The degree of flood protection level that will be achieved for each stretch by the implementation of each project phase is as follows:

Phase / Stretch	Present	Phase I	Phase II	Phase III
Upper Stretch				
Klang River				
K9	1/10~1/25	1/100	1/100	1/100
K10	~1/10	~1/10	1/100	1/100
K11	1/10~1/100	1/10~1/100	1/10~1/100	1/100
Gombak River				
G1	1/25	1/35	1/35	1/100
G2	1/10	1/10~1/25	1/10~1/25	1/100
G3	1/10~1/30	1/30	1/30	1/100
G4	1/5~1/10	1/100	1/100	1/100
Batu River				
B1	1/5~1/10	1/35	1/35	1/100
B2	~1/5	1/100	1/100	1/100
B3	1/10~1/20	1/100	1/100	1/100
Middle stretch				
klang River				
K6	~1/10	~1/10	1/35	1/100
K7	~1/10	~1/10	1/35	1/100
K8	~1/10	1/35	1/35	1/100
Lower Stretch				
K1	1/100~	1/100~	1/100~	1/100~
K2	1/100~	1/100~	1/100~	1/100~
K3	~1/10	~1/10	1/30	1/100
K4	~1/10	~1/10	1/100	1/100
K5	~1/10	~1/10	1/100	1/100

(3) Implementation Program

Considering the results of economic evaluation, degree of urgent social requirement, effect on the downstream area by river improvement and extent of compensation of lands and houses, implementation schedule for Master Plan was worked out as shown in Fig. 4-11.

4.6.4 Construction Cost for the Project

The construction cost for the project includes the costs of civil works, land acquisition, engineering service, administration, and contingency.

The cost required for civil works is calculated by multiplying work quantity by unit cost. The engineering and administration cost is assumed at 5% of the sum of those required for civil work and land acquisition. Cost for contingencies is assumed at 20% of the sum of the above costs.

The total project construction cost of Master Plan is estimated to be 619 million M$ in financial terms at 1988 price level. The cost breakdown of both the financial construction cost and the economic construction cost for each of the three phases of project implementation is as follows:

Phase	Total Cost (Million M$)	
	Financial	Economic
I	193.1	176.3
II	172.4	159.0
III	253.3	231.7

A detailed cost breakdown of each of these three (3) phases are given in Table 4-4 and Table 6-1.

4.6.5 Recommendation for Non-structural Measures

(1) General

For formulating a flood mitigation plan, structural measures alone will not always achieve the objectives effectively. This is due to the fact that the cost of investment required for purely structural measures is enormous. Consequently, a comprehensive flood mitigation plan should always consist of both structural and non-structural measures.

A major non structural measure incorporated is the natural retarding basin at Sg.Rasau (Ref. Fig. 4-5). In addition, the following measures are also recommended.

1) Institutional Framework

2) Establishment of Comprehensive Flood Mitigation Committee

3) Effective Management and Monitoring of the Basin Land Use

4) Identification and Publicizing of Flood Prone Area

5) Encouragement of Individual Flood-proofing Measures

6) Control of Discharge of Tributaries

7) Soil Erosion and Run off Control

8) Formulation of design criteria for river and related structures

9) Flood Forecasting and Warning System

(2) Institutional Framework

At present, there is no clearly defined institutional framework on flood mitigation works in the Klang River basin. This is evident from the adhoc nature of the flood mitigation activities that being carried out by various organizations independently and without a proper coordination among them. For example, some river improvement in tributaries and the upstream of the river were carried out without any consideration to the existing or planned flow capacity of the main river.

Thus, the improvement of river stretches and drains must be implemented in an orderly manner, taking into consideration the whole drainage system in the Klang River basin.

In order to enforce the flood mitigation works effectively it is necessary to set up the practical institutional framework with a clearly defined components.

(3) Comprehensive Flood Mitigation Committee

At present, there is no active coordinating body related to flood mitigation in the whole Klang River basin. In the basins of tributaries the respective local agencies execute the drainage improvement works

according to their own plans independently, whereas DID is responsible for such works in the main river. As such, co-ordination and integration among these Federal and local government agencies in regard to their respective drainage and improvement works is essential for realizing a comprehensive flood mitigation. This is because the improvement works in the upstream drainage basin may protect that area from flooding but may cause flooding at a downstream. Hence it is strongly recommended to set up a Sub-Klang River Comprehensive Flood Mitigation Committee under the Klang Valley Planning Secretariat, for which DID would play leading role as the coordinator because of it's technical and administrative capabities on river and drainage engineering. Such a committee will also offer an opportunity for local participation, thereby contributing further to the Klang river flood mitigation.

The specific functions and responsibilities of the Sub-Committee would include the following:

- To co-ordinate and integrate the various drainage plans and projects.

- To regulate the various basin development plans and projects.

- To maintain the retarding areas in a predetermined mode to mitigate flooding.

- To set up the comprehensive flood mitigation plan, in the whole Klang River Basin, to construct the necessary retention ponds and retarding areas and to formulate and enforce the legal restrictions on basin development activities for flood mitigation purposes.

The Sub-Committee should consist of personnel from the following organizations:

- DID
- EPU

- KVPS
- Ministry of Housing and Local Government
- JKR
- Kuala Lumpur City Hall
- Shah Alam
- Petaling Jaya
- Kelang town
- Port Kelang

(4) Effective Management and Monitoring of the Basin Land Use

This Master Plan is based on the land use pattern in the target year of 2005. Hence it is necessary to monitor actual land use pattern.

At present, there are many squatters in the river reserve area and consequently resulting in river pollution in addition to hindering the river improvement works.

Hence DID should take the appropriate measures to overcome these problems caused by these squatter settlements.

(5) Identification and Publicizing of Flood Prone Areas

It is very important to identify and publicize the flood prone areas in the form of a Flood Risk Map. The main purpose of publicizing the flood risk map is summarized as follows:

- To recognize the possibility of inundation of a built-up area by the inhabitants.

- To enhance the awareness and concern among residents on flood protection measures, and evacuation system in order to ensure an effective use of such flood protection activities / evacuation procedures in case of an emergency.

- To instil the adaptability to flooding problems and the necessary self precautionary measures.

The flood risk map will be prepared using the topographic map to a scale of 1:25,000.

However, in Malaysia the use of topographical maps are strictly restricted to offical purposes only. Further more, general publication of these maps is illegal.

Hence it is recommended to institute the necessary legal provisions, so that atleast the publication of topographical maps of the flood prone areas, the flood risk maps, showing the flood prone areas and its surroundings to include the places of evacuation, be allowed.

A simplified version of the Flood Risk Map for a 100 year return period floods is shown in Fig. 4-12.

(6) Encouragement of Individual Flood Proofing Measures

The main causes of recent flooding problem in the study area are the recent land development activities and increase in urbanization. The local residents should be made aware of this fact and their active participation should be sought in lessening flood discharge from their private residences. It is recommended that as far as possible, all new housing to be provided with pervious gardens, passages and rainwater retention ponds individually or in groups.

(7) Control of Discharge of Tributaries

It is recommended to set a maximum limit on discharge from the tributaries to the main rivers.

These tributaries are Sg.Jinjang, Sg.Keroh. Sg.Bunus, Sg.Kerayong and Sg.Damansara. Some of these tributaries often overflow their banks causing damage.

In order not to overload the main river beyond the design discharge, the maximum use of the existing ex-mining ponds along these tributaries as potential retention ponds is recommended.

A criteria of instituting new retention ponds in accordance with new land development activities in these tributary drainage basins instead of the drainage channel improvement works as being practised at present is recommended.

Location and flood control effectiveness of the potential retention ponds in the tributary basins are dealt with in details in chapter 10 and APPENDIX P.

(8) Soil Erosion and Run-off Control

There are many development activities in the study area which may often involve the removal of top soils thereby leading to severe soil erosion and sedimentation, a case of nonpoint source pollution. This problem is rather acute in slopy terrains with housing development activities. During the course of such development activities, sediment transport with storm water run-off should be controlled at the source itself. It is possible to control the discharge of sediments by flash floods using storm water retention ponds. It is recommended to formulate criteria for the installation of storm water retention ponds inaccordance with the degree of land development activities when potential soil erosion is anticipated.

After the completion of the land development activities like housing, etc., some regrassing and vegetation also should be retrieved as an erosion control measure at source.

(9) Formulation of Design Criteria for River and Related Structures

It is recommended to formulate design criteria for river and related structures such as bridges, weir, gate, etc.

This is to ensure that such river and related structures do not hinder free flow under the conditions of flooding.

The design criteria should clearly define minimum tolerance, clearance and space with respect to the river structure concerned.

(10) Flood Forecasting and Warning System

The flood forecasting and warning system should be capable of disseminating timely information on the danger of flooding to the maximum possible degree of accuracy. This would enable the residents of such flood prone areas to undertake the necessary precautionary measures.

In order to forecast rainfall quickly the installation of a radar rainfall gauge is recommended so that this gauge could collect the cumulative rainfall at every 5 minutes interval. It should also record an accurate measurement of the rainfall area in a very small unit.

Radar rain-gauge can detect areal torrential downpours and the processed radar data can be displayed on a CRT display for direct visual check.

Before the introduction of the Radar rain-gauge system, it is a prerequisite to have a thorough understanding of the hydrological requirements by carrying out a site survey, and by conducting a radio propagation. It is also important to make a thorough investigation of system requirement, the method of data collection and the scope of data processing. Other factors to be considered in introducing the Radar rain-gauge system include personnel requirement and training programs, and programs for operation and maintenance of equipment.

The important factors to be studied in the selection of Radar System are the required range of detection and the appropriate location of the radar station.

- Range of detection

  The suitable type and performance requirements of the Radar rain-gauge must be selected according to the scope of observations. In the Klang River basin, the Radar rain-gauge system is intended to cover the whole river basin. Since the occurrence of rainfall zones is unpredictable and highly

localised, the Radar is to be of short range type with a detecting range of up to 30 km in radius.

- Selection of Location for Radar Station

As alternative locations of Radar Station, the high-rise buildings in the center of the city, Genting Highland, Batu Cave, Bt Din din and JPT Ampang Building were studied.

The major high-rise buildings in the City are not suitable for the installation of Radar Station because of the heli-port on the rooftop. Genting Highland is too far from the City hence has difficulty with respect to maintenance and data transmission. The hill of Batu Cave has the difficulty of accessibility. Bt Din Din hill (HAWTHORNDEN), located in the right side of the Klang River, seems to be the most suitable place for the permanent location of Radar Station. But the approach road to the top of the hill has yet to be constructed. However it is recommended to secure the necessary land for the Radar Station in advance in case of future use after the completion of the access road. Until then the JPT Ampang Building seems to be suitable for installing the Radar Station for the time being, only as a temporary measure. This is because eventhough obstruction due to surrounding high-rise buildings is negligible at present, such obstructions are expected to increase in future.

However, a detailed alternative study is necessary to confirm the suitable location of the radar station. In addition it is also required to carefully identity the optimum and effective usage of the Radar System, to upgrade the existing data bases and systems of flood forecasting and warning, during this detailed studies.

(11) Areas of Non-Structural Measures

Non-structural measures will be adopted in the following areas (in addition to the retarding basin at Sg. Rasau) considering the present and future conditions of the basin.

Non-structural measures	Adopted area
- Land use planning and control	Whole basin, especially for ex-mining ponds proposed as potential retention pond and river reserve
- Identification and publicizing of flood prone area	Low lying area in the lower reach, and proposed natural retarding basin area
- Encouragement of individual flood-proofing measures	Newly developing area of the whole basin, especially for the upper basin
- Soil erosion and run-off control	Newly developing area, especially for the upper basin
- Flood forecasting and warning system	Upstream stretches of Puchong Drop of the Klang River and tributaries

4.7 ECONOMIC EVALUATION FOR MASTER PLAN

4.7.1 Benefit of Flood Mitigation Project

The benefit of flood mitigation project is defined as the difference in the amount of damage "with the project" and "without the project". In this study, six (6) cases of return period of flood damage i.e. 10-year, 30-year, 50-year, 80-year, 100-year and 200-year return period of flood were estimated and shown below (in million M$, for the year 2005):

	Market Cost	Economic Damage Cost
10-year return period	956.7	920.1
30-year return period	1,342.5	1,291.4
50-year return period	1,929.0	1,855.7
80-year return period	2,190.1	2,106.9
100-year return period	2,286.5	2,199.6
200-year return period	2,502.7	2,407.8

The average annual flood damage reduction is calculated by using the following equation:

$$D = \sum [(N_{m-1} - N_m) \times (L_{m-1} + L_m)/2]$$

where, D : Average annual damage reduction
N : Probability of floods
L : Damage potential corresponding to probability of flood
m : Ordinal number

In estimating the annual average damage, the 100-year return period is adopted as a maximum frequency because this return period corresponds to the design flood frequency of the Master Plan.

Average annual damage reduction in the year 1988 and 2005 were estimated as 70.1 and 160.9 million M$, respectively (1988 price).

4.7.2 Economic Evaluation

The economic evaluation of the project was made in terms of the Internal Rate of Return (IRR), Net Present Value (NPV) and Benefit-Cost ratio (B/C), based on the following assumptions:

1) The financial project cost could be converted into economic cost by applying the conversion factors.
The total construction cost is estimated at 618.8 (million M$, 1988 price).

2) The total economic construction costs were equally distributed to each year of the construction period. (Construction period is assumed to be 15 years from 1993 to 2007.)
The total economic construction cost is estimated at 567.2 (million M$, 1988 prices).

3) The annual operation and maintenance costs are assumed to be 1.0% of economic construction cost.

4) The project benefits are assumed to be realized from 5 years after the beginning of the project implementation, in 1998.

5) The opportunity cost of capital is 13.0%.

The results of this Economic Evaluation is as follows:

1) IRR = 19.5%
2) B/C = 1.66
3) NPV = 193,145 (M$1000)

Cash flows of costs and benefits for Master Plan is shown in Table 4-5. These results show that this flood mitigation plan is economically feasible.

CHAPTER 5. URGENT FLOOD MITIGATION PLAN

5.1 General

The comprehensive flood mitigation plan aims to mitigate flood damage not only in the existing, but also future urban area. The economic viability of the plan under the present stage is not high for the downstream stretches, where much capital will be required due to large project scale. However, as mentioned in the APPENDIX G, the existing urban area of Kuala Lumpur City often suffers from flood damage and requires immediate attention. For this reason, an "urgent flood mitigation plan" based on the master plan is studied to formulate a priority project for immediate implementation, aimed at mitigating of flood damage in the existing urban area.

