CHAPTER 4

DRAINAGE MASTERPLAN STUDY

4.0 DRAINAGE MASTERPLAN STUDY

4.1 INTRODUCTION

4.1.1 The water quantity in the Putrajaya Lake system depends on runoffs flowing into the Lake from the drainage system in the catchment. Thus, it is important that the drainage system in the catchment are planned, designed and constructed to ensure that it does not transport pollutants of any kind into the Lake together with the runoffs. This will be a challenging task because of the numerous solid and liquid pollutants, associated with human activities in the catchment, which can be washed and transported into the drainage system.

4.1.2 Recognising the need for high quality runoffs for the Lake a Drainage Masterplan for the Putrajaya area (Angkasa, 1996) has been prepared by the Perbadanan Putrajaya to ensure that the runoffs from the Putrajaya area are of high quality. However, the drainage systems in the catchment areas outside of the Putrajaya Area have not been planned with the same objective. Thus, there is a need to integrate the other drainage systems with that in the Putrajaya Area into an integrated Drainage Masterplan for the Lake catchment.

4.1.3 The integrated Plan should include all pertinent innovative strategies to minimise pollutant entry into the Lake system. There is also a need to define pertinent drainage planning and design guidelines to ensure that the runoff quality entering the Lake system is high. Such guidelines have also been developed for the Putrajaya Area (Angkasa, 1998).

4.1.4 The focus of this study will be on integrating the drainage systems outside of Putrajaya with the Putrajaya Area drainage system. Thus, most of the standards and guidelines for the Putrajaya Area will be applicable to the other drainage systems as well.

4.2 EXISTING AND PROPOSED DRAINAGE SYSTEMS IN THE CATCHMENT

4.2.1 Topographical mapsheets (3756 and 3575) of 1:50,000-scale published by the Jabatan Ukur dan Pemetaan in 1992, that encompasses the Sg. Chuau catchment, were used to delineate the catchment area, in relation to the Putrajaya and the other stakeholder areas. The result of the delineation exercise is shown in Figure 4.1.

4.2.2 Information on the existing and planned drainage systems for the following areas have been compiled:

- Putrajaya Area
- IOI Palm Garden Resort Area
- TNB Generation Area
- MARDI,
- UPM,
- West Country
- Cyberjaya (Flagship Zone).

4.2.3 The overall layout of the drainage system outside the Putrajaya area is as shown in Figure 4.2. Pertinent details on the above systems are described below.

4.2.1 Putrajaya Area

4.2.1.1 The drainage system proposed for the Putrajaya Area (Figure 4.3) consists of the following major components:

- Stormwater pipes or conduits
- Open channels
- Culverts
- Detention ponds
- Gross Pollutant Traps (GPTs)
- Water Pollution Control Ponds (WPCP)

4.2.1.2 The total length of the trunk or main drains in the Area is about 58.1km long. To ensure that no gross pollutants are carried into the Lake by the drainage runoff 116 GPTs have been proposed for the Area. A standard drawing of a major GPT is shown in Figure 4.4.

4.2.1.3 The design for the drainage system in the Area is based on the *Major/Minor* approach. This is also known as the Major/Initial Drainage System in the DID Urban Drainage Design Standard (1975) or UDDS.

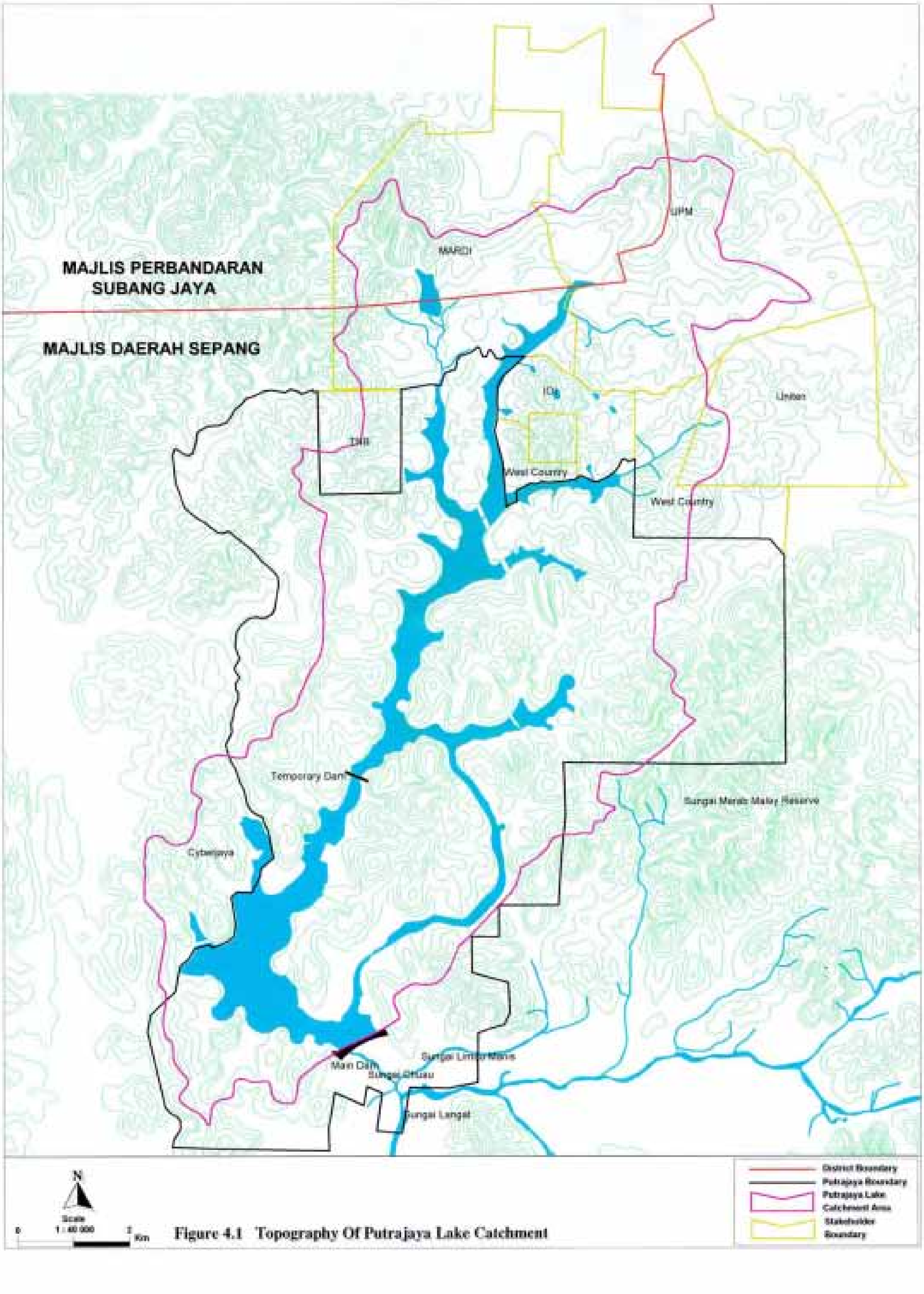


Figure 4.1 Topography Of Putrajaya Lake Catchment

Figure 4.2 Drainage Systems for Areas Outside Putrajaya

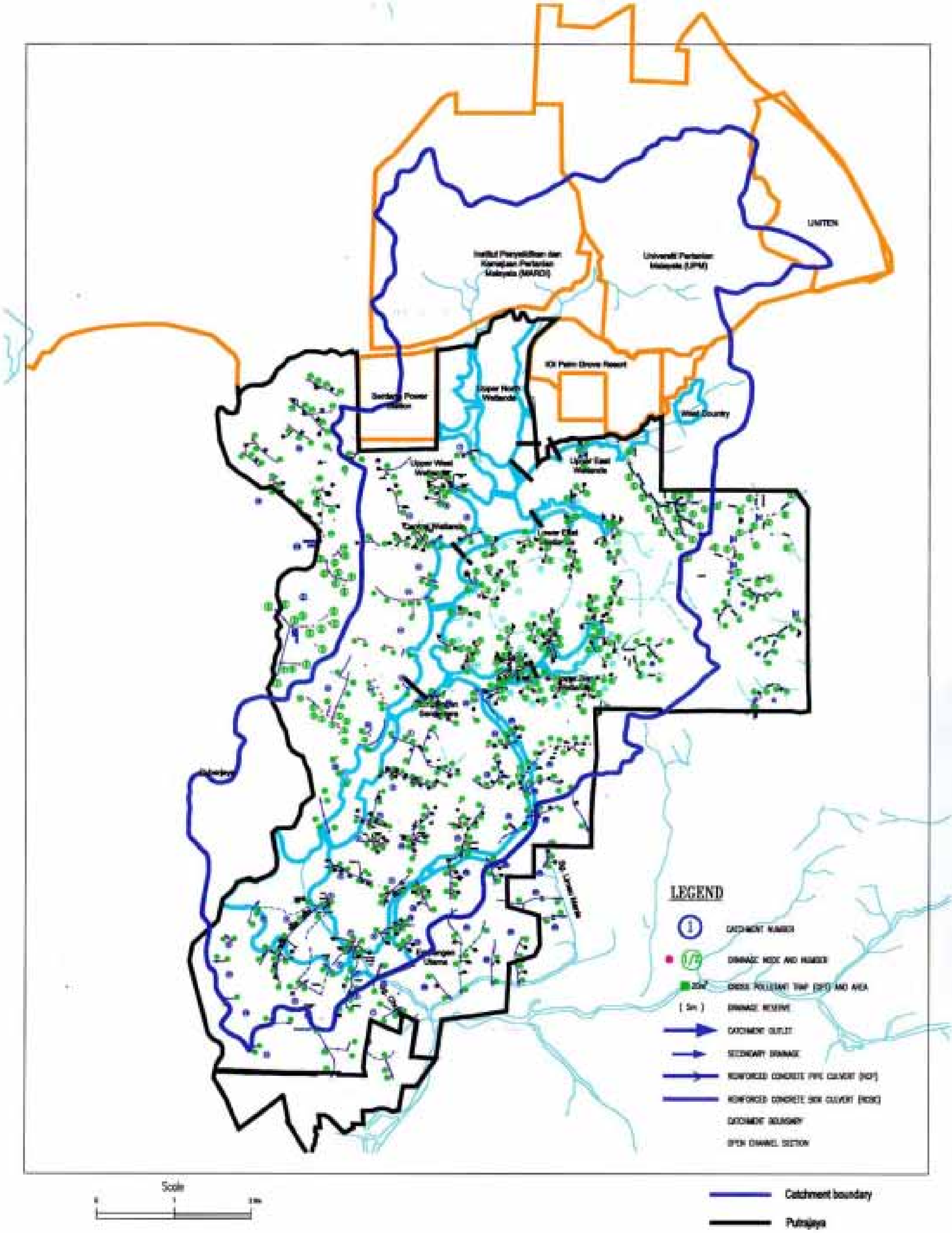


Figure 4.3 Drainage System for Putrajaya

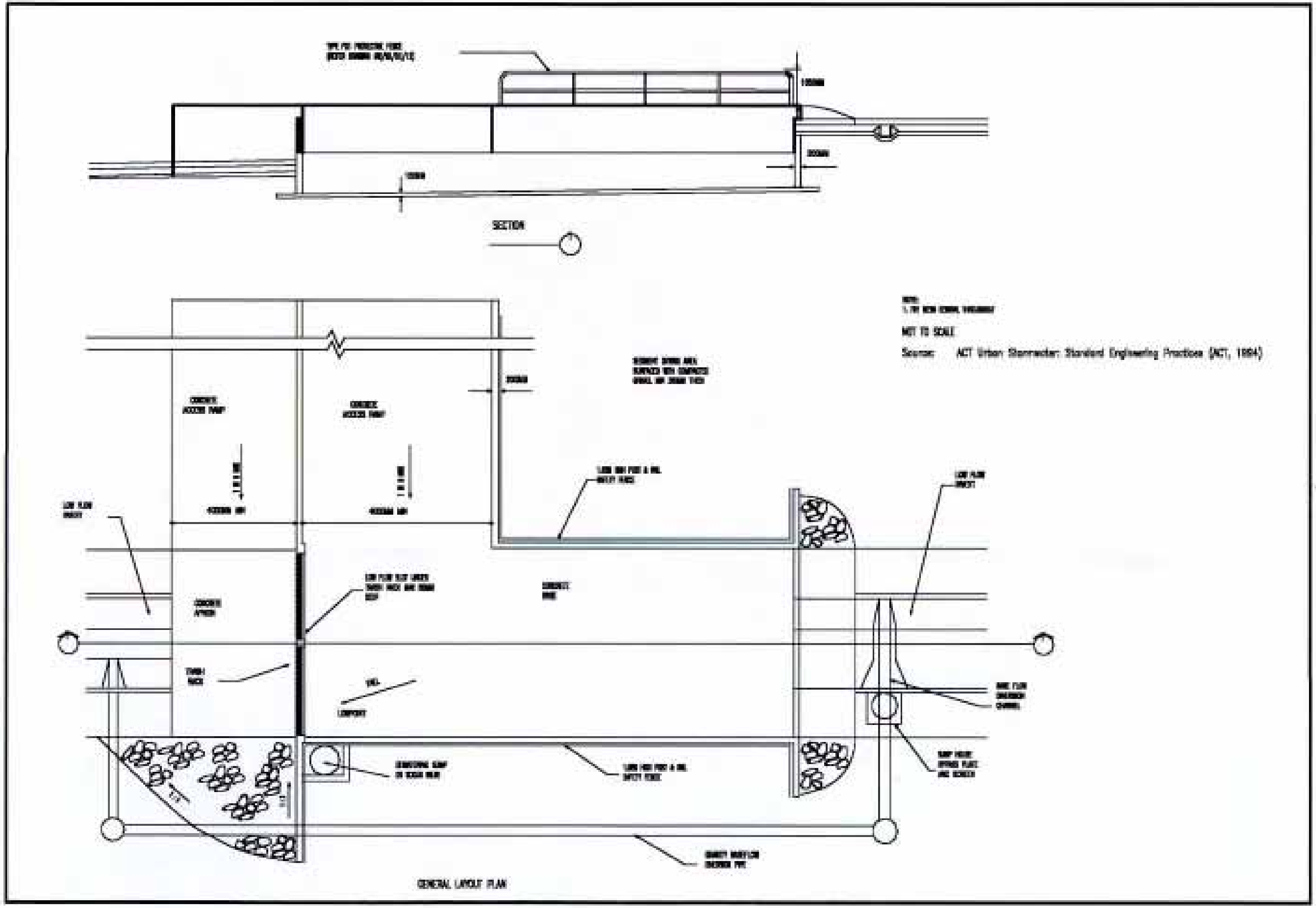


Figure 4.4 Standard Drawing of Major GPT (ST-033)

4.2.1.4 The *Minor system* comprises of the street gutters, inlets, channels and/or pipes. They are to be designed with conveyance capacities catering for storm runoff of 2 to 10-year average recurrence interval (ARI). The level of protection to be provided depends on the acceptable damages and inconvenience to the public in the surrounding areas caused by any 'exceedance'.

4.2.1.5 The *Major system* comprises of trunk drains or pipe networks. They are to be designed to convey, upon collection from the minor components, the 100-year ARI flood 'safely' to the receiving waters.

4.2.1.6 An example of the typical dimensions and conveyance of the open drains are given in Table 4.1 based on the schematic cross-sections given in Figure 4.5.

4.2.2 IOI Palm Garden Resort Area

4.2.2.1 The IOI Palm Garden Resort is located north of the Upper East Wetland and east of the Upper North Wetland. It consists of an existing club house, existing service apartment, an office and condominium development (under construction), proposed future office and hotel giving a total catchment area of 135 ha.

4.2.2.2 The area can be divided into 5 sub-catchment areas. The drainage system in the area comprises of a series of detention ponds draining into the Upper North and Upper East Wetlands. There are two existing drainage outlets. They are North-pointing and drains to the roadside drains connecting to the Upper North Wetlands. The other three drainage outlets are proposed. There are two outlets connecting to the Upper North Wetlands directly and one connecting to the Upper-East Wetland. The detention ponds in each subcatchment area have been provided to reduce flood peak discharges from the area.

4.2.2.3 Figure 4.6 shows the location of the detentions ponds and the drainage outlets. Table 4.2 gives the design discharges for the drainage system.

4.2.2.4 Most of the drainage system are underground reinforced concrete pipe from various sizes ranging from 0.75m diameter up to 1.5m diameter.

Table 4.1 Dimensions and Conveyance of Major and Minor Open Drains in the Putrajaya Area

Channel Type	Flow Regime	Horizontal Widths per Slope (1V:??H)					Composite Manning's n	Top Width (m)	Total Area (m^2)	Wetted Perimeter (m)	HydrauliсRadius (m)	Conveyance	Maximum Slope (%)
		Centre (m)	1 (m)	20 (m)	2 (m)	35 (m)							
1	Minor	0.90	0.45	1.50	0.40	0.00	0.045	6.5	1.8	6.9	0.26	17	4.7
	Major	0.90	0.45	1.50	0.40	7.00	0.055	20.5	4.5	20.9	0.22	29	9.4
2	Minor	0.90	0.45	2.20	1.00	0.00	0.049	9.1	3.2	9.5	0.33	31	4.2
	Major	0.90	0.45	2.20	1.00	9.00	0.056	27.1	7.8	27.5	0.28	60	6.8
3	Minor	0.90	0.45	3.70	1.50	0.00	0.052	13.1	5.7	13.5	0.42	61	3.5
	Major	0.90	0.45	3.70	1.50	11.00	0.057	35.1	13.3	35.6	0.37	120	4.9
4	Minor	0.90	0.45	4.80	1.80	0.00	0.054	15.9	7.9	16.4	0.48	90	3.1
	Major	0.90	0.45	4.80	1.80	13.00	0.058	41.9	18.6	42.4	0.44	187	4.0
5	Minor	1.05	0.53	5.20	2.00	0.00	0.053	17.6	9.8	18.1	0.54	121	2.6
	Major	1.05	0.53	5.20	2.00	14.00	0.057	45.6	22.4	46.1	0.49	241	3.5
6	Minor	1.05	0.53	6.20	2.50	0.00	0.054	20.6	13.3	21.1	0.63	180	2.2
	Major	1.05	0.53	6.20	2.50	16.00	0.058	52.6	30.0	53.1	0.57	355	2.9
7	Minor	1.20	0.60	7.00	2.70	0.00	0.054	23.0	16.5	23.6	0.70	239	1.9
	Major	1.20	0.60	7.00	2.70	19.00	0.058	61.0	39.3	61.6	0.64	503	2.4
8	Minor	1.20	0.60	7.00	3.30	0.00	0.055	24.2	19.3	24.8	0.78	299	1.7
	Major	1.20	0.60	7.00	3.30	20.00	0.058	64.2	44.6	64.9	0.69	599	2.2
9	Minor	1.20	0.60	9.00	4.80	0.00	0.056	31.2	32.8	31.9	1.03	599	1.2
	Major	1.20	0.60	9.00	4.80	26.00	0.058	83.2	75.3	83.9	0.90	1199	1.6

Source: Drainage Master Plan Study for Putrajaya Development (Angkasa, 1996)

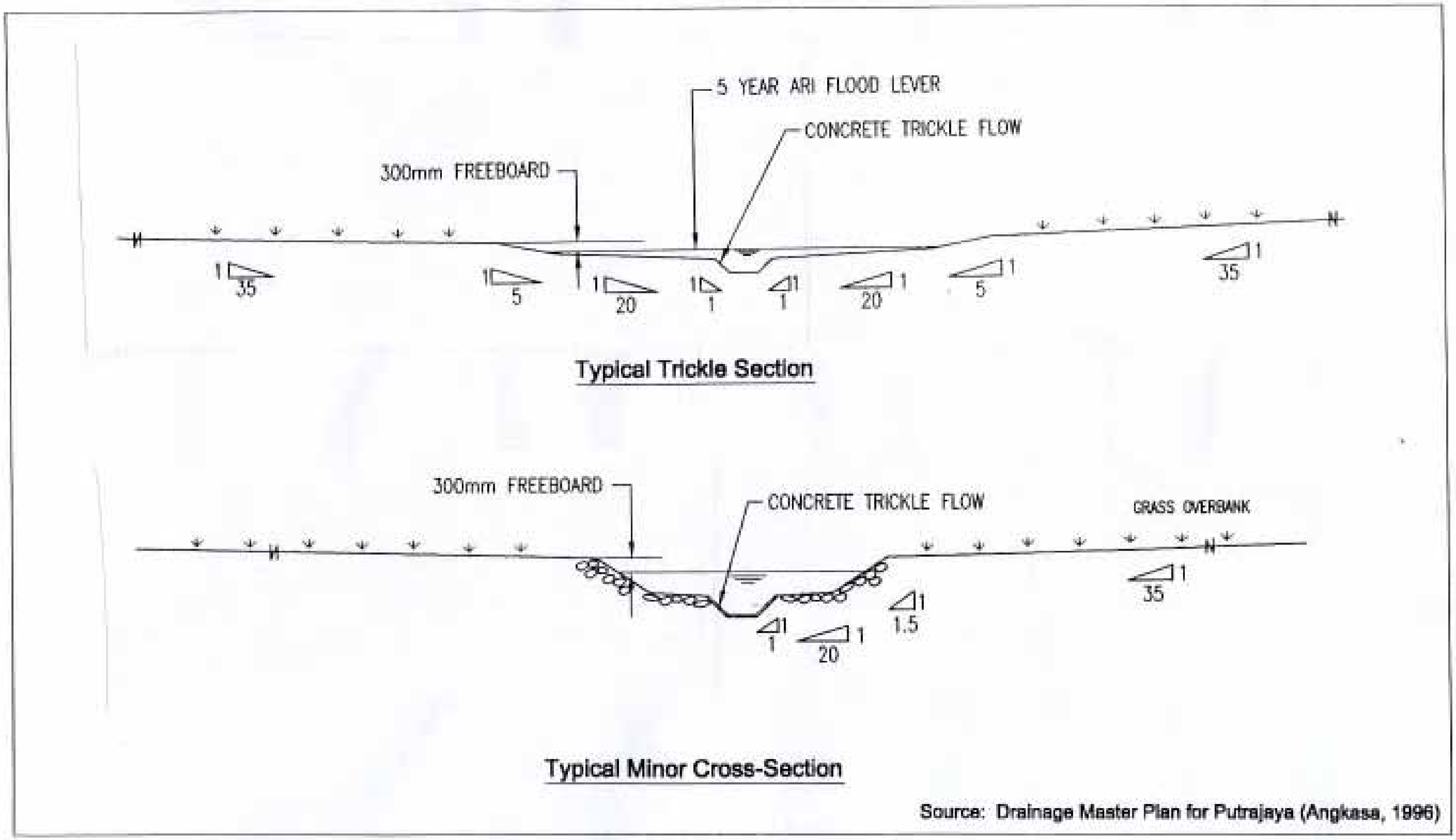


Figure 4-5 Typical Drain Types and Dimensions for Putrajaya

Table 4.2 Drainage System Design Data for IOI Palm Garden Resort Area

LOCATION		AREA			S-AREA TIME OF CON.			DESIGN DISCHARGE-INITIAL STORM							MAJOR STORM			TIME OF FLOW SECT.		
Drain Section	Sub- Area	Area (A) Ha	Runoff Coeff. (C)	Equiv. Area (C*A) Ha	Overland time Min	Drain time Min	Sub-Area TOC Min	Design Return Period Years	Total Equiv. Area (C*A) Ha	Critical Time of Concn. (tc) Min	Total Time in Drain (td) Min	Storage Coeff. (Cs)	Rainfall Intensity (i) mm/hr	Disch. Q= 0.00278* (C*A)*i*Cs Cumec	Design Return Period Years	Rainfal Intensity (i) mm/hr	Discharge Q= 0.00278* (C*A)*i*Cs Cumec	Velocity m/s	Length m	Time of Flow in Section Min
Outlet A	**1**	37.02	0.5	18.51	10	11	21	5	18.51	21	11	0.79245	150	**6.1166819**	100	220	**8.9711334**	0.90909	600	11.0
Outlet B	**2**	40.74	0.45	18.33	10	13	23	5	18.33	23	13	0.77966	130	**5.1656801**	100	190	**7.5498401**	0.89744	700	13.0
Outlet C	**3**	27	0.7	18.9	7	7	14	5	18.9	14	7	0.8	150	**6.30504**	100	240	**10.088064**	0.83333	350	7.0
Outlet D	**4**	18.7	0.6	11.22	9	9	18	5	11.22	18	9	0.8	145	**3.6182256**	100	220	**5.4897216**	0.55556	300	9.00
Outlet E	**5**	10.5	0.8	8.4	7	7	14	5	8.4	14	7	0.8	150	**2.80224**	100	240	**4.483584**	0.71429	300	7.00

