GOVERNMENT OF MALAYSIA

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

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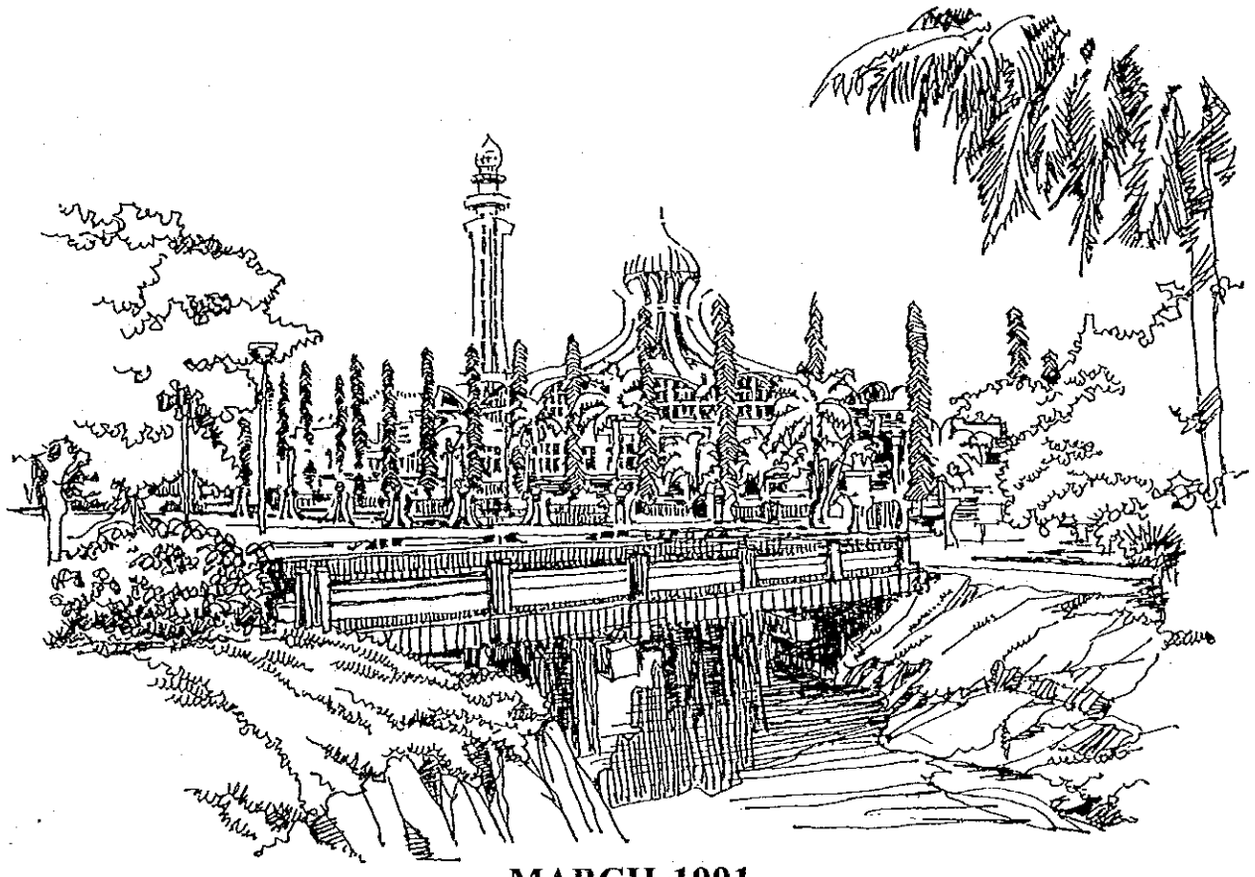

MARCH 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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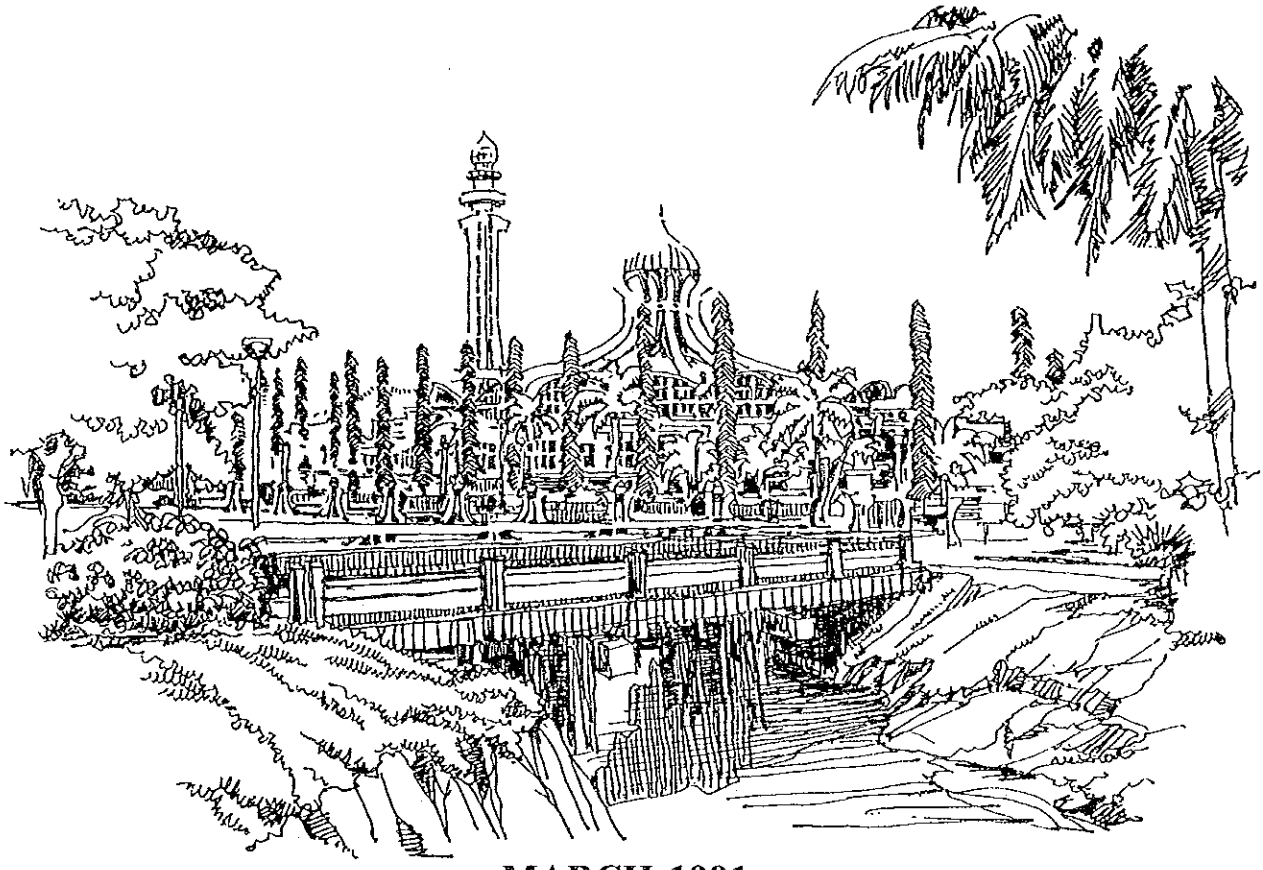

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DATA 1

PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT FOR THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

DATA 2

FACTUAL REPORT ON SOIL INVESTIGATION AND WATER QUALITY INVESTIGATION FOR THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

DATA 3

TABLES OF WATER LEVELS FOR 10 AND 100 YEAR FLOODS IN 25 RIVERS IN PENANG ISLAND

PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT FOR THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND, MALAYSIA

Report Submitted To The Japan
International Cooperation Agency (JICA)
By The Environmental Research Group,
Universiti Sains Malaysia, Penang.

September 1990

FINAL REPORT

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1.0 INTRODUCTION

1.1 Title and Type of Project

The title of this project is "The Urgent Flood Mitigation and Drainage Projects in Penang Island". This Preliminary Environmental Impact Assessment (EIA) is undertaken on the proposals for flood mitigation and drainage for objective feasibility study areas at Sg. Pinang and its tributaries. These proposals are the result of the Masterplan study of the Japanese International Cooperation Agency (JICA) Study Team.

1.2 Project Initiator

As flood mitigation and drainage is under the preview of the Department of Drainage and Irrigation (DID) the project initiator is The DID in the State of Penang. The JICA Study Team submits its proposals and recommendations through the DID to the Government of Malaysia to evaluate the environemntal impacts of the proposal Masterplan. The JICA Study team invited The Environmental Research Group (ERG) of the Universiti Sains Malaysia, Penang, to undertake the studies for the Preliminary EIA for the flood mitigation and drainage of the objective feasibility study areas at Sungai Pinang and its tributaries. This report summarises the findings of the preliminary EIA study and follows the format recommended by the Department of Environment (DOE) in its Handbook of Environmental Impact Assessment Guidelines (1987).

1.3 Statement of Need

1.3.1 Flood Situation of Penang Island

Flooding takes place periodically in various parts of Penang Island are caused by the seasonal monsoon storms as well as the year round thunderstorms. Monsoon storms are generally of long duration of up to 2 or 3 days, but with a low rainfall intensity. Thunderstorms are typically of short duration of a few hours, but they can be of high intensity. They occur throughout the year and can cause flash floods when the amount of rain exceeds the capacity of the rivers and drainage system. In Georgetown, in some lowlying areas, flooding occurs at high springtide even with no apparent rainfall.

1.3.2 Flood Prone Areas

Many of the low lying areas of Penang Island experience flood. These areas are indicated on the map of Penang Island (Figure 1.1). The most serious floods and those which have the greatest impacts are those in Georgetown where the population density is high and the area built-up (Figure 1.2).

1.3.3 Occurrence and Frequency of Floods

The incidence of serious floods in Penang from the year 1976 to 1987 are shown in Table 1.1. Most of the most severe floods in Georgetown occurred in the Caunter Hall Area and along Jalan Perak. However,

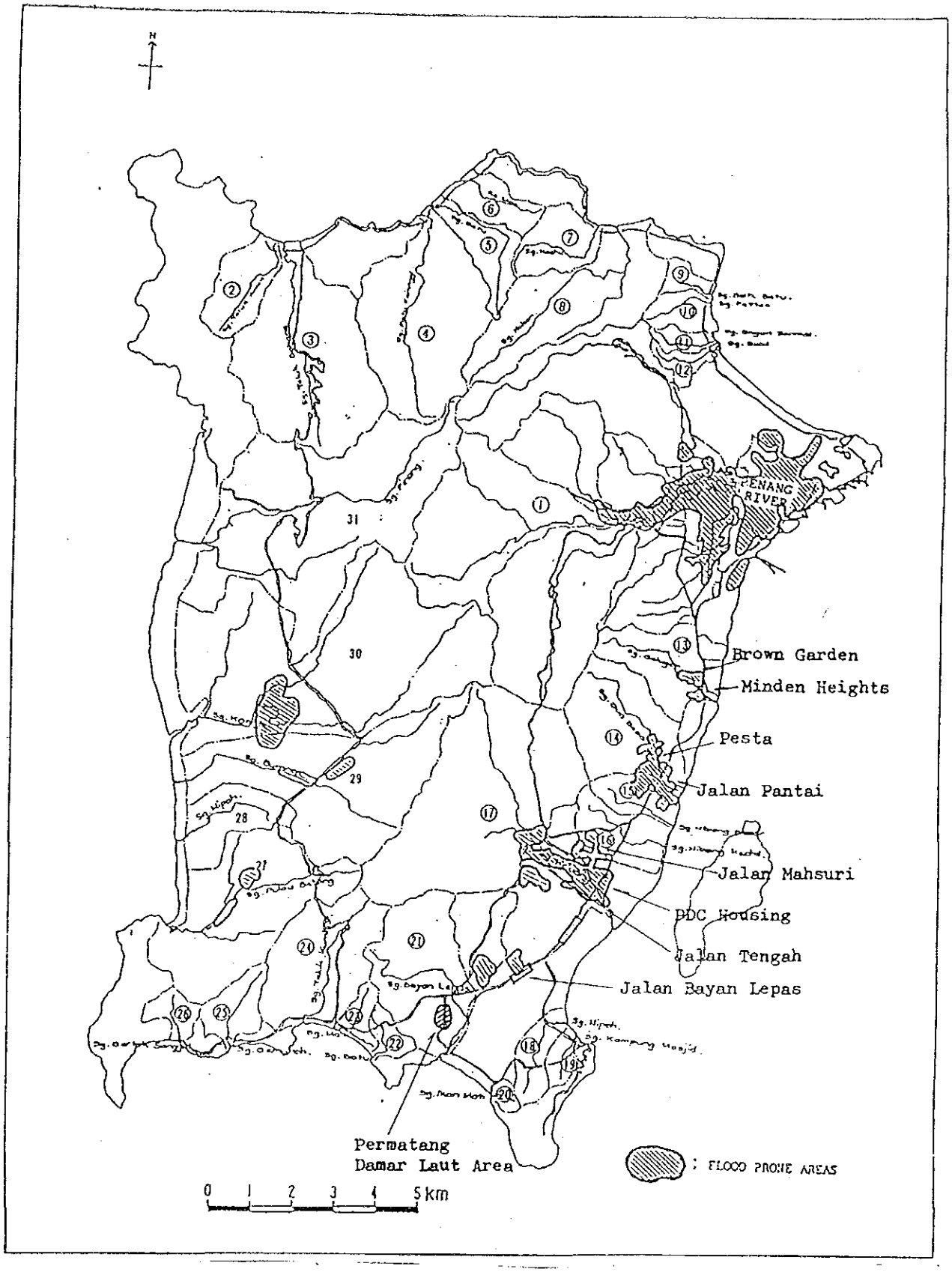


Figure 1.1: Experienced Flood Prone Areas in Whole Penang Island.
Source : JICA

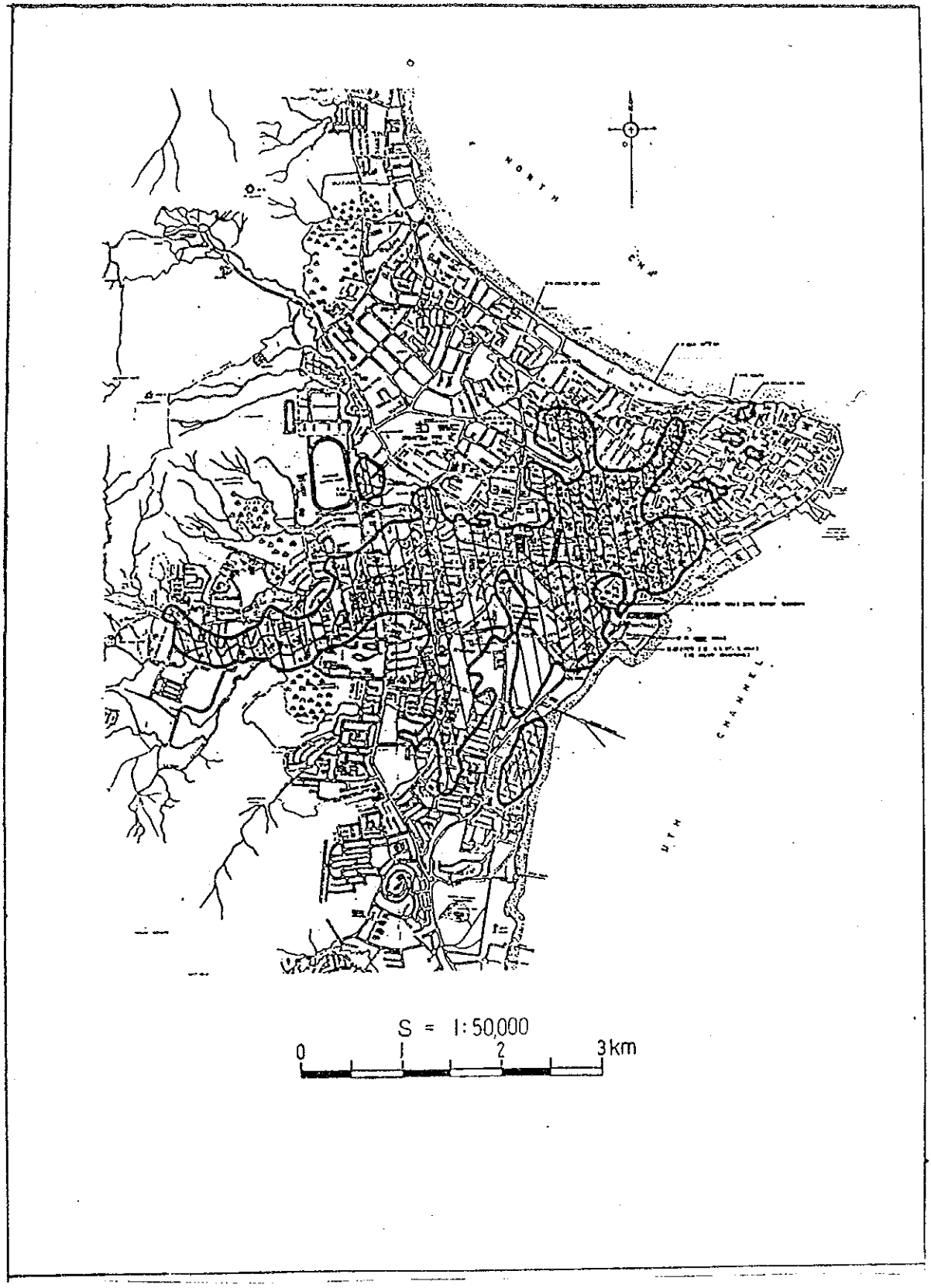


Figure 1.2: Experienced Flood Prone Areas in Georgetown.
Source : JICA

Table 1.1: Record Of Highest Flood Water Level And Rainfall In George Town.

Year	M.	D.	H.F.W.L	Observation Site
1976	9	18	R.L. + 10.0ft	Center Hall
1977	11	25	8.5	"
1978	9	6	8.9	"
1979	11	27	9.5	"
1980	9	5	9.5	"
1981	10	18	9.5	"
1982	10	29	8.5	"
1983	10	15	8.5	"
1984	4	16	8.2	"
		18 ~ 19	22;00~8;00~17;00 4.6ft-10.6ft-9.1ft	"
			20;00~4;00~10;00 7mm - 42mm - 5mm (255mm)	5402002 (Kolam Bersih)
		28	6;00~15;00~24;00 6.0ft-11.0ft-5.6ft	Center Hall
			1;00~9;30~13;00 0 - 40mm - 1mm (147.5mm)	5303001 (Rumah Kebajikan)
	5	17	5;00~9;30~15;30 5.3ft-9.3ft-6.0ft	Center Hall
			4;00~4;30~7;30 4mm - 46mm - 0.5mm (96mm)	5302003 (Kolam Takongan)
	7	14 15	22;00~2;00~6;00 4.3ft-8.5ft-6ft	Center Hall
		15 16	21;00~3;00~7;00 5.6ft-8.6ft-7.3ft	"
		16 17	23;00~4;00~8;15 5.6ft-10.5ft-8.7ft	"
1985	8	8	14;00~15;00~17;00 6.0ft-7.6ft-6.8ft	"
			13;00 - 15mm	5303001
	10	11	13;55~20;00~11;30 7.0ft-10.8ft-7.2ft	Center Hall
		12	10/10 2;00~18;00 16mm 11/10 6;00~24;00 232mm 12/10 2;00 6;30 25.5mm	5402002
	12	7 ~ 8	16;00~20;30~14;00 4.3ft-9ft-3.5ft	Center Hall
			7/12 16;30 17;30 57mm	5303001

Year	M.	D.	H.F.W.L	Observation Site
1986	9	14 ~ 15	22;0~12;45~11;00 6ft-7.5ft-3.9ft	Center Hall
			14/9 2;00 24;00 98mm 15/9 0;00 5;00 18mm	5303001
		20	5;00~10;00~12;00 6.8ft-9.6ft-9.2ft	Center Hall
			1;00 8;00 (92mm)	5303001
	10	5	15;00~18;00~10;00 4.6ft-7.2ft-4.0ft	Jalan Perak
		6	5/10 12;00~23;00 (70mm) 6/10 2;00 8;30 (40mm)	5302003
	11	13	5;00~9;00~15;00 5.5ft-7.1ft-4.6ft	Center Hall
			1;00~9;00 (81mm)	5402002
1987	3	19	7;00~9;30~12;30 4.2ft-7.1ft-5ft	Jalan Perak
			2;00 10;15 (55mm)	5402002
	6	5	5;00~9;00~13;00 4ft - 7.8ft - 5ft	Jalan Perak
			6;30 9;45 (70mm) 0;15 9;00 (87mm)	5202003 5402002
	7	22	6;00~7;30 5.8ft - 6.9ft	Jalan Perak
			2;00~10;00 (55mm)	5402002
	9	14 16	20;00~14;55~14;00 6.5ft-6.7ft-4.5ft	Center Hall
	10	25 ~ 26	18;00~21;30~4;30 5.6ft-8.5ft-3.6ft	Jalan Perak
			25/10~6;00~23;00 (105mm)	5402002
	11	9	2;15~5;00~12;00 5ft-8.4ft-4.8ft	Center Hall
			83mm	5402002
		13	10;30~13;15 14;00 3.6ft- 9ft - 8ft	Center Hall
			9;30~12;00 (80mm)	5402002

floods also occur in other areas and these are shown in Table 1.2.