5.2 Selection of Area for Urgent Flood Mitigation Project

The drainage basin and the corresponding river stretch for consideration to the flood mitigation facility of the urgent Flood Mitigation Project, that consists of structural measures of flood mitigation, is to be selected by taking into account the following factors;

- The extent of economic effectiveness
- Degree of urgency based on social requirement
- Scale of investment
- Frequency of inundation
- Current situation of on-going river improvement works
- Effects imparted to downstream due to the project realization
- Extent of compensation for existing facilities
- Time requirement for removal of squatters
- Degree of complexity involved in project execution

Among those flood prone areas that are in need of structural measures, the upper reach of Sulaiman Bridge was selected for feasibility study of the Urgent Flood Mitigation Plan due to the following reasons:

(1) Among the proposed flood control projects area, this stretch at upper reach of Sulaiman bridge has the highest economic viability.

(2) A retention pond is very reliable, and hence, the reduction of peak discharge could be achieved with high degree of certainty to mitigate flood damage at downstream.

(3) In this upper reach area of Sulaiman bridge, there are many flood prone areas including the low-lying area of Kg. Baru which is frequently inundated by flash floods. Based on this fact and governmental requirements, this area must be included in the urgent project.

(4) The river improvement work in the Kuala Lumpur city center, which forms a portion of this selected project area, is partly executed by DID, with problems involving land acquisition being partly solved.

5.3 Flood Protection Level of Urgent Project

As described in APPENDIX E, the river stretches in the central part of the City are already partially improved. These stretches have been widened to their final widths with only the excavation works of river beds still remain to be executed. The river beds of these stretches can be excavated only after the completion of improvement works of downstream stretches. Hence, the existing flow capacity of these stretches will be the same as that prior to the implementation of urgent project works, but the flood protection level will be raised due to the effect of flood mitigation by retention pond.

At Sulaiman Bridge of the Klang River, the flood protection level will be increased from 1/25 to 1/35 after the completion of this urgent flood mitigation plan.

Design flood distribution for urgent project is shown in Fig. 5-1.

5.4 Proposed Urgent Flood Mitigation Plan

5.4.1 Flood Mitigation Facilities for Urgent Project

The flood mitigation facilities to be executed in Phase-I of urgent project are shown in Table 5-1 and Fig. 5-2.

The river improvement works will be executed for the stretches of 10.4 km in length of the Klang, Gombak and Batu Rivers.

The stretch K9 of the Klang River is the one that has the highest priority for improvement, and also the stretches G4, B2 and B3 have to be improved for the effective use of the Batu Retention Pond.

The Batu Retention Pond and the Gombak Diversion Channel will also be constructed in this stage.

Five bridges across the Batu River and one bridge across the Klang River are to be reconstructed.

5.4.2 River Improvement

In the Klang River, the K9 stretch of 1.3 km in length between Tun Perak Bridge and Jln. Sultan Ismail Bridge is to be widened and deepened. With completion of this improvement works, the whole stretches between 3rd Mile Railway Bridge and Circular Road Bridge of the Klang River will be completed, with only a partial deepening works of the river bed still remain to be executed. K9 channel section is double cross section and consists of retaining walls with sheet piles and concrete lining on the berms.

In the Gombak River, the G4 stretch of 2.5 km in length between Sg. Belongkong confluence and Gombak Diversion channel is to be widened and deepened to facilitate diverting the design discharge into diversion channel. The channel has double cross section with concrete retaining walls in the low flow channel. The berm will be protected with sod-facing.

In the Batu River, the stretch B3 along the proposed retention pond and the stretch B2 between Ipoh Road Bridge and Sg. Batang Tolak confluence are to be widened and deepened to obtain the necessary effective water depth of retention pond. The channel is of 6.6 km long and double cross section with concrete retaining walls in low flow channel. The construction of three drop structures are also to be executed. Five bridges across to Batu River are to be reconstructed due to increased width of span of the proposed river section.

In the B3 stretch, there exists a primary regulation pond to serve during flooding. The design longitudinal profiles and cross sections of these stretches are shown in Figs. 5-3 to 5-6.

5.4.3 Batu Retention Pond

(1) Retention Pond

The Batu Retention Pond will be constructed using the ex-mining area bordering the western bank of the Batu River, lying between 6.0 km point and 8.4 km point of the Batu River.

During the design flood of 100-year return period, 60 m^3/s from the Gombak River and 40 m^3/s from the Batu River will flow into the retention pond.

The capacity of the Retention Pond is 2,700,000 cubic meters and the maximum effective depth for flood mitigation will be 7.3 meter. The dimensions of this pond are as follows:

Pond Capacity		2,700,000 m^3
Pond Area		61.4 ha
Permanent only		30.5 ha
Temporary only		30.9 ha

Entire Area of Retention Pond
including Park area 113.4 ha

Water Level of Pond

L.W.L.	:	EL. 38.20 m
H.W.L.	:	EL. 43.70 m
Max. H.W.L.	:	EL. 45.50 m

Top of Levee : EL. 47.00 m

Bottom level of permanent pond: 15.00 m

The retention pond is categorized into sections according to their functions in terms of flood mitigation. The plan of the Retention Pond is shown in Fig. 5-7.

The central section of the pond is permanently filled with water. The depth of this pond is about 23 m. The edges of this pond will be landscaped from upper reach down to the lower, adjoining the waterfront. This permanent pond will be capable of containing the flood water caused by a nominal flash floods only with a slight increase in pond water level. Typical sections of the retention pond are shown in Fig. 5-8.

The section surrounding the permanent pond is planned as the temporary pond. This portion of the pond serves for flood mitigation during flooding. However, this section is normally used as a parkland to cater for needs of diversified facilities of sports and recreational activities.

The entire temporary retention pond area will be sub-divided into several portions to meet the retention capacity required for various probable floods. Figs. 5-9 and 5-10 show the water level of the pond and water surface for various probable floods, respectively.

(2) Structures Related to Retention Pond

For the effective operation and maintenance of the Retention Pond, the following related structures will be necessary.

i) Regulation Pond

This pond will be constructed near the Retention Pond to the east as illustrated in Fig. 5-7. This pond is located at the confluence of the Batu River and Gombak Diversion Channel and serves as a regulation pond for diverting the design discharge over the diversion weir during flooding. Under normal circumstances, this pond serves as a sedimentation pond for the Batu River.

The floating debris can be screened ahead of the water gate and diversion weir through the screening facilities. This pond has an area of 55,600 square meters and a maximum depth of 4.5 m.

ii) Diversion Weir

The diversion weir is to be constructed between retention pond and regulation pond to divert the discharge of 100 m^3/s into the retention pond.

The weir is of 4.5 m high and 50 m long. The final dimensions of this weir as well as Gombak Diversion Weir should be decided by carrying out hydraulic model test. Fig. 5-11 shows longitudinal section of the weir.

iii) Inlet Sluice Gate

At the uppermost part of the Retention Pond the sluice gate (B = 1.0 m, H = 1.5 m) is to be installed to introduce the maintenance water from the Batu River to the Retention Pond. The plan and longitudinal profile are shown in Fig. 5-12.

iv) Outlet Sluice Gate

At the lowermost portion of the Retention Pond, the outlet gates (B = 2.5 m, H = 2.5 m, 4 sets) will be installed to release the pond water into the Batu River after flooding. The plan and longitudinal section are shown in Fig. 5-13.

v) Water Gate in the Batu River

In the south side of the regulation pond, the water gates with two double leaves will be constructed to release the maximum discharge of 25 m^3/s to the downstream during flooding. This gate will be fully opened after flooding or in the case of excess floods. The longitudinal and cross section of the Water Gate are shown in Fig. 5-14.

5.4.4 Gombak Diversion Channel

The diversion channel is to be located along the route connecting the 9.9 km point of the Gombak River to the 7.4 km point of the Batu River.

The channel route passes through the original ex-mining area which has been filled up and developed into housing and agricultural land. Only a few houses along the route will have to be relocated.

Major related structures are two box culverts which cross K.L.-Karak Highway and urban planning road near the Batu Retention Pond, and five bridges.

The overflow weir which is of 55 meter long and 2.60 meter high will be constructed at the entrance of the diversion channel. The diversion channel with 3,250 m length flows into the primary regulation pond.

For the stretch of 600 m length that will pass through the Malay reservation, two alternative types of channels are evaluated and the results are summanized below:

	Type	Direct Cost (M$)	Land Acquisition cost (M$)	Total Cost (M$)
A	Open channel	1,004,700	563,100	1,567,800
B	Closed channel	3,782,000	281,600	4,063,600

A type was selected in consideration to its ease of maintenance, and low construction cost. Plan, longitudinal profile, and cross sections of the channel are shown in Figs. 5-15 and 5-16 respectively.

5.4.5 Drainage Plan in Kampung Baru Area

Kampung Baru area is one of the infamous flood prone low lying areas and approximately 52 ha of resident area was inundated and severely damaged by the January 1971 floods.

About 35 ha of this area will be lower than the design flood level of the Klang River after completion of all improvement works. In this area, there are seven existing outlet structures. However, as these gates are not properly operated, this area is frequently inundated by flash floods. To solve this inner water problem, a pumped drainage system with underground pondage is proposed as the countermeasure.

Pump capacity and underground pondage capacity was selected based on the comparative study considering the hydrological and economic conditions. The details are described in APPENDIX J.

The selected optimum scale of the plan is summarized below:

Design recurrence intervals : 5-years
Pump capacity : 2 m^3/s
Underground pondage capacity : 32,700 m^3

Trunk drainage : Box culvert 2,050 m

The plan and sections of this pumping station are shown in Figs. 5-17 and 5-18.

5.4.6 Proposed Urgent Flood Mitigation Works

Based on the proposed river channel and retention pond mentioned above, the following major works are proposed to be necessary for the urgent flood mitigation project in this study.

(1) Main stream of the Klang River

a. Excavation/dredging of channel
b. Bank protection by means of concrete wall and steel sheet pile
c. Reconstruction of bridge
d. Construction of drop structure

(2) The Gombak River

a. Excavation of channel
b. Bank protection by means of concrete wall and steel sheet pile
c. Reconstruction of bridges
d. Construction of drop structures

(3) The Batu River

a. Excavation of channel
b. Bank protection by means of concrete wall and steel sheet pile
c. Reconstruction of bridges
d. Construction of drop structures

(4) The Gombak Diversion Channel

a. Construction of overflow weir for diversion
b. Excavation of channel
c. Construction of concrete box culverts
d. Construction of bridges
e. Bank protection of concrete block/concrete retaining wall

(5) The Batu Retention Pond

a. Excavation of pond
b. Embankment of levee
c. Bank protection by means of concrete block/sod facing
d. Construction of overflow-type diversion weir
e. Construction of inlet sluice gate/outlet sluice gate
f. Earthwork for park area
g. Construction of bridge

(6) Inner Water Drainage in Lowlying Areas

a. Construction of pumping station
b. Construction of underground pondage
c. Construction of trunk drainage

The quantities of the proposed work are summarized below.

River channel improvement

Excavation/dredging	838.5×10^3 m^3
Embankment	26.6×10^3 m^3
Bank protection	
Concrete wall	-
Steel sheet pile	111.0×10^3 m^2
Sod facing	231.1×10^3 m^2
Concrete facing	8.8×10^3 m^3
Concrete block	38.9×10^3 m^2
Construction of drop structure	3 nos
Reconstruction of bridges	6 nos

Construction of overflow weir	2 nos
Construction of concrete box culverts	2 nos

Retention pond

Excavation	$2,324.6 \times 10^3$ m^3
Embankment	$2,030.0 \times 10^3$ m^3
Bank protection	
Sod facing	501.7×10^3 m^2
Concrete block	2.1×10^3 m^2
Construction of sluice gate	1 no
Construction of bridge	1 no

Inner water drainage

Construction of pumping station	4 nos
Construction of underground pondage	1 no
Construction of trunk drainage	2,050 m

5.4.7 Land Acquisition

Land acquisition and compensation are required prior to the execution of the construction works. These quantities are summarized below:

Work Item	Land Acquisition
River channel improvement	13.43 ha
Diversion channel	19.50 ha
Inner water drainage	0.30 ha

CHAPTER 6. CONSTRUCTION PLAN AND COST ESTIMATE FOR URGENT PROJECT

6.1 General

The construction works for urgent flood mitigation project consist mainly of excavation, embankment and bank protection for channel improvement, and construction of retention pond, construction of structures such as diversion weirs, sluice gates, culverts, bridges and drop structures, and construction of drainage pumping station and improvement of major drainage channels in the urban area.

The five-year construction plan is adopted for executing the urgent flood mitigation project.

6.2 Construction Plan

6.2.1 Basic Considerations for Planning

The construction plan for executing the project is formulated taking into account the following:

a. The execution of the construction works will be roughly divided into five areas of interest: the Klang River, the Batu River, the Gombak River, Diversion Channel, Batu Retention Pond and drainage works in Kampung Baru.

b. A full-contracting system is adopted as the execution system for the project taking into account the scale of the project and experience in Malaysia. In general, major works will be executed by labor and time saving construction techniques. Whenever feasible, however, labor intensive methods will be encouraged, if time permits.

6.2.2 Construction Schedule

The proposed construction schedule for the urgent project is given in Fig. 6-1. This is planned based on the following assumptions.

a. Detailed design will be commenced in 1991 and completed by 1992 or within a period of 24 months. Immediately after completion of the detailed design, tendering will be started, and it will be completed by 1993.

b. Land acquisition will be commenced in 1989 prior to the execution of civil works.

c. Main civil works will be started in 1993 and completed by 1997 with a construction period of 5 years.

6.3 Construction Cost for the Project

6.3.1 Basic Conditions for Construction Cost Estimate

The construction cost consists of costs required for civil works, land acquisition and house compensation, engineering and administration cost, and contingency.

The construction cost is estimated on the basis of the following assumptions.

a. Construction cost for the project is estimated under the price level of 1988.

b. The following conversion rates are applied to the estimate.

US$1 = M$2.55 = ¥125

c. The unit prices of the construction materials are divided into two components of foreign and local currencies.

d. Execution of the works are carried out by the full-contracting system and all equipment and materials required for the works are to be provided by the contractor.

e. Engineering cost is estimated based on the cost requirement for design and supervision by consultant.

Administration cost is assumed at 5% of the total direct construction cost.

f. The physical and price contingency is assumed at about 20% of the total cost. It consists of the direct cost, and the costs of land acquisition, administration and engineering service.

6.3.2 Construction Cost for the Project

Construction cost for civil works, land acquisition and house compensation is estimated based on the unit prices.

The unit construction cost consists of direct cost, site expenses (20% of direct cost), contractor's overhead and profit (15% of the total cost of direct cost and site expenses), and tax (5% of total cost). The unit construction costs for major works are shown in Table K-9 of APPENDIX - K.

The construction cost for the project is estimated at 193 million M$, consisting of 42 million M$ of foreign currency portion and 151 million M$ of local currency portion.