Figure 4.6
Drainage Plan for IOI

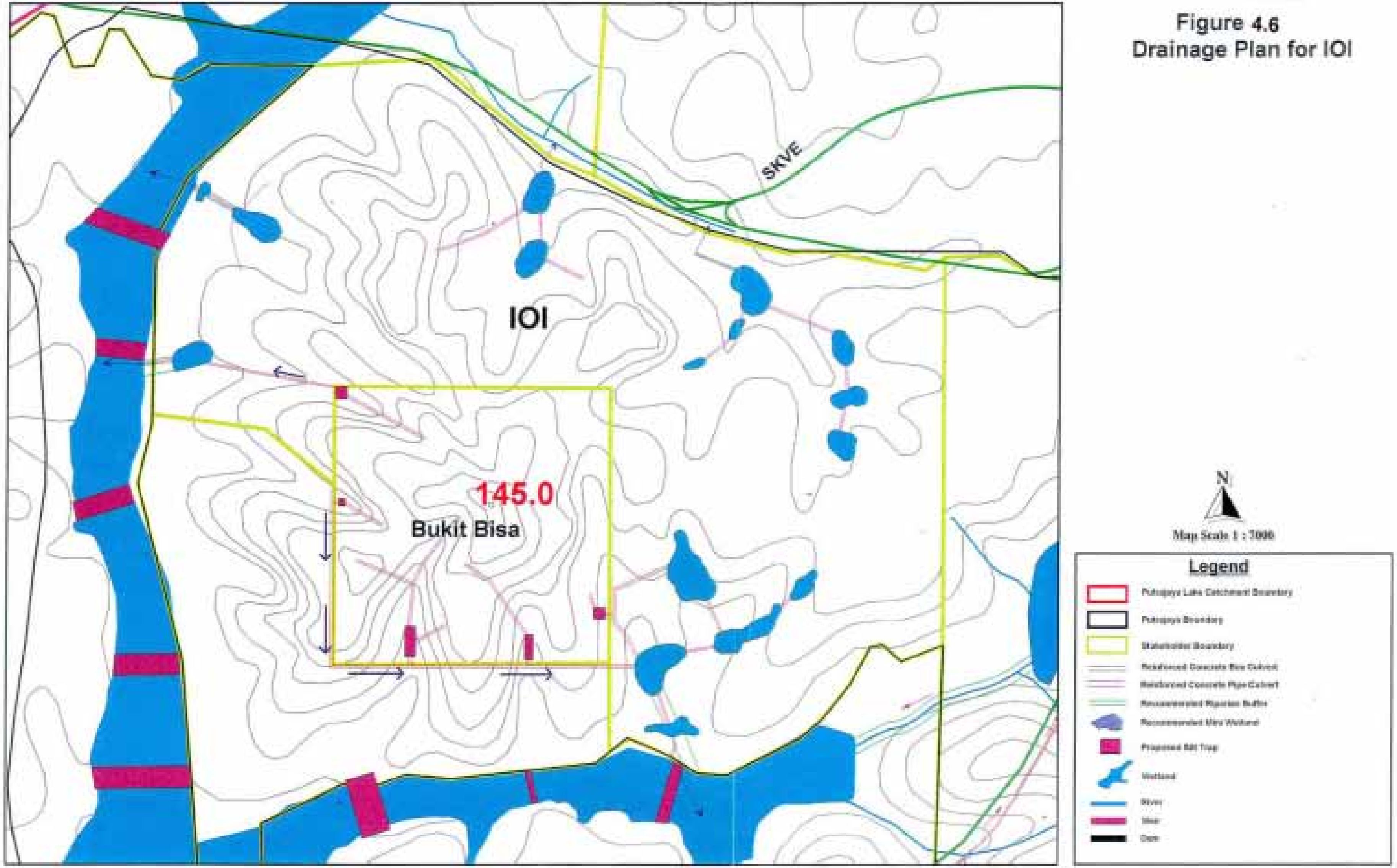


Table 4.3 Drainage System Design Data For MARDI

LOCATION		AREA			S-AREA TIME OF CO			DESIGN DISCHARGE - INITIAL STORM							MAJOR STORM			TIME OF FLOW SECT.		
Drain Section	Sub-Area	Area (A) Ha	Runoff Coeff. (C)	Equiv.Area (C*A) Ha	Overland time Min	Drain time Min	Sun- Area TOC Min	Design Return Period Years	Total Equiv. Area (C*A) Ha	Critical Time of Conc. (tc) Min	Total Time in Drain (td) Min	Storage Coeff. (Cs)	Rainfall Intensity (i) mm/hr	Disch. Q= 0.00278* (C*A)*i*Cs Cumec	Design Return Period Years	Rainfall Intensity (i) mm/hr	Discharge Q= 0.00278* (C*A)*i*Cs Cumec	Velocity m/s	Length m	Time of Flow in Section Min
A-C	**1**	161.2	0.35	56.42	20	93	113	5	56.42	113	93	0.708846	50	**5.556044**	100	78	**8.6674279**	0.30018	1675	93.0
B-C	**2**	295.3	0.35	103.4	20	156	176	5	103.4	176	156	0.69291	35	**6.968243**	100	50	**9.9546328**	0.30043	2812	156.0
Point C								5	159.8	176	156	0.69291	35	**10.77211**	100	50	**15.388723**			
Point E	**3**	560	0.45	252	20	136	156	5	252.00	156	136	0.69643	40	**19.5156**	100	60	**29.2734**	0.30172	2462	136.0

4.2.3 MARDI

4.2.3.1 MARDI is located adjacent to UPM and has a total area of about 752 ha. 65% of the MARDI area or 488 ha is located within the Putrajaya Lake Catchment. The principal land-use of MARDI is for agricultural research activities such as farms and orchards.

4.2.3.2 The existing drainage system is as shown in Figure 4.7. The area is largely undeveloped. There are a few existing large ponds which helps to reduce flood peak discharges from the area.

4.2.3.3 It will not be necessary to carry out any major improvement or treatment works to the drainage system. Table 4.3 gives the design discharge for the drainage system.

4.2.3.4 The drainage design discharge has been calculated with the assumption that the area is undeveloped, relatively flat and the runoff coefficient is 0.35. The result showed that the discharge for 5 years return period is 5.56 cu.m/s and 8.67 cu.m/s for 100 years return period.

4.2.4 UPM

4.2.4.1 The existing drainage system in the UPM area is as shown in Figure 4.8. The proposed development of the UPM area is not known as up-to-date the information has not been provided to the Consultant by UPM.

4.2.4.2 It is recommended in any case that UPM follow the guidelines as recommended in the Putrajaya Stormwater Management Design Guidelines. The area is large and there is plenty of space for detention ponds and constructed wetlands. UPM will therefore have little problem in following the guidelines.

4.2.5 Cyberjaya (Flagship Zone)

4.2.5.1 The catchment of Cyberjaya draining into the proposed Putrajaya Lake totals 231 ha and is made up of the following land use:

Land use	Area(ha)	Percentage
Open space	52.48	22.72
Housing	54.93	23.78
Road, drains, lake and other public facilities	119.1	51.56
Commercial	4.49	1.94
TOTAL	**231**	**100**

Source: Setia Haruman Sdn. Bhd.

4.2.5.2 The Cyberjaya area can be divided into 4 sub-catchments whose outfall into the Putrajaya Lake are A, B, C and D as shown in Figure 4.9.

4.2.5.3 The storm runoff for each location are tabulated as follows:

Location	Catchment Area (ha)		Storm Water Discharge	
	From Inside Cyberjaya	From Outside Cyberjaya	Q5 (cumec)	Q100 (cumec)
A	89	30	25.8	46
B	58	-	13.5	24
C	62	-	13.5	24
D	22	-	5.6	10

Source: Setia Haruman Sdn. Bhd.

The storm water discharge has been derived based on the guidelines given in the Urban Drainage Design Standards and Procedures for Peninsular Malaysia, Planning and Design Procedures No. 1 from DID.

4.2.5.4 Cyberjaya is quite advance in the design of the drainage system in its area. The system is designed to comply with the water quality standards required by the Department of Environment as surface runoff into the lake would be discharged through Gross Pollutant Traps (GPTs) and water quality enhancement pond. The proposed locations of GPTs and water quality enhancement pond are also shown in the Figure 4.9.

Figure 4.7
Drainage Plan for MARDI

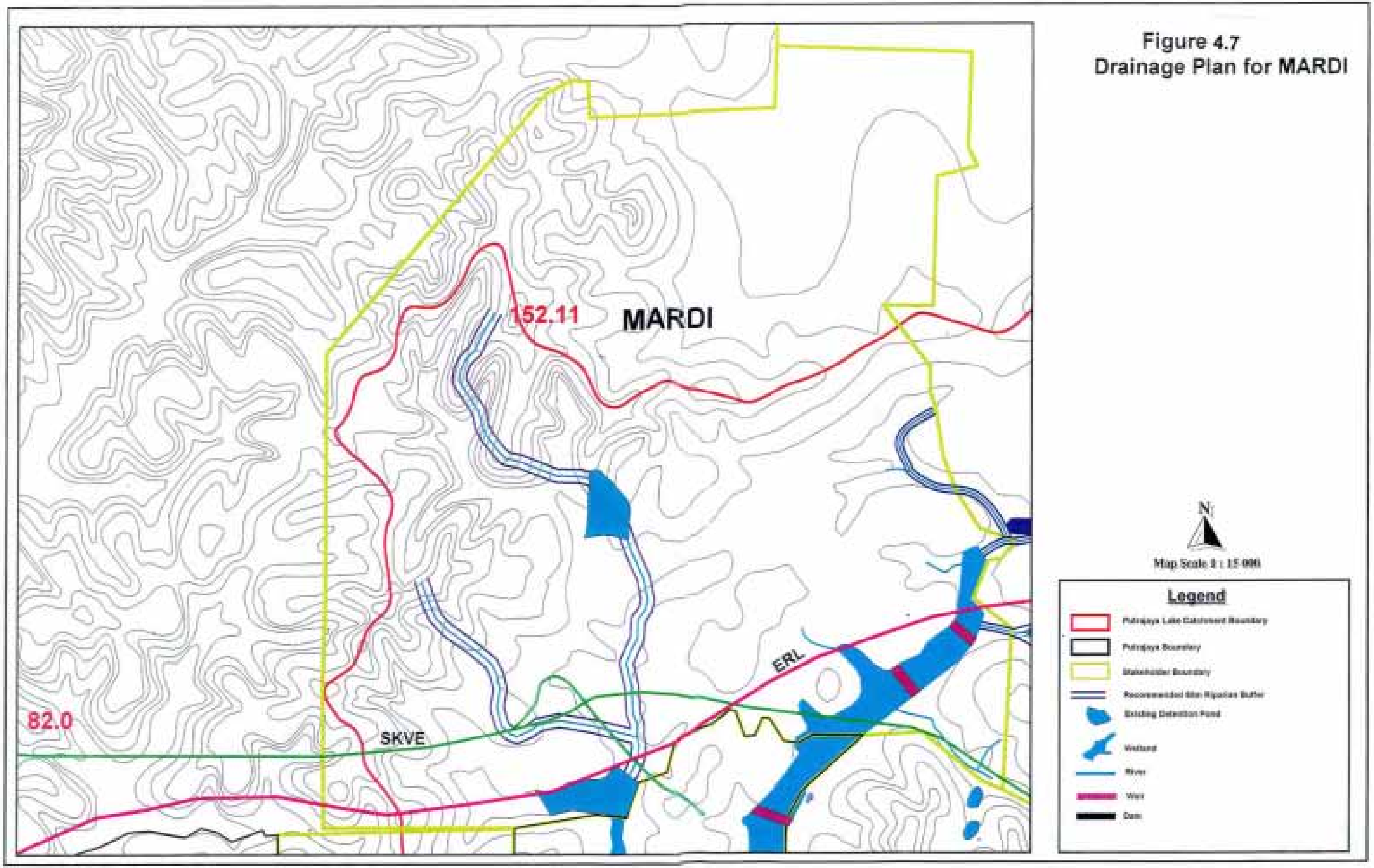
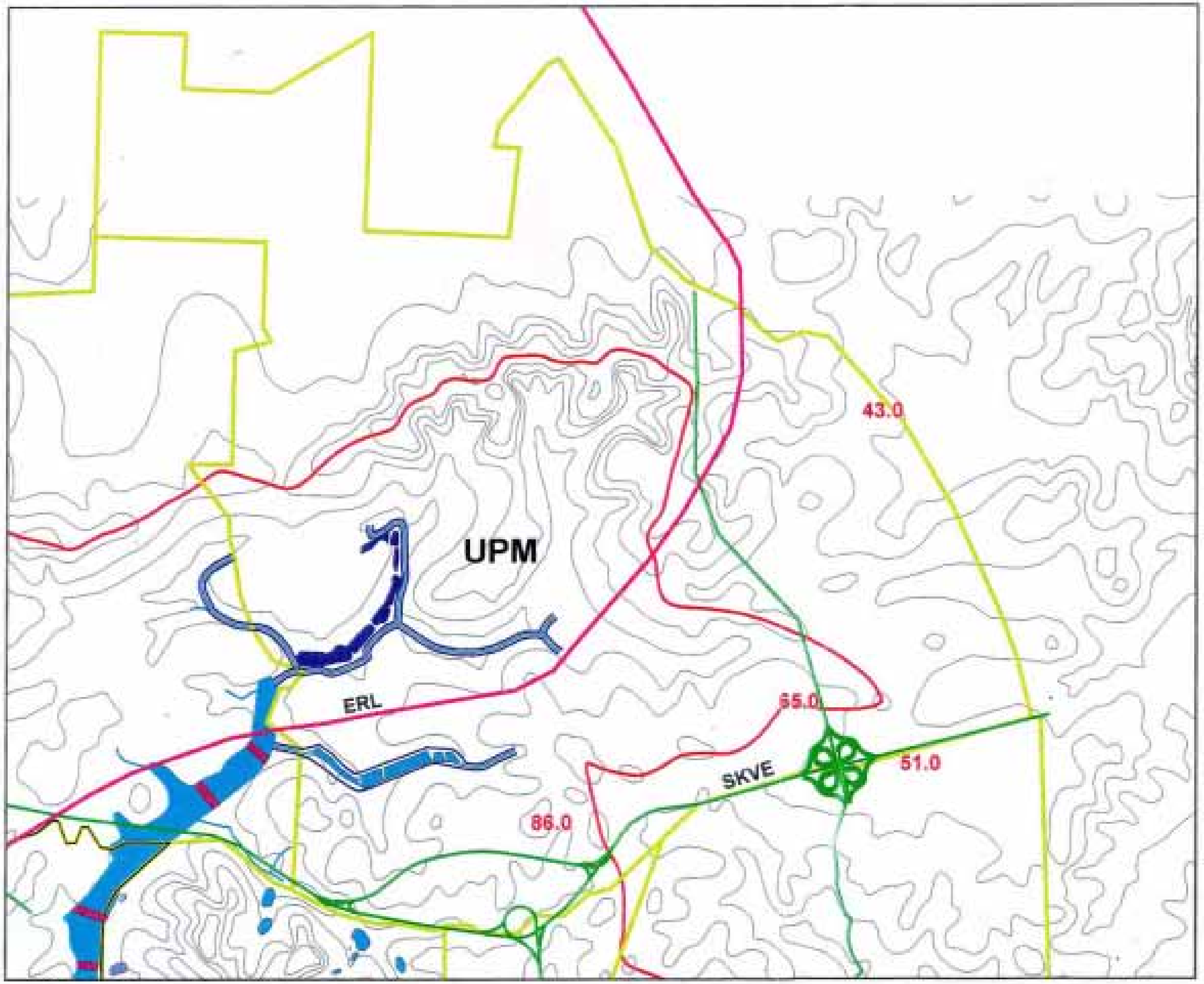
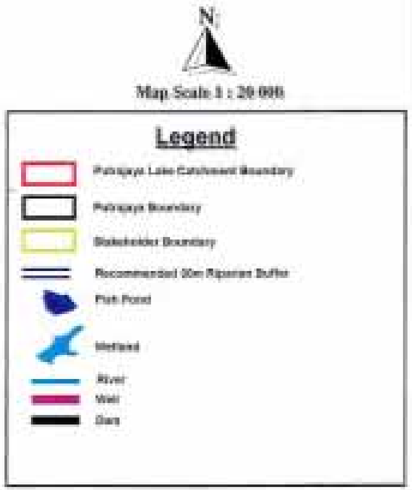


Figure 4.8
Drainage Plan for UPM





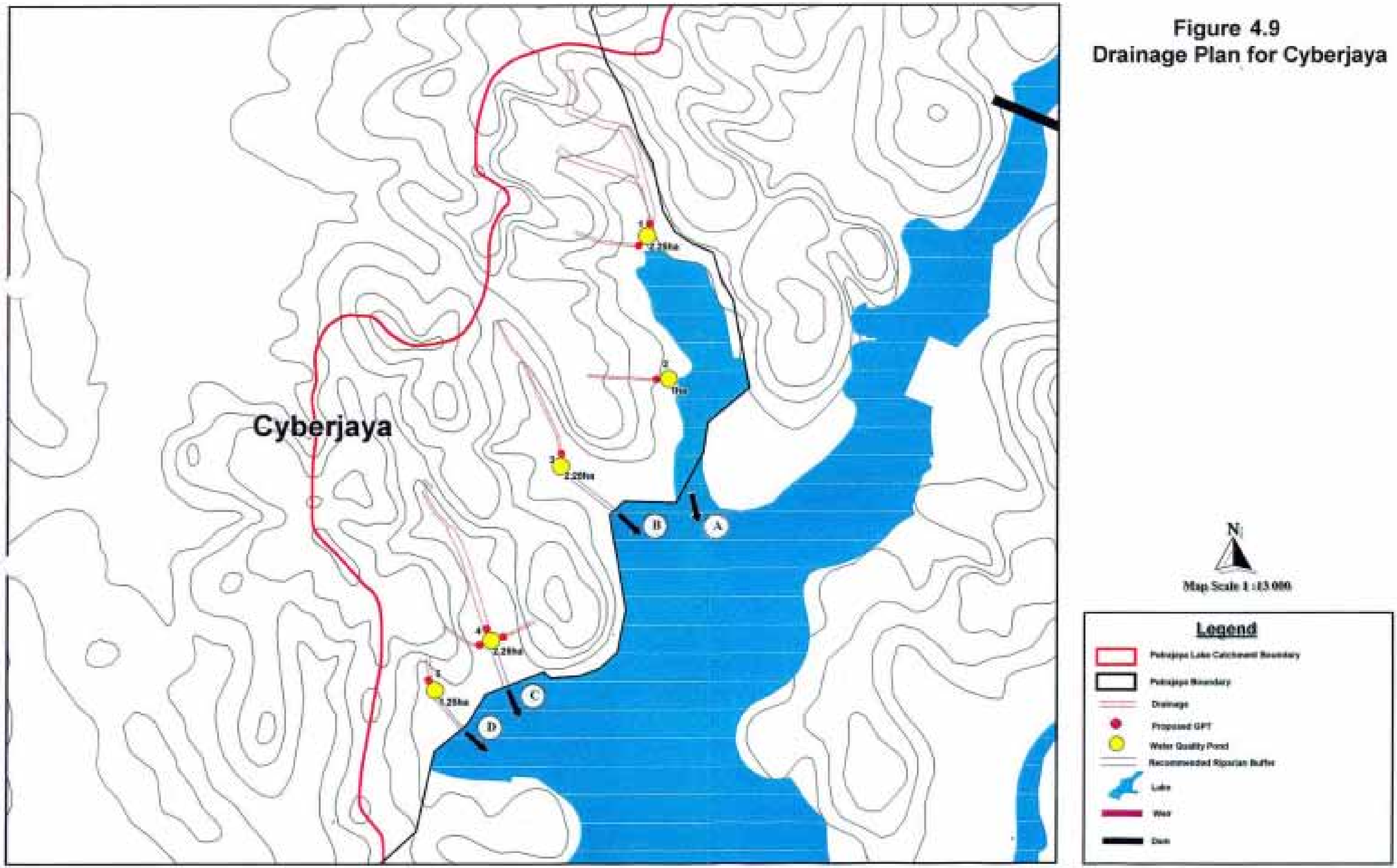


Figure 4.9
Drainage Plan for Cyberjaya

4.2.6 West Country

Figure 4.10 depicts the proposed drainage system, which will be directed into a detention pond just upstream of the Upper East Wetlands in Putrajaya, for West Country development. The proposed area of detention pond is about 11 acres (4.4 ha.) and will have one drainage outlet system MD1 flowing into the wetland in Putrajaya.

4.3 DRAINAGE PLANNING AND DESIGN GUIDELINES

(1) The Putrajaya Stormwater Management Design Guidelines (Angkasa, 1998) has been prepared to ensure a high quality runoff from the Putrajaya Area. To ensure uniformity in the drainage design standards, the Consultant recommends that the Guidelines be also applicable to the catchment areas outside of the Putrajaya Area. Table 4.4 gives an example of what is contained in the Guidelines. The table shows the lists of design considerations associated with 4 stormwater management objectives.

(2) An example of another appropriate drainage design guideline is the ASCE Manuals and Reports on Engineering Practice No. 77 (1992). An extract from the Practice No.77 Report is given below.

"If the (drainage) design is developed with the following concepts in mind, a good (storm) water quality management system will result.

- Design runoff quality controls to capture small storms.
- Design to maximise sediment removal, and removal of other pollutants.
- The most effective method for reducing urban runoff pollution is to minimise directly connected impervious areas (DCIA).
- Infiltration devices are most efficient but most difficult to maintain (and can only be used where groundwater is not a problem).
- Dry detention is easiest to design and operate, and efficiency is satisfactory if properly designed."

Figure 4.10
Drainage Plan for West Country

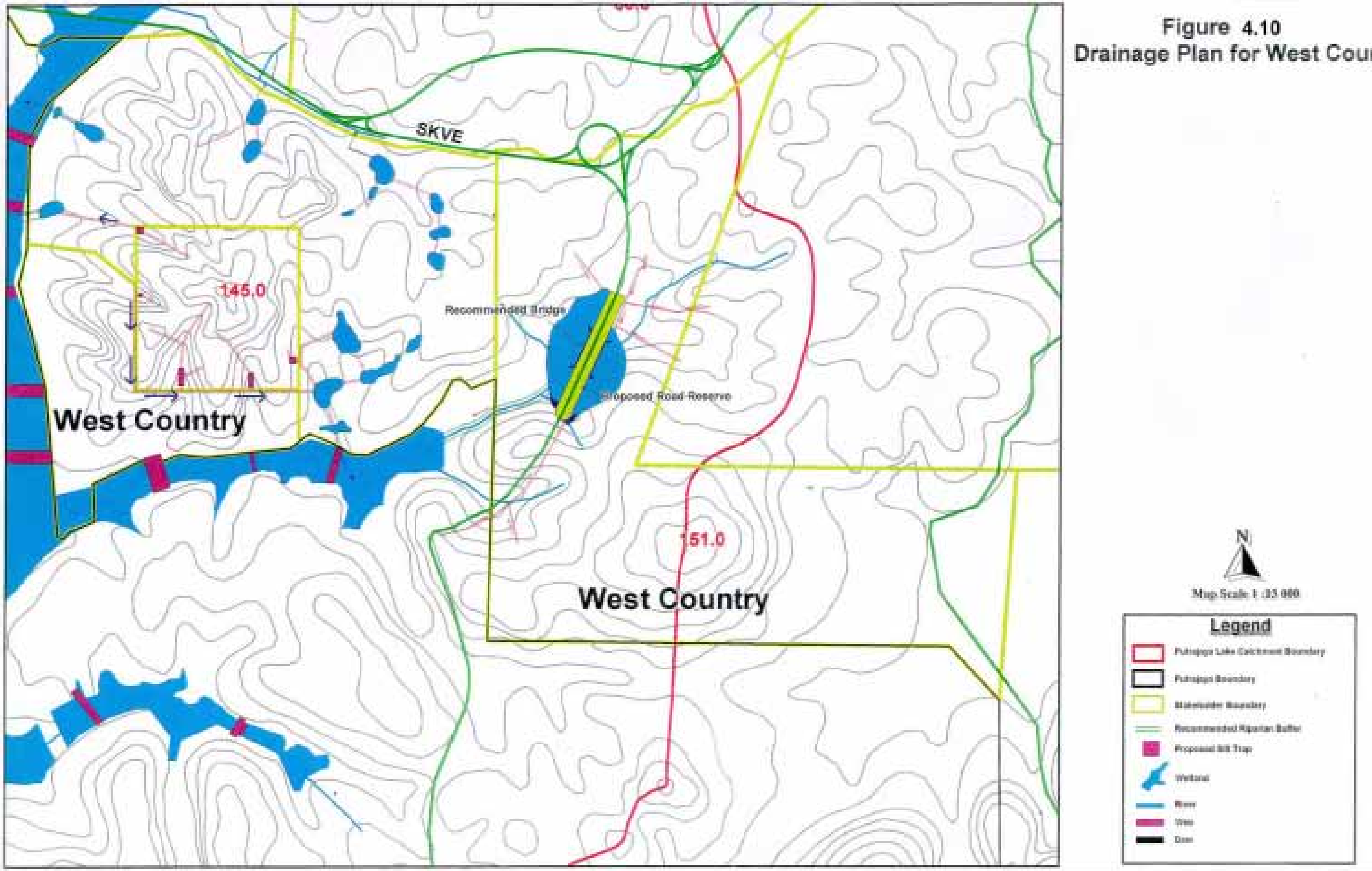


Table 4.4 Design Considerations Associated with 4 Stormwater Management Objectives

Stormwater Management Objectives	Design Considerations
1. Stormwater drainage	▪ Cost-effective means of stormwater conveyance system (a risk-based approach in selecting appropriate design standards for the minor and major drainage system); ▪ Prevention of nuisance flooding (minor drainage system); ▪ Safe conveyance of overland flow through the use of designated floodways and retarding basins (major drainage system); ▪ Structural measures to prevent the blockage of the drainage system by urban litter and flood debris.
2. Stormwater as a resource	▪ Removal of gross pollutants to facilitate the utilisation of stormwater to sustain urban features such as lakes and urban streams; ▪ Re-use of stormwater as a source of non-potable water supply
3. Protection of receiving water quality	▪ Removal of gross pollutants to facilitate further treatment of stormwater; ▪ Flow detention to facilitate sedimentation of coarse and medium sized particles ▪ Removal or reduction of stormwater pollutants to achieve water quality standards by a combination of source and in-transit control measures ▪ Environmental management of construction sites
4. Protection of downstream aquatic habitats	▪ Flow detention and in-stream retardation to prevent excessive physical disturbance of aquatic habitat by stormwater runoff ▪ Removal or reduction of stormwater pollutants to achieve water quality standards by a combination of source and in-transit control measures ▪ Environmental management of construction sites

Source: Putrajaya Stormwater Management Guidelines (Angkasa, 1998)

(3) The concepts of Best Management Practices (BMPs) have been established in developed countries during the past two decades for the design and construction of stormwater drainage systems. The practices are mainly policies, procedures, measures or structures implemented to mitigate the adverse impacts on surface water quality from development.

(4) In this drainage masterplan study, the BMPs highlighted, emphasized and recommended are focused primarily on surface run-off control to mitigate peak flows in drainage systems, with some consideration on preserving water quality by reducing gross pollutants (sediments). More elaborate control of pollution in the drainage as well as lake-wetland systems are presented in the environment and water quality studies.

