enough space for projection of the open channel type. This underground type diversion channel is not visible and presents no aesthetical problems throughout its route.

12.3 PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

12.3.1 Preliminary EIA in Malaysia and Its Relation to the Project

The Environmental Impact Assessment (EIA) for development projects became mandatory in April 1988. This is the result of an amendment to the Environmental Quality Act of 1974. By this amendment, the prescribed development activities must undergo a mandatory EIA. However, the projects concerning flood mitigation and drainage described in this Study do not legally require EIA.

Even though, the Department of Environment, Malaysia, encourages projects to undertake EIA as a mechanism for better project planning. The preliminary EIA process would be able to identify and resolve problems before the commencement of the projects.

The preliminary EIA study has been conducted by a research team from the University Science of Malaysia. The study results finalized during the feasibility study period and the preliminary EIA report are edited separately.

12.3.2 General Objectives of the Preliminary EIA.

1) Title and Type of Project

The title of this project is "The Urgent Projects for Flood Mitigation and Drainage in Penang island." And the preliminary EIA of the project is undertaken on the proposals made in the feasibility study for flood mitigation and drainage for Sg.Pinang and its tributaries.

2) Project Initiator

Since flood mitigation and drainage is under the superintendency of the Department of Irrigation and Drainage(DID), and urban drainage is under the Municipal Council (MPPP).

The project initiator is the DID of the State of Penang cooperation with the DID of Federal Government and MPPP.

3) Need for Flood Mitigation and Drainage

Because of the increased number of built up areas and the development trends in the water catchment of the rivers, the amount of run-off water after a storm has obviously increased. This has increased number of floodings in urban flood prone areas over the years. There is a clear need to take action to mitigate these frequent floods.

12.3.3 General Description of Preliminary EIA of the Projects and Mitigation, Abatement Measures

The Preliminary EIA of the proposed river improvement, retention ponds, and diversion channel has been carried by the USM research team following the guidelines laid down in the EIA handbook published by the Department of Environment, Ministry of Science, Technology and Environment, Malaysia. The physicochemical, biological, public health and safety, socioeconomic, aesthetic and cultural components of the environment have been examined.

1) River Improvement

The impacts of the river improvement are generated mainly during the construction phase. Some physicochemical and biological impacts may be considered, however, they are relatively minor things.

A great amount of earth and mud to be removed for river widening and deepening would generate a certain impact. However, the earth and mud would be utilized for land reclamation projects and would be considered as being a mutually beneficial solution.

The biological impacts are mainly in the changes to the riparian flora and fauna. However, the riparian vegetation is common types of grass without any particular value. The same thing can be said for the aquatic fauna.

The landscaping of the river corridor as a provision for the riverside park will be beneficial for enhancing and rehabilitating the aesthetical value of the riverine environment in the urban areas.

For acquiring the river reserve space to widen the river channel, the need for the compensation and relocation of many of the houses and buildings built right up to the river banks would have some serious impacts. This matter might be coordinated by government authorities and the concerned municipal council to come up with a relevant solution.

2) Dondang Retention Ponds

The use of heavy machinery for the earth works, that will have a short teme impact on nearby residents as a result of the noise, visual instruction, and earth moving. The transportating of excavated earth should be done during non-peak hours.

At the 30-year return period, the sediment load of the flood water may be high and this would settle at the bottom of the ponds.

During the construction phase, the site clearance and earth work will have a drastic impact on the existing

vegetation, such as grass, wayside plants; the inherent natural soil will be destroyed. However, no wild life or any endangered species are involved here. Soil erosion will appear after the earth works. Suitable mitigation measures and prompt revegetation of the exposed earth are to be adopted.

The retention pond spaces are to be landscaped and will be utilized for sports and recreational purposes. Also, the scenic improvement made to the environs will be appreciated by the area residents. Of course, if a flood having a 30-year return period occurs, the retention pond spaces will be placed off limits.

3) Diversion Channel

The impact related to the construction of box culverts, such as noise and dust problems, are usually unavoidable. The excavation also affects the root systems of roadside trees. Royal palms have a shallow and fibrous root systems and the old angsana trees have a tap fibrous root systems; the main roots of these trees are likely to be affected. Branches trimming may be required to maintain a balance with the roots.

The traffic flow, hawkers and commercial establishment and existence of two schools are the problems for the construction impacts along the Jln. Gottieb. Rather heavy traffic congestion and flow are generated for the school students, commercial activities and the hawkers clients at night time.

There would be a need to phase the construction in such a way as to allow for some traffic flow. Adequate sidewalks, along with adequate safety measures, would be needed to handle the pedestrian flow that includes students, and the handicapped.

The possible mitigation measure for the hawkers activities would be temporary relocation of the hawkers site incorporate construction phasing or something more permanent relocation to the hawkers complex in accordance with administrative guideline by the public authority.

4) Retention Ponds for the Urban Drainage

The construction of the retention ponds probably will have some short-term impacts, such as by visual instructions and by dust and noise problems, on the local community. However, the construction sites are at the coast line away from residential areas, these impacts will have no serious affects.

During the operation phase, the ponds will receive drainage water and run-off from urban areas. If the water in these ponds were permanently overtopped by organic loads, odour problem would develop. However, in a dry

condition, the odours emanating from the ponds would probably diminish somewhat.

The mitigation measures to be taken in an effort, to improve the quality of the water is a complex problem, one related to hygiene and public health. Rubbish screening, discharging pond waters on regular basis, and pond monitoring are some means for mitigating the problem.

Figures

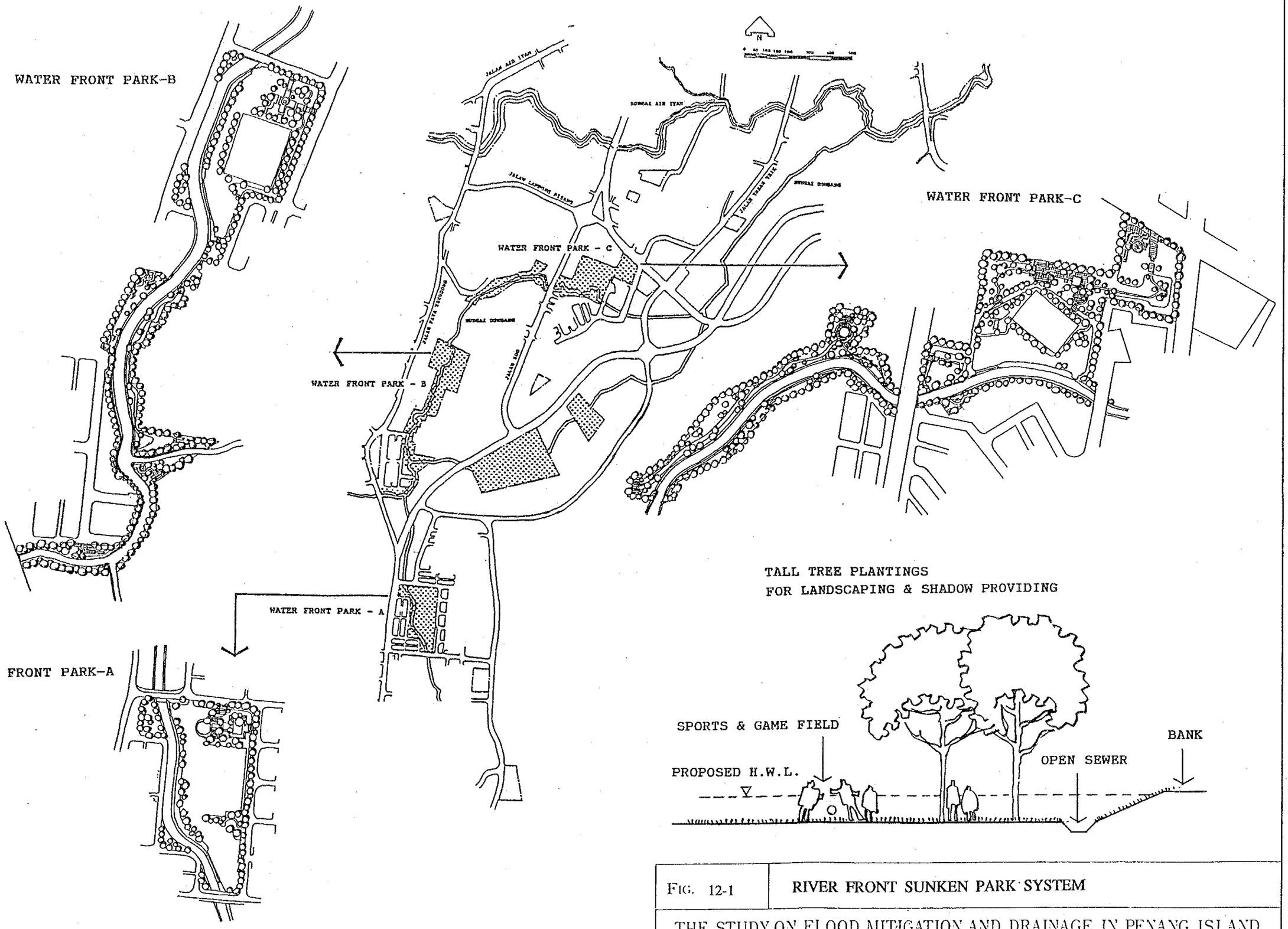
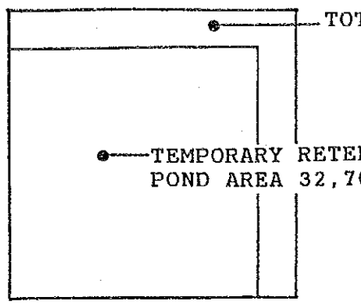
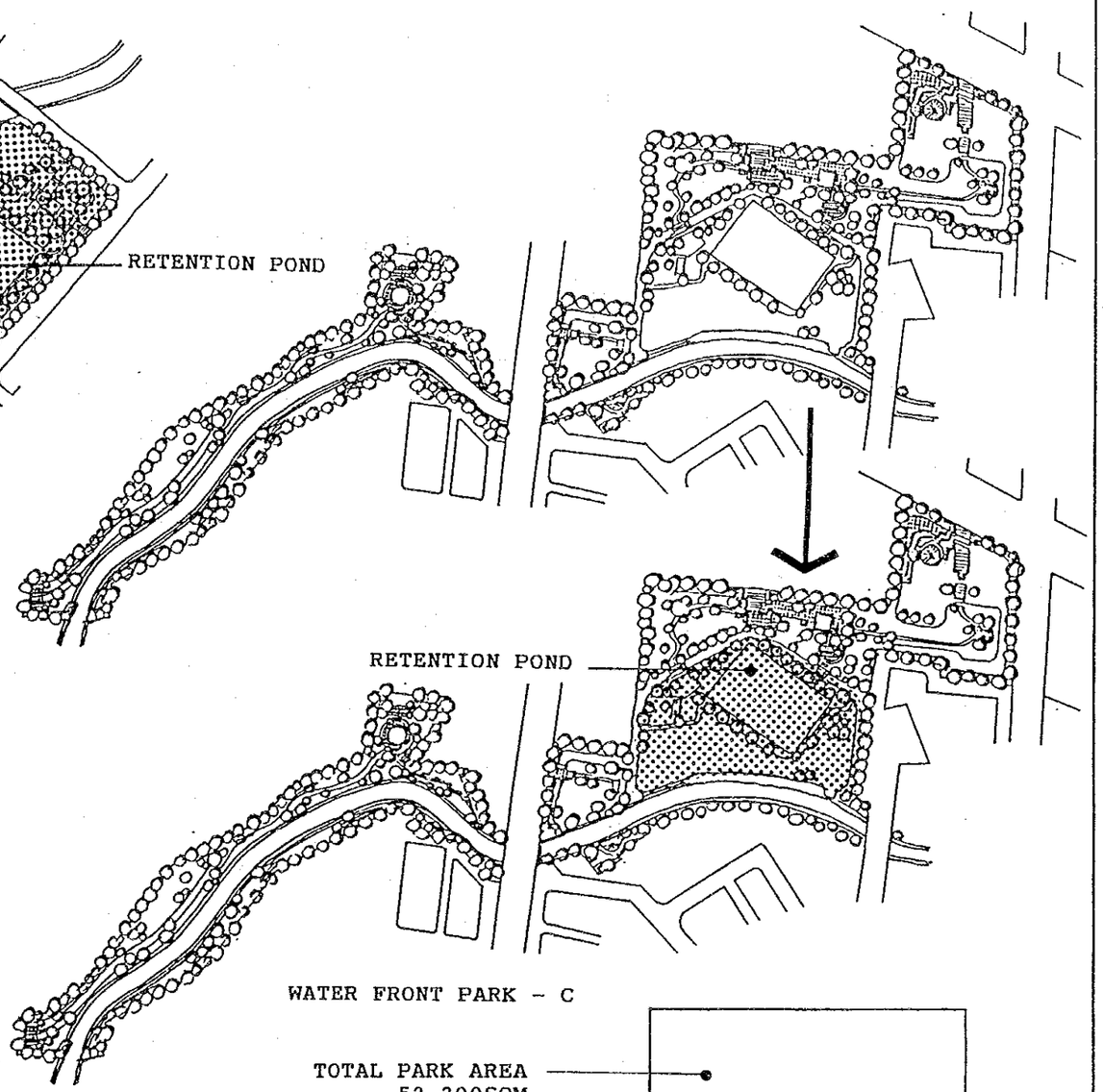


FIG. 12-1 RIVER FRONT SUNKEN PARK SYSTEM

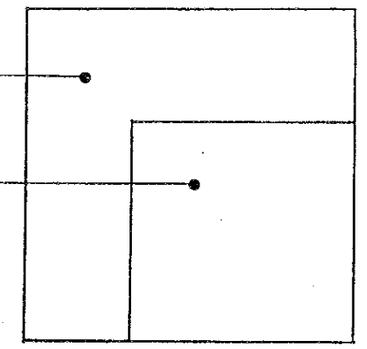
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

WATER FRONT PARK - B

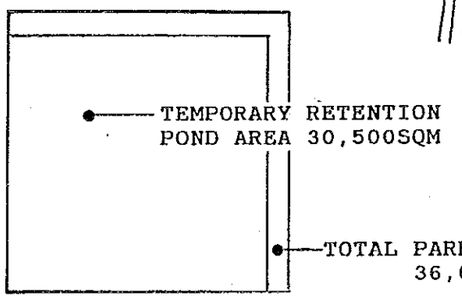


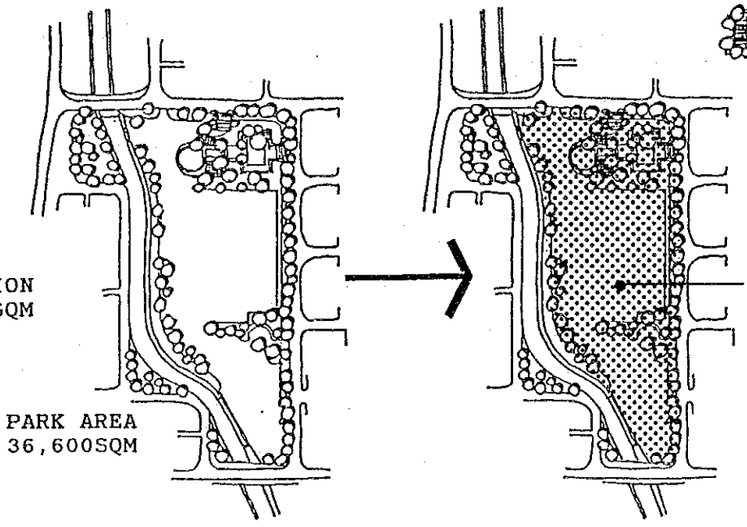


WATER FRONT PARK - C



WATER FRONT PARK - A





Note: Shadow portion shows temporary retention pond at 30 year return period.

FIG. 12-2 TEMPORARY RETENTION PONDS AND MULTI-USE WATER FRONT PARKS

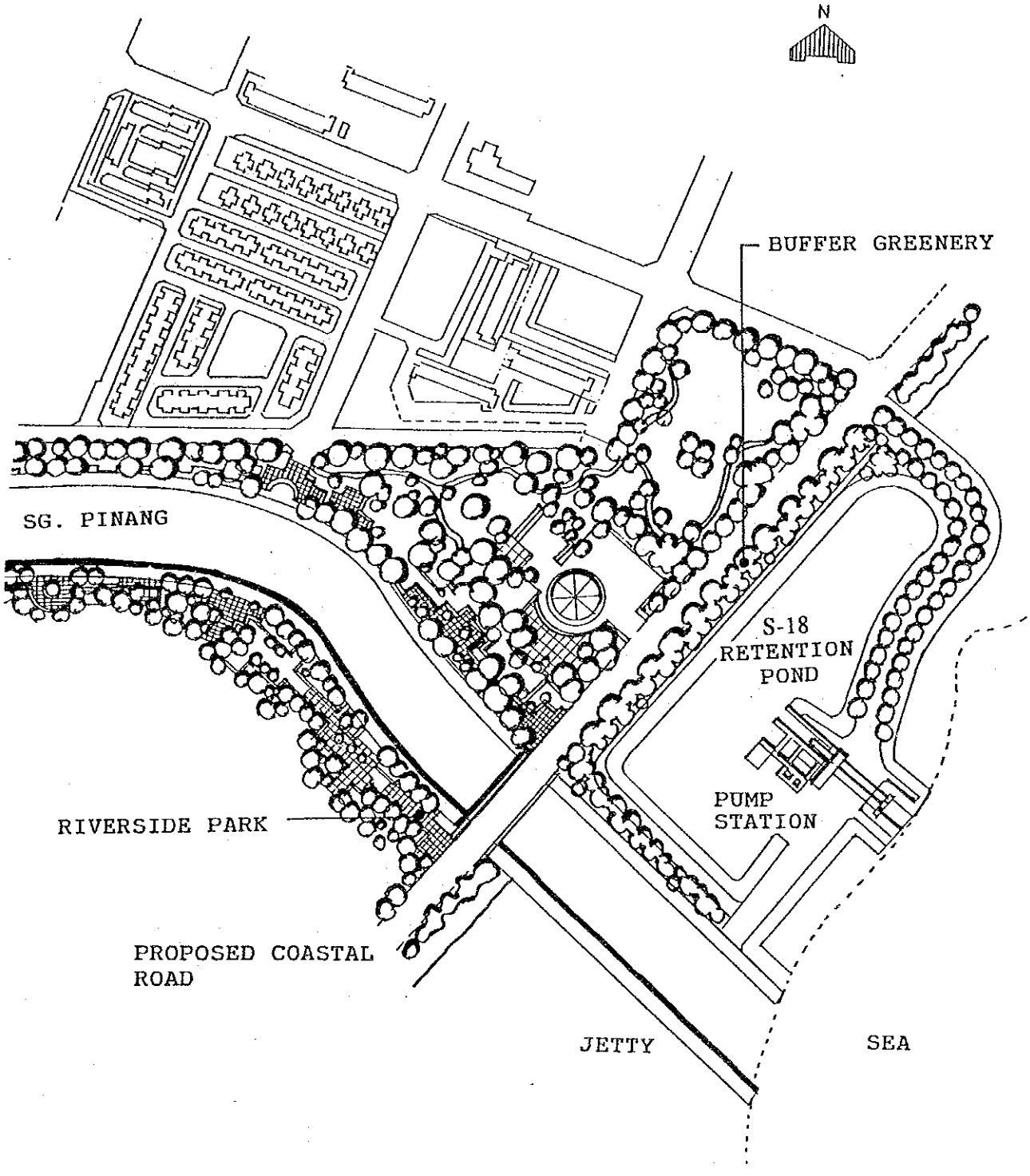


FIG. 12-3 RETENTION POND FOR URBAN DRAINAGE

Chapter 13 EVALUATION OF URGENT FLOOD MITIGATION AND DRAINAGE PROJECTS

CHAPTER 13 EVALUATION OF URGENT FLOOD MITIGATION AND DRAINAGE PROJECTS

13.1 ECONOMIC EVALUATION

This economic evaluation aims at assessing the investment efficiency of the three urgent projects identified in the Master Plan.

