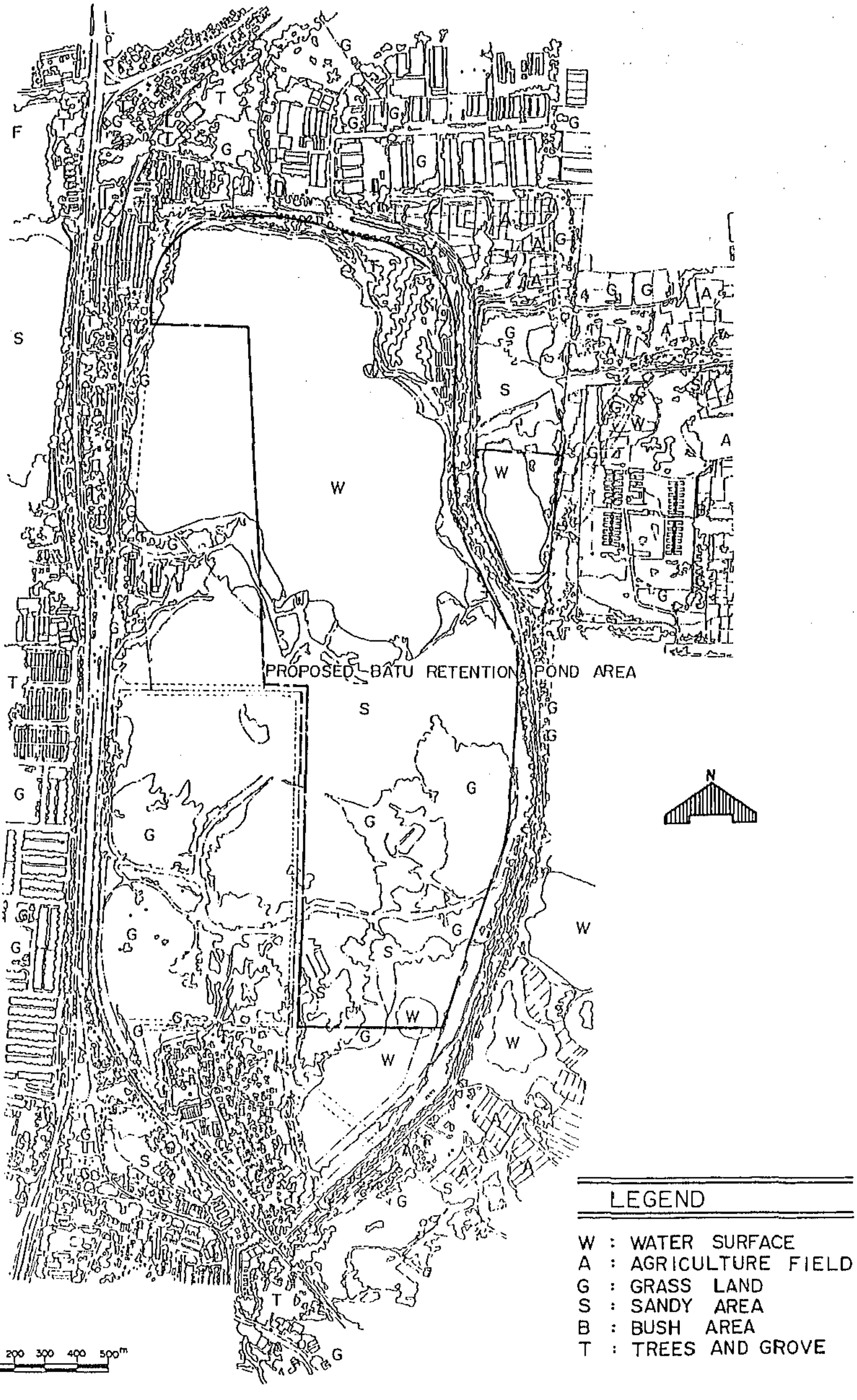

FIG. N-13	LOCATION OF PROPOSED RETENTION POND AND EXISTING ENVIRONMENTAL CONDITION

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

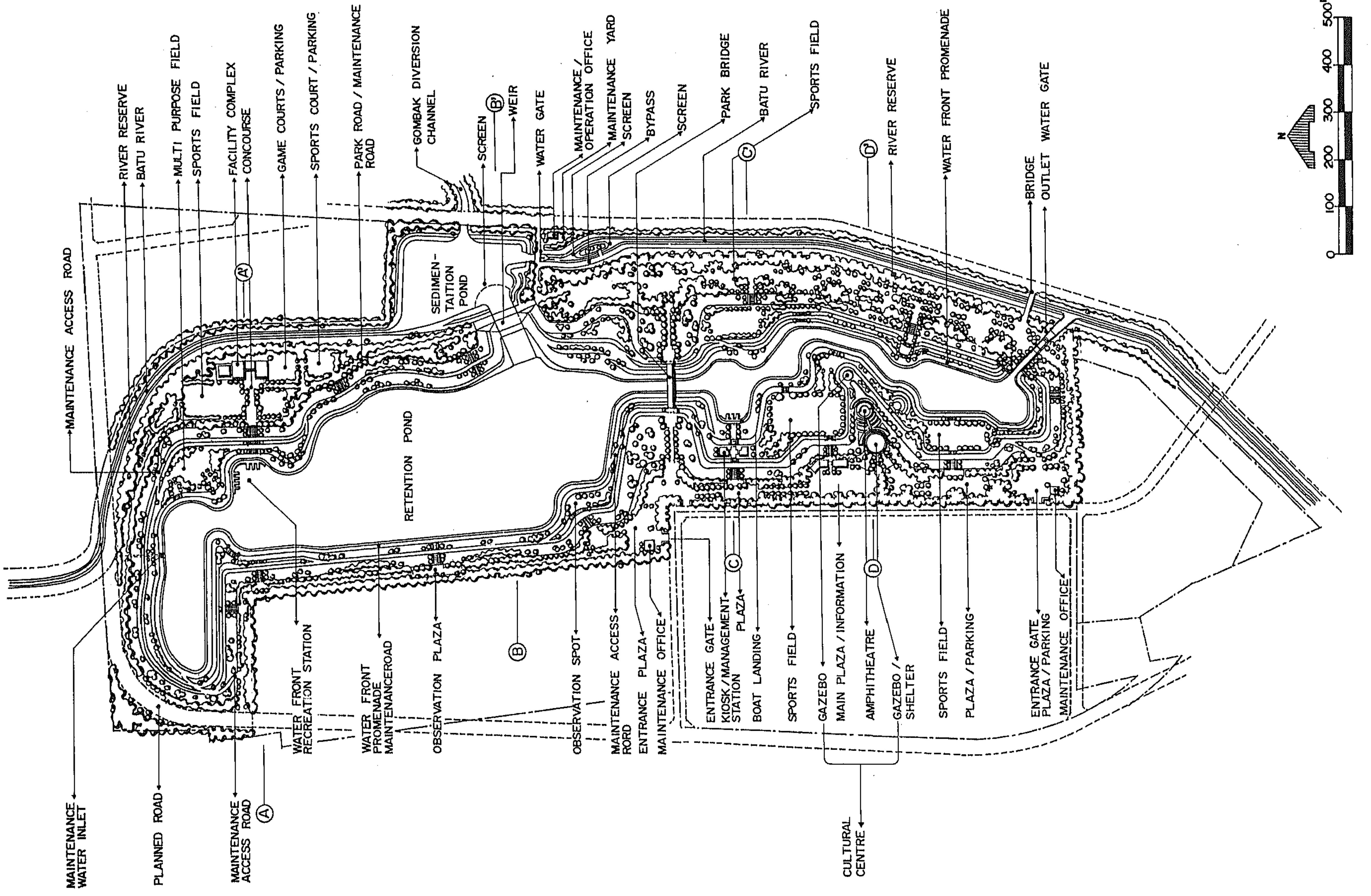

FIG. N-14	LAYOUT PLAN OF BATU RETENTION POND

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

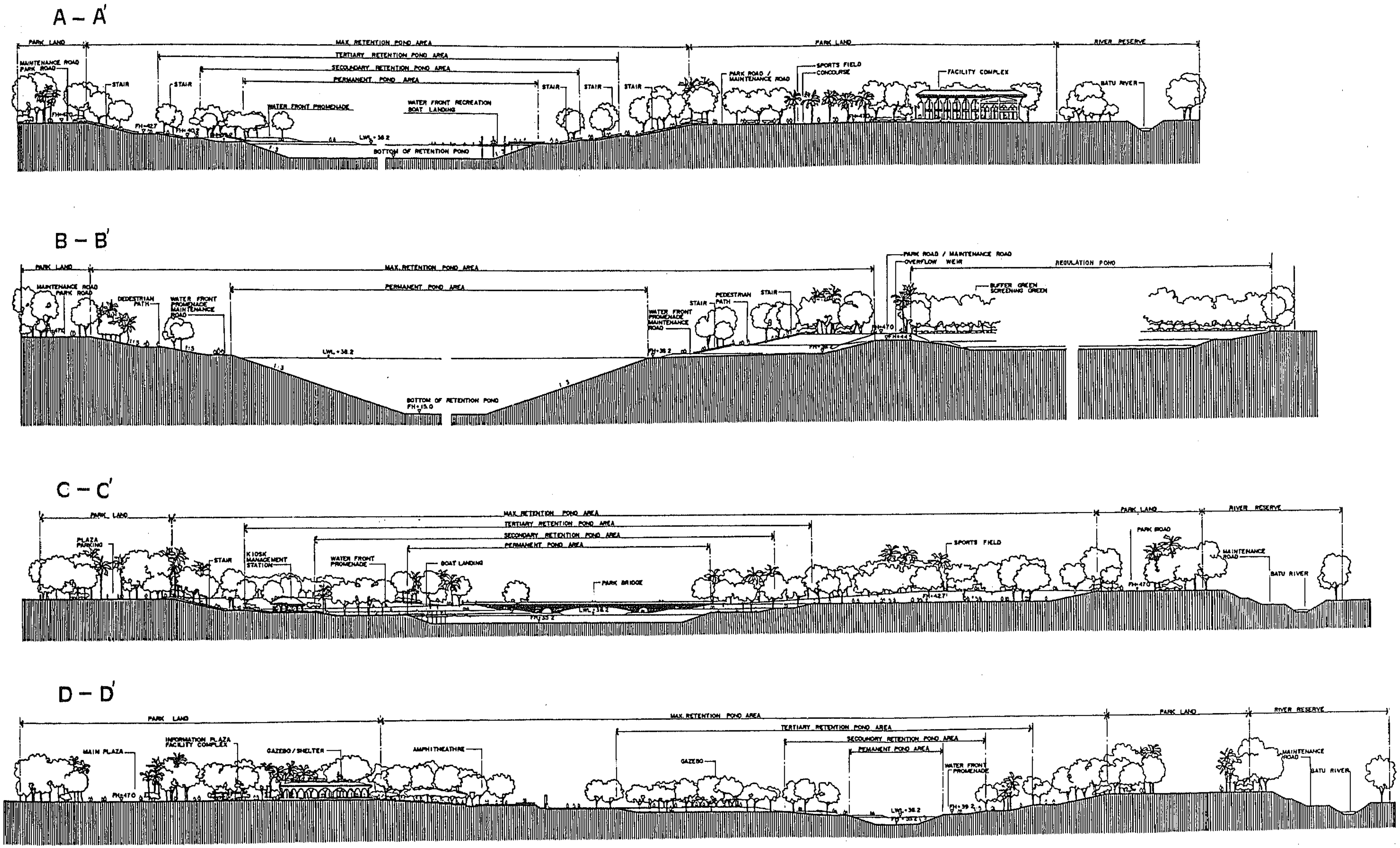

Fig. N-15	TYPICAL CROSS SECTIONS OF BATU RETENTION POND

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

TOTAL AREA		* 1, 133, 700 m²
PERMANENT POND	(LWL=38.2, up to WL<39.2)	305, 600 m²
SECONDARY RETENTION POND AREA	(40.7>WL≧39.2)	405, 600 m²
TERTIARY RETENTION POND AREA	(42.7>WL≧40.7)	549, 400 m²
Max. RETENTION POND AREA	(45.5>WL≧42.7)	* 670, 000 m²
SEDIMENTATION POND		* 55, 600 m²
PARK LAND AREA	(GL ≧ 45.5)	* 408, 100 m²