1.3.4 Need for Flood Mitigation and Drainage

With the increase of built up areas and the increasing development in the water catchment of the various streams and rivers, the amount of water run-off after a rain storm has increased. These have resulted in an increase of floods over the years, though this has been partly alleviated by the improvement of drainage in some areas, such as Jelutong and the Sungai Nibong Area.

There is a clear need to mitigate against floods. There are usually public calls for flood mitigation measures after every major flood event in Penang.

1.4 Environmental Impact Assessment in Malaysia

Environmental Impact Assessment (EIA) for developmental projects became mandatory on April 1st 1988. This is the result of an amendment to the Environmental Quality Act of 1974. Under this amendment, 19 different categories of development projects must undergo a mandatory EIA. Though there is a category of projects for drainage and irrigation which require EIAs, projects on flood mitigation do not legally require EIAs. However, the Department of

Table 1.2: Comprehensive Evaluation Of Rivers And Basins.

Catchment No.	Name	Scale of Cathcment	Experienced Floods	Flood Damage	Future Development	Flood Damage In Future	Total	Grade
1	Penang River	3	3	3	2	3	14	A
2	Sg. Teluk Awak	1	1	1	3	2	8	C
3	Sg. Teluk Bahang	3	1	1	3	2	10	B
4	Sg. Batu Ferringhi	3	1	1	1	1	7	C
5	Sg. Satu	1	1	1	2	1	6	C
6	Sg. Mas	1	1	1	3	2	8	C
7	Sg. kechil	1	1	1	1	1	5	C
8	Sg. kellan	2	1	1	1	1	6	C
9	Sg. Balik Batu	1	1	1	1	1	5	C
10	Sg. Feties	1	2	1	3	2	9	B
11	Sg. BaganJermal	1	1	1	2	1	6	C
12	Sg. Babi	1	2	1	2	1	7	C
13	Sg. Gelugor	1	2	2	2	2	9	B
14	Sg. Dua Besar	2	2	1	3	3	11	A
15	Sg. Nibong Besar	1	1	1	2	2	7	C
16	Sg. Nibong Kechil	1	1	1	2	2	7	C
17	Sg. Keluang	3	2	2	2	3	12	S
18	Sg. Nipah	1	1	1	3	1	7	C
19	Sg. Kampumg Masjid	1	1	1	3	1	8	C
20	Sg. Ikan Mati	1	1	1	3	1	7	C
21	Sg. Bayan Lepas	2	2	1	2	1	9	B
22	Sg. Batu	1	1	1	2	1	6	C
23	Sg. Mati	1	1	1	2	1	6	C
24	Sg. Teluk Kumbar	2	1	1	1	1	6	C
25	Sg. Gemuroh	1	1	1	1	1	5	C
26	Sg. Gertak Sanggul	1	1	1	1	1	5	C
27	Sg. Pulau Betong	3	2	1	1	1	8	C
28	Sg. Nipah	1	1	1	1	1	5	C
29	Sg. Burong	3	2	1	1	1	8	C
30	Sg. Kongsi	3	2	1	1	1	8	C
31	Sg. Pinang	3	1	1	1	1	7	C

The above are evaluated by following criteria:

Scale of Catchment	1	5.0 km^2
	2	5.0 - 10.0 km^2
	3	10.0 - km^2
Experienced Floods	1	Non-existence
	2	Sometimes
	3	Frequently
Flood Damaged	1	No damage
	2	Minor damage
	3	Serious damage
Future Development	1	No development or less than 10%
	2	10%-30% of urban expansion area
	3	30% and more
Flood Damage in Future	1	Not anticipated
	2	Minor damage anticipated
	3	Serious damage anticipated

Method of Grading :
Grade A for aggregate points > 10
Grade B for aggregate points ≥ 9 but ≤ 10
Grade C for aggregate points < 9

Environment, Malaysia, encourages projects to undergo EIAs as a mechanism of better project planning. This is especially encouraged when there are environmental impacts predicted at the planning stage. The EIA process would be able to systematically identify the physico-chemical, biological and socio-economic impacts and problems could be resolved before the start of the project so that there would be no delay once the project starts. However, as projects on flood mitigation are not on the list of scheduled activities that require an EIA (DOE, 1987), this project is not subject to EIA review process. This EIA report would be used as an aid to planning and decision making in this project.

2.0 PROJECT DESCRIPTION

2.1 Causes of Floods

The study area for the JICA Flood mitigation and drainage study covers the whole island of Penang. The flood prone areas were identified, as indicated in Figure 1.1. The major causes of floods in Penang were summarised in the JICA report (1990). These are:-

1. Increase of water run-off in the water catchment basins due to increased urbanisation.

2. Loss of natural potential retention ponds due to the filling up of these areas for housing development.

3. Increase of trunk drainage of tributaries beyond the discharge capacity of downstream parts of the river and drainage systems.

4. Construction of steep slope drainage system for housing development in hilly areas which increases the speed of run-off.

5. Increase of sedimentation as a result of soil erosion caused by land development. The sedimentation results in the decreased capacity of the river system as a result of shallowing of the river beds.

6. Presence of floating plant remains and other debris in the river channel during floods. These obstruct the smooth flow of the water.

7. Insufficient clearance at bridge crossing further aggravate the problem of floating logs and other obstructions.

8. Inadequate flow capacity of river channel or trunk drainage as a result of increased run-off.

9. Lack of pumping facilities in low-lying areas located below high tide level.

2.2 Structural and Non-Structural Flood Mitigation Measures

The identification of the major causes of floods in Penang Island led to the formulation of a two prong approach in flood mitigation in Penang. The first approach is a structural approach. This would require the construction of engineering structures which would increase the capacity of retention of flood waters in retention ponds. The increase in the capacity and numbers of the water channels and the increase in the numbers and capacity of water pumps. The second approach is the adoption of non-structural measures which would control soil erosion and run-off. This would require the strict protection of the upper reaches of the river basin since erosion is most severe

in slopes and hilly areas. There should be no development in the watersheds and water catchment areas that would result in soil erosion and also increase of water run-off. Non-structural measures would also include management methods such as the regular removal of plant remains and other debris that block the smooth flow of rivers.

While both approaches are recommended, only the environmental impacts of the structural approach is evaluated here as the non-structural measures have no adversed environmental impacts.

2.3 JICA's masterplan for Flood Control and Mitigation

The first consideration in the masterplan for flood control was the establishment of the level of flood protection to be achieved as there has to be a balance between economic cost and level of protection. The level accepted for this masterplan is the 50 year storm return period, which is the standard recommended by the "National Water Resources Study Malaysia", carried out by JICA in 1982. This level subsequently determined all the structural measures proposed in the masterplan. The structural measures that would be adopted to achieve this level are river improvements that would increase the capacity of the river, the use of diversion channels to divert the flow of water away from the normal water course and the use of retention ponds to store the flood water temporarily, reducing

the amount of water discharged into the lower reaches of the river.

To establish appropriate protective measures for each of the flood prone basins, various factors were considered. These include topographic features, existing condition in the rivers, present and future land use pattern and problems of land aquisition. These are the constraints to what can be proposed. It is assumed that there would be no major developments allowed in the head waters of the river systems.

The various flood prone areas were also prioritised, based on the number of persons that were affected as well as economic importance of the various areas. This would determine the sequence and phasing of flood mitigation measures that would be taken.

On the basis of these, the proposed projects for flood mitigation and drainage are divided into three phases.

(i) Phase 1

This consists of two parts. The first part involves the Penang River system and its tributaries. This entails the construction of the Air Terjun Diversion Channel, the Dondang Retention Ponds, the Kuala Sungai Pinang Retention Ponds and the river improvement works along the Penang River.

The second part of this phase also includes the river improvement works for the downstream stretch of Sungai Gelugor, Sungai Dua Besar and Sungai Keluang and its tributaries. The construction of the Relau Diversion Channel is also included under this part.

(ii) **Phase II**

This involves the river improvement of Sungai Jelutong and Sungai Air Terjun as well as the upstream reaches of Sungai Dondang. In addition, the Sungai Fettes, Sungai Bayan Lepas, Sungai Teluk Bahang, Sungai Teluk Awak, Sungai Mas and Sungai Nibong Kechil will also be improved.

(iii) Phase III

The other 14 rivers of Penang Island will be improved. The whole project would be implemented over a period of 8 years.

2.3.1 Project Options

The first project that would be implemented would be the flood mitigation and drainage for Sungai Pinang because of its population density and economic importance. The following measures were considered.

(a) River Improvement

To increase the capacity and flow, the river will be widened and deepened to the maximum possible. The Sungai Pinang passes through some of the most urbanised

areas in Georgetown. The tributaries of the Sungai Pinang will also be widened and deepened.

(b) Diversion Channel

For tributaries near the coast such as Sungai Air Terjun, diversion channel that would divert the discharge directly to the sea were considered. For the Sungai Air Terjun, five alternative routes were considered. In addition to these, a sixth diversion channel route with water from Sungai Air Itam to diversion channel route 5 was also considered (Figure 2.1).

The five diversion routes are as follows:-

Route No. 1 From the Botanic Gardens to Sungai Bagan Jermal.

Route No. 2 From the Botanic Gardens to Sungai Babi.

Route No. 3 Diversion channel under Jalan Gottlieb and Jalan Bagan Jermal to Sungai Babi.

Route No. 4 Diversion channel under Jalan Cantonment.

Route No. 5 Diversion channel under Jalan Residensi, Lebuh Raya Peel and Jalan Pangkor.

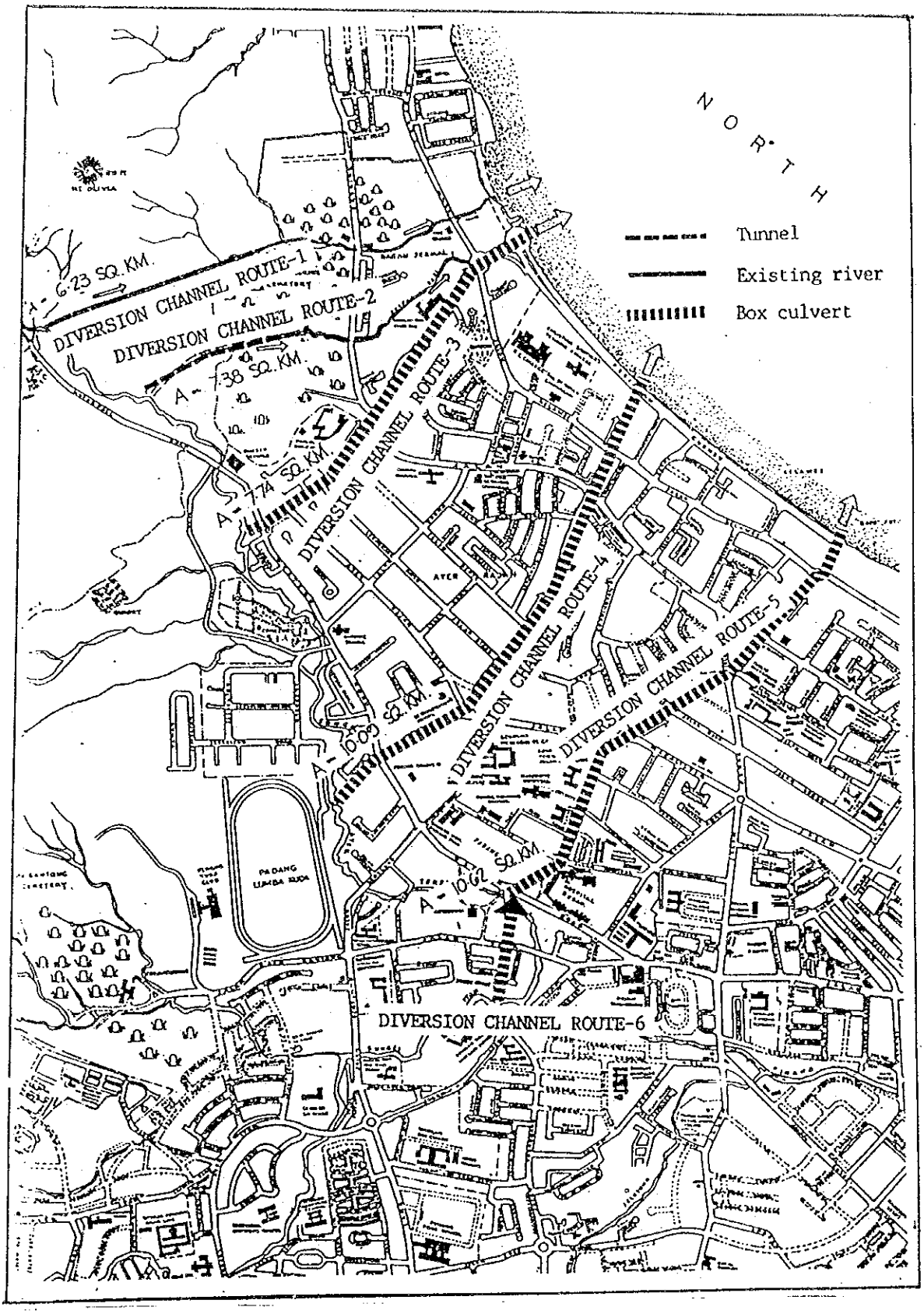


Figure 2.1: Alternative Diversion Channel Routes.
Source : JICA

Route No. 6 Diversion channel from Sungai Air Itam to Route No. 5 channel.

These alternative routes were evaluated from technical, economic and environmental aspects and the results summarised in a Table (See Table 2.1). Both Routes 2 and 3 were economically and technically viable. However, since route 2 passes through a cementary, it was considered socially unacceptable, and Route 3 considered optimum.

(c) Flood Control Dam

The possibility of a flood control dam was evaluated. The Air Itam Dam was considered and raising the dam height by 3 meters would increase the storage capacity by about 600,000 m^3. However, the catchment area is only about 5 km^2 and this would not contribute much so the solution of flood control problems in Air Itam and Georgetown. Other tributaries considered for damming were Sungai Air Putih and Sungai Air Terjun but their catchment areas were also very small and this option was rejected.

(d) Retention Ponds

The Dondang area of the Penang River basin is undergoing rapid development and is frequently affected by flash floods during heavy rain. Various areas of open space proposed by the Majlis Perbandaran Pulau Pinang (MPPP) Structure Plan for recreational use were

Table 2.1: Comparison Of Alternative Diversion Channels.

ROUTE NO.	* ROUTE	Catchment Area (km2)	Diverting Discharge (m3/sec)	Design Discharge Capacity (m3/sec)	Bed Slope	Flow Velocity (m/s)	Length (m)	Present Conditions On/along the Route	Rough Estimate of Construction cost (million M$)	Construction Problems	Evaluation
NO. 1	Sg. Air Terjun (CH.4450) ↓ Mount Ersking Cemetery ↓ Sg. Bagan Jermal	6.23 Sg. Air Terjun + 0.83 Sg. Bagan Jermal	50	65 (Tunnel) 65 + $\frac{8}{3}$ =73 (Open-channel)	$\frac{1}{100}$ (Tunnel) $\frac{1}{200}$ ~ $\frac{1}{100}$ (Open-channel)	5.8 (Tunnel) 4.3 ~ 5.8 (Open-channel)	850 (Tunnel) + 1,100 (Open-channel)	Hills and river There are some houses (about 5 houses) on the both sides of lower reach of Sg. Bagan Jermal (CH. 50 ~ 250)	7.56	- Construction works are comparatively difficult, because half of the diversion channel are tunnel type - In the lower reaches of Sg. Bagan Jermal, some houses and buildings will have to be relocated.	- The economical viability of the plan is not high.
NO. 2	Sg. Air Terjun (CH.4101) ↓ Mount Ersking Cemetery ↓ Sg. Babi	7.38 Sg. Air Terjun + 0.84 Sg. Babi	50 [60]	65 [78] (Tunnel) 65 + $\frac{8}{3}$ =73 [78] [86] (Open-channel)	$\frac{1}{100}$ (Tunnel) $\frac{1}{400}$ ~ $\frac{1}{100}$ (Open-channel)	5.8 (Tunnel) 3.2 ~ 5.7 (Open-channel)	290 (Tunnel) + 1,600 (Open-channel)	Hills and river There are some houses (about 20 houses) on the both sides of Sg. Babi CH. 50 ~ 250 CH. 450 ~ 500 CH. 750 ~ 1100 CH.1200 ~ 1300	4.70 [5.48]	- Construction works are easier than Alternative 1, because almost all reaches of the diversion channel are open - channel type. - Houses and buildings will have to be relocated, in some reaches of Sg. Babi.	- One of the best plans that have high economical/technical viability. - The major problem will be relocation of the houses and buildings along Sg. Babi.
NO.3	Sg.Air Terjun (CH.3155) ↓ Jl.Gottlieb ↓ Jl.Bagan Jermal ↓ Sg.Babi	7.74	50 [63]	65 [82] (Culvert)	1 / 400 ~ 1 / 100	3.4 ~ 5.7	1,493 (Culvert) + 65 (Culvert) + 150 (channel)	Roads Jl.Gottlieb Width = 6.7m Jl.Bagan Jermal Width = 7.4m and River	4.45 [5.09]	- Almost all reaches of the diversion channel are culvert type and are constructed under the existing roads. Therefore, construction work schedule will depend on whether the traffic is successfully controlled. - There are some buildings to be relocated, on the both sides of the mouth of Sg. Babi.	- The optimum plan - The major problem will be maintenance of the culvert.
NO. 4	Sg.Air Terjun (CH.1684) ↓ Jl.Brook ↓ Jl.Cantonment	10.09	50 [78]	65 [102] (Culvert)	1 / 500 ~ 1 / 150	3.1 ~ 4.8	2,252 (Culvert)	Roads Jl.Brook Width = 8.8m Jl.Cantonment width = 9.1~16.8m	6.75 [9.30]	- There are some trees (13 big trees and 114 small trees) to be preserved, along the diversion route. All diversion channel is culvert type, and it will be difficult to excavate under the road taking into account of preservation of the trees	- The economical viability of the plan is not high. - The major problem will be preservation of existing trees along the road
NO. 5	Jl.Residensi ↓ Leboh Raya Peel ↓ Jl.Pangkor	10.62	50 [83]	65 [108] (Culvert)	1 / 750	2.7	2,180 (Culvert)	Roads Jl.Residensi Width = 10~16m Leboh Raya Peel Width = 10m Jl.Pangkor width = 10m	7.54 [10.92]	- There are some trees (82 big trees and 47 small trees) to be preserved, along the diversion route. The riverbed elevation is 3.1m, and the slope of diversion channel is gentle. Therefore, the design culvert will be too wide to be constructed under the road taking into account of preservation of the trees.	- The economical viability of the plan is the lowest. - The major problem will be preservation of existing trees along the road.

* The figures in the boxes indicate the discharge or construction cost, if 90% of the flood discharge of Sg. Air Terjun are diverted.

considered for the construction of retention ponds that would mitigate the flooding problems in the area. The retention ponds proposed could also be used for recreation as these ponds would be dry except during times of flood.

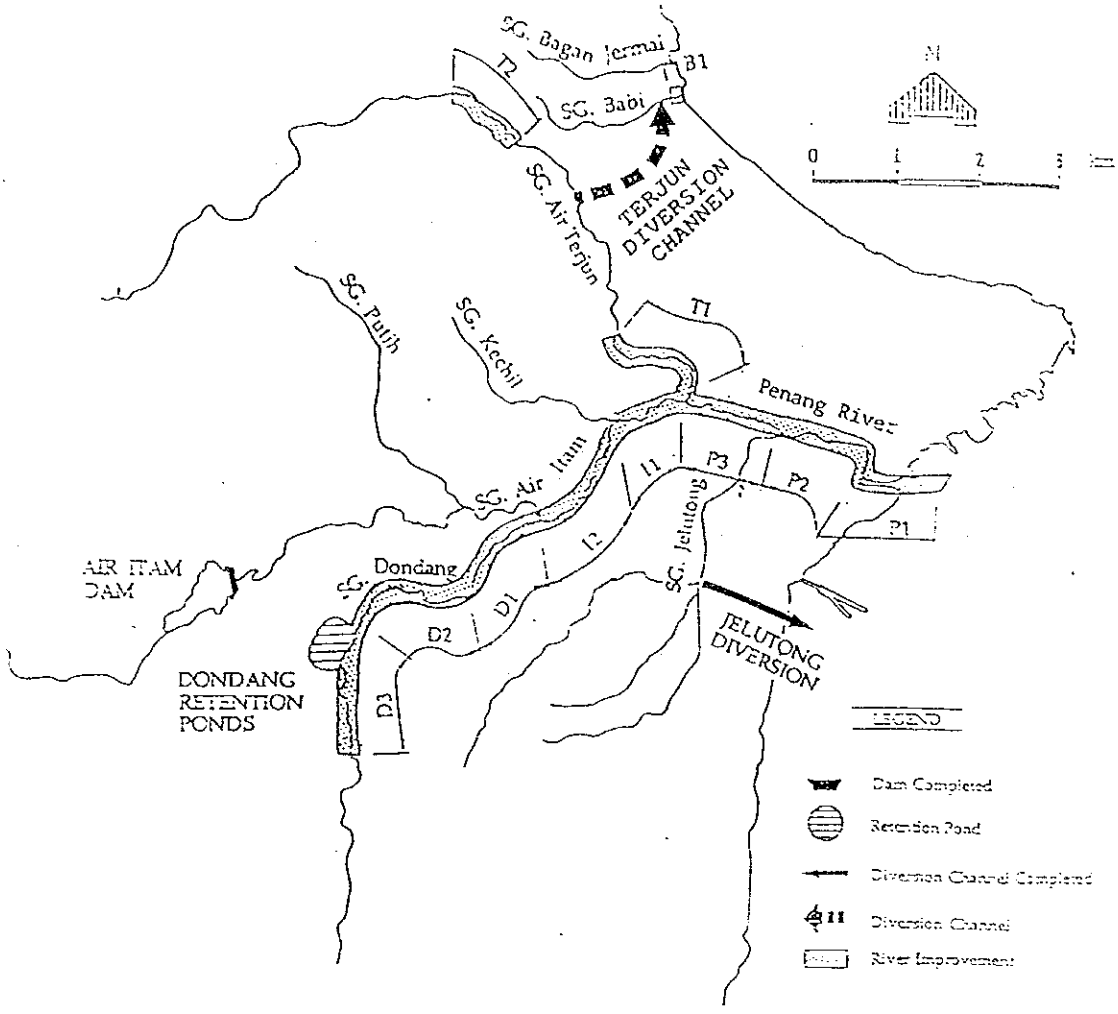
Two retention ponds for Urban Drainage near the estuary of Sungai Pinang were also considered for receiving the drainage waters from Georgetown. The water would be pumped out and discharged into the sea when necessary. These would alleviate the problem of flooding in certain lowlying areas of Georgetown because of hightide.

