NO.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE GOVERNMENT OF MALAYSIA
PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

THE STUDY
ON
INTEGRATED URBAN DRAINAGE IMPROVEMENT
FOR
MELAKA AND SUNGAI PETANI
IN MALAYSIA

FINAL REPORT

VOL. 1: SUMMARY

AUGUST 2000

CTI ENGINEERING INTERNATIONAL CO., LTD.
IN ASSOCIATION WITH
PASCO INTERNATIONAL, INC.

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ESTIMATE OF PROJECT COST

Price Level	:	As of May 1999
Currency Conversion Rate	:	US$1.00 = RM 3.8 = 121.4 Yen

PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct Development Study on Integrated Urban Drainage Improvement for Melaka and Sungai Petani and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Makihiko Otogawa of CTI Engineering International Co., Ltd. to Malaysia, three times between January 1999 and July 2000. In addition, JICA set up an advisory committee, which examined the study from specialist and technical points of view.

The team held discussion with the officials concerned of the Government of Malaysia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the Team.

August 2000

Kimio Fujita
President
Japan International Cooperation Agency

August 2000

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Sir:

We are pleased to submit herewith the Final Report on the Study on Integrated Urban Drainage Improvement for Melaka and Sungai Petani in Malaysia. Under a contract with the Japan International Cooperation Agency, the Study was conducted by CTI Engineering International Co., Ltd., in association with PASCO International, Inc., during the period from February 1999 to July 2000.

This Final Report presents the results of the two study phases. The first phase was the formulation of the drainage structure plan for two regional urban centers; namely, Sungai Petani and Melaka with the target year of 2020, while the second phase was for the feasibility study on the urban drainage improvement for the four (4) priority areas selected. The second phase further included the preparation of a technical guideline on the integrated urban drainage improvement. In the course of the Study, much attention was given to the particular issues on urban drainage in Malaysia, and reflected them in the proposed drainage improvement plan and the technical guideline.

We wish to take this opportunity to express our sincere gratitude to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Construction and other related agencies in Japan. We would also like to extend our deep appreciation to the officials concerned of the Government of Malaysia, especially the Economic Planning Unit, Prime Minister's Department and the Department of Irrigation and Drainage, Ministry of Agriculture.

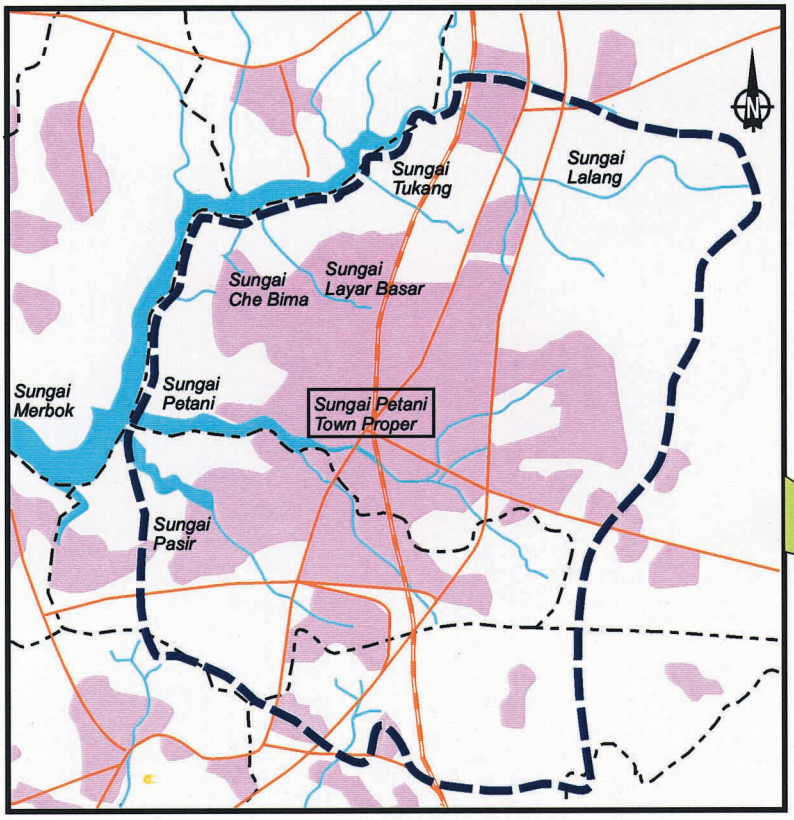
Finally, we hope that this Report will contribute to the urban drainage improvement in Malaysia.

Very truly yours,

MAKIHIKO OTOGAWA
Team Leader
Study on Integrated Drainage Improvement
for Melaka and Sungai Petani in Malaysia

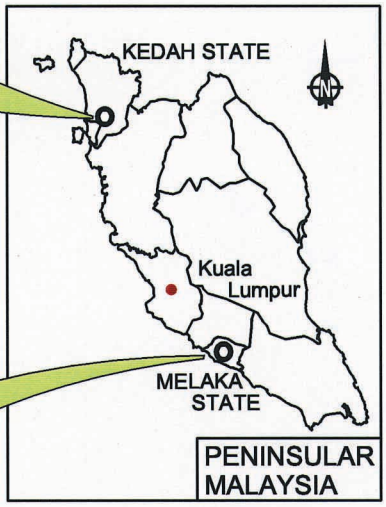
GENERAL MAP

SUNGAI PETANI



LEGEND

- Principal Road
- Railway
- Mukim Boundary
- Built-up Area
- Study Area



SCALE
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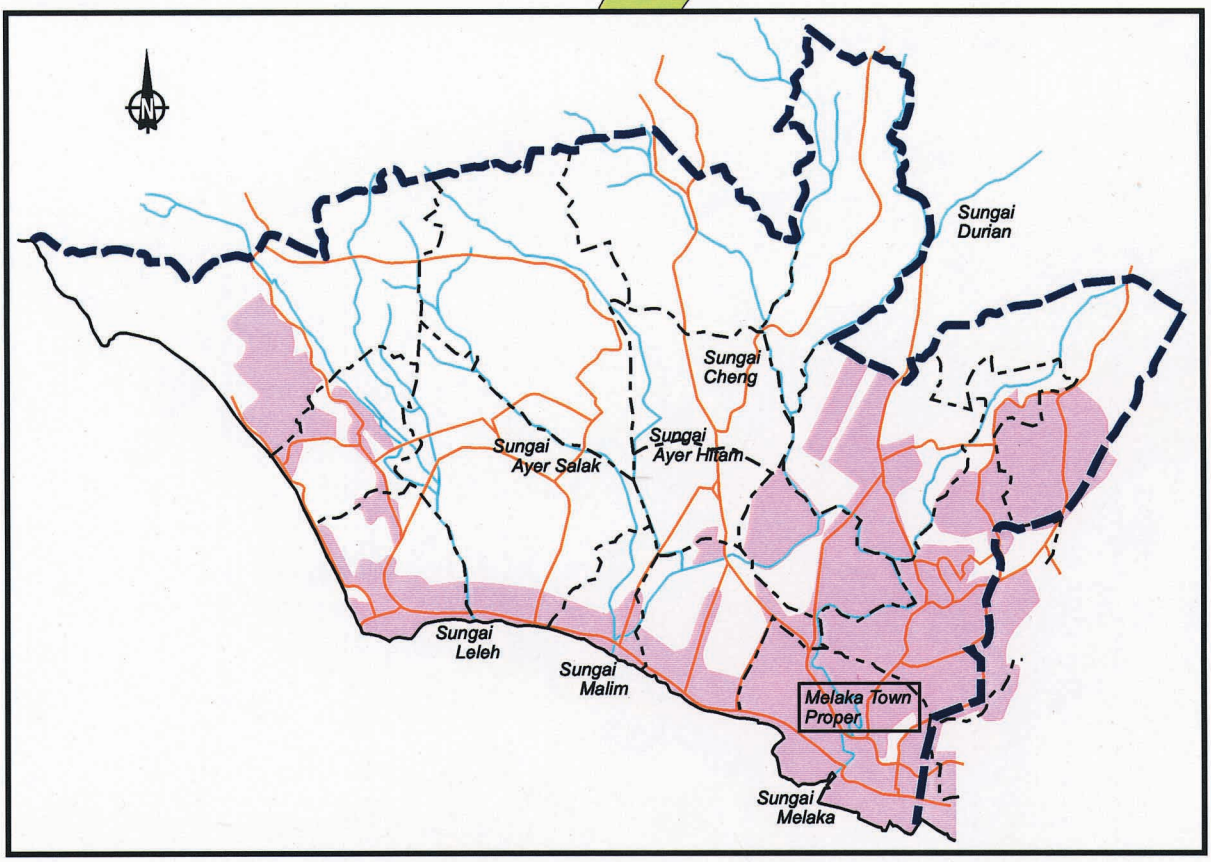
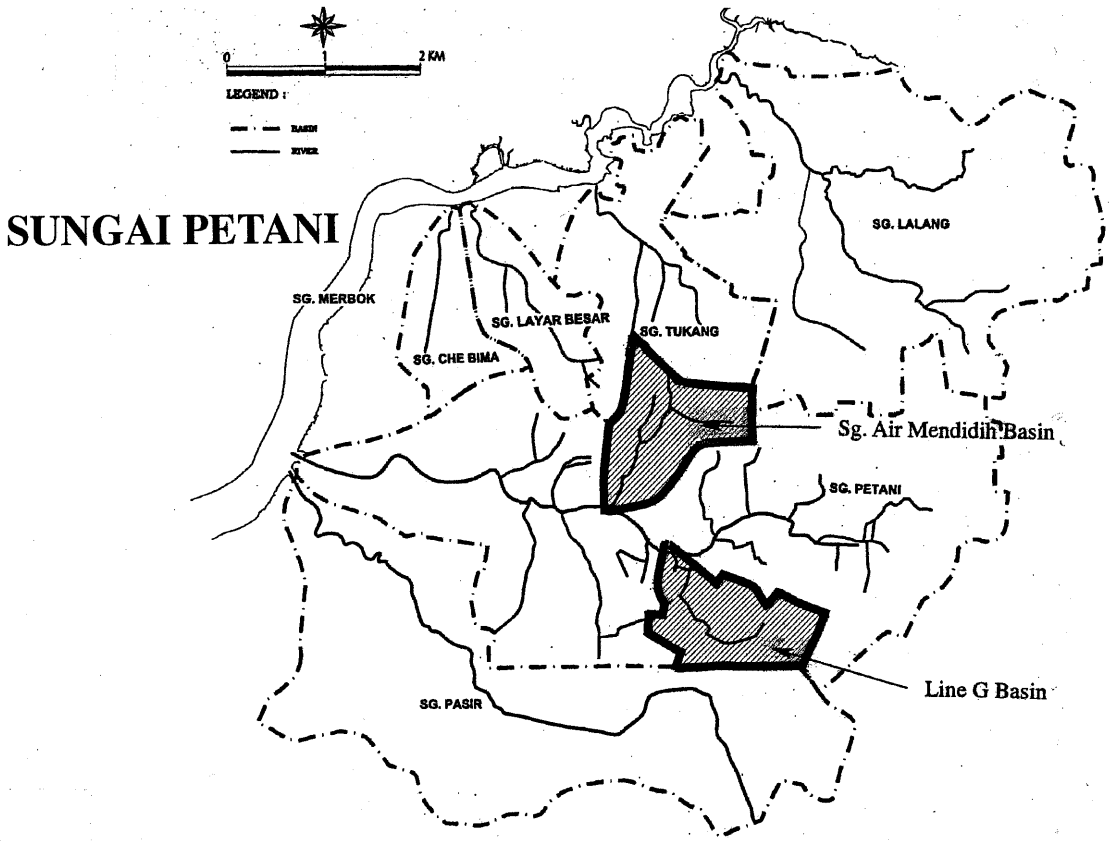
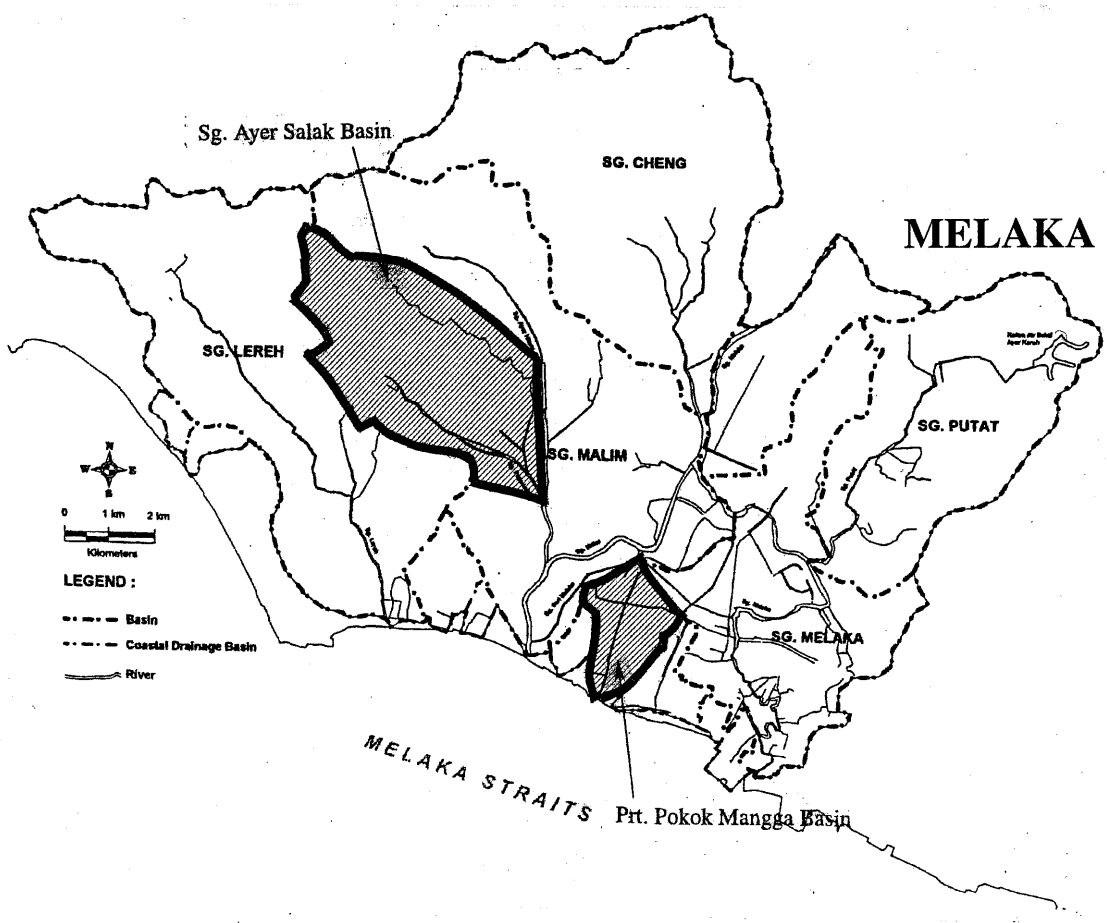
MELAKA



LOCATION MAP OF

PRIORITY AREAS





THE STUDY
ON
INTEGRATED URBAN DRAINAGE IMPROVEMENT
FOR MELAKA AND SUNGAI PETANI
IN MALAYSIA

LIST OF REPORTS

OUTLINE OF THE STUDY

1. Background of the Study

Many urban areas in Malaysia suffer from serious damage caused by storm rainfall associated with local torrential downpour. Anticipated is be more significant flood damage due to drastic increment of peak flood runoff discharge caused by the rapid progress of urbanization at present.

To cope with the flood damage issue, the Government of Malaysia had requested the Government of Japan to extend technical cooperation for the study on an urban drainage improvement plan for two major regional urban centers, Sungai Petani and Melaka. In response, the Government of Japan had decided to undertake "The Study on Integrated Urban Drainage Improvement for Melaka and Sungai Petani in Malaysia" (hereinafter referred to as "the Study").

The Study covers two phases, that is, Phase 1 and Phase 2. Phase 1 is for the formulation of a drainage structure plan with 2020 as target year, while Phase 2 is for the Feasibility Study on priority projects and the preparation of a technical guideline on urban drainage improvement.

2. Objectives of the Study

The primary objectives of the Study are: (1) to formulate the drainage structure plan with 2020 as the target year; (2) to conduct a feasibility study for the selected priority areas; (3) to prepare a technical guideline on urban drainage improvement; and (4) to transfer technical knowledge to counterpart personnel in the course of the Study.

3. Study Area

The study area comprises two regional urban centers; namely, Sungai Petani and Melaka. Sungai Petani covers an area of about 100 km^2 in the Kuala Muda District of Kedah State, while Melaka covers an area of 192 km^2 in the Melaka Tengah District of Melaka State.