AREA RATIO OF BATU RETENTION POND / PARK AREA

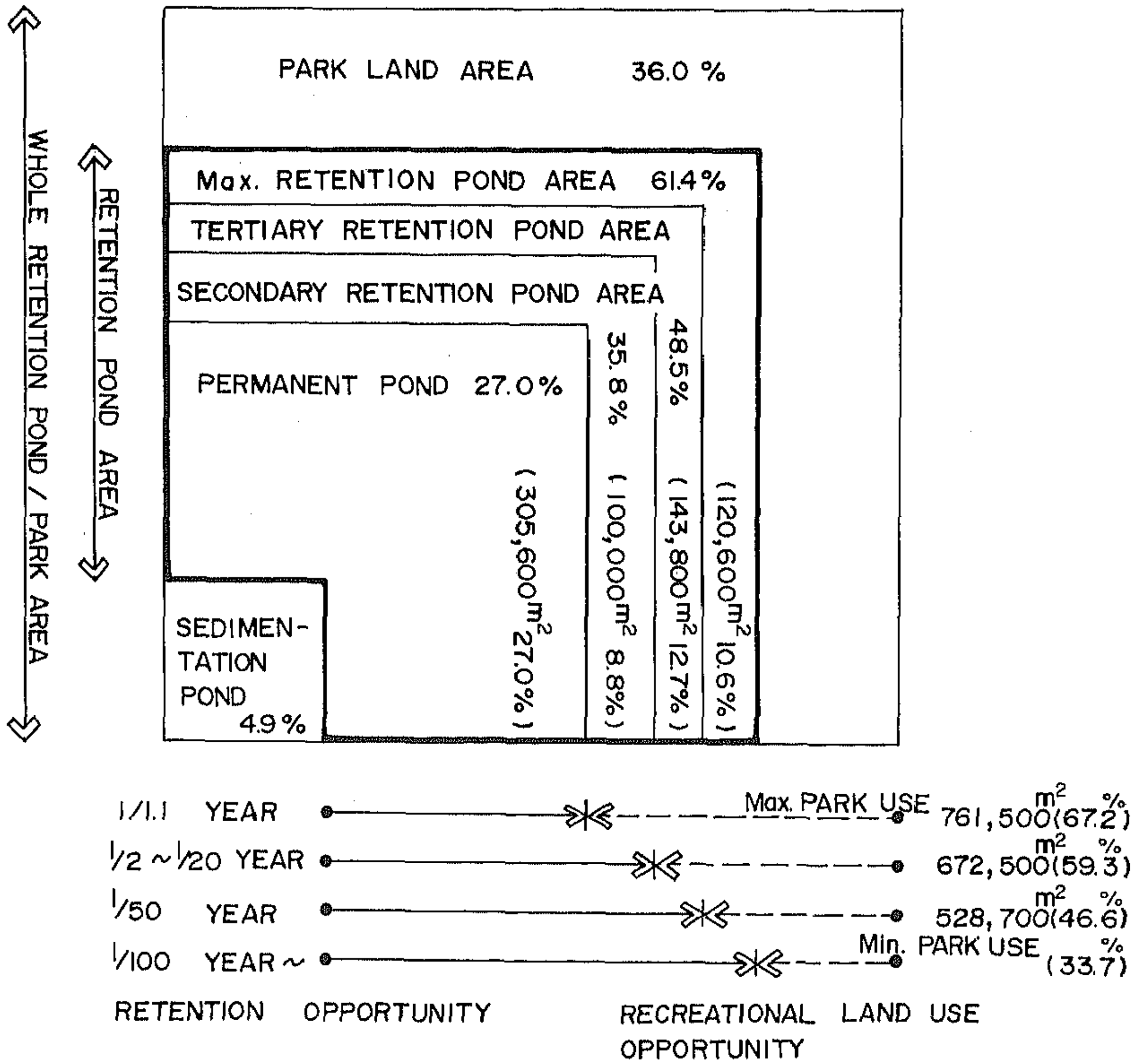

FIG. N-16 AREA OF BATU RETENTION POND / PARK AREA

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

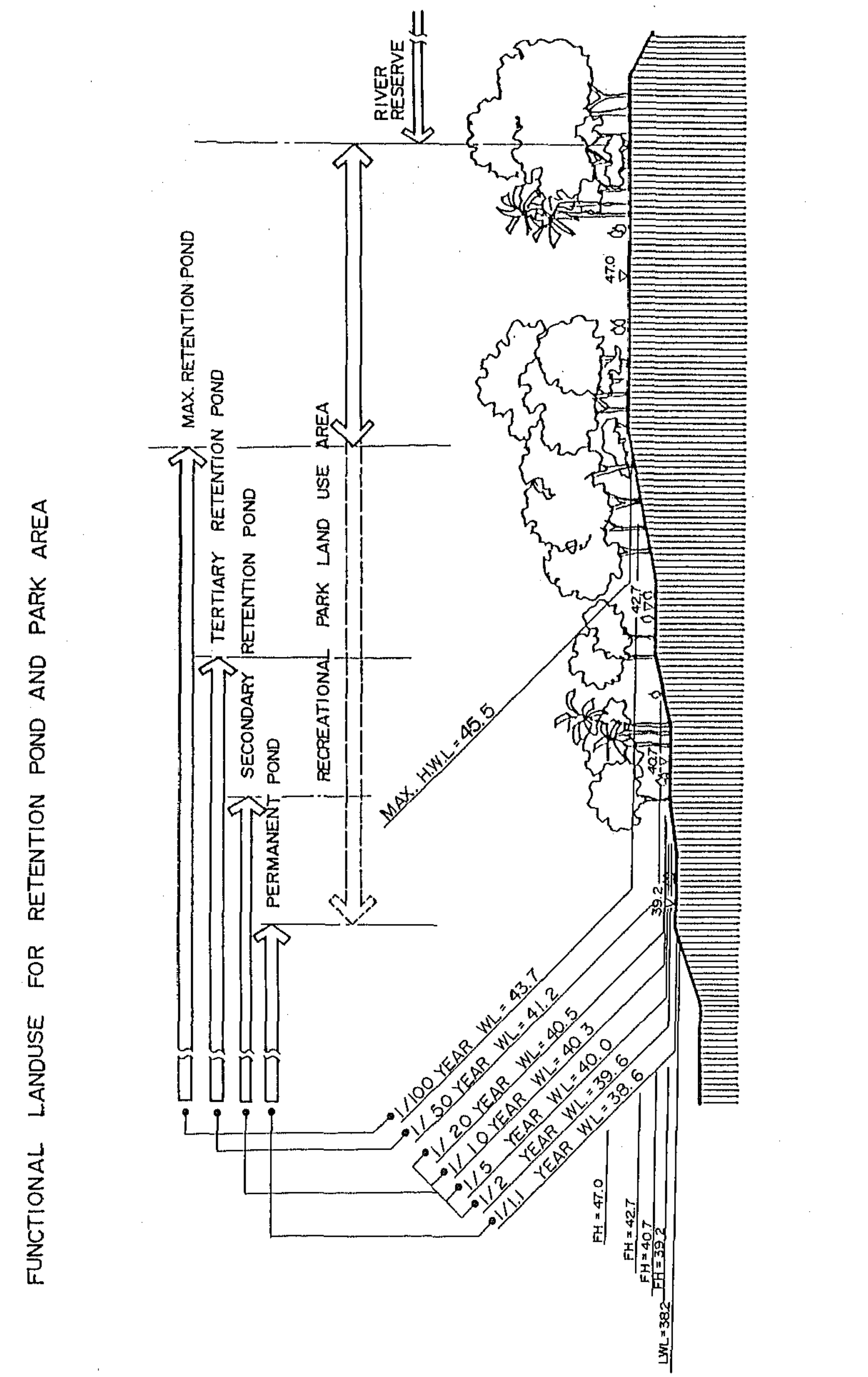

FIG. N-17	WATER LEVELS AND PARK AREA

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

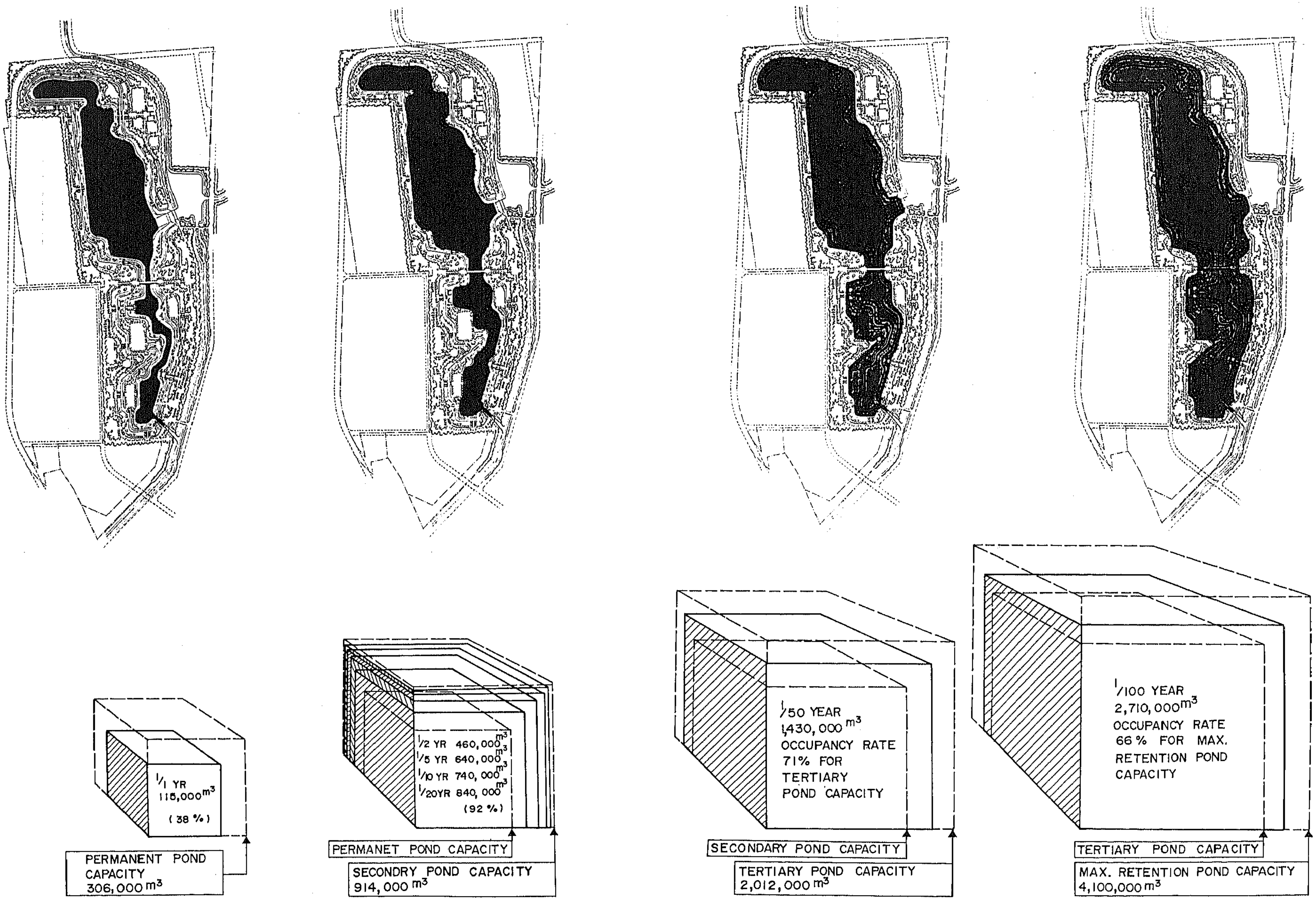

FIG. N-18 IMPOUND WATER VOLUMES AND AREAL CHANGES OF RETENTION POND THROUGH FLOOD CONTROL STAGES

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

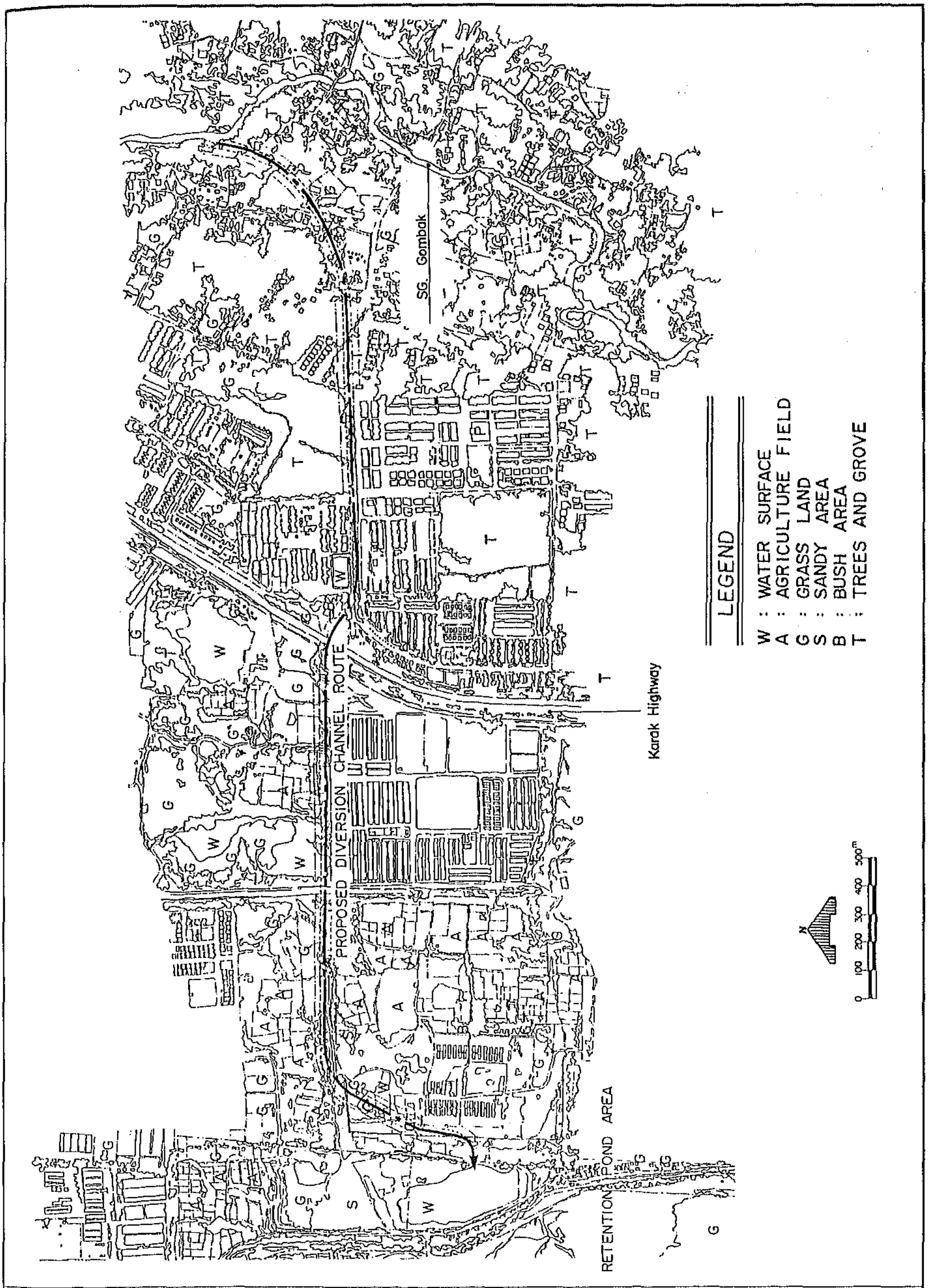

FIG. N-19	LOCATION OF PROPOSED DIVERSION CHANNEL ROUTE AND EXISTING ENVIRONMENTAL CONDITIONS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

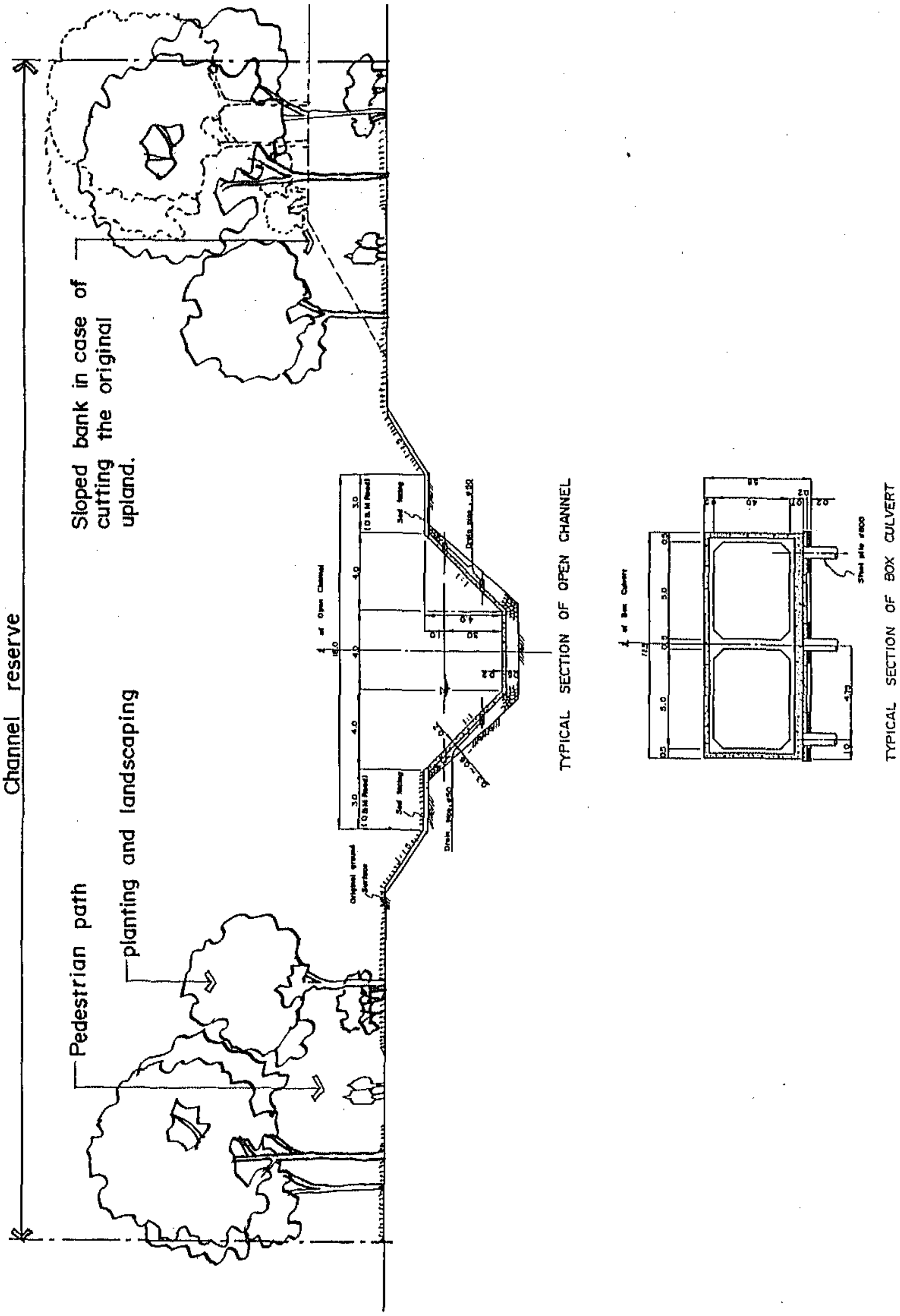

FIG. N-20 **TYPICAL SECTION OF GOMBAK DIVERSION CHANNEL**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

MATRIX
INTRODUCTION ON REVERSE SIDE

KEY

D Potentially significant adverse environmental impact for which a design solution has been identified.

U Adverse environmental impact that is potentially significant but about which insufficient information has been obtained to make a reliable prediction.

● Residual and significant adverse environmental impact.

E Significant environmental enhancement.

PROJECT ACTIVITIES — SITE INVESTIGATION

IDENTIFICATION OF ACTIVITIES	1 Access Roads and Tracks	2 Airstrips and Helipads	3 Site Surveying	4 Aerial Surveying	5 Hydrological Survey	6 Climatological Survey	7 Geophysical Survey	8 Timber Felling	9 Site Clearing	10 Drilling	11 Drilling and Blasting	12 Base Camps	13 Abandonment
Land 1 Landforms													
Land 2 Soil Profile													
Land 3 Soil Composition													
Land 4 Slope Stability													
Land 5 Subsidence and Compaction													
Land 6 Seismicity													
Land 7 Flood Plains/Swamps													
Land 8 Land Use													
Land 9 Engineering and Mineral Resource													
Land 10 Buffer Zones													
Surface Water 1 Shoreline													
Surface Water 2 Bottom Interface													
Surface Water 3 Flow Variation													
Surface Water 4 Water Quality													
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Surface Water 7 Flooding													
Surface Water 8 Existing Use													
Groundwater 1 Water Table													
Groundwater 2 Flow Regime													
Groundwater 3 Water Quality													
Groundwater 4 Recharge													
Groundwater 5 Acquifer Characteristic													
Groundwater 6 Existing Use													
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Atmosphere 2 Air Flow													
Atmosphere 3 Climatic Changes													
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Aesthetic and Cultural 12 Religious Places or Structures													
Aesthetic and Cultural 13 Landscape													
Aesthetic and Cultural 14 Compositions													

PROJECT ACTIVITIES — SITE PREPARATION AND CONSTRUCTION

IDENTIFICATION OF ACTIVITIES	1 Access Roads and Tracks	2 Stream Crossings	3 Airstrips and Helipads	4 Transportation	5 Hydrological Surveying	6 Climatological Surveying	7 Drilling	8 Drilling and Blasting	9 Timber Felling	10 Site Clearing	11 Stripping	12 Erosion Control	13 Drainage Alteration	14 Earthworks	15 Corridors	16 Coastal Works	17 River Works	18 Dredging	19 Reclamation	20 Dams, Barrages and Bunds	21 Canalisation	22 Pipelines	23 Tunnels and Culverts	24 Surface Structures	25 Housing	26 Equipment	27 Landscaping	28 Surfacing and Paving	29 Revegetation and Reforestration	30 Fortilizer Application	31 Pest Control	32 Labour Force	33 Waste Disposal and Recovery	34 Base Camps	35 Abandonment
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Aesthetic and Cultural 14 Compositions																																			

PROJECT ACTIVITIES — OPERATION AND MAINTENANCE

IDENTIFICATION OF ACTIVITIES	1 River Works	2 Stream Crossings	3 Alteration of Drainage	4 Coastal Works	5 Dredging	6 Reclamation	7 Cloud Seeding	8 Irrigation	9 Impoundment of Water	10 Groundwater Extraction	11 Pipelines	12 Corridors	13 Barriers and Fences	14 Equipment	15 Accidents	16 Energy Balance	17 Transportation	18 Labour Force	19 Erosion Control	20 Pest Control	21 Fertilizer Application	22 Waste Disposal and Recovery	23 Abandonment
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Aesthetic and Cultural 12 Religious Places or Structures																							
Aesthetic and Cultural 13 Landscape	E								E					E					E				
Aesthetic and Cultural 14 Compositions	E								E														

RELATED DEVELOPMENT

IDENTIFICATION OF ACTIVITIES	1 Agriculture	2 Urbanisation and Settlement	3 Municipal/Industrial Water Supply	4 Recreation
Land 1 Landforms				E
Land 2 Soil Profile				
Land 3 Soil Composition				
Land 4 Slope Stability				
Land 5 Subsidence and Compaction				
Land 6 Seismicity				
Land 7 Flood Plains/Swamps				
Land 8 Land Use				E
Land 9 Engineering and Mineral Resource				
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Aesthetic and Cultural 6 Climate				
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Aesthetic and Cultural 8 Sense of Community				
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Aesthetic and Cultural 11 Historic Places or Structures				
Aesthetic and Cultural 12 Religious Places or Structures				
Aesthetic and Cultural 13 Landscape				E
Aesthetic and Cultural 14 Compositions				E

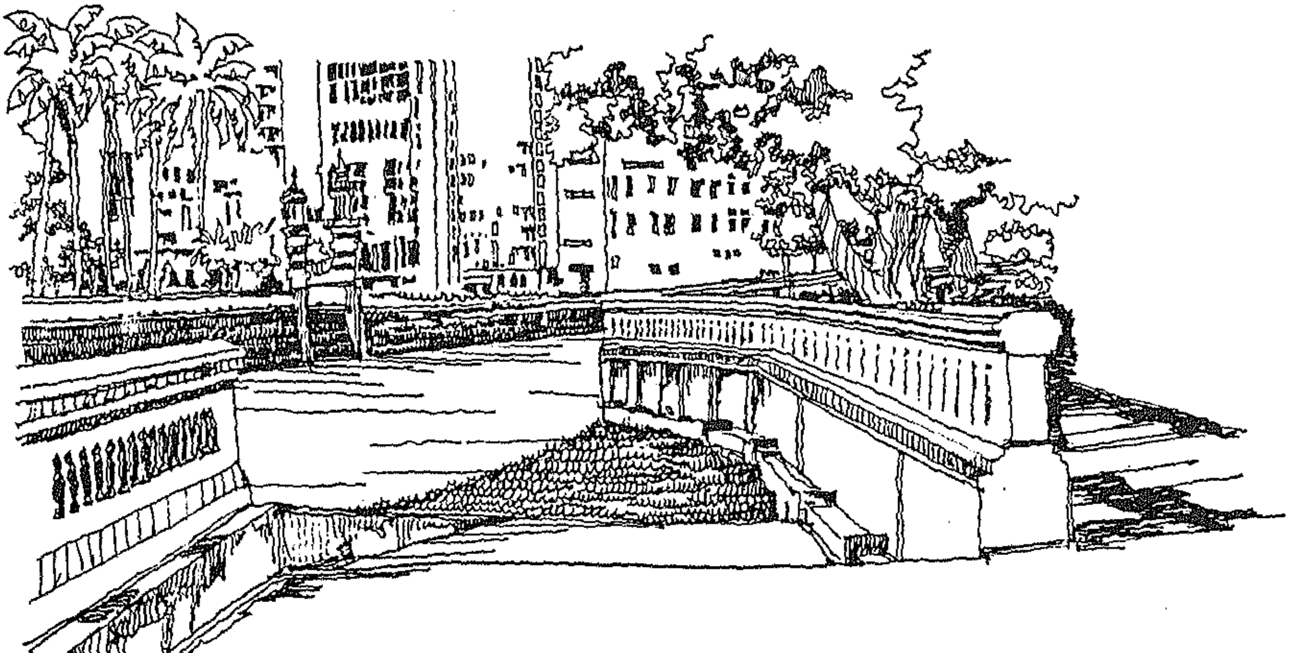
ENVIRONMENTAL COMPONENTS: PHYSICO-CHEMICAL (Land, Surface Water, Groundwater, Atmosphere, Noise); BIOLOGICAL (Species and Population, Habitats and Communities); HUMAN (Health and Safety, Social and Economic, Aesthetic and Cultural)

PROJECT ACTIVITIES HAVE BEEN GENERALLY IDENTIFIED IN ACCORDANCE WITH THE ENVIRONMENTAL IMPACT ASSESSMENT HAND BOOK PREPARED BY DOE

FIG. N-21 ENVIRONMENTAL MATRIX FOR THE PROJECT

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

APPENDIX O: CONSIDERATION ON WATER QUALITY IMPROVEMENT



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APPENDIX O. CONSIDERATION ON WATER QUALITY IMPROVEMENT

1. INTRODUCTION

The water quality of the Klang River and its tributaries is going to degrade according to the land development and population increase in the basin.

The maintenance and control of the quantity and quality of river water is very important from the ecological and aesthetic viewpoint.

For the stretches of the Klang, Gombak and Batu Rivers in the central part of the city, the present water conditions were grasped 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

2. PRESENT CONDITION OF KLANG RIVER WATER QUALITY

2.1 Physical Conditions

The Klang River Basin has reached a considerably polluted stage in that the river system has been affected directly by many sources of pollution which are discharge directly into the water course.

According to the Klang Valley Environmental Improvement Project (KVEIP) report 1987, the level of pollution worsens during low flows. The important controlling parameters have been identified as BOD (Biological Oxygen Demand) and DO (Dissolved Oxygen). Among these parameters which determine the water quality of the river, DO is by far the most important as it determines whether an aerobic condition exists in the river or not.

Using DO as the criterion, the quality in the upper reach of Klang River and its tributaries until the confluence at central district is acceptable with a minimum DO level in excess of 4 mg/l. However, after the river flows from the confluence of Sg. Kerayong to Puchong Drop, the DO level drops to a low of 2.2 to 2.3 mg/l.

At Puchong Drop a temporary improvement in DO may be realized due to aeration effects of the Puchong Drop weir. Downstream of this point up to the estuary, the DO level becomes very low, dropping to an unacceptable figure of 1.5 to 0.2 mg/l.

Using BOD as the criterion, the upper reach of Klang River upstream of the confluence at central district has an acceptable BOD level of less than 6 mg/l. However, as the river flows through the urbanized areas the BOD increases to 6 mg/l at the Puchong Drop while further down stream near the Damansara confluence, the BOD reaches a peak value of 11 mg/l. As the river flows further downstream the BOD decreases gradually to reach an approximately 4 mg/l at the estuary due to dilution by tidal intrusion.

Using suspended solid as a criterion, the upper reach upstream of the confluence at central district has a rather low level of suspended solid of slightly over 200 mg/l. Only a few upstream tributaries satisfys the acceptable level of less than 150 mg/l. Downstream of the confluence at central district, stretches the suspended solid level increases enormously to between 840 mg/l and 2500 mg/l (Fig. O-1, O-2).

2.2 Aesthetic Conditions

Visual perception represents the first impression gained by an observer on surface water quality. The observer's impression depends on whether floating debris, turbidity with suspended solids and dark muddy color are present in the flowing water or not.

In its present condition, muddy turbid water mixed with dark sanitary sewerage discharge is seen flowing through the Klang River System. Muddy turbid water is the result of erosion and siltation caused by large scale earthworks from various development projects.

At places, piles of debris and wastes have been dumped along the river banks causing obstruction to the flow. The existing poor water quality of the Klang river system degrades the aesthetic environment of the river even in the newly improved riverside in the central district.

3. CONSIDERATION ON WATER QUALITY IMPROVEMENT

3.1 Improvement Measure of River Water Quality

As referring the Klang Valley Environmental Improvement Project (KVEIP) recommendation and at a viewpoint of the Klang river basinwide environment concerned, the Intercepter Sea-Outfall (ISO) system will be a optimal overall solution and concept of restoring the Klang river to be an acceptable state of cleanliness in technological sound. And this practicable solution will be installed a system of intercepters along the river for intercepting the waste flows from communities and industries to transporting for disposal into offshore marine water. However this system is rather big difficulty for financial points of view at present time.

- Delineating the treatment and disposal facilities

  The distribution of the treatment and disposal facilities including level of treatment establishment by each communities and major industries is the most reliable approach the targets for sewerage planning to control discharge waste water to the river.

- Forecasting the Industrial Waste Permit System (IWPS)

  Every industries produced significant liquid and solid waste are required to apply and obtain a permit which specifies the conditions under which the industry will be allowed to discharge its wastes, whether the discharge is made to community sewerage system or independently.

- The Klang Valley Water Quality (KV/WQ) monitoring

  The on-going KV/WQ monitoring operated by DOE and together with by DID shall be considered to add some more sampling stations to establish strategic target area with step-by-step approach for improvement of water quality.

- Forecasting more effective solid waste disposal system

  A number of log booms are used for removing floating debris, but there are only partially effective. The real solution shall be necessitated more effective program to forecast the regional and district level of solid waste disposal system.

- Septic treatment permit control

  The pump out septic tanks and leaking pit shall be controlled by use of a permit system which requires the trucks to discharge to special transfer stations located on selected manholes in the community sewerage system.

- Erosion and siltation control

  The erosion from barren urban development lands is the biggest single erosion source. This problem should be immediately solved to ensure the enactment of bye-laws by the local authorities, pursuant to the local government act 171 of 1976, to empower the local authorities to regrass the exposed surface at the owner's expense with specific time limits.

Beside fundamental improvement measures described above, following tentative measures for river water quality shall be considered.

- Due to dilute the polluted water especially in low flow condition, some maintenance water from the reservoirs shall be necessitated to discharge at dry periods.

- Utilization of the ex-mining ponds without any use and program shall be taken place for diverting river water and silt sedimentation purposes as well as purification of water quality.

3.2 Interim National Water Quality Standard by the Department of Environment

The department of environment (DOE) has carried out a study on water quality standards and published a proposed National Water Quality Criteria and Standards for Malaysia in 1986.

According to the report, Klang river is categorized as a class III river system having the following major water quality parameteric values:

Parameters	units	Class III
Ammoniacal Nitrogen	mg/l	0.9
BOD	mg/l	6
COD	mg/l	50
DO	mg/l	3-5
pH		5-9
Color	TCE	-
Elect. Cond.*	µmhos/cm	-
Floatables		-
Odor		-
Salinity*	%	-
Taste		-
Total Diss. Solid*	mg/l	-
Total Susp. Solids	mg/l	150
Temperature	°C	Normal ±2
Turbidity	NTU	-
F. Colif.**	counts/100 ml	5000
		(2000)a
Tot. Colif.	counts/100 ml	50000

* = Related parameters, only one recommended for use

** = Geometric mean

a = Maximum not to be exceeded

3.3 Consideration on Objective Target Area and Level of Water Quality

In its existing condition almost the entire length of the Klang River fails to meet the class III standard given above at Section 3.2. As a matter of fact, the parameters defining the water quality varies from each observation point and is affected by river water discharge.

The Interim National Water Quality Standards will serve as target level towards which the water quality will be improved. However, most of the river stretch except the upper reach from the confluence at central district area is a deficient state in terms of the class III water quality levels.

The water quality will be improved through a step by step approach for each section of the river reach in compliance with regulations and directions of various government authorities, such as Department of Environment, the City Hall, Department of Irrigation and Drainage of both Federal Government and Selangor State, etc.

Consideration for possible improvement of the water quality shall be taken to set up a strategy for each section of the river.

(1) Objective Target Area

In this study, objective target area for improvement of water quality shall be recommended at the area where from upper reach of Klang River, Sg. Ampang, Batu River and Gombak River to the confluence at Jln. Pasar Busar of central district. This is the first step target area to improve degraded parameters and keep maintain acceptable level of parameters.

And this target area should be extended to down stretch way step-by-step along major confluences with other tributaries whenever the improvement target is cleared.

(2) Objective Target Level of Water Quality

Since the objectives for setting the target level of the water quality means rather aesthetic approach to rehabilitate water quality in cooperated with flood mitigation scheme and urban beautification scheme.

Primarily water quality outlooks require the condition of clean water without turbidity, coloring and floating debris and secondly require the visible condition of fish fauna habitat.

For these points of view, major improvement target level for water quality will be set as follows.

Paramters	Unit	Improvement Target Criteria for water quality
Turbidity	NTU	50
Suspended solids	mg/l	150
Dissolved solids	mg/l	500
BOD	mg/l	6.0
COD	mg/l	50
DO	mg/l	4.0
pH		6.5~8.5
Floating material		absent

Concerning with other parameters, the criteria of Interim National Water Quality shall be the target of the level at the stand point of comprehensive water quality improvement scheme.

4. USE OF EX-MINING PONDS FOR IMPROVING RIVER WATER QUALITY

There is a good example to contribute the improvement of river water quality on ex-mining ponds at Sg. Jinjang stretches. The obvious difference of the water quality condition can be observed that the upper reach pond looks turbid while down reach pond looks quite clean status.

4.1 Characteristics of the Ex-mining Ponds of Sg. Jinjang Stretch

4 ex-mining ponds are sited from north to southward each along Sg. Jinjang. 3 ponds of them are sequentially linked with narrow channel and the water of Sg. Jinjang has been naturally diverted into them, and discharged to Sg. Jinjang at the downstream again.

Areas of each ex-mining pond are approximately 12 ha, 17 ha and 28.5 ha from upper to downward of 2.5 km in length. The polluted river water is diverted into the first upper pond and continuously flows through the second middle pond and the third down pond.