4.3.1 Reduction of Peak Runoff Discharge

Wetlands require a continuous supply of water in order to function. However high peak flows will result in water being flushed out of the system since the excess water will be discharged rapidly. What is needed is a continuous yet slow supply of water to maintain the wetlands. A reduction in peak discharge of the runoff from the catchment before it enters the wetlands is important. The following steps must be carried out to ensure that this can be done.

4.3.1.1 Promote infiltration

(1) Rainwater that infiltrates into the ground and slowly enters the streams contributes to the base flow into the reservoir. This base flow is dependent on the infiltration capacity of the soil. A forested area has a high infiltration capacity. The dense root systems provide ingress to the subsoil. The layer of organic debris form a sponge like surface, while the burrowing animals and insects open up ways into the soil. The cover prevents compaction and the vegetations transpiration removes soil moisture.

(2) On the other hand, exposed soils can be rendered almost impermeable by the compacting of large drops coupled with the tendency to wash very fine particles into the voids. Compaction due to man or animals treading the surface, or to vehicular traffic can severely reduced infiltration capacity.

Similarly, paved surfaces can reduce the infiltration capacity of the soil.

(3) Typical schematics of infiltration devices are shown in Figures 4.11 and 4.12.

4.3.1.2 Zero increase in peak discharge

(1) The formula for peak runoff estimation based on the Modified Rational Method is;

$$Q = C_s C i A$$

where
- Q is the peak discharge
- i is the average intensity of rainfall
- A is the catchment area
- C is the runoff coefficient
- C_s is the storage coefficient

(2) If all other parameters remain constant, it can be seen from the above formula that an increase in the peak discharge is directly proportional to an increase in the runoff coefficient.

(3) At the moment, the land use in the basin is mainly agricultural. The coefficient of runoff based on the Rational Method is between 0.3 to 0.45. A fully built up area will have a coefficient of runoff between 0.8 to 0.9. Thus the peak discharge can double should the area be fully built up.

(4) While it may be necessary, due to development, to increase the built up area in the catchment, steps must be taken to ensure that the peak discharge is not increased. This can be achieved by careful drainage design.

(5) The Department of Irrigation and Drainage requires that at least 5% of any area proposed for development must be reserved for conversion into detention ponds.

(6) Using this guideline a hypothetical area (completely paved and impermeable) of 100 ha with a 5 ha detention pond was studied.

(7) Assuming a rainfall distribution as shown in Figure 4.13 and using the design IDF curves for Putrajaya (Figure 4.14), the

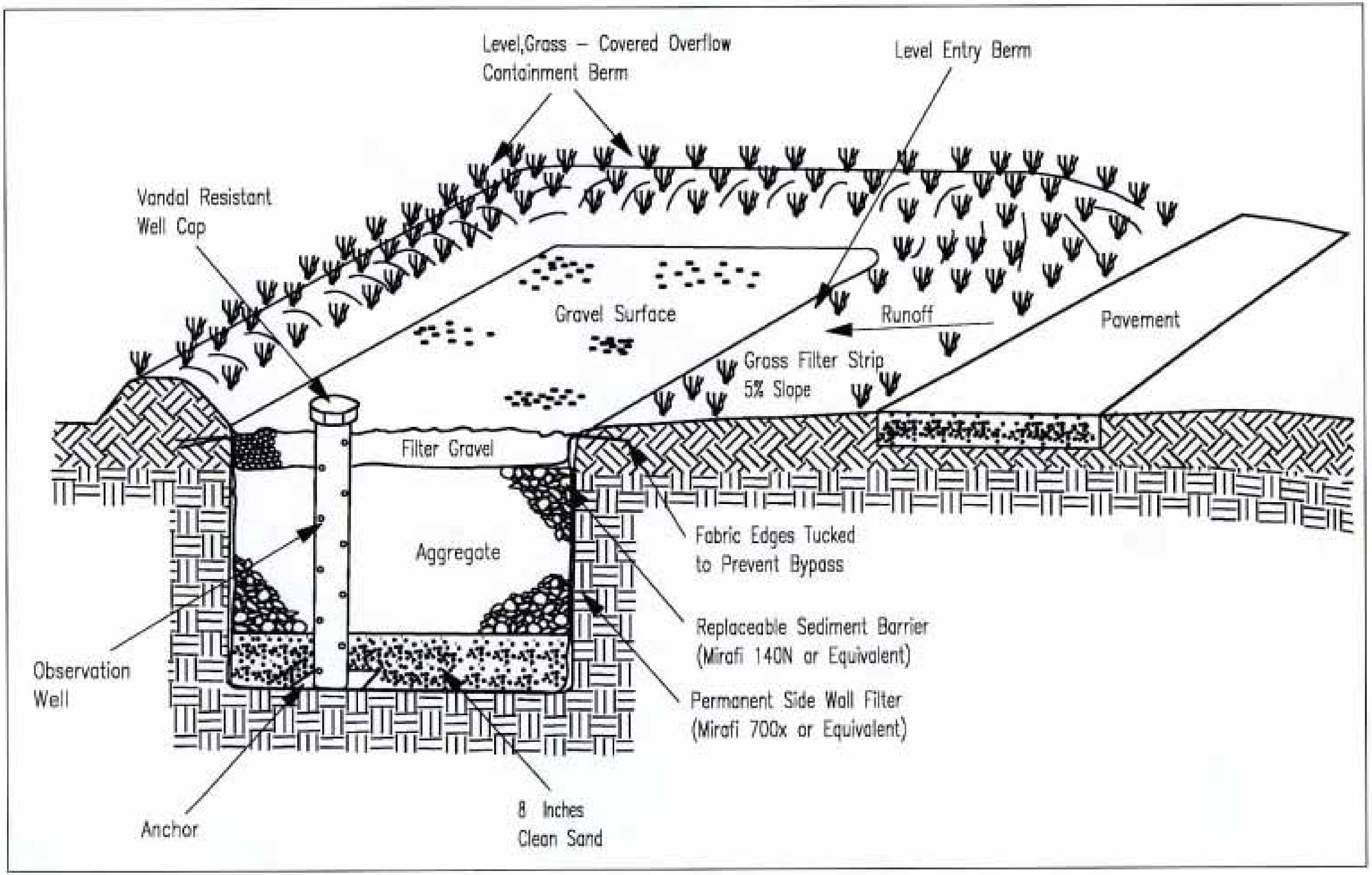


Figure 4.11 Typical infiltration trench.
(Source: Engineers & Surveyors Institute and Northern Virginia District Planning District Commision)

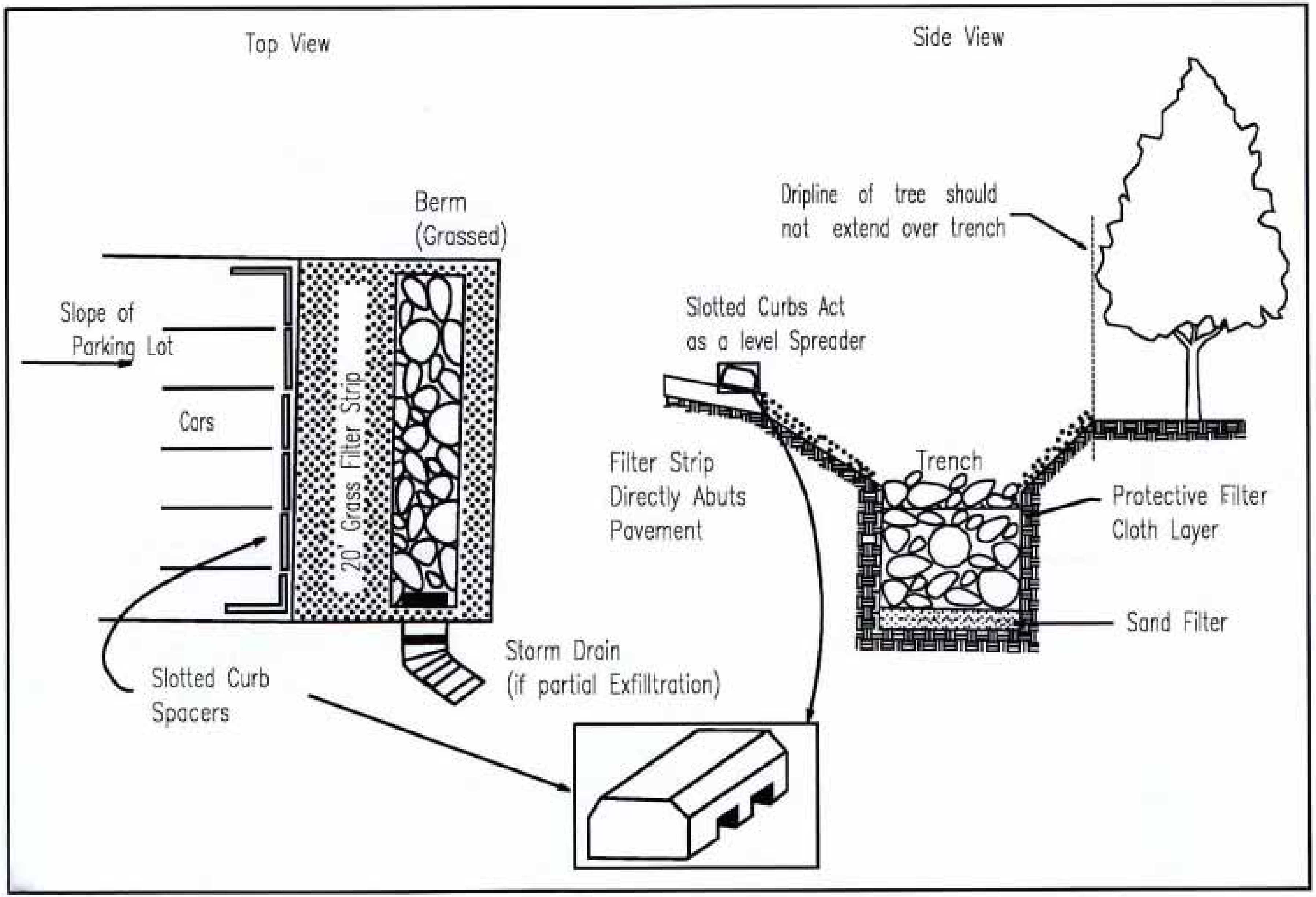
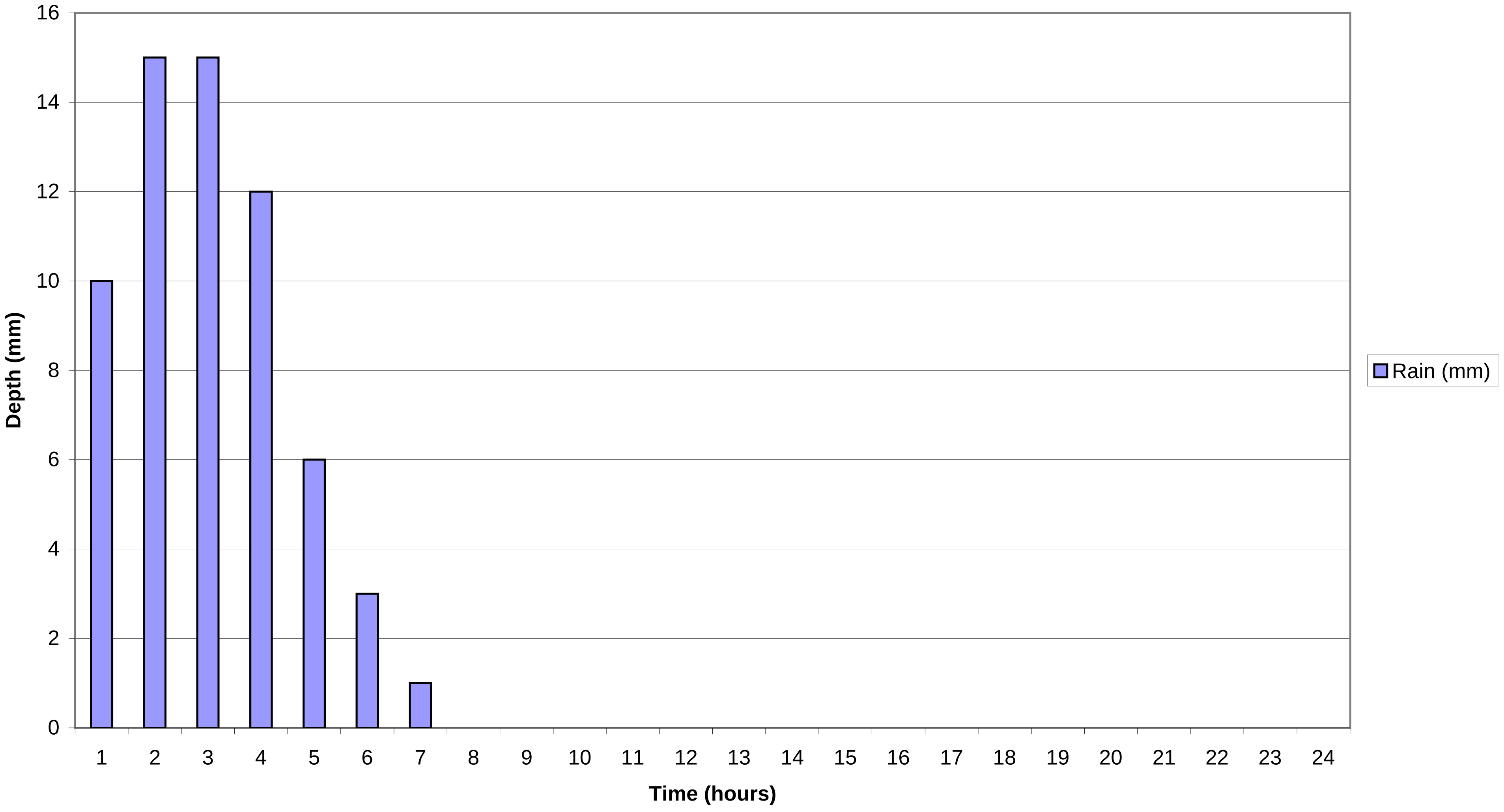


Figure 4.12 Parking lot perimeter trench. (Source: Schuler, 1987)

Figure 4.13   **Rainfall Distribution**



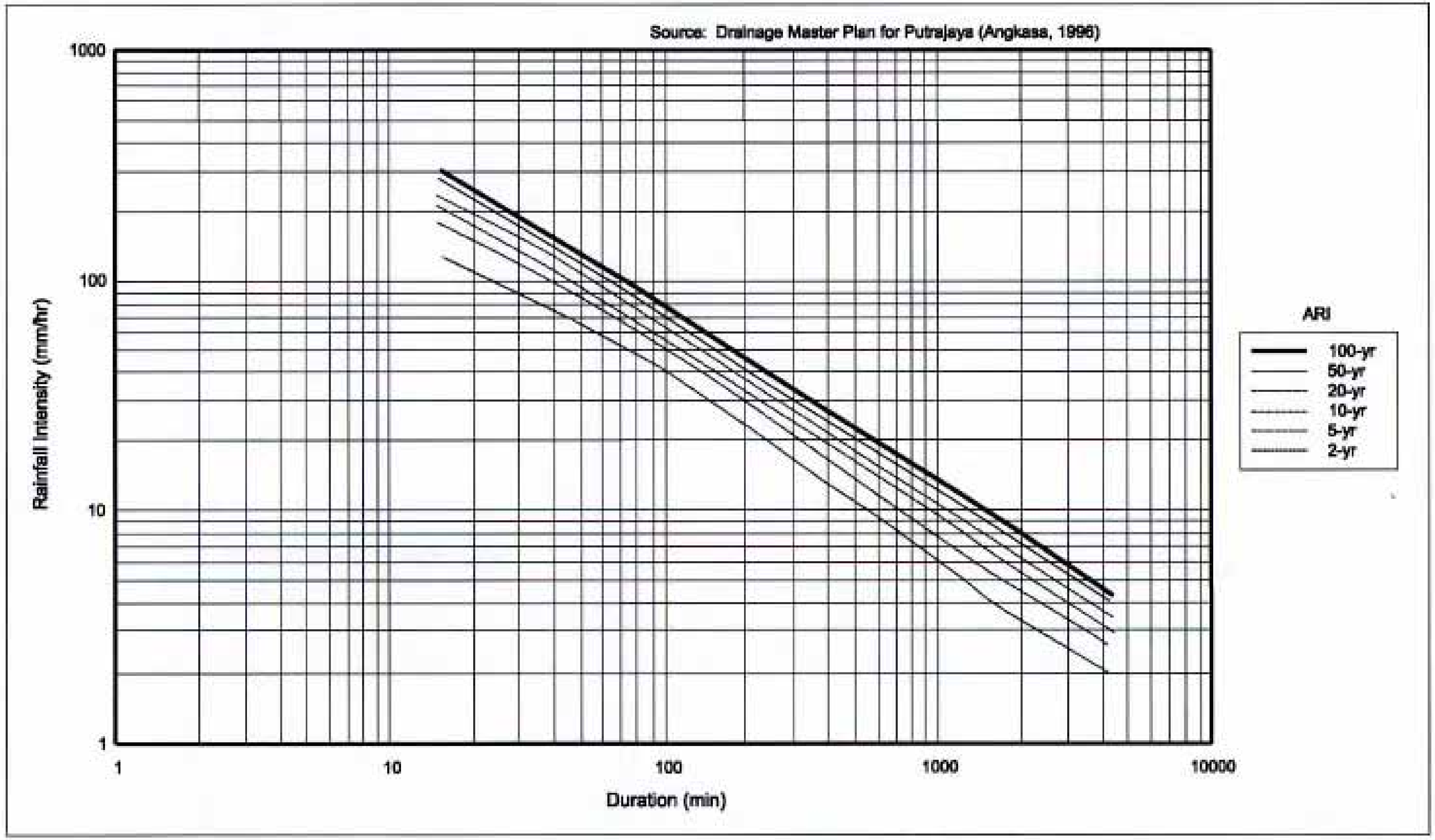


Figure 4.14 Design Rainfall IDF Curves for Putrajaya

flow from the runoff is routed through a detention pond. The cases tested were,

(i) A 5ha pond with a 0.5 m long weir.
(ii) A 5ha pond with a 1.0m long weir.
(iii) A 10ha pond with a 0.5m long weir.

(8) It can be seen from Figure 4.15 that the pond can significantly reduce the peak discharge and allow the runoff to be released over a longer period. The best option is of course option (iii). However, it may not be possible to provide such a big area. Option (i) is better than option (ii) but will require a deeper pond as can be seen in Figure 4.16. An advantage of providing detention ponds is that the outlet channels need not convey such high flows and therefore can be smaller, unlined and cheaper.

(9) One effective BMP for stormwater drainage systems is the utilization of extended detention (ED) ponds for both run-off and sediment control (see the Land Development Handbook (Dewberry and Davis, 1996)). This two-stage design for enhanced water quality control is illustrated in Figures 4.17 and 4.18.

(10) In some cases, wet ponds (also widely known as retention ponds) are required to function as multi-purpose facilities for flood retardation and water quality improvement. With the provision of a permanent pool, sediments are designed to settle while biological and chemical processes are invoked to remove pollutants. A typical profile and design schematic of wet ponds is shown in Figures 4.19 and 4.20.

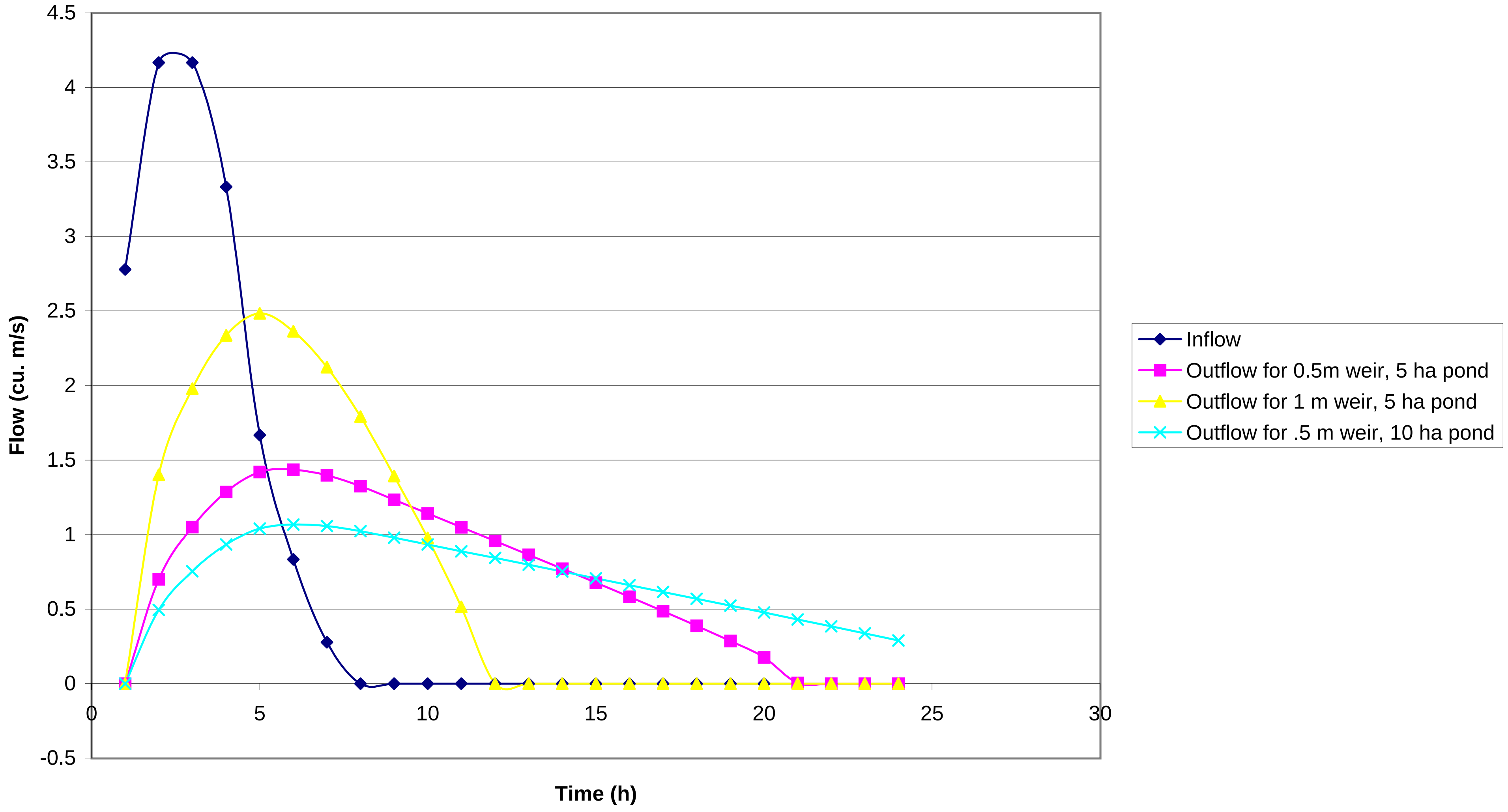
4.3.1.3 Control of land clearing

(1) Land clearing must be carefully controlled. The two undesirable effects of land clearing are;

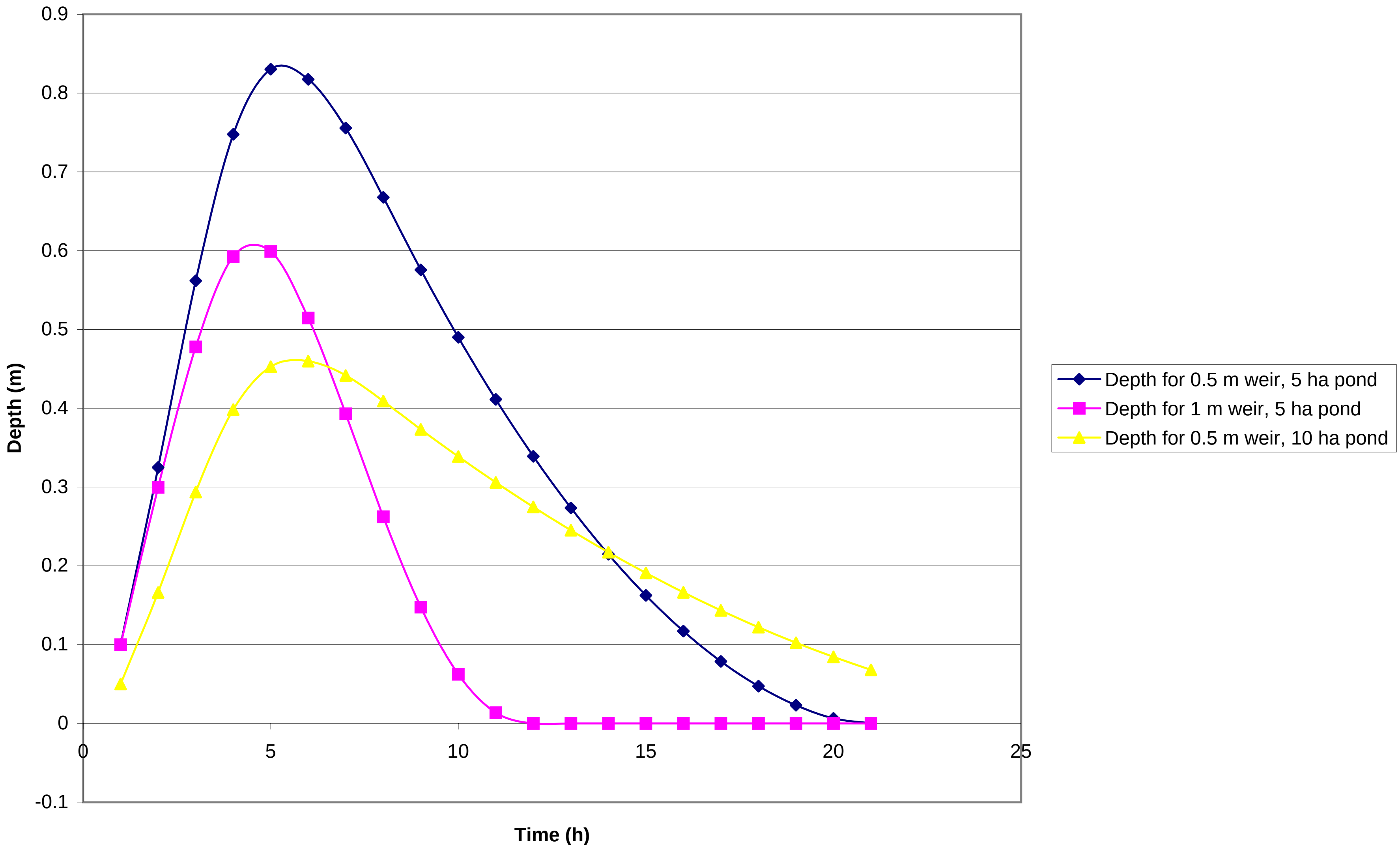
a. Soil erosion causing siltation in rivers and reduction of water quality.
b. Increase in runoff coefficient.

(2) Land clearing must therefore be carefully controlled. It is necessary to provide strict guidelines on land clearing in the catchment.

Figure 4.15 Flow through Retention Pond



<u>Figure 4.16</u> **Depth of water in pond**



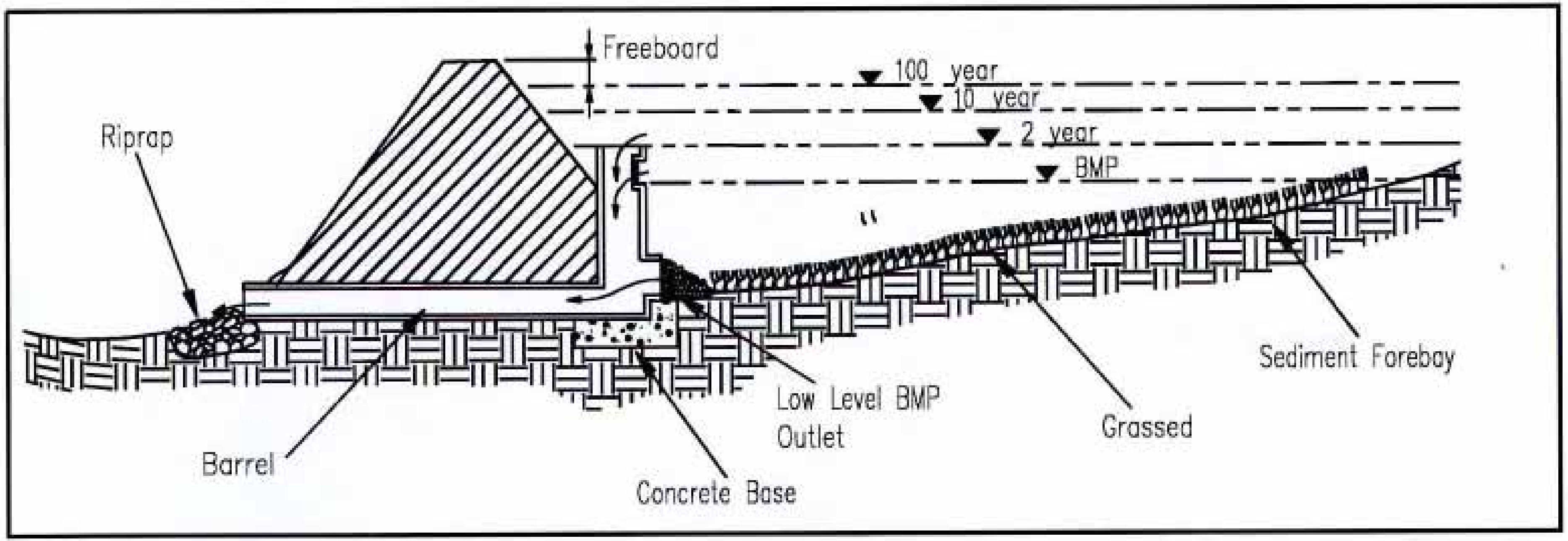


Figure 4.17 Typical Extended Detention (ED) pond.
(Source: Engineers & Surveyors Institute and Northern Virginia District Planning District Commision)

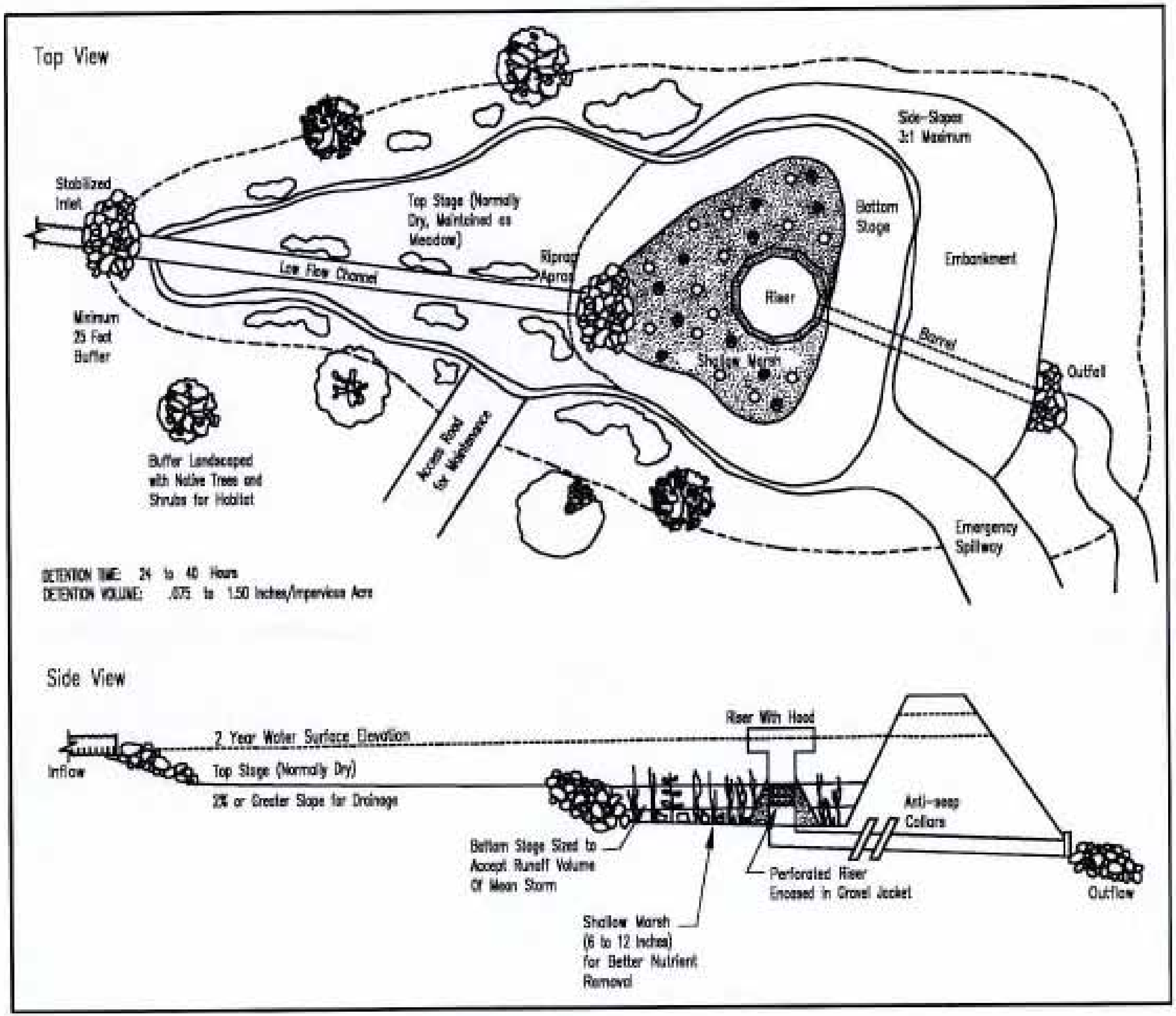


Figure 4.18 Schematic of ED pond design features. (Source: Schueler, 1987)

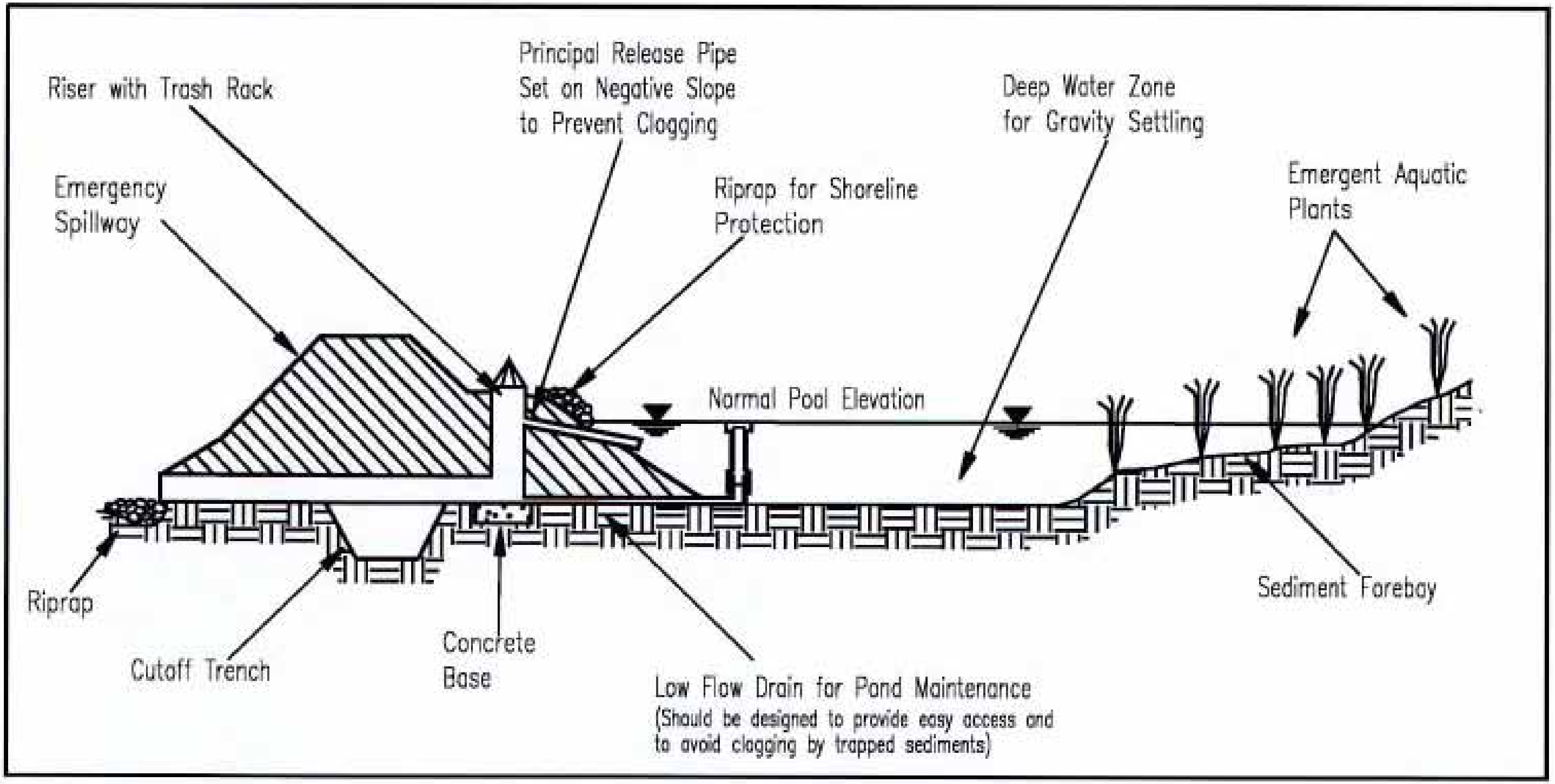


Figure 4.19 **Typical wet pond profile.**
(Source: Engineers & Surveyors Institute and Northern Virginia District Planning District Commision)

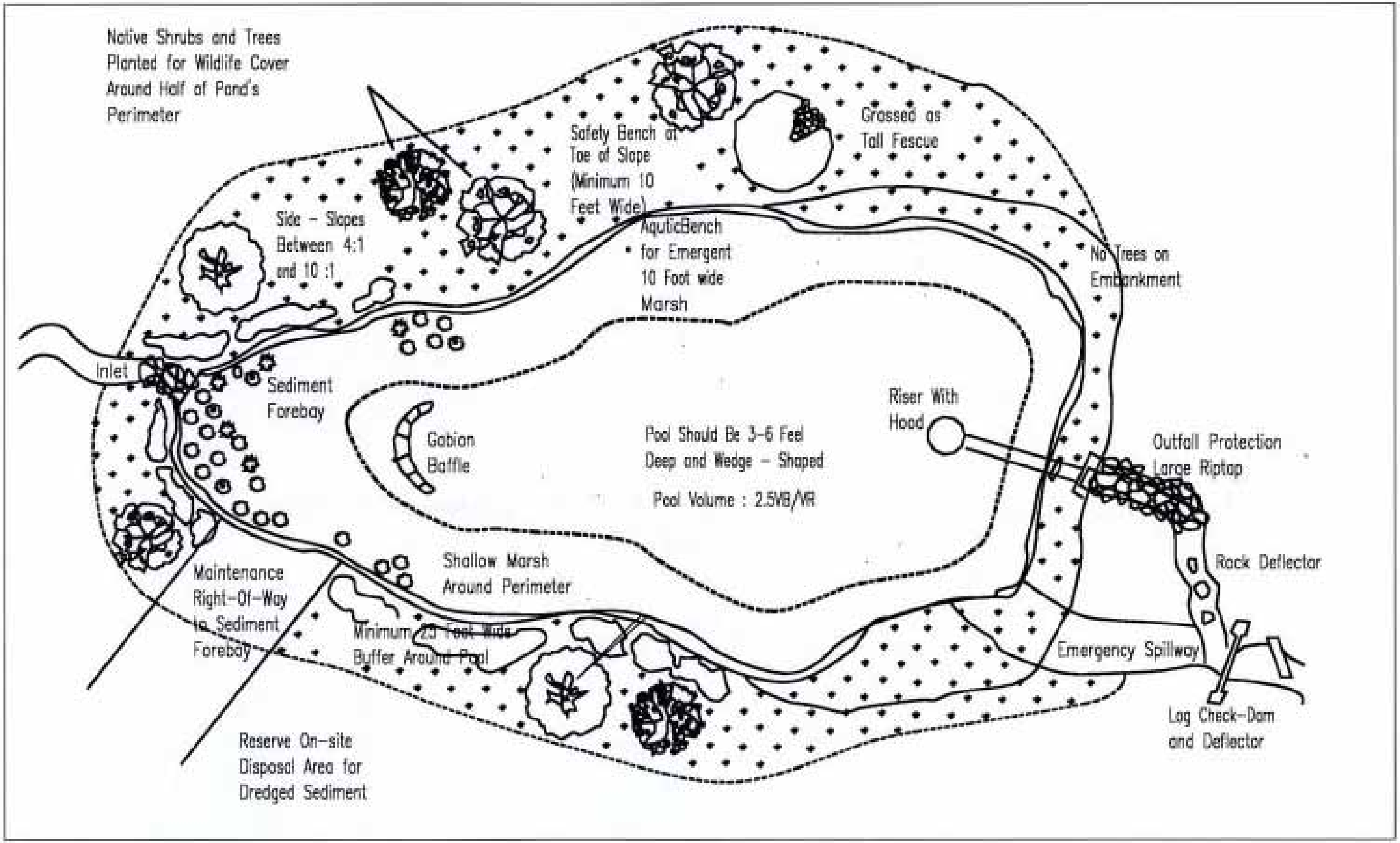


Figure 4.20 Design schematic of a wet pond. (Source: Schueler, 1987)

4.3.1.4 Limit the amount of built-up areas

Built-up areas must be controlled to ensure that there will not be increase in peak discharge. However, limiting the built-up areas will have an impact on the development of the areas.

4.3.2 Control of Sediments

4.3.2.1 The area within 0.5 km from the wetlands must be carefully managed to ensure that the sediment yield is kept to the minimum.

4.3.2.2 The streams entering the wetlands must be lined with vegetation so that sediments will be trapped by the streams.

4.3.2.3 At least 0.5 km of the stream measured from the downstream end must be kept natural.

4.3.2.4 One way of preventing sediments from entering the wetlands will be to place gross pollutant traps, GPTs, as recommended in the Putrajaya Stormwater Management Design Guidelines. From Putrajaya Master Drainage Plan, GPTs are required when the contributing catchment exceeds 20 hectares. Underground GPTs were sized based on 1.5 sq.m plan area per developed hectare. However, these GPTs can only trap sediments above the size of 0.25 mm.

4.3.2.5 To deal with finer materials and colloidal substances, it is recommended that treatment using constructed stormwater wetlands be provided. The guidelines recommend that wetland and wet detention basins should be constructed such that sufficient detention time is provided for particles to settle to the bottom of the wetland.

4.3.2.6 Colloidal substances that take too long to settle can be filtered by wetland vegetation. The Design Guidelines also provide guidelines for the design and construction of wetlands for stormwater treatment.

4.3.2.7 As described earlier, the usage of extended detention (ED) and wet ponds is an excellent example of integrated practices and measures to control run-off, sediment transport and water quality deterioration in a stormwater drainage system.

4.3.3 Control of Pollutants

For all streams and drains entering **directly** into the Putrajaya Lake or wetlands Gross Pollutant Traps (GPTs) should be installed. An example of a special-type of GPT is the Continuous Deflective Separation (CDS) structures used overseas. The CDS is supposed to require less maintenance. However, its effectiveness for our local condition is still under evaluation by the DID. Figures 4.21 and 4.22 shows the typical and schematic drawing of the CDS structures.

4.3.4 Construction Activities

4.3.4.1 The Putrajaya Stormwater Management Design Guidelines recommend that Best Practise in Environmental Management of Construction Activities be followed as a means of ensuring that the environment of Putrajaya Lake will not be damaged by construction activities.

4.3.4.2 The measures recommended are as follows:

(i) Runoff and Erosion Reduction

- Site isolation from runoff generated outside the immediate works area.
- Control of embankment slopes to reduce runoff velocity, e.g. using benches.
- Align tracks created by dozers such that the grooves are perpendicular to the slope.
- Installation of cut-off drains to isolate the face of the embankments from high runoff.

(ii) Runoff Filtration

- Silt-traps.
- Geofabric fences
- Maintaining vegetation

(iii) Scour Protection

- Placement of rocks or gravel.
- Vegetation.
- Geofabric lining of exposed surface.
- Runoff is not allowed to overfall freely over steep banks.

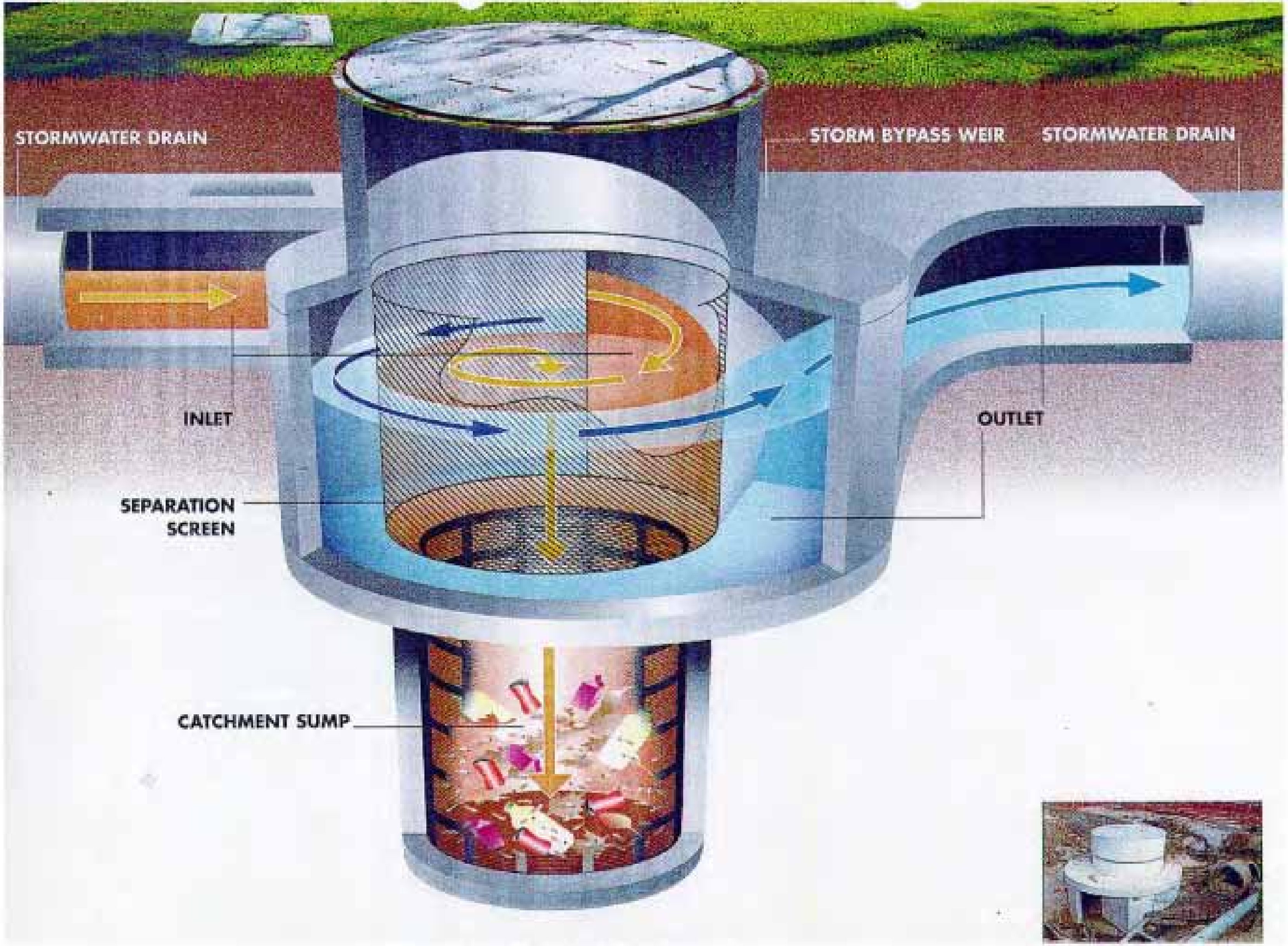


Figure 4.21 : Typical CDS Structure

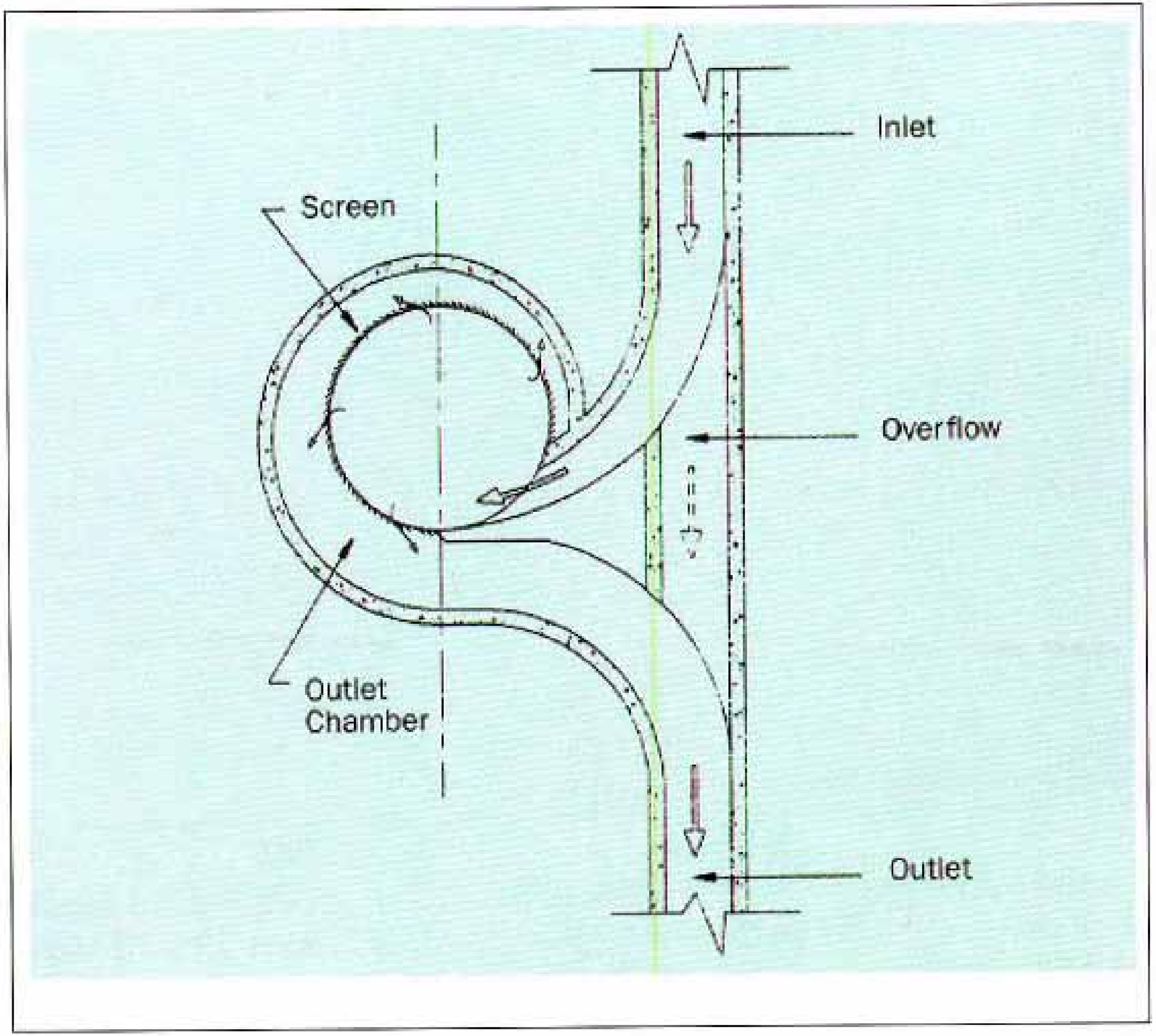


Figure 4.22 : Schematic Representative of the CDS structrure

(iv) Runoff Retention and Detention

- Sedimentation basins
- Floating skimmers

4.3.5 Bio-Engineering Techniques, Stream Rehabilitation and Aesthetic Treatment

4.3.5.1 In the past, most water bodies were designed with engineering rather than aesthetic considerations in mind and most watercourses have been developed as large functional channels. This situation is made worse because watercourses have to cope with large volumes of rain water during tropical storms and are therefore much larger than necessary for normal flow levels. As a result, they are often either empty or near-empty.