Three urgent projects are as follows:

- Sg. Pinang Flood Mitigation Project
- Sg. Keluang Flood Mitigation Project
- Georgetown Drainage Project (Zone N-12, S-10, and S-18)

Among these three projects, Sg. Pinang project area includes Georgetown Drainage project area.

In this common flood prone area, the flooding problems can not be solved by the sole project and the effect of flood mitigation or drainage project would be achieved only after implementing together these two projects.

Hence, for the economic evaluation, these two projects were also evaluated as one project.

The framework of evaluation method itself is the same as that for the Master Plan study. However, there are two major differences: first is the enlargement of benefit item coverage, and second is accuracy in cost estimation.

13.1.1 Economic Construction Cost

1) Conversion Factor

Project costs at 1990 market prices for each urgent project are shown in Tables L.6-3, L.6-4 and L.6-5 in APPENDIX L.

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

Conversion factors of every cost item are selected from "National Parameters for Project Appraisal in Malaysia, 1988" and presented as follows:

Cost Item	Conversion Factor
Direct Construction Cost	0.91
Land Acquisition & Compensation	0.88
Government Administration	0.82
Contingency	0.88

2) Economic Construction Cost

The project cost was divided into domestic and foreign portion in accordance with the availability of the materials in Malaysian boundary.

Domestic portion of the cost at the market was converted into economic cost by means of the above mentioned conversion factors. Foreign portion was used as economic cost without any modification. Exchange rate at August 1990 was used.

Economic costs of the three urgent projects are shown in Table 13-1 and summarized as follows:

(unit; Million M$)

Project	Economic Cost
Sg. Pinang Flood Mitigation	112,072
Sg. Keluang Flood Mitigation	33,343
Georgetown Drainage	32,544

The foreign exchange rate was adopted as below to convert to US$ and Japanese Yen.

One (1) US$ = M$ 2.70 = Yen 140.0

3) Operation, Maintenance and Replacement Costs

The annual operation and maintenance cost was estimated to be 1% of economic construction cost and summarized as follows:

(unit: 1000 M$)

	O/M Cost	Replacement Cost (0.91)*1
Sg. Pinang	1121	90 (88)*2 every 20 year
Sg. Keluang	333	-
Georgetown Drainage	325	3,000 (2,946) every 15 year

( )*1 : Conversion factor ( )*2 : Economic Cost

Enrollment is expected to start from the first year after the completion of construction works.

As for the replacement cost, facilities such as gates, pumping equipments, and trash racks are assumed to be replaced by new ones at the same prices as the present level every 15 or 20 years after completion of construction. The replacement cost for each urgent project is also shown above.

13.1.2 Economic Benefit

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

The following benefits were estimated in monetary terms:

i) Reduction of general property damage

ii) Reduction of public property damage

iii) Reduction of indirect damage

These flood damage potentials by damage item and flood frequency for each project are shown in Table 13-2-1 through 13-2-3 and summarized in Table 13-3.

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

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

Where,
- D : Average annual damage
- Nm : Excess probability for discharge level m
- Lm : Amount of probable flood damage at applicable discharge level m
- m : Ordinal number for discharge level corresponding to return period

Average annual flood damage for each urgent projects is as follows:

(unit; Million M$ in 1990 prices)

Project	1990	2010
Sg. Pinang	27.6	30.1
Sg. Keluang	0.4	11.4
Georgetown Drainage	3.4	3.9

13.1.3 Comparison of Costs and Benefits

The economic evaluation of the project was made in terms of the economic internal rate of return (EIRR), net present value (NPV) and benefit-cost ratio (B/C) based on the following assumptions:

- The total economic construction costs were distributed to each year of the construction period according to implementation program (see Table 13-4-1 ~ 13-4-4).
- The project benefits are assumed to be realized 5 years after the beginning of the project implementation in 1996.
- Enrollment of the annual operation and maintenance costs is expected to start from the first year (1996) after the completion of construction works.
- The benefit increases exponentially between 1990 to 2010 and remains constant after 2010.
- Opportunity cost of capital is 8%.
- Social discount rate is 8%.

Cash flows of economic costs and benefits are shown in Table 13-4-1 through 13-4-4.

The results of evaluation are as follows:

Project	EIRR (%)	NPV (1000 M$)	B/C
Sg. Pinang	17.5	132,212	2.34
Sg. Keluang	14.6	33,829	2.15
Georgetown Drainage	8.6	1,713	1.06
Sg. Pinang & G/T Drainage	16.0	133,925	2.06

As shown in the above table, all urgent projects are judged feasible because;

- The economic internal rate of return of each project shows a higher level than the opportunity cost of capital (=8%).
- The other two evaluation indicators also approve of the implementation of the projects.

13.1.4 Sensitivity Analysis

Results of the cost benefit comparison were assessed based on different assumptions of benefits and costs in order to measure the impacts of unexpected changes in benefits and costs on the investment efficiency.

In this study, benefits are assumed to fall down as much as 80% of the original level, while costs increase up to 120%. Changes in economic internal rate of return are shown in Table 13-5 and summarized as follows:

Project Title	Cost 20% up	Benefit 20% down	Cost 20% up and Benefit 20% down
Sg. Pinang Project	15.1	14.6	12.4
Sg. Keluang Project	12.8	12.5	10.9
Georgetown Drainage Project	6.8	6.4	4.8
Sg. Pinang & G/T Drainage Project	13.7	13.2	11.1

Results show that two flood mitigation projects are feasible even in the possible worst case with costs 20% higher than the original and benefits 20% less than original. While, in the case of evaluation for sole drainage project, the investment efficiency goes down lower than the opportunity cost of capital.

However, as described before, this drainage project should be evaluated together with Sg. Pinang Flood Mitigation project.

Furthermore, besides this damage reduction benefit, although not estimate in monetary terms in this report, Georgetown Drainage project generates the benefits as follows:

i) In the study area, there exist lowlying areas which are affected by high tides. During the high tides (about 2 weeks per month), extremely polluted water stagnates in the drains including domestic waste, catering industry waste and garbage disposal. These aggravated conditions are expected to be greatly improved by implementation of drainage works.

ii) Drainage project areas are included in the city centre and very valuable zone as a commercial, business and tourist area. In such area, improvement of sanitary condition generates enormous intangible merits.

Finaly, it is concluded that three flood mitigation and drainage projects are all feasible and their implementation are recommended.

13.2 SOCIAL IMPACTS

First, these projects can contribute to the removal of development constraints in the future. Floods generally interrupt traffic and makes it difficult to affects deliveries for the manufacturing sector. In some cases, their production schedules might be changed because of a flood. It is also anticipated that, without the project, future investment might be depressed. The projects can remove these development constraints.

Secondly, the projects can contribute to an improvement of people's public health and amenity. It is obvious that floodings, especially in the town area, cause disease epidemics and aggravate living amenity. In addition, it also gives other an unfavorable impression of the town, especially to foreign tourists. These flood drawback should be removed and agreeable living environment should be guaranteed by the projects.

Thirdly, implementation of the flood mitigation and drainage projects will effectively contribute to the

inhabitants' endorsement of the government investment policy. The interview survey makes it clear that the Drainage System Improvement Project ranks at the top of the project list in so far as the people of Penang Island are concerned. Priority preference is given to the projects listed below:

Top preference:	drainage system improvement
2nd preference:	sewage system improvement
3rd preference:	housing development
4th preference:	river/sea water purification
5th preference:	road network and traffic improvement
6th preference:	public transport system improvement

13.3 CONCLUSION

It is concluded that the three urgent projects are all feasible and their implementation are recommended.

The reason for this lies in the fact that the evaluation indicators of the three projects are higher than the opportunity cost of capital and the proposed flood mitigation and drainage projects will lead to the improvement of social welfare and will confirm opportunities for further economic development.

Tables

TABLE 13-1 ANNUAL DISBURSEMENT SCHEDULE OF ECONOMIC COST

(Sg. Pinang)
(Unit: 1000 M$)

Cost Items		Amount	1991	1992	1993	1994	1995
1. Direct Cost	F.C	19,040	0	0	7,616	5,712	5,712
	L.C	7,853	0	0	3,141	2,356	2,356
	Total	26,893	0	0	10,757	8,068	8,068
2. Land Acquisition & House Evacuation Costs	F.C	0	0	0	0	0	0
	L.C	66,836	0	33,418	33,418	0	0
	Total	66,836	0	33,418	33,418	0	0
3. Administration Cost	F.C	0	0	0	0	0	0
	L.C	1,132	226	226	226	226	226
	Total	1,132	226	226	226	226	226
4. Engineering Services Cost	F.C	1,901	475	475	317	317	317
	L.C	704	176	176	117	117	117
	Total	2,605	651	651	434	434	434
5. Physical Contingency	F.C	3,140	71	71	1,190	904	904
	L.C	11,466	70	5,078	5,524	397	397
	Total	14,606	141	5,149	6,714	1,301	1,301
Grand Total	F.C	24,081	546	546	9,123	6,933	6,933
	L.C	87,991	473	38,898	42,427	3,096	3,096
	Total	112,072	1,019	39,444	51,550	10,029	10,029

(Sg. Keluang)
(Unit: 1000 M$)

Cost Items		Amount	1991	1992	1993	1994	1995
1. Direct Cost	F.C	6,070	0	0	2,428	1,821	1,821
	L.C	2,457	0	0	983	737	737
	Total	8,527	0	0	3,411	2,558	2,558
2. Land Acquisition & House Evacuation Costs	F.C	0	0	0	0	0	0
	L.C	19,281	0	9,640	9,640	0	0
	Total	19,281	0	9,640	9,640	0	0
3. Administration Cost	F.C	0	0	0	0	0	0
	L.C	361	72	72	72	72	72
	Total	361	72	72	72	72	72
4. Engineering Services Cost	F.C	612	153	153	102	102	102
	L.C	222	56	56	37	37	37
	Total	834	209	209	139	139	139
5. Physical Contingency	F.C	999	22	22	379	288	288
	L.C	3,341	20	1,467	1,606	124	124
	Total	4,340	42	1,489	1,985	412	412
Grand Total	F.C	7,681	175	175	2,909	2,211	2,211
	L.C	25,662	148	11,235	12,338	970	970
	Total	33,343	323	11,410	15,247	3,181	3,181

(Georgetown Drainage)
(Unit: 1000 M$)

Cost Items		Amount	1991	1992	1993	1994	1995
1. Direct Cost	F.C	17,090	0	0	6,836	5,127	5,127
	L.C	7,271	0	0	2,908	2,181	2,181
	Total	24,361	0	0	9,744	7,308	7,308
2. Land Acquisition & House Evacuation Costs	F.C	0	0	0	0	0	0
	L.C	554	0	277	277	0	0
	Total	554	0	277	277	0	0
3. Administration Cost	F.C	0	0	0	0	0	0
	L.C	1,033	207	207	207	207	207
	Total	1,033	207	207	207	207	207
4. Engineering Services Cost	F.C	1,711	428	428	285	285	285
	L.C	655	164	164	109	109	109
	Total	2,366	592	592	394	394	394
5. Physical Contingency	F.C	2,820	64	64	1,068	812	812
	L.C	1,409	60	101	514	367	367
	Total	4,229	124	165	1,582	1,179	1,179
Grand Total	F.C	21,621	492	492	8,189	6,224	6,224
	L.C	10,923	430	749	4,015	2,864	2,864
	Total	32,544	922	1,241	12,204	9,088	9,088

TABLE 13-2-1 FLOOD DAMAGE POTENTIAL BY DAMAGE ITEM AND FLOOD FREQUENCY (SG. PINANG)

(unit: million M$ in 1990 Prices)

Damage Item	1990						2010					
	1/1.1	1/5	1/10	1/30	1/50	1/100	1/1.1	1/5	1/10	1/30	1/50	1/100
A. General Property												
(1) Houses	0.4	1.2	11.6	33.0	47.9	63.9	0.4	1.3	11.9	38.2	55.2	73.9
(2) Household Articles	0.6	1.8	8.9	27.3	45.7	69.2	0.6	1.9	9.3	31.4	51.9	78.7
(3) Commercial Assets	0.4	1.3	7.2	15.3	19.2	22.7	0.4	1.3	13.2	18.0	22.6	26.6
(4) Commercial Stocks	0.6	2.0	10.6	22.4	28.2	33.2	0.7	2.1	11.1	26.3	33.1	39.0
Sub-total	2.1	6.2	38.2	98.0	141.1	189.1	2.2	6.6	45.5	113.8	163.0	218.3
B. Public Property												
(1) Road	3.8	11.6	50.6	89.7	105.3	113.2	3.8	11.6	50.6	89.7	105.3	113.2
(2) Bridge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(3) Electricity Facility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(4) Telecomm. Facility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(5) School,Hospital	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(6) Gov. Building Facility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total	3.8	11.6	50.6	89.7	105.3	113.2	3.8	11.6	50.6	89.7	105.3	113.2
C. Agricultural Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D. Income/Sale Loss												
(1) Shop Revenue	0.0	0.1	0.5	0.9	1.1	1.2	0.1	0.2	0.8	1.4	1.7	1.8
(2) Factory Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(3) Bus Services	0.1	0.2	0.7	1.3	1.5	1.7	0.1	0.2	1.1	2.0	2.4	2.6
(4) Taxi Services	0.1	0.2	0.7	1.3	1.5	1.7	0.1	0.2	1.1	2.0	2.3	2.5
(5) Trishaw Services	0.1	0.2	1.0	1.9	2.2	2.4	0.1	0.3	1.5	2.8	3.3	3.5
Sub-total	0.2	0.7	3.1	5.5	6.5	6.9	0.3	1.0	4.6	8.2	9.6	10.3
E. Vehicle's Running Cost												
(1) Operating Cost	0.0	0.1	0.3	0.6	0.7	0.7	0.0	0.1	0.5	0.9	1.0	1.1
(2) Time Cost	0.2	0.6	2.7	4.9	5.7	6.1	0.3	0.9	4.1	7.3	8.7	9.3
Sub-total	0.2	0.7	3.1	5.5	6.4	6.9	0.3	1.0	4.6	8.3	9.7	10.4
Grand Total	6.4	19.1	94.9	198.7	259.1	316.1	6.7	20.2	105.4	219.9	287.4	352.2

Remarks; Flood damage potentials of 'General Property' for 1.1-year return flood are estimated based on flood prone area in proportion with that for 5-year return flood.

TABLE 13-2-2 FLOOD DAMAGE POTENTIAL BY DAMAGE ITEM AND FLOOD FREQUENCY (SG. KELUANG)

(unit; million M$ in 1990 Prices)

Damage Item	1990						2010					
	1/1.1	1/5	1/10	1/30	1/50	1/100	1/1.1	1/5	1/10	1/30	1/50	1/100
A. General Property												
(1) Houses	0.0	0.0	0.1	0.3	1.4	2.2	1.0	3.1	5.1	7.0	11.8	13.1
(2) Household Articles	0.1	0.2	0.5	0.8	2.2	3.3	2.6	7.7	12.7	17.6	29.4	32.1
(3) Commercial Assets	0.0	0.1	0.2	0.4	1.0	1.3	0.4	1.1	3.8	2.6	4.7	5.4
(4) Commercial Stocks	0.0	0.1	0.2	0.3	0.8	1.0	0.3	0.9	1.4	2.2	3.9	4.3
Sub-total	0.1	0.4	0.9	1.9	5.6	7.8	4.3	12.9	23.0	29.4	49.8	55.0
B. Public Property												
(1) Road	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	4.4	7.7	9.1	9.8
(2) Bridge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(3) Electricity Facility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(4) Telecomm. Facility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(5) School,Hospital	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(6) Gov. Building Facility	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	4.4	7.7	9.1	9.8
C. Agricultural Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D. Income/Sale Loss												
(1) Shop Revenue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(2) Factory Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(3) Bus Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(4) Taxi Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(5) Trishaw Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E. Vehicle's Running Cost												
(1) Operating Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(2) Time Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grand Total	0.1	0.4	0.9	1.9	5.6	7.8	4.7	13.9	27.4	37.2	58.9	64.8

Remarks; Flood damage potentials of 'General Property' for 1.1-year return flood are estimated based on flood prone area in proportion with that for 5-year return flood.

