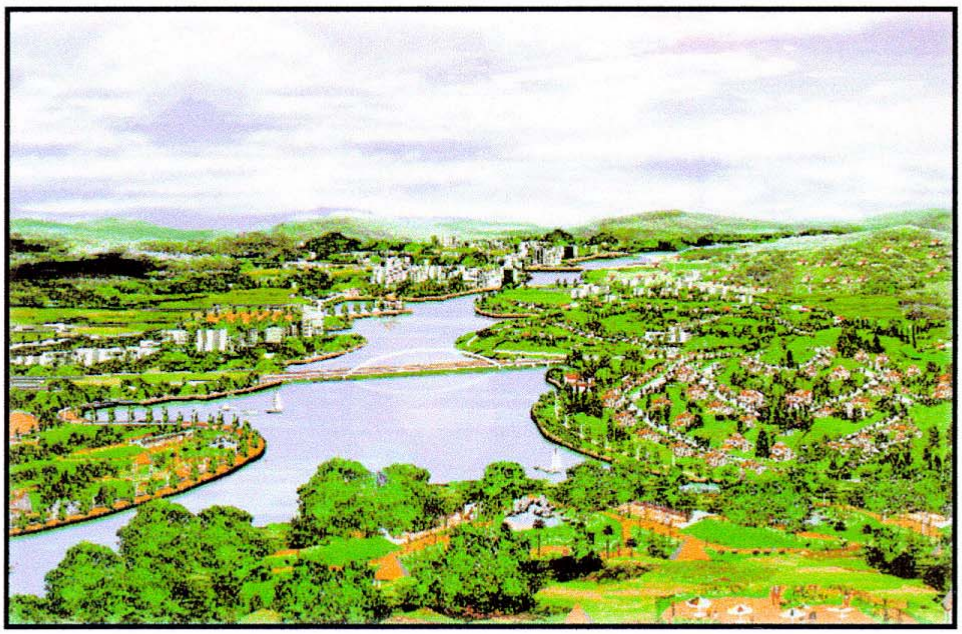
PERBADANAN PUTRAJAYA

CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

VOLUME 2 : SECTORAL REPORT



Submitted by :

Institut Penyelidikan Hidraulik Kebangsaan Malaysia
(National Hydraulic Research Institute of Malaysia)
Kementerian Pertanian, Blok A,
JPS Malaysia Cawangan Jalan Ampang,
KM 7, Jalan Ampang, 68000 Ampang.

In Association with :

KTA Tenaga sdn bhd
CONSULTING ENGINEERS * JURUTERA PERUNDING
Company No: 239199-V
Level 5, Uptown 2, Damansara Uptown,
No. 2, Jalan SS 21/37, Damansara Utama,
47400 Petaling Jaya. Selangor.
TEL: 03-7666 3333 FAX: 03-7666 3322
E-mail: ktaten@po.jaring.my

MHA Enviro. Consult. Sdn Bhd
No. 25, 2nd Floor,
Jalan Tengku Ampuan Zabedah F,
9/F Section 9,
40100 Shah Alam, Selangor.

June 2000

VOLUME 2 : SECTORAL REPORTS

CONTENTS

1.0 INTRODUCTION 1-1

1.1 Study Approach 1-1

1.1.1 Analysis of Systems 1-1

1.1.2 Development and Management Plans 1-3

1.1.3 Implementation Plans 1-3

2.0 ENVIRONMENTAL STUDIES 2-1

2.1 Objective 2-1

2.2 The Physical Setting 2-2

2.3 Landuse Setting 2-4

2.4 Pollutant input Sources 2-5

2.4.1 Land-use and Pollution Potential 2-5

2.4.2 Point and Non-point Pollutant Sources 2-7

2.5 Assessment of Pollutant Impact to Putrajaya Lake System 2-23

2.5.1 Upper West Sub-Catchment 2-23

2.5.2 Upper North Sub-Catchment 2-26

2.5.3 Upper East Sub-Catchment 2-30

2.5.4 Central Sub-Catchment 2-31

2.5.5 Limau Manis Sub-Catchment 2-32

2.5.6 Summary of Pollutant Potential and Recommendations 2-34

2.6 Water Quality Modeling 2-36

2.6.1 Introduction 2-36

2.6.2 Water Quality Monitoring 2-36

2.6.3 Water Quality Modelling 2-53

2.6.4 Model Results and Discussion 2-69

2.6.5 Recommendations 2-71

2.7 Wetland Ecological Status 2-71

2.7.1 The Lake and Wetland System 2-71

2.7.2 Flora 2-73

2.7.3 Fish and Fauna 2-78

2.7.4 Recommendations for Sustaining the Fauna and Flora 2-80

2.7.5 Flora and Fauna Outside Perbadanan Putrajaya 2-89

2.8 Short, Medium and Long Term Pollution Problems 2-93
2.8.1 Identification of Pollutants of Concern 2-93
2.8.2 Short Term Problems 2-93
2.8.3 Medium Term Problems 2-94
2.8.4 Long Term Problems 2-94
2.9 Technical and Management Measures 2-95
2.9.1 Point Sources 2-95
2.9.2 Non-point Sources 2-96
2.10 Summary 2-99
2.11 Recommendations 2-104
2.11.1 Catchment Management and Development 2-104
2.11.2 Monitoring 2-108
2.11.3 Special issues 2-110
2.12 References 2-111

3.0 WATER RESOURCES STUDIES 3-1
3.1 Hydrological Study 3-1
3.1.1 Introduction 3-1
3.1.2 Hydrological input data 3-1
3.1.3 Rainfall Runoff Modeling 3-4
3.1.4 Model calibration 3-7
3.1.5 Streamflow extension for current and future Landuse 3-9
3.1.6 Compensation flow 3-9
3.1.7 Rainwater Harvesting and Utilisation 3-12
3.1.8 Proposed Hydrological Stations Network 3-13
3.2 Erosion and Sedimentation Study 3-14
3.2.1 Introduction 3-14
3.2.2 The CALSITE Model 3-15
3.2.3 Preparation of input data 3-16
3.2.4 Model calibration and set-up 3-17
3.2.5 Model simulation 3-19
3.2.6 CALSITE Modelling Results 3-21
3.2.7 Review of Existing Guidelines and Legislation on Erosion and Sediment Control 3-23
3.2.8 Recommendations for Soil Erosion and Sediment Control 3-25
3.3 Geological and Hydrogeological Study 3-27
3.3.1 Introduction 3-27
3.3.2 The Geological Setting 3-27
3.3.3 The Hydrogeological Setting 3-28
3.3.4 Water Quantity Management Issues 3-31

3.4 References 3-34

4.0 DRAINAGE MASTERPLAN STUDY 4-1
4.1 Introduction 4-1
4.2 Existing and Proposed Drainage Systemsin the Catchment 4-1
4.2.1 Putrajaya Area 4-2
4.2.2 IOI Palm Garden Resort Area 4-3
4.2.3 MARDI 4-7
4.2.4 UPM 4-7
4.2.5 Cyberjaya (Flagship Zone) 4-7
4.2.6 West Country 4-9
4.3 Drainage Planning and Design Guidelines 4-9
4.3.1 Reduction of Peak Runoff Discharge 4-11
4.3.2 Control of Sediments 4-14
4.3.3 Control of Pollutants 4-15
4.3.4 Construction Activities 4-15
4.3.5 Bio-Engineering Techniques, Stream Rehabilitation and Aesthetic Treatment 4-16
4.4 Drainage Design Requirements and Standards 4-18
4.4.1 Design Rainfall IDF Curves 4-18
4.4.2 Drainage Reserves Requirements 4-18
4.4.3 Water Level Requirements in the Putrajaya Lake System 4-19
4.4.4 Design of Retention Ponds 4-21
4.5 Topographical and Drainage Analysis 4-21
4.5.1 Topographical Analysis 4-21
4.5.2 Drainage Analysis 4-21
4.6 The Drainage Masterplan 4-22
4.6.1 Putrajaya Area 4-22
4.6.2 Outside Putrajaya Area 4-22
4.7 Responsibilities of Authorities and Stakeholders 4-27
4.7.1 Construction 4-27
4.7.2 Operation and Maintenance 4-27
4.8 References 4-29

5.0 SEWERAGE MASTERPLAN STUDY 5-1
5.1 Introduction 5-1
5.2 Objective 5-1
5.3 Landuses and Population Equivalents in the Lake Catchment 5-2
5.4 Existing Sewerage Situations of Various Developments 5-7
5.4.1 General 5-7
5.4.2 Putrajaya Development 5-7
5.4.3 Cyberjaya Flagship Development Zone (Phase 1B) 5-8
5.4.4 Universiti Putra Malaysia 5-10
5.4.5 MARDI 5-12
5.4.6 IOI Palm Garden Resort Development 5-13
5.4.7 TNB Serdang Power Station 5-14
5.4.8 West Country Development 5-14
5.4.9 Sg. Merab Malay Reserve 5-14
5.5 Sewage Effluent Quality Requirements 5-14
5.5.1 Purpose of Effluent Standards 5-14
5.5.2 Existing DOE's Effluent Standards 5-15
5.5.3 Putrajaya Lake Ambient Water Quality Standard 5-15
5.5.4 Sewage Effluent Quality Requirements 5-15
5.5.5 Recommended Effluent Standard for Putrajaya Lake Catchment 5-17
5.6 Sewerage Planning and Design Guidelines 5-19
5.6.1 General 5-19
5.6.2 Sewerage Planning Guidelines 5-20
5.6.3 Sewerage Design Guidelines 5-21
5.6.4 Recommended Sewage Treatment Processes 5-23
5.6.5 Emergency Response Plan 5-26
5.7 The Sewerage Masterplan for Putrajaya Lake Catchment 5-28
5.7.1 General 5-28
5.7.2 Population Equivalent (PE) for Putrajaya Lake Catchment 5-29
5.7.3 Sewerage Plans for Various Developments 5-31
5.7.4 Sewerage Masterplan for Putrajaya Lake Catchment 5-34
5.8 Effluent Quality monitoring Programme 5-35

6.0 LAND-USE MASTERPLAN STUDY 6-1
6.1 Introduction 6-1
6.2 Review of the Land-use Policies and Guidelines 6-1
6.2.1 The Structure Plans 6-1
6.2.2 The Putrajaya Land-use Masterplan 6-3
6.2.3 The Putrajaya Urban Design Guidelines (UDG) 6-3
6.2.4 Multimedia Super Corridor (MSC) Guidelines 6-4
6.3 Existing and Committed Land-use Situation 6-5
6.3.1 Introduction 6-5
6.3.2 Universiti Putra Malaysia (UPM) 6-6
6.3.3 MARDI 6-8
6.3.4 Integrated Oxygen Industries (IOI) 6-10
6.3.5 Tenaga Nasional Berhad (TNB) 6-12
6.3.6 West Country Berhad 6-13
6.3.7 Cyberjaya 6-14
6.3.8 Sungai Merab Malay Reserve 6-16
6.3.9 Universiti Tenaga Nasional (UNITEN) 6-17
6.3.10 Comments on the existing developments 6-17
6.4 The Development Strategy and Concept 6-19
6.4.1 Introduction 6-19
6.4.2 Devleopment Component 6-19
6.4.3 Rationale and Justification 6-21
6.5 The Proposed Land-use Masterplan 6-22
6.5.1 Introduction 6-22
6.5.2 Zoning Plan 6-22
6.5.3 Use Class Order 6-23
6.6 Land-use Control Guidelines 6-23
6.6.1 Introduction 6-23
6.6.2 Existing Guidelines 6-23
6.6.3 Lake Catchment Guidelines 6-24

7.0 DEVELOPMENT OF THE BASIC ICMS 7-1
7.1 Introduction 7-1
7.2 Information Management Plan (IMP) 7-3
7.2.1 The Need for an IMP 7-3
7.2.2 Information Sharing 7-3
7.2.3 Obtaining Information 7-5
7.2.4 Assessment of Response to Information Request 7-6
7.2.5 Information Dissemination 7-6

7.2.6 Perbadanan Putrajaya as Lead Agency for Information Management 7-7
7.3 ICMS-User Requirements Study 7-8
7.4 System Design 7-9
7.4.1 Introduction 7-9
7.4.2 The Perbadanan's IT System 7-9
7.4.3 The Sumber Putra IT System 7-9
7.4.4 The Software Requirements 7-11
7.5 System Development 7-13
7.5.1 Development of the Integrated Digital Map 7-13
7.5.2 Development of the Database Structure 7-14
7.6 System Implementation 7-20
7.6.1 Installation and ICMS Training for Users 7-20
7.6.2 Database Training 7-20
7.7 System Maintenance and Support 7-20
7.8 Conclusions and Recommendations 7-21

8.0 INSTITUTIONAL AND LEGISLATION STUDIES 8-1
8.1 Legislation Study 8-1
8.1.1 Introduction 8-1
8.1.2 Background to review 8-1
8.1.3 The Status of Perbadanan Putrajaya 8-3
8.1.4 Review of Laws on Catchment Management 8-4
8.1.5 Review of Existing Legislation 8-8
8.1.6 Recommendations 8-17
8.2 Institutional Study 8-19
8.2.1 Introduction 8-19
8.2.2 Existing Institutional and Administrative Framework 8-20
8.2.3 Management and Control Systems 8-35
8.2.4 Assessment of Institutional and Administrative Framework for Catchment Management 8-40
8.2.5 Proposed Institutional Arrangement for Administration 8-42
8.2.6 Recommendation 8-44
8.2.7 References 8-52

9.0 COSTING, BUDGET AND FUNDING 9-1
9.1 Introduction 9-1
9.2 Indicative Costs of Estimates 9-1
9.2.1 Introduction 9-1
9.2.2 Water Quality Study 9-2
9.2.3 Hydrogeological Study 9-2
9.2.4 Hydrological Study 9-3
9.2.5 Drainage Masterplan Study 9-3
9.2.6 Sewerage Masterplan Study 9-5
9.2.7 ICMS Study 9-5
9.2.8 Institutional Study 9-6
9.3 Indicative Implementation Budget 9-6
9.4 Funding 9-7
9.4.1 Funding Sources 9-7
9.4.2 Funding Principles 9-8
9.4.3 Funding for the Recommended Programs 9-9
9.5 Cost Recovery 9-12

GLOSSARY

List of Figures

Figure 1.1 The Putrajaya Lake Catchment
Figure 1.2 A Schematic Illustration of the Work Sequence and Work Components within the Scope of Study
Figure 2.6.1 Location of Water Quality Sampling Sites (Kota Bistari, 1996)
Figure 2.6.2 Location of Baseline Water Quality Monitoring Stations
Figure 2.6.3 AQUALM Model Scheme
Figure 2.6.4 AQUALM Model Scheme - Total Phosphorus Loading in Lake and Wetlands Without Catchment Treatment
Figure 2.6.5 AQUALM Model Scheme - Total Phosphorus Loading in Lake and Wetlands With Catchment Treatment
Figure 2.6.6 Putrajaya Wetlands and Lake Networks
Figure 2.7.1 The Putrajaya Lake System
Figure 2.7.2 Typical Wetland Cross-section of a Wetland
Figure 2.7.3 Flora in the Upper North Wetland
Figure 2.7.4 Flora in the Upper East Wetland
Figure 2.7.5 Flora in the Upper West Wetland
Figure 2.7.6 Flora in the Lower East Wetland
Figure 2.7.7 Flora in the Upper Bisa Wetland
Figure 2.7.8 Flora in the Central Wetland
Figure 2.7.9 Flora in the Primary Lake
Figure 2.9.1 Small Water fall at the top of Sg. Kuyoh, MARDI. It can form part of mini wetlands of Sg. Kuyoh catchment
Figure 2.9.2 Small Water fall at the top of Sg. Kuyoh, MARDI. It can form part of mini wetlands of Sg. Kuyoh catchment
Figure 2.9.3 Large man-made Reservoir in MARDI. There is continuous water supply from the upstream waterfall. With planting of wetland plants along its edge, it can serve to sequester pollutants and nutrients
Figure 2.9.4 Overflow water from the MARDI Reservoir (Figure 2.9.3) enters into Sg. Kuyoh and finally discharge into Upper West Wetland
Figure 2.9.5 Existing UPM pond at the upstream of Upper North Wetland. Lotus *Nelumba Sucifera* can form a cover mat on the water surface to reduce plankton biomass in the water. The Rhizome system can help uptake of nutrients. The future mini-wetland may have lotus in the open water.
Figure 2.9.7 Wetland plants along the banks overhang the stream

Figure 3.1.1 Double-mass Curve Analysis of Rainfall Data (1981-1994)
Figure 3.1.2 Monthly Rainfall Distributions at the 4 Stations (1981-1994)
Figure 3.1.3 Monthly Distribution of Pan Evaporation at Prang Besar Station (1981-1992)
Figure 3.1.4 The Structure of the NAM Model
Figure 3.1.5 Sub-catchment Boundaries for Rainfall-runoff Modelling
Figure 3.1.6 Simulated Discharge versus Observed Discharge (Mar – Nov 1994) at Temporary Dam Site
Figure 3.1.7a Runoff into Upper West Wetland
Figure 3.1.7b Runoff into Upper North Wetland
Figure 3.1.7c Runoff into Upper East Wetland
Figure 3.1.7d Runoff into Lower East Wetland
Figure 3.1.7e Runoff into Sg. Bisa Wetland
Figure 3.1.8 Simulated Discharge at Putrajaya Main Dam (1981-1994)
Figure 3.1.9 Predicted Filling Times for Putrajaya Lake with and without Compensation Flow at 90% Probability (1 in 10 year dry minimum flow)
Figure 3.1.10 Existing and Proposed Hydrological Stations
Figure 3.2.1 Annual Spatial Rainfall Distribution Map
Figure 3.2.2 Elevation Map
Figure 3.2.3 Slope Map
Figure 3.2.4 R-Factor Map
Figure 3.2.5 K-Factor Map
Figure 3.2.6 CP-Factor Map
Figure 3.2.7 Soil Erosion (Current Landuse)
Figure 3.2.8 Sediment Yield (Current Landuse)
Figure 3.2.9 Soil Erosion Map (Future Landuse)
Figure 3.2.10 Sediment Yield (Future Landuse)
Figure 3.2.11 Soil Erosion (Without Cover)
Figure 3.2.12 Sediment Yield (Without Cover)
Figure 3.3.1 Geology of Putrajaya Lake Catchment
Figure 3.3.2 Hydrological Cycle
Figure 3.3.3 Location of Groundwater Piezometers and Wells
Figure 3.3.4 Geological Profile of HPB 4
Figure 3.3.5 Geological Profile of HPB 8
Figure 3.3.6 Geological Profile of HPB 10
Figure 3.3.7 Proposed Well Design
Figure 3.3.8 Geological Cross-section at Proposed Main Dam Site
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)
Figure 4.5 Typical Drain Types and Dimensions for Putrajaya
Figure 4.6 Drainage Plan for IOI
Figure 4.7 Drainage Plan for MARDI
Figure 4.8 Drainage Plan for UPM
Figure 4.9 Drainage Plan for Cyberjaya
Figure 4.10 Drainage Plan for West Country
Figure 4.11 Typical Infiltration Trench
Figure 4.12 Parking lot Perimeter Trench
Figure 4.13 Rainfall Distribution
Figure 4.14 Design Rainfall IDF Curves for Putrajaya
Figure 4.15 Flow through Retention Pond
Figure 4.16 Depth of water in Pond
Figure 4.17 Typical Extended Detention (ED) Pond
Figure 4.18 Schematic of ED Pond Design Features
Figure 4.19 Typical Wet Pond Profile
Figure 4.20 Design Schematic of a Wet Pond
Figure 4.21 Typical CDS Structure
Figure 4.22 Schematic Representative of the CDS Structure
Figure 4.23 Typical Details of Brush Mattress Technique for Stream Bank
Figure 4.24 Using natural materials in the development of water bodies
Figure 4.25 Providing easy/direct access to water bodies
Figure 4.26 Providing more varied profile for water curses
Figure 4.27 Covering water courses
Figure 4.28 Maintaining a permanent body of water
Figure 4.29 IOI Palm Garden Resort –Flow through Retention Pond
Figure 4.30 IOI Palm Garden Resort –Depth of water in Pond
Figure 5.4.1 Locations of Sewage Treatment Plant
Figure 5.4.2 Overall Layout of Proposed Putrajaya Development Sewerage Plan
Figure 5.4.3 Cyberjaya Flagship Zone- Phase 1A Proposed Sewerage System
Figure 5.4.4 IOI Palm Garden Resort Development Proposed Sewerage Works
Figure 6.1 Masterplan of Putrajaya
Figure 6.2 Existing and Committed Landuse Masterplan
Figure 6.3 Existing Landuse – Universiti Putra Malaysia

Figure 6.4 MARDI Landuse
Figure 6.5 Existing Landuse – IOI
Figure 6.6 Northern part of Bukit Bisa – with the development of low density mixed housing
Figure 6.7 TNB Serdang Gas Turbine Power Plant
Figure 6.8 Western part of West Country with proposed low-density housing -bungalow lots, located adjacent to IOI golf course
Figure 6.9 Committed Landuse – Cyberjaya
Figure 6.10 Concept Plan
Figure 6.11 Proposed Integrated Landuse Masterplan
Figure 6.12 Universiti Putra Malaysia – Landuse Zoning
Figure 6.13 MARDI – Landuse Zoning
Figure 7.1 The Complete ICMS
Figure 7.2 System Development Life Cycle for the Low Level Integrated Catchment Management System (ICMS)
Figure 8.2.1 Struktur Organisasi Jabatan Perancangan Bandar dan Desa
Figure 8.2.2 Carta Organisasi Jabatan Pengairan dan Saliran Negeri Selangor Darul Ehsan
Figure 8.2.3 Carta Organisasi JKR Selangor Darul Ehsan
Figure 8.2.4 Organisational Structure and Activities of the Perbadanan
Figure 8.2.5 Outline of Responsibilities of Units in City Planning Department
Figure 8.2.6 City Development Department
Figure 8.2.7 City Services Department
Figure 8.2.8 Carta Organisasi MPSJ
Figure 8.2.9 Carta Organisasi Majlis Daerah Sepang
Figure 8.2.10 Struktur Organisasi Pejabat Daerah/Tanah Petaling
Figure 8.2.11 Struktur Organisasi Pejabat Daerah/Tanah Sepang
Figure 8.2.12 Struktur Organisasi Jabatan Alam Sekitar Negeri Selangor
Figure 8.2.13 Proposed SWMA Organisational Structure and Function
Figure 8.2.14 Carta Cadangan Unit Tasik dan Wetland Jabatan Perancangan Bandar
Figure 8.2.15 Proposed Structure for Putrajaya Lake Catchment Management

List of Tables

Table 2.2.1 Catchment area of the Putrajaya Lake
Table 2.4.1 Estimated Annual Nutrient Loadings for Chesapeake Bay Watershed Model
Table 2.4.2 Average Urban Stormwater Pollutant Loads (Ibs/Year) in Bayfield, Wisconsin, USA
Table 2.4.3 Putrajaya Modelled future Pollutant Loads
Table 2.4.4 Landuse as a Pollutant Source
Table 2.4.5 Landuse Type and Pollution Potential in Putrajaya
Table 2.4.6 Possible Trace Pollutants in Putrajaya Lake
Table 2.4.7 Landuse and and Pollution Potential from External Sources
Table 2.4.8 External Point Sources
Table 2.6.1 Water Quality in Sg. Chuau
Table 2.6.2 Water Quality Baseline Monitoring Stations
Table 2.6.3 Summary of Water Quality Monitoring Results at the Pre-construction Stage (from Quek, 1997)
Table 2.6.4 Summary of Wetland Water Quality in May, 1999 (Source: Putrajaya Holdings).
Table 2.6.5 Putrajaya Ambient Lake Water Quality
Table 2.6.6 Range of Water Quality at the Dam
Table 2.6.7 Mean Annual flow rates from Contributing Sub-catchments (from Table 4.1, Perunding Kota Bistari, 1996)
Table 2.6.8 Mean Annual flow rates from Contributing Sub-catchments (from Table 3.6, Perunding Kota Bistari, 1996)
Table 2.6.9 Modelled Pollutant Input Concentrations
Table 2.6.10 Equilibrium Contaminant concentrations in the Putrajaya Lake
Table 2.6.11 Location of Weirs in each Wetland Cells and its Normal Water Level (NWL)
Table 2.6.12 Average Model Volume as Compared to the Survey Volume in the As-built Plan
Table 2.6.13 Water Quality for Stream Flow and Runoff for the Model Simulation
Table 2.6.14 Water Quality at the Primary Lake for the Model
Table 2.7.1 Nutrient uptake rates for selected crops
Table 2.7.2 Terrestrial Plants in the Upper North Wetland

Table 2.7.3 Terrestrial Plants in the Upper East Wetland
Table 2.7.4 Terrestrial Plants in the Upper West Wetland
Table 2.7.5 Terrestrial Plants in the Lower East Wetland
Table 2.7.6 Fish Species introduced into the Putrajaya Lake system
Table 2.7.7 Birds species observed in the Putrajaya Lake system
Table 2.7.8 Mammal species observed in the Putrajaya Lake system
Table 2.7.9 Plant species and nutrient uptake
Table 2.7.10 Flora Species
Table 2.7.11 Aquatic Plant Species around Putrajaya
Table 2.7.12 Fish Species
Table 2.7.13 Wildlife around Putrajaya
Table 2.7.14 Avifauna
Table 3.1.1 Details of Hydrological Stations located in the vicinity of the Study Area
Table 3.1.2a Monthly Rainfall (1981-1994)
Table 3.1.2b Monthly Rainfall (1981-1994)
Table 3.1.3 Monthly Pan Evaporation at Prang Besar (2916301) for 1981-1992
Table 3.1.4 Daily Streamflow Data at Temporary Dam for March-November 1994 (m3/s)
Tables 3.1.5 Selected Parameter Values for NAM Model
Table 3.1.6 Error Statistics for NAM Model
Table 3.1.7 Simulated Daily Streamflow Data at Temporary Dam for March -November 1994 (m3/s)
Table 3.1.8 Cost of Hydrological Stations
Table 3.2.1 Erosion Rate from Selected Watershed in Malaysia and Singapore
Table 3.3.1 Hydrogeological information from piezometers and wells
Table 3.3.2 Chemistry of Groundwater in the Sungai Chuau Basin
Table 4.1 Dimensions and Conveyance of Major and Minor Open Drains in the Putrajaya Area
Table 4.2 Drainage System Design Data for IOI Palm Garden Resort Area
Table 4.3 Drainage System Design Data for MARDI
Table 4.4 Design considerations associated with 4 Stormwater Management Objectives
Table 4.5 Drainage Reserves for Areas Less than 100 acres
Table 4.6 Drainage Reserves for Areas More than 100 acres
Table 4.7 Normal Operating and 1% AEP Water Levels for the Putrajaya Lake System

Table 4.8 IOI Palm Garden Resort- Recommendation of the Weir Length and Pond Sizes
Table 5.3.1 Existing and Proposed Landuses and Population Equivalent (PE)
Table 5.4.1 Existing UPM Sewerage Works
Table 5.5.1 Recommended Effluent Standard for Putrajaya Lake Catchment
Table 5.7.1 PE for Putrajaya Lake Catchment Masterplan
Table 5.8.1 Location of Effluent Monitoring
Table 5.8.2 Monthly Cost Estimates of Effluent Quality Monitoring Programme
Table 6.1 Existing and Committed Landuse for Putrajaya Lake Catchment (acres) outside Putrajaya
Table 6.2 Existing and Committed Landuse for UPM (within catchment)
Table 6.3 Existing and Committed Landuse for MARDI
Table 6.4 Existing and Committed Landuse for IOI
Table 6.5 Existing and Committed Landuse for Cyberjaya
Table 6.6 Proposed Landuse Masterplan for Putrajaya Lake Catchment (acre)
Table 6.7 Lake Catchment Landuse Masterplan - Use Class Order
Table 9.1 Indicative costs associated with the Water Quality monitoring Program for a 3-year period
Table 9.2 Indicative costs associated with the Drainage System Improvement works in the areas outside Putrajaya
Table 9.3 Implementation Schedule and Indicative Budget
Table 9.4 Possible Funding Sources

List of Appendix

Appendix 1.1	The Proposed Study Scope and Study Outputs for each of the 8 Sectoral Studies
Appendix 2.1	Putrajaya Water Quality Data as Monitored by UPM
Appendix 2.2	Putrajaya Water Quality Data for each Cell as Monitored by UPM
Appendix 2.3	Putrajaya Water Quality Data as Monitored by UPM
Appendix 2.4	Preliminary Model Simulations
Appendix 2.5	Time Series of Concentration for the 1984-run
Appendix 2.6	Time Series of Concentration for the 1993-run
Appendix 2.7	Time Series of Concentration for the 1988-run
Appendix A	Putrajaya Lake Catchment Fertilizer Use Guidelines
Appendix B	Putrajaya Lake Catchment Pesticide Use Guidelines
Appendix C	Putrajaya Lake Catchment Guidelines for the development of Mini Wetlands
Appendix D	Putrajaya Lake Catchment Guidelines for Development of Riparian Management Zones (RMZ)
Appendix 5.1	Recommended Population Equivalent (PE)
Appendix 5.2	Effluent Discharge Standards to Malaysian Inland Waters
Appendix 5.3	Putrajaya Lake Ambient Water Quality Standard
Appendix 5.4	Interim National River Water Quality Standards for Malaysia
Appendix 5.5	Comparison of Various Standards
Appendix 7.1	Information Management within Perbadanan Putrjaya
Appendix 7.2	Data Description for the Low-Level ICMS
Appendix 7.3	Database Manual for Low-Level ICMS
Appendix 7.4	Conceptual Proposal for Complete ICMS
Appendix 8.1.1	List of Legislation Relevant to the Management of the Putrajaya Lake Catchment area
Appendix 8.1.2	Review of the Selangor Waters Management Enactment, 1999
Appendix 8.2.1	Nota Ringkas Jawatankuasa Khas Pengurusan Kawasan Tadahan Tasik Putrajaya
Appendix 8.2.2	Members of the Putrajaya Lake Catchment Management Technical Committee
Appendix 8.2.3	DOE's Guideline for the Preparation of an Environmental Management Plan (Plan, Implement, Check and Review)
Appendix 8.2.4	Terms of Reference for Sub-catchment Management Committee

Appendix 8.2.4 Terms of Reference for Stakeholders' Consultative Committee
Appendix 9.1 Details of Indicative Cost estimates for Water Quality Study
Appendix 9.2 Details of Indicative Cost estimates for Hydrological Study
Appendix 9.3 Details of Indicative Cost estimates for Hydrological Monitoring Stations
Appendix 9.4 Drainage Master Plan
Appendix 9.5 Details of Indicative Cost Estimates for Sewerage Master Plan Study
Appendix 9.6 Details of Indicative Cost Estimates for the Data Conversion to SiCAD and Refinement Phase of the Low-level ICMS
Appendix 9.7 Details of Indicative Cost Estimates for the Institutional Study

LIST OF ABBREVIATIONS

AAR	Average Annual Rainfall
AE	Actual Evaporation
AEP	Annual Exceedance Probability
AD	Advection – Dispersion
ARI	Average Recurrence Interval
BMP	Best Management Practices
BOD	Biological Oxygen Demand
CALSITE	Calibrated Simulation of Transported Erosion
COD	Chemical Oxygen Demand
Cr	Chromium
CW	Central Weir
DCIA	Directly Connected Impervious Areas
DID	Department of Irrigation and Drainage
DO	Dissolved Oxygen
DOE	Department of Environment
ED	Extended Detention
EMP	Environmental Management Plan
EPF	Employee Provident Fund
EQA	Environmental Quality Act
ERL	Express Rail Link
ESCP	Erosion and Sediment Control Plan
ESS	Electronic Submission Standards
GIO	Geographical Information Officer
GIS	Geographical Information System
GPT	Gross Pollutant Trap
GSM	Geological Survey of Malaysia
GUI	Graphical User Interface
HAZOP	Hazards and Operability
HD	Hydrodynamics
Hg	Mercury
ICMS	Integrated Catchment Management System
IDF	Intensity – Duration – Frequency
IMP	Information Management Plan
INRWQSM	Interim National Water Quality Standards for Malaysia
IOI	Integrated Oxygen Industries Sdn Bhd

IPM	Integrated Pest Management
ITU	Information Technology Unit
IU	Information Unit
IWK	Indah Water Consortium
JAS	*Jabatan Alam Sekitar*
JKR	*Jabatan Kerja Raya*
JPBD	*Jabatan Perancangan Bandar dan Desa*
JPN	*Jawatankuasa Perancangan Negeri*
JPP	*Jabatan Perkhidmatan Pembentungan*
JPS	*Jabatan Pengairan dan Saliran*
KLIA	Kuala Lumpur International Airport
KPP	*Kawasan Perbadanan Putrajaya*
LE	Lower East Wetland
LGA	Local Government Act
MAM	Mean Annual Minimum
MAR	Mean Annual Rainfall
MARDI	Malaysian Agricultural Research and Development Institute
MDC	Multi-media Development Corporation
MDS	*Majlis Daerah Sepang*
MMKN	*Majlis Mesyuarat Kerajaan Negeri*
Mn	Manganese
MPN	*Majlis Pembangunan Negeri*
MPSJ	*Majlis Perbandaran Subang Jaya*
MS	Malaysian Standard
MSC	Multimedia Super Corridor
N	Nitrogen
NALIS	National Land Information System
NLC	National Land Council
NH_3	Ammonia
NPS	Non-point Source
NWRS	National Water Resources Study
O & G	Oil and Grease
OP	Dissolved Phosphorus
OSHA	Occupational Safety and Health Act
P	Phosphorus
Pb	Lead

PE	Population Equivalent
PLCMC	Putrajaya lake Catchment Management Committee
Phosphorus Dis.	Dissolved Phosphorus
Phosphorus Par.	Particulate Phosphorus
PP	Particulate Phosphorus
PPA	Perbadanan Putrajaya Act
PTD	*Pejabat Tanah dan Daerah*
PTG	*Pejabat Tanah dan Galian*
R & D	Research and Development
SAMM	*Skim Akreditasi Makmal Malaysia*
SCC	Stakeholders' Consultative Committee
SDBA	Street, Drainage & Building Act
SOCSO	Social Security Organisation
SPS	Serdang Power Station
STP	Sewage Treatment Plant
SWMA	Selangor Waters Management Authority
SWMAE	Selangor Waters Management Authority Enactment
TCPA	Town and Country Planning Act
TD	Temporary Dam
TN	Total Nitrogen
TNB	Tenaga Nasional Berhad
TOR	Terms of Reference
TP	Total Phosphorus
UB	Upper Bisa Wetlands
UDDS	Urban Drainage Design Standard
UDG	Urban Design Guidelines
UE	Upper East Wetlands
UN	Upper North Wetlands
UW	Upper West Wetlands
UNITEN	Universiti Tenaga Malaysia
UPEN	*Unit Perancang Ekonomi Negeri*
UPM	Universiti Putra Malaysia
URS	User Request Study
USLE	Universal Soil Loss Equation
WPCP	Water Pollution Control Pond
WQ	Water Quality
WQCMS	Water Quality Catchment Management System
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

The Study Report for the Catchment Development and Management Plan for Putrajaya Lake (see Figure 1.1) is contained in **Volume 1- Main Report** and **Volume 2 - Sectoral Reports**. This Volume 2 contains the 8 sectoral reports for this study. The detailed study for each of the components are described in the following chapters under the following headings:

1. Environmental Studies
2. Water Resources Studies
3. Drainage Masterplan Study
4. Sewerage Masterplan Study
5. Land-use Masterplan Study
6. Development of the Basic ICMS
7. Legislation and Institutional Studies
8. Costing , Budget and Funding

The study approach is briefly described below.

