CHAPTER 4. FORMULATION OF DRAINAGE IMPROVEMENT PLAN

4.1 Planning Framework

The future land use in the study area as well as the target design levels for urban drainage improvement is projected as the essential framework of plan formulation.

4.1.1 Target Year and Future Land Use

In accordance with the Scope of Work for the Study, the target year for the Drainage Structure Plan is set at the year 2020, and land use of the study area in the year 2020 is projected based on the local plans prepared by the municipal councils of Sungai Petani and Melaka. The projection year by the municipal council of Melaka is, however, set at 2015, while that by the municipal council of Sungai Petani is 2010. According to the projection by the respective municipal councils, the future land use states are classified as below (refer to Figs. 4-1 to 4-2).

(unit: ha)

Classification of land Use	Sungai Petani in 2010		Melaka in 2015	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
1. Built-up Area				
1.1 Residential Area	5,130	51.0	8,255	43.1
1.2 Commercial Area	1,111	11.0	649	3.4
1.3 Industrial Area	1,350	13.4	2,818	14.7
1.4 Institutional Area	647	6.4	1,066	5.6
1.5 Recreational Area	622	6.2	743	3.9
1.6 Road	938	9.3	868	4.5
Sub-total	9,798	97.3	14,399	75.2
2. Non-Built up Area				
2.1 Natural Area	266	2.6	265	1.4
2.2 Agricultural Area	0	0.0	3,811	19.9*
2.3 Others	0	0.0	682	3.6
Sub-total	266	2.6	4,758	24.9
Grand Total	10,063	100.0	19,157	100.0

* The area is reserved as the future development land, but remained as agricultural land in 2015.

As projected above, Sungai Petani will preserve only 2.6% of the area (around the river mouth of Sg. Petani) as natural mangrove area by 2010, but other areas are fully developed as built-up area. As for Melaka, about 75% of the study area also will be developed as built-up area by 2015. Thus, a substantial part of the study area is projected to be built-up areas in 2010 for Sungai Petani and in 2015 for Melaka.

In this study, the latest regional development frameworks are scrutinized with particular attention on the population growth (refer to Chapter 2). As the result, the total built-up area required for regional development by 2020 is clarified and compared with the foregoing projected values by Local Plans. Detailed clarification of the land use states in 2020 are as described in Sector II in Vol. 3, Supporting Report on Drainage Improvement Plan. The results of clarification are as given below:

(unit : ha)

Land Use Item	Sungai Petani		Melaka	
	Area Projected in 2010	Area Required in 2020	Area Projected in 2015	Area Required in 2020
Residential Area	5,129	5,432 (+5%)	8,255	6,390 (-23%)
Industrial Area	1,350	1,777 (+31%)	2,817	2,759 (-2%)
Commercial Area	1,111	812 (-27%)	649	766 (+18%)

Note: The figures in parenthesis are incremental rate of the projection value in this study as compared with that in Local Plan.

As shown above, there is no significant difference of more than 5% in the projections by the Local Plans and by this study on the residential area of Sungai Petani and the industrial area of Melaka. Thus, the projections in the local plans of Sungai Petani and Melaka were subject to the target years of 2010 and 2015, respectively, but they could be shifted to the target year 2020 as far as the residential areas for Sungai Petani and industrial areas for Melaka are concerned. This is probably because the local plans were prepared in the early 1990s with a very optimistic assumption of socio-economic growth.

As for the commercial area of Sungai Petani and the residential area of Melaka, the projections by the local plans significantly exceed the projection in this study. That is, the local plans are likely to provide an excessive commercial area of about 300 ha for Sungai Petani and residential area of about 1,900 ha for Melaka by the year 2020. However, land development works have been committed and started for a substantial part of these excessive lands as seen in Bandar Aman Jaya in Sungai Petani. Accordingly, in spite of the excessive land development, the projections in the local plans are deemed to be realized by the year of 2020.