4.2 Evidence of Remarkable Water Quality Improvement through Ex-mining Ponds

The recent water sampling survey was carried by the Department of Irrigation and Drainage (DID) at upper stream near inlet of the pond and downstream near outlet of the pond.

The samples were taken at same date and time, (9:45 to 10:00 AM at 7th Sept. 1988), and the examined results of sampled water quality in each major parameter are as follows.

Major Parameter	Unit	Location at Upperstream	Location at Downstream	Improvement Efficacy
1. Turbidity (NTU)		130	2.0	+65 times upgraded
2. Conductivity	µmhos/cm	165	160	+1.03 "
3. Total solids at 105°C	mg/l	661	118	+5.6 "
4. Suspended solids	mg/l	548	14	+39 "
5. Dissolved solids	mg/l	113	104	+1.1 "
6. BOD	mg/l	11	3.2	+3.0 "
7. COD	mg/l	40	32	+1.3 "

On the other parameters of the water quality, there are some improved parameters such as Potassium, Sodium, Nitrate, Ammonia, Phosphate and Flouride while slightly degraded parameters are identified such as pH, Alkalinity, Calcium, Chloride, Magnesium, Sulphate, Iron and Magnesium, and Color and Silica are not varied.

Most remarkable evidences of the water quality improvement are identified at turbidity, total solids, suspended solid and BOD levels and these evidences express on the improved water surface outlooks as clean conditions.

4.3 Recommendation for the Use of Ex-mining Ponds for River Water Quality Improvement

There are many ex-mining ponds along the Klang River and its tributary stretches, and most of them are remained without effective utilization on the scheme of water quality improvement.

Most of ex-mining ponds have been reclaimed for housing development in order to meet with rapid growth of urbanization of the Klang Valley Region. However there are still many ex-mining ponds that leave in vacant condition and utilize only few purposes such as fish culture.

Potential utilization of these ponds for flood mitigation together with improvement of river water quality should be mostly recommended at this moment.

5. SCREENING OF FLOOD DEBRIS AND CAMPAIGN FOR RIVER BEAUTIFICATION

As regards floating debris, City Hall has been operating three log booms and one screen equipment on each tributaries of the Klang river at locations before the confluence. These are efficiently operated and approximately 80% of the floating debris is collected in a normal day operation. As a result, visible debris on the river bed in the central district has been significantly reduced.

However there are large amount of floating debris appeared at the periods of frequent flush flood. For this solution, more log booms shall be provided at critical points of the river at vicinity of confluence and squatter area for efficient screening for floating debris.

Fundamental solution will be enlighten the citizenry to be aware of river side environment that is always kept clean and beautiful.

Establishment of a basinwide clean-up campaign for river water protection and conservation, river side beautification will be urgently taken part by DOE, DID and City Hall together with related authorities through various mass media.

6. POTENTIAL WATER RESOURCES FOR WATER PURIFICATION

6.1 Low Flow Analysis

(1) General

The Klang River Basin has reached a considerably polluted stage because of the increasing socio-economic activity, growth of urbanization and industrialization and other diversified human activity.

According to the Klang Valley Environmental Improvement Project (KVEIP) report 1987, the present water quality in the river system is critical for low flow conditions during the dry season.

In this section, the possibility to improve the water quality condition by water release from the existing and/or new reservoirs was studied.

Low flow analysis should be carried out to derive discharge at the target point for the required capacity estimation.

Fig. O-3 shows the flow chart of hydrological working.

(2) Discharge Data

In the upper Klang River Basin of the upstream at Sulaiman Bridge, daily discharge data are available at the following stations.

* Klang River at Sulaiman
* Klang River at Leboh Pasar
* Batu River at Sentul
* Gombak River at Jln. Tun Razak
* Batu River at Kg. tua

After Leboh Pasar station had been closed down in 1975, a new station was installed as Sulaiman Bridge in 1978.

Fig. O-4 lists the bar chart of discharge data at five stations and indicates that the data includes many unrecorded values after 1976.

(3) Annual Run-off Rainfall Relation

Fig. O-5 shows the relation of annual run-off and rainfall at 4 stations (Sulaiman, Leboh Pasar, Sentul, Jln. Tun Razak).

The relation of Sg. Batu at Sentul indicates that the value of annual loss (the difference between annual run-off and annual rainfall) is smaller than the values at other stations.

The secular variation of the annual run-off depth at the 4 stations is shown in Fig. O-6, and the depth's values at Leboh Pasar, Sentul, and Jln. Tun Razak were almost similar in 1966 and 1970.

The figure implies that serious draught occurred in 1986.

(4) Regression Analysis

The regression and correlation analysis was carried out on the monthly run-off among 5 stations to test the homogeneity of the observed run-off.

The analysis was carried out using the monthly specific discharge per 100 km^2.

According to the result listed in Table O-2, the high correlation is recognized between the Klang River at Leboh Pasar, and the Batu River at Sentul.

In addition, the regression analysis of 5 days series discharge was studied for the Klang River at Leboh Pasar, the Batu River at Sentul and the Gombak River at Jln. Tun Razak in 1966 and 1970 because of recording of the similar run-off depth at their stations. The correlation coefficients in mutual are higher than in the analysis of monthly run-off. (Table O-2)

(5) *Discharge Derivation*

Discharge data are essential for the reliable water resources development study.

Discharge derivation at target points is made for following two purposes.

- To study the behavior of the reservoirs using the long periods run-off sequence estimated for Klang Gates Reservoir, Batu Reservoir and Gombak Reservoir.

- To assess the water resources for water quality improvement using derived discharge for target points.

However, several years of records are complete for 4 stations.

For this study, the discharge at target points was estimated for a series of 10 years from 1966 to 1976 because of good availability at the stations.

As target points for discharge derivation, the Klang River at Leboh Pasar, the Batu River at Sentul and the Gombak River at Jln. Tun Razak are selected.

The missing data of unrecorded date and periods are filled up by the following way.

i) Data before and after missing data available, fill up by the running mean

ii) Data during the long period missing, fill up by the relation of the regression coefficients

iii) For Klang River, intake rate for municipal and industrial water supply at original Klang Gate Dam are regenerated.

Table O-3 lists the derived discharge of 5 days series at Leboh Pasar, Sentul and Jln. Tun Razak stations.

6.2 Required Capacity Calculation for Water Purification

6.2.1 Basic Condition

The present condition of water supply, reservoirs and new reservoir etc. in the upper Klang River Basin are summarized as follows;

i) Municipal and Industrial Supply

The water supplies available from existing sources are presented below;

Sources	Quantity (m^3/s)
Klang Gates Reservoir	1.94
Batu Reservoir	1.40*
Gombak	0.289

* include compensation flow (0.04 m^3/s).

ii) Gombak Reservoir

A possible site of new Gombak Reservoir is located away from the Sungai Pusu Malay Reservation and the Orang Asli land. The catchment area is approximately 40 km^2. The dam height has to be 56 m to contain 6.0×10^6 m^3 under the constraints of topographic and geological condition in view of few available information. Details are described in APPENDIX I.

iii) Sewage Water

Information on the sewage water regenerated from the upper Klang River Basin is not yet obtained.

6.2.2 Explanation of Study Cases

For the purpose to check the possibility of the water quality improvement, the following three cases were contemplated.

i) Case-1

Under the existing water supply from the reservoir, the volume requirement of the existing reservoir and the new Gombak reservoir should be checked for the condition of discharge security at each target point.

ii) Case-2

Under the existing water supply from the reservoir, the volume capacity should be checked for the condition of discharge security at Sulaiman by the regulation from the new Gombak reservoir.

iii) Case-3

Under the existing water supply from the reservoir, the volume capacity should be checked for the condition of discharge security at Sulaiman by the regulation from the existing reservoirs.

6.2.3 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	5.62
Flood control storage	6.13	4.84	-
Flood surcharge storage	3.40	-	-
Active conservation storage (Water Supply)	22.65	27.53	3.30
Inactive space	3.23	4.24	2.32

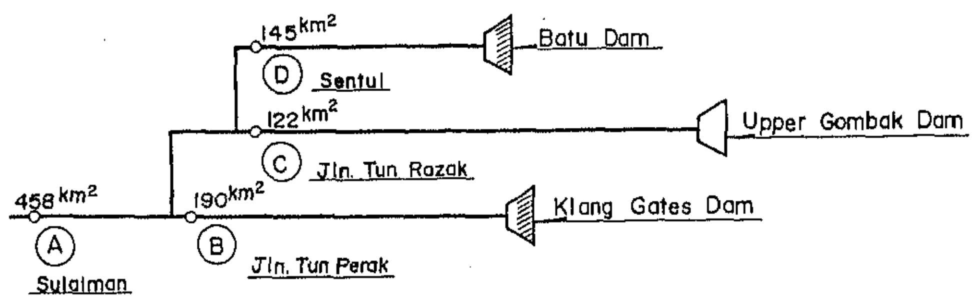
The Klang Gates Dam has already been enlarged with its crest level being raised to the maximum possible technical limit in height. In case of the Batu Dam, it is still possible to raise the crest level of it, technically, to increase the effective storage capacity, but by incuring very high cost. Hence 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. O-7.

Case	Target Point	Discharge (m3/s)	Required Storage Capacity ($10^6 m^3$) Water Supply	Dilution water	Total	Reservoir
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.

7. 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.

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Table O-1 PROPOSED INTERIM NATIONAL WATER QUALITY STANDARD

Parameters	(Units)	Class	III#
Al	mg/L	-	(0.06)
As	mg/L	0 .4	(0.05)
Ba	mg/L	-	
Cd	mg/L	0 0.01*	(0.001)
Cr (VI)	mg/L	1 .4	(0.05)
Cr (III)	mg/L	2 .5	
Cu	mg/L	-	
Hardness	mg/L	-	
Ca	mg/L	-	
Mg	mg/L	-	
Na	mg/L	-	
K	mg/L	-	
Fe	mg/L	1	
Pb	mg/L	0 .02*	(0.01)
Mn	mg/L	0 .1	
Hg	mg/L	0 .004	(0.0001)
Ni	mg/L	0 .9*	
Se	mg/L	0 .25	(0.04)
Ag	mg/L	0 .0002	
Sn	mg/L	0 .004	
U	mg/L	-	
Zn	mg/L	0 .4*	
B	mg/L	-	(3.4)
Cl	mg/L	-	
Cl2	mg/L	-	(0.02)
CN	mg/L	0 .06	(0.02)
F	mg/L	10	
NO2	mg/L	0 .4	(0.03)
NO3	mg/L	-	
P	mg/L	0 .1	
Si	mg/L	-	
SO4	mg/L	-	
S	mg/L	-	(0.001)
CO2	mg/L	-	
Gross-∂	Bq/L	-	
Gross-ß	Bq/L	-	
Ra-226	Bq/L	-	
Sr-90	Bq/L	-	

Parameters	(Units)	Class	III#
CCE	µg/L	-	
MBAS/BAS	µg/L	5000	(200)
O&G (mineral)	µg/L	N	
O&G (emulsified edible)	µg/L	N	
PCB	µg/L	6	(0.05)
Phenol	µg/L	-	
Aldriln / Dieldrin	µg/L	0 .2	(0.01)
BHC	µg/L	9	(0.1)
Chlordane	µg/L	2	(0.02)
t-DDT	µg/L	1	(0.01)
Endosulfan	µg/L	-	
Heptachlor / Epoxide	µg/L	0 .9	(0.06)
Lindane	µg/L	3	(0.4)
2,4-D	µg/L	450	
2,4,5-T	µg/L	160	
2,4,5-TP	µg/L	850	
Paraquat	µg/L	1800	

* = At hardness 50 mg/L CaCO3
N = Free from visible film, sheen, discoloration and deposits
\# = Maximum (unbracketed) and 24-hr average (brackedted) concentration

Source: Proposed National Water Quality Criteria and Standard for Malaysia. (DOE)

Table O-2 REGRESSION AND CORRELATION FOR RUN-OFF

MONTHLY

	Sulaiman	Leboh Pasar	Jln. Tun Razak	Sentul	Kg. Tua
Sulaiman	1.00	0.00	0.31	0.00	0.36
	1.00	0.00	0.14	0.00	0.43
	0.00	0.00	90.15	0.00	64.96
	43.	0.	19.	0.	20.
Leboh Pasar	0.00	1.00	0.43	0.87	0.79
	0.00	1.00	2.00	0.81	0.97
	0.00	0.00	-119.75	5.06	15.66
	0.	74.	49.	67.	7.
Jln. Tun Razak	0.31	0.43	1.00	0.53	0.18
	7.30	0.50	1.00	0.38	3.27
	-658.42	59.80	0.00	62.88	-247.86
	19.	49.	120.	70.	25.
Sentul	0.00	0.87	0.53	1.00	0.61
	0.00	1.24	2.64	1.00	1.85
	0.00	-6.28	-165.76	0.00	-21.59
	0.	67.	70.	109.	20.
Kg. Tua	0.36	0.79	0.18	0.61	1.00
	2.33	1.03	0.31	0.54	1.00
	-151.60	-16.18	75.73	11.69	0.00
	20.	7.	25.	20.	66.

LEGEND
0.36...Reg. Coe
0.43...Coe. A
64.96..Coe. B
20.....Sump NN

5 DAYS SERIES

	Leboh Pasar	Jln. Tun Razak	Sentul	*Compound Discharge
Leboh Pasar	1.00	0.87	0.83	0.88
	1.00	4.17	2.77	1.61
	0.00	-2.66	0.55	-0.10
	139.	139.	137.	137.
Jln. Tun Razak	0.87	1.00	0.83	0.94
	0.24	1.00	0.61	0.40
	0.64	0.00	1.13	0.52
	139.	144.	142.	142.
Sentul	0.83	0.83	1.00	0.97
	0.36	1.64	1.00	0.62
	-0.20	-1.85	0.00	-0.70
	137.	142.	142.	142.
*Compound Discharge	0.88	0.94	0.97	1.00
	0.62	2.53	1.61	1.00
	0.06	-1.31	1.12	0.00
	137.	142.	142.	142.

*Compound discharge means the sum of Jln. Tun Razak and Sentul.

Table O-3 AVERAGE DISCHARGE OF 5 DAYS SERIES (1/3)

LEBOH PASAR

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
66	25.64	14.70	12.78	13.07	16.12	16.72	11.25	12.74	14.09	22.49	16.02	26.41
66	24.40	11.98	13.90	16.81	12.86	17.46	16.21	30.04	13.04	18.41	18.63	36.16
66	35.18	14.80	12.72	25.96	13.99	16.41	46.34	21.39	15.17	16.75	24.17	34.15
66	26.18	18.78	27.70	27.61	12.76	12.66	17.98	18.15	11.97	21.88	38.20	35.34
66	18.18	14.51	29.30	29.90	11.20	16.73	13.62	21.74	12.12	19.59	34.71	26.92
66	15.26	11.14	15.69	24.51	10.24	12.16	12.97	28.68	20.90	16.86	22.79	45.94
67	22.70	18.59	17.26	16.31	27.96	14.94	14.72	12.61	13.51	18.94	41.64	35.77
67	19.77	18.20	15.56	23.90	24.88	14.46	13.33	12.73	19.16	55.78	145.67	140.89
67	30.85	14.62	23.25	19.79	18.70	14.26	12.94	12.50	16.72	15.77	37.12	17.89
67	19.49	14.16	19.08	16.71	26.30	34.78	15.96	13.35	20.11	15.28	42.13	21.95
67	21.06	15.53	19.52	25.79	27.28	16.36	15.79	13.70	20.04	27.82	32.36	37.50
67	24.70	17.03	18.73	34.70	17.94	25.06	12.72	16.81	22.50	38.31	44.61	13.54
68	12.61	10.29	7.37	28.96	16.74	13.50	22.18	12.61	12.40	16.88	35.01	13.39
68	15.63	13.40	5.75	17.75	14.89	13.90	14.59	12.61	10.96	20.42	24.03	26.76
68	13.49	9.63	5.94	12.49	23.24	25.80	13.95	13.24	11.74	23.83	23.53	36.79
68	13.60	10.84	5.35	22.39	28.37	29.73	27.93	12.67	22.43	16.92	22.80	23.08
68	10.71	7.59	12.14	18.01	13.71	14.44	19.10	18.67	11.84	23.57	18.37	16.21
68	8.69	7.78	20.13	15.30	17.28	11.56	15.97	17.72	12.98	32.94	17.25	36.92
69	19.68	13.81	12.07	23.17	26.15	28.61	15.35	18.32	14.65	14.96	24.47	27.64
69	18.71	11.18	11.38	14.04	22.44	20.30	15.36	8.75	12.75	19.84	36.81	24.36
69	27.23	11.98	10.34	16.30	19.68	19.92	13.57	20.58	10.91	40.66	31.11	21.15
69	20.71	14.61	11.88	14.63	36.91	15.56	17.12	22.91	13.36	35.63	28.62	17.76
69	12.89	15.57	13.68	12.97	32.40	18.70	15.19	26.00	15.99	52.67	23.11	13.21
69	19.03	12.61	29.64	15.67	17.80	18.80	12.66	18.99	12.36	40.51	29.58	20.82
70	26.04	14.62	13.72	19.80	17.32	11.99	20.04	14.71	15.78	19.62	18.88	25.05
70	33.46	14.38	14.12	18.81	22.49	11.96	17.90	14.63	17.64	19.73	20.27	21.25
70	29.10	13.89	14.34	14.22	12.22	11.54	16.54	15.96	21.13	19.59	22.56	22.89
70	17.10	14.23	16.96	15.14	13.19	8.87	15.51	16.14	19.78	22.56	22.79	23.45
70	14.32	14.26	14.21	22.62	17.15	7.79	15.27	15.81	18.49	18.22	33.67	34.12
70	15.89	13.66	23.43	12.05	13.28	11.27	15.73	16.47	18.51	18.10	21.90	26.93
71	175.90	26.13	25.78	14.76	14.01	12.74	15.50	15.43	31.13	17.72	15.82	20.77
71	66.34	26.13	11.92	16.74	15.93	11.70	13.19	13.52	43.96	17.19	33.16	22.82
71	32.41	26.32	14.40	15.42	12.68	13.29	16.40	26.49	36.99	19.40	21.36	20.96
71	27.59	25.59	24.43	14.92	12.55	13.27	18.91	21.94	27.55	21.52	23.30	20.96
71	26.93	26.01	22.06	14.61	15.24	17.69	23.93	36.15	29.81	17.69	20.63	20.58
71	26.38	26.20	15.38	15.01	16.45	16.06	20.54	22.71	20.49	21.48	19.30	19.24
72	14.32	15.32	9.25	27.99	18.77	17.40	15.98	16.69	15.92	15.67	30.86	24.74
72	13.99	19.22	10.33	16.12	17.51	19.15	15.15	14.18	16.64	20.03	24.12	24.35
72	15.64	17.70	14.73	21.11	20.26	28.28	14.38	14.05	17.81	19.83	30.32	23.15
72	14.63	14.93	14.60	21.86	27.44	34.38	18.99	14.06	16.71	18.18	55.63	22.33
72	14.47	17.54	10.89	21.52	24.30	29.97	17.74	14.63	15.89	23.81	24.07	28.21
72	15.77	12.26	10.60	26.65	16.37	18.73	16.61	15.95	17.62	27.97	30.61	22.70
73	21.37	15.77	18.96	40.09	19.84	33.93	17.23	28.75	21.03	40.06	34.92	31.11
73	22.38	15.70	15.67	25.52	34.40	28.58	16.14	30.22	22.52	24.79	34.85	65.35
73	24.01	13.73	21.35	83.96	29.54	21.59	15.49	23.46	24.63	30.00	28.52	30.40
73	22.83	14.21	16.06	77.84	27.08	18.57	14.76	18.26	37.09	39.76	30.35	31.91
73	22.98	22.32	18.21	65.25	42.56	22.45	14.83	20.47	32.83	54.41	39.29	31.78
73	19.77	21.73	25.46	31.02	47.73	19.46	16.94	16.01	24.74	42.92	35.25	23.27
74	21.48	16.14	16.21	17.80	26.64	18.34	22.94	20.02	21.06	21.37	17.73	19.75
74	19.18	18.44	25.22	26.11	31.58	18.44	19.37	19.32	18.84	19.35	15.71	24.94
74	17.52	15.76	18.84	19.71	28.43	16.73	21.06	17.43	20.27	17.15	26.55	22.01
74	16.73	24.28	16.59	18.26	30.92	25.27	20.95	16.37	26.11	16.86	20.91	22.39
74	16.74	19.23	15.35	20.00	27.98	41.27	18.18	15.35	23.22	17.25	21.29	19.69
74	17.45	16.36	15.94	20.04	21.32	23.81	20.69	15.03	24.83	16.65	24.75	25.69
75	28.78	18.42	26.09	23.80	23.41	22.58	22.33	25.90	52.24	21.66	33.16	25.37
75	20.70	17.73	25.04	19.25	19.92	16.86	24.54	22.48	20.62	20.49	27.38	25.65
75	21.31	29.00	18.73	27.46	15.91	18.75	22.27	17.81	18.54	17.98	20.50	17.52
75	24.53	27.52	18.84	26.40	14.69	17.86	26.54	16.46	19.83	17.36	31.19	13.48
75	17.83	17.20	16.48	39.21	18.72	16.14	30.61	17.12	22.24	16.38	27.23	21.15
75	16.80	15.91	18.93	26.88	26.85	17.59	23.08	17.44	26.70	19.39	22.08	19.69

Table O-3 AVERAGE DISCHARGE OF 5 DAYS SERIES (2/3)