1.1 STUDY APPROACH

The scope of the study is divided into 3 parts based on the sequence of work required to arrive at the Plan. However, during the study they are carried out in parallel and their outputs integrated continuously throughout. Figure 1.2 gives a schematic illustration of the work sequence and work components within the 3 parts as listed below:

(a) Analysis of systems
(b) Development and management plans
(c) Implementation plans

1.1.1 Analysis Of Systems

1.1.1.1 The first part of the study involves analysis of the physical and human systems existing in the catchment. The components of the physical system that was analysed can be grouped under two headings. They are:

(a) Environmental Studies
(b) Water Resources Studies

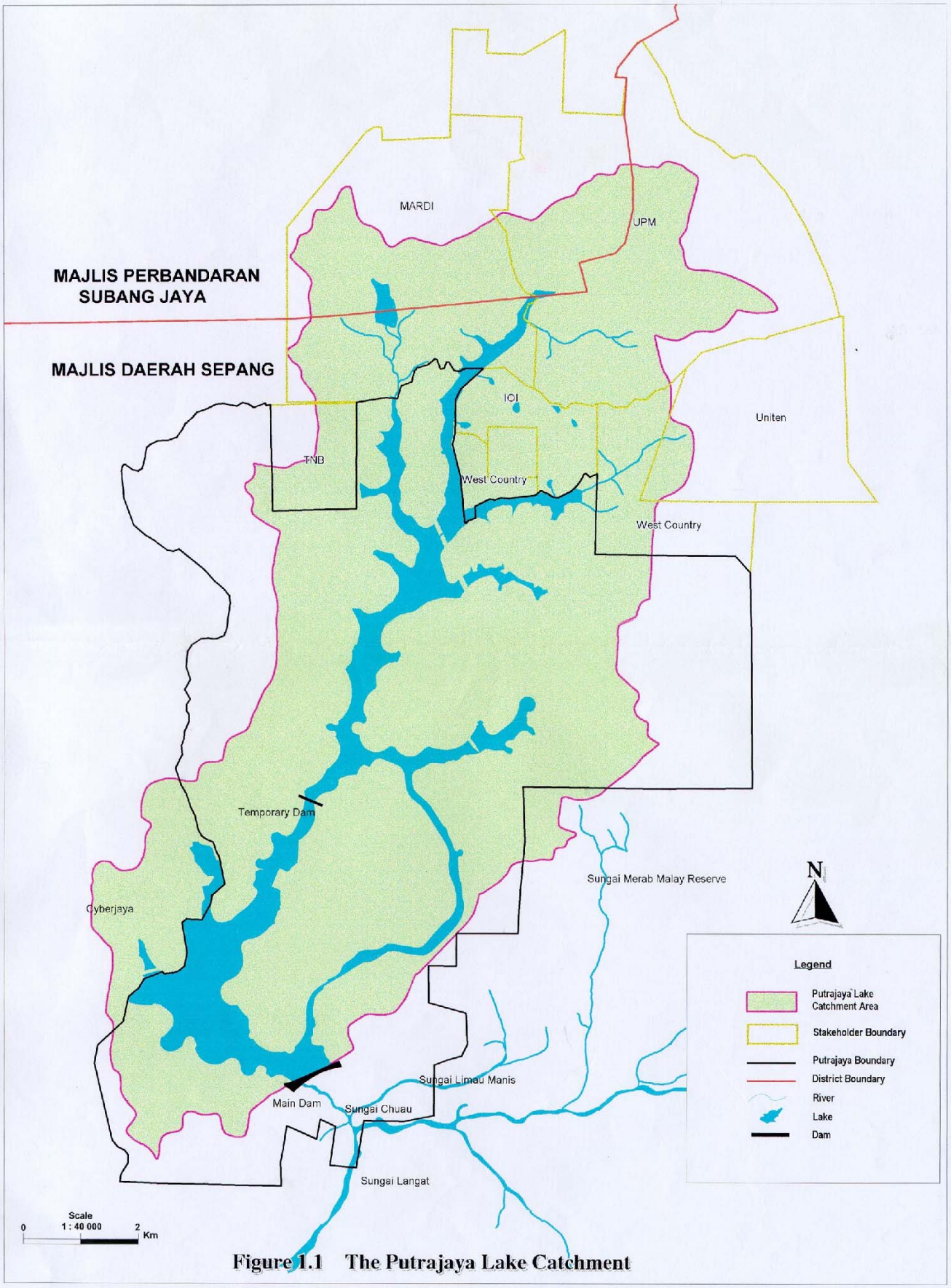


Figure 1.1 The Putrajaya Lake Catchment

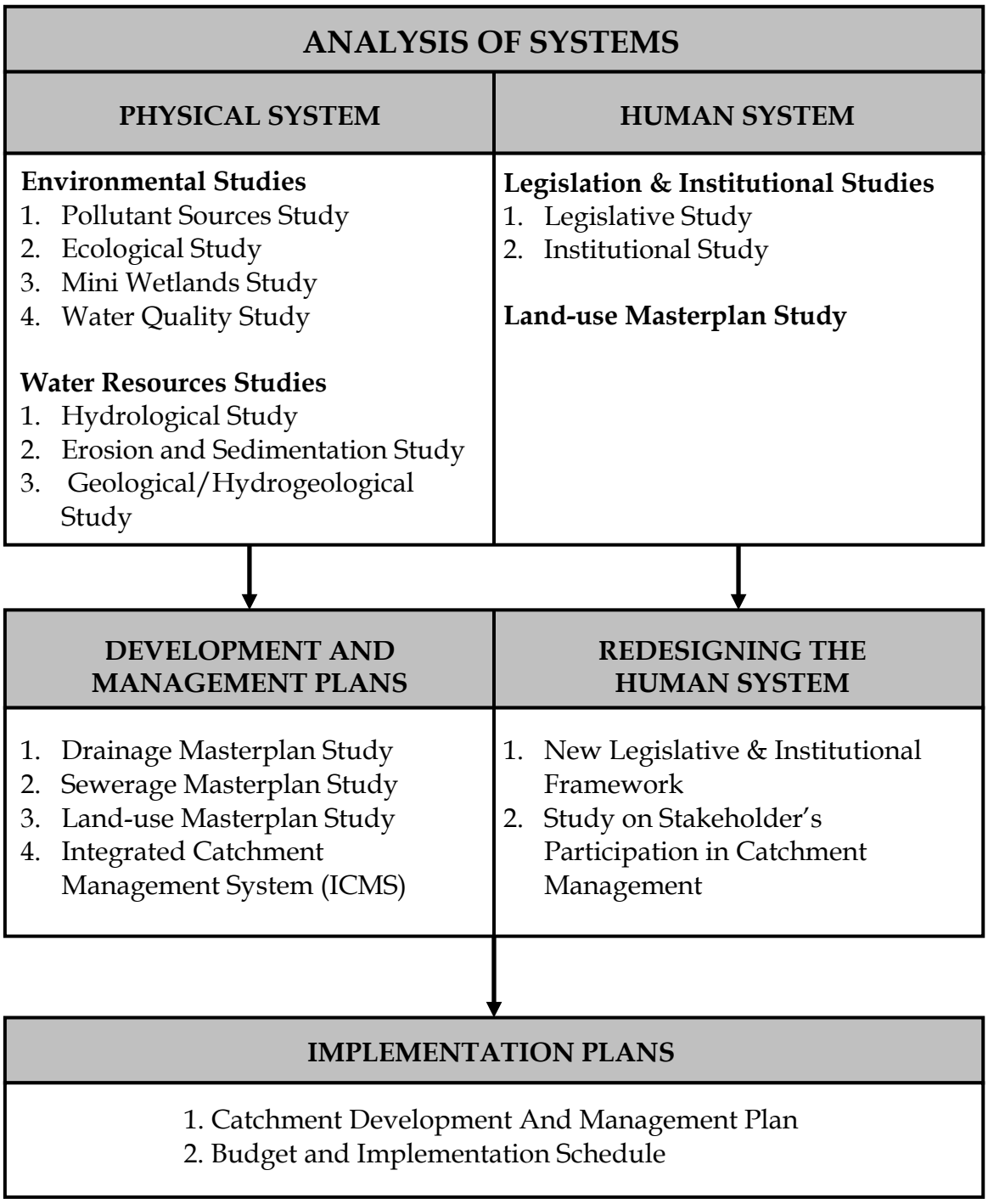


Figure 1.2 **A schematic illustration of the work sequence and work components within the scope of study**

1.1.1.2 The components of the human system that was analysed can be grouped under two headings. They are:

(a) Legislation & Institutional Studies
(b) Land-use Masterplan Study

1.1.2 Development And Management Plans

1.1.2.1 The second part of the study involves the preparation of the development and management plans to achieve the study objectives based on the outputs from the first part. To facilitate the implementation of the plans there is also a need to redesign the human system, i.e. the institutional and legislative aspects, based on the outputs from the analysis of the human system from the first part of the study.

1.1.2.2 The studies to prepare the development and management plans are as follows:

(a) Drainage Masterplan Study
(b) Sewerage Masterplan Study
(c) Land-use Masterplan Study
(d) Integrated Catchment Management System (ICMS) Study

1.1.3 Implementation Plans

1.1.3.1 The scope of work for the third part of the study involves the integration of the results from the second part into a Catchment Development and Management Plan. It also involves the preparation of a budget and implementation schedule.

1.1.3.2 The detail study scope and outputs for each of the 8 sectors are tabulated in Appendix 1.1, for ease of reference.

APPENDIX 1.1 - The Proposed Study Scope and Study Outputs for each of the 8 Sectoral Studies

STUDY SCOPE	STUDY OUTPUTS
1.0 ENVIRONMENTAL STUDIES	
1.1 <u>Pollutant Sources Study</u>	
(a) Identification of all pollutant sources, with potential immediate and medium term impacts on the Putrajaya Lake water quality, associated with all current and proposed land-use within the Putrajaya Lake catchment. (b) Identification of trace pollutants which may have long term impact on the Lake water quality. (c) Preparation of a map indicating the existing and potential point and non-point sources of pollution in the catchment. (d) Identification and recommendation of appropriate technical and management measures for controlling or eliminating the identified pollutant sources. (e) Identification of the appropriate types of fertiliser and agricultural chemicals for use in the catchment.	(a) A list of pollutant sources, with potential immediate and medium term impacts on the Lake water quality, associated with all current and proposed land-use within the catchment. (b) A list of trace pollutants, which may have long term impact on the Lake water quality. (c) A map indicating the existing and potential point and non-point sources of pollution in the catchment. (d) A list of recommended technical and management measures for controlling or eliminating the identified pollutant sources, including the appropriate types of fertiliser and agricultural chemicals for use in the catchment. (e) Recommendations on the most appropriate effluent treatment or other management measures, for the current and proposed development, that do not meet the desired pollutant loadings and effluent standards. (This will be prepared together with the Sewerage Specialist)
1.2 <u>Ecological Study</u>	
(a) An inventory of the fishes, flora and fauna existing in the current river and water courses environment, which will be presented in the form of an ecological inventory map of the river and water courses in the catchment. (b) Descriptions on the ecological environment sustaining the inventoried species and the possible consequences to the species arising from the	(a) An ecological inventory map, mapping the locations in the catchment to the list of fishes, flora and fauna existing in the current river and water courses environment. The map shall be accompanied by pertinent descriptions on the ecological environment sustaining the inventoried species and the possible consequences to the species arising from the likely changes to the

STUDY SCOPE	STUDY OUTPUTS
likely changes to the river and water courses environment due to the proposed and likely future developments in the catchment. (c) Assessment on the possible impacts on the desired ecological balance for the Putrajaya Lake and its associated wetlands. (d) Recommendation on the Best Management Practices (BMP) required to sustain the desired ecological balance for the Putrajaya Lake and its associated Wetlands.	river and water courses environment. (b) An assessment of the possible impacts on the desired ecological balance for the Lake and its associated wetlands, together with the best management practices to sustain the desired ecological balance.
1.3 <u>Mini Wetlands Study</u> (a) A map showing the existing ponds in the catchment, its current usage and potential to be converted into a mini-wetlands, accompanied by a report describing the current state and use together with photos. (b) A set of implementation guidelines, including the identification of suitable plants, for any ponds considered feasible to be converted into a mini wetland. (This will be prepared together with the Water Quality Modeller and the Environmental Specialist)	(a) A map showing the existing ponds in the catchment, its current usage and potential to be converted into a mini-wetlands, accompanied by a report describing the current state and use together with photos. (b) A set of implementation guidelines, including the identification of suitable plants, for any ponds considered feasible to be converted into a mini wetland. (This will be prepared together with the Water Quality Modeller and the Environmental Specialist)
<u>1.4 Water Quality Study</u> **a)** An inventory of the existing water quality at selected stations in the river and water courses in the catchment. It will be presented in a map showing the locations of the stations and the values of the pertinent water quality indexes.	**a)** Quantitative estimate of the pollutant treatment capacity of the Wetlands and the carrying capacity of the Lake.

STUDY SCOPE	STUDY OUTPUTS
(b) Evaluation on the possible impacts on the functional use of the Lake and operations of the wetlands based on an assessment of the water quality at selected stations for the proposed and likely future land-use scenarios in the catchment and the hydrological regimes arising from them. (c) A review of the proposed water quality monitoring strategy and plans for the Putrajaya Lake and Wetlands, with the objective of developing an integrated water quality monitoring strategy and plan for the Putrajaya Lake catchment.	(b) Quantitative estimate of the types and allowable pollutant loading, including effluent standards where applicable, from all current, proposed and future developments within the catchment. The results shall be presented on a map of the catchment, if possible. (c) A map showing the locations of the water quality stations in the catchment and the existing water quality expressed in terms of values of the pertinent water quality indexes. (d) An evaluation on the possible impacts on the functional use of the Lake and operations of the wetlands based on an assessment of the water quality at selected stations for the proposed and likely future land-use scenarios in the catchment. (e) An integrated water quality monitoring strategy and plan for the catchment
2.0 WATER RESOURCES STUDIES	
2.1 <u>Hydrological Study</u>	
(a) An assessment of the average monthly streamflows into the wetlands and Putrajaya Lake for the current, proposed and likely future water-use and land-use scenarios in the catchment. (b) A monthly water-balance study of the Putrajaya Lake and wetlands, based on the various monthly streamflow scenarios. (c) The study will also include all hydrological aspects required to support the evaluation of the impacts, due to the possible changes in the hydrological regimes in the catchment, on the river and water courses ecology in the catchment and on the water quality at selected stations along the river and water courses in the catchment.	Estimates of average monthly streamflows for the various water-use and land-use scenarios in the catchment will be simulated for use in the Water Quality Study

STUDY SCOPE	STUDY OUTPUTS
2.2 <u>Erosion and Sedimentation Analysis Study</u>	
(a) An analysis of the erosion and sedimentation potential in the Putrajaya Lake catchment, taking into account the results arising from the hydrological and geological/hydrogeological studies. Its result will be presented in the form of an erosion and sedimentation potential map of the catchment. (b) Preparation of recommendations and guidelines for the control of erosion and sedimentation in the catchment.	An erosion and sedimentation potential map of the catchment, together with pertinent recommendations and guidelines for the control of erosion and sedimentation in the catchment.
2.3 <u>Geological/Hydrogeological Study</u>	
(a) A classification and zoning plan of the terrain in the catchment, according to geological/hydrogeological characteristics, together with an analysis of the groundwater flow regimes in the catchment. (b) Descriptions on the nature of each identified characteristics and the appropriate environmental and land-use management issues related to them. **(c)** Provision of the geological/hydrogeological information support for the erosion and sedimentation analysis of the catchment, development of the integrated drainage and sewerage masterplans for the catchment, hydrological analysis of the catchment and the land-use zoning of the catchment.	A classification and zoning plan of the terrain in the catchment according to geological/hydrogeological characteristics. The plan will be accompanied by a report describing the nature of each identified characteristics and the appropriate environmental and land-use management issues related to them.
4.0 DRAINAGE MASTERPLAN STUDY	
(a) Develop an integrated Putrajaya Lake Catchment Drainage Masterplan. The scope of the development shall involve a review of the Kawasan Putrajaya Drainage Masterplan and the current and proposed drainage plans (if any) for the areas outside of it (that are within the Putrajaya Lake catchment), with the objective of integrating the drainage plans to	(a) An integrated Drainage Masterplan for the catchment, showing the locations of all gross pollutant traps and green-belt zones. (b) Pertinent drainage planning and design guidelines.

STUDY SCOPE	STUDY OUTPUTS
the Kawasan Putrajaya Drainage Masterplan. (b) The Drainage Masterplan should provide a strategy for the drainage development within the Putrajaya Lake catchment. (c) It should include the identification of the locations of all gross pollutant traps and green-belt zones. (d) The plan shall be accompanied by all pertinent planning and design guidelines.	
5.0 SEWERAGE MASTERPLAN STUDY	
(a) Develop an integrated Putrajaya Lake Catchment Sewerage Masterplan. The scope of the development shall involve a review of the Kawasan Putrajaya Sewerage Masterplan and the current and proposed sewerage plans (if any) for the areas outside of it (that are within the Putrajaya Lake catchment), with the objective of integrating the sewerage plans to the Kawasan Putrajaya Sewerage Masterplan. (b) The Sewerage Masterplan should provide a strategy for the sewerage development within the Putrajaya Lake catchment. (c) The plan should be accompanied by all pertinent planning and design guidelines. (d) A design guide for the treatment facility to treat the sewage effluent to the required standard shall be provided. (e) An appropriate sewage effluent monitoring program together with a budget for its implementation shall be provided.	(a) An integrated Sewerage Masterplan for the catchment. (b) All pertinent planning and design guidelines. (c) A design guide for the treatment facility to treat the sewage effluent to the required standard. (d) A sewage effluent monitoring program.
6.0 LAND-USE MASTERPLAN STUDY	
<u>Existing Land-use Study</u> (a) Identification of land-use zonings and their associated restrictions. It will include any changes on the zonings according to certain time frames, if any. (b) Compilation and review of developments that are being planned,	(a) An integrated Land-use Masterplan for the catchment, comprising of a Zoning Plan and a Concept Plan. (b) A set of land-use control guidelines, comprising of a Planning Standard, Land-use Classification and Sketches & Illustrations, for all proposed and future developments in the catchment.

STUDY SCOPE	STUDY OUTPUTS
submitted for planning approval, approved and under development in the catchment. (c) Evaluation, together with the other pertinent specialists, the existing land use and their physical characteristics, in relation to the subsequent development of the land-use masterplan for the catchment. **Land-use Masterplan Study** (a) Develop an integrated Land-use Masterplan for the Putrajaya Lake catchment. It shall involve a review of the Kawasan Putrajaya Land-use Masterplan and the current and proposed land-use plans (if any) for the areas outside of it (that are within the Putrajaya Lake catchment), with the objective of integrating the land-use plans to the Kawasan Putrajaya Land-use Masterplan. (b) A systematic technical analysis of the advantages and disadvantages of the possible land-use options, taking into account the results, recommended management measures and requirements specified by the respective specialists will be carried out. (c) Preparation of pertinent guidelines and development conditions for all proposed and future developments in the Putrajaya Lake catchment.	
7.0 INTEGRATED CATCHMENT MANAGEMENT SYSTEM	
(a) Information Management Study - To review the information needs of the stakeholders and to list the information requirements for decision-making. **(b) The Integrated Catchment Management System** - To design a **basic** integrated catchment management system which includes relevant project data and database of critical information and for the proposed environmental monitoring plans.	• A **basic** Integrated Catchment Management System, comprising of a GIS and pertinent information database.

STUDY SCOPE	STUDY OUTPUTS
(c) Technology transfer – Transfer and integrate the basic ICMS into the existing Perbadanan Putrajaya GIS/MIS and training of client's personnel.	
8.0 INSTITUTIONAL AND LEGISLATION STUDIES	
8.1 <u>Institutional Study</u>	
(a) Existing Institutional Framework Study A systematic review of the existing institutional arrangement/set-up and administrative framework in the catchment will be carried out. It shall involve the mapping of the organisational structure, responsibilities and interfacing between them, for the control of development in the catchment. (b) New Institutional Framework Study A study to develop and recommend the most effective and appropriate new institutional/administrative arrangement/set-up to implement the developed Catchment Development and Management Plan for Putrajaya Lake will be carried out. It shall involve the identification of all legislative and administrative amendments, to put into effect the new institutional/administrative arrangement or set-up. It shall be based upon the implementation, monitoring and development control requirements recommended by the various specialists in the project team and shall be developed jointly by the project team. (c) Study on Stakeholder's Participation in Catchment Management A study to define the strategies for engaging the current and future catchment stakeholder's participation for sustainable management of the catchment.	(a) A Catchment Management Statement Policy of Putrajaya. (b) A report on the existing institutional arrangement/set-up in the catchment. (c) Recommendation on the most appropriate institutional arrangement/set-up for the implementation of the developed Plan. (d) A set of strategies for participatory management of the Putrajaya Lake Catchment.

STUDY SCOPE	STUDY OUTPUTS
8.2 Legislation Study	
(a) To identify and review present legislation involving catchment management issues. Specifically this will involve the review of specific legislation related to the management, regulation and control of water resources, land, municipalities and town and country planning. It will also require a review of legislation that regulates and impinges on various activities such as pollution, mining, siltation, forestry, management of water resources, sewerage, drainage, farming, and recreational activities; (b) Interface with the various consultants on the legal basis for the implementation of various methods proposed to be adopted to enable effective management of the catchment area. Given the scenario where there are quite a number of stakeholders involved the Legislation consultant will have to work very closely with the institutional expert; (c) Make recommendations on any appropriate changes to existing legislation and propose the formulation of new legislation, if any, for the effective management and control of activities in the catchment area including enabling the various recommendations of this Study to be implemented; and (d) Liaise with the Perbadanan and other authorities on all legal issues pertaining to the effective management of the catchment area.	(a) Review of existing legislation at the State and local level. This review will be made available at the Preliminary Report Stage; (b) Recommendations on changes, if any, to existing legislation will be made in the Interim Report; (c) An identification, in the Interim Report, will be made of the most appropriate legislation that may be used as a vehicle to formulate subsidiary rules to enable the implementation of the various recommendations made in this Study; (d) Draft amendments, if any, to existing legislation *provided such amendments are minor involving not more than one statute and, in the opinion of the legislation specialist, the work involved may be accommodated within the present time frame allocated to the legislation specialist*. Such drafts shall be submitted in the Draft Final Report; (e) Recommendations, in the Draft Final Report, pertaining to the formulation of new legislation; and (f) A TOR for the formulation of such new legislation including major changes to existing legislation.

STUDY SCOPE	STUDY OUTPUTS
9.0 IMPLEMENTATION PLANS	
Catchment Development and Management Plan (a) Integration of all the requirements of the masterplans developed in the study together with the guidelines and management measures, recommended by each of the specialists in the study team, which shall culminate in a number of development control checklists. (b) Identification of the organisations and their officers who shall be responsible for the development control in the catchment, analysing their existing development control procedures and recommending changes, where necessary, to integrate the use of the checklists into the procedures. **Budget and Implementation Schedule** (a) Provide indicative costing of the proposed management measures to support the project team's decision on the most effective Catchment Development and Management Plan for Putrajaya Lake. (b) Prepare a master implementation schedule and an overall implementation budget. **(c)** Evaluation of possible funding options for the implementation of the recommendations arising from the study.	(a) A Catchment Development and Management Plan. (b) An indicative costing of the proposed management measures, an implementation budget for the Plan together with a list of the possible funding options. (c) An implementation schedule for the Plan.

CHAPTER 2

ENVIRONMENTAL STUDIES

2.0 ENVIRONMENTAL STUDIES

2.1 OBJECTIVE

2.1.1 The major concern for the Putrajaya Lake system is that catchment development, particularly outside the Kawasan Putrajaya, may compromise the Lake water quality. This is because although development within the Putrajaya area may be administered to take into consideration the impact on the Lake water quality, current requirements applicable elsewhere may be inadequate for the purpose.

2.1.2 The purpose of the environmental studies, therefore, is

- to assess the impact of the current and future catchment landuse and activities on the Lake environment (Section 2.5).;
- to identify the current and future point and non-point pollutant sources of potential immediate and medium term impact, and trace pollutants of potential long term impact (Section 2.6);
- to describe the current ecological setting of the existing ponds and wetlands in the catchment and assess the effect of pollutant inflow on the wetlands (Section 2.7);
- to evaluate the capacity of the wetlands system developed to treat the non-point pollutants (Section 2.8);

2.1.3 Based on the above findings, the following recommendations are to be made:

- the pollutant loadings for all current, and future developments within the catchment and the desired loadings and effluent standards (Section 2.8);
- the management measures to mitigate and minimise the pollutant loadings into the Lake from the catchment area through the development of softscapes (Section 2.9, Appendix D);
- the appropriate effluent treatment, for the current and proposed development, that do not meet the desired pollutant loadings and effluent standards (Section 2.9.1);

- the best management practices to sustain the desired ecological balance in the constructed wetlands (Section 2.9.2, Appendix C);
- the existing ponds in the catchment with potential to be converted into a mini-wetlands and the implementation guidelines (Section 2.9.2, Appendix C);
- the best management practices for pesticide and fertilizer use in the catchment (Section 2.9.2, Appendix A, B);
- the water quality monitoring programme to be carried out (Section 2.10.2).

2.2 THE PHYSICAL SETTING

2.2.1 The Putrajaya Lake is formed by the impoundment of the Sg Chuau, through the

- the Sg Chuau river valley,
- capture of the upper section of Sg Limau Manis, and
- creation of a connecting channel between the captured Sg Limau Manis and the Sg Chuau river valley.

2.2.2 The catchment area of the Sg Chuau river up to the dam is 50.5 km^2, while for the captured portion of the Sg Limau Manis the catchment is approximately 1.5 km^2 (Table 2.2.1). There are eight major sub-catchments:

- Upper-North,
- Upper-West,
- Upper-East,
- Lower-East,
- Bisa,
- Central,
- Lower, and
- Limau Manis.

2.2.3 The surrounding land varies between 8 m to 152 m LSD, giving an undulating terrain over the catchment area. Steep uplands occur in the upper northwest and the east sector of the catchment with hills occurring in the northeast, west, and central sector.

Table 2.2.1 Catchment area of the Putrajaya Lake

Sub-Catchment	Area, km^2	% Total Lake	Landowners (in importance)	Current Landuse
Upper North (Sg Chuau)	12.4	23.1	UPM, MARDI, PPJ, IOI	Agricultural, Institutional, Residential, Parks, Golf course, Commercial, Health facility
Upper West (Sg Kuyoh)	6.2	11.5	MARDI, PPJ, TNB	Agriculture, Power station, Parks, Residential
Upper East	4.2	7.8	PPJ, UNITEN, West Country	Residential, Parks, Government, Institutional, Commercial
Lower East	1.7	3.2	PPJ	Residential, Parks, Government,
Central (Sg Chuau)	7.1	13.2	PPJ	Residential, Health facility, Parks
Upper Bisa (Sg Bisa)	5.9	11.0	PPJ	Residential, Parks, Government, Commercial
Lower (Sg Chuau)	14.7	27.4	PPJ, Cyberjaya	Residential, Commercial, Government,
Total Sg Chuau	52.2	97.2		
Captured Limau Manis	approx 1.5	2.8	PPJ	Residential, Government
Total Lake	53.7	100.0		

2.3 LANDUSE SETTING

2.3.1 The catchment area of the Putrajaya Lake lies within the administrative jurisdiction of the Majlis Daerah Sepang, Majlis Perbandaran Subang Jaya and Perbandanan Putrajaya.

2.3.2 Prior to the development of the Kawasan Putrajaya, the catchment area was primarily under oil palm plantation in the central portion with institutional and R&D development in the northern portion owned by MARDI and UPM. A power station is located in a small portion of the mid Upper-West sub-catchment.

2.3.3 The lower three-quarters of the catchment area are now being developed for the Federal Administrative Centre and associated commercial and residential premises. In addition, residential and golf course development has and is being undertaken in the lower Upper-North sub-catchment (by IOI) and mid Upper-East sub-catchment (by West Country).

2.3.4 The upper catchment areas are relatively undeveloped at present with experimental or non-intensive agricultural activities being carried out over the whole of the Upper-West sub-catchment and most of the upper portion of Upper-North sub-catchment. Only minor institutional facilities lie within the upper catchment areas. There is also a 9-hole golf course and a health centre within UPM. There are, however, several residential (hostel) premises within the Upper-North sub-catchment. These are expected to accommodate approximately 10,000 students in UPM.

2.3.5 Among the stakeholders,

1. MARDI plans to develop their land into a green lung with experimental incubator centres;

2. UPM plans to develop offices, sports complex, mixed housing, and a medical faculty building including a hospital;

3. IOI may be considered to have fully developed their land;

4. West Country is in the planning stage to develop low-density (approximately 2 lots/acre) residential properties;

5. TNB has completed their development;

6. UNITEN plans to develop institutional facilities;

7. Cyberjaya plans to have commercial and residential development;

8. Sungai Merab area is under individual ownership and there may be plans by each owner to develop their own property.

2.4 POLLUTANT INPUT SOURCES

2.4.1 Landuse and Pollution Potential

2.4.1.1 Pollution Potential Concept

(1) Pollutant input sources may enter the lake system from within or outside the Putrajaya Administrative Area. The designation of pollutant input sources may be based on landuse. This is because land use alters the drainage characteristics of the land and the activities carried out result in new pollutants being discharged.

(2) The greater the extent of urbanization the greater the change in drainage characteristics. Normally the amount of runoff and the speed of flow of runoff will increase. This reduces infiltration and retention of water over the ground. As retention time is reduced and flow increases, the pollution carrying capacity is increased.

(3) **Thus to reduce the impact of urbanization of the land,**

- **the amount of runoff needs to be reduced,**
- **runoff flow speeds needs to be reduced, and**
- **water needs to be retained on the land surface as long as possible.**

(4) There are many structural and non-structural methods to achieve this. One example is by the utilisation of detention

ponds. A guideline by the Drainage and Irrigation Department is that 3% to 5% of the total land area should be allocated for use as flood detention ponds.

(5) In addition to drainage changes, the type of activity carried out also affects pollutant inputs. The more intense the level of activity, the greater the possibility of pollutants being discharged. Different activities are associated with different types of pollutants. Some are natural pollutants which will degrade in the environment, such as organic wastes. Others may persist for long periods of time (some pesticides) or accumulate (heavy metals).

2.4.1.2 Pollutant Loadings

(1) Pollutant loadings in a catchment may be approached in two ways. The first is to consider that landuse may be regarded as a direct indicator of amount of pollutant released annually. Such values are given in weight or mass per unit area per year. The second approach is to estimate the concentration of the pollutant which is discharged out of the catchment. Either method is an approximation of the actual load because factors such as distance to receiver, land management measures, dilution effects, slope, etc are not taken into account. More sophisticated model are currently being developed using a combination of techniques, of hydraulics, hydrology, concentration measurements and topography in order to assess the pollutant loading. Many of the results of such estimates and calibration are site specific because of the many variables involved. In Malaysia, pollutant loading studies have primarily been on sediment loss through land clearing or disturbance.

(2) For this study, some information has been gathered on data used for temperate conditions (Table 2.4.1 and 2.4.2). The pollutant loading values previously calculated by Angkasa GHD (1996) for the Drainage Masterplan was also based on data calibrated for urban catchment in Australia (see Table 2.4.3).

Table 2.4.1 Estimated Annual Nutrient Loadings for Chesapeake Bay Watershed Model. N=Nitrogen, P=Phosphorous. Chesapeake Bay Program Office, June 1996.

Federal Lands	Developed	Forest park	Total
Acres	12,661	3,091	**15,752**
N lb/Acre	7.76	2.53	
Total N, lb	98,249	7,820	**106,069**
P lb/Acre	0.623	0.032	
Total P, lb	7,888	99	**7,987**

2.4.2 Point and Non-point Pollutant Sources

2.4.2.1 Different landuse types may also be used to identify the type of pollution source which may be expected as point or non-point sources.

2.4.2.2 **Point sources** may be easily identified to be those sources where

- there is a defined wastewater discharge point such as a pipe or channel, or
- where air is emitted from a defined point or building, or
- from where solid wastes can be collected from an defined point.

2.4.2.3 Point source pollution usually can be identified to come from commercial or industrial and sewage treatment plants, including houses or individual buildings.

2.4.2.4 **Non-point source** (NPS) pollution comes from many diffuse sources. It may be due to rainfall and the subsequent runoff moving over and through the ground. As the water moves along, it dissolves and carries away natural and man-made pollutants, depositing them into lakes, rivers, wetlands, and the ground water. Non-point source pollution can be an important factor for water quality deterioration since they can occur from large areas of land.

Table 2.4.2 Average Urban Stormwater Pollutant Loads (lbs./Year) in Bayfield, Wisconsin, USA. (Wisconsin Division of Natural Resources, Bureau of Watershed Management , April 1997)

	Residential 150.09 ac	Commercial 54.59 ac	Industrial 9.45 ac	Institutional 42.75 ac	Open / Forest 14.59 ac	Total
Solids	60036	103721	16537.5	27787.5	671.14	208753.1
Phosphorus	48.03	68.24	7.09	11.37	2.19	136.91
Ammonia	72.04	27.84	7.75	28.64	3.50	139.78
N02+N03	139.58	52.95	14.74	55.15	6.71	269.14
TKN	579.35	220	61.43	228.71	27.87	1117.35
BOD	5664.40	2150.3	599.98	2235.83	262.62	10913.12
COD	42558	16154.8	4507.5	16797.8	2042.6	82060.7
Chlorides	4549.23	1726.68	481.76	1795.50	204.26	8757.43
Sulfates	2640.08	1001.73	279.63	1041.82	116.72	5079.97
Magnesium	1523.41	578.65	161.41	601.49	0	2864.97
Silver	0.15	0.055	0.019	0.043	0	0.266
Lead	15	131	11.8	4.7	0	162.5
Copper	1.5	3.28	0.51	1.28	0	6.57
Zinc	36.02	61.14	9.92	6.41	0	113.50
Total PAH's	3	1.6	.4	1.6	0	6.7

Table 2.4.3 Putrajaya Modelled Future Pollutant Loads (Putrajaya Drainage Masterplan, 1996)

Water Quality Parameter	Lake		Wetland		Offsite	
	t/a	mg/L	t/a	mg/L	t/a	mg/L
Government Precinct						
Suspended Solids	1260	231	300	173	-	-
Total Phosphorus	2.6	0.5	0.7	0.4	-	-
Total Nitrogen	8.1	1.5	3.2	1.8	-	-
CBD Precinct						
Suspended Solids	1000	155	-	-	-	-
Total Phosphorus	2.4	0.4	-	-	-	-
Total Nitrogen	10	1.6	-	-	-	-
Residential Precinct						
Suspended Solids	1870	124	330	135	1850	160
Total Phosphorus	4.3	0.3	0.7	0.3	4.4	0.4
Total Nitrogen	18.2	1.2	3.7	1.5	20.9	1.8
Sport & Recreation Precinct.						
Suspended Solids	430	148	-	-	340	146
Total Phosphorus	1	0.3	-	-	0.8	0.3
Total Nitrogen	4.2	1.4	-	-	3	1.3

2.4.2.5 The pollutants involved include:

1. excess fertilizers, herbicides, and insecticides from agricultural lands, parks, and residential areas;
2. oil, grease, and toxic chemicals from urban runoff and energy production;

3. sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks;
4. bacteria, viruses, and nutrients from livestock, wildlife, pet wastes, and combined sewerage systems;
5. pollutants from atmospheric deposition; and
6. modification of drainage systems.

2.4.2.6 Reduction and prevention of non-point source pollution include land management to reduce soil erosion by such methods as zoning or erosion control regulations, and the establishment of vegetated buffer zones.

2.4.2.7 Within the Putrajaya catchment boundary, the non-point sources may be given generally into the following four landuse types:

1. Green areas:
   Open spaces - Vegetated parks, experimental farms, orchards, pavements, golf courses;

2. Building areas:
   Offices - offices, institutional buildings, commercial businesses, health clinics;
   Medical/Chemical Centres - hospitals, laboratories;
   Residences - houses, flats, hostels;

3. Infrastructure:
   Transport - roads, highways, and bridges
   Drainage System - channels, streams, riparian areas, dams

4. Water bodies:
   Impounded Water - Lake, wetlands, retention ponds, riparian pools, buffer strips

5. Marinas - boats, jetties

2.4.2.1 Sources within Kawasan Putrajaya

(a) Landuse and Pollutants

(1) Point and non-point sources are identified within Putrajaya based on the landuse types (Table 2.4.4).

(2) In the Putrajaya Urban Design Guide Plan, 46 different land use

classes (Table 2.4.5) are identified. These may be grouped under the four landuse types and their pollution potential assessed. The pollution potential is based on a qualitative assessment of

- the possible intensity of use by people,
- the likelihood of ground disturbance or sediment introduction,
- the possibility of transitory pollutant sources (e.g. cars) being in the area, and
- the nature of materials and substances to be used in the area.

(3) Within Kawasan Putrajaya all interior building discharges are directed into a central sewage treatment system which discharges out of the catchment area. Therefore, sewage and most greywater does not present a problem in Kawasan Putrajaya.

(4) However, open areas such as residential gardens, car parks, roads, park areas, and the promenade, are not expected to be connected to the central system and these, therefore, are possible sources of pollution. The size and proximity of these areas to the lake will affect their possible impact on the Lake System.

(5) In addition, the presence of animals, whether pets, livestock, or wildlife, and their untreated wastes, can also introduce nutrients, and bacteria into the water bodies.