The breakdown of the construction costs is presented in Table 6-1 and a brief description is given below:

Unit: M$x10^3

	Foreign Currency	Local Currency	Total
Direct cost	29,791	60,454	90,245
Land acquisition/ compensation	-	62,138	62,138
Administration cost	-	4,422	4,422
Engineering cost	3,095	1,326	4,421
Contingency	6,377	25,506	31,883
Total	39,263	153,846	193,109

6.4 Operation and Maintenance Cost

The operation and maintenance cost is assumed to be annually 1.0% of the total cost of civil works. It is estimated at 902,000 M$.

As for the replacement of the facilities, it was considered that the metal structures such as gates, pumps, etc., are replaced only once during the entire period of the project life.

CHAPTER 7. OPERATION AND MAINTENANCE PLAN FOR URGENT PROJECT

7.1 Required Operation and Maintenance Work

The activities of operation and maintenance (O/M) for the major flood control facilities are as follows:

(1) O&M of Klang Gates Dam and Batu Dam
(2) O&M of sluice gates in Kampung Baru Area
(3) O&M of tidal gates in the Klang town reaches
(4) Periodical dredging in the Klang River and its tributaries
(5) Periodical removal of floating debris by screening
(6) Clearing of river banks and leveling of maintenance road surface
(7) (O/M) of flood forecasting and warning system

These activities are conducted by several agencies such as DID, DID Selangor, City Hall, etc. However due to budget constraints and lack of coordination, these flood control activities are still at rather an unsatisfactory level.

Also in the urgent project, several new facilities for flood mitigation are to be constructed. They are the Batu Retention Pond, Gombak Diversion Channel, water gates, drainage sluice gates and pumping station. Hence in order to ensure reaping the expected beneficial effects of both the existing and proposed flood mitigation facilities, the following O&M works are strongly recommended to be undertaken by the relevant agencies.

(1) O&M of the existing two dams
(2) O&M of water gate of the regulation pond in the Batu River
(3) O&M of maintenance sluice gate for maintaining an acceptable water quality in Batu retention pond.
(4) O&M of outlet gate in the Batu Retention Pond
(5) Periodical removal of flotable debris retained on the screens of the regulation pond

(6) Maintenance of temporary pond area and pond water surface of the Batu Retention Pond to ensure their intended service
(7) Periodical dredging of the Regulation Pond if necessary
(8) Clearing of river reserve of the Gombak Diversion Channel and the three rivers
(9) O&M of sluice gate and pumping station in Kampung Baru area
(10) Land use control, in cooperation with the agencies concerned, to maintain the existing ex-mining ponds as retention ponds along the selected tributaries

Operation and Maintenance of these flood control facilities require the provision of the following equipments.

(1) Trucks for garbage transportation : 2 nos.
(2) Motor boats for pond inspection : 2 nos.
(3) Supervision vehicles : 2 nos.

7.2 Operation and Maintenance of Gates and Pumping Station

(1) Pumping Station in Kampung Baru Area

The sluice gate at the end of trunk drainage is kept open under normal circumstances and shall be closed only when the water stage of the Klang River rises beyond an elevation of 28.2 m. This is necessary because the lowest ground level of Kampung Baru is about 0.5 m lower than the design high water level of the River.

After closing the gate, and when the water level in the underground pond has risen to a certain level, pump shall be operated to drain the inner water. Under normal circumstances the underground pond shall be kept empty to store the incoming storm water. The garbage retained on the screen shall be removed periodically. The gate and pump shall be operated automatically.

(2) Batu Retention Pond

Under normal circumstances the water-gate at Batu river is set so as to allow a free passage of river discharge up to 20 m^3/s. Even when the discharge exceeds 20 m^3/s, under normal flooding conditions, due to the orifice action of the gate, the discharge at downstream will not exceed so much beyond 20 m^3/s. However, a portion of the excess discharge will then be stored in the Batu retention pond. Hence this pond will be useful under normal flooding conditions. In case of excess flooding, no water shall be allowed for storage in the retention pond and the water-gate should be fully opened to allow an unrestricted free passage of river discharge.

The release of water stored in the retention pond has to be regulated by taking into consideration the effect of any release of water from the Batu Dam at further upstream as well, so that the discharge in the river will not exceed the allowable design discharge of 40 m3/s.

All the gates of flood mitigation shall be operated automatically.

7.3 Required Organization for Construction

The required organization for construction of the proposed urgent flood mitigation works is shown in Fig. 7-1. Such an organization is recommended to be created by reorganizing the existing organizational structure of DID. In addition, as the retention pond is planned for multipurpose usage, this execution works are to be co-ordinated between DID and City Hall.

CHAPTER 8. EVALUATION OF URGENT FLOOD MITIGATION PROJECT

8.1 Economic Evaluation

8.1.1 Economic Construction Cost

For economic analysis, the nominal project cost is converted into economic cost which excludes the portion of transfer items (tax, duties and subsidy). The economic costs were calculated by using conversion factors selected by each cost item.

The project cost at market price is 193.11 million M$ and estimated economic cost is 176.33 million M$ (1988 price level) as shown in Table 6-1. The required annual operation and maintenance cost is assumed at 1.0% of the total economic construction cost (1.763 million M$).

8.1.2 Benefit

Benefits of this urgent flood mitigation project are defined as difference between the flood damage potential cases, "with the project" and "without the project". This is equivalent to the magnitude of reduction in flood damage.

The following benefits are estimated in monetary terms:

i) Reduction of general property damage
ii) Reduction of public property damage
iii) Reduction of indirect damage

The estimated reduction of the flood damage potential of 10-year, 30-year, 35-year, 50-year return period of flood frequencies are shown below:

(Unit: 1000M$, 1988 price)

	1988	2005
10-year return period	201,213	263,964
30-year return period	276,868	368,927
(35-year return period)	(280,369)	(374,051)
50-year return period	290,873	389,422

Note: Damage potential for 35-year return period is estimated by interpolation between 30-year and 50-year return period.

Average annual flood damage reduction is calculated by the following equations:

$$D = \sum [(N_{m-1} - N_m) \times (I_{m-1} - I_m)/2]$$

where, D : Average annual damage

N_m : Excess probability for discharge level m

I_m : Amount of probable flood damage at applicable discharge level m

m : Ordinal number for discharge level corresponding to return period

In estimating the reduction of average annual damage for the feasibility study area, 35-year return period is adopted as a maximum frequency up to which annual damage is accumulated because this return period (flood frequency) is corresponding to the design frequency of this urgent flood mitigation project. Results are shown below:

D_{1988} = 27,191 (1000M$)

D_{2005} = 35,886 (1000M$)

In addition to the above figures, the annual benefits of drainage plan in Kampung Baru area are also included in benefit flows.

8.1.3 Comparison of Cost and Benefit

The economic evaluation of the project was made in terms of Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost ratio (B/C), based on the following assumptions:

i) The benefit increases exponentially between 1988 to 2005, and remains constant after 2005.
ii) Evaluation period is set at 50 years.
iii) Opportunity cost of capital is 13.0%.

Cash flows of economic costs and benefits are shown in Table 8-1.

The results of evaluation are as follows:

EIRR = 15.7%
B/C = 1.24
NPV = 32.576 million M$

8.1.4 Sensitivity Analysis

The above evaluation indicators were examined by sensitivity analysis. Results are summarized below:

Assumption	E.I.R.R	B/C	N.P.V
1) Original case	15.7%	1.24	32,576 (1000M$)
2) Cost: +10%	14.5	1.13	18,944
3) Cost: +20%	13.4	1.03	5,311
4) Benefit: -10%	14.3	1.12	15,686
5) Benefit: -20%	12.9	0.99	-1,204
6) Cost +10% & Benefit -10%	13.2	1.01	2,054
7) Cost +20% & Benefit -20%	10.9	0.83	-28,469

These results show that the project is economically feasible even if the cost increased by 20% or the benefit decreased by 10%, and also if both the simultaneous cost increase and benefit reduction are of 10%.

8.1.5 Privatization of the Batu Retention Pond

Among the urgent flood mitigation works, the multipurpose Batu Retention Pond is very attractive for private sector participation, hence private funds, for the construction and subsequent operation and maintenance of the pond facilities. This is because the pond area and the surrounding park area is planned to include open door sports and other recreational facilities having revenue generating potential. A similar case of private sector participation in Japan is described in APPENDIX L.

8.2 Social Impact

The major social impacts of the project are as follows:

(1) Land use potential of the flood prone area will be enhanced. The estimated flood prone area in the case of 35-year return period is 1,150 ha (in the feasibility study area).

(2) Environment of people's public health and amenities will be improved. The beneficial people in 2005 is estimated to be 107,000 persons.

CHAPTER 9. ENVIRONMENTAL ASPECTS

9.1 Enhancement of Riverine Landscape and Rehabilitation of Riverine Life

Within the forest reserves along some downstream reaches and in residential areas, pedestrian ways and resting plazas with focal gardening are effective additions to rehabilitate the riverside zone.

In the commercial area, diversified forms of pedestrian ways, plazas, resting places, etc. are recommended to recover and improve the urban riverine life.

For industrial and mining areas, selected greenery and/or reforested buffer zones are very effective to protect and ameliorate the riverine environment. In the recreational areas, the river reserves could be used for diversified recreational uses such as sports and gamefields, multipurpose open spaces; jogging and cycling courses may also be incorporated.

In the agricultural area and buffer zone, some recreational trails with grass covered land and some potential riverine ecological conservation areas shall be specially organized. Estuarine mangrove vegetation colonies shall be conserved to the maximum possible extent as a natural reserve.

General Guideline for Improvement of the Riverine Landscape are as follows:

(1) Improvement of River Revetments as Means of Improving Riverine Landscape
(2) Clearing of River Reserve
(3) Improvement of the River Reserve
(4) Provision of Observation Plazas and Resting Areas
(5) Provision of Walkways on Bridge Brinks
(6) Conservation of Natural Vegetation

(7) Riverside Walkway Improvement in Conjunction with the Development of nearby Central Business District

(8) Harmonized Design and Characteristics Allocation for Riverine Facilities and Structures

(9) Consideration for Pedestrian Walkway and Mall Network to Link Up with Adjacent Plaza, Parks through Riverside Area

General Guideline recommended for Basic Coordinations between DID and Other Government Authorities are as follows:

(1) Squatter resettlements, and recovery of the original river reserves along the riverside areas that are recognized as flood plains shall be properly managed.

(2) All tributaries which discharge into the Klang River should be provided with appropriate screening facilities and these should be maintained regularly.

(3) Provision of garbage and solid waste collection, transportatin, and sanitary disposal system shall be well maintained to prevent flow destruction of drainage and pollution due to floatables in the river.

(4) Requirement for the provision of sedimentation ponds, to control nonpoint source pollution due to suspended solids, shall be logally instituted for land development activities beyond a certain scale.

(5) Appropriate anti-pollution system for each type of industries shall be recommended to be equipped and a supervisory mechanism shall be established.

(6) Existing relevant regulations shall be enforced through co-ordinating agency to carry out each strict superintendent management for protecting water quality of the rivers.

(7) Environmental education and public awareness for conservation of riverine environmental quality shall be formulated and be implemented by making maximum use of mass communication medias.

9.2 Considerations for Environmental Assessment of the Project

The following environmental impact should be considered and the necessary environmental protection measures are recommended to be undertaken.

i. Positive Environmental Impacts

As an important environmental benefit, an effective flood mitigation plan can lead to the rehabilitation of barren land into green park land, thereby regenerating urban natural resources with a proper ecosystem. In addition, increased recreational opportunities and improvement of the aesthetic landscape of the riverside areas, improvement of water quality through screening and sedimentation of floating debris and suspended solids in the retention ponds, and improvement of riverine hygienic conditions could be realized.

ii. Negative Environmental Impacts

A negative environmental impact which could be cited is the temporary erosion and siltation due to large scale earthworks for retention pond, diversion channel and river channel. To minimize this negative effect, appropriate construction methods shall be undertaken with due environmental considerations. For example in case of earthworks on excavation for retention pond and diversion channel, installation of temporary sedimentation ponds are recommended to control non-point source pollution in the river due to sediment run-off.

9.3 Scheme for Environmental Improvement Related to the Proposed Urgent Works

Schemes for environmental improvement for three proposed major works are considered in conjunction with their hydrological aspects. They are river channelization of the Klang, Gombak and Batu River in the upper reach, and the construction of Batu Retention Pond and Gombak Diversion Channel.

(1) Riverside Improvement Scheme

- The residential areas shall be criss-crossed with pedestrian walkways, interspersed with small focal plazas among shady trees and flowering plants.

- Gentle bank slopes will be covered with green turf interspersed with trees planted in a sequential manner to mesh with the village groves. Maintenance roads will be provided which will serve as pedestrian walkways as well as catering to local light weight traffic.

- In housing development areas, river side improvement shall be in harmony with the character of the new townships.

- To cater to the recreational activities of the residents of all ages, waterfront access, pedestrian walkways, plazas with children's play ground and rest areas with seatings for elders surrounded by shady trees and flowering plants will be provided.

- For institutional areas, promenades with plazas on courtyards furnished with gardening, street lightings and outdoor furnitures may be considered.

- In commercial areas, good quality paving with balustrade on the revetment, street lighting, planting boxes, shade trees, and seating shall be aesthetically arranged throughout the entire area.

- Park and garden areas shall be interlinked with pedestrian walkways interspersed with plazas. The walkways shall be linked with shady trees to ameliorate the environment of the park area.

(2) Proposed Retention Pond and Its Environs

The proposed retention pond comprised a permanent pond portion supplemented by a temporary pond to provide a temporary storage only during flooding.

Under normal circumstances the temporary pond be utilized for recreational purposes including sports field by the citizens.

Inundation of the temporary pond area would occur once in 2 to 20 years at the lowest portion, once in 50 years at second lower portion and once in 100 years at higher portions of the pond area in accordance with the rainfall frequency. Fig. 5-10 shows the ponding area according to the storm return period.

Within the park area, a network of pedestrian walkways, maintenance roads and parking spaces, sports courts and fields, plazas and gazebos, resting areas and seating are to be built. Also security facilities, social amenities such as toilets, Kiosks, and maintenance, culture and sports facility complex as well as compound lighting will be provided. Fig. 5-7 shows the layout of these facilities.

Inside the pond area, water sport and recreation facilities may be provided to cater the needs of water sport enthusiasts.

Along the perimeter of the park area, a buffer zone of greenery will be established by reforestration and plantings. A variety of indigenous trees and shrubs may be introduced to regenerate the natural environment from the existing barren land condition.

Inside the park area, a suitable mix of shady trees, flowering shrubs and plants will be grown at strategical locations for enhancement of the park landscape.

To encourage wild birds and small animals to inhabit the present barren land, berry and fruits bearing plants should be introduced.

At the inlet of retention pond, a sedimentation pond will be provided to screen the floating debris, and to remove suspended solid and silt.

(3) Environmental Development of Proposed Diversion Channel

The diversion channel will be kept with a minimum maintenance water, and the channel reserve will be neatly landscaped with grass turfing and lined with rows of trees.