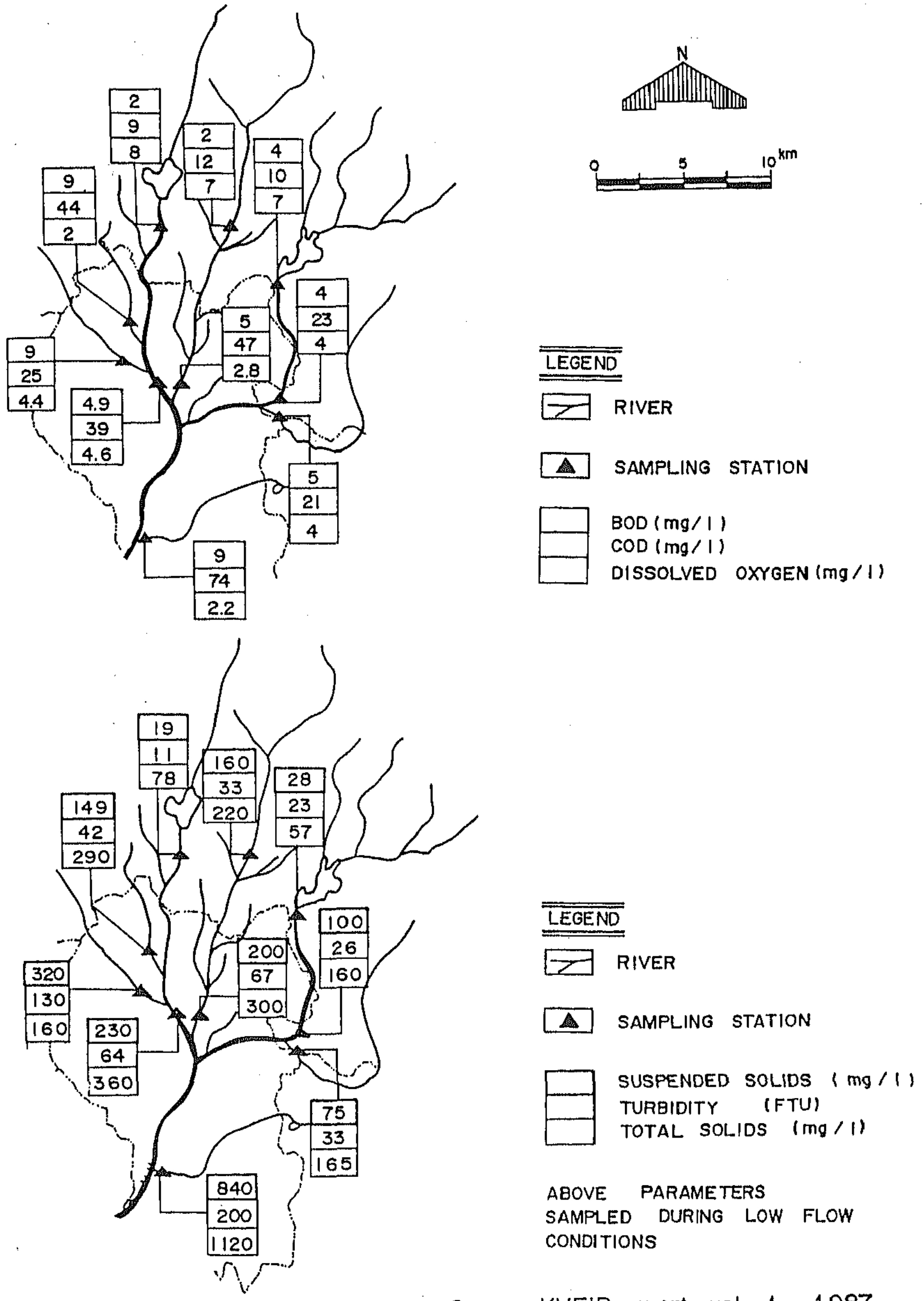
SENTUL

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
66	7.66	4.97	4.22	4.30	4.79	5.55	2.65	3.23	3.71	6.70	5.38	9.04
66	6.67	3.56	4.69	5.51	3.97	6.83	5.93	5.62	2.63	4.04	5.73	12.84
66	10.32	5.64	3.52	8.57	3.78	5.20	15.17	4.32	3.40	3.71	6.46	9.05
66	9.01	6.69	9.90	9.38	3.19	4.20	4.91	3.91	2.46	6.35	9.96	12.87
66	6.02	4.83	11.27	11.18	3.25	6.49	3.21	5.05	2.57	4.55	10.27	8.61
66	5.04	3.60	5.10	8.01	3.56	3.34	3.31	9.05	5.48	4.24	6.65	15.74
67	8.17	5.08	5.06	5.52	9.39	5.14	5.71	3.29	5.73	5.62	13.58	13.44
67	6.48	4.68	4.85	10.15	8.89	4.99	4.52	3.16	5.81	4.44	8.63	7.49
67	12.20	3.90	8.41	8.13	5.93	4.51	4.49	2.96	5.16	5.70	10.49	6.00
67	6.93	3.96	5.60	5.73	9.12	14.12	5.30	4.86	6.79	3.80	17.86	7.02
67	5.92	4.04	7.43	9.09	9.21	5.83	5.25	4.13	5.48	9.58	13.72	6.46
67	6.69	6.01	7.50	11.34	5.95	10.68	3.98	5.98	6.05	12.26	19.79	4.66
68	4.06	3.30	2.33	5.21	6.80	4.14	8.98	3.76	4.78	6.38	11.68	4.33
68	4.55	4.19	2.15	3.46	4.67	4.94	4.88	3.70	3.98	5.94	6.46	10.20
68	3.78	3.57	2.26	5.49	10.01	8.77	4.70	4.85	3.41	6.83	8.67	14.99
68	3.93	4.70	2.69	7.95	9.41	9.62	7.00	3.82	9.49	5.35	7.91	7.84
68	3.04	2.50	5.52	7.18	5.23	4.77	5.15	6.49	3.85	6.30	6.35	5.00
68	3.11	2.25	7.95	5.48	5.81	3.86	4.91	7.70	3.44	9.04	5.14	14.74
69	7.64	4.56	4.50	9.14	11.67	14.31	5.40	6.85	5.01	5.41	8.32	9.79
69	5.94	3.96	3.88	5.00	10.51	6.55	5.15	4.33	4.77	6.90	14.11	8.97
69	7.59	4.30	3.99	6.28	8.39	5.93	4.61	6.28	3.45	11.64	10.77	8.86
69	6.51	6.00	3.80	6.08	14.69	5.83	6.05	7.97	3.77	14.82	8.58	7.96
69	4.69	6.89	3.70	5.32	16.13	6.74	5.39	7.48	6.15	21.21	8.83	6.07
69	6.77	4.96	9.51	7.21	6.95	6.14	4.29	8.08	6.18	12.61	12.22	10.03
70	10.49	4.77	3.78	7.41	6.57	5.41	5.16	3.22	3.28	5.43	5.18	7.06
70	15.49	4.22	3.56	6.66	6.83	4.95	3.97	3.29	5.22	8.22	4.31	6.56
70	11.21	3.77	3.76	4.83	6.95	4.77	3.33	3.57	5.48	5.62	4.65	8.19
70	6.81	3.70	4.56	6.74	8.17	3.07	3.37	3.19	6.00	6.68	7.14	8.76
70	5.95	3.92	3.59	7.33	9.85	3.79	3.58	3.11	5.40	4.89	11.20	12.39
70	6.43	4.82	9.66	6.44	7.88	4.41	3.52	3.21	4.79	5.68	6.96	7.92
71	31.23	4.63	3.64	4.38	4.18	3.42	4.39	4.22	9.09	4.64	4.07	6.68
71	28.72	3.94	3.47	5.18	5.14	3.08	3.77	3.66	8.71	4.37	11.55	7.48
71	10.84	3.58	4.58	4.77	3.47	3.65	5.04	8.92	12.66	6.14	6.91	6.76
71	6.97	4.14	8.08	4.60	3.51	3.57	5.31	7.14	7.25	6.97	8.17	6.76
71	5.80	3.05	6.72	4.51	4.70	4.80	7.54	14.14	9.41	4.50	6.57	6.60
71	5.45	2.30	4.65	3.90	4.68	4.34	5.78	6.73	5.77	6.96	6.13	6.14
72	4.34	4.24	3.59	9.52	5.89	5.60	4.94	5.18	4.43	3.96	7.18	7.38
72	4.22	6.96	3.55	3.88	5.63	6.77	4.64	4.27	3.59	6.34	6.20	6.90
72	4.28	6.00	4.30	6.81	6.34	10.50	4.36	3.77	4.29	8.20	7.38	7.00
72	3.90	4.44	4.25	7.10	9.50	11.00	4.83	3.33	4.25	4.89	13.71	6.68
72	3.93	5.49	2.79	6.97	6.52	9.43	5.56	3.42	3.73	5.68	5.87	13.05
72	4.41	4.21	2.68	8.99	4.20	5.61	5.15	4.08	4.99	9.41	6.99	5.92
73	6.86	3.91	5.12	19.82	7.01	16.40	6.47	9.55	6.76	13.63	11.24	13.62
73	7.23	4.12	4.25	9.91	12.70	10.29	5.01	10.08	7.30	8.12	13.59	29.02
73	4.95	4.26	5.60	8.26	13.55	8.14	4.82	7.64	8.06	10.00	10.81	12.10
73	4.88	4.53	4.88	7.76	14.93	7.36	6.19	5.76	12.56	16.03	12.13	12.01
73	6.49	4.52	6.61	27.40	15.83	8.13	5.98	6.56	11.02	14.70	14.63	14.32
73	5.50	5.53	10.56	12.91	23.94	7.88	7.02	4.95	8.10	11.99	13.79	8.60
74	7.75	6.34	6.80	7.25	9.20	6.23	7.45	7.15	8.26	6.97	6.33	8.06
74	7.94	7.45	8.83	9.04	14.43	6.92	6.53	6.54	6.75	6.23	5.67	14.12
74	7.16	6.10	6.71	7.83	10.38	5.97	7.59	5.84	7.20	6.18	7.11	11.65
74	6.71	10.96	6.21	7.95	10.60	9.29	6.80	5.80	10.43	5.87	7.53	8.93
74	6.83	8.40	5.40	7.99	9.20	14.79	6.35	5.36	8.35	6.02	7.85	6.78
74	6.72	6.92	6.09	8.22	6.83	8.42	6.94	5.44	10.18	6.04	9.54	9.06
75	9.56	5.82	8.59	7.76	7.62	7.32	7.23	8.52	18.03	6.99	11.14	8.33
75	7.03	6.77	9.58	7.63	7.80	6.62	9.65	9.47	8.47	8.10	10.67	8.60
75	7.41	11.18	7.23	12.07	6.54	7.76	9.02	7.32	7.51	7.23	8.28	5.40
75	8.95	10.30	7.63	10.46	6.50	7.26	10.81	6.57	7.71	6.98	12.78	3.81
75	6.39	6.57	6.29	14.94	7.46	6.50	11.30	6.77	8.40	6.72	11.18	6.83
75	6.25	6.15	7.16	9.32	10.07	6.54	9.12	6.86	10.92	7.97	9.14	6.25

Table O-3 AVERAGE DISCHARGE OF 5 DAYS SERIES (3/3)

JLN. TUN RAZAK

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
66	5.30	3.52	2.76	3.53	4.07	4.73	3.14	3.53	3.92	5.35	4.90	7.54
66	5.06	2.85	3.45	4.13	3.46	4.80	4.93	6.76	3.54	4.52	5.58	9.75
66	8.03	3.28	3.15	5.91	3.58	4.30	11.37	5.38	3.72	4.36	6.05	8.84
66	5.94	2.66	3.72	6.16	3.24	5.65	4.57	4.67	3.33	4.86	8.88	10.12
66	4.29	3.84	6.56	6.91	3.14	4.23	3.77	4.96	3.41	4.51	7.95	7.90
66	3.22	3.11	4.30	5.26	2.76	3.22	3.60	6.37	5.51	4.65	6.08	11.77
67	7.89	6.06	5.68	5.17	7.47	5.88	2.03	1.12	1.84	2.89	6.25	6.77
67	7.35	5.75	5.34	6.55	7.52	5.80	1.36	1.14	2.85	1.90	6.33	3.33
67	9.59	5.38	6.81	6.20	6.74	5.61	1.62	1.13	2.88	2.29	6.50	2.95
67	6.61	5.13	6.00	5.47	7.51	11.24	1.93	2.47	3.56	2.55	6.33	3.53
67	6.86	5.11	6.38	7.63	8.26	5.47	1.95	1.37	3.01	4.01	7.02	2.85
67	7.64	5.88	5.86	8.92	6.10	7.37	1.56	2.16	3.51	5.97	9.22	2.23
68	3.25	2.70	2.13	7.17	4.24	3.46	5.54	3.25	3.20	4.27	8.62	3.43
68	3.97	3.44	1.85	4.48	3.79	3.56	3.72	3.25	2.87	5.12	5.99	6.64
68	3.46	2.62	1.89	3.28	5.80	6.41	3.57	3.40	3.04	5.94	5.87	9.05
68	3.48	2.93	1.84	5.59	7.03	7.36	6.92	3.26	5.60	4.28	5.69	5.76
68	2.79	2.18	3.23	4.54	3.51	3.69	4.80	4.70	3.06	5.88	4.63	4.11
68	2.42	2.19	5.05	3.89	4.37	2.99	4.05	4.47	3.34	8.13	4.36	9.08
69	4.41	2.79	2.53	4.40	5.10	7.08	3.38	4.70	3.98	3.96	5.35	6.37
69	3.06	2.48	2.36	2.29	3.35	4.06	3.22	3.12	3.31	5.79	8.17	5.63
69	5.21	2.74	2.83	2.76	3.26	4.77	3.20	4.06	2.41	8.33	7.02	5.01
69	4.13	3.59	2.69	2.85	6.60	3.69	4.06	4.84	3.49	7.91	8.15	4.25
69	3.16	3.44	3.21	2.90	6.89	3.60	3.87	5.60	4.00	9.82	6.88	3.57
69	3.80	2.50	6.12	3.77	3.14	4.00	2.91	3.54	3.64	7.44	6.98	6.08
70	5.32	4.16	3.32	5.08	4.11	3.67	3.98	3.15	4.14	5.97	5.26	5.45
70	8.40	3.79	2.96	5.68	4.49	3.07	3.52	3.35	4.71	6.79	6.86	5.20
70	6.98	3.22	3.09	3.78	4.57	2.90	2.52	3.03	6.62	4.85	7.71	6.75
70	4.74	3.09	4.12	3.88	4.13	3.04	2.66	2.57	5.26	6.91	6.35	5.92
70	3.75	3.35	2.96	5.10	5.15	3.25	2.49	2.75	4.50	4.49	8.69	7.78
70	4.68	3.33	5.38	4.21	3.85	4.34	3.20	3.66	3.63	3.91	5.62	6.09
71	42.65	6.49	3.47	3.76	3.50	3.47	4.21	4.34	9.22	5.34	4.73	5.20
71	16.14	6.49	2.91	4.19	3.73	3.16	3.40	3.71	17.57	5.28	8.17	5.69
71	8.00	4.21	3.34	3.78	3.38	3.58	4.12	6.57	8.85	4.87	5.34	5.24
71	6.84	4.38	6.07	3.64	3.26	3.66	5.41	5.48	8.84	5.38	5.28	5.24
71	6.68	4.57	5.96	3.54	3.74	5.16	6.30	7.29	8.08	5.46	5.22	5.16
71	6.55	4.34	3.88	4.40	4.51	4.61	5.95	6.35	5.93	5.37	4.83	4.88
72	3.78	4.25	1.13	6.93	4.72	4.18	4.14	4.23	4.04	0.83	5.45	3.66
72	3.70	3.95	1.84	5.11	4.22	4.10	3.96	3.62	2.24	2.04	3.56	2.86
72	4.41	3.97	3.75	5.28	5.22	6.04	3.79	3.59	1.27	1.97	5.04	3.36
72	4.16	3.81	3.72	5.46	6.52	9.33	4.78	3.59	0.87	1.81	13.32	2.63
72	4.03	4.38	2.83	5.38	7.55	8.16	4.48	3.73	4.03	1.89	3.33	4.44
72	4.36	2.38	2.76	6.61	4.94	5.00	4.21	4.05	4.45	4.27	3.81	2.35
73	5.35	4.00	4.77	9.84	4.98	8.36	4.36	6.96	5.25	9.44	8.60	7.69
73	5.59	3.99	3.98	6.34	8.48	7.08	4.09	7.28	5.58	6.08	8.58	15.90
73	5.98	3.52	5.34	20.37	7.31	5.40	3.94	5.79	6.05	7.23	7.06	7.52
73	5.70	3.63	4.07	18.90	6.72	4.68	3.76	4.64	8.79	9.76	7.50	7.88
73	5.74	5.58	4.59	15.88	10.43	5.61	3.78	5.13	7.85	13.28	9.65	7.85
73	4.96	5.44	6.33	7.66	11.68	4.89	4.29	4.15	6.07	10.52	8.68	5.80
74	3.42	2.51	2.06	1.87	7.16	2.93	3.37	3.33	3.67	3.99	2.73	5.15
74	3.15	2.43	5.67	4.54	7.63	2.89	2.63	2.72	3.00	3.24	2.07	10.40
74	2.81	1.67	2.62	2.58	5.69	2.26	2.84	2.02	3.53	3.49	6.40	5.99
74	2.57	4.14	1.45	3.33	9.19	6.37	2.82	1.84	6.50	2.83	4.24	4.89
74	2.55	2.97	1.49	3.63	5.59	10.88	2.67	1.65	4.97	2.60	5.11	3.72
74	3.02	2.37	1.40	5.86	3.55	3.92	3.36	1.57	5.36	2.62	5.15	5.74
75	6.96	4.68	6.37	5.86	5.78	5.60	5.54	6.33	12.13	5.39	7.93	6.21
75	4.80	3.22	4.95	3.30	3.55	2.83	4.57	3.47	3.31	3.60	5.31	6.37
75	4.80	5.81	3.38	3.96	2.32	2.86	3.79	2.72	2.98	2.91	3.43	4.42
75	5.26	5.77	3.05	4.91	1.60	2.81	4.65	2.63	3.58	2.78	5.57	3.45
75	3.66	3.09	2.92	8.39	3.14	2.50	6.69	2.84	4.39	2.43	4.71	5.29
75	3.16	2.71	3.57	6.35	5.58	3.36	4.19	2.95	4.64	3.05	3.55	4.94