In contrast with the above excessive land development, the local plan is likely to provide less industrial area for Sungai Petani and commercial area for Melaka as compared with the values estimated in this study. However, the local plan has already acknowledged the shortage of land and prepared countermeasures in such that the shortage of land will be compensated by land development located immediately outside of the study area. Due to these conditions, no further increase in commercial land projected by the local plan could be expected by the year 2020.

As stated above, the overall land use projections by the local plans could coincide with the required extent of residential area, industrial area and commercial area by the year of 2020, and therefore applied as planning framework for this study.

4.1.2 Design Level for Drainage Improvement

The flooding problem is classified into two types. First is the inundation by stagnant storm rainfall due to insufficiency of inland drainage capacity. Second is the overflow from river due to insufficiency of river flow capacity. The inundation by stagnant storm rainfall tends to occur more habitually than the river overflow causing a great hindrance to the regional economy and urban life including serious traffic jam. On the other hand, the river overflow tends to occur less frequently but causes more extensive and disastrous flood damage once it occurs. Due to the different natures of floods, different design levels are required for drainage improvement and for prevention of river overflow.

The principal planning framework in this study is given to the target design level of drainage improvement. However, a conceptual study on prevention of river overflow was made, since the drainage discharge finally flows into the downstream of river thus influencing the flood flow condition of the river channels. Moreover, among the facilities proposed in the drainage improvement plan, the flood detention pond could contain a large flood regulation potential, and its regulation effect could extend to not only drainage improvement but also prevention of river overflow. From these viewpoints, proposed are the target design levels for both the drainage improvement and prevention of river overflow as described hereinafter:

(1) Target Design Level for Urban Drainage Improvement

Through the "Urban Drainage Design Standards and Procedures for Peninsular Malaysia, 1975", the Department of Drainage and Irrigation (DID) prescribes a 2-year return period flood as the urban drainage design level for residential areas. It also prescribes a 5-year return period flood for commercial and industrial areas.

Immediately after issuing the Design Standard in 1975, DID started the urban drainage master plan for urban centres in Malaysia. Twenty-six (26) urban centres have been provided with their own master plans during the 3rd to 7th Five-Year Malaysia Plans. These urban drainage master plans have adopted the design level of 2 to 5-year return period for their proposed drainage facilities as prescribed in the above Design Standard.

Most of the major cities in Japan currently also adopt similar design levels of 5-year return period as given below. Among the cities, however, three (3) cities named Sapporo, Yokohama and Osaka adopt the higher design levels of 10 to 13-year return period. Moreover, Tokyo, the capital of Japan is going to implement a new drainage master plan where the design level will be upgraded to a 10-year return period by the early 21st century. The United Kingdom and the United States project to setup design levels of 5- to 30-year return period for new urban drainage improvement works.

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

As stated above, other countries currently apply similar design levels for urban drainage improvement as those in Malaysia, but they are going to upgrade the design levels to 10 to 30-year return periods. As for Malaysia, however, the aforesaid urban drainage master plans have been hardly implemented, and the current drainage capacity in most of the urban centres still maintain their drainage design levels of less than 2 to 5-year return period. In fact, the trunk drains as well as the river channels existing in the study area could not cope with even the storm rainfall of less than 2-year return period.

In due consideration of the current level of drainage capacity in Malaysia, it is virtually difficult to upgrade the target design level to be more than the present prescribed levels (i.e., 2 to 5-year return period). Instead of upgrading the design level, the most important issue for drainage improvement is judged to be the sustainable implementation of the urban drainage master plans for all major urban centres in Malaysia. From this viewpoint, a 5-year return period is applied as the target design level for this urban drainage master plan.

(2) Target Design Level for Prevention of River Overflow

The river improvement plans have been formulated and/or implemented only for 13 river systems out of the 150 river systems in Malaysia, including Sg. Melaka. Among the 13 river systems, the recent major improvement plans for the rivers in and around the regional urban centres adopt the design flood levels of 50 to 100-year return period with target completion year of 2000 to 2005, as shown below.