4. Outline of the Proposed Plans

4.1 Basic Policy

The Study aims at formulating a long-term urban drainage improvement plan of 20 years, i.e., up to the year 2020. Priority projects are identified from the long-term drainage structure plan,

whereupon, more detailed structure plans are formulated and their economic viability confirmed through a feasibility study. The priority projects are for implementation in the Eighth Malaysia Plan (2001 to 2005).

The drastic increment of peak flood runoff discharge due to intensive land development and the extremely small flow capacity of river channels downstream greatly influence drainage in the study area. In formulating the drainage structure plan, given is particular attention to the reduction of peak flood runoff discharge by various types of flood detention facilities (called "source control of flood").

4.2 Outline of the Drainage Structure Plan

4.2.1 Long-Term Drainage Structure Plan

With 2020 as the target year, the long term drainage structure plan proposes to construct drainage facilities within a period of 20 years. The following table gives the items of work and quantities of the plan.

Work Item	Unit	Work Volume		
		Sg. Petani	Melaka	Total
1. Channel Improvement				
Number of Channels		44	24	68
Channel Length	km	42.0	36.5	78.5
Earth Works	$1000m^3$	651.5	832.3	1,483.8
Concrete Works	$1000m^3$	145.2	172.0	317.2
Number of Box Culverts to be Reconstructed		14.0	14.0	28.0
Number of Bridges to be Reconstructed		101	57	158
2. Rehabilitation of Existing Detention Pond				
Number of Ponds		12	1	13
Area of Pond	ha	18.2	2.6	20.8
Catchment Area	ha	802.7	61.1	863.8
Earth Works	$1000m^3$	55.2	54.8	110.0
Surface Protection (Turfing and stone pitching)	$1000m^2$	394.2	33.1	427.3
Concrete Works	$1000m^3$	6.7	0.2	6.9
Metal Works	ton	36.0	2.8	38.8
Road Works	$1000m^2$	39.2	5.7	44.9
3. Construction of New Detention Pond				
Area of Pond	km^2	1.8	2.5	4.3
Catchment Area	km^2	46.0	63.6	109.6
Earth Works	$1000m^3$	7,141.4	9,869.8	17,011.2
Stone-pitching	$1000m^2$	410.8	567.8	978.6
Turfing	$1000m^3$	1,695.0	2,942.6	4,637.6
R.C. Structure	$1000m^3$	62.4	86.2	148.6
Metal Works	ton	207.0	286.0	492.0
Road Works	$1000m^2$	512.3	708.0	1,220.3
4. Construction of Storage Facility in Public Open Space				
Area of Open Space	km^2	0.3	1.4	1.7
Earth Works	$1000m^3$	80.2	422.0	502.2
Bottom Surface Protection (Turfing)	$1000m^2$	267.2	1,406.9	1,674.0
R.C. Structure	$1000m^3$	4.8	25.3	30.1
Metal Works	ton	3.3	17.6	20.9

4.2.2 Priority Projects

The priority projects selected from the long-term drainage structure plan comprise drainage improvement works for four (4) drainage sub-basins, as follows: (1) Sg. Air Mendidih in Sg. Petani for 3.62 km^2; (2) Line-G in Sg. Petani for 2.73 km^2;' (3) Pokok Mangga in Melaka of 4.71 km^2; and (4) Sg. Ayer Salak in Melaka for 17.20 km^2. These four drainage sub-basins contain a high flood damage potential, and expected is early implementation of priority projects by the government agencies concerned. The following table gives an outline of the priority projects.

Work Item	Unit	Work Volume				
		Sg. Air Mendidih	Line-G	Pokok Mangga	Sg. Ayer Salak	Total
1. Channel Improvement						
Number of Channel		4	3	5	8	20
Channel Length	km	4.4	3.0	10.8	15.7	33.9
Earth Work	$1000m^3$	90.4	20.0	239.4	443.9	793.7
Concrete Work	$1000m^3$	5.9	5.3	51.0	-	62.2
Number of Box Culverts		11	5	6	14	36
Number of Bridges		8	0	10	8	26
2. Rehabilitation of Existing Detention Pond						
Number of Ponds		-	2	-	1	3
Area of Pond	ha	-	3.3	-	2.1	5.4
Catchment Area	ha	-	97.6	-	98.1	195.7
Earth Work	$1000m^3$	-	32.7	-	12.9	45.6
Slope Protection	$1000m^2$	-	37.1	-	18.8	55.9
Concrete Work	$1000m^3$	-	0.4	-	0.3	0.7
Metal Work	ton	-	2.5	-	1.7	4.2
Road Work	$1000m^2$	-	3.9	-	2.0	5.9
3. Construction of New Detention Pond						
Number of Ponds		2	2	-	5	9
Area of Pond	km^2	3.6	6.1	-	29.4	39.1
Catchment Area	km^2	139.3	394.6	-	1,176.5	1,710.4
Earth Work	$1000m^3$	70.2	59.8	-	121.2	251.2
Slope Protection	$1000m^2$	31.6	58.7	-	45.2	135.5
Concrete Work	$1000m^3$	-	0.4	-	0.4	0.8
R.C. Structure	$1000m^3$	0.3	0.5	-	1.1	1.9
Metal Work	ton	0.9	0.9	-	2.3	4.1
Road Work	$1000m^2$	4.1	3.1	-	5.7	12.9
4. Construction of On-site Detention Pond						
Number of Ponds		3	-	-	-	3
Area of Open Space	ha	7.1	-	-	-	7.1
Earth Work	$1000m^3$	28.1	-	-	-	28.1
Bottom Protection	$1000m^2$	36.0	-	-	-	36.0
Concrete Work	$1000m^3$	0.7	-	-	-	0.7
Metal Work	ton	0.6	-	-	-	0.6

4.3 Outline of the Non-structural Drainage Improvement Plan

4.3.1 Establishment of Organizational Framework and Demarcation of Functional Responsibility

The responsibility for urban drainage improvement is currently shared by three (3) tiers of the Malaysian Government; namely, the Federal Government, the State Government, and the Local Government. Moreover, various government agencies in each of the tiers are involved in the drainage improvement works. Under such current situation, proposed are an interagency coordination body and the demarcation of functional responsibilities to promote a consistent policy on drainage improvement works.

(1) Establishment of Federal and State Interagency Coordination Bodies

In order to enhance the consistent urban drainage improvement in Malaysia, the interagency coordination bodies are required at both of Federal and State Level. From this viewpoint, establishment of the new coordination bodies as well as application of the existing coordination bodies are proposed as below:

(a) Establishment of the new National Rivers Council (NRC) at Federal Level;

(b) Application of the Existing State Planning Committee (SPC) at State Level; and

(c) Establishment of the new State Water Management Authority (SWMA) at State Level.

Among the above coordination bodies, both of NRC and SWMA are newly established at Federal and State Level, respectively in order to coordinate with the agencies related to the urban drainage improvement, and at the same time to adjust the drainage improvement policies formulated between the Federal and State Levels.

The SPC is the existing coordination body at State Level that has deliberated the formulation of state policies on the conservation and development of all land in the State. The on-going intensive land development in the study area would cause a rapid increment of peak storm runoff discharge, while the urban drainage improvement may hardly catch up with the rapid increment of discharge. To avoid such unbalance, it is recommended that the SPC should be the appropriate forum to coordinate projections on land development and the urban drainage. Moreover, the State Director of DID should be made a permanent member of SPC so as to take technical responsibility on river management and urban drainage.

(2) Demarcation of Functional Responsibility for Drainage Improvement

The drainage improvement works involve the planning, design, construction and operation/maintenance for various drainage facilities which cover the river and drainage channel, flood detention pond and other various on-site flood detention facilities. According to the present guideline and regulations, DID and the Local Authority are the major executive bodies for drainage improvement works. However, due to the lack of clear demarcation of the works between DID and the Local Authority, the consistent drainage improvement is hardly executed. In order to retrieve such unfavourable conditions, the demarcation is proposed as listed below:

Drainage Facility	Planning/Design/ Construction	Maintenance
1. Basin-wide Drainage Facility		
1) River Channel Improvement	DID	DID
2) Trunk Drain	DID	DID
3) Community Flood Detention Pond	DID	LA
2. Sub-basin Drainage Facility		
1) Infrastructure Drain/Secondary Drain	LD/LA	LA
2) Roadside Drain (Sate/Federal Road)	PWD	PWD
3) Road Drain (Municipal Drain)	LD	LA
4) Perimeter/Tertiary Drain	LD	LA
5) Off-site Flood Detention Pond	LD	LA
6) On-site Detention Facility in Public Space	LA	LA

Note: LA: Local Authority; D: Land Developer; PWD: Public Works Department

As listed above, it is recommended that DID be responsible to construction and maintenance for most of the major drainage facilities that could contain the basin-wide flood mitigation effect. Among the major drainage facilities, however, the community flood detention pond should be preferably maintained by the Local Authority, as the pond is incorporated with amenity space and meets the community recreational needs. Maintenance of the minor drainage facilities for local flood be principally under the responsibility of the Local Authority. The minor drainage facilities include those constructed by the Developer within his land development site, and eventually surrendered to the Local Authority as a public facility.

4.3.2 Cost Recovery

The following system of cost recovery for the drainage improvement is proposed in due consideration of particular features of each work item.

Drainage Improvement Works	Source of Fund	Cost Recovery Measures
1. Formulation of drainage policy and programme	Federal and State governments	Federal and State Development Grant
2. Project implementation of basin wide drainage facilities	Federal and State governments	Drainage Contribution
3. Project implementation of sub-basin drainage facilities		
(1) Infrastructure drain/secondary drain	Land Developer/Local Authority	Drainage Improvement Charge
(2) Flood detention pond and perimeter/tertiary drain	Land Developer	Drainage Infrastructure Cost
(3) Roadside drain	State Government	State Road Grant
4. Construction and maintenance of other on-site detention facilities		
(1) Rehabilitation and maintenance of existing flood detention pond	Local Authority	Drainage Rate
(2) Construction and maintenance of on-site detention facility in public open space	Local Authority	Drainage Rate

4.3.3 Legislation on Drainage Improvement

Among others, the following legislation, rules and regulations are proposed as major requirements drainage improvement projects.

(1) Enforcement of Guideline on Construction of Flood Detention Pond by Land Developer

According to the present guideline, the land developer is required to construct a flood detention pond for a land development area of more than 10 ha. This minimum land development area of 10 ha is, however, proposed to be reduced to 1 ha in due consideration of the drastic increment of peak flood runoff discharge by the current intensive land development activities.

(2) Securing of Drainage Reserve Area

To preserve the natural flood retarding effects and prevent unfavorable land development activities, proposed is the securing of drainage reserve area with widths of 15 m from both banks of drainage channels.

(3) Water Pollution Control

It is proposed to establish quality standards for storm water runoff similar to the existing Environmental Quality Regulations for Sewerage and Industrial Effluents. The storm water runoff tends to wash the dust, sediment and other water pollution sources and bring them into the flood detention ponds causing deterioration of their water quality. In Malaysia, however, the water quality is currently not monitored during the flood. From this viewpoint, the objectives of existing monitoring by DOE should be extended to the quality of storm runoff in order to ensure water quality standards for the flood detention ponds in particular in order to ensure that the water quality standards are not breached.

(4) Promotion of Public Awareness on Solid Waste Disposal

Most of the local authorities have the bylaws to prevent littering of solid wastes, but enforcement is difficult due to difficulties in identifying the polluters. Under this situation, both the DID and the Local Authority should take an active role in educating the public on proper solid waster disposal to prevent water pollution.

5. Project Cost

Project cost is estimated in Malaysian Ringgit (RM) applying the currency conversion rates of US$1.00 = RM 3.8 = 121.4 Yen prevailing in May 1999. The results of cost estimation are as summarized below.

(1) Drainage Structure Plan

(Unit: RM million out of Parentheses and Million Yen in Parentheses)

Item	Sungai Petani		Melaka		Total	
1. Construction Cost						
Channel Improvement	46.60	(1,489)	56.35	(1,800)	102.95	(3,289)
Rehabilitation of Existing Detention Pond	5.57	(178)	0.45	(14)	6.02	(192)
Construction of New Detention Pond	120.92	(3,863)	167.11	(5,339)	288.03	(9,202)
Storage Facility in Public Open Space	3.05	(97)	16.04	(512)	19.09	(609)
Total	176.13	(5,627)	239.95	(7,665)	416.08	(13,292)
2. Annual Operation and maintenance Cost						
Drainage Channel	0.20	(6)	0.22	(7)	0.42	(13)
Detention Pond	1.93	(62)	2.67	(85)	4.61	(147)
Total	2.13	(68)	2.89	(92)	5.02	(160)

(2) Priority Projects

(Unit: RM million out of Parentheses and Million Yen in Parentheses)

Item	Sg. Air Mendidih		Line G		Prt. Pokok Mangga		Sg. Ayer Salak		Total	
1. Construction Cost										
Channel Improvement	7.20	(230)	3.22	(103)	14.64	(468)	25.75	(823)	50.81	(1,624)
Rehabilitation of Existing Detention Pond	-	(-)	0.54	(17)	-	(-)	0.29	(9)	0.83	(26)
Construction of New Detention Pond	1.05	(34)	1.47	(47)	-	(-)	3.23	(103)	5.75	(184)
Storage Facility in Public Open Space	0.54	(17)	-	(-)	-	(-)	-	(-)	0.54	(17)
Total	8.79	(281)	5.23	(167)	14.64	(468)	29.27	(935)	57.93	(1,851)
2. Annual Operation and Maintenance Cost										
Drainage Channel	0.04	(1.2)	0.01	(0.3)	0.05	(1.6)	0.20	(6.4)	0.30	(9.6)
Detention Pond	0.11	(3.5)	0.10	(3.2)	-	(-)	0.33	(10.5)	0.54	(17.2)
Total	0.15	(4.8)	0.11	(3.5)	0.05	(1.6)	0.53	(16.9)	0.84	(26.8)

6. Project Evaluation

The proposed drainage improvement plans are economically and environmentally viable as described below.

6.1 Financial Affordability of the Drainage Structure Plan

Federal DID has secured the annual average budget of RM 127 million for flood control and drainage improvement in the recent five (5) years as listed below. This budget of DID is far larger than those allocated to other government agencies, and could be the major source to recover the project cost for drainage improvement.

(Unit : RM Million)

	1994	1995	1996	1997	1998	Average
Budget Allocated for Flood Mitigation and Urban Drainage	87	99	140	141	166	127

As listed in the above Clause 5, the construction cost for the drainage structure plan covers four (4) items; namely, (a) Channel improvement cost (RM 102.95 million in total); (b) Rehabilitation cost of existing detention ponds (RM 6.03 million); (c) Construction of new flood detention ponds (RM 288.03 million); and (d) Construction cost of storage facilities in public open space (RM 19.09 million). All items other than item (c) are oriented to basin-wide drainage improvement and need to be shouldered in principle by the government budget. On the other hand, the Item (c) is associated with new land development and a substantial part of the cost could be charged against the private land developers. Thus, the cost to be shared by the governmental budget is estimated at about RM 128 million as the sum of Items (a), (b) and (d).

The target completion year of the facilities proposed in the drainage structure plan is set at 2020 as agreed in the Scope of Works. Accordingly, the implementation of the optimum drainage improvement plan will continue for about 20 years until 2020, and the above construction cost of RM 128 million could be converted to the annual average disbursement cost of RM 6.4 million. This annual average disbursement cost corresponds to 5.0% of the average annual budget of Federal DID (i.e., RM127 million as listed above).

The budget has been allocated on the ad-hoc basis, and therefore, the percentages allocated to specific projects fluctuate according to the necessity of flood control works. Nevertheless, judging from the cost allocated to the previous major flood control projects, it is evaluated that the budgetary scale of Federal DID could very well afford the construction of the proposed overall drainage improvement plan.

6.2 Economic Viability of the Proposed Drainage Improvement Plan for Priority Areas

The following table gives the economic internal rate of return (EIRR) of the proposed drainage improvement project:

Objective Drainage Area	EIRR (%)
Sg. Air Mendidih	16.8
line G	13.8
Prt. Pokok Mangga	25.7
Sg. Ayer Salak	20.8
Total	19.6

As estimated above, the proposed drainage improvement for all priority areas could generate the EIRR of more than the opportunity cost of about 13%. Thus, the project is evaluated to contain economic viability.

