.

Fig.V.4.4

Cropping Calendars for Paddy Tobacco

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX VI

ENVIRONMENTAL IMPACT STUDY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

VI. ENVIRONMENTAL IMPACT STUDY

1. INTRODUCTION

The land in the study area, i.e. the Kelantan River basin is topographically classified into two; hilly and flat land in the northern part and mountainous land in the southern part. The northern part is well developed as agricultural lands. The southern part is reserved as forest lands. Various kinds of wildlives and aborigines in Malaysia called Orang Asli inhabit and migrate in the forest land. In fact, the southmost area is enacted as Taman Negara (National Park) for protecting wildlives. On the other hand, logging activities in this forest land progress in a considerably high pace as a major source of foreign exchange earning.

Flood mitigation in the downstream reaches of the Kelantan River is contemplated by regulating flood flow by the reservoirs created by dam in the upstream reaches and river improvement in the downstream river stretches. The dam schemes conceived to be promising for flood mitigation are the Kemubu and Lebir as shown in Fig. VI.1.1. These two dam schemes are finally selected as the structural measures for the flood mitigation in the downstream reaches of the Kelantan River.

The proposed two dam schemes are located in the southern hilly and mountainous areas covered with forests, and will have a considerably large reservoir area, resulting in property losses due to submergence and environmental changes. Considering these points, the objectives of the environmental impact survey are focussed on the following:

- to analyse the present environmental status of the Kelantan River basin, and
- to point out environmental problems in relation to basin-wide flood mitigation plan, especially the creation of reservoirs by dam schemes.

The following two environmental impact assessment reports are available in this study area;

(1) Nenggiri Dam Project Feasibility Study
Environmental Impact Assessment (September 1986)

(2) Environmental Impact Statement for the Lebir Dam Project in Malaysia (February 1988).

The environmental impact survey in this study is in principle based on the review of the above two reports. In this Pre-F/S Report, the present environmental status in the Kelantan River basin is presented.

Since the creation of reservoirs by dam is conceived to have considerable impacts to the surrounding environment, following

items will mainly be surveyed in the Kelantan River basin focussing on the impact due to the creation of reservoir:

- River Environment (water quality, and fish and fisheries)
- Flora
- Fauna
- Ethnicity
- Public Health.

2. PRESENT ENVIRONMENTAL STATUS OF THE PROJECT AREA

2.1 General

The objective of this section is to understand the present environmental status of the project area in relation to river environment, flora, fauna, ethnicity and public health which are anticipated to be influenced by the creation of large scale reservoirs.

2.2 River Environment

2.2.1 General

The Kelantan River drains a total area of 13,100 km^2 and comprises virtually the whole of the State of Kelantan located in the north-eastern part of Peninsular Malaysia. The basin area is bounded by the State of Perak and Thailand on the west, by the State of Pahang on the south and by the State of Terengganu on the east.

Main tributaries of the Kelantan River are the Galas and Lebir rivers. The Galas River is further divided into the Nenggiri and Pergau rivers.

Organic pollution in the rivers is caused by domestic and industrial sewage in the urban areas and effluent from rubber factories, palm oil mills and animal husbandries in the rural areas. Fig. VI.2.1 shows the organic pollution sources in the Kelantan River, which are mainly located downstream of Kuala Krai. A part of waste water from Kota Bharu, which is the largest pollution source in the basin, drains to the Kelantan River some 10 km upstream from the estuary, resulting in no direct relation with this environmental impact study.

2.2.2 Water quality of the Kelantan River system

Chemical quality of surface water in the Kelantan River was recently surveyed by DID at five monitoring stations as shown in Fig. VI.2.2. The results of analyses are shown in Tables VI.2.1 to VI.2.3. On the other hand, some environmental impact assessment of dam projects in the Kelantan River reports the results of water quality survey as shown in Tables VI.2.4 and VI.2.5.

(i) pH

The Kelantan River system is in general neutral with pH values ranging from 6.3 to 7.6 (refer to Tables VI.2.1 to VI.2.3). A little lower value representing slightly acidic water is observed at the Lebir River. Fig. VI.2.3 depicts the variation of pH values observed at Guillemard Bridge.

(ii) Suspended solid (SS)

Suspended solid in water samples shows high concentration with the range of 5.0 to 244.0 mg/l in surface water as given in Fig. VI.2.4. High concentration of suspended solids detected in the Kelantan River is considered to be associated with heavy rainfall prior to sampling. At the monitoring stations located upstream, SS level is relatively low. However, river water presents a reddish brown colour which indicates characteristics of laterite.

(iii) Dissolved oxygen (DO)

Dissolved oxygen measured in the Kelantan River indicates an amount of more than 7.0 mg/l except for the measurement on September 15, 1987, the level of which accounts for high saturation as given in Fig. VI.2.5.

(iv) Biochemical oxygen demand (BOD)

BOD concentration in the Kelantan River is low except for the measurement on July 28, 1987 as shown in Fig. VI.2.6. This means that there are no high pollution sources along the Kelantan River.

(v) Total phosphorus (T-P)

The level of phosphorus indicates the values of 0.08 to 0.60 mg/l in the Kelantan River. This high level of phosphorus is likely to be associated with heavy rainfall prior to sampling; that is, heavy rainfall flushes out sediments deposited in the riverbed. On the contrary, the level of phosphorus in the upper reaches of the Kelantan River indicates the low values of N.D - 0.23 mg/l at the Lebir River and 0.01 - 0.07 mg/l at the Nenggiri River (refer to Tables VI.2.4 and VI.2.5).

(vi) Other parameters related with water quality

Although the Kelantan River is a tidal river, the average of the chloride level is 2.8 mg/l at Guillemard Bridge. Therefore, there is no influence of tide in the middle stream of the Kelantan River. Further discussions on salt water intrusion are discussed in the Master Plan Study (Annex VI of Part I).

The level of all metal ions is low in all the water samples obtained from the Kelantan River system.

2.2.3 Fish and fisheries

(1) Fish fauna

The number of species of fishes that inhabit in rivers,

stream and swamps in Peninsular Malaysia is probably less than two hundred. This is far less, of course, than sea fishes, but the fresh-water ones are not without economic importance.

The Kelantan River system is well known as an abundant area of freshwater fishes. Table VI.2.6 shows the fish species in the Kelantan River system. Besides, there are some rare and endangered fish species in the Kelantan River system as given in Tables VI.2.7 and VI.2.8.

(2) Fisheries

The existing fisheries in the Kelantan River system consist mainly of artisanal fisheries in a small scale. The majority of participants within riverine fisheries is part-time fishermen who catch fish mainly for their own consumption. There is only a small group of fishermen who actively participate in the fisheries in full time.

The majority of part-time fishermen within the Kelantan River system fishes using artisanal gears such as hand lines, cast nets, small gill nets and traps.

The most common species are Lompan Jawa, Lee Koh, Tongsang Makan Rumput, Tongsang Kepala Besar which constitute about 60% of the total freshwater fish production in 1985 as shown in Table VI.2.9. Recently, the production of Jelawat and Udang Galah is increasing.

2.2.4 Assessment of existing river environment

(1) Water quality

The water quality of the Kelantan River system in its upstream and middle stretches is not highly contaminated except for the total phosphorus. The level of total phosphorus indicates the high value in middle reach of the Kelantan River. While, the level of Suspended Solid indicates the high value. This high level is considered to be caused by crumbly laterite of river banks.

The water quality in the downstream stretch of the Kelantan River has been deteriorated by industrial and domestic sewage, especially by sewage from Kota Bharu.

(2) Fish and fisheries

There are 55 species observed in the Kelantan River system. However, it is impossible to assess the number of species of fish fauna in the Kelantan River system from these data. It is reported that there are some rare and endangered fish species in the Kelantan River system.

2.3 Flora

2.3.1 General

The flora of Malaysia (Peninsular Malaysia and Singapore, 132,100 km^2) is exceedingly rich, and is conservatively estimated to comprise 7,900 species and 1,500 genera of seed plants. While, the British Isles (311,000 km^2) in the north temperate zone have an area 2.3 times larger than Malaysia, but the kind of species is not so much as being 1,430 species (18%) and 628 genera (42%) native.

Sumatra, Malaysia and Borneo, lying on the Sunda shelf in the centre of the western part of the Indo-Malaysia tropical forest, have close floral similarities, but there are also marked diversities among species in the different regions of the tropical forest.

2.3.2 Forest

The natural vegetation in the Kelantan River basin mostly consists of tropical rain forest which has the most complex and abundant species. This forest mainly consists of lowland Dipterocarps.

The type of vegetation in the Kelantan River basin will be classified into the five categories, i.e. (i) lowland Dipterocarp forests, (ii) hill Dipterocarp forests, (iii) riverine vegetation, (iv) secondary vegetation which is defined as planted forest and (v) mixed vegetation which is the combined type of the riverine and secondary forests. Although there are no data showing their distribution, it is presumed that lowland and hill Dipterocarp forests are located in the upper reach of the Kelantan River basin, and riverine vegetation is located along the Kelantan River system. Almost all secondary vegetation and mixed vegetation are located in the middle and lower reaches of the Kelantan River basin.

According to the foregoing two EIS reports, there are no data about precious or rare species in the Kelantan River basin. Tow EIS reports described as follows;

Lebir dam project;

There was a total of 452 samples in Plot 1 comprising 122 plant species from 79 Genera and 35 Families. In Plot 2 only 311 specimens were recorded and was made up of 95 Species, 65 Genera and 27 Families. When the two plots were combined, 185 species were recorded consisting of 102 Genera and 40 Families. Those species common to the both plots were very few. This represents a typical distribution of the plant species in tropical zones.

Kemubu dam project;

There are various endemical species of plants and ferns in the examined area. Hibiscus floccolusus, a 25 m high tree, is a regional species which could be an attractive ornamental tree. Another regional species is Ficus semicordata which bears fruits at ground level. Among rare ferns are to be quoted the epiphyte Davallia corniculata, two terrestrial species (Amphineuron terminans and Mesophlebion trichopodum) and two new species for the region, Lygodium auriculatum and Osmunda bachelli.

While, in respect of the nature conservation, forest reserve areas are designated in the south-east and south-west of the State of Kelantan as shown in Fig. VI.2.7. A part of Lebir reservoir is in the forest reserve area.

2.4 Fauna

2.4.1 General

Animals of south-east Asia are divided into two groups corresponding to the Sunda and Sahul shelf areas by the Weber's line. Animals in Malaysia belong to the Sunda group.

The Sunda group is an extensively placental mammal fauna and of clear continental Asiatic origin. It includes primates, tigers, elephants, monkeys and ungulates. Majority of them is strictly arboreal and is living in the dense forest for habitat and food.

2.4.2 Present status of fauna

(1) Mammals

It is stated in the previous EIS reports that the mammalian fauna in the State of Kelantan is rich. Mammals recorded in the upper reaches of the Kelantan River system are shown in Table VI.2.10. Among those mammals, eight species are endangered. They are Stump-tailed macaque, Indian elephant, Red dog, Leopard panther, Malaysian tiger, Banteng, Malaysian tapir and Sumatran rhinoceros.

In Peninsular Malaysia, there are two most popular macaques observed. They are Long-tailed and Pig-tailed macaques. However, it becomes very difficult and rare to observe them at hinterland areas.

(2) Avifauna

Tables VI.2.11 shows the bird record in the project areas. This table shows that 65 species for Lebir dam project have been observed. Among these species, pheasants, hornbills and carnivorous birds are considered to be endangered.

The pheasants are ground living birds that are found in primary and secondary forests. The outstanding one is Great Argus Pheasant which is normally found in primary forests.

The hornbills are the primary indicators of tropical Dipterocarp forests. According to the previous studies, six species are observed. They are Black hornbill, Rhinoceros hornbill, Helmeted hornbill, Wrinkled hornbill, Bushycrested hornbill and Wreathed hornbill.

Carnivorous birds are famous for their wide territory during their food phase of livelihood, and six species are observed. They are Black eagle, Crested serpent eagle, Short-toed eagle, Blythis hawk eagle, Black kite and Black-shouldered kite.

2.4.3 Assessment of existing fauna

Fauna in the State of Kelantan is rich and comprises typical tropical species. Furthermore, many endangered species are observed. They are Stump-tailed macaque, Indian elephant, Red dog, Leopard panther, Malaysian tiger, Banteng, Malaysian tapir, Sumatran rhinoceros, Pheasants, Hornbills and carnivorous birds. The reason why such abundant species exist in the basin is due to the fact that the Kelantan River basin still keeps the abundant nature in spite of the progress of land development.

2.5 Ethnicity

2.5.1 General

The population is overwhelmingly Malay (92.4% of the population) in the State of Kelantan. Chinese constitute 5.6% of the population, while Indians and others constitute 2.0%.

It is reported that Orang Asli, indigenous group of Malaysians, is gradually accepting to live in the specific area adjusted by the Orang Asli Department (JOA). But, its progress is rather slow.

The current population of Orang Asli is about 72,000 in Peninsular Malaysia, sharing less than 0.5% of the Malaysian population. Orang Asli is classified into three ethnic groups which comprise various tribes; Negritos, Senoi and Proto-Malay.

The Negritos, the smallest ethnic group, is considered as the earliest migrant group among the present West Malaysian inhabitants. They are nomads living in the north of the Peninsular such as the States of Perak, Kelantan, Kedah and Pahang and also in South Thailand.

The Senoi constitutes the largest ethnic group, and is localized mainly in the centre of the Peninsular such as the States of Pahang, Perak and Kelantan.

The Proto-Malays speak an archaic form of Malay and are concentrated in the south of Peninsular. The way of life is similar to that of the rural Malays.

Among the Orang Asli, around 60% are living in the jungle, while some villages are located near Malay villages. Their economy is based on hunting, fishing, gathering wild roots, cutting and selling rattan or product of temporary jobs.

There are 18 settlements of Orang Asli in the survey area as shown in Fig. VI.2.8. Population and member of families are shown in Table VI.2.12.

The biggest settlement is Kuala Betis which is located along the Nenggiri River. Almost all settlements of Orang Asli are observed along the Nenggiri River system, and all settlements are located in the upper reaches of the Kelantan River system.

2.5.2 Brief description of the settlements

There are 18 settlements of Orang Asli in the State of Kelantan. Almost all settlements were established by JOA which has provided schools, clinics and religious schools. A main objective is to provide a more permanent settlement to the Orang Asli.

Orang Asli has no common public facilities like hospitals. A new approach should be considered to integrate the Orang Asli communities with the general Malaysian communities, when the resettlement of Orang Asli is unavoidable for the implementation of projects.

2.5.3 Socio-demographic profile

The majority of Orang Asli living in the State of Kelantan is Senoi and Negritos. They may be further classified into dialect groups. The difference between dialect groups is not significant since they understand each other and mix freely.

Orang Asli has been treated as nomadic hunting and gathering people who mainly subsist on wild tubers, fruits, and small game which they hunt with blow pipes and poisoned darts. They are therefore dependent on the forest for their livelihood.

Orang Asli has a strong sense of solidarity to survive in the forest. They go hunting in groups, and all the forest products captured are shared by all. They have no concept to keep private property besides only a few basic essential household items. On the other hand, there are households with better living quarters having more modern essentials such as radio and clothings. The women folk are already using cosmetics.