Name of River System	State	Design Level	Target Project Completion Year	Proposed in
1. Klang	Selangor	1/100 year	2005	1989
2. Muda	Kedah/Penang	1/50 year	2010	1995
3. Rivers in Georgetown, Penang	Penang	1/50 year	2010	1991
4. Melaka	Melaka	1/50 year	Completed	1990

According to an interview survey with DID, all of the future river improvement plans for regional urban centers will apply the design flood level of 100-year return period in principle, unless particular difficulties in applying the design level arise. In due consideration of these future and foregoing design levels, the design level of 100-year return period is preliminarily assumed as the target design level for the prevention plan of river overflow in this study.

4.1.3 Classification of Drainage and River Channels

The existing guidelines and/or design standards related to flood control in Malaysia do not clearly classify the open channels into river channel and drainage channel. As the result, management responsibility for river channels and drainage channels could not be clearly demarcated. Moreover, difficulties arise in determining the target design level for river channel improvement and drainage channel improvement.

Principal classification between river channel and drainage channel in Japan is based on the areal size of drainage area. The open channels with a drainage area of more than 2 km^2 are classified into river channels, while those with less than 2 km^2 are drainage channels. This classification is adopted to the open channels in the existing and/or projected urban areas in particular. The rivers are managed by the Ministry of Construction or the Local Authority in Japan according to the classification of rivers. On the other hand, local authorities solely manage drainage channels.

In the study area, the trunk drains are idiomatically called as "Line", "Alur" or "Cabang" in Sungai Petani and "Parit" in Melaka, while the rivers are called as "Sungai". Most of the trunk drains have their drainage area of less than 4km^2 as shown Fig. 2-2, and collect the drainage discharge flowing from several roadside drains and infrastructural drains (i.e., secondary and tertiary drains). On the other hand, the rivers have more than 4km^2 collecting flow discharge from several trunk drains.

Among the trunk drains, however, two trunk drains, "Line A1" in the Sg. Petani and "Alur A" in Sg. Lalang have the drainage area of more than 4 km^2. These trunk drains diverge upstream, and their downstream stretches before diverging collect drainage discharge flowing from two trunk drains. Thus, the downstream stretches of these exceptional trunk drains substantially contain the same function as that of rivers. There are also several rivers called as "Sungai" which have their drainage areas of less than 4 km^2 but substantially have the same drainage function as that of trunk drains.

As stated above, the classification of trunk drains and the rivers in the study area could be based on the drainage area as boundary. Drainage improvement for trunk drains is proposed to the channels with a drainage area of less than 4 km^2 in this study.

4.2 Structural Measures for Drainage Improvement

4.2.1 Applicable Measures

The flood discharge is generated from storm rainfall in the basin and finally extracted to the sea through the following levels: (1) basin runoff → (2) flow into drainage channels → (3) concentration into the major river channels → (3) extraction into the sea. The drainage conditions could be improved either at the level of "basin runoff" by reduction of peak discharge or at the level of "flow into drainage channels" by increment of channel flow capacity.

Reduction of the peak basin runoff discharge is made by various types of basin flood detention facilities. The types of facilities include the flood detention pond, storage in public open space, and storage tank at an individual house lot; detailed hydraulic features of these types are as described in Section 3.3. Increment of channel flow capacity is also made by channel improvement which is performed by combinations of widening of channel cross-sections, raising of bank levels, re-alignment of channel lines. Thus, the drainage improvement could be made by a combination of various types of basin flood detention facilities and improvement of drainage channels. Based on this concept, the following items are conceived as the possible structure measures in this Study.

(1) Drainage Channel Improvement

This measure has been conventionally adopted in Malaysia. As the storage capacity of flood detention facilities increases, the peak discharge of the drainage channel is reduced, and therefore, the work volume of drainage channel improvement could be also reduced. However, the increment of storage capacity of flood detention facilities has a limit, while the present flow capacity of drainage channel is extremely small as compared with the design drainage discharge of 5-year return period. Accordingly, all alternatives need to include this measure in common, although the scale of channel improvement varies according to the scale of flood detention facilities assumed in each alternative.

(2) Rehabilitation of Existing Flood Detention Pond

All of the above alternatives are also subject to rehabilitation of existing flood detention ponds. There are twenty (20) ponds in Sungai Petani and one (1) pond in Melaka. Out of these twenty-one (21) existing ponds, thirteen (13) ponds were selected as the eligible facilities for drainage improvement (refer to Table 4-1). The selected ponds have an index of V/A of more than 4000 m^3/ha, or ponding area of 4,000 m^2 together with the sufficient height difference between bottom of pond and outlet drain. The rehabilitation is to be made in the following procedures:

(a) Reform the existing wet pond into a dry pond by reconstruction of the inlet/outlet structure and construction of drain in the ponding areas so as to mitigate the present environmental deterioration of the impounding water;

(b) Reconstruct the outlet structure to remove the rubbish and other hindrances which cause closure of outlet; and

(c) Upgrade the inlet structure to trap the rubbish flashed out by storm water.

Among the objective ponds for rehabilitation, six (6) ponds are further selected as the objectives of excavation of pond bottom judging from the favorable topographic conditions. The excavation increases the storage capacity of the ponds and reduces the peak flood runoff discharge of 100-year return period from the land development area to be the same as the peak discharge before land development. The required excavation depth and volume for the six (6) ponds are as given 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	-	-

Note: V/A = [Storage Volume] / [Catchment Area]

(3) Construction of New Basin Flood Detention Facilities

The facilities to store and regulate flood runoff discharge are classified into either detention type or retention type. The detention type stores runoff discharge and gradually releases it toward the downstream through the outlet structure. On the other hand, the retention type stores runoff discharge but does not release it toward the downstream or slowly releases it over an extended period of several days. A major part of floodwater stored in the retention type is released via infiltration.

Among these two types of flood storage facilities, the retention type is judged to be not feasible due to the low infiltration capacity of the surface soil in the study area as described in the Section 2.7. Instead, the detention type is applied as the design standard for the objective flood detention pond in this study, and the following three (3) types of flood detention facilities are assumed as the possible measures for drainage improvement:

(a) Storage Tank in House Lot

A storage tank with a small outlet hole at the side bottom is installed in each individual house lot to collect the rainfall from the rooftop of the house and regulate outflow discharge from the tank. This storage type has smaller storage capacity and rather high installation cost. Accordingly, this type has less storage efficiency than the other two types. However, this could be installed even in the existing built-up area, where the other two types of detention facility are hardly placed. From this viewpoint, this type is assumed to be placed in the existing residential areas in this Study.

(b) Storage Facility in Public Open Space

The storage measure of this type is such that a public open space (i.e., sport ground and car parking area, etc.) is enclosed by a low wall of about 30 cm in height with a surrounding drain and an outlet collecting the rainfall from the entire public compound. This type has a low construction cost and rather large storage capacity. However, this type could be effective only when an extensive public open space is available and arranged to have lower ground level than the surrounding public compound. Due to the limitation of available public open space, this type is assumed to be placed only in the projected institutional area in this study.

(c) Flood Detention Pond

The flood detention pond stores the flood runoff from a rather extensive catchment area and reduces the peak discharge flowing into the downstream channel. This type of facility contains a much larger flood regulation capacity than the other two types but requires a rather extensive land acquisition. Due to the necessity of an extensive land acquisition, the flood detention pond is assumed, in this study, to be placed only for new land development areas.

4.2.2 Alternative Plans

As described in the foregoing subsection, the alternative plans are three (3) applicable measures, i.e., (1) improvement of drainage channels, (2) rehabilitation of existing regulation ponds, and (3) construction of new flood detention facilities. Among these applicable measures, the first and second measures are applied to all alternative measures in common, and a variation of alternatives is made by difference of new flood detention facilities.

