VOLUME 3 – SECTOR IV

URBAN DRAINAGE IMPROVEMENT PLAN

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

FINAL REPORT

VOLUME 3: SUPPORTING REPORT ON DRAINAGE STRUCTURE PLAN

SECTOR IV: URBAN DRAINAGE IMPROVEMENT PLAN

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URBAN DRAINAGE IMPROVEMENT

1. INTRODUCTION

1.1 The Study Area

The study area is divided into two areas, Sungai Petani and Melaka. Both Sungai Petani and Melaka are assumed to represent the regional centers in Malaysia.

Among these study areas, Sungai Petani is composed of six (6) river systems, Sg. Petani, Sg. Lalang, Sg. Tukan, Sg. Pasir, Sg. Che Bima and Sg. Layar Besar, which have a total catchment area of about 100 km^2. These rivers are the tributaries of Sg. Merbok, and their basins are located in the Kuala Muda District of Keda State and administered under the Sungai Petani Municipal Council [refer to Fig. IV-1(1/2)].

On the other hand, Melaka covers three (3) river systems, Sungai (hereinafter Sg. as an abridgment) Melaka, Sg. Malim and Sg. Lereh, which have a total catchment area of approximately 192 km^2 that drains directly into the Melaka Strait. All of these river basins are located within the Melaka Tengah District of Melaka State and administered under the Melaka Municipal Council [refer to Fig. IV-1(2/2)].

1.2 Study Phases

The Study consisted of two phases, Phase 1 and Phase 2. The Phase 1 study was for the formulation of the drainage structure plan with 2020 as the target year, and the Phase 2 study was for the feasibility study on the priority projects selected in Phase 1. Phase I (drainage structure plan) was to delineate a strategic plan for long-term drainage improvement works up to the year of 2020 including setup of planning frameworks and selection of priority projects. Phase 2 (feasibility study) was carried out to formulate the detailed plan for priority projects including preliminary design of facilities and selection of optimum plan through socio-economic and environmental evaluation.

This supporting report covers the study results of the drainage structure plan in the Phase I study.

2. PRESENT CONDITIONS

2.1 Drainage Conditions

2.1.1 Definition of Drainage Basin

(1) Definition and Classification of Drainage System in Malaysia

In Malaysia, the drainage system is classified into three components in accordance with the scale of drainage area and the functions. The following table summarizes the type, functions of drains and their responsible agencies (refer to "An Introduction to Urban Drainage Works in Malaysia and Possible Strategies for the Future", Department of Irrigation and Drainage (DID), July 1993).

Type of Drainage	Definition	Responsible Agency
Roadside drain	• Receiving water from road surface	PWD
Infrastructural drain	• Basic component of drains including secondary and tertiary drains • Drainage area: generally less than 40 ha	LA
Trunk drain	• Receiving water from the above drains • Drainage area: generally more than 40 ha	DID for integral part of river flood control
		LA for others

In spite of the above classifications, the management responsibility for the trunk drains is not clearly demarcated between the DID and the Local Authorities (LA). Further, there is no distinct classification between rivers and drains. A practicable classification is crucial for proper management of both rivers and drains.

(2) Demarcation of River and Drainage Management in Japan

In Japan, the classification of rivers and drains is based on the drainage area in principle. Streams with a drainage area of 2 km^2 or more are categorized into rivers, while streams with less than 2 km^2 in area are categorized into drains. In particular this classification is adopted for streams in the urbanized areas and those in the potential urbanizing areas.

The rivers are managed by the Ministry of Construction or the Local Authorities in accordance with the management responsibility for rivers. On the other hand, the Local Authorities manage the drainage channels.

(3) Classification of Trunk Drains in the Study Area

In the study area the drainage system is called Line, Alur or Cabang in Sungai Petani and Parit in Melaka. In comparison with the classification in Japan, the classification of trunk drains is based on their drainage areas, as shown in Fig. IV-2. The figure shows that a majority (95%) falls within the 4 km^2 of drainage area.

There are several rivers in the study area whose drainage areas are similar in scale to those of trunk drains. In addition, the rivers with a small catchment, which are also named Sungai, may be classified into the drainage system. Fig. IV-2 also shows this case including the small-scale rivers.

The two drainage basins exceeding 4 km^2 in the figure are Line A1 in the Sg. Petani and Alur A in the Sg. Lalang. Since they join their tributaries that are also defined as the trunk drains, their catchment areas exceed 4 km^2 after the confluence. Thus their entire stretch can be divided into two segments, and should be defined as a river after the confluence and a trunk drain before that, even though they are called Line or Alur.

Accordingly a stream with a catchment area of less than 4 km^2 can be classified into a drainage basin in the study. Figs. IV-3 and IV-4 illustrate the drainage network including rivers in the study area.