Pedestrian walkways will be provided along the channel and at some strategic locations, small plazas will be built to enhance waterfront landscape. Also some access to the waterfront may be provided.

9.4 Preliminary Environmental Impact Assessment

Implementation of this project will lead to some environmental impacts directly or indirectly. Hence due cosiderations should be given to this environmental effects in accordance with the National Environmental Quality Standards.

One of the most significant environmental impacts is the temporary increase in suspended solids (Turbidity by mud) caused by river dredging and widening. However, the environmental impacts by temporary pollution on the riverine fauna is expected to be rather insignificant. This is because the existing base line water quality itself is rather poor and turbid, and fish inhabiting the rivers are species those quite well adapted to this muddy conditions.

Construction vehicles will cause noise and dust pollution in the surrounding areas while traffic congestion may occur in the residential areas having narrow access to the river bank. This is an important matter, hence, traffic access, safety of operation, the effects on the

residents must be considered to minimize any friction and problems with the residents concerned.

Some of the river reserve areas with private land ownership will be problematic as resettling of these dwellers will be necessary. Efforts for land acquisition is recommended to be carried out with the cooperation of City Hall and other government agencies concerned so that it can be executed smoothly in advance to the commencement of actual construction works at site.

Another social impact which needs careful consideration concerns land acquisition and compensation of land under private ownership along a portion of the diversion channel. These lands are located in a Malay reserve area. The intense subdivision of land ownership of this area may cause land acquisition rather tedious and a time consuming proceduce.

A monitoring program for vector disease control and public health / hygenic effects due to filling and discharge of the flood water in the retention pond is recommended to be carried out to ensure a safe use of the temporary retention pond area as park land.

In general, quite large beneficial effects will be achieved by the implementation of this urgent works, which include, creation of a clean riverside environment with superior aesthetic conditions, enhanced opportunities for recreation and sports, urban greenification, and improvement of water quality in addition to flood mitigation, and others.

Fig. 9-1 shows the environmental matrix for the urgent flood mitigation project.

9.5 Consideration on Water Quality Improvement

9.5.1 General

As described in Chapter 2, the water quality of the Klang River and its tributaries are prone to deteriorate along with land development, industrial development and population increase in the basin.

The maintenance and control of the quantity and quality of river water is very important to ensure their benefitial use, in addition to ecological and aesthetic considerations.

For the stretches of the Klang, Gombak and Batu Rivers in the central part of the city, the present water conditions were observed and the water quality improvement measures described below were studied.

- Recommendation for the use of ex-mining ponds
- Screening of floating debris and campaign for river beautification
- Water purification by storage

9.5.2 Recommendation for the Use of Ex-mining Ponds

Water quality improvement of the river by means of using ponds at Sg. Jinjang stretches is already evident.

The obvious difference of the water quality between the pond at upper reach in which the water is turbid, and the pond at lower reach where the water looks clean and nonturbid, can be visibly noted.

There are many ex-mining ponds along the Klang River and its tributaries, and most of them remain being not utilized for water quality improvement. Hence, it is recommended to consider utilizing these ponds wherever possible for the purpose of river water quality improvement.

9.5.3 Screening of Floating Debris and Campaign for River Beautification

In regard to floating debris, City Hall has been operating three log booms and one screen on each tributary of the Klang River. These are efficiently operated and approximately 80% of the floating debris is collected.

However, a large amount of floating debris appear during the periods of frequent flash flood. For this reason, more log booms shall be provided at critical points of the river.

At the same time, establishment of a basinwide clean-up campaign for river water protection and conservation, river side beautification shall be immediately under taken by DOE, DID and City Hall.

9.5.4 Water Quality Improvement by Dilution Water

In order to improve the water quality in the central part of the City during dry season, the possibility of using stored fresh water, in the two existing dams and/or the proposed dam, as dilution water was investigated. The existing two dams, the Klang Gates Dam and Batu Dam, are multi-purpose ones for flood mitigation and water supply. The proposed Upper Gombak Dam's storage capacity is exclusively for water supply.

The main features of these dams are as follows.

Unit : 10^6 m^3

	Klang Gates Dam	Batu Dam	Upper Gombak Dam
Total storage	35.41	36.61	6.00
Flood control storage	6.13	4.84	-
Flood surcharge storage	3.40	-	-
Active conservation storage (Water Supply)	22.65	27.53	3.60
Inactive space	3.23	4.24	2.40

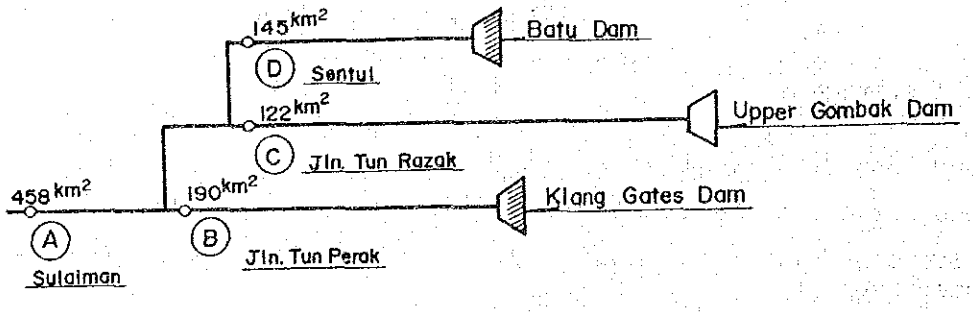
The Klang Gates Dam has already been enlarged with its crest level being raised to the maximum possible technical limit in height. In case of the Batu Dam, it is still possible to raise its crest level, technically, to increase the effective storage capacity, but by incuring very high cost. Hence any possibility of increasing the storage capacities of these dams are excluded.

Regarding the storage for flood mitigation of these dams, it is not advisable and also very dangerous to use such a storage of these dams for any other purposes, including dilution, because of the occurance of flash flooding all around a year. Hence such a case was not considered in the analysis. In addition the dead storage was also excluded.

As such, the available storage of conservation in excess of the actual water supply demand is considered as the maximum amount of water that could be utilized for the purpose of dilution to improve the water quality.

Also the proposed Upper Gombak Dam will have only active conservation storage.

The target points selected for water quality improvement by dilution along the river reaches are, Sulaiman, Sentul, Jln. Tun Razak and Yap Kwan Seng. The location of these target points and the dilution water source dams are schematically illustrated below:



The required storage and discharge of dilution water depends on target point location. Three alternative cases were studied and the results are summarized below and also illustrated in Fig. 9-2.

Case	Target Point	Discharge (m3/s)	Required Storage Capacity ($10^6 m^3$)			Reservoir
			Water Supply	Dilution water	Total	
1-1	B	4.8 (2.5)*1	4.7 (1.94)*2	17.3	22.6	Klang Gates
1-2	C	2.3 (1.9)	-	3.6	3.6	Upper Gombak
1-3	D	4.3 (3.0)	1.9 (1.40)	25.7	27.6	Batu
2	A	6.4 (1.4)	-	3.6	3.6	Upper Gombak
3	A	11.5 (2.5)	4.7 (1.94)	9.3	14.0	Klang Gates
			1.9 (1.40)	19.1	21.0	Batu

*1 The numbers within the parenthesis indicate the specific discharge per 100 km^2. ($m^3/s/100\ km^2$)

*2 The numbers within the parenthesis indicate present water supply demand. (m3/s)

In Case 1, the possible secured discharge attainable at each target point using the maximum available conservation storage capacity of each reservoir was examined independently for each of the three sub-cases.

As for target point B (Case 1-1), it is possible to attain a maximum discharge of 4.8 m^3/s, which corresponds to 2.5 m^3/s as specific discharge, during the dry season using its net available active conservation storage capacity of 17.3 million m3 for dilution excluding the required water supply storage of 4.7 million m^3. (Hence the total active storage is 22.6 million m^3) Similarly Case 1-2 (point C) and Case 1-3 (point D) studies were carried out.

In Case 2, utilizing the maximum available conservation storage (3.6 million m^3) of the proposed Upper Gombak Dam only as the sole source of dilution water, the increase in discharge attainable at target point A (Sulaiman), during low flow conditions, was examined. Accordingly it is possible to attain a discharge of 6.4 m^3/s, which

corresponds to 1.4 m^3/s as specific discharge, only a 20% increase in discharge.

In Case 3, the discharge requirement at target point A is set at about twice that under low flow conditions with a discharge of 11.5 m^3/s, which corresponds to a specific discharge of 2.5 m^3/s. The possibility of attaining this condition is investigated utilizing the required dilution water only from the two existing dams, the Klang Gates Dam and Batu Dam. Accordingly, the dilution water requirements are determined as 9.3 million m^3 and 19.1 million m^3, respectively, for Klang Gates and Batu dams. This water requirement is about 60-70% of the maximum available conservation storage capacity that could be utilized for dilution, which is a resonable amount allowing a safety factor.

Hence from this Case 3, it is evident that doubling of low flow discharge at Sulaiman (point A) is possible resulting in a pollution level reduction by 50%. In other words, assuming the base-line BOD at Sulaiman is 10 mg/l, by introducing this dilution water the stream water quality could be improved with a reduction in BOD to 5 mg/l.

Conclusion

It seems to be possible to improve the Klang River water quality by dilution water from the two existing dams. However, it is necessary to conduct further detailed studies by taking into account other conflicting future benefitial water demand such as water supply and the resulting increase in wastewater generation.

CHAPTER 10. STORM RAINFALL RUN-OFF STUDY OF TRIBUTARIES

10.1 General

In the Klang River Basin, there are many important tributaries other than the Gombak and Batu Rivers, which were also examined under the Master Plan. Among these tributaries, some of them often overflow their banks causing damage. Although partial drainage improvement works have been executed by several agencies, these works do not always take into consideration the existing discharge capacity of the main stream. Under these conditions, the influence exerted by the tributaries on the main stream will increase year by year.

In order not to overload the design discharge of the main river, some countermeasures of discharge control are required for these tributaries. Withholding or temporary storage of the rainfall run-off to reduce the flood peak is considered to be the principal countermeasure.

In this study, five (5) tributaries are selected with consideration of the seriousness of flooding, rapid urbanization, etc. These are the Sg. Jinjang, Keroh, Bunus, Kerayong and Damansara.

For these tributaries, run-off discharge and the effect of using the ex-mining ponds as retention ponds were estimated and the most appropriate improvement level was recommended.

10.2 Run-off Study of the Basin

The run-off discharge of the tributaries estimated under the land use conditions in the year of 2005 are shown below.

Tributary	Catchment (km^2)	Discharge (m^3/s)			
		1/10	1/20	1/50	1/100
Sg. Keroh	39.6	88	102	132	150
Sg. Jinjang	29.5	9	12	58	66
Sg. Bunus	16.7	67	75	94	108
Sg. Kerayong	61.8			163	189
Sg. Damansara	147.6	131 *122	148 *164	172 *202	196 *260

*: Discharge by monsoon flood

The comparison of design discharges proposed by the existing plan, "Kuala Lumpur flood Mitigation Project Drainage Improvement, Master Drainage Plan", and Master Plan of JICA are shown below.

Unit: m^3/s

Tributary	Existing Plan 1/100	M/P of JICA 1/100		Discharge by Flash Flood 1/100
		Peak Discharge of Tributary	Design Discharge of Main Stream	
Sg. Keroh	410	110	240	150
Sg. Jinjang	210	80	120	66
Sg. Bunus	170	-	300	108
Sg. Kerayong	460	95	870	189
Sg. Damansara	-	260	1180	196

As shown in the table, discharge by flash flood is normally greater than that by monsoon storm especially for small catchment.

10.3 Basin Storage Plan

In order to mitigate flooding by flash floods in the basins of tributaries, the potential retention ponds were selected and studied to clarify the effect of flood retention. These ex-mining ponds are shown in Figs. 10-1~10-5.

The results of the alternative study on the effect of flood mitigation by the ex-mining ponds, in each of these five (5) tributaries, are summarized in the Table given below.

PROBABLE DISCHARGE OF TRIBUTARIES
(Refer along with Figs. 10-1 ~ 10-5)

Unit: m^3/s

Tributary	Return Periods (Year) 10	20	50	100	Remarks
Sg.Keroh					(Ref. Fig. 10-1)
ALT (1)	88.3	102.1	132.0	150.0	Without pond
ALT (2)			80.1	95.5	With A and B ponds
Sg.Jinjang					(Ref. Fig. 10-2)
ALT (1)			58.0	66.0	Without pond
ALT (2)	9.1	11.5	16.0	20.0	With A,B and C ponds
ALT (3)			41.0	48.2	With A pond
ALT (4)			26.0	32.0	With A and B ponds
Sg.Bunus					(Ref. Fig. 10-3)
ALT (1)	66.6	74.9	94.0	108.0	Without pond
ALT (2)			82.0	94.0	With A pond
ALT (3)			42.0	50.0	With A and B ponds
Sg.Kerayong					(Ref. Fig. 10-4)
ALT (1)			163.0	189.0	Without pond
ALT (2)			95.0	111.0	With B pond
ALT (3)			89.0	103.0	With A and B ponds
Sg.Damansara					(Ref. Fig. 10-5)
ALT (1)	131.2	147.9	172.0	196.0	Without pond
ALT (2)			103.0	118.0	With A and B ponds
ALT (1)*	122	164	202	260	Without pond
ALT (2)*	114	151	186	240	With A and B ponds

*: Discharge by monsoon flood

In consideration to the effectiveness of retention ponds, future land use conditions of the basin, and present flow capacity of the river and trunk drainage, the following plans are recommended for each tributary.

(1) Sg. Keroh

Alternative (2) (Ref. Table 10-1) is recommended for this basin. By using ponds A and B, about 35% to 55% of peak discharge is expected to be reduced compared to the case without ponds.

(2) Sg. Jinjang

Alternative (2) is recommended for this basin. About 70% of peak discharge will be reduced by the three ponds. If the pond C site is to be used for sewage treatment plant, Alternative (4) is recommended.

(3) Sg. Bunus

Alternative (3) is recommended. About 55% of peak discharge is expected to be reduced by the 2 ponds.

Discharge capacity of existing by-pass channel is only about 20 m^3/s and another by-pass channel with a discharge capacity of 30 m^3/s is recommended to be constructed along Jln. Tun Razak to the Klang River.

(4) Sg. Kerayong

Alternative (3) is recommended. The ex-mining pond A site is already handed over to housing developers. However, reclaiming of this pond is not yet commenced because of its large depth along with high water depth. This pond is not much effective to mitigate flash floods in the Kerayong basin because of it's location, but it will be very useful to mitigate flooding due to discharge diverted from the Sg. Ampang to the Sg. Kerayong.

The ex-mining pond at east of pond B is situated in the Tun Pazak Metropolitan Park proposed by City Hall. A multipurpose pond similar to the Batu retention pond is recommended for this site as well, though this pond was not included in the alternative study.

(5) Sg. Damansara

Alternative (2) is recommended. The retention ponds are not so much effective for monsoon storm, but are very effective for flash floods.