4.3.5.2 There is a wealth of information in the literature on the utilization of bio-engineering techniques for stream and channel design as a superior alternative to conventional practices. An example is the provision of natural vegetation and material to protect and stabilize streambanks (Figure 4.23). Such techniques have been developed through time and experience since before modern design are developed, and ironically these are now considered as a new emerging field.

4.3.5.3 In the process to make water bodies more attractive, it is necessary to ensure that engineering standards like storm flow capacity are not compromise. Some of the ways to improve the aesthetic qualities of water bodies are as follows:

- <u>Adopt a multi-disciplinary approach to waterbody design</u>
  The design of waterbodies should involve not only engineers but architects, landscape designers and town planners. Proper design guidelines should be developed at the outset of the planning process so that waterbodies can be given a decorative as well as practical function.

- <u>Using natural materials in the development of waterbodies</u>
  For greater variety, natural materials should be considered to complement concrete, especially for the exposed banks of waterbodies. This can be further enhanced by planting riverside vegetation (Figure 4.24). However, in such cases, a larger channel may be necessary in order to maintain sufficient flow capacity.

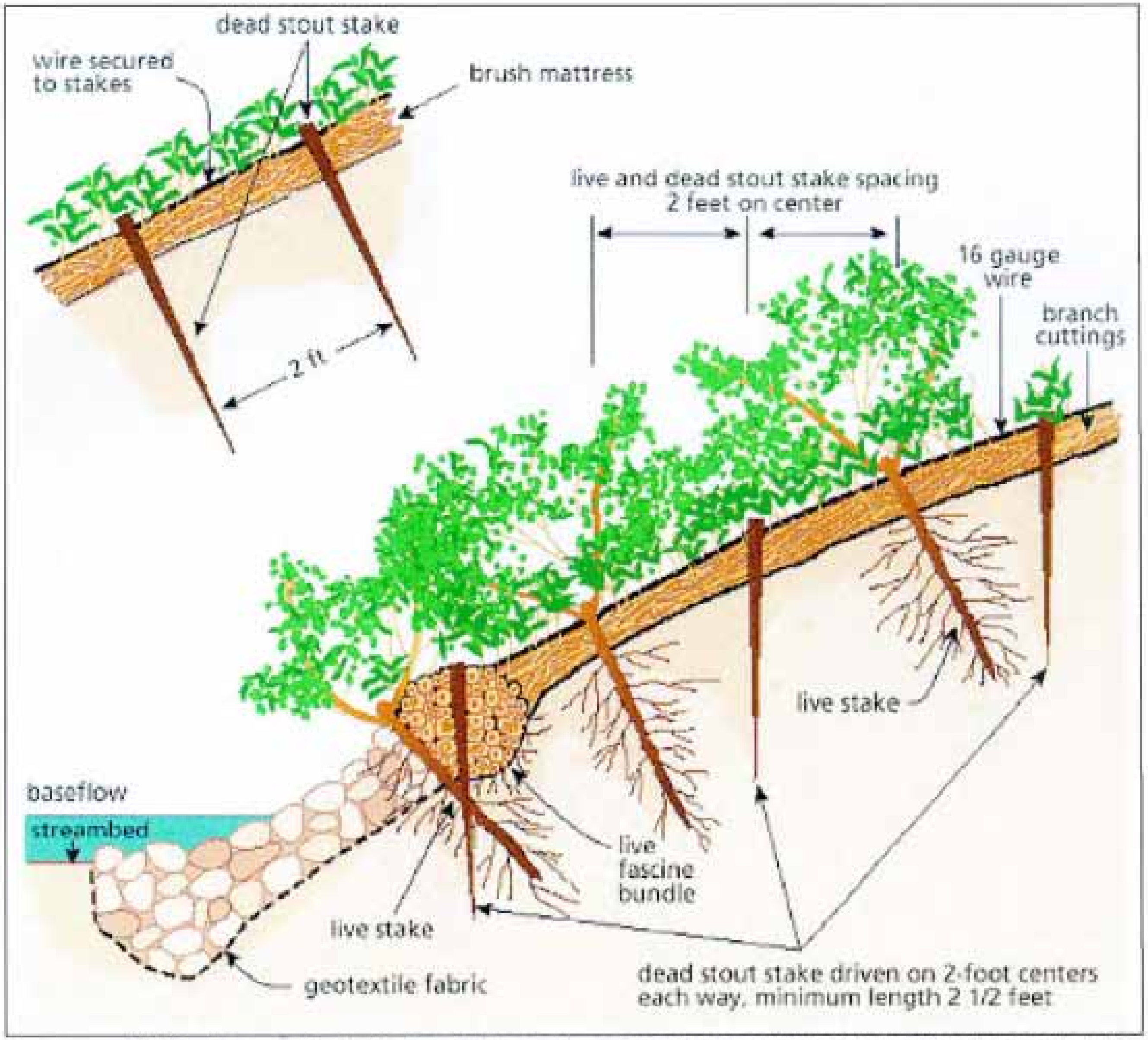


Figure 4.23 Typical details of brush matress technique for streambank.
(Sources: Stream Corridor Restoration-Principles,Practices, and Processes, USDA SCS,1998, and Chapter 16 Engineering Handbook, NRCS 1997).

- Providing easy/direct access to waterbodies
  Easy access to waterbodies by way of footpaths, tracks bridges or roads allow people to get close to, and enjoy, the water (Figure 4.25). These developments should pay particular attention to the needs of the physically handicapped and to public safety.

- Keeping watercourses in their natural state where possible
  Not all watercourses need to be drainage channels. In certain instances they can be preserved in a near natural state.

- Providing more varied profiles for watercourses
  Ensure that watercourses feature a greater variety of longitudinal and cross-sectional profiles. In addition to the standard U-shaped and trapezoidal outlines, other natural profiles can also be explored (Figure 4.26).

- Covering watercourses
  Where watercourses have little potential for aesthetic upgrading, there could be a case for covering them. This can create more space for parks and green areas and can remove the physical barrier imposed by such watercourses (Figure 4.27).

- Allowing sufficient width for watercourses to achieve design objectives
  The DID guideline recommends the amount of land that must be set aside along watercourses as a drainage reserve. This land area varies according to the width and maintenance requirements of the watercourse. For greater design opportunities, allocation of sufficient land should be made during the planning stage.

- Maintaining a permanent body of water
  The presence of water in watercourses helps reduce the amount of visible concrete, significantly improving their appearance (Figure 4.28).

Figure 4.24 Using natural materials in the development of waterbodies.

Figure 4.25 Providing easy/direct access to waterbodies.

Figure 4.26 Providing more varied profile for water courses.

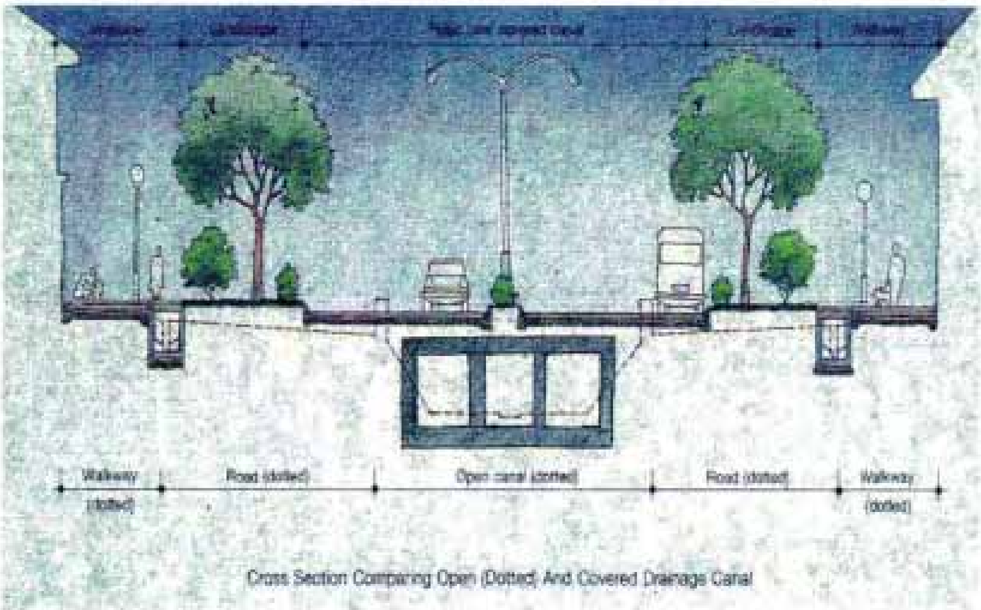


Figure 4.27 Covering water courses.

Figure 4.28 Maintaining a permanent body of water.

4.4 DRAINAGE DESIGN REQUIREMENTS AND STANDARDS

The following design requirements and standards are applicable for the design of the drainage system in the catchment.

4.4.1 Design Rainfall IDF Curves

Figure 4.14 shows the design rainfall Intensity-Duration-Frequency (IDF) curves for Putrajaya. It is recommended that all drainage design in the catchment use these IDF curves since the curves have been specifically developed for the Putrajaya area.

4.4.2 Drainage Reserves Requirements

The drainage reserve requirements in the catchment shall follow those specified in the DID Urban Drainage Design Standards (UDDS) as given in Tables 4.5 and 4.6 below.

4.4.3 Water Level Requirements in the Putrajaya Lake System

The weir crest levels in the Putrajaya Lake System have been designed to operate between a normal operating and a 1% Annual Exceedance Probability (AEP) water level. This implies that the design of all upstream drainage system should take the water level requirements in the Putrajaya Lake system as a design condition to be met. Table 4.7 gives the water levels associated with the various components in the Lake System.

Table 4.5 Drainage Reserves for Areas Less than 100 Acres

Drainage Area **Drain Location**	**0 – 10 Acres**	**10-100 Acres**
Between building Lots	Top Width + 4 feet	Top Width + 12 feet
Alongside roads	Top Width	Top Width

Source: Urban Drainage Design Standards and Procedures (DID, 1975)

Table 4.6 Drainage Reserves for Areas More than 100 Acres

100 Year Discharge *(X cusecs)	Reserve Width(chains)
<1000	11/2
1000 < X < 3000	2
3000 < X < 7000	21/2
7000 < X < 10000	3
10000 < X	Special Consideration

* Based on predicted ultimate land use

Source: Urban Drainage Design Standards and Procedures – (DID, 1975)

4.4.4 Design of Retention Ponds

It is recommended that the DID guideline of 3% to 5% of the developed area to be reserved for construction of detention ponds be provided. For the actual design of the ponds, a competent engineer must be employed. Flood routing calculation must be carried out to ensure that the pond will have the desired effect of reducing the peak discharge without impeding the inflow or water overtopping the banks of the pond. The inflow into the pond may be calculated using the Modified Rational Method. The outflow from the pond may be determined using a weir formula if a weir is provided. For the purpose of estimating the pond and weir sizes in this study, flooding routing through ponds of different sizes based on different catchment areas were carried out

Table 4.7 Normal Operating and 1% AEP Water Levels for the Putrajaya Lake System

Location	Normal Operating Level (m)	Weir Crest Level (m)	1% AEP Level (m)
Upper North Wetland			
UN 1A	24.50	25.65	26.50
UN 1B	24.50	25.65	26.50
UN 2A	25.00	26.15	27.50
UN 2B	25.00	26.15	27.50
UN 3	26.00	27.15	28.50
UN 4	26.75	27.90	29.50
UN 5	27.50	28.65	30.00
UN 6	29.00	30.65	32.00
UN 7	30.50	31.65	33.00
UN 8	31.00	32.15	33.50
Upper West Wetland			
UW 1	24.50	25.50	26.50
UW 2	25.25	26.25	27.50
UW 3	26.00	27.00	28.00
UW 4	27.00	28.00	29.00
UW 5	27.75	28.75	30.00
UW 6	28.50	29.50	30.50
UW 7	29.00	30.00	31.00
UW 8	28.00	29.00	30.00
Upper East Wetland			
UE 1	28.00	29.50	30.50
UE 2	29.00	30.00	31.00
UE 3	30.00	31.00	32.00
Lower East Wetland			
LE 1	27.00	28.00	29.00
LE 2	30.00	31.00	32.00
Upper Bisa Wetland			
UB 1	24.50	24.50	25.50
UB 2	30.00	30.00	31.00
Central Wetland	23.50	23.50	25.00
Phase 1A Lake (Temporary Dam)	21.00	21.00	22.50
Phase 1B Lake (Main Dam)	21.00	21.00	21.50

Source: Putrajaya Stormwater Management Guidelines (Angkasa, 1998)

4.5 TOPOGRAPHICAL AND DRAINAGE ANALYSIS

4.5.1 Topographical Analysis

4.5.1.1 A topographical analysis of the catchment was carried out based on the contour information given in 2 printed topographical map sheets (3756 and 3575) of 1:50,000-scale published by the Jabatan Ukur dan Pemetaan in 1992. As evident from Figure 4.1, the analysis is limited by the large map scale (1:50,000) and lack of elevation data (only 20-m contours available).

4.5.2 Drainage Analysis

4.5.2.1 The Modified Rational Method, as described in the DID UDDS, is used to compute the design discharge rate for the drainage analysis. The design rainfall is based on the IDF curves for Putrajaya, as shown in Figure 4.14.

4.5.2.2 The locations of drainage components, such as detention ponds, etc. were decided based on the results of the soil erosion and hydrogeological studies. The calculation for the drainage system design data for IOI Palm Garden Resort Area and MARDI are shown in Table 4.2 and Table 4.3.

4.6 THE DRAINAGE MASTERPLAN

4.6.1 Putrajaya Area

No major modification is proposed for the drainage system within the Putrajaya Area, as they have been planned to meet the objectives of a high quality runoff from the Putrajaya Area. What is required in this study is the integration of the outside drainage systems to the drainage system in the Putrajaya Areas to give an integrated drainage system for the whole catchment that will meet the objective of a high quality runoff.

4.6.2 Outside Putrajaya Area

Modifications in the drainage systems for the areas outside Putrajaya may be required so as to achieve the required water quality and reduction in peak discharge. Where the drainage systems have been designed to the Urban Drainage Design Guidelines, it is assumed that the drains will cater for the flooding of Minor and Major storms. The modifications are made in the designed to achieve the standards required for the Putrajaya wetlands-lake system. Based on a preliminary assessment of the existing and planned drainage systems in the areas outside Putrajaya the following are the recommended improvements and changes to the systems.

4.6.2.1 IOI Palm Garden Resort Area

(1) A series of existing and proposed detention ponds are located in this area as shown in Fig. 4.6.

(2) To improve the water quality of the runoff from the area it is recommended that the last pond in the series of proposed ponds draining into the Upper North and Upper East Wetlands be converted into mini-wetlands and design as wet-detention ponds. Also, it is recommended that the drain leading from the last pond into the wetlands be designed as earth-drains, vegetated and landscaped to blend into the surroundings.

(3) The detention ponds in the proposed development must be properly designed. It must follow the DID guideline of 5% of the catchment area.

(4) The weir outfall from the ponds must be sufficiently small to have a significant impact on the reduction of the peak discharge, yet not too small that there will be flooding of the detention ponds. A recommendation of the weir length and pond sizes based on catchment area is given in Table 4.8.

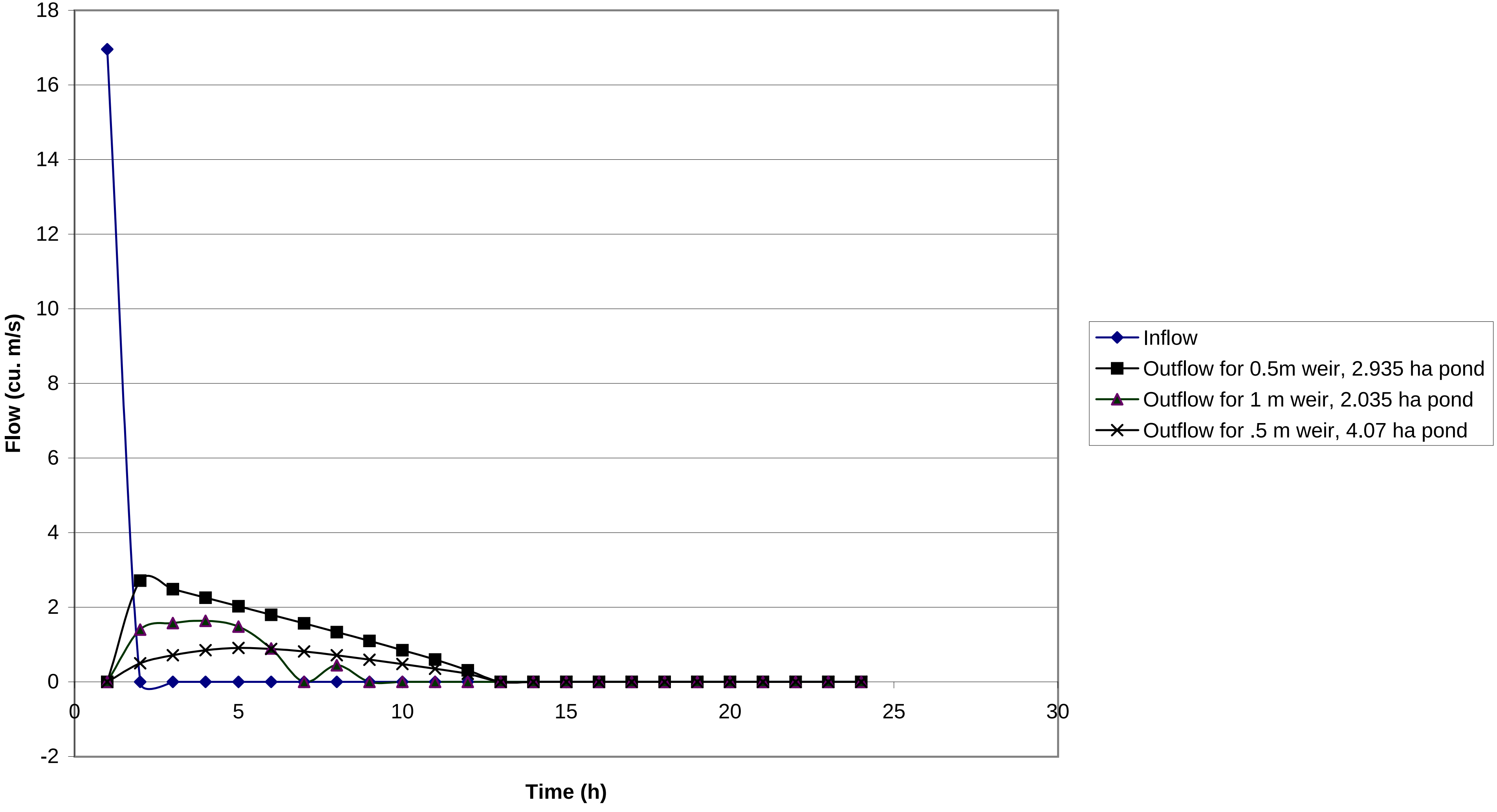
(5) Figures 4.29 and 4.30 shows the results of the flood routing analysis for the ponds.

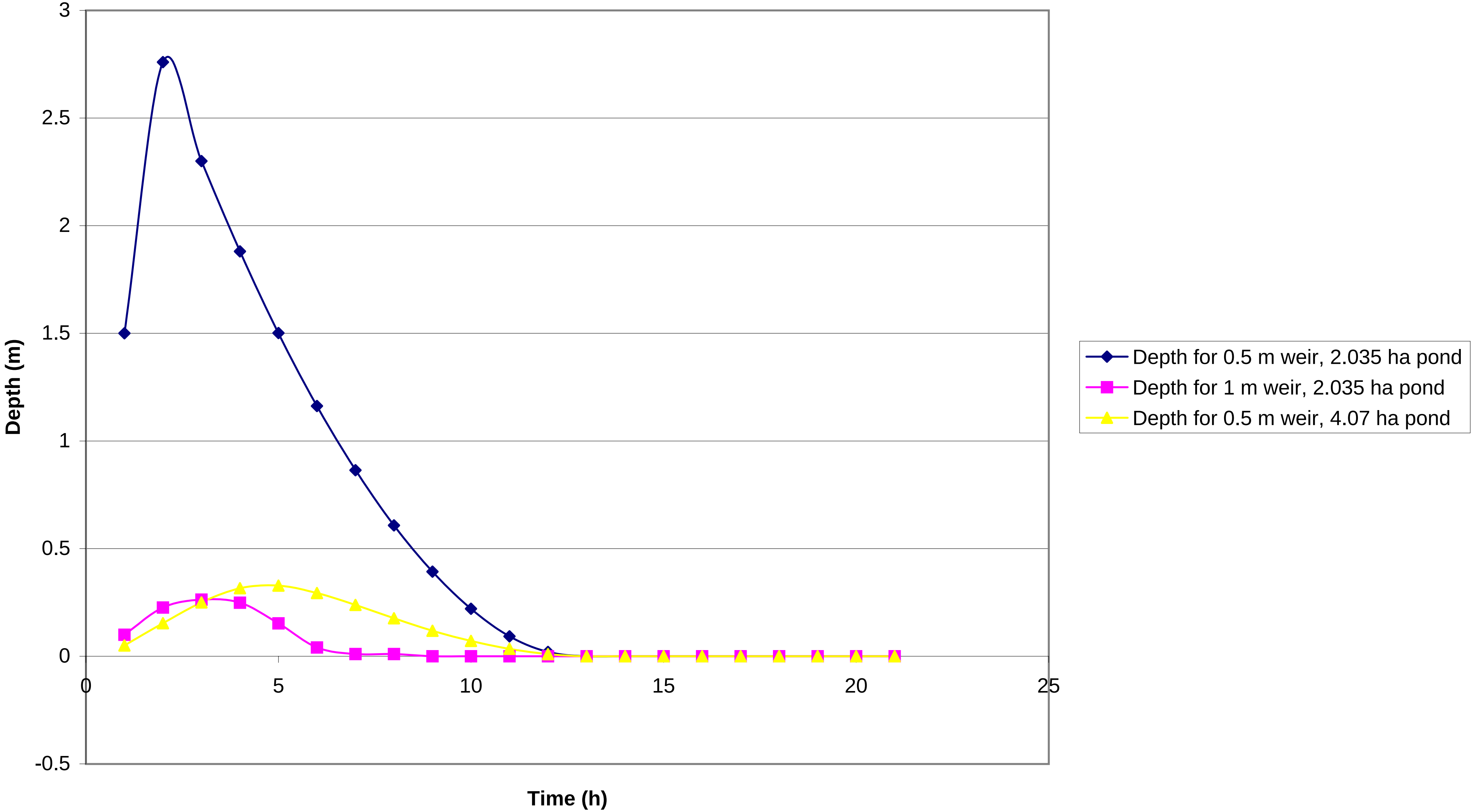
4.6.2.2 MARDI

(1) This area will be conserved as a green-lung area and will be developed as a natural and green theme park. Thus, its development should focus on utilizing bio-engineering methods for the preservation and enhancement of the existing streams and water bodies.

(2) The existing drainage system is shown in Figure 4.7. It is based on a scanned map provided by MARDI. It is recommended that the existing stream be improved with the provision of a vegetated river corridor as shown in Figure 4.7. The width of the corridor has been computed based on the design discharge given in Table 4.3.

Figure 4.29 IOI Palm Garden Resort - Flow through Retention Pond





3
2.5
2
1.5
1
0.5
0
-0.5
Depth (m)
0
5
10
15
20
25
Time (h)
Depth for 0.5 m weir, 2.035 ha pond
Depth for 1 m weir, 2.035 ha pond
Depth for 0.5 m weir, 4.07 ha pond

(3) The design for the river corridor is based on the following principles.

(i) Water shall flow slowly in the channel and should not cause scouring of the drainage channel.

(ii) Grass and reeds shall be allowed to grow in the channel to retard the flow. They will also reduce the pollutants and sediments carried by the runoff into the channel.

(4) Based on the above principles, the stream has been designed to convey flows with a maximum speed of not more than 0.3 m/s. The vegetation within the drainage channel should be allowed to grow and should be cut only twice a year at the onset of the monsoon seasons, which will keep the Manning's n to a value of 0.05.

(5) The proposed South-Klang Valley Expressway (SKVE) and Express Rail Link (ERL) passes through the South of MARDI. There will be some diversions and realignment of the existing drainage lines in the area. However, it is recommended that the existing riparian buffer and natural vegetated river corridor concept be preserved for the revised drainage lines. They should not be replaced with concrete channels.

(6) Also, the drainage outlets from the SKVE and ERL drainage systems should be provided with GPTs before they drain into the existing natural vegetated landscape drainage system connecting to the Upper West Wetland.

4.6.2.3 UPM

(1) It is recommended that the drainage design for all proposed developments in the UPM comply with the requirements of the Putrajaya Stormwater Management Design Guidelines. There should not be any problem for compliance since there is enough natural green area, with existing ponds, for the drainage engineer to be creative in the design of the drainage system.

<u>Table 4.8</u> **IOI Palm Garden Resort – Recommendation of the Weir Length and Pond Sizes**

Catchment No	Catchment Area (ha)	Pond Area (ha)	Depth of Pond (m)	Height of weir (m)	Length of Weir (m)	Peak Discharge, Q100, (m3/s)
1	37	1.85	1.3	0.5	0.5	1.34
2	40.7	2.04	1.3	0.5	0.5	1.34
3	27	1.35	1.2	0.5	0.5	1.32
4	18.7	0.94	1.2	0.5	0.5	1.28
5	10.5	0.53	1.2	0.5	0.3	0.76

(2) The Consultant cannot provide firm and specific drainage recommendation for this area, since detail information on UPM's proposed development are not available to the Consultant. Due to this, an overall drainage concept has been proposed for the UPM area and is given in Figure 4.8.

(3) The concept is to retard the flow of water into the wetlands, from the UPM area, through a series of detention ponds. Also, to improve the quality of the runoff before it flows into the wetlands it is recommended that natural vegetated landscape riparian buffers and river corridors be provided.

4.6.2.4 Cyberjaya (Flagship Zone)

(1) The proposed drainage system by the Cyberjaya consultant shown in Figure 4.9 is based on the runoff that will be discharged into the proposed water quality enhancement pond before it flow into the Putrajaya Lake. To remove gross pollutants from the runoff GPTs have been provided in all outlets into the pond.

(2) To improve the quality of the runoff flowing into the Lake the Consultant recommends that, the drainage system should be based on vegetated landscape drainage corridors and conversion of water quality enhancement ponds into mini-wetlands. Also, all drainage lines should terminate at water quality ponds converted into mini-wetlands. To improve the quality of the runoff before it flows into the Lake it is recommended the water quality ponds shall be connected to the Lake through a vegetated landscape drainage corridor.

4.6.2.5 West Country

(1) A 4.4 ha. (11 acres) Lake has been proposed as part of the proposed layout for the development in this area. The lake also acts as a flood detention pond for the proposed development. The proposed layout for the lake as shown in Figure 4.10 shows that the alignment of the proposed road leading into Putrajaya from the SKVE cuts the lake into two and is connected by a balancing box culvert under the road.

(2) The drainage consultant for West Country has proposed a number of main drains flowing into the lake and also a drain connecting the lake to the Upper East wetlands. However, there

are no provisions for GPTs at the inlets into the lake. This will result in entry of gross pollutants into the proposed lake, which will spoil the aesthetic feature of the lake. The drainage consultant for West Country should ensure that GPTs are installed in all outlets into the lake or ponds in its revised layout plan for the lake.

(3) It is recommended that the last detention pond leading to the Upper East wetland should be converted into a mini-wetland. Also, it is recommended that the proposed concrete drain leading from the pond to the Upper East wetland be changed to a vegetated landscape drainage corridor. In this way, the quality of the runoff flowing into the Upper East wetland can be improved and any gross pollutants in the pond will also be trapped by the vegetation in the pond and along the drainage corridor.

4.7 RESPONSIBILITES OF AUTHORITIES AND STAKEHOLDERS

4.7.1 Construction

Outside the Putrajaya area, it is the responsibility of the individual land owners and project proponents to construct the drainage systems in their individual lots. The local authorities must monitor and ensure that the drainage systems are constructed according to the recommended guidelines.

4.7.2 Operation and Maintenance

4.7.2.1 Operation and maintenance of the drains in the individual lots such as UPM and MARDI will be by the respective land owners.

4.7.2.2 However, for the areas that will be developed and handed over to the buyers, the operation and maintenance of the drainage system will be by the local authorities.

4.7.2.3 Operation and maintenance manuals for the structures must be prepared and handed over to the local authorities when the projects are completed.

4.8 REFERENCES

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CHAPTER 5

SEWAGE MASTERPLAN STUDY

5.0 SEWERAGE MASTERPLAN STUDY

5.1 INTRODUCTION

5.1.1 A self-sustaining and balanced lake ecosystem is important to the functioning and design philosophy of the Putrajaya Lake.

5.1.2 Other than suspended solids, the clarity of the lake water is generally related to the population of algae in the lake. The existence of many other organic and inorganic materials will also contribute to the trophic condition of the lake.

5.1.3 An oligotrophic lake is very much desired. This can only be achieved if the minimum or controlled pollutant loadings from water courses draining into the lake are ensured.

5.1.4 Domestic or municipal wastewater discharges containing nutrients, biodegradable organics, suspended solids, and pathogens, if inadequately treated, will cause damage to the aquatic environment and transmission of communicable diseases.

5.1.5 Sewage effluent discharge is considered a potential point source pollutant into the Putrajaya Lake. The proper collection, treatment and disposal of residual (sludge) will ensure the treated sewage effluents ultimately discharging into the Putrajaya Wetlands and Lake do not create any adverse effects on the required lake water quality.

5.1.6 An overall Putrajaya Lake Catchment Sewerage Masterplan accompanied by sewage effluent standards, pertinent sewerage planning and design guidelines, emergency response plan and an appropriate monitoring programme for the treated sewage effluent discharges, is therefore needed to be incorporated in the Putrajaya Lake Catchment Development and Management Plan.

5.2 OBJECTIVE

The objective of the sewerage masterplan is to minimise and control sewage pollutant loadings within the lake catchment from entering the water courses draining into the Putrajaya Lake.

5.3 LANDUSES AND POPULATION EQUIVALENTS IN THE LAKE CATCHMENT

5.3.1 The owners and developers of the lands in the Putrajaya Lake Catchment are:

i. Putrajaya Holdings Sdn Bhd for the Putrajaya Development

ii. Setia Haruman Sdn Bhd for the Cyberjaya Flagship Development Zone

iii. Universiti Putra Malaysia (UPM)

iv. Malaysian Agricultural Research and Development Institute (MARDI)

v. Industrial Oxygen Incorporated Berhad (IOI) for the Palm Garden Resort Development

vi. West Country Bhd for the West Country Development

vii. TNB Generation Sdn Bhd for the Serdang Power Station

viii. Private Owners for the Sg. Merab Malay Reserve area.

5.3.2 The existing landuses, proposed development landuses and the proposed Putrajaya Lake Catchment Landuse Masterplan are described in detail in Chapter 6.0: Landuse Masterplan Study.

5.3.3 As the land terrain of Putrajaya, Cyberjaya Flagship Zone, UPM, West Country and TNB Serdang Power Station also lies in some other river or tributary catchments, the landuses outside the lake catchment and the information on the sewage population equivalent (PE) there will not be described.

5.3.4 The recommended Population Equivalents (PE) for various types of premises and establishments are provided in Appendix 5.1.

5.3.5 Table 5.3.1 summarises the existing landuses as well as the committed proposed landuse developments in the lake catchment.

5.3.6 The treated sewage effluents of total 22,006 PE (4,950 m^3/d or

0.057 m^3/s) will be discharged into the wetlands and lake when the presently proposed developments are completed in year 2001.

5.3.7 The estimated existing total sewage effluent discharging into the Putrajaya Wetlands and lake is 1,780 m^3/d or 0.0198 m^3/s for the 7,597 PE consisting :

UPM	:	4,925 PE
MARDI	:	600 PE
IOI - Palm Garden	:	912 PE
Cyberjaya	:	1160 PE

TOTAL		7,597 PE

Table 5.3.1 Existing and Proposed Landuses and Population Equivalent (PE)

	DEVELOPMENT	LANDUSES		ESTIMATED PE					REMARKS
		Existing	Proposed	Existing	Proposed	Total	Other River	Sg Chuau	
1	Putrajaya	Phase 1 Federal Administration City Development	Phase 2 Federal Administration City Development	100,000	500,000	600,000	100,000+ 500,000*		+ Sg Air Hitam *Downstream of Sg Chuau Phase 1 Development in progress
2	Cyberjaya Flagship Zone	MDC Head Office, Cyber Lodge, Site Offices, Service Apartments	Phase 1B – Country Heights Low Density Residential Development (27 ha)	1160*	560	1,720	-	1,720*	*Temporary Discharges

Table 5.3.1 Existing and Proposed Landuses and Population Equivalent (PE) (cont'd)

	DEVELOPMENT	LANDUSES		ESTIMATED PE					REMARKS
		Existing	Proposed	Existing	Proposed	Total	Other River	Sg Chuau	
3	Universiti Putra Malaysia	Kolej 8 Kolej 9 Kolej Matrikulasi Pusat Kesihatan Pelajar Kafe UPM-MTDC (Research Centre) Time Telekom UPM Golf Club Infor Post	Kolej Baru*	1,097 1,038 2,000 25 50 150 5 360 200	7,000				*Kolej Baru is under construction Expected completion year 2000/2001 Only landuses in the catchment are included
				4925	7000	11,925	-	11,925	
4	Malaysian Agricultural Research & Dev. Institute	Pejabat-pejabat Quarters		500 100		500 100			
				600		600	-	600	

Table 5.3.1 Existing and Proposed Landuses and Population Equivalent (PE) (cont'd)

	DEVELOPMENT	LANDUSES		ESTIMATED PE					REMARKS
		Existing	Proposed	Existing	Proposed	Total	Other River	Sg Chuau	
5	Palm Garden Resort Development	Club-house Service Apartments Office Development* Condominium*	Future Office Development Future Hotel	**300** **612** 1255 1920	1394 2280				* Under Construction Expected Completion Year 2000
				4087	3674	7761		7761	
6	TNB Serdang Power Station	Existing Power Plant with 50 operation staff		50	-	50	50+		+Sg Gajah
7	West Country Development	-	Residential and Commercial Development*		16,090	16,090	16,090+		● Preliminary Planning Stage + Sg. Air Hitam
				110,822	527,324	638,146	616,140	22,006	

5.4 EXISTING SEWERAGE SITUATIONS OF VARIOUS DEVELOPMENTS

5.4.1 General

5.4.1.1 Figure 5.4.1 shows the locations of the existing, under-construction and proposed sewage treatment plants in and around the lake catchment.

5.4.1.2 The existing sewerage situations including the sewerage planning status for the various developments in the catchment are described herein to assess the impacts of the sewage effluents on the lake.

5.4.2 Putrajaya Development

The sewage effluent sources in the Putrajaya Development areas are categorised into three groups :

(a) Septic Tanks
(b) Temporary Sewage Treatment Plant
(c) Permanent Sewage Treatment Plants

5.4.2.1 Septic Tanks

(1) There are several plantation living quarters located in the Putrajaya Development area. These quarters are very old and served with localised septic tanks where the effluent discharges into open drains or infiltrate into the ground. The effluents are likely to meet the Department of Environment's (DOE) effluent Standard B.

(2) The quarters of Ladang Sedgelay are located outside the lake catchment of Sg. Chuau but within the Sg. Air Hitam catchment.

(3) Ladang Perang Besar quarters and Ladang Bukit Permai quarters are located downstream of Phase 1 Lake. These quarters will be relocated, similar to that of Ladang Eastnor quarters in Upper North Wetland, when the development at the areas commences.

(4) Since the effluents from the quarters' septic tanks do not drain into the lake they have no impact on the lake water quality.

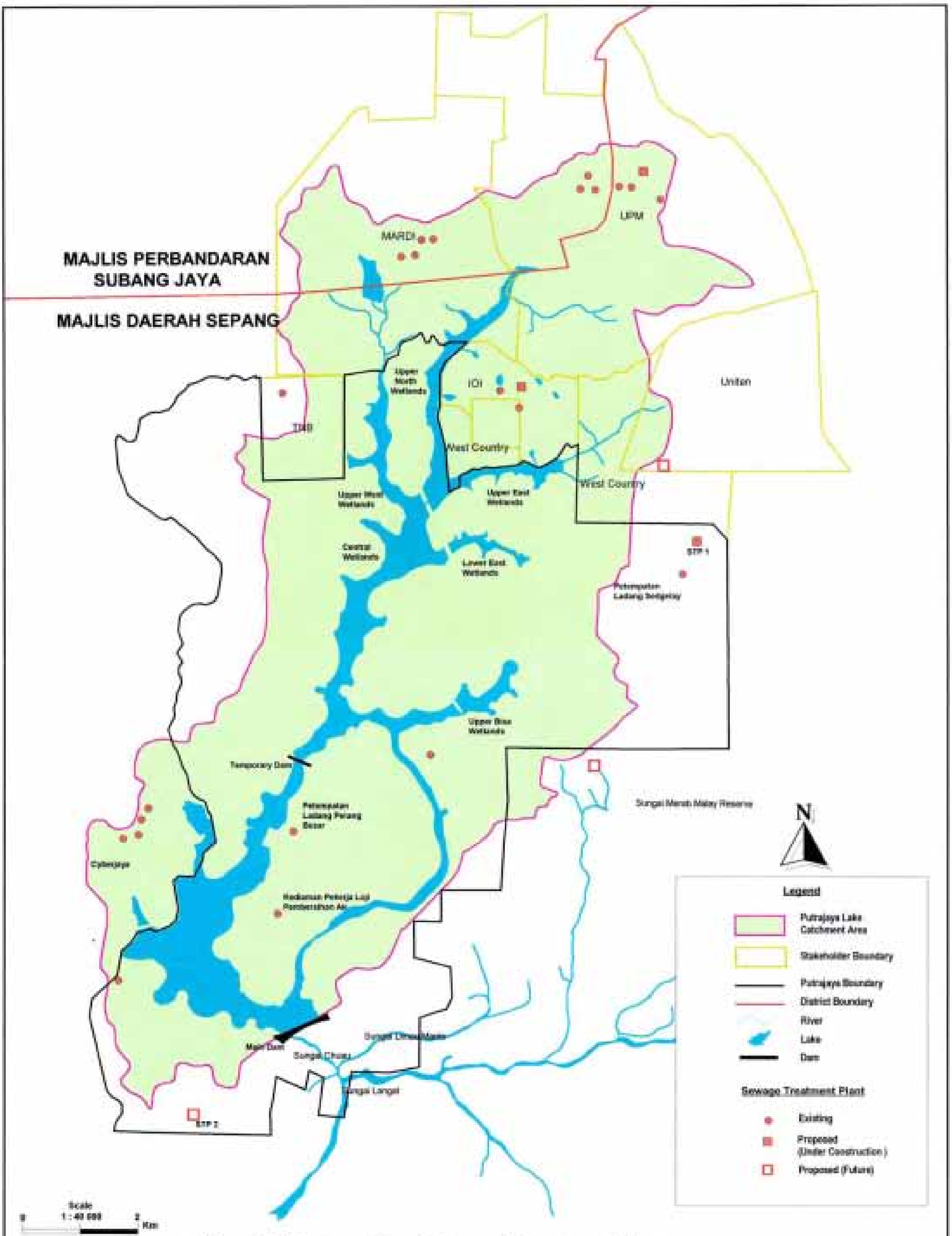

Figure 5.4.1 Locations of Sewage Treatment Plant

5.4.2.2 Temporary Sewage Treatment Plant

(1) There is an existing temporary packaged sewage treatment plant maintained by Charterfield, the company providing temporary accommodation to the construction workers in the Putrajaya area.

(2) The temporary sewage treatment plant is located near Gate 5, which is downstream of the temporary dam.

5.4.2.3 Permanent Sewage Treatment Plants

(1) Two proposed permanent sewage treatment plants STP1 and STP2 of capacity 100,000 PE and 500,000 PE respectively together with modern sewage collection systems with lifting stations have been designed to serve the entire Putrajaya Development sewerage requirements.

(2) The proposed sewage treatment plants STP1 and STP2, trunk gravity sewers, lifting and regional pumping stations and pumping mains are shown in the Putrajaya Development Sewerage Plan Layout in Figure 5.4.2.

(3) The STP1 is designed to cater for the Phase 1A Development. It is located at the North East of Putrajaya and its treated effluent meets the DOE's effluent standard A. It will be discharged into the Sg. Air Hitam. Thus its effluent poses no threat to the Putrajaya Lake system.

(4) The STP1 is designed using conventional activated sludge process and is practically completed. However, it has not been handed over to the developer, Putrajaya Holdings Sdn Bhd.

(5) The STP2 plant located at the south of the development is planned and designed to cater to the sewage treatment needs of the Phase 1B and Phase 2 Putrajaya Development. Since the plant is located after the Main Dam and the treated effluent will be discharged outside of the lake body it posed no threat to the water quality of the lake.

5.4.3 Cyberjaya Flagship Development Zone (Phase 1B)

5.4.3.1 The whole Cyberjaya Development covers about 70,000 hectares of land for development, which encompasses mixed development for an ultra modern and High Technology City. The initial phase of development of about 2800 hectares is located on the eastern half of Cyberjaya and it is referred as the Cyberjaya Flagship

PERBADANAN PUTRAJAYA

FIGURE 5.4.2

OVERALL LAYOUT OF PROPOSED PUTRAJAYA DEVELOPMENT SEWERAGE PLAN

Development Zone.

5.4.3.2 The proposed Phase 1B Development area of approximately 398 hectares is located at the South East of the Cyberjaya Flagship Zone and fronting the Phase 2 Putrajaya Lake. It is also located within the Lake catchment.

5.4.3.3 There are four existing temporary packaged sewage treatment plants located at the north west of the Phase 1B Development Area. The plants are treating the sewage flows from the Multi-Media Development Corporation (MDC) head office, Cyber Lodge, site offices and some low-rise service apartments. The plants are of the enclosed (underground) type with extended aeration activated sludge system and its treated effluents meets DOE's Standard A. The capacities of the plants are : Plant A (425 PE), Plant B (170 PE), Plant C (65 PE) and Plant D (500 PE). The treated effluents discharge into open earth drains which are approximately one kilometre from the bank of the Phase 2 Putrajaya Lake, i.e. downstream of the temporary dam.

5.4.3.4 One parcel of land of about 27 hectares of low density residential development (Country Heights Development) is located south of Phase 1B and will be implemented in the very near future. (The implementation date is not confirmed). A small temporary sewage treatment plant of capacity 560 PE will be built for this planned development. The treated effluent from the plant will be discharged into the Putrajaya Lake, downstream of the temporary dam.

5.4.3.5 The overall proposed Cyberjaya Sewerage Plan of the Flagship Zone Phase 1A as shown in Figure 5.4.3 has formulated the following planning and implementation strategies :

- All sewered sewage flows for the whole Cyberjaya will be transferred to a permanent centralised sewage treatment plant located in the south-west of the Cyberjaya Development Township.

- All sewered sewage flows of the Cyberjaya Flagship Zone will be treated by a proposed temporary sewage treatment plant located at the western part of the Flagship Zone.

- The early and initial developments within the Flagship

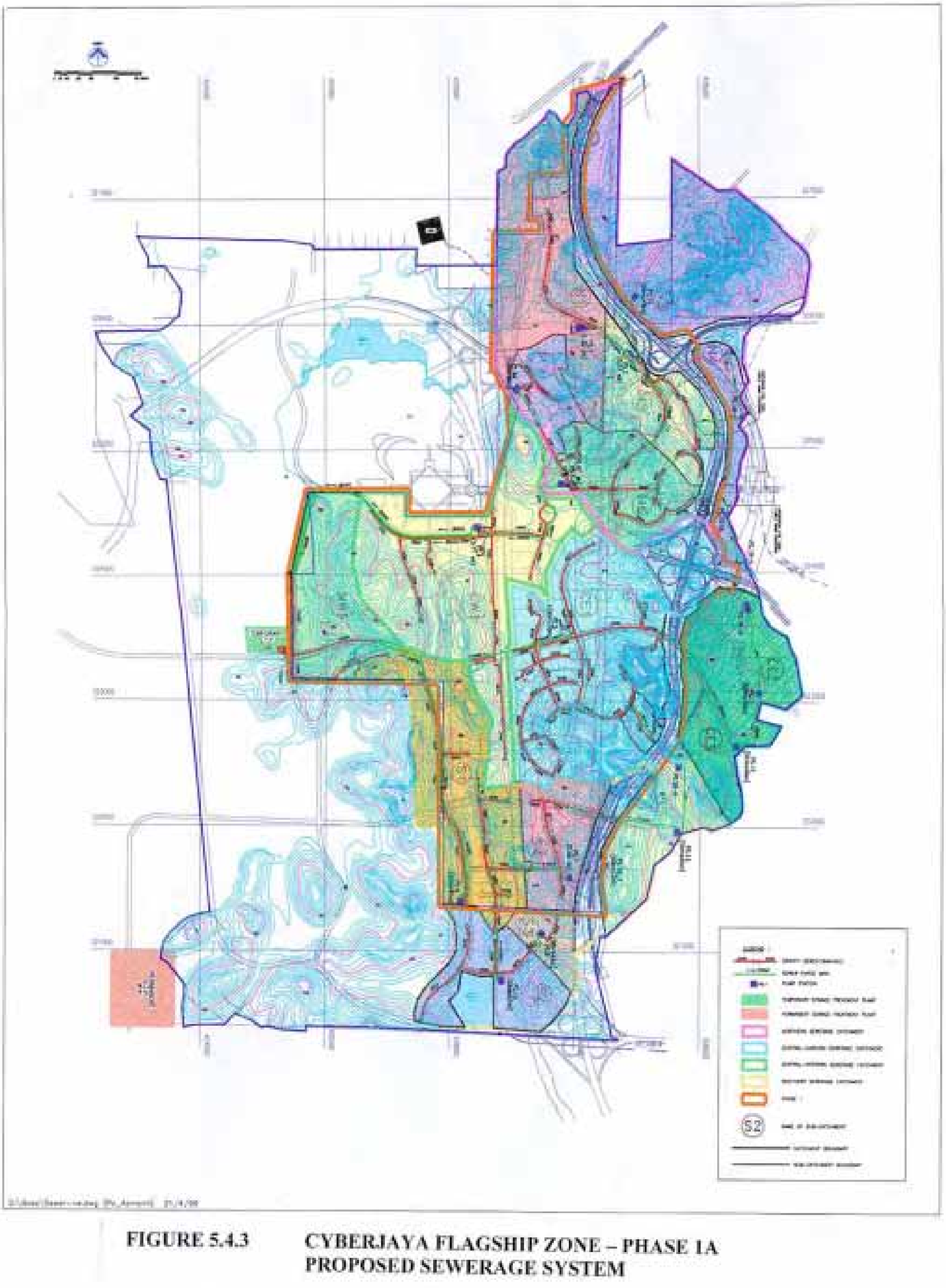

FIGURE 5.4.3 CYBERJAYA FLAGSHIP ZONE – PHASE 1A PROPOSED SEWERAGE SYSTEM

Zone will have their own temporary sewage treatment plants to treat the sewered sewage, respectively. These sewage flows will later be transferred to the Flagship Zone major temporary sewage treatment plant in the very near future.

- The sewage flows in Phase 1B of the Flagship Zone (within the lake catchment) will be transferred, treated and discharged outside the Sg Chuau or Lake Catchment.

5.4.4 Universiti Putra Malaysia

5.4.4.1 Universiti Putra Malaysia (UPM) has an area of about 1170 hectares and approximately half of the area is located in the northern part of the lake catchment. The streams and ponds in UPM are the tributaries of the upstream stretches of Sg. Chuau, which connects to the constructed Upper North Wetland.

5.4.4.2 There is no sewage collection system or sewer reticulation to convey sewage flows from the various buildings to a central sewage treatment plant. Individual sewage treatment plant(s) were provided at these buildings (which were built in stages) to treat the receiving sewage flows before discharging into the streams and ponds, which finally flow into the Upper North Wetland.

5.4.4.3 The existing sewerage works in the lake catchment are summarised in Table 5.4.1.

Table 5.4.1 Existing UPM Sewerage Works

Building	Estimated PE Served	Sewage Treatment Plant	Effluent Discharging Into
Kolej 8	1,097	Three Septic Tanks (Sullage water separated)	Existing stream
Kolej 9	1,038	Imhoff Tank (Sullage water separated)	Existing stream and pond
Kolej Matrikulasi	2,000	Packaged Activated Sludge Treatment Plant	Existing stream and pond
Pusat Kesihatan Pelajar	25	Septic Tank	Open drain
Kafe	50	Septic Tank	Open drain
Time Telekom	5	Septic Tank	Open drain
UPM-MTDC	150	Septic Tank(s)	Open drain
UPM Golf Club	360	Septic Tank	Drain and pond
Putra Info Port	200	Septic Tank	Open drain
Total	4,925		

5.4.4.4 Sewage flows with sullage water separated, from Kolej 8 and 9 are treated by an imhoff tank and three septic tanks respectively. These sewage treatment septic tanks each consist of simple compartments for scum/ sludge digestion and settlement, and a simple filter media for slow filtration of effluent flows. These sewage tanks are required to be regularly desludged and cleaned to avoid any accumulation of excess sludge and filter blockage which will cause overflow or by-passing the simple treatment processes of the septic tanks. It is known that the septic and imhoff tanks have very limited biological treatment and no aeration facilities in the simple sludge compartments. Thus, they are not capable of treating the domestic sewage to DOE's Standard A effluent requirements. Further treatment of septic tank effluent using trickling or percolating filters or filter trenches etc are required, depending on the location, soil permeability and ground water conditions. The level of sewage treatment of the tanks is further strained due to the over loading of the sewage flows resulting from more students per room in the hostels.

5.4.4.5 A packaged activated sludge treatment plant of capacity 2,000 PE treats sewage flows from Kolej Matrikulasi. The two-year-old treatment plant has been in operation without any major reported problems. However, there is no sampling and testing of the treated effluents from the plant to check that DOE's Standard A effluent requirements are met.

5.4.4.6 The UPM privatised hostel project referenced as Kolej Baru is under construction and is expected to be completed by 2000/2001. The proposed sewage treatment plant consists of modules of compact packaged plants of Hi-Kleen (Trade name) using extended-aeration activated sludge system with total capacity of 7000 PE. The treated effluent, meeting DOE's Standard A will be discharged into the existing UPM ponds in series and finally into the Upper North Wetland.

5.4.4.7 A privatised teaching hospital located close to the existing Putra Infoport has been proposed. However, the proposed hospital is still in the very preliminary stage and no information or data is available.

5.4.5 Malaysian Agricultural Research and Development Institute (MARDI)

5.4.5.1 Malaysian Agricultural Research and Development Institute (MARDI) is located adjacent to UPM and has a total area of about 752 hectares. The principal land-use of MARDI is for agricultural research activities such as farms and orchards.

5.4.5.2 MARDI's head office and associated buildings accommodate about 1500 office staff. The generated sewage flows from these buildings are treated by four existing septic tanks. The estimated PE of MARDI is 500 PE.

5.4.5.3 There are about twenty old living quarters in MARDI and would contribute a small PE of 100 to the sewage flow, which is treated by individual septic tanks.

5.4.5.4 The treated effluents from the MARDI's septic tanks are discharged into the existing open drains, flowing through low land, ponds, streams and finally into the Upper North Wetland.

5.4.5.5 The treated effluents are likely to meet DOE's Standard B. However, the total effluent quantity is small and estimated at 135 m^3/day or 0.0016 m^3/s for 600 PE. In addition, the repatriation of the effluents with stream water along the flow path of grass-lined channels before reaching the wetland will greatly enhanced the quality of the combined flow.

5.4.6 IOI Palm Garden Resort Development

5.4.6.1 The IOI Palm Garden Resort Development is located north of the Upper East Wetland and east of the Upper North Wetland. It consists of an existing club house (300 PE), existing service apartments (612 PE), an office and condominium development (under construction) (3175 PE), proposed future office (1394 PE) and hotel (2280 PE), giving a total sewage load of 7761 PE.

5.4.6.2 The existing sewage treatment system consists of two small packaged Super-Sept (Trade name) tanks and one aerated lagoon sewage treatment plant. The effluents from the system are discharged into the existing golf landscaping cum retention ponds, which are connected to a stream leading to the Upper North Wetland.

5.4.6.3 The Jabatan Perkhidmatan Pembentungan (JPP) has approved the proposed mechanised sewage treatment plant, with extended aeration activated sludge process, to serve the entire development sewage load of 7761 PE. The treated effluent is designed to meet DOE's Standard A and is discharged into the retention pond, which flows into the Upper North Wetland, after crossing the Kajang-Puchong road. The approved sewerage works are shown in Figure 5.4.4.

5.4.6.4 There is no water quality monitoring program for the combined discharge of surface runoff and treated effluents at the outlet of the retention pond. However, it is anticipated that the final discharge into the Upper North wetlands will not have any adverse pollutant overloading impact on the wetlands, in view of the holding period and dilution of the effluent in the retention pond. The pond, acts to some extent, as a maturation pond for polishing the soluble organic wastes of the treated effluent.

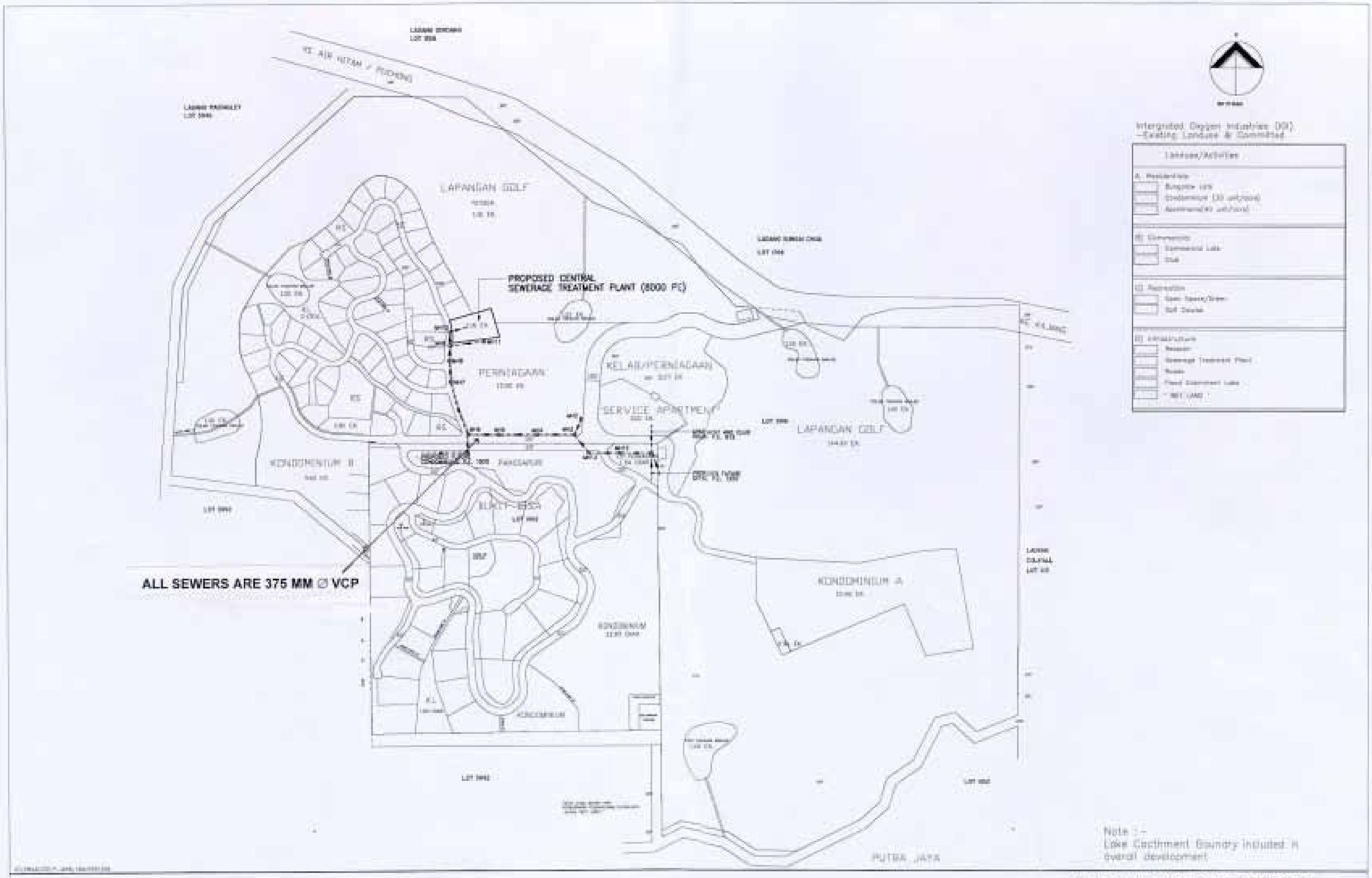

FIGURE 5.4.4 IOI PALM GARDEN RESORT DEVELOPMENT
PROPOSED SEWERAGE WORKS

5.4.7 TNB Serdang Power Station

5.4.7.1 The Serdang Power Station (SPS) is an existing open cycle gas turbine power plant which comprises 2 units of 110 MW and 3 units of 135 MW gas turbines. More than half of the plant land is located in the Sg. Chuau Lake catchment, and the power plant is situated adjacent to Upper West Wetland, which encroaches slightly into the power plant land.

5.4.7.2 The SPS is manned by about 50 TNB staff. The small sewage flow generated from the station is treated by a local septic tank. The sewage effluent together with storm water runoff from the area and the machinery cleaning water is collected and passed through specially designed oil water separator. The combined flow discharges at only one outlet point into Sg. Gajah via an existing stream at the north west of the SPS site.

5.4.7.3 As the SPS combined effluent discharges outside of the lake catchment, there is no impact on the Putrajaya Lake water quality.

5.4.8 West Country Development

5.4.8.1 Presently this area is an oil palm estate and is undeveloped. The developer is proposing to develop the area into a mixed development consisting of residential and commercial units. The planning for the layout plan is still in the preliminary stage. The developer has told the Consultant that they are planning to pump the sewage, arising from the low density development within the catchment, for treatment outside the catchment.

5.4.9 Sg Merab Malay Reserve

Sg. Merab Malay Reserve is owned by individual private land owners. They are presently planted with rubber trees.

5.5 SEWAGE EFFLUENT QUALITY REQUIREMENTS

5.5.1 Purpose of Effluent Standards

Sewage effluent quality standards or requirements are used to regulate the quality of treated effluent from sewage treatment plants to receiving waters. The regulation of effluent discharges will protect receiving waters such as rivers and lakes from the harmful effects of inadequately treated sewage.

5.5.2 Existing DOE's Effluent Standards

5.5.2.1 The Environmental Quality Act (EQA) 1974 specifies two standards for effluent discharges:

Standard A: For discharge upstream of any raw water intake for potable water supply

Standard B: For discharge downstream of any raw water intake

5.5.2.2 The two standards are listed in the Third Schedule of the EQA 1974, under the Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979, Regulation 8(1), 8(2) and 8(3). An extract of the standards is given in Appendix 5.2.

5.5.3 Putrajaya Lake Ambient Water Quality Standard

5.5.3.1 The Putrajaya Lake Management Guide (1998) has established the ambient lake water quality standard for the Putrajaya Lake body so that it can meet the intended functions of recreation, boating and fishing for the lake, in addition to enhancing the aesthetics of the landscape surrounding the lake.

5.5.3.2 The Putrajaya Lake ambient water quality standard is appended in Appendix 5.3.

5.5.3.3 The established standard is close to that of Class IIB of Interim National River Water Quality Standards for Malaysia (INRWQSM), which is appended in Appendix 5.4.

5.5.4 Sewage Effluent Quality Requirements

5.5.4.1 Based on the water quality requirements for the lake established in the preceding sections, the receiving water, i.e. Putrajaya Lake will require the removal of nutrients such as nitrogen and phosphorous, lower BOD_5, lower suspended solids and control of coliform levels for the treated sewage effluents.

5.5.4.2 It is also recognised that the required effluent standards for the treated effluents will be higher than DOE’s Standard A and shall include additional parameter limits with reference to DOE's Standard A.

5.5.4.3 The treated effluents from the sewage treatment plants discharging into the drainage system in the Sg. Chuau or Putrajaya Lake catchment are required to meet an effluent standard that will eventually be established from the water quality modelling study, based on the carrying capacity of the Putrajaya Lake system, which consists of wetlands.

5.5.4.4 It is noted that only the treated sewage flow of Standard A from the Phase 1B Cyberjaya Flagship Development Zone will be temporarily discharged directly into the Phase 2 Putrajaya Lake, i.e. downstream of the temporary dam.

5.5.4.5 The existing and the future treated effluents from UPM, MARDI, IOI Palm Garden Resort and West Country Resort will be discharged only into the Upper North Wetland and Upper East Wetland, where the effluents will be further treated. The wetland vegetation facilitates attachment of bacteria films, aids in the filtration and absorption of wastewater constituents, transfers oxygen into the water column and also controls algae growth. In this respect, the functions of the Putrajaya Wetlands are considered in the water quality modelling for the treated sewage pollutant loading and other pollutant loadings.

5.5.4.6 In a typical composition of untreated or raw sewage, the concentrations of nitrogen and phosphorus are :

Nitrogen		**Phosphorus**	
Total nitrogen	20 - 85 mg/l	Total phosphorus	2-20 mg/l
Organic nitrogen	8 - 35 mg/l	Organic phosphorus	1-5 mg/l
Ammonia nitrogen	12 - 50 mg/l	Inorganic phosphorus	1-15 mg/l
Normal total nitrogen	40 mg/l	Normal Total phosphorus	8 mg/l

5.5.4.7 The combined nitrification and denitrification processes in biological sewage treatment plant are capable of removing up to 90% of the total nitrogen. (TN).

The use of advanced wastewater treatments such as combined removal of nitrogen and phosphorus using biological A_2/O processes could achieve effluent total phosphorus (TP) concentration less than 2.0 mg/l without effluent filtration.

5.5.4.9 In consideration of the possible treatability values of TN and TP using more-mechanised sewage treatment plant, and the wetland treatment capability evaluated by the water quality modelling results, the recommended effluent parameter limits for TN and TP are to be set at 10 mg/l and 2.0 mg/1, respectively.

5.5.4.10 It is also important to recognise, however, that the concentration of phosphorus necessary to support an algae bloom is only 0.005 to 0.05 mg/l as TP, and that this level may be readily exceeded from natural sources in many surface waters. In such circumstances, treatment of the sewage to remove phosphorus totally will not prevent algae growth.

5.5.4.11 The faecal coliform counts and total coliform counts can be controlled to INRWQSM Class IIB parameter limits of 400 counts/100ml and 5000 counts/100ml, respectively by chlorination treatment.

5.5.4.12 In order to improve the aquatic environment of the lake body and wetlands, the residual chlorine is recommended to be limited to 0.5 mg/l instead of 1.0 mg/l of DOE's Standard A.

5.5.4.13 Appendix 5.5 has been prepared to facilitate comparison of the values of the parameter limits for the followings standards :

(i) Interim National River Water Quality Standard for Malaysia - Class II B.

(ii) Putrajaya Ambient Lake Water Quality Standard

(iii) EQA Effluent Standard A

(iv) Recommended Effluent Standard for Putrajaya Lake Catchment

5.5.5 Recommended Effluent Standard For Putrajaya Lake Catchment

The recommended sewage effluent quality standard for Putrajaya Lake Catchment is presented in Table 5.5.1.

Table 5.5.1 Recommended Effluent Standard for Putrajaya Lake Catchment

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE
		RECOMMENDED EFFLUENT STANDARD FOR PUTRAJAYA LAKE CATCHMENT
1.	Temperature (°C)	40
2.	pH (units)	6.0 - 9.0
3.	BOD_5 at 20°C	20
4.	COD	50
5.	Suspended Solids	50
6.	Mercury	0.005
7.	Cadmium	0.01
8.	Chromium, hexavalent	0.05
9.	Arsenic	0.05
10.	Cyanide	0.05
11.	Lead	0.10
12.	Chromium, trivalent	0.20
13.	Copper	0.20
14.	Manganese	0.20
15.	Nickel	0.20
16.	Tin	0.20
17.	Zinc	1.0
18.	Boron	1.0
19.	Iron	1.0
20.	Phenol	0.001
21.	Free Chlorine	0.5
22.	Sulphide	0.5
23.	Oil and Grease	Not Detectable
24.	Dissolved Oxygen	5.0
25.	Total Phosphorous	2.0
26.	Total Nitrogen	10.0
27.	E-Coli (Counts/100 ml)	400
28.	Total Coliform (Counts/100 ml)	5,000

5.6 SEWERAGE PLANNING AND DESIGN GUIDELINES

5.6.1 General

5.6.1.1 Sewerage refers to the collection, treatment and disposal of domestic wastewater or sewage flow.

5.6.1.2 Sewerage works include all physical structures such as sewers, manholes, sewage lifting or pumping stations, sewage treatment plants etc. required for that collection, treatment, and disposal of sewage flows.

5.6.1.3 This Section intends to provide, in relation to this sewerage masterplan, some pertinent points on the sewerage planning and design guidelines, particularly for the sewage treatment plants, which are required to treat the collected sewage flows to the Recommended Effluent Standard For The Putrajaya Lake Catchment, before being discharged into the receiving waters leading to the Putrajaya Wetlands.

5.6.1.4 Recommended sewage treatment practices are also included for reference.

5.6.1.5 The detailed planning and design requirements and criteria for the sewerage works can be obtained from many reference materials. The following are most relevant :

(i) MS 1228 (1991) : Code of Practice for Design and Installation of Sewerage Systems

(ii) Guidelines for Developers on the Design and Installation of Sewerage Systems published by Ministry of Housing and Local Government, Sewerage Service Department

Volume 1	New Developments
Volume 2	Sewerage Works Procedures
Volume 3	Sewer Networks and Pump Stations
Volume 4	Sewage Treatment Plants
Volume 6	Mechanical and Electrical Equipment

(iii) Environmental Quality Act (Sewage and Industrial Effluents) Regulations, 1979

(iv) Occupational Safety and Health Act, Malaysia, 1994 (OSHA)

(v) Wastewater Engineering - Treatment, Disposal and Reuse (Third Edition), 1991 by Metcalf & Eddy

(vi) Operation of Municipal Wastewater Treatment Plants - Manual of Practice No. 11 Volume I, II, III (Second Edition) 1990 : Water Pollution Control Federation USA.

5.6.2 Sewerage Planning Guidelines

The following are the pertinent points for the sewerage planning in relation to the Putrajaya Lake Catchment Plan :

5.6.2.1 Wherever possible and applicable, all treated sewage effluents from the developments in the catchment shall be channelled outside the drainage system of Sg Chuau or the Putrajaya Lake catchment.

5.6.2.2 The treated effluents, where possible are to be directed into the Putrajaya Wetlands or mini wetlands, instead of direct discharge into the Putrajaya lake.

5.6.2.3 Unless severely restricted by the topography or difficult terrains of the development area, one single central sewage treatment plant shall be planned and constructed to treat the sewage flows from the whole development.

The provision of strategically located transfer pumping stations will convey the sewage flows to the central sewage treatment plant(s) effectively.

The central sewage treatment plant could be implemented in few phases or modules to cater for the incremental increase of sewage flows resulting from phased developments.

5.6.2.4 The treated effluent, where possible, are to be discharged into drainage detention ponds, which would act as water dilution body and maturation pond for polishing the soluble organic wastes of the treated effluent. The resulting pollutant loads will be further reduced while entering into the wetlands.

5.6.2.5 The industrial wastewater shall not be allowed to discharge into the sewers or sewage treatment plants. These wastewater discharges may contain significant quantities of toxic pollutants and other substances that can affect the sewage treatment system and interfere with the plant performance.

5.6.3 Sewerage Design Guidelines

Good and established design guidelines and practices for the sewerage works, particularly the sewage treatment plants, shall ensure :

(i) effluent quality consistently comply to the required standard

(ii) safety and ease of operations and maintenance

As stated earlier, there are many reference materials for the sewerage design guidelines outlining the design data, criteria, parameters, best practices requirements including materials and standard details, etc. The following provided herein are some pertinent points of sewerage design requirements including the design considerations for emergency response measures.

5.6.3.1 Safety

(1) The layout planning and design of plant process components for a sewage treatment plant shall comply with the standards and procedures as set out in the Occupational Safety and Health Regulations Design. Considerations shall be given to safety aspects on storage and handling of hazardous chemicals, confined spaces, safety exits, operation access, ventilation, odour, noises, lighting, warning labelling and posting, slick or wet floors, personal protective equipment provision, etc.

(2) A Hazards and Operability (HAZOP) audit is to be carried out on the completed treatment plant design to ensure all the safety measures are provided.

5.6.3.2 Lifting Station

The lifting station could be provided in the sewer network for two occasions :

(a) as the sewage flows by gravity in a long sewer along flat terrains or against sloping terrains, the use of a lifting station to pump the sewage to a higher level could thereby avoid having deep sewers downstream.

(b) lifting station transfers the collected sewage flow at a localised low sub-sewerage catchment, at times over high elevation delivering the sewage to a sewage treatment plant or a receiving gravity sewer.

5.6.3.3 Power Supply

(1) Power failure or interruption will stop the plant and pump operations.

(2) The following arrangements are to be made, depending on the capacities of the sewage treatment plants and the lifting stations, in the descending orders :

(a) Two completely separate power supplies (> 20,000 PE)

(b) Dual incoming mains from the same substation zone (> 5,000 PE)

(c) Back-up diesel generators and stand-by power supply (> 5,000 PE)

(d) Facility to hook up transportable diesel generator (This is applicable to small pumpsets in lifting stations).

5.6.3.4 Standby Units and Back-up Capacity

(1) The standby units and back-up capacity provision shall be provided for the following processes of a sewage treatment plant:

(i) Screen Facilities
(ii) Inlet Works / Pumps
(iii) Grease and Grit Removal Chambers
(iv) Biological Treatment
(v) Secondary Clarifiers
(vi) Sludge Treatment Facilities

(2) The standby units will come into operation to avoid plant stoppage time and overloading of process units.

(3) The back-up capacity provided shall be such that when one unit is taken out for maintenance or is out of operation, the other remaining unit(s) shall not be overloaded beyond 50% of their rated capacities.

(4) The requirements for standby units and back-up capacity of

process units, which are well documented in Guidelines for Developers Volume 4 : Sewage Treatment Plant, should be adhered to and incorporated into the design of sewage treatment plants and pumping stations to ensure reliable operation.

5.6.3.5 Pumping Station Storage Capacity

For lifting or pumping stations located near to the Putrajaya Lake and Wetlands, two (2) hours storage capacity in the station should be provided. The requirement is to allow time for connecting to or hook up to a standby generator.

5.6.3.6 Provision of Portable Pumps in Sewage Treatment Plant

Portable pumps operating on diesel could be used to bypass the sewage in the event that the sewer breaks or sewer blockage occurs. This will prevent sewage overflowing into the nearby drains or streams without control.

5.6.3.7 Treatment Process Controls

(1) The sewage treatment plant, though designed to discharge treated effluent meeting the required effluent quality standard, may fail in its performance thus leading to pollution of receiving waters.

(2) Thus, the sewage treatment plant has to be operated by qualified and trained personnel. Also, the plant shall be designed to incorporate process monitoring and on-line control instrument or equipment shall be installed at designated locations. This will enable the plant operator to anticipate the need for operational adjustments based on changes in process performance and on review of past operating records.

(3) The characteristics of the wastewater being treated in the process units may include temperature, pH, turbidity, flow rate, conductivity, dissolved oxygen and free chlorine. Any variances of parameter limits in these wastewater characteristics in the process units will provide an early warning of process deviations, which can then be captured before they can affect the plant's biological treatment systems.

5.6.4 Recommended Sewage Treatment Processes

5.6.4.1 The normal treatment processes of a sewage treated plant consist of :

(a) *Preliminary Wastewater Treatment that includes :*

- preliminary screening
- pumping to lift sewage and provides consistent flow to the treatment system
- secondary screening
- grease and grit removal

(b) *Secondary Treatment that includes :*

- biological treatment
- secondary sedimentation
- disinfection

(c) *Sludge Treatment and Disposal*

5.6.4.2 Sewage Treatment Processes

(1) Biological treatment is the principal sewage treatment process, where the sewage is exposed to living organisms that remove major pollutants in the sewage.

(2) There are two basic biological treatment systems and their combinations, viz. :

- Suspended Growth System
- Fixed Film Growth System
- Combined Process (Contact Aeration) System

(3) In Malaysia, the following biological treatment processes are commonly used :

Suspended Growth System

(a) Conventional activated sludge process
(b) Extended aeration activated sludge process
(c) Oxidation ditch
(d) Sequence batch reactor

Fixed Film Growth System

(a) Rotating biological contactor
(b) Trickling filter

(4) In the Putrajaya Lake Catchment, the receiving water bodies such as the wetland require higher treated effluent quality as set out in the Recommended Effluent Standard for Putrajaya Lake Catchment. The standard includes the parameters of total nitrogen (TN), total phosphorus (TP), and coliforms.

(5) Treatment effluent discharges containing excessive nitrogen and phosphorus may accelerate the eutrophication of lakes and may stimulate the growth of algae.

(6) Only about 20% to 30% of the total nitrogen and the total phosphorus in the wastewater can be removed by conventional secondary treatment. As such, advanced wastewater treatment is required as additional treatment to remove or reduce suspended and dissolved substances remaining after conventional secondary treatment.

(7) The advanced wastewater treatment normally utilises a combination of the following unit operations and processes:

- granular-medium filtration
- carbon absorption
- chemical precipitation
- extended biological treatment such as nitrification/ denitrification

(8) A number of biological processes have been developed for combined removal of nitrogen and phosphorus. These processes involve a form of the activated sludge process but employ combinations of anaerobic, anoxic, and aerobic compartments or zones to effect nitrogen and phosphorus removal. The commonly used processes are the A2/O process, UCT process, VIP process, sequencing batch reactor, and five-stage Bardenpho process. (Ref Metcalf & Eddy). However, successful performance of these processes depends upon sophisticated process monitoring and control, and specific local conditions.

5.6.4.3 The Recommended Sewage Treatment Practices (Processes)

(1) It is recommended to use :

- biological nitrification/denitrification to remove nitrogen followed by addition of alum to remove phosphorus

- chlorination to remove and control pathogenic organisms in the effluent.

(2) The biological nitrification/denitrification firstly converts ammonia aerobically (nitrification) to nitrates, then convert nitrates to nitrogen gas (denitrification). It is considered the best process option for nitrogen removal for the following reasons : (1) high removal efficiency, up to 90%, (2) more stable and reliable process, (3) relatively easy process control (4) economical, and (5) operates as secondary biological treatment (with alum addition to remove phosphors)

(3) The oxidation ditch has been used to achieve nitrification and denitrification by having mixed liquor flows around a loop type channel, driven and aerated by mechanical aeration devices.

(4) The addition of alum in secondary clarifiers not only removes phosphorus but also to coagulate colloidal particles and together with the metallic precipitates, will settle readily in the secondary clarifier, thus reducing the suspended solids in the effluent more effectively.

(5) Chlorination is recommended for effluent disinfection because of its simple feed and control procedure, and its low cost compared to other methods. The residual chlorine in the effluent can be easily controlled not to exceed 0.5 mg/l in chlorine feeding operation so that aquatic life in the wetland and lake will not be affected.

5.6.5 Emergency Response plan (ERP)

5.6.5.1 The Emergency Response Plan (ERP) for sewerage works is the continuous development and documentation of actions and procedures to deal with all anticipated hazards, both natural and man-made, that could adversely affect the operation of the sewerage facilities or the environment.

5.6.5.2 There are four phases of emergency activities, viz.

i. Emergency Preparedness Planning
ii. Mitigation
iii. Response, and
iv. Recovery

5.6.5.3 The planning process is to identify the hazards and dangers arising from the operation of the sewerage works. The common natural hazard in Malaysia is flood while man-made hazards are chemical release, supply shortage, pipe ruptures, fire, strike etc. The corresponding dangers are electrocution, power failure, health risks and death, damage to the environment such as sewage overflowing the manholes, plant shutdown, plant inaccessible to operation workers etc.

5.6.5.4 Some of the emergency response measures and planning have been incorporated in the sewerage design guidelines of Section 5.6.3.

5.6.5.5 However, emergency response plans (ERP's), one for each potential situation caused by the occurrence of the hazards, should be developed and prepared. A typical ERP outlines the following:

- Emergency flow chart
- Contact lists: name, position, location, telephone numbers (including home numbers)
- Chain of commands for the line of authority in an emergency
- Organisation chart of duties identifying each group and its emergency response activities
- Emergency equipment list of all heavy equipment and vehicles by their locations
- Damage assessment forms
- Maintenance or clean-up contractor list
- Public information procedures for communication about emergency and response activities
- Emergency operations centre

It is prudent to test the ERPs for their effectiveness.

5.6.5.6 In the mitigation phase, it is important to provide regular and appropriate training to personnel in emergency preparedness procedures. Operation management staff would need to constantly review and correct improper operation and maintenance practices such as deferred preventive maintenance.

5.6.5.7 The response is to carry out the relevant ERP activities involving mobilising emergency personnel and equipment, evacuating plant personnel and alerting the public when necessary. Upon completion of ERP and response, recovery is followed to reconstruct or rehabilitate the damaged works as well as to develop hazard reduction programmes or measures. A review and improvement on the ERP will also have to be made.

5.7 SEWERAGE MASTERPLAN FOR PUTRAJAYA LAKE CATCHMENT

5.7.1 General

5.7.1.1 The overall Sewerage Masterplan for the Putrajaya Lake Catchment shall map out the planning and implementation strategies of sewerage works in the catchment areas so as to minimise and control sewage pollutant loadings from water courses draining into the Putrajaya Lake.