Table 2.4.4 Landuse as a Pollutant Source

Landuse Type	Pollutants Introduced			
	Nutrients	**Organics**	**Sediment**	**Metals**
Green areas				
parks, promenade	P, N	pesticide, herbicide, O&G	sediment, litter	metals in fertilizer, sediment
Building areas				
Offices Institutional buildings, commercial businesses, car parks	P, N, BOD	O&G	sediment, litter	metals in sediment
Medical/ Chemical Centres Hospitals, laboratories	P, BOD	clinical wastes		clinical wastes
Residences houses, flats, hostels	P, N, BOD	pesticide, herbicide, O&G	litter	
Infrastructure				
Transport Lines roads, highways, and bridges, reserves		herbicide, O&G	sediment, litter	metals in sediment
Drainage System Channels, streams, retention ponds, dams	transports P, N	transports pesticide, herbicide, O&G	transports sediment, litter	transports metals
Water bodies				
lake, wetlands, ponds, riparian areas	NH_3 stores P	stores pesticide, herbicide	stores sediment	stores metals
Marinas				
Boats	P	O&G	litter	metals in paint

Table 2.4.5 Landuse Type and Pollution Potential in Putrajaya

LanduseType	Pollution Potential		
	Low	Medium	High
GREEN AREAS			
Cemetery	x		
Metropolitan Parks	x		
Urban Parks		x	
City Parks		x	
Residential Pocket Parks		x	
BUILDINGS			
Offices			
Government Use	x		
Commercial		x	
Neighbourhood Commercial		x	
Mixed Use		x	
Civic and Cultural		x	
Public School Complex			x
Special School Complex			x
Postal		x	
Police		x	
Fire Brigade		x	
Mosque		x	
Other religious		x	
Library	x		
Public Facilities	x		
Information Centre	x		
Putrajaya Service Centre	x		
Service Industry		x	
Bus Depot			x
Sports and Recreation	x		
Water Reservoir/Treatment Plant		x	
Waste Water Facility		x	
Solid Waste Facility		x	
Substation		x	
Gas Supply Facility	x		
Utility Building	x		
Medical/Chemical Centres			
Health Facilities			x
(Laboratory)			x
Residential			
Residential		x	
INFRASTRUCTURE			
Transport lines			
TNB Reserve	x		
Telecommunication Facility	x		
Radio Site	x		
Gas Pipeline Reserve	x		
District Cooling	x		
Transportation Hub	x		
LRT Line/Station		x	
Park and Ride Station		x	
Road Reserve			x
Road Buffers		x	
Drainage system			
(Riparian buffer)	x		
(Drainage reserve)		x	

LanduseType	Pollution Potential		
(Detention ponds)		x	
WATER BODIES			
Promenade	x		
(Riparian parks adjoining Lake)	x		
Wetlands		x	
Lake/Water body		x	
MARINAS			
(Marinas)			x

(6) The more important aspects of landuse and associated activities in Putrajaya are:

a) the presence of buildings and associated impermeable surfaces, allowing higher runoff and lowered retention over the ground;

b) large green areas for public parks which may be potential sources of fertilizers and pesticides, if uncontrolled;

c) the location of bridges and roadways close to the open water, which may be sources of oil and grease, sediment and associated metals, and litter;

d) boating activity which will be sources of oil and grease, metals and toxic paints;

e) the development of the lake edge within 30 m of the shoreline in a manner which may not act to reduce runoff flow velocities or trap materials carried by runoff.

(7) The most important pollutants of concern which may be linked to landuse practices and activities are, in order, sediments, phosphorus, nitrogen, organic solvents, such as oil and grease, and agricides.

(b) Construction Sites

(1) Construction sites are important sources of sediment into the waterways and Lake system. Improperly planned and managed land clearing activities expose soil to natural forces of wind and rain, allowing the surface soil to be transported as dust or suspended and bedload sediment. It is therefore extremely important to ensure adequate soil erosion control measures,

proper drainage of the construction site, and correct placement of silt traps.

(2) In the Putrajaya Lake Management Guide several measures were proposed and are also relevant and should be applied also to areas outside of Putrajaya to protect waterways leading into the Lake and wetlands.

(3) The measures are:

- implementing infiltration design measures and green corridors along waterways (Appendix D);
- installation of rubbish and pollutant trapping structures along the stormwater drainage system;
- creation of riparian systems along water courses;
- creation of grassed swales around the lake perimeter at grassed areas, and infiltration drains in constructed areas.

(4) The following measures are to be taken during construction activities:

- To protect the lake quality, during construction phase it is important to ensure only necessary and for immediate need earthworks are carried out. Earthworks should only be prepared for projects within 6 months of expected use for construction;
- Silt traps are to be sized, based on the daily rainfall record at Putrajaya Catchment, to the one in five-year rainfall or greater;
- Silt trap maintenance operation is to be regularly scheduled;
- A radius of 100m grassed/ forested buffer strip between any portion of the dammed part of the lake and any other project development earthworks is to be maintained;
- This grassed/ forested strip may subsequently be developed for individual projects. If grassed, the grass should be long, or deep layer of cover crop. The purpose is for increased surface roughness and retard overload flow velocities, thereby encouraging sedimentation.
- Within the 100m grassed/ forested strip surrounding the lake, the maximum area of earthworks which is to be carried out at any one time should not exceed 0.5ha within a 1km distance;

(5) In addition,

- A minimum radius of 3m grassed/ turfed strip from any drainage channel leading to silt traps, 8m for natural streams, and any project development earthworks is to be maintained. Not more than 50m distance next to the stream/ drain cleared/ worked at any one time. The cleared earth should be turfed/ grassed over before another 50m is cleared/ worked.

(6) Reference may be made to the Erosion Control Guidelines of DOE, the Urban Design Guidelines, and the Drainage Design Masterplan for Putrajaya.

(7) The soil erosion potential for the Putrajaya Catchment has been defined and discussed in Section 3.2 in Volume 2 of the Main Report. They should be referred to especially for construction and earth clearing activities. Greater care would need to be taken in the high erosion potential areas.

(8) Perbadanan's experience has shown that there is extreme difficulty in ensuring that all silt trap and drainage designs for construction sites are adequate to prevent sediments entering the waterways. In this respect, it is recommended that a new "Erosion and Sediment Control By Law" be enacted by the Perbadanan Putrajaya and Majlis Daerah Sepang. The recommended By-Laws needs to be supported by a new manual detailing procedures, work order, and design standards for erosion and sediment control. The manual should detail the specifications and design or erosion and sediment control measures and works.

(c) Phosphorus

(1) As far as lake health is concerned, the most important chemical parameter of concern is phosphorus. Phosphorus is one nutrient essential for plant growth. Another nutrient is Nitrogen. In the natural environment, nitrogen concentrations are normally in abundance while phosphorus concentrations are usually very low.

(2) Phosphorus in natural waters may be divided into several forms. The description given below is taken from Chapra (1997). One

method of dividing the different forms of Phosphorus is related to the analytical methods available. Figure 2.4.1 shows the relationship between the different forms.

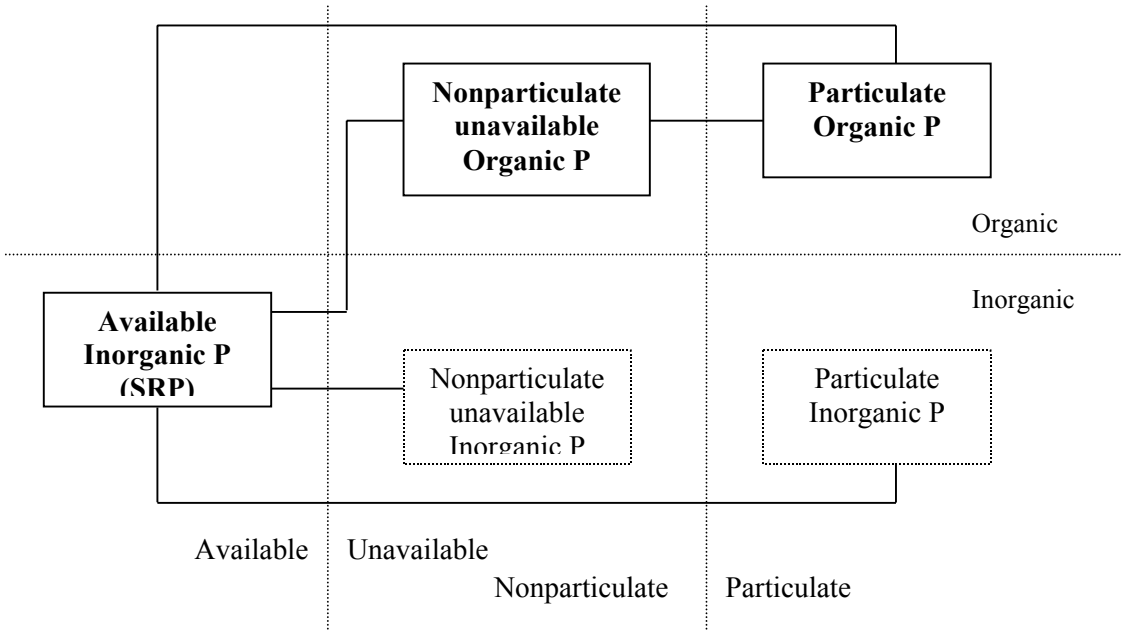


Figure 2.4.1 Different forms of phosphorus found in natural waters. (The main forms contributing to the plant life cycle is indicated in bold lines).

(3) The Total Phosphorus analysis measurement is widely used to assess euthrophication. It gives a measure of all available Phosphorus which might be available for plant growth in future. However, for measuring present plant growth the measure of the SRP or available dissolved P, is a more meaningful measure. It is therefore recommended that for assessing long term euthrophication potential, the Total Phosphorus measure be used but that for the existing status of plant growth potential, then the available dissolved phosphorus be measured.

from Chapra 1997.

Soluble reactive Phosphorus (SRP). Also called orthophosphate or soluble inorganic P, this is the form that is readily available to plants. It consists of the species $H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-}.

Particulate organic P. This form mainly consists of living plants, animals, and bacteria as well as organic detritus.

Nonparticulate organic P. These are dissolved or colloidal compounds containing phosphorus. Their primary origin is the decomposition of particulate organic P.

Particulate inorganic P. This category consists of phosphate minerals (e.g. on clays), and phosphate complexed with solid matter. This group includes condensed phosphates such as those found in detergents.

The distinction between particulate and non particulate forms is made so that the former can selectively be removed (from the analysis) by setting. The division of available phosphorus from the other species is made because it is the only form that is directly available for plant growth. It should be understood that the other forms are not absolutely "unavailable". Rather, they must first be converted to SRP before they can be consumed by plants.

(4) Thus Phosphorus is usually regarded as a limiting factor to growth. When Phosphorus levels are high it leads to increased plant growth. It is therefore of paramount importance to prevent the inflow of phosphorus into the system. In this respect, the sources of phosphorus in the catchment may be given to point sources and non point sources. The point sources are from sewage treatment systems and the non point sources are from land use activities, such as the use of fertilizers, land development and drainage system changes, and from soil erosion.

(5) Point sources inputs are dealt with in the Sewage Master Plan section of the Main Report while non point sources are dealt with in this study. Recommendations are made on controlling non point source pollutants through the establishment of buffer zones and through issuance of guidelines on fertilizer use in the catchment.

(d) Trace Pollutants

(1) Most of the pollutants mentioned above are formed of natural compound readily found in the environment, thus they will degrade in time, such as organic wastes. Other pollutants, although also naturally occurring may persist for long periods of time (organic compounds such as in pesticides, solvents) or accumulate (heavy metals). These are usually present in very low concentrations, ppb and ppm levels, are usually complicated to measure and usually cause toxic effects. These pollutants may be regarded as trace pollutants which need to be monitored because the Lake system functions as a sink for them to accumulate in. As they are normally in very low concentrations, however, their accumulation to produce toxic effects normally occur over a period of tens of years rather than months. Therefore they need only be monitored every year or twice a year at most. The trace pollutants include but are not limited to the list in Table 2.4.6.

(e) Accidental Spillages

(1) Pollutants may also enter the Lake system through accidental spillages of oil or chemicals from the promenade or, more importantly, from roads and bridges crossing the Lake and Wetlands. In such a case an Emergency Response Plan, ERP, will need to be initiated to reduce the amount of pollutant entering the water, to contain the spillage already in the water, and to recover or neutralise the pollutant spill in the water.

(2) The formulation, control, and command of the ERP must be coordinated among the Lake and Wetland Management Unit, the Environment Unit, the Marine Police, the Fire Department as well as the Traffic Police and the road, bridge, or highway Operator. The participation of the pollutant owner is of course necessary in the implementation of the Plan.

(3) In order to reduce such likelihood of spills entering the wetlands, however, road or bridge side containment vessels or channels should be incorporated into the design of the utility.

Table 2.4.6 Possible Trace Pollutants in Putrajaya Lake

Trace Pollutant	Unit	Putrajaya Ambient Lake Water Quality Standards
Metals		
Aluminium	mg/l	<0.05 if pH<6.5* <0.1 if pH>6.5
Arsenic	mg/l	0.05
Antimony	mg/l	0.03
Beryllium	mg/l	0.004
Cadmium	mg/l	0.002
Chromium, Total	mg/l	0.05
Copper	mg/l	0.02
Cyanide	mg/l	0.02
Lead	mg/l	0.05
Mercury	mg/l	0.0001
Nickel	mg/l	0.02
Selenium	mg/l	0.01
Silver	mg/l	0.05
Radioactivity		
Gross-alpha	Bq/l	0.1
Gross-Beta	Bq/l	1
Radium-226	Bq/l	<0.1
Strontium-90	Bq/l	<1
Organics		
Carbon Chloroform extract	ug/l	500
MBAS/BAS	ug/l	500
PCB	ug/l	0.1
Phenol	ug/l	10
Aldrin/Dieldrin	ug/l	0.02
BHC	ug/l	2
Chlordane	ug/l	0.08
t-DDT	ug/l	0.1
Endosulfan	ug/l	10
Heptachlor/Epoxide	ug/l	0.05
Lindane	ug/l	2
2,4-D	ug/l	70
2,4,5-T	ug/l	10
2,4,5-TP	ug/l	4
Paraquat	ug/l	10

2.4.2.2 Sources From Outside Kawasan Putrajaya

(1) Pollutant sources from outside the Putrajaya area also can be classified in the same manner as for Putrajaya. Table 2.4.7 shows the pollution potential associated with the current landuse.

(2) Within the upper catchments of Upper-West and Upper-North, much of the land is covered with grass or under tree-cover, with orchards, rubber trees and small experimental plots. There is a nine-hole golf-course in UPM. There are no major drainage works and the small streams have slight to moderate vegetation growth within them, which act as filters and absorbers of nutrients, organics, and sediment which are carried by the streamflow. The major pollutant input from such areas is of non-point sources and are nutrients and organics..

(3) There are few buildings in the smaller Upper-West sub-catchment. These are served by septic tank systems. The Upper-North Catchment is larger and more developed. There are several hostels in UPM and these are on individual treatment systems. In the middle section of the catchment, there are residential developments with individual treatment systems, and a golf course. There are also new residential developments being proposed by West Country. All the treatment systems for the developments are point sources (Table 2.4.8). The details on the systems are presented in Chapter 5. There is a possibility that some of the discharges will be pumped out of the catchment. The major pollutants are organic wastes, phosphorus, and bacteria. The golf course is a non-point source of nutrients and pesticides.

(4) In the Upper-East sub-catchment, UNITEN is likely to develop the land for institutional facilities. Any buildings with treatment systems will be point sources.

(5) In the Lower sub-catchment, the proposed developments of Cyberjaya will result in point source pollutants from the treatment system. It is possible that the discharge will be pumped out of the catchment, however.

Table 2.4.7 Landuse and Pollution Potential from External Sources

LAKE CATCHMENT AREA (Acre)	UPM %	MARDI %	IOI %	TNB %	WEST COUNTRY %	CYBER JAYA %	SUNGAI MERAB %	UNITEN %	TOTAL %	Pollution Potential		
										Low	Medium	High
GREEN AREAS												
Open space/Fields	20.06	3.33	2.61	0.00	0.00	100.00	0.00	0.00	12.28	x		
Golf Course	17.83	0.00	97.39	0.00	0.00	0.00	0.00	0.00	13.63		x	
Farms	20.45	58.00	0.00	0.00	0.00	0.00	0.00	0.00	25.26		x	
Orchards	41.66	38.67	0.00	0.00	0.00	0.00	0.00	0.00	26.74		x	
Others	0.00	0.00	0.00	100.00	100.00	0.00	100.00	100.00	22.09	x		
% of Total	75.26	76.37	42.59	87.02	100.00	19.32	100.00	100.00	67.16			
BUILDINGS												
Administration/Offices	0.00	61.13	0.00	0.00	0.00	27.40	0.00	0.00	19.35	x		
Hostels	36.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.41			x
Housing/Quarters	2.21	16.59	82.14	0.00	0.00	50.00	0.00	0.00	38.90	x		
Commercial	0.00	0.00	10.86	0.00	0.00	5.01	0.00	0.00	4.17		x	
Power Station	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	4.07		x	
Facilities	60.90	0.00	7.00	0.00	0.00	15.02	0.00	0.00	20.60		x	
Others	0.00	22.28	0.00	0.00	0.00	2.49	0.00	0.00	4.50	x		
% of Total	11.66	9.66	30.77	12.98	0.00	39.96	0.00	0.00	16.13			
WATER BODIES												
Pond/Lake	100.00	100.00	14.29	0.00	0.00	100.00	0.00	0.00	52.13		x	
Wetland	0.00	0.00	85.71	0.00	0.00	0.00	0.00	0.00	47.87		x	
Total	1.74	2.66	21.41	0.00	0.00	8.40	0.00	0.00	4.98			
INFRASTRUCTURE												
Roads/Drainage	39.07	39.14	89.63	0.00	0.00	24.58	0.00	0.00	36.26		x	
Express Rail Link	46.87	35.47	0.00	0.00	0.00	18.23	0.00	0.00	30.53		x	
Highway	14.06	25.39	0.00	0.00	0.00	41.72	0.00	0.00	26.79		x	
Others	0.00	0.00	10.37	0.00	0.00	15.47	0.00	0.00	100.00		x	
% of Total	11.34	11.31	5.23	0.00	0.00	32.32	0.00	0.00	11.74			
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00			
TOTAL AREA	1389.80	1204.58	522.91	222.98	276.37	607.04	89.60	93.80	4407.08			

Table 2.4.8 External Point Sources

Landowner	Source Type	Current	Future
MARDI	Office Septic Tank	4	
	House Septic Tank	approx . 20	
UPM	Hostel Septic Tank	2	
	Hostel Hi-Kleen	(1)	
	Hostel Sewage Treatment Plants	2	
	Student Health Centre	1	
	Cafeteria	1	
	Office/Laboratory Septic Tank	4	
IOI	House Septic Tanks	0	
	Office Septic Tank	2	
	Sewage Treatment Plant	1	1
West Country	Sewage Treatment Plant	0	1
UNITEN		0	
Sungai Merab		0	
Cyberjaya	Hi-Kleen Treatment Plant	1	0

( ) - under construction.
Future denotes known plans.

(6) The small Limau Manis sub-catchment includes some lots in the Sungai Merab area. The waste treatment systems of the houses to be developed will be point sources.

2.5 ASSESSMENT OF POLLUTANT IMPACT TO PUTRAJAYA LAKE SYSTEM

2.5.1 Upper-West Sub-Catchment

2.5.1.1 The land in this catchment is owned by MARDI and TNB. This catchment is drained by Sg. Kuyoh into the Upper-West wetlands. A small portion of the wetland tributary intrudes into TNB land. The wetlands are crossed at the northern end by the South Klang Valley Expressway (B11) and the ERL.

2.5.1.2 Much of the land is under non-intensive agriculture and forest. Only a small number of buildings exist here comprising worker quarters and low-rise office blocks.

2.5.1.3 The streams are small, less than 2 m width at low flow, and shallow (1 m). The streams enter a constructed pond approximately in mid-catchment and receives most of the artificial stormwater drainage as well as septic tank overflow in MARDI.

2.5.1.4 At present only about 1,000 persons work on the whole in the MARDI area with only a few hundred residents. The future working population is not expected to increase beyond 2,000 persons.

2.5.1.5 The sewage contribution from here is low (with less than 2,000 persons). What was of major concern previously was the rearing of a large population of farm animals on the site and the resultant wastes. Due to the presence of the Putrajaya development, the animals had been relocated elsewhere and the farm section is expected to be closed down shortly. Any future animal rearing is expected to be dispersed and of small numbers. The numbers planned are unknown at this stage but are expected to be less than 100.

2.5.1.6 The stream waters are clear and it is expected that any nutrients washed off in runoff would be mostly taken up by the many plants lining the stream. During storm events, however, it is likely that this uptake will be reduced as flow velocities increase.

2.5.1.7 In their future development plans, MARDI has proposed the development of additional ponds in the lower part of their catchment. This should be able to increase the retention of water and enhanced nutrient uptake.

2.5.1.8 The pesticides used in MARDI are of the soluble type and non-persistent, quickly degrading in the environment. Application is controlled and follows the guidelines of the Department of Agriculture. Since the agriculture practised is non-commercial, dispersed and of small size, it is not expected that agro-chemicals will be an issue from this catchment.

2.5.1.9 In the TNB sector of the catchment, routine monitoring of discharges is carried out as required by the Department of Environment. Their reports indicate that all discharges comply to the regulations. The discharges from this sector are not expected to be an issue.

2.5.1.10 The southern sector of what was MARDI land, however, has been acquired for the development of the South Klang Valley Expressway (B11) and the ERL. It is expected that the construction activities from this development will contribute to increased sediments in the streams and release of soil-bound phosphorous.

2.5.1.11 At present, the Kajang-Puchong (B11) road crosses the wetlands. The risk of traffic accidents from cars, lorries and fuel tankers is always present. At present there are no buffers or barriers on either side of the road to prevent fuel spillages from flowing into the lake.

2.5.1.12 In summary,

- nutrient input current (measured Total Phosphorus concentrations are approximately 0.4 - 5 mg/l) and future is minimal;
- fertilizer, pesticide input is controllable;
- no large flow input variations (<30%) are expected in future;
- sewage input (<0.003 m^3/s) is insignificant because of the low population;
- pollutant input from the road crossing the wetland is possible.

2.5.1.13 The recommendations for this catchment are primarily to enhance the landuse setting:

- maintain streams and introduce riparian buffer strips (non-point BMP);
- ensure dispersed development in the catchment with higher intensity development, if required, upstream of detention ponds;
- maintain forested areas in steep slopes to the north-northwest of the catchment;

- landuse changes and development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring and re-evaluation of impacts. Land earthwork clearing should not extend over more than 15% of the catchment at any one time and preferably less than 10% in a 6 month period.

2.5.1.14 Of immediate concern is the need to

- install mitigating measures to prevent pollutant input from the roads crossing the wetland.

2.5.1.15 The proposed future development of the area in MARDI as a "green lung" is in line with the maintenance of the Putrajaya Lake environment.

2.5.1.16 The current development at TNB is not expected to alter and currently contributes no significant pollutant input to the Lake. The risk of explosion is the only concern but is unlikely to affect the Upper-West wetlands directly. There is an approximately 200 m distance from the station proper to the station boundary.

2.5.2 Upper-North Sub-Catchment

2.5.2.1 MARDI, UPM and IOI own the land in this catchment which is drained by Sg. Chuau into the Upper-North wetlands. It is twice the size of the Sg. Kuyoh Upper-West catchment at 12.4 km^2. The South Klang Valley Expressway and the ERL cross the wetlands at the northern end.

2.5.2.2 Much of the land is under vegetation with some farms, orchards, and two golf courses. The northeastern portion is covered by oil palm and rubber. There are institutional buildings, including laboratories, a student health centre, offices, hostels, and a number of constructed ponds.

2.5.2.3 The streams are small, less than 1 m width at low flow and shallow. The streams do not enter any of the ponds.

2.5.2.4 Besides the small working population in MARDI, there are about 10,000 students in UPM, and a small residential population in IOI. In MARDI and IOI the population is

unlikely to change by more than 1,000. In UPM, the future working and residential population is uncertain. The student hostel population may increase slightly but unlikely to be more than 3,000. This is based on the proposal to build a Medical Faculty with housing, a sports complex, and some mixed development within the catchment.

2.5.2.5 At present the sewage contribution from here is low but of much greater amounts than in the Upper-West catchment. All septic tank outflows, serving a population of about 3,000, discharge into a stream tributary in the upper part of the catchment. The High Clean system discharges into one of the constructed ponds also in the upper part of the catchment.

2.5.2.6 By the time the stream reaches the boundary with Putrajaya, the waters are clear and it is expected that there has been some natural biodegradation of the organic wastes. During low flow any nutrients in the water will probably be taken up by the small number of plants lining the stream. During storm events, however, it is likely that the fast-flowing runoff and septic tank overflow will worsen water quality. This will be balanced with dilution effects.

2.5.2.7 In IOI the individual bungalow lots are served by septic tank systems. Some discharge into storm drains directly draining into the Upper-West while the rest drain into a pond before entering into the upper section of the Upper-West.

2.5.2.8 The use of fertilizers and pesticide is expected to be limited. The agriculture practised here is non-intensive, and of small size, mainly being student farms. It is not expected that agro-chemicals will be an issue due to this activity. However, because of the nature of the agriculture practised the chemical use is not centrally controlled. Therefore, there must be controls and monitoring of the chemicals used.

2.5.2.9 There are two golf courses within the catchment area and fertilizer and herbicide use on the grounds may be of concern. Usually there are many internal ponds which help to capture most of the chemicals and these may be used to monitor fertilizer use. In addition, however, the downstream borders of the golf course should be designed to function as runoff buffers to reduce overland flow of the chemicals. Grass should be

allowed to grow or swales introduced to streamline flow and increase retention time. In addition use of herbicides, in an effort to control vegetation growth, should not be encouraged along streams and water courses. Manual gardening methods should be used instead, if necessary.

2.5.2.10 The future development of MARDI follows the concept of "green lung" and is in line with the issues discussed for the Upper-West catchment.

2.5.2.11 In their future development plans, UPM has proposed several different types of development. These include institutional and recreational facilities. There is also a proposal to develop a Medical Faculty and teaching hospital. This latter development is of some concern because of the issue of clinical waste.

2.5.2.12 In the IOI sector of the catchment, no further development is expected.

2.5.2.13 In this catchment too, the southern sector of what was MARDI and UPM land, has been acquired for the development of the South Klang Valley Expressway (B11). In the eastern sector, there are proposal to upgrade the existing Serdang-Kajang road It is expected that the construction activities from these developments will contribute to increased sediments in the streams and release of soil-bound phosphorous

2.5.2.14 Similar to the case for the Upper-West wetlands, the Dengkil-Puchong road crosses the wetlands. The risk of traffic accidents from cars, lorries and fuel tankers is always present. There are presently no buffers or barriers on either side of the road to prevent fuel spillages from flowing into the lake.

2.5.2.15 In summary,

- current nutrient input is small (measured phosphate concentrations are approximately);
- fertilizer and pesticide input needs to be controlled and monitored;
- some flow input variations are expected due to future developments;

- sewage input is small (see above) but of concern as they are currently only treated through septic tank systems;
- golf course maintenance may be a source of nutrients and chemicals;
- pollutant input from the road crossing the wetland is possible.

2.5.2.16 The recommendations for this catchment are to improve water quality in streams:

- enhance and introduce riparian buffer strips (non-point BMP);
- utilise constructed ponds to retain drainage and stream flow;
- development in the catchment should grade from lower intensity near streams to higher intensity development, if required, upstream of detention ponds;
- adequacy of the current and future sewerage treatment systems needs to be addressed;
- the constructed ponds may be used as discharge points for sewage treatment systems before overflow to streams;
- medical/laboratory wastes should be discharged out of the catchment;
- landuse changes and development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring and re-evaluation of impacts. Land earthwork clearing should not extend over more than 15% of the catchment at any one time and preferably less than 10% in a 6 month period.

2.5.2.17 Of immediate concern is the need to

- ensure optimum function of the current sewage treatment system;
- install mitigating measures to prevent pollutant input from the roads crossing the wetland.

2.5.2.18 The proposed future development of the area can be sustained provided:

- fertilizer and pesticide use is controlled and monitored;
- adequate sewage treatment facilities are installed;

- medical and laboratory wastes are exported from the catchment.

2.5.3 Upper-East Sub-Catchment

2.5.3.1 Perbadanan Putrajaya, West Country and UNITEN own the land in this catchment. The sub-catchment is only 4.2 km^2. This catchment drains into the Upper-East wetland.

2.5.3.2 West Country has two separated land lots in the mid and upper catchment, while the UNITEN land is only in the upper catchment. At present the land is under rubber forest.

2.5.3.3 The development plan for the upper catchment lot of West Country is for low density (2 lots/acre) residential development. A similar development is proposed for the mid catchment lot. The mid catchment lot directly borders the Upper-East wetland.

2.5.3.4 In their future development plans for the upper catchment lot, West Country has proposed the development of detention ponds following the DID guidelines. These ponds should be able to increase the retention of water and allow for sedimentation and nutrient uptake.

2.5.3.5 For the upper catchment lot, West Country have elected to pump out all sewage from the single sewage treatment plant in the catchment. Only the sewage from the mid-catchment lot will be of concern.

2.5.3.6 For the upper catchment area of UNITEN, it is expected that the development will be for institutional purposes.

2.5.3.7 In summary,

- nutrient, fertilizer, pesticide input is currently negligible with some small increase expected in future ;
- some flow input variations are expected due to future developments;
- sewage input is small because of the small population but may be of concern because of the proximity to the wetland.

2.5.3.8 The recommendations for this catchment are related to development issues:

- introduce riparian buffer strips (non-point BMP) along drainage lines;
- adequate sewage treatment measures need to be developed;
- treated sewage discharges should enter upstream of detention ponds;
- earthwork clearing should follow the guidelines applied within Perbadanan Putrajaya.

2.5.3.9 There are no immediate concerns as the land is under rubber forest at present.

2.5.3.10 The proposed future development of the area can be sustained provided:

- fertilizer and pesticide use is controlled and monitored;
- riparian buffers are installed along drainage lines and the wetland shoreline;
- adequate sewage treatment facilities are installed.

2.5.4 Central Sub-Catchment

2.5.4.1 The Central sub-catchment includes input from Cyberjaya. Land is owned by Perbadanan Putrajaya also.

2.5.4.2 The sewage contribution from here is expected to be low. However, since the discharge is to the downstream portion of the lake it is a matter of great concern. It is understood that Cyberjaya intends to export the sewage discharge.

2.5.4.3 In their future development plans, Cyberjaya should include the development of detention ponds in the lower part of their catchment. This should be able to increase the retention of water and enhanced nutrient uptake.

2.5.4.4 The pesticides used are expected to be of small amounts. It is not expected that agro-chemicals will be an issue from Cyberjaya.

2.5.4.5 Construction activities for development in this area is expected to be of concern. It will contribute to increased sediments in the streams and release of soil-bound phosphorous. Shoreline development should be completed prior to Main Dam closure. Earthworks should follow the guidelines within Putrajaya.

2.5.4.6 In summary,

- nutrient, fertilizer, pesticide input is currently negligible with some small increase expected in future ;
- some flow input variations are expected due to future developments;
- sewage input is small because of the small population but may be of concern because of the proximity to the wetland.

2.5.4.7 The recommendations for this catchment are related to development issues:

- introduce riparian buffer strips (non-point BMP) along drainage lines;
- adequate sewage treatment measures need to be developed;
- treated sewage discharges should enter upstream of detention ponds;
- earthwork clearing should follow the guidelines applied within Perbadanan Putrajaya.

2.5.4.8 The immediate concern is

- development of the Lake shoreline before Main Dam closure;
- sewage discharge into the catchment.

2.5.4.9 The proposed future development of the area can be sustained provided:

- fertilizer and pesticide use is controlled and monitored;
- shoreline and riparian buffers are planned along drainage lines and the Lake;
- adequate sewage treatment facilities are installed.

2.5.5 Limau Manis Sub-Catchment

2.5.5.1 The Limau Manis sub-catchment, which is the result of the capture of an upper section of the Sg Limau Manis, includes a small portion of the Sungai Merab village.

2.5.5.2 At present the land is under forest.

2.5.5.3 In summary,

- nutrient, fertilizer, pesticide input is currently negligible with some small increase expected in future ;
- some flow input variations are expected due to future developments;
- sewage input is expected to be small because of the small area.

2.5.5.4 The recommendations for this catchment are related to development issues:

- adequate sewage treatment measures need to be developed. As this is a small catchment with a small number of lots, Perbadanan Putrajaya should consider connecting the lots to the Putrajaya Central Sewage Treatment line.

2.5.5.5 The immediate concern is

- the rate of development of the lots is unknown.

2.5.5.6 The proposed future development of the area can be sustained provided:

- fertilizer and pesticide use is controlled and monitored;
- adequate sewage treatment facilities are installed.

2.5.6 Summary of Sources of Pollutant Potential and Recommendations

Sub-Catchment	Sources of pollutants	Recommendations
Upper West	• nutrient input • fertilizer and pesticide input • flow input variations • sewage input • pollutant input from the road crossing the wetland	• maintain streams • introduce riparian buffer strips • ensure dispersed development in the catchment • maintain forested areas in steep slopes • landuse changes and development should occur in stages • Land earthwork clearing should not extend over more than 15% of the catchment at any one time • install mitigating measures to prevent pollutant input from the roads crossing the wetland.
Upper-North	• nutrient input • fertilizer and pesticide input • flow input variations • sewage input - septic tank systems; • golf course maintenance - source of nutrients and chemicals; • pollutant input from the road crossing the wetland is possible.	• enhance and introduce riparian buffer strips • fertilizer and pesticide use is controlled and monitored; • utilise constructed ponds to retain drainage and stream flow; • ensure dispersed development in the catchment • the constructed ponds may be used as discharge points for sewage treatment systems before overflow to streams; • medical/laboratory wastes should be discharged out of the catchment; • landuse changes and development should occur in stages, • Land earthwork clearing should not extend over more than 15% of the catchment at any one time • ensure optimum function of the current sewage treatment system; • install mitigating measures to prevent pollutant input from the roads crossing the wetland.

Upper-East	• nutrient, fertilizer and pesticide input • flow input variations • sewage input	• introduce riparian buffer strips (non-point BMP) along drainage lines and wetland shorelines; • fertilizer and pesticide use is controlled and monitored; • adequate sewage treatment measures need to be developed and facilities installed; • treated sewage discharges should enter upstream of detention ponds; • earthwork clearing should follow the guidelines applied within Perbadanan Putrajaya.
Central	• nutrient, fertilizer and pesticide input; • flow input variations • sewage input – proximity to the wetland.	• introduce riparian buffer strips (non-point BMP) along drainage lines and wetland shorelines; • fertilizer and pesticide use is controlled and monitored; • adequate sewage treatment measures need to be developed and facilities installed; • treated sewage discharges should enter upstream of detention ponds; • earthwork clearing should follow the guidelines applied within Perbadanan Putrajaya. • development of the Lake shoreline before Main Dam closure;
Limau Manis	• nutrient, fertilizer, and pesticide input • flow input variations • sewage input	• fertilizer and pesticide use is controlled and monitored; • adequate sewage treatment measures need to be developed and facilities installed and connected to the Central Sewage Treatment line.

2.6 WATER QUALITY MODELLING

2.6.1 Introduction

In order to ensure that the water quality in the Putrajaya Lake system meets the Putrajaya Lake Water Quality Standard, there is a need to continuously manage and monitor the water quality in the system. Also, to assess the pollutant-carrying capacity of the Putrajaya Lake system there is a need to model the water quality of the system for various scenarios of discharge and pollutant input into the system.

2.6.2 Water Quality Monitoring

(1) For a development project, monitoring may be divided into three stages:

1. baseline or pre-construction;
2. construction and commissioning;
3. operation or post-construction.

(2) Putrajaya Holdings Sdn. Bhd., the main developer in Putrajaya, is currently monitoring the water quality in the Putrajaya Lake system through the various development contractors.

(3) At present, the wetlands and Phase 1A of the lake is in the commissioning stage. Therefore only two stages of monitoring had been carried out by them. There are also information on water quality of the area from several previous studies.

2.6.2.1 Baseline stage and pre-construction

A. Baseline Information

(1) The previous water quality samplings undertaken in the Sungai Chuau catchment was summarised by Perunding Kota Bistari (1996) in its Water Quality Control and Management Study on the Putrajaya Lake Development. The data reviewed and summarised were from the following studies:

1. The Geological and Geotechnical Study (JPK, 1994)
2. Pakar Management Sdn Bhd (Pakar, 1994)

3. The Environmental Impact Assessment for Putrajaya (UPM, 1995)
4. Minconsult/HGM, November 1995

(2) The summary of the water quality data is shown in Table 2.6.1. The sampling locations within the respective sub-catchment, that is the Upper West, Upper North, Upper East, Bisa, Central and Lower Sg Chuau are shown in Figure 2.6.1.

Table 2.6.1 Water Quality in Sg Chuau.

a. Physico-chemical Characteristics of the Lower Sg Chuau (Minconsult/HGM)

	JPK (April 1994)	Pakar (Date unknow)	UPM (June 1995)	Minconsult/ HGM (Nov 1995)
Station No	33	2	12	10
Temp ^{o}C	-	27.3	28.0	27.5
TDS, mg/l	20	805	42	-
Cond, uS/cm	36	-	60	46
Turbidity,NTU	11	110	27	35
TSS,mg/l	74	275	20	14
DO, mg/l	-	7.2	6.8	7.0
BOD, mg/l	-	13.5	1.0	1.0
COD, mg/l	-	29.0	3	<1
pH	6.7	6.4	6.6	6.8
Alkalinity,mg/l	-	-	-	12.3
Hardness, mg/l	12.0	-	-	13.8

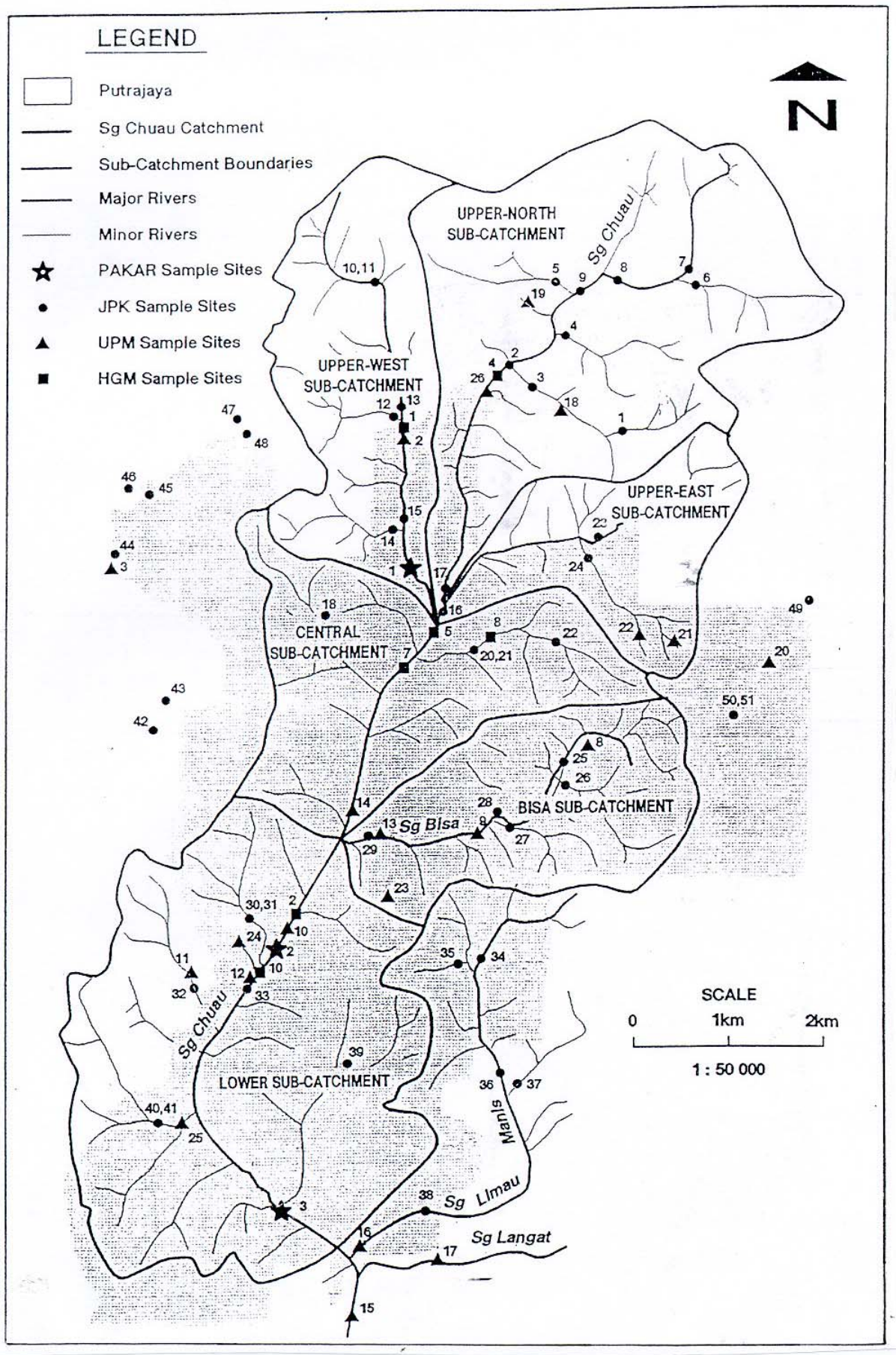


Figure 2.6.1: Location of Water Quality Sampling Sites (Kota Bistari, 1996)

b. Mean Ionic Composition of Catchment Stream Waters (Source: JPK, 1994)

Ion	Mean concentration (ppm)
Ca	3.39
Mg	0.70
Na	1.49
K	1.05
CO_3	1.02
HCO_3	17.65
F	0.5
Cl	2.06
SO_4	3.13

c. Mean Dissolved Oxygen, BOD and COD Concentrations and Ranges Obtained Over the Project Area.

	DOE class IIB	Minconsult/HGM (1995)	Previous other studies
DO, mg/l	507	6.4(5.0-7.1)	1.1-7.6
BOD, mg/l	3	1.5(0.8-3.0)	0.2-15.5
COD, mg/l	25	11.0(<1-18)	1.0-53.0

d. Bacteriological Characteristics of Sg Chuau Obtained Over the Project Area

	DOE class IIB	Minconsult/HGM(1995)	Pakar(1994)
Feacal coliform, count/100ml	100	17,000-160,000	-
Total coliform, count/100ml	5000	17,000-180,000	140,000-150,000

e. Metal Concentrations in Water and Sediment Samples in Relation to Selected Standards and Previous Data

	Water, mg/l		Sediment, mg/kg	
Metal	Minconsult/HGM (1995)	Previous studies	Minconsult/ HGM(1995)	Previous studies
As	<0.001-0.007	<0.005-0.03	<0.1- 32	10- 200
Al	-	<0.1-0.3	-	-
Fe	0.31-3.79	<0.1-0.3	0.59	0.1- 7.6
Mn	-	<0.1-0.3	1.95	3- 254
Cu	<0.01	<0.1	<1- 8.93	1- 51
Pb	0.05-0.15	<0.1	<5- 24.94	1- 40
Zn	<0.07-<0.02	<0.1-0.2	1.69- 31.18	3- 96
Co	-	<0.1	-	1- 5
Mo	-	<0.1	-	0.1- 9.4
Ni	<0.02	<0.1	<2	1- 16
Cd	<0.02	<0.01	<2	1
Sn	-	<0.01	-	10- 40
Ba	-	<0.1	-	16- 87
Se	-	<0.005	-	-
B	-	<5	-	-
Cr	<0.03-0.05	<0.01	<3- 17.87	3- 137
Ti	-	-	470- 8580	-
Hg	<0.001	0.00002-0.00012	0.5- 1.49	0.02- 0.8

B. Pre-Construction Information

(1) Nine monitoring stations were established by the PJH consultant (Angkasa GHD) prior to construction of the wetlands and lake. The locations of the nine stations are indicated in Figure 2.6.2 and described in Table 2.6.2. Monthly sampling was carried out for a period of six months from December 1996 to May 1997. The analysis was carried out by Core Laboratories. A summary of the

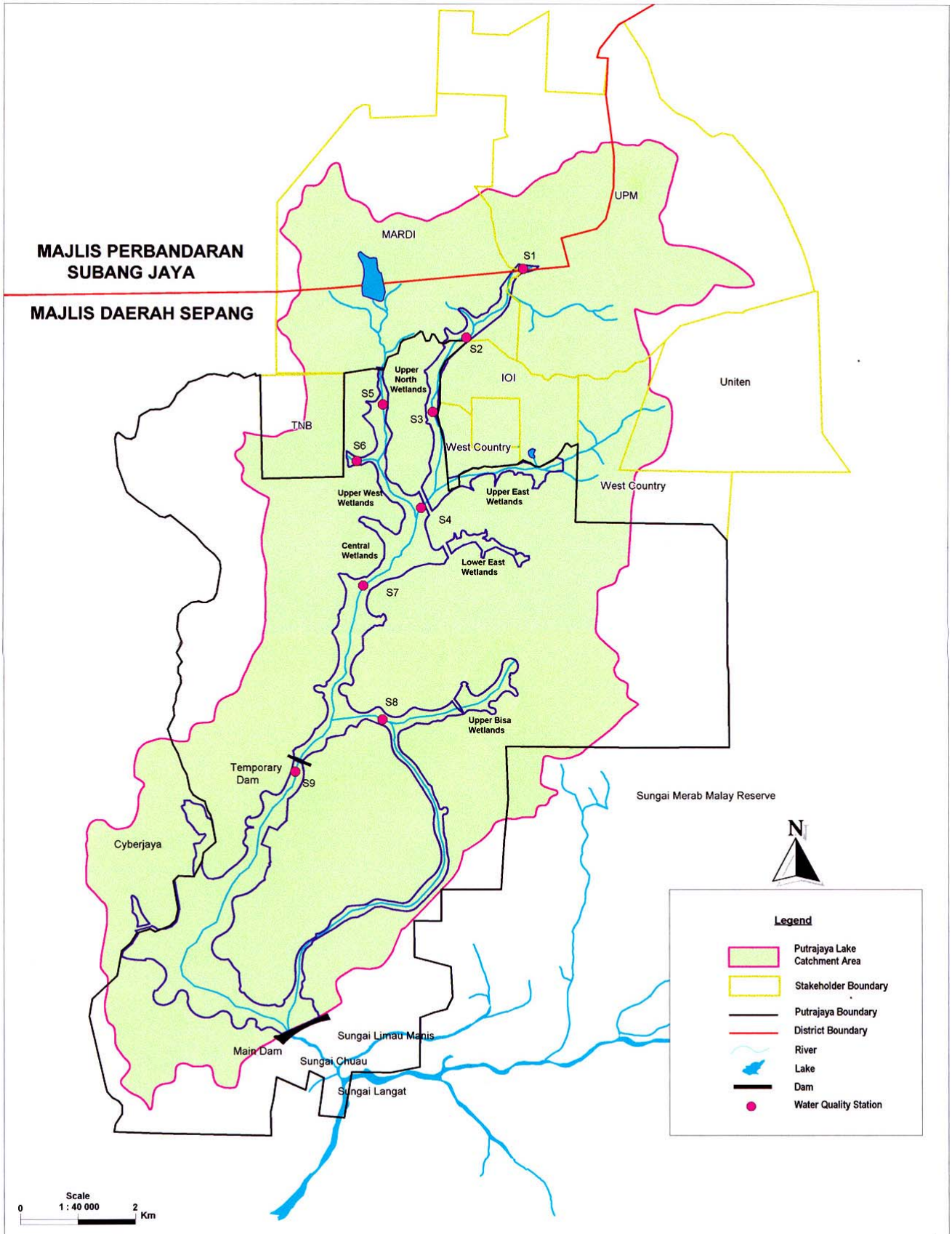


Figure 2.6.2 Locations of Baseline Water Quality Monitoring Stations

results of the water quality monitoring at the nine stations is given in Table 2.6.3.

(2) The results indicate that :-

(i) the water from the upper Sg Chuau catchment of Upper-North and from the Sg Bisa catchment contains high Total Phosphorous but that most of the phosphorus is in the particulate form. The concentration from the Sg. Kuyoh catchment, or the Upper-West, is lower.

(ii) The Total Nitrogen from both catchments, however, exceeds the guidelines.

(iii) The coliform counts from all catchments exceed the guidelines.

(iv) Several heavy metals exceed the guideline levels. A high Total Iron and Manganese concentration is not unusual but the high Total Mercury is of concern.

(v) Insecticide and herbicide concentrations were all low.

C. Commissioning Stage

(1) The wetlands is still in the commissioning stage. Monitoring is carried out by Putrajaya Holdings Sdn. Bhd.′s subcontractor Marimas) twice monthly at each wetland cell from 1997. A sample of the data for the month of April 1999 is given in Table 2.6.4. The data are compared to the Baseline Monitoring Stations as listed in Table 2.6.2.

(2) These indicate that nutrient input is negligible but the amounts of coliform again exceeded the proposed Putrajaya Ambient Lake Quality Standards (Table 2.6.5). Some values also exceed the value of 2000 counts/100 ml which may be regarded as the upper limit for health considerations of recreational use without body contact. Due to the low concentration analysed, the results for

several parameters are only indicated to be less than a certain value. Thus, the wetland efficiency could not be assessed especially for phosphorus.

Table 2.6.2 Water Quality Baseline Monitoring Stations

Station No.	Description
S1	Sg Chuau northeast tributary
S2	Inlet to Upper North Wetland
S3	Stormwater outlet at IOI Palm Golf Course
S4	Upper East Wetland, downstream of IOI Palm Golf Course
S5	Inlet to Upper West Wetland
S6	TNB Power Station stormwater drain outlet
S7	Secondary Lake Weir
S8	Sg Bisa
S9	Temporary Dam, near JPS gauging station

Table 2.6.3 Summary of Water Quality Monitoring Results at the Pre-construction Stage (from Quek, 1997)

Parameter	**S1** UN	**S2** UN	**S3** UN	**S4** UE	**S5** UW	**S6** UW	**S7** CW	**S8** UB	**S9** TD
Temperature, ^{o}C	28-30.2	27-31	27-34	26-34	29-32.4	27-29	27-32.8	26-32	28-32.3
Conductivity	68-100	62-76	64-80	22-29	28-42	21-27	43-55	29-37	44-52
Ph	6.6-7.1	6.5-7.4	6.5-6.9	5.98-6.8	6.2-7.1	5.6-6.9	6.4-7.37	5.68-7.0	6.12-7.3
Colour, PtCo	2-21	7-20	7-44.7	4-39	6-29	1-9	14-82	6-21	13-42
Turbidity, FTU	7.8-251	10.47-60.0	9.36-60.0	5.42-39.1	0.19-41.2	0.18-24.83	8.2-102	10.4-67	25.36-193
TSS, mg/l	6-101	6-68	7-46	4-23	4-140	4-33	10-75	4-94	11-146
Total P, mg/l	0.03-0.36	0.01-0.19	0.01-0.29	0.01-0.15	0.01-0.29	0.01-0.15	0.01-0.18	0.02-0.13	0.01-0.12
Filterable P, mg/l	0.1-0.18	0.1-0.18	0.1-0.18	0.1-0.18	0.1-0.18	0.1-0.18	0.1-0.18	0.1-0.18	0.1-0.18
Total N, mg/l	4.04-9.41	3.54-8.79	3.49-4.57	1.68-2.86	1.93-3.12	1.1-2.13	2.13-3.42	1.45-2.79	2.12-3.54
Total oxidised N, mg/l	1.72-2.88	1.72-3.65	1.72-3.8	1.08-1.63	0.93-1.93	0.66-1.2	1.4-2.23	0.69-1.38	1.44-2.1
Ammonia N, mg/l	0.12-1.59	0.16-6.24	0.09-0.55	0.04-0.18	0.17-0.49	0.01-0.2	0.16-0.47	0.21-0.37	0.14-0.58
BOD5, mg/l	0.85-7.16	0.54-3.48	0.31-6.27	0.74-4.82	0.02-14.7	0.47-2.23	0.81-4.78	0.45-4.21	0.08-4.3
COD, mg/l	6-24	1-9	1-24	1-7	1-41	1-5	1-10	1-10	1-9
DO, ppm	3.81-6.9	4.13-6.8	4.66-7.52	5.44-6.8	3.74-6.9	4.25-7.0	5.8-6.8	5.66-7.05	6.25-6.9
Total Coliform, MPN/100ml	16000-90000	3000-30000	16000-90000	9000-90000	3000-90000	70-17000	5000-50000	16000-18000	16000-50000
Faecal Coliform,	700-3000	700-1600	210-1600	220-900	270-9000	2-230	1300-	260-800	500-2400

Parameter	**S1** UN	**S2** UN	**S3** UN	**S4** UE	**S5** UW	**S6** UW	**S7** CW	**S8** UB	**S9** TD
MPN/100ml	0	0	0				3000		
Total Iron, mg/l	0.66-5.74	0.88-1.69	0.76-2.21	0.34-2.27	0.48-10.92	0.18-1.58	0.54-3.48	0.91-3.29	0.6-4.66
Total Mn, mg/l	0.07-0.17	0.08-0.13	0.09-0.19	0.05-0.13	0.02-0.07	0.11-0.18	0.09-0.22	0.05-0.18	0.09-0.36
Total Zn, mg/l	0.002-0.06	0.02-0.08	0.002-0.09	0.03-0.06	0.002-0.06	0.002-0.19	0.01-0.06	0.002-0.28	0.002-0.1
Total Pb, mg/l	0.03-0.04	<0.03-0.03	<0.03	<0.03	0.03-0.07	0.03-0.05	<0.03	<0.03	<0.03
Total Hg, mg/l	0.001-0.007	0.001-0.004	0.001-0.005	0.001-0.005	0.001	0.001	0.001-0.04	0.001-0.004	0.001-0.008
Total Cr, mg/l	0.02-0.06	0.02-0.04	<0.02	<0.02	0.02-0.1	0.02-0.06	0.02-0.06	<0.02	<0.02
Insecticides	<	<	<	<	<	<	<	<	<
Herbicides	<	<	<	<	<	<	<	<	<

> : exceeds the Class II Guidelines for water quality; < : less than; = : equivalent to; UN : Upper-North; UW : Upper-West; UE : Upper-East; UB : Upper-Bisa; CW : Central Weir;
TD : Temporary Dam

Table 2.6.4 Summary of Wetland Water Quality in May, 1999 (Source: Putrajaya Holdings).

1. Upper-West

Parameter	Unit	Range	Mean	Core Lab S5	Core Lab S6	Class IIB
pH	-	4.8- 6.7	5.9	6.2	5.6	6.5- 9.0
Temp	^{o}C	31.4- 37.0	33.4	-	-	-
TSS	mg/l	12.0- 46.0	22.4	43.0	15.0	50.0
Cond.	µmhos/ cm	44.0- 100.0	68.3	-	-	-
Ammonia	mg/l	0.12- 0.25	0.19	0.3	0.2	0.3
Nitrate	mg/l	0.26- 3.67	1.27	1.9	1.1	-
Phosphorus	mg/l	<0.01	<0.01	0.01	<0.01	-
Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	-
Lead	mg/l	<0.006	<0.006	0.07	<0.03	-
DO	mg/l	3.8- 6.6	5.8	7.3	7.4	4.5- 6.4
COD	mg/l	<1.0- 27.0	<8.4	4.0	2.0	25.0
F.coli	MPN/ 100ml	1000- 5000	2970	300	2	400
BOD	mg/l	<2.0- 2.3	<2.0	<0.8	<0.5	25.0

2. Upper North

Parameter	Unit	Range	Mean	Core Lab S1	Core Lab S2	Core Lab S3	Class IIB
pH	-	5.6-6.5	6.2	7.0	7.4	6.5	6.5- 9.0
Temp	^{o}C	30.4-32.8	31.6	-	-	-	-
TSS	mg/l	7.0-25.0	16.4	6.0	23.0	24.0	50.0
Cond.	µmhos/cm	54.0-86.0	76.5	-	-	-	-
Ammonia	mg/l	0.11-0.76	0.30	0.4	0.3	0.4	0.3
Nitrate	mg/l	0.48-5.10	2.01	2.3	2.2	2.1	0.3
Phosphorus	mg/l	<0.01	<0.01	0.03	<0.01	<0.01	-
Mercury	mg/l	<0.001	<0.001	<0.001	0.002	<0.001	-
Lead	mg/l	<0.006	<0.006	0.03	0.03	<0.03	-
DO	mg/l	4.7-6.1	5.4	7.3	7.2	7.3	4.5- 6.4
COD	mg/l	<1.0-37.0	<11.9	6.0	6.0	24.0	25.0
F.coli	MPN/100ml	1300-45500	13670	5000	700	500	400
BOD	mg/l	<2.0-2.3	<2.1	<0.9	<0.8	<0.3	25.0

3. Upper East

Parameter	Unit	Range	Mean	Core Lab S4	Class IIB
pH	-	5.7- 6.5	6.1	6.0	6.5-9.0
Temp	^{o}C	28.2- 31.2	30.4	-	-
TSS	mg/l	7.0- 16.0	11.8	21.0	50.0
Cond.	µmhos/cm	24.0- 52.0	40.5	-	-
Ammonia	mg/l	0.18- 0.28	0.22	0.1	0.3
Nitrate	mg/l	0.66- 1.57	0.99	1.4	-
Phosphorus	mg/l	<0.01	<0.01	<0.01	-
Mercury	mg/l	<0.001	<0.001	<0.001	-
Lead	mg/l	<0.006	<0.006	<0.03	-
DO	mg/l	5.6- 6.4	5.9	7.2	4.5-6.4
COD	mg/l	6.0- 30.0	18.8	7.0	25.0
F.coli	MPN/100 ml	2900-5900	4750	500	400c
BOD	mg/l	<2.0- 2.2	<2.1	<0.7	25.0

4. Lower East

Parameter	Unit	Range	Mean	Core Lab S7	Class IIB
pH	-	6.1- 6.3	6.2	6.5	6.5-9.0
Temp	^{o}C	29.4- 32.2	31.1	-	-
TSS	mg/l	15.0- 54.0	29.0	14.0	50.0
Cond.	µmhos/cm	98.0- 99.0	98.7	-	-
Ammonia	mg/l	0.24- 0.41	0.31	0.3	0.3
Nitrate	mg/l	0.73- 1.98	1.28	2.0	-
Phosphorus	mg/l	<0.01	<0.01	<0.01	-
Mercury	mg/l	<0.001	<0.001	<0.001	-

Lead	mg/l	<0.006	<0.006	<0.03	-
DO	mg/l	5.1- 6.7	6.1	7.2	4.5-6.4
COD	mg/l	<1.0- 11.0	<7.0	3.0	25.0
F.coli	MPN/ 100ml	500-900	666.7	500	400c
BOD	mg/l	<2.0- 2.0	<2.0	<0.8	25.0

5. Upper Bisa

Parameter	**Unit**	**Range**	**Mean**	**Core Lab S8**	**Class IIB**
pH	-	6.8-7.3	7.1	5.7	6.5-9.0
Temp	^{o}C	30.4-31.3	31.0	-	-
TSS	mg/l	12.0-18.0	14.3	14.0	50.0
Cond.	µmhos/cm	120.0-169.0	148.0	-	-
Ammonia	mg/l	0.12-0.35	0.25	0.3	0.3
Nitrate	mg/l	0.56-2.64	1.77	1.2	-
Phosphorus	mg/l	<0.01	<0.01	0.03	-
Mercury	mg/l	<0.001	<0.001	<0.001	-
Lead	mg/l	<0.006	<0.006	<0.03	-
DO	mg/l	6.0-7.4	6.5	7.0	4.5-6.4
COD	mg/l	<1.0-12.0	<5.7	10.0	25.0
F.coli	MPN/ 100ml	900-5300	3066.7	500	400c
BOD	mg/l	<2.0-2.8	<2.3	<0.5	25.0

6. Central Wetland

Parameter	Unit	Range	Mean	Core Lab S7	Class IIB
pH	-	6.2-6.7	6.6	6.5	6.5-9.0
Temp	^{o}C	30.8-31.9	31.5	-	-
TSS	mg/l	11.0-21.0	17.0	14.0	50.0
Cond.	µmhos/cm	73.0-76.0	75.0	-	-
Ammonia	mg/l	0.09-0.10	0.10	0.3	0.3
Nitrate	mg/l	0.35-3.72	1.21	2.0	-
Phosphorus	mg/l	<0.01	<0.01	<0.001	-
Mercury	mg/l	<0.001	<0.001	<0.03	-
Lead	mg/l	<0.006	<0.006	<0.03	-
DO	mg/l	6.0-6.5	6.3	7.2	4.5-6.4
COD	mg/l	<1.0-11.0	<6.8	3.0	25.0
F.coli	MPN/100ml	100-800	525	3000	400c
BOD	mg/l	<2.0	<2.0	<0.8	25.0

7. Primary Lake

Parameter	Unit	Range	Mean	Core Lab S7	Class IIB
pH	-	6.6-7.2	7.0	6.5	6.5-9.0
Temp	^{o}C	30.9-31.9	31.4	-	-
TSS	mg/l	7.0-18.0	13.3	14.0	50.0
Cond.	µmhos/cm	82.0-115.0	99.3	-	-
Ammonia	mg/l	0.07-0.16	0.11	0.3	0.3
Nitrate	mg/l	0.42-0.73	0.58	2.0	-
Phosphorus	mg/l	<0.01	<0.01	<0.001	-
Mercury	mg/l	<0.001	<0.001	<0.001	-
Lead	mg/l	<0.006	<0.006	<0.03	-
DO	mg/l	6.1-7.4	6.7	7.2	4.5-6.4
COD	mg/l	<1.0-16.0	<4.8	3.0	25.0
F.coli	MPN/100ml	800-3700	1900	3000	400c
BOD	mg/l	<2.0	<2.0	<0.8	25.0

Table 2.6.5 Putrajaya Ambient Lake Water Quality

Lake Water Quality Parameter	Unit	Putrajaya Ambient Lake Water Quality Standards
Aluminium	mg/l	<0.05 if pH<6.5* <0.1 if pH>6.5
Ammoniacal Nitrogen	mg/l	0.3
Ammonia	mg/l	0.02-0.03
Arsenic	mg/l	0.05
Antimony	mg/l	0.03
Barium	mg/l	1
Beryllium	mg/l	0.004
Boron	mg/l	1
Cadmium	mg/l	0.002
Free Chlorine (revised)	**mg/l**	**0.02***
Chromium, Total	mg/l	0.05
Copper	mg/l	0.02
Cyanide	mg/l	0.02
Flourine	mg/l	1.5
Iron	mg/l	1
Lead	mg/l	0.05
Manganese	mg/l	0.1
Mercury	mg/l	0.0001
Nickel	mg/l	0.02
Nitrate (NO3-N)	mg/l	7
Nitrite (NO2-N)	mg/l	0.04
Total Phosphorus	mg/l	0.05*
Silica	mg/l	50
Selenium	mg/l	0.01
Silver	mg/l	0.05
Sulphur	mg/l	0.05
Sulphate	mg/l	250
Zinc	mg/l	5
BOD	mg/l	3
COD	mg/l	25
Colour	TUC	150
Conductivity	uS/cm	1000
Salinity	ppt	1
Total suspended solids	mg/l	50
Turbidity	NTU	50
Transparency (Secchi)	m	0.6*
Hardness	mg/l	250
Taste		No Objectionable Taste
Dissolved Oxygen	mg/l	5 – 7

Lake Water Quality Parameter	**Unit**	**Putrajaya Ambient Lake Water Quality Standards**
Odour		No Objectionable Odour
pH		6.5 - 9.0
Temperature	^{o}C	Normal±2
Oil & Grease	mg/l	1.5
Chlorophyll a	ug/l	0.7*
Floatables		No Visible Floatables
Microbiological Constituents		
Feacal coliform (clarification)	**counts/100 ml**	**100*** **
Total coliform	counts/100ml	5000
Salmonella	counts/l	0
Enteroviruses	PFU/l	0
Radioactivity		
Gross-alpha	Bq/l	0.1
Gross-Beta	Bq/l	1
Radium-226	Bq/l	<0.1
Strontium-90	Bq/l	<1
Organics		
Carbon Chloroform extract	ug/l	500
MBAS/BAS	ug/l	500
Oil & Grease (mineral)	ug/l	40;NF
Oil & Grease (emulsified edible)	ug/l	7000;NF
PCB	ug/l	0.1
Phenol	ug/l	10
Aldrin/Dieldrin	ug/l	0.02
BHC	ug/l	2
Chlordane	ug/l	0.08
t-DDT	ug/l	0.1
Endosulfan	ug/l	10
Heptachlor/Epoxide	ug/l	0.05
Lindane	ug/l	2
2,4-D	ug/l	70
2,4,5-T	ug/l	10
2,4,5-TP	ug/l	4
Paraquat	ug/l	10

* - addition to Class II

** - 24 hour average (based on Class III)

*** - geometric mean of minimum of 5 samples in a 30-day period

2.6.2.2 Study Data

(1) For the calibration of the water quality in this study, monitoring of the inflow water quality and the water quality has been carried out by UPM.

(2) There are three different monitoring data targets. One set of data is for model calibration purpose The monitored data are shown in Appendix 2.1. The monitored water quality is at the top and the last cell of each wetlands for this purpose.

(3) The second target of the data collection is the water quality at each cell of the wetland to assess each cell removal efficiency (see Appendix 2.2).

(4) The third data target is the water quality in stream flows in UPM and MARDI under heavy pollutant load (see Appendix 2.3). Upper Bisa Wetland was not monitored as it was still under construction at the time of water quality monitoring by the UPM team.

(5) The pattern of the monitored water quality between the top cell and last cell of each wetlands is not simple; the parameter value can be reduced or increased. This effect may be due to the effect of lateral inflow from runoff or the resuspension of sediment-attached pollutants.

(6) The water quality along the wetlands fluctuates between cells. It could be reduced or increased from the previous cell. Similarly, as was discussed for the data in Table 2.6.6, this effect could be due to lateral inflow of runoff or resuspension of sediment-attached pollutants in the cells.

(7) Along the reed-lined streams in UPM and MARDI, removal of Total Phosphorus does occur with distance. This removal is primarily of the reactive dissolved phosphorus form, not the particulate. For other parameters the pattern is not distinct with some parameters showing increase and decrease along the distance. Again this may be due to lateral inputs from runoff. Turbidity in both cases reduce substantially, thus pollutant inflow must be of aqueous source such as interflow or surface runoff.

(8) From the monitored data in Appendix 2.1, the range of water quality at the dam can be summarised as in Table 2.6.6.

Table 2.6.6 Range of Water Quality at the Dam

	Range at the Dam, mg/l
DO	2.8- 4.0
BOD	0.11- 1.89
NO3	0.5- 2.9
TP	0.04- 0.57
Turbidity, NTU	2.0- 26.68
Ecoli, count/100ml	0- 4000
Tcoli, count/100ml	0- 5000

2.6.3 Water Quality Modelling

Water quality modelling is conducted for the Putrajaya Lake System. The software programme , MIKE 11 is used to assess the water quality for the proposed and likely future land-use scenarios in the catchment and the hydrological regimes arising from them.

2.6.3.1 Review of Previous Model

(1) Water quality modelling had been conducted in the previous studies by Perunding Kota Bistari in its Water Quality Control and Management Study on Putrajaya Lake Development (1996) and Angkasa GHD Engineers in its Putrajaya Lake Phase 1 Concept Design Report Wetland Component (1996). The two studies used slightly different data and information. The data presented here are from their study reports.

A. Water Quality Control and Management Study (Perunding Kota Bistari, 1996)

(2) In this report, Minconsult/HGM had set up a simple water quality model to estimate the equilibrium concentrations of suspended solids, nutrients and BOD/COD in the lake

on the basis of the estimated mean annual flow rates from each sub-catchment and the design input pollutant concentrations as shown in Table 2.6.7 and Table 2.6.9. The data given in Table 2.6.7 differs from that in another section of the report on existing river flow as shown in Table 2.6.8.

Table 2.6.7 Mean Annual flow rates from Contributing Sub-catchments (from Table 4.1, Perunding Kota Bistari)

Sub-catchment	Upper-west	Upper-north	Upper-east	Upper-Bisa	Lower-east	Central	Lower Chuau	Total
Net Area, km^2	6.2	12.4	4.2	4.0	1.7	5.5	10.0	44.0
Mean Annual Inflow, m^3/s	0.33	0.67	0.23	0.22	0.09	0.30	0.54	2.38

Table 2.6.8 Mean Annual flow rates from Contributing Sub-catchments (from Table 3.6, Perunding Kota Bistari)

Sub-catchment	Upper-west	Upper-north	Upper-east	Upper-Bisa	Lower-east	Central	Lower Chuau	Total
Net Area, km^2	6.2	12.4	4.2	5.9	-	7.1	14.7	50.5
Total Annual Inflow, m^3/s	0.16	0.33	0.11	0.16	-	0.19	0.39	1.33

Table 2.6.9 Modelled Pollutant Input Concentrations

	Design input concentrations from direct drainage, mg/l	Assumed pollutant removal efficiency in Primary Wetlands	Design input concentrations via Primary Wetlands, mg/l
TSS	150	90%	15
Total phosphorus	0.5	60%	0.2
Total nitrogen	0.5	90%	0.05
BOD	10.0	90%	1.0
COD	50	90%	5.0

(3) In the model, the water quality of Putrajaya Lake had been estimated by assuming the lake was a well mixed system with constituent concentrations approximately uniform within the lake but subject to first-order decay.

(4) The modelled equilibrium concentrations of total suspended solids, nutrients and BOD/COD in the lake are presented in Table 2.6.10.

The report concluded that an inflow phosphorus concentration of 0.1 mg/l would be the acceptable upper limit of mean TP concentration in the catchment.

Table 2.6.10 Equilibrium Contaminant Concentrations in the Putrajaya Lake

Contaminant	Equilibrium concentration, mg/l
TSS	16
Total nitrogen	0.14
Total phosphorus	0.20
BOD	0.8
COD	5.6

B. Putrajaya Lake Phase 1 Concept Design Report Wetland Component (Angkasa GHD Engineers, 1996)

(5) The AQUALM model was chosen to model water quality in the wetlands and the primary lake. AQUALM is an integrated rainfall runoff and water quality model which simulates long term pollutant export and retention using a daily time step. The model requires rainfall, evaporation and catchment data as well as estimates of export rates from various land use types. The pollutant selected for the analysis were total phosphorus, total nitrogen and suspended solids.

(6) The model uses pollutant retention curves (based on hydraulic residence time) to estimate daily pollutant removal rates. Eutrophication potential is assessed using Vollenweider analysis - assuming phosphorus is the limiting nutrient. The values of bio-available phosphorus was taken to be 0.3 for urban areas, 0.1 for rural areas and 0.9 for sewage sources for this study's model.

(7) The pollutant retention curves were derived from data sourced from Canberra (Australia) wetlands. It was considered that adoption of these curves would be a conservative approach to estimating pollutant retention capabilities of the Putrajaya Wetlands because of increased macrophyte cover and increased flood retention storage.

(8) Initial model parameters of water balance were based on calibration of two urban catchments in Brisbane (Australia), later modified to reflect the runoff volumes estimated by DID.

(9) The loading rates for pollutant export loads adopted for established urban conditions were based on calibrated loads from two established urban catchments located in Brisbane, Australia.

(10) To simplify the model, cells for each wetlands were modeled as a single cell by referencing each cell's storage and area values to the cell's normal water level.

(11) The model scheme used is shown in Figure 2.6.3 and the total phosphorus loads with and without catchment treatment as shown in Figure 2.6.4 to Figure 2.6.5.

(12) The Vollenweider analysis showed that the maximum tolerable average loading rates is approximately 4 $gP/m^2/y$.The maximum desirable loading rate is approximately 1.5 g $P/m^2/y$. Only the Phase 1 lake (to the temporary dam) is less than this value.

(13) All wetlands reduced phosphorus concentration by about 70% except for the Bisa wetland which was modeled as a sedimentation system rather than as a macrophyte system.

(14) This analysis showed that under normal urban loadings, the target 0.05 mg/l phosphorus influent concentration into the Primary Lake is not achieved. The calculated influent concentration was 0.13 mg/l.This implies that average influent concentration into the wetlands must be reduced from 0.4 mg/l to 0.15 mg/l. Likewise runoff concentrations from non-treated areas must be of the same quality.

(15) Modelling was only carried out for Phase 1A of the Lake. Most of the inputs into Phase 2 of the Lake would not be treated by wetlands. Based on this Angkasa-GHD concluded that the maximum permissible average concentration would likely be lower than 0.15 mg/l and may possibly be about 0.1 mg/l. This concurs with the Kota Bistari model report.

(16) **This implies that influent entering through the wetlands should be of at most 0.15 mg/l of Total Phosphorus but that the influent entering directly into the Lake, from within Putrajaya and Cyberjaya, must be lower than 0.15 mg/l of Total Phosphorus.**

2.6.3.2 MIKE 11 Software

(1) MIKE 11 is a professional engineering software package for the simulation of flows, water quality and sediment transport in estuaries, rivers, irrigation systems, channels and other water bodies. It is a dynamic, one-dimensional modelling tool for the

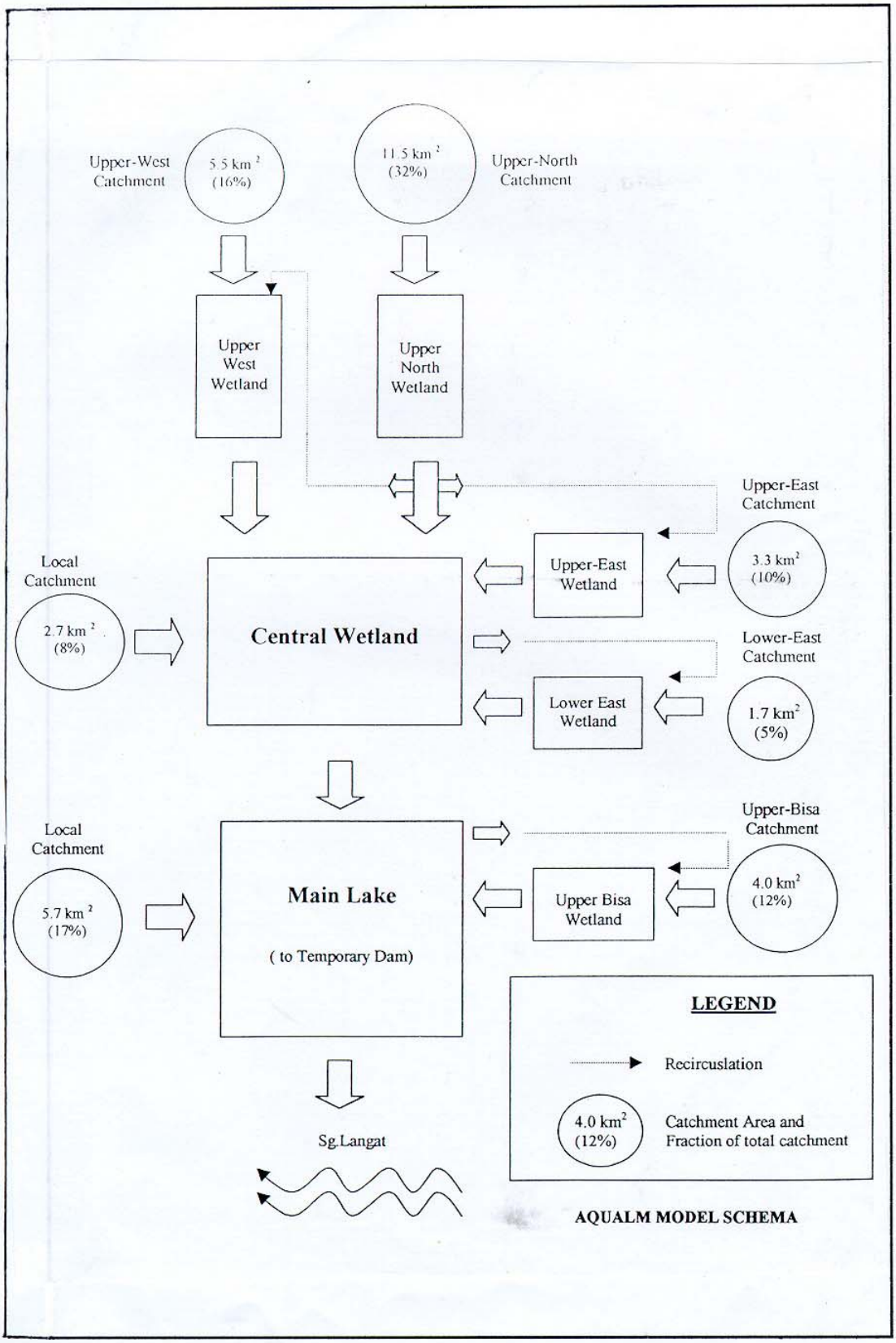


Figure 2.6.3: AQUALM Model Scheme

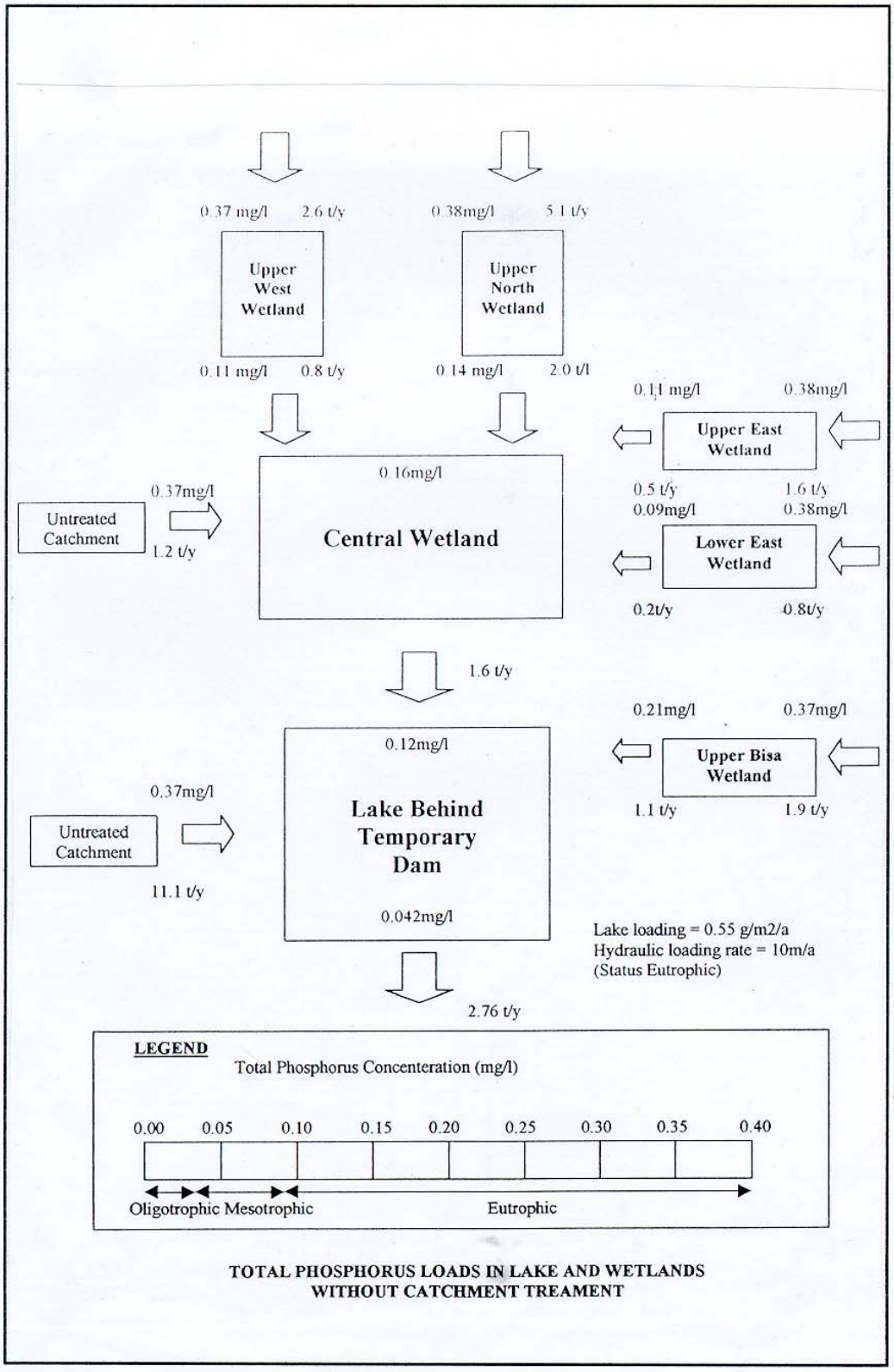


Figure 2.6.4: AQUALM Model Scheme - Total Phosphorus Loading in Lake and Wetlands Without Catchment Treatment

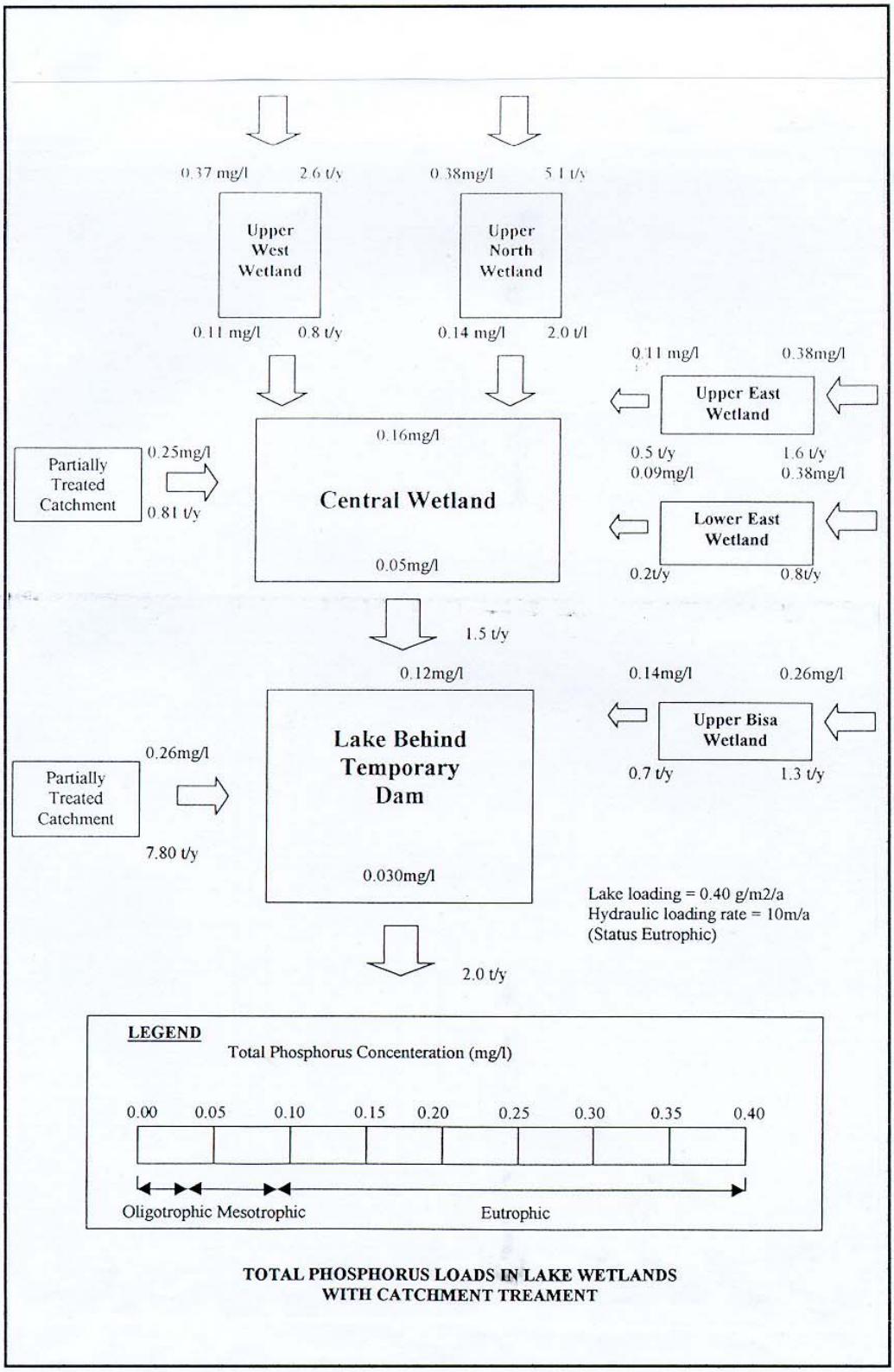


Figure 2.6.5: AQUALM Model Scheme - Total Phosphorus Loading in Lake and Wetlands With Catchment Treatment

design, management and operation of river and channel systems.

(2) The Hydrodynamics (HD), Advection-Dispersion (AD) and the Water Quality (WQ) modules were applied for assessment of the water quality in the Lake system.

(a) Hydrodynamic Module (HD)

(3) The HD module contains an implicit, finite difference computation of unsteady flows in rivers and estuaries. The formulations can be applied to branched and looped networks.

(4) The computational scheme is applicable to vertically homogeneous flow conditions ranging from steep river flows to tidally influenced estuaries. Both subcritical and supercritical flow can be described by means of a numerical scheme which adapts according to the local flow conditions.

(5) The complete non-linear equations of open channel flow (Saint Venant) can be solved numerically between all grid points at specified time intervals for given boundary conditions.

(6) Within the standard HD module advanced computational formulations enable flow over a variety of structures to be simulated :

- Broadcrested weirs
- culverts
- user-defined structures

(7) The HD module essentially calculates the hydraulic flow through the cross-sections and under the controls defined by the user.

(b) Advection Dispersion Module (AD)

(8) This module describes the flow of a mass through the hydraulic system predicted by the HD module. The AD module is based on the one-dimensional equation of conservation of mass of a dissolved or suspended material (eg salt or cohesive sediments). The behaviour of

conservative materials which decay linearly can be simulated. The module requires output from the hydrodynamic module, in space and time, of discharge and water level, cross-sectional area and hydraulic radius.

(9) The advection-dispersion equation is solved numerically using an implicit finite difference scheme which has negligible numerical dispersion. Concentration profiles with very steep fronts can be simulated accurately.

(c) Water Quality Module (WQ)

(10) A water quality module is coupled to the AD module and simulates the reaction processes of multi-compound systems including the degradation of organic matter, the photosynthesis and respiration of plants, nitrification and the exchange of oxygen with the atmosphere.

(11) The mass balance for the parameters involved are calculated for all grid points at all time steps using a rational extrapolation method in an integrated two-step procedure with the AD module.

(12) Using the MIKE 11 simulation, the variation and longitudinal profile of the mean water quality concentration at selected sections for the given hydrological regimes will be assessed for the study of the Catchment Development and Management Plan for Putrajaya Lake.

(13) The state variables that are used for the modelling include: Dissolved Oxygen, Temperature, Ammonia, Nitrate, BOD, Dissolved Phosphorus, Particulate Phosphorus. The processes involved Degradation of Organic Matter, Oxygen Processes, Temperature, Nitrification, Denitrification, Bottom/Sediment, Phosphorus Processes in the Water Pase, Phosphorus Pocesses at the Bttom, Ntrient Utake by Pants and Agae.

(14) The model is very applicable to general studies of effects of discharges of municipal and agricultural run-off.

2.6.3.3 Model Physical Setup

Information for the model programme was obtained from secondary data as provided by other consultants and Perbadanan Putrajaya**.**

1. The river networks, the longitudinal section, cross sections and the weir geometry were taken from the Putrajaya as-built plan and the Bulk Earthworks and Drainage plan.

2. Water quality data on each cell of the wetlands was provided by Putrajaya Holdings for preliminary assessment. The monthly sampling records were from May 1997 to May 1999. Time series data collection was carried out by Universiti Putra Malaysia. Some variations in phosphorus values were apparent and the use of the Putrajaya Holdings data is discontinued until an intercomparison of the data set is carried out.

(a) Model Setup

(1) The Putrajaya Wetlands and Lake Networks was setup with the data linking the Upper West wetland, Upper North wetland, Upper East wetland, Lower East wetland, Upper Bisa wetland, the Central wetland, the primary Lake and the looped secondary Lake as shown in Figure 2.6.6. The hydrological inputs are as explained in the Hydrological section.

(2) The whole network utilised the design normal water levels as determined by the weir's crest and the dam spillway level as shown in Table 2.6.11. The average volume of each wetlands at their normal water levels as compared to the survey volume in the as-built plan are in Table 2.6.12.

(3) The pollutant inputs into the networks will be subjected to the model's Water Quality processes as stated above. The water quality model requires input of a number of physical and biological parameters with temperature coefficient.

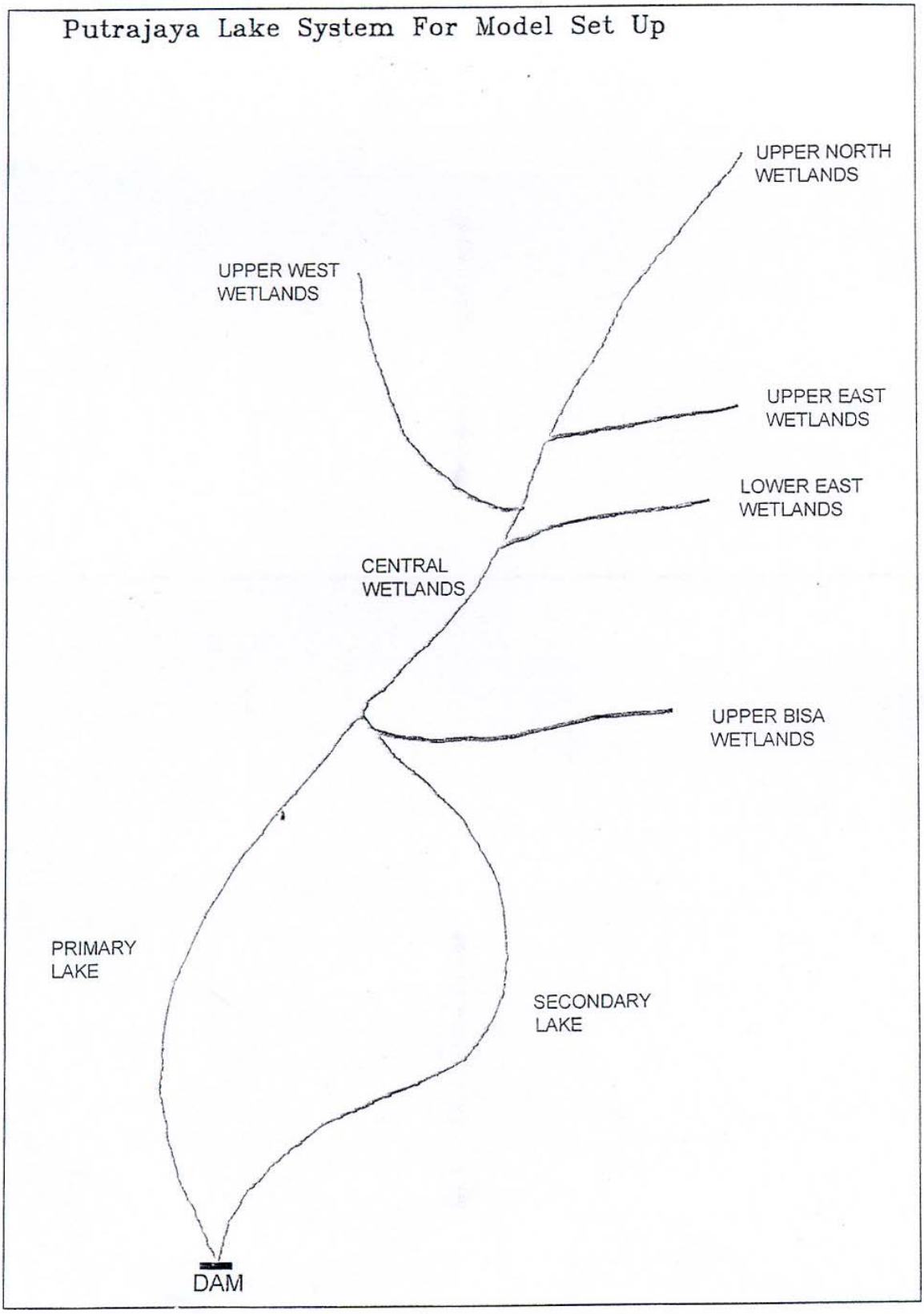


Figure 2.6.6 Putrajaya Wetlands and Lake Network

(b) Calibration

(1) For the calibration of the model, it is important that data on the time series of the observed water quality parameters be obtained. Thus, monitoring of the inflow water quality and the water quality at selected stations over a time period is being carried out by UPM to be used to calibrate the performance of the wetlands and lake.

Table 2.6.11 Location of Weirs in each Wetland Cells and its Normal Water Leval (NWL).

Cell No.		8	7	6	5	4	3	2	1
UW	Dis,m		612	790	1150	1340	1587	1960	2300
	NWL, m		29.0	28.5	27.75	27.0	26.0	25.25	24.5
UN	Dis,m	400	720	1520	1795	2110	2415	2745	3260
	NWL, m	30.0	29.0	28.0	27.5	26.75	26.0	25.0	24.5
UE	Dis,m						230	458	853
	NWL, m						30.0	29.0	28.5
LE	Dis,m							680	1355
	NWL, m							30.0	27.0
UB	Dis,m							1100	1947
	NWL, m							30.0	24.5
CW	Dis,m								1040
	NWL, m								23.5

Table 2.6.12 Average Model Volume as Compared to the Survey Volume in the As-built Plan

Wetland	Survey Volume (ML)	Model Volume (ML)	% Difference
Upper North	193.0	243.0*	+0.25
Upper West**	187.5	185.0	-1.3
Upper East	142.0	156.0	+9.8
Lower East	202.5	185.0	-8.6
Upper Bisa	628.0	625.0	-0.5
Central Wetland	1250.0	1115.8	-10.7

* including the whole UN6, UN7 and UN8
** excluding UW8

(2) For assessment of the water quality, the following assumptions have been made in this study.

a) the MIKE 11 computes flow condition as vertically homogeneous, the water quality parameters are fully mixed in the water column at each cross-sections.
b) the water processes take into account the immediate oxygen demand due to degradation of the dissolved and suspended organic matter. It implies that the reaction is immediate for oxygen uptake.
c) the water processes described above are the major controlling factors for water quality.
d) the simulation utilises an unsteady state to study the dynamic effects of the water quality aspects, neglecting the long term phenomena such as the retention of nutrients in the river system.

2.6.3.4 Model Water Quality Processes

(1) Preliminary runs (Appendix 2.4) of the Water Quality processes involve the following WQ parameters with their default global values:

(a) Oxygen processes

No. of reaeration expression	3
Reaeration temperature coefficient	1.024
Respiration of animals and plants at 20 deg.	3.000
Respiration temperature coefficient	1.047
Max. Oxygen production by photosynthesis	3.500
Displacement of oxygen production maximum	1.000

(b) Temperature

Latitude	3.000
Maximum absorbed solar radiation (kJ/m2/hour)	520.000
Displacement of solar radiation max from 12 pm	1.000
Emitted heat radiation (kJ/m2/hour)	67.000

(c) Denitrification

Reaction order	1st
Nitrate decay at 20 deg. C	1.000
Temperature coefficient for decay rate	1.160

(d) Nitrification

Reaction order	1st
Ammonium decay rate at 20 deg. C	1.540
Temperature coefficient of decay rate	1.130
Oxygen demand by nitrification	4.470

(e) Nitrogen contents

Ratio of ammonium released at BOD decay	0.290
Uptake of ammonium in plants	0.066
Uptake of ammonium in bacteria	0.109

(f) Degradation

1^{st} order decay rate at 20 deg. C	0.500
Temperature coefficient for decay rate	1.024
Half-saturation oxygen concentration	2.000

(g) Bed/ sediment

Sediment oxygen demand at 20 deg. C	0.500
Temperature coeff for sediment oxygen demand	1.000
Resuspension of organic matter	0.500
Sedimentation rate for organic matter	0.800
Critical flow velocity (net sed. = 0)	1.000

(h) Phosphorus contents

Ratio of P released at BOD decay	0.009
Uptake of P in plants	0.009

(i) Phosphorus exchange with the bed

Resuspension of particulate phosphorus	0.500
Deposition of particulate phosphorus	0.800
Critical velocity of flow (susp. = dep.)	1.000

(j) Phosphorus processes

Decay constant for particulate phosphorus	0.100
Temperature coeff for decay	1.000
Formation constant for particulate phosphorus	0.100
Temperature coeff for formation	1.000

(k) Coliforms

1st order decay faecal	0.700
1st order decay total	0.800
Temperature coeff for decay rate	1.090
Salinity coeff for decay rate	1.006
Light coeff of decay rate	7.400
Light coefficient	1.400
Salinity	0.000

2.6.3.5 Model Calibration

(1) The model was calibrated to the study data monitored by UPM together with the other water quality data collected. The model WQ parameters were determined by several iteration runs for this calibration process.

(a) Oxygen process

No. Of reaeration expression	1
Reaeration temperature coefficient	1.000
Respiration of animals and plants at 20 deg.	2.000
Respiration temperature coefficient	1.024
Max. Oxygen production by photosynthesis	1.000
Displacement of oxygen production maximum	0.000

(b) Temperature

Latitude	0.000
Maximum absorbed solar radiation (kJ/m2/hour)	0.000
Displacement of solar radiation max from 12 pm	0.000
Emitted heat radiation (kJ/m2/hour)	0.000

(c) Denitrification

Reaction order	1st
Nitrate decay at 20 deg. C	1.000
Temperature coefficient for decay rate	0.500

(d) Nitrification

Reaction order	1st
Ammonium decay rate at 20 deg. C	1.540
Temperature coefficient of decay rate	0.500
Oxygen demand by nitrification	4.470

(e) Nitrogen contents

Ratio of ammonium released at BOD decay	0.350
Uptake of ammonium in plants	0.066
Uptake of ammonium in bacteria	0.109

(f) Degradation

1st order decay rate at 20 deg. C, kBOD	0.100
Temperature coefficient for decay rate	1.000
Half-saturation oxygen concentration	4.000

At the following locations global values are substituted:

UW : kBOD=0.15
UN : kBOD=0.07
LE : kBOD=0.05
UE : kBOD=0.30

(g) Bed/ sediment

Sediment oxygen demand at 20 deg. C	0.500
Temperature coeff for sediment oxygen demand	1.100
Resuspension of organic matter	1.000
Sedimentation rate for organic matter	0.300
Critical flow velocity (net sed. = 0)	0.800

(h) Phosphorus exchange with the bed

Resuspension of particulate phosphorus	0.500
Deposition of particulate phosphorus	0.800
Critical velocity of flow (susp. = dep.)	0.800

At the following locations global values are substituted:

MAIN_LAKE : Critical flow=1.5
SIDE_LAKE : Critical flow=1.0
UN : Resuspension=0.55
UW : Resuspension=0.55
UE : Resuspension=0.57
LE : Resuspension=0.65

(i) Coliforms

1st order decay faecal	0.700
1st order decay total	0.800
Temperature coeff for decay rate	1.000
Salinity coeff for decay rate	1.006
Light coeff of decay rate	7.400
Light coefficient	3.000
Salinity	0.000

(2) The calibration used existing water quality parameters in the stream flow and runoff to the wetlands and lake as pollutant inputs as shown in Table 2.6.13. A normal year runoff in 1984 with an annual rainfall of 2153mm was used as the hydraulic inflow. The initial condition of the model, which is unstable, will not be taken into account.

Table 2.6.13 Water Quality for Stream Flow and Runoff for the Model Simulation

Parameter	**Stream flow**	**Runoff**
DO, mg/l	5.0	5.0
Temperature, ^{o}C	29	29
NH3, mg/l	1.0	0.3
NO, mg/l	1.0	1.0
BOD, mg/l	5.0 (for UW=3.0)	3.0
Dis.P, mg/l	0.3	0.1
Par.P, mg/l	0.4	0.1
F.coli, mil/100ml	0.008	0.001
T.coli, mil/100ml	0.015	0.005

(3) The simulated results in each wetlands, top and the last cell, and at the Primary Lake are as shown in the figures of 1984-run Time Series of Concentrations (see Appendix 2.5).

(4) The simulated results in each wetlands are consistent of the monitored data; reflecting the effect of runoff and the current state of wetlands. There is little degradation or removal of nutrients between the top and the last cell of each wetland.

(5) At the Primary Lake, from the 1984-run Time Series of Concentrations for Primary Lake, the nitrate is at the range of 0.85 to 0.95 mg/l as compared to the monitored values in Appendix 2.2 which is from 0.5 to 2.9 mg/l.. The values shown are for the Primary Lake at 1500 m, which is near to the site of the present Temporary Dam.

(6) For the BOD at the Primary Lake, the values are from 0.05 to 0.8 mg/l, as compared to the monitored values in Appendix 2.2 which is from 0.11 to 1.89 mg/l.

(1) For Total Phosphorus at the Primary Lake, the values of Dissolved Phosphorus and Particulate Phosphorus are from 0.01 to 0.10 mg/l and 0.01 to 0.04 mg/l as compared to the monitored values in Table 2.6.6 which is from 0.01 to 0.27 mg/l and 0.01 to 0.56 mg/l.

2.6.3.5 Model Scenarios

(1) Two scenarios are modelled. The first utilised existing top inflow pollutant concentration and estimated lateral inflow concentrations. Three hydrological conditions were used: normal, wet and dry hydrological years. The wet year of 1993 with an annual rainfall of 2730 mm and the dry year of 1988 with an annual rainfall of 1591 mm were used as hydraulic inputs (Table 2.6.13). The normal hydrological year is used for the calibration run. From the results of the first scenario, a second scenario was modelled. This used reduced phosphorus top inflow concentrations, but the same estimated lateral inflow concentrations. This second scenario will indicate the effect of water quality of the upper streams compared to the effect of lateral inputs from runoff and drains.

(2) The simulated results are as shown in Appendix 2.6 and Appendix 2.7, the 1993-run Time Series of Concentration and the 1988-run Time Series of Concentration. The water quality at the Primary Lake between the three scenarios are as shown in Table 2.6.14.

Table 2.6.14 Water Quality at the Primary Lake for the Model

	Wet Year	**Normal Year**	**Dry Year**	**Putrajaya Ambient Water Quality**
Nitrate, mg/l	0.9- 1.0	0.85- 0.95	0.86-0.92	7.0
BOD, mg/l	0.1- 1.6	0.05- 0.8	0.05-0.6	3.0
Dis.Phosphorus, mg/l	0.03-0.07	0.01- 0.10	0.01- 0.10	Total Phosphorus = 0.05
Par.Phosphorus, mg/l	0.01- 0.04	0.01- 0.04	0 - 0.04	
F. coli, c/100ml	0 - 200	0 – 100	0 - 100	100
Total coli, c/100ml	0 - 1000	0 - 300	0 - 200	5000

2.6.4 MODEL RESULT AND DISCUSSION

2.6.4.1 In Scenario 1, nitrate and BOD concentrations are below the Putrajaya Ambient Water Quality under the three conditions using the water quality concentrations assumed. BOD increases due to the higher hydraulic loading during the wet year as compared to the dry year. For Total Phosphorus, the values are at the Ambient Water Quality of 0.05 mg/l or higher for the three scenarios. Therefore, phosphorus will appear to be the factor that will affect the lake water quality under the current loading conditions.

2.6.4.2 In Scenario 2, despite the reduced Phosphorus loading from incoming streams, the values of Phosphorus in the Lake showed little discernable change. This indicates that the unchanged lateral inflows play an important role in controlling the Lake water quality.

2.6.4.3 Based on the model results for the wet, dry and normal year in Table 3.2.17, nitrate and BOD meet the Putrajaya Ambient Water Quality under these three conditions with existing water quality. BOD increases with hydraulic loading during the wet year as compare to the dry year.

2.6.4.4 For Total Phosphorus, the values are at the Ambient Water Quality of 0.05 mg/l or higher for the three scenarios. Phosphorus will appear to be the factor that will affect the lake water quality under existing condition.

2.6.4.5 The present concentration of Total Phosphorus of 0.7 mg/l, into the inflow waters of the wetlands at the upper portion, is unable to be reduced for input to the Primary Lake system. This is because present wetland removal, overall, does not appear to be occurring. There is little change, indicating degradation or removal, of nutrient concentration between the top and the last cell of each wetland series. This contrasts with the previous AQUALM model results obtained in the Putrajaya Lake Phase 1 where removal efficiencies of 20%-80% for phosphorus were expected.

2.6.4.6 The causes of the dissimilarity between the AQUALM model and the MIKE11 model is at yet uncertain. Several factors are different between the models:

(a) tr.eatment of wetland cells as a single entity rather than separate cells,
(b) no lateral inflow to the wetlands,
(c) calibration to Australian conditions instead of actual existing conditions.

2.6.4.7 The advantage of this study is the ability to use the present monitoring data to calibrate the model. The previous AQUALM model could only be calibrated on speculation of removal efficiencies.

2.6.4.8 The efficiency of each cell is not calculated due to the variable pattern of parameter concentration in each wetland cell as indicated in the UPM monitoring of each wetland cell.

2.6.5 Recommendation

2.6.5.1 The lateral inflow of runoff to the wetlands and lake affects the water quality greatly. It could be the reason why there is little degradation or removal of nutrients between the top and the last cell of each wetlands. There should be continuous water quality monitoring as recommended in the Lake Management Guidelines.

2.6.5.2 **The construction activities at the surrounding areas may contribute adversely to the water quality in the lake and careful control of such activities is vital in the immediate term.**

2.6.5.3 **To reduce non-point source pollutant inflow, particularly of nutrients and agricides, it is recommended that riparian buffer zones, on both sides of the drainage lines and water bodies, be built. This is to trap and reduce the sediment and other pollutants in the surface runoff, and interflow, from entering the water system.**

2.7 THE WETLANDS

2.7.1 Wetland Ecological Status

2.7.1.1 The Lake and Wetland System

(a) The Putrajaya Lake System

(1) The Putrajaya Lake system comprises of the primary Putrajaya Lake and six artificial wetlands as shown in Figure 2.7.1. The six artificial wetlands are the Upper West (8 cells), Upper East (3 cells), Upper North (8 cells), Lower East (2 cells), Central (1 cell) and the Upper Bisa (2 cells) Wetlands. The wetlands have been designed as a measure to improve the runoff and enhance the water quality in the Lake and as another natural landscape feature of the "Garden-in-a-city concept" of Putrajaya. They

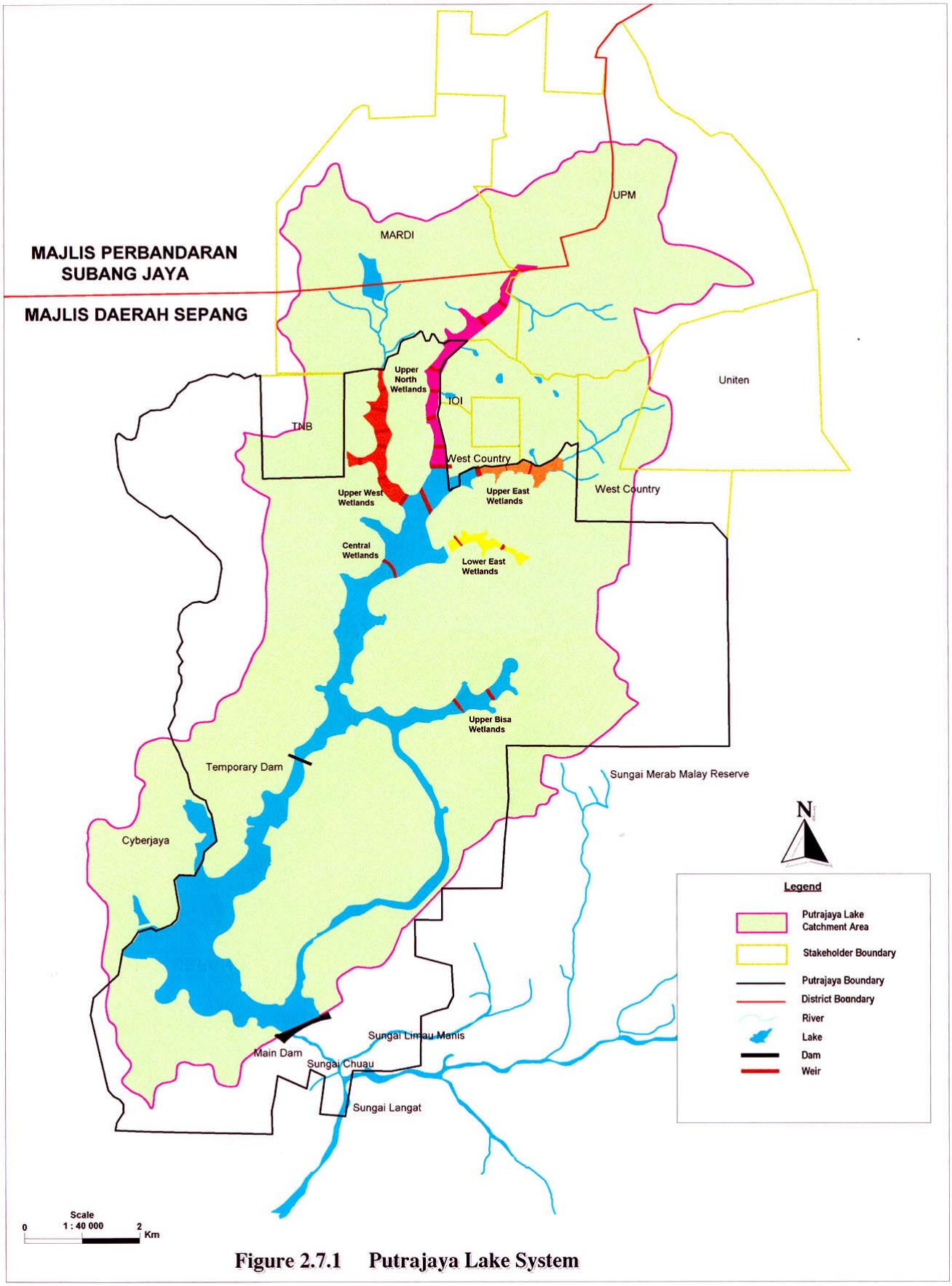


Figure 2.7.1 Putrajaya Lake System

have been designed as secondary measures for the reduction of runoff pollutants into the Lake. The primary measure is through implementation of appropriate land-use control and innovative drainage design in the catchment.