2.4 Flood Migration Proposals for the Sungai Pinang River Basin

After evaluating the different proposals and combinations of river diversion, retention ponds and river improvement. The optimum combination of flood mitigation facilities were chosen and these are indicated in Figure 2.2.

2.4.1 Retention Ponds of Sungai Pinang and its tributaries.

The retention ponds proposed can be grouped into two categories, namely, the inland retention ponds at the Sungai Dondang area and the retention ponds for



RIVER IMPROVEMENT

	CHAINAGE	DISTANCE (m)	RIVER BED WIDTH (m)	WIDTH (m)	WATER DEPTH (m)	DESIGN DISCHARGE (m3/s)
P1	-0.71 to 0.4	1,110	36.5	44.46	3.38	210
P2	0.4 to 1.9	1,502	36.5	40.45	3.36	210
P3	1.9 to 3.1	1,253	23.0	30.40	3.10	195
T1	0.0 to 1.396	1,590	5.1	11.30	2.50	45
T2	4.013 to 4.644	707	5.6	11.80	2.50	70
I1	0.0 to 3.1	1,080	18.2	25.40	3.00	160
I2	3.1 to 2.9	1,898	16.4	23.60	3.00	145
D1	0.0 to 1.547	1,315	7.8	14.00	2.50	60
D2	1.547 to 3.732	1,988	2.7	8.90	2.50	60
D3	3.732 to 6.094	1,999	4.0	10.20	2.50	45

Subject to be changed by results of the Feasibility Study

TERJUN DIVERSION CHANNEL

LENGTH about 1,700 m
SIZE C1: Open Channel 10.5(W) x 2.0(D) 1/400
C2: Box Culvert 6.0(W) x 2.3(H) 1/100
C3: Box Culvert 6.5(W) x 3.45(H) 1/400
DISCHARGE CAPACITY 65 m3/s

DONDANG RETENTION PONDS

	AREA (m2)	MAXIMUM CAPACITY (m3)	DEPTH (m)
A	30,500 + 5,900	128,500	4.0
B	32,700	108,150	3.6
C	21,200	75,850	4.0
E	18,700	51,060	3.0

Figure 2.2: Proposed Flood Mitigation Facilities For Master Plan of Penang River.

Source : JICA

Urban Drainage at the vicinity of the estuary of the Sungai Pinang.

(a) The Retention Ponds

The retention ponds along the Sungai Dondang are located in the proposed open spaces of the MPPP structure plan. As such there will be no problem of relocation of people. The design of the ponds are such thet they serve both recreational as well as flood control functions. During the period of heavy water flow, the water diverted into the ponds and then drained out at low water flow by weirs, sluice gates and flap gates. Three sets of ponds, A, B and C are proposed and these are indicated in Figures 2.3, 2.4 and 2.5. The ponds would normally be dry and would be landscaped and used for recreation. The total pond area would be about 9 hectares with a pond capacity of 782,500 m^3. The major construction work for the ponds would be excavation, revetment, sodding, backfill and landscape works. About 0.36 million m^3 of earth will be carried out and this earth would be used for coastal land reclamation works.

(b) Retention Ponds for Urban Drainage

Two retention ponds located at the estuary of Sungai Pinang are proposed (Fig 2.6). These are meant primarily for drainage of the Georgetown flood prone areas. The drainage systems have been labelled S-10 to

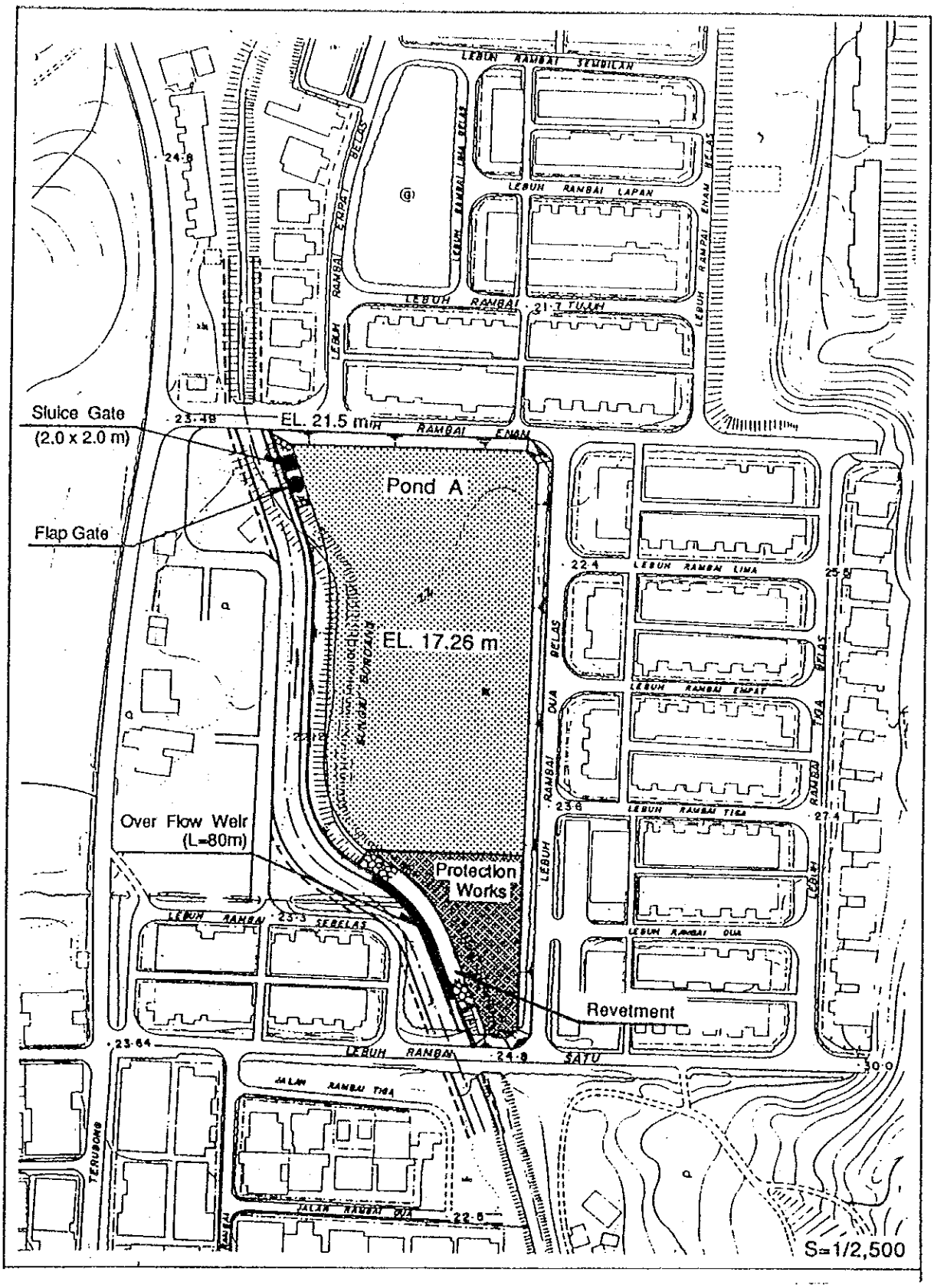


Figure 2.3: Plan Of Retention Pond A.
Source : JICA

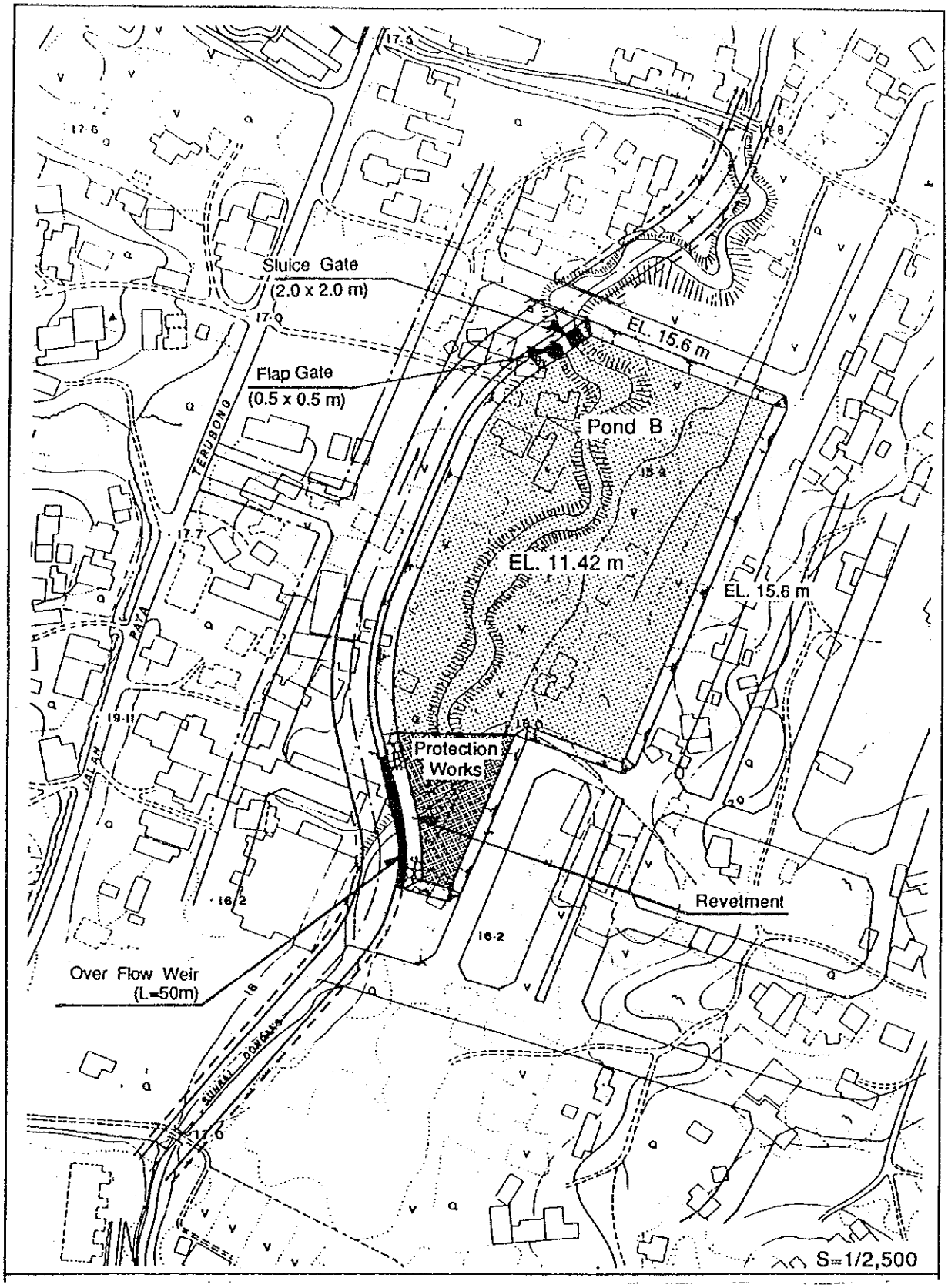


Figure 2.4: Plan Of Retention Pond B.
Source : JICA

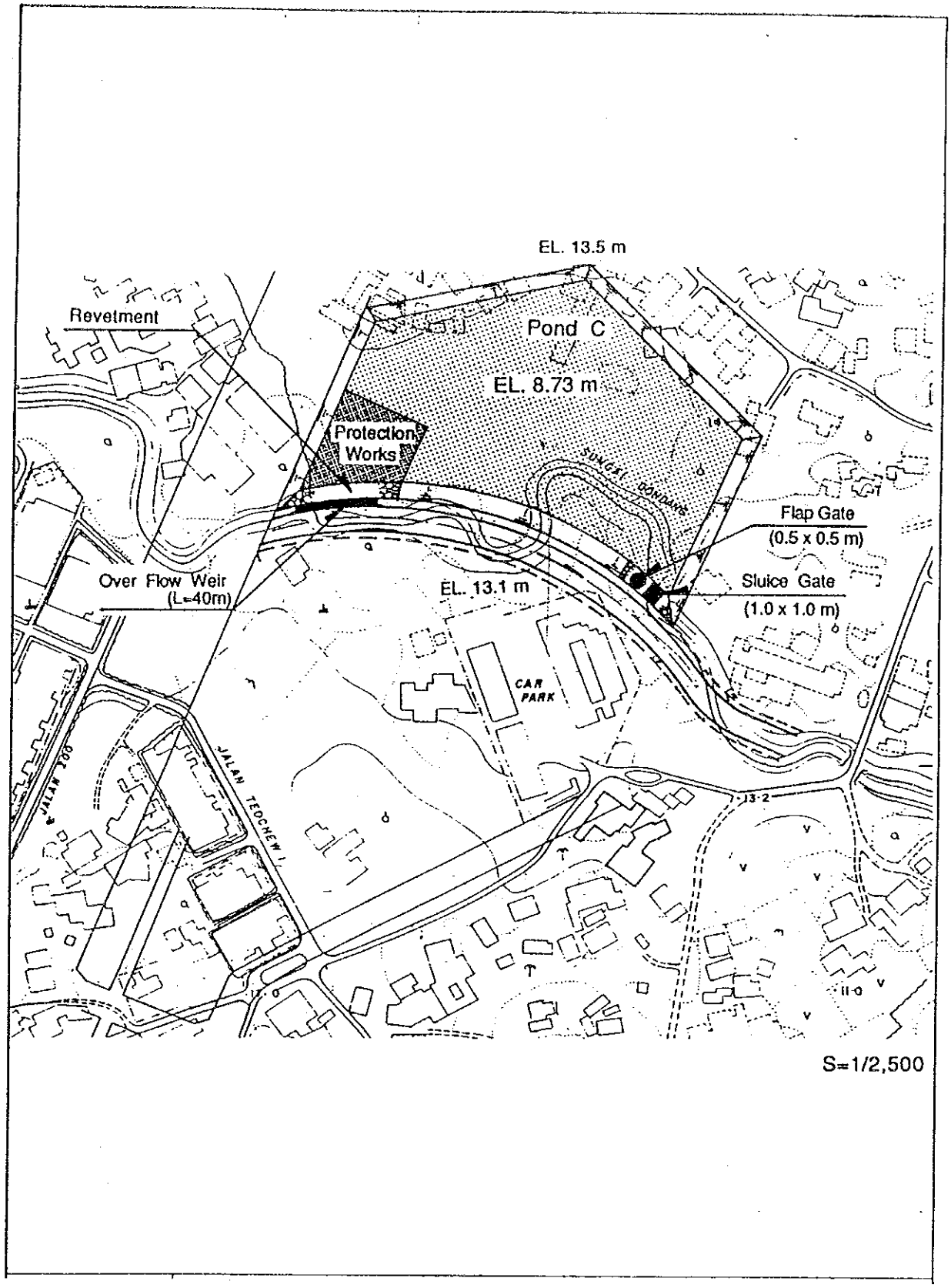


Figure 2.5: Plan Of Retention Pond C.
Source : JICA

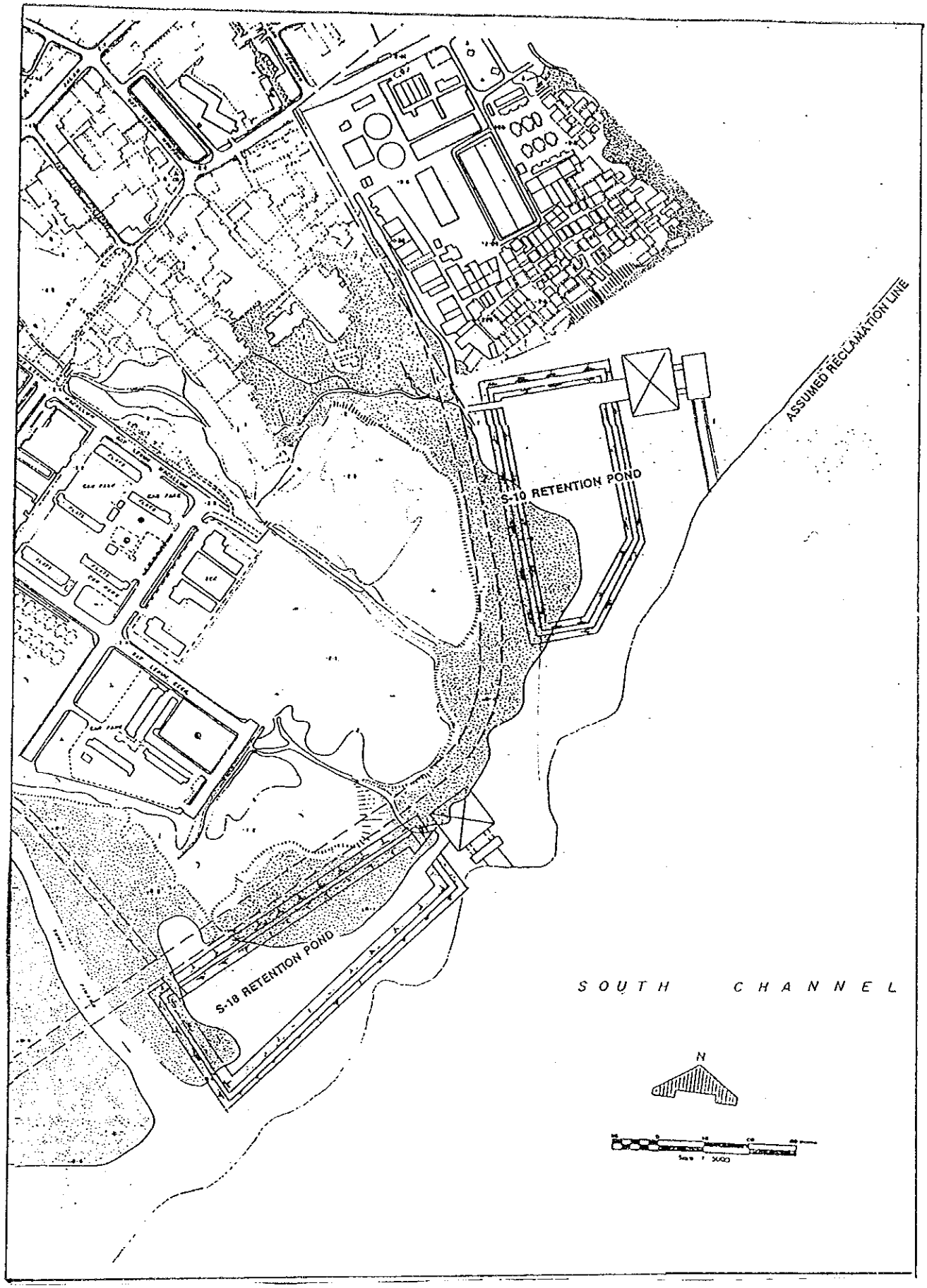


Figure 2.6: Retention Ponds For Urban Drainage.
Source : JICA

S-18. The drainage systems involve 4 kinds of construction work, namely (1) improvement of trunk drains, (2) construction of retention ponds, (3) construction of a drainage pumping station with the retention pond and (4) construction of outlet channels. The retention ponds S-10 and S-18 will be located in the proposed CDD-21 Coastal Reclamation Area. With coordination with the land reclamation project, less excavation would be required for the construction of the ponds.

2.4.2 Diversion Channel at Jalan Gottlieb and Jalan Bagan Jermal

The diversion of Sungai Terjun would be below the road of Jalan Gottlieb and Jalan Bagan Jermal. The structure would be a concrete rectangular box culvert (width = 5.5 meters, height = 3.2 meters) for 1273 meters below Jalan Gottlieb and Jalan Bagan Jermal. This will lead to a concrete open channel at sungai Babi for 195 meters (width = 6.3 meters, height = 2.76 meters). The major construction works are excavation, concreting for box culvert, open channel and drop structures, wet masonry at confluence, backfill, restoration of roads and landscape.

2.4.3 Sungai Pinang Improvement

The improvement works along the Sg. Pinang will involve Sungai Pinang and its tributaries, sungai Jelutong, Sungai Air Itam and Sungai Dondang. The total length of rivers involved will be 11.8 km.