5.7.1.2 The existing landuses, the proposed developments which are confirmed or being implemented and the proposed future landuses or the ultimate catchment masterplan landuses, are the major factors for the formulation of the catchment sewerage masterplan.

5.7.1.3 The existing sewerage situations of the developments in the catchment are reviewed in the Section 5.3.

5.7.1.4 The existing landuses and catchment masterplan landuses are detailed in Chapter 6.

5.7.1.5 Indah Water Konsortium Sdn. Bhd. (IWK), the Privatisation Company undertaking the National Sewerage System Project, has carried out the Sewerage Catchment Strategy Study for the region of Daerah Petaling in 1998. The study report has identified a major sewerage sub-catchment called Kota Perdana/ Listari Sub-Catchment, covering MARDI, UPM and southern areas of Majlis Perbandaran Subang Jaya. A regional central sewage treatment plant located in the south of UPM has been proposed to cater for the sewage loads of the existing developments, where the treatment facilities are not satisfactory, and also for the future developments in the sewerage sub-catchment.

5.7.2 Population Equivalent (PE) For Putrajaya Lake Catchment

5.7.2.1 Based on the available ultimate landuses information, the sewage discharge loadings in the form of Population Equivalent (PE) in the Putrajaya Lake Catchment are estimated and summarised in Table 5.7.1.

5.7.2.2 The Table also shows the existing and future sewerage loads of various developments within the lake catchment.

5.7.2.3 The effluent discharges into the Sg. Chuau and into other river systems outside the lake catchment are also identified.

5.7.2.4 The total average sewage effluent discharging into Sg. Chuau or Putrajaya Lake catchment is 9168 m^3/d or 0.106 m^3/s of 40,746 PE consisting:

MARDI	0.0135 m^3/s (5180 PE)
UPM	0.0724 m^3/s (27,805 PE)
IOI Palm Garden Resort	0.0201 m^3/s (7,761 PE)

Table 5.7.1 PE for Putrajaya Lake Catchment Masterplan

DEVELOPMENT	LANDUSES	TOTAL * AREA (Ha)	ESTIMATD PE			ESTIMATED PE SEWAGE LOADING	
			EXISITING	FUTURE	TOTAL	SG CHUAU	OTHER RIVERS
PUTRAJAYA	Federal Government Administrative Centre Residential Commercial Recreational	4,200	100,000	500,000	600,000	-	600,000
CYBERJAYA FLAGSHIP ZONE (Phase 1B)	Commercial Residential	225	1,160	52,240	53,400	-	53,400
MARDI	Research Centre	488	600	4,580	5,180	5,180	-
UPM	Educational Research	562	11,925	15,880	27,805	27,805	-
IOI Palm Garden Resort	Residential Hotel Offices	170	4,087	3,674	7,761	7,761	-
West Country	Residential Commercial	111	-	16,090	16,090	-	16,090
TNB Serdang Power Plant	Industrial	90	50	-	50	-	50
Kg Sg. Merab Lands	Mixed Development	36	-	6,670	6,670	-	6,670
Total		5882	117,822	599,134	716,956	40,746	676,210

* Area in the Putrajaya Lake Catchment

5.7.3 Sewerage Plans For Various Developments

Ideally, all the development areas within the Putrajaya Lake catchment could be planned as an integrated development in terms of overall landuses, utilities and infrastructures including the sewerage works. However, there are private and public land owners and Government institutions in the catchment. Also some of the developments have been in existence for many years. It is imperative, therefore, to strategise the sewerage planning for each development and where applicable the combined developments, to formulate the overall sewerage masterplan for the lake catchment.

5.7.3.1 Putrajaya Development

(1) Putrajaya Development has a comprehensive sewerage masterplan consisting of modern sewage collection systems with lifting stations and two central sewage treatment plants STP 1 (100,000 PE capacity) and STP 2 (500,000 PE).

(2) The proposed sewerage works of Phase 1A Development is being implemented and near completion with STP 1 physically completed. Other proposed sewerage works will be carried out according to the development phasing plan.

(3) The treated effluents of DOE's Standard A of STP 1 will be discharged into Sg. Air Hitam, and that of STP 2 into downstream of the proposed Main Dam to the Putrajaya Lake. The treated effluents in Putrajaya Development will not be discharged into the lake body and therefore pose no threat to the lake water quality.

(4) The proposed Putrajaya Development Sewerage Plan shall be implemented as part of the Putrajaya Lake Catchment Sewerage Masterplan.

5.7.3.2 Cyberjaya Flagship Development Zone (Phase 1B)

(1) The sewage flows from the Phase 1B Cyberjaya Flagship Zone that lies within the lake catchment, will be transferred outside the Sg. Chuau drainage system in accordance with its overall sewerage development plan. The treated effluents will not therefore be discharged into the lake body.

(2) However, there are four existing temporary sewage treatment

plants of total capacity of 1,160 PE in the Phase 1B Development area and the treated effluents are discharging into the open drains that lead to the Phase 2 Putrajaya Lake, i.e. downstream of the temporary dam. Presently, there is no impact because the Phase 2 Putrajaya Lake is not constructed yet.

(3) It is recommended that, when the Phase 2 Putrajaya Lake is formed, the treated effluents from the existing temporary sewage treatment plants shall be collected and transferred outside the lake catchment.

(4) The proposed Cyberjaya Sewerage Development Plan and strategy shall be implemented to ensure that the sewage flow in Phase 1B Cyberjaya Flagship Zone is not discharged into the Phase 2 Putrajaya Lake, which is scheduled to be completed and commissioned by 2001.

5.7.3.3 MARDI

(1) It is recommended that the existing sewage flows of 600 PE and sewage flows from future development in MARDI are to be sewered to a proposed new central sewage treatment plant.

(2) It is anticipated that a sewerage plan would be proposed to cater for the combined sewage treatment requirements for the MARDI and UPM developments lying within the lake catchment. The plan will be developed when the future landuses of MARDI and UPM are available.

5.7.3.4 UPM

(1) The sewage treatments for the wastewater of Kolej 8 (1,097 PE) and Kolej 9 (1,038 PE) are far from satisfactory. Similar to that of MARDI, it is recommended to upgrade the existing sewage treatment plants (imhoff and septic tanks) of the two hostels.

(2) The sewage flows from the two hostels, together with those from the Pusat Kesihatan Pelajar, Kafe, UPM-MTDC and future developments including UPM Hospital are to be sewered to a proposed new and central sewage treatment plant located upstream of UPM ponds and Upper North Wetland.

(3) The proposed central sewage treatment plant could also treat the sewage flows from MARDI.

(4) The proposed central sewerage plan can be integrated in the IWK sewerage development plan of Kota Perdana/ Listari sewerage sub-catchment in the region of Daerah Petaling. It is recommended that the sewerage services of UPM and MARDI are taken over by IWK so that the operation and maintenance of the existing sewerage facilities, interim sewerage upgrading works, and future sewerage development can be carried out effectively by IWK. The treated effluents from the proposed Kota Perdana/ Listari central sewage treatment plant shall be transferred outside the lake catchment.

5.7.3.5 IOI Palm Garden Resort

(1) The presently proposed sewer reticulation and a central sewage treatment plant of capacity 7,761 PE have been approved by Jabatan Perkhidmatan Pembentungan (JPP).

(2) The proposed sewerage plan is to cater for the whole IOI Palm Garden Resort Development with the estimated 7,761 PE.

(3) The central sewage treatment plant is currently being constructed.

(4) It is recommended that the water quality of the combined discharge of surface runoff and the treated effluent at the outfall of the retention pond be monitored. In the event that the sewage is inadequately treated and does not meet the Recommended Effluent Standard, the sewage treatment plant is to be upgraded with supplementary processes for the nutrients (TN and TP) removal. This would involve provision of anoxic tank and introduction of alum for the denitrification of TN removal and chemical precipitation of phosphorous removal respectively.

5.7.3.6 West Country Development

(1) The proposed mixed development of West Country will have sewer networks and sewage treatment plant(s). The preliminary development plan is being prepared.

(2) The West Country development extends over two drainage basins, viz. Sg. Chuau and Sg. Air Hitam.

(3) It is recommended that the sewage flows inside the Sg. Chuau basin be collected and transferred to the Sg. Air Hitam basin, where the proposed single central sewage treatment plant could be located. The treated effluent can be of DOE's Standard A and

will be discharged into the tributary of Sg. Air Hitam, which is outside the lake catchment.

5.7.3.7 TNB Serdang Power Plant

It is recommended that the sewage flow from future development, if any, shall be treated and discharged into Sg. Gajah, which is located outside the lake catchment.

5.7.3.8 Sg. Merab Malay Reserve

(1) Part of the Sg. Merab Malay Reserve are included in the Putrajaya Lake Landuse Masterplan as mixed development.

(2) The 36 hectares of small rubber lands are located just outside the boundary of Putrajaya. It is anticipated that the Reserve will be developed jointly with the adjacent lands located in the Sg. Merab catchment.

(3) It is recommended that the treated sewage effluent of the future mixed development in the area be diverted into the Sg. Merab River system.

5.7.4 Sewerage Masterplan for Putrajaya Lake Catchment

The Overall Sewerage Masterplan for Putrajaya Lake Catchment is formulated as follows:-

1. The proposed Putrajaya Development Sewerage Plan shall be implemented.

2. The proposed Cyberjaya Flagship Zone Sewerage Plan shall be implemented to ensure there is no sewage discharge into the Phase 2 Putrajaya Lake when the lake is formed.

3. The proposed sewerage works of sewer networks and a central sewage treatment plant located at the north of the Upper North Wetland catering for existing and future development, in MARDI, as well as the existing two hostels and associated future developments in UPM shall be implemented. The proposed central sewerage works can be integrated in the IWK sewerage development plan for the Kota Perdana/ Listari sub-catchment for the region. The treated effluent discharges from the central sewage treatment plant shall be transferred outside the lake catchment.

4. The proposed sewerage plan for the whole IOI Palm Garden Resort Development is being implemented. Monitoring of the water quality for the combined flows at the outfall shall be carried out.

5. The treated effluent of West Country Development shall be planned to be discharged into Sg. Air Hitam, thus outside the lake catchment.

6. Treated effluent from future development of TNB Serdang Power Plant, if any, shall be discharged into Sg. Gajah, thus outside the lake catchment.

7. Treated effluent from the future mixed development of Sg. Merab Malay Reserve shall be diverted into the Sg. Merab, which is outside the lake catchment.

5.8 EFFLUENT QUALITY MONITORING PROGRAMME

5.8.1 The Recommended Effluent Standard for the Putrajaya Lake Catchment as presented in Section 5.5.5 are sets of quantitative criteria established to maintain or enhance the quality of receiving waters, i.e. Putrajaya Lake.

5.8.2 The standard is also required to regulate the disposal of treated effluents discharged into the lake body.

5.8.3 The proposed monitoring programme for the treated effluent discharges in the catchment involving the locations, parameters of testing and frequency of testing are specified in Table 5.8.1 as follows:-

Table 5.8.1 Location of effluent monitoring

Stakeholders	No. of locations	Location
MARDI	4 locations:	One each at the effluent outlet of the four existing septic tanks
UPM	6 locations:	Effluent outlets at Imhoff tank of Kolej 8, at two septic tanks of Kolej 9, at packaged plant of Kolej Matrikulasi and two discharge points of streams into Putrajaya Upper North Wetland.
IOI Palm Garden	1 location	At the combined flow outfall of retention pond
Cyberjaya Flagship Zone (Phase 1B)	4 locations:	One each at the effluent outlets of four existing temporary sewage treatment plants
Total	15	

Two sets of testing parameters are proposed.

Set A : Consists of complete list of parameters in the Recommended Effluent Standard For Putrajaya Lake Catchment (Appendix 5.2). Total numbers of parameters: 28

Set B Consists of 11 parameters i.e. Temperature (°C) pH, Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorous (TP), Free Chlorine (Cl_2), E-Coli and Total Coliform

Frequency of Testing:

For each location, the frequency of testing shall be:

Month	Week	Testing Parameters
Month 1 (Commencing month)	1	Set A
	2	Set B
	3	Set A
	4	Set B
Month 2	4	Set A
Month 3	4	Set B
Month 4	4	Set B
Month 5 onwards	Repeat cycle from Month 2	

5.8.4 The budgetary monthly cost estimates of the effluent quality monitoring programme applied to the fifteen (15) locations are summarised in Table 5.8.2.

5.8.5 The sampling and testing of effluents shall be carried out by an accredited laboratory company certified by Skim Akreditasi Makmal Malaysia (SAMM) of Jabatan Standard Malaysia.

Table 5.8.2 Monthly Cost Estimates of Effluent Quality Monitoring Programme

COST FOR SAMPLING AND TESTING FOR SET A : RM 550/SAMPLE

COST FOR SAMPLING AND TESTING FOR SET B : RM 300/SAMPLE

DEVELOPMENT	NOS. OF LOCATIONS	MONTH					
		1		2	3	4	5 ON-WARDS
		SET A	SET B	SET A	SET B	SET A	
MARDI	4	8	8	4	4	4	(Repeat cycle from Month 2)
UPM	6	12	12	6	6	6	
IOI	1	2	2	1	1	1	
CYBERJAYA	4	8	8	4	4	4	
TOTAL	15	30	30	15	15	15	
ESTIMATED MONTHLY COST (RM)		2,250		8,250	4,500	8,250	

APPENDIX 5.1
RECOMMENDED POPULATION EQUIVALENT (PE)

Type of Premises/Establishment	Population Equivalent (Recommended)
Residential	5 per house
Commercial: includes offices, shopping complex, entertainment/recreational centres, restaurants, cafeteria, theatres	3 per 100 m^2 gross area
Schools/Educational Institutions:	
- Day schools/Institutions	0.2 per student
- Fully residential	1 per student
- Partial residential	0.2 per non-residential student 1 per residential student
Hospitals	4 per bed
Hotels with dining and laundry facilities	4 per room
Factories, excluding process water	0.3 per staff
Market (wet type)	3 per stall
Market (dry type)	1 per stall
Petrol kiosks/Service stations	15 per toilet
Bus terminal	4 per bus bay
Taxi terminal	4 per taxi bay
Mosque	0.2 per person
Church/Temple	0.2 per person
Stadium	0.2 per person
Swimming pool/Sports complex	0.5 per person
Public toilet	15 per toilet
Airport	0.2 per passenger bay 0.3 per employee
Laundry	10 per machine
Prison	1 per person
Golf course	20 per hole

Source : Guidelines for Developers, Volume 4 ; Sewerage Services Department (Ministry of Housing and Local Government)

APPENDIX 5.2
Effluent Discharge Standards to Malaysian Inland Waters

Parameter (mg/l unless otherwise stated)	Maximum Permitted Value Standard A	Standard B
Temperature (°C)	40	40
pH (units)	6.0 - 9.0	5.5 - 9.0
BOD_5 at 20°C	20	50
COD	50	100
Suspended Solids	50	100
Mercury	0.005	0.05
Cadmium	0.01	0.02
Chromium, hexavelant	0.05	0.05
Arsenic	0.05	0.10
Cyanide	0.05	0.10
Lead	0.10	0.5
Chromium, trivalent	0.20[#]	1.0[+]
Copper	0.20[#]	1.0[+]
Manganese	0.20[#] 0.20[+]	1.0[+]
Nickel	0.20[#] 0.20[+]	1.0[+]
Tin	0.20[#]	1.0[+]
Zinc	1.0	1.0
Boron	1.0	4.0
Iron	1.0	5.0
Phenol	0.001	1.0[⇳]
Free Chlorine	1.0	2.0[⇳]
Sulphide	0.5	0.5
Oil and Grease	Not detectable	10.0

Source: Environmental Quality (Sewage and Industrial Effluents) Regulations 1979

Notes

* The legislation does not specify any tolerance percentiles for the maximum permitted values and as such they are absolute values.

Where two or more of these metals are present in the effluent, the concentration of these metals shall not be greater than 0.50 mg/l in total.

\+ Where two or more of these metals are present in the effluent, the concentration of these metals shall not be greater than 3.0 mg/l in total or 1.0 mg/l in total for soluble forms.

⇳ When both phenol and free chlorine are present, the concentration of phenol shall not be greater than 0.2 mg/l nor the concentration of free chlorine greater than 1.0 mg/l.

APPENDIX 5.3

PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE
		PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD
1.	Temperature (°C)	Normal ± 2
2.	pH (units)	6.5 - 9.0
3.	BOD_5 at 20°C	3
4.	COD	25
5.	Suspended Solids	50
6.	Mercury	0.0001
7.	Cadmium	0.002
8.	Chromium, hexavalent	0.005
9.	Arsenic	0.05
10.	Cyanide	0.02
11.	Lead	0.05
12.	Chromium, trivalent	-
13.	Copper	0.02
14.	Manganese	0.10
15.	Nickel	0.02
16.	Boron	1.0
17.	Iron	1.0
18.	Phenol	
19.	Free Chlorine	1.5
20.	Oil and Grease	1.5
21.	Dissolved Oxygen	5.0 - 7.0
22.	Total Phosphorous	0.05
23.	Total Nitrogen	
24.	Nitrate (NO_3 - N)	7.0

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD
25.	Nitrite (NO_2 - N)	0.04
26.	E-Coli (Counts/100 ml)	100
27.	Total Coliform (Counts/100 ml)	5,000
28.	Salmonella (Counts/l)	0
29	Enteroviruses (PFU/l)	0
30.	Chlorophyll a (ug/l)	0.7
31.	Floatables	Not Visible
32.	Colour (TUC)	150
33.	Conductivity (ms/cm)	1,000
34.	Salinity (ppt)	1.0
35.	Turbidity (NTU)	50
36.	Transparency (Secchi)	0.6
37.	Hardness	250
38.	Taste	No Objectional
39.	Odour	No Objectional
40.	Aluminium	<0.05 if pH < 6.5 <0.01 if pH > 6.5
41.	Ammoniacal Nitrogen	0.3
42.	Ammonia	0.02 - 0.03
43.	Antimony	0.03
44.	Barium	1.0
45.	Beryllium	0.004
46.	Flourine	1.5
47.	Silica	50
48.	Selenium	0.01
49.	Silver	0.05
50.	Sulphur	0.05
51.	Sulphate	250
52	Gross-alpha (Bq/l)	0.1

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD
53.	Gross-Beta (Bq/l)	1.0
54.	Radium-226 (Bq/l)	<0.1
55.	Strontium-90 (Bq/l)	<1.0
56.	Carbon Chloroform Extract (ug/l)	500
57.	MBAS/BAS (ug/l)	500
58.	Oil & Grease (mineral) (ug/l)	40, NF
59.	Oil & Grease (emulsified edible) (ug/l)	700, NF
60.	PCB (ug/l)	0.1
61.	Aldrin/Dieldrin (ug/l)	0.02
62.	BHC (ug/l)	2.0
63.	Chlordane (ug/l)	0.08
64.	t-DDT (ug/l)	0.1
65.	Endosulfan (ug/l)	10
66.	Heptachlor/Epoxide (ug/l)	0.05
67.	Lindane (ug/l)	2.0
68.	2,4-D (ug/l)	70
69.	2,4,5-T (ug/l)	10
70.	2,4,5-TP (ug/l)	4.0
71.	Paraquat (ug/l)	10

APPENDIX 5.4

Interim National River Water Quality Standards for Malaysia

Parameters (units)	Classes					
	I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen (mg/l)	0.1	0.3	0.3	0.9	2.7	>2.7
BOD_5 (mg/l)	1	3	3	6	12	>12
COD (mg/l)	10	25	25	50	100	>100
DO (mg/l)	7	5-7	5-7	3-5	<3	<1
pH	6.5 - 8.5	6-9	6-9	5-9	5-9	-
Colour (TCU)	15	150	150	-	-	-
Elect. Cond.# (mmhos/cm)	1,000	1,000	-	-	6,000	-
Floatables	N	N	N	-	-	-
Odour	N	N	N	-	-	-
Salinity# ($^0/_{00}$)	0.5	1	-	-	2	
Taste	N	N	N	-	-	
Total Diss. Solid# (mg/l)	500	1,000	-	-	4,000	
Total SS (mg/l)	25	50	50	150	300	>300
Temperature (°C)	-	Normal± 2	-	Normal± 2	-	-
Turbidity (NTU)	5	50	50	-	-	-
F. Colif+ (counts/100 ml)	10	100	400	5,000	5,000	-
Tot. Colif. (counts/100 ml)	100	5,000	5,000	(20,000)* 50,000	(20,000)* 50,000	>50,000

N No visible floatable materials/debris, or no objectionable odour, or no objectionable taste

\# Related parameters, only one recommended for use

\+ Geometric mean

* Maximum not to be exceeded

APPENDIX 5.5
COMPARISON OF VARIOUS STANDARDS

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE			
		RECOMMENDED EFFLUENT STANDARD FOR PUTRAJAYA LAKE CATCHMENT	DOE'S STANDARD A	PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD	INTERIM NATIONAL RIVER WATER QUALITY STANDARD MALAYSIA - CLASS IIB
1.	Temperature (°C)	40	40	Normal ± 2	
2.	pH (units)	6.0 - 9.0	6.0 - 9.0	6.5 - 9.0	6.0 - 9.0
3.	BOD_5 at 20°C	20	20	3	3
4.	COD	50	50	25	25
5.	Suspended Solids	50	50	50	50
6.	Mercury	0.005	0.05	0.0001	0.001
7.	Cadmium	0.01	0.01	0.002	0.01
8.	Chromium, hexavalent	0.05	0.05	0.005	0.05
9.	Arsenic	0.05	0.05	0.05	0.05
10.	Cyanide	0.05	0,.05	0.02	0.02
11.	Lead	0.10	0.10	0.05	0.05
12.	Chromium, trivalent	0.20	0.20	-	-
13.	Copper	0.20	0.20	0.02	0.02
14.	Manganese	0.20	0.20	0.10	0.1
15.	Nickel	0.20	0.20	0.02	0.05
16.	Tin	0.20	0.20		-
17.	Zinc	1.0	1.0		5.0

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE			
		RECOMMENDED EFFLUENT STANDARD FOR PUTRAJAYA LAKE CATCHMENT	**DOE'S STANDARD A**	**PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD**	**INTERIM NATIONAL RIVER WATER QUALITY STANDARD MALAYSIA - CLASS IIB**
18.	Boron	1.0	1.0	1.0	1.0
19.	Iron	1.0	1.0	1.0	1.0
20.	Phenol	0.001	0.001		10
21.	Free Chlorine	0.5	1.0	1.5	-
22.	Sulphide	0.5	0.5		
23.	Oil and Grease	Not Detectable	Not Detectable	1.5	
24.	Dissolved Oxygen	5.0		5.0 - 7.0	5.0 - 7.0
25.	Total Phosphorous	2.0		0.05	0.2
26.	Total Nitrogen	10.0			
27.	Nitrate (NO_3 - N)	-		7.0	7.0
28.	Nitrite (NO_2 - N)	-		0.04	0.4
29.	E-Coli (Counts/100 ml)	400		100	400
30.	Total Coliform (Counts/100 ml)	5,000		5,000	5,000
31.	Salmonella (Counts/l)			0	
32.	Enteroviruses (PFU/l)			0	
33.	Chlorophyll a (ug/l)			0.7	
34.	Floatables			Not Visible	Not Visible
35.	Colour (TUC)			150	150
36.	Conductivity (ms/cm)			1,000	1000

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE			
		RECOMMENDED EFFLUENT STANDARD FOR PUTRAJAYA LAKE CATCHMENT	DOE'S STANDARD A	PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD	INTERIM NATIONAL RIVER WATER QUALITY STANDARD MALAYSIA - CLASS IIB
37.	Salinity (ppt)			1.0	1.0
38.	Turbidity (NTU)			50	50
39.	Transparency (Secchi)			0.6	
40.	Hardness			250	250
41.	Taste			No Objectional	No Objectional
42.	Odour			No Objectional	No Objectional
43.	Aluminium			<0.05 if pH < 6.5 <0.01 if pH > 6.5	-
44.	Ammoniacal Nitrogen			0.3	0.3
45.	Ammonia			0.02 - 0.03	
46.	Antimony			0.03	
47.	Barium			1.0	1.0
48.	Beryllium			0.004	
49.	Flourine			1.5	1.5
50.	Silica			50	50
51.	Selenium			0.01	0.01
52.	Silver			0.05	0.05
53.	Sulphur			0.05	0.05
54.	Sulphate			250	250
55	Gross-alpha (Bq/l)			0.1	0.1

ITEM	PARAMETER (mg/l Unless Otherwise Stated)	LIMITING VALUE			
		RECOMMENDED EFFLUENT STANDARD FOR PUTRAJAYA LAKE CATCHMENT	DOE'S STANDARD A	PUTRAJAYA LAKE AMBIENT WATER QUALITY STANDARD	INTERIM NATIONAL RIVER WATER QUALITY STANDARD MALAYSIA - CLASS IIB
56.	Gross-Beta (Bq/l)			1.0	1.0
57.	Radium-226 (Bq/l)			<0.1	<0.1
58.	Strontium-90 (Bq/l)			<1.0	<1
59.	Carbon Chloroform Extract (ug/l)			500	500
60.	MBAS/BAS (ug/l)			500	500
61.	Oil & Grease (mineral) (ug/l)			40, NF	40 ; NF
62.	Oil & Grease (emulsified edible) (ug/l)			700, NF	7,000 ; NF
63.	PCB (ug/l)			0.1	0.1
64.	Aldrin/Dieldrin (ug/l)			0.02	0.02
65.	BHC (ug/l)			2.0	2.0
66.	Chlordane (ug/l)			0.08	0.08
67.	t-DDT (ug/l)			0.1	0.1
68.	Endosulfan (ug/l)			10	10
69.	Heptachlor/Epoxide (ug/l)			0.05	0.05
70.	Lindane (ug/l)			2.0	2.0
71.	2,4-D (ug/l)			70	70
72.	2,4,5-T (ug/l)			10	10
73.	2,4,5-TP (ug/l)			4.0	4.0
74.	Paraquat (ug/l)			10	10