(2) Figure 2.7.2 shows the typical cross-sections of two tropical wetlands of different widths. The forests and shrubs are located along the intermittent flooding zones of the banks of the wetlands whereas the macrophytes of the marshlands are contained within the litoral zones. A total of about 6 million indigenous plants, shrubs, palms, ferns and trees, taken from more than 70 wetland sites around the country, are being used to create the marshlands and "forests" along the intermittent flooding zones of the banks of the wetlands and the primary Putrajaya Lake.

(b) Wetland Plant Nutrient Uptake

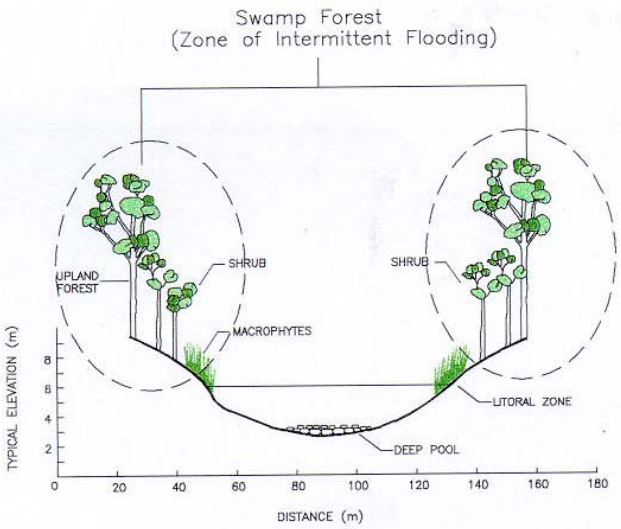
(1) There has been no comprehensive study to date on the rate at which the nutrients are absorbed in the plant cells of individual species. Thus it is difficult to assess individual wetland species of each wetland cell as regards to their role in improving the lake water quality. Nevertheless, some information is available about the main wetland species that were planted in all wetland cells throughout the wetland system. They are as follows:

- *Lepironia articulata* holds high biomass, 2 kg dry wt./m^2, implying high nutrient sink and microbial carrying capacity.

- *Eleocharis* sp. holds high biomass varying 1.5 and 2.5 kg dry wt./m^2, holds high nutrient uptake capacity and can withstand high fluctuation in flow rates.

- *Phragmites karka* holds high nutrient uptake capacity and provides refuge for fish and other invertebrates. Withstand high fluctuation in flow rates, turbidity and nutrient loadings.

- *Scleria* sp. has low foliage, holds high nutrient uptake capacity and provides refuge for fish and other invertebrates. Withstands high fluctuation in flow rates, turbidity and nutrient loading.



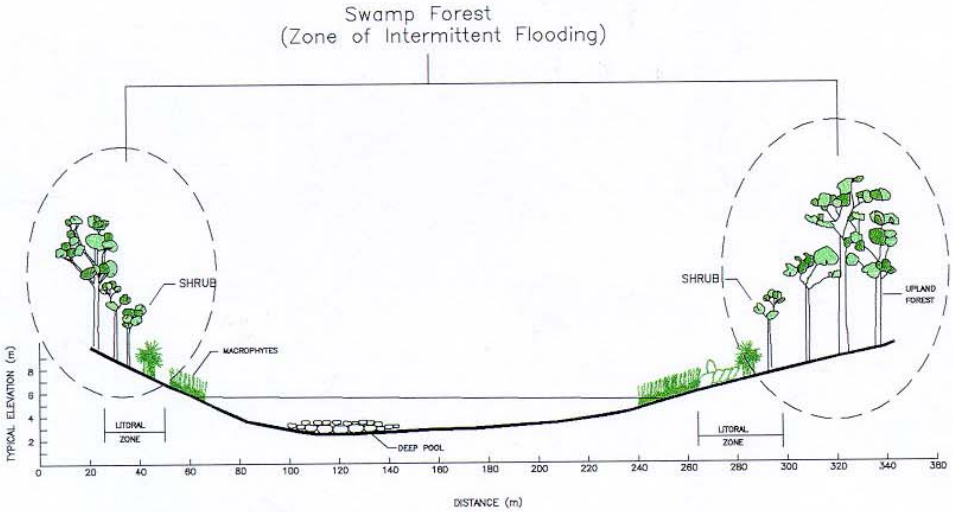


Figure 2.7.2 Typical Cross-section of a wetland

(2) Some information on nutrient uptake by temperate species grass crops are also available (Table 2.7.1) based on fertilizer requirements. The information indicates that selection of species can have different implications for nutrient uptake.

(3) From the field study it was found that planting in the Upper North, Upper West, Upper East and Lower East Wetlands have been completed while those for the other wetlands are still in progress. Terrestrial plants have also been planted in the intermittent flooding zone of the banks of the Upper North, Upper West, Upper East, and Lower East Wetlands, whereas, the zones along the banks of the Central and Upper Bisa Wetlands, and the primary Lake will be developed into swamp forest to provide habitats for a variety of fauna.

Table 2.7.1 Nutrient uptake rates for selected crops

Crop	Nutrient Uptake lb/acre.yr		
	Nitrogen	Phosphorus	Potassium
Forage Crops			
Alfalfa	200-480	20-30	155-200
Broome grass	116-200	35-50	220
Coastal Bermuda grass	350-600	30-40	200
Kentucky bluegrass	180-240	40	180
Quack grass	210-250	27-41	245
Reed canary grass	300-400	36-40	280
Rye grass	180-250	55-75	240-290
Sweet Clover	158	16	90
Tall Fescue	135-290	26	267
Orchard Grass	230-250	20-50	225-315

Source:` Metcalf & Eddy, 1991. Wastewater Engineering - Treatment, Disposal & Reuse. McGraw-Hill.

2.7.2 Flora

An inventory of the flora planted and to be planted in the six wetlands and the primary Lake given below. This was based primarily on secondary information supported by field survey where pertinent. The references consulted are Idris and Rozaina (1992), Holttum (1954), Corner (1978), Ng (1978), Pancho and Soerjani (1978), and Wyatt-Smith and Kochumen (1979).

2.7.2.1 Upper North Wetland

The Upper North Wetland consists of eight cells, each with a number of plots planted with single wetland plant species (mono-culture), as shown in Figure 2.7.3. The wetland plant species in each cell are also shown in the figure whereas the terrestrial plant species planted along the banks of the wetlands are given in Table 2.7.2. Incoming water, laden with organic and inorganic pollutants, enter into the uppermost wetland cell (UN8) and passes from one cell to another via weirs. During the process suspended sediments will settle to the bottom while the nutrients will be taken up by a variety of wetland plant species in the various cells.

2.7.2.2 Upper East Wetland

The Upper East Wetland consists of three cells, each with a number of plots planted with single wetland plant species (mono-culture), as shown in Figure 2.7.4. The wetland plant species in each cell are also shown in the figure whereas the terrestrial plant species planted along the banks of the wetlands are given in Table 2.7.3.

Table 2.7.2 Terrestrial Plants in the Upper North Wetland

Scientific Name	Common English/ Malay Name
Caryota mitis	Fish Tail Palm – Rabok, tukas
Cerbera odollam	Pong Pong
Colocasia gigantea	Keladi
Crinum asiaticum	
Cyrtostachys renda	
Dillenia suffruticosa	Simpoh Air
Eugenia aquae	Jambu Air
Ixora javamica	Siantan
Melaleuca cajuputi	Gelam
Pometia piumata	Kasai
Flagellaria indica	
Arundina graminifolia	Bamboo Orchid
Saraca thaipingiensis	Seraca
Fagraea fragrans	Tembusu
Eugenia obana	Kelat
Ploiarum atternifolium	Riang-riang
Shorea sp	
Ficus microcarpa	
Ficus benjamima	
Eugenia grata	
Alocasia macrrhiza	

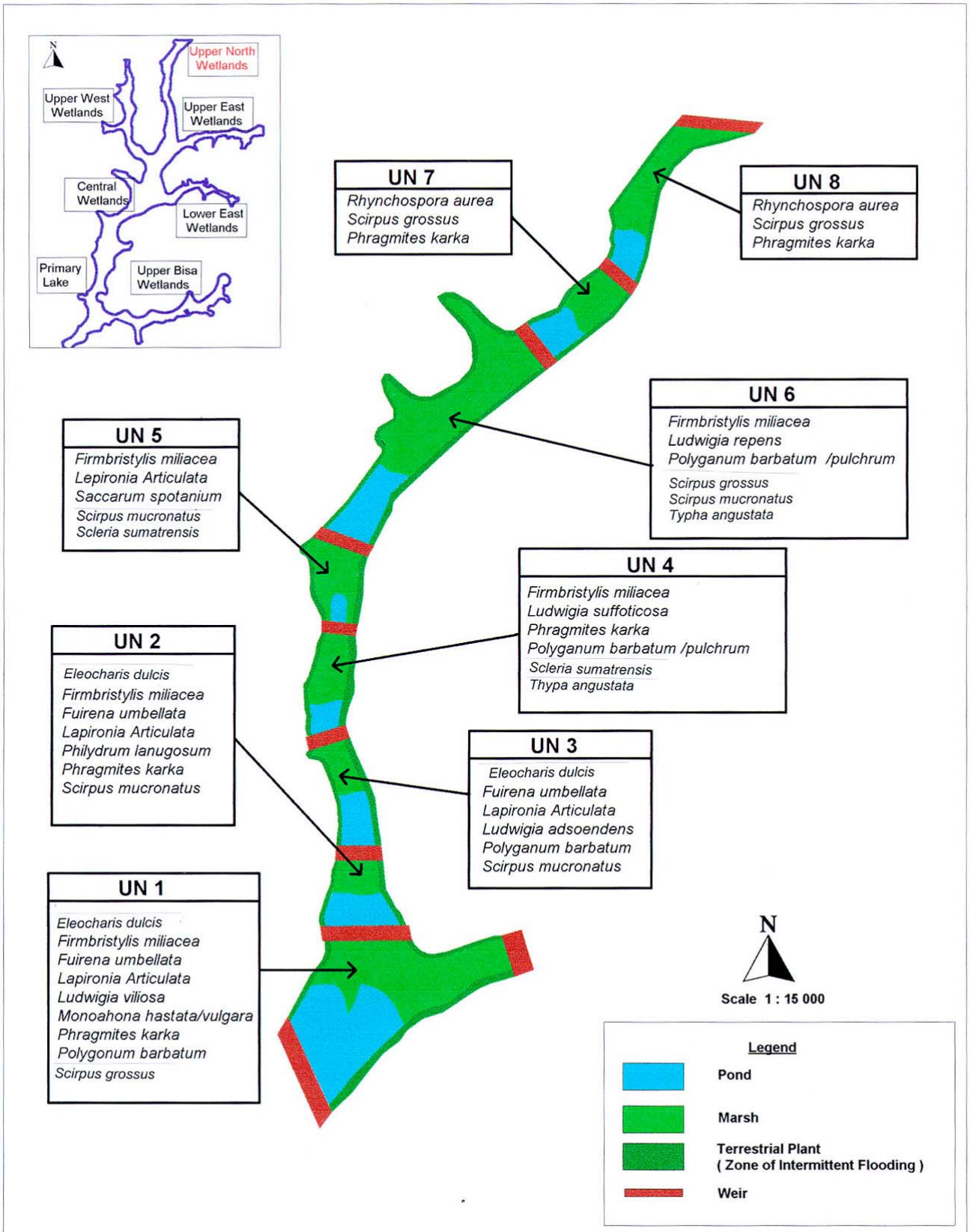


Figure 2.7.3 Flora in the Upper North Wetland

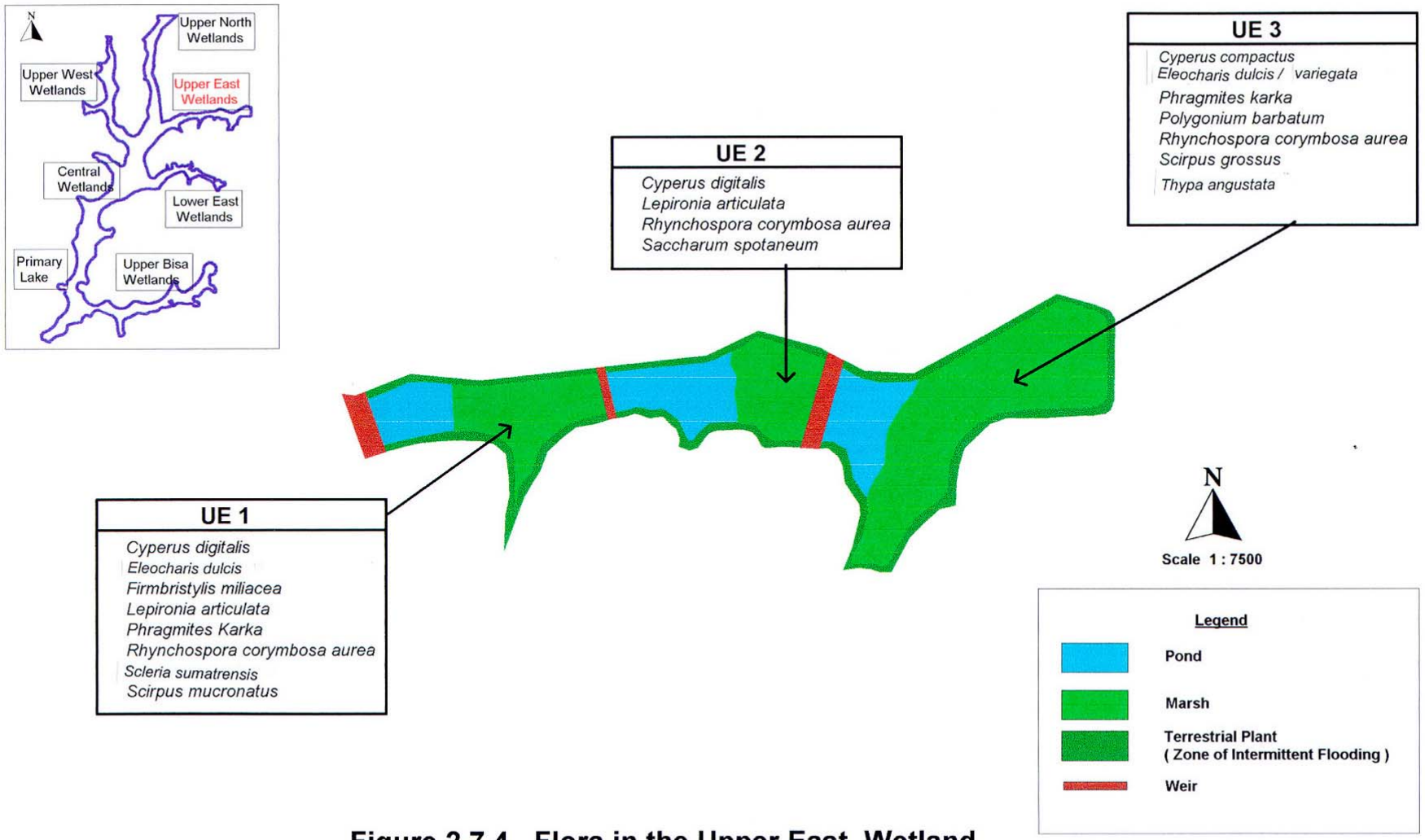


Figure 2.7.4 Flora in the Upper East Wetland

Table 2.7.3 Terrestrial Plants in the Upper East Wetland

Scientific Name	Common English/ Malay Name
Alstonia spathulata	Pulai Paya
Caryota mitis	Fish Tail Palm
Cerbera odollam	Pong Pong
Colocasia gigantea	Keladi
Crinum asiaticum	Sea Shoce Crinum
Cyrtostachys renda	Sealing Wax Palm
Dillenia suffruticosa	Simpoh Air
Eugenia aquae	Jambu Air
Ixoea javamica	Siantan
Melaleuca cajuputi	Gelam
Pometia pirmata	Kasai
Flagellaria indica	
Arundina graminifolia	Bamboo Orchid
Saraca thaipingiensis	Seraca
Fagraea fragraus	Tembusu
Hibiscus tilleaceas	Hibiscus
Eugenia obana	Kelat
Ixora finlaysonia	Siantan
Ficus microcarpa	
Ficus berjamina	
Shorea Sp.	

2.7.2.3 Upper West Wetland

The Upper West Wetland consists of eight cells, each with a number of plots planted with single wetland plant species (mono-culture), as shown in Figure 2.7.5. The wetland plant species in each cell are also shown in the figure whereas the terrestrial plant species planted along the banks of the wetlands are given in Table 2.7.4.

2.7.2.4 Lower East Wetland

The Lower East Wetland consists of two cells, each with a number of plots planted with single wetland plant species (mono-culture), as shown in Figure 2.7.6. The wetland plant species in each cell are also shown in the figure whereas the terrestrial plant species planted along the banks of the wetlands are given in Table 2.7.5.

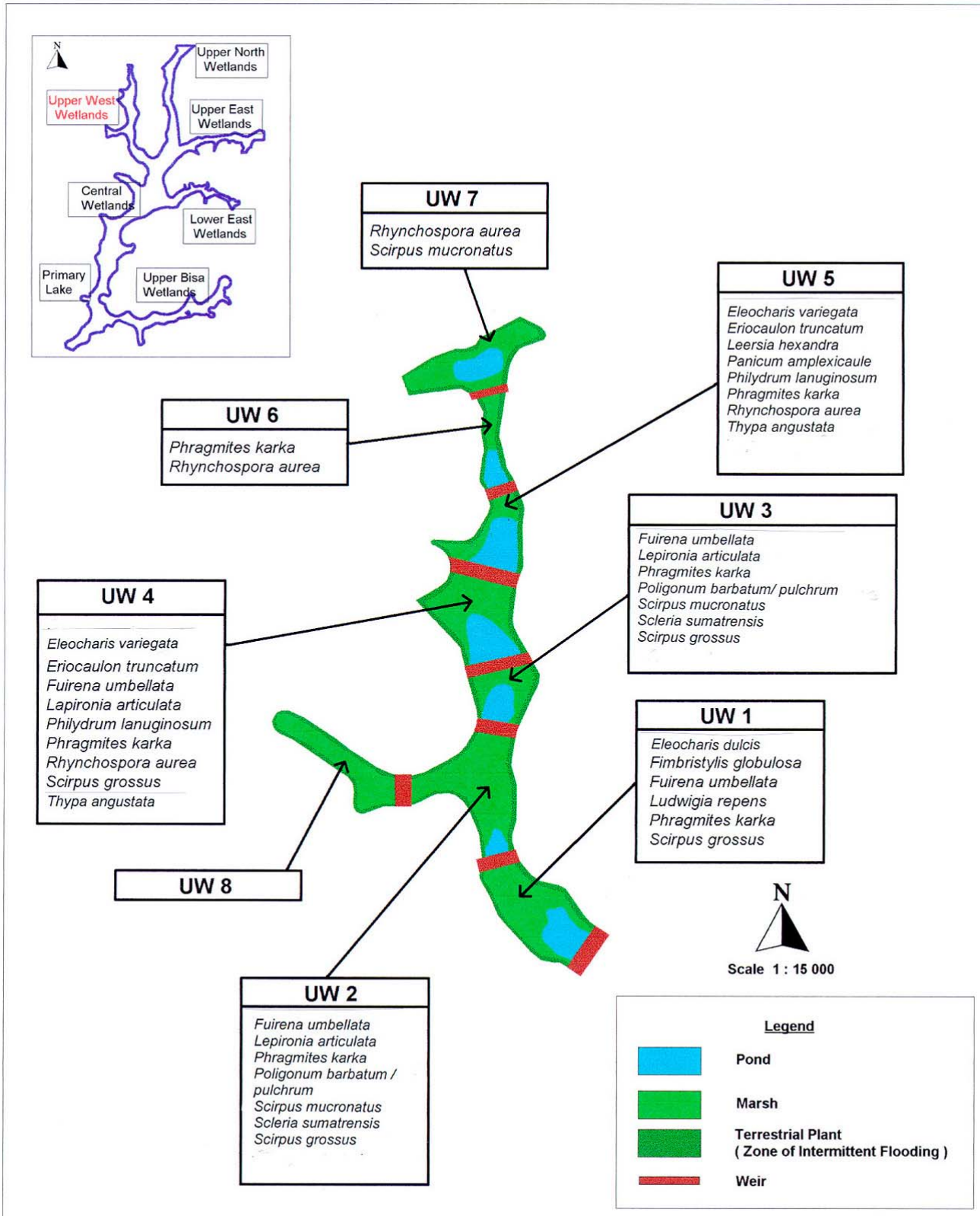
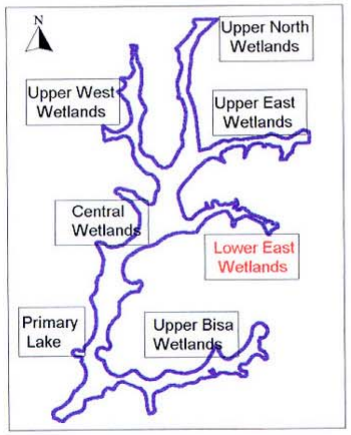


Figure 2.7.5 Flora in the Upper West Wetland



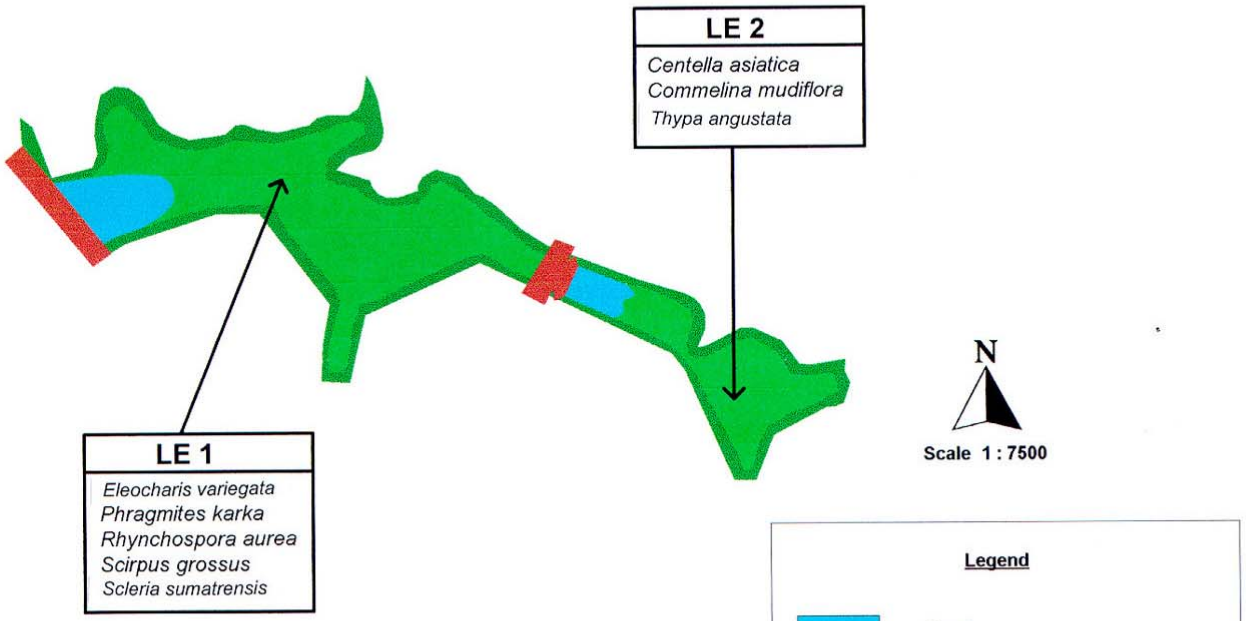


Figure 2.7.6 Flora in Lower East Wetland

Table 2.7.4 Terrestrial Plants in the Upper West Wetland

Scientific Name	Common English/ Malay Name
Alstonia spathulata	Pulai Paya
Alstonia angustiloba	Pulai
Caryota mitis	Fish Tail Palm
Cerbera odollam	Keladi
Colocasia gigantea	Keladi
Crinum asiaticum	Sea Shore Crinum
Cyrtostachys renda	Seabing Wax Palm
Dillenia suffruticosa	Simpoh Air
Engenia aquae	Jambu Air
Ixoea javamica	Siantan
Lubirgina villosa	Malaysia Willow Herli
Melaleuca cajuputi	Gelam
Pometia pirnata	Kasai
Arundina graminifolia	Bamboo Orchid
Saraca thaipingiensis	Seraca
Fagraea fragrans	Tembusu
Licuala spinosa	Palas
Ploiarum altermifolium	Riang riang
Ixora finlaysonia	Siantan
Eugenia obana	Kelat
Koompasia malaccensis	Tualang

2.7.2.5 Upper Bisa Wetland

The Upper Bisa Wetland consists of two cells, each with a number of plots planted with single wetland plant species (mono-culture), as shown in Figure 2.7.7. The wetland plant species in each cell are also shown in the figure whereas swamp forest trees will be planted along the banks of the wetlands. The swampy habitat will allow the colonisation of the wetland by fauna (mammals, amphibians and birds). Since planting has not started yet a list of the tree species could not be provided.

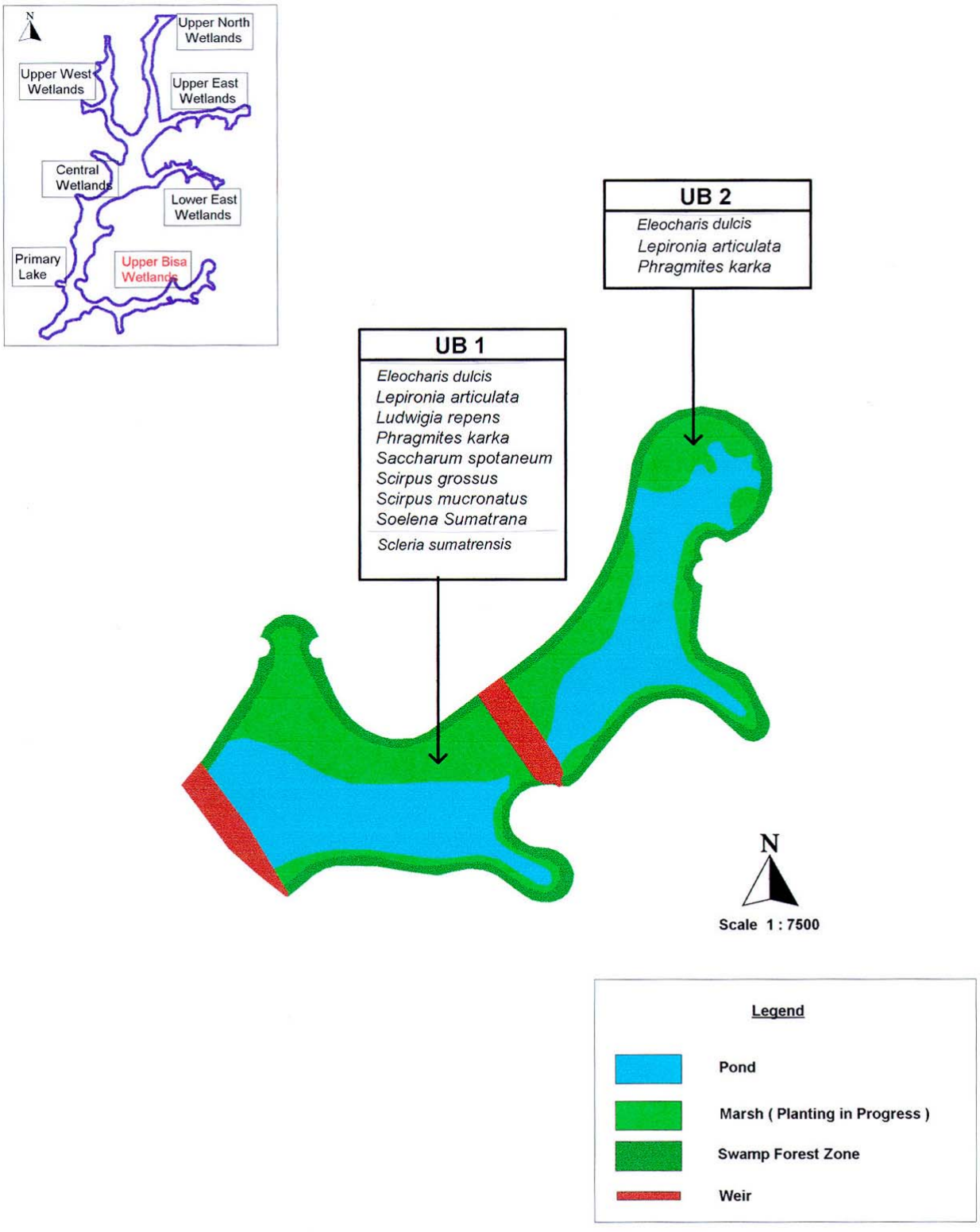


Figure 2.7.7 Flora in the Upper Bisa Wetland

Table 2.7.5 Terrestrial Plants in the Lower East Wetland

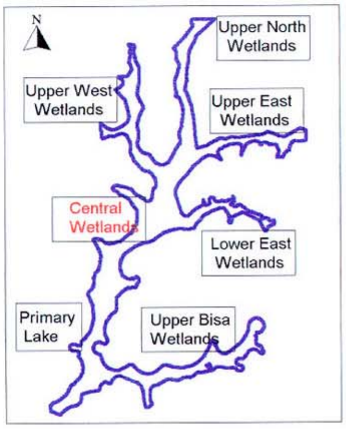
Scientific Name	Common English/ Malay Name
Alocasia macrorrhiza	
Colocasia gigantea	
Crinum asiaticum	Sea Shore Crinum
Dillenia suffruticosa	Simpoh Air
Ixora javamica	Siantan
Ludwigia villosa	Malaysia Willow herb
Melaleuca cajuputi	Gelam
Arundina graminifolia	Bamboo Orchid
Saraca thaipingiensis	Seraca
Fagraea fragrans	Tembusu
Hibiscus tilleaceus	Hibiscus
Ixora finlaysonia	Siantan
Eugenia obana	Kelat

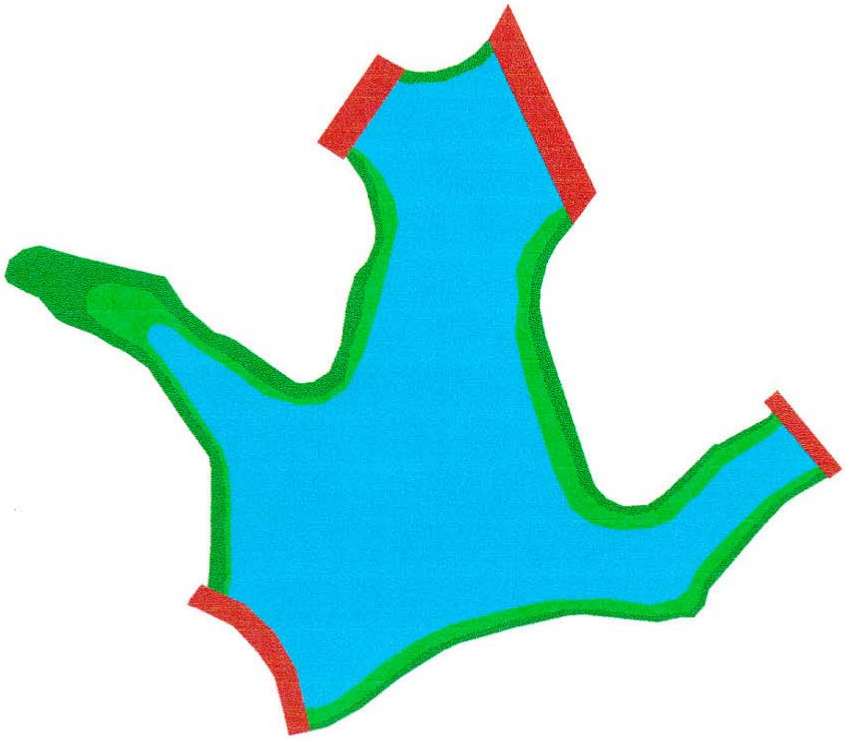
2.7.2.6 Central Wetland

The Central Wetland (Figure 2.7.8) is only one cell and has water depths exceeding 5 m. Wetland species cannot survive in such deep water. Thus, most of the wetland species are being planted along the limnetic zone (marshy area) around the periphery. The planting exercise has just started and is currently in progress. The incomplete list of the wetland plant species is given in Figure 2.7.8. Swamp forest trees will be planted along the banks of the wetlands. Since planting has not started yet a list of the tree species could not be provided**.**

2.7.2.7 Primary Lake

Like the Central Wetland, the primary Lake (Figure 2.7.9) has depths exceeding 5 m, and wetland species cannot survive in such deep water. Thus, most of the wetland species are being planted along the marsh zone around the lake side. The planting exercise has just started and is currently in progress. The incomplete list of the wetland plant species is given in Figure 2.7.9. Swamp forest trees will be planted along the banks of the wetlands. Since planting has not started yet a list of the tree species could not be provided.





N

Scale 1 : 10 000

Legend

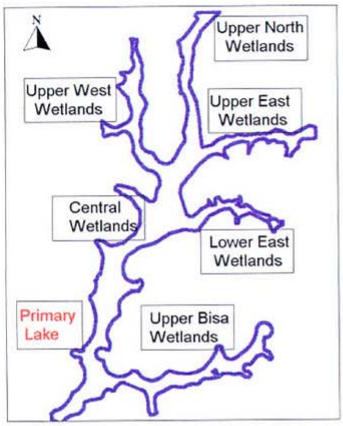
Pond

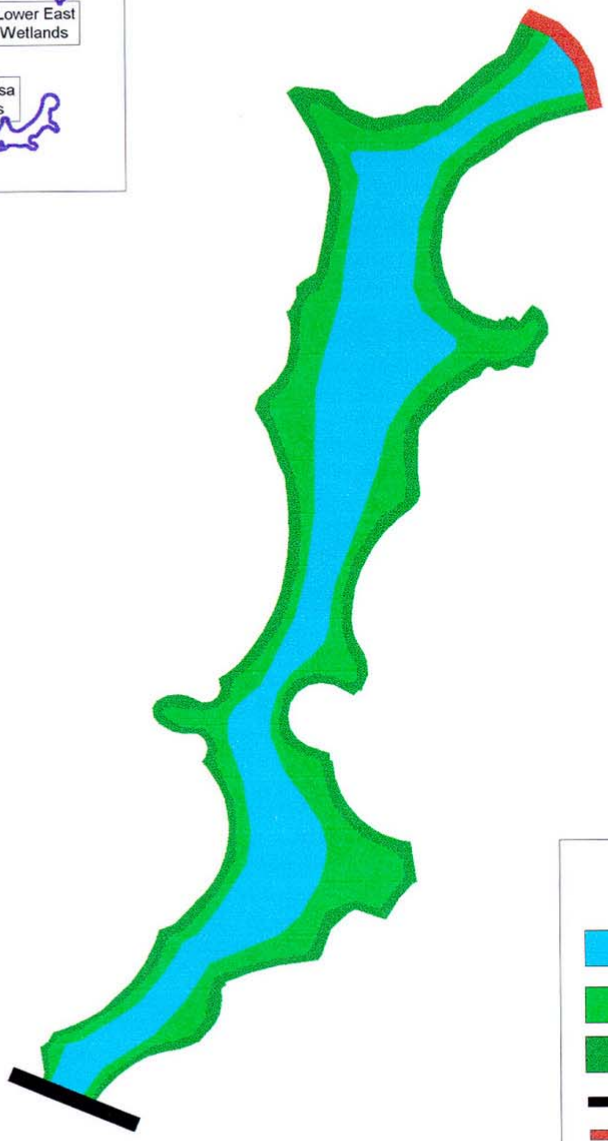
Marsh (Planting in Progress)

Swamp Forest Zone
(Planting not done yet)

Weir

Figure 2.7.8 Flora in the Central Wetland





N

Scale 1 : 15 000

Legend

- Pond
- Marsh (Planting in Progress)
- Swamp Forest Zone (Planting not done yet)
- Temporary Dam
- Weir

Figure 2.7.9 Flora in the Primary Lake

2.7.3 Fish and Fauna

An inventory of the fauna (birds, amphibians and mammals) and fish stock is given based primarily on secondary information and supported by field survey where pertinent. The following are the results from the study.

2.7.3.1 Fish

(1) The identification of fish species were based on taxonomic keys developed by Alfred (1964), Mohsin and Ambak (1982), Inger and Chin (1962), Ng, et. al. (1992) and IUCN (1994). No records of fish sampling survey for the stretch of Sg. Chuau, which has been impounded to form the Putrajaya Lake system has been found. However, general information are available which indicated that the Sg. Chuau is rich in a variety of indigenous and exotic species (Mohsin and Ambak, 1982).

(2) Some of the common species are *Puntius gonionotus*, *Puntius schwanenfeldii*, *Puntius* Spp., *Rasbora* Spp., *Trichogaster pectoralis*, *Clarias batrachus*, *Channa striatus*, *Tilapia* Spp., *Notopterus notopterus*, *Macrobrachium lancestri*. Due to the impoundment the habitat of the species has now changed from riverine to lacustrine. The species will thrive well in the lake because of the availability of shelter, rich feeding and breeding grounds in the lake. It is also known that fish stocking exercise has also been carried out after the impoundment of the river. Table 2.7.6 shows the species introduced into the Putrajaya Lake system.