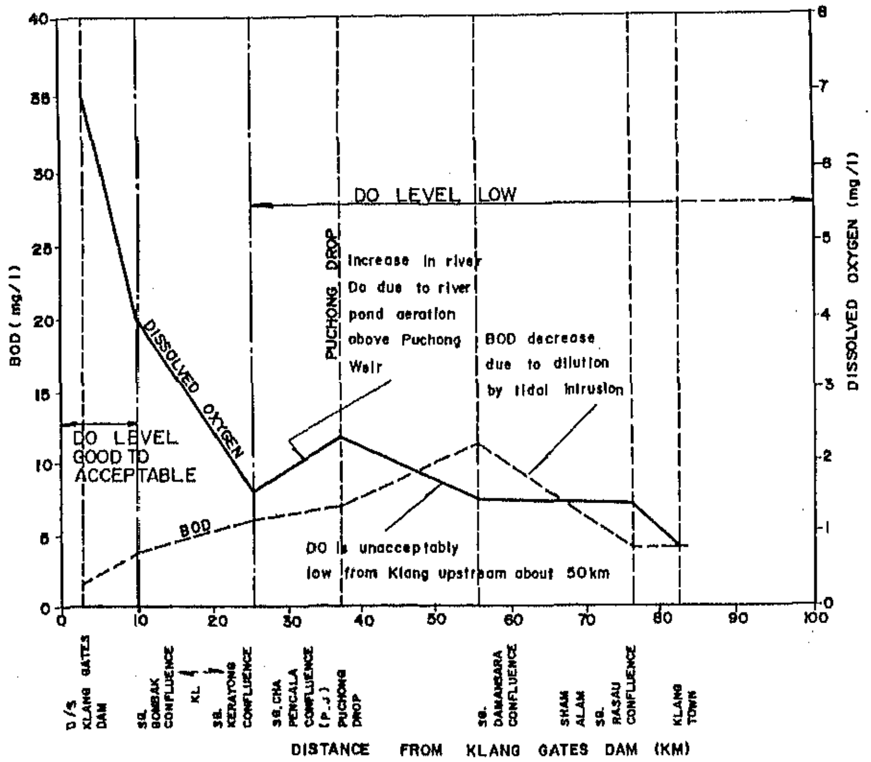


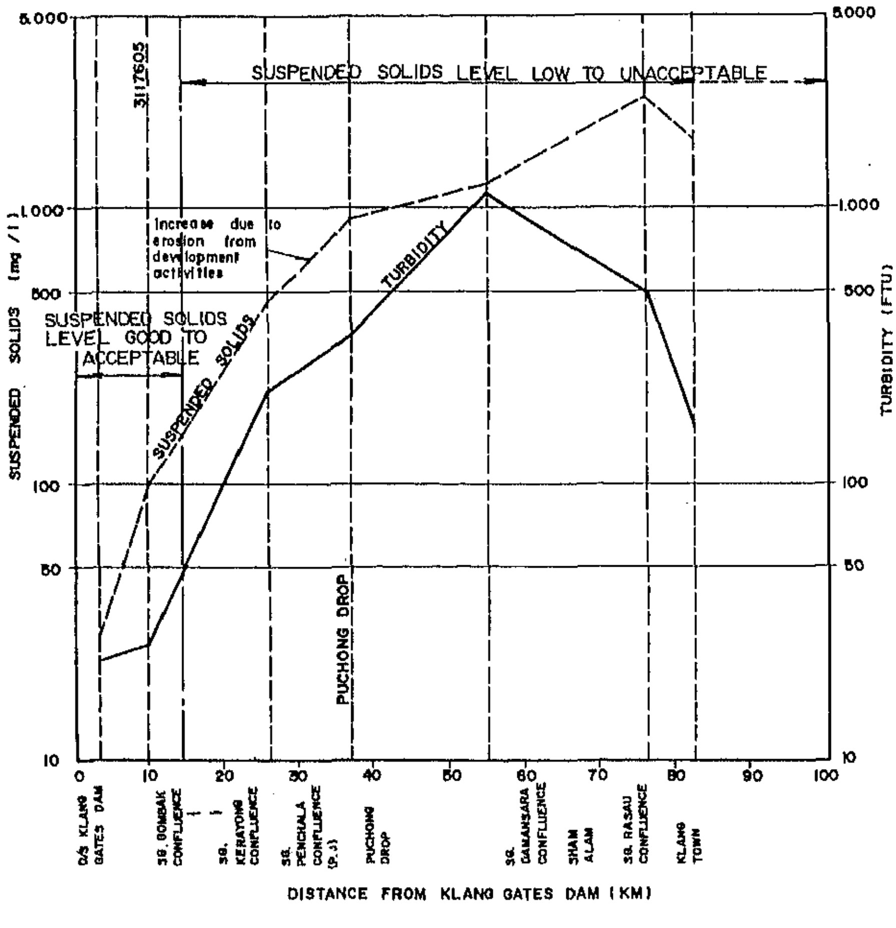
Source KVEIP report vol. 1. 1987

FIG. O-1	PRESENT WATER QUALITY LEVELS AT EACH STATION OF UPPER STRETCHES OF KLANG RIVER

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA





Source: KVEIP report vol. 1. 1987

FIG. O-2	**PRESENT CONDITION OF WATER QUALITY OF KLANG RIVER**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

FLOW CHART OF LOW FLOW ANALYSIS

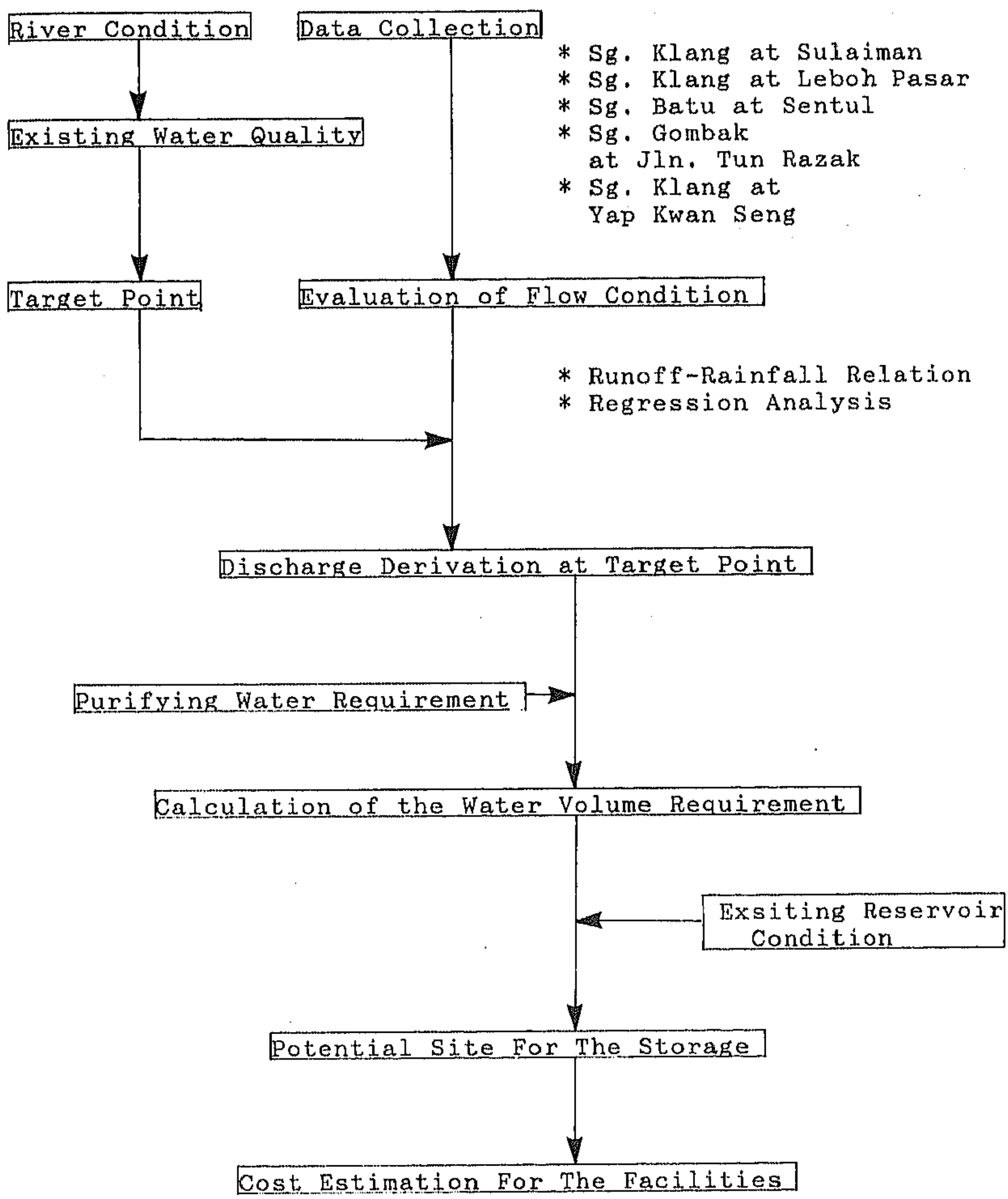


FIG. O-3 FLOW CHART OF HYDROLOGICAL WORKING

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

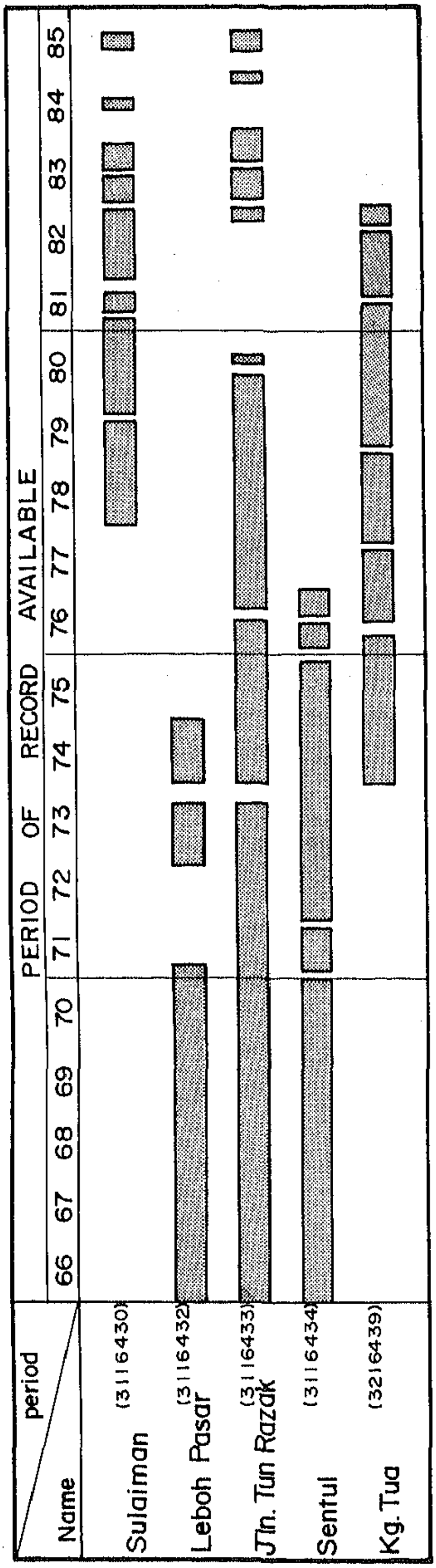


FIG. O-4	BAR CHART OF DISCHARGE DATA

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

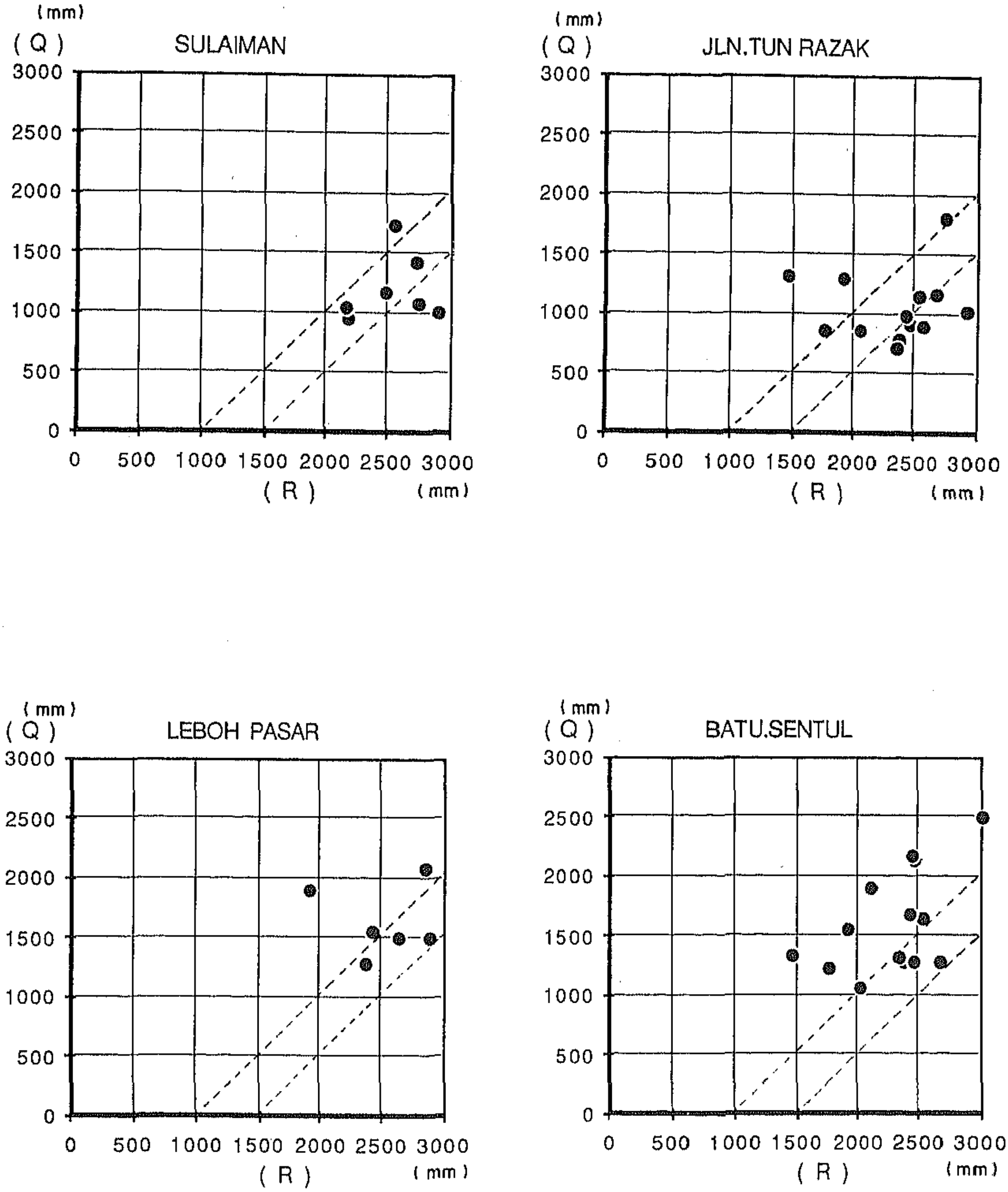


FIG. O-5 **ANNUAL RUN-OFF RAINFALL RELATION**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

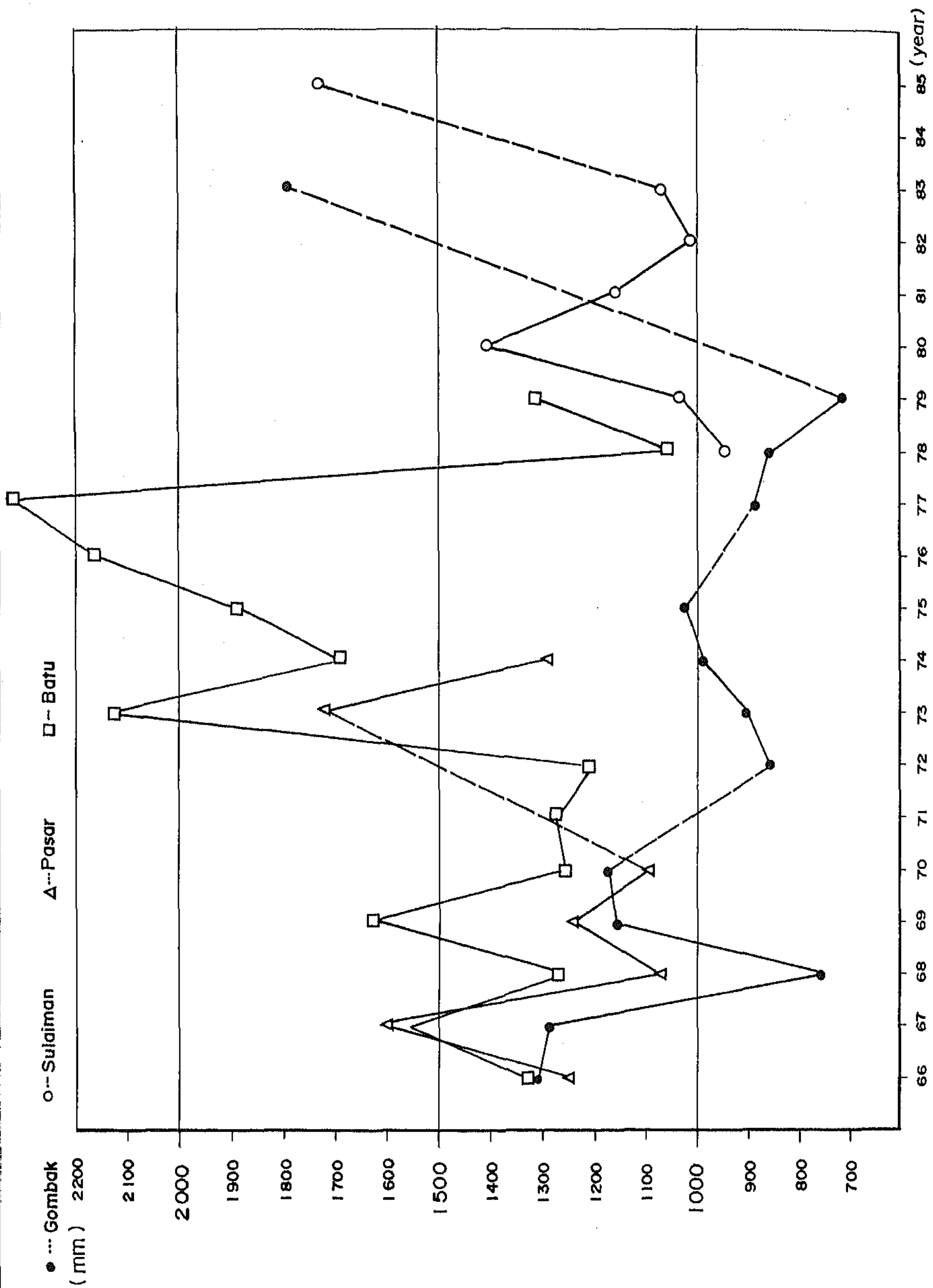
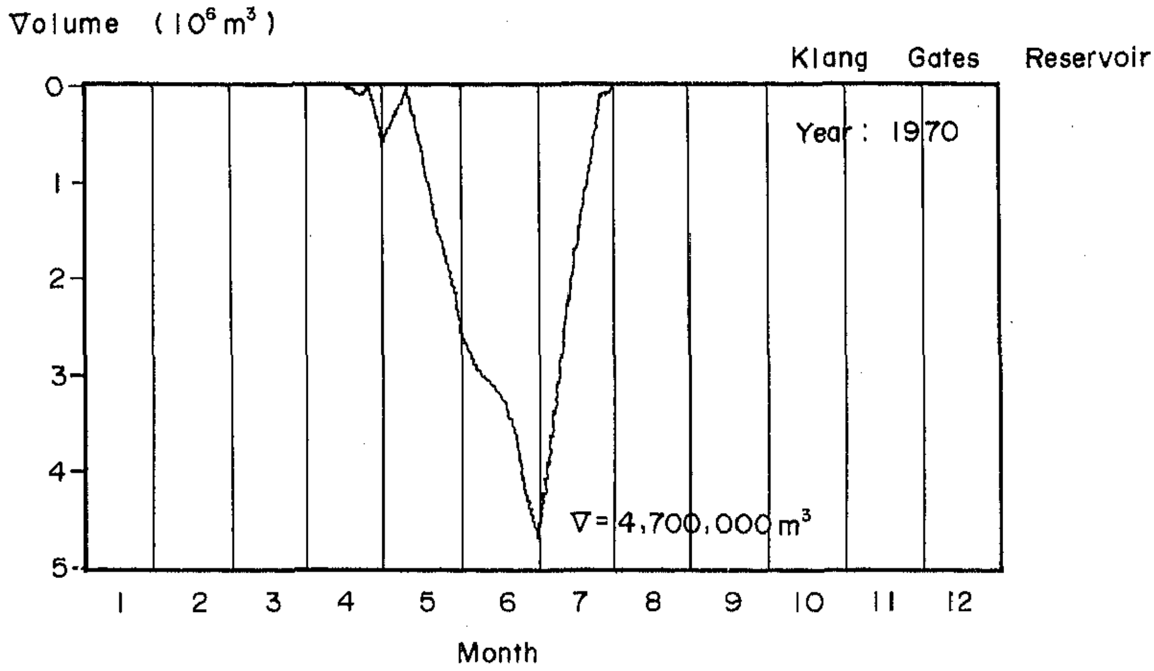


FIG. O-6	SECULAR VARIATION OF ANNUAL RUN-OFF DEPTH

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN



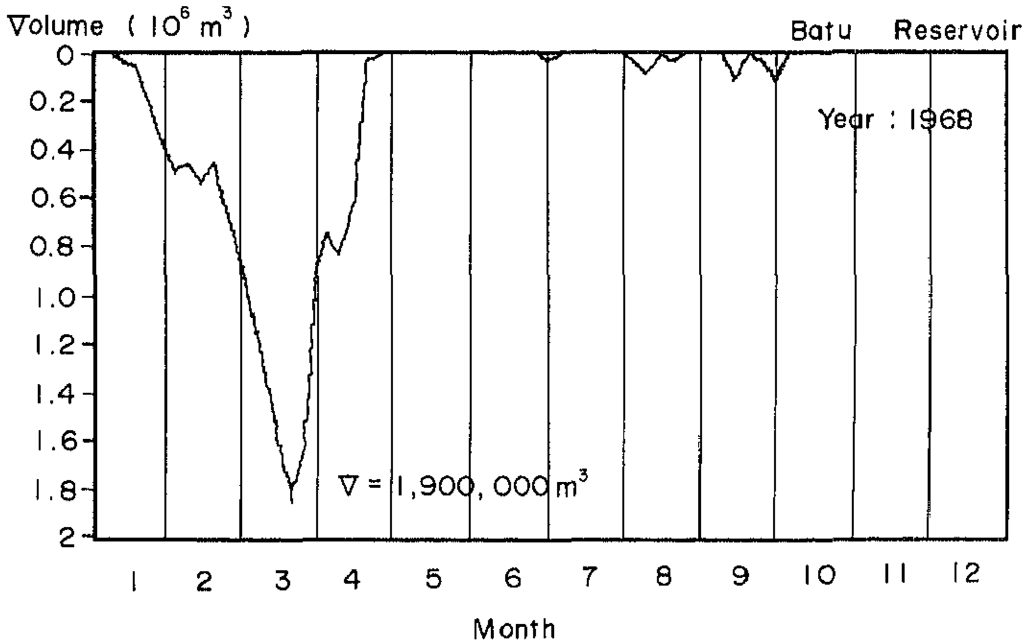


FIG. O-7	RESERVOIR OPERATION FOR WATER SUPPLY

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

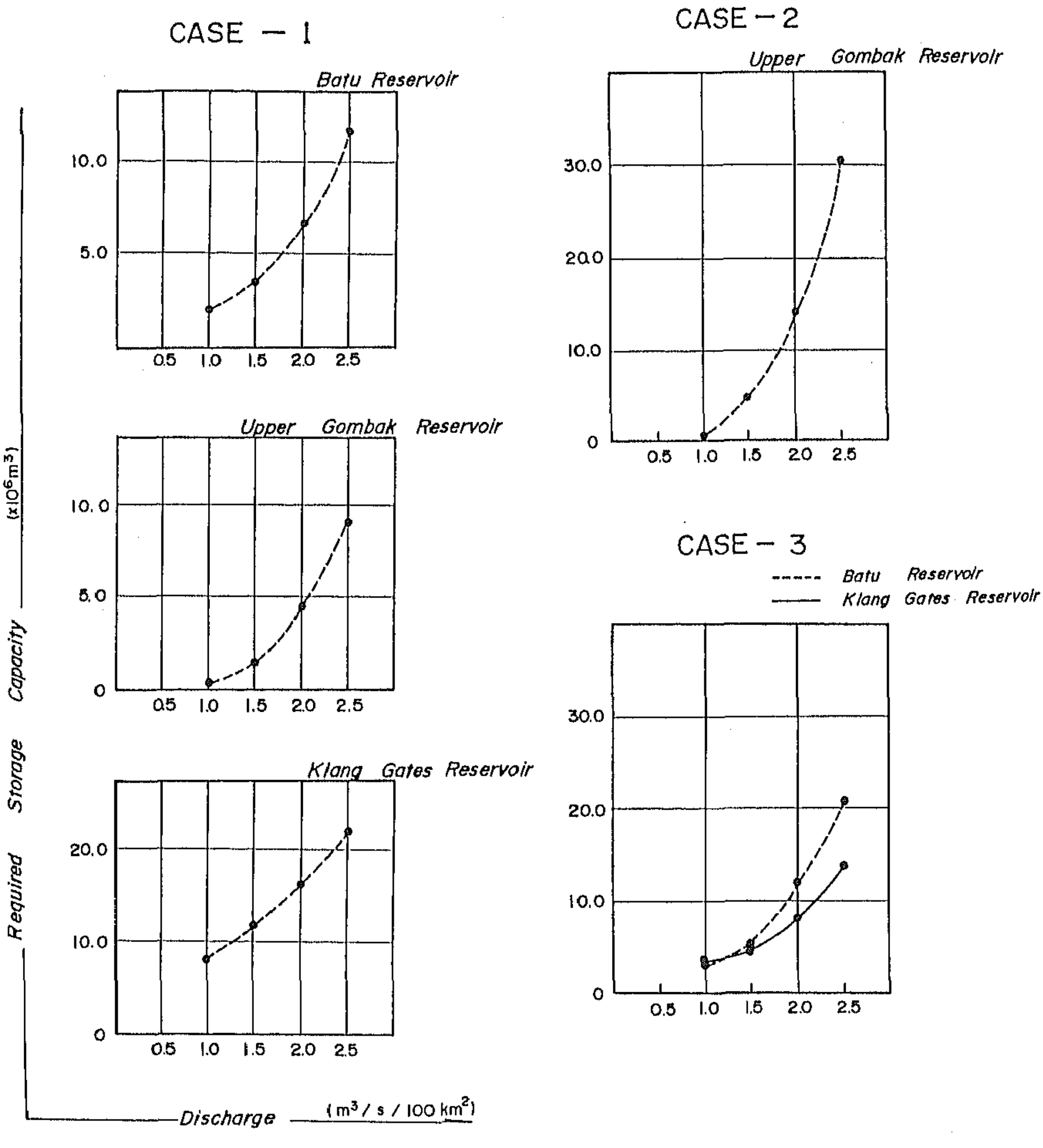
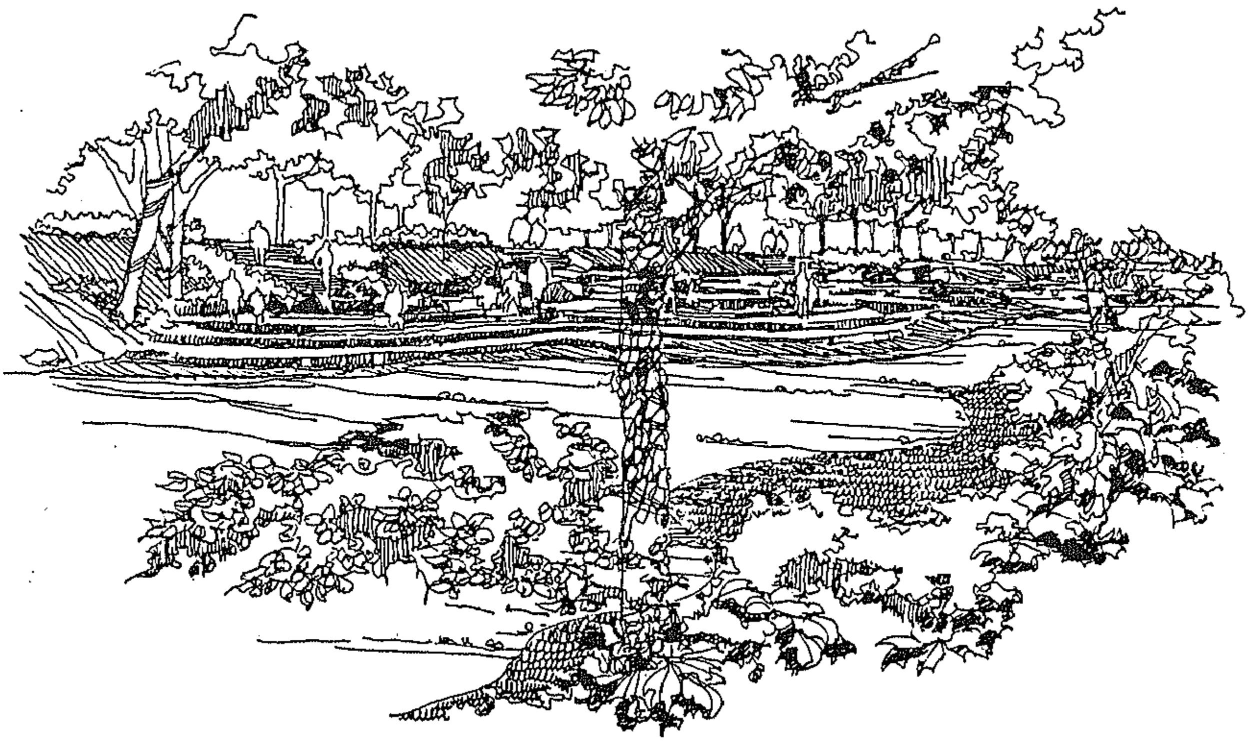


FIG. O-8 SECURED DISCHARGE-CAPACITY RELATION

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

APPENDIX P: RUN-OFF STUDY OF TRIBUTARIES



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APPENDIX P. RUN-OFF STUDY OF TRIBUTARIES

1. INTRODUCTION

In the Klang River Basin, there are many other tributaries to be studied in addition to the two main ones, namely the Gombak and Batu Rivers, which were examined under the Master Plan. Among these tributaries, some of them often overflowed their banks causing damages to household properties. These tributaries therefore also required urgent flood mitigation countermeasures.

Partial drainage improvement works have been executed by various relevant agencies such as Drainage and Irrigation Department (DID) Federal Territory, DID Selangor State, City Hall and etc., in the flood prone areas where damage are severe or frequency of flooding is high. By these urban drainage improvements, floods were mitigated by the newly constructed drains. However, these urban drainage improvement works do not consider the influence of coming flows on the existing discharge capacity of main streams such as the Klang, Gombak and Batu Rivers.

In this basin, especially in the surrounding areas of Kuala Lumpur, urban development such as large-scale housing schemes has encroached on the abandoned tin mining sites and mountain slopes. The change of land uses status from reserved land to housing scheme land and other uses gives rise to the reduction of retention capacity of water and the increase of flood peak run-off from a downpour.

Under these circumstances, the influence on the main stream exerted by the tributaries will increase year by year. Hence, it is necessary to formulate the basic flood mitigation plan for the tributaries with due consideration to the flood mitigation plan of the main streams.

In order to hold down the discharge to the main river, some countermeasures are required for tributaries. To withhold or store the rainfall run-off from immediately reaching the river to reduce the flood peak is considered the principal countermeasure. Expected methods are as follows:

- Conversion of ex-mining pond to retention pond

- Creation of multipurpose pond especially in or around the new developing areas. This pond is used for retention pond during flood and other purpose during off-flood periods.

- Planting trees on bare ground and excavated lands.

Among these methods, conversion of ex-mining pond to retention pond and creation of multipurpose pond are considered the most effective tool for flood mitigation purpose for the time being.