It has been observed that political power is almost non-existent in the Orang Asli communities. Decisions concerning the problems of the community are made through discussions among its

members. Their traditional way of life based on hunting and gathering forest products prevents from making their community larger.

Athough authority in terms of power relationship is weak, there are leaders in the Orang Asli communities. They are called "Penghulu"s (headman) in the Malaysian language. The status of headman is bestowed by JOA. The headman has the power to relate with outsiders.

2.5.4 Assessment of existing ethnicity

The economy of Orang Asli is still based on forest products such as hunting, fishing, gathering wild roots, cutting and selling rattan. Orang Asli has a strong sense of community attachment.

If the development of Lebir and Kemubu dam schemes requires the resettlement of Orang Asli, an attention should be drawn to search the relocation places so that they can keep their way of life.

2.6 Public Health

2.6.1 General

Malaria, acute respiratory infections and diarrhoea diseases have high infection percentage. However, the most prevalent disease is malaria in the State of Kelantan. It is reported that schistosomiasis is not in fashion in Peninsular Malaysia.

Malaria is a disease transmitted from person to person by certain species of mosquito belonging to the genus Anopheles, and causes acute bouts of fever which recur at intervals. Table VI.2.13 shows the biological information on Anopheles.

Although malaria has been eradicated in some countries, it is still a major public health problem in many parts of the world including Malaysia as shown in Fig. VI.2.9.

The control measure for the particular species of Anopheles has been established, however, this control measure is not applicable to other environment and species. It will need much time to eradicate malaria.

2.6.2 Present status of malaria

Malaria in the State of Kelantan tends to increase little by little until 1986, while the number of occurrence decreased in 1987. Furthermore, malaria cases in the State of Kelantan share high percentage in Peninsular Malaysia in spite of all efforts of the Department of Health at Kelantan as shown in Fig. VI.2.10.

Figs. VI.2.11 and VI.2.12 show malaria cases per 1,000

population in the State of Kelantan and infection area, respectively. Gua Musang is the highest infectious area, followed by Kuala Krai and Jeli. Almost all the upper reaches of the Kelantan River system are in the infection or prone area.

On the other hand, the newest statistics on malaria cases of Orang Asli have shown that there were 1,320 malaria cases in Kelantan as compared with 115 cases in 1980. One of reasons for the increase of malaria cases is that remote areas become more accessible, and due to this transportation, more accurate number of the malaria cases is confirmed.

According to the Department of Public Health, now DDT (Dichloro Diphenyl Trichloro Ethane) is only one insecticide which exterminates Anopheles.

2.6.3 Assessment of existing public health

The most serious problem for public health in the State of Kelantan is to share high percentage in malaria cases among Peninsular Malaysia. Furthermore, the hinterland of the State of Kelantan is the highest infectious area of malaria. Unceasing efforts are required to eradicate malaria in these regions.

3. ENVIRONMENTAL IMPACT BY THE LEBIR AND KEMUBU DAM SCHEMES

Flood mitigation in the downstream reaches of the Kelantan River is contemplated by regulating flood flow by Lebir and Kemubu dams in the upstream reaches and river improvement in the downstream river stretch.

The creation of the reservoir by dam will bring about the transformation of the existing natural riverine ecosystem to man-made lacustrine ecosystem, although this change may be brought with some time lag.

As for river environment, the level of total phosphorus is not so high at the upper reaches of the Kelantan River system that the eutrophication will not occur by nutrients from rivers which flow in a reservoir. However, the value of parameters showing water pollution such as BOD and COD will increase. To cope with such pollution of the water quality, burning of trees in the reservoir area would be one of appropriate measures.

With the change in the river environment that river changes to reservoir, the fish fauna is anticipated to change to lacustrine fauna. But, it is considered that many existing fish species would be able to adapt to the new environment.

The existing EIS reports state on flora that there exist no precious or rare species and forest groups in the proposed reservoir areas, so that it is not expected at this moment that dam construction will give environmental impacts on precious or rare species.

The creation of the reservoir area due to the dam construction may result in the impact to animals inhabitated there. However, since broad rain forest is spreading in the upstream reaches of the Kelantan River basin, it is considered that the creation of reservoir scarcely exerts to living of the wildlives.

There are many settlements of Orag Asli in the upper basin of the Nenggiri River, many of which are not located in the proposed Lebir and Kemubu reservoir areas. However, it is necessary for Orag Asli to look for the appropriate resettlement place so that they can keep their way of life, when their settlement is submerged under both reservoirs.

4. ENVIRONMENTAL IMPACT BY RIVER IMPROVEMENT

River improvement by levee construction will be carried out between Kuala Krai and the estuary as part of the overall flood mitigation works of the Kelantan River. Since a 5 m high class levee will at most be constructed along the river, it is not considered that river improvement would cause the notable environmental impact.

However, there may be a discussion that the value of SS (suspended solid) will increase during the construction of levee. The SS level under the natural condition is so high that slight increase of turbidity will hardly cause the environmental impact. It is finally noted that it would be convenient for riparian people to provide gentle slopes or stairs on the levee.

REFERENCES

1. Nenggiri Dam Project Feasibility Study, Environment Impact Assessment, ELC, September 1986.

2. Pergau Hydroelectric Project, Environment and Socio-economic Study, SMEC, June 1987.

3. Environmental Impact Statement for the Lebir Dam Project in Malaysia, JICA, February 1988.

4. Tropical Rain Forest of the Far East, T.C. Whitemore, Oxford University Press.

5. Environmental Health Engineering in the Tropics, an Introductory Text, Sadny Cairncross and Richard G. Feachem.

Table VI.2.1 Water Quality In The Kelantan River System (1/2)
(DID Station)

Name of River		Kelantan River								
Sampling Point		Guillemard Bridge								
Sampling Date		14.1.87	27.1.87	14.2.87	25.2.87	15.3.87	29.3.87	15.4.87	29.4.87	18.5.87
Time of Sampling		10:05	11:00	10:30	12:00	11:00	11:30	11:35	09:50	09:43
Temperature	C	28.0	28.0	28.0	27.0	28.0	28.0	28.0	28.0	30.0
pH		7.6	7.6	7.4	7.3	7.4	7.4	7.3	7.0	6.9
Suspended Solid	mg/l	40.0	72.0	16.0	16.0	26.0	34.0	128.0	77.0	87.0
Dissolved Oxygen (Do)	mg/l	7.1	7.1	7.1	7.1	7.0	7.0	7.3	7.3	7.1
BOD	mg/l	1.2	1.4	1.1	0.90	1.1	1.0	1.3	1.2	1.1
Phosphorus (Total)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.2	0.25	0.23
Colour (Hazen Unit)		30	10	5	5	10	15	85	30	85
Turbidity (Silica-Scale Unit)		105	120	60	25	80	95	270	80	210
Dissolved Solid	mg/l	61.0	70.0	50.0	60.0	60.0	68.0	80.0	56.0	112.0
Volatile Suspended Solid	mg/l	15.0	20.0	5.0	10.0	12.0	20.0	55.0	30.0	23.0
Total Solid	mg/l	101.0	142.0	66.0	76.0	86.0	102.0	208.0	133.0	199.0
Hardness (CaCo3)		16	18	18	20	20	22	18	17	7
Conductivity	umbos/cm	39	48	49	58	48	48	39	48	48
COD	mg/l	6.4	12.7	3.2	28.7	6.4	25.5	35.1	66.7	6.4
Nitrogen (Ammonia)	mg/l	0.16	0.08	0.10	0.02	0.20	0.24	1.7	1.6	1.3
Nitrogen (Nitrate Nitrite)	mg/l	0.46	0.52	0.8	0.86	0.92	1.0	7.3	3.0	2.6
Nitrogen (Kjeldahl)	mg/l	1.5	1.8	1.5	12.9	6.4	6.4	10.3	4.8	7.0
Chloride	mg/l	1.0	9.0	3.0	3.0	1.0	1.0	2.8	1.0	2.0
Alkalinity (Total)	mg/l	18.0	19.0	25.0	26.0	26.0	27.0	20.0	23.0	7.0
Flouride	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.1	0.1	N.D.
Phosphorus (Ortho)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.15	0.20	0.1
Arsenic	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Silica (Reactive)	mg/l	12.0	15.0	110.0	12.0	20.0	20.0	19.0	23.0	23.0
Iron (Total)	mg/l	2.0	2.8	0.8	3.2	0.8	0.8	4.8	3.2	2.8
Manganese	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.15	0.1	0.15
Potassium	mg/l	0.1	0.5	0.4	0.4	0.2	0.2	-	-	-
Sodium	mg/l	1.0	1.4	0.9	1.2	1.3	3.1	-	-	-
Sulphate	mg/l	2.0	2.0	2.0	2.0	1.0	1.0	N.D.	N.D.	N.D.
Barium	mg/l	0.9	N.D.	N.D.	N.D.	0.9	N.D.	N.D.	N.D.	N.D.
Calcium	mg/l	4.8	6.0	5.6	5.2	6.8	6.0	3.2	0.7	2.0
Magnesium	mg/l	N.D.	N.D.	0.97	1.7	0.73	1.7	2.4	0.7	0.5

Notes: N.D. means Not Detected and - means Not Observed.

Table VI.2.1 Water Quality In The Kelantan River System (2/2)
(DID Station)

Name of River		Kelantan River								
Sampling Point		Guillemard Bridge								
Sampling Date		15.6.87	15.7.87	28.7.87	16.8.87	15.9.87	13.10.87	31.10.87	29.11.87	16.1.88
Time of Sampling		11:00	10:44	11:45	11:01	10:30	13:56	12:25	11:10	10:40
Temperature	C	29.0	29.0	28.0	28.0	29.0	29.0	29.0	29.0	29.0
pH		7.1	6.8	6.8	6.7	7.0	7.0	7.2	7.3	7.3
Suspended Solid	mg/l	64.0	36.0	244.0	63.0	184.0	122.0	173.0	155.0	84.0
Dissolved Oxygen (Do)	mg/l	7.0	7.2	7.3	7.2	6.2	7.7	7.4	9.4	7.8
BOD	mg/l	0.9	1.2	9.1	1.0	0.3	1.3	0.7	0.2	1.9
Phosphorus (Total)	mg/l	0.2	0.15	0.22	0.32	0.6	0.08	0.05	0.1	0.2
Colour (Hazen Unit)		40	15	20	150	150	-	225	150	60
Turbidity (Silica-Scale Unit)		85	45	125	80	135	-	750	425	75
Dissolved Solid	mg/l	86.0	74.0	150.0	94.0	42.0	-	86.0	50.0	7.0
Volatile Suspended Solid	mg/l	15.0	12.0	127.0	31.0	88.0	41.0	120.0	60.0	25.0
Total Solid	mg/l	150.0	110.0	394.0	157.0	226.0	-	259.0	205.0	91.0
Hardness (CaCo3)		24	26	17	21	19	-	15	28	18
Conductivity	umbos/cm	58	58	39	48	58	48	39	48	43
COD	mg/l	6.4	22.0	22.0	45.2	4.1	20.0	20.0	20.0	19.8
Nitrogen (Ammonia)	mg/l	1.7	0.9	1.6	1.8	1.8	1.7	0.01	0.01	0.32
Nitrogen (Nitrate Nitrite)	mg/l	6.6	0.39	0.46	0.18	0.43	2.0	0.21	1.0	2.10
Nitrogen (Kjeldahl)	mg/l	11.0	6.6	3.6	4.2	4.8	3.6	1.21	2.40	2.62
Chloride	mg/l	8.0	1.0	3.0	3.0	1.0	1.0	N.D.	N.D.	N.D.
Alkalinity (Total)	mg/l	31.0	32.0	20.0	22.0	25.0	20.0	19.0	25.0	22.0
Flouride	mg/l	0.1	N.D.	N.D.	N.D.	N.D.	0.4	0.1	0.1	N.D.
Phosphorus (Ortho)	mg/l	0.1	0.1	0.12	0.18	0.5	0.02	0.05	0.05	0.05
Arsenic	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Silica (Reactive)	mg/l	16.0	12.0	10.0	12.0	12.0	55.0	12.0	9.0	2.0
Iron (Total)	mg/l	4.0	0.8	2.8	4.8	1.2	0.4	3.2	2.4	2.8
Manganese	mg/l	0.2	N.D.	0.02	0.02	N.D.	N.D.	N.D.	0.3	0.5
Potassium	mg/l	-	2.0	2.6	1.6	1.7	1.3	1.1	1.4	1.4
Sodium	mg/l	-	4.7	4.6	4.0	4.6	4.8	2.2	2.4	2.3
Sulphate	mg/l	3.0	3.0	3.0	2.0	5.0	N.D.	2.0	N.D.	2.0
Barium	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Calcium	mg/l	8.0	8.0	4.0	4.0	6.0	4.0	4.4	6.0	6.0
Magnesium	mg/l	1.0	1.5	1.7	2.7	1.0	1.9	1.0	3.2	0.7

Notes: N.D. means Not Detected and - means Not Observed.

Table VI.2.2 Water Quality In The Kelantan River System (DID Station)

Name of River		Lebir		Galas	
Sampling Point		Kg. Tualang		Dabong	
Sampling Date		28.1.87	28.7.87	26.1.86	25.2.86
Time of Sampling		13:45	13:00	14:45	15:45
Temperature	C	-	-	-	-
pH		6.3	6.7	7.0	7.1
Suspended Solid	mg/l	13.0	16.0	21.0	25.0
Dissolved Oxygen (Do)	mg/l	-	-	-	-
BOD	mg/l	-	-	-	-
Phosphorus (Total)	mg/l	-	-	-	-
Colour (Hazen Unit)		10	60	10	5
Turbidity (Silica-Scale Unit)		35	35	60	25
Dissolved Solid	mg/l	77.0	14.0	31.0	25.0
Volatile Suspended Solid	mg/l	-	-	-	-
Total Solid	mg/l	90.0	30.0	52.0	50.0
Hardness (CaCo3)		22	31	20	17
Conductivity	umbos/cm	49	63	39	48
COD	mg/l	0.92	-	-	-
Nitrogen (Ammonia)	mg/l	-	-	-	-
Nitrogen (Nitrate Nitrite)	mg/l	-	0.8	0.26	0.40
Nitrogen (Kjeldahl)	mg/l	-	-	-	-
Chloride	mg/l	7.0	1.0	6.0	3.0
Alkalinity (Total)	mg/l	25.0	32.0	22.0	17.0
Flouride	mg/l	-	-	-	-
Phosphorus (Ortho)	mg/l	-	-	-	-
Arsenic	mg/l	-	-	-	-
Silica (Reactive)	mg/l	18.0	15.0	9.0	6.2
Iron (Total)	mg/l	1.6	0.4	0.4	0.4
Manganese	mg/l	-	-	-	-
Potassium	mg/l	0.1	1.3	N.D.	0.3
Sodium	mg/l	9.0	3.9	1.9	3.0
Sulphate	mg/l	1.0	N.D.	2.0	2.0
Barium	mg/l	-	-	-	-
Calcium	mg/l	6.8	9.2	6.0	6.0
Magnesium	mg/l	1.2	1.9	1.2	0.5

Notes: N.D. means Not Detected and - means Not Observed.