About 40% of peak discharge will be reduced. The area of retention pond B, a swampy area of 40 ha, is recommended to be used as a multipurpose pond like the proposed Batu Retention Pond.

10.4 Recommendation

It is very clear that the use of existing ex-mining pond in the four tributary basins, except Sg. Bunus, can mitigate flooding due to flash flood discharges from the tributaries to the Master Plan protection level of the main river.

The discharges of the tributaries, however, are expected to increase according to the drainage improvement works and / or land development activities after the year 2005.

Hence, the following countermeasures are strongly recommended to be undertaken.

- The maximum use of the existing ex-mining ponds as potential retention ponds.

- A criteria of instituting new retention ponds inaccordance with new land development activities instead of the drainage channel improvement works as being practised at present.

- Any increase in run-off discharge caused by land development activities shall be stored in retention ponds.

- Flood protection level of tributaries should be decided with due considerations to the discharge capacity of the main river and its implementation schedule.

CHAPTER 11. CONCLUSION AND RECOMMENDATIONS

(1) The master plan on flood mitigation of the Klang River Basin is proposed consisting of both structural and non-structural measures. The protective measures proposed are river improvement works, retention pond, diversion channel, retarding areas and others. The proposed plan is both technically and economically feasible, and also socially justifiable.

(2) Immediate implementation of the urgent project, Phase I of the 3 Phases of Master Plan, is extremely important, because of the presence of flood prone built-up areas and low-lying areas undergoing frequent flood damage caused by flash floods.

(3) The required land acquisition shall be completed before the commencement of construction works in order to ensure a smooth implementation of the Project.
It is also recommended to reserve immediately the required land area for the natural retarding basin at Sg.Rasau.

(4) It is very important to control the discharges from the tributaries. The existing ex-mining ponds in the Klang River Basin serve as retention ponds of flood mitigation.
Hence, it is strongly recommended to preserve these ponds for flood mitigation.

(5) It is strongly recommended to institute the Klang River Comprehensive Flood Mitigation Committee under the Klang Valley Planning Secretariat chaired by DID.

(6) It is necessary to publicize the importance of flood mitigation. In this regard, especially, it is recommended to publicize the flood risk maps to enhance the awareness and concern of the residents on the required flood protection measures and the available evacuation systems, in case of emergency.

(7) It is recommended to formulate the creteria to institute new retention ponds inaccordance with land development activities in the basins of the tributaries.

(8) Instituting the Radar Raingauge system of rainfall measurement is a very important step towards modernizing the existing flood forecasting and warning system of the Klang River basin. Further detailed study on this Radar Raingauge system requirement is recommended to be carried out, if necessary, utilizing international expertise.

(9) It seems to be possible to improve the Klang River water quality by dilution water from the two existing dams. However, it is necessary to conduct further detailed studies by taking into account other conflicting future benefitial water demand such as water supply and the resulting increase in wastewater generation.

(10) It is recommended to institute a training centre of river engineering to train local technical personnel on advanced techniques of flood mitigation, drainage and coastal engineering.

Tables

Table 2-1 MONTHLY METEOROLOGICAL DATA

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Temperature °C (mean)	26.6	27.0	27.3	27.4	27.6	27.6	27.1	27.1	26.9	26.9	26.5	26.5	27.0
Humidity %	78.4	78.9	79.7	81.8	81.1	78.8	79.6	78.6	81.1	82.1	84.1	82.3	80.5
Evaporation mm/day	3.5	3.9	4.0	3.9	3.6	3.4	3.4	3.6	3.4	3.4	3.1	3.0	3.5
Sunshine hours Hour	5.9	6.3	6.5	6.1	6.2	5.5	6.1	5.9	5.2	5.3	4.4	4.7	5.7
Wind Speed m/s	1.0	1.0	1.1	1.0	1.1	1.1	1.2	1.2	1.1	1.2	1.0	0.9	1.1

Station: Petaling Jaya (Lat: 03° 06' N, long: 101° 39' E, Alt: M.S.L. + 45.7m)

Source: Malaysia Meteorological Service

Table 2-2 PROBABLE AREAL RAINFALL

Unit : mm

T	SULAIMAN BRIDGE		
	1 DAY	2 DAYS	3 DAYS
200	151.7	197.1	251.7
100	138.9	181.5	230.6
80	134.7	176.5	223.8
50	125.9	165.9	209.5
30	116.3	154.4	193.8
20	108.7	145.1	181.3
10	95.4	129.1	159.5

Unit : mm

T	PUCHONG DROP		
	1 DAY	2 DAYS	3 DAYS
200	131.3	184.6	230.3
100	120.6	169.7	211.3
80	117.1	164.8	205.2
50	109.8	154.6	192.3
30	101.8	143.5	178.2
20	95.5	134.6	166.9
10	84.4	119.1	147.2

Unit : mm

T	RIVER MOUTH		
	1 DAY	2 DAYS	3 DAYS
200	122.1	168.8	211.5
100	111.9	154.9	193.8
80	108.6	150.4	188.2
50	101.7	141.0	176.2
30	94.0	130.6	163.0
20	88.0	122.4	152.5
10	77.4	108.0	134.3

Table 2-3 ANNUAL MAXIMUM DISCHARGE AT FIVE STATIONS

Unit : m3/s

River	Klang	Klang	Gombak	Batu	Batu	
C.A. (sq.km)	468.0	464.0	122.0	145.0	55.7	REMARK
Location	Sulaiman	Market	Street Jln.Tun	Razak	Sentel	Kg. Sg. Tua
I.D. No.	3116430	3116432	3116433	3116434	3216439	
1960		113.31 Nov.07	32.86 Nov.07	38.81 Nov.06		
1961		79.89 Apr.30	19.89 Jul.31	25.21 Feb.25		
1962		85.84 Oct.31	25.92 Aug.26	29.29 Aug.26		
1963		150.14 Dec.03	41.93 Nov.13	41.93 Dec.03		
1964		116.15 Jan.20	41.93 Sep.14	32.44 Sep.08		
1965		121.81 May.10	34.42 May.10	39.26 May.10		
1966		131.62 Jul.12	37.40 Jul.12	39.76 Dec.29		
1967		109.82 Dec.01	33.10 Jun.18	44.83 Jun.18		
1968		104.72 Dec.29	22.00 Dec.29	43.14 Dec.29		
1969		104.72 Oct.24	25.10 Dec.31	42.01 Jun.03		
1970		74.47 Jan.14	23.69 Dec.24	31.86 Jan.06		
1971		667.90 Jan.05	171.90 Jan.05	97.10 Jan.05		
1972		594.48 Nov.25	99.12 Nov.17	43.84 Nov.17		
1973	131.33 Oct.07	191.60 Dec.07	90.19 May.26	70.79 Dec.08		
1974	125.69 Jun.22	148.72 Jun.23	53.34 May.17	56.09 Jun.22	20.96 May.21	
1975	165.28 Dec.08		30.15 Dec.08	51.65 Sep.03	14.64 Dec.27	
1976	26.11 Jun.05		35.14 Oct.17	68.63 Mar.26	31.50 Oct.16	
1977	149.44 Oct.08		76.09 Oct.08	72.75 Oct.06	21.15 Oct.08	
1978	99.55 Oct.21		22.89 Nov.16	36.36 Nov.20	20.55 Oct.26	
1979	80.48 Apr.13		34.16 Jun.08	32.08 Sep.15	23.30 Jun.07	
1980	120.16 Oct.16			20.76 Apr.09	39.48 Jul.26	
1981	175.53 May.25			91.01 Sep.08	32.52 Apr.19	
1982	196.15 May.01		118.35 Nov.01	93.89 Apr.30	18.52 Oct.15	
1983	298.59 Jun.07		58.70 Aug.03	86.34 Jun.13		
1984			46.90 Jan.31	675.90 Nov.17		

Table 2-4 PRESENT RIVER CONDITIONS

Stretch	River Length (km)	River Width (m)	Flow Capacity (m3/s)	Slope	Inundation	Remarks
Sg. Klang K1	-50.9k -37.4k 13.5	250 - 300	More than 1500	1/7000	No	
K2	-37.4k -29.0k 8.4	130 - 190	More than 650	1/7000	Inundated H=4.0m	
K3	-29.0k -15.5k 13.5	80 - 130	150 - 950	1/5500	Inundated	
K4	-15.5k -6.4k 9.1	25 - 70	50 - 450	1/1800	Inundated H=4.2m	
K5	-6.4k 0k 6.4	40 - 85	100 - 440	1/1650	Inundated H=10.6m	
K6	0k 10.1k 10.1	40 - 70	110 - 430	1/1550	Inundated H=10.6m	
K7	10.1k 14.5k 4.4	35 - 40	120 - 570	1/1550	Inundated H=22.5m	
K8	14.5k 20.2k 5.7	30 - 50	100 - 380	1/990	Inundated H=26.4m	
K9	20.2k 24.3k 4.1	25 - 40	30 - 520	1/700	Inundated H=32.7m	
K10	24.3k 27.6k 3.3	10 - 30	30 - 170	1/700	Inundated H=36.5m	
K11	27.6k 33.8k 6.2	20 - 40	30 - 360	1/350	Inundated H=49.8m	
Sg. Gombak G1	0k 2.4k 2.4	25 - 40	80 - 240	1/850	Inundated H=31.2-33.4	
G2	2.4k 5.2k 2.8	15 - 20	40 - 200	1/760	Inundated	
G3	5.2k 7.4k 2.2	20 - 30	60 - 200	1/390	Inundated	
G4	7.4k 9.9k 2.5	15 - 25	30 - 130	1/320	Inundated	
Sg. Batu B1	0k 1.4k 1.4	30 - 45	170	1/1180	Inundated H=33.4m	
B2	1.4k 4.8k 3.4	10 - 20	30 - 40	1/450	Inundated H=35.8m	
B3	4.8k 8.0k 3.2	15 - 30	15 - 100	1/640	Inundated H=39.9m	

Table 2-5 OVERALL EVALUATION FOR BRIDGE UNDER EXISTING CONDITIONS

Ref. No.	Bridge Name	Span	Clea-rance	Width Reduct. Ratio	Area Reduct. Ratio	Actual Damage occured	Total Estimate	Max.W.H. / Pier Width	Shape of Pier	Possibi-lity of Scouring	Pipe etc.
K- 17	Jalan Sulaiman	A	A	A	A	A	A	A	C	B	C
K- 18	Jalan Kinabalu (flyover)	A	A	A	A	A	A	C	C	C	A
K- 19	Jalan Cheng Lock	A	C	A	A	A	B	B	C	C	A
K- 20	Dayabumi Foot Bypass	B	A	A	A	A	A	C	B	C	A
K- 21	Lebuh Pasar	A	B	A	A	A	A	A	A	A	C
K- 22	Jalan Tun Perak (2 Lanes)	A	C	A	C/B	A	C/B	B/A	B	B	C
K- 23	Jalan Munshi Abdullah (2 Lanes)	C/A	B	B/A	B/A	A	B/A	B/A	B	B	B
K- 24	Jalan Dang Wangi	A	B	A	A	A	A	A	A	A	B
K- 25	Jalan Sultan Ismail	B	A	A	A	A	A	C	B	C	C
K- 26	Jalan Tun Razak (2 Lanes)	B	B	A	B/C	C	B/C	A	B/C	B	B
K- 26'	Jalan Damai (broken)	C	C	B	C	C	C	C	C	C	A
K- 27	Jalan Jelatek	A	A	A	B	A	A	B	B	B	B
K- 28	Near Sterling Drug	C	B	A	B	A	B	A	B	B	C
K- 29	Near Taman Seri Keramat Tengah	B	C	A	B	A	B	A	B	B	A
K- 30	Jalan Hulu Klang Zoo	B	A	A	A	A	A	A	B	B	C
K- 31	Jalan Melawati Lima	A	C	A	A	A	B	A	A	A	A
G- 1	Sultan Hishamuddin	A	A	A	A	A	A	A	A	A	A
G- 2	Jalan Parlimen	B	B	A	B	A	B	B	A	B	B
G- 3	Jalan Sultan Ismail (flyover)	A	A	A	A	A	A	A	B	B	A
G- 4	(Jalan Putra) Near PWTC	B	A	A	A	A	A	A	B	B	C
G- 5	Jalan Ipoh (2 Lanes)	B	A	A	A	A	A	B	B	B	B
G- 6	Jalan Tun Razak (2 Lanes)	B	B	A	C	A	B	A	B	B	A
G- 7	Near Sentul Flats off Jalan Pahang	B	A	B	A	A	B	A	A	A	A
G- 8	Jalan Kampung Puah Sabarang	A	B	A	C	A	B	A	A	A	A
G- 9	Jalan Chubadak Dalam	C	A	B	A	A	B	A	A	A	A
G- 10	Foot Bridge (2 Lanes)	C/A	B	A	B	A	B	A	C	B	A
G- 11	Jalan Batu Cave	C	A	A	A	A	B	A	C	B	A
G- 12	Karak Highway (flyover)	A	A	A	A	A	A	A	B	B	C
B- 1	Jalan Tun Ismail	C	A	A	B	A	B	A	C	B	A
B- 2	Jalan Kolam Air	B	B	A	B	A	B	A	C	B	A
B- 3	2.5 Mile Jalan Ipoh Railway	A	A	A	A	A	A	A	A	A	C
B- 4	Jalan Selvadurai	C	B	A	A	A	B	B	C	C	A
B- 5	Jalan Segambut	C	A	C	A	A	C	A	B	B	C
B- 6	Jalan Cenderuh	C	B	A	A	A	B	B	B	B	A
B- 7	4.25 Mile off Jalan Ipoh	B	B	A	C	A	B	B	C	C	A
B- 8	4.5 Mile Jalan Ipoh	C	A	A	A	A	B	B	C	C	C
B- 9	4.5 Mile Jalan Ipoh Railway	A	A	A	A	A	A	A	A	A	A
B- 10	7.5 Mile Jalan Ipoh Railway	A	A	A	A	A	A	A	A	A	A
B- 11	7,5 Mile Jalan Ipoh (flyover)	A	A	A	A	A	A	A	C	B	A
B- 12	Jalan Batu Cave	B	A	B	A	A	B	A	A	A	C
B- 13	Kg Nakhoda Bridge off Jalan Sg Tua	A	A	A	B	A	A	A	A	A	A
B- 14	Kg Nakhoda Bridge off Jalan Sugai Tua	A	C	A	B	A	B	A	A	A	A
B- 15	Near Dam Site	A	A	A	A	A	A	A	A	A	A

Rank (A) means that the brigde has no problem.
Rank (B) means that the bridge has some problem.
Rank (C) means that the bridge has severe problem.