TABLE 13-2-3 FLOOD DAMAGE POTENTIAL BY DAMAGE ITEM AND FLOOD FREQUENCY
(GEORGETOWN DRAINAGE)

(unit: million M$ in 1990 Prices)

Damage Item	1990			2010		
	1/1.1	1/5	1/10	1/1.1	1/5	1/10
A. General Property						
(1) Houses	0.1	0.4	2.4	0.1	0.4	2.5
(2) Household Articles	0.2	0.6	2.7	0.2	0.6	2.8
(3) Commercial Assets	0.1	0.4	1.3	0.2	0.5	1.0
(4) Commercial Stocks	0.2	0.6	1.9	0.2	0.7	2.1
Sub-total	0.7	2.2	8.3	0.7	2.3	8.4
B. Public Property						
(1) Road	0.4	1.1	5.1	0.4	1.1	5.1
(2) Bridge	0.0	0.0	0.0	0.0	0.0	0.0
(3) Electricity Facility	0.0	0.0	0.0	0.0	0.0	0.0
(4) Telecomm. Facility	0.0	0.0	0.0	0.0	0.0	0.0
(5) School,Hospital	0.0	0.0	0.0	0.0	0.0	0.0
(6) Gov. Building Facility	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total	0.4	1.1	5.1	0.4	1.1	5.1
C. Agricultural Products	0.0	0.0	0.0	0.0	0.0	0.0
D. Income/Sale Loss						
(1) Shop Revenue	0.0	0.0	0.2	0.0	0.1	0.3
(2) Factory Production	0.0	0.0	0.0	0.0	0.0	0.0
(3) Bus Services	0.1	0.2	0.7	0.1	0.2	1.1
(4) Taxi Services	0.1	0.2	0.7	0.1	0.2	1.1
(5) Trishaw Services	0.1	0.2	1.0	0.1	0.3	1.5
Sub-total	0.2	0.6	2.8	0.3	0.9	4.1
E. Vehicle's Running Cost						
(1) Operating Cost	0.0	0.1	0.3	0.0	0.1	0.5
(2) Time Cost	0.2	0.6	2.7	0.3	0.9	4.1
Sub-total	0.2	0.7	3.1	0.3	1.0	4.6
Grand Total	1.5	4.6	19.1	1.8	5.4	22.2

Remarks; Flood damage potentials of 'General Property' for 1.1-year return flood are estimated based on flood prone area in proportion with that for 5-year return flood.

TABLE 13-3 FLOOD DAMAGE POTENTIAL BY FLOOD FREQUENCY

(Sg. Pinang)
(unit: million M$ in 1990 Prices)

Year	1.1-year Return Flood	5-year Return Flood	10-year Return Flood	30-year Return Flood	50-year Return Flood	Annual Average Flood Damage Potential
1990	6.4	19.1	94.9	198.7	259.1	27.6
2010	6.7	20.2	105.4	219.9	287.4	30.1

(Sg. Keluang)
(unit; million M$ in 1990 Prices)

Year	1.1-year Return Flood	5-year Return Flood	10-year Return Flood	30-year Return Flood	50-year Return Flood	Annual Average Flood Damage Potential
1990	0.1	0.4	0.9	1.9	5.6	0.4
2010	4.7	13.9	27.4	37.2	58.9	11.4

(Georgetown Drainage)
(unit: million M$ in 1990 Prices)

Year	1.1-year Return Flood	5-year Return Flood	10-year Return Flood	Annual Average Flood Damage Potential
1990	1.5	4.6	19.1	3.4
2010	1.8	5.4	22.2	3.9

TABLE 13-4-1 FLOWS OF ECONOMIC COST AND BENEFIT (SG. PINANG)

0.08 (Unit: 1000 M$ in 1990 Prices)

Year	Costs									Economic Benefits	Balance
	Economic Construction Cost						Maintenance Cost	Replacement Cost	Total Costs		
	Direct Cost	Land Acqu. & House Evacuation	Admini. Cost	Engineering Services Cost	Physical Contingency	Sub-total	1%			27578	
1990	0	0	0	0	0	0	0		0	0	0
1991	0	0	226	651	141	1,019	0		1,019	0	-1,019
1992	0	33,418	226	651	5,149	39,444	0		39,444	0	-39,444
1993	10,757	33,418	226	434	6,714	51,550	0		51,550	0	-51,550
1994	8,068	0	226	434	1,301	10,029	0		10,029	0	-10,029
1995	8,068	0	226	434	1,301	10,029	0		10,029	0	-10,029
1996							1,121		1,121	28,321	27,200
1997							1,121		1,121	28,445	27,324
1998							1,121		1,121	28,569	27,448
1999							1,121		1,121	28,692	27,572
2000							1,121		1,121	28,816	27,696
2001							1,121		1,121	28,940	27,819
2002							1,121		1,121	29,064	27,943
2003							1,121		1,121	29,188	28,067
2004							1,121		1,121	29,312	28,191
2005							1,121		1,121	29,435	28,315
2006							1,121		1,121	29,559	28,439
2007							1,121		1,121	29,683	28,562
2008							1,121		1,121	29,807	28,686
2009							1,121		1,121	29,931	28,810
2010							1,121		1,121	30,055	28,934
2011							1,121		1,121	30,055	28,934
2012							1,121		1,121	30,055	28,934
2013							1,121		1,121	30,055	28,934
2014							1,121		1,121	30,055	28,934
2015							1,121	88	1,208	30,055	28,846
2016							1,121		1,121	30,055	28,934
2017							1,121		1,121	30,055	28,934
2018							1,121		1,121	30,055	28,934
2019							1,121		1,121	30,055	28,934
2020							1,121		1,121	30,055	28,934
2021							1,121		1,121	30,055	28,934
2022							1,121		1,121	30,055	28,934
2023							1,121		1,121	30,055	28,934
2024							1,121		1,121	30,055	28,934
2025							1,121		1,121	30,055	28,934
2026							1,121		1,121	30,055	28,934
2027							1,121		1,121	30,055	28,934
2028							1,121		1,121	30,055	28,934
2029							1,121		1,121	30,055	28,934
Total	26,893	66,836	1,132	2,605	14,606	112,072	38,104	88	150,264	1,008,854	858,590
PV=	19,961	55,179	904	2,121	11,716	89,880	8,838	13	98,731	230,943	132,212
										EIRR=	17.5%
										B/C =	2.34

TABLE 13-4-2 FLOWS OF ECONOMIC COST AND BENEFIT (SG. KELUANG)

0.08 (Unit: 1000 M$ in 1990 Prices)

Year	Costs								Total Costs	Economic Benefits	Balance
	Economic Construction Cost						Maintenance Cost	Replacement Cost			
	Direct Cost	Land Acqu. & House Evacuation	Admini. Cost	Engineering Services Cost	Physical Contingency	Sub-total	1%			392	
1990	0	0	0	0	0	0	0		0	0	0
1991	0	0	72	209	42	323	0		323	0	-323
1992	0	9,640	72	209	1,489	11,410	0		11,410	0	-11,410
1993	3,411	9,640	72	139	1,985	15,247	0		15,247	0	-15,247
1994	2,558	0	72	139	412	3,181	0		3,181	0	-3,181
1995	2,558	0	72	139	412	3,181	0		3,181	0	-3,181
1996							333		333	3,706	3,372
1997							333		333	4,258	3,924
1998							333		333	4,810	4,477
1999							333		333	5,362	5,029
2000							333		333	5,914	5,581
2001							333		333	6,467	6,133
2002							333		333	7,019	6,685
2003							333		333	7,571	7,238
2004							333		333	8,123	7,790
2005							333		333	8,675	8,342
2006							333		333	9,228	8,894
2007							333		333	9,780	9,446
2008							333		333	10,332	9,999
2009							333		333	10,884	10,551
2010							333		333	11,436	11,103
2011							333		333	11,436	11,103
2012							333		333	11,436	11,103
2013							333		333	11,436	11,103
2014							333		333	11,436	11,103
2015							333		333	11,436	11,103
2016							333		333	11,436	11,103
2017							333		333	11,436	11,103
2018							333		333	11,436	11,103
2019							333		333	11,436	11,103
2020							333		333	11,436	11,103
2021							333		333	11,436	11,103
2022							333		333	11,436	11,103
2023							333		333	11,436	11,103
2024							333		333	11,436	11,103
2025							333		333	11,436	11,103
2026							333		333	11,436	11,103
2027							333		333	11,436	11,103
2028							333		333	11,436	11,103
2029							333		333	11,436	11,103
Total	8,527	19,281	361	834	4,340	33,343	11,337	0	44,680	330,859	286,179
PV=	6,329	15,918	288	679	3,475	26,689	2,629	0	29,318	63,147	33,829
										EIRR=	14.6%
										B/C =	2.15

TABLE 13-4-3 FLOWS OF ECONOMIC COST AND BENEFIT (GEORGETOWN DRAINAGE)

0.08 (Unit: 1000 M$ in 1990 Prices)

Year	Costs									Economic Benefits	Balance
	Economic Construction Cost						Maintenance Cost	Replacement Cost	Total Costs		
	Direct Cost	Land Acqu. & House Evacuation	Admini. Cost	Engineering Services Cost	Physical Contingency	Sub-total	1%			3354	
1990	0	0	0	0	0	0	0		0	0	0
1991	0	0	207	592	124	922	0		922	0	-922
1992	0	277	207	592	165	1,241	0		1,241	0	-1,241
1993	9,744	277	207	394	1,582	12,204	0		12,204	0	-12,204
1994	7,308	0	207	394	1,179	9,088	0		9,088	0	-9,088
1995	7,308	0	207	394	1,179	9,088	0		9,088	0	-9,088
1996							325		325	3,527	3,201
1997							325		325	3,556	3,230
1998							325		325	3,584	3,259
1999							325		325	3,613	3,288
2000							325		325	3,642	3,317
2001							325		325	3,671	3,345
2002							325		325	3,700	3,374
2003							325		325	3,728	3,403
2004							325		325	3,757	3,432
2005							325		325	3,786	3,461
2006							325		325	3,815	3,489
2007							325		325	3,844	3,518
2008							325		325	3,872	3,547
2009							325		325	3,901	3,576
2010							325	2,946	3,271	3,930	659
2011							325		325	3,930	3,605
2012							325		325	3,930	3,605
2013							325		325	3,930	3,605
2014							325		325	3,930	3,605
2015							325		325	3,930	3,605
2016							325		325	3,930	3,605
2017							325		325	3,930	3,605
2018							325		325	3,930	3,605
2019							325		325	3,930	3,605
2020							325		325	3,930	3,605
2021							325		325	3,930	3,605
2022							325		325	3,930	3,605
2023							325		325	3,930	3,605
2024							325		325	3,930	3,605
2025							325	2,946	3,271	3,930	659
2026							325		325	3,930	3,605
2027							325		325	3,930	3,605
2028							325		325	3,930	3,605
2029							325		325	3,930	3,605
Total	24,361	554	1,033	2,366	4,229	32,544	11,065	5,892	49,500	130,597	81,097
PV=	18,081	458	825	1,926	3,181	24,471	2,566	831	27,869	29,581	1,713
										EIRR=	8.6%
										B/C =	1.06

TABLE 13-4-4 FLOWS OF ECONOMIC COST AND BENEFIT (SG. PINANG , GEORGETOWN DRAINAGE)

0.08

(Unit: 1000 M$ in 1990 Prices)

Year	Costs									Economic Benefits	Balance
	Economic Construction Cost						Maintenance Cost	Replacement Cost	Total Costs		
	Direct Cost	Land Acqu. & House Evacuation	Admini. Cost	Engineering Services Cost	Physical Contingency	Sub-total					
										30,932	
1990	0	0	0	0	0	0	0		0	0	0
1991	0	0	433	1,243	265	1,942	0		1,942	0	-1,942
1992	0	33,695	433	1,243	5,314	40,685	0		40,685	0	-40,685
1993	20,502	33,695	433	828	8,296	63,754	0		63,754	0	-63,754
1994	15,376	0	433	828	2,480	19,117	0		19,117	0	-19,117
1995	15,376	0	433	828	2,480	19,117	0		19,117	0	-19,117
1996							1,446		1,446	31,848	30,402
1997							1,446		1,446	32,000	30,554
1998							1,446		1,446	32,153	30,707
1999							1,446		1,446	32,306	30,860
2000							1,446		1,446	32,458	31,012
2001							1,446		1,446	32,611	31,165
2002							1,446		1,446	32,764	31,317
2003							1,446		1,446	32,916	31,470
2004							1,446		1,446	33,069	31,623
2005							1,446		1,446	33,221	31,775
2006							1,446		1,446	33,374	31,928
2007							1,446		1,446	33,527	32,081
2008							1,446		1,446	33,679	32,233
2009							1,446		1,446	33,832	32,386
2010							1,446	2,946	4,392	33,985	29,592
2011							1,446		1,446	33,985	32,538
2012							1,446		1,446	33,985	32,538
2013							1,446		1,446	33,985	32,538
2014							1,446		1,446	33,985	32,538
2015							1,446	88	1,534	33,985	32,451
2016							1,446		1,446	33,985	32,538
2017							1,446		1,446	33,985	32,538
2018							1,446		1,446	33,985	32,538
2019							1,446		1,446	33,985	32,538
2020							1,446		1,446	33,985	32,538
2021							1,446		1,446	33,985	32,538
2022							1,446		1,446	33,985	32,538
2023							1,446		1,446	33,985	32,538
2024							1,446		1,446	33,985	32,538
2025							1,446	2,946	4,392	33,985	29,592
2026							1,446		1,446	33,985	32,538
2027							1,446		1,446	33,985	32,538
2028							1,446		1,446	33,985	32,538
2029							1,446		1,446	33,985	32,538
Total	51,254	67,390	2,165	4,972	18,834	144,615	49,169	5,980	199,764	1,139,451	939,686
PV=	38,042	55,637	1,729	4,047	14,897	114,351	11,404	844	126,600	260,525	133,925
										EIRR=	16.0%
										B/C =	2.06

TABLE 13-5 SUMMARY OF SENSITIVITY TESTS

Project Title		Economic Internal Rate of Return									
		Cost				Benefit				Cost 15% up Benefit 15% down	Cost 20% up Benefit 20% down
		5% up	10% up	15% up	20% up	5% down	10% down	15% down	20% down		
Sg. Pinang Flood Mitigation Project	EIRR	16.8	16.2	15.6	15.1	16.8	16.0	15.3	14.6	13.6	12.4
	B/C	2.23	2.13	2.03	1.95	2.22	2.11	1.99	1.87	1.73	1.56
Sg. Keluang Flood Mitigation Project	EIRR	14.1	13.6	13.2	12.8	14.1	13.5	13.0	12.5	11.8	10.9
	B/C	2.05	1.96	1.87	1.79	2.05	1.94	1.83	1.72	1.59	1.44
Georgetown Drainage Project	EIRR	8.1	7.6	7.2	6.8	8.1	7.5	7.0	6.4	5.7	4.8
	B/C	1.01	0.96	0.92	0.88	1.01	0.96	0.90	0.85	0.78	0.71
Sg. Pinang Flood Mitigation & Georgetown Drainage Project	EIRR	15.3	14.7	14.2	13.7	15.3	14.6	13.9	13.2	12.3	11.1
	B/C	1.96	1.87	1.79	1.71	1.95	1.85	1.75	1.65	1.52	1.37

Chapter 14 WATER QUALITY IMPROVEMENT

CHAPTER 14 WATER QUALITY IMPROVEMENT

14.1 INTRODUCTION

As severe pollution conditions of the rivers in the Study area were recognized during the formulation stage of the project, the study on river water quality was added to the original scope of work for the flood mitigation and drainage study.

In the Study, the water quality analysis and data/information collection for river water and pollution sources were conducted to identify river water conditions and to analyses the causes of the pollution. Regarding river water conditions, the results of the study have been mentioned in the previous section of this report.

In this section, the results of the pollution analysis, which identifies the major sources of the present river pollution, will be summarized and the improvement of water quality will be discussed.

14.2 POLLUTANT SOURCES

In the Study, pollutant sources were classified into the following categories and the amount of pollutant load from each source was estimated from the existing data:

- Domestic Waste
- Industrial Waste
- Livestock Waste (Pig Farming)
- Catering Industry Waste
- Garbage Disposal

14.2.1 Domestic Waste

Domestic waste is wastewater originating from daily human activities, such as the discharges from kitchen, laundries, and toilets, and from cleaning and bathing. The amount of the pollution load from domestic waste to rivers varies depending on the disposal system. Presently, the systems shown below are being used to dispose of domestic waste from each home in Penang Island. The types of domestic waste disposal and their characteristics are summarized in Table 14-1. The population to be served by each system are estimated as shown in Table 14-2.

(a) Sewer collection
(b) Sewage treatment plant
(c) Individual septic tank
(d) Bucket type toilet
(e) Pour flush toilet

14.2.2 Livestock Waste (Pig Farming)

Pig farming is one of the largest industries in Penang Island, it is also considered to be one of the biggest pollutant sources. During the site observation, severe deterioration of the river water conditions, apparently by discharge from pig farms, were noted and it was found that the wastewater was discharged to the river without proper treatment.

Throughout the island there are more than 600 pig farms having a combined total of about 100,000 pigs. The numbers of pigs in each catchment are summarized in Table 14-2.

14.2.3 Industrial Waste

Factories in Penang Island can be divided into the two groups based on their discharge quantity. The Environmental Quality (Sewage and Industrial Effluents) Regulations defines 60 m^3/day of discharge quantity as a lower limit to which discharge standards will be applicable. There is, however, an exemption for rubber and palm oil industries.

There are 16 factories in the Bayan Lepas Industrial Area and 11 factories outside the Industrial area that discharge large amounts of wastewater. For most of these factories, either the Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 or the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 is applicable. The effluent quality could be controlled by the discharge quality standards.

Many household factories and workshops are located in the Georgetown city area and along the main roads. Although the quantity of individual discharges from such sources are not so large, their combined effect on river water quality may be significant because of their large numbers. However, little data on such small industries was available.

14.2.4 Catering Industry Waste

There are many hawkers and stallholders conducting business on the street. According to the information from the Health Department of MPPP, more than 3500 hawkers are operating throughout the island. 80% of them are concentrated in Georgetown.

Judging from the number of hawkers and their business operations, it is considered that their discharges affect on the water quality of the rivers to quite an extent.

14.3 ESTIMATION OF POLLUTANT LOAD

The pollutant load to each river was calculated from the number of pollutant sources and the unit pollutant load for each source for the purpose of identifying the major pollution sources of each river.

14.3.1 Unit Pollution Load

The unit pollution load used in the calculation are shown below. These values were obtained from technical literature since no survey was conducted during the study to determine the unit pollution load nor was there any relevant data available in the Study area.

(BOD g/cap/day)

Source	Toilet	Others	Total
Domestic	13	61	74
Pig			170

SOURCE: Guideline for the Comprehensive Basin-wide Planning of Sewerage System, JAPAN.