2.7.3.2 Fauna

(1) With site clearance, earthwork and construction activity in the catchment, the diversity of the fauna population have been greatly reduced. However, since the constructed wetlands will provide a good habitat for the fauna, colonisation by the fauna such as birds are expected. The wetlands are located near a flyway which crosses the new international airport at Sepang near Putrajaya. The flyway is the flying route for migratory birds from the west during overwintering period. The birds fly over Putrajaya and Sepanang of West Malaysia to Indonesia. Thus there is a possibility of significant colonisation of the wetlands by water birds in the near future.

Table 2.7.6 Fish Species introduced into the Putrajaya Lake system

Scientific Name with Local/ English Name	Ecological Attributes
Puntius tetrazona (Tiger Berb)	Predate mosquito, zooplankton feeder and indigenous and have high ornamental value
Puntius gonionotus	Indigenous, Insectivorous and zooplankton feeder and sport fish with ornamental value
P. schwanenfeldii (Lampam Jawa)	Insectivorous, zooplankton feeder, ornamental value indigenous and good sport fish
Rasbora Spp. (Seluang)	Ornamental species, Predate mosquito larvae, insects and some aquatic plants.
Trichogaster pectoralis (Sepat)	Indigenous, control algal population and resistant species
Betta splendens (Ikan laga)	Feed both phyto- and zooplankton, ornamental value.
Aplochilus panchax (Kepala Timah/Whitespot fish)	Insectivorous and predate mosquito larvae
Xenontodon cancila (Needle fish)	Insectivorous and predate mosquito larvae.
Leptobarbus hoevenii (Jelawat)	Phytoplankton feeder, also feeds on aquatic plants, good ornamental fish
Channa striata (Haruan)	Carnivorous and predate small fish and mosquito larvae

(2) A general survey of the fauna in the area after the impoundment phase was undertaken. It was observed that amphibians such as the crab-eating frog (*rana cancrivora*) and cricket frog (*rana limnocharis*) were found in the area. Species of waterfowl and heron were also spotted. The bird species observed are given in Table 2.7.7 whereas the mammals are given in Table 2.7.8.

Table 2.7.7 Birds species observed in the Putrajaya Lake system

Scientific Name	Environmental Status
Charadrius leschemaultii	P*
Egretta eulophotes	P
Xenus cinereus	P
Tringa Spp.	P
Nycticorax Spp.	P
Haliastur indus	P
Malacopteron Spp.	P
Trichastoma Spp.	P
Prinia Spp.	P
Phylloscopus Spp.	P
Loriculus galgulas	P
Halcyon Spp.	P

P* - 'Protected' species according to the *Wildlife Protection Act, 1972*.

Table 2.7.8 Mammal species observed in the Putrajaya Lake system

Scientific Name	Environmental Status
Macaca fascicularis	P*
Presbytis obscura	P
P. cristata	P
Callosciurus prevostii	P
Ratufa bicolor	P

(3) The primary information collected indicates that there are incidences of colonisation of the Putrajaya Lake system by the fauna. However, it will take some time for the wetlands and open water lake to have a fully developed fauna population.

2.7.4 Recommendations for Sustaining the Fauna & Flora

2.7.4.1 Wetland Plants

(a) Plant Harvesting

(1) Plant die-off, due to overcrowding, pest infestation and weed's invasion in the wetland cells, is common and expected. It should not interrupt the ecological cycle as each wetland cell has its own microbial carrying capacity.

However, if the die-off is significant involving large planting area, there will be need for harvesting. Thus, routine harvesting of senescent plants due to disease or overcrowding or to reasons unexplained, is very appropriate and this exercise to be completed during drought period rather than monsoon. Plant harvesting will have environmental impacts on water quality and fish and invertebrates and it must be addressed properly. One of the options to maintain the water quality, is to raise temporarily the stop logs in the weir to increase retention time by increasing volume. This will allow for the sediments to settle at the bottom. The rise in the stop logs will temporarily stop water flow into the downstream.

(b) Planting Density

(2) Planting density is to be as low as possible so as not to repeat the past experience of overcrowding of plants in some of the cells. The previous density for planting the wetland cells is relatively high, varying from 15-18 plants/m^2. The recommended density for transplanting the harvested cells is as follows:

- *Scleria* sp. - <6 plants/m^2
- Others, such as *Phragmites* sp. *Lepironia* sp. and *Scirpus* sp. - <10 plants./m^2

(c) Species Selection

(3) Currently there is limited information on the ability of an individual wetland species to uptake of particular nutrients at a particular aquatic habitat type. The wetlands at Putrajaya represent an excellent opportunity for research into this area.

(4) It is generally known that Nitrogen, Phosphorus and Potassium are three major nutrient elements required for the growth and propagation of plant species including those of wetland plants. But the intricate physiology of nutrient uptake and cellular absorption are little known. Especially very little is known particularly on the tropical and equatorial wetland plants with some information available from temperate regions (section 2.7.1.2). However, the information available on the temperate

wetland plants may be of little relevance to the tropical wetland species because of the different rates and annual pattern of growth, and the temperature difference which may affect the rates of the biochemical processes themselves. Nevertheless, some general information which may be applicable of the tropical wetlands which are shown in Table 2.7.9.

Table 2.7.9 Plant species and nutrient uptake

Species	Information Available
Phragmites karka	Ability to polish sewage effluents
Lepironia articulata	High nutrient absorber
Saccharum sp.	Good nutrient absorber, shading and refuge for fish
Scirpus grossus	Good nutrient absorber

(5) Although other wetland plant species are well known to have ability in nutrient uptake in cleaning up of euthrophicated lakes, ponds, reservoirs and marshland, quantitative field experiments have not been done yet. As such precise information are not available.

(6) For the shoreline, Elephant Grass, *Scleria* sp. is less foliaceous and fast growing. It is relatively more resistant than other species and withstands more water level fluctuation in the cells. As a replacement of harvested species, it can be given priority.

(d) Control of Unwanted Aquatic Weeds

(7) Weeds are the major problems in the non-inundated or improperly inundated cells than in the inundated ones. They are prevalent in UN 5, UN6 and UW5, UW6 and UW7 and also in the Lower East wetland. Weeds are competitive and fast growing compared to wetland plants. They are resistant to harsh environment. Common weeds in the wetland are Mimosa, *Pudica* sp. *Galinsoga* sp. *Rhyncospora* sp. *Fimbristylis* sp. and *Limnocharis* sp.

(8) The following steps are to be taken:

- Continuous monitoring

- Manual weeding to be done periodically and consistently in all wetland cells. The exercise has to be limited to noxious and exotic species.

- Maintain the required water level so that weeds are submerged under water. This will prevent further germination of seeds and seedlings.

- Manual weeding of oil palm seedlings in UN 5 and UN 6. They are found in large numbers in Upper North Wetland.

(9) A successful way of removal of unwanted aquatic weeds is by the use of biodegradable herbicides which would have little effect on fish and other invertebrates. The pesticide BMP can be consulted for appropriate herbicides. Regular manual weeding is the best non-polluting method.

(e) Pest Infestation

(10) Pest problems have been documented at early stage (Putrajaya Constructed Wetlands, Advisory Report # 8, Wetland International -Asia Pacific). Disease attacks on some wetland plants in UN and UW cells are also found in the present study. *Phragmites karka* and *Scirpus grossus* were found to have been attacked by aphids and stem borer respectively. This was found sporadically in some cells. The problems are, however localised and can be addressed effectively. The following steps are to be considered for action immediately.

1. To develop an Integrated Pest Management Techniques (IPM). IPM is a well-established pest management system whereby pests are killed at a threshold level without having any impact on non-target organisms.

2. Immediate harvesting of the infected plants and transplanting with new plants. Planting density must not exceed 10 sp./m^2 for species other than Elephant Grass. Elephant Grass, *Scleria* can be planted more

than *Phragmites karka* due to latter's resistance to environmental constraints.

3. Biological control method using natural predators of pest and insects. Biopesticide, *Bacillus thuringinesis* can control the pests namely caterpiller leaf rollers (*Craphalocrocis medinalis*) and rice step borer, *Scirpophaga incertulas*.

(f) Water Level management

(11) Maintenance of required water level is extremely important for survival and propagation of wetland plants. Water level varies with rate of establishment of wetland plants. Shortage or lack of water in UN 5, UN 6 and UW 5 has put wetland plants under stress and reduced plant vigour. It increases the chance of secondary attack by pests. Water level in UN 5 and UN 6 should be increased to control of unwanted aquatic weeds at the fringe of the marsh zone and to make available adequate nutrients and pollutants to variety of wetland plants. Water level rise in UN 5, UN 6, UW 5, UP 6, and UW 7 is also recommended to allow fish to feed on the marginal and shallow marsh.

(g) Monitoring Plant Performance

(12) It is expected that a plant biologist/botanist or horticulturist will be involved in the vegetation monitoring. The following points have to be considered and provide biological indicators of plant health:

1. The colour of plant leaves should be monitored;

2. Leaves should be observed for chlorosis;

3. Removal of plant litter manually;

(13) Removal of plant litter at the substratum can be achieved by ensuring the following:

1. Water circulation from upstream to downstream via wetland cells and primary lake;

2. Establishment of roots of wetland plants into the substratum;

3. Stocking more detritivorous, and omnivorous fish species in the wetland cells.

(h) Plant Nursery

(14) Supply wetland plants as, and when, necessary, to replenish the harvested plants is crucial to operation and management of wetland system. The outdoor nursery should be ideally located within the Putrajaya wetland at a strategic location so that they can be supplied readily in any affected wetland arms. The wetland nursery used by the wetland contractors is suitable.

(15) Periodic replanting will be necessary in wetland arms due to die off and occasional harvesting of overcrowded and diseased plant species. In the outdoor nursery, at least 1% of seedlings of all wetland species planted in six constructed wetlands should be readily available for replanting purpose as and when necessary. This amounts to approximately 20,000 – 25,000 wetland plants, of the various species, which will have to be propagated in the outdoor nursery.

(16) All the potted wetland plant species should attain a reasonable height before they are ready for transplanting purpose. The wetland plant species height will vary depending upon the location and depth of water body of the replanting area in question.

(i) Wetland Plant Monitoring

(17) Long term monitoring and management are important for maintenance of a healthy wetland system. Weekly supervision of general health of all dominant plant species in the wetland cells is to be undertaken. Immediate actions are to be taken for remedy if incidences of any of the following are apparent:

1. Lack/shortage of water in any of the wetland cells; water levels should be in the region of 0.3 to 2 m for aquatic plant growth.

2. Overcrowding of any of the species in the cells that have caused stress, pest infestation and reduced plant vigour resulting in the stunting of growth.

3. Insect attack of significant proportion in any of the species in the wetland cells.

4. Illegal poaching on wetland plants for hunting purpose.

(j) Community Awareness and Education

(18) Apart from the bio-chemical and other physical controls, community awareness and education amongst common people to appreciate wetland and its associated plants are important for their conservation and management.

2.7.4.2 Fish Community

(a) Fish Species

(1) There has been fish stocking in Putrajaya wetland system in late 1998. Prior to this an inventory of fish naturally occurring the water system was established by fish sampling using locally available fishing gears. The inventory included both indigenous and exotic species. The dominant local species were those of Cyprinids and Clariids. Other than the species of these families, indigenous, *Channa striatus* and exotic Tilapia, *Oreochromis mossambicus*, were also dominant species recorded.

(2) The fish stocking exercise included the release of both local and exotic species, the major species of the former being *Betta pugnax* and *Trichogaster pectoralis*, *Clarias* sp., *Puntius* sp., Osphronemus sp. And *Channa* sp. The exotic species to be stocked at later stage are grass carp and bighead carp. The objective of fish stocking is to control mosquito larvae, maintain good water quality and support sport and recreational fishery.

(3) The performance of the fish community in achieving the objective is not fully known. Nonetheless, our frequent survey in wetland cells of UN, UW, UE, LE, and UB indicated that species of exotic Tilapia, and indigenous *Trichhogaster* sp. (Sepat Siam), and *Rasbora* sp.

(Seluang), *Puntius* sp., *Channa* sp. (Haruan), *Betta* sp. (Pelaga) are well established. The overgrowth of Tilapia is a cause of concern and the following control measures are necessary:

(b) Control of Undesirable Species

(4) Removal of *Channa* sp. (Haruan) and *Pectoralis* sp. (Sepat Siam) from the wetland system may prove to be costly and unwise as the species are known to feed effectively on mosquito larvae. Mosquito breeding in shallow and stagnant creeks and marsh are commonly expected. Species of Tilapia is always a nuisance to the aquatic system for its fast growing nature which if not controlled will affect other fish species. They can be controlled by:

1. Fish sampling using netting (cast and gill netting) and scooping

2. Angling and sport fishing

3. Biological control by introducing more predatory sport and game fish.

(5) Some species need to be controlled at the early stage. Generally, the Grass carp, *Ctenopharyngodon idellas*, is the herbivore of concern. Its daily intake of grass is expected to be three times its body weight. Thus it should not be stocked in the initial 2-3 years. Other members of the carp family are not herbivores. Once the wetland plants are established, the Grass Carp can be introduced in deeper waters, at low numbers, so as not to destroy the plant leaves of the Primary Lake and Central Wetlands. In addition, cut grass leaves can be a food source for the Grass Carp population in the water body.

(c) Routine Fish Sampling and Restocking

(6) Routine fish sampling is to be conducted to realise the level of fish recruitment and adaptability to a new habitat. Exact density and availability (comprehensive inventory) will not be known at this stage. However, based on the approximate data, some crude idea will be formed which will be suffice to plan a new stocking exercise. The

general aim is to establish a food chain where fish can thrive well without much external feeding and naturally propagate to establish a breeding population. Special emphasis on stocking of Cyprinid species, prawn, *Macrobrachium lancestri* and other invertebates is to be given. The reason is that they form the food of many carnivorous and omnivorous fish species. Care is to be taken so that sampling exercise does not cause problems to ambient water quality, wetland plants and fish stocks. Once established few carp species can be released into main lake and wetlands.

(d) Stocking of Endangered and Rare Species

(7) Stocking of endangered and rare species can be one of the important stocking programmes because the wetland's unique feature and ecological characteristics. The potential species are *Oxyleotris marmoratus*, *Leptobarbus hoevenii*, *Probarbus jullieni* and *Tor tambroides* and *Osphronemus goramy* and *Scalophagus formosus*.

(e) Illegal Fishing

(8) Illegal fishing will be difficult to stop once the wetland system is established when a variety of fish species occupy the productive habitat. Prohibition of illegal fishing can be done by enacting new laws and legislation.

2.7.4.3 Bird Community

(a) Bird Protection

(1) Once the wetland plants and its associated swamp forest are well-established, a diversity of terrestrial and water birds will colonize the habitat. A variety of resident and migratory birds are commonly expected to colonize the habitat. To encourage this, the following steps are to taken:

1. Enact legislation to prohibit bird hunting in any form.
2. Long-term monitoring during the period of migration.
3. The island of Upper Bisa Wetland should have sheltered sites for for birds to graze, perch and roost. Floating rafts anchored to the bottom for

example, can provide nesting and protection from disturbance.

(2) The impact of the birds also need to be monitored to ensure the population numbers and type of birds do not compromise water quality.

(b) Community Awareness and Education

(3) Community awareness and education programme can be undertaken amongst local residents, school and university students and community leaders and other interested groups to encourage public participation in bird watch and their conservation. A warden service needs to be established to provide public liaison and education on water bird watching.

2.7.4.4 Wildlife Community

(1) Undisturbed forest cover is indispensable for animal (wildlife) colonization. Once the vegetation cover of the riparian park (swamp strip) of the wetland is established, wildlife colonization will be widely expected. The following points to be considered for implementation:

1. Enact legislation against wildlife hunting in any form.

2. Increase community awareness and education to prevent poaching, encroachment and hunting.

2.7.5 Flora and Fauna Outside Perbadanan Putrajaya

2.7.5.1 General Condition

(1) Outside the area under Perbadanan Putrajaya, the flora, fauna species found around ponds and waterways are similar to that within Putrajaya. The diversity and abundance of vegetation, fish, avifauna and wildlife community around the Putrajaya lake catchment are one of disturbed types where no pristine forest, game park, bird and wildlife sanctuary were existed. There are no records of unique, endangered or threatened species either plant, fish, avifauna or wildlife reported elsewhere around the vicinity of the lake catchment area.

(2) The fishes introduced into the Putrajaya artificial lake systems are common to aquatic environments of the surrounding areas. Similarly the transplanted aquatic plant species in the wetland systems are generally found in the wetlands and aquatic bodies outside of Putrajaya lake. The inventory of plants, birds and wildlife occurring in the Putrajaya lake and its surrounding areas were recorded in the preliminary EIA report prepared prior to the impoundment of the lake.

2.7.5.2 Flora around Putrajaya

(1) There are about 126 species belonging to 59 Genus and 18 Families recorded in the area outside of Putrajaya Catchment and are shown in Table 2.7.10. The list is by no means a complete and exhaustive one and further field survey may record more species. The species recorded in the EIA study vary in diameter from 5.0 to 20.0 cm. There are no primary forests in areas outside of Putrajaya, however, there are secondary forests.

Table 2.7.10 Flora species

Family	Genus	Species
Myrtaceae	3	17
Lauraceae	4	11
Euphorbiaceae	10	19
Annonaceae	3	3
Anacardiaceae	5	7
Myristicaceae	4	13
Rubiaceae	5	6
Rutaceae	3	5
Leguminosae	1	1
Burseraceae	3	13
Rhizophoraceae	2	3
Flacourtiaceae	4	7
Meuaceae	2	2
Sapindaceae	2	5
Sapotaceae	4	6
Polygalaceae	2	5
Ulmaceae	1	2
Olacaceae	1	1

2.7.5.3 Aquatic Plant Species

There are numerous aquatic plants found in Mardi and UPM ponds, swamps and streams outside of Putrajaya lake catchment area. The common aquatic plants are shown in Table 2.7.11.

2.7.5.4 Fish

The fish species are recorded from the streams and static reservoirs and other water bodies present outside of Putrajaya near UPM and MARDI. They are shown in Table 2.7.12. The list is by no means a complete and exhaustive one and further survey may record more new species.

Table 2.7.11 Aquatic Plant Species around Putrajaya

Scientific Name	Common Name	Status
Lepironia articulata	NA	C
Alstonia spathulata	NA	C
Najas indica	NA	C
Nymphoides indica	NA	C
Ficus microcarpa	NA	C
Cerebra odollam	NA	VC
Pandanus helicopus	Rasau	C
Eleocharis sp.	NA	C
Utricualria sp.	NA	C
Saccharum spontaneum	NA	C
Cyperus sp.	NA	VC
Polygonum barbatum	NA	C
Ludwigia sp	NA	VC
Typha angustifolia	NA	VC
Nelumbo nucifera	Lotus	C
Colocasia gigantea	NA	C
Shorea sp.	NA	C
Eugenia sp.	NA	C

NA - not available; C - common; VC - very common

Table 2.7.12 Fish Species

Scientific Name	Local Name
Oreochromis nilotica	Tilapia
O mossambicus	Tilapia Hitam
Oreochromis sp.	Tilapai Merah
Notopterus chitala	Belida
Clarias batrachus	Keli Kayu
C macrocephalus	Keli Bunga
Mystus sp	Baung
Hampala macrolepidota	Sebarau
Rasbora sp.	Seluang
Puntius sp.	NA
Channa striatus	Haruan
Channa sp.	NA
Trichogaster pectoralis	Sepat Siam

2.7.5.5 Wildlife

The wildlife has been fast depleting in areas outside of Putrajaya because of developmental pressure as more land come under conversion into housing and commercial and other land use schemes. Tables 2.7.13 and 2.7.14 shows the list of wildlife and birds recorded in areas outside of Putrajaya catchment. The list is by no means a complete and exhaustive one and further field survey may record more species present.

Table 2.7.13 Wildlife around Putrajaya

Scientific Name	Local Name	Status
Presbytis obscura	Lotong Chengkong	P
Macaca fascicularis	Kera	P
Cynocephalus variegatus	Kubong	FP
Callosciurus prevostii	Tupai Gading	FP
Tragulus napu	Napuh	P
Ratufa bicolor	Tupai Kerawak Hitam	FP
Presbytis cristata	Lotong Kelabu	P
Helarctos malayamus	Beruang	FP
Tragulus javanicus	Pelandok	P

FP - Fully Protected under Wildlife Act 1972

P - Protected under Wildlife Act 1972

Table 2.7.14 Avifauna

Scientific Name	Local Name	Status
Haliastur indus	Burung Lang	P
Egretta sp.	Burung Pucong	FP
Phylloscopus sp.	Burung Cekup	FP
Pellorneum sp.	Burung Rimba	FP
Pericrocotus flammeus	Mas Belukar	FP
Streptopelia chinensis	NA	P
Halcyon smyrnensis	Burung Pekaka	FP
Amaurornis phoenicurus	NA	FP

NA - Not Available; FP - Fully Protected; P - Protected

2.8 SHORT, MEDIUM AND LONG TERM POLLUTION PROBLEMS

2.8.1 Identification of Pollutants of Concern

2.8.1.1 The major pollutants of concern to the Lake water quality are nutrients, bacteria, and organic chemicals and trace metals which may accumulate in the sediments and flora and fauna.

2.8.1.2 The main nutrient of concern is phosphorous. This enters the water system through non-point and point sources through fertilizer application, detergents containing phosphorous and sewerage waste.

2.8.1.3 The problems faced may be divided into short, medium and long term depending on when in the future the problem may arise and the duration of the problem.

2.8.2 Short Term Problems

The short-term problems are of short duration and may occur any time. They are:

- sediment inflow from construction sites;
- short-circuiting of the wetland function during storm events.

2.8.3 Problems in the Medium Term

The medium term problems will be of importance in the middle future (2-5 years) and can result in problems lasting a few years (2-10 years) if not controlled. For example, lack of control of short term problems of soil erosion may lead to medium term problems of lake sedimentation. The medium term problems are:

- the high (>2,000 counts/100 ml) of faecal coliform;
- sediment inflow from construction sites;
- possible short-circuiting of the wetland function during storm events.

2.8.4 Problems in the Long Term

2.8.4.1 In the long term (>10 years), the problem will be accumulation of

- trace metals, for example mercury, as indicated by the high concentrations in the baseline data
- sediments in the wetlands;
- phosphorus in the sediments.

2.8.4.2 In addition as the wetland system progresses in its natural development and growth, euthrophication will become a problem.

2.8.4.3 Organic chemicals from pesticides and herbicides may be detected by monitoring and their use controlled within the catchment.

2.8.4.4 For metals, accumulation will occur in the sediments and their sources may be more difficult to trace. Fertlizers may be a source of trace metals as are roads and stormwater.

2.9 TECHNICAL AND MANAGEMENT MEASURES

2.9.1 Point sources

2.9.1.1 Central Sewage Treatment Systems

(1) The model results indicate that a Total Phosphorus loading of 2 mg/l at design discharge will be the uppermost concentration which could be handled by the model to ensure a Lake target value of 0.05 mg/l.

(2) Therefore, Sewage Treatment systems which could produce an effluent of this concentration would be recommended for the catchment.

(3) Within the Kawasan Perbadanan Putrajaya, however, there are the recommendations for Parameter Limits of Effluent discharged into any waterways or land (Appendix 18 of the Putrajaya Environmental Management Guide). The limits for Total Phosphate here is 0.05 mg/L.

(4) Within the Kawasan Perbadanan Putrajaya, most discharges will not have the benefit of having wetlands to ameliorate the effects of discharges to the Lake. The Lake model indicates also that runoff flow and flow entering the Lake without the benefit of wetlands can greatly affect the Lake phosphorus level. Thus the standards for effluent discharged are much stricter.

(5) In addition the following recommendations are made to the Parameter Limits of Effluent:

- The parameter limits for Faecal Coliform should be reduced from 2000 counts/mL to 200 counts/100 mL by 1 January 2002.

- The parameter limits for Total Coliform should reduce from 10000 to 5000 counts/mL by 1 January 2002.

2.9.1.2 Septic Tank Systems

(1) There are several septic tank systems already existing in the catchment in IOI, MARDI and UPM.

(2) The effluent from these systems need to be co-ordinated into the recommended UPM-MARDI sewage treatment facility

prior to discharging into the Upper-West or Upper-North wetlands.

(3) There are expected to be several more systems in Sg Merab. The plans for these areas are unclear at present. Considering the small area involved and the expected low-density of future development, Perbadanan Putrajaya should consider incorporating the wastewater from these areas into their central sewage system.

(4) Considering the small area involved and the expected low-density of future development, Perbadanan Putrajaya should consider incorporating the wastewater from these areas into their central sewage system.

2.9.2 Non-point sources

2.9.2.1 Land Design

(1) The concept of "core zone" in land use design is the main principle in developing conservation areas. The central core is considered most sensitive and is most protected from development. This is fringed by an intermediate buffer zone of low intensity use with increasing intensity use located in the outer fringe to the central core.

(2) Within the catchment, the wetlands and natural streams may be considered the most sensitive. Therefore,

- riparian management zones or buffer strips (see below) of 30 to 10 m width on each side should be maintained;
- higher intensity development should be located further away from the water courses.

2.9.2.2 Best Management Practices

(1) Management of non-point pollutant input into waters is normally carried out by different management practices based on observations, experimentation and experience. Generally the best management practices for pollutant reduction tries to mimic the natural environment which has been disturbed by man. Thus the more natural-looking an environment the less likely is the pollutant input that might be expected.

(2) Based on such premise, therefore, there should be as much an abundance of vegetation as possible without it being detrimental to human activities. Within the Putrajaya Lake Catchment the best example of this enforced 'naturalness' is the Sungai Kuyoh sub-catchment in MARDI. Here the streams and ponds are line with tall grasses and trees. What might be regarded as an overgrowth of grasses in the streams actually serve multiple functions.

(3) They

- increase channel, reduce flow velocity, and carrying erosive or load carrying capacity;
- trap particulates, and encourage sedimentation;
- reduce sunlight penetration in the water column, discouraging algal growth, even in excess of nutrients;
- uptake nutrients in the water column and store in plant materials;
- provide stable habitats for aquatic ecological systems.

(4) The development of the Putrajaya Catchment area therefore should try to simulate such stream or riparian environments along the natural water courses, ponds and even storm drains. Riparian Management Zones (RMZ) should be established following the practice in forestry management. The guidelines for buffer zone widths based on land slope is given in Appendix D.

2.9.2.3 Recreational and Fish Ponds

There are a number of recreational and fish ponds in the MARDI ands UPM area. Figure 2.9.1 to 2.9.6 shows the landscape of some of these ponds. They serve a useful function in terms of preserving the water quality.

2.9.2.4 Guidelines for the Development of Mini-Wetlands

(1) Wetlands should be shallow whereas detention ponds are deep. For the detention ponds that have been identified as possible to function also as mini-wetlands, a number of factors are to be considered. In particular, ponds which drain directly into the Putrajaya Lake should have longer retention times compared to those ponds draining into one of the six wetlands. The

Figure 2.9.1 Small waterfall at the top of Sg. Kuyoh, MARDI. It can form part of mini wetlands of Sg. Kuyoh catchment.

Figure 2.9.2 Small waterfall at the top of Sg. Kuyoh, MARDI. It can form parf of mini-wetlands of Sg. Kuyoh catchment

Figure 2.9.3

Large man-made Reservoir in MARDI. There is continuous water supply from the upstream water fall. With Planting of wetland plants along its edge, it can serve to sequester pollutants and nutrients.

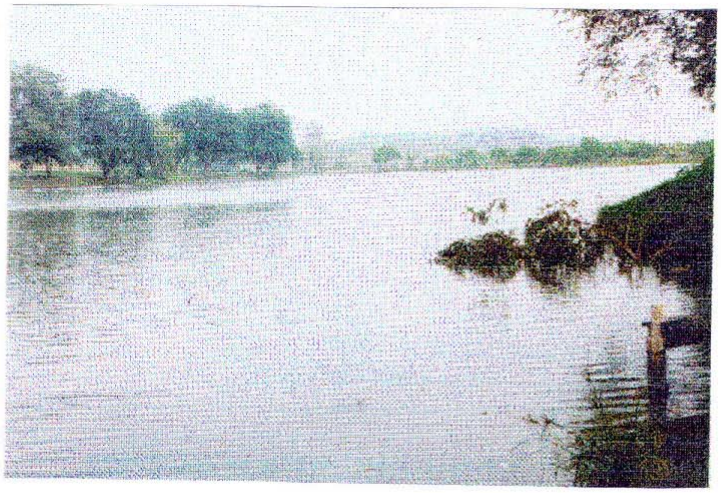


Figure 2.9.4

Overflow water from the MARDI Reservoir (Figure 2.9.3) enters into Sg. Kuyoh and finally discharge into Upper West Wetland.

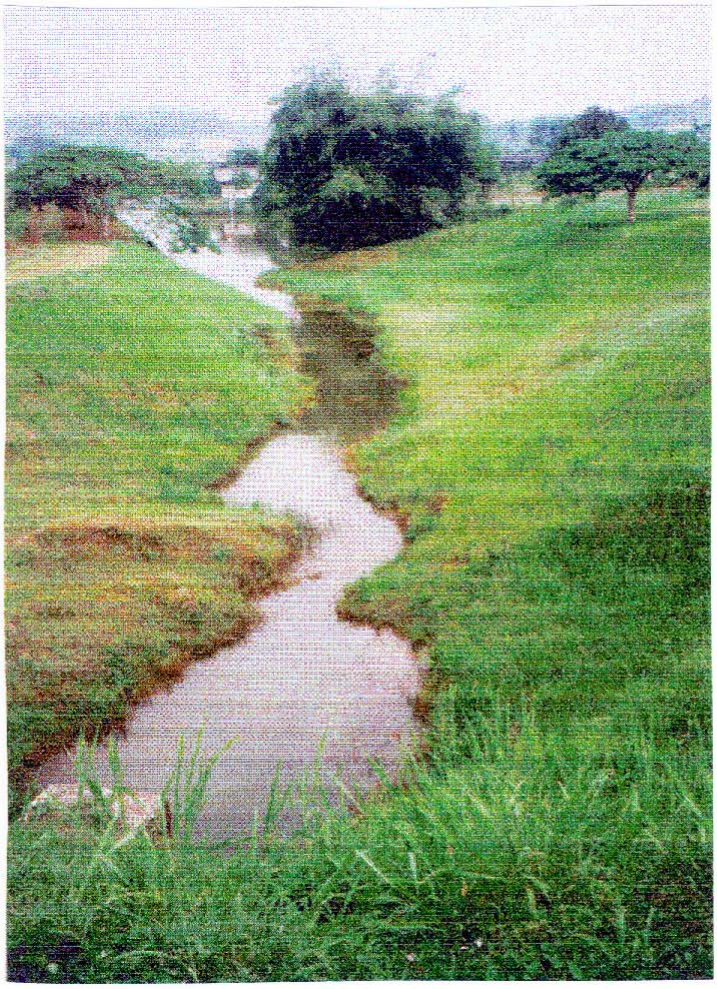


Figure 2.9.5 Existing UPM Pond at the upstream of upper North Wetland. Lotus *Nelumba Sucifera* can form a cover mat on the water surface to reduce plankton biomass in the water. The Rhizome system can help uptake of nutrients. The future mini-wetland may have lotus in the open water.

Figure 2.9.6 Wetlands plants along the banks overhang the stream.

retention times for the latter can be shorter because of the additional retention time and thus treatment capacity in the downstream wetlands.

(2) Mini-wetlands are intended as public open spaces but the public should have limited access to them to ensure ecological preservation. By virtue of limited access, the wetland will become a refuge for nature.

(3) The selection of plants to be planted in the wetlands and the use of agricides must follow the regulations governed by the Plant Quarantine Act 1976 (Act 167), and the Pesticide Act.

(4) The function and usefulness of mini-wetlands are almost the same as for riparian parks, lake valley parks and retention ponds to be provided within the Putrajaya Federal Government Administrative Centre Peripheral areas (refer to Urban Design Analysis and Strategy). Nonetheless, there will be differences in the physical shape, size and depth of mini-wetlands with those of parks and retention ponds proposed in the Urban Design Masterplan. Despite these physical spatial differences, the basis of species selection and planting strategy at various zones of wetlands will be based on the guidelines spelt out in the Urban Design Masterplan.

(5) Additional guidelines for the development of mini-wetlands are given in Appendix C.

2.9.2.5 Gross Pollutant Trap

(1) Gross pollutant traps (GPTs) act to trap litter and sediment. Since much nutrients are adsorbed onto sediments it is expected that sediment trapping will also result in nutrient trapping. Previous model studies making such assumptions on nutrient-sediment relationships have been carried out by Angkasa GHD in the Putrajaya Drainage Master Plan Study Report (1996). The data present there is given in Table 2.9.2 along with the net removal efficiencies predicted by their model. Nevertheless, the Report also cautioned that such assumptions are 'tenuous'.

(2) Based on stream environment and the proposed developments in the catchment, GPTs are only required for areas of substantial drainage modification and build up. The GPT locations proposed are indicated in the Catchment Drainage Masterplan.

2.10 SUMMARY

2.10.1 In order to fulfil the role and function of the Lake for Putrajaya, we must control the **water quality**.

2.10.2 In the ideal condition, the desired Lake conditions would determine the needs for the wetlands and the catchment development. The original design for the Lake and wetlands adopted this approach.

2.10.3 After construction of the Lake and wetlands, we need to consider the reality of the situation and look at the response and interactions between the Lake and the wetlands and the wetlands with the catchment.

2.10.4 This is essentially a matter of :

LAND ←→ WATER
interaction

2.10.5 In addition we need to recognize that the definition of pollutants are things which are **not wanted**, and that even natural chemicals, flora and fauna may be considered to be polluting to the Lake system.

2.10.6 The different factors affecting the Lake system are a complex interplay of hydraulic, biological and chemical aspects. In the study, this complex system is simplified in order to model the factors which may affect the Lake behaviour. We hope that the model results can provide an understanding of the system so that recommendations may be made on the management of the whole catchment development.

Table 2.9.2 Modelled GPT (with treatment) sediment and nutrient removal efficiency in Perbadanan Putrajaya
(from Perbadanan Putrajaya Drainage Masterplan Study Report, 1996)

Water Quality Parameter		Lake		Wetland		Offsite	
		t/a	mg/L	t/a	mg/L	t/a	mg/L
Government Precinct							
Suspended Solids	No Treatment	1260	231	300	173	-	-
	With Treatment	760	139	180	104	-	-
	Removal Efficiency %	39.7	39.83	40.00	39.88	-	-
Total Phosphorus	No Treatment	2.6	0.5	0.7	0.4	-	-
	With Treatment	1.8	0.3	0.5	0.3	-	-
	Removal Efficiency %	30.77	40.00	28.57	25.00	-	-
Total Nitrogen	No Treatment	8.1	1.5	3.2	1.8	-	-
	With Treatment	5.7	1	2.2	1.3	-	-
	Removal Efficiency %	29.6	33.3	31.3	27.8	-	-
CBD Precinct							
Suspended Solids	No Treatment	1000	155	-	-	-	-
	With Treatment	600	93	-	-	-	-
	Removal Efficiency %	40.0	40.0	-	-	-	-
Total Phosphorus	No Treatment	2.4	0.4	-	-	-	-
	With Treatment	1.7	0.3	-	-	-	-
	Removal Efficiency %	29.17	25.00	-	-	-	-
Total Nitrogen	No Treatment	10	1.6	-	-	-	-
	With Treatment	7	1.1	-	-	-	-
	Removal Efficiency %	30.00	31.25	-	-	-	-
Residential Precinct							
Suspended Solids	No Treatment	1870	124	330	135	1850	160
	With Treatment	1120	74	200	82	1110	96
	Removal Efficiency %	40.1	40.3	39.4	39.3	40.0	40.0
	No Treatment	4.3	0.3	0.7	0.3	4.4	0.4

Water Quality Parameter		Lake		Wetland		Offsite	
		t/a	mg/L	t/a	mg/L	t/a	mg/L
Total Phosphorus	With Treatment	3	0.2	0.5	0.2	2.6	0.2
	Removal Efficiency	30.23	33.33	28.57	33.33	40.91	50.00
Total Nitrogen	No Treatment	18.2	1.2	3.7	1.5	20.9	1.8
	With Treatment	12.8	0.9	2.6	1.1	9.8	0.8
	Removal Efficiency %	29.7	25.0	29.7	26.7	53.1	55.6
Sport & Recreation Precinct.							
Suspended Solids	No Treatment	430	148	-	-	340	146
	With Treatment	260	90	-	-	210	90
	Removal Efficiency %	39.53	39.19	-	-	38.24	38.36
Total Phosphorus	No Treatment	1	0.3	-	-	0.8	0.3
	With Treatment	0.7	0.2	-	-	0.5	0.2
	Removal Efficiency %	30.00	33.33	-	-	37.50	33.33
Total Nitrogen	No Treatment	4.2	1.4	-	-	3	1.3
	With Treatment	2.9	1	-	-	1.7	0.7
	Removal Efficiency %	30.95	28.57	-	-	43.33	46.15

2.10.7 In the Land-Water system, the LAND Components are the different sub-Catchments.

1. Upper North
2. Upper West
3. Upper East
4. Lower East
5. Upper Bisa
6. Central Sg Chuau
7. Lower Sg Chuau
8. Captured Sg Limau Manis

2.10.8 The current and future pollutant potential assessment is presented in Section 2.5, along with recommendations to control point and nonpoint pollutant.