Table 4-1 CAUSE OF FLOODING AND COUNTERMEASURES

River Stretch	Cause of flooding	Countermeasures
K1	no flooding	levee, widening
K2	tidal effect	levee, widening
K3	tidal effect	levee, widening
K4	insufficiency of channel section	levee, excavation of channel
K5	insufficiency of channel section	levee, excavation, natural retarding basin
K6	insufficiency of channel section	excavation of channel removal of Puchang Drop Structure
K7	insufficiency of channel section partially low lying area	excavation of channel partial levee
K8	no completion of deepening	deepening
K9	insufficiency of channel section partially, low lying area obstruction such as bridge	excavation of channel partially, levee pumping station
K10	insufficiency of channel section	excavation of channel, Reconstruction of brige
K11	insufficiency of channel section	excavation of channel
G1	no completion of deepening	deepening
G2, G3, G4	insufficiency of channel section	excavation of channel, reconstruction of briges (diversion channel)
Upper reaches of G4	insufficiency of channel section	flood forecasting and warning only
B1	no compeletion of deepening	deepening
B2, B3	insufficiency of channel section	excavation of channel, reconstruction of briges (retection Pond)
Upper reaches of B3	no flooding after completion of Batu Dam	

Table 4-2 ALTERNATIVE PROTECTIVE MEASURES

	Upper Reach	Middle Reach	Lower Reach
I-1	* Klang Gates Dam * Batu Dam Batu Retention Pond Gombak Retention Pond River improvement	River improvement Natural Retarding Basin	River improvement
I-2	* Klang Gates Dam * Batu Dam Batu Retention Pond Upper Gombak Dam River improvement	- ditto -	- ditto -
II-1	* Klang Gates Dam * Batu Dam Batu Retenton Pond Gombak Diversion Channel River improvement	- ditto -	- ditto -
II-2	- ditto -	River improvement	- ditto -
III	* Klang Gates Dam * Batu Dam Batu Retention Pond Ampang Diversion Channel Kerayong Retention Pond River improvement	River improvement Natural Retarding Basin	- ditto -
IV	* Klang Gates Dam * Batu Dam Gombak Dam Batu Retention Pond River improvement	- ditto -	- ditto -
V	* Klang Gates Dam * Batu Dam Ampang Diversion Channel Kerayong Retention Pond River improvement	- ditto -	- ditto -

*; Existing dam

Table 4-3 FLOOD MITIGATION FACILITIES FOR MASTER PLAN (1)

- River Improvement Works

Stretch	River Length (km)	River Width (m)	Slope	Design Discharge (m3/s)	Remarks
Sg. Klang	-48.8k -37.4k				
K1	11.4	315 , 260	1/10000	1200	
	-37.4k -29.0k				
K2	8.4	200	1/10000	1200	
	-29.0k -15.5k				
K3	13.5	150	1/5000	1200	
	-15.5k -6.4k				
K4	9.1	90	1/2000	800	
	-6.4k 0k				
K5	6.4	100	1/2000	1150	
	0k 10.1k				
K6	10.1	71	1/1252 , 1/1200	1100, 1000	
	10.1k 14.5k				
K7	4.4	62	1/1139	870	
	14.5k 20.2k				* L=4.1km
K8	5.7	45 , 47	1/1000 , 1/760	760	R9(1.3km)R8(2.8km)
	20.2k 24.3k		1/865 , 1/120		* L=1.7km
K9	4.1	20, 26, 37	1/1000, 1/769	730, 300	R11(1.7km)
	24.3k 27.6k				
K10	3.3	32	1/640	300	
	27.6k 33.8k				
K11	6.2	29	1/422	130	
Sg. Gombak	0k 2.4k				
G1	2.4	30 , 27	1/1370, 1/1100	430	
	2.4k 5.2k		1/600		
G2	2.8	26, 32	1/655 , 1/692	180, 200	
	5.2k 7.4k				
G3	2.2	19, 26	1/600 , 1/400	180	
	7.4k 9.9k				
G4	2.5	16	1/300	120	
Sg. Batu	0k 1.4k				
B1	1.4	30	1/1040	240	
	1.4k 4.8k				
B2	3.4	26, 34	1/905 , 1/600	120, 240	
	4.8k 8.0k				
B3	3.2	12, 16	1/500 , 1/400	40, 60, 70	

Note: * River improvement completed.

Table 4-3 FLOOD MITIGATION FACILITIES FOR MASTER PLAN (2)

- Diversion Channel

Location	Length (km)	Width (m)	Slope	Design Discharge (m3/s)	Remarks
Sg. Gombak to Sg. Batu	3.25	12.0	1/200	60	

- Batu Retention Pond

River	Location (km)	Reservoir Surface (m2)	Capacity (m3)	Water Level (m)	Effective depth (m)	Remarks
Sg. Batu	7.4	233,000	2,400,000	45.0	6.0	

- Drainage Facilities in Low Lying Area

Location	Facility	Capacity	Remarks
Kg. Baru	Pump station Underground Pondage	Q= 2.0 m3/s V= 40,000 m3	
Kg. Haji Abdulah Hukom to Kg.Sentosa	Pump stations	Q= 0.5 m3/s x 3	

Table 4-4 CONSTRUCTION COST OF PHASE 2 AND PHASE 3

(Financial Cost)

River Section	Direct Cost			Land Acquisition	Compensation	Engineering Service	Government Administration	Contingency	Grand Total
	Sub Total	Miscella-neous	Total						
Phase 2.									
K7	8,943,200	1,341,500	10,284,700	16,287,200	814,360	514,200	514,200	5,682,932	34,097,592
K6	21,516,000	3,227,400	24,743,400	9,418,600	470,930	1,237,200	1,237,200	7,421,466	44,528,796
K2	14,821,300	2,223,200	17,044,500	1,776,000	88,800	852,200	852,200	4,122,740	24,736,440
K2	10,000,000	1,500,000	11,500,000	0	0	575,000	575,000	2,530,000	15,180,000
K10	5,956,200	893,400	6,849,600	0	0	342,500	342,500	1,506,920	9,041,520
K4	10,061,100	1,509,200	11,570,300	9,490,500	474,525	578,500	578,500	4,538,465	27,230,790
K5	6,157,300	923,600	7,080,900	3,293,000	164,650	354,000	354,000	2,249,310	13,495,860
K3	2,230,200	334,500	2,564,700	555,000	27,750	128,200	128,200	680,770	4,084,620
Phase 3.									
Puchong Drop Removal	1,416,000	212,400	1,628,400	74,000	3,700	81,400	81,400	373,780	2,242,680
K6	1,422,400	213,400	1,635,800	0	0	81,800	81,800	359,880	2,159,280
K7	547,600	82,100	629,700	0	0	31,500	31,500	138,540	831,240
K8	1,540,000	231,000	1,771,000	0	0	88,600	88,600	389,640	2,337,840
G1	6,130,700	919,600	7,050,300	0	0	352,500	352,500	1,551,060	9,306,360
G2	3,629,000	544,400	4,173,400	38,843,300	1,942,165	208,700	208,700	9,075,253	54,451,518
G3	5,483,900	822,600	6,306,500	28,763,400	1,438,170	315,300	315,300	7,427,734	44,566,404
K1	44,304,900	6,645,700	50,950,600	7,770,000	388,500	2,547,500	2,547,500	12,840,820	77,044,920
K3	20,695,500	3,104,300	23,799,800	0	0	1,190,000	1,190,000	5,235,960	31,415,760
K11	11,027,800	1,654,200	12,682,000	8,948,000	447,400	634,100	634,100	4,669,120	28,014,720
B1	125,800	18,900	144,700	0	0	7,200	7,200	31,820	190,920
Total	176,008,900	26,401,400	202,410,300	125,219,000	6,260,950	10,120,400	10,120,400	70,826,210	424,957,260

Table 4-5 CASH FLOWS OF COSTS AND BENEFITS FOR MASTER PLAN

(Unit : 1000 M$)

	Year	Economic Construction Costs	Operation & Maintenance Costs	Total Economic Costs	Economic Benefits
1	1993	37,813		37,813	
2	1994	37,813		37,813	
3	1995	37,813		37,813	
4	1996	37,813		37,813	
5	1997	37,813		37,813	
6	1998	37,813	1,891	39,704	38,000
7	1999	37,813	1,891	39,704	39,900
8	2000	37,813	1,891	39,704	68,400
9	2001	37,813	1,891	39,704	71,800
10	2002	37,813	1,891	39,704	75,400
11	2003	37,813	3,781	41,594	79,200
12	2004	37,813	3,781	41,594	83,200
13	2005	37,813	3,781	41,594	160,900
14	2006	37,813	3,781	41,594	160,900
15	2007	37,813	3,781	41,594	160,900
16	2008		5,672	5,672	160,900
17	2009		5,672	5,672	160,900
18	2010		5,672	5,672	160,900
19	2011		5,672	5,672	160,900
20	2012		5,672	5,672	160,900
21	2013		5,672	5,672	160,900
22	2014		5,672	5,672	160,900
23	2015		5,672	5,672	160,900
24	2016		5,672	5,672	160,900
25	2017		5,672	5,672	160,900
26	2018		5,672	5,672	160,900
27	2019		5,672	5,672	160,900
28	2020		5,672	5,672	160,900
29	2021		5,672	5,672	160,900
30	2022		5,672	5,672	160,900
31	2023		5,672	5,672	160,900
32	2024		5,672	5,672	160,900
33	2025		5,672	5,672	160,900
34	2026		5,672	5,672	160,900
35	2027		5,672	5,672	160,900
36	2028		5,672	5,672	160,900
37	2029		5,672	5,672	160,900
38	2030		5,672	5,672	160,900
39	2031		5,672	5,672	160,900
40	2032		5,672	5,672	160,900
41	2033		5,672	5,672	160,900
42	2034		5,672	5,672	160,900
43	2035		5,672	5,672	160,900
44	2036		5,672	5,672	160,900
45	2037		5,672	5,672	160,900
46	2038		5,672	5,672	160,900
47	2039		5,672	5,672	160,900
48	2040		5,672	5,672	160,900
49	2041		5,672	5,672	160,900
50	2042		5,672	5,672	160,900

Table 5-1 FLOOD MITIGATION FACILITIES OF URGENT PROJECT

- River Improvement Works

Stretch	River Length (km)	River Width (m)	Slope	Design Discharge (m3/s)	Remarks
Sg. Klang K9	20.2k 24.3k 4.1	20, 26, 37	1/865 1/120 1/1000 1/769	730 300	* L=1.7km R11(1.7km)
Sg. Gombak G4	7.4k 9.9k 2.5	16	1/300	120	
Sg. Batu B2	1.4k 4.8k 3.4	26, 34	1/905 1/600	120, 240	
B3	4.8k 8.0k 3.2	12, 16	1/400 1/500	40, 60, 70	

- Retention Pond

River	Location	Reservoir Surface	Capacity	Water Level	Effective Depth	Remarks
Sg. Batu	7.4km	233,000 m2	2,700,000 m3	45.0 m	6.0 m	

- Diversion Channel

Location	Length (km)	Width (m)	Slope	Design Discharge (m3/s)	Remarks
Sg. Gombak to Sg. Batu	3.25	12.0	1/1200	60	

- Drainage Facilities in Low Lying Area

Location	Facility	Capacity	Remarks
Kampung Baru	Pump Station Requlating Pond	Q= 2.0 m3/s V= 40,000 m3	
Kg. Haji Abdulah Hukom to Kg.Sentosa	Pump stations	Q= 0.5 m3/s x 3	

Table 6-1 CONSTRUCTION COST FOR URGENT PROJECT

(Unit : Million M$, 1988 price)

	1992		1993		1994		1995		1996		1997		Total
COST AT MARKET PRICE	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	
(1) Direct Cost													
- River Improvement	-	-	2.00	2.59	2.30	3.01	2.47	3.03	4.72	5.63	3.37	5.13	34.25
- Retention Pond	-	-	3.10	9.30	2.40	7.19	2.07	5.89	-	-	-	-	29.95
- Diversion Channel	-	-	0.20	0.85	0.90	3.59	1.20	4.86	1.50	4.70	-	-	17.80
- Drainage Plan	-	-	-	-	-	-	-	-	1.10	1.67	2.20	3.28	8.25
Sub total of (1)	0 / 0	0	5.30 / 18.04	12.74	5.60 / 19.39	13.79	5.74 / 19.52	13.78	7.32 / 19.32	12.00	5.57 / 13.98	8.41	90.25
(2) Land Acquisition	-	8.59	-	14.08	-	13.41	-	13.03	-	13.03	-	-	62.14
(3) Government Administration	-	-	-	1.08	-	0.88	-	0.88	-	0.88	-	0.70	4.42
(4) Engineering Service	-	-	1.08	-	0.88	-	0.88	-	0.88	-	0.70	-	4.42
(5) Contingency	-	-	1.20	4.80	1.20	4.80	1.30	5.20	1.36	5.44	1.32	5.26	31.88
Sub total of (2) - (5)	0 / 8.59	8.59	2.28 / 22.24	19.96	2.08 / 21.17	19.09	2.18 / 21.29	19.11	2.24 / 21.59	19.35	2.02 / 7.98	5.96	102.86
Grand total	0 / 8.59	8.59	7.58 / 40.28	32.70	7.68 / 40.56	32.88	7.92 / 40.81	32.89	9.56 / 40.91	31.35	7.59 / 21.96	14.37	193.11
ECONOMIC COST													
(1) Direct Improvement													
- River Improvement	-	-	2.00	2.36	2.30	2.74	2.47	2.76	4.72	5.12	3.37	4.67	32.51
- Retention Pond	-	-	3.10	8.46	2.40	6.54	2.07	5.36	-	-	-	-	27.93
- Diversion Channel	-	-	0.20	0.77	0.90	3.27	1.20	4.42	1.50	4.28	-	-	16.54
- Drainage Plan	-	-	-	-	-	-	-	-	1.10	1.52	2.20	2.98	7.80
Sub total of (1)	0 / 0	0	5.30 / 16.89	11.59	5.60 / 18.15	12.55	5.74 / 18.28	12.54	7.32 / 18.24	10.92	5.57 / 13.22	7.65	84.78
(2) Land Acquisition	-	7.56	-	12.39	-	11.80	-	11.47	-	11.47	-	-	54.69
(3) Government Administration	-	-	-	0.89	-	0.72	-	0.72	-	0.72	-	0.57	3.62
(4) Engineering Service	-	-	1.08	-	0.88	-	0.88	-	0.88	-	0.70	-	4.42
(5) Contingency	-	-	1.20	4.22	1.20	4.22	1.30	4.58	1.36	4.79	1.32	4.63	28.82
Sub total of (2) - (5)	0 / 7.56	7.56	2.28 / 19.78	17.50	2.08 / 18.82	16.74	2.18 / 18.95	16.77	2.24 / 19.22	16.98	2.02 / 7.22	5.20	91.55
Grand total	0 / 7.56	7.56	7.58 / 36.67	29.09	7.68 / 36.97	29.29	7.92 / 37.23	29.31	9.56 / 37.46	27.90	7.59 / 20.44	12.85	176.33