6.3 Environmental Evaluation

Implementation of the proposed urban drainage improvement plan would reduce the present habitual flood inundation. Moreover, channel dredging and rehabilitation of the existing flood detention ponds proposed as a part of the plan would remove a large volume of sludge that contain organic materials. At the same time, dredging would create an amenity space in the urban area and improve the urban scenery. Thus, the proposed drainage improvement could contribute to better urban living conditions. Nevertheless, anticipated are some adverse effects, and countermeasures are required before and during the implementation. Major adverse effects and their countermeasures are as enumerated below:

(1) House relocation is unavoidable to a certain extent, and utmost effort should be made to minimize the number of house relocation through a detailed resettlement plan;

(2) Water quality preservation and/or improvement should be made taking the following aspects into account:

   (a) To minimize the basin-wide water pollutant sources through the expansion of separate sewerage systems as being undertaken by “Indah Water Konsortium”, the monitoring/control of industrial effluent, and good housekeeping practices.

   (b) To design particular structural devices such as the dry pond structure, and rubbish traps to minimize the polluted water inflow to the proposed urban drainage facilities;

(c) To execute sustainable maintenance on the proposed drainage facilities; and

(d) To secure the proper disposable site for dredged materials.

7. Conclusion and Recommendation

The following are concluded and/or recommended in connection with the proposed drainage improvement plans:

(1) Basic Concept on Urban Drainage Improvement and Implementation of Drainage Improvement Projects in the Priority Areas

Most of the present river flow capacities are extremely low and could not cope with even the probable flood runoff discharge of a 2-year return period. Under such a condition, should the existing drainage channels be drastically enlarged in line with drainage channel improvement, runoff from drainage areas in the upper reaches would concentrate to the downstream river channel and cause a more serious river overflow. In order to avoid such adverse effect, one of the crucial issues for urban drainage improvement should be to regulate and minimize the peak storm runoff discharge within the basin by various types of flood detention facilities.

In due consideration of the above crucial issues as well as the economical and technical viability of alternative plans, the followings are recommended as the optimum drainage improvement plans for the priority areas. It is also recommended that the optimum plans should be implemented with the target completion year of 2005.

Drainage Area	Improvement Measures as Components of the Optimum Plan
Sg. Air Mendidih	1. Channel improvement of four (4) existing trunk drains 2. Construction of on-site flood detention ponds at two (2) sites of public open spaces 3. Construction of new flood detention ponds at three (3) possible sites.
Line-G	1. Channel improvement of one (1) existing trunk drain 2. Construction of one (1) new diversion channel 3. Rehabilitation of the existing two (2) off-site flood detention ponds 4. Construction of new flood detention ponds at two (2) possible sites
Pokok Mangga	1. Channel Improvement of three (3) existing trunk drains 2. Construction of one (1) new trunk drain which runs along almost centre-line of the basin
Sg. Ayer Salak	1. Channel improvement of one (1) river channel and two (2) existing trunk drains 2. Rehabilitation of one (1) existing flood detention pond 3. Construction of five (5) new flood detention pond

(2) Application of Storage Tank in a House Lot for Drainage Improvement in the Densely Populated Area

The storage tank in a house lot is one of the flood detention measures. However it is not applied as a component of the optimum drainage improvement plan for the priority areas due to its higher installation cost than other alternative measures and difficulties in obtaining the individual agreement of house owners. However, verified in the detailed hydrological study for the priority areas was a certain flood detention effect of the measure. Moreover, the measure does not require any house relocation and, the water stored in the storage tank could serve as secondary water resources. From this point of view, the measure should be applied to a densely populated area in particular, where no alternative drainage improvement measure other than the storage tank in a house lot is applicable. The subsidy system should also be established to encourage the house owners to install the facility.

(3) Countermeasures for Environmental Adverse Effect to Drainage Facilities

Garbage and solid waste are among the main pollutant sources of the existing drainage facilities, and often clog them causing adverse effect to flood mitigation. To cope with these adverse effects to the drainage facilities, the following countermeasures should be taken:

(a) When the catchment of the flood detention pond includes a substantial extent of the existing built-up area where the inflow of polluted domestic wastewater is expected, the dry pond type with rubbish trap at the inlet should be adopted. This type will minimize the polluted inflow into the ponds.

(b) Sustainable maintenance should be given to the ponds so as to desludge and clean the accumulated rubbish and scum.

(c) To control the industrial effluents, it is required to arrange the proper sites of industries and to screen the polluting industries.

(d) The sludge dredged from the drainage channel, if no-toxicity is found, could be composted and used for agriculture purpose, or used as embankment materials. In the event, that sludge is found to contain the toxic materials, it should be disposed as hazardous waste through a company in Malaysia that is licensed to treat toxic waste.

(4) Use of Flood Detention Pond as Amenity Space and Preservation of Wet Land

The proposed flood detention ponds are designed either as dry pond, wet pond or wet land. Among them, the dry pond does not allow impounding of water in the pond during the non-flooding time, while both of the wet pond and the wet land continue to impound water even during non-flooding time. The difference between the wet pond and the wet land is that the wet pond is enhanced as an artificial pond through extensive excavation work. On the other hand, the wet land is applied to the existing natural swampy area on the premise of minimum earth works so as to preserve the present natural conditions. All wet ponds is provided with an amenity space around the impounding space, and some dry ponds are also used as community pond, provided that they are placed in a rather extensive vacant space where large scale amenity facilities could be provided. These amenity functions could contribute to the improvement of urban environment and therefore should be applied to the future drainage improvement projects. At the same time, an attempt should be made to maintain the existing swamp area as wet land to preserve the natural flood retarding effect and the natural ecological system as proposed in this Study.

(5) Establishment of Interagency Coordination Bodies at Federal and State Level

In order to enhance the consistent urban drainage improvement in Malaysia, the interagency coordination bodies are required at both of Federal and State Level. From this viewpoint, establishment of the new coordination bodies as well as application of the existing coordination bodies are proposed as enumerated below:

(a) Establishment of the New National Rivers Council (NRC) at Federal Level

There is recent proposal to establish a National Rivers Council (NRC) with its secretariat at Federal DID to deliberate and formulate the policies and programmes on the nation-wide river management which includes the matters on the flood control and urban drainage. In this connection, it is recommended to establish the NRC as the most appropriate platform at Federal Level to undertake formulation of the uniform policies on urban drainage improvement for all states.

(b) Application of the Existing State Planning Committee at State Level

There is a existing coordination body called State Planning Committee (SPC) at State Level. The SPC deliberates the formulation of policies on the conservation, development and use of all land in the State. The on-going intensive land

development in the study area would cause a rapid increment of peak storm runoff discharge, while the urban drainage improvement may hardly catch up with the rapid increment of discharge. To avoid such unbalance, the SPC should be the forum to coordinate projections on land development and the urban drainage. Moreover, the State Director of DID should be made a permanent member of SPC so as to take technical responsibility on river management and urban drainage.

(c) State Water Management Authority (SWMA) at State Level

The SWMA is recently proposed as the interagency coordination body among the agencies related to the river management and urban drainage at State Level. It is recommended that the SWMA should be established to coordinate the drainage management plans that emanate from the State DID and/or Local Authority in order to promote a consistent drainage improvement plan. At the same time, the SWMA should coordinate with NRC to enhance the consistent drainage improvement policies between Federal and State Levels.

(6) Demarcation of Functional Responsibility for Drainage Improvement

The drainage improvement works involve the planning, design, construction and operation/maintenance for various drainage facilities which cover the river and drainage channel, flood detention pond and other various on-site flood detention facilities. According to the present guideline and regulations, DID and the Local Authority are the major executive bodies for drainage improvement works. However, due to the lack of clear demarcation of the works between DID and the Local Authority, the consistent drainage improvement is hardly executed. In order to retrieve such unfavourable conditions, the demarcation is proposed as listed below:

Drainage Facility	Planning/Design/ Construction	Maintenance
1. Basin-wide Drainage Facility		
1) River Channel Improvement	DID	DID
2) Trunk Drain	DID	DID
3) Community Flood Detention Pond	DID	LA
2. Sub-basin Drainage Facility		
1) Infrastructure Drain/Secondary Drain	LD/LA	LA
2) Roadside Drain (Sate/Federal Road)	PWD	PWD
3) Road Drain (Municipal Drain)	LD	LA
4) Perimeter/Tertiary Drain	LD	LA
5) Off-site Flood Detention Pond	LD	LA
6) On-site Detention Facility in Public Space	LA	LA

Note: LA: Local Authority; D: Land Developer; PWD: Public Works Department

(7) Capacity Building of Local Authority

As stated above, the Local Authority shoulders the extensive responsibilities on the drainage improvement, and the responsibilities will significantly expand as the urbanization progresses very rapidly. In spite of the extensive responsibility on the drainage improvement, both Local Authorities of Sungai Petani and Melaka are suffered from a lack of qualified technical manpower, and there does not exist even a drainage division within their Engineering Department. In order to retrieve this unfavorable situation, it is required to promote the plan for reinforcement of the present capacity building of Local Authority into more practical programmes through deliberations among the related departments and agencies.

THE STUDY ON INTEGRATED URBAN DRAINAGE IMPROVEMENT FOR MELAKA AND SUNGAI PETANI IN MALAYSIA

FINAL REPORT

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ABBREVIATIONS AND GLOSSARY

GOVERNMENT OFFICES

AIFM	:	Asian Institute of Forest Management
DBKL	:	Kuala Lumpur City Hall Council
DGSM	:	Department of Geological Survey, Malaysia
DID	:	Department of Irrigation and Drainage
DOA	:	Department of Agriculture
DOE	:	Department of Environment
DOF	:	Department of Fisheries
DOLM	:	Department of Lands and Mines
DOS	:	Department of Statistics
DSMM	:	Department of Survey and Mapping, Malaysia
DSMP	:	Department of Survey and Mapping, Perak
DWNP	:	Department of Wildlife and National Parks
EPU	:	Economic Planning Unit
EXCO	:	State Executive Council
FAMA	:	Federal Agricultural and Marketing Authority
FD	:	Forest Department
FDPM	:	Forest Department of Peninsular Malaysia
JICA	:	Japan International Cooperation Agency
LGD	:	Local Government Department
LKIM	:	Fisheries Development Authority of Malaysia
LPP	:	Farmers Organization Authority
MD	:	Marine Department
MHLG	:	Ministry of Housing and Local Government
MMS	:	Malaysia Meteorological Service
MOA	:	Ministry of Agriculture
MPMBB	:	Melaka Historical City Municipal Council
MPSP	:	Sungai Petani Municipal Council
NCLG	:	National Council for Local Government
PWD	:	Public Works Department
SEDC	:	State Economic Development Corporation
SEPC	:	State Economic Planning Committee
SEPU	:	State Economic Planning Unit
SPC	:	State Planning Committee
TCPD	:	Town and Country Planning Department, Peninsular Malaysia

UNITS OF MEASUREMENT

(Area)

Ha, ha	:	hectare
m^2	:	square meter
km^2	:	square kilometer

(Weight)

Kg, kg	:	kilogram
ton	:	1,000 kg

(Volume)

GRT	:	Gross Relative Tonnage
L, l, ltr	:	liter

(Other Measurements)

Cu., cu.	:	cubic
cusec	:	cubic feet per second
m^3/s	:	cubic meter per second
dia.	:	diameter
DPI	:	dot per inch
GB	:	gigabyte
Kbps	:	kilo bit per second
KB	:	kilo byte
Km, km	:	kilometer
Mbps	:	megabit per second
sec, s		second

m^3	:	cubic meter	Sq., sq.		square
MCM		million cubic meters			

(Electric)

MHz	:	megahertz	H, Hz	:	hertz
VA	:	volt ampere	kW	:	kilowatt
W	:	watt	V		volt, voltage

MALAYSIAN TERMS

Jl.	:	jalan (road)
Kg.	:	kampong (village)
P., Pulau	:	island
Mk.	:	mukim
Sg.	:	sungai (river)

CURRENCY

RM	:	Malaysian Ringgit
US$		United States Dollar
¥	:	Japanese Yen

OTHERS

AAGR	:	Average Annual Growth Rate
EIA	:	Environment Impact Assessment
EIRR	:	Economic Internal Rate of Return
ESCP	:	Erosion and Sediment Control Plan
GDP	:	Gross Domestic Product
GIS		Geographic Information System
GNP	:	Gross National Product
GRDP	:	Gross Regional Domestic Products
IWK	:	Indah Water Konsortium Sdn Bhd
LGA	:	Local Government Act
LSD	:	Land and Survey Datum
MIEL	:	Malaysian Industrial Estate Limited
MP	:	Malaysia Plan
NLC	:	National Land Code
RSO	:	Rectified Skewed Orthomorphic
SDBA	:	Street Drainage and Building Act
SMIs	:	Small and Medium Scale Industries
URBL	:	Uniform Building By-laws
VJR	:	Virgin Jungle Reserve

CHAPTER 1. INTRODUCTION

1.1 Background of the Study

Many urban areas in Malaysia suffer from serious damage by storm rainfall associated with local torrential downpour. Anticipated is more significant flood damage due to drastic increment of peak flood runoff discharge caused by the rapid progress of urbanization at present.

Implemented are various plans and countermeasures for urban drainage by the Department of Irrigation and Drainage (DID) as well as other related government agencies. Most countermeasures so far adopted are however oriented to the widening of drainage channels that could hardly achieve a successful urban drainage.

Under such circumstances, the Government of Malaysia had selected two major regional urban centers, Sungai Petani and Melaka, and requested the Government of Japan to extend its technical cooperation for the study on an integrated urban drainage structure plan. In response to the request, the Government of Japan had decided to undertake "The Study on Integrated Urban Drainage Improvement for Melaka and Sungai Petani in Malaysia" (hereinafter referred to as "the Study").

The Study covers two phases, that is, Phase 1 and Phase 2. Phase 1 is for the formulation of a drainage structure plan with 2020 as the target year, and Phase 2 is for the feasibility study on the priority projects selected and the preparation of a technical guideline on urban drainage improvement.

1.2 Objectives of the Study

The objectives of the Study are:

(1) To formulate the drainage structure plan aiming at delineating a strategic plan of long-term drainage improvement up to the target year 2020;

(2) To conduct a feasibility study on the drainage improvement plan for the selected priority areas;

(3) To prepare a technical guideline on urban drainage improvement, which prescribes the necessary work procedures and engineering standards for urban drainage improvement; and

(4) To transfer knowledge on the drainage improvement to counterpart personnel in the course of the Study.

1.3 Study Area

The study area comprises two regional urban centres; namely, Sungai Petani and Melaka. Among them, Sungai Petani has the total area of about 100 km^2 in the Kuala Muda District of Kedah State. This area includes six (6) river basins; namely, Sungai Petani, Sungai Lalang, Sungai Tukan, Sungai Pasir, Sungai Che Bima and Sungai Layar Besar. All of these rivers are the tributaries of Merbok River that flow into the Melaka Strait.

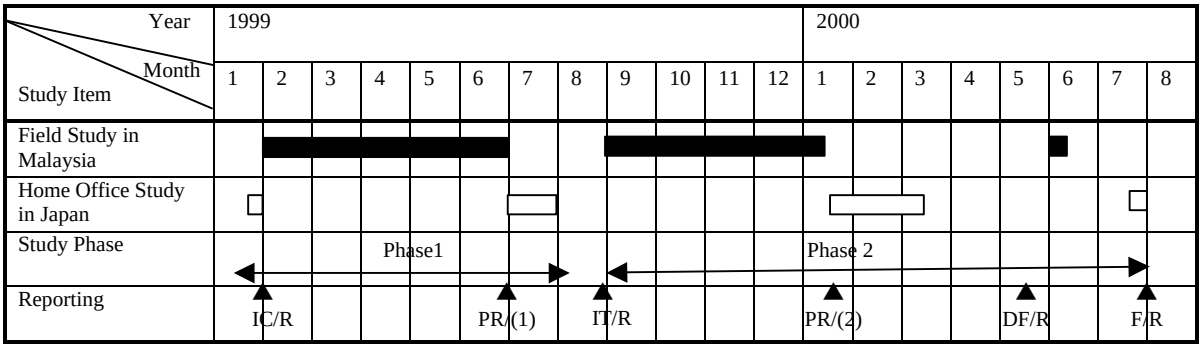
Melaka is located in the Melaka Tengah District of Melaka State and covers an area of about 192 km^2. There are three (3) river basins in this area; namely, Sungai Melaka, Sungai Malim and Sungai Lereh that drain directly into the Melaka Strait.

1.4 Implementation Organization for the Study

The Government of Japan (GOJ) entrusted the Study to the Japan International Cooperation Agency (JICA), the institution responsible for implementation of technical cooperation programs of the Japanese Government, and JICA formed an Advisory Committee and the Study Team to undertake the Study. The Study Team, composed of nine (9) experts, executed the Study, with technical advice provided by the Advisory Committee. On the other hand, the Government of Malaysia (GOM) designated the Department of Irrigation and Drainage (DID) as the counterpart agency and, at the same time, organized a Steering Committee and a Technical Committee to assist in the Study and to discuss various issues concerning the output of the Study.