2.1.2 Present Conditions of Detention Pond

There are many detention ponds constructed by developers in accordance with the administrative guidance for land development. The detention ponds can play a crucial role to reduce the peak discharge for drainage management, if the proper design and maintenance are made. At present the responsible government agencies guide the land developers in the construction of detention ponds, applying the development area of 10 ha or more.

The existing detention ponds were surveyed in the study through simple measurement on site and their results are tabulated in Table IV-1. The storage volume in the table is estimated in consideration of a freeboard of 0.6 m referring to the standards in Japan. The locations of the ponds together with the sub-basin boundary are presented in Fig. IV-5. The present condition of each pond observed through ocular inspection is given in the Appendix.

The following are the observations in the course of the field survey for proper management of detention ponds in future.

(1) Ponding Area and Storage Capacity

Generally the land developers are to ensure an area of 3 to 5% of the whole development area for detention ponds in accordance with the guidelines of the Town and Country Planning Department. Fig. IV-6 illustrates the ratio of an existing ponding area with the development area. Most of the ponds fall below the ratio of 3%.

For evaluation of the storage capacity, an index of V/A (m^3/ha) is convenient, where V is the storage volume and A is the catchment area of the pond. If the ponding area is assured to follow the guidelines and a pond with a storage depth of 2 m is constructed for instance, the V/A index can easily be estimated as follows:

Extent Rate of Pond	Storage Depth	V/A Index
3 %	2 m	600 m^3/ha
5 %	2 m	1,000 m^3/ha

The V/A index also can be converted to storage depth over the catchment. For instance, 600 m^3/ha and 1,000 m^3/ha are equivalent to 60 mm and 100 mm in rainfall depth over the catchment, respectively. Considering that the severest part of a 5-year storm is 85 mm in one hour in both Sg. Petani and Melaka, the pond with a 600 m^3/ha capacity can accommodate most parts of a 1-hr intensive rainfall assuming 0.8 as the average runoff coefficient in the urban area.

Fig. IV-6 also shows the storage conditions of existing ponds using the V/A index. From viewpoints of flood control function, all existing ponds are not necessarily well functioning. Half of the ponds may malfunction for flood control due to lack of ponding area and/or storage depth compared to their catchment areas.

(2) Environmental Considerations

In the course of the field survey, environmental degradation was noticed in most of the existing ponds. This might have originated from the following situations:

(a) All ponds have actually two functions, flood control for storm water and oxidation for domestic wastewater. Thus impounded wastewater emits offensive odor, and leads to sludge accumulation and methane fermentation due to lack of proper maintenance.

(b) In the rainstorm, the thrown rubbish in the drain channels and roadside drains is flushed out into the ponds. The accumulated rubbish mainly causes the outlet clogging.

For the former issue, Indah Water Konsortium Sdn Bhd (IWK), which is the organization responsible for domestic wastewater management in Malaysia, revised the guidelines in 1998. According to the new guidelines, the mechanical treatment facilities using microbiological contact media have to be constructed in newly developed areas instead of the prevailing oxidation ponds. Thus domestic wastewater in the new estates will not directly enter the detention ponds any longer.

Regarding the rubbish accumulation problem, the following comprehensive approaches are necessary to solve the problem.

(a) A rubbish trap screen should be considered for both sides of inlet and outlet in the structural design of detention ponds. After construction of the ponds, a periodical and proper maintenance work is crucial for sustaining the flood control function of ponds.

(b) Ponding area should be considered for multiple use including recreational purpose in the pond designing so that the resident's concern for environmental enhancement will be deeper since they will frequently use the facilities installed inside of the area.

(c) The government agencies should continuously make people increase their general concern in cleaning up the town area through mass media campaign like the "save forests, save rivers, safe water" being done at present. In parallel with this activity, it is necessary for the responsible agencies to intensively pursue the upgrade of solid waste management.

2.1.3 Flow Capacity of Drainage Channel

Based on the cross-sectional survey results and additional field measurement, flow capacity is computed under bank-full conditions using mainly uniform flow method as described in Supporting Report Sector I, Hydrology, Volume 3.

Fig. IV-7 presents the longitudinal flow capacity in each drainage channel where the cross-sectional survey was made. Supplementing flow capacity of the channels where the field measurement was made, the present conditions including the whole sub-basins are summarized in Tables IV-2 and IV-3.

There are many culverts and bridges along the drainage channels. Most of the existing culverts form the bottleneck of flow capacity. The longitudinal flow capacity presented in Fig. IV-7 includes the capacity of those culverts.