Table 8-1 CASH FLOWS OF COSTS AND BENEFITS FOR URGENT PROJECT

(Unit : 1000 M$)

	Year	Economic Construction Costs	Operation & Maintenance Costs	Replacement Costs	Total Economic Costs	Economic Benefits
1	1992	7,560			7,560	
2	1993	36,670			36,670	
3	1994	36,970			36,970	
4	1995	37,220			37,220	
5	1996	37,460			37,460	
6	1997	20,440			20,440	33,258
7	1998		1,763		1,763	33,795
8	1999		1,763		1,763	34,340
9	2000		1,763		1,763	34,895
10	2001		1,763		1,763	35,457
11	2002		1,763		1,763	36,029
12	2003		1,763		1,763	36,609
13	2004		1,763		1,763	37,200
14	2005		1,763		1,763	37,799
15	2006		1,763		1,763	37,799
16	2007		1,763		1,763	37,799
17	2008		1,763		1,763	37,799
18	2009		1,763		1,763	37,799
19	2010		1,763		1,763	37,799
20	2011		1,763		1,763	37,799
21	2012		1,763		1,763	37,799
22	2013		1,763		1,763	37,799
23	2014		1,763		1,763	37,799
24	2015		1,763		1,763	37,799
25	2016		1,763		1,763	37,799
26	2017		1,763	3,308	5,071	37,799
27	2018		1,763		1,763	37,799
28	2019		1,763		1,763	37,799
29	2020		1,763		1,763	37,799
30	2021		1,763		1,763	37,799
31	2022		1,763		1,763	37,799
32	2023		1,763		1,763	37,799
33	2024		1,763		1,763	37,799
34	2025		1,763		1,763	37,799
35	2026		1,763		1,763	37,799
36	2027		1,763		1,763	37,799
37	2028		1,763		1,763	37,799
38	2029		1,763		1,763	37,799
39	2030		1,763		1,763	37,799
40	2031		1,763		1,763	37,799
41	2032		1,763		1,763	37,799
42	2033		1,763		1,763	37,799
43	2034		1,763		1,763	37,799
44	2035		1,763		1,763	37,799
45	2036		1,763		1,763	37,799
46	2037		1,763	3,308	5,071	37,799
47	2038		1,763		1,763	37,799
48	2039		1,763		1,763	37,799
49	2040		1,763		1,763	37,799
50	2041		1,763		1,763	37,799