1.5 Study Schedule

The Study commenced in February 1999, and all activities are completed in May 2000. The following chart presents the study schedule from commencement until its completion.



IC/R: Interim Report, PR: Progress Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report

CHAPTER 2. DRAINAGE STRUCTURE PLAN

2.1 Present and Projected Conditions of the Study Area

2.1.1 Socio-economic Conditions

The Malaysian economy in general continued to show impressive performance with the annual GDP growth rate of 8.7 percent during the Seventh Malaysia Plan (1996-2000). The national economic growth reflected the economic growth of the states of Kedah and Melaka where the study areas are located. In fact, the states of Kedah and Melaka had the GDP growth rates of 9.9% and 9.2%, respectively. The economic structure of Kedah as well as Melaka is undergoing significant transformation with a shift towards the secondary and tertiary sectors. The major impetus for these economic growths was made by the manufacturing, construction and service sectors.

The study area of Sungai Petani is strategically located in the economic growth center of Kedah State. The area has excellent road network including Federal Road No. 1, North-South Superhighway and the railway. The area also enjoys proximity to the international port services at Butterworth and freight services at Penang Island and Alor Setar. The effect of development in Penang Island in particular has tremendous spillover effects to the study area. This is not only due to its well-connected transportation system and infrastructure but also due to the rapid expansion of industrial activities in Penang Island. The study area as well as other southern Kedah areas could offer lower land cost and labor wages as compared with Penang Island, and therefore be competitive and able to attract foreign investments.

The study area of Melaka is located in the District of Melaka Tengah which remains the most popular location for investors due to better road infrastructure and industrial facilities. Due to this background, the area is situated as the focus of economic development of Melaka State. In line with the policy to make Melaka an industrial state by 2010, a high concentration of industrial activities is being input to the study area. The study area is also the main commercial center in the state, having 68% of the total commercial establishment in the District of Melaka Tengah.

The population in the study areas of Sungai Petani and Melaka tend to increase due to their strategic locations as economic growth center of the states. The increment of population is further pushed up by the spatial strategy of “concentrated decentralization”. The following are the future trend of population increase as well as employment increase in the study areas of Sungai Petani and Melaka:

Description	Present	2010	2020
Sungai Petani			
Population	173,727	277,000	372,000
Industrial Workers	23,000	46,000	63,000
Commercial Workers	23,000	52,000	79,000
Melaka			
Population	332,453	500,000	594,000
Industrial Workers	52,000	99,000	120,000
Commercial Workers	54,000	102,000	123,000

2.1.2 Topography

The topography of the study area is broadly classified into the low-lying flat plain and the hilly area. The rivers in the study area originate in the hilly area, flow down to the low-ling flat plain, and finally pour into either the estuary of Sg. Merbok or the Strait of Melaka. The rivers have frequently caused flood overflow that progressively developed the thick alluvial deposits along the rivers, forming the low-lying flat plain.

The old city cores exist in the low-lying flat plains along the downstream of rivers, and the intensive land developments have extended to the hilly areas along the upstream of rivers transforming a substantial part of the hilly areas into a flat terrain. Several swamp areas have dotted the low-lying flat plain and a part has been used as paddy field, but most of them are now being reclaimed and converted to residential, commercial or industrial areas.

2.1.3 Land Use

Sungai Petani and Melaka are at the stage of rapid development with several large projects committed and approved. The built-up area of Sungai Petani has already reached about 50% of the whole study area and is projected to cover almost all of the area by the year 2020. As for Melaka, about 70% of the entire study area still remain as a non-built-up area, but this non-built-up area is expected to reduce to about 25% of the whole study area by the year 2020. Moreover, out of the non-built-up area in Melaka in 2020, about 80% is reserved as future development land. The present and projected land use for both Sungai Petani and Melaka are as given below (refer to Figs. 2-1 and 2-2).

Classification of Land Use	Sungai Petani				Melaka			
	Present		2020		Present		2020	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
1. Built-up Area								
1.1 Residential Area	2,758	27.4	5,130	51.0	3,007	15.7	8,255	43.1
1.2 Commercial Area	245	2.4	1,111	11.0	246	1.3	649	3.4
1.3 Industrial Area	853	8.5	1,350	13.4	1,221	6.4	2,818	14.7
1.4 Institutional Area	634	6.3	647	6.4	556	2.9	1,066	5.6
1.5 Recreational Area	103	1.0	622	6.2	236	1.2	743	3.9
1.6 Road	415	4.1	938	9.3	518	2.7	868	4.5
Sub-total	5,008	49.8	9,798	97.3	5,784	30.2	14,399	75.2

Classification of Land Use	Sungai Petani				Melaka			
	Present		2020		Present		2020	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
2. Non-Built up Area								
2.1 Natural Area	601	6.0	266	2.6	563	29.3	265	1.4
2.2 Agricultural Area	4,359	43.3	0	0.0	9,233	48.2	3,811	19.9*
2.3 Others	97	1.0	0	0.0	3,577	18.7	682	3.6
Sub-total	5,057	50.2	266	2.6	13,373	69.8	4,758	24.9
Grand Total	10,063	100.0	10,063	100.0	19,157	100.0	19,157	100.0

* The area is reserved as future development land.

2.1.4 Drainage Conditions

In the study area, waterways with a catchment area of less than 4 km^2 are colloquially called as trunk drains with a few exceptions, while those with a catchment area of more than 4 km^2 are called as rivers. In accordance with this definition, the existing waterways in the study areas could be divided into seventy (70) trunk drains and seven (7) river systems.

About 90% of all trunk drains have a flow capacity of less than the probable flood peak discharge of 2-year return period, while less than 10% may have the flow capacity of over the probable discharge of 5-year return period. Thus, the existing flow capacity of trunk drains is so low that inundation by storm rainfall occur a few times every year.

In addition to the trunk drains, there exist twenty (20) flood detention ponds in Sungai Petani and one (1) in Melaka. It was determined that about half of the 21 existing ponds have a sufficient storage capacity for the effective control of probable storm rainfall of 5-year return period. The inlet/outlet structures of the ponds are, however, not well maintained and, as a result, water impounds in the ponds even during the non-flooding time and remarkably reduces the original storage capacity of the ponds. Moreover, water impounded in the ponds contains wastewater that emits offensive odor because of sludge accumulation and methane fermentation.

The drainage trunks drain into the following river systems: four (4) river systems in Sungai Petani (i.e., Sg. Lalang, Sg. Tukang, Sg. Petani and Sg. Pasir) and three (3) river systems in Melaka (i.e., Sg. Lereh, Sg. Malim and Sg. Melaka). Except Sg. Malim and Sg. Melaka the other river systems have remained as natural waterways without any major improvement and the banks along a substantial part of the river channels are lower than the Mean High Spring Tide Level. Due to these conditions, the flow capacity of most of the river channels is marginal and flood overflow occurs even in a probable flood runoff of 2-year return period. Usually, serious floods occur when flash floods hit the river channels during high tide.

River channel improvement works have been provided only for Sg. Malim and Sg. Melaka. As for the river system of Sg. Malim, the downstream of the main channel and its tributary, Sg. Ayer Salak have a rather large channel flow capacity which could prevent channel overflow

from the probable flood runoff discharge of 5 to 100-year return period. The downstream of Sg. Melaka was also improved by the construction of a flood bypass channel together with channel improvement works and could accommodate a probable discharge of 50-year return period without any channel overflow.

2.1.5 Hydrology

The intensive urbanization in the study area will have a significant influence on basin runoff conditions. To confirm this point of view, the basin runoff discharge was simulated through a model called the "Quasi-linear Storage Type Model", which could well express the incremental basin runoff discharge induced by intensive land development in a basin. As the result of simulation, a remarkable increment of probable peak discharge was estimated, particularly, in the river basins of Sg. Lalang, Sg. Che Bima, Sg. Malim, Sg. Cheng and Sg. Melaka (upper reaches of diversion weir). All of these river basins are located in the outskirts of the existing urban centres, and new residential, commercial or industrial estates are projected in these basins. The following table gives the estimated probable peak flood discharge of 5-year return period in each river basin.

Sungai Petani			Melaka		
Name of River Basin	Peak Discharge (m^3/s) *1		Name of River Basin	Peak Discharge (m^3/s) *1	
	Present	in 2020		Present	in 2020
1. Lalang	209	393 (+88%)	1. Lereh	172	299 (74%)
2. Tukang	81	91 (+12%)	2. Malim	261	538 (+106%)
3. Layar Besar	62	69 (11%)	3. Cheng	184	333 (+81%)
4. Che Bima	33	78 (136%)	4. Putat	171	192 (+12%)
5. Petani	259	277 (+7%)	5. Melaka (1) *2	221	408 (+85%)
6. Pasir	194	231 (+19%)	6. Melaka (2) *2	211	262 (+12%)

*1: The probable peak discharge of 5-year return period at the down-most point of each river basin.
*2: Melaka (1) is the upstream from the existing diversion weir, while Melaka (2) is downstream from the weir.

2.1.6 Flood Damage Conditions

The habitual inundation in the study area are as shown in Table 2-1 and Fig. 2-3, and the major causes of flooding are attributed to the following factors:

(1) The flow capacity of the existing drainage channels/the existing rivers and the flood control capacity of the existing flood detention ponds are extremely small as mentioned in the foregoing subsection.

(2) Development activities in the upper reaches tend to cause drastic increment of flood runoff discharge and accelerate flooding in the lower reaches.

(3) There are the topographically unfavorable areas for drainage such as low-lying flat plains and depressed hinterlands, which are usually situated as the habitual inundation areas.

2.1.7 Surface Soil Conditions and Ground Infiltration Capacity

Sungai Petani and Melaka have a strong similarity in the component of soil in each of the low-lying flat plains (i.e., coastal plain areas) and the hilly areas. The coastal plain areas in both Sungai Petani and Melaka show unconsolidated and sandy clay as the major components of surface soil that have impermeability characteristics. Moreover, the coastal plain areas have a high groundwater level that reaches LD. –0.3m to 1.2m. Due to the impermeable surface soil and the high groundwater level, storm rainfall could hardly infiltrate the ground of the coastal plain.

On the other hand, most of the hilly areas are made up of lateritic soil which has a rather high permeability due to its high void ratio and large macro-pores. However, the layer of lateritic soil is thin, having the thickness of only less than 1m in Sungai Petani and 1 to 2m in Melaka. Variegated and pallid layers lay under the surface lateritic soil and these underlying layers are impermeable because they have massive structures and clay to silty facies. The ongoing land development in the hilly areas tends to remove the surface lateritic soil, exposing the underlying impermeable layers and causing puddles on the surface ground after every storm rainfall.

2.1.8 Environmental Conditions

Most channel flow of trunk drains and rivers, as well as water impounded in the existing flood detention ponds, tend to be polluted. Extremely serious water pollution is seen in the river flow of Sungai Petani, in particular, where the water quality is in Class III of the INWQ Standard. Main pollution sources are rubbish, effluent from septic tanks of individual houses, effluent from factories, and the nutrient-laden runoff from agricultural areas. Eutrophication of water impounded in the flood detention ponds has also led to massive algae bloom and water lily growth. These decompose in the water leading again to organic loading into the drainage channels and rivers, thus deteriorating water quality.

2.2 The Drainage Structure Plan

2.2.1 Planning Framework

The drainage structure plan is proposed considering the flood runoff condition under the projected land use in the target year 2020 and the target design level of 5-year return period. Among the planning premises, the target year is one of the conditions set in the Scope of Work,

while the target design level was determined through the Study in due consideration of the design levels adopted to other long-term drainage structure plans in Malaysia and in other countries.

2.2.2 Possible Drainage Improvement Measures

Drainage improvement could be made by either increment of discharge flow capacity through drainage channel improvement (called "quick disposal of flood") or reduction of flood runoff discharge through a flood detention facility (called "source control of flood"). Flood detention facilities are effective to minimize the flood flow discharge of a river downstream and contribute to the prevention of flood overflow. However, a flood detention facility without any drainage channel improvement may not always provide the target design level due to limited flood detention capacity. From this viewpoint, possible improvement measures are applied, as follows:

Possible Drainage Improvement Measure	Description
1. Channel improvement	The channel improvement is made through re-alignment, widening, and/or deepening of the channel.
2. Rehabilitation of existing flood detention pond	Among the existing ponds, thirteen (13) ponds are selected as the objectives of rehabilitation, and their full utilization for flood control are proposed.
3. Construction of new flood detention facility	
(1) Storage tank in a house lot	A storage tank is installed in a house lot to collect rainfall from the rooftop and a small outlet hole is provided at the side bottom to regulate outflow discharge from the tank. The standard type of facility is to have the storage volume of $2m^3$ for a unit house lot space of $200m^2$ and a roof area of $100m^2$ (refer to Fig. 2-4).
(2) Storage in a public space	The public open space is enclosed by a low wall of about 30cm in height with a surrounding drain to collect rainfall from the entire public compound and an outlet to regulate outflow discharge from the open space. The standard type of facility is to have the storage volume of $1,200m^3$ for a unit public compound of $20,000m^3$ and a storage space of $4,000m^2$ (refer to Fig. 2-5).
(3) Flood detention pond	The pond is constructed at the downstream end of the new land development area to regulate the flood runoff discharge from the area. The standard type of pond is to have a $4,000m^3$ for a unit land development area of 10ha (refer to Fig. 2-6).

2.2.3 Alternative Plans

Among the above three (3) types of flood detention facility as possible improvement measures, the storage tank in a house lot has a far smaller storage capacity than the others, but could be installed in the existing house lots. Accordingly, this type is preferably for pre-built residential areas rather than the new residential areas. On the other hand, the storage in a public open space is the second largest storage capacity next to the flood detention pond and requires a low construction cost, but its construction requires an extensive public open space such as a school

ground and a car parking area. As for the flood detention pond, its storage capacity is far larger than the others, but requires an extensive land acquisition.

The existing guideline in Malaysia requires a land developer to construct a flood detention pond for a new land development having an area of more than 10ha. Should the guideline be applied to previous land development projects, the catchment area of the flood detention pond could cover practically about 80% of the projected land development areas. In due consideration of the features of the flood detention facilities, the following six (6) alternative measures are prepared by a combination of various types of flood detention facilities and improvement of drainage channels.

Type of Detention Facility	Objective Area of Detention Facility	Coverage Ratio of Objective Area by Detention Facility					
		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Storage in House Lot	Existing Residential Area	0%	0%	100%	0%	0%	100%
Storage in Public Open Space	Projected Institutional Area	0%	0%	100%	0%	100%	100%
Flood Detention Pond	Projected Built-up Area (except Institutional Area)	0%	50%	50%	80%	80%	80%

Note: All alternatives are basically subject to improvement of drainage channel and rehabilitation of the existing flood detention pond.

2.2.4 The Optimum Plan

A comparative study was made among the above six (6) alternative plans, and Alternative 5 was selected as the optimum plan in accordance with the following viewpoints:

(1) Least Adverse Effect to Downstream River Channel

As drainage channel improvement is more intensively made with less construction of detention facility, the more runoff discharge will concentrate into the downstream river channels increasing the peak discharge. Moreover, any ongoing land development will accelerate the increment of peak runoff discharge. In spite of the increment of peak runoff discharge flowing into the river channels, however, the present flow capacities of most of the major river channels are extremely small as mentioned before, and thus it is virtually difficult to pliably cope with the increment of river flow discharge.

Due to the present river conditions and the ongoing land development, the most important criterion for the selection of optimum plan is that the drainage improvement should minimize the increment of the present river channel flow. That is, the improvement should satisfy the target drainage capacity with least adverse effect to the downstream river channels.

As confirmed from the results of hydrological simulation, the flood detention pond and the storage facility in a public open space contain significant regulation effects on peak

flood runoff discharge. The storage tank in individual house lots also has a certain flood detention effect, but the effect is far smaller than those of other alternative measures which leads to the comparatively high installation cost of the storage tank. Moreover, difficulties are foreseeable in obtaining the individual agreement of house owners for installation of the storage tank. Hence, Alternative 5 is preferable to minimize the adverse effect of drainage improvement to the downstream rivers. Should Alternative 5 be applied, no significant increment of peak runoff discharge of a 5-year return period flood would ensue between the land use states at present and in 2020, as given below:

(Unit: m^3/s)

Name of River Basin	Present State	State in 2020	
	Without Project	Without Project	With Project
Sungai Petani			
1. Lalang	209	393 (+88%)	187 (-11%)
2. Tukang	81	91 (+12%)	63 (-22%)
3. Layar Besar	62	69 (+11%)	55 (-11%)
4. Che Bima	33	78 (+136%)	36 (+10%)
5. Petani	259	277 (+7%)	216 (-17%)
6. Pasir	194	231 (+19%)	168 (-13%)
Melaka			
1. Lereh	172	299 (+74%)	203 (+18%)
2. Malim	261	538 (+106%)	326 (+25%)
3. Cheng	184	333 (+81%)	202 (+10%)
4. Putat	171	192 (+12%)	163 (-5%)
5. Melaka	221	408 (+85%)	244 (+10%)

Note: The above figures are simulated as the probable peak discharge of 5-year return period flood at the down-most point of each river basin. The simulation is made on the assumption that all flood runoff discharge concentrates to the down-most point without any flood overflow on the way.