Table VI.2.3 Water Quality In The Kelantan River System
(DID Station)

Name of River		Nenggiri				
Sampling Point		Bertam				
Sampling Date		17.2.87	23.3.87	4.4.87	10.5.87	15.6.87
Time of Sampling		12:40	15:00	13:05	14:00	14:00
Temperature	C	-	-	-	-	-
pH		7.6	7.1	7.0	6.9	7.2
Suspended Solid	mg/l	5.0	48.0	6.0	71.0	18.0
Dissolved Oxygen (Do)	mg/l	-	-	-	-	-
BOD	mg/l	-	-	-	-	-
Phosphorus (Total)	mg/l	-	-	-	-	-
Colour (Hazen Unit)		100	50	5	15	30
Turbidity (Silica-Scale Unit)		25	55	20	25	15
Dissolved Solid	mg/l	50.0	61.0	124.0	87.0	119.0
Volatile Suspended Solid	mg/l	-	-	-	-	-
Total Solid	mg/l	55.0	109.0	130.0	158.0	137.0
Hardness (CaCo3)		14	17	16	23	16
Conductivity	umbos/cm	48	39	39	39	48
COD	mg/l	-	-	-	-	-
Nitrogen (Ammonia)	mg/l	-	-	-	-	-
Nitrogen (Nitrate Nitrite)	mg/l	0.92	6.6	3.3	3.0	3.9
Nitrogen (Kjeldahl)	mg/l	-	-	-	-	-
Chloride	mg/l	2.0	1.0	2.0	2.0	3.0
Alkalinity (Total)	mg/l	25.0	18.0	21.0	19.0	22.0
Flouride	mg/l	-	-	-	-	-
Phosphorus (Ortho)	mg/l	-	-	-	-	-
Arsenic	mg/l	-	-	-	-	-
Silica (Reactive)	mg/l	19.0	22.0	20.0	22.0	10.0
Iron (Total)	mg/l	0.4	1.6	0.8	4.0	1.6
Manganese	mg/l	-	-	-	-	-
Potassium	mg/l	0.4	-	-	-	1.9
Sodium	mg/l	1.2	-	-	-	4.2
Sulphate	mg/l	2.0	N.D.	N.D.	1.0	N.D.
Barium	mg/l	-	-	-	-	-
Calcium	mg/l	4.0	4.4	4.0	4.0	60.0
Magnesium	mg/l	0.97	1.4	2.6	3.1	0.2

Notes: N.D. means Not Detected and - means Not Observed.

Table VI.2.4 Water Quality In The Kelantan River System
(Lebir Dam EIS Stations)

Name of River		Lebir River												
Sampling Point		SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9	SL10	SL11	SL12	SA1
Sampling Date		-	-	-	-	-	-	-	-	-	-	-	-	-
Time of Sampling		-	-	-	-	-	-	-	-	-	-	-	-	-
Temperature	C	26.0	26.0	26.0	26.5	25.0	25.5	27.0	27.0	27.0	27.0	29.5	28.0	27.0
pH		6.6	6.7	6.9	6.7	6.7	6.4	6.8	6.5	6.4	6.8	7.4	7.6	6.6
Suspended Solid	mg/l	10.0	21.0	14.0	46.0	43.0	49.0	29.0	16.0	197.0	138.0	46.0	-	32.0
Dissolved Oxygen (Do)	mg/l	7.6	7.4	7.3	7.2	7.5	7.5	7.2	7.1	7.0	7.3	7.9	6.5	7.1
BOD	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (Total)	mg/l	N.D.	N.D.	N.D.	N.D.	0.03	0.03	N.D.	N.D.	0.17	0.23	N.D.	0.08	N.D.
Colour (Hazen Unit)		-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity (Silica-Scale Unit)		-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Solid	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatile Suspended Solid	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Solid	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness (CaCo3)		-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	umbos/cm	20.0	45.0	35.0	35.0	35.0	35.0	60.0	60.0	60.0	70.0	70.0	80.0	80.0
COD	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen (Ammonia)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrogen (Nitrate Nitrite)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen (Kjeldahl)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/l	2.6	2.5	2.6	2.7	2.5	2.6	2.7	2.7	2.6	2.6	2.7	2.7	2.6
Alkalinity (Total)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Flouride	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (Ortho)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Silica (Reactive)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron (Total)	mg/l	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.4	1.1	0.4	0.4	0.5	N.D.
Manganese	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Potassium	mg/l	0.8	0.7	0.7	0.8	0.8	0.7	0.7	0.8	1.3	1.6	1.4	1.7	-
Sodium	mg/l	3.0	2.6	2.1	1.8	2.0	2.4	2.9	2.0	2.9	3.2	3.4	3.8	-
Sulphate	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Barium	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/l	0.3	0.3	0.2	0.1	0.1	0.1	0.9	1.2	0.7	1.4	-	-	2.8
Magnesium	mg/l	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.2	-	-	0.2

Notes: N.D. means Not Detected and - means Not Observed.
Source: Environmental Impact Statement For The Lebir Dam Project in Malaysia (February, 1988).

Table VI.2.5 Water Quality In The Kelantan River System (Nenggiri Dam EIS Stations)

Name of River		Nenggiri									
Sampling Point		SN1	SN2	SN3	SN4	SN5	SN6	SN7	SN8	SN9	SN10
Sampling Date		-	-	-	-	-	-	-	-	-	-
Time of Sampling		-	-	-	-	-	-	-	-	-	-
Temperature	C	-	-	-	-	-	-	-	-	-	-
pH		7.5	7.5	7.6	7.5	7.0	8.5	-	7.8	7.5	7.3
Suspended Solid	mg/l	-	-	-	-	-	-	-	-	-	-
Dissolved Oxygen (Do)	mg/l	9.8	9.4	10.5	9.3	10.5	9.0	10.1	9.9	10.2	10.0
BOD	mg/l	-	-	-	-	-	-	-	-	-	-
Phosphorus (Total)	mg/l	0.03	0.06	0.02	0.03	0.01	0.01	0.07	0.01	0.03	0.06
Colour (Hazen Unit)		-	-	-	-	-	-	-	-	-	-
Turbidity (Silica-Scale Unit)		32.0	29.0	39.0	29.0	-	-	-	53.0	26.0	31.0
Dissolved Solid	mg/l	-	-	-	-	-	-	-	-	-	-
Volatile Suspended Solid	mg/l	-	-	-	-	-	-	-	-	-	-
Total Solid	mg/l	-	-	-	-	-	-	-	-	-	-
Hardness (CaCo3)		-	-	-	-	-	-	-	-	-	-
Conductivity	umbos/cm	-	-	-	-	-	-	-	-	-	-
COD	mg/l	-	-	-	-	-	-	-	-	-	-
Nitrogen (Ammonia)	mg/l	-	-	-	-	-	-	-	-	-	-
Nitrogen (Nitrate Nitrite)	mg/l	-	-	-	-	-	-	-	-	-	-
Nitrogen (Kjeldahl)	mg/l	-	-	-	-	-	-	-	-	-	-
Chloride	mg/l	-	-	-	-	-	-	-	-	-	-
Alkalinity (Total)	mg/l	-	-	-	-	-	-	-	-	-	-
Flouride	mg/l	-	-	-	-	-	-	-	-	-	-
Phosphorus (Ortho)	mg/l	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/l	-	-	-	-	-	-	-	-	-	-
Silica (Reactive)	mg/l	-	-	-	-	-	-	-	-	-	-
Iron (Total)	mg/l	-	-	-	-	-	-	-	-	-	-
Manganese	mg/l	-	-	-	-	-	-	-	-	-	-
Potassium	mg/l	-	-	-	-	-	-	-	-	-	-
Sodium	mg/l	-	-	-	-	-	-	-	-	-	-
Sulphate	mg/l	-	-	-	-	-	-	-	-	-	-
Barium	mg/l	-	-	-	-	-	-	-	-	-	-
Calcium	mg/l	-	-	-	-	-	-	-	-	-	-
Magnesium	mg/l	-	-	-	-	-	-	-	-	-	-

Notes: N.D. means Not Detected and - means Not Observed.
Source: Nenggiri Dam Project Feasibility Study Environmental Impact Assessment.

Table VI.2.6 List of Fish Species in the Kelantan River System

Name	Name
Acrossocheilus deauratus-Kelah putih	Osteocheilua hasselti-Terbol
Acrossocheilus hezagonolepis-Tengas	Osteocheilua microcephalus-Rong
Acanthopsis choirorhynchos-Pasir, Tali	Osteocheilua spilrus-Rong
Barbichthys laevis-Butu hulu	Osteocheilua melanopleura-Kelabu
Barilus guttatus-Sikang	Osphronemus goramy-Kalui
Channa micropeltes-Toman	Osteochilus hesselti-Terbui
Channa striatus-Aruan	Pangasius microneus-Lawang
Cyclocheilichthys apogon-Temperas	Pangasius sp,-Patin (Cat fish)
Cyclocheilichthys armatus-Temperas	Pristolepis fasciatus-Patong
Epalzeorhynchos siamensis-Selimang siam	Puntioplites Bulu-Tenggalan
Hampala macrolepidota-Sebarau	Puntius daruphani-Kerai
Helostoma temmincki-Tebakang	Puntius schwanefeldi-Lampang Sungei
Kryptopterus cryptoterus-Lais	Puntius lateristriga-Bagoh
Labiobarbus lineatus-kawan	Puntius orphoides-Pipi merah
Leiocassis sp.	Rasbora elegans-Selung
Lobocheilus cornutus-Jemerong	Rasbora bankanensis-Selung
Luciosoma trinema-Nyuar	Rasbora dusonensis-Selung
Mastacembelus armatus-Tilan	Rasbora smatrana-Selung
Mystacoleucus Marginatus-Sia	Scleropages formosus-Kelisa
Mystus Nemurus-Baung	Tetraodon fluviatilis-Buntal
Mystus planiceps-Baung	Tor Tambroides-Kelah
Mystus baramensis-Baung	Wallage Attu-Tapah
Mystus wyckii-Tengku loah	Mcrobrachium rosenbergii-Udang galah
Mystus sp.-Baung	Clyptothorax major-DEPU
Notopterus chitala-Belida	G. platypogonoides-Kenerak Batu
Puntius binotatus-Tebal Sisik	L. lepetocheilus-daun
M. chilopterus-Sia	Laides hexanema-juara
Nemacheilus sp.-Pasir	

Source: (1) Environmental Impact Statement for the Lebir Dam Project in Malaysia (Feb. 1988)

(2) Pergau Hydroelectric Project
Volume 6 Environmental and Socio-economy Study (June 1987)

Table VI .2.7 List of Endangered Species (Fish Fauna)

Endangered Species

Scleropages formosus
Notopterus chitala
Rasbora dorsiocellata
Barilius guttatus
Puntius pentazona
Probarbus jullieni

Balantiocheilos melanopterus
Cyclocheilichthys heteronema
Macrochirichthys macrochirus
Labiobarbus leptocheilus
L. ocellatus
L. siamensis
L. lineatus
L. sumatranus
L. fasciatus
Tor tambroides
T. soro
Lobocheilus cornutus
Tylognathus caudimaculatus
Barbichthys laevis
Epalzeorhynchos kalopterus
Crossocheilus oblongus
Homaloptera zollingeri
Sphaerichthys osphoronemoides
Betta pugnax
B. splendens
Helostoma temminckii
Luciocephalus pulcher
Monopterus albus

Acanthopthalmus kuhlii
A. anguillaris
A. muraeniformes
A. vermicularis
Botia hymenophysa
B. modesta

Lepidocephalus octocirrhus
L. macrochir
Silurichthys phaisoma
Kryptopterus micronema
Wallago attu
Prophagorus nieuhofi
Bagarichthys hypselopterus
Mystus wyckii
Acrochordonichthys ichnosoma
Parakysis verrucosa
Laides hexanema
Anguilla bicolor
Channa micropeltes
C. lucius
Trichogaster leeri
Osphronemus goramy
Parosphronemus deissneri
Nandus nebulosus
Pristolepis fasciatus
Glossogobius giuris
Oxyleotris marmoratus
Mastacembelus maculatus
M. armatus

Table VI .2.8 List of Rare or Extinct Species (Fish Fauna)

Rare or Extinct Species

Chela johorensis
C. laubuca
C. maasi
C. maculicauda
Rasbora dorsimaculata
R. bankanensis
R. borapetensis
R. caudimaculata
R. dusonensis
R. kalochroma
R. maculata
R. taeniata
R. paucisquamis
R. vaillanti
R. pauciperforata
R. rasbora
R. lateristriata
R. meinkeni
R. myersi

Puntus douronensis
P. burmanicus
P. belinka
P. baranoides
P. strigatus
P. everetti
P. leiacanthus
P. birtwistlei
Acrossocheilus hendersoni
A. dukai
Mystacoleucus chilopterus
Osteocheilus microcephalus
O. spilurus
O. kahajanensis
O. triporus
O. brachynotopterus
O. kelabu
O. waandersii
Cyclocheilichthys zwaani
C. siaja
C. janthochir
C. amatus
C. repasson
C. lineatus
C. enoplos
Labiobarbus burmanicus
L. cuvieri
Homaloptera johorensis
H. nigra
H. leonardi
H. ogilviei
H. smithi
H. tweediei
H. wassinkii
Acanthopthalmus javanicus
A. shelfordi
A. pangia
Cobitophis perakensis
Nemacheilus fasiatus
N. masyae

Lepidocephalus furcatus
Vaillamella maassi
Silurichthys indragiriensis
S. schneideri
Ompok leicanthus
Kryptopterus limpok
K. macrocephalus
K. cryptopterus
Wallagonia leeri
W. tweediei
Siluroides hypophthalmus
Parasilurus cochinchinensis
Clarias melanoderma
C. leiacanthus
C. teysmanni
Encheloclarias tapeinopterus
Leiocassis bicolor
L. baramensis
L. fauscus

L. micropogon
L. stenomus
Batasio tengana
Mystus wolffi
M. johorensis
M. gulio
M. pahangensis
M. micracanthus
Glyptothorax platypogonoides
G. platypogon
Acrochordonichthys melanogaster
A. rugosus
Pangasius ponderosus
P. polyuranodon
Hemiramphus tweedie
Doryichthys deokhatoides
Channa bistriatus
C. puncatuts
C. orientulis
C. melanosoma
C. maruloides
C. gachua
Betta picta
B. taeniata
B. anabantoides
B. fusca
B. bellica
B. brederi
Macropodus cupanus
Belontia hasselti
Nandus nandus
Oxyleotris urophthalmus
Macrognathus aculeatus
Mastocembelus perakensis
M. unicolor
M. erythrotaenia
M. guntheri
M. circumcinctus
Chonerhinus naritus
C. modestus

Table VI.2.9 Freshwater Fish Production in the State of Kelantan

(M/Tons)

Year	Lampan Jawa	Leekoh	Tongsang Makan Rumput	Tongsang Kepala Besar	Patin	Tilapia	Jelawat	Udang Galah	Sepat Siam	Total
1970	0.11	0.06	-	-	-	0.22	-	-	-	0.39
1971	0.18	0.14	-	-	-	-	-	-	-	0.32
1972	0.22	0.22	1.78	0.60	-	-	-	-	0.23	3.05
1973	1.38	0.27	0.85	0.98	-	-	-	-	0.83	4.31
1974	0.27	0.12	0.88	0.15	-	-	-	0.08	0.12	1.62
1975	0.33	0.47	0.52	0.13	-	0.12	-	-	0.08	1.65
1976	0.48	1.33	0.32	0.65	-	-	-	-	-	2.78
1977	0.07	0.03	0.11	0.18	-	0.13	-	0.03	-	0.55
1978	0.22	0.06	0.31	0.28	-	0.06	-	0.02	-	0.95
1979	0.04	0.40	0.65	0.34	-	0.03	-	0.03	0.02	1.51
1980	1.13	0.64	6.67	7.40	-	0.28	-	0.02	0.13	16.27
1981	1.53	1.71	3.90	3.77	-	0.05	-	0.03	0.08	11.07
1982	2.36	1.13	4.78	3.45	-	-	0.04	0.04	0.13	11.93
1983	4.15	2.22	4.83	4.01	-	-	1.24	0.23	-	16.68
1984	3.67	2.22	3.22	1.55	-	0.62	5.82	1.28	0.05	18.43
1985	4.95	2.38	3.97	1.93	0.79	0.10	6.33	-	-	20.45

Source : Fisheries Department, Kelantan.

Table VII.2.10 Mammals Recorded in Precious Survey
(Lebir Dam)

Name
Hylobates agilis-Agile gibbon
Macaca arctiodes-Stump tailed macaque
Rattus sabanus-Long tailed giant rat
Bandicoota indica-Large bandicoof rat
Tupaia glis-Common tree shrew
Rattus whiteheadi-White headed rat
Tragulus javanicus-Lesser mouse deer
Trimevesurus sumatranus-Sumatran pit viper
Macaca fascicularis-Long tailed macaque
Corvus unicolor-Sambur
Muntiacus muntjak-Barking deer
Sus spp.-Wild pig
Tragulus napu-Large mouse deer
Elephas maximus-Indian elephant
Cuon alpinus-Red dog
Ratufa bicolor-Black giant squirrel
Ratufa affinis-Cream coloured giant squirrel
Petaurista petaurista-Red giant flying squir
Herpastes sp.-Mongoose
Panthera pardus-Leopard panther
Presrtytis obscura-Dusky leaf monkey
Panthera tigris-Tiger
Felis marmorata-Marbled cat
Bos javanicus-Banteng
Tapirus indicus-Malayan tapir
Acrtitis binturong-Binturong
Dicerorhinus sumatransis-Sumatran rhinoceros
Hystrix brachyura-Malayan porcupine

Table VI.2.11 Bird Record in the Survey Areas of Lebir Dam (1/2)

Name	Name
Arusianus argus-Great Argus	Elanus caeruleus-Black shouldered kite
Arachnothera longirostra-Little spider Hunter	Eurostopodus temminckii-Malayan eared nightjar
Aegithena lafresnayei-Great iora	Eurystomus orientailis-Dollarbird
Aegithena viridissima-Green iora	Eurylaimus ochromalus-Black yellow broadbill
Aplonis paragensis-Philippine glossay starking	Gracula religiosa-Hill myna
Accipiter sp.-Hawk	Gallus gallus-Red jungle foel
Anthracoceros malayanus-Black hornbill	Hemirpocne coronata-Crested Tree Swift
Buceros rhinocerus-Rhinocerus hornbill	Hemirpocne comata-Whiskered Tree Swift
Blythipicus rubiginosus-Maroon woodpecker	Halcyon smyrnensis-White throated kingfisher
Calyptomena viridis-Green Broadbill	Hypseppmtes criniger-Hairy backed bulbul
Coprychus saularis-Magpie Robin	Hypsipetes malaccansis-Streaked bulbul
Coprychus malabraricus-White rumped shama	Hirundapus giganteus-Brown needletail
Cocomantis merulinus-Plaintive cuckoo	Hypothymis azurea-Black naped monarch
Centropus sinensis-Greater concal	Irena puella-Asian fairy bluebird
Cicomantis merulinus-Plaintive cuckoo	Lonchura leucogasta-White bellied minia
Circaetus gallicus-Short toed eagle	Megalaima chrysopogon-Gold-whiskered Barbet
Dicrurus remifer-Leser racquet tailed drango	Megalaima henricii-Yellow crowned barbet
Dicrurus leucophaeus-Ashy drongo	Megalaima mystacophanus-Red throated barbet
Dicrurus aeneus-Bronzed drongo	Megalaima franklinii-Golden throated barbet
Dicrurus paradiceus-Greater racquet tailed drongo	Megalaima austraris-Blue eared barbet
Ducula aenes-Green imperial pigeon	Milrus migrans-Black kite

Table VI.2.11 Bird Record in the Survey Areas of Lebir Dam (2/2)

Name	Name
Nyctyornis amictus-Red bearded beecater	Pycnonotus zeylanicus-Straw headed bulbul
Orthotomus atrogularis-Dark necked tailorbird	Prionichilus thoracicus-scarlet breasted flowerpecker
Orthotomus sericeus-Ruous tailed tailorbird	Platysmurus leucopterus-Black magpie
Psilopogon pyrolophus-Fire-pufted Barbet	Pellorneus ruficeps-Puff throated babbler
Pericrocotus flammeus-Scarlet Minivet	Rhipidura Javanica-Pied fortail flycatcher
Pericrotus brevivostris-Short billed minivet	Rhinoplax vigil-Helmeted hornbill
Pelargopsis capensis-Stock billed kingfisher	Rhyteceros corrugatus-Wrinkled hornbill
Pitta moluccensis-Blue winged pitta	Spiornis cheela-Crested Serpent Eaggle
Pitta caerulea-Giant pitta	Spizaetus alboniger-Blyths hawk Eaggle
Phaenicophaeus curvirostris-Chestnut breasted malkoha	Turnix suscitator-Barred buttonguail
Picus puniceus-Crimson winged woodpecker	Terpsiphone paradisi-Asian paradise flycatcher
Pycnonotus goiavier-Yellow vested bulbul	

Source: Environmental Impact Statement for the Lebir Dam Project in Malaysia (Feb. 1988)
Source: Environment

Table VI.2.12 Population and Family Number in the Orang Asli Settlements

Name of Settlement	Population	Family
1.Blau	217	47
2.Kuala Betis	1,050	315
3.Tohoi	144	34
4.Gemalah	35	24
5.Wias	288	40
6.Pulat	73	12
7.Lebir	376	52
8.Aring	145	38
9.Pasik	351	80
10.Gob	421	80
11.Simpor	321	70
12.Bihai	348	52
13.Hau	308	72
14.Hendrop	381	91
15.Brooke	783	149
16.Belatim	391	106
17.Sg. Rual	240	70
18.Kuala Lah	73	23
Total	5,945	1,355

Source: The Department of Orang Asli Affairs (JOA)

Table VI.2.13 Generalized Biological Information Concerning the Vectors of Malaria

Disease	Vector or intermediate host	Reproductive potential: Number of eggs	Egg-to-egg cycle	Number of broods	Life-span
Malaria	Anopheles	200	10-14 days	6-10	20 weeks

Preferred behaviour: Feeding time	Resting place	Source of blood	Flight of dispersal range
Night	Indoors and outdoors	Man and animals	1.5 km

Source : WHO reports

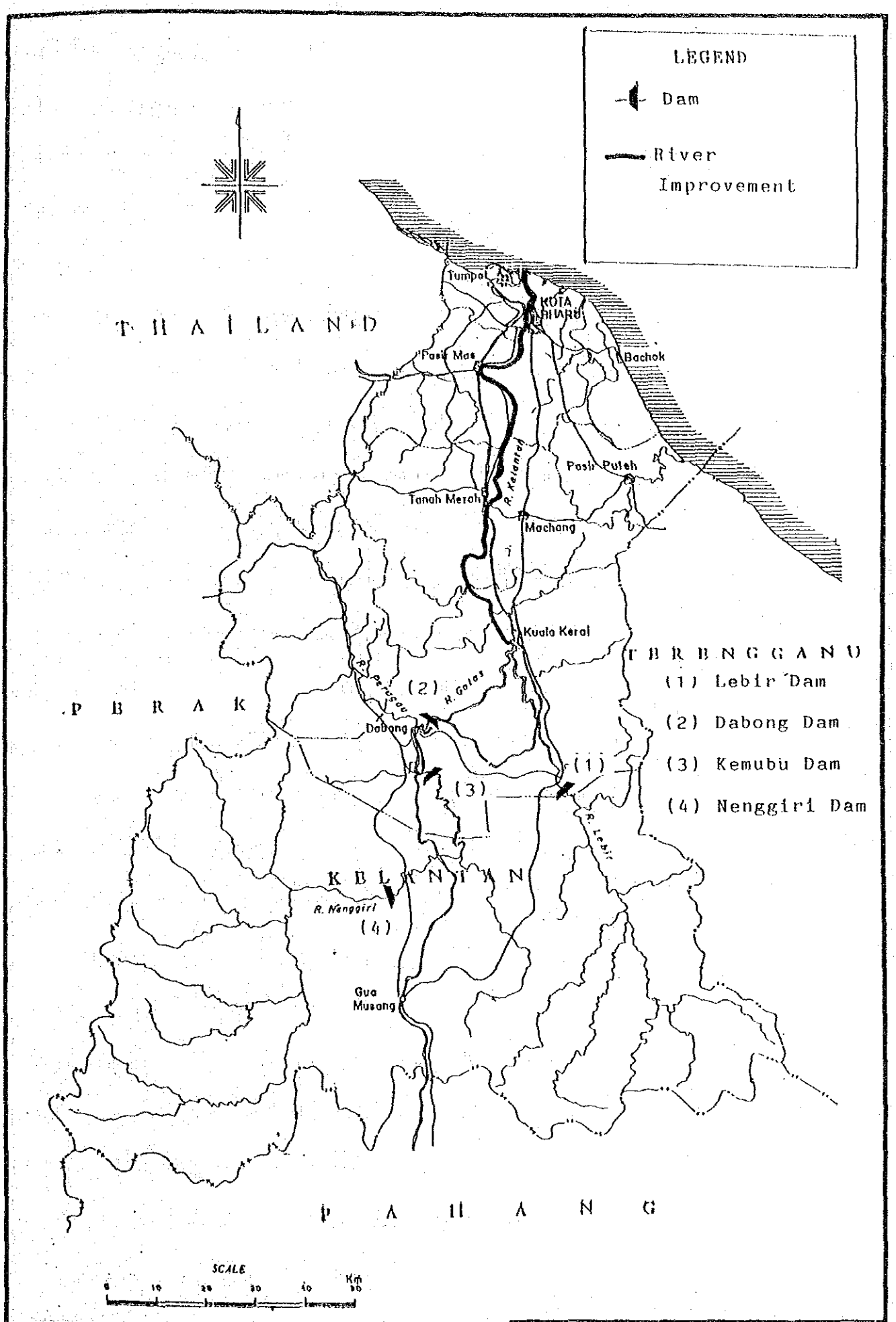

Fig.VI.1.1

Proposed Flood Mitigation Dams

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

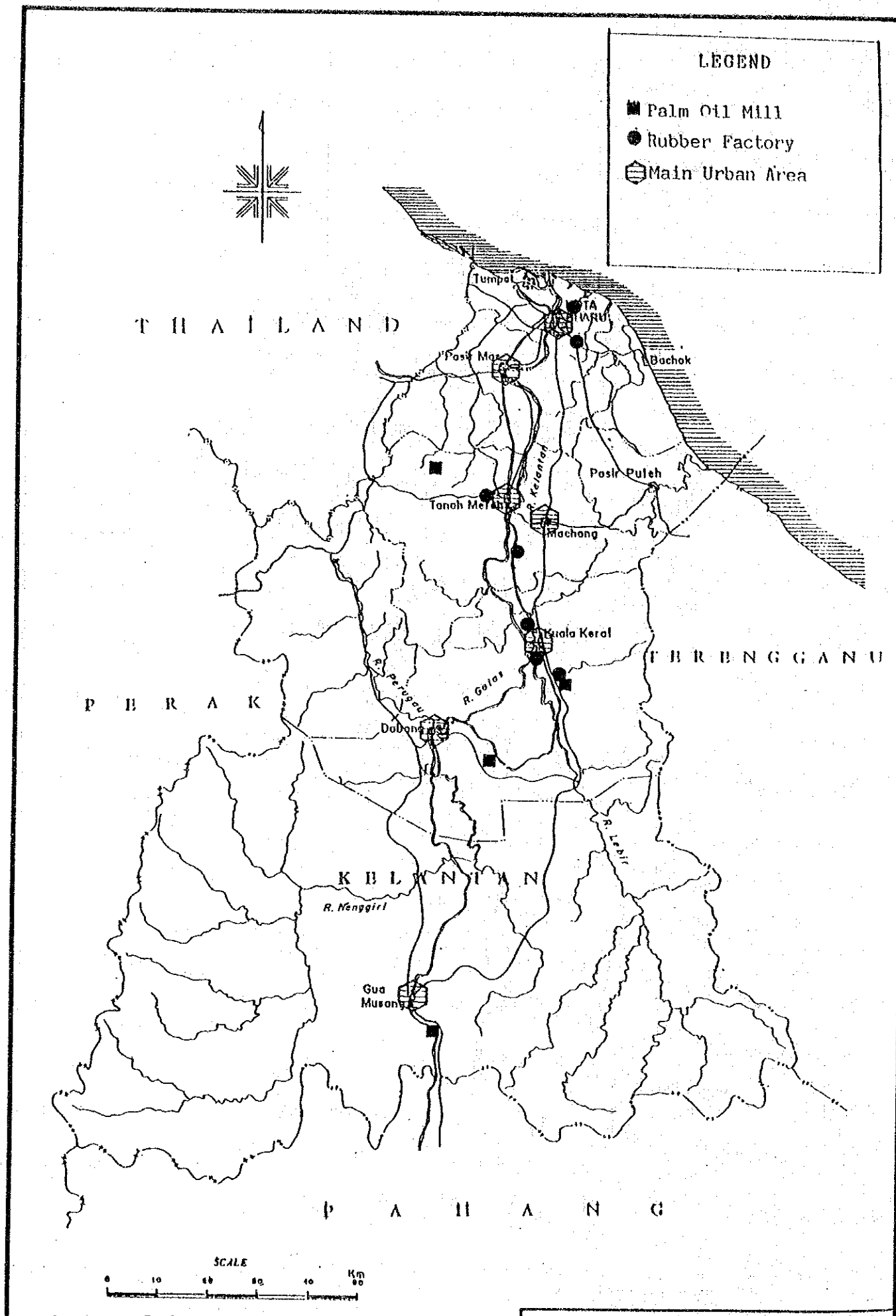

Fig.VI .2.1

Location of Main Pollution Sources

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

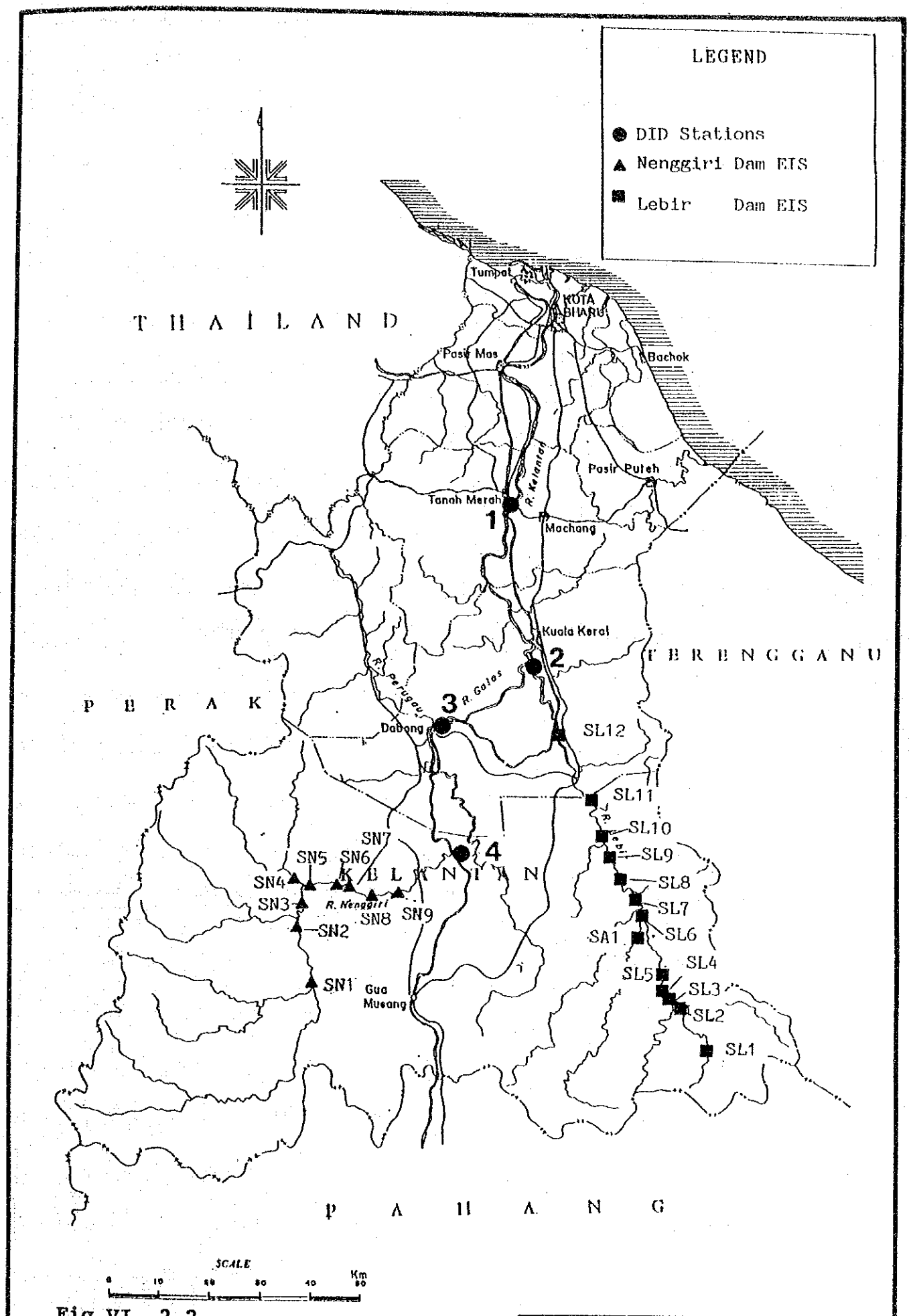

Fig.VI .2.2

Location of Water Quality Monitoring Stations

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

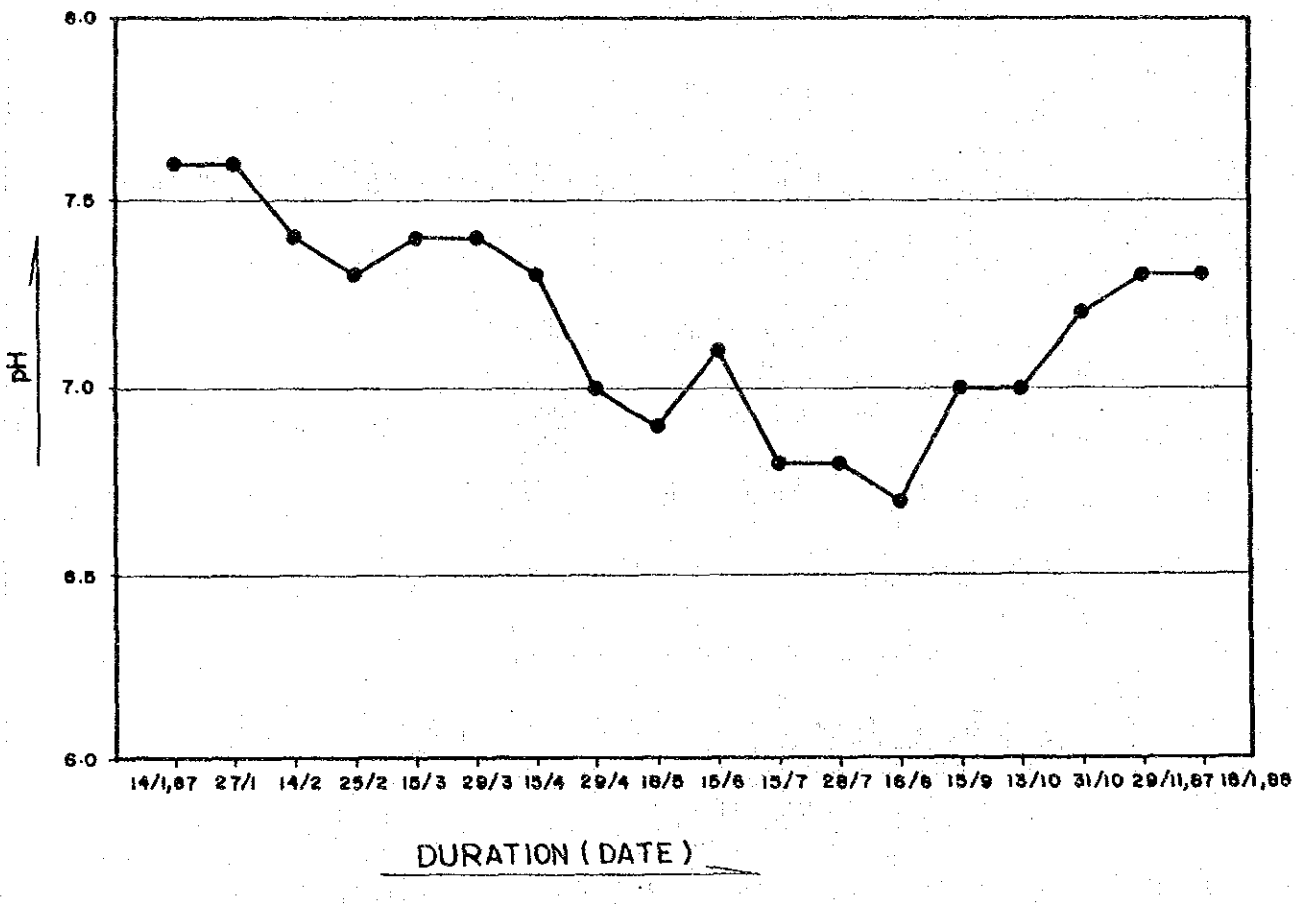

Fig.VI .2.3

pH in the Kelantan River
(Guillemard Bridge)

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

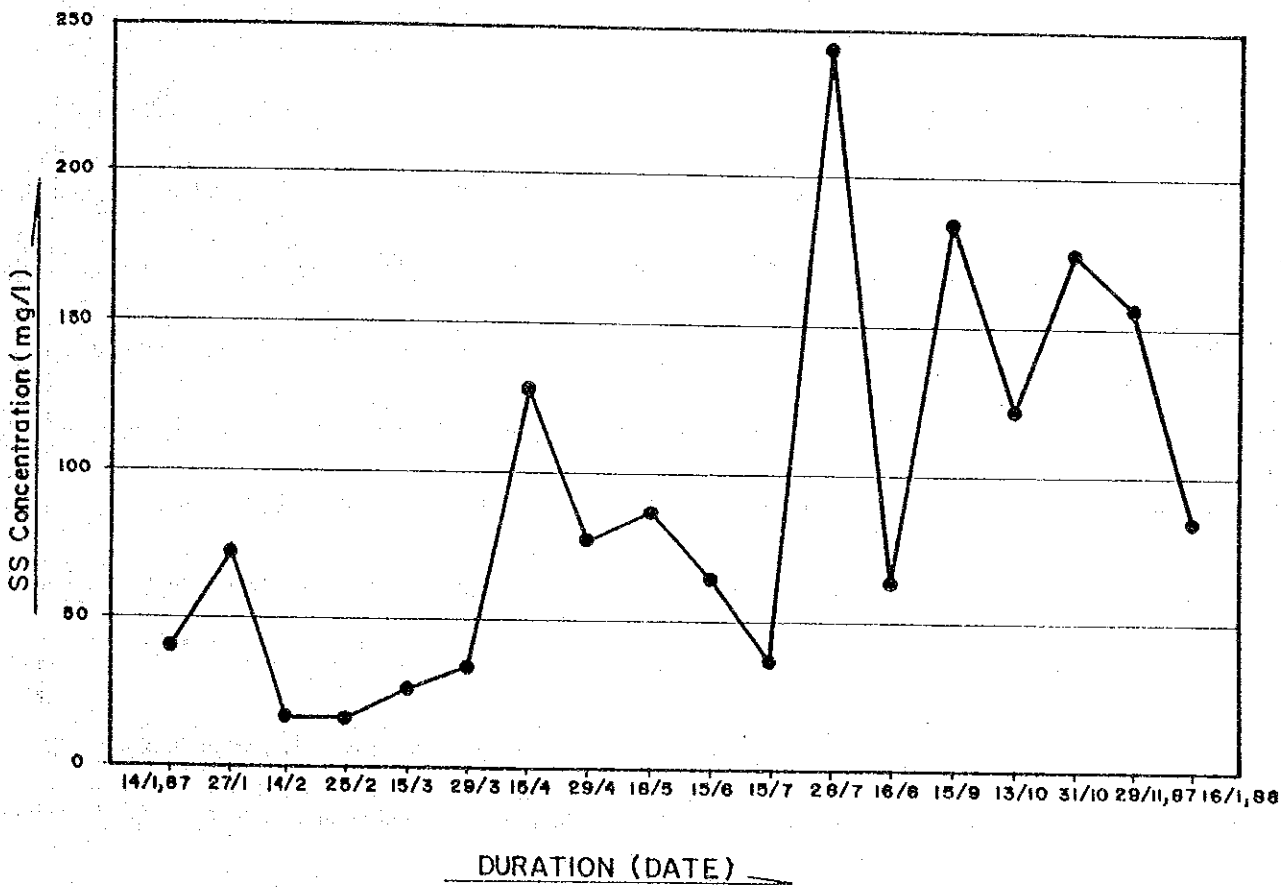

Fig.VI .2.4

SS Concentration in the Kelantan River (Guillemard Bridge)

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

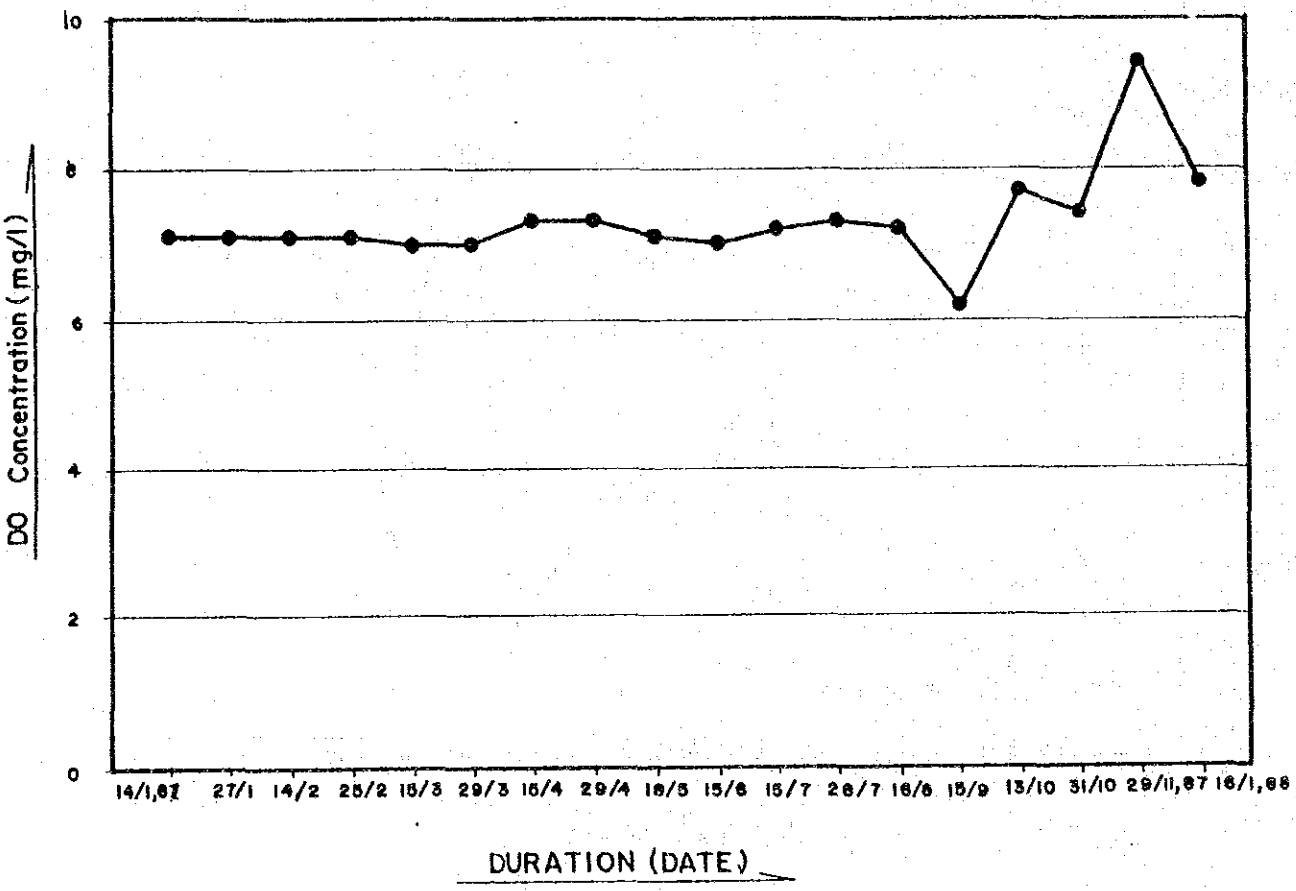

Fig.VI .2.5

DO Concentration in the Kelantan River (Guillemard Bridge)

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

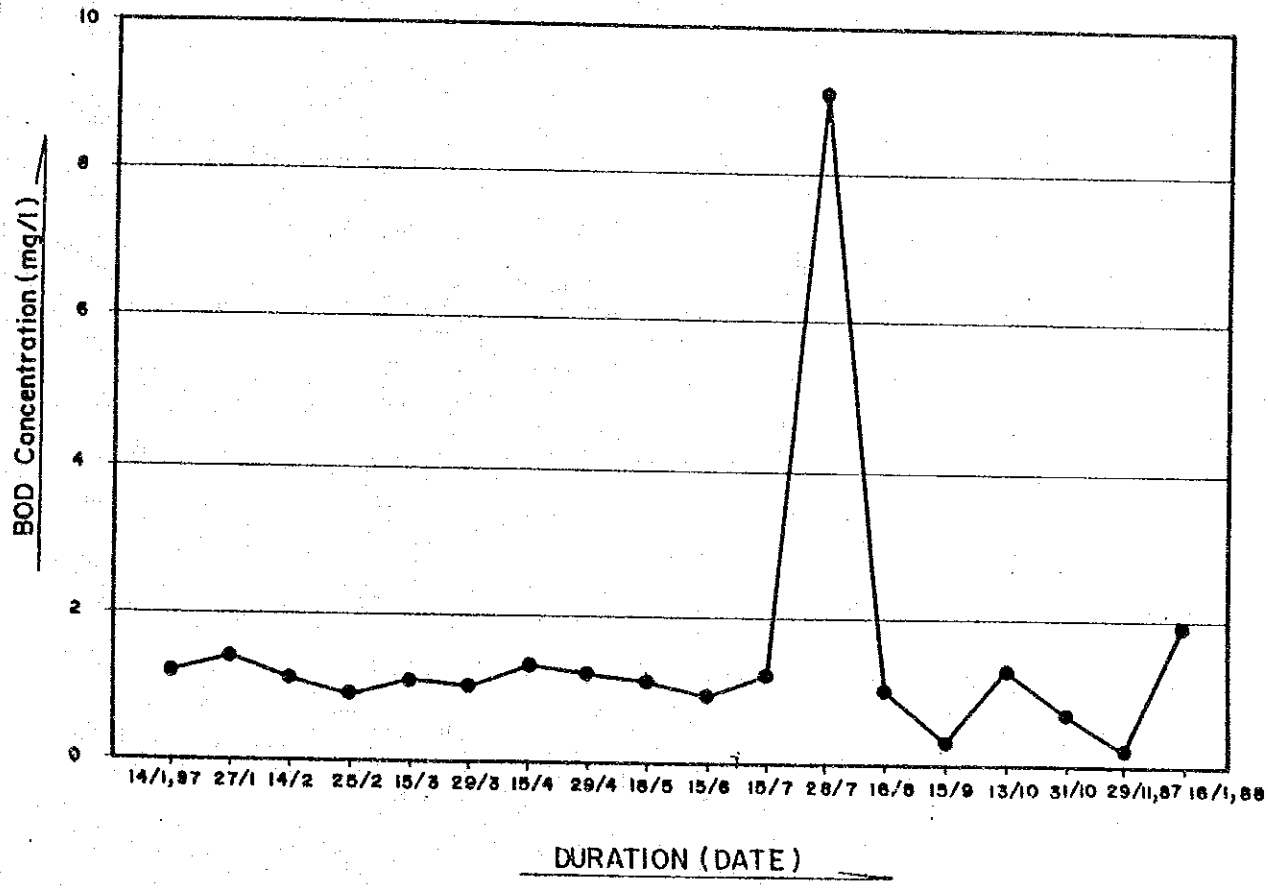

Fig.VI .2.6

BOD Concentration in the Kelantan River (Guillemard Bridge)

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

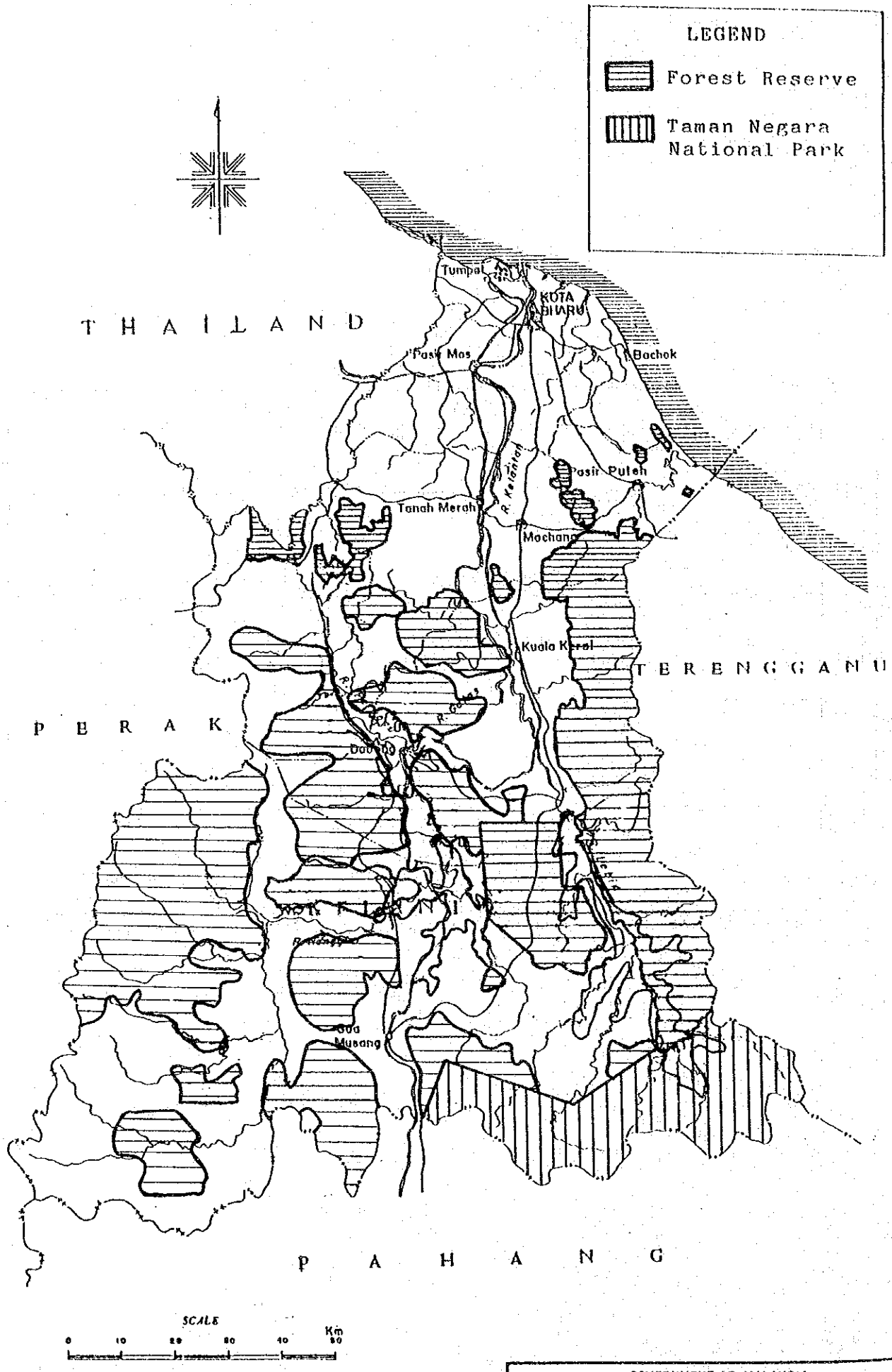

Fig.VI .2.7

Forest Reserve Area Map

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

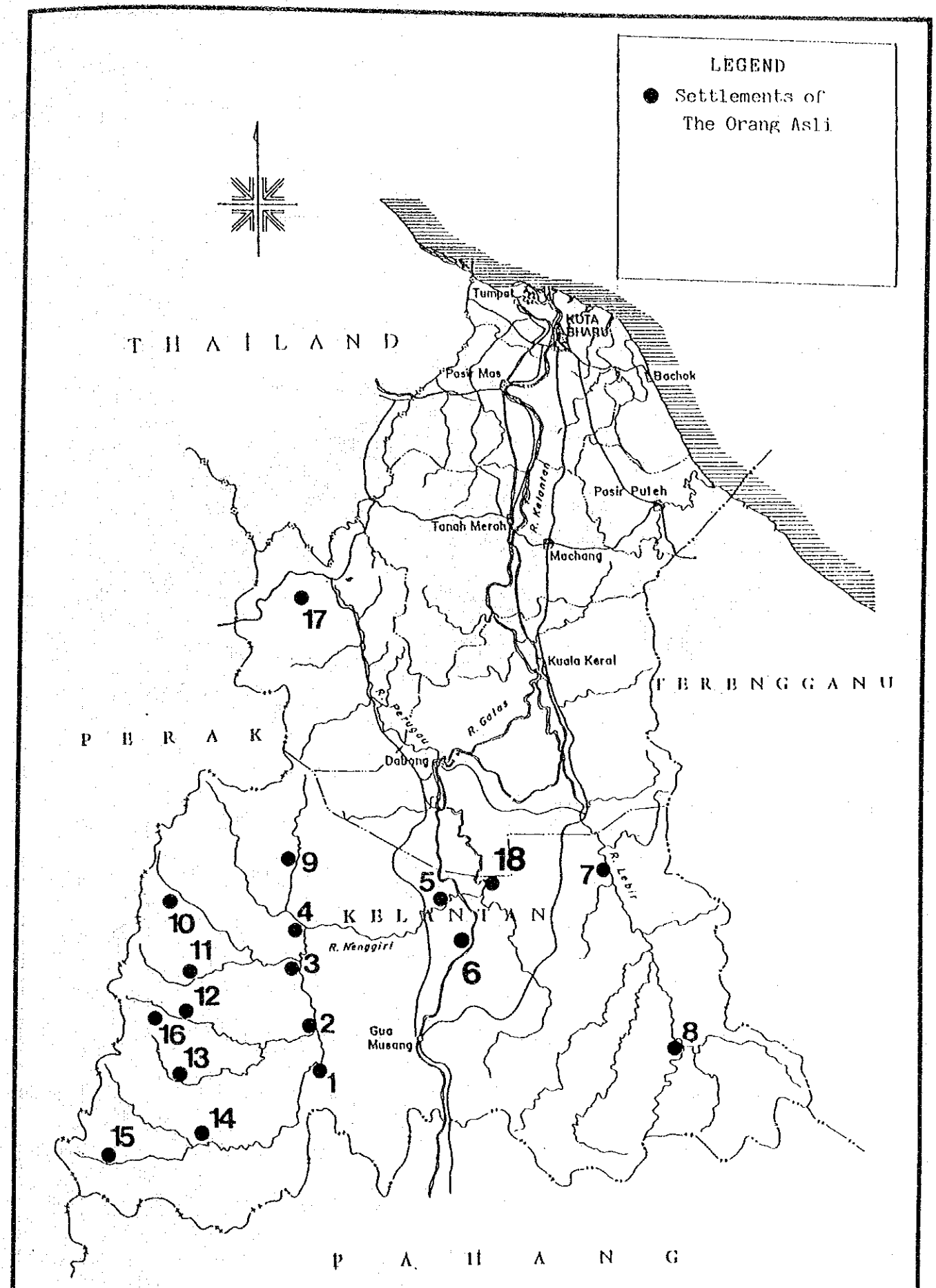

Fig.VI .2.8

Distribution Map of Orang Asli Settlements

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

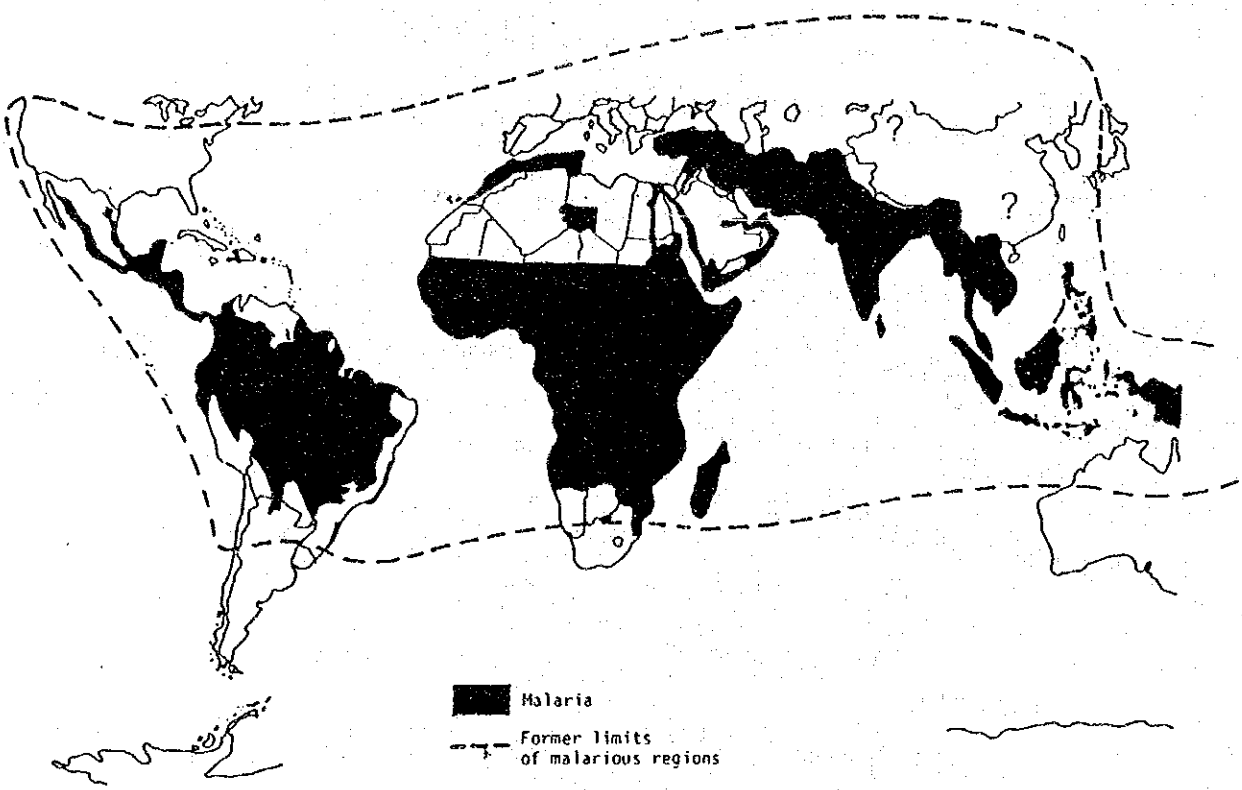

Fig.VI .2.9

Distribution of Malaria, Past and Present
(Source : WHO and Busvine (1975))

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

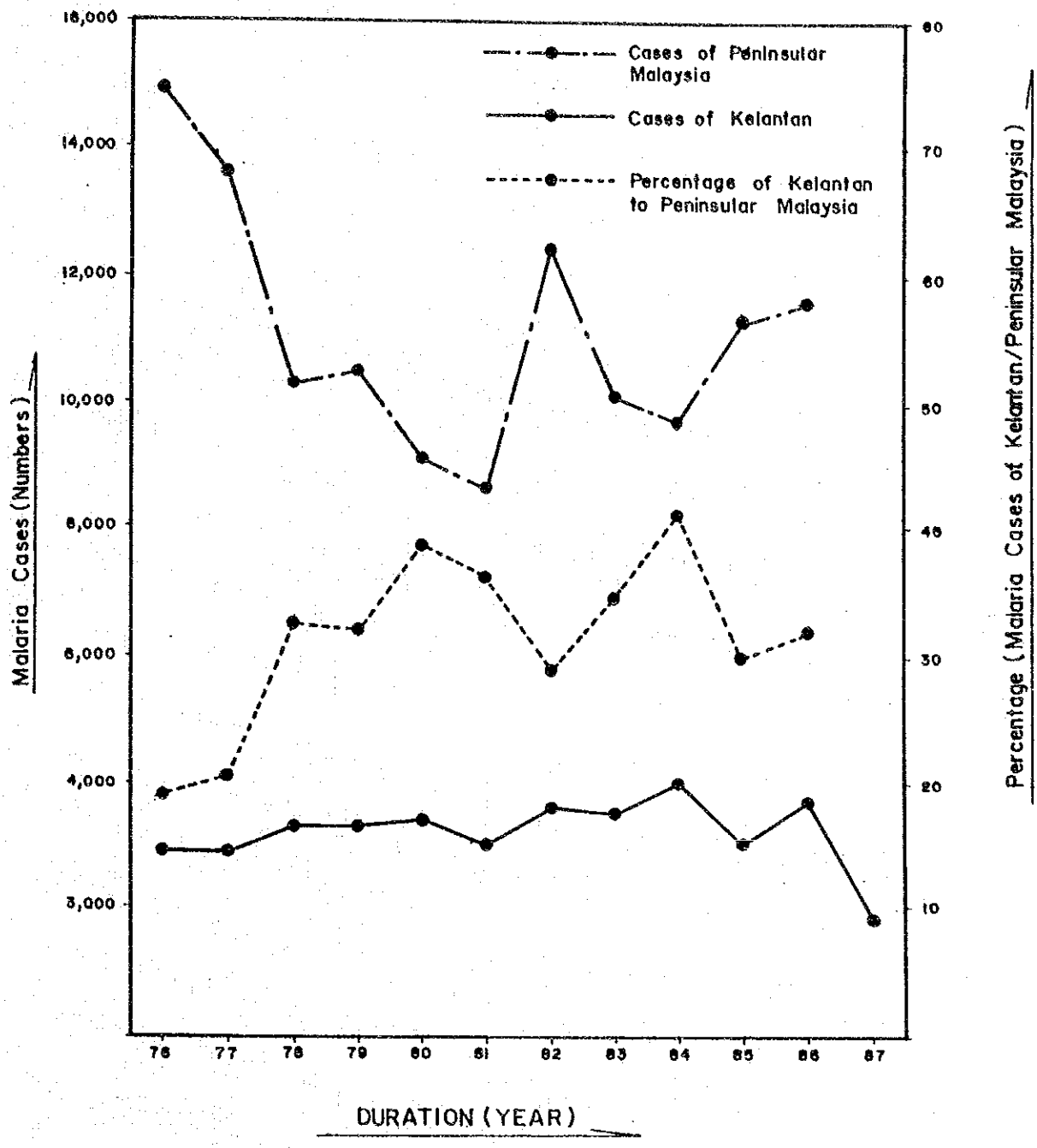

Fig.VI .2.10

Number of Malaria Cases at Peninsular Malaysia and the State of Kelantan

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

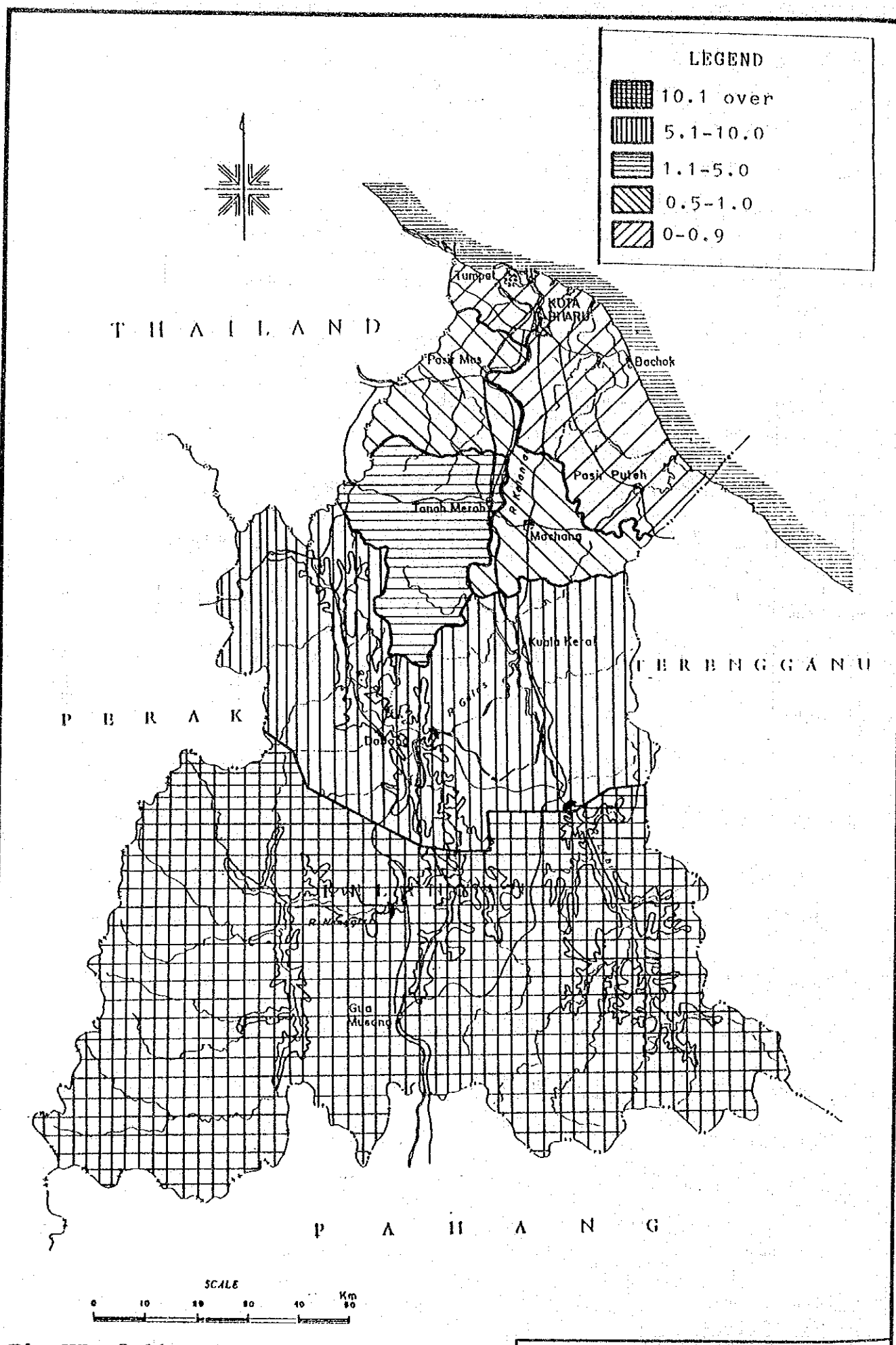

Fig.VI .2.11

Malaria Cases (per 1,000 population)

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

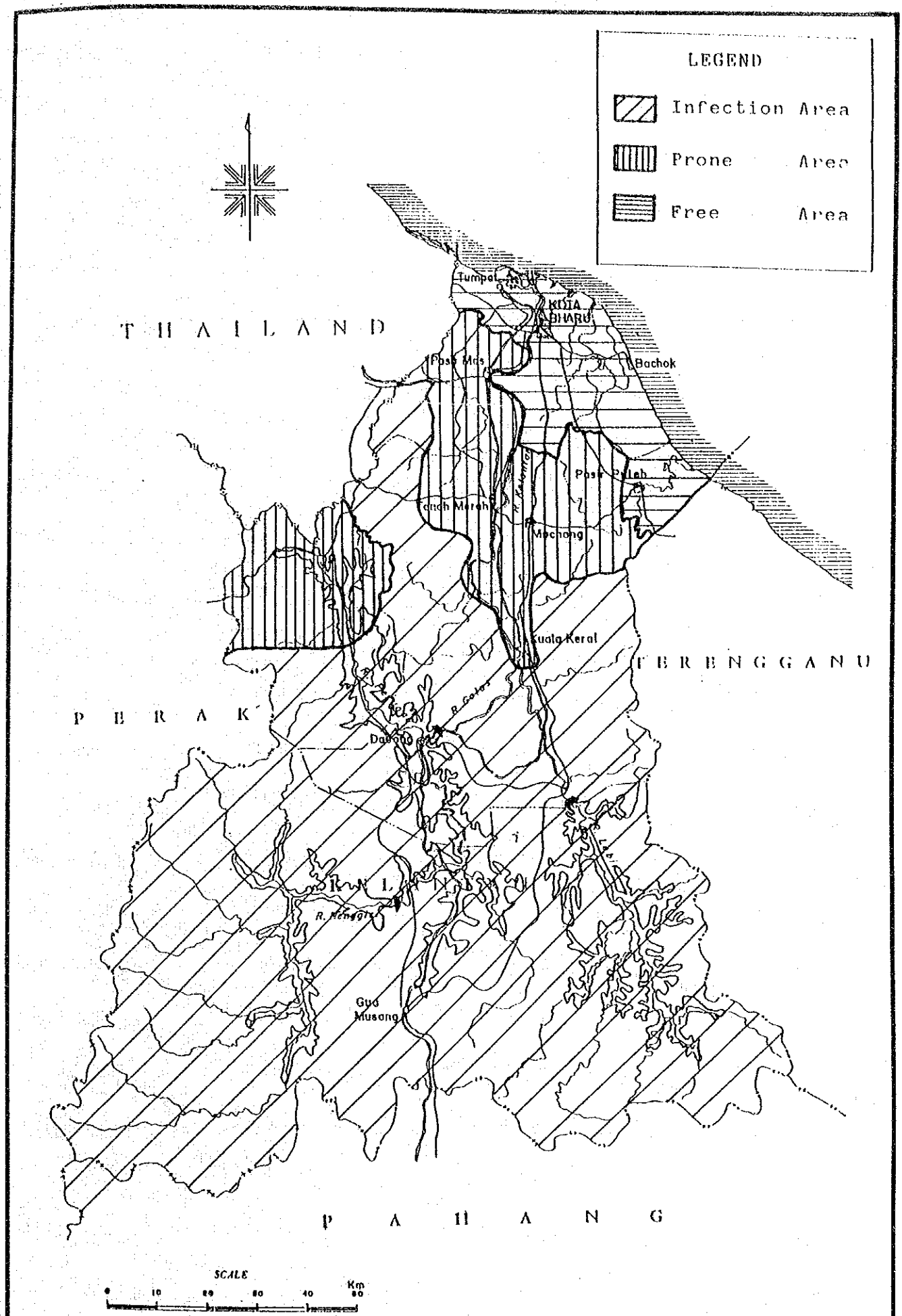

Fig.VI .2.12

Malaria Infection Area

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX VII

STUDY

ON

FLOOD MITIGATION PROJECT

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

VII. STUDY ON FLOOD MITIGATION PROJECT

1. INTRODUCTION

The Kelantan River basin with a catchment area of 13,100 km^2 lies in the northeastern part of Peninsular Malaysia, occupying more than 85% of the Kelantan State. The basin area is bounded by the State of Perak and Thailand on the west, by the State of Pahang on the south and by the State of Terengganu on the east. The northern part of the basin faces the South China Sea. A location map of the Kelantan River basin is shown in Fig. VII.1.1.

The Kelantan River is divided into the Galas and Lebir rivers just at the upstream reach of Kuala Krai, about 100 km upstream from the river mouth. The Galas River is further divided into the Nenggiri and Pergau rivers. The Nenggiri River originates from the central mountain range in the southwestern part of the State of Kelantan, and flows down northeastward collecting many tributaries and changing its name to the Galas River.

The Galas River joins the Pergau River near Dabong, flows down eastward and joins with the Lebir River which originates from the Taban mountain range. After joining the Lebir River with the Galas River, the river changes its name to Kelantan and flows down northward passing along such major towns as Kuala Krai, Tanah Merah, Pasir Mas and Kota Bharu, finally debouching to the South China Sea near Kota Bharu. A total river length is about 360 km.

The topographic features of the Kelantan River basin are characterized by geological strata from north to south direction and it is formed by high mountaneous ranges in the eastern and western zones, which are extending from north to south direction, hilly area in the middle zone and flat area in the downstream reaches.

High mountains situated in the eastern and western parts of the basin consist mainly of granites which are intruded during the Palaeozoic-Tertiary period. They are massive and sound and shape the steep mountain slopes.

The hilly area in the middle zone is predominated by the Palaeozoic-Mesozoic rocks comprising sandstones, shales, limestones, tuffs and volcanics, which are very often regionally metamorphosed into phyllites and slates and further into crystalline schists. Particularly, phyllites, slates and schists are deeply weathered because of plenty of developed cracks and foliations. Limestone having strong resistance to weathering forms high pinnacles which are visually recognized easily.

Geological structure trends strongly north-south or northwestward. The axes of folding and major faults are also oriented in these directions.

The flat area of downstream reaches situated in about 40 km long endmost river stretches consists of the alluvial deposits comprising mainly sand, silt and clay and forms the soft ground. Coarse sand carried by the westward littoral current forms the dunes around the mouth of the Kelantan River and along the coastal area within 10 km inland from the coastline.

The Kelantan River basin is characterized by ample rainfall. The annual rainfall in the basin is about 2,700 mm. Especially, much rainfall occurs in the northeastern part of the basin in the period from October to December due to the northeast monsoon which brings about a half of the annual rainfall amount.

The annual mean temperature is about 27°C. There exists little seasonal variation around the annual mean, in spite of having 28°C of the maximum temperature in May and 25°C of the minimum temperature in December to January. The average relative humidity in the basin is about 81%. The mean annual discharge in the Kelantan River is about 570 m^3/sec at Guillemard Bridge.

Population of the Kelantan State is estimated at 1,091,800 as of 1988. North Kelantan comprising six Districts of Bachok, Kota Bharu, Machang, Pasir Mas, Pasir Puteh and Tumpat occupies 20% of area and 80% of population in the whole state. Whereas, South Kelantan consists of four Districts of Tanah Merah, Jeli, Kuala Krai and Gua Musang, covering 80% of the state area and 20% of the state population.

There are four major towns in the Kelantan River basin which are important in terms of location, population and population density; Kota Bharu, Pasir Mas, Tanah Merah and Kuala Krai. Their respective population in 1988 is estimated at 224,719, 23,145, 15,641 and 16,273. Also, their respective density of population in same year is calculated at 1,782,. 1,165, 182 and 61 per km^2. They are all located in the flood prone area.