Figures

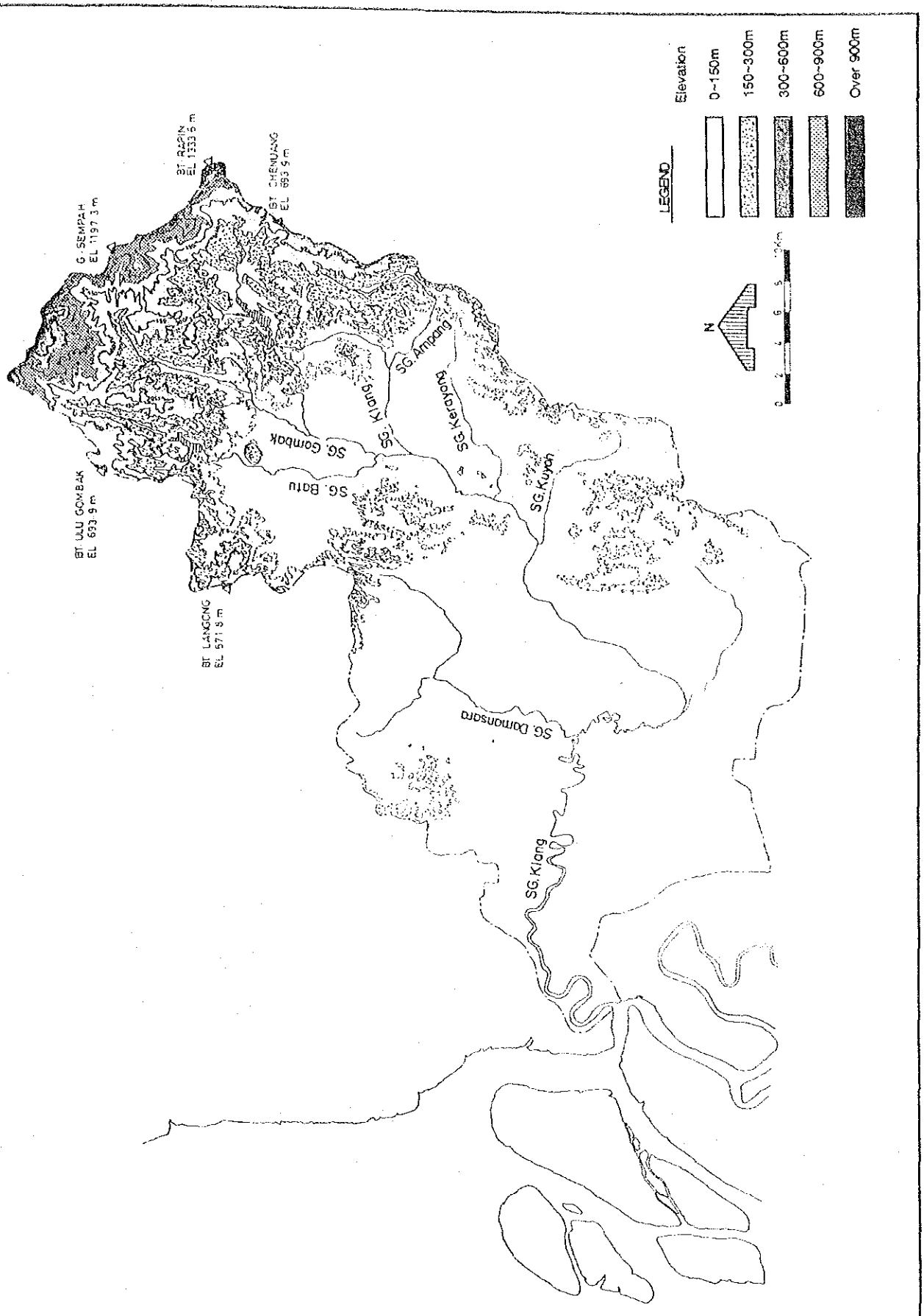


FIG. 2-1 TOPOGRAPHICAL MAP OF STUDY AREA

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

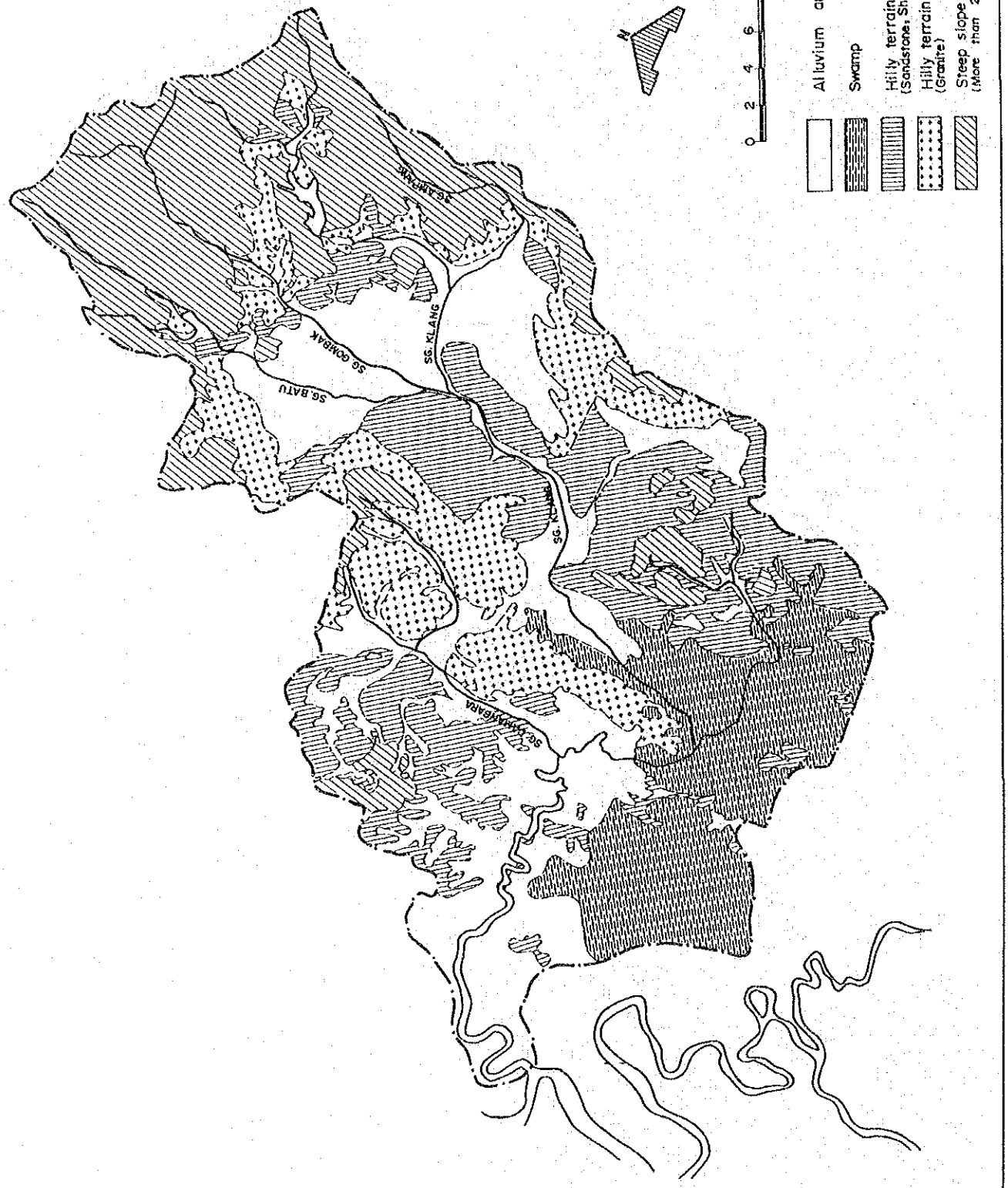


FIG. 2-2 GEOMORPHOLOGICAL MAP OF STUDY AREA

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

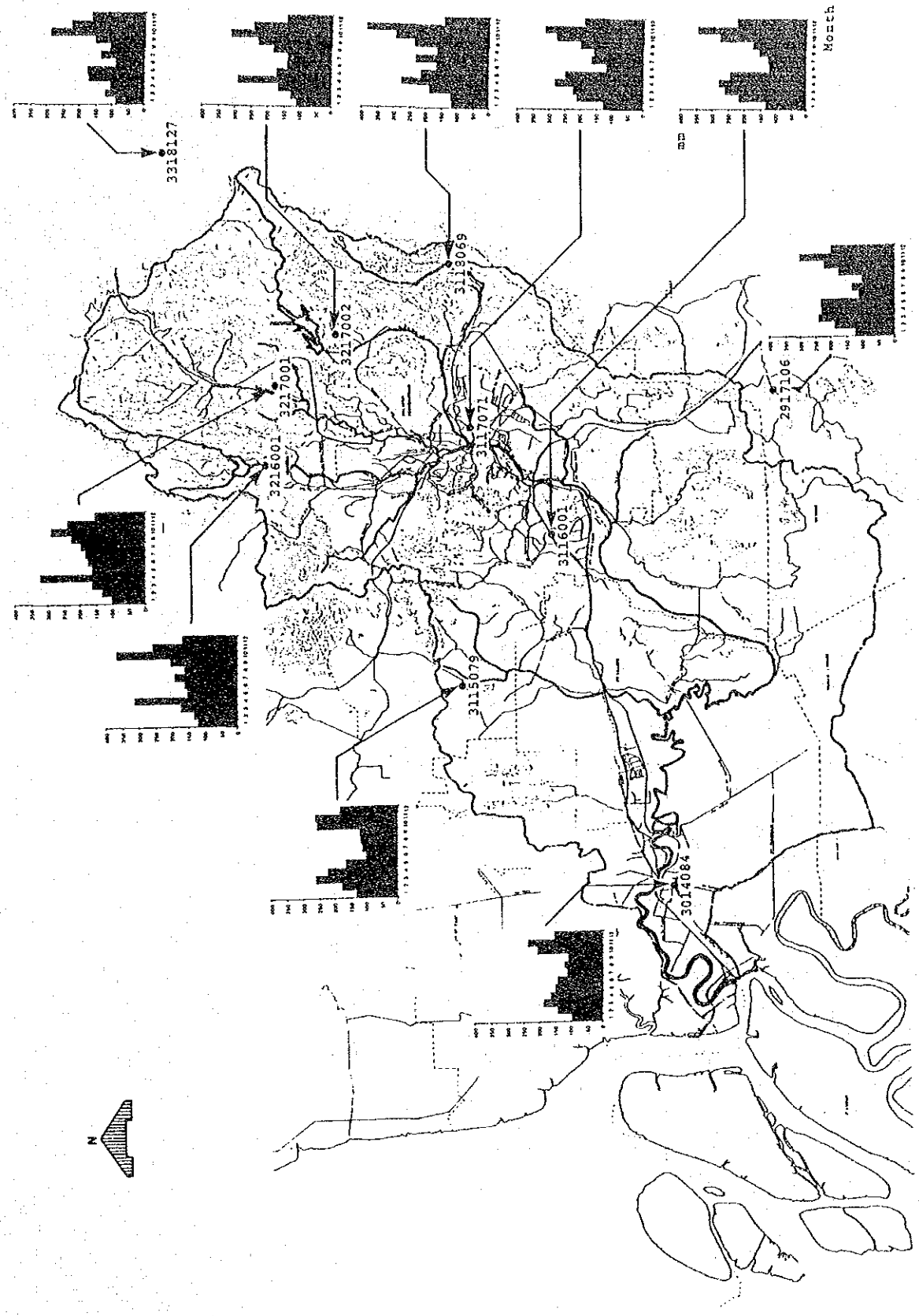


FIG. 2-3 MONTHLY RAINFALL PATTERN AT THE STATIONS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

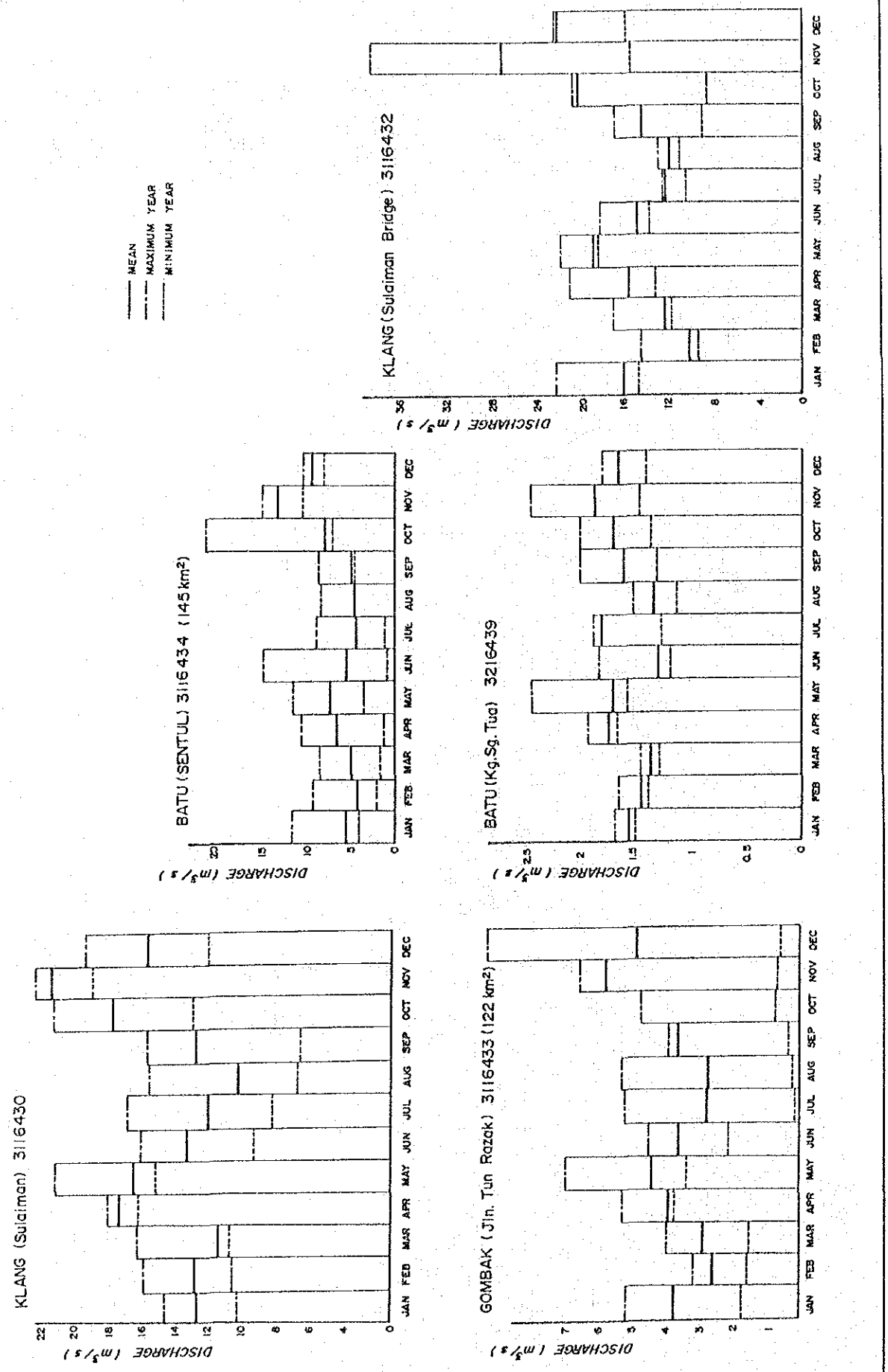


FIG. 2-4 MONTHLY DISCHARGE AT 5 STATIONS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

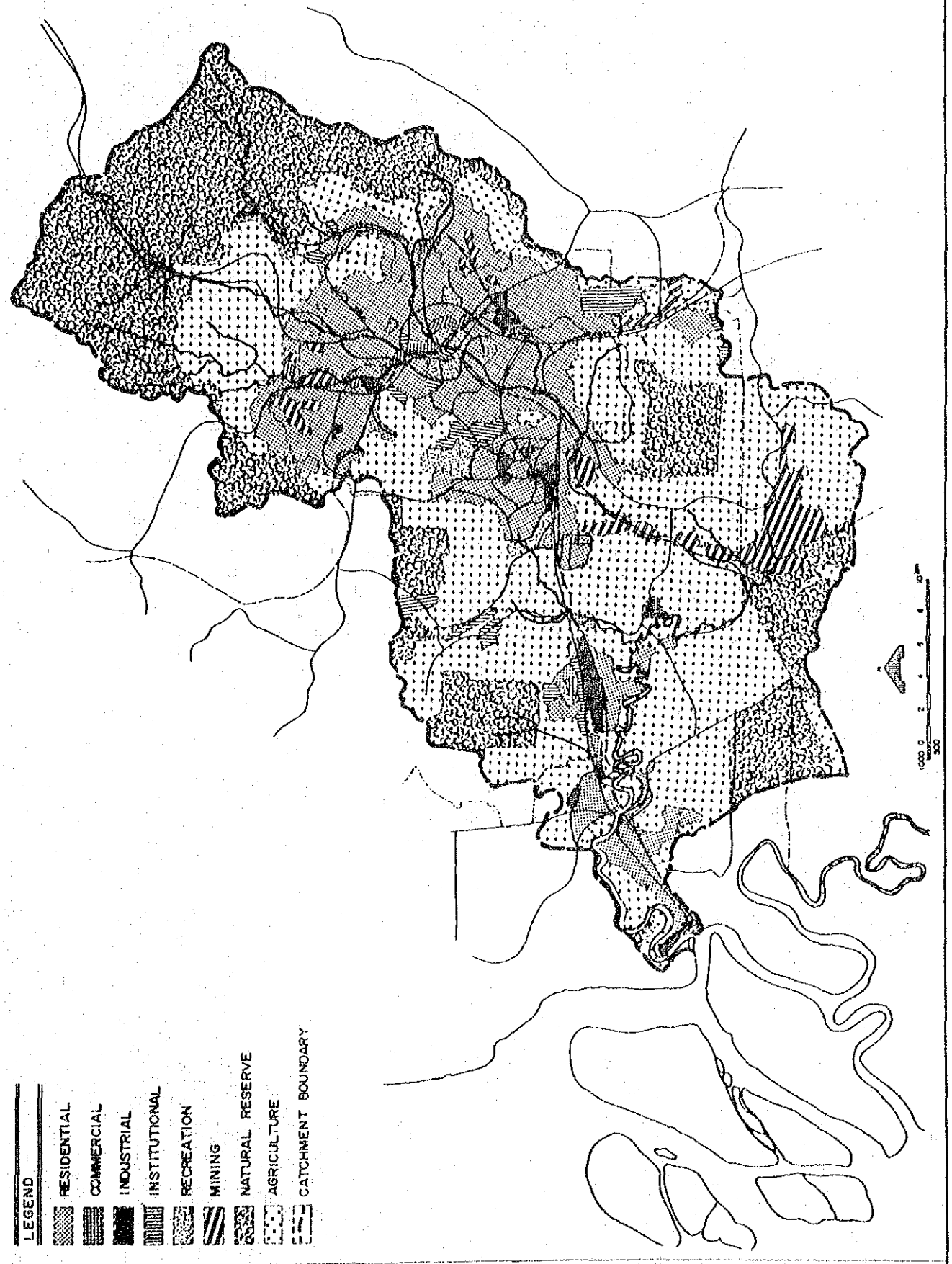


FIG. 2-5 PRESENT LAND USE IN THE KLANG RIVER BASIN, 1985

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

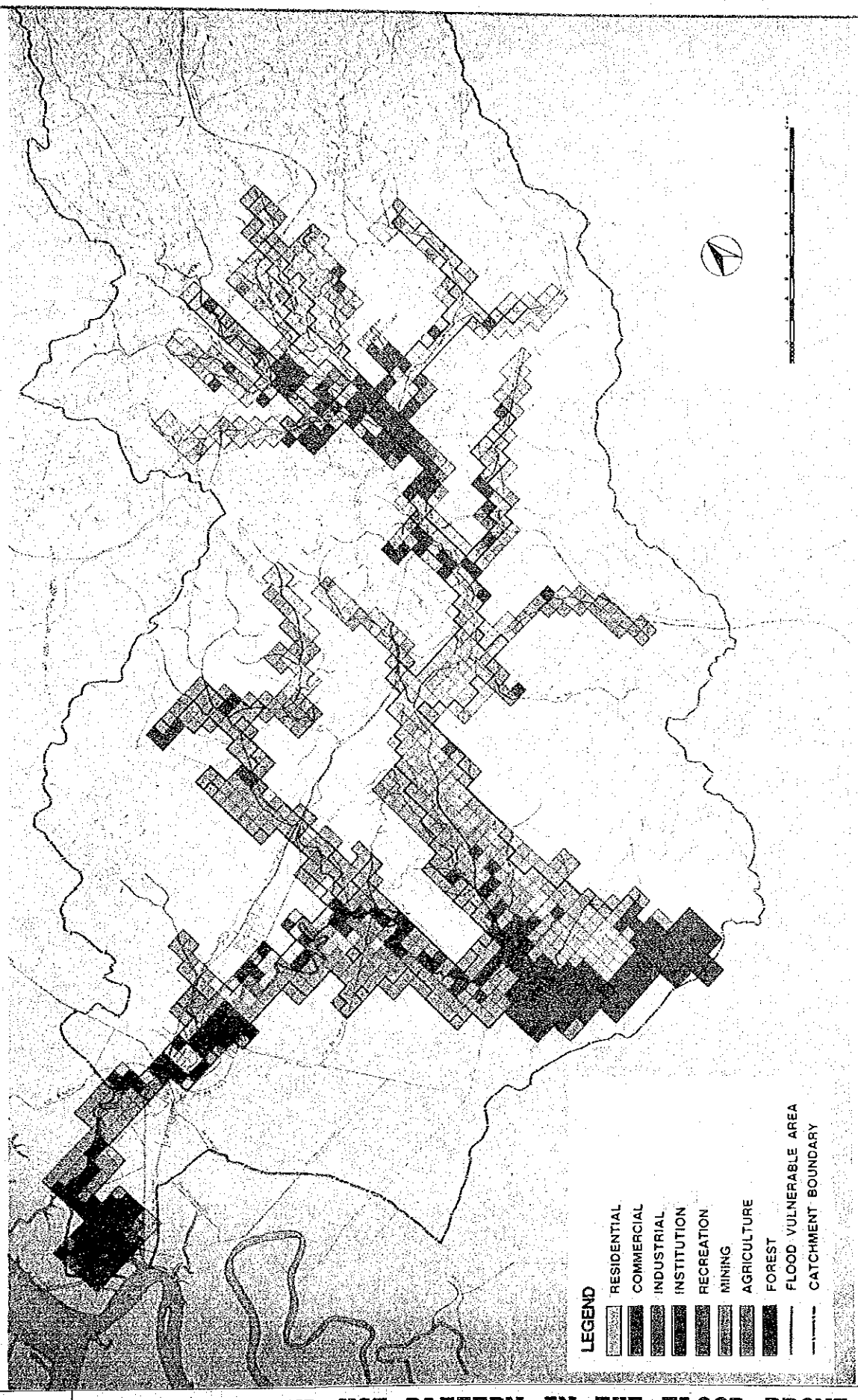


FIG. 2-6 **PRESENT LAND USE PATTERN IN THE FLOOD PRONE AREA, 1985**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

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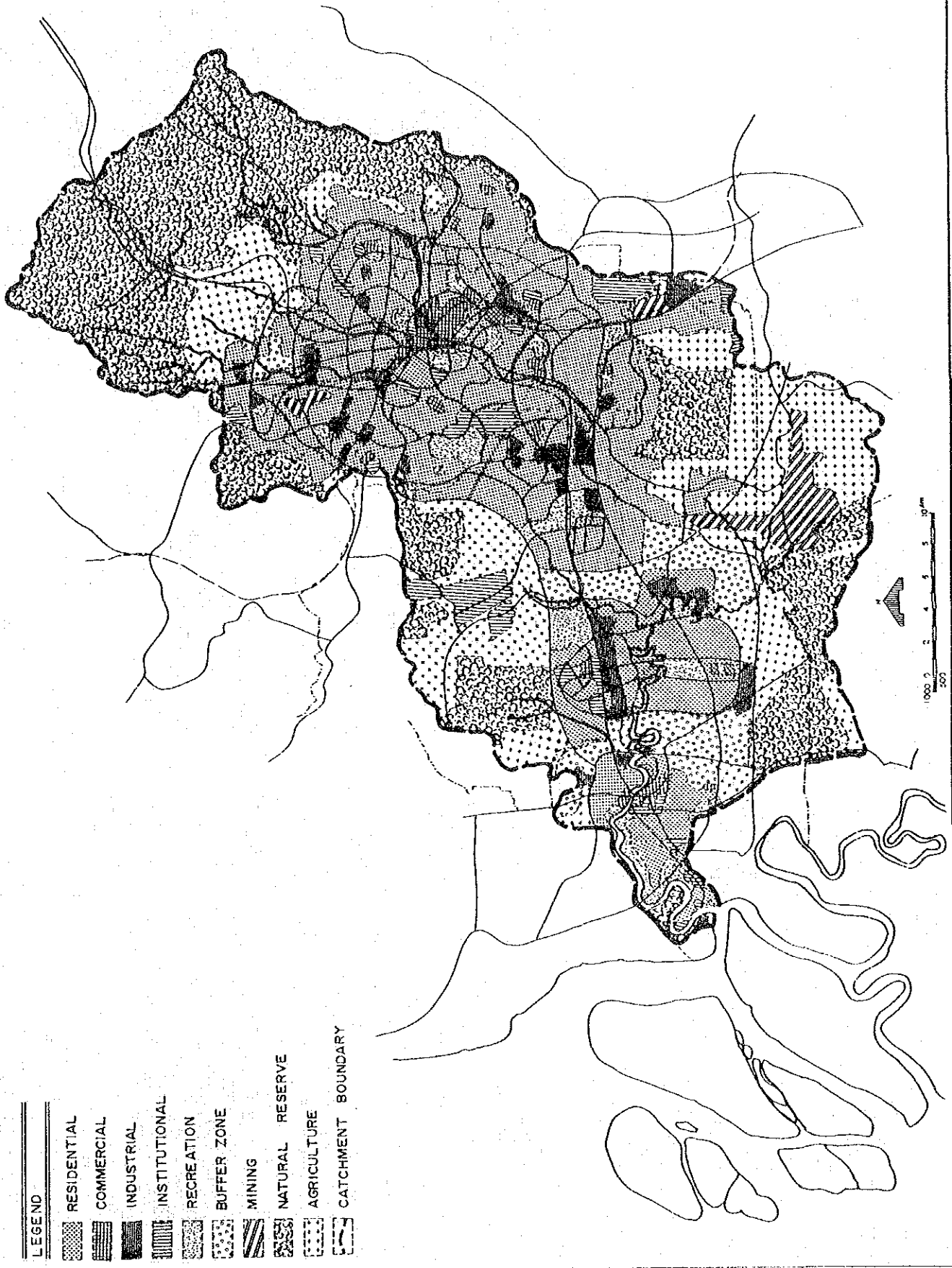

FIG. 2-7 FUTURE LAND USE PLAN IN THE KLANG RIVER BASIN, 2005