In this study, five (5) tributaries are selected in consideration of the seriousness of floods situation, rapid urbanization and etc. for incorporation into the basic plan. These are the Sg. Jinjang, Keroh, Bunus, Kerayong and Damansara. In these basins, there are some ex-mining ponds and the potential sites for creation of the multipurpose pond still remaining. Therefore, the effectiveness of these ponds were evaluated in this study.

2. PRESENT CONDITIONS OF SELECTED TRIBUTARIES

The present conditions of the five (5) selected tributaries are summarized below;

a) Sg. Jinjang

Sg. Jinjang basin has an area of 29.5 km^2 and is situated in the north west area of Kuala Lumpur. The basin is drained by 24.5 km of trunk drains, and Sg. Jinjang is discharging into the Batu River about 600 m downstream of the Jln. Kuching, Jln. Ipoh roundabout. About 23% of the catchment area and 40% of the trunk drains are in Federal Territory. The remaining area and drains are in Selangor State.

Present urban development includes Jinjang, sections of Selayang Baru, Batu caves Taman Selayang Baru and Taman Kok Lian. The upper catchment is natural jungle characterized by rough, steep sided terrain and narrow bottomed valleys. The remaining area is flat and has been or is still being mined for tin.

The abandoned tin mining sites and slopes of mountains had been encroached upon by rapid urbanization. This is especially so in the upstream reaches in Selangor State.

The influence to the Batu River is great because the catchment ratio between Sg. Jinjang and Batu River is 29% at the confluence.

b) Sg. Keroh

Sg. Keroh basin has an area of 39.6 km^2 and is situated in the north west area of Kuala Lumpur or south area of Sg. Jinjang basin. The basin is drained by 36.4 km of trunk drains, and Sg. Keroh is discharging into the Batu River just south of Jln. Segambut. About 70% of the catchment area and 80% of the trunk drains are in Federal Territory. The remaining area and drains are in Selangor State.

Present urban development includes Kepong Town, Kepong Baru, Desa Jaya, Taman Kepong and some light industries and squatters along Jln. Segambut near the confluence with the Batu River. Virtually all the relatively flat land in the catchment has been, or is being mined for tin. The catchment in the southern end of the basin is developed as rubber plantation on medium sloped land with narrow valleys. The remaining area in the upper reaches of the basin is natural jungle with steep sided, narrow valleys.

The slopes of mountains in southern part of this basin has been encroached on by rapid urbanization. Some areas along downstream reaches such as Kg. Benteng, Segambut Dalam and Kg. Railway Gate are often inundated by flash flood.

The influence to the Batu River is great because the catchment ratio between Sg. Keroh and the Batu River is 29% at the confluence.

c) Sg. Bunus

Sg. Bunus basin has an area of 16.7 km^2. This basin lies between the Gombak River to the west and the Klang River to the east and south, and falls entirely within Federal Territory. The basin is drained by 15.9 km of trunk drains, and Sg. Bunus is discharging into the Klang River about 500 m downstream of the Jln. Tun Razak bridge through bypass conduit.

Together with the present urban development such as Taman Bunga Raya and Setapak Jaya, about 65% of the catchment is urbanized area. The remaining area is predominately abandoned tin mining with some rubber and jungle areas.

The abandoned tin mining sites and slopes of mountains has been encroached on by rapid urbanization especially at the upstream reaches in north-eastern area.

At Jln. Tun Razak, the Sg. Bunus has been diverted to the Klang River by means of a 12 feet diameter Armco pipe and 15 feet width concrete culvert. The conduit is severely undersized and water backs up and overflow to Jln. Tun Razak and causing widespread disruption to traffic so after. The flood run-off then flows down to the old water course of Sg. Bunus and causing nuisance flooding in Kg. Periok and Kg. Doraisamy.

d) Sg. Kerayong

Sg. Kerayong basin including Pudu Cut and Chan Sow Lin basins has an area of 61.8 km^2 . This basin is situated in south east area of Kuala Lumpur. The basin is drained by 61.6 km of trunk drains, and Sg. Kerayong is discharging into the Klang River at the 4th miles Jln. Klang Lama. About upper 35% of the catchment is in Ulu

Langat District in Selangor State. The remaining catchment and 60% of the trunk drains are in Federal Territory.

Present urban development includes Taman Mega Jaya, Taman Seraya, Taman Muda, Taman Cheras, Taman Ikan Emas and etc. Together with the present urban development area, about 60% of the catchment is urbanized area. The remaining area is predominately has been, or is being mined for tin with some natural jungle area.

The abandoned tin mining sites and slopes of mountains has been encroached on by rapid urbanization especially at the upstream reaches in south-eastern area.

Some areas along middle and downstream reaches such as Jln. Cheras 3-1/2 miles, Chan Sow Lin, Jln. Sungai Besi 3-1/2 miles and Jln. Klang Lama 4-1/2 miles are often flooded and causing widespread disruption to traffic.

e) Sg. Damansara

Sg. Damansara basin has an area of 147.6 km^2. This basin lies between Kuala Lumpur and Shah Alam, and falls almost within Selangor State. Only upstream reaches of Sg. Kayu Ara, a tributary of Sg. Damansara, is situated in Federal Territory.

Sg. Damansara flows generally south-eastward and is joined by some tributaries such as Sg. Payong, Rumput and Kayu Ara in middle reaches or at east of the Subang International Airport. Then Sg. Damansara flows southward and is discharging into the Klang River about 16 km downstream of the Puchong Drop.

The land in this basin is used predominately for agriculture such as rubber and oil palm plantation. Urbanized areas including developing areas are situated in the downstream reaches of Sg. Damansara, around the Subang International Airport and in the middle reaches of Sg. Kayu Ara. The remaining area is mainly natural jungle with steep sided and narrow valleys in the upper reaches of the basin. Some ex-mining land lies along downstream reaches of Sg. Kayu Ara.

In this basin, rapid urbanization, comprising industrial development in the downstream reaches of Sg. Damansara and housing development in the upstream reaches of Sg. Kayu Ara, which is included in Kuala Lumpur conurbation, has taken place.

Some drainage improvements have been carried out by DID Selangor State. However, there is no proper flood mitigation or drainage plan for this basin.

Urban drainage works within these basin have been carried out by DID Federal Territory, DID Selangor and City Hall. In addition to these, some drains were constructed by housing developers after approval from related agencies when they developed the housing schemes.

These drainage works have been implemented based on "Urban Drainage Standards and Procedures for Peninsular Malaysia", established by DID in 1975. According to this design standards and procedure, the drainage systems are designed for the floods caused by a 2-year return period storm in residential areas and a 5-year return period storm in commercial and industrial areas. In addition, whenever possible the system is designed to contain the 100-year storm within the proposed reserves, to avoid substantial damages from a major storm.

The relevant agencies have concentrated on urban drainage improvement works in flood prone areas where damage are severe or frequency of flooding are high. Some flood prone areas had already been mitigated by improved drainage works, however, many places are still affected by floods.

On the five (5) selected tributaries, a master drainage plan had been prepared for four (4) of them, namely Sg. Jinjang, Keroh, Bunus and Kerayong in DID's "Kuala Lumpur Flood Mitigation Project Drainage Improvement, Master Drainage Plan". Based on this Master Drainage Plan, local drainage works have been carried out with minor modifications by the relevant agencies. Progress of this urban drainage works are as follows;

PROGRESS OF DRAINAGE WORKS

Tributary	Catchment Area (km^2)	Planned Drain Length (km)	Improved Drain Length (km)	Progress (%)
Sg.Jinjang	29.5	24.5	4.9	20
Sg.Keroh	39.6	36.4	8.2	33
Sg.Bunus	16.7	15.9	10.1	64
Sg.Kerayong/1	61.8	61.6	27.2	44

Note: /1: includes Pudu Cut and Chan Sow Lin basins.

Location of improved drains are shown in Figs. P-1 to P-4.

However, these local improvement on the drainage system, based on the Master Drainage Plan, do not consider the capacity of the river stretches downstream of the ingress points. This can lead to anomalous situations at the confluence with the main rivers; for example, Sg. Jinjang and Keroh are both tributaries of the Batu River but having design discharges greater than the design capacity of the Batu River as seen from the following;

DESIGN DISCHARGE OF TRIBUTARY AND MAIN RIVER

(100 year flood)

Tributary		Main River	
Name	*Design Discharge (m^3/s)	Name	Design Discharge (m^3/s)
Sg.Jinjang	210	Batu	120
Sg.Keroh	410	Batu	240
Sg.Bunus	170	Klang	300
Sg.Kerayong	460	Klang	870

* Design discharges for the tributaries estiamted in the Master Drainage Plan.

In addition to these tributaries, drainage and river improvement works had been carried out on Sg. Damansara by DID Selangor Stage. Location of improvement sections are shown in Fig. P-5.

In these selected five tributaries, there are some potential sites for the retention ponds as shown in Figs. P-1 to P-5. By applying these potential sites, the effectiveness of retention ponds were studied as follows.

3. FLOOD RUN-OFF CALCULATION

3.1 Flash Flood Storm

In the Kuala Lumpur area, certain seasons bring conditions conductive to more frequent occurrence of local storm rainfall with high intensity, short duration, and thunderstorm. These are the inter-monsoonal months of March-April-May, when the northeast monsoon of winter retreats northeast-ward, gradually replace by the south-west monsoon; and September-October-November, when the southwest monsoon retreats to lower latitudes.

3.1.1 Actual Storm Pattern

The significant hourly hyetograph recorded at 5 gauging stations in the upstream basin are shown in Fig. P-6.

Rainfall depth for three durations of 1, 3 and 12 hours are summarized in Table P-1.

As implied by the Figures, flash flood rainfall is characterized by high intensity, short duration.

3.1.2 Rainfall Intensity

Based on short duration time records at JPT Ampang station, the rainfall intensity duration curve for Kuala Lumpur compiled for internal use in DID as shown in Fig. P-7.

3.1.3 Areal Reduction Factor

Areal reduction factor for conversion from point rainfall to areal average rainfall has been studied (Hydrological Procedure No. 1). The result was shown on Table P-2.

In addition, the average areal reduction factor estimated from maximum point rainfall was studied for Kuala Lumpur area in Hydrological Procedure No. 17 and listed in Table P-3 and Fig. P-8.

3.2 Flood Run-off Calculation

3.2.1 General

Alternative flood mitigation plans had been studied for the target point of Sulaiman Bridge in the Master Plan Study.

Otherwise, flash flood occurs in intermonsoon is serious and urgent countermeasures should be formulated.

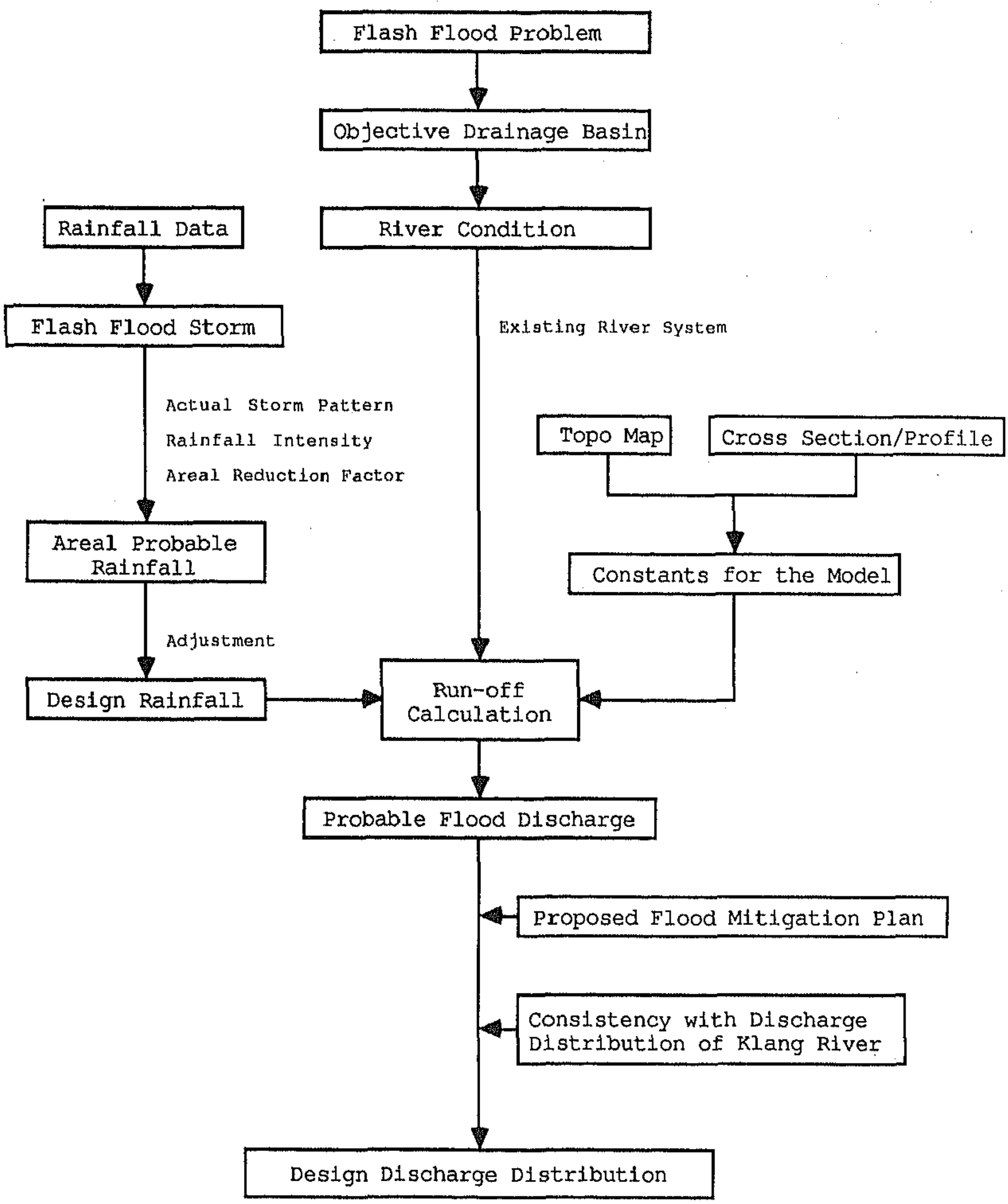
In 1978, Master Drainage Plan in Kuala Lumpur Flood Mitigation Project Drainage Improvement was formulated and the improvement works is strongly under implementation.

Owing to the growth of urbanization and industrialization, the discharge run-off from main tributaries is rapidly towards increasing and critical to existing discharge capacity of the Batu, the Gombak and the Klang Rivers.

From view point of planning consistency maintaining between the main river and its tributaries, consideration should be given for formulation of flood mitigation plan in the one river system.

Flow chart of flood run-off calculation for the tributaries is shown below.

FLOW CHART OF RUN-OFF CALCULATION



3.2.2 Modelling and Coefficients

(1) Objective Drainage Basin

In view of the rapid urbanization and frequent occurrences of flash floods in the basin, run-off calculation should be carried for the following drainage basin:

- Sg. Jinjang
- Sg. Keroh
- Sg. Bunus
- Sg. Kerayong
- Sg. Damansara

(2) Simulation Model

The storage function method will be applied for the conversion of areal rainfall to flood hydrograph. (The idea and basic equation are summarized in the Main Report.)

(3) River System Model

Based on the existing river system of objective drainage basins, the system for the simulation model shall be incorporated with the diversion channel and the retention pond.

Figs. P-9 to P-13 show the catchment divisions and the river system model for the five drainage basins.

(4) Land Use Condition

Land use condition in the catchment in 2005 years will be based on feature land use plan (Scale 1/20,000) issued by the Government.

(5) Target Point

The target point of the objective drainage basin should be modified from the bridge site/confluence of the river appointed is the Master Drainage Plan.

(6) Coefficients (K, P, TL, f)

The coefficients of the basins and channels for the catchment are summarized in Figs. P-9 to P-13.

Constants "K, P" of the channel are based on the relation between the discharge and storage volume of the channel.

3.2.3 Probable Areal Rainfall

(1) Rainfall Pattern

Based on the actual flash flood rainfall pattern, the probable discharges were simulated through the model by the typical pattern as following. Fig. P-14 shows the 3 typical rainfall patterns.

* Type I (Forward Concentration) ------ 1973.12.6
* Type II (Center Concentration) ------ 1977.4.27
* Type III (Backward Concentration) ------ 1979.6.5

(2) Areal Rainfall Duration

The duration of the areal rainfall will be determined as 3 hours in respect of the storm duration which governs peak discharge in the flash flood.

(3) Rainfall Depth

Rainfall depth for the objective drainage basin will be estimated with consideration of areal reduction factor and 1 and 3 hours duration depth of the rainfall intensity at the JPT Ampang Station.

(4) Adjustment to Probable Areal Rainfall

Probable Areal Rainfall will be adjusted by enlargement/reduction from actual storm pattern in the flash flood to the probable rainfall depth of 10, 20, 50 ad 100 years return periods.

The probable rainfall in 3 typical types for the 5 catchments are listed in Table P-4.

3.2.4 Probable Floods

Probable flood hydrographs at the confluence for 5 catchments are converted from the probable areal rainfall using the Storage Function Model.

Through the comparison of the discharges put out in 3 typical rainfall pattern, the values converted from Type III indicate bigger than other patterns. Therefore the probable discharges were converted from Type III rainfall pattern using the Model.

In addition, the value converted from monsoon flood rainfall types is bigger than the value from flash flood rainfall pattern for Sg. Damansara.

The probable flood discharges for the 5 catchments is listed below.

PROBABLE DISCHARGE FROM 5 TRIBUTARIES

Unit: m^3/s

Catchment	Return Periods (Year)				
	10	20	50	100	
Sg.Jinjang					
AL (1)			58	66	
AL (2)	9	12	16	20	
AL (3)			41	48	
AL (4)			26	32	
Sg.Keroh					
AL (1)	88	102	132	150	
AL (2)			80	96	
Sg.Bunus					
AL (1)	67	72	94	108	
AL (2)			82	94	
AL (3)			42	50	
Sg.Kerayon					
AL (1)			163	189	
AL (2)			95	111	
AL (3)			89	100	
Sg.Damansara					
AL (1)	131	148	172	196	(Flash Flood)
AL (2)			103	118	
AL (1)	122	164	202	260	(Monsoon Flood)
AL (2)	114	151	186	240	

(AL means Alternative case)

4. BASIN STORAGE PLAN

4.1 General

For the purpose to estimate the reduction of flood peak run-off and to evaluate the effectiveness of retention ponds, flood run-off analysis was executed by applying the ex-mining ponds and the potential sites for creation of the multipurpose pond.

In this flood runoff analysis, some diversion channels were considered for the purpose to connect with the retention ponds. In addition to this condition, some assumptions were introduced as follows;

- River is connected with the retention pond directly, i.e., river water flows in pond not only during flood period but also off-flood period.

- Run-off water in the retention pond is controlled naturally, i.e., gated structures is not introduced in this study.

4.2 Alternative Study

By applying the meteorological and hydrological condition, and some assumptions as described before, flood run-off calculation was carried out for the selected five tributaries. For the purpose to judge the effectiveness of the retention pond, some alternative cases were considered as follows;

ALTERNATIVE CASES

Tributary	Alternative Case No.	Condition
Sg. Jinjang	AL (1)	Without pond
	AL (2)	With A, B and C ponds
	AL (3)	With A pond
	AL (4)	With A and B ponds
Sg. Keroh	AL (1)	Without pond
	AL (2)	With A and B ponds
Sg. Bunus	AL (1)	Without pond
	AL (2)	With A pond
	AL (3)	With A and B ponds
Sg. Kerayong	AL (1)	Without pond
	AL (2)	With A pond
	AL (3)	With A and B ponds
Sg. Damansara	F.AL (1)/1	Without pond
	F.AL (2)	With A and B ponds
	M.AL (1)/2	Without pond
	M.AL (2)	With A and B ponds

Note: /1: F means that flash storm is applied.
/2: M means that monsoon storm is applied.

Location of ponds, which were applied in alternative study, are shown in Figs. P-1 to P-5 with pond areas and present land use conditions.

As the results of flood run-off calculation, the effectiveness of the retention ponds were made clear as shown in Fig. P-15 and Table P-5, and summarized as follows;

RESULTS OF FLOOD RUN-OFF ANALYSIS

(In case 100-year rainfall was adopted)

Tributary	Alternative Case No.	Peak Discharge at Confluence (m^3/s)
Sg. Jinjang	AL (1)	66
	AL (2)	20
	AL (3)	48
	AL (4)	32
Sg. Keroh	AL (1)	150
	AL (2)	96
Sg. Bunus	AL (1)	108
	AL (2)	94
	AL (3)	50
Sg. Kerayong	AL (1)	189
	AL (2)	111
	AL (3)	100
Sg. Damansara	F.AL (1)	196
	F.AL (2)	118
	M.AL (1)	260
	M.AL (2)	240

4.3 Recommendation

In consideration of the effectiveness of retention ponds, following plans are recommended for each tributary in this study.

a) Sg. Jinjang

Alternative case AL (2) is recommended for this tributary. By applying the three ponds, about 70% of peak discharge is expected to be cut as compared with the case of without pond for 100-year flood.

On the other hand, City Hall is proposing the sewerage treatment plant in Pond C site. In case this sewerage treatment plan will be realized, two ponds plan of AL (4) is recommended secondly.

The upper catchment of this basin is natural jungle at present. However, this area is expected to be developed by housing or other purposes, and then there is a possibility that the flood run-off pattern will be changed in future. Therefore, it is necessary to keep the ex-mining ponds for retention ponds as much as possible.

b) Sg. Keroh

Alternative case AL (2) is recommended for this basin. By applying the Pond A and B, about 35% or 55 m^3/s of peak discharge is expected to be cut as compared with the case of without pond for 100-year flood.

DID Federal Territory commenced the preparatory works for retention pond at Pond A in 1988. This pond has a great effect on flood mitigation for downstream reaches, then careful plan and construction is necessary.

c) Sg. Bunus

Alternative case AL (3) is recommended for this basin. By applying the Pond A and B, about 55% or 60 m^3/s of peak discharge is expected to be cut as compared with the case of without pond for 100-year flood.

Pond B is located in the squatter area. However, this pond has a great effect on flood mitigation for downstream reaches such as at Jln. Tun Razak where is often inundated by overflowed water from Sg. Bunus. Therefore, prompt action for implementation is necessary.

Discharge capacity of existing by-pass channel is about 20 m^3/s and this capacity is not enough to carry 50 m^3/s which is the peak discharge of the recommended case AL (3). Therefore, another by-pass channel, which has a capacity of 30 m^3/s, is recommended to be constructed along Jln. Tun Razak to the Klang River.

d) Sg. Kerayong

Alternative case AL (3) is recommended for this basin. By applying the both ponds, about 45% or 90 m^3/s of peak discharge is expected to be cut as compared with the case of without pond for 100-year flood.

Ex-mining Pond A Site is already handed over to housing developers. However, reclaiming of this pond is not yet commenced because of deep water. This ex-mining pond is necessary for not only the flood mitigation plan of this basin but also the flood mitigation of the Klang River in case of a diversion channel connecting Sg.Ampang to Sg.Kerayong is planned. Therefore, it is recommended to use this pond for retention pond.

The east side ex-mining pond of Pond B is situated in the Tun Razak Metropolitan Park proposed by City Hall. Therefore the multipurpose pond like the proposed Batu Retention Pond is recommended for this site.

e) Sg. Damansara

Alternative case AL (2) is recommended for this basin. Two rainfall patterns were applied for flood run-off analysis in this basin, one is flash storm and the another is monsoon storm. The effect of retention ponds is not so much for monsoon storm, however these ponds have a great effect for flash storm. About 40% or 80 m^3/s of peak discharge is expected to be cut as compared with the case of without pond for 100-year flash flood.

Recommended retention pond B site is situated in swampy area. Broad area approximately 40 ha is necessary for retention pond. In order to use the land effectively, the multipurpose pond like a proposed Batu retention pond is recommended for this site.

By introducing the retention ponds, it was made clear that a great effect is expected for flood mitigation. In addition to this effect, retention ponds will produce other benefits. The expected intangible benefits are as follows;

- Retention ponds help to improve the quality of river water.
- Retention ponds help to trap the silt and sand in river water.