The total land area of the Kelantan State is 14,943 km^2 and the average density of population is 73 persons per km^2. The average growth rate of population is estimated at 2.5% for the past eight years.

Total employees are 327,700 with 158,300 (48.3%) in the primary industry, 50,700 (15.5%) in the secondary industry and 18,700 (36.2%) in the tertiary industry. The GDP of Kelantan State for 1988 is estimated to be M$2,684.4 million. Thus, per capita GDP works out at M$2,459. The State economy has grown at the average annual rate of 6.1% during the past eight years.

Out of the total land use area of 1,504,009 ha, 1,119,076 ha (74.4%) is covered with forest, while 320,583 ha (21.3%) for agriculture, 5,365 ha (0.4%) for urban and associated areas and 58,985 ha (3.9%) for other areas. Out of the total area of the agricultural land, 129,413 ha (40.4%) is used for rubber, 71,248 ha (22.2%) for paddy, 61,261 ha (19.1%) for oil palm and 58,661 ha (18.3%) for other crops.

The downstream lowland area in the basin has suffered from

severe flood damages every year. The flood data show that the downstream area of more than 200,000 ha inundated up to the maximum depth of 6 m and about 540,000 of inhabitant has suffered from inundation at the flood time in 1967. It is reported that the duration of inundation lasted about 3 to 4 weeks in the longest period.

The flood mitigation facilities such as levee, revetment, groyne and so on to cope with such repeating inundation have only been constructed by JPT partly in the downstream stretches of the Kelantan River. These facilities are, however, insufficient to decrease flood damages.

In this situation, a basin-wide flood mitigation plan of the Kelantan River has been formulated as discussed in Part I of this study. A combination plan of Lebir and Kemubu dams and river improvement has been selected as the optimal one for the flood mitigation of the Kelantan River basin. This Annex VII deals with the flood mitigation of the Kelantan River by the combination of Lebir and Kemubu dams and river improvement in the pre-feasibility study level.

2. RIVER CHARACTERISTICS AND FLOOD DAMAGE

2.1 Present River Conditions and Characteristics

The longitudinal profile of the river system in the Kelantan River basin is illustrated in Fig. VII.2.1.

About 30 km long Nenggiri River stretches with an altitude of higher than El. 300 m have a steep slope of 1 to 30 to 1 to 40. The Nenggiri River flows down northward to northeastward in a V-shaped river channel passing through the mountaneous zones and joins the Galas River at about 180 km upstream from the river mouth. The river bed slope gradually changes from 1:100 to 1:1,000 in this river stretch. The river width in this stretch is less than 100 m.

After joining the Nenggiri River with the Galas River, the river changes its name to the Galas River, flows down northward and joins with the Pergau River at about 140 km upstream from the river mouth. The river bed slope in the stretch varies from 1:1,000 to 13,000. The river width is around 100 m. Afterward, the Galas River changes its direction to northeast, debouches to plain area changing the river channel from V-shape to U-shape and joins with the Lebir River at about 103 km upstream from the river mouth. The river bed slope in this stretch is around 1:4,000. The river width gradually increases from around 100 m to 400 m.

The Lebir River which originates from the southeastern mountaneous range flows down northwestward to the confluence with the Galas River and changes its river bed slope from around 1:200 to 1:4,000. The V-shaped river channel changes to U-shape after debouching to plain area at about 30 km upstream from the Galas confluence. The river width changes from less than 100 m to around 300 m.

After the confluence of the Galas and Lebir rivers, the river changes its name to the Kelantan River and flows down northward. The river bed slope in this stretch is about 1:6,000. The river channel forms a single cross section with the width of about 300 m to 900 m and bankful depth of about 5 m to 15 m as shown below and further details are given in Fig. VII.2.2:

Section	River width, m	Bankful depth, m
Estuary to Pasir Mas (25 km upstream from the estuary)	600 to 900	5 to 10
Pasir Mas to Tanah Merah (55 km upstream from the estuary)	500	10 to 12
Tanah Merah to Kuala Krai (101 km upstream from the estuary)	300	10 to 15

After the Kelantan River passes along the Kota Bharu town, it flows down about 8 km long stretch and divides into the main river channel to northern direction and several mesh-like river channels to northwestern direction to Tumpat. Large scale sand dunes are being developed at the river mouth from the east to west direction causing closure of the river mouth especially in the dry season.

The variation of the river bed in the Kelantan River was evaluated by the following data:

(i) The variation of lowest river bed elevation at Guillemard Bridge, and

(ii) The comparison between the cross sectional data in this Study and those in 1975 by ENEX.

Fig. VII.2.3 shows the variation of lowest river bed elevation at Guillemard Bridge. The data show that the river bed elevation is quite stable. Although the degradation of river bed was caused by the flooding, the sediment deposits supplying from the upstream basin have gradually aggraded the river bed.

The variation of the river bed in the Kelantan River was also tried to see by comparing the river cross-sections surveyed with an interval of 1 km in this study with the ones prepared by ENEX in 1975 with an interval of 5 km. It was clarified in the comparison of these river cross-sections that the variation of the river bed was little observed in the further upstream reaches.

As for the river bed material, the samples were collected at Kuala Krai, Pasir Mas and the river mouth. As shown in Fig. VII.2.4, the results of sieve analysis show that the river bed material consists of the coarse sand with a median grain size of about 1.2 mm at the river mouth and Pasir Mas and of about 1.8 mm at Kuala Krai.

The comparison of the topographic map prepared in 1955 to 1967 and aerial photograph shot in 1974 to 1976 shows that the sand dune in the river channel varies remarkably in the downstream stretch from Pasir Mas. This comparison also shows that the river channel of the Kelantan becomes wider at the river mouth, the direction of the river mouth shifts westward probably due to the effect of the littoral current, and the original river mouth is being closed by the littoral sand dune.

An island called P. Dollah located at the endmost of the Kelantan River bifurcates its main channel into two; one channel toward Kuala Besar and the other toward Kuala Suri as shown in Fig. VII.2.5. According to the topographic maps prepared in 1955 to 1967, both channels flow in the South China Sea separately. It is observed that sand dunes are not developed in front of both channels and that the channel toward Kuala Besar has a wider channel than that of Kuala Suri. Furthermore, the flow direction of the Kelantan River goes toward Kuala Besar. Taking into

consideration the above facts, the channel toward Kuala Besar is judged to have had a larger function to release flood water than that toward Kuala Suri.

Aerial photographs shot in 1974 to 1976 show such drastic change that the sand dunes developed from the right bank of Kuala Besar extend upto the front of Kuala Suri passing behind P. Dollah. Furthermore, aerial photographs shot in 1980 to 1985 depict further development of sand dunes toward west.

The reconnaissance to the estuary in 1988 observes that the sand dunes in front of Kuala Besar are opened to the South China Sea in spite of narrow width and that the remaining split sand dunes are connected with P. Dollah. Although the endmost of the Kelantan River returns to the condition with two channels toward Kuala Besar and Kuala Suri as observed in the map of 1955 to 1967, clogging of the river channel is still serious.

The 1988 floods occurred on November and December flushed away the sand dunes developed in front of Kuala Besar, resulting in the wider channel at the endmost reaches of the Kelantan River. The formation of sand dunes is however expected to develop at the estuary by the force of westward littoral current in near future, unless the Kelantan River flow with strong tractive force, flood, will arise.

Flow capacity of the Kelantan River by means of non-uniform flow calculation was computed using the cross-sectional maps with an interval of 1 km newly prepared in this study. There are several places where the present bankful flow is less than 5,000 m^3/sec in the downstream reaches of Pasir Mas as illustrated in Fig. VII.2.6, and the present bankful flow at several major points is summarized as follows:

River stretch	Flow capacity (m^3/sec)
Kota Bharu	4,500
Pasir Mas	6,600
Tanah Merah	10,200
Guillemard Bridge	11,000
Kuala Krai	10,500

It is noted that the bankful flow at Kuala Krai shows the capacity of opposite river bank of town area, since inundation takes place at the opposite bank of Kuala Krai at first. Thus, Kuala Krai is free from the bigger flood than 10,500 m^3/sec.

According to the frequency analysis of flood discharges recorded at Guillemard Bridge, flood with peak discharge of greater than 5,500 m^3/sec occurs almost once in two years. It can therefore be said that the Kelantan River inundates more frequently than once in two years.

2.2 Existing Flood Mitigation Facilities

The flat ares in the downstream reaches of the Kelantan River have suffered from habitual inundation mainly due to overtopping of flood water from the Kelantan River channel. To cope with such repeating inundation, JPT has implemented the flood mitigation works at several places in the downstream stretches of the Kelantan River as shown in Fig. VII.2.7.

To prevent the flood flow in the Kelantan River from overflowing to the Kemubu irrigation area, an about 10.5 km long trapezoidal levee of 4 to 5 m in crest width and 1.5 to 2 m in height was constructed in the right bank downstream from the Kemubu pumping station in 1971. Although the levee is cut in several places to make access roads to the Kelantan River, the levee structure is still in a good condition at present. Following this work, an about 1.8 km long revetment comprising sheet piling and foot protection by concrete and stone piling was constructed to protect the left river bank where the river sharply meanders along the Pasir Mas town in 1972. It seems that this work is effective for the prevention of bank erosion in this sharply bent river channel, but a part of the revetment is falling down to the river side at present.

In order to prevent flood water in the Kelantan River from overflowing into the Lemal irrigation scheme, an about 3 km long and 2 to 3 m high levee was constructed in 1984 just at the opposite side of the Kota Bharu town.

In 1986, Kedai Buloh river protection work comprising the stone pitching groyne and revetment with stone piling was constructed for about 800 m long stretches to protect the river bank against bank erosion in Kedai Buloh village at about 3 to 4 km upstream from the river mouth. Besides, tendering work to construct an about 1.2 km long revetment in this stretch is being carried out by JPT.

Temporary river bank protection work by means of sand bag piling was executed in 1987 to protect sandy river bank from severe erosion in the left river bank at about 3 to 4 km downstream from Kota Bharu and tendering work to construct the permanent bank protection work is being carried out.

The river mouth of the Kelantan River is shifting westward due to the closure by sand bar. In order to improve the navigation condition at the river mouth portion, JPT executed about 200 m long open-cut work with the trapezoidal shape of about 5 to 6 m in bottom width in 1983 to cross this sand bar to the South China Sea. However afterward, this open-cut channel was buried by a littoral current and the river mouth is shifting westward at present.

To prevent the flood flow in the Golok River from overflowing to the Malaysian side, an about 17 km long levee was constructed in 1960 in the stretch upstream from river mouth. However, a road with higher embankment which has a function of the levee, was thereafter constructed in the Thailand side, and

consequently flood water overflowed the levee flows into the riparian area of Malaysian side at present.

2.3 Flood Problem and Damage

2.3.1 Rainfall characteristics and past large scale floods

(1) Rainfall characteristics

An isohyetal map of average annual rainfall is prepared using data from 21 rain gauges in the basin as given in Fig. VII.2.8, showing that annual basin rainfall is 2,700 mm on an average.

The isohyetal map so prepared suggests that annual rainfall in the Pergau River basin is the greatest in the basin with the annual rainfall of 3,200 mm in the Jeli area. On the other hand, an isohyetal line of 2,600 mm a year passes in the Lebir River basin, causing a depression of annual rainfall with the value of 2,200 mm a year in the Galas and Nenggiri river basins. This may be resulted from the lee of the north-east monsoon which brings considerable rainfall in the coastal area (2,800 mm a year).

Table VII.2.1 and Fig. VII.2.9 give the distribution of monthly rainfall in the Kelantan River basin, showing that around 50% of annual rainfall on an average occurs from October to December in the coastal plain, while there is no distinctive rainy season and the monthly rainfall depth is evenly distributed in the upstream river basin. The downpour in the period from October to December may endorse the habitual flooding in the downstream area of the Kelantan River.

(2) Past large scale floods

Floods with a magnitude of more than 5,500 m^3/sec occur almost once in two years in the downstream stretches. Among them, the floods occurred in 1967 and 1983 have relatively sufficient data, including hourly rainfall records and data for inundation phenomena.

On 2nd January 1967, heavy rainfall occurred and lasted up to 7th January in the entire Kelantan River basin. The recorded maximum daily rainfall was 585 mm at JPT store, Kota Bharu and 420 mm at Machang P.S. Flood peak discharges at the major gauges were 3,400 m^3/sec at Chegar Atas, 8,700 m^3/sec at Dabong, 4,200 m^3/sec at Tualang and 16,000 m^3/sec at Guillemard Bridge. On 4th January, flood water overtopped the bank of the Kelantan River and the entire coastal plain was inundated. Most of the Kota Bharu town was under water at night time on 4th January.

On 1st December 1983, rain started and lasted up to 15th December in the entire basin area. The maximum rainfall occurred during 3rd to 5th December. The recorded maximum daily rainfall was 290 mm at Machang and 270 mm at Kuala Krai. Flood water overtopped the river bank, and the Kota Bharu town inundated on 5th December. Flood peak discharges were about 1,900 m^3/sec at

Chegar Atas, 6,000 m^3/sec at Dabong, 4,000 m^3/sec at Tualang and 12,000 m^3/sec at Guillemard Bridge.

The floods with double peaks hit the downstream area on November and December of 1988, causing considerable damage. A detail survey for these floods is discussed in the separate Volume (Part III).

2.3.2 Flood flow analysis

The daily rainfall data in the upstream basin for the period of flooding at Guillemard Bridge are not available before 1970, while the records of annual maximum flood peak discharge at Guillemard Bridge are available for the period from 1941 to 1986. The number of samples of annual maximum peak discharge is about two times more than that of basin mean rainfall data.

Furthermore, the second, third and fifth largest floods were recorded in a series of annual maximum peak discharges, while the basin mean rainfall is unable to estimate for those floods because of no rainfall data in the upstream basin.

In the study, probable rainfall depth of 5-day basin mean was estimated to enlarge the recorded hourly hyetographs.

The recorded hyetographs during the flood in December 1983, December 1984 and November 1986 were enlarged up to the 5-day rainfall depth with the selected return period from which the simulated peak discharge corresponding to the probable peak discharge is derived at Guillemard Bridge.

The probable rainfall depth and probable flood peak discharges at storage damsites, Kuala Krai and guillemard Bridge are enumerated in Table VII.2.2.

According to the probable distribution of annual peak discharge at Guillemard Bridge, the peak discharge of 15,589 m^3/sec in 1967 corresponds to the probability of once in about 50-year. The simulated 50-year probable flood hydrograph is verified with the flood hydrograph recorded at Guillemard Bridge in 1967 as shown in Fig. VII.2.10.

2.3.3 Flood damage

A large magnitude flood in 1967 caused heavy flood damage in the downstream plain areas of the Kelantan River basin. Flood damage exerts not only to the destruction of houses, losses of properties and damage to the social infrastructures, but also to the loss of lives especially in the riparian areas.

Such major towns along the Kelantan River as Kuala Krai, Tanah Merah and Pasir Mas were inundated at the beginning of January 1967. In the river stretches along Kota Bharu, flood water overtopped the Kelantan River bank on 4th January and inundated gradually the town area. The maximum inundation depth