The generated load from domestic waste is reduced by a certain treatment before being discharged into the rivers. The removal efficiency depends upon the type of treatment. In the calculation, the removal ratio shown in Table 14-3 was applied.

The waste from pig farms was assumed to be discharged into rivers without reduction since all the waste generated in the farms was washed out and discharged into the rivers without treatment and the most of the pig farms were located along the river.

14.3.2 Estimated Pollution Load

The estimated pollution load was calculated from the above unit pollution load and the number of pollutant sources in each catchment. The results are shown in Table 14-4. It should be noted that the estimated pollution load does not include the load from sources other than domestic waste and pig farm waste, such as industrial waste, commercial waste, etc., because data on the unit pollution load for such sources was not available. However, it has been found that most river conditions can be described by them as explained in the next section. The estimated BOD load and ratio of domestic and pig farming are illustrated in Fig.14-1 and Fig.14-2.

14.4 CAUSE OF POLLUTION

Fig.14-3 shows a comparison of the actual BOD and the estimated BOD concentration for each river. (The estimated BOD was calculated by using the estimated pollutant load and the river flow which was estimated by assuming the specific run-off to be 0.1 cum/sec/sq·km.)

As can be seen in the figure, water quality conditions of most river can be explained by the estimated pollutant load since the estimated BOD coincides with the actual BOD. Therefore, it is concluded that the existing pollution in most rivers is mainly caused by domestic waste and pig farm waste.

Furthermore, major pollution sources of the extremely polluted rivers and the Sg. Pinang are identified as follows:

Sg. Nibong Kechil:	Pig farm waste
Sg. Nipah:	Pig farm waste
Sg. Gertak Sanggul:	Pig farm waste
Sg. Pinang:	Pig farm and Domestic waste

14.5 CONSIDERATION ON IMPROVEMENT OF RIVER WATER QUALITY

14.5.1 General

Everybody knows that the rivers in Penang Island are polluted. However, not a single person can tell how polluted the rivers are quantitatively or just how much they should be improved.

What is necessary and important, in consideration of the river water quality improvement, is, firstly, to know the existing water quality conditions and, secondary, to establish the goal of the improvement. The policies for achieving the improvement will be determined by selecting optimum measures to economically and technically overcome the difference between the existing and required conditions. Therefore, in general, a comprehensive study, including the following actions, are proposed to consider the water quality improvement of the rivers in Penang Island:

i) Long-term and periodical water quality monitoring should be undertaken. Within the peninsular, side water quality monitoring stations have been established in many rivers and periodical water quality monitoring is being conducted by DOE. Such stations should be established at rivers in Penang Island; at least one station in the Sg. Pinang.

ii) The goal of the water quality improvement should be established considering the uses of the river. The National Water Quality Standards for Malaysia,

(shown in Table 14-5) provides water quality criteria by classes which represent the water uses. Therefore, the improvement goal can be determined by applying the class considering the actual water uses and required the water uses of the rivers in Penang Island.

iii) The pollution analysis should be carried out to describe the relationship between river water quality and pollutant generation in the basin. This will require basic information on pollutant sources by basins, such as the number of pollutant sources, unit pollutant discharges from each source, etc., and water quality data of the rivers, including yearly changes, annual fluctuations, relation to flow rate, etc. As a result of this analysis, the allowable discharge of pollutants to achieve the goal will be calculated.

iv) There are several measures for reducing the existing pollutant generation in the basin to an allowable level. Regulating the pig farm discharge, strengthening the industrial wastewater discharge and domestic wastewater discharge, installation of the central sewerage treatment system would reduce the pollutant discharges. The optimum solution would be determined by combining such measures.

14.5.2 Reducing Pollutant Load

As a result of the pollution analysis, it was revealed that the river pollution was mainly caused by the discharge of domestic waste and pig farm waste without proper treatment. It is apparent that the most essential matter for river quality improvement is to reduce the pollutant load to rivers.

1) Pig Farm Waste

Particularly in the three extremely polluted rivers, it is strongly required to implement means for reducing pig farm waste. For example, if they change the pig sty so as to be able to collect and dispose of feces separately from urine and washing water, the pollutant discharge would be reduced by 80%.

Since this would possibly require spaces for feces disposal and additional manpower to collect and dispose of the feces, it may not be readily acceptable by the pig farm industry. This will require further study to find out feasible economical and technical methods.

However, at first, it should be decided upon to implement regulations concerning pig farming. Why should they operate their business without paying

for wastewater treatment while industrial factories are required to pay for treatment of their wastewater?

2) Domestic Waste

Reducing the pollutant load from domestic waste would be possible by strengthening wastewater treatment. The strengthening of the existing wastewater treatment should be studied from the viewpoint of improving the communal plants and master plan of sewerage treatment system for the entire island. Particularly in the Sg. pinang, the improvement of the communal plant will be effective in improving the Pinang river water quality because it is presently suspectedly of being polluted by the discharge from the communal plants.

From this viewpoint, a study on the improvement of the communal plants was contemplated and carried out in the second year of the study. For the result of this study, please refer to Appendix Q in Supporting Report.

14.5.3 Purification of River Water

Although improvement of the river water quality should be done by reducing the pollutant load, it may be required to implement an urgent water quality improvement measure for Sg. Pinang, in case flood mitigation plans are implemented there. The reason for this is because the plans include an idea of a waterfront park system which could require water quality environment where one could gain access to the waterfront. To create such an environment, it is necessary to decrease the BOD concentration of the river to less than 10 ppm at which BOD water can be maintained in aerobic conditions, or to supply oxygen artificially.

Therefore, the application of direct purification to Sg. Dondang was studied in the second year of the study. However, as the results, shown in Appendix Q of the Supporting Report, the existing water quality of the Sg. Dondang was found to be too polluted to apply such direct purification methods.

14.5.4 Retention Ponds for Drainage

In the urgent project for drainage in Georgetown, it is proposed to construct two retention ponds (S-10 and S-18) at the outlet to the sea. In the operation of these ponds, drain water is to be introduced into the ponds and discharged by tidal fluctuations or pumping during flood periods.

Basins S-10 and S-18 are located in the areas served by a sewer collection system. Sewer generated in the basins are to collect the sewer systems and are never

discharged to the drain. However, in these areas, most houses and building only toilet wastewater enter sewer system; sullage water is discharged to the drains. Seventy to eighty percent are said to discharge their sullage water to drains. In addition, many hawker shops discharge their wastewater to the road side drains. Therefore, the drain water during fine days is supposed to be comprised mostly of sullage water.

With such a situation, it is anticipated that the water of the retention ponds will deteriorate. Such water with abundant organic matter could easily generate anaerobic conditions in the ponds, causing obnoxious methane and hydrogen sulfide odors.

To provide for such conditions, buffer greenery is proposed between the residential area and the pond sites. This will reduce the odor problems in the residential areas. However, as a more fundamental resolution, it is recommended to cut off the inflow of sullage water to the drain.

Tables

TABLE 14-1 TYPE OF DOMSTIC WASTEWATER DISPOSAL

Type	Description	Discharge from Toilet	Discharge from other than toilet
Sewer Collection	Domestic discharge are collected through sewer lines and discharged to the sea without treatment	Collected	Collected in newly constructed buildings but not collected in old buildings.
Sewerage treatment plants (Communal Plant)	Domestic discharge from houses constructed under the housing scheme are collected and treated. The effluent are dischrged to river.	Treated	Treated
Individual Septic Tank	Installed in individual houses. Effluents are discharged to rivers.	Treated	Treated in newly constructed house, but not in old house.
Bucket Type Toilet	Night soil are stored and collected. No discharge to river.	Collected	Not collected
Pour Flush Toilet	Night soil are flushed into pit, digested and penetrated into ground. No discharge to river.	Collected	Not collected

TABLE 14-2 POPULATION AND PIG NUMBERS IN EACH RIVER CATCHMENT

No.	River Name	Basin Area (Km2)	Population by type of domestic waste treatment					Population Total	No. of Pigs
			Communal Plant	Sewer Collection	Pour Flush Toilet	Bucket Toilet	Others (Septic Tank)		
1	Sg. Pinang	51.0	33846	105913	0	20604	65961	226,324	16,543
2	Sg. Teluk Awak	3.0	0	0	1600	0	450	2,050	
3	Sg. Teluk Bahang	12.3	0	0	1840	0	210	2,050	300
4	Sg. Batu Ferringghi	11.3	0	0	650	0	458	1,108	175
5	Sg. Satu	2.6	0	0	650	0	638	1,288	
6	Sg. Mas	2.1	0	0	829	0	829	1,658	
7	Sg. Kecil	2.8	1886	0	0	0	28	1,914	3,499
8	Sg. Kelian	9.0	7719	0	0	0	4223	11,942	
9	Sg. Balik Batu	0.8	1670	3185	0	0	1515	6,370	
10	Sg. Fettes	1.4	2200	4470	0	0	2270	8,940	29
11	Sg. Bagan Jermal	0.8	0	1170	0	0	1170	2,340	150
12	Sg. Babi	0.8	0	1409	0	0	1409	2,818	
13	Sg. Gelugor	4.1	7325	0	12861	0	5536	25,722	
14	Sg. Dua Besar	6.2	2200	0	4475	0	2275	8,950	3,609
15	Sg. Nibong Besar	1.5	2200	1243	664	0	35	4,142	
16	Sg. Nibong Kecil	2.8	3327	2248	1823	0	96	7,494	15,811
17	Sg. Keluang	22.2	7559	5108	4141	0	218	17,026	17,723
18	Sg. Nipah	1.7	2144	0	462	0	24	2,630	27,083
19	Sg. Kampong Masjid	0.8	0	0	2499	0	132	2,631	
20	Sg. Ikan Mati	0.4	0	0	1041	0	55	1,096	
21	Sg. Bayan Lepas	7.0	0	0	2142	0	945	3,087	1,060
22	Sg. Batu	0.9	0	0	1029	0	454	1,483	
23	Sg. Mati	1.0	0	0	693	0	306	999	
24	Sg. Teluk Kumbar	7.1	432	0	3900	0	1323	5,655	980
25	Sg. Gemuroh	1.9	0	0	529	0	238	767	
26	Sg. Gertak Sanggul	1.0	0	0	854	0	385	1,239	9,220
	Total	156.3	72508	124746	42682	20604	91183	351723	96182

TABLE 14-3 REMOVAL EFFICIENCY OF DOMESTIC WASTEWATER DISPOSAL

Type	Removal efficiency (%)		Discharged BOD Load (BODg/day)		
	Discharge from toilet	Discharge from other than toilet	Discharge from toilet	Discharge from other than toilet	Total
Sewer Collection	100	100	0	0	0
Sewerage treatment plants (Communal Plant)	75	75	3.3	15.3	18.6
Individual Septic Tank	50	50	6.5	30.5	37
Bucket Type Toilet	100	50	0.0	30.5	30.5
Pour Flush Toilet	100	50	0.0	30.5	30.5

BOD Load: Toilet 13 g/day
Other than Toilet 61 g/day

TABLE 14-4 CALCULATED POLLUTANT LOAD IN EACH CATCHMENT

River Name	BOD load(kg/day)		
	Domestic	Pig Farm	Total
SG. Pinang	2,929	13,539	16,468
Sg. Teluk Awak	65	0	65
Sg. Teluk Bahang	63	51	114
Sg. Batu Ferringghi	36	30	66
Sg. Satu	43	0	43
Sg. Mas	56	0	56
Sg. Kecil	36	595	631
Sg. Kelian	299	0	299
Sg. Balik Batu	87	0	87
Sg. Fettes	125	5	130
Sg. Bagan Jermal	43	26	69
Sg. Babi	52	0	52
Sg. Gelugor	726	0	726
Sg. Dua Besar	259	614	873
Sg. Nibong Besar	62	0	62
Sg. Nibong Kecil	120	2,688	2,808
Sg. Keluang	272	3,013	3,285
Sg. Nipah	54	4,604	4,658
Sg. Kampong Masjid	80	0	80
Sg. Ikan Mati	33	0	33
Sg. Bayan Lepas	99	180	279
Sg. Batu	48	0	48
Sg. Mati	32	0	32
Sg. Teluk Kumbar	174	167	341
Sg. Gemuroh	25	0	25
Sg. Gertak Sanggul	40	1,567	1,607
Total	5,858	27,079	32,937

TABLE 14-5 NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETERS	(UNITS)	CLASSES I	IIA	IIB	III	(IV)	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1	3	3	6	12	>12
COD	mg/l	10	25	25	50	100	>100
DO	mg/l	7	5-7	5-7	3-5	5-9	-
pH		6.5-8.5	6-9	6-9	5-9	5-9	-
Colour	TCU	15	150	150	-	-	-
Elect. Cond.*	µmhos/cm	1000	1000	-	-	6000	-
Floatables		N	N	N	-	-	-
Odour		N	N	N	-	-	-
Salinity*	°/oo	0.5	1	-	-	2	-
Taste		N	N	N	-	-	-
Total Diss. Solid*	mg/l	500	1000	-	-	4000	-
Total Susp. Solids	mg/l	25	50	50	150	300	>300
Temperature	°C	- Normal±2		- Normal±2		-	-
Turbidity	NTU	5	50	50	-	-	-
F. Colif.**	counts/ 100ml	10	100	400	5000 (2000)[a]	5000 (2000)[a]	
Tot. Colif.	counts/ 100ml	100	5000	5000	50000	50000	>50000

N = No visible floatable materials/debris, or No objectionable odour, or No objectionable taste.
* = Related parameters, only one recommended for use
** = Geometric mean
a = Maximum not to be exceeded

CLASS	USES
I	Conservation of natural environment Water supply I - practically no treatment necessary (except by disinfection or boiling only) Fishery I - very sensitive aquatic species
IIA	Water supply II - conventional treatment required Fishery II - sensitive aquatic species
IIB	Recreational use with body contact
III	Water supply III - extensive treatment required Fishery III - common, of economic value, and tolerant species Livestock drinking
IV	Irrigation
V	None of the above

Figures

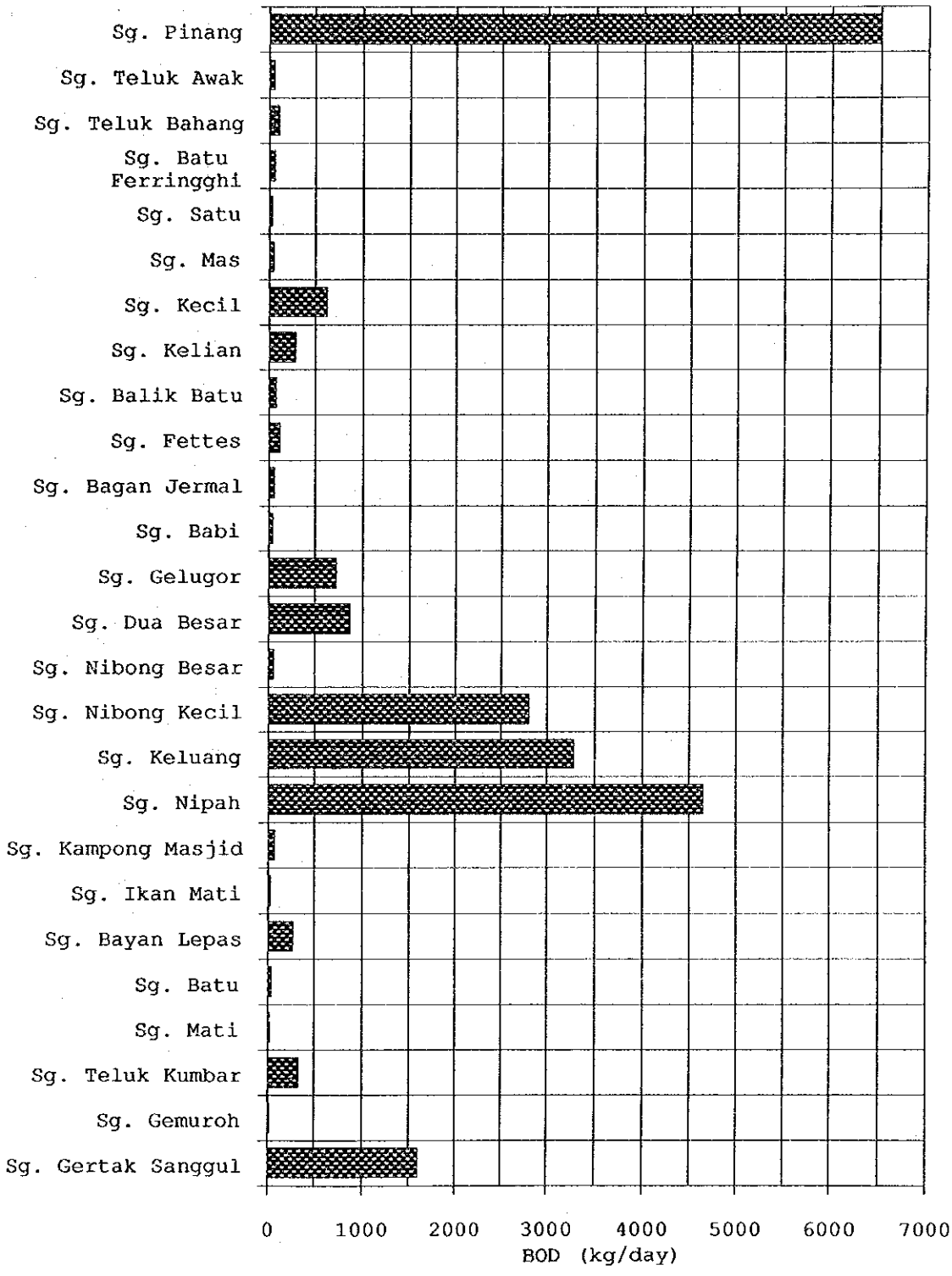


FIG. 14-1 ESTIMATED BOD LOAD

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

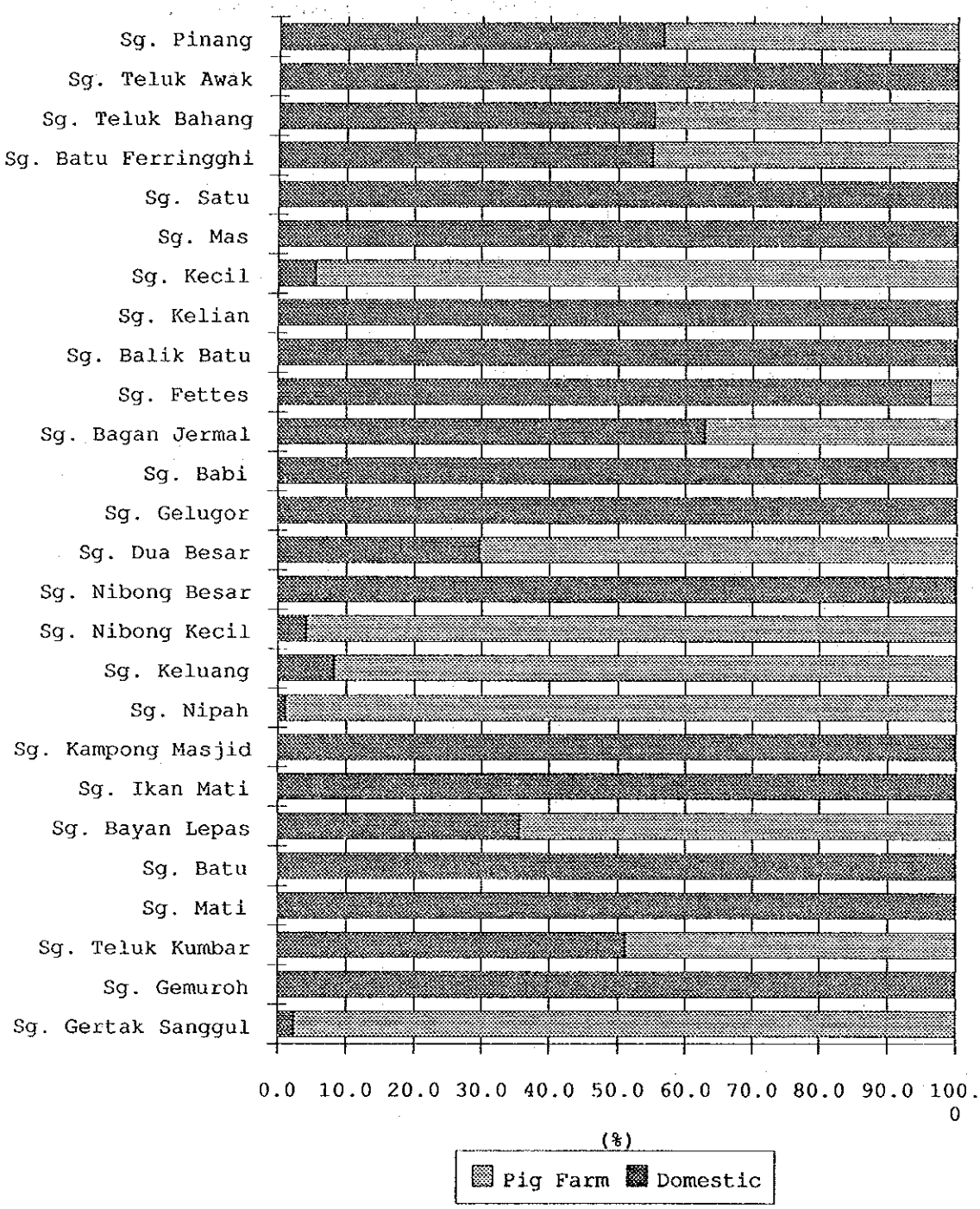


FIG. 14-2 SOURCE OF POLLUTION LOAD

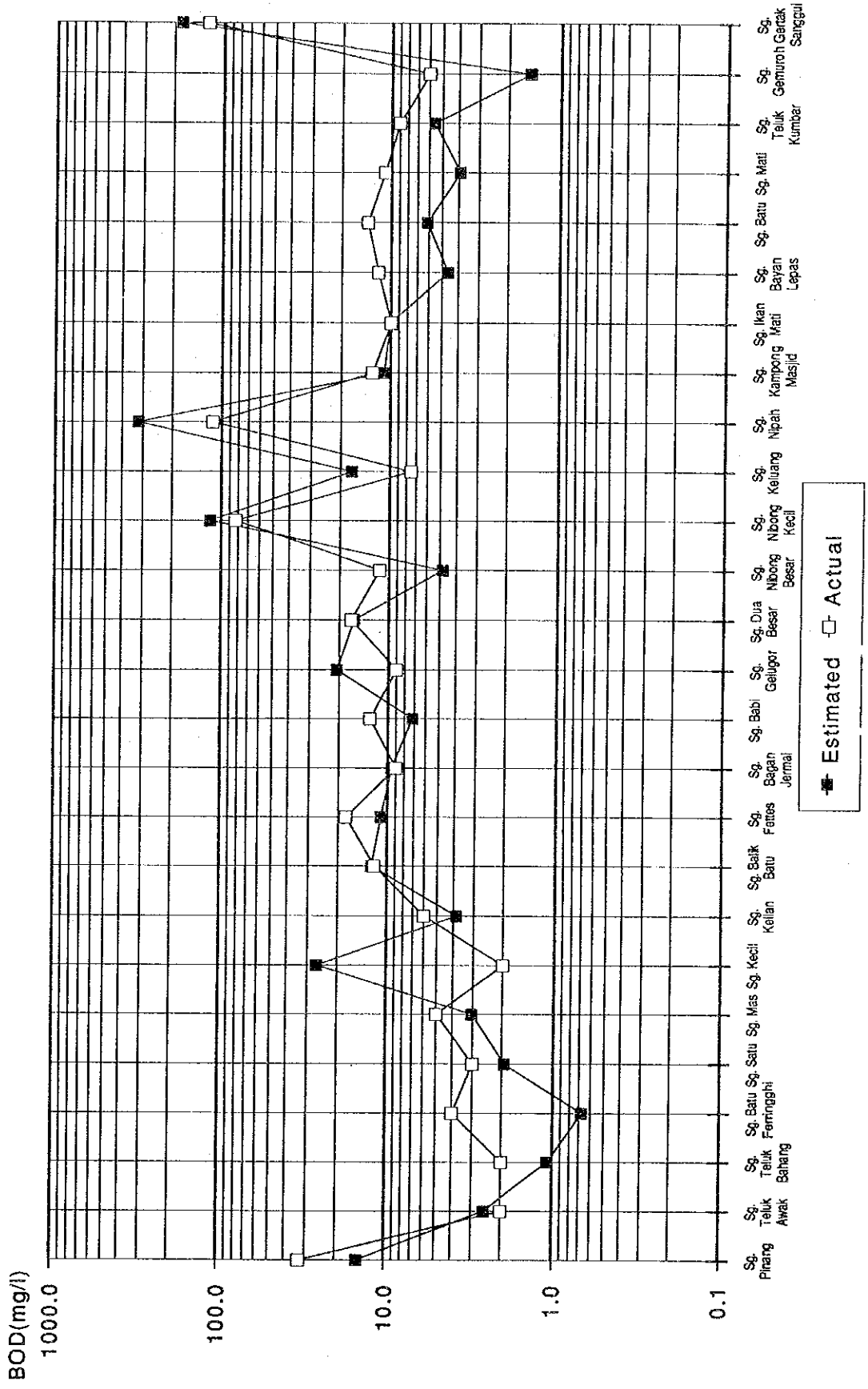


FIG. 14-3 COMPARISON OF ESTIMATED AND ACTUAL BOD

Chapter 15 LANDSCAPING OF RIVER CORRIDOR

CHAPTER 15 LANDSCAPING OF RIVER CORRIDOR

15.1 LANDSCAPE FEATURES OF RIVERS IN PENANG ISLAND

Regarding the landscape condition of the riverside area, the riparian condition of most rivers in urbanised areas lack aesthetic appeal due to water pollution, clogged solid wastes, and the condition of sedge and vegetation growing on the banks.

River reserve areas are often shown in a poor light with over grown plants and disorderly arrangement of huts and articles in the surrounding areas.

Some riparian areas are recognized as having rich landscape potential.

In conjunction with the consideration of future riverside open space use, Fig.15-1, Fig.15-2 and Fig.15-3 show a characteristic existing features of riverside landscape at Georgetowm and at other riversides in Penang Island.

15.2 THE STRUCTURE PLAN AND SG. PINANG IMPROVEMENT PLAN

The structure plan of the Municipal Council of Penang Island has issued the policy for the Sg.Pinang and its corridor. The policy described that the amenity potential for the Sg. Pinang and its corridor will be realised.

Regarding the policy, three objectives should be necessary to implement the Sg. Pinang Improvement Plan and they are:

1) To improve the environmental quality of the river and its corridor.

2) To improve access to the river and its corridor.

3) To realise the potential of the river and the corridor for recreation and other amenities.

As mentioned, the landscape planning process should involve an analysis of the problems, and the assets and opportunities for changes within the corridor.

15.3 LANDSCAPING DESIGN INVOLVED WITH SCENIC ATTRIBUTES AND DIVERSIFIED ACTIVITIES

15.3.1 Findings of Scenic Attributes

Future planning, design and management decisions for river corridor landscaping will have a great potential impact on the river corridor views. These may be enhanced

to create high quality views by changing landuse character, removing certain distracting features, or managing vegetation growth in certain ways.

The development of a recreational, educational and interpretive programme stressing the importance of scenic resources and the need for municipal and state governments to develop appropriate policies and legal tools to control adverse private development.

The development of overlay zoning and site review mechanism to restrict encroachment by private development on high quality view areas. Design guidelines could be developed for problematic landuse and development activities.

Fig.15-4 shows the characteristics of landscape component of the river.

15.3.2 Activities Within the River Space

The river fronts in urban areas are somehow quite important places having specific value incorporated life style and dynamic activities.

A close-to-home recreation resource that can be provide for wide variety recreational activities is a desired commodity today due to increasing public demand. Even communities that are located within the midst of unlimited recreational resources, are demanding closer recreational facilities.

15.4 ENHANCEMENT OF THE RIVER CORRIDOR LANDSCAPE

Together with the future riverside park areas, spaces of the river reserve itself are becoming valuable open spaces utilized as recreational cores with pedestrian walks. These spaces along the river can be made into well harmonised environmental areas that will represent effective facades for the urban area.

The existing landscape condition will be changed to be more attractive environmentally through the improvements made by the riverside development work.

The spaces of the river reserve itself will be valuable for vicinity recreational activity and pedestrian path network use. Furthermore these existence may contribute to the landscape beautification of the vicinity townscape.

These spaces along the river reserve can be made well harmonised environment to be represented the face of the each district and to be a major structural spine of the city townscape as well as the regional framework.

The functional services in these spaces will be pedestrian ways, resting areas, plazas (focal gathering

places), and some landscaped gardening areas. The new environmental functions of the river side spaces will be effective in addition to the rehabilitation of existing reiverside zone conditions.

In some of the areas, adjacent to the commercial zones or institutional facility areas, more amicable and attractively designed river front improvements will allow the people gather and enjoy themselves.

For these cases, well designed plazas, resting places, kiosks, event and performance areas together with a properly planned landscape layout, would upgrade the quality of the area.

Thus, the existing landscape condition will become more attractive environmentally through the improvements made by the riverside development work.

In Penang Island, there is a great potential of tourism resources and historical background which show the variety of townscape and social dynamism. Together with these potential, the reiverside environment should express adequate outlooks toward future development scheme.

Fig.15-5, Fig.15-6, Fig.15-7 and Fig.15-8 show the river corridor landscape improvement schemes and variations.

In the rural area and hillside zone, where rivers flow under more natural conditions, river reserve areas are to be utilised giving consideration to providing some recreational trails and spaces for such activities as sports and games.

Some potential riverine ecology conservation areas shall be specially organized. On the other hand, the estuary mangroves and related vegetation colonies shall be conserved to the maximum as a nature reserve.

15.5 GENERAL GUIDELINE OF IMPROVEMENT OF THE RIVER CORRIDOR LANDSCAPE

As for considering the riverside improvement schemes of river systems in Penang Island, the following improvement guidelines may be suggested for the river corridor landscaping:

1) Qualitative improvement of river revetments as a means for improving the riverside landscape.

   For the ongoing and planned implementation of revetment work, consideration is to be given to the prospective activities in corresponding riverside areas and to aesthetic space solutions.

2) Keeping the river reserve clean.

Most of the rivers are without maintenance. To prevent further environmental degradation, intensive care and maintenance of the river reserve shall be carried out.

3) Improving the river reserve and establishing recreational open space usage in the area.

Smoothing the bank areas, and grading and grassing of the ground surfaces are required. Some trees and shrubs should be allowed to remain for conservation and aesthetical reason. Improved spaces along the revetments shall be also utilised for vicinity recreational activities, and incorporated into the adjacent parks and open spaces.

4) Providing some attractive observation places, plazas, and rest areas at strategic riverside points.

In order to expose and emphasize the view of the riverine landscape at focal points, observation plazas and rest areas shall be introduced.

5) Providing a walkway system along the river and establishing aesthetic spaces at bridge sites.

Consideration should be taken to provide access to the walkway system from nearby roads and public places. These areas shall serve as aesthetical focal points for the riverine zone.

6) Efficient projection of the riverside walkway, improvement in conjunction with the development of nearby strategic commercial and business district areas.

Considering of the pedestrian walkways, plazas and malls network to link up with adjacent development of riverside commercial and business facilities.

In the commercial landuse area and in some park landuse area, the riverine facade is expected to present a good view to citizens and tourists. Within this area, riverside reserves are to be limited.

Further development shall be considered taking into account the possibility of increasing the width of riverside walkways, and adding additional plazas and landscaping to strengthen the area as the strategic core for urban amenities.

7) Conservation of valuable natural vegetation along environmentally sensitive areas.

Well balanced natural vegetations are observed at the upstream banks in the hillside forest areas and at some

areas of estuary mangrove colonies. In these ares, very little improvement work would be needed to have pedestrian trails lead the water margin and to set up small observation spaces.

15.6 CONSIDERATION INCORPORATED WITH PRIVATE SECTORS

Due to the enhancement of the riverine environmental quality condition and the park areas involving retention ponds, it may be important to incorporate the use of the private sector along with the contributions from DID.

Companies or individuals in the private sectors who have proven capabilities in the development of housing or commercial complexes, or in the development of tourism may be welcomed into the area for the purpose of sharing the costs of waterfront development such as the implementation of pedestrian walks, plazas, afforestation and gardening work beside the basic works of revetments and river works.

The well landscaped spaces will have greater commercial value and will appear attractive to visitors as well as to vicinity residents. Also, there will be investment opportunities here. In some cases, spaces or facilities can be rented to the private sector through contracts with the pubic superintendency side for sharing certain amounts of counterpart investments or payments.

15.7 POSSIBLE PARTICIPATION BY THE PRIVATE SECTOR

The areas surrounding parks having retention ponds have residential use with less opportunities for commercial use.

The space occupied by retention ponds is large enough for the installation of sports and game facilities, such as tennis courts, roller skating and skate board courts, and others. Well organized sports clubs or fitness clubs from the private sector may be set up to meet the needs of the residents of the new township and of those who live in nearby areas.

With this in mind, MPPP agencies, such as the Superintendency of Parks, with cooperation from State D.I.D, might mount a public relations campaign aimed at getting individuals or organizations in the private sector to participate in park projects either in the form of monetary contributions or by providing maintenance or operation services.

Recreational and health related businesses would establish a trend for meeting the life style of people in the middle to upper-middle class. The park would be quite suitable for such activities, but first the private sector must be convinced that the benefits to be reaped are worthwhile.

In the riverside area, the river reserve spaces should be maintained by the public sector while the responsibility for improving these spaces rests in the hands of the State D.I.D.'s side. However, there is sufficient space at the higher level portion of the river reserve that is adjacent to the commercial area where it would be possible to set up some beneficial private concessions, such as kiosks, refreshment stands, and the like. Of course, these concessions must be located where they will not be in peril at any time during a flood occurrence.

It is possible for the Superintendency's side to negotiate contracts with appropriate private sector parties. They will have the authority to grant permission to use the spaces, and to approve the installation of facilities and landscape improvements. They will establish and collect space usage fees and will inform the parties of their cleaning and maintenance responsibilities. The superintendency's side shall prepare proper requirements and design guidelines for space usage, facilities and landscaping. These requirements and guidelines will be made available to the private sector and to project participants.

Many future land use spaces are located in areas on the adjacent riverside. For landscaping the river corridor, a proper scale of development shall be necessary to suit the variety of sites along the river. Some sites may only require simple landscaping work while others may need more extensive work. Plans for the landscaping must be made based on the characteristics of each objective site and on the environmental conditions in the area. For implementing the river corridor landscaping consideration must be given to the cost. Fig. 15-9 shows the standard cost plan for the landscaping work.

15.8 NECESSITY OF WATER QUALITY IMPROVEMENT

To upgrade the river corridor landscaping is of utmost importance for improving the existing riverine conditions and the quality of the river environment for the benefit of the public.

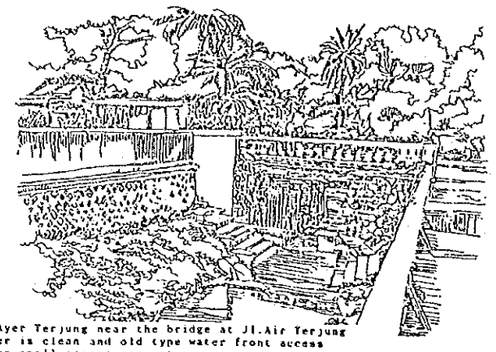
From a perceptional point of view, at the initial stage of upgrading the river environment, a nicely landscaped riverside area gives the people the impression that the environmental value of the area is highly recognized.

The improvement of the river environment can not only be accomplished by landscaping the river corridor. Consideration must also be given to improving river water quality. Contributing to both the improvement of the riverside area and the water quality will bring about a more idealistic and comprehensive resolution of the river improvement plan.

Improvement of river water quality is vitally important and absolutely essential if the upgrading of the total environmental quality of the river is to be realized.

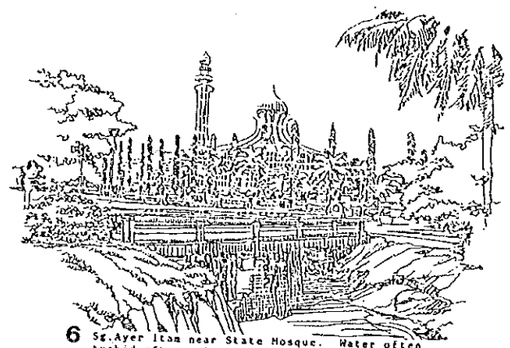
The State Government and the Municipal Council will meet to proceed with the administrative programme and campaign for increasing the public awareness of the river water improvements and for the need of cleaning the river water.

Figures

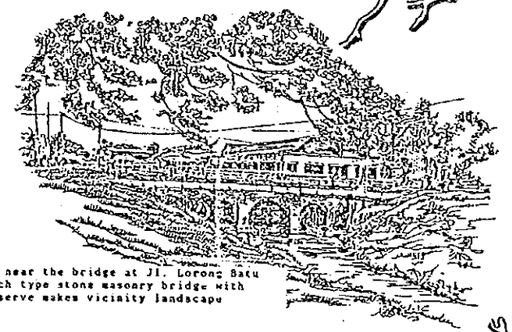


1 Sg.Ayer Terjung near the bridge at Jl.Air Terjung
Water is clean and old type water front access
makes small scenic accsent.

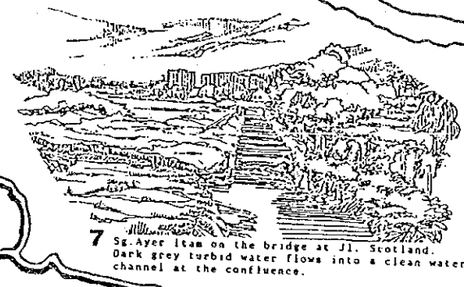
5 Sg.Ayer Terujung on the bridge at Jl.Pesiaran
Kuari. Deep old masonry channel with clean
water represents good river side landscape.



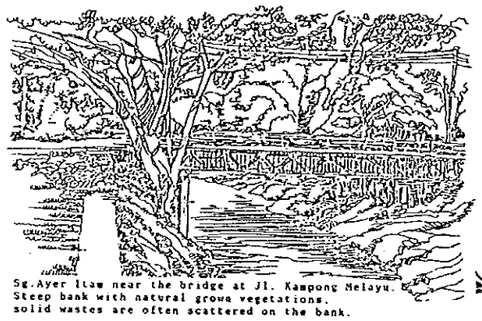
6 Sg.Ayer Itam near State Hosque. Water often
turbid after rain, some portion of the bank
is under improvement works.



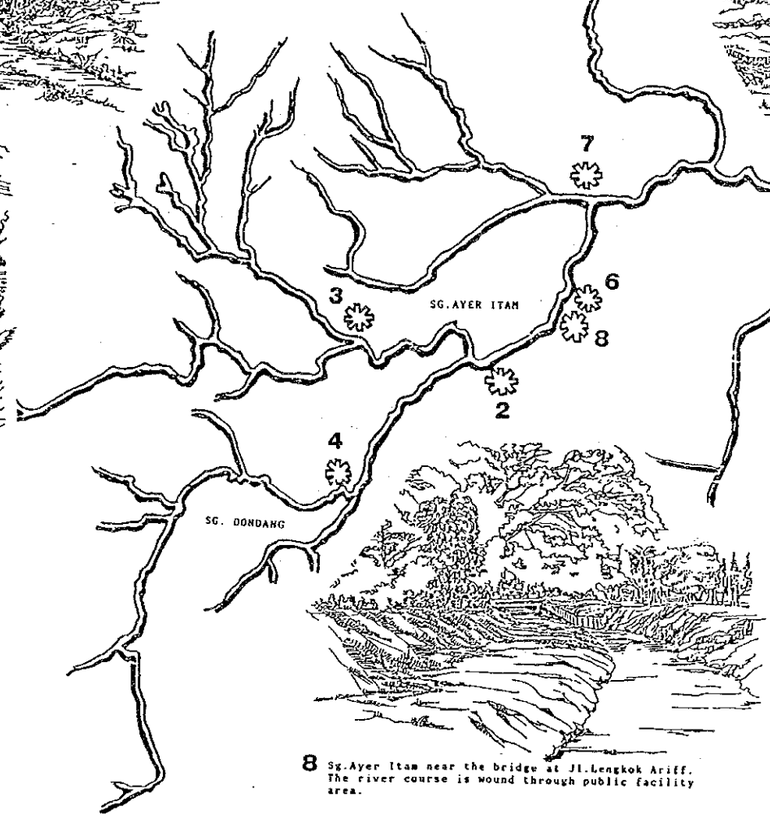
2 Sg. Ayer Itam near the bridge at Jl. Lorong Baru
Lanchang. Arch type stone masonry bridge with
wide river reserve makes vicinity landscape
focus.

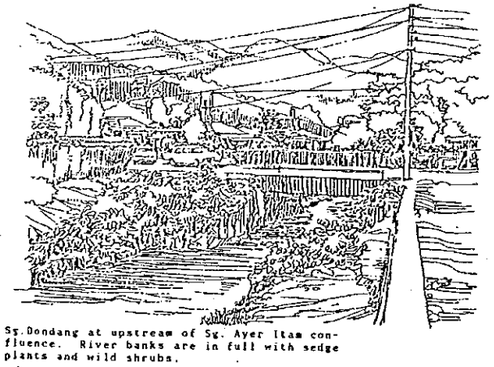


7 Sg.Ayer Itam on the bridge at Jl. Scotland.
Dark grey turbid water flows into a clean water
channel at the confluence.



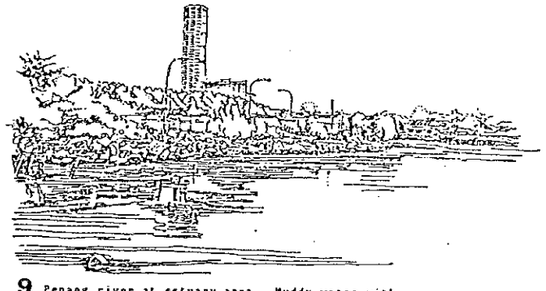
3 Sg.Ayer Itam near the bridge at Jl. Kampong Melayu.
Steep bank with natural grows vegetations,
solid wastes are often scattered on the bank.





4 Sg.Dondang at upstream of Sg. Ayer Itam con-
fluence. River banks are in full with sedge
plants and wild shrubs.

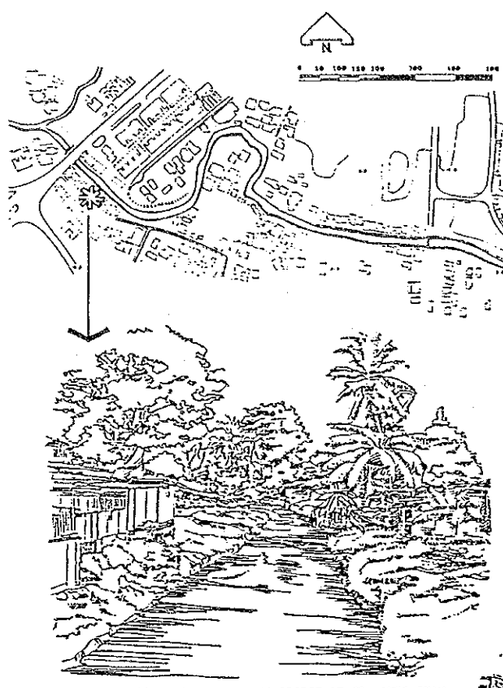
8 Sg.Ayer Itam near the bridge at Jl.Lengkok Ariff.
The river course is wound through public facility
area.



9 Penang river at estuary area. Muddy water with
some floating debris are destroied the scenic
potentials. Komtar building can be seen as a
huge landmark.

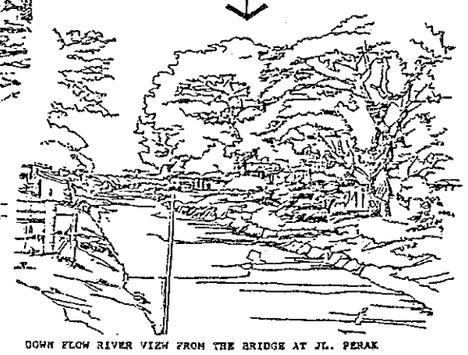
FIG. 15-1 EXISTING RIVERSIDE LANDSCAPE IN GEORGETOWN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



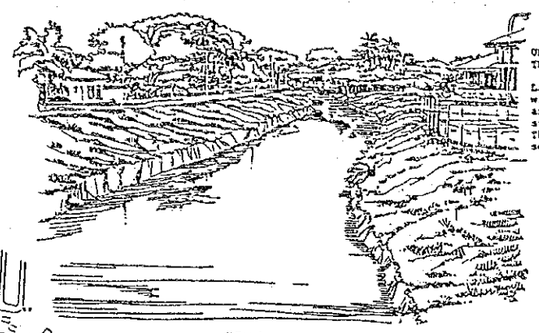
DOWN FLOW RIVER VIEW FROM THE BRIDGE AT JL. AYER ITAM

Here is the most narrow area of Penang river, unqualified settlements, huts with grown sedge plants, rubbishes are exposed to open public.



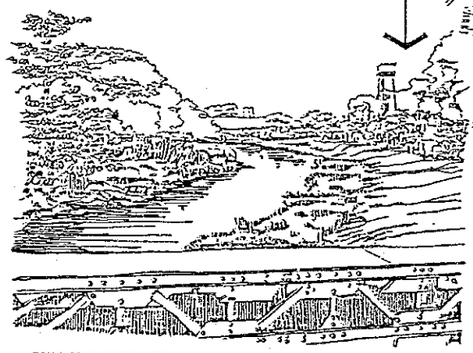
DOWN FLOW RIVER VIEW FROM THE BRIDGE AT JL. PERAK

Large crowned trees are made a nice scenic composition, however dis-ordered flow edges, irregular form of banks and some floating debris show somewhat miserable riverine conditions.



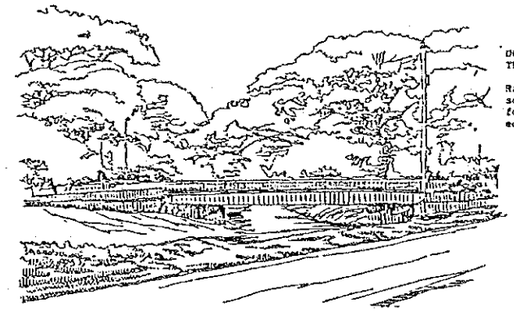
UPPER FLOW RIVER VIEW FROM THE BRIDGE AT JL. PANTAI

Large expanded river banks with maintained grass area are represented a mid-stream of Penang river. This area has also high scenic potentials.



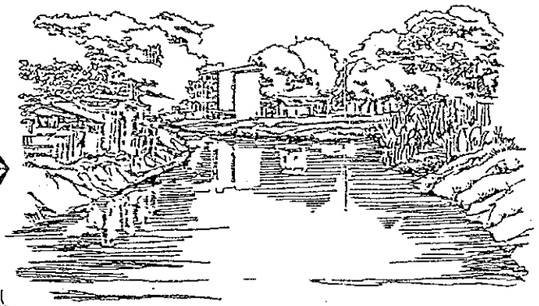
DOWN FLOW RIVER VIEW FROM THE BRIDGE AT JL. SUNGAI

Full grown sedge plants are dominated along water front of the low river banks.



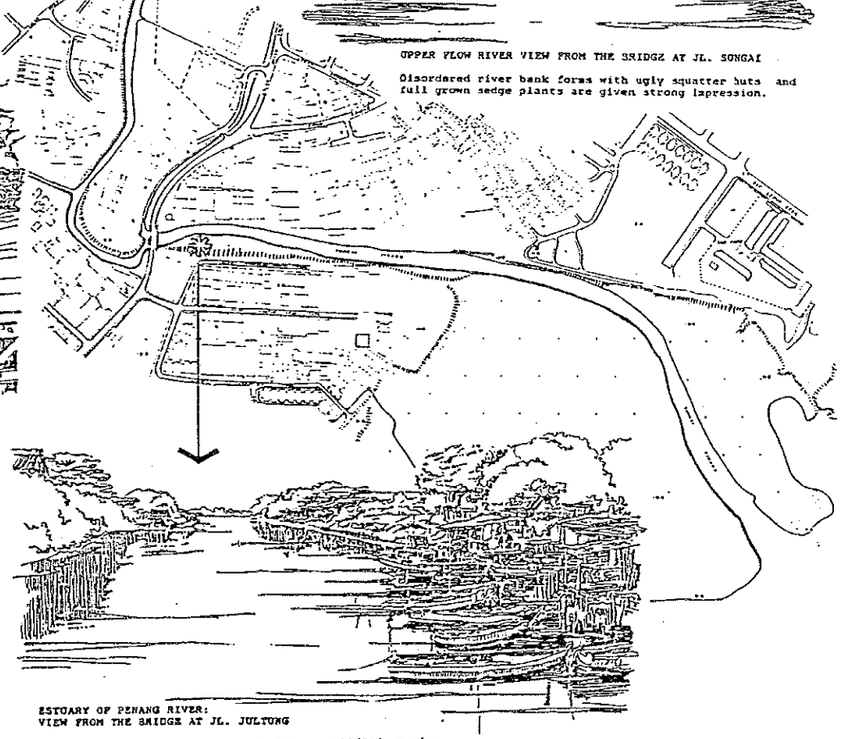
DOWN FLOW RIVER VIEW NEAR THE BRIDGE AT JL. PANTAI

Rather wide open riverine scape with groups of large foliaged trees is presented big scenic potentials.



UPPER FLOW RIVER VIEW FROM THE BRIDGE AT JL. SUNGAI

Disordered river bank forms with ugly squatter huts and full grown sedge plants are given strong impression.



ESTUARY OF PENANG RIVER:
VIEW FROM THE BRIDGE AT JL. JULTUNG

Small fishing boats are moored with unqualified wooden fisherman's huts. Dark turbid water with strong odour and disordered riverin scape are dominated on this environ.

PROPOSED RIVER IMPROVEMENT SCHEME

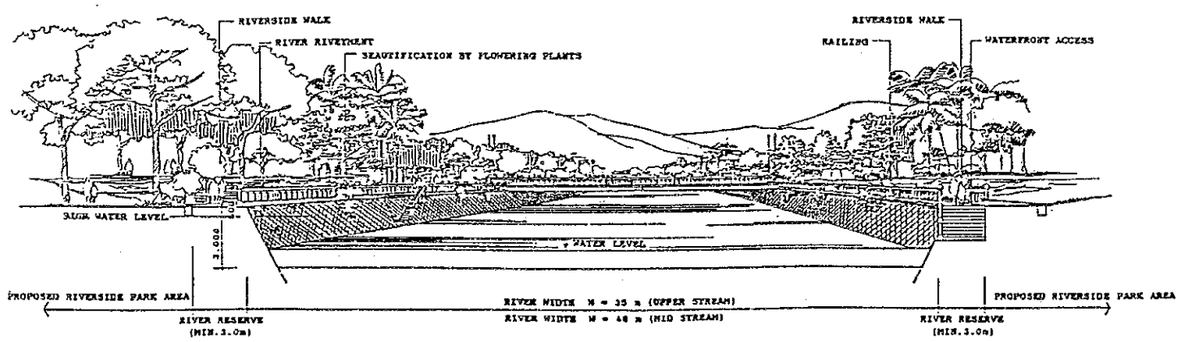
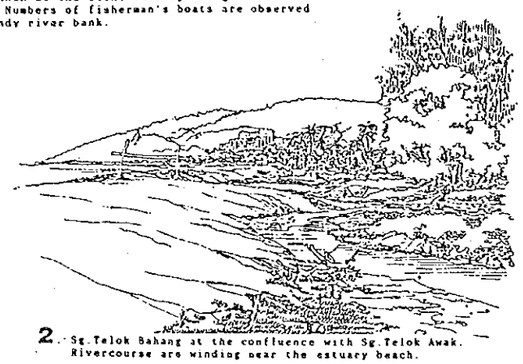


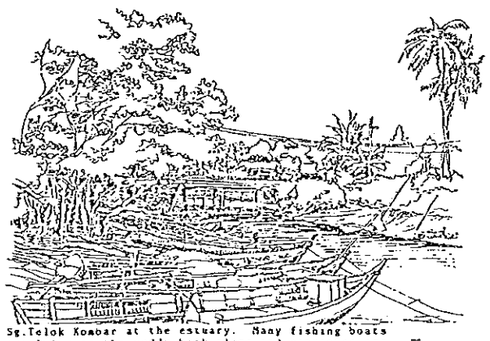
FIG. 15-2 EXISTING RIVERSIDE LANDSCAPE IN GEORGETOWN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

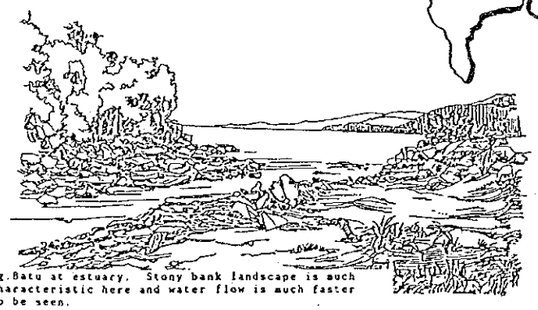
1. Sg.Telok Awak at the stone masonry bridge near estuary. Numbers of fisherman's boats are observed at the sandy river bank.



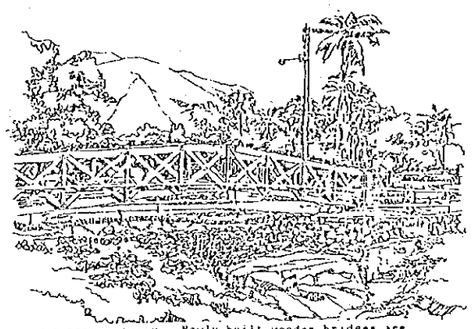
2. Sg.Telok Bahang at the confluence with Sg.Telok Awak. Rivercourse are winding near the estuary beach.



3. Sg.Telok Kombar at the estuary. Many fishing boats are lying on the muddy bank slope and mangroves are dencely inhabited near here.



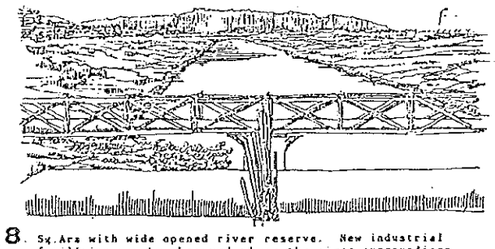
4. Sg.Batu at estuary. Stony bank landscape is such characteristic here and water flow is much faster to be seen.



5. Sg.Satu near estuary. Newly built wooden bridges are more attractive and safe strolling for the tourists visited Batu Feringgi resort area.

6. Sg.Dua luar on the bridge at Jl.Gelugor. Rather gentle shaped river banks are streched towards upstream.

7. Sg.Nibong Kechil. Exstra dark turbid flow with intollerable smells are allways in such a condition. yet some mangroves are still survived.



8. Sg.Ara with wide opened river reserve. New industrial facilities can be observed along the river surroundings.

9. Sg.Nipa at Batu Maung. Heavy polluted water with intorellable smell is dominated along mangrove foreat.

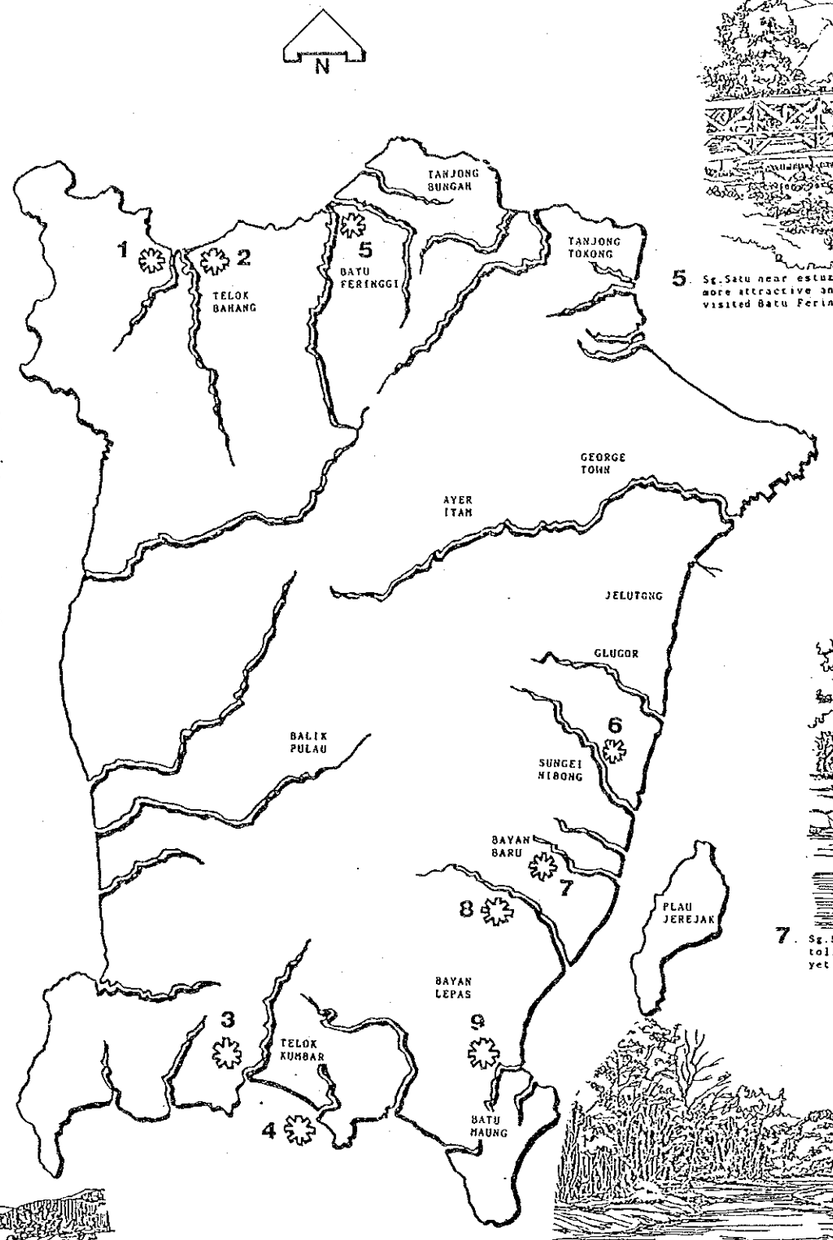


FIG. 15-3	EXISTING RIVERSIDE LANDSCAPE OUTSIDE GEORGETOWN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

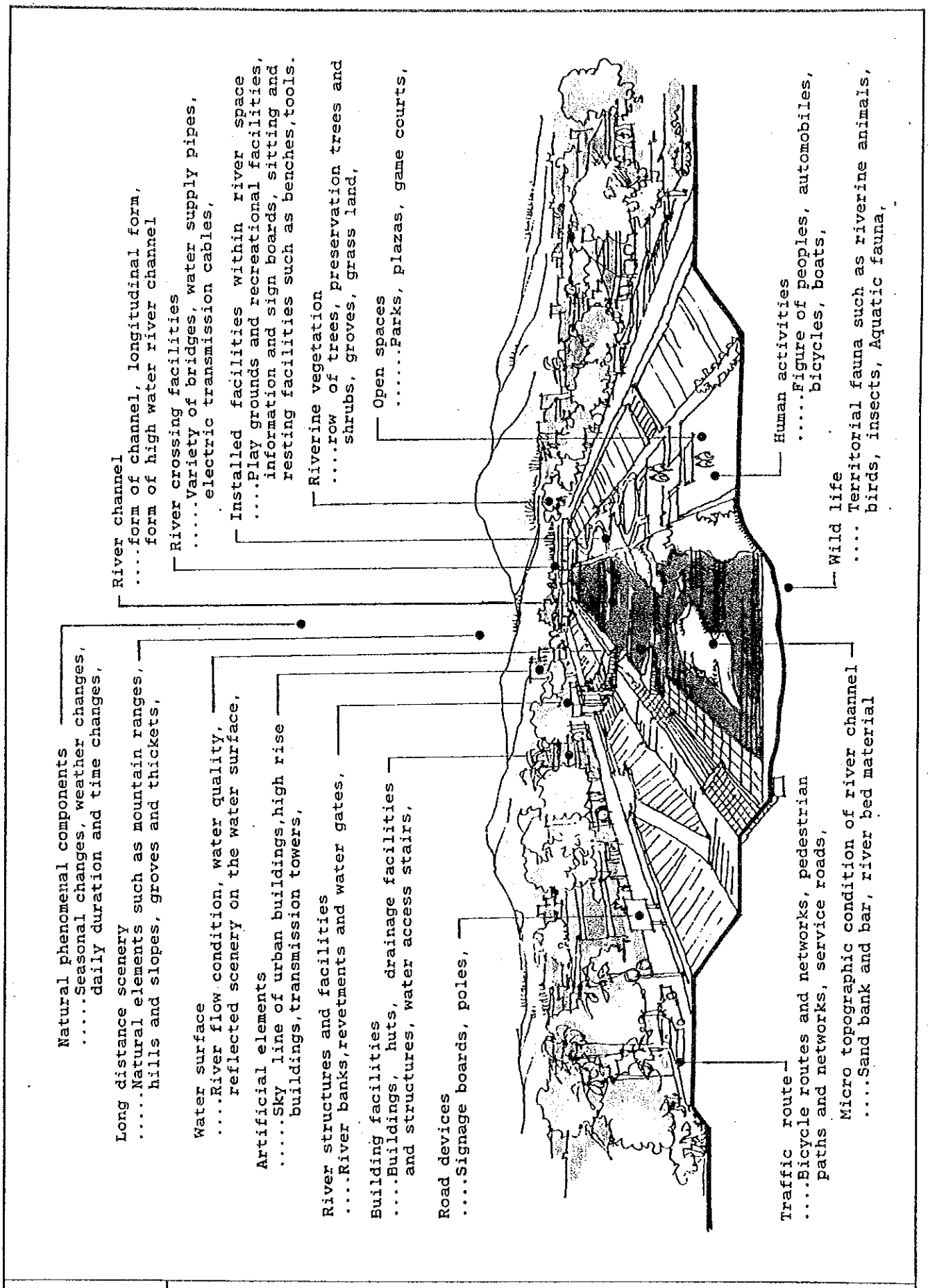
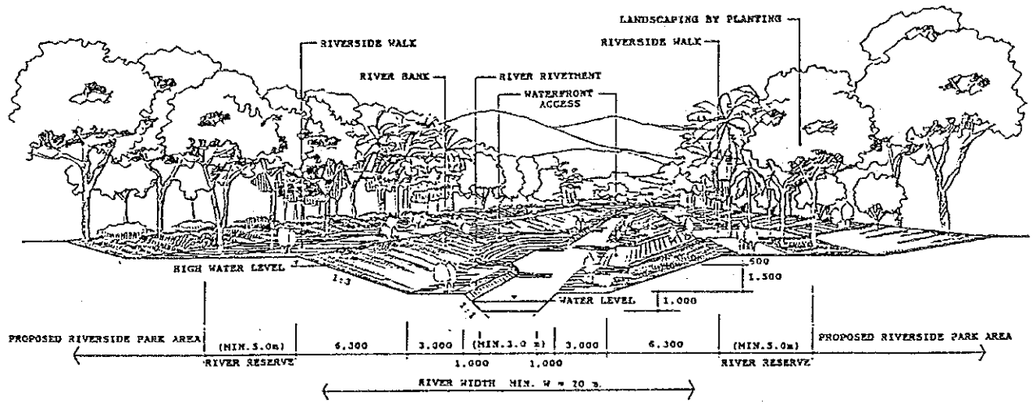
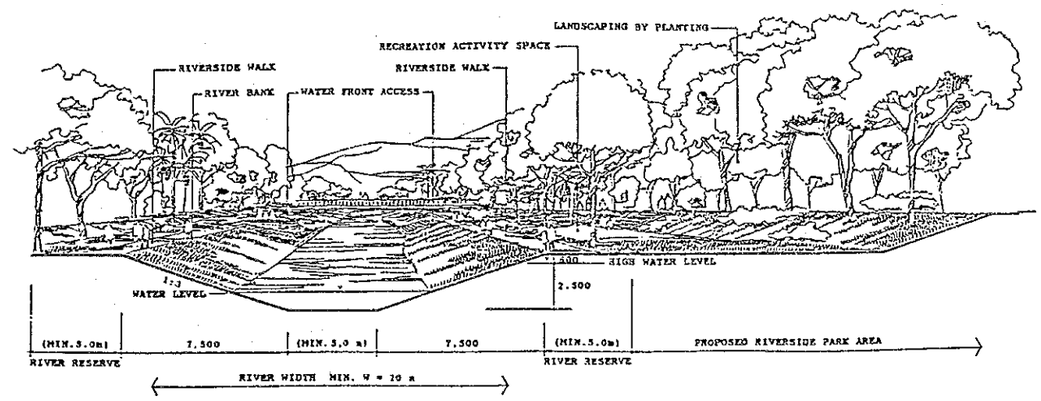


FIG. 15-4 CHARACTERISTICS OF LANDSCAPE COMPONENT OF THE RIVER

PROPOSED RIVER IMPROVEMENT SCHEME--1



PROPOSED RIVER IMPROVEMENT SCHEME--2



PROPOSED RIVER IMPROVEMENT SCHEME

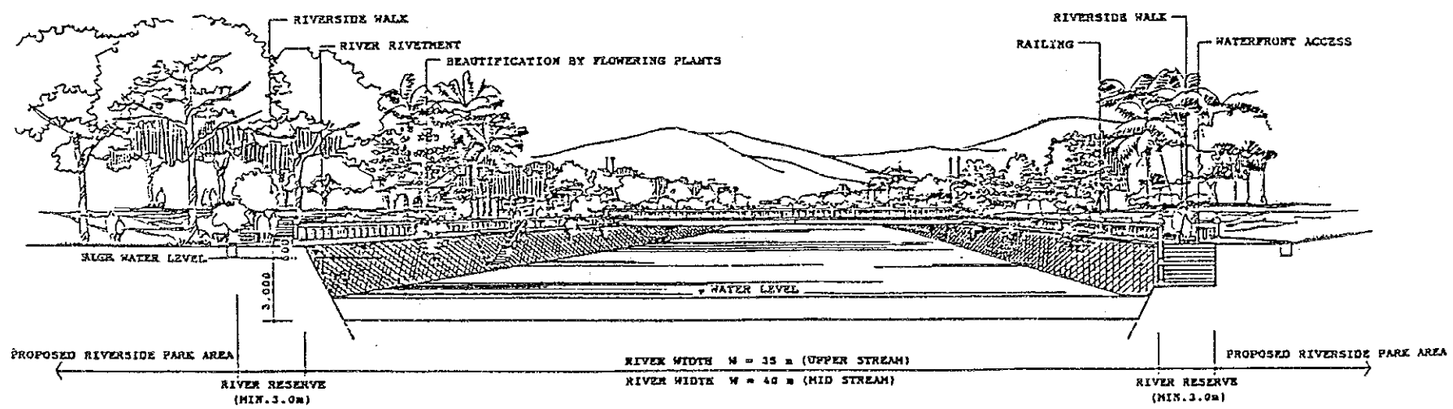
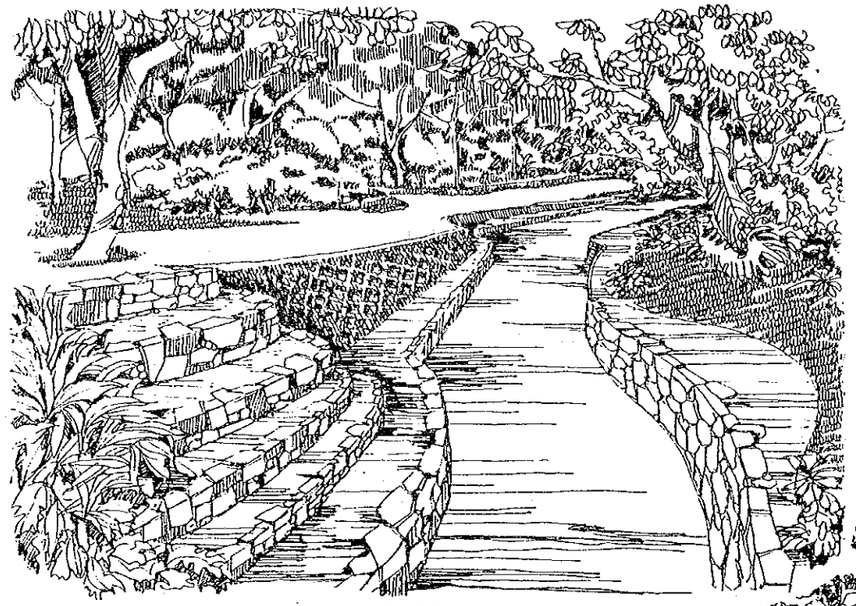


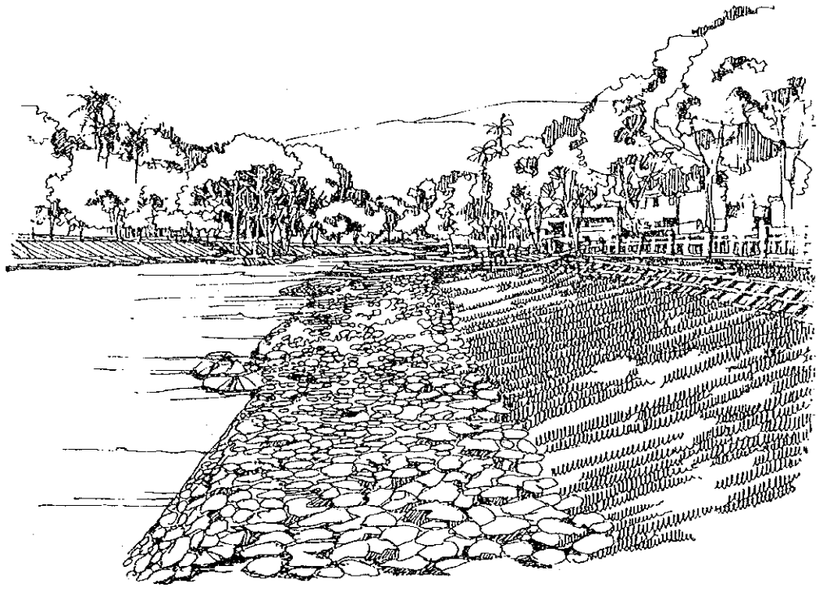
FIG. 15-5 RIVERSIDE IMPROVEMENT VARIATIONS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



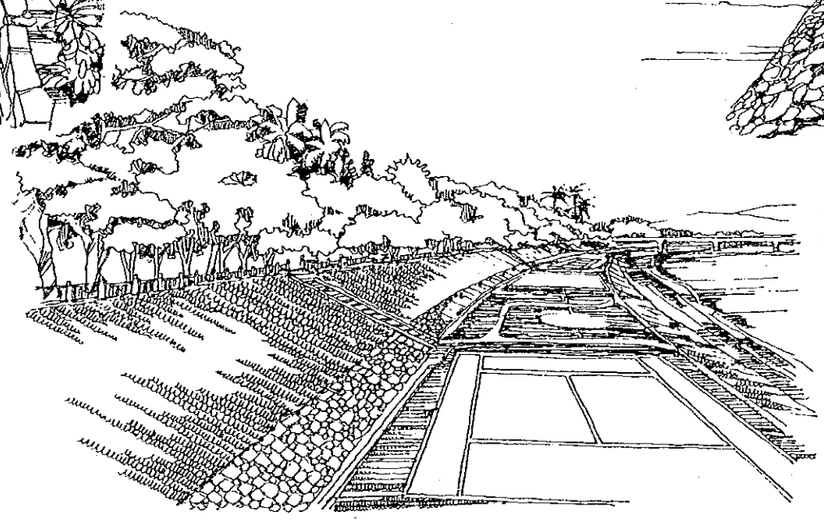
VARIETY OF WATER ACCESS FEATURES AT UPPER STREAM

Amenity full waterfront focus improvement and it's variations would be introduced along the upper stream area or through the recreation park areas.



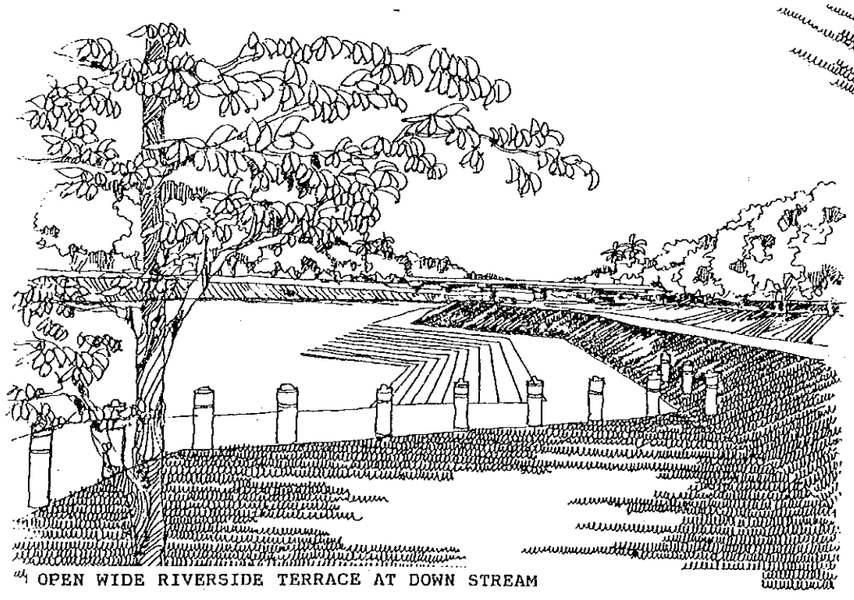
NATURE ORIENTED RIVER BANK SOLUTION AT MID STREAM

Some expansion of stone piling bank may encourage bionomic purification of the water quality and also may produce more natural riverine landscape at mid stream of the river.



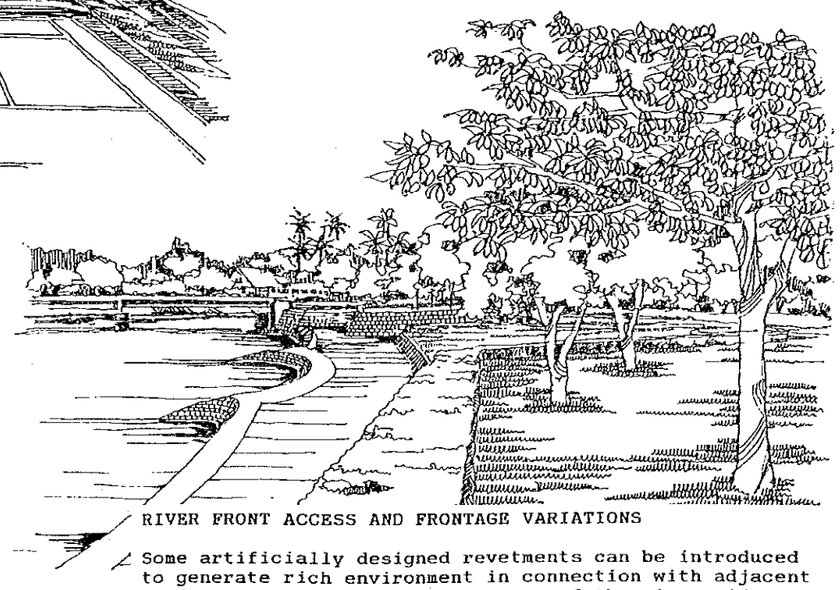
SPORTS AND GAME USE SPACE AT RIVER TERRACE NEXT TO THE BANK

Open wide river terrace would be maximum utilized for variety of sports and game fields if it is enough reserve width.



OPEN WIDE RIVERSIDE TERRACE AT DOWN STREAM

As spaces for observation and events performance, terrace type water access will be introduced when river reserve is wide enough.



RIVER FRONT ACCESS AND FRONTAGE VARIATIONS

Some artificially designed revetments can be introduced to generate rich environment in connection with adjacent land use or development characters of the river side area.

FIG. 15-6 **RIVERSIDE IMPROVEMENT REFERENTIAL SCHEME**

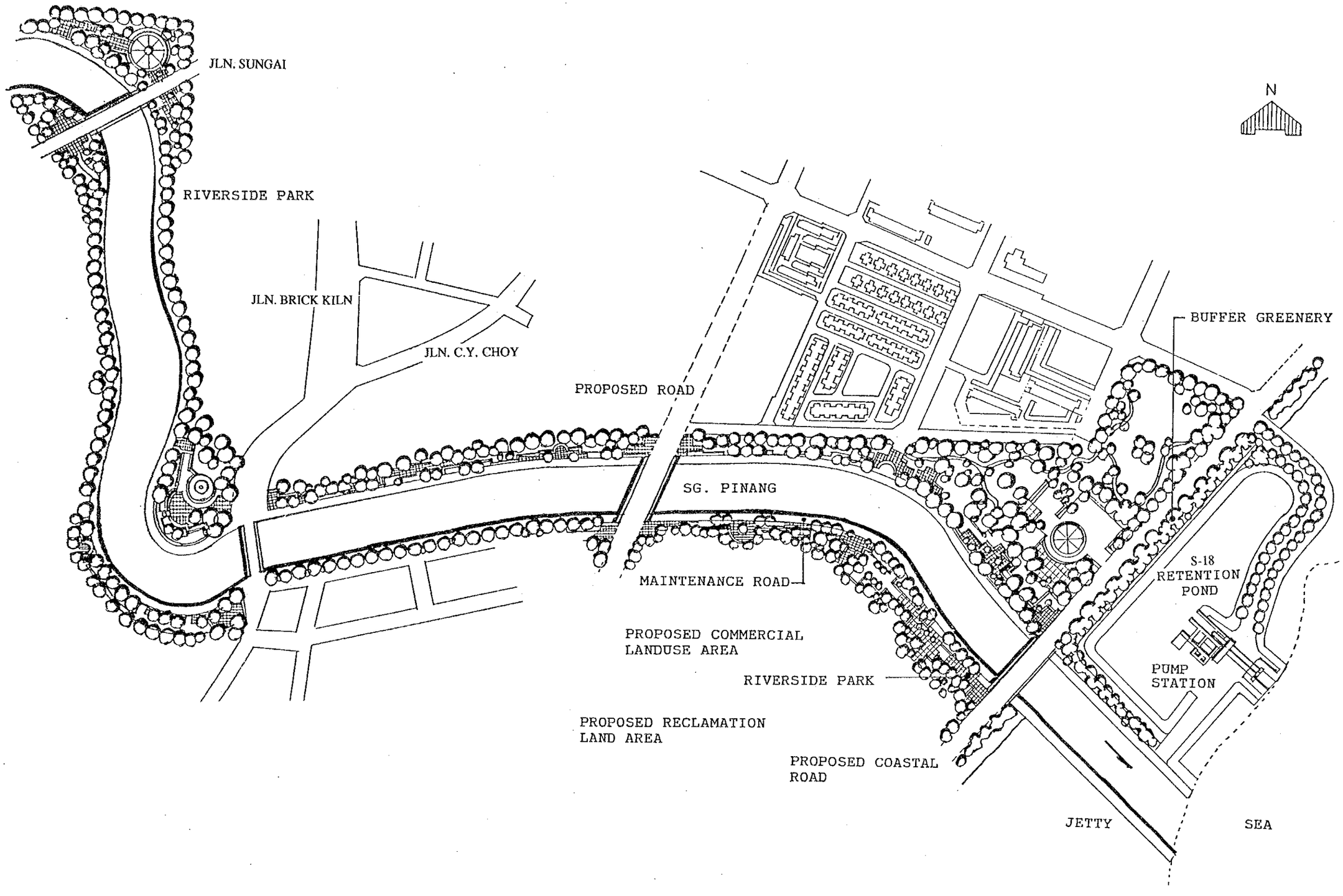
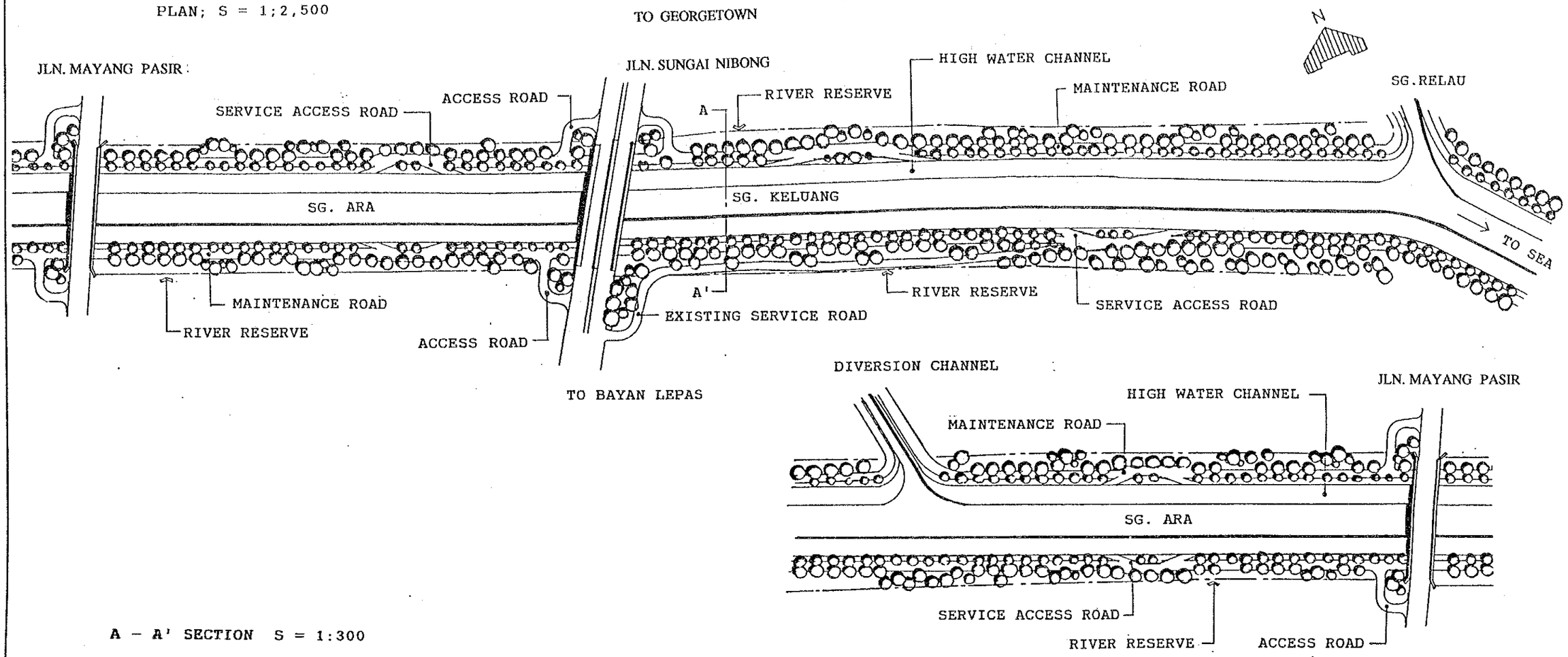


FIG. 15-7	RIVERSIDE LANDSCAPE AND FUTURE IMPROVEMENT SCHEME : SG. PINANG AT ESTUARY

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

PLAN; S = 1;2,500



A - A' SECTION S = 1:300

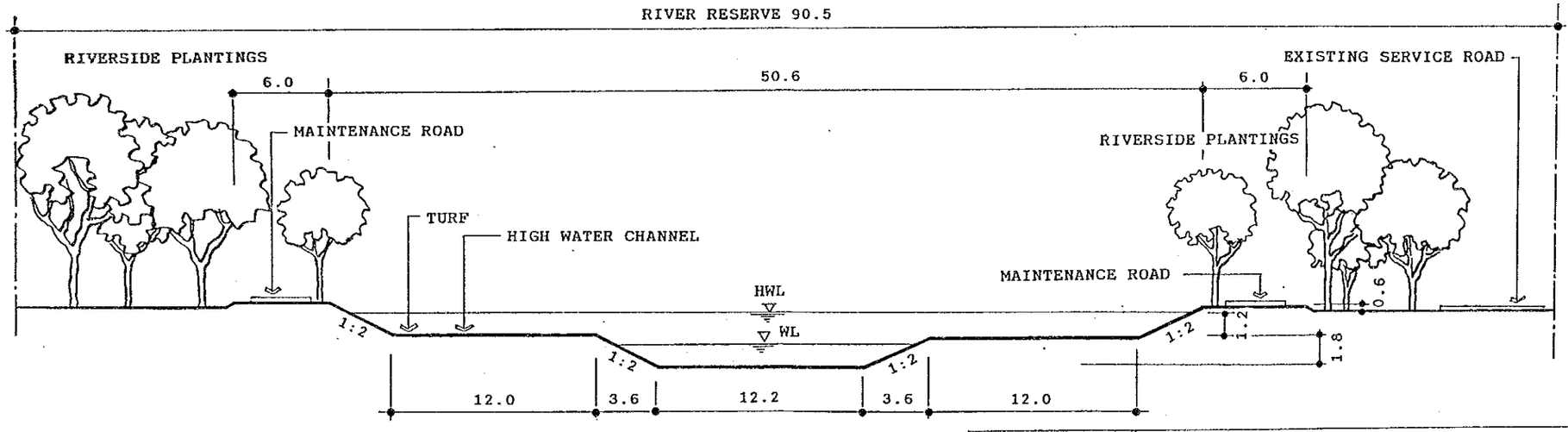
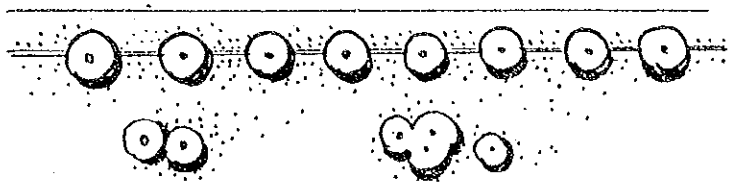


FIG. 15-8 RIVERSIDE IMPROVEMENT SCHEME : SG. KELUANG AND SG. ARA AT DOWNSTREAM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

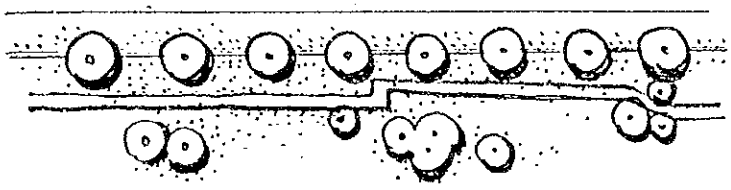
Grade 1. landscaping case:

Turf grass furnishings on the ground modeled base
.....M$ 40,000 to 50,000 / ha
Tree planting with approx. 7 to 8 meter interval and turf grass ground finish based landscaping
.....M$ 80,000 to 100,000 / ha



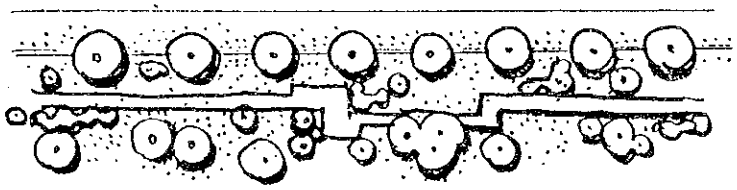
Grade 2. landscaping case:

Simple hard surfaced pedestrian walk with approx. 2 meter width through the river side and tree planting with approx. 7 to 8 meter interval on the turf grass bases along the paved walk.....M$ 100,000 to 120,000 / ha



Grade 3. landscaping case:

Simple hard surfaced pedestrian walk with approx. 2 meter width through the river side and tree planting with approx. 7 to 8 meter interval and flowering shrubs planting at focal points and edges on the turf grass bases along the paved walk.....M$ 130,000 to 180,000 / ha



Grade 4. landscaping case:

Rather high hard surfaced pedestrian walk with approx. 2 meter width and some plaza, river side access with stairs, seating and resting facility installation through the river side and tree planting with approx. 7 to 8 meter interval and planting of flowering shrubs at focal points and edges on the turf grass bases....M$ 200,000 to 300,000 / ha

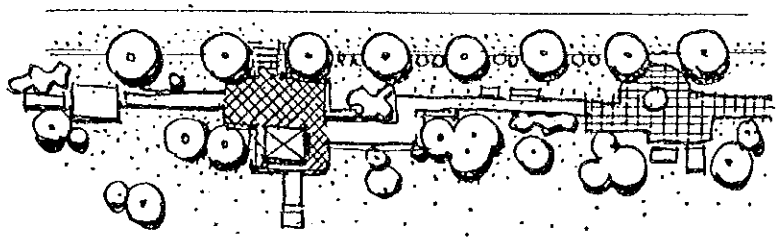


FIG. 15-9 **SCHEME OF STANDARD COST FOR RIVER CORRIDOR LANDSCAPING**

Chapter 16 CONCLUSION AND RECOMMENDATIONS

CHAPTER 16 CONCLUSION AND RECOMMENDATIONS

(1) The Master Plan on Flood Mitigation of the Rivers in Penang Island is proposed consisting of both structural and non-structural measures. The structural measures are river improvement works, retention ponds and diversion channels. The proposed plans for the major rivers are both technically and economically feasible, and are socially justifiable.

(2) The proposed urgent drainage plan for S-10, S-18 and N-12 consists of drain improvement, retention ponds and pump stations. The proposed plan is both technically and economically feasible, and is justifiable.

(3) The immediate implementation of the urgent project, (Phase I) of three phases of Master Plan, is strongly recommended, because of the presence of flood prone built-up areas and lowlying areas that experience frequent flood damage as a result of flash floods and high tides.

(4) The required land acquisition for the project shall be completed before the commencement of construction works in order to ensure smooth project implementation. It is also recommended that the appropriate authority control the type of development within the river reserve in order to facilitate land acquisition activity in the future.

(5) It is strongly recommended that the Comprehensive Flood Mitigation Committee of Penang Island under SEPU be instituted in order to realize the overall watershed management of the island.

(6) For the lowlying areas along the east coast of the island, as a basic strategy, it is recommended to fill up the areas to a ground level sustainable for future development instead of installing pumping facilities.

(7) It is recommended that land development activities on hilly or mountainous terrains, especially in the Penang Hill, be strictly controlled to prevent such disasters, as debris flow, or sediment run-off.

(8) It is recommended that criteria for installing localized retention ponds (sedimentation ponds) be formulated in accordance with the degree of land development activities in the basins in order to control sediment run-off.

(9) Since it has been revealed that most rivers are polluted by garbage disposal and discharge of domestic and pig farming waste into the rivers, it is proposed i) to strengthen the sewage treatment in the Island,

ii) to implement effective regulations concerning wastewater discharge from pig farming and iii) to strictly prohibit the dumping of garbages.

(10) It is necessary to publicize the importance of maintaining conducive and clean river environment. In this regard, it is highly recommended that the public be informed not to throw garbage into the river or drain.