The new detention facilities are classified into the storage tank in an individual house lot, the storage facility in the public open space, and the flood detention pond. Among these, the flood detention pond is regarded as the principal measure for drainage improvement. However, the flood detention pond may not be constructed for a land development area of less than 10 ha due to immunity of the land developer from construction as stipulated by the "Guideline for Flood Detention Pond" prepared by the Town and Country Planning Department. In this connection, the histogram of the past land development area by scale is estimated through the record on housing development schemes in Sungai Petani and Melaka for the past 40 years. As the results, it is clarified that the land development of more than 10 ha takes 78.5% of the whole development area in Sungai Petani and 73.0% in Melaka. Based on this clarification, it is assumed that the flood detention pond could practically cover a maximum of about 80% of the whole projected land development area.

In due consideration of the above, the following six (6) alternatives are selected to attain the design drainage capacity for a probable storm rainfall of 5-year return period.

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.

4.2.3 Optimum Plan

Since the drainage channel improvement is more intensively made with less construction of basin flood detention facility, the runoff will more concentrate into the downstream of river channels and increase its peak discharge. Moreover, the ongoing land development will accelerate the increment of peak runoff. In spite of such increment of peak runoff into the river channel, the present flow capacity of most major river channels is extremely small as mentioned in Subsection 2-5, 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 the results, it is clarified that Alternatives 2 and 3 would still cause significant increments of the peak runoff discharge from the present to the year 2020, as shown in Figs. 4-3, 4-4 and 4-5. On the other hand, should Alternatives 4, 5, or 6 be assumed, no significant difference is 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 it is clarified that 80% of the coverage is required to perform the target drainage capacity without a significant adverse effect to the downstream river channels.

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, which could contain the following distinct advantages:

(1) Drainage Improvement Independent of River Improvement

As described above, the optimum drainage improvement plan could minimize the increment of the peak runoff discharge caused by the land use change as listed below. 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.

(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.

(2) Security of Financial Resource for Project Implementation

The land developer has to construct a flood detention pond for his land development area of more than 10 ha. Since the optimum plan includes the flood detention pond as the principal drainage improvement measure, a substantial part of cost for the optimum plan could be secured from the land development cost of 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 open 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.

4.3 Non-structural Measures

4.3.1 Establishment of Organizational Framework and Demarcation of Functional Responsibility

Malaysia practices a Federal system of Government with governmental functions and responsibilities shared by three tiers of government at Federal, State and Local Levels. Local Government is, however, not independent but is part of the State Administration. The drainage improvement works is currently made through the three tires, but according to the interview survey, three (3) major problems were recognised in the existing organization set-up.

The first problem is the lack of a federal-state interagency coordinating bodies to implement a consistent and comprehensive drainage improvement works. The drainage improvement works fundamentally come under both Federal and State competence as described under the Concurrent List in the Ninth Schedule of the Constitution. The nation-wide urban drainage policy is currently initiated at Federal Level, while the actual implementation of the drainage improvement work vests with the State and the Local Authorities. However, due to the lack of adequate coordination between Federal and State/Local Authorities, the consistent nation-wide drainage policy is hardly reflected to actual implementation of drainage improvement by various agencies in the State/Local Authority level.

The second problem is the lack of the clear demarcation of drainage improvement works. 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. Under the Federal System of Government, the Department of Drainage and Irrigation (DID) is entrusted with the responsibility for flood mitigation and river conservancy works as contained in the Ministerial Functions Act of 1969 (MFA) and the Cabinet Directive of June 1996. However, the legal responsibility for drainage within Local Authority areas still lies with the Local Authorities. The Cabinet Directive of 1996 divided this responsibility between DID and the Local Authorities with the former being responsible for all rivers while the latter for all drains in Local Authority areas. Thus, 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.