By these effects, river water will be cleaned.

REFERENCE

1) KUALA LUMPUR FLOOD MITIGATION PROJECT HYDROLOGY APPENDIX, United States Bureau of Reclamation, Department of the Interior, DID, Ministry of Agriculture, Malaysia, 1980

2) HYDROLOGICAL PROCEDURE NO. 11 DESIGN FLOOD HYDROGRAPH ESTIMATION FOR RURAL CATCHMENTS IN PENINSULAR MALAYSIA, Drainage and Irrigation Department, Ministry of Agriculture, Malaysia, 1980

3) HYDROLOGICAL PROCEDURE NO. 16 FLOOD ESTIMATION FOR URBAN AREAS IN PENINSULAR MALAYSIA, Ministry of Agriculture, Malaysia, 1980

4) KUALA LUMPUR FLOOD MITIGATION PROJECT RIVER IMPROVEMENT WORKS RIVER WORKS MASTER PLAN 1980 VOL. III HYDRAULIC DESIGN CALCULATION, Project Engineer Office, Flood Mitigation Planning, Kuala Lumpur, Drainage & Irrigation Department, Ministry of Agriculture, Malaysia, 1980

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7) THE ESTIMATION OF STORAGE-DRAFT RATE CHARACTERISTICS FOR RIVERS IN PENINSULAR MALAYSIA (HYDROLOGICAL PROCEDURE NO. 13), Drainage & Irrigation Department, Ministry of Agriculture, Malaysia, 1976

8) HYDROLOGICAL STATION REGISTERS (HYDROLOGICAL PROCEDURE NO. 7), Drainage & Irrigation Department, Ministry of Agriculture, Malaysia, 1974

9) JLN. DARI KOMPLEKS T.U.D.M SUBANG KE JLN. PUCHONG (SG. DAMANSARA DEVIATION), Jabatan Kerja Raya Selangor

Table P-1 RAINFALL DEPTH FOR VARIOUS DURATIONS

			RAINFALL	DEPTH	(MM)
DATE	NUMBER	STATION N.	1 HOUR	3 HOUR	12 HOUR
72-11-16	3117070	JPT AMPANG	66.5	85.6	89.0
73-12-06	3217002	G.KELANG(AB)	69.7	98.7	102.9
74-06-21	3117070	JPT AMPANG	30.4	60.2	73.0
74-12-09	3216001	SG.TUA (AB)	31.2	59.0	59.0
75-12-22	3217002	G.KELANG(AB)	43.9	53.5	53.5
76-04-21	3217002	G.KELANG(AB)	44.3	69.0	75.0
77-04-27	3217002	G.KELANG(AB)	62.0	115.5	116.0
77-10-04	3117070	JPT AMPANG	44.4	69.0	73.5
78-04-15	3217001	GOMBAK (AB)	58.2	64.4	64.9
78-10-19	3117070	JPT AMPANG	32.1	41.7	45.2
78-11-15	3217002	G.KELANG(AB)	22.9	43.8	64.5
79-06-05	3216001	SG.TUA (AB)	45.2	89.1	133.0
80-05-13	3217002	G.KELANG(AB)	37.9	70.9	71.6
81-04-06	3216001	SG.TUA (AB)	35.9	78.0	79.0
81-09-11	3216001	SG. TUA (AB)	29.9	59.5	64.5
81-11-29	3217001	GOMBAK (AB)	31.5	66.0	67.0
82-04-27	3117070	JPT AMPANG	30.9	73.1	63.1
88-05-13	3116004	JPT W. PER.	54.0	102.0	104.0

Table P-2 AREAL REDUCTION FACTOR

Area (km2)	ARFs for various storm duration (hours)			
	1	3	6	24
0	1.00	1.00	1.00	1.00
50	0.88	0.94	0.96	0.97
100	0.82	0.91	0.94	0.96
150	0.78	0.89	0.92	0.95
200	0.75	0.87	0.90	0.93
250	0.73	0.85	0.89	0.93
300	0.71	0.84	0.88	0.93
400	0.68	0.81	0.86	0.92

(Source : Hydrological Procedure 1)

Table P-3 AREAL REDUCTION FACTOR ESTIMATED FROM MAXIMUM POINT RAINFALL

Area (km2)	ARFs for various storm duration (hours)				
	1	3	6	12	24
50	0.79	0.83	0.86	0.87	0.88
100	0.70	0.75	0.79	0.80	0.81
150	0.64	0.72	0.75	0.77	0.79
200	0.63	0.70	0.74	0.76	0.78

(Source : Hydrological Procedure 17)

Table P-4 PROBABLE AREAL RAINFALL

Sg.Jingjang

TYPE 1 (73-12-06) (mm)

Hourly	Depth	2	5	10	20	30	50	100
Total	98.7	72.2	86.5	96.0	104.7	109.9	115.9	125.4
1	69.7	54.7	65.2	72.5	78.9	83.7	87.7	92.6
2	25.2	15.6	18.5	20.4	22.4	22.8	24.5	28.5
3	3.8	2.4	2.8	3.1	3.4	3.4	3.7	4.3

TYPE 2 (77-4-27)

Hourly	Depth	2	5	10	20	30	50	100
Total	115.5	72.7	86.5	96.0	104.7	109.9	115.9	125.4
1	23.3	7.8	9.3	10.3	11.2	11.4	12.3	14.3
2	62.0	54.7	65.2	72.5	78.9	83.7	87.7	92.6
3	30.2	10.1	12.0	13.2	14.6	14.8	15.9	18.5

TYPE 3 (79-6-05)

Hourly	Depth	2	5	10	20	30	50	100
Total	71.1	72.7	86.5	96.0	104.7	109.9	115.9	125.4
1	11.5	8.0	9.5	10.5	11.4	11.6	12.5	14.6
2	14.4	10.0	11.8	13.0	14.4	14.6	15.7	18.2
3	45.2	54.7	65.2	72.5	78.9	83.7	87.7	92.6

Sg.Keroh

TYPE 1 (73-12-06) (mm)

Hourly	Depth	2	5	10	20	30	50	100
Total	98.7	74.8	89.0	98.8	107.7	113.0	119.3	129.1
1	69.7	57.1	68.0	75.6	82.3	87.4	91.6	96.6
2	25.2	15.4	18.2	20.1	22.1	22.2	24.0	28.2
3	3.8	2.3	2.8	3.1	3.4	3.4	3.7	4.3

TYPE 2 (77-4-27)

Hourly	Depth	2	5	10	20	30	50	100
Total	115.5	74.8	89.0	98.8	107.7	113.0	119.3	129.1
1	23.3	7.7	9.1	10.1	11.0	11.2	12.0	14.1
2	62.0	57.1	68.0	75.6	82.3	87.4	91.6	96.6
3	30.2	10.0	11.9	13.1	14.4	14.4	15.7	18.4

TYPE 3 (79-6-05)

Hourly	Depth	2	5	10	20	30	50	100
Total	71.1	74.8	89.0	98.8	107.7	113.0	119.3	129.1
1	11.5	7.8	9.3	10.3	11.3	11.4	12.3	14.4
2	14.4	9.9	11.7	12.9	14.1	14.2	15.4	18.1
3	45.2	57.1	68.0	75.6	82.3	87.4	91.6	96.6

(To be continued)

Sg. Bunus

TYPE 1 (73-12-06) (mm)

Hourly	Depth	2	5	10	20	30	50	100
Total	98.7	70.1	83.5	92.7	101.0	106.0	111.9	121.1
1	69.7	61.5	73.3	81.5	88.7	94.1	98.6	104.1
2	25.2	7.5	8.9	9.7	10.7	10.3	11.6	14.8
3	3.8	1.1	1.3	1.5	1.6	1.6	1.7	2.2

TYPE 2 (77-4-27)

Hourly	Depth	2	5	10	20	30	50	100
Total	115.5	70.1	83.5	92.7	101.0	106.0	111.9	121.1
1	23.3	3.7	4.4	4.9	5.4	5.2	5.8	7.4
2	62.0	61.5	73.3	81.5	88.7	94.1	98.6	104.1
3	30.2	4.9	5.8	6.3	6.9	6.7	7.5	9.6

TYPE 3 (79-6-05)

Hourly	Depth	2	5	10	20	30	50	100
Total	71.1	70.1	83.5	92.7	101.0	106.0	111.9	121.1
1	11.5	3.8	4.5	5.0	5.5	5.3	5.9	7.5
2	14.4	4.8	5.7	6.2	6.8	6.6	7.4	9.5
3	45.2	61.5	73.3	81.5	88.7	94.1	98.6	104.1

Sg. Kerayong

TYPE 1 (73-12-06) (mm)

Hourly	Depth	2	5	10	20	30	50	100
Total	98.7	69.3	82.5	91.6	99.8	104.8	110.6	119.6
1	69.7	51.0	60.8	67.5	73.5	78.0	81.8	86.3
2	25.2	15.9	18.8	20.9	22.8	23.3	25.0	28.9
3	3.8	2.4	2.9	3.2	3.5	3.5	3.8	4.4

TYPE 2 (77-4-27)

Hourly	Depth	2	5	10	20	30	50	100
Total	115.5	69.3	82.5	91.6	99.8	104.8	110.6	119.6
1	23.3	8.0	9.5	10.5	11.5	11.6	12.5	14.5
2	62.0	51.0	60.8	67.5	73.5	78.0	81.8	86.3
3	30.2	10.3	12.2	13.6	14.8	15.2	16.3	18.8

TYPE 3 (79-6-05)

Hourly	Depth	2	5	10	20	30	50	100
Total	71.1	69.3	82.5	91.6	99.8	104.8	110.6	119.6
1	11.5	8.1	9.7	10.7	11.7	11.9	12.8	14.8
2	14.4	10.2	12.0	13.4	14.6	14.9	16.0	18.5
3	45.2	51.0	60.8	67.5	73.5	78.0	81.8	86.3

(To be continued)

Sg.Damansara

TYPE 1 (73-12-06) (mm)

Hourly	Depth	2	5	10	20	30	50	100
Total	98.7	60.9	72.5	80.5	87.7	92.1	97.2	105.1
1	69.7	44.2	52.7	58.5	63.7	67.6	70.9	74.8
2	25.2	14.5	17.2	19.1	20.8	21.3	22.8	26.3
3	3.8	2.2	2.6	2.9	3.2	3.2	3.5	4.0

TYPE 2 (77-4-27)

Hourly	Depth	2	5	10	20	30	50	100
Total	115.5	60.9	72.5	80.5	87.7	92.1	97.2	105.1
1	23.3	7.3	8.6	9.6	10.5	10.6	11.4	13.2
2	62.0	44.2	52.7	58.5	63.7	67.6	70.9	74.8
3	30.2	9.4	11.2	12.4	13.5	13.9	14.9	17.1

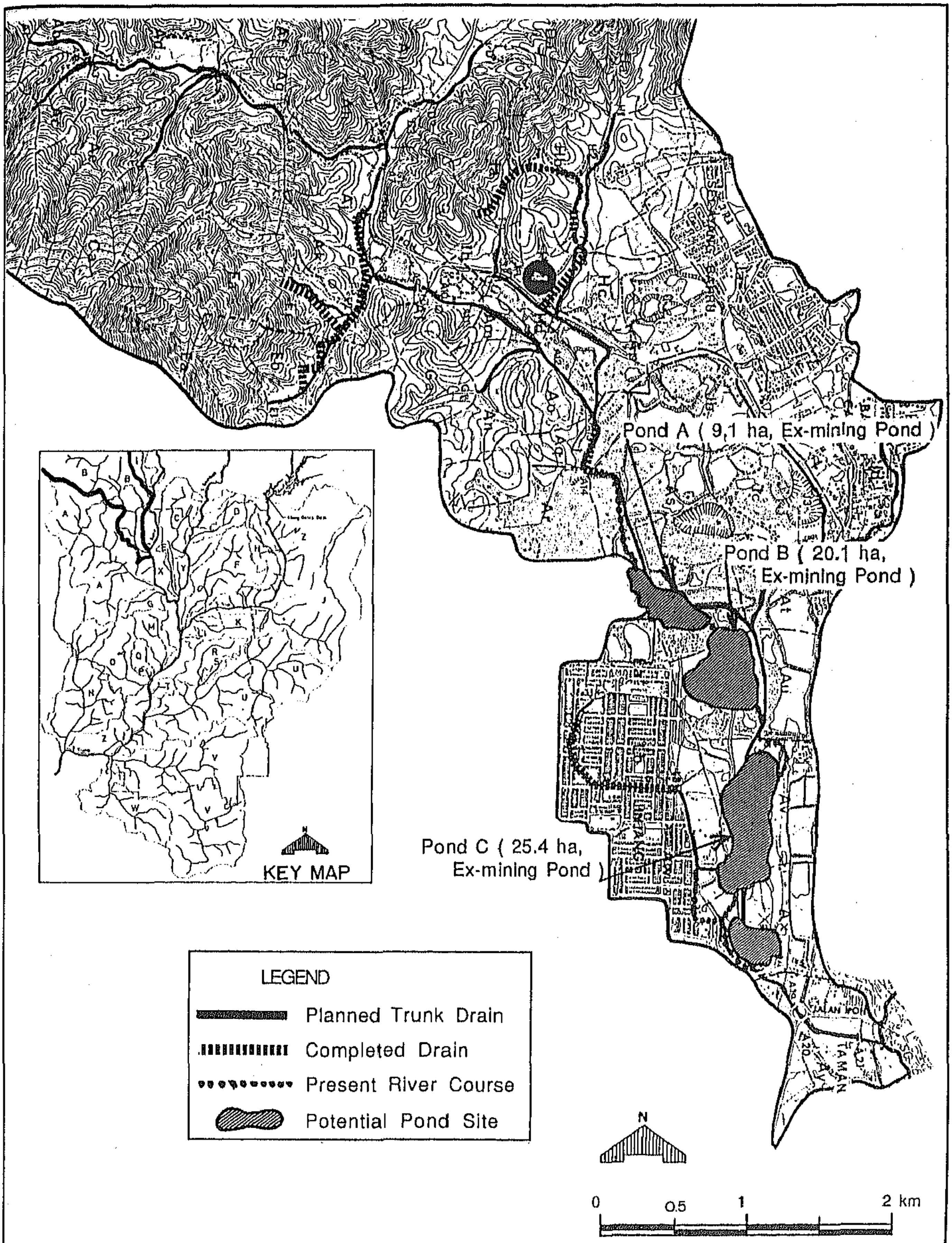
TYPE 3 (79-6-05)

Hourly	Depth	2	5	10	20	30	50	100
Total	71.1	60.9	72.5	80.5	87.7	92.1	97.2	105.1
1	11.5	7.4	8.8	9.8	10.7	10.9	11.7	13.5
2	14.4	9.3	11.0	12.2	13.3	13.6	14.6	16.8
3	45.2	44.2	52.7	58.5	63.7	67.6	70.9	74.8

Table P-5 RESULTS OF FLOOD RUN-OFF CALCULATION IN CASE 100-YEAR RAINFALL

Tributary	Alternative Case Number	Peak Discharge at Confluence (m3/s)	Total Retention Vol. (x 1,000 m3)	Surcharge Water Depth (m)	Condition
Sg. Jinjang	AL(1)	66	0		without pond
	AL(2)	20	1,098	Pond A=2.1, Pond B=2.2, Pond C=1.9	with Ponds A,B and C
	AL(3)	48	195	Pond A=2.1	with Pond A
	AL(4)	32	628	Pond A=2.1, Pond B=2.2	with Ponds A and B
Sg. Keroh	AL(1)	150	0		without pond
	AL(2)	96	449	Pond A=2.4, Pond B=2.0	with Ponds A and B
Sg. Bunus	AL(1)	108	0		without pond
	AL(2)	94	84	Pond A=1.1	with Pond A
	AL(3)	50	417	Pond A=1.1, Pond B=3.5	with Ponds A and B
Sg. Kerayong	AL(1)	189	0		without pond
	AL(2)	111	745	Pond B=3.7	with Pond B
	AL(3)	100	1,003	Pond A=1.7, Pond B=3.1	with Ponds A and B
Sg. Damansara	F.AL(1)<1	196	0		without pond
	F.AL(2)<1	118	1,277	Pond A=2.4, Pond B=2.7	with Ponds A and B
	M.AL(1)<2	260	0		without pond
	M.AL(2)<2	240	1,884	Pond A=2.4, Pond B=4.2	with Ponds A and B

Note: <1; F means that flash storm is adopted.
<2; M means that monsoon storm is adopted.



Source: Kuala Lumpur Flood Mitigation Project Drainage Improvements, Master Drainage Plan

FIG. P-1	LOCATION OF IMPROVED DRAINS AND POTENTIAL SITES FOR RETENTION POND IN SG.JINJANG BASIN

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

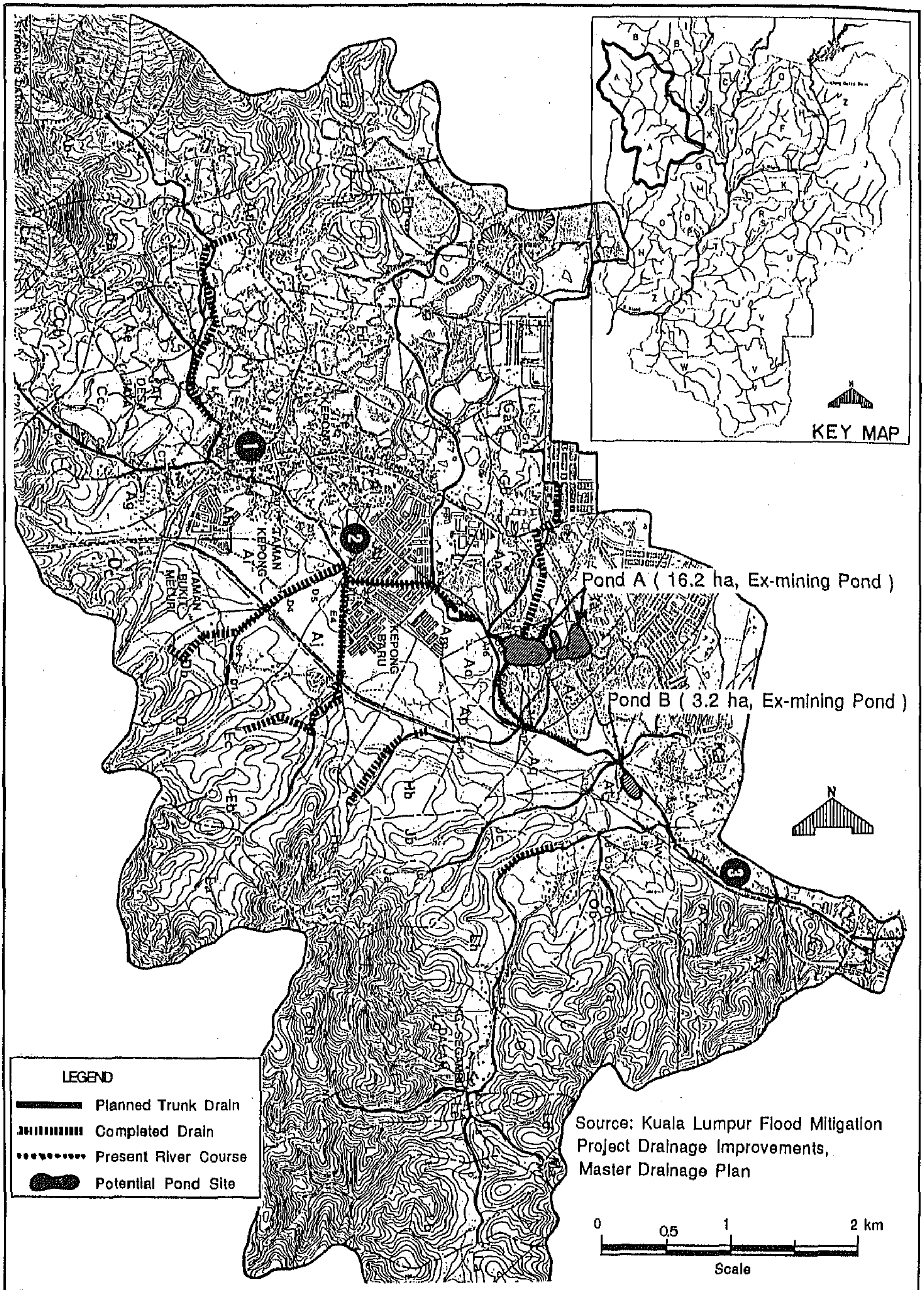
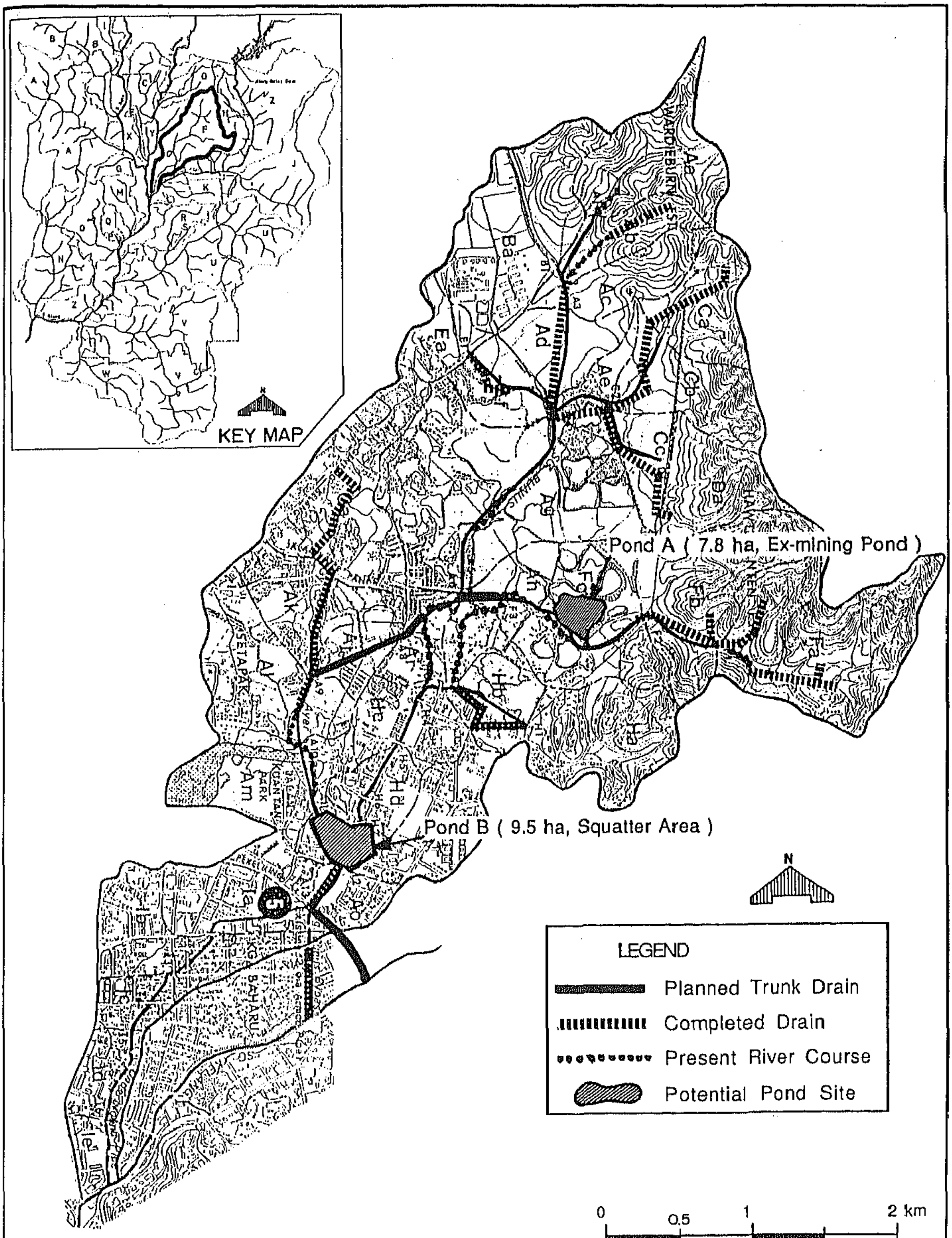