In order to evaluate the existing drainage capacity, comparison with the computed probable discharge under present conditions was made. Fig. IV-8 illustrates a ratio of the drainage capacity to probable flood discharge in 2 and 5-year recurrences. The following gives a summary of the evaluation.

Range	Number of Drainage Channels		
	Sg. Petani	Melaka	Total
$Q<0.2Q_2$	27 (63%)	7 (26%)	34 (49%)
$0.2Q_2 \le Q<0.5Q_2$	12 (28%)	9 (33%)	21 (30%)
$0.5Q_2 \le Q<Q_2$	2 (5%)	6 (22%)	8 (11%)
$Q_2 \le Q<Q_5$	1 (2%)	- -	1 (1%)
$Q_5 \le Q$	1 (2%)	5 (19%)	6 (9%)

Note
Q: Drainage Flow Capacity, Q_2: Peak Discharge of 2-yr Flood,
Q_5: Peak Discharge of 5-yr Flood

As shown in the above table, the drainage capacity in both areas can be generally regarded as low level. Forty-nine percent (49%) of all drainage channels fall into the lowest level of less than 20% of 2-year flood. In particular, 63% of the channels in Sungai Petani fall into this level. Further, 90% of all channels have a capacity smaller than a 2-year flood discharge.

2.1.4 Flood Mitigation Capacity of Existing Detention Pond

As described in Subsection 2.1.2, the storage capacity of the existing detention ponds varies in a wide range. From flood control viewpoints, the ponds, which can play an important role in the flood control plan, were selected in accordance with the following criteria:

(a) An index of V/A is greater than 400 m^3/ha, or

(b) Ponding area is larger than 4,000 m^2 and there is a possibility for excavation work judging from the height deference between bottom of pond and invert level of outlet drain.

Twelve (12) ponds were selected as functional ponds (refer to Tables IV-2 and IV-3.

In order to evaluate flood control effects of the existing detention ponds, a hydrological analysis was made for Sungai Petani using a 5-year flood under present conditions. Flood hydrographs were computed on the assumption of functioning under proper relationship between outlet and storage volume, since the detailed survey for the existing detention ponds has not been made yet. The computed results are tabulated in Table IV-4, and the following is a summary of the results:

(a) In Sg. Petani basin and Sg. Pasir basin, catchment of the detention ponds already covers 10% and 8% of the entire basin, respectively.

(b) All of the selected detention ponds function well for flood control in line with coverage of their catchment areas.

(c) The effects of the pond on flood mitigation are expected to be almost equivalent to the coverage of catchment at the outlet of sub-basin, even at the river mouth.

2.2 Flood Damage Conditions

Flooding information was obtained from the Welfare Department, the DID and the Municipal Council. Further flooding situation was also obtained through interview survey from the residents on site. The habitual flooding areas and their situations are tabulated in Table IV-5 and their locations are presented in Fig. IV-9.

Based on the flooding situations, the major causes of flooding can have the following individual mechanisms:

(a) Key drainage system has poor flow capacity.

(b) Development activities in the upper reaches cause increment of flood discharge and this affects the urbanized areas and rural villages in the lower reaches.

(c) Originally the areas are located in a flood-prone area or a poor-draining area, such as low-lying area and depressed hinterland.

Actually the flooding problems occur as a phenomenon compounded with the above-mentioned mechanisms. Thus flood control measures should be appropriately selected to remedy the flooding mechanisms in the locality. In particular, increment of flood discharge caused by land development will share a greater part of the causes in near future, considering the tendency of intensive land development in the study area. In this context, the importance of the detention pond will increase more than ever in the urban flood control planning.

3. DRAINAGE STRUCTURE PLAN

3.1 Planning Framework

3.1.1 Projected Land Use

Sungai Petani and Melaka are at the stage of rapid development with several large-scale projects committed and approved. The detail is described in the supporting report on Regional Development Framework and Land Use, Sector II, Volume 3. Land use in both study areas is summarized in the following table:

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
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.

3.1.2 Target Extent of Drainage Improvement

The trunk drain basins are targeted for improvement in the drainage structure plan. Their drainage areas generally extend between 0.4 km^2 and 4 km^2, as described in Subsection 2.1.1 (refer to Fig. IV-2).

The target extents under the drainage structure plan are summarized in the following table:

Drainage System	Number of Trunk Drains	Total Catchment Area (km^2)	Total Channel Length (m)
Sungai Petani			
Sg, Petani	21	28.07	22,770
Sg. Pasir	6	4.93	2,790
Sg. Lalang	5	9.73	6,060
Sg. Tukang	5	7.04	3,990
Sg. Layar Besar	2	3.77	4,980
Sg. Che Bima	1	3.27	3,570
Subtotal	40	56.81	44,160
Melaka			
Sg. Melaka (Downstream of Merdeka Barrage)	3	9.19	5,200
Sg. Putat	3	9.13	3,900
Sg. Melaka (Upstream of Merdeka Barrage)	10	13.56	13,050
Sg. Malim	4	10.25	7,670
Coastal Drainage System	8	11.91	9,530
Subtotal	28	54.04	39,350
Grand Total	68	110.85	83,510

3.1.3 Design Level for Drainage Improvement

The design level for drainage improvement in the drainage structure plan is proposed with reference to the design level in the developed countries and the present hydrological conditions.

(1) Basic Considerations

The drainage network is one of the crucial infrastructures in the urban areas to upgrade the living standard of the people. On the contrary, the improvement of the drainage system will directly and adversely affect the downstream areas in the following mechanisms:

(a) Before the improvement, storm water inundates in many places over the catchment.

(b) The function of drainage system is collecting and draining storm water without inundation within a certain level.

(c) From the hydrological viewpoints, urbanization mainly increases the runoff coefficient and drainage improvement mainly increases the flood concentration time. Compounding both effects, flood peak discharge drastically swells.

(d) Further the time required for drainage improvement is usually much shorter than the one for river improvement in the lower reaches, since most parts of drainage improvement can be achieved utilizing private capital in line with urban development.

(e) As a result of the above-mentioned process, storm water will rush into a river channel and serious flood damage will occur in the lower reaches where urban centers are mostly located, if the river channel does not have enough flow capacity.

In addition, although the flooding along the drainage channel frequently takes place, the damage is usually not so serious. On the contrary, the damage becomes serious once flooding occurs along the river course.

Therefore, particular attention should be paid to the present conditions of both drainage and river systems to determine the design level for drainage improvement.

(2) Design Level in Developed Countries

The guidelines prescribe 5 to 10-year return period as the design level for drainage improvement in Japan (refer to Sewerage and Drainage Association, Japan, "Guidelines for Sewerage and Drainage Structures", 1994). In fact, drainage improvement works have been implemented on the following levels in the major cities of Japan. In Tokyo, the new drainage master plan was established in 1994 and the improvement works in 10-year design scale was commenced for completion in the early 21st century (refer to Tokyo Metropolitan Government, Japan, "Second Generation Sewerage Master Plan", 1992).

Name of City	Design Scale	Statistical Information		
		Area (km^2)	Population (thousand)	Time of Data
Sapporo	10-year	1,121	1,800	Jun. 1998
Sendai	5-year	788	993	Apr. 1999
Tokyo (Special Wards)	3-year	621	8,039	May 1999
Yokohama	10-year	434	3,387	Jun. 1999
Kawasaki	5-year	144	1,239	Jun. 1999
Nagoya	5-year	326	2,164	May 1999
Kyoto	5-year	610	1,460	May 1999
Osaka	12-year	212	2,590	Apr. 1999
Kitakyushu	5-year	484	1,012	Jun. 1999
Fukuoka	5-year	338	1,325	May 1999

In addition, the design scale ranges from 5-year to 30-year in the United Kingdom and the United States, according to Water Research Center in the United Kingdom.

(3) Proposed Drainage Design Level

In order to achieve a well-balanced flood control system in an entire basin, the following present conditions should be considered:

(a) As described in Subsection 2.1.3, most of the existing drainage capacities are still below the 2-year safety level even under present conditions.

(b) As described in the supporting report on River Channel Improvement Plan (Sector V, Volume 3), most of the existing river capacities are also still below the 2-year safety level even under the present conditions, except for the Sg. Melaka-Malim system in Melaka.

In addition, taking the drainage design level of 5 to 10-year in Japan into consideration, the level of 5-year is proposed for the drainage improvement in the Study.

3.2 Alternative Measures for Drainage Improvement

3.2.1 Components of Alternative Measures

Prior to establishment of alternatives, the applicable improvement measures are enumerated on the basis of field survey results and the experiences in Japan. Furthermore, potential coverage of detention ponds, which are applied to the development area of 10 ha or more at present, was studied using the historical data of land development schemes. Finally the realistic alternatives are established as below.

(1) Applicable Measures

Applicable measures for drainage improvement can be classified into four categories.

(a) Channel improvement as a conventional measure;

(b) Rehabilitation of the existing detention pond, such as outlet improvement and excavation of pond bottom;

(c) Retarding basin as an alternative measure to channel improvement; and

(d) Flood detention in a catchment.

Flood detention measures considered applicable are composed of the following schemes:

(a) Detention pond for newly developed area;

(b) Storage in public open space for newly developed institutional area; and

(c) Storage tank in individual houses for urbanized area.

Regarding retarding basin, its adaptability depends on topographic and land use conditions on the site. In the drainage structure plan stage, the precise conditions have not been clarified yet, since the detailed topographic survey was not made in this stage. Thus this kind of alternative measure was studied in the feasibility study stage.

(2) Tendencies of Land Development

For the establishment of future direction in the administrative guidance, the review study was made through data collection of previous development activities, and estimation and histogram analysis of land development areas.

The available data of number of housing that has been developed for almost 40 years was obtained from Majlis of Sungai Petani and Melaka. The listed housing schemes and developed houses totaled 455 and 94,472 units in Kuala Muda District, 532 and 83,940 units in Melaka Tengah District, respectively.

Based on the number of housing units, the typical housing development and necessary infrastructure and open space are assumed as follows. Estates can be assumed as simple residential estates for the development area of less than 2 ha, whereas estates can be assumed as complex estates with necessary infrastructures and open spaces for the areas of 2 ha or more.

Development Scale	Equivalent Housing Units	Type of Estate	Density of Units	Sharing Ratio
A < 2 ha	N < 60 units	Residential	12 units/0.4 ha	-
A ≥ 2 ha	N ≥ 60 units	Complex	Bungalow: 6 units/0.4 ha	20%
			Semi-D: 12 units/0.4 ha	30%
			Terrace: 15-20 units/0.4 ha	50%
		Necessary Components	Infrastructure	30%
			Open Space	10%
			(Housing)	(60%)

Fig. IV-10 shows the histogram of estimated land development area by scale. The following table also enumerates coverage of land development scale to the whole development area.

Development Scale	Coverage	
	Sg. Petani	Melaka
A ≥ 10 ha	78.5 %	73.0 %
A ≥ 5 ha	89.8 %	89.1 %
A ≥ 1 ha	98.8 %	98.2 %
A ≥ 0.5 ha	99.6 %	99.5 %

As presented above, if the guideline on flood detention is newly applied for the land development of 1 ha or more, the catchment of detention facilities will cover an area of 98 to 99% of the whole development area. On the other hand, the number of development schemes to be guided in the construction of detention facilities will increase three to three-and-half times as given below. This fact means the volume of administrative work will increase in parallel with lowering the guidance limits of development area.

Development Scale	Number of Development Schemes	
	Sg. Petani	Melaka
A ≥ 10 ha	88	119
A ≥ 5 ha	159	211
A ≥ 1 ha	307	350
A ≥ 0.5 ha	360	417

(3) Alternatives

The following alternatives were studied through hydrological analysis:

Alternative	Channel Improvement	Rehabilitation of Existing Pond	Flood Detention		
			Coverage of Detention Pond	Storage in Public Space	Storage Tank in House Lot
1	Execute	Execute	0%	No	No
2	Execute	Execute	50%	No	No
3	Execute	Execute	50%	Execute	Execute
4	Execute	Execute	80%	No	No
5	Execute	Execute	80%	Execute	No
6	Execute	Execute	80 %	Execute	Execute

Alternatives were also set up for clarification of the following items:

Alternative 1	Increment of the flood discharge in 2020
Alternative 2	Flood control effects of detention pond under intermediate coverage
Alternative 3	Additional effects of storage in public and private spaces
Alternative 4	Flood control effects under expected maximum coverage
Alternative 5	Additional effects of storage in public space
Alternative 6	Additional effects of storage in private house space

3.2.2 Concept of Alternative Measures

(1) Drainage Channel Improvement

In the study area most drainage networks have already been constructed in the urban and urbanizing areas. Basically the drainage channel improvement will be made for augmentation of the drainage capacity to fulfill the design discharge of a 5-year flood, following the existing channel alignment. In principle, drainage channels are planned as concrete-lined with a rectangular shape.

(2) Rehabilitation of Existing Detention Pond

As described in Subsection 2.1.2, there are several problems in the existing detention ponds. The following are the items to be rehabilitated in accordance with the present conditions of the selected ponds, as given in Tables IV-3 and IV-4.

(a) Reconstruction of outlet structure;

(b) Upgrading of inlet structure to trap the rubbish flashed out by storm water; and

(c) Excavation of pond bottom, if possible.

Regarding excavation of ponds for augmentation of storage capacity, six (6) ponds are considered as the potential ponds for rehabilitation. The proposed depth to be excavated is determined as the smaller depth through comparison between the necessary depths to fulfill the following limitations:

(a) 4 m as maximum depth of pond; and

(b) 1,280 m^3/ha of maximum storage capacity as described in the following section.

The required excavation depth and volume are given in the table below.

Detention Pond	Excavation		Storage after Rehabilitation	
	Depth (m)	Volume (m^3)	Volume (m^3)	V/A (m^3/ha)
Taman Ria	1.0	23,260	79,080	710
Taman Semarak (II)	1.3	3.260	8,640	900
Taman Sri Wang (K/Api)	1.5	6,400	14,720	900
Taman Sri Wang (J/Raya)	2.5	15,480	21,050	560
Taman Kempas (Atas)	1.5	6,810	15,440	310
Kaw. Industri Bukit Rambai	1.2	54,760	78,210	1,280
Total	-	109,970	-	-

(3) Concept for Basin Flood Detention

Basin flood detention measures are composed of three kinds of facilities depending on the site to be constructed. These are detention pond for newly developed areas, storage for newly developed institutional areas and storage tank for individual houses. Their salient features are presented in the supporting report of Design, Construction Plan and Cost Estimate of Proposed Facilities, Sector VI of Volume 3.

(a) Detention Pond

The required extent of detention pond and capacity to fulfill the control function for both 5 and 100-year floods is explained in the supporting report on Hydrology, Sector I of Volume 3. The required average land for detention pond is equivalent to 5.5% of the area to be developed. This figure slightly exceeds the 3 to 5% of development area as required by the Town and Country Planning Department. Multiple use of open space in the detention pond area should be facilitated in order to resolve the problem.

Regarding the required capacity of 1,280 m^3/ha, five (5) ponds out of twenty-one (21) almost attained this level in the study area, as shown in Fig. IV-6. Thus the required capacity is not considered excessive.

(b) Storage in Public Open Space

Usually, an open space in an institutional area is utilized for playground or park. For installation of storage in this area, particular attention is paid not to obstruct the original purposes of the storage area. Thus the minimal storage depth of 0.3 m is determined.

(c) Storage Tank in Individual House

Affordability of residents is considered in the design of storage tank for an individual house. As a result, the minimum capacity of 2 m^3 is determined.

3.3 Optimum Drainage Improvement Plan

3.3.1 Comparative Study on Alternatives

As drainage channel improvement is more intensively made with less construction of basin flood detention facilities, storm waters will concentrate into the downstream river channels and peak discharge will correspondingly increase. Moreover, the ongoing land development will accelerate the increment of peak runoff discharge. In spite of such increment of peak runoff discharge flowing into the river channel, the present flow capacity of most major river channels is extremely small as mentioned in Subsection 2.1.3, and 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 selection of the optimum plan is such that the drainage improvement should minimize the increment of the basin runoff discharge, and perform the target drainage capacity with the least adverse effect to the downstream river channels. Based on this criterion, the comparative study on the above six (6) alternatives was made. As a result, it was clarified that Alternatives 2 and 3 would still cause significant increments of peak runoff discharge from the present to the year 2020, as shown in Figs. IV-11, IV-12 and IV-13. On the other hand, should Alternatives 4, 5, or 6 be adopted, no significant difference was estimated in the peak discharges from the present to the year 2020.

In Alternatives 2 and 3, the flood detention ponds are assumed to cover 50% of the projected land development area, while the flood detention ponds cover 80% of the projected land development area under Alternatives 4, 5, and 6. Thus, the coverage of flood detention ponds could be the dominant factor for increment of the peak runoff discharge, and 80% of the coverage is required to minimize the increment of peak runoff discharge.

Moreover, it is identified that the storage in the public open space could be effective for the sub-basins where the institutional area is projected to cover a substantial part of the total catchment area. That is, Alternatives 5 and 6 which include storage in a public space could have significant effects to control the increment of peak runoff discharge as compared with Alternative 4 which excludes the storage in public open space. The following are the peak runoff discharge by each alternative for sub-basins where the projected institutional area is dominant:

River Basin	Sub-basin		Coverage Ratio of Projected Institutional Area (%)	Probable Peak Discharge (5-year return period) (m3/s)			
	Code No.	(ha)		Present	In 2020		
					Alt. 4	Alt. 5	Alt. 6
Lereh	UD-1	385	90.1	45	106	27	25
Cheng	SB-2	140	27.1	15	25	16	16
Minor Basin	CD-1	44	26.7	14	16	12	11

The difference between Alternatives 5 and 6 is such that Alternative 6 includes the effect of storage tank at an individual house lot, while Alternative 5 excludes the effect. The following are comparisons of peak runoff discharge effected by Alternatives 5 and 6 in sub-basins where there exist a higher coverage rate of the existing area.

River Basin	Sub-basin		Coverage Ratio of Existing Residential Area (%)	Probable Peak Discharge (5-year return period) (m3/s)		
	Code No.	(ha)		Present	In 2020	
					Alt.5	Alt.6
Petani	PE-16	90	44.1	42	42	42
Petani	PE-15	32	42.7	17	16	16
Petani	PE-21	21	41.7	11	11	11

A certain flood detention effect by the storage tank in an individual house lot was confirmed through the hydrological simulation as described in the subsection 3.3.3. As the results of the above comparison, however, no difference in the peak discharges is estimated, and therefore, no significant superiority of Alternative 5 to Alternative 6 is recognized. This could be attributed to the limited coverage ratio of existing residential area which leads to the limited storage capacity of the storage tank as compared with the flood runoff volume. Moreover, difficulties are foreseeable in obtaining the individual agreement of house owners for installation of the storage tank, unless an applicable subsidy system could be established to encourage the house owners to install.

Through the clarifications as mentioned above, Alternative 5 is selected as the optimum plan. The following are the peak runoff discharges when Alternative 5 is adopted as the drainage improvement project.

(unit: m^3/s)

Name of River Basin	5-year Return Period Flood*1			100-year Return Period Flood*1		
	Present	In 2020		Present	In 2020	
	w/o Project	w/o Project	w/ Project	w/o Project	w/o Project	w/ Project
Sungai Petani						
1. Lalang	209	393	187	322	592	281
2. Tukang	81	91	63	128	139	98
3. Layar Besar	62	69	55	92	106	85
4. Che Bima	33	78	36	53	115	54
5. Petani	259	277	216	411	433	335
6. Pasir	194	231	168	308	367	256
Melaka						
1. Lereh	172	299	203	334	540	357
2. Malim	261	538	326	507	969	565
3. Cheng	184	333	202	368	581	384
4. Putat	171	192	163	294	329	285
5. Melaka (1) *2	211	262	225	393	478	399
6. Melaka (2) *2	221	408	244	425	720	441

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

The distinct advantages of the optimum plan (i.e., Alternative 5) are summarized below.

(1) Drainage Improvement Independent of River Improvement

As described above, the optimum drainage improvement plan could minimize the increment of peak runoff discharge that flows into the downstream river. Due to such advantage, drainage improvement could be made without any significant adverse effect to the flood flow conditions of the river and not requiring the river channel improvement.

(2) Security of Financial Resource for Project Implementation

The land developer has to construct a flood detention pond for his land development area of 10ha or more. Since the optimum plan includes the flood detention pond as the principal drainage improvement measure, most of the cost for the optimum plan could be secured by the investment of land developers.

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

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

(4) Minimizing of Adverse Social Impact

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

3.3.2 Proposed Optimum Plan and Component

Based on the comparative study made in the preceding subsection, Alternative 5 is proposed as the optimum plan. The proposed optimum plan is composed of the following components.

(a) Drainage channel improvement;

(b) Rehabilitation of existing detention pond;

(c) Detention pond for newly developed area; and

(d) Storage in open space inside newly developed institutional area.

The required storage volume in Alternative 5 is summarized in the following table.

River System	Required Storage Volume (thousand m^3)		
	Detention Pond	Storage in Public Space	Total
Sg. Petani	1,700	24	1,724
Sg. Pasir	1,549	-	1,549
Sg. Lalang	1,758	37	1,795
Sg. Tukang	476	17	493
Sg. Layar Besar	141	2	143
Sg. Che Bima	267	-	267
Sub Total in Sungai Petani	5,891	80	5,971
Sg. Melaka (upstream)	1,771	88	1,859
Sg. Putat	523	17	540
Sg. Melaka (downstream)	697	37	734
Coastal Drainage System	546	29	575
Sg. Malim	3,336	28	3,364
Sg. Lereh	1,270	224	1,494
Sub Total in Melaka	8,143	423	8,566
Grand Total	14,034	503	14,537

The required total storage volume is $5{,}971 \times 1000\ m^3$ in Sungai Petani and $8{,}566 \times 1000\ m^3$ in Melaka. This figure includes a volume of the existing detention ponds. Ninety-seven percent (97%) of the required total volume can be achieved until the year 2020 as the proper governmental guidance for construction of detention pond is continuously imposed on land developers.

Regarding the target trunk drainage basin in the drainage improvement plan including the channel to be improved, the required storage volumes and necessary information are given in Table IV-6, based on Alternative 5.

3.4 Non-structural Measures for Drainage Improvement

3.4.1 Applicability of Non-structural Measures

Non-structural measures are crucial for attaining the flood-free circumstances as well as the structural measures that are proposed in the optimum plan. In this subsection, the applicability of non-structural measures are examined considering the characteristics of flash floods.

(1) Non-structural Measures

The difference between structural and non-structural measures can be easily understood by using the disaster management cycle. A standard cycle is illustrated below.

Preparedness	→	Disaster Impact	→	Response
↑				↓
Prevention/Mitigation	←	Development	←	Recovery

Structural measures come under the stage of prevention/mitigation in the disaster management cycle. They are composed of the drainage structures such as channeling works, diking systems, retarding basins, pumping facilities, detention ponds and rainwater infiltration facilities. On the contrary, non-structural measures come under the other stages. For instance, the concrete measures are enumerated below following each stage of the cycle.

Disaster Management Cycle	Non-structural Measures
Preparedness	Preparation and public awareness of flood risk map
	Flood insurance
Response	Flood forecasting and warning
	Flood fighting
	Evacuation and rescue
Recovery	(Restoration and reconstruction of damaged structures)
	Community rehabilitation
Development	Land use regulation
	Land development guidance

(2) Examination of Necessity and Applicability

The following are the characteristics of flash floods caused by overflow of drainage channels:

(a) Duration of heavy rainfall and flooding is considerably short, but flooding occurs frequently and repeatedly.

(b) Direct damages by flash floods are not so serious to the residents, compared with the floods along a river course of a large-scale basin, but indirect damages widely influence the socio-economic activities particularly in the urban areas.

(c) Hyetal region of heavy rainfall is also considerably small and mobile so that it is difficult to precisely forecast the rainfall amount and place.

Considering the above-mentioned characteristics, the necessity and applicability of the non-structural measures are examined for the drainage improvement plan. The results are tabulated below.

Measures	Applicability /Necessity	Note
Preparation and public awareness of flood risk map	High	Flood risk map is a basic information for most of the non-structural measures.
Flood insurance	Mid	Long time is necessary for establishment of the system.
Flood forecasting and warning	Low	Establishment of precise forecasting system is difficult.
Flood fighting	Mid	Direct flood damage is not so serious. Welfare Dept. and another related agencies already established the systems.
Evacuation and rescue	Mid	
Community rehabilitation	Mid	
Land use regulation	High	Natural retarding function should be preserved.
Land development guidance	High	Detention ponds should be constructed for the newly developed area.

As evaluated above, the following measures are crucial for the drainage improvement plan:

(a) Preparation and public awareness of flood risk map;

(b) Land use regulation; and

(c) Land development guidance.

3.4.2 Issues on the Implementation of Non-structural Measures

In the preceding subsection, the suitable non-structural measures were selected from their necessity and applicability for the drainage improvement. The issues to be considered are summarized below for the smooth implementation of measures.

(1) Preparation and Public Awareness of Flood Risk Map

The following is a brief of guidelines for preparation of flood risk map in Japan.

(a) Purposes

The following are major purposes of preparation and public awareness of the map:

- To facilitate self-defensive activities by the residents through prior dissemination of the necessary information on flood risk of the locality.
- To facilitate appropriate guidance by the local government to the residents and the developers.
- To assist the local government in reflecting the flood risk on the related planning such as urban planning, disaster prevention plan, flood fighting plan, and so on.

(b) Contents of the Map

In general, the flood risk map contains the following information on the topographic map with a scale of 1/2,500 to 1/25,000:

- Inundation area and depth in previous floods;
- Inundation area and depth in a certain recurrence period by computation through a flooding simulation;
- Evacuation centers and suitable routes to be taken during floods; and
- Storage of implements and materials for flood fighting.

(c) Public Information

The mayor of the local government makes the flood risk map properly known to the residents through the following information activities:

- The local government makes the map open through the information channel, such as a public relations bulletin, an information board and a community cable TV network.

- The local government delivers the map to each household with a public relations bulletin.

(2) Land Use Regulation

Based on the simulation results and the flood risk map, DID can select the effective natural retarding areas and designate the areas as river reserves. DID also should discuss the preservation of natural retarding functions with the related agencies, Town and Country Department and the local government. If an area to be preserved is large and can be clearly delineated, the area should be designated as a natural preservation area or a river reserve area in an urban development plan.

Any type of land development activities shall be prohibited in the area, except for a specific type of development that can preserve the retarding function, such as piling type of buildings.

(3) Land Development Guidance

At present the responsible agencies guide the land developers in the construction of detention ponds, applying the development area of 10 ha or more. Thus the land development with an area of less than 10 ha falls out of this guidance. If the land developer divides the land in pieces with an area of less than 10 ha and applies for their development one by one to the responsible agencies, the necessary detention ponds would not be constructed in the developed area.

In order to avoid the above-mentioned unfavorable circumstances, the baseline of the area should be lower considering the proper balance between increment of flood detention effectiveness and increment of inspection works for the project proposals. In general, the baseline of development area is set at 0.1 ha to 1 ha in Japan.

Furthermore, some local governments require construction of detention facilities for the land development with an area of 0.05 ha or more.