The Sungai Pinang stretch will be 3.1 km long and the improvements planned would be :-

(a) Deepening and widening of the river by means of channel excavation of 275000 m^3

(b) Levee embankment of 15200 m^3

(c) Revetment of 38000 m^2 by wet masonry

(d) Jetty construction of 710 m long

(e) Renewal of 7 sets of bridges

(f) Replacement of public utilities

(g) Landscaping works

The Sungai Jelutong river improvement works of 2.015 km stretch from the estuary consist of :-

(a) Excavation of river channel

(b) Levee embankment

(c) Revetment

The Sungai Air Itam stretch of 2.9 km would be improved by :-

(a) Deepening and widening of river

(b) Levee embankment

(c) Revetment

(d) Renewal of 3 sets of bridges

The Sungai Dondang stretch of 3.792 km would involve :-

(a) Deepening and widening of river

(b) Revetment

2.5 Scope of Work of Preliminary EIA

The scope of the preliminary EIA study is confined to the evaluation of the proposed structural works of the Sungai Pinang and its tributaries as described in section 2.4.

3.0 ENVIRONMENTAL FEATURES OF THE STUDY SITES

3.1 Retention Ponds Study Sites

3.1.1 Retention Ponds

(a) Physico-Chemical Features

The retention ponds will be constructed at the middle reaches of Sg. Dondang which is one of the tributaries of Sg. Pinang. To date, a number of water quality surveys on Sg. Pinang and its tributaries have been conducted, the most recent ones being the water quality survey under the Penang Island Structure Plan Study (Lim et al., 1984) and the survey conducted by the JICA team as part of the Flood Control Study (JICA, 1990). The mean values of key water quality parameters at selected sampling stations of Sg. Pinang and its tributaries determined in these two studies are shown in Table 3.1. The location of the sampling stations are shown in Fig. 3.1.

As far as the water quality of Sg. Dondang is concerned, the data in Table 3.1 indicate that the river is polluted with organic matter especially at the places upstream of the proposed retention ponds study site. This is probably caused by the discharge from a rubber processing factory nearby.

In terms of the microbial quality of Sg. Dondang, the high counts of coliforms found in the Structure Plan Study (see Table 3.1) are confirmed in this study.

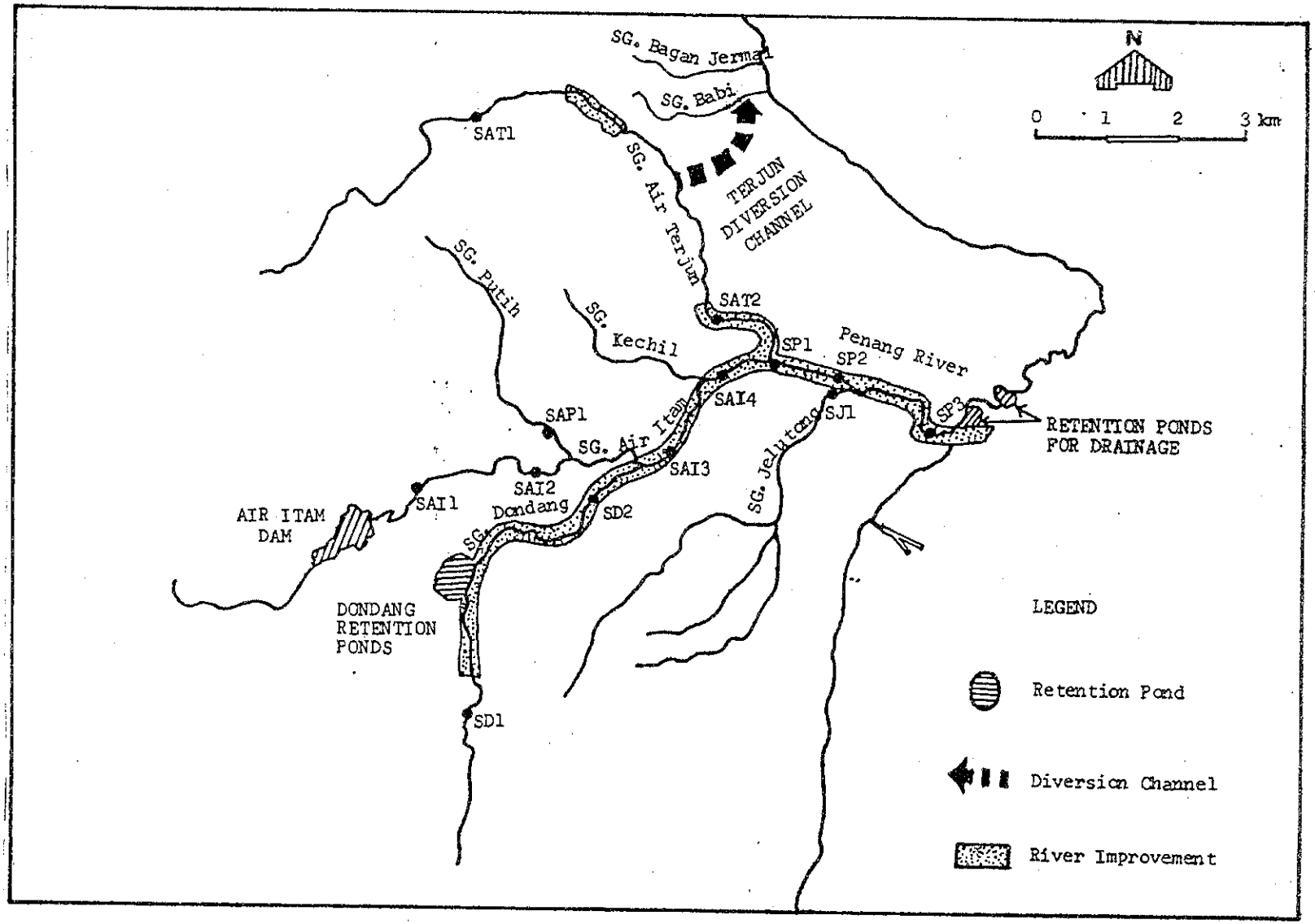


Figure 3.1: Water Sampling Stations Of Penang River And Its Tributaries.
Source : USM Environmental Research Group.

Table 3.1: Mean Values Of Water Quality Parameters At Selected Stations Of Sg. Pinang And Its Tributaries.

River	Sampling Station	Parameter										Reference
		DO (mg/l)	pH	BOD (mg/l)	COD (mg/l)	SS (mg/l)	TS (mg/l)	Ammoniacal N (mgN/l)	Oxidised N (mgN/l)	TC (MPN/ (100ml)	FC (MPN/ (100ml)	
Sg. Pinang	SP3	2.8	7.0	37	123	497	725	4.51	0.52	2.3×10^6	8.0×10^5	Lim et al., 1984
		2.4	6.8	28	49	27	318	11.08	-	-	-	JICA, 1990
Sg. Pinang	SP2	3.2	6.9	16	47	146	241	4.37	0.95	1.3×10^6	6.1×10^5	Lim et al., 1984
Sg. Pinang	SP1	3.9	7.0	17	44	196	324	4.04	1.00	7.4×10^5	3.8×10^5	Lim et al., 1984
		4.4	6.9	17	29	31	170	3.4	-	-	-	JICA, 1990
Sg. Air Itam	SAI3	7.2	7.0	5	80	1137	1630	0.20	0.80	$>2.4 \times 10^7$	7.5×10^5	Lim et al., 1984
		1.8	7.0	33	59	37	255	3.2	-	-	-	JICA, 1990
Sg. Air Terjun	SAT2	7.1	7.0	1	16	36	120	2.16	1.13	1.2×10^5	3.9×10^4	Lim et al., 1984
		6.8	6.6	1.8	4	5	63	0.5	-	-	-	JICA, 1990
Sg. Dondang	SD2	5.2	6.9	7	51	314	437	2.67	0.73	6.5×10^5	1.8×10^5	Lim et al., 1984
Sg. Dondang	SD1	2.5	7.1	53	180	232	368	4.04	0.27	1.1×10^7	3.2×10^5	Lim et al., 1984
Sg. Jelutong	SJ1	1.9	7.0	68	121	91	280	12.87	0.70	9.8×10^6	3.0×10^6	Lim et al., 1984
		2.1	7.2	38	70	15	129	14.1	-	-	-	JICA, 1990

Table 3.2 shows the total coliform (TC), faecal coliform (FC), faecal streptococcus (FS) counts and the ratio of FC to FS at stations SD1 and SD2 located upstream and downstream of the inland retention ponds respectively (see Fig. 3.1). At both stations, the values of the FC/FS ratios are greater than 4.0 indicating that the river is contaminated with sewage of human origin. The relatively higher counts of FS detected at stations SD1 and SD2 also suggest that sewage of animal origin such as pig wastes are polluting the river. The poor water quality of Sg. Dondang has rendered it unsuitable for any meaningful beneficial usage.

(b) Biological Features

The river tributary flowing through the retention ponds study site is the Sg. Dondang. Here the Dondang river flows through both established as well as new developing housing estates.

The proposed Retention Pond A is located in the established Taman Rambai housing garden. The site consists of a large grass covered flat land used presently as a play field by the local residents. The Sg. Dondang, originating from the Paya Terubong and Bukit Meriyam Hills, enters the study site from the south and drains northwards along the western fringe of the play field. Its channel has clearly been deepened

Table 3.2: Total Coliform (TC), Faecal Coliform (FC), Faecal Streptococcus (FS) and Ratios of FC/FS at Selected Stations of Sungai Pinang and Its Tributaries

	TC	FC	FS	FC/FS
SD1*	1.10×10^6	1.22×10^6	2.36×10^5	5.17
SD2	1.07×10^6	1.47×10^6	1.15×10^5	12.78
SAP1	4.37×10^5	3.85×10^5	1.51×10^4	25.50
SAT1	5.08×10^4	3.52×10^4	1.00×10^3	35.2
SAT2	4.40×10^4	3.70×10^4	5.87×10^3	6.30
SAI1	2.26×10^5	1.53×10^5	1.70×10^4	9.00
SAI2	1.25×10^6	3.94×10^5	7.18×10^4	5.49
SAI3	1.19×10^6	8.80×10^6	9.15×10^4	9.62
SAI4	2.17×10^6	1.06×10^6	5.98×10^4	17.73
SP1	1.22×10^5	6.22×10^5	7.46×10^4	8.34
SP2	2.60×10^6	1.44×10^6	5.71×10^4	25.22
SP3	2.72×10^6	1.95×10^6	2.39×10^4	81.59
SJ1	1.22×10^7	7.04×10^6	7.61×10^4	92.51

*Note: SD = Sungai Dondang; SAP = Sungai Air Putih; SAT = Sungai Air Terjun; SAI = Sungai Air Itam; SP = Sungai Pinang and SJ = Sungai Jelutong.

in the recent past. The river bed is now located at a level lower than that of the play field. At certain places, the relatively steep river banks are reinforced with concrete and rocks. Elsewhere, the river banks are covered by low riparian vegetation consisting predominantly of the common grasses, *Imperata cylindrica*, *Axonopus compressus*, *Cynodon dactylum*, other weeds like *Commelina nudiflora*, arrow-head *Sagittaria* sp., creeper *Mikania cordata*, *Digitaria longiflora*, *Centella asiatica* and the yam plant *Colocasia esculentus* .

The proposed Retention Ponds B and C are located further downstream of the Sg. Dondang. The former is located within the Paya Terubong housing estate and the latter further downstream in the Halaman Zoo area.

The general limnology of the Sg. Dondang is typical of most lowland rivers or streams found in peninsula Malaysia (Ho & Furtado, 1982).

A denser and relatively more diverse riparian vegetation is found along this part of the Dondang. Besides the common plant species already mentioned above, taller plants such as the palm *Caryota* sp., shrubs like *Draceana* sp., *Urena lobata*, banana *Musa* sp., tapioca *Manihot* sp. and bamboo plants *Bambosa* sp. are found growing in scattered areas along the river banks.

On the whole, the water level in the Sg. Dondang is generally low (< 50 cm) on non-rainy days. The flow is however continuous and seldom turbulent with Froude numbers generally less than unity. The river bed is predominantly made up of sand and silt. The river in the vicinity of the proposed Retention Pond B site smells of organic decay and its water appears murky at times owing to periodic waste water discharge from further upstream.

Owing to poor river competence and increased building construction activities in the area, ubiquitous deposition of the eroded sediments occurs, which reduces channel capacity, increases flood potential and at the same time reduces niche diversity too.

The scarcity of dense canopy cover over water in most areas causes the Sg. Dondang to be exposed to direct sunlight. Water temperature thus becomes high, with values ranging between 25°C to 32°C. Partial shade is generally provided by mature bamboo plants found growing in scattered areas on the river banks.

The algal flora in the Sg. Dondang is limited in number, diversity and reproductive potential. This is due mainly to the ubiquitous presence of high silt-sand load in the water which exerts considerable influence in moderating the full growth potential of algae.

Another notable reason is the shortage of algal biotopes in the river. The absence of large stones or boulders in the rivers, for example, automatically precludes the development of epilithic algal communities. The unstable bottom substrate also excludes the development of any stable epipelic algal communities. The submerged stems or leaves of the riparian plants do however harbour a few epiphytic algal species. Algal distribution is often patchy and at times ephemeral. Overall, the common species found are those belonging to four main taxa viz. Bacillariophyta, Chlorophyta, Cyanophyta and Euglenophyta. The ubiquitous species include those of *Anabaena, Oscillatoria, Closterium, Navicula, Synedra, Pinnularia, Chlorella, Spirogyra, Stigeoclonium Euglena* and others. The most common members in most algal communities are *Spirogyra* and *Oscillatoria*. Organic pollution favours the development of the cyanophytes and euglenophytes.

Like the algae, the river fish fauna is extremely limited in numbers and diversity. Only the hardy guppy *Lebistes reticulatus* has been encountered in this preliminary study. The incidence of high silt-sand load, and possibly of other pollutants as well, are threatening the survival of the ichthyofauna in the Sg. Dondang.

The remaining vertebrate fauna is represented only by the ubiquitous anurans like *Bufo asper*, *Bufo malaniosticta* and *Rana erythreae*.

As regards the invertebrate fauna, the absence of fast erosive currents precludes the existence of swift-current adapted species. This therefore reduces the number of biotopes available in the rivers. Species that are present are those which usually inhabit a "depositing" substrate. Very often, the proliferation of the obviously more tolerant species is hampered by adverse conditions such as high suspended silt-load and unstable river bed configuration. The absence of slope and shade in most places (generally correlated with reduction of niche diversity) and river bank concretion along certain stretches of the river are also responsible determinants.

The macroorganisms that have been encountered in the water samples include the ciliates, notably *Paramecium* spp., *Tetrahymena* sp., etc., the peritrichs, *Carchesium* sp., *Vorticella* spp., other protozoans, *Arcella* sp. and *Defflugia* sp.. No copepods were encountered in the snap samples taken so far.

The benthic invertebrates are dominated by the oligochaete worm *Tubifex* sp.. In the less organically contaminated areas, odonate nymphs of *Paragomphus* sp. *Macromia* sp. have been seen.

The generally low calcium concentration in the river water coupled with the scarcity of algal food supply in most parts of the river limit the distribution and development of the snail populations. The common snail species found include the prosobranchs *Bellamya* sp., *Pila scutata*, and the pulmonate *Lymnaea* sp. and *Achatina* sp..

Gerrids are found in the backwater regions. Most of the other groups of animals are poorly represented or are absent altogether.

The Sg. Dondang from its confluence with Sg. Air Itam till beyond the Batu Lanchang Lane has relatively more interesting species of birds when compared with the common species of birds found on the lower reaches of the river system under study.

The common birds inhabiting the wayside trees and overgrown vegetations include the common and Crested Mynas, Philippine Glossy Starling, Common Tailorbird, Eurasian Treesparrow, Scarlet-backed Flowerpecker, House Crow, Brown-throated Sunbird, Olive-backed Sunbird, Yellow-vented Bulbul, Black-naped Oriole, Spotted Dove and the migratory Brown Shrike. Here again the Common Sandpiper has been seen feeding on the banks of the river. The Pied Fantail is exclusively found in the bamboo groves that line most parts of the river banks. The Common Iora not encountered elsewhere

down river, has also been seen along this river. Another common bird, but not encountered further downstream except at the coastal landfill area, is the Yellow-bellied Prinia which inhabits the reeds and overgrown area along the banks. Small flocks of the White-headed Munia and the Baya Weaver have been observed feeding on the grass seeds along the river bank. The Baya Weaver is not often seen in George Town. The White-throated Kingfisher and the migrant Black-capped Kingfisher have also been sighted.

Another interesting bird seen is a migrant, the Japanese Sparrowhawk. These birds use the wayside trees and bamboo groves as a perch from which to scoop upon their prey. They have been seen gliding over the river. The White-bellied Sea-eagle has also been seen flying over the river. It might have been using the river to hunt, on its way to and from the sea to its roosting site. The open area in some sections of the river allowed the Pacific Swallow to hawk for insects. The Blue-tailed Bee-eater also hawking for insects over the river. The bee-eater not found in open areas along the rivers further downstream.

(c) Socio-Economic Activities Along Sg. Dondang

Population

The population density map (Figure 3.2) shows that the upper reaches of Sg. Dondang has a population density of 12 - 24 persons per ha. This is based on

the 1980 population census, the latest available figure.

It is expected that the current densities would have changed quite significantly in the upper reaches of Sungei Dondang. This is because there have been major residential/commercial developments in the Thean Teik and Paya Terubong area. In fact, this area has been earmarked as a new township which is expected to have a population 8,000 - 10,000 in the year 1995.

Landuse

The landuse found along the upper reaches of Sg. Dondang is residential (Figure 3.3). Although the upper reaches proper is the Penang Hill watershed area. At this point in Paya Terubong, the river passes through new housing schemes such as at Taman Terubong Jaya, Bandar Sun Moon and Taman Rambai. Sited along this point is the Lee Rubber processing factory which is an important source of water pollution in Sg. Dondang. Further downstream after Taman Rambai a new housing scheme is under construction. The Taman Desa Pertama will provide about 452 units of housing. The river then passes through residential areas at Halaman Zoo and the adjoining areas is expected to be developed into more residential units. At Thean Teik the Sg. Dondang would be affected by the proposed new town of Air Itam. The new town project proposed by Farlim when completed would provide about 8,000 units of houses.

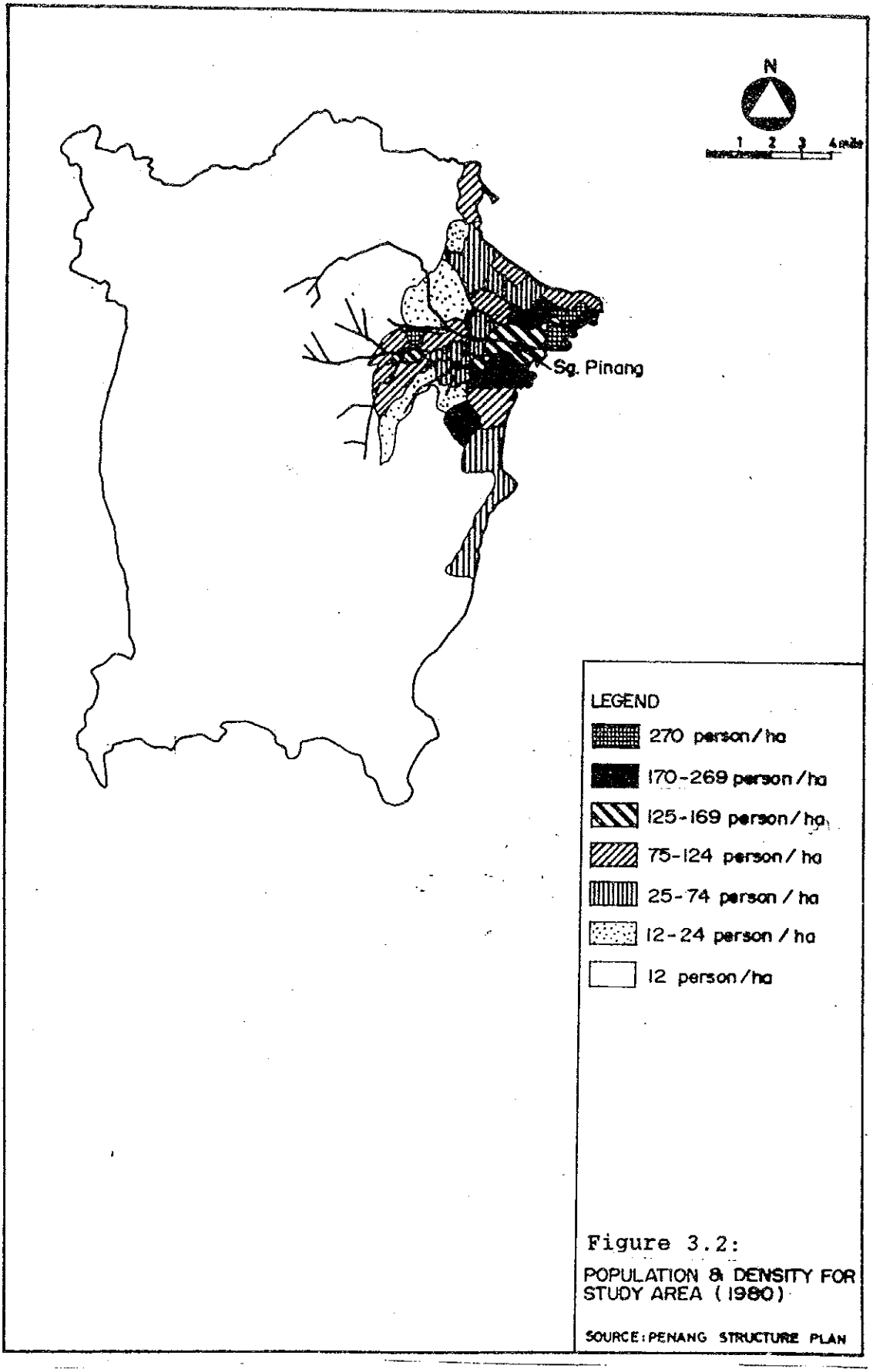


Figure 3.2:
POPULATION & DENSITY FOR STUDY AREA (1980)

SOURCE: PENANG STRUCTURE PLAN

The housing development is a mixture of flats, terrace and semi-detached house units. The new town would be expected to provide housing for 50,000 - 60,000 people in 1995. In addition, along the Paya Terubong road, several large housing schemes of double and single storey terrace houses, semi-detached houses and flats have been approved for construction. Along the Thean Teik ring road more housing schemes are coming up. These development would further increase the population of the area to about 70,000 - 80,000 people in the year 1995.