FIG. P-2	LOCATION OF IMPROVED DRAINS AND POTENTIAL SITES FOR RETENTION POND IN SG.KEROH BASIN

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

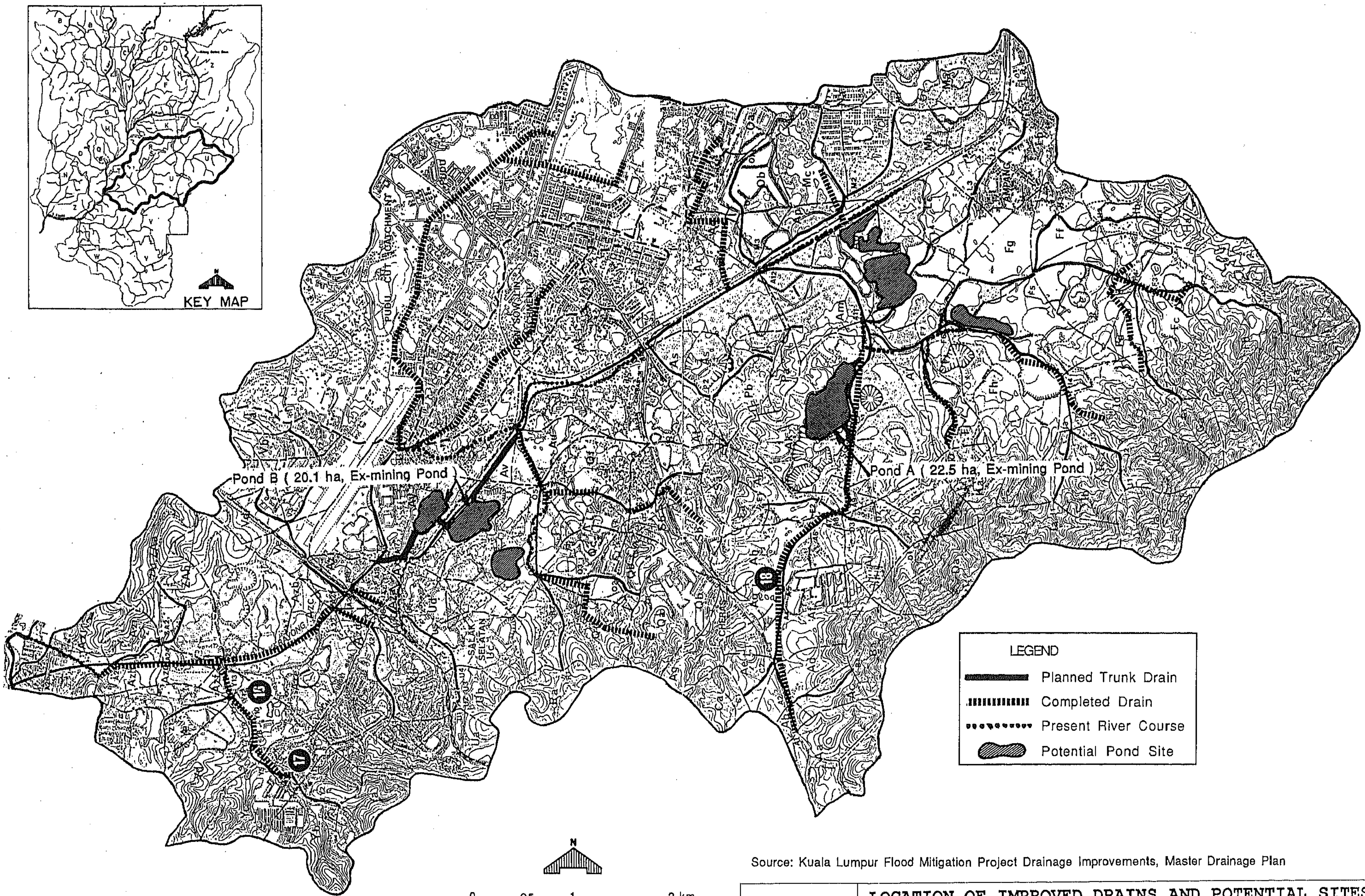
JICA



Source: Kuala Lumpur Flood Mitigation Project Drainage Improvements, Master Drainage Plan

Fig. P-3	LOCATION OF IMPROVED DRAINS AND POTENTIAL SITES FOR RETENTION POND IN SG.BUNUS BASIN

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN



Source: Kuala Lumpur Flood Mitigation Project Drainage Improvements, Master Drainage Plan

FIG. P-4	LOCATION OF IMPROVED DRAINS AND POTENTIAL SITES FOR RETENTION POND IN SG.KERAYONG BASIN

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

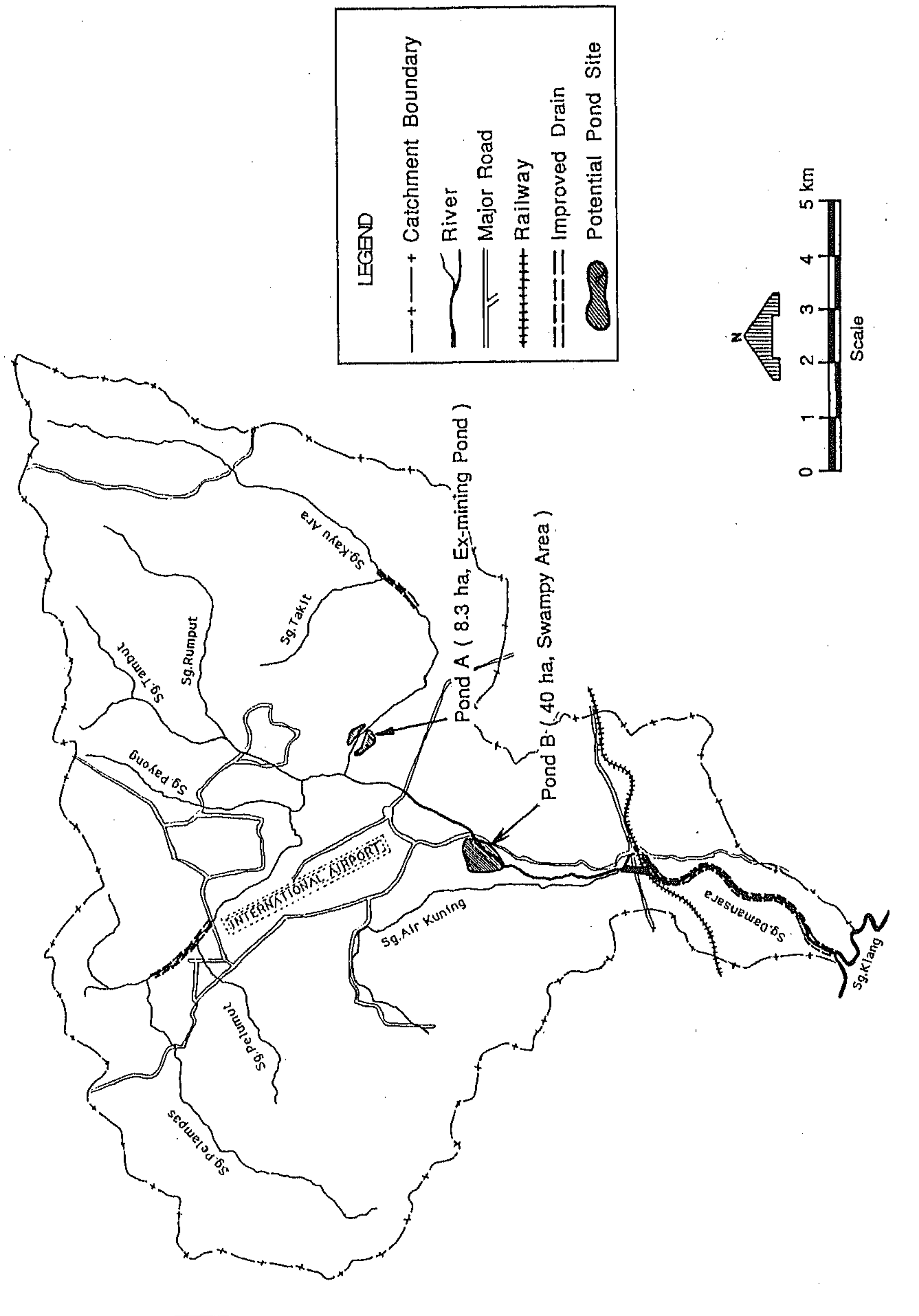


FIG. P-5	LOCATION OF IMPROVED DRAINS AND POTENTIAL SITES FOR RETENTION POND IN SG. DAMANSARA BASIN

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

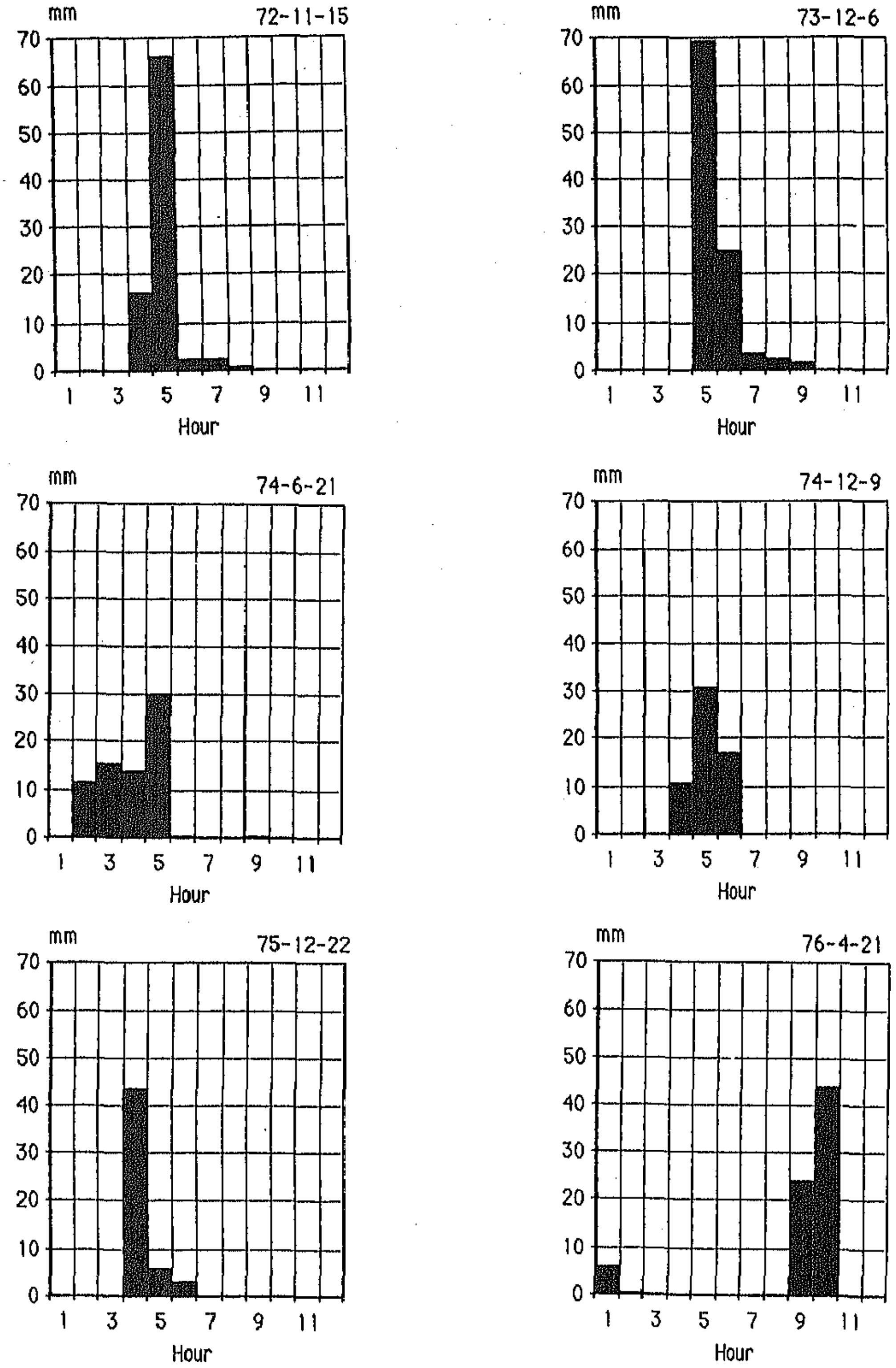


FIG. P-6	ACTUAL HYETOGRAPH RECORDED DURING FLASH FLOOD (1/3)

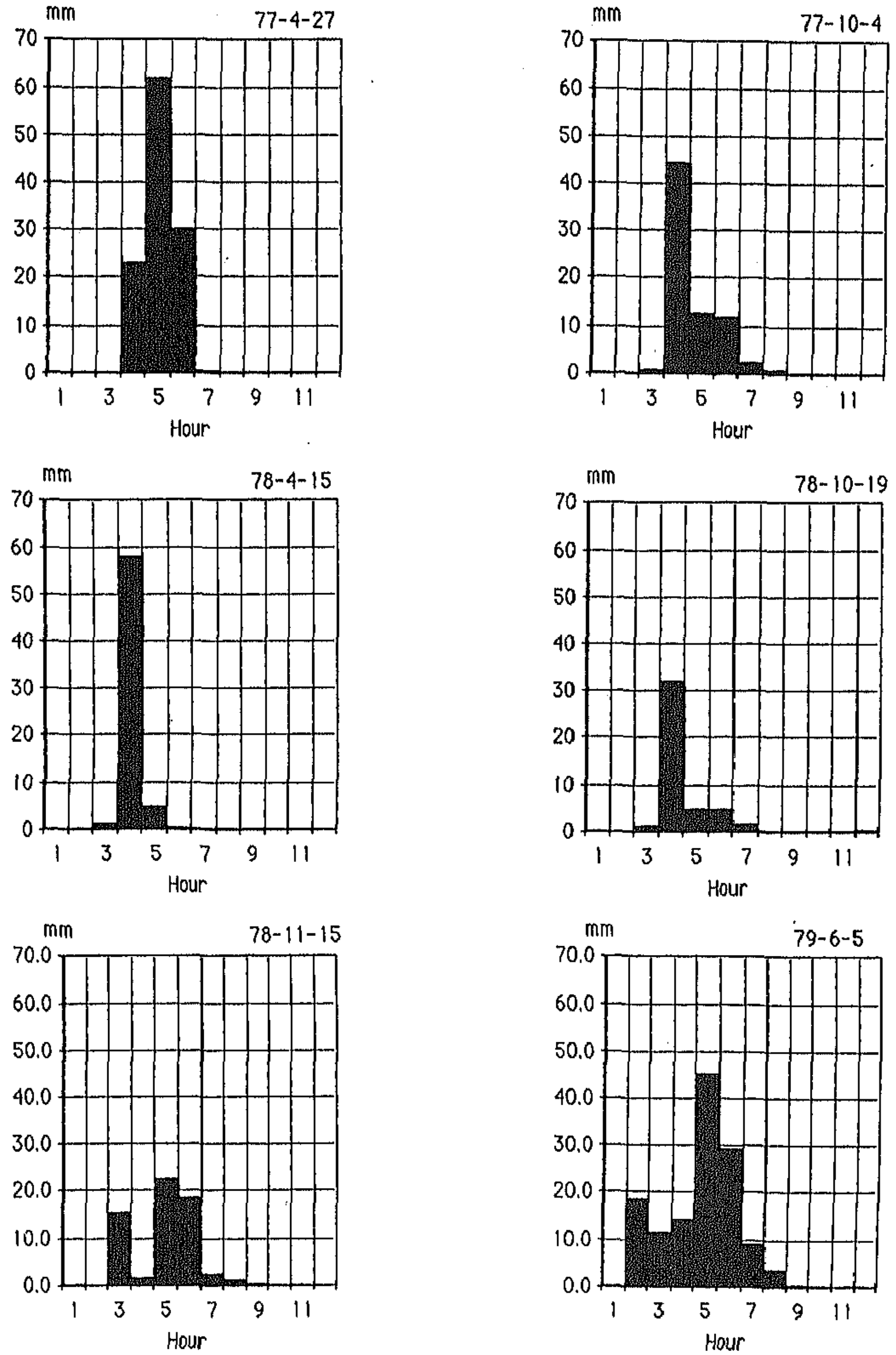


FIG. P-6 ACTUAL HYETOGRAPH RECORDED DURING FLASH FLOOD (2/3)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

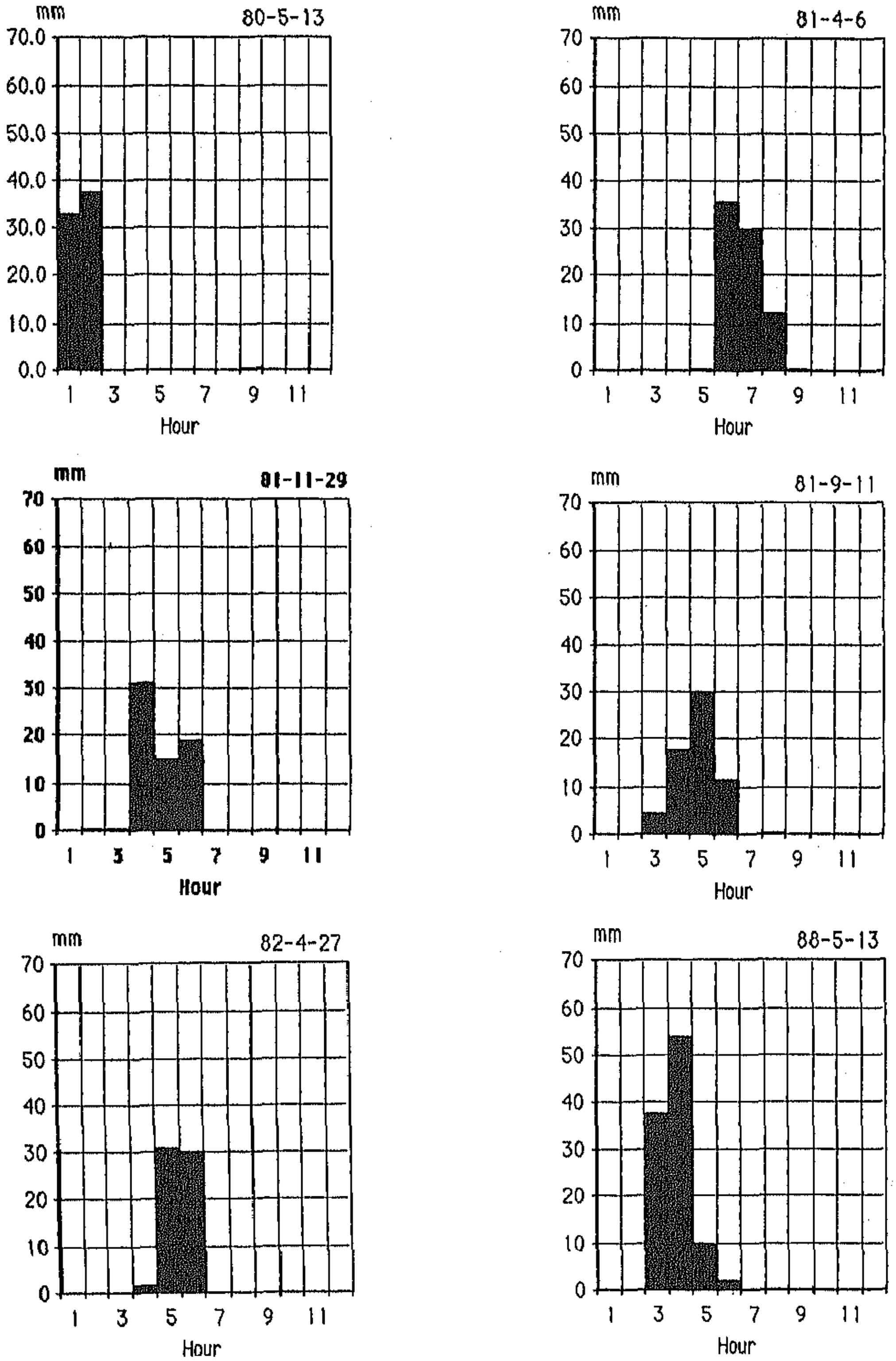
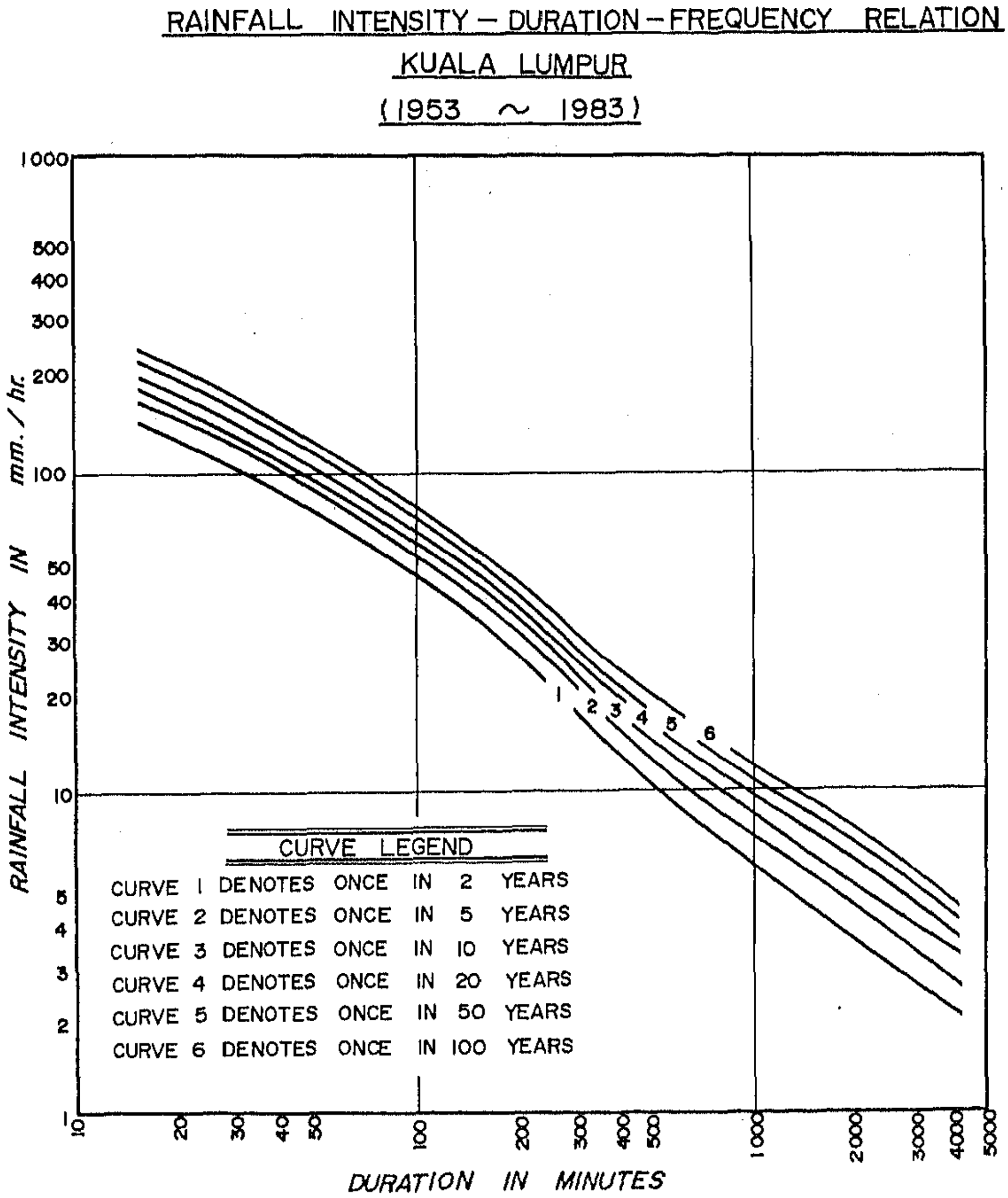


FIG. P-6 **ACTUAL HYETOGRAPH RECORDED DURING FLASH FLOOD (3/3)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN



unit : mm

	Return Period (years)				
Storm Duration (hrs)	2	5	10	20	50
1	68	81	90	98	109
3	84	100	111	121	134
6	90	112	126	140	159

FIG. P-7 RAINFALL INTENSITY DURATION CURVE

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN