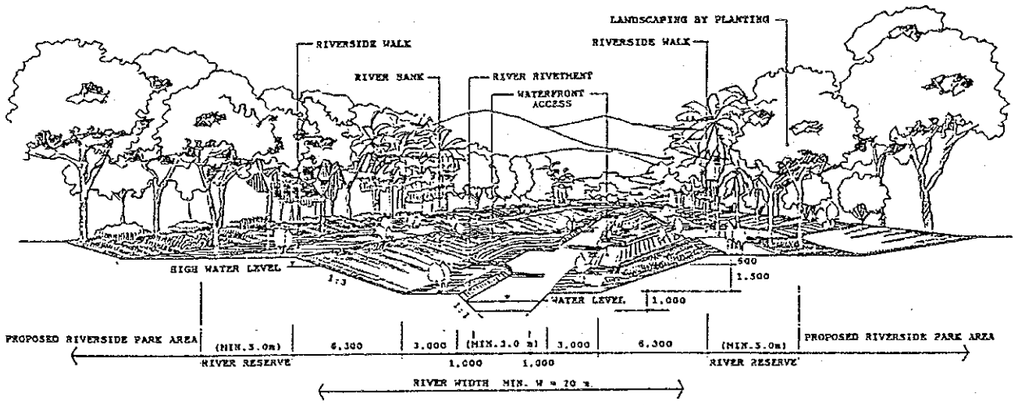
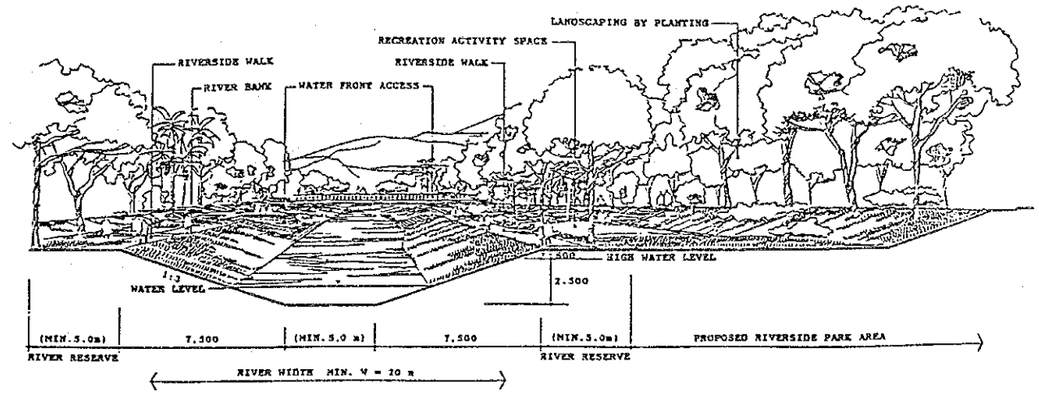
PROPOSED RIVER IMPROVEMENT SCHEME-1



PROPOSED RIVER IMPROVEMENT SCHEME-2



PROPOSED RIVER IMPROVEMENT SCHEME

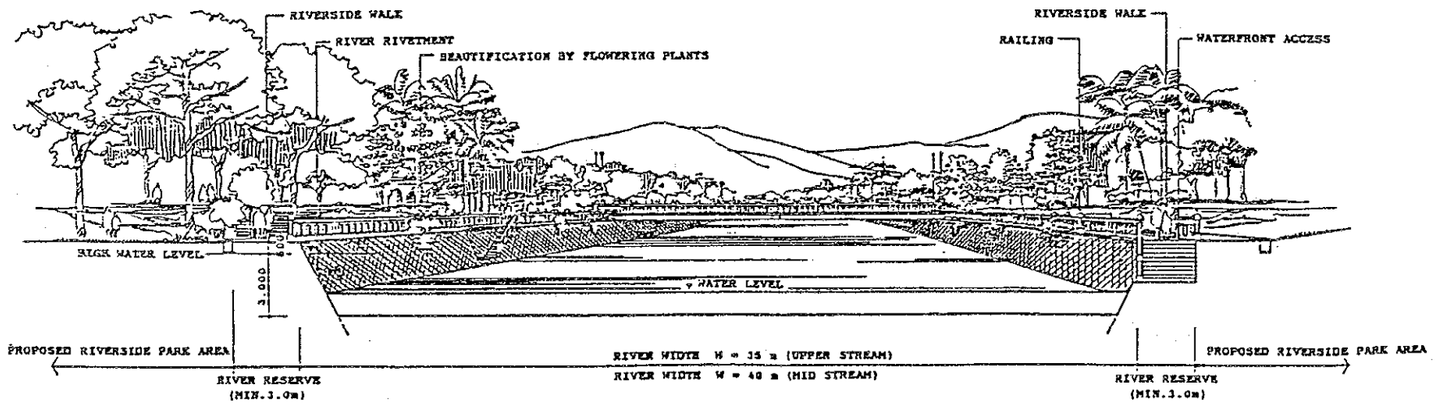
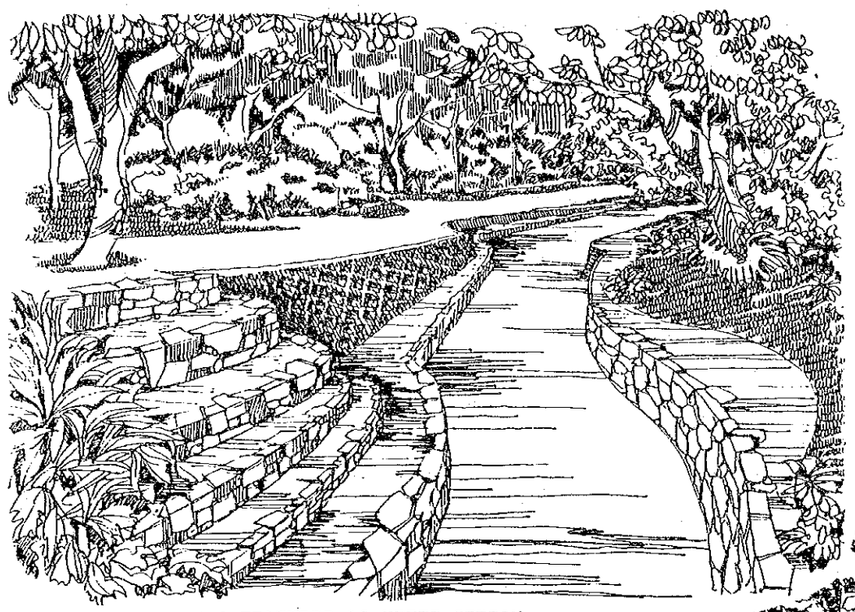


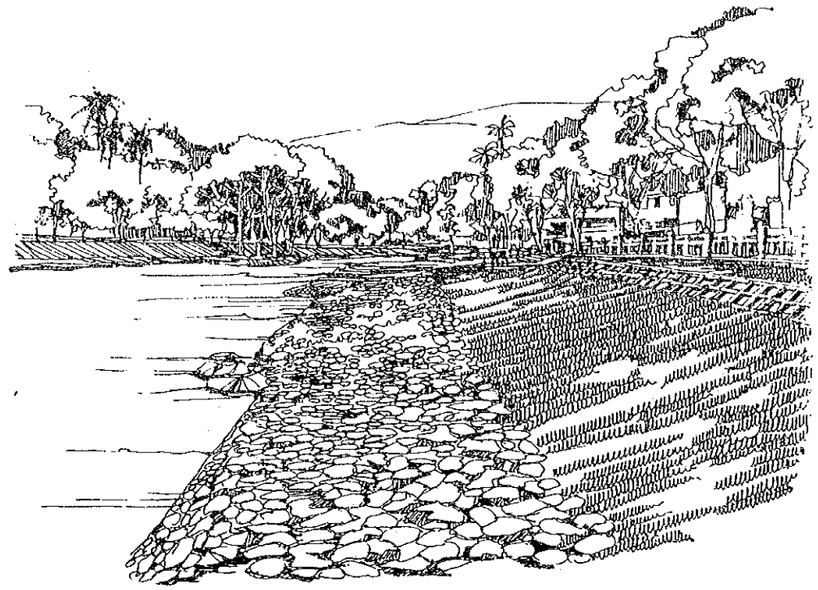
FIG. O-6 RIVERSIDE IMPROVEMENT VARIATIONS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



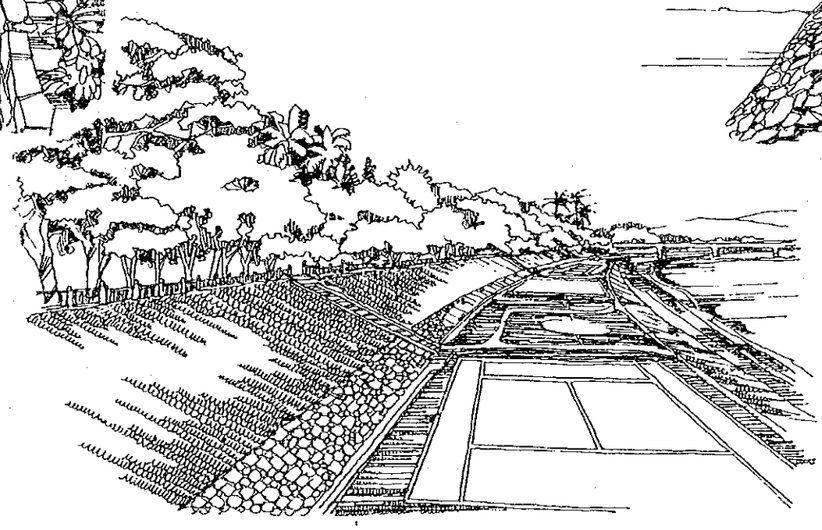
VARIETY OF WATER ACCESS FEATURES AT UPPER STREAM

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



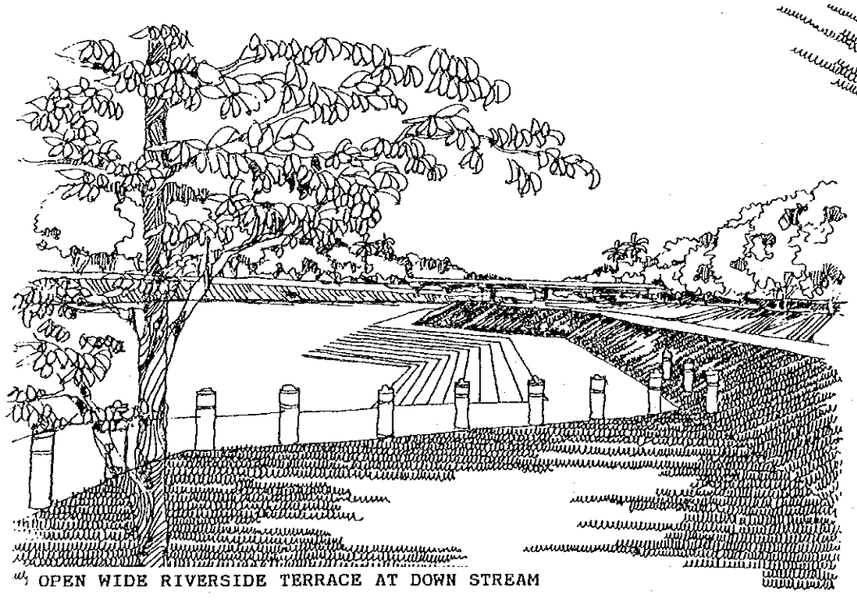
NATURE ORIENTED RIVER BANK SOLUTION AT MID STREAM

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.



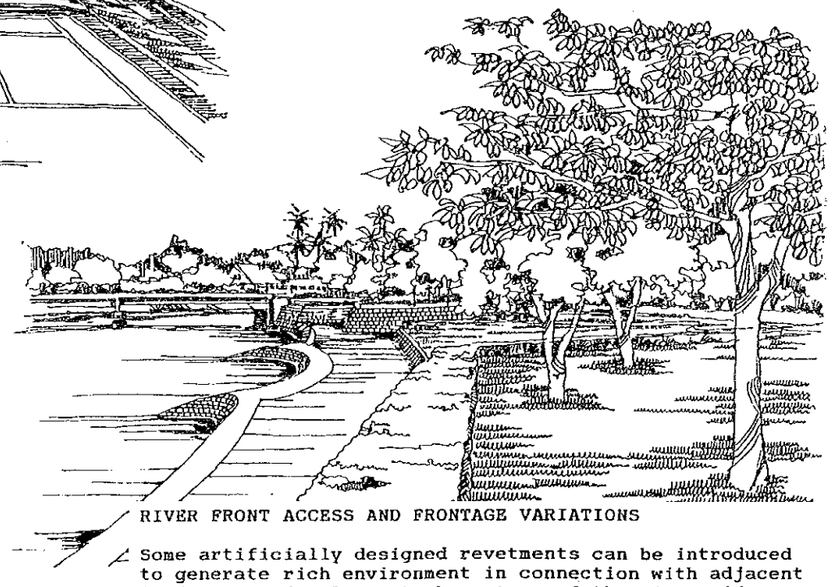
SPORTS AND GAME USE SPACE AT RIVER TERRACE NEXT TO THE BANK

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

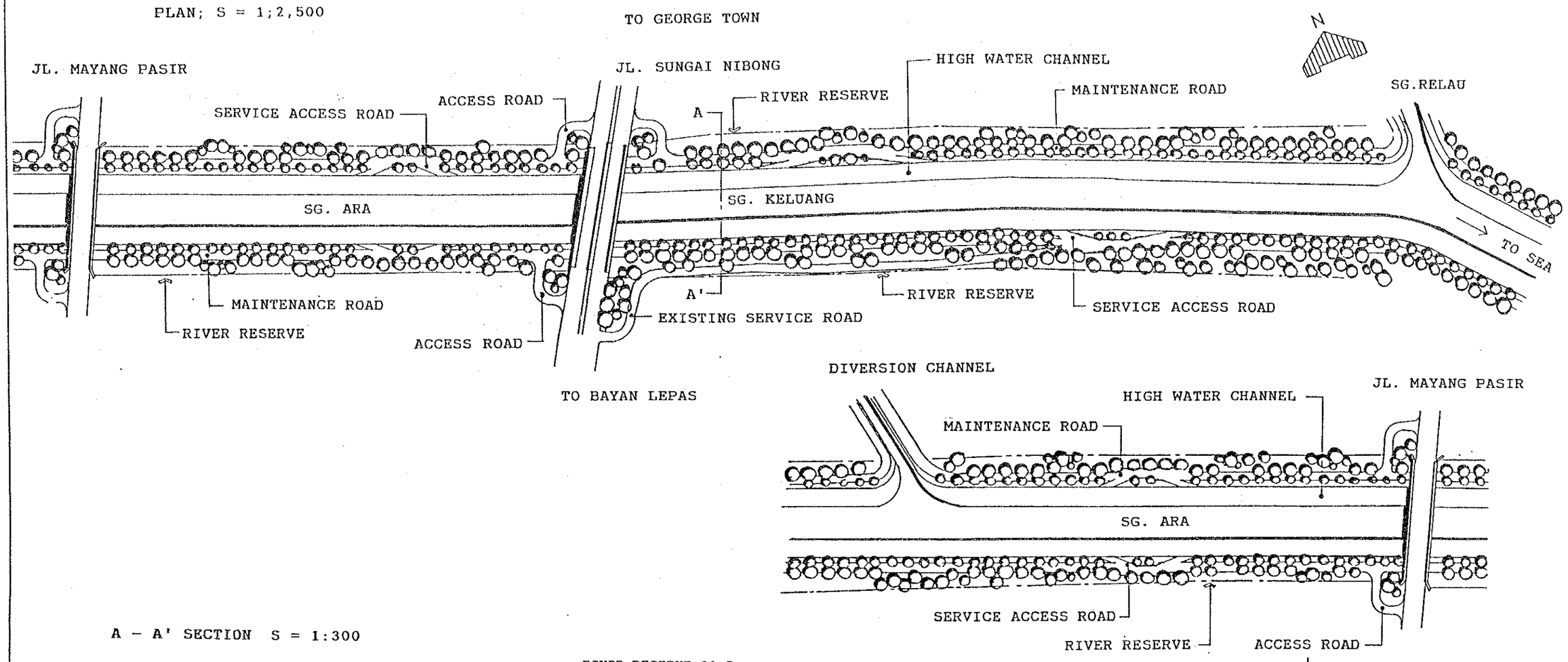
Some artificially designed revetments can be introduced to generate rich environment in connection with adjacent land use or development characters of the river side area.

FIG. O-7 **RIVERSIDE IMPROVEMENT REFERENTIAL SCHEME**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

PLAN; S = 1;2,500



A – A' SECTION S = 1:300

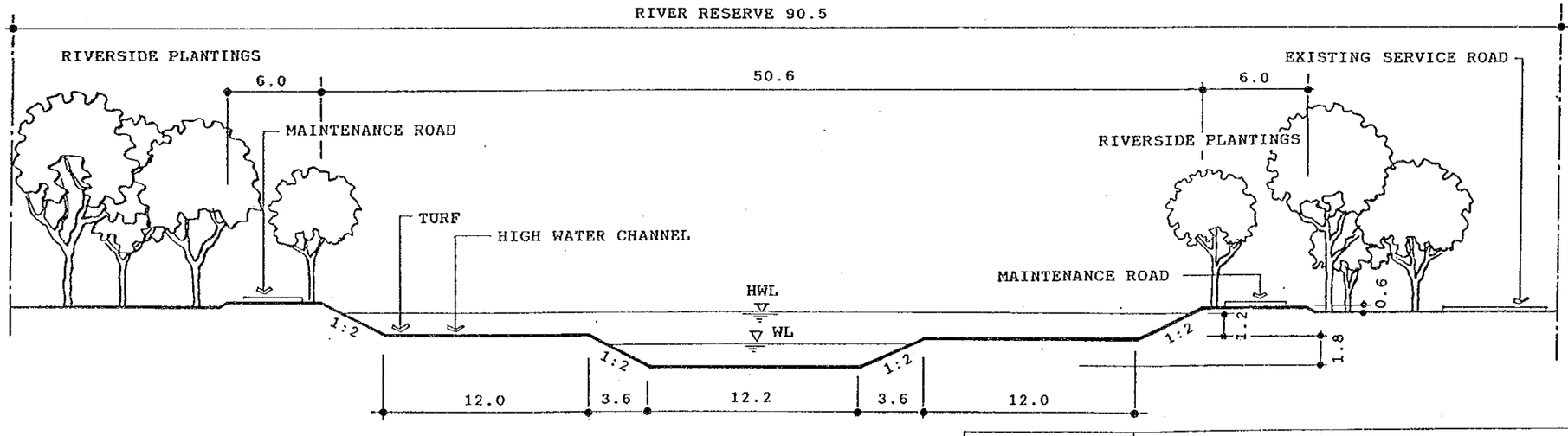
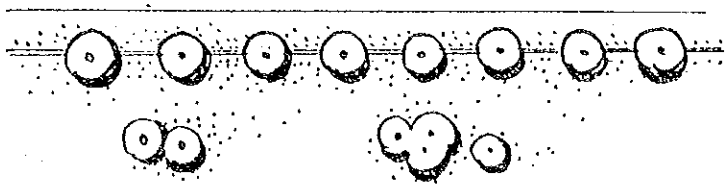


FIG. O-8 RIVERSIDE IMPROVEMENT SCHEME: SG. KELUANG AND SG. ARA AT DOWN STREAM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

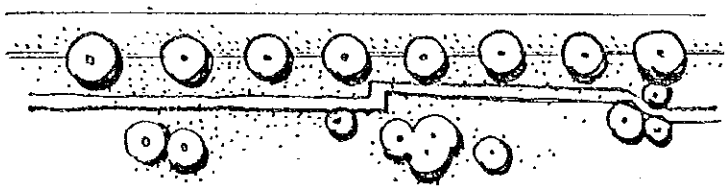
Grade 1. landscaping case:

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



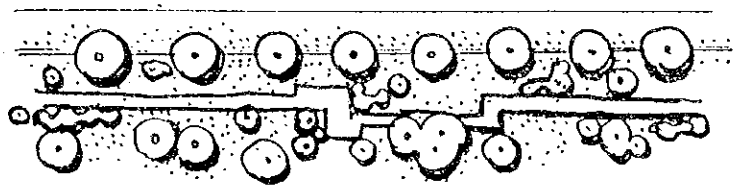
Grade 2. landscaping case:

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

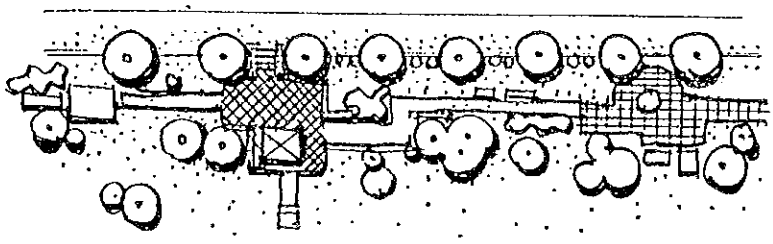


FIG. **O-9** **SCHEME OF STANDARD COST FOR RIVER CORRIDOR LANDSCAPING**

APPENDIX P

ENVIRONMENTAL ASPECTS

APPENDIX P. ENVIRONMENTAL ASPECTS

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APPENDIX P. ENVIRONMENTAL ASPECTS

1. INTRODUCTION

The Objectives of the environmental study are:

i) Review of existing collected data concerned with vegetation, relevant environmental conditions of the Sg. Pinang and other river systems in Penang Island.

ii) Review of existing river and watershed environmental condition data associated with vegetations, waterfront scheme and aesthetic aspects of the river system in Penang Island incorporating the flood mitigation and drainage, master plan and Feasibility study.

iii) General study for conceptual environmental improvement is made in concerning with the retention ponds, river channels, diversion channel of the surrounding area.

iv) The preparation of scope of work for the preliminary environmental impact assessment to local assessor to cooperate the flood mitigation and drainage study for covering the objective sites. In this report on the environmental aspect, Preliminary Environmental Impact Assessment has been carried by the Environmental Research Group, University Science of Malaysia, Penang and Preliminary Environmental Impact Assessment report as the study results would be attached separately.

2. OUTLINE OF EXISTING ENVIRONMENTAL CONDITIONS

Existing environmental conditions of the study area in Penang island have various characterized aspects by the background of natural environment woven with dynamic human activities comprising of urbanization, industrialization, tourism and other developments throughout ages up to present time.

Topographically Penang Island is clearly identified with rather steeply hilly terrains which ranges from north to southwards in the interior of the Island.

The highest point at 830.5 m above sea level at western hill, `63 and smaller hill range on the eastern part is separated by Paya Turbon valley.

The rest of the Island is composed of two major coastal plains where urbanized Georgetown to Bayan Lepas at eastern coastal plain and agricultural area of Balik Pulau at western coastal plain are located.

According to the hilly terrain features, about 48% of the island has slopes of 10% and above, and about 26% of the island has slopes more than 20%. In general, land in the elevation range of 45 m to 60 m are quite steep. The urbanized area at eastern coastal plain and agricultural area at western coastal plain are generally distributed at slopes less than 5%.

Meanwhile environmental sensitive areas consisting of valuable and sensitive natural resources have been identified during the survey and study of Draft Structure Plan by Municipal Council, and are shown in Fig. P-1.

2.1 Natural Vegetation

The vegetation and flora of Penang Island is recognized as evergreen rain forest formation and the most typical family of the forest vegetation is the Dipterocarpacea which is known as the predominant family of timber tree.

In the forest, its representative form projects a high proportion of the upper story. The main forest areas are at an elevation range of 30 m to 750 m with the extent of forest thinning down hill and at 45 m elevation it is interspaced with scrub. Forest in Penang Island may be classified under 2 main groups, with each group comprising 2 sub-groups:

i) Lowland rain forests
   Lowland Dipterocarp forests
   Hill Dipterocarp forests

ii) Swamp and low-lying forests
   Marine alluvial swamp forests (Mangrove)
   Riparian fringes

2.1.1 Lowland Dipterocarp forest

This type of forest is distributed on undulating land and foothill up to an average elevation of 300 meters above sea level. The forests are usually dense, through comparative freedom of movement on the ground is possible. They are composed of many thousands of species of trees as well as shrubs, herbs and woody climbers.

The representative tree belong to the family of Dipterocarpacea (Arisoptera, Dipterocarps, Dryobalanops, Hopea, Shorea and Parashorea). Many of the tree are buttressed and some have stilt roots. Also many sub-serial communities exist in this type of forest.

2.1.2 Hill Dipterocarp Forest

This forest type exists at an altitude higher than 300 m and extend up to peak hill range of Penang Island. Many of the common lowland forest species found in Penang Hill forest belongs to Shorea curtisii which tend to be of gregarious character.

The vegetation of hilly slope, is often poorly stocked in woody species and the under-story is unusually very rich in stemmed palms. In the base of the valley, large woody species are comparatively poor and the forest is characterized by its richness of ground flora and shrubs.

2.1.3 Marine Alluvial (Mangrove) Swamp Forests

Mangrove swamp forests are confined to muddy shores, lagoons and estuaries of the tidal river zones. They exist mainly along west coast of the Penang Island and sometime in

northern and southern east coast as well. The vegetation is simple in structure with a comparatively even and unbroken canopy, a very poor under-story layer. Avicennia alba and Avicennia officinalis are pioneer species on the less sheltered parts of the river and exposed swampy portions of the coast.

2.1.4 Riparian Fringes

Numerous types of riparian fringes occur as a narrow strip along the banks of the estuaries, rivers and streams throughout Penang Island. Their composition and hence their structure varies enormously and depend on tidal effect, the rate of water flow,the elevation, the width of the river or stream, the nature and aspect of the terrain and the enrichment of the site by water or soil.

Under saline influence, vegetation types are Mangrove forest. further upstream where the waters are brackish, thatching palm and Nipa fruticans usually lines the bank and characterizes the vegetation, particularly in the case of rather wider rivers with even flow. However, Nipa is seldom seen along the coastal area between Tg. Tokong and Batu Maung.

The trees Artocarpus penduncularis, Brownlowia argentana, Cerbera odollan, Excoeecaris agallocha, Ficus retusa, stemmed palm Oncos perma filamentosa, Terminalia catappa and thickets of rattans and palms Calamus, Lucuala, Zalacca, the sedge Scirpodendoron ghaeri and the climbing fern Stenochlaena palustries are also sometime found.

Further up-stream still, where the water is no longer brackish but still tidal, the trees, Barringtonia conoidea, Gluta spp., and Pandanus helicops line the edge of the banks.

Beyond the tidal affected zones the "Gallery" forests, where the common species are Calophyllum spp., Cralloxylon spp., Terminalia phellocarpa, Tristania smatrana, Vatica spp., Donax grandis and others, exist.

On the foothill ranges, the streams becomes narrow with faster flow and rocky riverine. The small to medium size trees becomes dominant. Sarraca spp., is a characteristic species. Dipterocarps hesseltii and several species of Shoreas, and many Zingiberaceae, etc., are also common.

In area where human activities are recognized, the vegetation are more simple with lower sedge, bushes together with variety of fruit trees. within urbanized area some range of landscape trees for urban beautification purposes are also planted.

2.2 Agricultural Vegetation

In general, the agricultural vegetation scheme depends on the landuse at different altitude and this vegetational scheme reflects a characteristic trend of activities in Penang Island. Most of the rubber and fruit orchards are distributed above 45 m range and some above 150 m ranges, but not more than 300 m on the Hill range.

Mixed horticulture, such as coconut, diversified crop and rice, is generally distributed below 15 m range on even land

area. On the other hand, the bulk of market nurseries with a variety of flowering ornamental plants, are distributed mainly either in the lower flatlands of above 15 m or range between 300 m and 750 m of the hilly land. Table P-1 shows the agricultural landuse pattern in Penang Island.

2.3 Wildlife and Birds

In general, based on its topography and small area there remains only a rather few kinds of small size wildlife in Penang Island. However, many kinds of birds are still inhabited in the Island. But their population is decreasing rapidly under pressure from urbanization and human activities.

Within urbanized area and even in newly developed land, wildlife and birds with strong survival characters are still in existence in case of the area with rich plantings such as grown trees and shrubs along riparian fringe environs.

In Penang state the fully protected animals consists of 43 species in first priority, 37 species in second priority and in the listed wild birds, 78 species according to the Wildlife Act. among these protected animals only about 15 species may inhabited the Island in reality.

Small animals such as wild pigs, long tailed macaque, dusky leaf-monkey, Malayan flying fox, python and water monitor are still in abundant.

As per the birds approximately about 20 protected species are in existence, and some common bird species are also included within them. However there can be counted up to about 100 species of birds, specially in non-urbanized area along the west to north coastal zone of the Island.

On the upper stream of the rivers, there are many species of small mammals such as rats and squirrels. Reptiles such as python and other snakes, and lizards are also common.

Regarding aquatic fauna there exists only few variety of the fish species, which is attributed to the seriously polluted water quality at most of down stream of rivers, especially along Georgetown and other urbanized area of east coastal zone. Only some turtles are observed at upper to mid stream region.

Table P-2 and Table P-3 show the inhabited protected species of wildlife and birds in Penang Island.

3. ENVIRONMENTAL FEATURES OF RIVER SYSTEM IN PENANG ISLAND

This section outlines the existing environmental conditions of major river systems in the study area.

Generally speaking, the river systems in Penang Island are comprised of many small rivers of short range, with some tributaries originated from the hill range and it's foothill. One of a major river system is Sg. Pinang which has several tributaries within the city of Georgetown.

On the other hand, in comparison to Sg. Pinang system, many small to medium size rivers are distributed equally along the

coastal range of the Island. Some exceptions are recognized at western coastal plain such as Sg. Kongsi and Sg. Pinang. Regarding environmental condition of the riverside area, generally riparian condition of the most rivers that are in urbanized area is rather degraded due to water pollution, solid wastes, and natural grown sedge and vegetation on the banks. Inadequate maintenance and care for the river reserves area often exposes their poor outlooks even in focal areas.

The potential resource of environmental and landscape is still recognized being in rich conditions at some riparian area.

In conjunction with the consideration for future riverside open space, Table P-4, and Fig. P-2 show existing public parks and the future plan in Penang Island and Fig.P-1 shows environmentally sensitive area in Penang Island.

4. ENVIRONMENTAL DEGRADATION AND PROBLEMS

Due to ever expanding socio-economic development, human activities have encroached and degraded the riparian environmental qualities in Penang Island, especially in zone from Tg. Tokong through Georgetown to Batu Maung at the east coastal range.

The river systems in Penang Island which serves as conditions of natural drainage are loaded with a diversified variety of pollutants. In the hilly area, the rich forest vegetation is being threatened mainly by housing development and mining activities and uncontrolled small mosaic private land developments.

The hill area where is barely stripped and exposed without trees and vegetation, as a result of fast urbanization in the Island, has been brought a serious threat of frequent flood damage which is caused by increased runoff and compounded with erosion and siltation towards downstream areas.

Frequent flooding is one of the worst environmental degradation to the inhabitants of the urbanized area especially in down town area of Georgetown.

5. IMPACT OF FLOODING ON ENVIRONMENTAL DEGRADATION

Along the hillside areas of the east coastal zone of the Island, rapid urbanization, especially the large scale housing development schemes have being implemented, and these development sites have being stripped the ground surface with its vegetations.

The eroded mass of soil runs off into the river and it causes siltation. Also the tidal effects caused multiple flooding impact, especially when heavy rains is associated with high tide. These are the major reasons behind frequent flooding along each river systems in the Island.

In comparing to land development in down stream area, the development activities around hilly area are more visibly causing much serious impacts to over all the catchment area.

Other important agents of degradation are solid wastes that either dumped or thrown away on the river banks, especially when the rivers are at backyard of residential or commercial areas. These solid wastes often cause clogging near and under the bridges.

Also in some critically narrow river reserve, naturally grown sedge plant and their dead remains often make condition worse, a fact that could be attributed to improper maintenance of river reserve.

Even though the Municipal Council and State Government concerned are doing their best on riverine maintenance. However more public campaign to arise the awareness of residents, especially system concerning proper disposal of wastes is more necessary to be programmed.

6. ENVIRONMENTAL FEATURES OF THE OBJECTIVE FEASIBILITY STUDY AREA

This section outlines the existing environmental conditions and landscape of objective feasibility study areas.

Regarding environmental and landscape condition of the objective riverside areas, generally riparian condition of these area are in urbanized area is degraded due to water pollution, solid waste, natural grown sedges and vegetation on the banks. More often maintenance and care for the river reserves are much expected especially at focal points.

Yet the potential resource of the landscape is still recognized being in rich conditions.

6.1 Sg. Pinang Area for River Improvement

The proposed river improvement involves widening and deepening of the whole stretch of Sg. Pinang, and the part of lower stretches of Sg. Air Terjun and the Sg. Dondang.

All the river stretches of the improvement objectives beside Sg. Air Terjun are grossly polluted. At this moment the rivers are not suitable for any meaningful beneficial uses.

The riparian vegetation along the river in upstream areas is shaded by wayside trees, however the areas near the estuary and down stream are rather exposed to the sun.

The river is highly polluted and reflected by the odour and colour of both the water and sediments, so that the river fauna and flora are very narrow-based development in these polluted water result. However fish fauna as the catfish, the half-break and the guppy are inhabited.

The Upper stream of the Sg. Pinang, common residential houses, traditional residential houses and government facilities are sited along the river but numbers of squatter settlements are also sited at both side area of the river edge. Most of these stretch of open space covered with grasses and sedge plants and some wayside trees.

The lower reaches of the Sg. Pinang are rather consisted warehouse, small industrials and workshops,while high-rise and high density residential are also existed near the estuary, the boat landing area for local fishermen is situated opposite of the Public Works Department workshop at the estuary too.

6.2 Sg. Dondang Retention ponds and Park Areas

The three numbers of Retention ponds will be constructed at the middle reaches of Sg. Dondang is concerned, the recent water quality survey conducted, that have indicated the river water is grossly polluted in term of organic load.

The major wastes being discharged into the river include raw and semi-treated domestic sewage and pig wastes. Such poor water quality of Sg. Dondang has rendered it unsuitable for any meaningful beneficial usage.

The proposed retention pond A is located in the established Taman Rambai housing area. The site consists of grass covered flat land, and is used as play ground. Relatively steep river banks are covered with low riparian vegetation of common grasses.

The proposed retention pond B is located the Paya Terubong hosing estate at rather down stream of Sg. Dondang. Other proposed retention pond C is located further down stream at the Halaman Zoo residential area.

Around these area, densely and diverse riparian vegetation is observed in growing. Common grasses, palms, shrubs and bamboo are inhabited along river banks. The river in the vicinity of retention ponds appears wastes and organic decay with poor condition of smell and deposition of eroded sediment caused housing development activities.

The dense canopy especially mature bamboo thicket is covering over the river. The river fish is extremely limited in numbers and diversity because of polluted quality of water.

6.3 Diversion Channel Route Area

The proposed diversion channel will divert a major flow of Sg. Air Terjun during heavy storms. Under normal condition, there will be introduced to the diversion channel from the river. The Sg. Air Terjun is still keeping quite clean condition of water.

The vicinity of the proposed diversion channel where is the point to divert into Jln. Gottlieb, is rather flat area with rich vegetation of grass, palm, bamboo thicket and tall wayside trees at riparian fringe. The fish fauna includes species of common guppy and others.

Along the street sides there are well grown palm trees planted and they make a good street scape in line with residential facades, and some rows of palm trees intermittently are made characteristic demarcation of the street way.

The area of the proposed diversion channel at the Jln. Gottlieb contains most of commercial activities, shop-houses,

hotels and hawkers. Especially hawkers activities are increasing along Jln. Gottlieb and their principal activities at night, while the area along Jln. Bagan Jermal is more residential and institutional use.

The traffic volume of Jln. Gottlieb and Jln. Bagan Jermel is not available an exact study and data, but presuming the previous study result of a vicinity traffic volume of along stretch of road, Jln. Mt. Erkine and Green Lane having already exceeded their capacities, and Jln. Gottlieb and Jln. Bagan Jermal are to be said alike the same of these.

Along the Jln. Gottlieb, about thirty numbers of hawker cater approximately a thousand of clients at each night. This site has no parking facilities and the hawker's clients park along the both side of the road.

Sg. Babi is utilized for other small portion of diversion channel at down stream, and this area has rather flat spread Kampong style residential houses are settled with some representative village groves along the river banks.

6.4 Area of Sg. Ara and Sg. Keluang

Objective area of Sg. Ara and Sg. Keluang is approximately 3.8 km in length from new reclamation area at estuary to part of upper reach of the river. Down reach of the river itself is under the condition of reclamation works in implementation by PDC, this area is in airport field and industrial zone and wide expanded river reserve may have a high potential for establishing river front greenery landscape.

At the mid-stream to upper stream, residential, government reserved area and Kampong type residential are allocated with relatively low density along the widely expanded river reserve.

Most of river banks are clearly wide enough with gentle slopes and given a good view and represented amicable riverside scenery. On upper reach of the river, the river banks become narrow and steep condition and banks are covered with group of bamboo thickets, wild grown trees and shrubs.

6.5 Area of Retention Ponds for Urban Drainage

Proposed area of retention ponds for urban drainage is located at the reclamation area adjacent the high rise low cost residential development area near Sg. Pinang estuary. Present condition of the area is vacant open space with quite flat expanded land facing the sea, and this area is to be a part of CDD 21 reclamation project area.

This ponds are to be collected storm water run-off from the south part of Georgetown area.

The proposed retention ponds are to be built on the coastal edge of proposed future reclamation land area known as CDD21. And both ponds will locate on the seaward side of the proposed coastal road.

The proposed site is muddy area near shore and patches of green, blue-green algal mats are mostly seen on the mud-flat

with garbage and other solid wasters. These have been flushed out by the river flow or deposited by the tidal affection.

Some aqua-culture activities are presently on going in the near by the coastal waters at south of the proposed retention ponds.

Around of this area, high rise housing flats are located in the reclamation land at west direction and dense squatter settlements are located at north west direction not so far from the proposed ponds site.

7. ENVIRONMENTAL APPROACH TO FLOOD MITIGATION

7.1 General

There are many environmental factors related to the study on mitigation and drainage in Penang Island. The growing trend of urbanization and socio-economic development increase the propensity for floods in the urban and suburban areas.

In the urban area and it's vicinity, the growth of population has caused large scale housing development schemes and related urban facilities, and further increase of such developments can be foreseen.

With continuing urbanization, the ground will become more impermeable as more and more grassed and natural ground are replaced by impermeable areas. As a result, the storm water run-off coefficient takes on a much higher value than before. So that the storm water discharge from its catchment, into the river has reached a critical stage at which the capacity of the river is insufficient.

In this section two conceptual approaches to mitigate flooding are proposed in conjunction with the flood mitigation and drainage study. One approach is to use some future park areas and open spaces as retention ponds where the flood water is temporarily diverted into and another approach is to provide diversion channel to divert the flood water away directly into the sea.

7.2 Retention Ponds and Multi-use Park Environment

Within series of three future park areas, the function of the retention ponds are to be formulated, their flood water is diverted into these temporary pond areas and there are retained during peak hours at critical points of downstream.

To provide sufficient retention pond capacity, the volume of the ponds required would be quite large enough to cut the peak runoff, the retention ponds may be formed into an occasional temporarily pond and only filled with diverted water during critical hours at more than 10 year return period, so that normally these are no water impounded in this portion of the pond areas.

These major portion of the retention pond areas are provided as spaces for diversified recreational activities. These park areas of the retention pond are to be landscaped for multi-use purpose recreation areas.

Fig.P-3 and P-4 shows retention ponds and sunken formed water front parks system at Sg. Dondang.

7.3 Retention Ponds for Urban Drainage

Two places of the retention pond for urban drainage mitigation may be allocated near estuary of Sg. Pinang at coastal reclamation zone in Georgetown, there would be future project of public facilities such as condominium type housing and open spaces near these retention ponds.

These two retention ponds have spaces of each approximately 2 hectors with forested green belt at inner surroundings for screening and preventing odour problem, and the other side of the retention ponds are faced open to the sea side for easy ventilation of air. Fig.P-5 shows retention pond for urban drainage at Sg. Pinang estuary.

7.4 Diversion channel

A proposed diversion channel which tend to be located at mid-stream of Sg. Air Terjun shall be necessary to divert the excessive flood water from the upper reach into the sea to avoid the flood water from the central area of Georgetown.

The diversion channel should be provided with sufficient section with channel reserves for enhancing the environmental and aesthetical values of their surroundings when there is a open portion of the channel or utilization of existing river.

In these open portion channel case, the channel reserve area shall be provided with neat bank slopes and landscaped plantings on the flat tops of the berms, or in the case of limited reserve width, revetments and nearby riverside space should be furnished with solid landscaping.

Along the channel, some access ways to the water front for maintenance purpose and pedestrian walk may be necessary, Spaces where bridge crosses are to be observation points, there shall be projected sufficient landscaping for beautification of the spaces as nodal points.

Meanwhile, in connection with open diversion channel, box culvert type of diversion channel shall be provided under the existing road area where there has not enough space for projection of open channel type. This underground type diversion channel is no more visible and any aesthetical problem through the route.

8. GENERAL GUIDELINE FOR BASIC CONSIDERATIONS INCORPORATED WITH OTHER AUTHORITIES

Due to enhance the riverine environmental quality condition, some incorporation with other government authorities may be vitally important beside D.I.D's contributions. Following items shall be some of these aspects to be desired.

i) Retention and sedimentation pond shall be compulsory provided by legally for the certain scale of development of housing, mining and other area

development due to cut the surface water runoff and siltation.

ii) Regulating excessive logging or clearance of hillside forest and agriculture area for private property land even in authorized development projects, and reforestation or greenification shall be guided for avoiding exposed ground condition.

iii) Provision of appropriate screening means and systems for collecting floating debris at strategic points of major polluted rivers and its tributaries.

iv) Provision of garbage, solid waste collection and disposal system shall be necessary, and adequate management and operation shall be projected due to avoid the condition of the increases of river pollution.

v) Appropriate anti-pollution system, proper inspection and guide for each type of industries which produce worse pollutants shall be practically programmed.

vi) Environmental education and public awareness for conservation of riverine quality shall be programmed and emphasize them maximum use of public relation media.

9. PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT STUDY

9.1 Preliminary EIA. in Malaysia and a relation to the project.

Environmental Impact Assessment (EIA) for development projects became mandatory on April 1988. This is the result of an Amendment to the Environmental Quality Act of 1974. Under this amendment, the prescribed development activities must under go a mandatory of EIA. Though the projects concerning the flood mitigation and drainage of this study do not legally requires EIA.

However, the Department of Environment, Malaysia, encourages projects to undertake EIA as a mechanism for better project planning. This is especially encouraged when there are environmental impacts predicted at the planning stage. The preliminary EIA process would be able to identify and problems could be resolved before the commencement of the projects.

This preliminary EIA is to be conducted on the basis of review of the contents of the preparation of preliminary EIA in the Interim Report I prepared by JICA.

Preliminary EIA. study has being conducted by research team of the University Science of Malaysia, the study results is finalized during feasibility study period and the preliminary EIA report is edited separately.

9.2 Preliminary EIA Description

Preliminary EIA study is to be comprised in the followings:

i) The assessor, equipped with knowledge of the existing environment and the project activities, examines the project options and identifies the potential residual significant impact in relation to the normal engineering practice to be engaged on the project.

ii) For each of the significant impacts identified, the factors are to be considered in judging significance, the assessor examines mitigation and abatement measures that can be taken avoid or minimize these impacts to a level considered acceptable to the surrounding environment.

iii) The assessor shall also identifies those of residual impacts which may still remain potentially significant or unacceptable to the surrounding environment in spite of the mitigation and abatement measure taken.

9.3 General Objective of the Preliminary EIA

9.3.1 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 environmental impact assessment (EIA) of the project is undertaken on the proposals of the feasibility study for flood mitigation and drainage for Sg. Pinang and its tributaries.

9.3.2 Project initiator

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

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

9.3.3 Need for flood mitigation and drainage

In accordance with both increase of built up areas and development trends in the water catchment of the rivers, the amount of run-off water after a storm has obviously increased. This has been resulted in an increase of frequent floods over the years to urban flood prone areas.

This is a clear need to mitigate against occurs of frequent floods.

9.4 General Descriptions of Preliminary EIA of the Projects and Mitigation, Abatement Measures

The Preliminary EIA of the proposed river improvement, retention ponds, diversion channel have been carried by USM research team following the guidelines laid down in the EIA handbook produced 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.

9.4.1 River Improvement

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

The high volume of disposal of the earth and for river widening and deepening would be generated the impacts, however such volume of them would be utilized for the lands reclamation projects and would appear to be mutual beneficial solution.

The biological impacts are mainly in the changes of the riparian flora and fauna. However the riparian vegetation is quite common grasses with any particular valuable species, same thing can be recognized for aquatic fauna also.

The landscaping of the river corridor as provision of river side park will be more beneficial to enhance and rehabilitate the aesthetical value of the riverine environment for the urban area.

For acquiring the river reserve space in order to widen the river channel, the need of compensation and relocation for many of the houses and buildings which are built right up to the river banks would be some serious impacts. This might be coordinated with the government authorities and municipal council concerned for relevant solution of this matters.

Another impact would be the temporary traffic flow disturbance as a result of reconstruction of the bridges that would be necessary for river widening. There would be a need of traffic control scheme on a bridge section basis by relevant authorities concerned.

9.4.2 Dondang Retention Ponds

The construction phase of the retention ponds will involve the use of heavy machinery for the earth works. There will be short time impacts associated with noise, visual instruction, earth moving and dust problems, due to excavation work to the residents near by. Transportation of excavated earth should be done during non-peak hours. At the 30 years return period, the sediment load of the flood water may be high and this would settle at the bottom of the ponds. On the subsidence of the flood water, a layer of sediment may remain which need to be cleared up.

During construction phase, the site clearance and earth works will exert drastic impacts in that existing vegetation, such as grasses, wayside plants and its inherent natural soil will be destroyed. However no wild life or any endangered species are involved here.

The soil erosion will appear after earth works so that as a suitable mitigation measure, quick ground re-vegetation for exposed earth are adopted.

The retention pond spaces are landscaped and utilized for recreational and sports field as well as scenic improvement of the environs to the vicinity residents unless flood time of 30 years of return period.

9.4.3 Diversion channel

There are some impact on the physical and biological environment, however the serious problems may be socioeconomic aspects.

The impacts related the construction of box culvert may be caused such as noise and dust problems, but they are usually unavoidable. The excavation also affects to the root systems of the roadside trees, the royal palms have a shallow and fibrous root system, the old angsana trees have a tap-root system so that main roots are not unlikely to be affected. Some trimming of branches may require to maintain the balance to the roots.

The traffic flow, hawkers and commercial establishment and existence of two schools are the problems for the construction impacts along the Jln. Gottlieb. 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 that it would be possible to allow some traffic flow, and some adequate side walks with safety measures for the pedestrian flow for the school students especially for the handicapped also.

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.

9.4.4 Retention Ponds for Urban Drainage

The construction of the retention ponds probably will have some shot-term impacts such as visual instruction and dust and noise problems on the local community in the vicinity. However the construction sites are sited at coastal edge and rather off the vicinity residential so that the impact will be not so serious.

During the operation phase, the ponds will receive the drainage water and runoff from urban areas. These ponds would be permanently covered with water with high organic load, and they may also be generated odour problem. However the generative odour may be more less affecting than when they dry up.

The mitigation measures to improve the quality of the water is a complex problem and related hygiene and public health. The screening the rubbishes, regular discharge of the pond waters and monitoring work may taken.

Tables

TABLE P-1 AGRICULTURAL LANDUSE PATTERN OF PENANG ISLAND IN 1980

Zone	North-East Distrect		South-West Distrect		Penang Island	
Type of agriculture landuse	Area (ha)	% of Distrect	Area (ha)	% of Distrect	Area (ha)	% of whole Island
Rubber	678	5.6	3222	18.6	3900	13.2
Coconut	98	0.8	1802	10.4	1900	6.4
Padi	0	0	1130	6.5	1130	3.8
Orchards & Spices	635	5.4	1605	9.2	2240	7.6
Market Gardening	97	0.8	38	0.2	135	0.5
Mixed Horticulture	773	6.4	1786	10.3	2559	8.7
Diversified Crops	60	0.5	99	0.6	159	0.5
Total	2341	19.5	9682	55.8	12023	40.5

Source: Report of Survey, Penang Island Structure Plan

TABLE P-2 INHABITED SPECIES OF PROTECTED WILDLIFE IN PENANG ISLAND

Scientific name	English name	Malay name
Manis javanica	Scaly Ant Eater,Pangolin	Tenggiling
Felis marmorata	Marbled Cat	Kucing dahan
Nycticebus coicang	Slow Loris	Kongkang,Kera duku
Aeromys tephromelas	Large Black Flying Squirrel	Tupai terbang hitam
Petaurista petaurista	Red Giant Flying Squirrel	Tupai terbang merah
Cynocephalus variegatus	Malayan Flying Lemur	Kubong
Lutra lutra	Common Otter	Memberang utara
Felis bengalensis	Leopard Cat	Kucing batu
Tragulus javanicus	Lesser Mouse-Deer	Pelanduk
Sus scrofa	Wild Pig	Babi hutan
Amblonyx clinerea	Small-claewd Otter	Memberang kecil
Macaca fascicularis	Lonf-tailed Crab-eating Macaque	Kera
Presbytis melalophos	Banded Leaf-Monkey	Lotong Ceneka
Presbytis obscura	Dusky Leaf-monkey	Lotong Cengkong
Presbytis cristata	Silvered Leaf-Monkey	Lotong kelabu
Hystrix brachyura	Malayan Porcupine	Landak raya
Callasciurus presvostii	Prevost's Squirrel	Tupai gading
Ratufa bicolor	Black Giant Squirrel	Kerawak hitam
Pteropus vampyrus	Malayan Flying Fox	Keluang
Python roticulatus	Python	Ular sawa
Varanus salvator	Water monitor	Biawak air
Varanus nebulosus	Clouded Monitor	Biawak tikus
Varanus rudicollis	Harlequin Monitor	Biawak serunai
Varanus dumerili	Dumeril's Monitor	Biawak kudung

Imformation Source: University of Science Malaysis
State Department of Wildlife and National Parks

TABLE P-3 INHABITED SPECIES OF PROTECTED BIRDS IN PENANG ISLAND

Scientific name	English name	Malay name
Pulvialis dominica	Golden plover	Burung keriyut
Tringa hypoleucas	Common sandpiper	Kedidi kelicap
Treron curvirestra	Lesser thick-billed green pigeon	Punai daun
Anas guerguedula	Gargany teal	Itik gargany
Gallicrex cinerea	Watercock	Ayam-ayam
Coturnix	Painted quail	Puyuh
Turnix suscitator	Barred bustard quail	Puyuh
Chalcophaps indica	Emerald dove	Punai tanah
Pcynonotus jocosus	Red-whiskered bulbul	Merbah telinga merah
Gracula religiosa	Hill myna	Tiong mas
Gopsychus malabaricus	Common shama	Murai batu
Zosterops palpebrosa	Oriental white-eyed	Kelicap kunyit

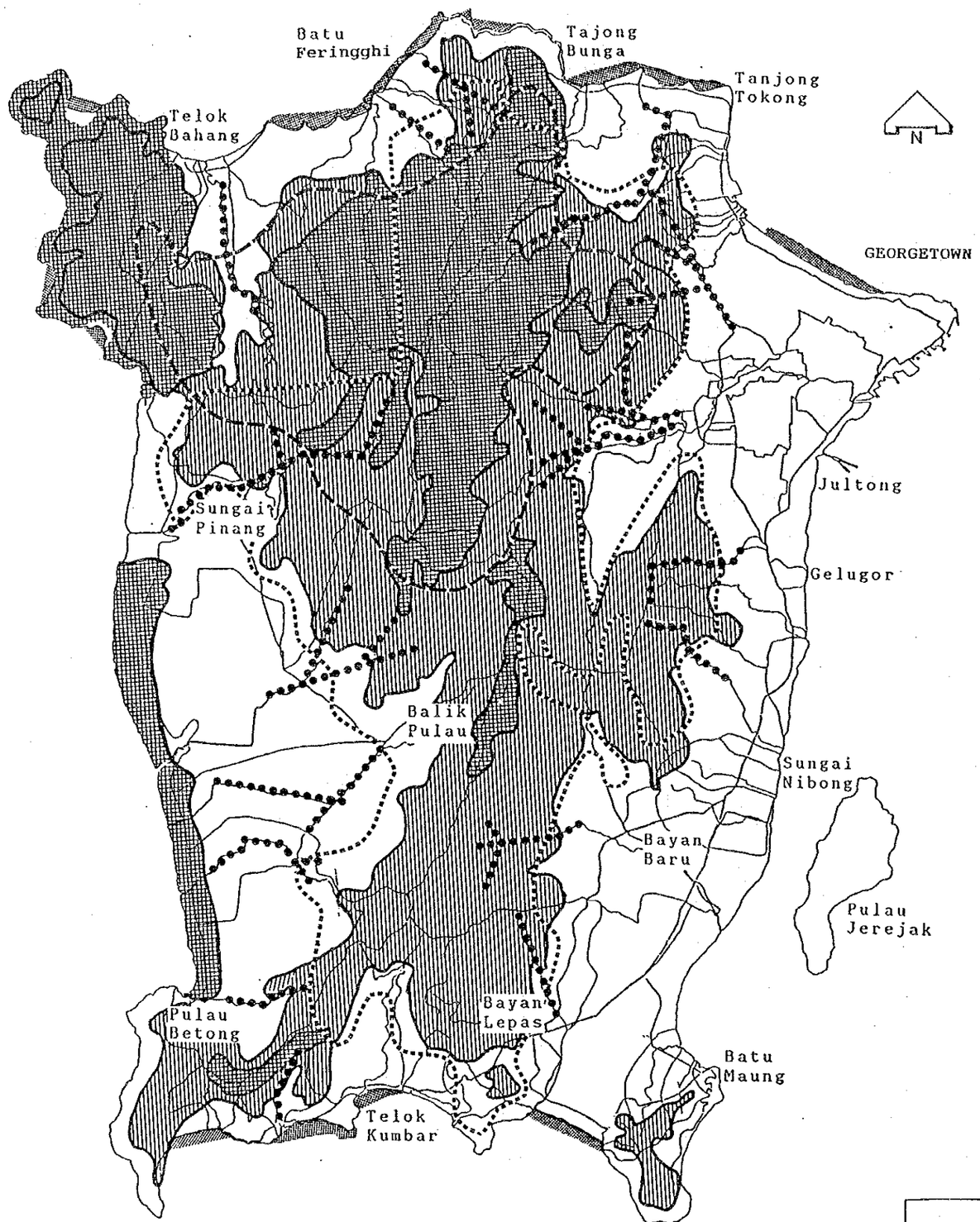
Imformation Source: University of Science Malaysis
State Department of Wildlife and National Parks

TABLE P-4 EXISTING PUBLIC PARKS, GARDENS AND FUTURE SCHEME IN PENANG ISLAND

Item	Existing site	Present area (ha)	Future available land (ha)
Regional park	Rimba Rekreasi Telok Bahang	116.0	116.0
Metropolitan park	1.Botanic garden	29.0	165.0
	2. Ayer Itam dam	29.0	-
Community or Town park	1. Bukit Dumbar reservoir	5.7	4.0
	2. Youth park	16.0	51.6
Neighbourhood Open space	Various sites	35.3	-

Source: Report of Survey, Penang Island Structure Plan

Figures



LEGEND

- FOREST RESERVE AREAS
- GAZETTED HILL LAND AREAS
- LAND ABOVE 60 METER CONTOUR
- WATER CATCHMENT AREAS
- SANDY BEACH AREAS
- •••• CLEAN WATER RIVERS

Source: Draft Structure Plan of Penang Island

Fig. P-1	ENVIRONMENTALLY SENSITIVE AREAS IN PENANG ISLAND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

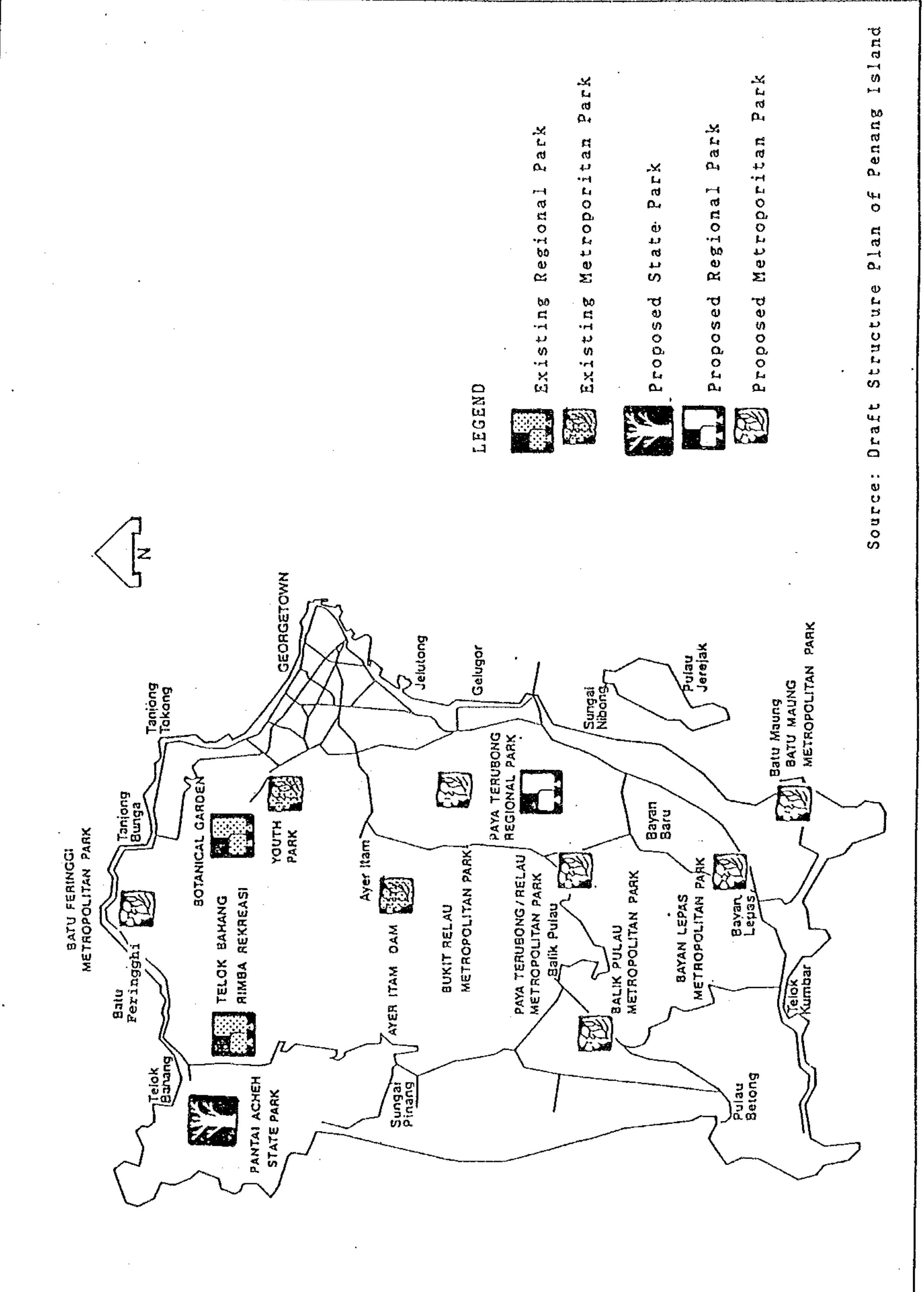


Fig. P-2 DISTRIBUTION OF RECREATIONAL PARKS IN PENANG ISLAND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

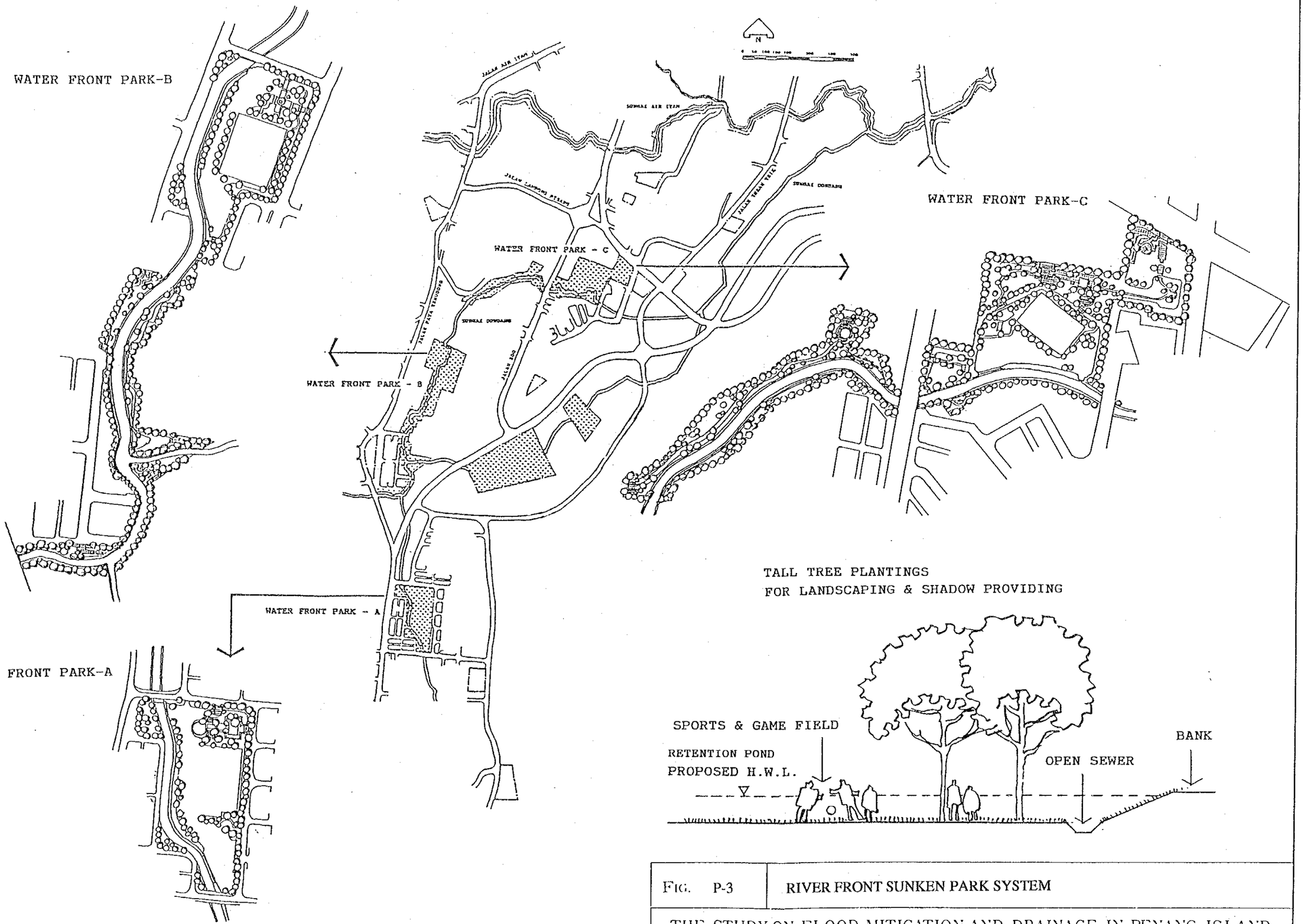
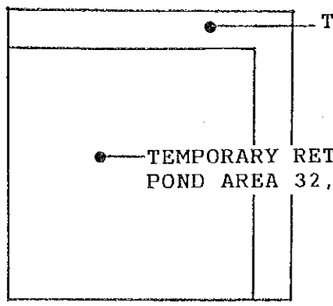
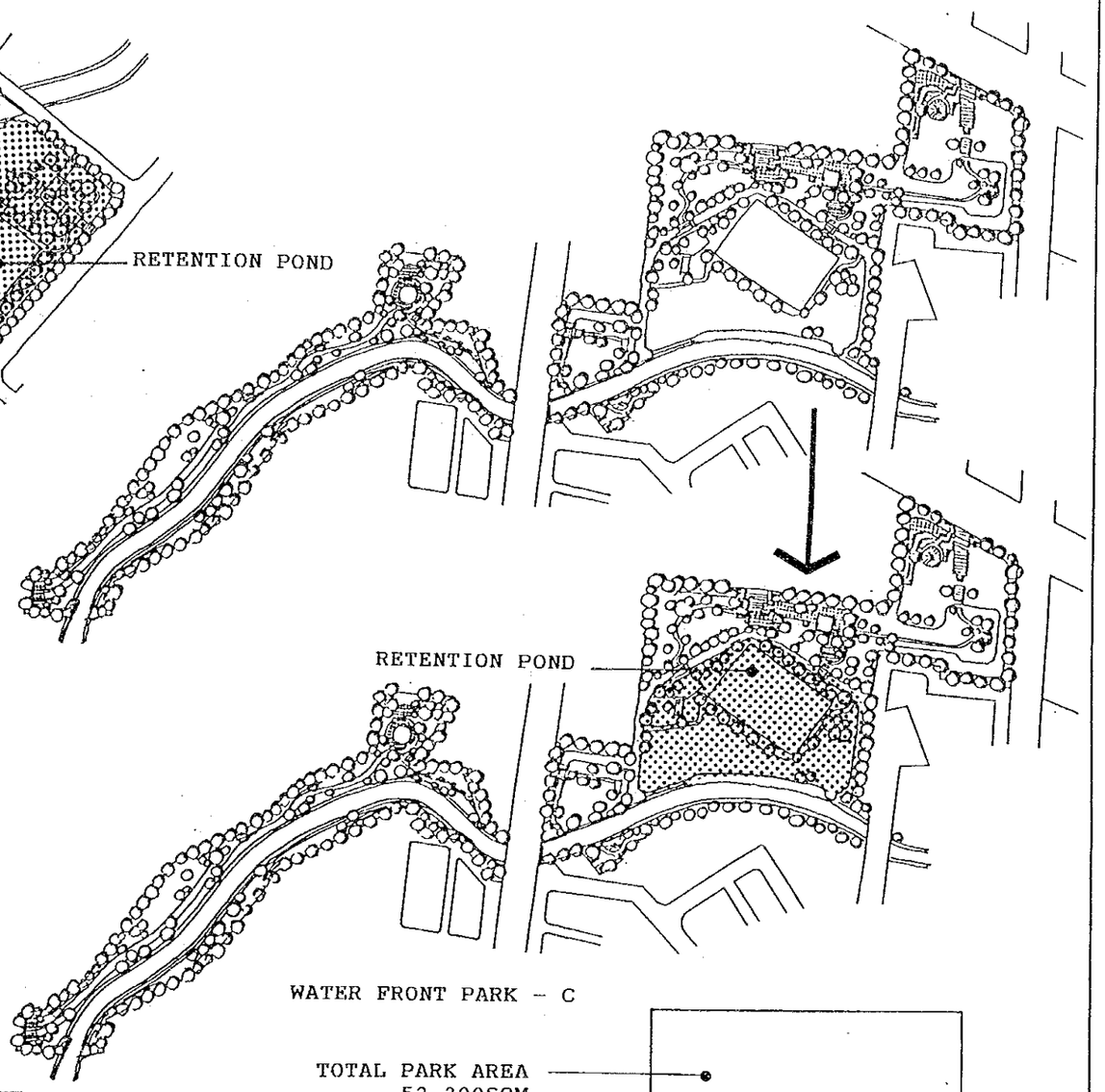


FIG. P-3	RIVER FRONT SUNKEN PARK SYSTEM

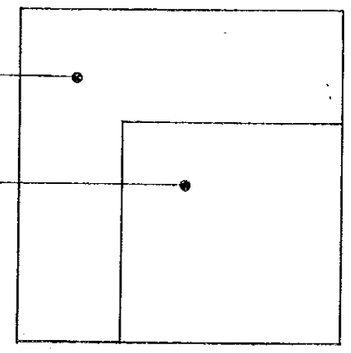
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

WATER FRONT PARK - B

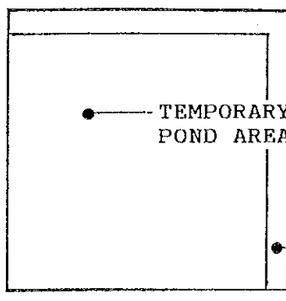


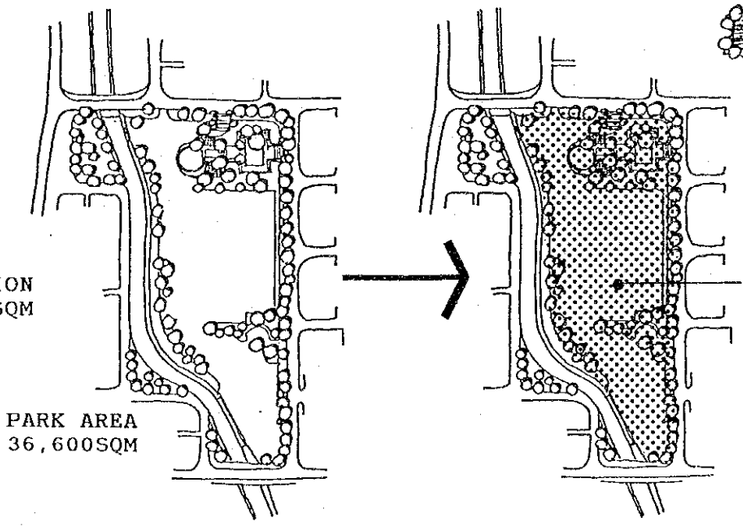


WATER FRONT PARK - C



WATER FRONT PARK - A





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

FIG. P-4	TEMPORARY RETENTION PONDS AND MULTI-USE WATER FRONT PARKS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

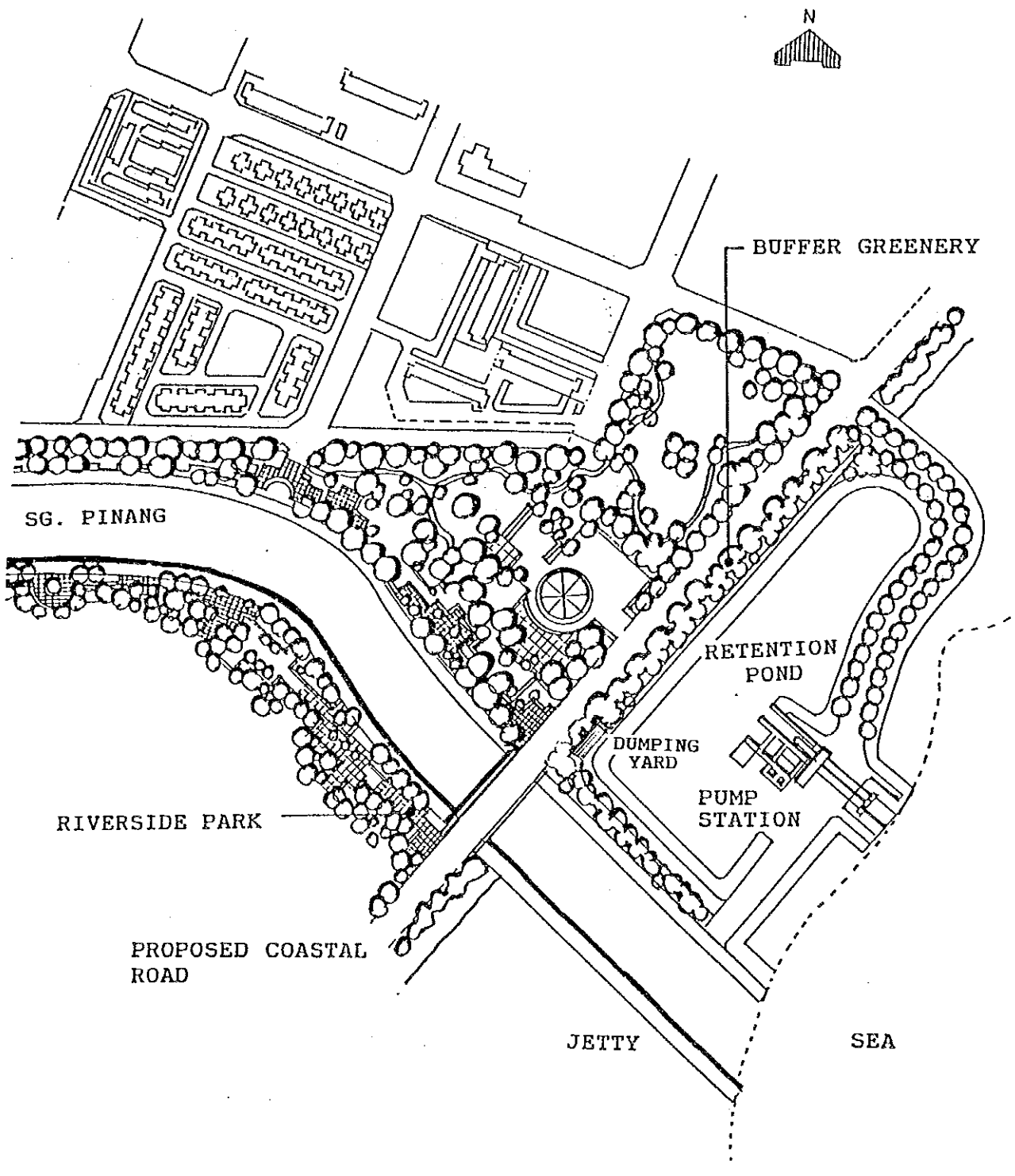


FIG. P-5	RETENTION POND FOR URBAN DRAINAGE

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

APPENDIX Q

CONSIDERATION ON WATER QUALITY IMPROVEMENT

APPENDIX Q CONSIDERATION ON WATER QUALITY IMPROVEMENT

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APPENDIX Q CONSIDERATION ON WATER QUALITY IMPROVEMENT

1. INTRODUCTION

As the severe pollution conditions of the rivers in the study area were recognized during the stage of the formulation 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 first year, the phase for the master plan, the study was carried out to evaluate the river pollution conditions and to identify the major pollution sources. As a result of the study, the rivers were classified by their pollution levels and the pig farming and improper treatment of the domestic wastewater were identified as major causes of the pollution.

Therefore, it was recommended to regulate the pig farming wastewater discharge and to enforce the domestic wastewater treatment to improve the river water quality.

In the second year, the phase for the feasibility study, operations of communal plant were surveyed to propose the improvement of the operation and the application of direct purification for the river water was investigated to seek for the improvement measures of Sg. Dondang water quality.

2. WATER QUALITY STUDY

2.1 River Water Quality Study

In this study, the water quality data of the rivers in Penang Island have been collected from the previous reports and surveys, visual observations of the river water including river bank and river bed has been carried out, and water quality surveys have been conducted according to the schedule which was prepared considering the results of the review of existing water quality data and site observation.

2.1.1 Existing river water quality data

DID and DOE are undertaking the continuous, periodical water quality monitoring at water quality stations established throughout the country, but such stations have not been established in any river in Penang Island yet.

The Penang Water Authority is monitoring water quality at its water intake points for water supply in several rivers in Penang Island. Since the purpose of the monitoring is to check the raw water quality for water supply, all the monitoring stations are located at upstream of rivers where pollutant source hardly exists. Therefore, these data are not appropriate to assess the overall river water quality conditions.

Comprehensive water quality survey in Penang Island was undertaken by MPPP in the Structure Plan study in 1985. In this study, water quality was measured at 66 sampling sites

from 20 river systems throughout the Island from August 1982 to January 1983.

Other water quality data available are ones obtained for the Solid Waste Management Study for Pulau Pinang and Seberan Perai Municipalities by JICA, March 1989. In the study, water quality was measured in Sungai Pinang (west) and Bagan Air Itam, both of which flow into the west coast.

2.1.2 Preliminary Survey for Water Quality Conditions

To understand general conditions of the river, the site observations were carried out along the stream of rivers in the study area. During the site observations, color and turbidity, suspended and floating materials, smell, and river bed conditions such as color, type of material and smell were observed. While chemical analysis are very important to assess the water quality quantitatively, it is also important to consider general appearance, smell and aesthetics of the rivers as this is how water quality is assessed by general appearance. Also the bed material characteristics and conditions represent the cumulative effect of pollutant inputs and the effects of pollutant on water quality.

According to the site observations, general conditions of the rivers in the study area are summarized as shown in Table Q-1. For the water color, while the ocher color would be considered to be due to clay and silt, thus it could not be regarded as polluted. However, the grey and black color generally indicate that the water being polluted by mostly organic pollutants. The smell of water may be caused by the discharged pollutants and/or the reduction of organic materials under anaerobic conditions and subsequent emission of H_2S and CH_4. Whether it is because of the pollutants or the reduction of the materials, obnoxious smell directly indicates the sever polluted conditions.

The river bed conditions indicate cumulative effects of pollution load to water body and water quality. For example, muddy sediments would tell that the water could be rich with organic suspended solids and black bed would suggest the anaerobic conditions. Therefore, river bed conditions are sometimes more general index for river water quality of long term than pure water quality which indicates only instantaneous characteristics.

2.1.3 Water Quality Survey

Water quality survey has been carried out in order to analyze the water quality of the rivers in the study area according to the plan mentioned below. Water quality survey was conducted both during dry season and rainy season, from 2nd September to 4th September, 1989 and from 10th to 12th October, 1989 respectively.

1) Determination of sampling points and timing

Sampling points in each 26 rivers of the study area were selected, in general, at utmost downstream, where it is possible to collect water sample free from tidal effects and salinity. In addition to these sampling points, additional sampling points were selected in tributary(s) of following

rivers that were classified as severely polluted rivers in the above section in order to investigate the pollution mechanism:-

Sg. Pinang	total 7 points
Sg. Dua Besar	total 2 points
Sg. Nibong Kecil	total 2 points
Sg. Keluang	total 3 points
Sg. Nipah	total 2 points

Sampling is done once in each season in general, however in the above sampling points, and in all other sampling points of that are classified as severely polluted, sampling is done twice in each season.

The sampling points and their frequency are given in Table Q-2 and their locations are shown in Fig.Q-1 and Fig.Q-2.

2) Sampling methods

River water sampling is done just below the water surface at the center of stream. Wherever tidal effects might prevail, sampling is done during low tide period so as to avoid mixing of sea water.

3) Analytical parameters and methods

The water quality parameter selected for determination are tabulated below. All sampling and analysis are conducted according to the "Standard Methods for the Examination of Water and Wastewater", APHA, WPCF, AWWA:-

- Dissolved Oxygen (DO)
- pH
- Chemical Oxygen demand (COD)
- Biochemical Oxygen demand (BOD)
- Suspended Solids (SS)
- Total Solids (TS)
- Ammonium Nitrogen (NH_4-N)
- Organic Nitrogen
- Chloride (Cl^-)
- Electric Conductivity (EC)

In addition to the above parameters, water temperature was measured and water color, river bed conditions and smell were observed at the sampling site.

4) **Result**

The results of the water quality analysis and observations are summarized in Table Q-3.

2.1.4 Assessment of the Water Quality Conditions of Rivers

1) **Organic Pollution Conditions**

BOD is a parameter which represents the amount of the organic matters in water and BOD suggests a possible contamination by organic wastes, such as domestic waste, pig farming waste, etc.

The BOD concentrations at the river mouth of each river are shown in Fig. Q-3 to illustrate the organic pollution conditions. Except several rivers, mainly flowing into north coast, BOD of the rivers in the study area exceeds 10 mg/l and are judged to be organically polluted. Among them, three rivers, namely Sg. Nibong Kecil, Sg. Nipah and Sg. Gertak Sanggul, are severely polluted and showing septic conditions as shown in Fig. Q-4.

It is considered that they are showing septic conditions due to the decomposition of organic matters.

2) **Seasonal Change of Pollution conditions**

In the water quality survey, water quality were analyzed in dry and rainy seasons and are compared in Fig. Q-5. In this figure, BOD in dry season is apparently higher than in rainy season.

This is understood that organic pollutants are diluted by large river flow, thus river conditions in dry season are worse than in rainy season. Therefore, discussion on river water conditions should be based on the water quality in dry season.

3) **Classification of the Rivers by Pollution Conditions**

The Environment Quality Standards in Malaysia, shown in Table Q-4, prescribe the allowable level of some parameters by class which is applied to certain areas or sections of the rivers, considering the water use of the river. River water conditions could be assessed by comparing its water quality to the allowable level in the Standards.

However, there is no river in Penang to which the above Standards are applied. Also there is no particular water use in any of rivers in the study area, except water supply at the very upstream of some rivers. Therefore, it is difficult to assess the river water quality by comparing it to the desirable water quality. In other words, it can be said that river conditions can be assessed only by assuming the desirable water quality.

Since not particular water use is expected in rivers in Penang Island, it seems reasonable to assume a desirable quality by which adverse visual impression and smell are not

caused, as a minimum object. Fig. Q-6 shows the relations between BOD and smell. From this relation, the allowable BOD can be read 10 mg/l, at which concentrations smell of water is not significant. This concentrations of BOD is approximately same as Class IV in the Standards.

Therefore, it is possible to classify the rivers by assuming that Class IV is to be applied to rivers in the study area. Furthermore, it would be also reasonable to classify three rivers as an extremely polluted river which is causing obnoxious conditions along the stream.

Based on the above considerations, the rivers in the study area have been classified into the following three groups as shown in Table Q-5.

(1) Extremely Polluted Rivers

Extremely polluted rivers, causing obnoxious, unhealthy conditions where nobody likes to assess. It is likely considered that the vicinity of such stream is not a place to play, walk or live.

(2) Polluted Rivers

The rivers not satisfying the Class IV in the Environment Quality Standards in Malaysia. Such rivers are lowering the environment conditions around the rivers.

(3) Not Polluted or Tolerable Rivers

The rivers satisfying Class IV. They would not cause particular adverse effects on environment conditions around the rivers, however it dose not always mean clean river.

4) Water Quality Conditions of Sg. Pinang

Sg. Pinang is the biggest river among the rivers in the study area and runs through center of Gorgetown which is the most urbanized city in the Island. Therefore, the pollution of this river would affect on wider area and more people. The pollution conditions has been classified as a polluted river as mentioned in the above section, but it may be classified as an extremely polluted river, if the degree of the affects in terms of area and population would be taken into consideration.

Fig. Q-7 illustrated the BOD level in Sg. Pinang system which comprise of a main stream and several branch streams. As can be seen in the figure, Sg. Pinang is polluted from very upstream and also branch rivers are severely polluted except Sg. Air Terjun.

Rivers conditions as such BOD exceeds 30 mg/l are not tolerable to live near-by in terms appearances and smell. In addition, existing water conditions are not suitable for a park environment, while the construction of water front parks are suggested in the flood mitigation Master Plan.

2.2. Pollutant Sources Study

River pollution caused by wastewater discharge of organic nature resulting from various human activities seems very significant in Penang Island. In consideration of improving river water quality, data relating to the amount of the pollution load generated in catchment areas and discharged to the river are essential.

In this study, pollutant sources are classified into following categories and characteristics of each source are investigated in order to estimate the unit pollution load generated and unit pollution load reaching the rivers in the subsequent study:-

- Domestic waste
- Industrial waste
- Livestock waste
- Catering industry waste
- Garbage disposal

2.2.1 Domestic Waste

Domestic waste is the wastewater which originates from daily human activities, such as discharges from kitchen, laundry, cleaning, bathing and toilet.

1) Kinds of domestic waste

Domestic waste can be divided to following two categories based on characteristics, ie. grey water and black water:-

- Grey water : domestic wastewater excluding toilet wastewater.
- Black water: wastewater from toilet only.

2) Type of disposal

Domestic waste generated in each house is removed by several methods, such as sewage collection, septic tank treatment, night soil collection and disposal, and so on. Since the amount of pollutant reaching to the river from source strongly depends on the disposal methods, it is to be necessary to study the existing disposal system in catchment area. Disposal systems of the Island are outlined below:-

(1) Sewer collection

In city area of Georgetown, sewage from residences and other commercial buildings are collected through the sewer pipeline, and finally discharged into the sea without treatment. In this system, since all the sewage is conveyed through pipeline, no pollutant is discharged into the rivers.

However, while both black water and grey water are collected from the buildings built after 1975, only black water is collected from the buildings built before 1975. Therefore, some portion of grey water reaches to the river through ditches and drains.

(2) Sewage treatment plant

Existing sewage treatment plants are the facilities constructed along with the residential development projects. Black water and some portion of grey water from the residences are collected through sewers line, treated by treatment facility and the effluent is discharged to the river. There presently exist around hundred such treatment plants throughout the Island and domestic wastewater from around ten thousand of residences are estimated to be treated by this system.

The treatment methods used are septic tank with/without filtration bed, activated sludge and rotating biological contactor. Generally, these methods are capable to reduce the organic pollutants to less than 10 %, if they are well designed and maintained. However, some of them were found to be operated improperly and it is suspected that such plants might be one of the serious pollutant source to rivers.

(3) Individual septic tank

In residences located outside of sewer collection area and sewage treatment service area, domestic wastewater is treated by individual household septic tanks.

Black and grey water are treated by the septic tank installed after 1975 and only black water is treated by septic tank installed before 1975. In this system, treated effluent are discharged to rivers.

(4) Bucket type toilet

In the residence other than the mentioned above, night soil is stored in Bucket and collected by municipality service periodically. Night soil collected are discharged into the sea. However, in this type the whole grey water is discharged to rivers.

This type of toilet are now decreasing and only around 3000 are remaining in Georgetown.

(5) Pour flush toilet

In this type of toilet, night soil is flushed to pit by small amount of water and stored in pit. Night soil is anaerobically digested and the effluent is penetrated into ground. This type is common in rural area and grey water is discharged to rivers.

3) Estimation of Population Served by Each Type

As mentioned above, pollutant load to rivers from domestic waste discharge would vary according to disposal type applied. In the study, population in each catchment was divided according to the disposal type as mentioned below and result is shown in Table Q-6.

(1) Estimation of the population in each catchment

Since the information on the population by river catchment had not been available, it was estimated by the following method using the data in the Structure Plan Unit, MPPP:-

(a) Population Data

Basic data for the estimation was "BANCI PEDUDUK DAN PERUMAHAN, MALAYSIA 1980", obtained from the Structure Plan Unit, MPPP. The data consists of the population by the Sub-Section.

(b) Allocation of the sub-section population

The boundary of the river basins and sub-section boundary are not coincided with each other. Therefore, the population of the sub-section which covers more then one basin is allocated to the basins proportionally according to the areal ratio.

(2) Sewered Population

There was no information on the population served by sewer systems in Georgetown and Bayan Baru area. The existing sewer collection networks are spread throughout the following basins as shown in Fig.Q-8 and Fig.Q-9:-

Georgetown	Sg. Balik Batu
	Sg. Fettes
	Sg. Bagan Jermal
	Sg. Babi
	Sg. Pinang
Bayan Baru	Sg. Nibong Besar
	Sg. Nibong Kecil
	Sg. Keluang

To estimate the sewered population in each basin, the ratio of the connected population were assumed as follow:-

River	Sub-Basin	Ratio of Connection (%)
Balik Batu		50
Fettes		50
Bagan Jermal		50
Babi		50
Pinang	Air Itam	20
	Air Itam Branch	50
	Jelutong	50
	Lower reach	80
Nibong Besar		50
Nibong Kecil		50
Keluang		50

(3) Pour flush toilet

Number of the houses served by the pour flush toilet by MUKIM was given by the Health Department, MPPP. Since boundary of Mukim and River basins are no matched (Mukim are usually wider than basin and they cover several basins), the houses are allocated according to the areal ratio.

(4) Communal Plant

The location and served population of each plant were given by the Engineering Department, MPPP.

(5) Bucket toilet

The location and numbers were given by the Health Department, MPPP.

2.2.2 Industrial Waste

In principle, industrial waste would be the wastewater from every industries including the service industry, livestock industry, as well as factories. In this study, however, only wastewater from factories will be dealt under this category and others will be considered separately taking into consideration differences in background of each industry.

Factories in Penang Island can be divided into 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.

1) Factories with large quantity discharge

According to information from DOE (Northern Region), there are 16 factories in Bayan Lepas Industrial Area and 11 factories outside the Industrial area, which discharge large amount of wastewater. Table Q-7 and Table Q-8 show quantity and nature of wastewater discharge from these factories.

To 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,

effluent quality could be controlled by discharge quality standards. However, the river conditions around Bayan Lepas Industrial Area, for instance, Sg. Nibong Kecil and other open drains in the area, are far from the conditions where such regulations seem to be observed.

Factories outside the Industrial area are scattered in the Island and located at relatively upstream of river. They also discharge wastewater to open drains and watercourses without proper treatment and are considered to be major pollutant sources to rivers.

2) Factories with small quantity of discharge

Many household factories and work shops are located in Georgetown city area and along the main roads. Although the quantity of individual discharge from such a factory is not so large, their effect to river water quality could not be ignored because of their large numbers.

Especially, motor garages located along the main roads in Georgetown are supposed to discharge the waste oil directly to open drains. They are considered to be one of the pollutant sources in Sg. Pinang, but no relevant information such as numbers of shops, nature of wastewater and so on is available at present since the Regulations are not applicable to the discharge from such scale of factories.

2.2.3 Pig Farm Waste

Pig farming is one of the largest industries in Penang Island and also considered to be one of the biggest pollutant sources. This fact has been well realized and several studies have been carried out.

During the site observation, severe deterioration of the river water quality apparently by discharges from pig farms were noted in many areas. Particularly, Sg. Gertak Sanggul and Sg. Nipah seemed to be used as wastewater conveyances from pig farms to the sea. In the other rivers also, some were found to be polluted at upstream by discharge of untreated wastewater from pig farms scattered in rural area.

As such, effects of pig farms on river water quality are very serious in following two points. One is its high pollutant load to rivers and another is polluting the river from very upstream, because many pig farms are located in rural areas. For the latter, it is being encouraged to move the farms to Batu Maung area. However, from present condition of Sg. Nipah, which runs through Batu Muang, it cannot be said that it will resolve the problems. In Batu Muang, oxidation ponds are under operation to treat the water from Sg. Nipah which consists of mostly wastewater from pig farms. But it should be noted that river water quality never improve as long as the river is used as a conveyance of wastewater.

1) Number of pig farms and number of pigs

Data on the each pig farm in Penang Island were obtained from the Health Department, MPPP. Each pig farms were plotted on the map so that it could be classified by a river basin. The numbers of pigs in the river basin are shown in

Table Q-6 and number of pigs in each basin is shown Fig. Q-10.

Total numbers of the pig farms and bred numbers in the study area are 615 and 96,182 respectively, and the account 99% and 90% of those in the whole land.

2) Wastewater discharge

In most of pig styes, 30 to 40 pigs are bred in one block with duckbord bottom and pig's excreta are collected on concrete lining floor through duckboad bottom. Collected excreta are flushed out into the ditch by water once or twice a day. Wastewater are collected in a sump tank through ditch and discharged to rivers.

Water consumption data for flushing was not available but it is estimated as 100 to 200 litters per pig per day based on the interviews at pig farms. While sump tank, which is the only treatment facility, if it can be called so, are installed in 80% of pig farms according to the data from the Health Department of MPPP. However, during site inspection, most pig farms were found to by-pass the sump tank in actual operations. Therefore, it can be concluded that wastewater from pig farms is discharged to watercourse or river without any treatment at all.

2.2.4 Catering Industry Waste

In city area, such as Georgetown, many hawkers and stallholders serving on the street can be seen. According to the information from the Health Department of MPPP, more than 3500 hawkers are operating in whole Island and 80 % of them are concentrated in Georgetown, as shown in Fig. Q-11.

In hawkers' operations, they cook foods, serve them and wash dishes on the street. They discharge all the wastewater to the ditches along the street. As far as Georgetown area, although most hawkers are operating within sewer collection service area, they discharge their wastewater (grey water) to ditches and finally to rivers because there is no connection to the sewer line.

According to the interviews to hawkers, they consume 100 to 200 l of water per night for their operation. The total volume of wastewater discharged from hawkers in Gorgetown is estimated 300 m^3 to 600 m^3, assuming that the total numbers of hawkers in Georgetown is 3000.

2.2.5 Garbage disposal

A garbage disposal to rivers could cause esthetic deterioration by floating materials, as well as water quality deterioration by direct discharge of pollutants. It could also decrease a discharge capacity of rivers by accumulating the debris to the river structures, such as piers, weirs and water pipes etc.

Since the garbage collection services by MPPP are available everywhere in the Island, garbage disposal to rivers is matters of habit and moral of residents. Once most people would recognize an importance of this matter, most of problems

derived from garbage disposal will be resolved without any further cost. Therefore, it will be the most important to enlighten the people not to dispose garbage to river.

2.3. Pollution Analysis

Pollutant load to each river were calculated from numbers of the pollutant sources and unit pollutant load for each source to identify the major pollution sources of each river.

2.3.1 Unit Pollution Load

Unit pollution load used in the calculation are shown below. These values were obtained from literatures since neither any survey for the unit pollution load was conducted in the study nor any relevant data in the study area was available.

Source	Toilet (Black)	Others (Grey)	Total
Domestic	13	61	74
Pig			170

(BOD g/cap/day)

Generated load from domestic waste is reduced by a certain treatment before being discharged to rivers. The removal efficiency depends on the type of treatment. In the calculation, the removal ratio shown in Table Q-9 were applied.

The waste from pig farms were assumed to be discharged to rivers with no reduction, since all the waste generated in the farms were wash out and discharged to rivers without any treatment and most pig farms were located along the river.

2.3.2 Estimated Pollution Load

The estimated pollution load were calculated from the above unit pollution load and the numbers of pollutant sources in each catchment. The results are shown in Table Q-10. It should be noted that the estimated pollution load does not include the load from other sources than domestic waste and pig farm waste, such as industrial waste, commercial waste, etc., because any data on 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 farm are illustrated in Fig.Q-12 and Fig.Q-13.

2.3.3 Major Pollution Sources

Fig.Q-14 shows a comparison of the actual BOD and the estimated BOD concentration for each river. (The estimated BOD were calculated by the estimated pollutant load and riverflow which was estimated by assuming specific runoff was 0.1 cum/sec/sqkm.)

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 are mainly caused by domestic waste and pig farm waste.

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

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

3. IMPROVEMENT OF SG. DONDANG WATER QUALITY

3.1 Background

In the structural measures for flood mitigation of Sg. Pinang, it is planned to construct several retention ponds along upper reach of Sg. Dondang. The retention ponds are designed as a multi-purpose retention pond which is used as parks and sports ground during normal period; the probability of the occurrence of submergence of the pond is estimated once thirty years.

Meanwhile, the existing conditions of Sg. Dondang are severely polluted as identified in earlier stage of this study. Smell and appearance of the river water could adversely affected on the park environment where people expect to feel comfortable. In worst case, nobody may ever use such park because of the deteriorated environment due to bad river water quality. Improvement of the water quality, therefore, is strongly required to ensure the conditions where the ponds can function as a multi-purpose retention pond.

The improvement of water quality of the Sg. Dondang could be achieved by the reduction of pollutants discharges from various sources in principle. Thus it is recommended to make a political decision to introduce regulations for wastewater discharge from pig farming and to enforce the domestic wastewater treatment in order to reduce the pollutants discharge.

In reality, however, it is hardly expected that the water quality will have been improved as an effect of the reduction of pollutants discharges by the time of construction of the retention ponds. The reasons why are because;

i) it will take considerably long time to implement actual wastewater discharge control as it used to require complicated political procedures,

ii) there could be economical constraints in implementation of the regulation for the wastewater from pig sties,

iii) furthermore, even if it is possible to implement adequate wastewater controls, it may be difficult to expect effective water quality improvement. Because, while most water treatment technology, in reality in terms of economy, purify wastewater to the degree where the effluent becomes acceptable after being diluted by the water of receiving water body, there are few water for dilution

in rivers in the urbanized areas, such as Sg. Dondang, where most river water consists of wastewater.

Although reduction of pollutants discharge from the pollutants sources is a principle of the water quality improvement, this is sometimes not a realistic countermeasure in case where the water quality improvement is required for specified water uses in certain water bodies.

Direct purification is a concept introduced to overcome similar situations in Japan by treating the water in water body. While it has not been clearly defined yet as this is a very new concept, its common features are summarized as follow from the examples which have been conducted in Japan:-

i) Purification facilities are constructed in the water body or the vicinity of the water body.

ii) River water or lake water itself is directly purified.

iii) In most case, the facilities are constructed and operated by the authorities who are responsible for the management of the concerned water bodies.

iv) The principle of the purification methods are the ones in which one or more of the self-purification abilities of natural water bodies are enforced.

v) Accordingly, most of them are of less maintenance and energy consumption type, while it would require rather large amount of facility in terms of required spaces and volumes.

As such, direct purification is considered as one of possible solutions to improve water quality of Sg. Dondang so as to be acceptable for the park environment. Therefore, it seems worth to investigate the possibility of the application of direct purification to Sg. Dondang.

3.2 Determination of the Design Conditions

In the selection of the purification methods and the design of the facility, it is necessary to specify the design conditions, such as quality and quantity of inlet water and the target of purification. These are determined considering the present conditions of the rivers and expected use of the retention ponds.

3.2.1 Target of the Improvement

1) Required water

In the Urgent Project, it is proposed that the water will be introduced to the ponds from overflow weir only when runoff peak cut is necessary during flood period. This is estimated to occur once thirty (30) years. The ponds are planned to be used as sports ground such as for football, tennis, etc during normal conditions.

Judging from the use of the ponds and rare occurrence of the flooding, it can be considered that the river and ponds exist independently or that the river runs through just near the ground. There will be few physical contact between people and water, thus the bacteriological and chemical safe is not necessarily required. This, however, would not mean no need of the improvement of the existing water quality of Sg. Dondang. Even if required water quality would not so strict, at least it must not be offensive to the park environment but it must be aesthetically pleasing.

2) Water quality standards

There are several standards for the water quality for recreational water use. Table Q-4 shows the Environment Quality Standards in Malaysia in which the allowable water quality level for water uses are prescribed. It mentions the water quality level for the redactional use with body contact but does not mention about the aesthetically pleasing level. Table Q-11 shows Japanese water quality standards for Environment Criteria. This prescribes the water quality level for not offensive environment, which is Class E.

There are several water quality items in the standards. Among them, BOD and SS are important index to evaluate the organic pollution and visual appearance of the water both of which are severe in Sg. Dondang. In the Japanese Standards mentioned above, allowable BOD level for Class E is 10 mg/l and SS is 50 mg/l. These value approximately correspond to Class IV in Malaysian Standards, which is for irrigation purpose.

3) Relation between smell and BOD

The results of the river water quality study conducted in 1989, which is mentioned in the previous section, shows the relationship between smell of water and its BOD concentrations. Among 26 rivers surveyed, smelling were significant at the rivers where its BOD concentration exceeded 10 mg/l.

4) Design water quality

As a target of the water quality improvement for the multipurpose retention ponds, it is necessary to assure an aesthetically pleasing conditions. Water quality level which achieves such aesthetically pleasing conditions is determined by referring the Malaysian and/or Japanese standards as follow:-

pH	6.8 - 8.5
DO	NOT LESS THAN 2 mg/l
BOD	10 mg/l
SS	50 mg/l

3.2.2 Capacity of the Facility

In direct purification of the river, river water is introduced to the facility. And a river has a wide fluctuation range of flow rate. Huge capacity of the facility would be required should the flood flow be treated. Therefore,

treatment capacity of the facility must be determined considering the flow regime of the river.

1) Estimation of the flow rate of Sg. Dondang

There exist no river flow data in Sg. Dondang. Therefore, flow rate of Sg. Dondang were estimated from daily flow data of Sg. Air Terjun and Sg. Teluk Bahang.

Daily flow data of Sg. Teluk Bahang were obtained from PBA. Data for Sg. Air Terjun were obtained from water level data at Jln. Brook, where a water level gauging station was installed by JICA last year, and H-Q curve were prepared by flow observation and uniform flow calculation.

Fig.Q-15 and Fig.Q-16 show daily flow and the flow regime of Sg. Air Terjun and Fig.Q-17 and Fig.Q-18 show those of Sg. Teluk Bahang. Based on these data, the probability of non-exceedence flow rate were calculated for each river as shown in Fig.Q-19 and Fig.Q-20.

Table Q-12 shows the non-exceedence flow rate for several probabilities for each river. While the period of the observation was not the same for the two rivers, the specific flow rate of Sg. Air Terjun seems larger than that of Sg. Teluk Bahang. Since the catchment area of Sg. Dondang is close to Sg. Air Terjun, the flow rate of Sg. Dondang was calculated by using the specific flow rate of Sg. Air Terjun.

The estimated non-exceedence flow rates of Sg. Dondang at several probabilities are as below:-

Non-Exceedence Probability	Flow Rate (m^3/s)
50 %	0.26
75 %	0.54
80 %	0.67
90 %	0.87

2) Design capacity

During flood periods, river water quality used to deteriorate due to flush-out of deposits of river bed and other materials from basins even in natural river, where no pollutants sources exist. And in a polluted river, river water is expected to be diluted by flood runoff. Furthermore, nobody will ever use the sports ground under the heavy rain conditions. Thus, it will not cause any remarkable inconvenience, if it could not treat river water during flood period.

The average flow rate of Sg. Dondang has been estimated to be 0.26 m^3/s. If the design capacity is fixed at 2 times of the average considering the flow fluctuation, it will cover 75% of a year as explained in the above section. Conversely speaking, it means that river water will not be treated for 25% of a year. However, it will not so affect on functions of the retention ponds, since the numbers of rainy day (precipitation more than 5 mm/day) in Penang is about 25% of a year.

Therefore, the treatment capacity of the purification facility is determined 0.5 m^3/s referring the 75% non-exceedence probability flow rate of Sg. Dondang.

3.2.3 Design Inlet Water Quality

In order to determine the design inlet water quality to the facility, a water quality survey was conducted at the proposed sites of the retention ponds along Sg. Dondang. The sampling points are shown in Fig. Q-21.

The results of the water quality survey are shown in Table Q-13. At every points, water quality shows the typical characteristics of organic pollution such as high BOD, COD, SS and NH_4-N, low DO concentrations and high bacteria counts. It should be noted that these surveys were conducted in short period, end of dry season, while river water quality does have a big fluctuation through a year being affected by a flow change. The design inlet water quality should be determined based on the river water quality data throughout year. However, it is understood that obtained data would cover the worse range of the water quality fluctuation because it was in dry season. Therefore, it is considered that these data would give a safe side value for the design.

In the comparison of water quality among the sampling points, which were established just upstream of proposed site of each pond to investigate the change of water quality along the stream, the improvement of the water quality along the stream are observed as shown in Fig.Q-22. This is supposingly because of the settling of the suspended materials with flowing down and the dilution by water from small streams which join to Sg. Dondang stream. Consequently, design water quality should be determined by referring the water quality of the most upstream.

As conclusion, the design inlet quality is determined based on the average of most upstream point (D-1) as follow:-

BOD	50 mg/l
SS	70 mg/l
DO	1 mg/l
pH	7.5

3.3 Consideration on the Selection of Purification Method

Direct purification is a very new concept thus there is no established definition for what is direct purification. It is planned case by case depending on the requirements for the improvement and allowable site conditions. Therefore, the purification method for Sg. Dondang should be selected so that it may suit the actual site conditions and satisfy the design conditions mentioned above .

3.3.1 Features of the direct purification methods

There are several methods of direct purification which are supposed to be applicable to Sg. Dondang. Their features are outlined below:-

1) Gravel Contact Purification (GCP)

In GCP method, water is introduced to the channel packed with gravels and purified by such actions as i) settling in the small spaces formed among the gravels, ii) adsorption by biofilms formed on the surface of the gravels, and iii) decomposition of the organic matters by aerobic and/or anaerobic micro organisms. Water quality is improved mainly by removing suspended materials, which result in reduction of suspended solid and organic matters (BOD).

In this method, suspended materials removed from water is accumulated in the gravel bed, reducing the effective space for purification. While some portion of organic materials in the accumulated sludge may be decomposed by anaerobic digestion, the sludge would certainly be accumulated along with the operation since organic portion in the sludge generally accounts at most several tens percents. Therefore, it is necessary to replace the gravels or to wash the gravel at certain intervals (every several years).

2) Aerations

The river water is aerated by the aeration facility such as defuser pipes settled on the river bed. Water quality is improved mainly in term of smell by maintaining aerobic condition of water.

3) Settling Ponds

River is damed up to form a pond or river water is introduced to pond. During the retention time, suspended materials are removed by settling.

4) Soil infiltration

Water is spread on the surface of the ground and penetrates into the soil. Suspended materials are captured in small spaces in the soil particles and some soluble materials, such as Nitrogenous and Phosphorous substances are adsorbed on the surface of soil particles.

3.3.2 Comparison of Method

Comparison of each method were made to select a suitable purification methods for Sg. Dondang. Advantages and disadvantages of each method are discussed as follow:-

1) Aeration

Anaerobic condition will be improved by this method but no significant effect on BOD and SS will not be expected. Therefore, it would be difficult to obtain the required water quality by this method alone.

It can be installed in the river, then it does not require any land except for small house for blowers. It might be better not to install aeration equipment (defuser pipings) in the river because such equipment are apt to be damaged by flood or because they may reduce the flow capacity of the river. If it is the case, aeration ponds, which is small in size, can be constructed in the retention pond site, where water is diverted from the river, aerated, and return to the river. As such, this method has an advantage in land requirement.

From view point of operation, it needs an operation of blowers and operational cost besides some of other direct purification does no need particular operation of facility.

2) Settling ponds

Settling pond will remove suspended materials by sedimentation. By removing suspended materials, improvement of BOD and SS are expected, but no improvement of DO. Removal efficiency for BOD and SS by this methods are known maximum 30 %, thus the treated water quality are estimated as follow;-

BOD	35 mg/l
SS	50 mg/l

Apparently, these are not sufficient for water quality targets.

There are two ways to instal a settling pond; i) to dam up the river, and ii) to construct a pond in the retention ponds site. Judging from the actual cross section of the river, it seems difficult to instal a pond by damming up the river. While it may possible to construct a pond in the retention pond site, it will naturally eliminate the possibility to be used as multipurpose ponds.

Even if it would be possible to instal a settling pond, it could cause environmental problems to expose such dirty water under open space.

3) Soil infiltration

In terms of the purification efficiency, soil infiltration must be the best method because it can remove not only suspended materials but also dissolved materials. It can produce water which is almost similar to underground water quality.

However, as this is a kind of filtrations by very fine particles, its filtration rate is very low and thus requires very wide area. Furthermore, as it is also easy to be clogged, it requires spare ponds.

To filtrate 0.5 m^3/s of river water, necessary area is calculated as follow;-

0.5 (m^3/s) x 86,400 / 3 ($m^3/m^2/s$) = 14,400 (m^2).

The calculated area necessary for soil infiltration accounts more than 40 % of the area for the retention pond-A and it becomes more than 80 % of the retention pond if a spare pond is considered.

4) GCP

GCP can remove BOD and SS in some extents. According to the result of the experiment and the actual operations, the removal efficiency is expected as follow:-

BOD	75 %
SS	90 %

As far as considering the removal efficiency, it will have enough capacity to achieve water quality target.

For the necessary area for the facility, it is estimated to be approximately 2,000 m^2. Furthermore, it should be noted that the surface of the facility can be utilized as ground or park by covering the gravels by soils.

However, there is a limitation in oxygen supply, which is essential for biological purification, in this methods. Only available oxygen is dissolved oxygen in inlet water and the oxygen will be easily consumed by high BOD, but any oxygen supply from air is not expected in the gravel bed. Thus, generally, applicable BOD concentration in this method is said 10 -20 mg/l.

Therefore, preliminary treatment, which reduces BOD concentrations less than 20 mg/l, would be necessary in order to apply GCP to the present Sg. Dondang water.

3.3.3 Conclusion

Two methods, namely settling pond and soil infiltration are eliminated from possible methods because of the removal efficiency and the land availability respectively. Aeration alone, also, is not applicable because it will not improve the water quality in terms of BOD and SS.

Remaining GCP methods seems to be the most applicable method for the application of direct purification. However, the present water quality of Sg Dondang is judged too bad to apply GCP. It can be said that such high BOD concentrations as 50 mg/l should be classified as wastewater rather than river water and is not suitable to direct purification. Again, it is reminded that it must be improved by reducing pollutants discharges.

In further discussion, therefore, the possible application of GCP method will be discussed under the assumption that water quality of Sg. Dondang will be improved by reducing pollutants discharge.

3.4 Preliminary Design of GCP

Since there is no design standards/criteria for GCP, the design is carried out based on the informations of MOC, Japan.

The purpose of the preliminary design is to determine the feasibility of the installation considering the site conditions, such as land availability and water levels. Therefore, mainly, dimension of the facility and profile of the water levels will be discussed in this considerations.

3.4.1 Flow sheet of Purification

The flow sheet of the GCP purification is shown in Fig. Q-23 and conceptual drawing of the facility is shown in Fig.Q-24. The facility consists of the following three major works:-

1) Water intake works

Water is intaken from the river. To enable the gravity flow from intake to outlet through gravel beds, river water level is raised up by a weir.

Not to obstruct the flow capacity of the river during flood, the weir is of the tilting type, which is a rubber-coated fabrics, inflatable dam.

Screen should be installed at inlet to prevent the inflow of the floating materials.

Some other works such as river bed protection and bank protection should be included in intake works.

2) Purification works

The water is transferred from inlet to distribution box through inlet pipes. From distribution box, the water is introduced into the gravel bed through distribution pipes which are perforated and installed in the bed.

The gravel bed is constructed by packing the excavated ground with gravels, without impermeable wall works.

The water from the distribution pipes moves in the gravels toward the collection pipes, which are perforated pipes and installed in the gravel at a certain distance away from distribution pipes.

The water is transferred to outlet through collection box and outlet pipes.

These all components are installed underground.

3) Outlet works

The water is returned to the river from outlet. The outlet should be installed as closer to the weir as possible, otherwise no water or no flow section may appear downstream of the weir. Also, the water should be discharged to the river with falling so that oxygen could be dissolved by aeration, because outlet water from gravel bed are expected to be completely consumed out.

Outlet works should include the protection works for the river banks and bed.

3.4.2 Design of the GCP facility

1) Gravel bed

(1) Necessary volume

Necessary retention time for the purification is known to be 2 hours as shown in Fig.Q-25. The necessary volume of the bed is calculated as follow:-

$0.5\ m^3/s \times 60 \times 60 \times 2\ hr = 3,600\ m^3$

(2) Layout

It is known that the removal efficiency depends on the distance of flow as well as the retention time. The necessary distance of flow is around 15 m as shown in Fig. Q-26.

By supposing the depth of the bed 2 m, the dimension of the gravel bed are fixed as follow:-

Length	15 m
Depth	2 m
Width	90 m

The above are divided in units as follow and layout plan is shown in Fig.Q-27:-

Dimension of the unit

length	15 m
width	30 m
depth	2 m

No of units = 4

2) Water levels

Water levels from inlet to outlet are calculated as follow and results are shown in Fig. Q-28:-

(1) Outlet weir

To enable to recover dissolved oxygen in the outlet water, outlet level is set at 0.8 m from the river bed.

(2) Outlet water level

Over flow depth is set at 0.2 m, by setting the width of the weir 3 - 4 m.

(3) Water level of collection box

The level is fixed at 0.1 m higher than outlet level by assuming the head loss in the outlet pipe is 0.1 m.

(4) **Water level of distribution box**

The level depends on the head loss in the gravel bed. In the design it is assumed 0.1 m.

(5) **Water level of inlet**

The head loss in the distribution pipe is assumed 0.1 m.

(6) **Inlet weir**

The level of the inlet weir is set 0.5 m higher the water level of inlet to provide for the case where head loss mentioned above are higher than the estimated.

The width of the weir is set at 3 - 4 m in order to enable the overflow with depth of 0.2 m.

3) **Tilting weir**

The height of the tilting weir is designed 2.1 m from the river bed. Water level of tilting is set at 2.0 m from river bed, which equivalents to 0.2m of overflow depth of the inlet weir. The relation among the inlet weir, outlet weir and tilting weir are illustrated in Fig.Q-29.

4 IMPROVEMENT OF COMMUNAL PLANT OPERATION

4.1 Background

As a result of the study in 1989, it was recommended, as one of the water quality improvement measures, to improve the operation of the communal plant to reduce the pollutant load discharges. Particularly in the Sg. Pinang basin, where the pollution load from discharges from these plants was estimated to be more than 50 % of total pollutant load discharges, the improvement of the operation of plants could more contribute to the water quality improvement of the river.

Presently, wastewater in the center of Georgetown is collected by a sewer system and is discharged to the south channel without treatment. The construction of a treatment plant for the collected sewage is being planned by MPPP. In the Batu Ferringghi area, a sewage treatment plant, with an existing treatment capacity to treat wastewater of 20,000 persons and with ultimate capacity of 60,000 persons, has been constructed by MPPP and is now in operation.

As such, sewage treatment by centralized plants seems to be becoming common on the Island. This is more reasonable than the construction of many small plants, in terms of cost effectiveness, treatment efficiency, operation and maintenance, etc. This trend should be encouraged and will result in a relative decrease in the amount of wastewater treated by communal plants.

Even though, however, communal plants will have an important role in domestic wastewater treatment in the Island, since centralized treatment systems may not be able to cover whole the Island nor the city, thus the outskirts of the city

and rural area may remain in out of their service areas. Especially in Georgetown, urbanization is developing in such outskirts and the amount of wastewater to be treated by the methods other than centralized system will increase in future.

Therefore, the study was made to investigate the possible improving measures of the plant operations by surveying the actual operation conditions at the representative plants.

4.2 Outline of the Communal Plant

The features of the existing communal plants in Georgetown are outlined as below:-

4.2.1 Number of Communal Plants

According to the information from MPPP, there are 50 communal plants operated by MPPP in the Sg. Pinang basin; these plants comprise 60 % of the total number of plants in the Island and treat 15 % of wastewater from Georgetown's population. The name of plants are shown in Table Q-14.

4.2.2 Type of sewage

There are two types in domestic sewage; i) sewage containing only wastewater from flush toilet and ii) sewage containing all wastewater from daily life. Therefore, communal plants are divided into two types by sewage to be treated as follow:-

- Combined type — Plant which treats sewage containing all wastewater
- Excreta type — Plant which treats sewage containing only wastewater from flush toilet.

Since 1970, it has been required to instal a combined type by the regulations. However, only 6 plants are of the combined type among 50 plants, and the remaining treat excreta only because most plants were constructed before 1970.

4.2.3 Type of Treatment Methods

The treatment methods adopted in the existing communal plants are classified into the following five types:-

- Activated sludge
- Septic Tank
- Septic Tank with Rectangular Filter
- Septic Tank with Trickling Filter
- Rotating Biofilm Contact

The numbers of plants and connected houses by treatment types are summarized in Table Q-15.

There are four plants of activated sludge type. They are the plants which were constructed in the relatively recent

housing development and have a large scale treatment capacity compared to the other types. There is only one plant of RBC type which is one of the most advanced wastewater treatment technology in the world. This is the newest plant among the existing communal plants in the Island and has a treatment capacity for 1500 houses, which is considered to be equivalent to 7500 persons. The plants of which types are either of the above two are all the combined type and cover about 60 % of total population served by the communal plants.

The plants with septic tank have a smaller scale of treatment capacity and treat excreta only. The plants with septic tank followed by rectangular filter are the most popular type at present and treat excreta only. There are two plants with septic tank followed by trickling filter and one of two has large scale treatment capacity (about 6000 persons), which treats combined sewerage.

4.2.4 Operation and Maintenance

The communal plants are constructed by developers in housing schemes and are transferred to MPPP for operations. Since 1970, the plants with more than 30 housing units are transferred to MPPP for operations and ones with less than 30 housing units are not transferred to MPPP, being operated by the developer.

In case of the Sg. Pinang basin, most plants were constructed before 1970 and MPPP is responsible to the operation of these plants including small ones.

4.3 Survey for Actual Operation Conditions

In order to study the operation of the existing communal plants, surveys of both water quality and operation conditions were conducted at four plants which represented common treatment types in Georgetown area.

4.3.1 Plants selected for the survey

The plant selected for each treatment type are as follow:-

Activated Sludge	Halaman Zoo 2
Activated Sludge	Lintang Batu Maung
Septic Tank with Rectangular Filter	Jalan Air Putih
Septic Tank with Trickling Filter	Kampung Melayu Flats

Among the above list, Plant Lintang Batu Maung was added at the request of MPPP, while it is located outside Sg. Pinang basin. Two treatment types, namely PBC and septic tank only, were eliminated from the survey because i) RBC plant is newly constructed and being well maintained and ii) the population served by type of septic tank is only 3 % of the total population.

4.3.2 Method of Survey

The first survey were conducted from 6th to 7th August, 1990 at four plants listed above and the second survey were conducted from 22nd to 23rd August, 1990 at Lintang Batu Maung and Halaman Zoo 2.

Water samples were collected at sewage inlet and the outlet of the each process to evaluate the function of each process. Sampling interval was determined considering the fluctuation of the inlet water quality. Sampling location and intervals are shown in Table Q-16.

For the operation conditions, inflow rate, MLSS, aeration rate and sludge return rate were measured.

4.3.3 Result of Survey

Result of the water quality analysis are shown in Table Q-17 to Q-20.

4.4 Consideration on the Existing Plant Operation

4.4.1 Plant Design

To evaluate the possible treatment capacity of plants from view points of facility design, design conditions of each plant are compared:

1) Septic tank

Major design condition for the existing septic tank type plants are summarized in Table Q-21.

The functions of septic tank are to separate suspended materials from liquid phase by sedimentation and to decompose sedimented sludge by anaerobic fermentation. Therefore, retention time are very important design factor and the volume of septic tank is determined by number of persons to be served. According to the Japanese Standards for Septic tank, the relation between necessary tank volume and the persons is given by the following equation.:-

$$V = 1.5 + (n-5) \times 0.1 \quad (m^3),$$

where V ; necessary volume, n ; persons.

The comparison between actual tank volume and the necessary tank volume calculated by the design persons served for each septic tank is illustrated in Fig. Q-30. As can be seen in the figure, most of plants have enough tank volume to the necessary volume.

Important design factor of the filters is a BOD-volume load, which is expressed by total BOD inflow per day per unit volume of filter media ($BODkg/d/m^3$). According to the Japanese Standards for Septic Tank, this value is 0.035 $BODkg/d/m^3$, assuming that 30 % of BOD is removed by the septic tank.

Design BOD-volume load is calculated by the following equation:-

BOD-volume Load =
Design flow rate x Design BOD / Volume of media

BOD-volume load of each plant with filter calculated are 0.028 - 0.030 BODkg/d/m^3 in most plants. In the calculation, design BOD was estimated 260 mg/l, which is recommended value in the Japanese Standards.

Therefore, it is judged that the design conditions of the septic tank methods, including filters, are in proper ranges.

2) Activated Sludge

Major design conditions of the existing activated sludge type plants are summarized in Table Q-22.

The design conditions are evaluated by comparing to the Japanese Standards shown in Table Q-23 as follow:-

i) Volumetric loadings of aeration tank are all smaller than the Standard.

ii) BOD loadings of aeration tank are smaller than the standard.

iii) Volumetric loading of sedimentation tank are smaller than the Standard but areal loading is larger than the Standard.

Form above findings, it can be said that design conditions regarding size for the aeration tanks lay in proper range, while design of sedimentation is not necessary seems proper because the surface area of sedimentation is tank seems smaller than the required.

4.4.2 Operation Conditions

1) Plant with Septic tank

Information on actual operation conditions of the plants with septic tank is available only in the plants where the survey were conducted. They are shown in Table Q-24. According to the result of the survey, two plants, namely Jalan Air Putih and Kampung Melayu Flats seem to be operated under the conditions where the loading rate is less than the design. Thus, as far as the survey result, septic tanks seem to be operated better conditions in term of the loading conditions.

For the operation of the septic tank method, sludge withdrawal and filter bed cleaning are rather important to keep normal operation. Such operational records are shown in Table Q-24. There are only two records for the septic tank and there is big difference in the frequency of the maintenance works between two plants. Kampung Melayu Flats plant seems to be well maintained than Jalan Air Putih. Particularly, no record was found in sludge withdrawal of

Jalan Air Putih Plant. In such plant, it can be suspected that there may be sludge carry-over resulting in deterioration of removal efficiency.

2) **Activated Sludge Plant**

In the operation of activated sludge, the following factors are considered to be important to obtain expected removal efficiency:-

i) Retention time: Since the reaction is biological reaction, proper retention time in the aeration tank must be maintained

ii) Ratio between BOD loading and concentration of activated sludge: Because BOD is removed by the interaction of the sludge and BOD materials. It is represented by BOD/MLSS loading.

iii) Aeration ratio: Oxygen is one of the essential factors to activate the sludge. Dissolved oxygen concentration in aeration tank must be kept at higher than 1 mg/l. Furthermore, aeration play a role to agitate and circulate the sludge in the tank in order to ensure the contact between the sludge and BOD materials and also to avoid the sedimentation of the sludge in the tank.

iv) Sludge return rate: MLSS concentration in the tank is to be controlled to maintain proper concentrations by the sludge returned from the sedimentation tank.

v) Sludge withdrawal: In the activated sludge methods, pollutants are removed from water by sludge. Therefore, it is necessary to withdraw sludge from sedimentation tank. Otherwise amount of the sludge in the system increase and finally the system will be filled with sludge.

In two plants surveyed, Halaman Zoo 2 and Lintang Batu Muang, the actual daily inflow rates exceed the designed by about 40 %, causing over volumetric loading to both aeration tank and sedimentation tank. In terms of BOD loading, however, loadings are lower than the designed as inlet BOD concentration is smaller than the designed.

Suspended solid (SS) in the aeration tank is considered as MLSS. According to the survey results shown in Table Q-19 and Q-20, they are from 20 to 2000, mostly less than 500 mg/l, which are extremely lower than the required MLSS concentration, 2000 - 3000 mg/l.

Aeration rate are represented by ratio of oxygen to BOD. Actual aeration rate is 30 % lower than the designed as shown in Table Q-22. Since oxygen is mainly consumed by sludge (MLSS) and MLSS is very low, aeration rate may be enough for oxygen supply. However, it may be not enough for the agitation of liquid and may allow sedimentation of the sludge in the tank.

For the sludge return rate, it is said to be 100 % of inflow rate, but no actual operational data was available.

According to the operation and maintenance records shown in Table Q-24, sludge withdrawal in activated sludge plants is only taken place every several months. In general, at such a long interval of sludge withdrawal, sedimentation tank is to be filled with sludge.

4.4.3 Existing Problems in Communal Plant Operations

The problems existing in actual operation are discussed as below:-

1) Plants with Septic Tank

In terms of facility design and operation conditions, septic tanks (including filters) are considered within the allowable range. Regarding effluent water quality, it does not seem to be bad compared to the expected effluent quality by septic tank system, which is 50 - 100 BOD mg/l, as far as results of water quality analysis.

However, daily operations and maintenance are not seemed to be done at the scheduled intervals. Particularly, low frequency of the sludge withdrawal is suspected of causing sludge carry-over from septic tank.

2) Activated Sludge Plants

As results of the consideration mentioned in the previous section and the observation during the site surveys, following problems were found in the operations of the activated sludge plants:-

i) Volumetric loading is higher than the designed. Moreover, there exists wide fluctuation of the flowrate in a day and it could directly affect on the retention time in the aeration tank as there is no flow adjustment tank. Therefore, retention time must be not enough in the period of peak flow.

ii) MLSS concentration is too low as an extended activated sludge methods. This may cause low removal efficiency. The reasons of such low MLSS are considered to be that improper sludge return control and not sufficient mixing in the aeration tank. During the site surveys, it is observed that operation of some aerator has been stopped and large amount of sludge are accumulated on the bottom of the aeration tanks.

iii) It is not proper to stop aeration in the some part of the aeration tank, because activated sludge can not be mixed with sewage and are settled on the bottom.

iv) Sludge return rate is not controlled in terms of quantity and concentration. Due to low concentration of MLSS and excess areal loading in the sedimentation tank, concentration of return sludge is supposed to be

low. Uncontrolled sludge return rate can not correspond to the fluctuation of the in flow rate. These are possibly one of the causes of low MLSS in the aeration tank.

v) Structural defects were found in Lintang Batu Muang Plant.

4.5 Recommendation on Improvement of Plant Operations

4.5.1 Septic Tank

Particular problem was not found in the operation conditions of the septic tank plant. In order to maintain normal operation, it is considered important to withdraw accumulated sludge in the septic tank in time. The timing of withdrawal should be determined by monitoring the accumulation conditions. Fig. Q-31 illustrates the typical shape of sludge and scum accumulation in the tank. In general, sludge should be withdrawn when bottom of the scum reaches 10 cm from bottom of inlet pipe or sludge reaches 10 cm from bottom of outlet pipe.

4.5.2 Activated Sludge

1) Inspection and Maintenance

To maintain normal operation, periodical inspection and maintenance works should be carried out. Table Q-25 shows an example of inspection and maintenance schedule.

2) MLSS Control

It is necessary to maintain MLSS concentration at 1000 - 4000 mg/l. In order to do so:-

i) All the aerators should be run to ensure the full mixing in the aeration tank.

ii) Sludge return rate should be adjusted from 100 - 200 %.

3) Modification of Lintang Batu Muang Plant

Structural defects were found in Lintang Batu Muang. To improve the removal efficiency, following improvement of facility would be necessary:-

i) Enforcement of surface aeration.

ii) Removal of baffle plates.

iii) Installation of skirt baffle.

iv) Installation of additional aeration

v) Discarding sedimentation tank.

vi) Modification of sludge digestion tank and sludge storage tank to sedimentation tank.

5 RECOMMENDATION ON IMPROVEMENT OF RIVER WATER QUALITY

Everybody knows that rivers in Penang Island are polluted, however, nobody can tell how polluted they are quantitatively nor 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. Then the policies to achieve the improvement will be determined by selecting a optimum measures in terms of economically and technically to overcome the difference between the existing and required conditions.

Therefore, in general, comprehensive study, including the following actions, are recommended to improve the water quality improvement of rivers in Penang Island:-

5.1 Establishment of the Master Plan

To execute the comprehensive management of the water quality control of rivers in Penang Island, the master plan based on the following studies should be established:-

i) Programme for long term and periodical water quality monitoring should be commenced. In peninsular side water quality monitoring stations have been established in many rivers and periodical water quality monitoring are being conducted by DOE. Such station should be established at rivers in Penang Island, at least one station in Sg. Pinang.

ii) Goal of the water quality improvement should be established considering the uses of the river. National Water Quality Standards for Malaysia provides water quality criteria by classes which represent the water uses. Therefore, improvement goal can be determined by applying the class considering the actual water uses and required water uses of rivers in Penang Island.

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

iv) There would be several measures to reduce the existing pollutant generation in the basin to the allowable level. Regulation of the pig farm discharge, strengthening the industrial wastewater discharge and

domestic wastewater discharge, installation of the central sewerage treatment system would reduce the pollutants discharges. Optimum solution would be determined by combining such measures.

5.2 Decision Making to Reduce Pollutant Load

As a result of the pollution analysis in this study, it was revealed that the river pollution were 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 Wastewater

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

Since it could require spaces for faces disposal and additional man power for collecting and disposing feces, it may not be easy to be accepted by pig farm industry. It will require further study to find out feasible methods in economically and technically.

However, at first, it should be decided to implement the regulation to pig farming. Why they can operate their business without paying for wastewater treatment while industrial factories are paying for treatment of their wastewater.

2) Domestic Wastewater

Reducing pollutant load from domestic waste would be possible by strengthen the wastewater treatment. The strengthen of the existing wastewater treatment should be studied from view point of improvement of the communal plants and master plan of sewerage treatment system for whole Island.

There is a trend to construct centralized sewerage treatment systems in Penang Island. This will remarkably contribute to reduce the total pollutants discharge from domestic activities to the water bodies. Therefore, it is recommended that this trend be further encouraged in future.

For the existing sewerage treatment, improvement of communal plant would be necessary for improvement of Sg. Pinang water quality because it could have an important role even centralized sewerage treatment would have developed.

Some recommendations have been made in this study to improve mainly operation of activated sludge type plants. The execution of these recommendation will considerably contribute to the improvement of water quality of effluent water.

5.3 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 introduced into the ponds and discharged by tidal fluctuation or pumping in flood period.

Basins of S-10 and S-18 are located in the areas served by sewer collection system. Sewer generated in the basins are to be collected to the sewer systems and never be discharged to the drain. However, in the area, most premises connect only toilet wastewater to sewer system and discharges sullage water to the drains. Seventy to eighty percents of the premises 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 are supposed to comprise of mostly sullage water.

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

To provide for such conditions, buffer greenery is proposed between the residential area and ponds site. This will reduce the smell problems in the residential areas. However, as more fundamental solution, it is recommended to cut off the inflowing of sullage water to the drain.

Tables

TABLE Q-1 VISUAL OBSERVATION OF RIVER CONDITION

(Result of the site observation conducted in August, 1989)

Catchment No.	River Name	Water		River bed	
		Colour	Smell	Materials	Colour
1	Sg. Pinang	black	medium	muddy	black
2	Sg. Teluk Awak	ocher	no	sand	ocher
3	Sg. Teluk Bahang	ocher	no	sand	ocher
4	Sg. Batu Ferringghi	ocher	no	silt	ocher
5	Sg. Satu	ocher	no	silt	ocher
6	Sg. Mas	ocher	no	silt	ocher
7	Sg. Kecil	ocher	no	silt	ocher
8	Sg. Kelian	ocher	no	silt	ocher
9	Sg. Balik Batu	ocher	no	sand	ocher
10	Sg. Fettes	ocher	no	sand	ocher
11	Sg. Bagan Jermal	ocher	no	sand	ocher
12	Sg. Babi	ocher	no	sand	ocher
13	Sg. Gelugor	ocher	no	muddy	grey
14	Sg. Dua Besar	ocher	fair	muddy	grey
15	Sg. Nibong Besar	black	strong	muddy	black
16	Sg. Nibong Kecil	black	strong	muddy	black
17	Sg. Keluang	ocher	no	silt	ocher
18	Sg. Nipah	black	strong	muddy	black
19	Sg. Kampong Masjid	black	strong	muddy	black
20	Sg. Ikan Mati	grey	medium	rock	black
21	Sg. Bayan Lepas	ocher	no	sand	grey
22	Sg. Batu	clean	no	sand	ocher
23	Sg. Mati	clean	no	sand	ocher
24	Sg. Teluk Kumbar	ocher/grey	no	silt	ocher
25	Sg. Gemuroh	clean	no	sand	ocher
26	Sg. Gertak Sanggul	black	strong	muddy	black

TABLE Q-2 LIST OF SAMPLING POINTS

Catchment No.	River Name	Sampling point	point No.	Dry Season		Rainy Season		TOTAL
				1st	2nd	1st	2nd	
1	Sg. Pinang	Jln. Jelutong	p11	1	1	1	1	4
		Jln. Air Itam	p12	1	1	1	1	4
		Sg. Air Item : Jln. Scotland	p13	1	1	1	1	4
		Sg. Air Itam : Jln. Lorong	p14	1	1	1	1	4
		Sg. Jelutong : Jln. Sg. Pinang	p101	1	1	1	1	4
		Sg. Air Terjun : Jln. York	p102	1	1	1	1	4
		Sg. Air Itam A : Jln. Sekolaha la Salle	p103	1	1	1	1	4
2	Sg. Teluk Awak	Tukun Bahang	20	1		1		2
3	Sg. Teluk Bahang	Tukun Bahang	30	1		1		2
4	Sg. Batu Ferringghi	Bridge at most downstream	40	1		1		2
5	Sg. Satu	Bridge at most downstream	50	1		1		2
6	Sg. Mas	Bridge at most downstream	60	1		1		2
7	Sg. Kecil	Bridge at most downstream	70	1		1		2
8	Sg. Kelian	Bridge at most downstream	80	1		1		2
9	Sg. Balik Batu	Bridge at most downstream	90	1		1		2
10	Sg. Fettes	Bridge at most downstream	100	1		1		2
11	Sg. Bagan Jermal	Bridge at most downstream	110	1		1		2
12	Sg. Babi	Bridge at most downstream	120	1		1		2
13	Sg. Gelugor	Jln. Bayan Lepas	130	1	1	1	1	4
14	Sg. Dua Besar	Jln. Bayan Lepas	141	1	1	1	1	4
		Upstream	142	1	1	1	1	4
15	Sg. Nibong Besar	Jln. Bayan Lepas	150	1	1	1	1	4
16	Sg. Nibong Kecil	Jln. B Lepas : Stream from Residential Area	161	1	1	1	1	4
		Jln. B Lepas : Stream from Industrial Area	162	1	1	1	1	4
17	Sg. Keluang	Jln. Bayan Lepas : North	171	1	1	1	1	4
		Jln. Bayan Lepas : South	172	1	1	1	1	4
		Stream from Airport	173	1	1	1	1	4
18	Sg. Nipah	Bridge near Oxidation Pond	181	1	1	1	1	4
		Outlet of Oxidation Pond	182	1	1	1	1	4
19	Sg. Kampong Masjid	Near River Mouth	190	1		1		2
20	Sg. Ikan Mati	Near River Mouth	200	1		1		2
21	Sg. Bayan Lepas	Bridge at most downstream	210	1		1		2
22	Sg. Batu	Bridge at most downstream	220	1		1		2
23	Sg. Mati	Bridge at most downstream	230	1		1		2
24	Sg. Teluk Kumbar	Bridge at most downstream	240	1		1		2
25	Sg. Gemuroh	Bridge at most downstream	250	1		1		2
26	Sg. Gertak Sanggul	Bridge at most downstream	260	1	1	1	1	4

TABLE Q-3 RESULT OF WATER QUALITY SURVEY OF RIVERS

Rivers other than Sg. Pinang

Sampling Point No	Name of River	DATE (1989)	DO (mg/l)	BOD (mg/l)	NH4-N (mg/l)	Color	Smell
20	Sg. Teluk Awak	3-Sep	6.9	2.0	0.1	1	0
		11-Oct	7.0	1.0	0.1	1	0
30	Sg. Teluk Bahang	3-Sep	6.9	2.0	5.5	1	0
		11-Oct	7.0	1.0	0.1	1	0
40	Sg. Batu Ferringghi	4-Sep	5.6	4.0	0.9	0	0
		11-Oct	6.5	1.0	0.1	1	0
50	Sg. Satu	3-Sep	6.8	3.0	0.6	1	0
		11-Oct	6.9	1.0	0.1	1	0
60	Sg. Mas	3-Sep	6.8	5.0	0.1	1	0
		11-Oct	6.6	6.0	0.1	1	0
70	Sg. Kecil	3-Sep	6.8	2.0	1.4	1	0
		11-Oct	7.0	2.0	0.1	1	0
80	Sg. Kelian	3-Sep	6.7	6.0	1.0	1	0
		11-Oct	6.9	1.0	0.1	1	0
90	Sg. Balik Batu	3-Sep	5.8	12.0	5.3	1	0
		11-Oct	6.0	10.0	0.6	1	0
100	Sg. Fettes	3-Sep	5.0	18.0	4.5	1	2
		11-Oct	4.0	6.0	0.4	1	1
110	Sg. Bagan Jermal	11-Oct	5.9	9.0	3.2	1	1
120	Sg. Babi	3-Sep	5.5	13.0	1.5	1	2
		11-Oct	5.6	12.0	1.5	1	2
130	Sg. Gelugor	2-Sep	5.4	12.0	11.2	1	2
		4-Sep	5.8	6.0	3.6	1	2
		1-Oct	4.1	14.0	2.3	1	2
		11-Oct	6.4	5.0	2.4	1	2
141	Sg. Dua Besar Downstream	2-Sep	5.8	15.0	7.1	1	2
		4-Sep	2.9	19.0	12.1	1	2
		1-Oct	6.1	12.0	3.8	1	2
		11-Oct	4.5	16.0	4.5	1	2
142	Sg. Dua Besar Upstream	2-Sep	5.1	8.0	2.6	1	2
		4-Sep	6.4	3.0	2.0	1	1
		11-Oct	6.3	2.0	1.8	1	1
		12-Oct	6.3	4.0	0.6	1	1
150	Sg. Nibong Besar	2-Sep	5.1	11.0	10.2	1	2
		4-Sep	5.9	12.0	12.0	1	2
		1-Oct	5.4	6.0	1.4	1	2
		11-Oct	6.1	9.0	3.5	1	2
161	Sg. Nibong Kecil Resdential Area	2-Sep	0.4	94.0	78.2	3	3
		4-Sep	0.4	72.0	38.4	1	4
		1-Oct	0.9	41.0	25.0	3	3
		12-Oct	1.0	46.0	11.1	1	2
162	Sg. Nibong Kecil Industrial Area	2-Sep	0.4	78.0	65.3	2	3
		4-Sep	0.4	70.0	71.2	1	2
		1-Oct	1.1	62.0	9.1	1	3
		12-Oct	2.3	24.0	7.6	1	2
171	Sg. Keluang North	2-Sep	5.6	12.0	1.3	1	2
		4-Sep	5.8	3.0	1.1	2	2
		1-Oct	5.8	9.0	1.5	1	1
		12-Oct	5.9	2.0	0.8	1	1
172	Sg. Keluang South	2-Sep	5.4	14.0	1.1	1	2
		4-Sep	4.5	17.0	1.8	1	2
		1-Oct	5.2	18.0	0.7	1	2
		12-Oct	5.1	8.0	1.1	1	1
173	Sg. Keluang Airport	3-Sep	0.8	35.0	6.2	1	3
		4-Sep	1.7	38.0	204.0	1	2
		1-Oct	1.5	29.0	3.6	1	3
		12-Oct	2.4	21.0	11.5	1	2

TABLE Q-3 RESULT OF WATER QUALITY SURVEY OF RIVERS (CONTINUED)

Rivers other than Sg. Pinang

Sampling Point No	Name of River	DATE (1989)	DO (mg/l)	BOD (mg/l)	NH4-N (mg/l)	Color	Smell
181	Sg. Nipah Oxidation Pond Inlet	2-Sep	0.5	120.0	116.0	3	4
		4-Sep	0.1	108.0	45.4	3	4
		1-Oct	0.5	70.0	78.8	3	4
		12-Oct	12-Oct	48.0	33.0	2	3
182	Sg. Nipah Oxidation Pond Outlet	2-Sep	6.4	38.0	2.0	2	4
		4-Sep	4.5	75.0	26.1	1	4
		1-Oct	5.1	13.0	6.0	2	3
		12-Oct	5.2	3.0	22.5	1	1
190	Sg. Kampong Masjid	4-Sep	5.3	13.0	6.3	1	2
		1-Oct	5.4	15.0	7.2	1	2
200	Sg. Ikan Mati	4-Sep	5.9	10.0	6.1	1	1
		1-Oct	5.6	6.0	1.5	1	1
210	Sg. Bayan Lepas	2-Sep	5.0	12.0	0.8	1	2
		1-Oct	5.7	2.0	0.3	1	2
220	Sg. Batu	4-Sep	5.7	14.0	0.8	1	1
		12-Oct	5.8	12.0	1.2	1	1
230	Sg. Mati	2-Sep	5.2	11.0	2.0	1	2
		12-Oct	5.7	9.0	1.1	1	1
240	Sg. Teluk Kumbar	3-Sep	5.9	9.0	0.5	1	2
		12-Oct	5.9	7.0	0.7	1	1
250	Sg. Gemuroh	2-Sep	6.8	6.0	0.5	0	0
		1-Oct	6.9	1.0	0.1	0	0
260	Sg. Gertak Sanggul	3-Sep	0.3	88.0	22.0	3	4
		4-Sep	0.1	160.0	48.4	3	4
		1-Oct	2.7	45.0	20.7	3	4
		12-Oct	3.5	16.0	6.4	2	3

Sg. Pinang

Sampling Point No	Name of River	DATE (1989)	DO (mg/l)	BOD (mg/l)	NH4-N (mg/l)	Color	Smell
P11	Sg. Pinang Down stream	2-Sep	2.3	30.0	14.0	2	2
		4-Sep	1.8	35.0	18.0	1	2
		1-Oct	3.3	20.0	2.4	2	2
		11-Oct	2.0	27.0	9.9	1	2
P101	Sg. Jelutong	2-Sep	0.3	81.0	42.1	1	3
		4-Sep	2.8	28.0	10.2	1	2
		1-Oct	1.6	20.0	1.0	1	2
		11-Oct	3.7	23.0	3.1	1	2
P12	Sg. Pinang	2-Sep	3.5	24.0	8.3	1	2
		3-Sep	5.0	15.0	2.0	1	2
		1-Oct	3.8	19.0	2.1	1	1
		11-Oct	5.4	9.0	1.2	1	2
P102	Sg. Air Terjun	2-Sep	6.4	3.0	1.5	1	1
		3-Sep	7.0	2.0	0.4	1	0
		1-Oct	6.8	1.0	0.1	1	1
		11-Oct	7.1	1.0	0.1	1	0
P13	Sg. Pinang	2-Sep	2.4	30.0	11.3	1	2
		3-Sep	1.8	30.0	2.9	1	2
		1-Oct	3.6	17.0	2.5	1	1
		11-Oct	2.2	14.0	2.3	1	2
P103	Sg. Air Puti	2-Sep	0.6	72.0	40.5	1	3
		3-Sep	0.9	37.0	4.5	1	3
		1-Oct	1.6	24.0	4.3	1	3
		11-Oct	2.5	26.0	2.5	1	3
P14	Sg. Air Itam	2-Sep	0.5	78.0	4.4	1	3
		3-Sep	1.5	28.0	3.5	1	2
		1-Oct	3.3	12.0	2.1	2	2
		11-Oct	2.0	12.0	2.8	1	2

TABLE Q-4 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

TABLE Q-5 POLLUTION CLASSIFICATION OF RIVERS IN THE STUDY AREA

Classification	Description	Name of River
Extremely Polluted	Considered to be sewerage	Sungai Nibong Kecil Sungai Nipah Sungai Gertak Sanggul
Polluted	Not satisfying Water Quality Standards Class-IV	Sungai Pinang Sungai Fettes Sungai Dua Besar Sungai Nibong Besar Sungai Kampong Masjid Sungai Babi Sungai Bayan Lepas Sungai Batu
Not polluted or tolerable	Satisfying Water Quality Standards Class-IV	Sungai Teluk Awak Sungai Teluk Bahang Sungai Batu Ferringghi Sungai Satu Sungai Mas Sungai Kecil Sungai Kelian Sungai Bagan Jermal Sungai Gelugor Sungai Keluang Sungai Ikan Mati Sungai Teluk Kumbar Sungai Gemuroh

TABLE Q-6 POPULATION AND PIG NUMBERS IN EACH RIVER CATCHMENT

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)		
Sg. Pinang	51.0	33846	105913	0	20604	65961	226,324	16,543
Sg. Teluk Awak	3.0	0	0	1600	0	450	2,050	
Sg. Teluk Bahang	12.3	0	0	1840	0	210	2,050	300
Sg. Batu Ferringghi	11.3	0	0	650	0	458	1,108	175
Sg. Satu	2.6	0	0	650	0	638	1,288	
Sg. Mas	2.1	0	0	829	0	829	1,658	
Sg. Kecil	2.8	1886	0	0	0	28	1,914	3,499
Sg. Kelian	9.0	7719	0	0	0	4223	11,942	
Sg. Balik Batu	0.8	1670	3185	0	0	1515	6,370	
Sg. Fettes	1.4	2200	4470	0	0	2270	8,940	29
Sg. Bagan Jermal	0.8	0	1170	0	0	1170	2,340	150
Sg. Babi	0.8	0	1409	0	0	1409	2,818	
Sg. Gelugor	4.1	7325	0	12861	0	5536	25,722	
Sg. Dua Besar	6.2	2200	0	4475	0	2275	8,950	3,609
Sg. Nibong Besar	1.5	2200	1243	664	0	35	4,142	
Sg. Nibong Kecil	2.8	3327	2248	1823	0	96	7,494	15,811
Sg. Keluang	22.2	7559	5108	4141	0	218	17,026	17,723
Sg. Nipah	1.7	2144	0	462	0	24	2,630	27,083
Sg. Kampong Masjid	0.8	0	0	2499	0	132	2,631	
Sg. Ikan Mati	0.4	0	0	1041	0	55	1,096	
Sg. Bayan Lepas	7.0	0	0	2142	0	945	3,087	1,060
Sg. Batu	0.9	0	0	1029	0	454	1,483	
Sg. Mati	1.0	0	0	693	0	306	999	
Sg. Teluk Kumbar	7.1	432	0	3900	0	1323	5,655	980
Sg. Gemuroh	1.9	0	0	529	0	238	767	
Sg. Gertak Sanggul	1.0	0	0	854	0	385	1,239	9,220
Total	156.3	72508	124746	42682	20604	91183	351723	96182