The present residential development in the area has affected the drainage system of the area. The Sg Dondang channel and its flow have been affected. Further intensive development would scar the river channels as more drains are constructed in the area. The effectiveness of the retention ponds to control the flood water would be reduced with the altered river system.

Further downstream, Sg. Dondang passes through the Chinese Cemetery along Batu Lanchang before it meets the main river, Sg. Air Itam.

The Sg. Air Itam at this point flows through traditional housing and modern residential areas and finally the institutional areas such as schools and

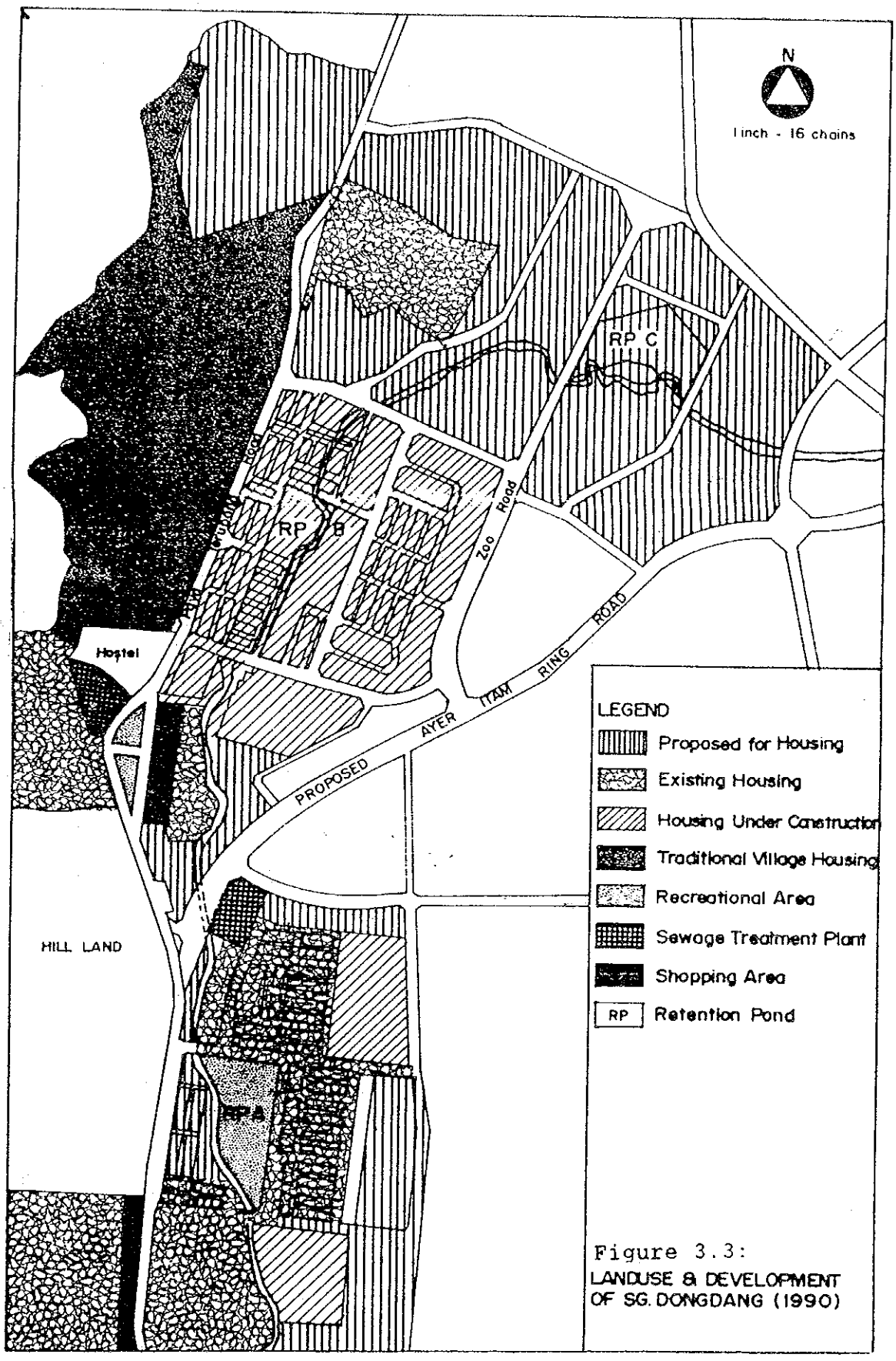


Figure 3.3:
LANDUSE & DEVELOPMENT OF SG. DONGDANG (1990)

government housing quarters before it joins up with Sg. Air Terjun.

3.1.2 Retention Ponds for Urban Drainage

(a) Physico-Chemical Features

The coastal retention ponds will be constructed on the reclaimed areas near the Sungai Pinang estuary. The ponds will be receiving sullage water and surface runoff from the Georgetown areas, both of which are known to have high BOD loads.

(b) Biological Features

The proposed coastal retention ponds S-10 and S-18 are to be built on the mudflat just north of the mouth of Sg. Pinang estuary. Pond S-18 will be located nearer to the river mouth than Pond S-10. Both ponds will eventually located on the seaward side of the proposed but yet to be built new coastal road.

Except for the occurrence of scattered thin patches of epipelic green and blue-green algal mats on the more exposed muddy area nearer shore, there is presently little sign of other plant life on the accreted mudflat itself. At low tide, the area is seen to be overstrewn with domestic garbage and other solid wastes. These have either been flushed out by the river or transpoted from elsewhere and deposited by the preceeding high tide.

Like most mudflats in Malaysia, the resident fauna is dominated by sedentary tube-dwelling polychaete worms like *Sabella* sp., *Glycera* sp., and *Diopatra* sp.; molluscs like *Anadara granosa*, *Cerithidea quadrata*, *Cerithidea cingulata*, *Nassarius tersites*, *Dorsinia* sp.; crabs like *Uca* spp.; and mudskippers notably *Periophthalmus* sp.. Marine animal density increases generally with increasing distance from the river mouth.

It is noteworthy that some aquaculture activities are presently on going in the nearby coastal waters south of the S-10 and S-18 pond sites. These consist of grow-out cage-culture of fishes such as the grouper *Epinephalus tauvina*, the siakap *Lates calcarifer*, the snapper *Lutianus malabaricus*, and the common mud crab *Scylla serrata*.

The birds feeding on the banks of the mouth of the Sungei Pinang and the mudflats of the proposed coastal Retention Ponds sites S-10 and S-18 are mainly migrant birds. These include the waders - the Common Sandpiper, Rufous-necked Stint, Mongolian Plover, Lesser Golden Plover and the Common Greenshank. Of these the Rufous-necked Stint and Common Sandpiper are the most numerous. The resident Little Heron is ever present as could be expected in any mudflats in Peninsular Malaysia. Two species of kingfishers are also feeding on the mudflats, the resident Collared

Kingfisher and the migrant Black-capped Kingfisher. The Black-capped Kingfisher is not a common bird in George Town due to extensive development. Two species of birds of prey, the scavenging Brahminy Kite and the predatory White-bellied Sea-eagle have been seen scavenging or hunting over the mudflats. Though the sea-eagle hunts over the sea it can also be found over coastal mudflats. Three species of starlings, the Common Myna, Crested Myna and the Jungle Myna have been feeding on the drier parts of the mudflats and on the edge of the shoreline along the mudflats. The Jungle Myna though common in rural Penang, are not that common in urban areas of Penang. Two species of crows, the House Crow and the Large-billed Crow also use the same habitant as the mynas for feeding. The Eurasian Tree-Sparrows also carrying out their feeding activity along the shoreline at the mudflats. The Little Terns, mainly a coastal seabird, can be seen hunting for food over sections of the mudflats covered by a few centimeters of seawater.

Land birds that were inhabiting the overgrown reclaimed area at the mudflats include the migrants Great Reed Warbler and the Brown Shrike. The resident birds are the Black-naped Oriole, Yellow-vented Bulbul, Philippine Glossy Starling, Common Myna, Crested Myna, Jungle Myna, House Crow, Large-billed Crow, Common Tailorbird, White-headed Munia, Scaly-breasted Myna,

Spotted Dove, Yellow-bellied Prinia and the Olive-backed Sunbird. A flock of Pink-necked Pigeons have also been observed in this area. This is rather unusual as they are more of the inhabitants of wooded areas rather than sparsely vegetated urban areas. The Pacific Swallow and the migrant Barn Swallow have been seen hawking for insects between the reclaimed area and the mudflats.

The Black-capped Kingfisher had only been found in the Sungei Pinang estuary and mudflats of the study area. The soggy side tables on the river bank supported two species of rails, the White-breasted Waterhen and the Watercock. The Watercock is a very uncommon bird and there are very few reported sightings even for Penang Island let alone George Town.

The soggy side tables on the banks of the river here provide a good habitat for the two species of rails, the Pied Fantail and the Kingfishers. Efforts must be made to maintain the side tables while deepening and widening the river. The fairly wide side tables also provided a good habitant for the munias and weavers.

(c) Socio-Economic Features

Population

From the density map of 1980 the population around the proposed rentention pond area is about 124

persons per ha. This is attributed to the dense squatter settlements located not far from the mouth of Sungai Pinang and the housing flats at Leboh Cecil.

Landuse

The landuse of the area is mainly mudflats at the mouth of Sungai Pinang. Further inland up to the Sungai Pinang Bridge are the warehouses, workshops and industrial establishments such as Ban Hin Lee Oil Co. Ltd, Lam Hong Traders, Pekyear Foundry, Sin Chuan Marketing Company Ltd. and Sin Tatt Frozen Foodstuff and Sin Tatt Gases Co. Ltd. Adjacent to these establishments is the squatters settlement. There are several wooden jetties located on the river mouth opposite the squatters settlement. These jetties are used by the local fishermen residing in the mainly Chinese squatter area. Along the foreshore area there are 9 cage culture operators rearing Siakap, Jenahak and Kerapu. Further south at Jelutong there are 8 cage culture operators. The cage culture is carried out on a large scale ranging between 50-200 cages. The mudflats area is to be reclaimed and there will be an expected change in landuse pattern in the near future.

3.2 Diversion Channel at Jalan Gottlieb and Jalan Bagan Jermal

(a) Physico-Chemical Features

The proposed diversion channel will divert a major portion of the flow of Sg. Air Terjun during storms. Under normal condition, there will be no flow from Sg. Air Terjun into the diversion channel.

Among all the tributaries of Sungai Pinang, Sungai Air Terjun is still the cleanest (see Table 3.1). However, in terms of the microbial quality, the data indicate that the river is contaminated with sewage and sullage water probably discharged from residential houses in the vicinity. The lower part of Sg. Air Terjun is also contaminated with animal wastes (see Appendix B) as reflected by low FC/FS ratio in some samples.

(b) Biological Features

The proposed river diversion involves the Sungai Air Terjun. This is the cleanest of all tributaries within the Sungai Pinang river system. This river has its origin from the forested hills of the Waterfalls Catchment Area. It flows through the Penang Botanic Garden and continues in a south-easterly direction to finally join the Sungai Air Itam near the Jalan Air Itam - Jalan Langkawi junction. While the upper reaches of Sg. Air Terjun drain a large predominantly

undisturbed forest reserve area, the middle reaches of river drain a relatively sparsely populated flat residential area. Hence the cleaner and clearer nature of the river water.

In and around the vicinity of the proposed river diversion point (into Gottlieb Road), the river meanders through a relatively flat area. Water depth seldom exceeds 50 cm on a normal dry day. The river bed is sandy with a riparian vegetation that resembles that found in lower reaches of the Sg. Dondang. The additional species found here include the sedges such as *Cyperus* spp., *Scirpus mucronata*, *Scleria bancana*, the hastate-leaved pond weed *Monochoria hastata*, and the common *Hydrilla verticillata*. Exposure to insolation is moderate in most places owing to the presence of more established riparian vegetation. Partial shading is provided by the long extended branches of tall wayside trees like bamboos *Bambusa* sp., coconut palms, the Angsana *Pterocarpus indicus*, mahogany *Swietania macrophylla* and the Rain Tree *Enterolobium saman*.

The river algal species composition found here differs slightly from that found in the Sg. Dondang. Here the chlorophytes predominate the cyanophytes in numbers. The desmids, in particular *Cosmarium* spp., *Scenedesmus* spp. and *Clostridium* spp., are found in greater abundance in the Sg. Air Terjun. This is

attributable to the cleaner water found here.

The fish fauna includes species of *Puntius* and the common guppy. The snail populations are generally poor in number. The aquatic insects are represented ubiquitously by the odonate nymphs of *Paragomphus*, *Macromia*.

The Sg. Air Terjun from its confluence with Sg. Air Itam to the Ross Road Bridge does not support any bird life except for the Common Sandpiper. The river wayside trees and bushes only attracted the Common Tailorbird, Common Myna and the House Crow.

Due to the better quality of the water and denser vegetated banks of Sungei Air Terjun from the Ross Road Bridge to the Botanical Gardens, the number of species of birds found here is greater. In the grass, bushes and wayside trees on the banks of the river are the Common Tailorbird, Common Myna, Crested Myna, Yellow-vented Bulbul, Black-naped Oriole, Scarlet-backed Flowerpecker, Brown-throated Sunbird, Olive-backed Sunbird, Philippine Glossy Starling and House Crow. The Barn Swallow and the Pacific Swallow have also been seen over the river. The uncommon Common Kingfisher has been sighted near the Ross Road Bridge and at the Western Road Cemetery. This kingfisher has been found only on this stretch of the river and it is extremely difficult to see them in other parts of George Town as

most of the other rivers flowing through George Town are highly polluted. Secondly the river current in most parts of this river is fairly slow which allows the kingfisher to dive into the river to fish. Fast river current will affect the kingfisher's ability to fish for food.

(c) Socio-Economic Activities Around Sungai Air Terjun

Population

Also based on the population density map of 1980 census (Figure 3.2) prepared by the Penang Structure Plan the population density in the upper reaches of Sungei Air Terjum has values ranging between 12 - 24 persons per ha. The population density would change with the expected Penang Hill development project. The lower reaches which have pass through residential areas have slightly higher values. The density is expected to change in the upper reaches with the proposed development of Penang Hill.

Landuse

The upper reaches of Sg. Air Terjun pass through the important Penang Hill recreational and water catchment area. The middle reaches the river pass through high class residential areas, the race course and finally through schools and more residential areas before reaching its confluence with Sg. Air Itam. The landuse around the middle and lower reaches is under no

development pressure.

At the upper reaches of Sg. Dondang in Penang Hill, a major proposal to develop the area into a leisure and recreational area is envisaged by the state government. A memorandum of Understanding between the State of Penang and Berjaya Corporation, the private developer was signed on September 3, 1990. The project costing about $460 million Malaysian ringgit will take about 10 years to complete. The project involves two areas of development, namely the upland and lowland development. The upland development would consist of large-scale construction of international class hotels, condominiums, resort village, recreational theme park, a shopping complex, chalets and a golf course. The development is proposed to cover the existing built areas of Penang Hill as well as new land areas around it. It is likely that the proposed project would cause soil erosion, siltation of streams and exacerbate the existing flood situation if these development do not pay any attention to the effects of soil erosion and river siltation. The implications of this project on the mitigation measures for flood control would need to be studied further. The highland development would result in severe environmental impacts in the drainage within the area. The lowland development is not likely to have much of an impact on the flood situation in Penang.

Landuse in Jalan Gottlieb and Jalan Bagan Jermal

The landuse of the area is shown in Figure 3.4 below. As can be seen, the Jalan Gottlieb road section contains most of the commercial activities - a hotel, three rows of shophouses, and a major hawker pitch. At the junction of Western Road and Jalan Gottlieb, there is an Indian temple which has been in existence for a long time. The Penang Chinese Girls' High School is also located along this stretch. Taman Gottlieb, a residential scheme is also located near to the junction from Air Rajah Road. A few of the bungalows along this road have been converted to showrooms and for commercial activities.

This area is under great development pressure, especially the Gottlieb road section. Just opposite the Penang Chinese Girls' High School, two blocks of 4 storey shophouses have been built over the past three years. Hawking activities have increased tremendously along Jalan Gottlieb, and remains one of the principal activities at night.

Along Jalan Bagan Jermal, the landuse is more residential and institutional. Except for the Wayton flats, the flats next to the Penang Chinese Girls' Union building, and the Sunrise towers at Pesiaran Gurney, most of the residential buildings are single storey bungalows. The change in density zoning was

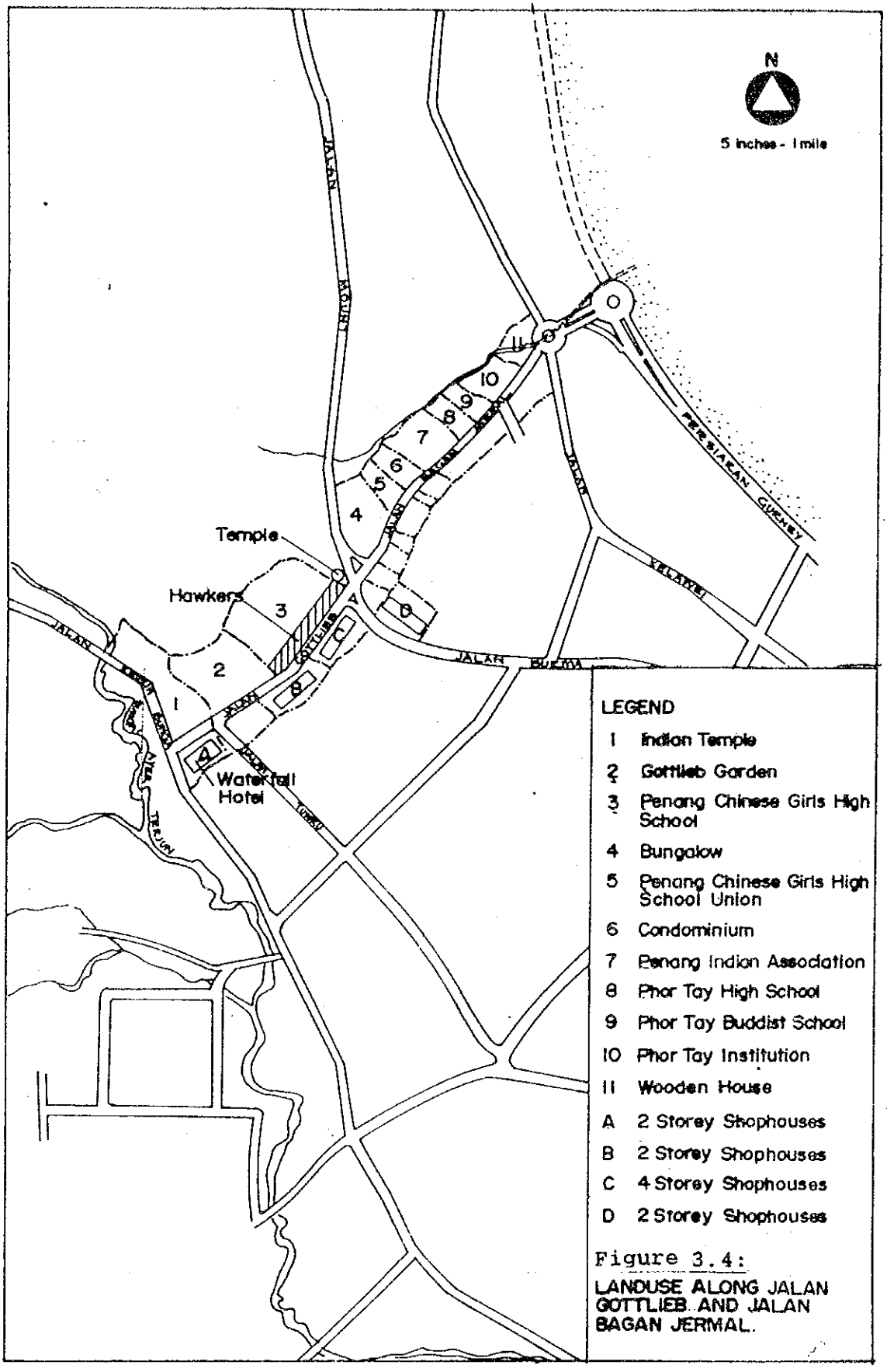


Figure 3.4:
LANDUSE ALONG JALAN GOTTLIEB AND JALAN BAGAN JERMAL.

started with the block of flats next to the Penang Chinese Girls' Union building in the early 1980s. Prior to that, the MPPP did not give any approval for constructing even a two storey extension. According to the New Straits Times, August 31, 1990 issue, the area is regarded as an exclusive residential location.

The major institutional buildings along this road are: the St Nicholas School For The Visually Handicaped, the Penang Indian Association, the Phor Thay school, and the Penang Chinese Girls' Union.

Traffic

The 1983 study of traffic volume along this stretch of road shows that the capacities along Jalan Mt Erskine and Green Lane have already exceeded their capacities. Two other studies were carried out in 1987 and 1989.

The 1983 MPPP Structure Plan study did not record information for Jalan Gottlieb, but had information on Jalan Mount Erskine and Jalan Green Lane. The traffic volumes for both these streets can be taken as proxies for the traffic along Jalan Gottlieb and Jalan Bagan Jermal.

In 1983, the volume of the Mt Erskine road was 17,900 PCU/16 hr day. A PCU is passenger car unit - a unit of measurement for traffic, i.e. motorcycles,

lorries, etc are converted into PCUs. This volume was higher than the capacity of the road which was estimated by MPPP to be 16,700 PCU/16 hr day (MPPP, 1985: 164-5). The same overloading was also seen along Green Lane - with a capacity of 18,300 PCUs, but registering a traffic volume of 23,000 PCUs.

In terms of which parts of the day/night the traffic is heaviest, the 1989 study of the traffic junction at Jalan Mt Erskine/ Gottlieb is indicative. Table 3.3 shows the results of a traffic survey carried out by the JICA traffic study team which is currently on assignment in MPPP.

As can be seen, the largest traffic volumes occur on all the straight through traffic. On the turn traffic, the largest occur from Jalan Mt Erskine turning right into Jalan Gottlieb, and vice versa (i.e. Jalan Gottlieb turning left into Jalan Mt Erskine).

The figures from Table 3.3 shows that Jalan Gottlieb is among the busiest stretches of the road junctions. And it occurs between 8-9am, 5-6pm and 6-7pm periods. This is to be expected. The periods where the office and school traffic overlap show the heaviest traffic on these roads.

Table 3.4 shows that data from another traffic survey by JICA carried out in January 1989. As can be seen, the same traffic patterns occur as in 1986

Table 3.3: Traffic Survey at Jalan Burma/Gottlieb Junction, 1986

Date: 16 September 1986

Time / Junction	7-8am	8-9am	12-1pm	1-2pm	4-5pm	5-6pm	6-7pm	Total
1	166	200	275	283	314	394	521	2186
2	122	86	123	155	74	144	143	847
3	437	449	254	252	295	280	386	2353
4	466	308	196	137	130	212	279	1728
5	215	152	143	273	73	93	163	1112
6	324	430	395	441	294	274	459	2617
7	167	241	226	272	256	293	332	1787
8	35	47	37	49	19	64	66	317
9	394	285	328	315	300	300	385	2995
10	137	115	95	131	123	93	129	923
11								
12	139	74	163	190	82	102	180	930

Source: JICA-MPPP Traffic Survey counts

Table 3.4: Traffic Survey at Jalan Burma/ Gottlieb Junction, 1989

Directions	7am-8am	8am-9am	12pm-1pm	1pm-2pm	4pm-5pm	5pm-6pm	6pm-7pm
1	69	193	236	386	221	436	494
2	47	59	86	149	70	131	160
3	123	382	191	268	185	276	237
4	164	304	193	205	168	236	209
5	48	99	46	155	105	52	145
6	145	328	238	303	246	250	279
7	74	194	156	163	217	252	219
8	27	30	26	56	15	40	134
9	161	278	264	297	311	447	385
10	44	88	78	131	99	109	61

Directions:

1 = from Jalan Burma straight through to Jalan Mt. Erskine.
2 = from Jalan Burma turn right into Jalan Bagan Jermal.
3 = from Jalan Mt. Erskine striaght through to Jalan Burma.
4 = from Jalan Mt. Erskine turn right into Jalan Gottlieb.
5 = from Jalan Gottlieb turn right into Jalan Burma.
6 = from Jalan Gottlieb straight through to Jalan Bagan Jermal.
7 = from Jalan Gottlieb turn left into Jalan Mt. Erskine.
8 = from Jalan Bagan Jermal turn right into Jalan Mt. Erskine.
9 = from Jalan Bagan Jermal straight through to Jalan Gottlieb.
10 = from Jalan Bagan Jermal turn left to Jalan Burma.
11 = from Jalan Mt. Erskine turn left to Jalan Bagan Jermal.
12 = from Jalan Burma turn left to Jalan Gottlieb.

Source: MPPP, Unpublished Data of Traffic Survey on 10.1.89.

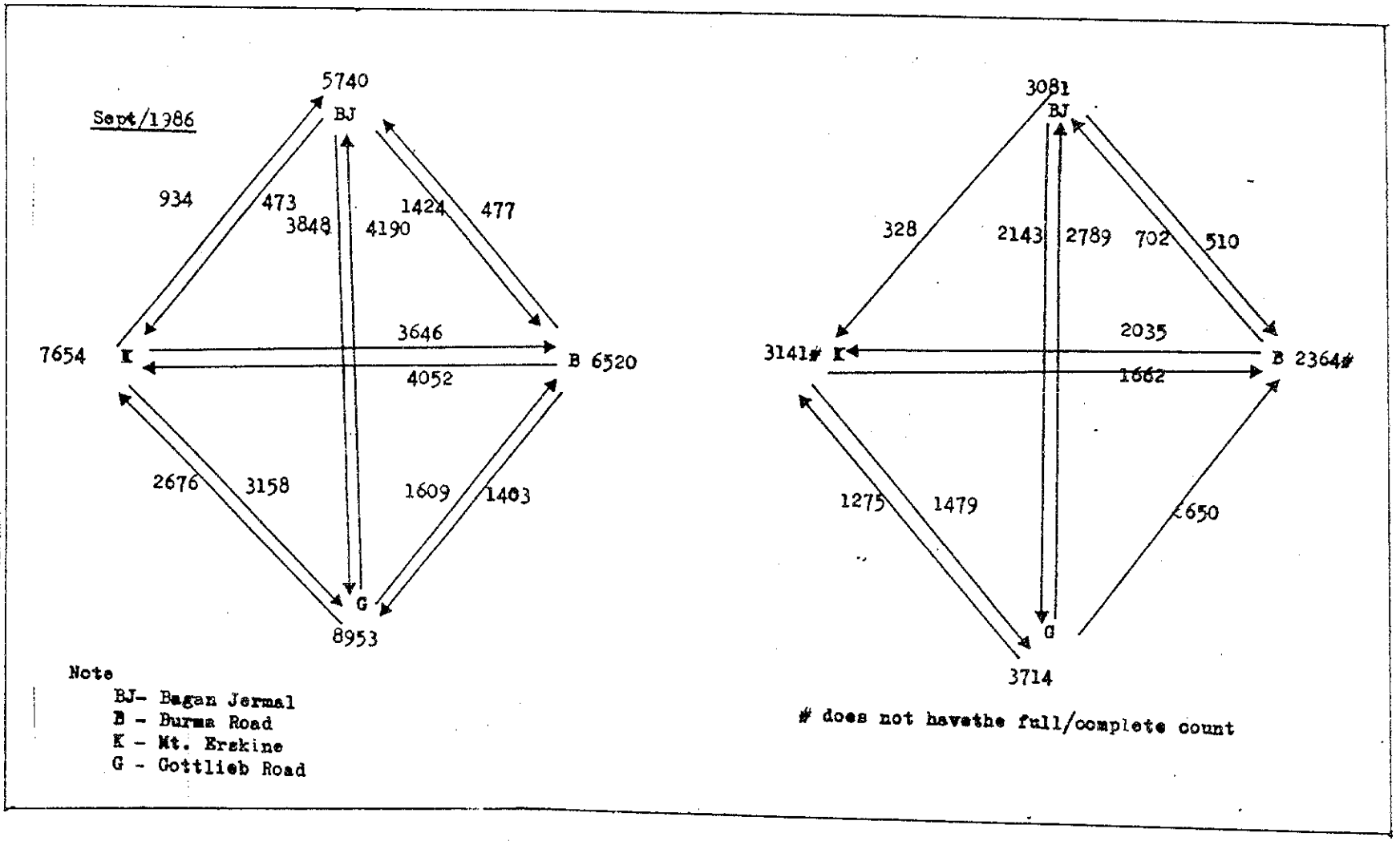


Figure 3.5: Traffic Counts Along Jalan Burma/Mt. Erskine/Gottlieb/Bagan Jermal

(Figure 3.5). The heaviest traffic flow occurs during office and lunch hours, and the traffic is still heaviest along the Jalan Gottlieb and the through traffic from Jalan Burma to Jalan Mt.Erskine. It is interesting to note the total or maximum PCUs.

It may also be important to note that the Jalan Gottlieb and Jalan Bagan Jermal is part of the outer ring road, a long term road reticulation scheme. However, the implementation of this long term scheme is not expected until into the next century (Mr. Fujita, JICA traffic consultant with MPPP, August 1990, per com). This outer ring road will be connected to the Bandar Baru Air Itam through Jesselton Heights and Rifle Range. At the other end of Jalan Bagan Jermal, a new coastal highway would be built to handle the traffic (see JICA, 1981 for more details).

Hawkers Along Jalan Gottlieb

The 1983 MPPP Structure Plan study had a technical report on the nature of Commerce on Penang Island. In the section on hawkers, the Jalan Gottlieb hawker pitch was mentioned as a major hawker pitch. However, the technical report did not enumerate the number of hawkers in the Gottlieb road area. The hawkers are located on the road shoulder fronting the Penang Chinese Girls' High School.

An observational survey was carried out on two nights along the Jalan Gottlieb stretch. On the first night which was raining, a total of 20 hawker push carts were enumerated. On the second night, a total of 30 hawker push carts were enumerated.

Almost all the hawkers sell cooked food or drinks. One or two sell newspapers and magazines. They usually begin work just after the afternoon school children have gone home - around 7pm, and work in cases till about 1-2am. It would appear from the clientele, that the Jalan Gottlieb hawker pitch is a major centre for hawking for the area.

The hawker population along Jalan Gottlieb was enumerated by the USM study team on two nights in September 1990. The time period was from 9.00 p.m. till 12.00 midnight. Table 3.5 shows the results of the survey.

Additionally, the customer profile was also recorded. A very small estimate was made on the average length of time customers spent at the stalls on the first night; about 15-25 minutes seemed to be the average. As such, a count of customers was made every 20 minutes from 9 p.m. till midnight. The results of this survey is shown in Table 3.3. It is important to note that such an attempt is an ad-hoc estimate which not take into account the extent of variation

Table 3.5: Enumeration of Hawkers and Client Profile

25 September 1990			20 September 1990		
Time (pm)	No. of Hawkers	Clients	Time (pm)	No. of Hawkers	Clients
9.00	32	103	9.00	24	71
9.20	32	123	9.20	24	103
9.40	32	113	9.40	26	110
10.00	32	133	10.00	26	121
10.20	32	144	10.20	26	139
10.40	32	106	10.40	26	128
11.00	30	94	11.00	25	114
11.20	30	95	11.20	22	87
11.40	15	59	11.40	18	67
12.00	15	48	12.00	16	51

Source: Jalan Gottlieb Hawkers Survey, September 1990.

throughout the year and also the increase in numbers over time.

As can be seen, the peak periods are before 11.20 p.m. where the hawker an clientele population is high. It may be important to note that there was a slight drizzle on 26 September, and that may have accounted for the fewer number of hawkers and clients.

The hawker site caters to about 1,000 clients each night. The hawker population is thus quite stable, with about 32 stalls staying open in most nights.

Since there is no parking, the clientele park along both sides of the road; some park on the road shoulders which are quite wide on both sides of Jalan Gottlieb.

Commercial Activity Along Jalan Gottlieb and Jalan Bagan Jermal

There are three main blocks of commercial activities in shops and other converted buildings along Jalan Gottlieb. There are no commercial activities along Jalan Bagan Jermal, except the ground floor of the Wayton flats, and in the premises of the Penang Chinese Girls' School ex-pupils Association building.

At the junction of Jalan Gottlieb and Western Road, there is the Waterfall Hotel (a second rank hotel

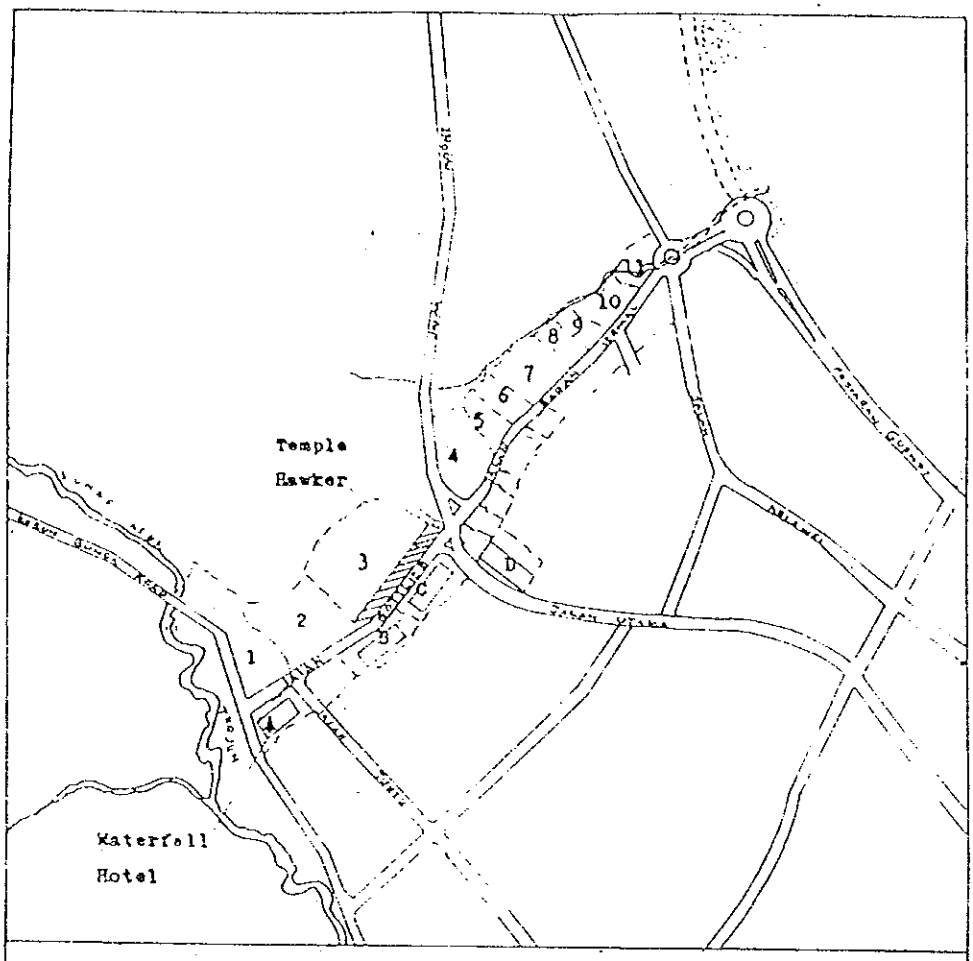
in terms of the number of rooms [only 34] and hotel charges), and a row of two storey shop houses. The most famous businesses are Prosperous Restaurant, and the Eden Cake shop.

The next two rows of shophouses are 4 storey high, located just opposite the Penang Chinese Girls' High School. The row which is further away from the Jalan Burma junction has only opened for business this year. The other row, located at the Jalan Burma junction has opened for business much longer - around 1985/6.

A list of the major shops along Jalan Gottlieb is shown below in Table 3.6. This list was compiled from a survey of the shops conducted on September 24-26, 1990. Table 3.2 was compiled from an observational survey of the shops conducted on September 1, 1990.

There are four major rows of shophouses along Jalan Gottlieb and Jalan Bagan Jermal. They have been marked A - D on the map (Figure 3.6). The main activity of the "A" row of shops (opposite the Indian Temple) is restaurant and catering, with a hotel, and two service firms (securities and real estate) (Figure 3.7).

The second row of shophouses ("B") is a four storey block. Some of which are currently vacant. There is a mix of personal and household goods services



LEGEND

1	Indian Temple	A	2 Story Shophouse
2	Gottlieb Garden	B	2 Story Shophouse
3	Penang Chinese Girls High School	C	4 Story Shophouse
4	Bungalow	D	2 Story Shophouse
5	Penang Chinese Girls High School Union		
6	Condominium		
7	Penang Indian Association		
8	Phor tay High School		
9	Phor Tay Buddist School		
10	Phor Tay Institution		
11	Wooden House		

Figure: 3.6

Land use along Jalan Gottlieb and Jalan Bagan Jermal

Table 3.6: Gottlieb Road Survey Opposite Indian Temple - A

Co. Name	Address	Activity	Year of Establish-ment	Workers
Eden Cake House	25	Selling Cake	-	-
Prosperous Cateror	25A	-	-	-
Prosperous Restaurant	25B,C,D	Restaurant	1970	60
Snow Hill Cake House	25E	Selling Cake	1980	8
New Bob Realty s/b Bob Auctioners	25F 25Q	Realty, Money-Loaner, Auctioner	1960	50
Kedai Arak Perniagaan Maju Jaya	27	Selling Wine	1968	-
(Name in Chinese)	27A	Coffee Shop	1980	10
Dragon Inn Restaurant	27B	Restaurant	-	-
Sport Toto	27D	-	-	-
Securicor Express	27C	Securities	1990	105
d'Cottage Restaurant	27E,F,G	Restaurant	-	-
Hotel Waterfall	27H	Hotel	-	-

Shophouse B

Co. Name	Address	Activity	Year of Establish-ment	Workers
The Art Gallery	7	Display & Selling Painting	1900	2
Diethelm Furniture	7-1	Display	-	-
Ban Poh Chon Art House	7-3	-	-	-
Alan's Place	7M-1	Restaurant	-	-
Akitek Ketika Jurutera Perunding	7M-2	Architectural Consultant	1988 1988	4 2
The Iner. Exchange Inst. of Japan	7L-1	Under Renova-tion	-	-
Mal Rattan Trading Sdn. Bhd.	7L	Furniture	-	-
Allied Resources		Giving Training on Computers	-	-
The Elie Beauty Academy	7K-2	Facial School	1989	2
Flair	7J-1	Face & Body Treatment Center	-	-
North Malaya	7H	Furniture	Not participating	
Hyton Industries Sdn. Bhd. PT Management s/b	7G-1	-	-	-
Sykt. Hisham Bersaudara	7G-2	-	-	-
Business Machines System	7G-3	-	-	-
Wooi Que Trading	7-F	Stationery & Antique	1990	Nil
Nirvana Trading	7T-1	Shoes	1990	1

Co. Name	Address	Activity	Year of Establish-ment	Workers
Computer Assisted Learning	7E-1	Computer Education	1990	4
Pacific Prestige	7D-1 7A-7E	Tourism Business & Duty Free Centre	1990	50
Carmelita Sdn.	7C-1	Contractor (Building)	1982	8
Ritronics Semiconductor	7C-3	-	-	-
Colt Engineering	7C-2	-	-	-
		Hair and Beauty Center	-	-
Sen Dental Clinic	7D-2			

Shophouse C

Co. Name	Address	Activity	Year of Establish-ment	Workers
Kedai Makan Kwong Chow	1W	Coffee Shop	-	10
Teletech Supply & Services		-	-	-
O & C Decorator	1T	Interior	1980	3
Elite System Sdn. Bhd.	1O	Trading	1990	4
Chong Yee Music Center	1V	Music Center	1982	-
Choong Opto-metrist	1Q		1985	2
Good Wind Engineering	1S	-	-	-
Conaire Engineer-ing	1R	-	-	-
Khoo Hoe Enterprise	1P	-	-	-
Milex Sdn. Bhd.		Selling paint	-	-
Kohnic (M) Sdn. Bhd.	-	-	-	-
Classic Art Center	1L	Painting School	-	-
Modern Mini Market	1C & 1F	Trading	-	-
Akino Fashion	1G	Tailoring	-	-
Design Mas	-	Decorator	-	-
Digital Music System (Authorised Yamaha Music Center)	-	Music Center	-	-
Pusat Bimbingan Suka	1B	Tuition Center	-	-

Shophouse D (Jalan Burma)

Co. Name	Address	Activity	Year of Establish-ment	Workers
Auto Fin Associates	386	EON Distributor	-	-
Tomo Express (M) Sdn. Bhd.	386A	-	-	-
Tatt Seng Pemborong Letrik	386B	-	-	-
Immanuel Tabernacle	386C	Church	-	-
Auto Bavaria	388	BMW Showroom	-	-
Bristol Trading	388B	-	-	-
Stella-in Beauty Center	388C	Hair Saloon	-	-
Youngshen Chai	388C	-	-	-
Malaysia Farmasi Sdn. Bhd.	390A	Wholesale & &Retail Chemist	-	-
Perfect Touch	390A	Hair Center	-	-
Chez Aun	390B	Hair Saloon & Academy	-	-
City Mass Realty	390C	Real Estate Agent	-	-
Fusia Corporation	392	Selling Carpets & Furnishing	-	-
Stella-in Beauty Academy	392B	School of Beauty Care	-	-
Kedai Kopi Way Ton Cafe	394 & 396	Coffee Shop	-	-
Multiple Success Center	394A	-	-	-

Co. Name	Address	Activity	Year of Establish-ment	Workers
Siamson Tours & Travel	394B	Travel Agent	-	-
Total Beauty Therapy	394C	-	-	-
Academik Counselling Center	396B	-	-	-

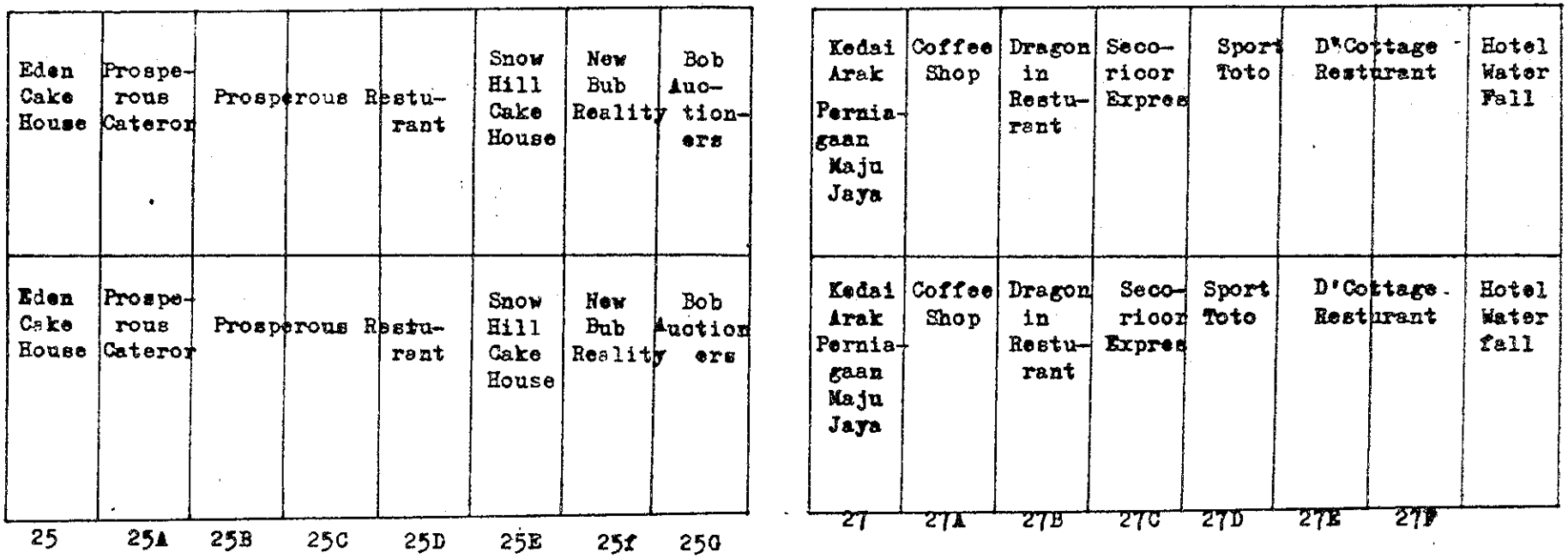


Figure 3.7: Layout Of Business Establishments In Shophouse A

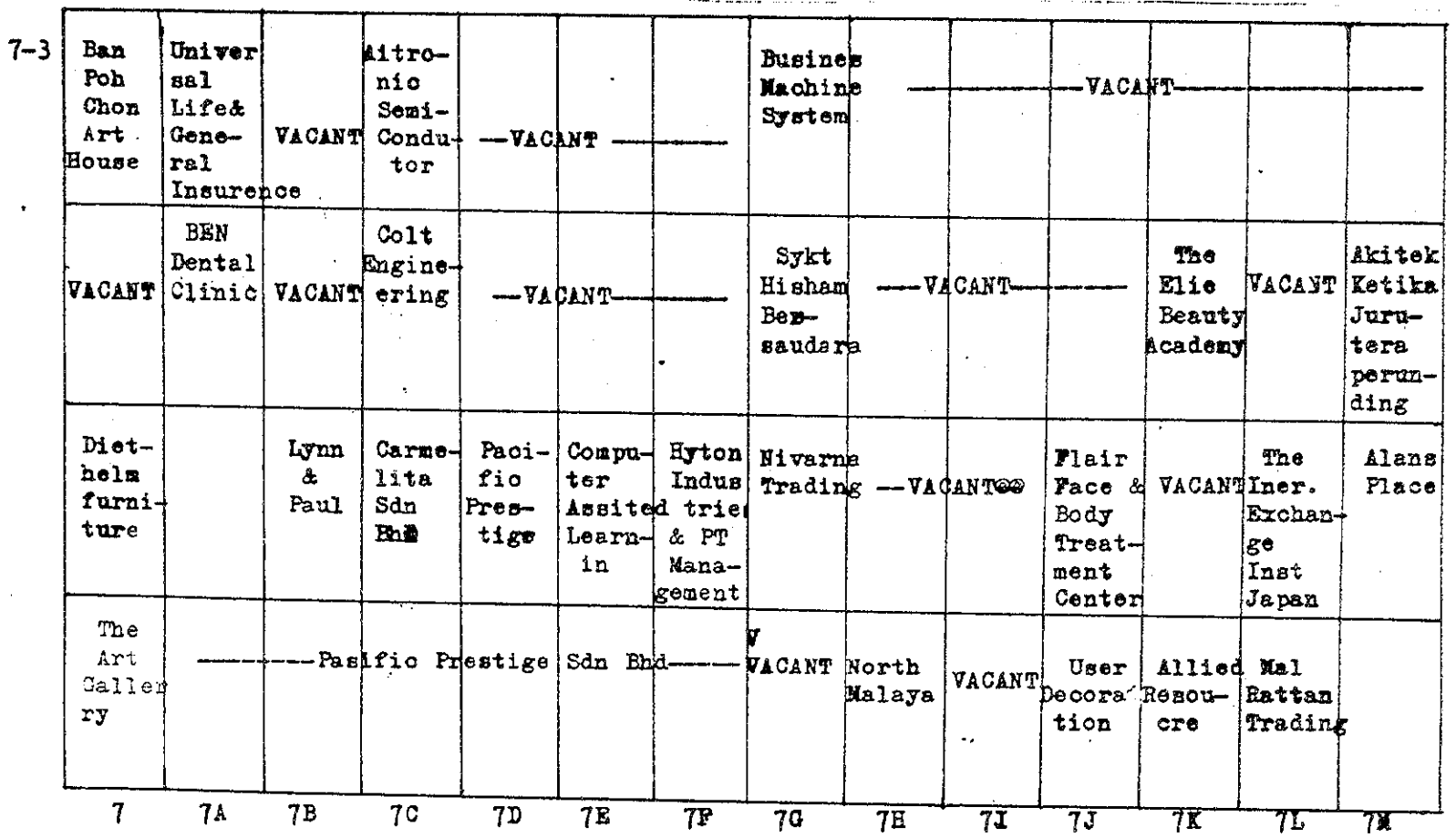


Figure 3.8: Layout Of Business Establishments In Shophouse B

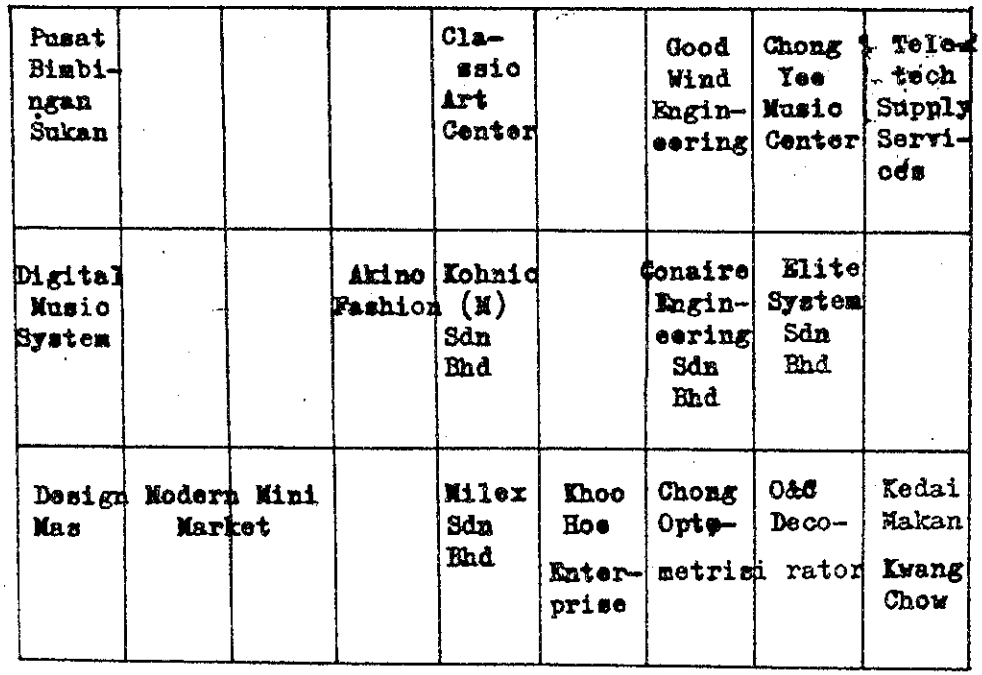


Figure 3.9: Layout Of Business Establishments In Shophouse C

396	394	392	390	388	
	Total Beauty Therapy Academy		City Mass Realty	Youngshen Chai	Immanual Tablenacle
Academik Counselling Center	Siakson Tours & Travel	Stella-in Beauty Academy	ches Aun Hair Salon and Academy	Stella-in Beauty Centre	Tatt Seng Pemborong Letrik
Klinik Ortopedik Gaafar	Multiple Success Center	Perfect Touch (Hair Creation)		Bristal Trading	Tomo Express Sdn Bhd
Kedai Kopi	Way Ton Caf	Fusia Corporation	Malaysia Farmasi Sdn Bhd	Auto Bavaria	Auto Fin Associates

Figure 3.10: Layout Of Business Establishments In Shophouse D

firms, along with offices and one or two convenience goods shops. This row of shop houses have only been recently occupied ; the earliest being in 1988 (Figure 3.8).

The third row of shophouses ("C") is the second oldest along Jalan Gottlieb. It opened for business in the early to mid-1980s. Apart from several offices, the rest are mainly engaged in selling personal and household goods (Figure 3.9).

The fourth row of shophouses ("D") is a new block, along Jalan Burma, although one end of the shops abut onto Jalan Bagan Jermal and thus may be affected. This is a relatively new block of shops and offices, and most of it has been occupied (Figure 3.10).

3.3 River Improvement Along Sungai Pinang

(a) Physico-Chemical Features

The proposed river improvement involves widening and deepening of the whole stretch of Sg. Pinang, the lower reaches of Sg. Air Itam, and Air Terjun as well as a major stretch of Sg. Dondang. Other than Sg. Air Terjun, all the other river stretches affected by the proposed river improvmement are grossly polluted in terms of both organic and bacterial loads as indicated by the results of the water quality surveys conducted under the Structure Plan Study (Lim et al., 1984), the

JICA Study (1990) and this study (see Tables 3.1 and 3.2).

Since the river improvement would necessitate dredging of river bed and result in the probable release of large quantities of toxic pollutants into water bodies, the trace metal contents of the surface sediment were therefore determined in this study. The experimental procedure is briefly described below.

The surface sediment was collected at stations SP1, SP2, SP3, SAI3, SAT1, SAT2, SD1 and SD2, dried and sieved using a nylon sieve of size 1150 um. The sediment of size <1150 um was then digested with "ARISTAR" grade concentrated nitric acid in a teflon "bomb" for one hour. The digested solution was filtered and analysed by flame atomic absorption spectrophotometer for zinc (Zn), nickel (Ni), copper (Cu), lead (Pb) and cadmium (Cd). The determination of mercury (Hg) employs a simple reduction and aeration procedure as described in FAO (1975).

The mean concentrations of the various trace metals are shown in Table 3.7. The detailed results are shown in Appendix A. Comparison of the mean concentrations of the tested heavy metals at the various sampling stations of Sg. Pinang, Sg. Air Itam and Sg. Dondang with those reported to be present in SAT1 and SAT2 of Sg. Air Terjun, i.e. the control

Table 3.7 : Mean Concentrations (ug/g dry wt.) of Heavy Metals in Surficial Sediments.

River	Sampling Station	Pb	Cu	Zn	Ni	Cd	Hg
Sg. Pinang	SP1	8	3	53	1	0.2	0.61
Sg. Pinang	SP2	24	10	69	3	0.3	1.01
Sg. Pinang	SP3	63	32	128	8	1.4	0.73
Sg. Air Itam	SAI3	11	4	46	1	0.2	1.28
Sg. Dondang	SD1	9	3	41	1	0.1	1.39
Sg. Dondang	SD2	13	5	38	2	0.3	1.22
Sg. Air Terjun	SAT1	6	1	20	N.D	0.2	2.34
Sg. Air Terjun	SAT2	5	1	17	1	0.2	1.03

N.D. Not detectable

sites, reveals that the rivers are polluted to various degree by heavy metals. Among the rivers studied, Sg. Pinang is the most polluted. It is also observed that the concentrations of Pb, Cu, Zn, Ni and Cd consistently increase towards the Sg. Pinang estuary indicating that there are more inputs of heavy metals as the river flows through the City of George Town.

(b) Biological Features

The Sungai Pinang itself has features that are characteristic of those of an estuary.

The riparian vegetation along the river is rather similar to that found on the Sg. Air Itam. Some areas upstream are shaded by tall wayside trees while the areas near the river mouth are completely exposed to the sun.

The river is considered highly polluted both chemically and organically as reflected by the smell and colour of both the water and bottom sediment . This has resulted in the development of a very narrow-based river fauna and flora.

The algal flora now includes the imported marine species of *Coscinodiscus*, *Chaetocerus*, *Biddulphia*, *Cymbella*, *Ceratium* and *Stephanodiscus*.

The benthic fauna is limited to the polychaete worm *Tubifex* sp. which are tolerant of organic pollution.

The fish fauna includes the catfish *Clarias batrachus*, the half-beak *Demogenys pussilus* and of course the guppy *Lebistes reticulatus*.

The number of species of birds using the river bank from the Sungei Pinang Bridge to the Patani Road Bridge is very small as the existing vegetation there is not very hospitable to birds. The House Crow, Large-billed Crow and the Common Sandpiper have been feeding on the banks when the water level was low. The Common Myna, Black-naped Oriole and Eurasian Tree-Sparrow are seen on the river side trees. A few swifts and swallows have been sighted over the river.

The stretch from the Patani Road Bridge to the Air Itam Road Bridge also do not support much bird life and the birds seen along this stretch are found mainly on the river side trees. The birds are of the same species as those found at the Sungei Pinang Bridge and the Patani Road Bridge areas except for the Yellow-vented Bulbul and Common Tailorbird because of the traditional type of human habitats found along the banks. A Brahminy Kite has been flying over the river near the City Stadium. This could be due to the availability of open space there, which allows the bird

to scoop down to the river to pick up its meal if any.

The Sungei Air Itam from the confluence of Sungei Air Terjun and the confluence of Sungei Dondang has the Common Myna, Crested Myna, House Crow, and the Common Tailorbird feeding on the banks.

The White-throated Kingfisher which feeds on insects and not actually on fish has been sighted on the stretch of the river.

(c) Socio-Economic Activities Along Sungai Pinang

Population

The population of the entire study area can be partially estimated from Figure 3.2 which shows the density of various planning zones where the rivers flow through. This data is from the 1980 Population Census. Although it is 10 years old, it is about the most recent data that is available.

As can be seen, the lower reaches of Sg. Pinang has the highest density of 270 persons per ha.

The lower reaches would probably have much higher densities because there have been very significant high-rise and high-density residential construction. Areas such as the Macallum Street Ghaut and Sg. Pinang/Bakau Street and River Road have been the sites of major high-rise flat construction in the last

decade.

The middle stretches of Sg. Pinang have densities of 25-74 persons per ha.

The lower reaches would probably have much higher densities because there have been very significant high-rise an high-density residential construction. Areas such as the Macallum Street Ghaut and Sg. Pinang/Bakau Street and River Road have been the sites of major high-rise flat construction in the last decade. The middle stretches of Sg. Pinang have densities of 25-74 persons per ha.

Landuse

The landuse at the lower reaches of Sg. Pinang consists of warehouse, small scale industrial areas and workshop. The industrial areas produces oil products, charcoal, boxes, papers and shoes. The warehouses provide storage for frozen food, charcoal and other miscellaneous products. The boat landing area for the local fishermen is situated just opposite of the Public Works Department Workshop. Further down at the river mouth on the right bank is the Chinese squatter settlement. After the Sungai Pinang Bridge upstream, is the pig market, slaughter house and the veteniary centre and a Tamil Primary School. On the other bank is the private office buildings, a small scale factory and two blocks of flats under construction. The river

at this point has been dredged and the dump site is situated right at the backyard of the factory.

After the Jalan Sungai Bridge, further upstream on both sides of the bank are the Government Quarters. The three Government Quarters are owned by the Electricity Board (LLN) whilst the three blocks of flats is owned by MPPP. And this area stretches right up to the Jalan Patani Bridge. Then further upstream are traditional and squatters housing (30 houses) and several small scale establishments such as the Citilight Electrical Engineering, two car repair workshop and a hardwware traders. Further up stream right up to the Perak Road Bridge are squatters settlements which are built right up to the edge of the river. There are 29 squatter houses with adjoining extensions. The landuse is found on both sides of the river. At this point there are stretches of open space covered with vegetation. The important institution in this stretch is the Japanese School and the Kehyon Ree Methodist School with several quarters. There several stretches of open space along the river owned by the DID, MPPP and LLN.

The upper reaches of Sungai Pinang up to the confluence of Sungai Air Itam and Sungai Air Terjun passes through traditional residential housing at Jalan Rawang up to Jalan Terengganu. Opposite Jalan Rawang is the City Stadium and the bus depot at Lorong

Kulit. Several hawkers' sites such as at the Penang Stadium, coffee shops, and a market are found along this stretch of river.

Important institutional buildings such as a community centre and mosques are also found along the upper and lower reaches of Sungai Pinang. There are also spirit houses and Hindu Temples scattered along the lower and upper reaches of the river. Other important institutions are the burial ground for Muslims, Sikhs and Japanese.

Upstream the tributaries of Sg. Pinang are Sg. Air Terjun, Sg. Air Itam and Sg. Dondang.

Sg. Air Terjun before it meets Sg. Air Itam passes through the York Road historical areas with old bungalows and shophouses. There are two Indian temples and a mosque within the river reserved. As it merges with Sg. Air Itam and Sg. Pinang the area is called the Dobi (laundry) area.

The Sg. Air Itam passes through institutional areas such as the Suffolk House, secondary schools (Sekolah Hj. Zainal Abidin and Sekolah Lelaki Methodist), the Girls' Orphanage and the Government Quarters before it meets Scotland Road. Opposite these institutional areas is the proposed Heritage Park. Further upstream after Scotland Road, the river passes through housing schemes located on both sides of the

river. Upstream as it reaches the confluence of Sg. Air Itam and Sg. Dondang the river traverse through more institutional areas such as the State Mosque, several schools (Shang Wu Primary School, Tunku Abd. Rahman Technical School, Chun Hwa Confucian Primary School, Chung Ling Secondary School) and the Little Sister of the Poor Home for the Aged. Opposite the institutional areas close to the confluence are found two car repairs workshop and two brick making factories.

Further upstream along Sg. Dondang after the junction with Sg. Air Itam, there are about 14 wooden house built within the river reserve. The Batu Lanchang Chinese Cemetery is just across the river on the southern side. A brick making factory is found beside the Sin Kang Primary School. Upstream, as the river enters the traditional Air Itam Village at Thean Teik, the landuse is associated with agriculture. There are four pig rearing areas and about five areas identified as agricultural areas with planting of vegetables for the urban market. A plant nursery is located nearby. Recent development within the area suggest that the area is to be developed into residential areas which would form a part of the proposed Air Itam New Town.

4.0 ENVIRONMENTAL IMPACTS

The assessment of the impact of the proposed inland and coastal retention ponds construction and river improvement projects on the environment was made following the guidelines laid down in the EIA Handbook produced by the Department of Environment, Ministry of Science, Technology and Environment, Malaysia. The physico-chemical, biological, public health and safety, socio-economic, aesthetic and cultural components of the environment were examined. The assessment took into consideration all project activities which are envisaged to be operating during the site preparation, site construction, operational and maintenance stages of the proposed project.

The interactions of the project activities and the environment components are summarised in the form of a matrix as shown in Figure 4.1. The matrix has been organised such that it provides a means of identifying the areas of possible impact of each relevant project activity on the respective environmental components.

An impact may be adverse or beneficial. A beneficial impact is depicted by a hollow circle, whereas an adverse one by a solid circle. In both cases, three circle sizes have been chosen with the largest one representing major impact, the smallest representing minor impact and the medium-sized one representing intermediate impact. Thus the extent of each impact is broadly classified as major

intermediate and minor as portrayed in the Matrix. The largest hollow circle therefore depicts a major beneficial impact whereas the smallest solid circle depicts a minor adverse impact. The Matrix clearly provides us with a graphical summary of the types and extent of environmental consequences which could arise from the project. A total of 4 Matrices have been prepared and inserted in relevant sections in this report, viz.

Figure 4.1: Matrix for Retention Pond

Figure 4.2: Matrix for Retention Pond for Urban Drainage

Figure 4.3: Matrix for Diversion Channel

Figure 4.4: Matrix for River Improvement

The following sections describe in further detail, the main environmental impacts relevant to this whole study.

4.1 Retention Ponds

4.1.1 Retention Ponds

(a) Physio-Chemical Impacts

The construction phase of the retention ponds will involve the use of heavy machinery for earthworks. As such, the noise generated will be a nuisance to the residents nearby. There will also be short-term impacts associated with visual intrusion and dust problems due to excavation work.

ENVIRONMENTAL COMPONENTS / PROJECT ACTIVITIES		SITE PREPARATION & CONSTRUCTION										OPERATION & MAINTENANCE				
		Site Clearing	Equipment Transportation	Earth Works	Erosion Control	Spoils Dumping	River Diversion	Structure Demolition	Structure Relocation	Coastal Works	Revegetation	Flow Regulation	Pond Management	Channel Management	Pest Control	Health Control
LAND	Land			●												
	Soil Profiles															
	Soil Composition															
	Slope Stability	●		●							○					
	Subsidence & Compaction															
	Flood Plains/Swamps															
	Landuse	●		●							○					
	Buffer Zones															
SURFACE WATER	Shoreline					●										
	Bottom Interface					●										
	Flow Variation	●		●								○				
	Water Quality	●		●	○	●						○				
	Drainage Pattern											○				
	Water Balance															
	Flooding															
	Existing Use															
ATMOSPHERE	Air Quality			●												
	Visibility															
NOISE	Intensity		●	●												
	Duration			●												
	Frequency															
SPECIES & POPULATIONS	Terrestrial Vegetation	●		●							○					
	Terrestrial Wildlife			●												
	Other Terrestrial Fauna										○					
	Aquatic/Marine Flora					●										
	Fish															
	Other Aquatic/Marine Fauna					●										
HABITATS & COMMUNITIES	Terrestrial Habitats	●		●							○	○				
	Terrestrial Communities	●		●							○	○				
	Aquatic Habitats											●				
	Aquatic Communities											●				
	Estuarine Habitats															
	Estuarine Communities															
	Marine Habitats					●										
	Marine Communities					●										
HEALTH & SAFETY	Physical Safety			●								○				
	Psychological Well-Being			●							○	○				
	Parasitic Disease											○				○
	Communicable Disease															
	Physiological Disease															
SOCIAL & ECONOMIC	Employment	○		○												
	Housing															
	Education															
	Utilities															
	Amenities										○	○				
AESTHETIC & CULTURAL	Landform			●		○					○					
	Biota															
	Wilderness															
	Water Quality			●	○	●						○				
	Atmospheric Quality			●												
	Tranquility	●		●												
	Historic Places/Structures															
	Religious Places/Structures															
	Landscape			●							○		○			

Figure 4.1: Matrix of Potential Environmental Impacts of the Construction of Inland Retention Ponds A, B & C.

ENVIRONMENTAL COMPONENTS / PROJECT ACTIVITIES		SITE PREPARATION & CONSTRUCTION									OPERATION & MAINTENANCE				
		Site Clearing	Equipment Transportation	Earth Works	Erosion Control	Spoils Dumping	River Diversion	Structure Demolition	Structure Relocation	Coastal Works	Revegetation	Flow Regulation	Pond Management	Channel Management	Pest Control	Health Control
LAND	Land Soil Profiles Soil Composition Slope Stability Subsidence & Compaction Flood Plains/Swamps Landuse Buffer Zones									●						
SURFACE WATER	Shoreline Bottom Interface Flow Variation Water Quality Drainage Pattern Water Balance Flooding Existing Use			● ● ● 						 ● ● 		○ ○ ○ ○	 ○ ○ 		○ 	
ATMOSPHERE	Air Quality Visibility															
NOISE	Intensity Duration Frequency			● 						● 						
SPECIES & POPULATIONS	Terrestrial Vegetation Terrestrial Wildlife Other Terrestrial Fauna Aquatic/Marine Flora Fish Other Aquatic/Marine Fauna			 ● ●		 ● ●				 ● ●		 ○ ○ ○				
HABITATS & COMMUNITIES	Terrestrial Habitats Terrestrial Communities Aquatic Habitats Aquatic Communities Estuarine Habitats Estuarine Communities Marine Habitats Marine Communities			 ● ●		 ● ●				 ● ●		 ○ ○	 ○ ○			
HEALTH & SAFETY	Physical Safety Psychological Well-Being Parasitic Disease Communicable Disease Physiological Disease	●											○			○
SOCIAL & ECONOMIC	Employment Housing Education Utilities Amenities		○			○				○			○		○	○
AESTHETIC & CULTURAL	Landform Biota Wilderness Water Quality Atmospheric Quality Tranquility Historic Places/Structures Religious Places/Structures Landscape												○			○

Figure 4.2: Matrix of Potential Environmantal Impacts of the Construction of Coastal Retention Ponds S10 & S18.

ENVIRONMENTAL COMPONENTS / PROJECT ACTIVITIES		SITE PREPARATION & CONSTRUCTION										OPERATION & MAINTENANCE				
		Site Clearing	Equipment Transportation	Earth Works	Erosion Control	Spoils Dumping	River Diversion	Structure Demolition	Structure Relocation	Coastal Works	Revegetation	Flow Regulation	Pond Management	Channel Management	Pest Control	Health Control
LAND	Land Soil Profiles Soil Composition Slope Stability Subsidence & Compaction Flood Plains/Swamps Landuse Buffer Zones			●												
SURFACE WATER	Shoreline Bottom Interface Flow Variation Water Quality Drainage Pattern Water Balance Flooding Existing Use					● ● ● ●						○ ○				
ATMOSPHERE	Air Quality Visibility			●												
NOISE	Intensity Duration Frequency		●	● ○ ●												
SPECIES & POPULATIONS	Terrestrial Vegetation Terrestrial Wildlife Other Terrestrial Fauna Aquatic/Marine Flora Fish Other Aquatic/Marine Fauna			●		● ●										
HABITATS & COMMUNITIES	Terrestrial Habitats Terrestrial Communities Aquatic Habitats Aquatic Communities Estuarine Habitats Estuarine Communities Marine Habitats Marine Communities					● ● ● ●										
HEALTH & SAFETY	Physical Safety Psychological Well-Being Parasitic Disease Communicable Disease Physiological Disease			● ●								○ ○ ○ ○ ○ ○				
SOCIAL & ECONOMIC	Employment Housing Education Utilities Amenities			● ● ● ● ●												
AESTHETIC & CULTURAL	Landform Biota Wilderness Water Quality Atmospheric Quality Tranquility Historic Places/Structures Religious Places/Structures Landscape		●	● ●		● ●										

Figure 4.3: Matrix of Potential Environmental Impacts of the Construction of Sg. Air Terjun Diversion Channel.

ENVIRONMENTAL COMPONENTS / PROJECT ACTIVITIES		SITE PREPARATION & CONSTRUCTION										OPERATION & MAINTENANCE				
		Site Clearing	Equipment Transportation	Earth Works	Erosion Control	Spoils Dumping	River Diversion	Structure Demolition	Structure Relocation	Coastal Works	Revegetation	Flow Regulation	Pond Management	Channel Management	Pest Control	Health Control
LAND	Land	•		●	○						○					
	Soil Profiles															
	Soil Composition															
	Slope Stability	•		●	○						○					
	Subsidence & Compaction			●							○					
	Flood Plains/Swamps											○				
	Landuse			●									●			
	Buffer Zones	•		●							○					
SURFACE WATER	Shoreline					●										
	Bottom Interface			●												
	Flow Variation			●								○				
	Water Quality			●	○						○					
	Drainage Pattern	•		●												
	Water Balance															
	Flooding				○						○	○	○	○		
	Existing Use	•		●							○	○	○	○		
ATMOSPHERE	Air Quality															
	Visibility															
NOISE	Intensity			●		●										
	Duration			●												
	Frequency			●												
SPECIES & POPULATIONS	Terrestrial Vegetation	•			○						○		●	○		
	Terrestrial Wildlife				○											
	Other Terrestrial Fauna	•									○					
	Aquatic/Marine Flora			●												
	Fish			●												
	Other Aquatic/Marine Fauna			●												
HABITATS & COMMUNITIES	Terrestrial Habitats	•			○						○		●			
	Terrestrial Communities				○						○					
	Aquatic Habitats			●								○				
	Aquatic Communities			●								○				
	Estuarine Habitats			●								○				
	Estuarine Communities											○				
	Marine Habitats					●										
	Marine Communities					●										
HEALTH & SAFETY	Physical Safety			●	○						○		○	○		
	Psychological Well-Being			●												
	Parasitic Disease															
	Communicable Disease															
	Physiological Disease															
SOCIAL & ECONOMIC	Employment		○		○								○			
	Housing															
	Education															
	Utilities															
	Amenities															
AESTHETIC & CULTURAL	Landform	•			○	●					○					
	Biota															
	Wilderness															
	Water Quality				○											
	Atmospheric Quality															
	Tranquility	•	•	●												
	Historic Places/Structures															
	Religious Places/Structures															
	Landscape			●	○	●					○					

Figure 4.4: Matrix of Potential Environmental Impacts of the River Improvement Works.

During the operation phase, the inland retention ponds located at the middle reaches of Sungai Dondang would be dry most of the time except during rainy seasons when surface runoff and river water from Sungai Dondang may fill up the ponds. When the ponds are filled, it may pose as a potential health hazard to the local residents as the water quality of the pond may be as bad as Sungai Dondang and is not suitable for any activity involving body contact with water. However, it is likely that the rain water which increases the water volume of the river to overflow into the retention ponds would dilute the organic pollutants to the point where water quality would be acceptable. However, the sediment load of the flood waters may be high and this would settle at the bottom of the ponds. On subsidence of the flood water, a layer of sediment may remain which would need to be cleared up.

(b) Biological Impacts

During the pond construction phase, the site clearing activity and earth works will exert drastic impacts in that all existing terrestrial vegetation (mainly common grasses, wayside weeds and fruit trees) and its inherent natural soil animal communities within it will be destroyed. However no wildlife or any endangered species is involved here.

The construction of Retention Ponds - A, B and C would not adversely affect the birds here except when the ponds get flooded, which would temporarily cut off their food supply as the vegetation would all be covered by the rising waters.

Beyond the Retention Pond-A the birds were very few along the river except for the Common Tailorbird, the mynas and Yellow-vented Bulbul.

The problem of basin and slope instability and hence soil erosion will appear unless suitable mitigating measures such as rapid ground revegetation and revetment of exposed earth are adopted and implemented as soon as possible. Such measures will improve the aesthetic value of the area.

The proposed dumping of the spoils in the form of excavated earth at sea for land reclamation purposes will mean the destruction of the existng marine benthic flora and fauna at the reclamation site. However, this is a problem of land reclamation, as any type of fill material for reclamation will exert the same effect.

Some amount of vehicle noise and exhaust fumes will be generated during the equipment transportation, earth excavation and spoils removal phases. The tranquility of the surrounding residential area will be disturbed during this period.

The safety of the public especially children who may wander into the work site will be at risk. Hence the whole work area must be properly fenced up and adequate warning signboards posted to prevent unauthorized entry.

Employment opportunities become available for both unskilled and skilled workers.

With proper pond design, management and flow regulation, the problem of flooding in the downstream areas during prolonged periods of heavy rain should have been reduced since part of the potential flood water would be retained by the retention ponds. This is a major beneficial impact.

Sedimentation and organic debris deposition can occur when the water-filled pond is drained of its water. Besides making the drained pond area look unsightly, the deposited fine silt can give rise to dust pollution when stirred up by strong wind during the dry season. Proper management and debris removal practice are needed to maintain the aesthetic value of the pond area especially during the non-rainy season.

During the dry season, the pond area, if landscaped and equipped with appropriate (e.g. water tolerant) infrastructural and recreational facilities, can provide good healthy recreational benefits to the local residents.

(c) Socio-Economic Impacts

As discussed above the proposed inland retention ponds are situated and located in a rapidly developing area. The development pressure in the area leads to high land values. The high land value in the area would affect the construction of the proposed retention pond as landowners would be reluctant to part with their land. Initial study of the development pressure in the area by MPPP indicates that retention pond B is located on land proposed for housing. However, the landuse study indicates that retention pond B is located on land proposed for recreational purposes at Taman Desa Permata housing scheme which is presently under construction.

Retention pond A is situated in an existing housing area at Lebuh Rampai. Presently the open space is used for recreations. There is no major socio-economic impact except during flooding when the field is temporarily closed for recreational purposes.

Retention pond C which is to be located within a residential area also lies opposite to an important access road to the nearby flats and traditional housing. The construction of the retention pond would affect temporarily access to the area.

The location of fresh water retention ponds at the middle and upper reaches of Sg. Dondang suggests that

the ponds will be dried most of the time except during raining seasons when massive surface runoff may partially fill up the ponds. The water quality is expected to be as bad as the Sg. Dondang and is probably objectional to any activity involving body contact with water. However, water uses for fish and wildlife may be possible if the condition of the water is improved within the retention ponds.

(b) Retention Ponds for Urban Drainage

The coastal retention ponds for urban drainage receives the polluted water from the urban center and is considered objectional to use for any human activity due to its possible health hazards. The water may contain unwanted human pathogens that may cause diseases such as typhoid, cholera or infectious hepatitis and other virus or bacteria related diarrheal diseases. The discharge of this water into the sea will pollute the nearby areas which become unsuitable for fish and shell fish culture and other water-based activities. However, the present discharge of this water into Sg. Pinang has already made this area polluted. It is envisaged that the coastal retention ponds will not further deteriorate the present environment but may enhance the microbial quality if the water is held long enough in the ponds for the natural decay and die-off of the faecal bacteria and pathogens before these are discharged into the sea.

As the purpose of the coastal retention ponds is to receive urban runoff from the George Town areas, there is some likelihood that the ponds may become anaerobic due to the high BOD load carried in the surface runoff.

4.1.2 Coastal Retention Ponds

(a) Physico-Chemical Impacts

The construction of the coastal retention ponds will have some short-term impacts on the local communities in the vicinity. These impacts include visual intrusion, dust and noise problems.

During the operation phase, the ponds will be receiving the sullage water and runoff from the urban areas. The water may contain unwanted microbial pathogens that may cause diarrheal diseases if ingested. The periodic sudden discharge of this water with high organic matter into the coastal sea may pollute the nearby areas and threaten the viability of fish and shellfish cultures as well as other water-based activities.

Provided that the water is held long enough in the ponds for the natural decay and die-off of the faecal bacteria and pathogens, the microbial quality of the water discharged into the sea may be improved. On the other hand, there is some likelihood that the ponds may

become anaerobic due to the high BOD load carried in the urban discharge. Since the ponds will be filled all the time, there will be breeding of mosquitoes which may act as vectors for many human diseases. Some mosquitoes are known to survive in brackish waters, but these mosquitoes are not known to be associated with any disease.

(b) Biological Impacts

During the construction phase, the coastal earth works will destroy the existing marine habitats and benthic life at the two pond construction sites. However, no endangered species will be affected here.

The construction of the coastal Retention Ponds S-10 and S-18 would further affect the size of the area of the mudflats available for the waders and other birds feeding on the mudflats. As it could be seen at present, the coastal reclamation project itself had shrunk the available land area for them to feed on. With the completion of the reclamation project and the coastal retention ponds, there would hardly be any mudflats on the eastern coast of the Island for the waders to feed and we would probably loose all these waders from the East Coast of Penang Island. One possibility is that the coastal retention ponds might attract the waders from their other feeding grounds across from the mainland, which would be flooded during

high tide. Much would depend on the types of organisms that would be found in the waters of the retention ponds. Waders are known to be attracted to oxidation ponds but since the organisms in them will be different from those of the flooded retention ponds, the waders may not be attracted to these ponds.

The water quality in the vicinity of the work area will certainly deteriorate as far as its suspended silt load is concerned. Under the influence of sea current movement, this increased suspended silt load may also be transported and deposited to other areas of the Penang South Channel.

The disposal of the dredged mud out into the sea, whether for land-fill purposes or otherwise, will exert an adverse impact on the marine benthic life at the receiving dump site. However, since the the excavated mud is basically marine in nature, the impact will not be as serious as that exerted by the excavated earth of terrestrial origin. Recolonization of marine substrate by marine life occurs faster by comparison.

Some amount of vehicle and other machine generated noise and exhaust fumes will be felt during the construction phase. The tranquility of the surrounding residential area will as such be disrupted.

The project provides employment opportunities for skilled and unskilled work force.

The ponds, once operational, should be able to store and regulate the final discharge of sullage water originating from their respective feeder (discharge) drainage network. This beneficial impact should be maximised with proper pond management and flow regulation by the relevant authorities. In this respect, the recruitment of additional supporting staff personnel, hence the creation of new employment opportunities, would be necessary.

The bulk release of sullage water from the ponds into the sea will contaminate the receiving coastal water and affect marine life. A sensible and less deleterous pond water discharge schedule and impact monitoring program are therefore needed.

With proper pond management, all existing aquaculture activities going on in the nearby coastal area can be continued provided that they are located outside the immediate impact zone of discharge waters.

(c) Socio-Economic Impact

The proposed coastal retention ponds are to be located on reclaimed land off Lebuh Macallum/Lebuh Cecil just off the mouth of the Sungai Pinang estuary. The possible socio-economic impacts on the coastal resources are not known. Extensive fish culture activities and fishing occur along the coast. This aspect needs further study.

The socio-economic impact of the coastal retention ponds on the land-based activities is minimal.

4.2 River Diversion

(a) Physico-Chemical Impacts

The construction of the Air Terjun diversion channel will have some short-term impacts on the local communities nearby. These impacts include visual intrusion, dust and noise problems. The water quality of the Air Terjun is considered to be relatively clean although its bacterial quality has deteriorated over the years to the level found in the seawater off Jalan Gurney (FC counts at 10^4 - 10^5 MPN/100 ml) where the water will eventually be discharged.

During the operation phase, the channel will be diverting a considerable portion of the flow of Sg. Air Terjun at times of storms into Sg. Babi and the coastal waters off Jalan Gurney. It is envisaged that the high faecal loads found in the coastal waters off Jalan Gurney may be reduced due to dilution effect during a heavy storm.

However, the construction of the enclosed diversion channel under Jalan Gottlieb may create new niches for pests like rats, cockroaches and mosquitoes which may act a vectors for many human diseases.

(b) Biological Impacts

As far as Sg. Air Terjun is concerned, the construction of the diversion channel at the branch-off point will remove permanently a small part of its riparian vegetation. The animal life within the river bed itself will be destroyed, but no endangered species is involved here.

Other adverse impacts include instability of the denuded river banks, resulting therefore in bank erosion and increased suspended sediment load in the water. This incidence of bank erosion due to the construction activity is however localized and supposedly short-lived.

The construction of the rest of the diversion channel along Jalan Gottlieb and Jalan Bagan Jermal may incur the cutting of all obstructing underground roots of wayside trees like the angsana *Pterocarpus indicus* and mahogony *Swietania macrophylla* which line the roads.

The whole of the Gottlieb Road will be dug up in stages. During such times, the relevant sections of the road will for pratical reasons be impassable to all motor vehicles and pedestrians.

The disposal of the excavated earth through dumping into the sea as proposed will affect marine

habitats and communities at the coastal land reclamation site.

The diversion of flood water occurs during the wet season. This is a major beneficial impact.

Siltation and hence clogging of the diversion channel by spilled sediment, organic debris and other solid wastes will occur unless an effective solid-waste screening system is installed.

(c) Socio-Economic Impact

The main socio-economic issues identified by the study team are the disruption to traffic, hawkers and the businesses in the shop houses along Jalan Gottlieb.

The traffic data indicates Jalan Gottlieb as a busy route for through traffic as well as internal traffic from the schools and offices situated on this road. Jalan Bagan Jermal is also providing through traffic with internal traffic movement from the schools and institutions nearby. The construction period would affect and disrupt the traffic flow and access to the school, institutions, commercial establishments in the area.

The hawkers operating nightly from 25 - 30 stalls would be affected by the construction activitiy. The road access to this hawker site would be close during construction period. There will be a loss of income as

well as loss of an important source of cheap and fast food for the urban consumers.

The commercial establishments from the 50 shophouses (not including block "D") has an employee population of about 100-150 persons who would be affected during the diversion channel construction period. The businesses of three restaurants would be affected by the construction activity. Access to the restaurants will be blocked, and resulting to parking problem which will cause a drop in the number of clientele, hence a drop in income.

4.3 River Improvement

(a) Physico-Chemical Impacts

The river improvement which involves deepening and widening of Sungai Pinang, Sungai Dondang and a short stretch of Sungai Air Terjun necessitates dredging activities. The major adverse impacts associated with dredging are increased turbidity and the release of large quantities of trapped nutrients, organic matters and toxic pollutions from the river sediments. The increase in turbidity will result in reduced light penetration and reduced photosynthesis. Increase in nutrients and organic matters will result in entrophication and depletion of dissolved oxygen in the river stretch downstream of the dredging activities.

The disposal of the dredged materials estimated at 800,000 m^3 poses a big problem. It has been suggested that part of the spoils be used as fill materials in the proposed coastal reclamation project north of the Penang Bridge. The use of the spoils as fill materials will have adverse impacts on coastal water quality and benthic life. These impacts include increased turbidity, sediment build up, oxygen depletion and the release of toxic pollutants such as heavy metals which may leach out into the surrounding coastal waters.

(b) Biological Impacts

Site clearing of the riparian vegetation before river channel widening will mean the removal of natural plant and animal habitats and communities along the affected river banks and adjacent buffer zones. The extent of removal depends on the scale of river widening proposed.

River bed configuration will be altered. River bed deepening and widening will lead to destruction of benthic plant and animal communities in the river.

River bank erosion will occur unless rapid revegetation or revetment of the affected areas is carried out promptly. Earthworks will disrupt the tranquility of the area.