(2) Security of Financial Resource for Project Implementation

The land developer of an area of more than 10 ha is being required under the existing guideline to construct a flood detention pond for the particular land. Since the optimum plan has the flood detention pond as the principal drainage improvement measure, a substantial part of its cost is ensured through the land development cost of developers.

(3) Progressive Upgrade of Drainage Capacity in Response to Change of Land Use

Flood detention ponds as well as flood storage facilities in public open spaces could be constructed immediately after land development for a new built-up area. Due to such an advantage, the optimum plan could progressively upgrade the drainage capacity in response to the change of land use in the drainage area.

(4) Minimization of Adverse Social Impact

The flood detention facility could be located in a new land development area, while a substantial part of the drainage channel usually runs in the existing built-up areas. Accordingly, the construction of a flood detention facility will require far less house evacuation than the drainage channel improvement. Due to this advantage, the optimum plan could minimize the adverse social impact.

2.2.5 Work Volume of the Optimum Drainage Improvement Plan

The work volume for construction of the optimum drainage improvement plan is estimated on the basis of the preliminary design. The results of the estimation are summarized below.

Work Item	Unit	Work Volume		
		Sg. Petani	Melaka	Total
1. Channel Improvement				
Number of Channels		44	24	68
Channel Length	km	42.0	36.5	78.5
Earth Works	$1000m^3$	651.5	832.3	1,483.8
Concrete Works	$1000m^3$	145.2	172.0	317.2
Number of Box Culverts to be Reconstructed		14.0	14.0	28.0
Number of Bridges to be Reconstructed		101	57	158
2. Rehabilitation of Existing Detention Pond				
Number of Ponds		12	1	13
Area of Pond	ha	18.2	2.6	20.8
Catchment Area	ha	802.7	61.1	863.8
Earth Works	$1000m^3$	55.2	54.8	110.0
Surface Protection (Turfing and stone pitching)	$1000m^2$	394.2	33.1	427.3
Concrete Works	$1000m^3$	6.7	0.2	6.9
Metal Works	ton	36.0	2.8	38.8
Road Works	$1000m^2$	39.2	5.7	44.9
3. Construction of New Detention Pond				
Area of Pond	km^2	1.8	2.5	4.3
Catchment Area	km^2	46.0	63.6	109.6
Earth Works	$1000m^3$	7,141.4	9,869.8	17,011.2
Stone-pitching	$1000m^2$	410.8	567.8	978.6
Turfing	$1000m^3$	1,695.0	2,942.6	4,637.6
R.C. Structure	$1000m^3$	62.4	86.2	148.6
Metal Works	ton	207.0	286.0	492.0
Road Works	$1000m^2$	512.3	708.0	1,220.3
4. Construction of Storage Facility in Public Open Space				
Area of Open Space	km^2	0.3	1.4	1.7
Earth Works	$1000m^3$	80.2	422.0	502.2
Bottom Surface Protection (Turfing)	$1000m^2$	267.2	1,406.9	1,674.0
R.C. Structure	$1000m^3$	4.8	25.3	30.1
Metal Works	ton	3.3	17.6	20.9

2.2.6 Necessity and Potential Measures of Prevention of Flood Overflow from River

The basin flood detention facilities proposed under the foregoing drainage improvement plan could minimize the increment of peak runoff discharge induced by future land development and contribute to the prevention of river overflow. However, the flood detention facilities could not remarkably decrease the peak runoff discharge far below the present level. Thus, the

present states of river overflow will continue in the future unless particular works against river overflow is provided. Furthermore, the present river flow capacity is extremely low; however, the intensive urbanization in the study area at present will certainly require expansion of built-up areas into the present habitual inundation areas along the rivers and will not allow retention of overflow from the rivers. Hence, the Study was extended to the plan for prevention of flood overflow from the rivers.

It is mentioned in this connection that the recent major improvement plans for rivers in and around the regional urban centers applied the design levels of 50 to 100-year return period with target completion years of 2000 to 2005. Moreover, DID will apply the design flood level of 100-year return period in principle to all future river improvement plans unless particular difficulties arise. In due consideration of these foregone and future design levels, the design level of 100-year return period is proposed in the Study as the target design level for prevention of flood overflow.

The two (2) possible countermeasures for river overflow are: (1) enlargement of river channel and/or construction of new bypass channel; and (2) construction of flood retarding basin and/or flood control dam. The measures in Item (1) function to increase the river flow capacity, while the measures in Item (2) are to store the flood runoff discharge and reduce the peak of design flow discharge.

The target design discharge of 100-year return period has a large gap with the present channel flow capacity (less than 5 year return period) of most of the rivers in the study area. Accordingly, the measures in (1) will require far larger channel cross-sections than the existing sections. Moreover, the measures need to be implemented from downstream toward upstream to avoid any excessive discharge concentrating on the downstream. Since a substantial part of the downstream reaches of rivers are located in the existing built-up areas, difficulties are naturally expected in the acquisition of necessary land spaces.

Due to the foreseeable difficulty of land acquisition, highlighted are the measures in Item (2), and their possible sites were scrutinized through field reconnaissance. As the result, it was determined that a possible site for flood control dam would be difficult to secure due to the rather flat topography of the study area, but four (4) prominent sites were identified for retarding basins, as shown in Fig. 2-7. These sites for retarding basins are presently swamp areas and/or vacant grasslands in the low-lying plain along the rivers. Moreover, the sites are located along the downstream and/or middle stream of the rivers covering a substantial part of catchment area, and therefore have significant effects on reduction of peak flood discharge.

From this viewpoint, a detailed topographic survey for the above sites is required to clarify the potential flood storage capacity, as well as to determine the design flood discharge and structural features for both the retarding basins and the river channels. At the same time, a detailed parcel survey will be required to clarify the contents of land acquisition for the construction of retarding basins and the river channel improvement.

2.3 Non-structural Drainage Improvement Plan

2.3.1 Establishment of Organizational Framework and Demarcation of Functional Responsibility

The responsibility for urban drainage improvement is currently shared by three (3) tiers of the Malaysian Government; namely, the Federal Government, the State Government, and the Local Authority. The demarcation of functional responsibilities of the tiers and the interagency coordinating council are proposed to promote a consistent drainage policy and ensure smooth implementation of drainage improvement works (refer to Fig 2-8).

(1) Federal and State Interagency Council

In order to enhance the consistent urban drainage improvement in Malaysia, the interagency coordination bodies are required at both of Federal and State Level. From this viewpoint, establishment of the new coordination bodies as well as application of the existing coordination bodies are proposed as enumerated below:

(a) Establishment of the New National Rivers Council (NRC) at Federal Level

A National Rivers Council (NRC) with its secretariat at the Federal DID was recently proposed with the function to deliberate and formulate policies and programs on nationwide river management including flood control and urban drainage. However, the Ministry of Agriculture had argued against the setup of the new NRC. Instead, the Ministry suggested that the function should be entrusted to the existing National Water Resources Council, or it could be involved in the function of the Natural Resources Council whose establishment is still under consideration.

This present Study believes that it is virtually difficult for the existing National Water Resources Council as well as the Natural Resources Council to deal with the objective coordination of functions of agencies involved including flood control and urban drainage. Therefore, the reconsideration of the NRC is proposed as the most appropriate platform at the Federal Level to undertake the

formulation of a uniform policy on urban drainage improvement for all states, in view of the following reasons:

(i) The existing National Water Resources Council (NWRC) has its secretariat at JKR (Public Works Department) and its principal function is to formulate policies and strategies for potable water supply and interstate water transfer. The NWRC may be the appropriate platform for ensuring the national policy on water resources development, but not for flood control and urban drainage improvement. Likewise, the proposed Natural Resources Council has the function to deliberate on policies and regulations pertaining to land resources, mineral resources, forest resources, marine resources and other various natural resources. The above functions on water and land resources are very different from those of flood control and urban drainage.

(ii) A comprehensive hydraulic and hydrological knowledge related to flood runoff and flood flow is required in flood control and urban drainage improvement. Hence, DID would be the most appropriate agency as the secretariat for the interagency coordination body for flood control and urban drainage because of its intensive hydraulic and hydrological knowledge.

(iii) The objective interstate coordination body needs to involve various agencies such as DID, JKR, DOE , Department of Town and Country, and Department of Local Government. Accordingly, it is virtually difficult for the existing National Water Resources Council or the proposed Natural Resources Council to undertake the objective coordination in addition to their originally conceived functions.

(b) Application of the Existing State Planning Committee at State Level

There is a existing coordination body called State Planning Committee (SPC) at State Level. The SPC deliberates the formulation of policies on the conservation, development and use of all land in the State. The on-going intensive land development in the study area would cause a rapid increment of peak storm runoff discharge, while the urban drainage improvement may hardly catch up with the rapid increment of discharge. To avoid such unbalance, the SPC should be the forum to coordinate projections on land development and the urban drainage. Moreover, the State Director of DID should be made a permanent

member of SPC so as to take technical responsibility on river management and urban drainage.

(c) State Water Management Authority (SWMA) at State Level

The SWMA is recently proposed as the interagency coordination body among the agencies related to the river management and urban drainage at State Level. It is recommended that the SWMA should be established to coordinate the drainage management plans that emanate from the State DID and/or Local Authority in order to promote a consistent drainage improvement plan. At the same time, the SWMA should coordinate with NRC to enhance the consistent drainage improvement policies between Federal and State Levels.

(2) Demarcation of Functional Responsibility and Budgetary Allocation for Drainage Improvement

The drainage improvement works involve the planning, design, construction and operation/maintenance for various drainage facilities which cover the river and drainage channel, flood detention pond and other various on-site flood detention facilities. According to the present guideline and regulations, DID and the Local Authority are the major executive bodies for drainage improvement works. However, due to the lack of clear demarcation of the works between DID and the Local Authority, the consistent drainage improvement is hardly executed. In order to retrieve such unfavourable conditions, the demarcation is proposed as listed below:

Drainage Facility	Planning/Design/ Construction	Maintenance
1. Basin-wide Drainage Facility		
1) River Channel Improvement	DID	DID
2) Trunk Drain	DID	DID
3) Community Flood Detention Pond	DID	LA
2. Sub-basin Drainage Facility		
1) Infrastructure Drain/Secondary Drain	LD/LA	LA
2) Roadside Drain (Sate/Federal Road)	PWD	PWD
3) Road Drain (Municipal Drain)	LD	LA
4) Perimeter/Tertiary Drain	LD	LA
5) Off-site Flood Detention Pond	LD	LA
6) On-site Detention Facility in Public Space	LA	LA

Note: LA: Local Authority; D: Land Developer; PWD: Public Works Department

As listed above, it is recommended that DID should be responsible for construction and maintenance of most of the major drainage facilities that could contain a basin-wide flood mitigation effect. Among the major drainage facilities, however, the community flood detention pond should be preferably maintained by the Local Authority, as the pond is incorporated with amenity space and meets the community recreational needs. Maintenance of the minor drainage facilities for local flood be principally under the

responsibility of the Local Authority. The minor drainage facilities include those constructed by the Developer within his land development site, and eventually surrendered to the Local Authority as a public facility.

The government budget for drainage improvement is derived from three (3) main sources; namely, the Federal Government, the State Government and the Local Authority, and expended by DID and Local Authority . The objectives of their budgetary allocations are, however, not clearly demarcated, and hence the following recommendations are made based on the above-proposed demarcation of functional responsibility and the functions of the above-proposed Interagency Council.

As proposed above, the Local Authority, which is one of the principal implementing agencies for drainage improvement should shoulder the cost of maintenance of sub-basin drainage facilities using the budgetary allocation from the Local Authority. On the other hand, DID is to undertake the construction and maintenance of major drainage facilities that include river channel improvement, trunk drains and community ponds, and therefore, DID will shoulder most of the necessary urban drainage improvement cost.

The budgetary allocations of DID come from either the Federal or the State Government according to the burden of expenditure as stated in Article 82 of the Federal Constitution. If the expenditure results from a Federal Commitment in accordance with the Federal Policy and with the approval of the Federal Government, the expenditure should be covered under the Federal allocation. Otherwise, it is covered under the allocation from the State Government.

Under the current setup, Federal Commitments are made by EPU and the Treasury, where there are difficulties in securing the consistency of Commitment due to lack of the clear demarcation of the functional responsibility for drainage improvement and inadequacy of the interagency coordination. In this connection, the proposed demarcation could facilitate to ensure the consistency of Commitments. Moreover, the proposed interstate coordination body, i.e., the National Rivers Council, could be the appropriate platform to address the budgetary allocation of the Federal source before the allocation is forwarded to EPU and the Treasury.

2.3.2 Cost Recovery

In accordance with the current laws and regulations in Malaysia, the available cost recovery measures for drainage improvement could be broadly classified into two (2) categories. The first is the recovery cost secured from government grants such as the “Federal and State Grant”

and the "State Road Grant". The second is recovery cost obtained from the charges imposed on land developers and the direct beneficiaries of drainage improvement such as:

(1) "Drainage Contribution" imposed on land developers to compensate for the adverse effects of flood due to land development;

(2) "Drainage Improvement Charges" borne by the direct beneficiaries of drainage improvement and by land developers;

(3) "Drainage Rates" imposed on house/building holders; and

(4) "Drainage Infrastructure Cost" borne by land developers for constructing drainage facilities related to their land development works.

An overview of the possible cost recovery measures for each of the drainage improvement work in due consideration of their particular features is given in the following table.

Drainage Improvement Works	Source of Fund	Cost Recovery Measures
1. Formulation of drainage policy and programme	Federal and State governments	Federal and State Development Grant
2. Project implementation of basin wide drainage facilities	Federal and State governments	Drainage Contribution
3. Project implementation of sub-basin drainage facilities		
(1) Infrastructure drain/secondary drain	Land Developer/Local Authority	Drainage Improvement Charge
(2) Flood detention pond and perimeter/tertiary drain	Land Developer	Drainage Infrastructure Cost
(3) Roadside drain	State Government	State Road Grant
4. Construction and maintenance of other on-site detention facilities		
(1) Rehabilitation and maintenance of existing flood detention pond	Local Authority	Drainage Rate
(2) Construction and maintenance of on-site detention facility in public open space	Local Authority	Drainage Rate

2.3.3 Legislation on Drainage Improvement

Among others, the following legislation, rules and regulations are proposed as major requirements for drainage improvement projects.

(1) Enforcement of Guideline on Construction of Flood Detention Pond by Land Developer

According to the present guideline, the land developer is required to construct a flood detention pond for his land development area of more than 10 ha. In words, the land developer could avoid construction of a flood detention pond as far as the land is less than 10 ha. Land development is, however, now being intensively made causing drastic increment of peak flood discharge, and the channel flow capacities of the existing drainage channels as well as the downstream river channels are extremely small. In due consideration of such critical conditions, the flood runoff from almost all of the new land development area should be subject to regulation by a flood detention facility. From this viewpoint, one (1) hectare instead of 10 hectares as currently required is provisionally proposed as the minimum land development scale for which the land developer is obliged to construct a flood detention pond.

(2) Securing of Drainage Reserve Area

In Malaysia, the construction of any building is not permitted within 50 feet from the riverbanks as prescribed in the Water Act of 1920. Based on the prescription, DID proposes the width of 15 m from the riverbanks as river and drainage reserves useful to preserve the natural flood retarding effect. In spite of the flood control effect, the river reserves have not been demarcated, and even the buildings are constructed adjacent to the riverbanks in the study area. To remedy such unfavorable conditions, the reserves should be gazetted, and DID should be designated as the controlling agency. The reserved should be shown in a zoning plan and declared as public land. Any type of land development activity shall be prohibited in the area, except for a specific type of development that could preserve the retarding function, such as piling type of buildings.

(3) Water Pollution Control

The enforcement of water pollution control principally lies with DOE. In the long run, there is a need to establish quality standards for storm water runoff similar to the existing Environmental Quality Regulations for Sewerage and Industrial Effluents established in 1979. The storm water tends to wash the dust, sediment and other water pollution sources and bring them into the flood detention ponds causing deterioration of their water quality. In Malaysia, however, the water quality is currently not monitored during the flood. From this viewpoint, the objectives of existing monitoring by DOE should be extended to the quality of storm runoff in order to ensure water quality standards for the flood detention ponds in particular in order to ensure that the water quality standards are not breached.

(4) Promotion of Public Awareness on Proper Solid Waste Disposal and Water Pollution Control

Garbage and other solid wastes are among the main pollutants of storm water and they often clog drains causing flush floods. Most of the local authorities have bylaws to prevent littering of solid wastes, but enforcement is difficult due to difficulties in identifying the polluters. Under this situation, both the DID and the Local Authority should take an active role in educating the public on proper solid waste disposal to prevent water pollution.

2.4 Project Evaluation

2.4.1 Project Cost

Project cost is estimated in Malaysian Ringgit (RM) by applying the currency conversion rates of US$1.00 =RM 3.8 RM = 121.4 Yen prevailing in May 1999. The results of the cost estimation are summarized in the table below.

(Unit: RM million out of Parentheses and Million Yen in Parentheses)

Item	Sungai Petani		Melaka		Total	
1. Construction Cost						
Channel Improvement	46.60	(1,489)	56.35	(1,800)	102.95	(3,289)
Rehabilitation of Existing Detention Pond	5.57	(178)	0.45	(14)	6.02	(192)
Construction of New Detention Pond	120.92	(3,863)	167.11	(5,339)	288.03	(9,202)
Storage Facility in Public Open Space	3.05	(97)	16.04	(512)	19.09	(609)
Total	176.13	(5,627)	239.95	(7,665)	416.08	(13,292)
2. Annual Operation and maintenance Cost						
Drainage Channel	0.20	(6)	0.22	(7)	0.42	(13)
Detention Pond	1.93	(62)	2.67	(85)	4.61	(147)
Total	2.13	(68)	2.89	(92)	5.02	(160)

2.4.2 Financial Affordability

The financial affordability for the aforesaid project construction cost as well as the annual operation and maintenance cost is as evaluated below.

(1) Affordability of Construction Cost

Federal DID has secured the annual average budget of about RM 127 million for flood control and drainage improvement in the recent five (5) years, and this budget is far larger than those of other government agencies as listed below:

Tier of Government		Annual Average Budget (RM million)	Remarks
Federal DID		127.00	The annual budget tends to increase.
State DID	Kedah	0.70	The annual budget has tended to increase.
	Melaka	2.26	The annual budget is rather constant.
Local Authority	Sg. Petani	0.65	The annual budget is constant.
	Melaka Tengah	6.48	The annual budget has a large fluctuation.

Note: The budget for Federal DID is the average value for the period 1994–1998, while those for State DID and Local Authority is the average of 1995–1999.

Moreover, Federal DID has increased its annual budget for flood control and drainage improvement from RM 87 million in 1994 to RM 166 million in 1998 as listed below:

(Unit : RM Million)

	1994	1995	1996	1997	1998	Average
Budget Allocated for Flood Mitigation and Urban Drainage	87	99	140	141	166	127

In comparison with the above annual budget of Federal DID, the construction cost for the drainage structure plan covers four (4) items; namely, (a) Channel improvement cost (RM 102.95 million in total); (b) Rehabilitation cost of existing detention ponds (RM 6.03 million); (c) Construction of new flood detention ponds (RM 288.03 million); and (d) Construction cost of storage facilities in public open space (RM 19.09 million). All items other than item (c) are oriented to basin-wide drainage improvement and need to be shouldered in principle by the government budget. On the other hand, the Item (c) is associated with new land development and a substantial part of the cost could be charged against the private land developers. Thus, the cost to be shared by the governmental budget is estimated at about RM 128 million as the sum of Items (a), (b) and (d).

The target completion year of the facilities proposed in the drainage structure plan is set at 2020 as agreed in the Scope of Works. Accordingly, the implementation of the optimum drainage improvement plan will continue for about 20 years until 2020, and the above construction cost of RM 128 million could be converted to the annual average disbursement cost of RM 6.4 million. This annual average disbursement cost corresponds to 5.0% of the average annual budget of Federal DID (i.e., RM127 million as listed above).

Federal DID had allocated about 33.0% of the total budget for flood control and urban drainage to the objective states of Kedah and Melaka in the 5th Malaysia Plan (1986-1991) and 22.2% in the 6th Malaysia Plan (1991-1995). The allocation was based on the ad-hoc level, and therefore, the percentages allocated to the states could fluctuate according to the necessity of flood control projects. Nevertheless, the percentages allocated for flood control projects of Kedah and Melaka are far larger than the above value of 5.0% estimated as the percentage of average disbursement cost for the proposed optimum drainage improvement plan to the annual average annual budget of Federal DID. Moreover, the percentage of 5.0% would likely reduce since the annual budget for Federal DID tends to increase. Judging from these available budgets of Federal DID, it is concluded that the construction cost for the proposed drainage improvement plan could be financially affordable.

(2) Operation and Maintenance Cost

The operation and maintenance cost for flood detention pond which takes the major part of the total operation and maintenance cost is to be shouldered by the budget of the Local Authority of Sungai Petani and of Melaka. The required annual operation and maintenance cost for flood detention pond is estimated at RM 1.9 million for Sungai

Petani and RM 2.7 million for Melaka (refer to Subsection 2.4.1). On the other hand, the Local authorities of Sungai Petani and Melaka have allocated the budget for drainage maintenance of RM 0.35 million and RM 2.2 million on the average, respectively, for the recent five years as mentioned above. Thus, the necessary operation and maintenance cost exceeds the previous average budget allocated for operation and maintenance of the drainage facilities. The Local Authority of Sungai Petani, in particular, will encounter a significant shortage in operation and maintenance cost. However, such less operation and maintenance cost for Sungai Petani is attributed to the fact that no major drainage facility has been constructed in Sungai Petani.

The current budget for the Local Authorities could not cover the operation and maintenance cost for the proposed drainage improvement plan, and hence following actions will be required:

(a) A major part of the budget for the Local Authority is dependent on the Federal Fund. In this connection, the Local Authority should coordinate with the Federal Government (i.e., the Ministry of Housing and Local Government) to secure the necessary operation and maintenance cost.

(b) The Local Authority should also attempt to reinforce its power under the present acts related to urban drainage such as the "Street Drainage and Building Act" and the "Local Government Act". Further, it should look for incremental revenue for the operation and maintenance cost through the "Drainage Improvement Charges" and Drainage Rates" (refer to Sector III, Institutional Setup Plan in Vol.3, Supporting Report on Drainage Structure Plan).

2.4.3 Environmental Evaluation

Implementation of the proposed drainage structure plan would reduce the present habitual flood inundation. Moreover, channel dredging and rehabilitation of the existing flood detention ponds proposed as a part of the drainage structure plan would remove a large volume of sludge which contains organic materials. This would, at the same time, create the amenity space in the urban area as well as improve the urban scenery. Thus, the proposed drainage improvement plan would contribute to better urban living conditions. Nevertheless, some adverse effects by the implementation are anticipated; hence, countermeasures are required before and during the implementation. Major adverse effects and their countermeasures are as mentioned below:

(1) House relocation is unavoidable to a certain extent, and utmost effort should be made to minimize the number of house relocations through a detailed resettlement plan;

(2) Water quality preservation and/or improvement should be made aiming at the following:

(a) Minimization of basin-wide water pollutant sources through expansion of separate sewerage systems as being undertaken by “Indah Water Konsortium” under control of the Department of Sewerage Service, Ministry of Housing and Local Government, monitoring/control of industrial effluent, and good housekeeping practices.

(b) Design of particular structural devices, such as the dry pond structure, and rubbish traps to minimize polluted water inflow to the proposed urban drainage facilities;

(c) Execution of sustainable maintenance for the proposed drainage facilities; and

(d) Provision of a proper disposable site for dredged materials.

CHAPTER 3. FEASIBILITY STUDY

3.1 Introduction

Four (4) priority drainage areas are selected for the Feasibility Study from among the objective drainage sub-basins of the Drainage Structure Plan in Chapter 2. Two (2) of the drainage areas belong to the Sungai Petani river system located in the Kuala Muda District of Kedah State, while the other two (2) belong to the Malim river system or its adjacent coastal drainage system located in the Melaka Tengah District of Melaka State. The four drainage areas are as follows:

(1) Drainage area of Sg. Air Mendidih in Sungai Petani consisting of 3.62 km^2
(2) Drainage area of Line G in Sungai Petani consisting of 2.73 km^2
(3) Drainage area of Prt. Pokok Mangga in Melaka consisting of 4.71 km^2
(4) Drainage area of Sg. Ayer Salak in Melaka consisting of 17.20 km^2

All of the four priority areas are identified to contain a high flood damage potential and hence early implementation of the drainage improvement plans is expected by the related government agencies. Moreover, the priority areas require a wide variety of drainage improvement measures due to the difference in topography and land use and, therefore, the results of this Feasibility Study are expected to present a certain technical guideline for the future drainage improvement works in Malaysia. Together with the Feasibility Study, the guideline on urban drainage improvement is prepared as part of the entire study objectives, so that a substantial part of the results of the Feasibility Study are used as materials of the guideline.

3.2 Present and Projected Conditions of Priority Areas

3.2.1 Land Use

The existing and projected land use at the priority areas has been updated, as shown in Tables 3-1 to 3-2 and Figs. 3-1 to 3-8. It has been clarified that their urbanized ratio will remarkably increase, as shown below:

Priority Drainage Area	Catchment Area (km^2)	Urbanized Ratio (%)	
		in 1999	in 2000
1. Sg. Air Mendidih in Sungai Petani	3.62	65.8	99.7
2. Line G in Sungai Petani	2.73	41.0	98.2
3. Prt. Pokok Mangga in Melaka	4.71	50.4	99.5
4. Sg. Ayer Salak in Melaka	17.20	26.5	99.3
Total	28.26	36.9	99.3

There is a common land use pattern in the priority areas other than Prt. Pokok Mannga. That is, the existing built-up area will remain situated at the low-lying flat plain in the lower reaches,

while the intensive land development progresses toward the hilly land in the upper reaches. As for Prt. Pokok Mannga, the agricultural area will remain situated at the central inland area which occupy almost half of the entire drainage area, but the area will be fully developed as residential area by 2020.

3.2.2 Topography and Drainage Conditions

The existing topographic and drainage conditions of the priority areas are summarized below.

(1) Sg. Air Mendidih

The entire drainage area tends to slope gently toward the junction with the main stream of Sg. Petani, and an alluvial plain belt of 50 to 500m has developed along the trunk drains. Four (4) trunk drains exist; namely (1) Sg. Air Mendidih, (2) Line-N, (3) Line-O and (4) Line-P (refer to Fig. 3-9). Together with the others, Line-N collects storm water from about 70% of the entire drainage area and drains into the downstream channel of Sg. Air Mendidih. Both Line-O and Line-P are the branches of Line-N that collect storm water from the northern part of the area. The sizes of these trunk drains are extremely small and cannot cope with even the probable peak runoff discharge of a 2-year return period. The flow capacity of each trunk drains is further reduced by the culverts, which are used to pass the road over the drains.

(2) Line-G

The drainage area is broadly divided into the hilly area and the gently sloping area. The hilly area spreads in the northeastern part, and there is one (1) trunk drain called Line-G, which originates from a hilly area located in this northeastern part (refer to Fig. 3-10). The trunk drain is composed of the downstream concrete-lined channel and the upstream earth channel. The concrete-lined channel has a length of about 800m, out of which the downstream section of about 300m has a cross-sectional size smaller than the upstream section of about 500m. Such a reverse channel size leads to an excessive flood discharge to the downstream channel, and channel overflow easily occurs. The present channel flow capacity of the trunk drain could not meet the probable peak runoff discharge of even a 2-year return period.

There are also two (2) flood detention ponds. The ponds regulate the flood runoff discharge from two (2) existing residential areas named “Taman Keladi” and “Taman Sri Wang” in the southern part of the drainage area. The catchment area and the flood storage capacities of these ponds are as given below.

Name of Pond	Catchment Area (ha)	Effective Storage Capacity (m^3)
Taman Keladi	69.7	36,050
Taman Sri Wang	28.1	7,300

(3) Pokok Mangga

The entire drainage area is a typical coastal plain where the ground level is extremely low and flat and the ground water level is high. The storm water in each of the sub-drainage basins is currently drained into the Strait of Melaka through three (3) trunk drains named Prt. Pokok Mangga, Prt. Limbongan and Prt. Malim (refer to Fig. 3-11). However, due to the extremely low and flat topography, the channel flow capacities of these trunk drains are marginally small, and extensive flood inundation occurs during high tide in particular.

(4) Sg. Ayer Salak

This drainage area is broadly divided into the hilly area in the northern part and the coastal plain in the southern part. The drainage network of this area is represented by Sg. Ayer Salak, a tributary of Sg. Malim, and two (2) trunk drains named Prt. AB-1 and Prt. AB-2 (refer to Fig. 3-12). Sg. Ayer Salak originate from the hilly land in the north-east upper reaches, where land development is in progress and a flood detention pond has been almost completed. The channel improvement of Sg. Ayer Salak is also in progress, and upon completion of the improvement works, its channel flow capacity could cope with the probable runoff discharge of a 25-year return period. In contrast with Sg. Ayer Salak, the two (2) trunk drains named Prt. AB-1 and Prt. AB-2 have far smaller flow capacity which could not cope with the probable peak runoff discharge of even a 2-year return period. An industrial estate called “Bukit Rambai” is located in the upper reaches of Prt. AB-1, and there exists a flood detention pond to store the flood runoff discharge from the estate.

3.2.3 Hydrology

The results of simulation on the basin runoff discharge was reviewed on the basis of the supplementary hydrological observation record, the topographic maps newly developed with a scale of 1 to 2000, and the revised detailed land use maps. Moreover, a simulation on the flood inundation was made on the basis of the new topographic maps.

As the results of the simulations on basin runoff discharge and flood inundation, it was confirmed that the probable flood runoff discharge of 5-year return period could cause the following extent of flood inundation (refer to Fig. 3-13):

Name of Priority Area	Extent of Probable Flood Inundation Area in 5-year Return Period	
	Under Present Land Use	Under Projected Land Use in 2020
Sg. Air Mendidih	40 ha	47 ha
Line G	14 ha	23 ha
Prt. Pokok Mangga	268 ha	320ha
Sg. Ayer Salak	340 ha	427 ha

Due to the flood inundation, the channel flow discharge is hardly propagated from the upstream to the downstream, and the peak channel flow discharge is reduced in appearance. Should the channel improvement for the existing trunk drains be implemented to eliminate the flood inundation, the basin flood runoff discharge would concentrate into the channel and increase the peak channel flow discharge, as given below:

Name of Drain	Catchment Area (ha)	Peak Flow Discharge of 5-year Return Period at Downstream End			
		Under Present Land Use		Under Projected Land Use in 2020	
		With Inundation	Without Inundation	With Inundation	Without Inundation
Sg. Air Mendidih	362.4	33	76	38	112
Line G	272.8	18	79	25	99
Prt. Pokok Mangga	470.9	6	37	21	51
Sg. Ayer Salak	1,721.0	59	81	102	170

3.2.4 Environmental Conditions

The following situations were confirmed as the typical features of present water quality and ecology in the priority areas:

(1) Water Quality

Water quality monitoring was carried out at 20 points in total for the four (4) priority areas. As the result, it was confirmed that suspended solids and organic wastes are the common significant pollutant sources of the existing drainage channels and flood detention ponds. Eutrophication of water by inorganic forms of phosphorous and nitrogen was also detected as another problem associated with water quality leading to massive algae blooms. The results of water quality monitoring are summarized below.

Parameter	Sg. Petani		Melaka	
	Sg. Air Mendidih	Line-G	Prt. Pokok Mangga	Sg. Ayer Salak
ph	4.5 – 6.7	5.8 – 6.8	6.5 – 7.6	3.9 – 6.8
BOD	3 – 35	2 – 26	2 – 42	4 – 17
COD	13 – 139	13 – 104	10 – 141	13 – 96
SS	10 – 90	12 – 52	8 – 932	10 – 602

Note: No significant content of toxic compound of heavy metals was detected.

(2) Ecology

The ecology of all of the four priority areas is, in general, relatively sterile due to the built-up nature of the sites. It is however noted that there exists a mangrove forest along the downstream of Sg. Petani, which creates the richer ecology. The mangrove is located downstream from the confluence points of Sg. Air Mendidih and Line-G, and therefore, the drainage improvement plan for the two priority areas in Sungai Petani could influence the ecological system of the mangrove.

3.3 Principal Features of the Proposed Project

3.3.1 Components of the Proposed Drainage Improvement Plan

The optimum drainage improvement plan is selected from alternative combinations of "quick disposal of flood" and "source control of flood", as described in the formulation of the Urban Drainage Structure (refer to Subsection 2.2.2). The quick disposal of flood is made through channel improvement, construction of diversion channel and/or installation of drainage pumping station. On the other hand, the source control of flood is by various types of flood detention facilities such as the flood detention pond, the storage tank in a house lot, and the storage in a public open space.

In accordance with the above planning principles, delineated are the alternative drainage improvement plans, where determination of definitive locations and structural features of improvement measures as the facility components is based on the detailed topographic and hydrological conditions. Comparative study on the alternative plans was made taking the project cost, the number of relocation houses, and other social and environmental impacts into account. As the result, the following components of the drainage improvement measures are selected as the optimum plan for each of the priority areas (refer to Table 3-3 and Figs. 3-14 to 3-17):

Drainage Area	Improvement Measures as Components of the Optimum Plan
Sg. Air Mendidih	1. Channel improvement of four (4) existing trunk drains 2. Construction of on-site flood detention ponds at two (2) sites of public open spaces 3. Construction of new flood detention ponds at three (3) possible sites.
Line-G	1. Channel improvement of one (1) existing trunk drain 2. Construction of one (1) new diversion channel 3. Rehabilitation of the existing two (2) off-site flood detention ponds 4. Construction of new flood detention ponds at two (2) possible sites
Pokok Mangga	1. Channel Improvement of three (3) existing trunk drains 2. Construction of one (1) new trunk drain which runs along almost centre-line of the basin
Sg. Ayer Salak	1. Channel improvement of one (1) river channel and two (2) existing trunk drains 2. Rehabilitation of one (1) existing flood detention pond 3. Construction of five (5) new flood detention pond

The main advantages of the optimum plans are as enumerated below:

(1) Least project cost among the alternative plans is expected;

(2) Least relocation of houses among the alternatives is also expected, thus minimizing the social impact of project implementation;

(3) Channel improvement is minimized by the flood detention facility, which could minimize the drainage discharge flowing into the downstream river channel thus reducing the possibility of river channel overflow. Minimum channel improvement could also minimize the dredging volume of sludge accumulated in the channel, and could reduce the adverse environmental impact of project implementation.

The advantage in Item (3) above is, however, not expected of the optimum drainage improvement plan for Pokok Mangga. That is, the optimum drainage improvement for Pokok Mangga is solely for "quick disposal of flood" without any flood detention facility. This is attributed to the topographic conditions. That is, Pokok Mangga is a typical coastal plain area where hardly secured is a possible site with a large flood detention capacity due to the extremely flat, low-lying ground level and the high ground water level. Conceived was pumping drainage as one of the eligible drainage measures for Pokok Mangga due to its topographic condition. It was, however, verified through hydraulic simulation that gravity drainage could be possible for the area, and hence, pumping drainage is not applied as one of components of the optimum plan.

3.3.2 Principal Structural Features of Proposed Facilities

The principal structural features of the proposed facilities are as described hereinafter.

(1) Channel Improvement of Trunk Drains

The channel improvement is made for all priority areas in common (refer to Fig. 3-18). Deepening of channel rather than widening is applied as the principal measure for channel improvement so as to minimize the land acquisition and the number of house relocation. Utmost effort was further given to "natural river engineering" on the channel improvement whereby wildlife conservation and natural beauty are enhanced. The natural river engineering involve construction of earth channel with sod facing and/or stone pitching on the channel, preservation of wet land and construction of flood retarding basin. The concrete-lined channel is, however, applied to congested areas where acquisition of right-of-way is difficult. The length of the proposed channel improvement is as given below:

Drainage Area	Name of Trunk Drain or River	Improvement Length (m)		
		Earth Channel	Concrete Channel	Total
Sg. Air Mendidih	1. Sg. Air Mendidih	1,310	-	1,310
	2. Line-N	430	660	1,090
	3. Line-O	-	630	630
	4. Line-P	-	1,410	1,410
	Sub-total	1,740	2,700	4,440
Line-G	Line-G	-	3,020	3,020
Pokok Mangga	1. Prt. Pokok Mangga	-	3,260	3,260
	2. Prt. Besar Limbongan	-	920	920
	3. Prt. Malim	-	3,230	3,230
	4. Prt. Lolong Pandan	-	1,870	1,870
	Sub-total	-	9,280	9,280
Sg. Ayer Salak	1. Sg. Ayer Salak	4,780	-	4,780
	2. Prt. AB-1	3,910	-	3,910
	3. Prt. AB-11	2,950	-	2,950
	4. Tributary	4,100	-	4,100
	Sub-total	15,740		15,740
Total		17,480	15,000	32,480

(2) Construction of New Trunk Drain

There are three (3) existing trunk drains in the drainage area of Pokok Mangga, but their flow capacities are extremely small. Should the design runoff discharge be drained only by these existing trunk drains, the channels need to be widened to an extremely large extent leading to the significant number of house relocation (refer to Table 3-3). To avoid such unfavorable conditions, one (1) new trunk drain is proposed in the drainage area of Pokok Mangga, which would run along almost the centerline of the area where a non-built-up area still remains [refer to Fig. 3-18 (3/6)]. The principal features of the new trunk drain are as given below:

Station No.	Catchment Area (ha)	Design Discharge (m^3/s)	Channel Length (m)	Average Channel Bed Slope	Average Channel Width (m)	Average Channel Depth (m)
0 – 1.1K	267	33	1,100	1/3,060 (0.0327%)	13.0	1.8
1.1 – 2.0K	180	21	900		8.5	1.8
2.0 – 2.55K	114	16	550		7.0	1.8
Total	561	70				

(3) Construction of New Diversion Channel

A new diversion channel is constructed for the existing trunk drain of Line-G to divert from its downstream meandering portion [refer to Fig. 3-18(2/6)]. The length and catchment area of the diversion channel and the existing meandering portion are as given below:

Description	Features of Diversion Channel of Line-G	
	Length (m)	Catchment Area (ha)
New diversion channel	280	255
Existing meandering section	400	17
Total	680	

(4) Rehabilitation of Existing Flood Detention Ponds

Rehabilitation is made for the existing two (2) flood detention ponds in the area of Line-G and one (1) in the area of Sg. Ayer Salak (refer to Figs. 3-19 to 3-21). All of these existing ponds are of the wet pond type, and impounding water is seriously polluted due to inflow of wastewater. To remedy such an environmental deterioration, the ponds are dried up during non-flooding time by the following structures: (a) outfall to divert the non-flooding discharge from inflow to the pond; (b) ditch at the bottom of the pond; and (c) outlet structure which is placed lower than the inlet point (refer to Fig. 3-22 to 3-23). The storage volumes of the existing ponds are also enlarged to increase the flood detention capacity, as given below:

Drainage Area	Name of Pond	Active Storage Capacity (m^3)	
		Existing	After Rehabilitation
Line-G	1. Taman Keladi	36,050	63,000
	2. Taman Sri Wang	7,300	16,800
Ayer Salak	3. Bukit Lambai	15,850	59,000
Total		59,200	138,800

(5) Construction of New Flood Detention Ponds

The new flood detention ponds are constructed in three (3) priority areas other than Pokok Mangga (refer to Figs. 3-24 to 3-26). The ponds are designed either as dry pond, wet pond or wet land. The structural features of the dry pond are as described in the foregoing rehabilitation of existing ponds. As for the wet pond and the wet land, both of them continue to impound water even during non-flooding time. However, they could be applied only when a substantial part of the catchment area is covered with new land development where less non-treated water is expected to inflow into the pond. The difference between the wet pond and the wet land is that the wet pond is enhanced as an artificial pond through extensive excavation work. On the other hand, the wet land is applied to the existing natural swampy area on the premise of minimum earth works so as to preserve the present natural conditions.

All wet ponds are provided with an amenity space around the impounding space, so that they could function as community pond. Some dry ponds are also used as community pond, provided that they are placed in a rather extensive vacant space where large scale amenity facilities could be provided. The following table gives the principal features of the proposed new flood detention ponds:

Drainage Area	Name of Pond	Name of Downstream Trunk Drain	Pond Type	Active Storage Capacity (m^3)	Remarks
Sg. Air Mendidih	1. Police Hutan	Line-P	Wet Pond	48,700	Community Pond
	2. Upper Line-P	Line-p	Dry Pond	8,900	
	3. Line-N	Line-N	Dry Pond	16,000	
Line-G	1. Upper Line-G	Line-G	Wet Pond	24,640	
	2. Middle Line-G	Line-G	Dry Pond	17,000	Community Pond
Sg. Ayer Salak	1. Tg. Minyak (1)	Sg. Ayer Salak	Wet Pond	63,560	
	2. Upper Ayer Salak	Sg. Ayer Salak	Dry Pond	19,920	
	3. Tg. Minyak (2)	Prt. AB-1	Wet Pond	70,370	Community Pond
	4. Middle AB-1	Prt. AB-1	Wet Land	29,280	
	5. Middle AB-11	Prt. AB-11	Dry Pond	54,150	Community Pond
Total				352,520	

(6) Construction of On-site Flood Detention Pond in a Public Open Space

Two (2) on-site flood detention ponds are proposed in the area of Sg. Air Mendidih. The principal features of these on-site flood detention are as given below:

Name of Pond	Name of Downstream Trunk Drain	Catchment Area (ha)	Ponding Area (ha)	Storage Depth (m)	Storage Volume (m^3)
Sek. Men, Sains	Line-N	15.0	4.4	0.2 – 0.4	16,600
IKM	Line-N	7.4	1.1	0.3	3,300
Total		22.4	5.5		19,900

(7) Rise of Platform Level

There are low-lying areas along the drainage channels where land development for new residential, industrial and/or commercial areas is projected but its existing ground level is lower than the design high water level of the proposed drainage channel improvement and the storm rainfall is hardly drained into the channel. The land developers will need to elevate the such ground level (called “platform level”) to the design high water by land reclamation. From this viewpoint, the necessary extent of land elevation as well as its corresponding reclamation volume is estimated. The land reclamation effects to facilitate the drainage of storm rainfall. At the same, the reclamation areas could be used as dumping sites for dredged and/or excavated materials from flood detention ponds and drains provided that the premises that any toxicity is not assessed in the materials.

The proposed reclamation areas in the low-lying areas are located as shown in Fig.3-27. Listed below are the estimated volumes for reclamation and the volumes for dredging/excavation for flood detention pons and drainage.

Name of Drainage Area	Reclamation Volume ($1,000m^3$)	Dredging/Excavation Volume ($1,000m^3$)
1. Sungai Petani		
1.1 Sg. Air Mendidih	42.2	186.1
1.2 Line G	170.5	62.3
Sub-Total	212.7	248.4
2. Melaka		
2.1 Prt. Pokok Mangga	262.7	239.4
2.2 Sg. Ayer Salak	1,097.8	568.5
Sub-total	1,360.5	807.9
Ground Total	1,573.2	1,056.3

As estimated above, the dredging and/or excavation volume could cover the necessary reclamation volume for the proposed drainage improvement works in Sungai Petani. Thus, the land developers could expect the source of reclamation materials from the proposed drainage improvement works. Nevertheless, the dumping site is required for the excessive dredging and/or excavation volume of about 35.7 thousand m^3. The excessive volume should be dumped through the measures described in the sub-section 3.4.3 (3). In contrast to the case of Sungai Petani, the reclamation volume exceeds the dredging/excavation volume in Melaka, and therefore, the land developers are required to obtain the alternative sources for reclamation materials of about 483.1 thousand m^3.

3.3.3 Project Cost

The total project cost is estimated at RM 57.93 million (US$ 15.2 million) for construction cost and RM 0.84 million (US$ 0.22 million) for annual average operation and maintenance cost on the price level as of May 1999. The details of project cost are as given as below.

(Unit: RM million out of Parentheses and Million Yen in Parentheses)

Item	Sg. Air Mendidih		Line G		Prt. Pokok Mangga		Sg. Ayer Salak		Total	
1. Construction Cost										
Channel Improvement	7.20	(230)	3.22	(103)	14.64	(468)	25.75	(823)	50.81	(1,624)
Rehabilitation of Existing Detention Pond	-	(-)	0.54	(17)	-	(-)	0.29	(9)	0.83	(26)
Construction of New Detention Pond	1.05	(34)	1.47	(47)	-	(-)	3.23	(103)	5.75	(184)
Storage Facility in Public Open Space	0.54	(17)	-	(-)	-	(-)	-	(-)	0.54	(17)
Total	8.79	(281)	5.23	(167)	14.64	(468)	29.27	(935)	57.93	(1,851)
2. Annual Operation and Maintenance Cost										
Drainage Channel	0.04	(1.2)	0.01	(0.3)	0.05	(1.6)	0.20	(6.4)	0.30	(9.6)
Detention Pond	0.11	(3.5)	0.10	(3.2)	-	(-)	0.33	(10.5)	0.54	(17.2)
Total	0.15	(4.8)	0.11	(3.5)	0.05	(1.6)	0.53	(16.9)	0.84	(26.8)

3.3.4 Implementation and Disbursement Schedule

The implementation and disbursement schedules are as shown in Fig. 3-28 and Table 3-4, respectively.

3.4 Project Evaluation

3.4.1 Economic Evaluation

The economic internal rate of return (EIRR) of the proposed drainage improvement projects are as given below. The proposed drainage improvement for all priority areas could generate the EIRR of more than the opportunity cost of about 13%. Thus, the projects are evaluated to contain economic viability.

Objective Drainage Area	EIRR (%)
Sg. Air Mendidih	16.8
line G	13.8
Prt. Pokok Mangga	25.7
Sg. Ayer Salak	20.8
Total	19.6

The above estimation of EIRR is made under the conditions and assumptions given below:

(1) Economic benefit include the reduction of the direct damages of building properties/assets and the indirect damages expressed as the economic loss and traffic damages by implementation of the proposed projects.

(2) The economic benefit is assumed to increase in accordance with increase of the land value by the land development until year 2020.

(3) The project economic cost is converted from its corresponding financial cost by reducing the price contingency from the financial cost and multiplying the following conversion factors with local currency portion of the financial cost.

Item	Conversion Factor	Estimation Base of Conversion Factor
Construction Cost	0.89	SCR x (1-TP)
Labor Cost	0.87	SCR x (1-TP) x OC-Land
Land Acquisition Cost	0.80	SCR x (1-TP) x OC-Labor
Administration and Engineering Cost	0.89	SCR x (1-TP)
Physical Contingency	0.89	SCR x (1-TP)

Note: SCR = Standard Conversion Rate assumed as 0.90
TP = Transfer Payment assumed as 0.10
OC-Land = Opportunity Cost of Land assumed as 0.90
OC-Labor = Opportunity Cost of Labor assumed as 0.97

(4) The construction period and economic life of the proposed facilities is taken as 5 years and 50 years after completion of construction works, respectively.

(5) Partial benefit of the project are assumed to accrue during construction period in proportion to the progress of construction work, i.e., the benefits are estimated by a ratio of the invested construction cost to the total construction cost.

3.4.2 Financial Evaluation

The financial affordability for implementation of the proposed drainage projects in the priority areas are as evaluated below:

(1) Affordability of Construction Cost

The construction cost for the projects is estimated at RM 57.9 million in total. Out of the total cost, the construction cost of RM 2.5 million for the following five flood detention ponds could be borne to the Land Developer. Accordingly, the cost to be shared by the government budget is estimated at RM 55.4 million, which is to be disbursed for the next five-year period for 8th Malaysian Plan (2001 – 2005).

Name of Flood Detention Pond	Name of Drainage Basin	Type of Pond	Construction Cost (RM thousand)
1. Upper Line P	Sg. Air Mendidih	Dry Pond	329
2. Upper Line G	Line G	Wet Pond	467
3. Tg. Minyak (1)	Sg. Ayer Salak	Wet Pond	605
4. Upper Ayer Salak	Sg. Ayer Salak	Dry Pond	559
5. Middle AB 1	Sg. Ayer Salak	Wet Pond	536
Total			2,497

In comparison with the above required, the Federal DID has allocated a budget of RM 633 million for flood mitigation and drainage improvement during the recent five (5) years (1994 – 1998). Accordingly the above required cost of RM 55.5 million to be shared by the government corresponds to 8.8% of the five-year budget allocated to flood mitigation and drainage improvement.

Federal DID has allocated about 33.0% of the total budget for flood control and urban drainage to the objective states of Kedah and Melaka in the 5th Malaysian Plan (1986 – 1991) and 22.2% in the 6th Malaysian Plan (1991- 1995). The allocation is on the ad-hoc base, and therefore, the percentages allocated to each of the projects could fluctuate according to the necessity and urgency of flood control. Nevertheless, the percentages previously allocated for flood control projects to Kedah and Melaka are far larger than the above value of 8.8%. Judging from these, available budgetary

conditions, it is concluded that the construction cost of the proposed projects for priority areas could be financially affordable.

(2) Operation and Maintenance Cost

The operation and maintenance cost for the proposed projects are estimated at RM 0.25 million for Sungai Petani and RM 0.58 million for Melaka as listed below:

Proposed Facilities	Maintained by	Annual Required Maintenance Cost (RM thousand)		
		Sungai Petani	Melaka	Total
River and Trunk Drains	DID	0.04	0.25	0.29
Flood Detention Pond	Local Authority	0.21	0.33	0.54
Total		0.25	0.58	0.83

In comparison with the necessary maintenance cost, the annual average budget allocated for flood mitigation and drainage to DID as well as the Local Authorities of Sungai Petani and Melaka in the recent five (5) years are as enumerated bellow (refer to sub-section 2.4.1):

Federal DID	:	RM 126.66 million
State DID (Kedah)	:	RM 0.70 million
State DID (Melaka)	:	RM 2.26 million
Local Authority of Sg. Petani	:	RM 0.65 million
Local Authority of Melaka	:	RM 6.48 million

As listed above, all necessary maintenance cost other than that to be shared by the Local Authority of Sungai Petani takes less than 10% of the allocated annual average budget and therefore, could be financially affordable. However, the maintenance cost to be shared by the Local Authority of Sungai Petani takes about 32% of the allocated budget, and difficulties are foreseeable in securing the maintenance cost. Such less budget for the Local Authority of Sungai Petani is attributed to the fact that no major drainage facility has been constructed in Sungai Petani. A major part of the budget for the Local Authority is dependent on the Federal Fund. Hence, the Local Authority of Sungai Petani should coordinate the Federal Government (i.e., the Ministry of Housing and Local Government) to secure the necessary maintenance cost.

3.4.3 Environmental Evaluation

The major environmental issues related to the proposed drainage improvement plan have been screened, and the eligible countermeasures are proposed and incorporated into the proposed plan.

(1) Issues on House Relocation

Implementation of the project will require about 97 houses to be relocated, as estimated below:

Objective Drainage Area	Number of Relocation House
Sg. Air Mendidih	30
Line G	0
Prt. Pokok Mangga	29
Sg. Ayer Salak	38
Total	97

This estimation is on the premise of present land use conditions, and the estimated number of houses would remarkably increase due to the projected intensive land development, unless the proper and early arrangement of land acquisition is made. To smoothly execute the house relocation, the following measures are required:

(a) To gazette the reserve areas for implementation of the drainage improvement project and incorporate them into the Local Plan;

(b) To promote public awareness on the necessity of the drainage improvement project and enhance the agreement and cooperation of residents on project implementation.

(2) Particular Issues on Rehabilitation and Construction of Flood Detention Ponds

The water quality of almost all existing flood detention ponds are seriously polluted. Domestic wastewater composed of sewage and sludge is a significant source of pollution especially in the town center. In order to improve the domestic sewerage system, the Government of Malaysia awarded the national sewerage privatization project to “Indah Water Konsortium (Indah Water)”. A modern and separate sewerage system is going to be developed and managed through the services of Indah Water and this will prevent the polluted domestic sewage from flowing into the flood detention ponds. Thus, it is crucial to promote the services of Indah Water. At present, however, most of the study areas are served by individual septic tanks, and it is virtually difficult to immediately replace them with the new and separate sewerage system. Moreover, it

is also difficult to control the effluent from industrial areas. Hence, the separate sewerage system is likely to be provided only to the new residential areas for the time being. To cope with this issue, the following considerations are required for the construction and maintenance of flood detention ponds:

(a) When the catchment of the flood detention pond includes a substantial extent of the existing built-up area where the inflow of polluted domestic wastewater is expected, the dry pond type with rubbish trap at the inlet is adopted. This type will minimize the polluted inflow into the ponds.

(b) Sustainable maintenance should be given to the ponds so as to desludge and clean the accumulated rubbish and scum.

(c) To control the industrial effluents, it is required to arrange the proper sites of industries and to screen the polluting industries. An attempt should also be given to the development of cleaner technology such as zero discharge of wastewater and good housekeeping practices.

(3) Particular Issues on Channel Improvement

Dredging made as a part of the proposed drainage improvement will increase the channel flow capacity and at the same time clean the channel through removal of a large volume of sludge that contain organic materials. However, the sludge when removed by dredging may release a foul odor as well as gases, and the aquatic fauna and flora will absorb the organic materials. Moreover, the sludge once removed must be disposed at a proper site that will not cause further environmental pollution. From this viewpoint, required is dredging taking minimal impact on fishes and other aquatic life into account. Temporary diversion may be made, if dredging is required along a stretch sensitive to aquatic life. Toxicity and contaminants of dredged sludge should also be assessed. The sludge, if no-toxicity is found, could be disposed offshore. The sludge could also be composted and used for agricultural purposes, or used as embankment materials, unless it contains inappropriate levels of sodium chloride or causes the emission of foul smell. In the event that the sludge material is found to be toxic, then the only recourse will be to dispose the material as hazardous waste through a company in Malaysia that is licensed to treat toxic waste.

Utmost effort should further be given to “natural river engineering” on channel alignment and embankment whereby wildlife conservation and natural beauty are enhanced. The natural river engineering should involve preservation of wet land or

construction of flood retarding basins which will provide areas for aquatic fauna and flora to exist in large numbers and encourage the formation of a rich and stable ecosystem.

CHAPTER 4. CONCLUSION AND RECOMMENDATION

4.1 Structural Measures for Urban Drainage

4.1.1 Basic Concept on Urban Drainage Improvement and Implementation of Drainage Improvement Projects in the Priority Areas

The urban drainage improvement in the structural aspect could be made by a combination of (a) drainage channel improvement to increase the drainage discharge (called "quick disposal of flood") and (b) basin flood detention to decrease the flood peak runoff discharge (called "source control of flood"). In Malaysia, the major concerns have been given to the quick disposal of flood, while less concerns to the source control of flood. However, the disposal of flood contains the adverse effects as enumerated below:

(1) Most of the present river flow capacities are extremely low and could not cope with even the probable flood runoff discharge of a 2-year return period.

(2) Under such a condition, should the existing drainage channels be drastically enlarged in line with the quick disposal of flood, runoff from drainage areas in the upper reaches would concentrate to the downstream river channel and cause a more serious river overflow.

(3) Moreover, the on-going intensive land development in the study area will accelerate the overflow of drainage channels as well as their downstream river.

In order to avoid the above adverse effect, one of the crucial issues for urban drainage improvement should be given to the source control of flood so as to regulate and minimize the peak storm runoff discharge within the basin by various types of flood detention facilities.

In due consideration of the crucial issue as well as the economical and technical viability of alternative plans, ***the following optimum plans for the priority areas. are recommended to be implemented with the design flood level of 5-year return period and the target completion year of 2005.***

Drainage Area	Improvement Measures as Components of the Optimum Plan
Sg. Air Mendidih	1. Channel improvement of four (4) existing trunk drains (Total length: 4,440m). 2. Construction of on-site flood detention ponds at two (2) sites of public open spaces (Total Storage Capacity: 19,900m^3). 3. Construction of new flood detention ponds at three (3) possible sites.
Line-G	1. Channel improvement of one (1) existing trunk drain (Total length:3,020m). 2. Construction of one (1) new diversion channel (Total length: 4,440m). 3. Rehabilitation of the existing two (2) off-site flood detention ponds 4. Construction of new flood detention ponds at two (2) possible sites
Pokok Mangga	1. Channel Improvement of three (3) existing trunk drains (Total length: 8,280m). 2. Construction of one (1) new trunk drain which runs along almost center-line of the basin
Sg. Ayer Salak	1. Channel improvement of one (1) river channel and two (2) existing trunk drains (Total length: 16,740m). 2. Rehabilitation of one (1) existing flood detention pond 3. Construction of five (5) new flood detention pond

Channel improvement as well as the peak drainage discharge flowing into the downstream river could be minimized by the above proposed flood detention facilities. This advantage is, however, not expected to the drainage area of Prt. Pokok Mangga, where the land is a typical coastal plan area with the high ground water level, and it is virtually difficult to construct the flood detention facilities. Thus, the flood detention facilities without drainage channel improvement could not always perform the target design drainage improvement level depending on the physical conditions of the basin .

4.1.2 Application of Storage Tank in a House Lot for Drainage Improvement in the Densely Populated Area

The storage tank in a house lot is one of the flood detention measures. The storage tank is installed at a house lot to collect rainfall from the rooftop and a small outfall is provided at the side bottom to regulate the outflow discharge from the tank. The standard type of the facility is to have the storage volume of $2m^3$ for a unit house lot of $200m^2$ and a roof top area of $100m^2$. The installation cost of the storage tank is estimated at about RM 2,600 per house unit.

The storage tank in a house lot was not applied as a component of the proposed drainage improvement plan in the Study due to its higher installation cost than other alternative measures and difficulties in obtaining the individual agreement of house owners.

However, verified in the detailed hydrological study for the priority areas was a certain flood detention effect of the measure. Moreover, the measure does not require any house relocation and, the water stored in the storage tank could serve as secondary water resources. From this point of view, ***the measure should be applied to a densely populated area in particular, where no alternative drainage improvement measure other than the storage tank in a house lot is applicable. The subsidy system should also be established to encourage the house owners to install the facility.***

4.1.3 Countermeasures for Environmental Adverse Effect to Drainage Facilities

Water quality monitoring was carried out at 20 points in total for the four (4) priority areas. As the result, it was confirmed that suspended solids and organic wastes are the common significant pollutant sources of the existing drainage channels and flood detention ponds. Eutrophication of water by inorganic forms of phosphorous and nitrogen was also detected as another problem associated with water quality leading to massive algae blooms. The results of water quality monitoring are summarized below.

Parameter	Sg. Petani		Melaka	
	Sg. Air Mendidih	Line-G	Prt. Pokok Mangga	Sg. Ayer Salak
ph	4.5 – 6.7	5.8 – 6.8	6.5 – 7.6	3.9 – 6.8
BOD	3 – 35	2 – 26	2 – 42	4 – 17
COD	13 – 139	13 – 104	10 – 141	13 – 96
SS	10 – 90	12 – 52	8 – 932	10 – 602

Note: No significant content of toxic compound of heavy metals was detected.

To cope with the above environmental adverse effects to the drainage facilities, the following countermeasures should be taken:

(1) When the catchment of the flood detention pond includes a substantial extent of the existing built-up area where the inflow of polluted domestic wastewater is expected, the dry pond type with rubbish trap at the inlet should be adopted. This type will minimize the polluted inflow into the ponds.

(2) Sustainable maintenance should be given to the ponds so as to desludge and clean the accumulated rubbish and scum.

(3) To control the industrial effluents, it is required to arrange the proper sites of industries and to screen the polluting industries.

(4) The sludge dredged from the drainage channel, if no-toxicity is found, could be composted and used for agriculture purpose, or used as embankment materials. In the event, that sludge is found to contain the toxic materials, it should be disposed as hazardous waste through a company in Malaysia that is licensed to treat toxic waste.

4.1.4 Use of Flood Detention Pond as Amenity Space and Preservation of Wet Land

The proposed flood detention ponds are designed either as dry pond, wet pond or wet land. Among them, the dry pond does not allow impounding of water in the pond during the non-flooding time, while both of the wet pond and the wet land continue to impound water even during non-flooding time. The difference between the wet pond and the wet land is that the wet pond is enhanced as an artificial pond through extensive excavation work. On the other hand, the wet land is applied to the existing natural swampy area on the premise of minimum earth works so as to preserve the present natural conditions.

All wet ponds is provided with an amenity space around the impounding space, and some dry ponds are also used as community pond, provided that they are placed in a rather extensive vacant space where large scale amenity facilities could be provided. ***These amenity functions could contribute to the improvement of urban environment and therefore should be applied to the future drainage improvement projects. At the same time, an attempt should be made***

to maintain the existing swamp area as wet land to preserve the natural flood retarding effect and the natural ecological system as proposed.

In the drainage improvement plan for the priority areas, proposed are the ten (10) flood detention ponds which are classified into five (5) dry type ponds, four (4) wet type ponds and one (1) wet land as listed below:

Drainage Area	Name of Pond	Name of Downstream Trunk Drain	Pond Type
Sg. Air Mendidih	1. Police Hutan	Line-P	Wet Pond
	2. Upper Line-P	Line-p	Dry Pond
	3. Line-N	Line-N	Dry Pond
Line-G	1. Upper Line-G	Line-G	Wet Pond
	2. Middle Line-G	Line-G	Dry Pond
Sg. Ayer Salak	1. Tg. Minyak (1)	Sg. Ayer Salak	Wet Pond
	2. Upper Ayer Salak	Sg. Ayer Salak	Dry Pond
	3. Tg. Minyak (2)	Prt. AB-1	Wet Pond
	4. Middle AB-1	Prt. AB-1	Wet Land
	5. Middle AB-11	Prt. AB-11	Dry Pond

4.2 Non-structural Measures for Urban Drainage Improvement

The following restructuring of the existing organization set-up for urban drainage improvement is recommended.

4.2.1 Establishment of Interagency Coordination Bodies at Federal and State Level

In order to enhance the consistent urban drainage improvement in Malaysia, the interagency coordination bodies are required at both of Federal and State Level. From this viewpoint, establishment of the new coordination bodies as well as application of the existing coordination bodies are proposed as enumerated below:

(1) Establishment of the New National Rivers Council (NRC) at Federal Level

There is recent proposal to establish a National Rivers Council (NRC) with its secretariat at Federal DID to deliberate and formulate the policies and programmes on the nation-wide river management which includes the matters on the flood control and urban drainage. In this connection, ***it is recommended to establish the NRC as the most appropriate platform at Federal Level to undertake formulation of the uniform policies on urban drainage improvement for all states.***

(2) Application of the Existing State Planning Committee at State Level

There is a existing coordination body called State Planning Committee (SPC) at State Level. The SPC deliberates the formulation of policies on the conservation, development and use of all land in the State. The on-going intensive land development in the study area would cause a rapid increment of peak storm runoff discharge, while the urban drainage improvement may hardly catch up with the rapid

increment of discharge. To avoid such unbalance, ***the SPC should be the forum to coordinate projections on land development and the urban drainage. Moreover, the State Director of DID should be made a permanent member of SPC so as to take technical responsibility on river management and urban drainage.***

(3) State Water Management Authority (SWMA) at State Level

The SWMA is recently proposed as the interagency coordination body among the agencies related to the river management and urban drainage at State Level. ***It is recommended that the SWMA should be established to coordinate the drainage management plans that emanate from the State DID and/or Local Authority in order to promote a consistent drainage improvement plan. At the same time, the SWMA should coordinate with NRC to enhance the consistent drainage improvement policies between Federal and State Levels.***

4.2.2 Demarcation of Functional Responsibility for Drainage Improvement

The drainage improvement works involve the planning, design, construction and operation/maintenance for various drainage facilities which cover the river and drainage channel, flood detention pond and other various on-site flood detention facilities. According to the present guideline and regulations, DID and the Local Authority are the major executive bodies for drainage improvement works. However, due to the lack of clear demarcation of the works between DID and the Local Authority, the consistent drainage improvement is hardly executed. ***In order to retrieve such unfavourable conditions, the demarcation is proposed as listed below:***

Drainage Facility	Planning/Design/Construction	Maintenance
1. Basin-wide Drainage Facility		
1) River Channel Improvement	DID	DID
2) Trunk Drain	DID	DID
3) Community Flood Detention Pond	DID	LA
2. Sub-basin Drainage Facility		
1) Infrastructure Drain/Secondary Drain	LD/LA	LA
2) Roadside Drain (Sate/Federal Road)	PWD	PWD
3) Road Drain (Municipal Drain)	LD	LA
4) Perimeter/Tertiary Drain	LD	LA
5) Off-site Flood Detention Pond	LD	LA
6) On-site Detention Facility in Public Space	LA	LA

Note: LA: Local Authority; D: Land Developer; PWD: Public Works Department

4.2.3 Capacity Building of Local Authority

As stated above, the Local Authority shoulders the extensive responsibilities on the drainage improvement, and the responsibilities will significantly expand as the urbanization progresses very rapidly. In spite of the extensive responsibility on the drainage improvement, both Local Authorities of Sungai Petani and Melaka are suffered from a lack of qualified technical

manpower, and there does not exist even a drainage division within their Engineering Department. In order to retrieve this unfavorable situation, ***it is required to promote the plan for reinforcement of the present capacity building of Local Authority into more practical programmes through deliberations among the related departments and agencies.***