2.10.9 In general, for areas outside Putrajaya, there is a need to:

- upgrade sewage treatment facilities,
- control the pesticide and fertilizer use,
- develop riparian buffer strips or management zones along streams,
- utilisation/development of existing and proposed ponds as mini-wetlands.

2.10.10 The WATER components are the Water and Biota.

2.10.11 Water quality data were reviewed and additional measurements were made for purpose of model calibration (Section 2.6).

2.10.12 At the Temporary Dam Stilling Basin (Table 2.6.6),

- DO is low
- BOD is low
- NO_3 is low
- TP is at or slightly above Ambient Level
- Coliform count is high

2.10.13 From the water quality data and field observations, it is observed that:

- the pattern between top and bottom cells is not simple, reduction as well as increases occur (from -167% to 94% change);
- this is not expected, therefore we speculate that other source inputs, such as lateral inflows, internal resuspension or introduction, may occur.

2.10.14 In the Water Quality Modelling (Section 2.6.3) section the purpose was:

- to estimate capacity of Wetlands and Lake to treat pollutants;
- to predict behaviour of water quality conditions under different scenarios of rainfall and pollutant inputs; and
- to understand factors influencing water quality conditions.

2.10.15 The model used was the MIKE 11 software. This includes hydrodynamic, advection-dispersion, and water quality modules. The model was calibrated for water processes for a normal rainfall (2.2 m) year (1984) to the monitored data of this study. The model results tend to lie in lower range of observed monitored data.

2.10.16 The major parameter of concern is Phosphorus. The modelled parameters were Available Dissolved OrthoPhosphorus and Particulate Phosphorus. The scenarios and results are summarized below.

2.10.17 Scenario 1 - for current TP Pollutant loading from Top, compared to reduced, low TP loading from Top, Same Lateral inflow loading

Results
in wetlands
- low loading slightly better water quality

in Central Wetland
- water quality almost same

in Lake
water quality almost same
➔ Lateral Inflows to system are important

2.10.18 Scenario 2 - for dry (1.6 m) and wet (2.7 m) year, coincides with lower and higher pollutant loading respectively (constant low concentration).

Results
wet year slightly worse water quality
dry
year very slightly better water quality
➔ increased flow in wet year may short-circuit processes

2.10.19 An assessment of the wetland vegetation was also carried out. The vegetation within the wetland cells are expected to provide an ecosystem where nutrient input may be utilised for growth and thus removed from the water column.

2.10.20 The current conditions in the wetlands are presented in Section 2.7.

2.10.21 The observations indicated that both vegetation and aquatic fauna, i.e. fish, will need to be managed in future. The issues to be addressed are:

- plant growth patterns - density and distribution of species,
- weed overgrowth,
- disease and pest infestation,
- water levels management,
- fish community distribution - overpopulation of dominant fish species will be undesirable ecologically, and must be controlled,
- birds and wildlife population number appropriate for the system.

2.10.22 Monitoring measures need to be implemented for:

- vegetation
- fish
- birds and other wildlife

2.10.23 Investigative and research studies need to be carried out on the vegetation communities and their appropriate structure within the Wetlands as well as along the Lake shoreline.

2.10.24 Their effectiveness in

- improving water quality,
- enhancing ecological habitat, and
- ease of maintenance,

are among the factors to be considered.

2.11 RECOMMENDATIONS

2.11.1 Catchment Management and Development

2.11.1.1 Catchment management and development entails that planning be carried out on a catchment basis, following the drainage pattern.

2.11.1.2 The catchment area of Putrajaya Lake comprises of eight major sub-catchments:

- Upper-North,
- Upper-West,
- Upper-East,
- Lower-East,
- Bisa,
- Central,
- Lower, and
- Limau Manis.

2.11.1.3 Comments on the current and potential future development in these sub-catchments for the area outside of Kawasan Putrajaya have been discussed in section 2.5 above and recommendations have been made.

2.11.1.4 The approach of sensitive central core is an appropriate concept in the landuse planning of the area. It allows for the introduction of development in a gradual manner, increasing away from the sensitive zones.

2.11.1.5 The application of softscape designs, such as a riparian management zone (RMZ), especially for natural streams will greatly alleviate the problems of non-point source pollution from overland flow. The riparian zones are planted with

- trees, for shade, and to provide organic detritus for ecosystem development;

- shrubs, to provide prevent incursion across the riparian area, provide bird habitat, and uptake nutrients from the root zone; and

- long grasses, to streamline overland flow, reduce flow velocity, precipitate sediment and capture trash.

2.11.1.6 For point source pollution, centralisation of waste facilities will reduce loadings to levels which can be handled by the wetland systems introduced. In addition the utilisation of existing or future detention ponds will allow for dispersed treatment of point and non-point pollutants prior to discharge into the Putrajaya Wetlands.

2.11.1.7 Monitoring of chemical usage through a register will allow for ease in control and management to prevent possible future problems and allow for assessment of land and buffer zoning measures.

2.11.1.8 In particular the following steps should be taken:

1. Control of lateral surface runoff inflow into the Lake and Wetlands is imperative;

2. Land management measures, such as introduction of vegetated buffer strips, cover of exposed soil, must be carried out;

3. Lake Water and Biological Quality Monitoring, including Discharge monitoring along streams and stormwater outlets, such as recommended in the Lake Management Guide must be implemented;

4. Investigative Monitoring needs to be initiated, aside from standard monitoring, in order to understand the processes occurring within the Wetlands and Lake. The parameters of relevance are Phosphorus (dissolved and particulate), Chlorophyll *a*, Secchi depth, Coliform, Nitrogen (nitrate and ammonia), Dissolved Oxygen. Surface and depth sampling along and across the water bodies and within vegetated areas.

5. Given that the Wetlands and Lake now exist, and the knowledge gained from this study, a detailed assessment of the existing and expected future condition of each Wetland cell and each portion of the Lake would need to be carried out. This is to determine the behaviour of the system and the appropriateness and availability of facilities and infrastructure to control and manage the hydraulic and biological conditions. The behaviour of the vegetation systems, their effectiveness and suitability for the system need to be researched.

Such information will contribute towards better implementation of the development of mini-wetlands, buffer strips, and other land measures, and towards a more effective plan for the management of the Catchment.

6. As the areas around the catchment are still under development, it is important to ensure effective control of erosion and sediment during earthworks and construction activities. It is recommended that a new "Erosion and Sediment Control By Law" be enacted by the Perbadanan Putrajaya and Majlis Daerah Sepang. The recommended By-Laws should be supported by a new manual on "Procedural Standards for Erosion and Sediment Control" which would detail the specifications and design of erosion and sediment control measures and works.

7. The best management practices and guidelines in this report, especially as outlined in Appendices A, B, C, and D, should be made conditions of approval for permission to commence with the project development plan (kelulusan merancang pelan susun atur) within Putrajaya as well as in the Local Plans of the areas within the Putrajaya Lake catchment.

8. A full report on the present status of the wetlands and Lake needs to be prepared to provide the basis for comparison of future change. The report should form the baseline to assess cumulative effects as well as to understand the changes to the Phase 1A Lake prior to Phase 1B being flooded.

9. There is also a need to outline the possible technical and engineering controls that may be implemented to support the management of the wetland system. In addition to the Lake and Wetland Operation Manual there should be consideration of flow inducement, vertical mixing of the water column, weir technology, mechanical systems for wetland management, chemical treatments for phosphorus fixing, sediment removal, as well as possible design modifications.

2.11.2 Monitoring

2.11.2.1 Biological Monitoring

(1) There should be at least quarterly reports on the status of wetland, their efficiency, their input and outputs as well as on water levels. The use of chemicals, their types and quantities applied in the wetlands and lake area must be recorded and reported, for example, for pesticides via the Pesticide Register. The application of fertilizers should follow the guidelines issued by the Department of Agriculture for crop plants.

(2) The details of biological monitoring of vegetation is outlined in the Perbadanan Putrajaya Lake Management Guide and is suitable for application for the mini-wetland areas.

(3) Fish stocks need only be assessed twice a year by sampling through various fishing methods: hook and line, nets, and catch-effort in hours spent. The routine fish sampling recommended previously will provide input for this twice annual assessment.

(4) Wildlife sampling, either through tagging of animals and subsequent trapping or by visual observation and counting, should be carried out seasonally, particularly for birds. This would mean observations in March-April and September-October.

(5) The mini-wetlands maintenance managers for outside of the Perbadanan Putrajaya area should prepare reports on the wetland status, efficiency and maintenance programme at least once every three months. Information on each mini-wetland is to be available. Within Putrajaya the Lake and Wetlands Management Unit should prepare or have a maintenance contractor prepare, the reports for each wetland cell, the Riparian Parks and the Detention Ponds.

2.11.2.2 Water Quality Monitoring

(1) Water quality monitoring for the catchment area outside of Putrajaya is proposed to be on

- a self-monitoring basis in the form of monthly reports on sewage effluent quality and treatment plant efficiency by the plant operators. The Sewage Masterplan section deals with this programme;

- mutual data exchange basis for natural stream flows. The monitoring programme which has been proposed for Perbadanan Putrajaya already includes monitoring of cross-boundary water flow at the different wetlands and at the Cyberjaya border on the Lake. These points represent the effectiveness of non-point source pollutant control measures which will be implemented by the different stakeholders.

(2) Within Perbadanan Putrajaya, the Lake Management Guide provides information on the monitoring programme to be carried out.

(3) The specific water quality parameters of importance are suspended **sediment, Dissolved Phosphorus (Ortho-phosphate), Total Phosphate, and Chlorophylla**. The effect of the three parameters may be estimated by using the **Secchi disk reading**. The Secchi disk reading can be related to the three parameters mentioned by regression analysis. In addition the three parameters may be used to calculate the Carlson Index as outlined in the Lake Management Guide. Investigative monitoring of the three parameters for at least one month on a daily basis should be sufficient to form the basis for the correlation. The monitoring should preferably be repeated at different hydrological/meteorological seasons to take into account flushing rates in the Lake.

(4) The present Putrajaya Lake ambient water quality level for the Secchi disk reading is 0.6 m. As a guide, an observed reading of less than 0.3 m in the Lake will indicate that one, or the combination of the three parameters is reaching undesirable concentrations. Sources of the pollutants should then be sought and some measure of control, e.g. turfing, silt trap maintenance or effluent regulation will need to be implemented on sediment and phosphorus release.

(5) It is expected that in future the ambient Secchi Disk level can be increased depending on observations in the Lake. Possibly a level of 1.0 m may be adopted at the end of 2001 and that a level of 2.5 m might be adopted in 2003.

2.11.3 Special issues

A few specific issues need immediate attention, however. They are

1. the planning, construction, control, and operation of the transport lines crossing the Upper-West and Upper-North Wetlands;

2. the designation of a special habitat area for birds (section 2.9.2.5c) located at the top of the Upper-West Wetland buffer area and north of the proposed B11 highway;

3. the need to develop the promenade area, including the Cyberjaya promenade, and GPTs in the Lake shore between the temporary Dam and Main Dam prior to closure of the Main Dam;

4. revision of landscaping of the shoreline bordering natural streams and wetlands to conform to riparian management zone functions.

2.12 REFERENCES

1. Alfred, E.R. (1964), Some colourful fishes of the Geneus *Puntius H*amilton,Bull. Nat. Mus. Singapore, Vol. # 32, pp.# 135-142

2. Angkasa GHD Engineers Sdn. Bhd., GHD Pty. Ltd. (1996), Putrajaya Lake Phase 1 Concept Design Report Wetland Component, August 1996. PJ Holdings Sdn. Bhd.

3. Corner, E.J.H. (1978), The freshwater swamp of South Johor and Singapore. Gardens Bulltin Suppl. No. 1, 266 pp

4. Holttum, R.E. (1954), A revised flora of Malaya, Vol. # 1, Orchids, Vol. 2 Ferns. Government Printing Office, Singapore

5. Idris, M.S & Rozaina, Z. (1992), An updated list of wetland plant species of Peninsular Malaysia with particular reference to those having socio-economic value. AWB Publication No. 79, 103 pp.

6. Inger, R.F & Chin, P.K. (1962), The freshwater fishes of North Borneo, Fieldiana Zool. Vol. # 45, pp. 1-268

7. IUCN (1994), IUCN red list categories. Gland, Switzerland: IUCN

8. Kumpulan Perunding Kota Bistari Sdn. Bhd. (1996), Water Quality Management Control and Mangement Study Report, Draft Final report, February 1996. Putrajaya Lake Development. Putrajaya Holdings Sdn Bhd.

9. Mohsin, A.K.M. & Ambak, M.A. (1982), Freshwater fishes of Peninsular Malaysia. UPM Publication. 283pp

10. Ng, F.S.P. (1978), Tree Flora of Malaya, Vol.# 3, Forest Department, Ministry of Primary Industries, 339 pp.

11. Ng, P.K.L., Tay, J.B., Lim, K.K.P. and Yang, C.M. (1992), The conservation of fish and other aquatic fauna of North Selangor Peat Swamp Forest and adjacent areas. AWB Publication # 81, 90 pp, KL Malaysia.

12. Pancho, J. & Soejani, M. (1978), Aquatic weeds of South-East Asis. National Publishing Cooperatives, Quezon City, 109 pp.

13. Ridley, H.N. (1922-1925), The flora of Malay Peninsula, Vol. # 1-5, Reeve, London.

14. Whitmore, T.C. (1988), Forest types and forest zonation. Key environments Malaysia. IUCN, Pergamon Press, pp # 20-30.

15. Wyatt-Smith, J. & Kochumen, K.M. (1979), Pocket check list of timber trees. Malayan Forest Records # 17, Forest Department, Peninsular Malaysia. 362 pp.

APPENDIX 2.1
PUTRAJAYA WATER QUALITY DATA AS MONITORED BY UPM

Date:30.8.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	6.2	4.4	6.8	9.4	3.2	8.2	6.4	4.4	7.8	-
BOD	3.93	0.79	0.47	1.10	0.41	0.85	1.46	1.33	2.00	-
NO3	0.8	0.4	0.4	0.7	0.6	0.3	0.2	0.6	0.8	-
TP	0.31	0.07	0.11	0.09	0.07	0.07	1.76	0.33	0.31	-
Dis.P	0.29	0.04	0.09	0.05	0.07	0.03	1.46	0.05	0.09	-
Par.P	0.02	0.03	0.02	0.04	0	0.04	0.30	0.28	0.22	
Turbidity,NTU	6.49	0.99	9.24	0.07	14.75	1.90	5.57	0.07	4.66	-
Ecoli	5000	0	10000	0	0	0	0	0	0	-
Tcoli	10000	0	25000	0	2000	0	0	5000	1000	-

Date:6.9.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	3.0	3.5	4.2	4.8	3.4	4.6	0.6	4.8	7.0	4.0
BOD	3.45	0.69	0.14	0.68	0.16	0.49	2.19	0.40	1.16	1.09
NO3	0.9	0.8	0.7	0.5	0.1	0.8	0.2	1.4	0.4	1.1
TP	4.36	8.53	1.53	3.66	2.73	1.16	0.77	1.86	0.37	0.34
Dis.P	2.4	3.16	1.13	3.0	1.26	0.86	0.65	1.5	0.32	0.27
Par.P	1.96	5.37	0.40	0.66	1.47	0.3	0.12	0.36	0.05	0.07
Turbidity,NTU	15.67	7.41	13.83	6.49	23.00	8.33	29.43	4.66	4.66	8.33
Ecoli	10000	10000	20000	10000	20000	1000	0	2000	7000	4000
Tcoli	15000	12000	25000	25000	30000	5000	5000	14000	10000	0

Date:8.9.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	1.8	2.9	2.2	3.6	2.6	4.0	3.8	4.6	-	4.2
BOD	4.04	0.06	1.86	0.73	0.35	0.79	0.52	0.56	-	0.41
NO3	0.9	0.7	0.8	0.7	0	0.5	0.8	0.9	-	0.7
TP	0.35	0.08	0.15	0.07	0.06	0.08	0.40	0.85	-	0.57
Dis.P	0.17	0.03	0.05	0.03	0.02	0.04	0.03	0.04	-	0.01
Par.P	0.18	0.05	0.10	0.04	0.04	0.04	0.37	0.81	-	0.56
Turbidity,NTU	17.5	12.0	75.3	6.49	27.59	9.24	6.49	4.66	-	7.41
Ecoli	1200	100	1000	6000	300	200	0	300	-	2000
Tcoli	8000	1500	3000	16000	2000	900	1000	1200	-	5000

Date:10.9.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	1.8	3.2	2.4	3.3	2.0	2.8	2.2	4.0	3.4	2.8
BOD	5.46	0.87	1.51	1.17	0.58	0.68	2.56	0.65	1.49	1.89
NO3	0.8	0.2	0	0.6	0	0.2	0	0.4	0.4	0.5
TP	0.44	0.13	0.18	0.16	0.18	0.13	0.17	0.10	0.11	0.15
Dis.P	0.29	0.06	0.11	0.06	0.08	0.05	0.12	0.05	0.05	0.05
Par.P	0.15	0.07	0.07	0.1	0.1	0.08	0.05	0.05	0.06	0.1
Turbidity,NTU	15.67	14.75	24.84	9.24	35.85	10.16	23.01	9.24	8.33	19.34
Ecoli	10000	15000	5000	600	5000	2000	0	0	1500	3000
Tcoli	15000	20000	12000	4000	12000	5000	1000	600	3100	5000

Date:13.9.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	1.8	2.6	2.0	2.8	3.4	2.0	2.0	3.8	3.2	-
BOD	7.5	0.93	1.29	0.76	0.68	0.90	2.53	0.66	0.90	-
NO3	5.1	0.4	0.1	0.2	2.3	0.2	0.5	0.5	0.7	-
TP	0.32	0.21	0.12	0.05	0.04	0.09	0.64	0.04	0.05	-
Dis.P	0.09	0.15	0.07	0.04	0.04	0.08	0.61	0.02	0.03	-
Par.P	0.23	0.06	0.05	0.01	0	0.01	0.03	0.02	0.02	-
Turbidity,NTU	13.83	3.74	12.0	5.57	9.24	31.26	45.94	0.07	4.66	-
Ecoli	800	0	400	0	500	600	200	0	200	-
Tcoli	2500	1500	2500	2000	20000	3200	2500	400	1000	-

I. Date:15.9.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	1.8	2.8	2.4	2.8	2.0	3.2	1.8	3.6	3.5	3.8
BOD	2.5	0.58	0.17	0.96	0.75	0.7	1.02	1.07	1.0	1.3
NO3	2.1	0.4	0.6	1.6	1.1	0.5	0	1.5	0.9	2.8
TP	0.1	0.11	0.1	0.08	0.08	0.12	0.07	0.14	0.05	0.07
Dis.P	0.06	0.04	0.06	0.05	0.04	0.09	0.03	0.06	0.04	0.04
Par.P	0.04	0.07	0.04	0.03	0.04	0.03	0.04	0.08	0.01	0.03
Turbidity,NTU	39.52	23.01	14.75	32.18	45.03	11.08	49.61	3.74	6.49	9.24
Ecoli	1000	100	300	100	200	100	0	200	0	200
Tcoli	2500	500	1200	300	400	400	300	1000	2200	400

Date:17.9.99

	UN8	UN1	UW7	UW1	UE3	UE1	LE2	LE1	CW	Dam
DO	2.2	2.4	2.2	2.4	2.2	3.2	1.2	4.6	4.0	3.6
BOD	4.32	1.14	1.01	0.84	1.63	0.81	0.64	4.46	1.26	1.63
NO3	0.2	1.5	4.4	2.9	5.2	1.8	7.6	3.1	2.9	2.9
TP	0.14	0.08	0.55	0.08	0.04	0.11	0.5	0.1	0.09	0.1
Dis.P	0.05	0.05	0.4	0.06	0.03	0.08	0.14	0.09	0.06	0.05
Par.P	0.09	0.03	0.15	0.02	0.01	0.03	0.44	0.01	0.03	0.05
Turbidity,NTU	34.93	18.42	202.84	6.49	124.85	12.91	140.45	4.66	7.41	26.68
Ecoli	2000	1200	1400	0	2200	100	2000	0	200	400
Tcoli	7000	2500	4000	1000	3200	600	2500	1500	2200	700

APPENDIX 2.2
PUTRAJAYA WATER QUALITY DATA FOR EACH CELL AS MONITORED BY UPM

Upper North Wetland
Date: 22.9.99

	UN8	UN7	UN6	UN5	UN4	UN3	UN2	UN1
DO	2.0	2.8	3.4	2.6	2.4	3.0	1.8	2.6
BOD	3.56	3.1	1.42	0.57	0.50	0.17	0.25	0.11
NO3	1.1	0.9	1.4	1.3	1.0	0.7	1.8	0.9
TP	0.04	0.03	0.04	0.04	0.04	0.02	0.02	0.02
Dis.P	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Par.P	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Turbidity, NTU	20.25	29.43	10.16	25.76	11.08	10.16	11.08	13.83
Ecoli	3000	200	0	0	100	1200	0	0
Tcoli	4000	900	500	800	1000	200	500	700

Upper West Wetland
Date:24.9.99

	UW7	UW6	UW5	UW4	UW3	UW2	UW8	UW1
DO	2.2	2.0	2.2	2.6	2.8	2.6	3.2	2.8
BOD	2.12	0.98	1.57	1.22	2.92	1.56	1.66	1.88
NO3	0	0.4	0	0.5	0.6	0.4	0.3	0.6
TP	0.1	0.01	0.02	0.08	0.04	0.05	0.08	0.03
Dis.P	0.03	0	0	0.02	0	0.02	0.02	0.01
Par.P	0.07	0.01	0.02	0.06	0.04	0.03	0.06	0.02
Turbidity,NTU	405.6	19.3	28.5	7.4	7.4	10.1	17.0	4.0
Ecoli	2500	100	1000	200	300	0	500	0
Tcoli	3500	200	2000	700	800	500	2800	300

Upper East and Lower East Wetland
Date:24.9.99

	UE3	UE2	UE1	LE2	LE1	CW	DAM
DO	2.2	2.2	3.3	3.2	3.8	3.8	4.0
BOD	0.48	0.39	0.25	0.31	0.49	0.93	0.85
NO3	0	0	0.5	0.5	0.4	1.0	1.0
TP	0.41	0.11	0.02	0.05	0.06	0.01	0.04
Dis.P	0.34	0.09	0.01	0.02	0.04	0	0.01
Par.P	0.07	0.02	0.01	0.03	0.02	0.01	0.03
Turbidity,NTU	39	6	5	15	1	4	2
Ecoli	0	100	200	0	0	0	100
Tcoli	2000	600	600	700	1000	500	5000

APPENDIX 2.3
PUTRAJAYA WATER QUALITY DATA AS MONITORED BY UPM

a. Upstream Sg Chuau from UPM side entering MARDI

	U0	U10	U30	U100	U150
Distance, m	0	10	30	100	150
DO	0.6	0.4	0.4	0.5	2.0
BOD	12.75	9.7	11.7	13.75	7.35
NO3	0.6	1.0	0.8	0.9	0.9
TP	5.0	3.6	2.8	3.4	3.7
Dis.P	0.8	0.9	1.1	1.2	1.1
Par.P	4.2	2.7	1.7	2.2	2.6
Turbidity, NTU	0.99	1.90	2.82	12.91	0.07
Ecoli	10000	15000	15000	20000	12500
Tcoli	15000	20000	20000	25000	20000

b. Downstream Sg Chuau from MARDI entering UPM

	M0	M50	M110	M210	M310	M410	M440
Distance, m	0	50	110	210	310	410	440
DO	0.4	0.2	0.6	0.8	1.0	1.8	1.8
BOD	18.42	17.07	17.52	17.61	17.49	14.64	12.99
NO3	0.6	2.3	1.3	2.8	2.7	1.4	1.3
TP	8.5	6.4	7.7	6.0	4.2	5.1	4.6
Dis.P	8.0	6.3	7.1	4.6	3.4	4.2	4.0
Par.P	0.5	0.1	0.6	1.4	0.8	0.9	0.6
Turbidity,NTU	34.93	32.18	30.35	32.18	18.42	17.5	12.0
E. Coli	20000	30000	25000	15000	25000	20000	20000
Total Coli	25000	40000	30000	20000	30000	25000	25000

APPENDIX 2.4
PRELIMINARY MODEL SIMULATIONS

1.0 Preliminary Model simulation and performance

Model runs were carried out to compare removal efficiencies in the wetlands. Three scenarios were *simulated*:

a) with design inflow and ambient water quality parameter;
b) with high hydraulic loading and
c) with high concentrated loading.

The run-off scenario with the expected pollutant from each landuse area will be simulated to assess the long term aspects of water quality in the lake.

a) Scenario 1: Design inflow and ambient parameters

The model was run with the design inflow rates and the values of the average day's sampling(May 20 1999) as shown in Table 1.1. The phosphorus content was less than 0.01mg/l for the sampling data. A concentration value of 2 mg/l for Total Phosphorus was given for modelling with 30% Dissolved Phosphorus and 70% Particulate Phosphorus . The modelling results and performance was as shown in Table 1.2. The values of the parameters are the depth averaged concentrations. For the lake, the value was the average of a 3-metre water column depth.

Upper East wetland showed lower performance generally.Since it drained into the Upper North wetland, the overall reduction is reflected in the Upper North's final performance. Except for the Upper East wetlands, the carbon (BOD) removal was 62% - 86%; the nitrogen (ammonia) removal was 86% - 94%; the phosphorus removal was 42% - 67% for dissolved phosphorus and 71% - 83% for particulate phosphorus.

Table 1.1 Parameter inputs for the Model Run.

Parameter		**UN**	**UW**	**UE**	**LE**	**UB**
Design Inflow, m^3/s		0.376	0.188	0.114	0.059	0.137
Temp, ^oC		32.8	37.0	28.2	29.4	30.4
DO, mg/l		6.0	5.2	5.6	5.1	6.0
Ammonia,	mg/l	0.33	0.25	0.28	0.41	0.35
	kg/day	10.72	4.06	2.76	2.09	4.14
Nitrate,	mg/l	1.61	3.67	0.80	0.73	2.64
	kg/day	52.30	59.61	7.88	3.72	31.25

BOD,	mg/l	2.0	2.0	2.0	2.0	2.0
	kg/day	64.97	32.48	19.70	10.19	23.67
Phosphorus Dis. mg/l		0.6	0.6	0.6	0.6	0.6
Phosphorus Par., mg/l		1.4	1.4	1.4	1.4	1.4
Tot. Phosphorus, mg/l		2.0	2.0	2.0	2.0	2.0
	kg/day	64.97	32.48	19.70	10.19	23.67

Table 1.2 Model Performance of the Various Wetlands.

Parameter	**BOD (mg/l)**	**NH (mg/l)**	**NO (mg/l)**	**OP (mg/l)**	**PP (mg/l)**	**DO (mg/l)**
UN*i*	0.300	0.036	0.160	0.158	0.241	3.483
UN*o*	0.042	0.002	0.005	0.055	0.040	1.671
% change	**-86**	**-94**	**-97**	**-65**	**-83**	**-52**
UW*i*	0.307	0.034	0.432	0.170	0.241	2.596
UW*o*	0.042	0.002	0.005	0.055	0.040	1.671
% change	**-86**	**-94**	**-99**	**-67**	**-83**	**-35**
UE*i*	0.091	0.008	0.019	0.080	0.082	2.365
UE*o*	0.050	0.003	0.007	0.060	0.048	1.845
% change	**-45**	**-62**	**-63**	**-25**	**-41**	**-22**
LE*i*	0.163	0.027	0.049	0.088	0.123	1.780
LE*o*	0.038	0.002	0.003	0.051	0.036	1.584
% change	**-76**	**-92**	**-94**	**-42**	**-71**	**-11**
UB*i*	0.082	0.007	0.036	0.058	0.066	1.296
UB*o*	0.031	0.001	0.001	0.028	0.018	0.998
% change	**-62**	**-86**	**-97**	**-52**	**-73**	**-23**
P_Lake	0.031	0.001	0.001	0.029	0.018	1.011

i : inflow at the first cell
o : outflow from the last cell

The particular water quality at the primary lake was within the Lake Water Quality Standards. The DO reflected the immediate oxygen demands and so low values were obtained. This may be contrasted with the mean measured surface DO which were of reasonable concentrations (5.3 - 6.7 mg/l).

The carbon and nitrogen pollutants were decomposed in the wetlands whereas the phosphorus concentration had still not reached equilibrium and was accumulating. The phosphorus is expected to be bound in the sediments or plants. However, the phosphorus contents may be released during high flow when sediments are agitated.

b) Scenario 2: High Hydraulic Loading - High inflow and ambient parameters. Error! Bookmark not defined.

A high hydraulic loading with five times the design inflow and ambient condition for concentration was run to determine the limit of the wetlands performance for high flows. The results were as shown in Table 1.3.

Table 1.3 Model Performance of the Various Wetlands with Five Times Design Inflow.

Parameter	**BOD (mg/l)**	**NH (mg/l)**	**NO (mg/l)**	**OP (mg/l)**	**PP (mg/l)**	**DO (mg/l)**
UN*i*	1.043	0.115	0.535	0.458	0.847	4.221
UN*o*	0.171	0.008	0.018	0.241	0.213	1.817
% change	**-84**	**-93**	**-97**	**-47**	**-75**	**-57**
UW*i*	0.904	0.089	1.143	0.460	0.724	3.266
UW*o*	0.171	0.008	0.018	0.241	0.213	1.817
% change	**-81**	**-91**	**-98**	**-47**	**-70**	**-44**
UE*i*	0.372	0.030	0.079	0.311	0.369	2.795
UE*o*	0.214	0.011	0.030	0.257	0.250	2.048
% change	**-42**	**-63**	**-62**	**-17**	**-32**	**-27**
LE*i*	0.630	0.112	0.199	0.332	0.504	2.666
LE*o*	0.145	0.007	0.012	0.226	0.188	1.682
% change	**-77**	**-94**	**-94**	**-32**	**-62**	**-37**
UB*i*	0.286	0.029	0.170	0.242	0.289	1.661

UB*o*	0.076	0.003	0.003	0.148	0.102	1.069
% change	**-73**	**-89**	**-98**	**-39**	**-65**	**-35**
P_Lake	0.076	0.003	0.003	0.149	0.103	1.077

i : inflow at the first cell
o : outflow from the last cell

With five times the design inflow, the removal rate of carbon(BOD) was 73% to 84% and for nitrogen(ammonia), 89% to 94% by the wetlands except Upper East wetland. There was a better circulation effect as indicated by the higher initial DO value. The water was flowing over faster in the cells.

For Dissolved Phosphorus, the removal rate was 32% to 47% and for Particulate Phosphorus, 62% to 75% which were lower than at design inflow. Phosphorus may be released into the water when agitated at high flow and carried down.

The water quality at the primary lake was within Ambient Lake Standards for BOD and nitrogen. For total phosphorus(= 0.252 mg/l), it was higher than ambient Standards(=0.05 mg/l).

At high discharges therefore, the wetlands are unabled to remove the phosphorus sufficiently due to the shorter retention times.

c) **Scenario 3**: Sewage Loading and half design inflow.

A loading of treated sewage discharge to all the wetlands with half the design inflow as in Table 1.4 was run to simulate the performance at high concentration loading. The results are in Table 1.5.

Table 1.4 Sewage Loading Parameters

Parameter input	**Concentration**	**Loading, kg/day**				
		UN	**UW**	**UE**	**LE**	**UB**
Inflow, m^3/s	-	0.188	0.094	0.057	0.029	0.068
Temp, ^oC	30.0	-	-	-	-	-
DO, mg/l	5.0	-	-	-	-	-
Ammonia, mg/l	10.0	162.5	81.1	49.2	24.9	58.8
Nitrate, mg/l	10.0	162.5	81.1	49.2	24.9	58.8
BOD, mg/l	20	324.9	162.2	98.4	49.9	117.6

Phosphorus Dis., mg/l	0.6	9.8	4.8	2.9	1.4	3.4
Phosphorus Par., mg/l	1.4	22.8	11.3	6.9	3.6	8.2

Table 1.5 Model Performance of the Various Wetlands with Sewage Loading

Parameter	**BOD (mg/l)**	**NH (mg/l)**	**NO (mg/l)**	**OP (mg/l)**	**PP (mg/l)**	**DO (mg/l)**
UN*i*	1.647	0.568	0.690	0.089	0.131	1.926
UN*o*	0.183	0.020	0.027	0.028	0.021	1.322
% change	**-89**	**-96**	**-96**	**-68**	**-84**	**-31**
UW*i*	1.846	0.787	0.839	0.101	0.142	1.532
UW*o*	0.183	0.020	0.027	0.028	0.020	1.322
% change	**-90**	**-97**	**-81**	**-72**	**-86**	**-14**
UE*i*	0.457	0.114	0.139	0.043	0.043	1.698
UE*o*	0.227	0.031	0.044	0.031	0.024	0.889
% change	**-50**	**-73**	**-68**	**-28**	**-44**	**-47**
LE*i*	0.806	0.339	0.346	0.046	0.063	1.302
LE*o*	0.157	0.015	0.019	0.026	0.018	1.283
% change	**-80**	**-95**	**-94**	**-43**	**-71**	**-1**
UB*i*	0.382	0.091	0.081	0.030	0.034	0.881
UB*o*	0.084	0.005	0.004	0.013	0.009	0.876
% change	**-78**	**-94**	**-95**	**-56**	**-73**	**-1**
P_Lake	0.083	0.005	0.004	0.013	0.009	0.889

i : inflow at the first cell
o : outflow from the last cell

With low flow, there are longer retention time for wetland processes. The removal rate was generally better. For carbon(BOD), 78%-90%; for nitrogen(ammonia), 94%-97%; for dissolved phosphorus, 43%-72% and for particulate phosphorus, 71%-86% except Upper East which flows into Upper North wetland. With high pollutant loading and less flushing, the water became septic as indicated by the low DO in the inflows and outflows of the wetlands.

The water quality at the primary lake was within Ambient Lake Water Standards.

2.0 Model summary and discussion

From the simulation of the dynamic processes of the water quality, it was predicted that the wetlands performed well for the removal of BOD and nitrogen even with typical treated sewage effluents. For phosphorus, the uptake by plants in the wetlands should remove the accumulated phosphorus in the sediments. The plants debris and dying plants must be regularly removed to improve the uptake of phosphorus and reduce the accumulated sink in the wetlands.

The model results was comparable to the designed wetlands performance as reported in Putrajaya Lake Phase 1: Concept Design Report - Wetland Component (Perbadanan Putrajaya,1996). The report indicated that the removal of the main nutrients by the wetlands processes should be:

1. 20-80% for Phosphorus,
2. 90% for Nitrogen and
3. 50-90% for carbon

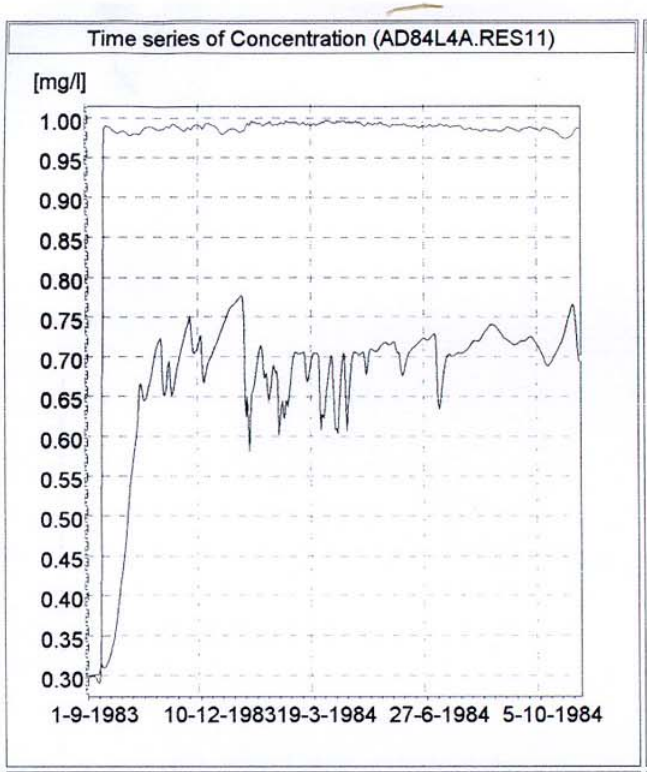
based on the earlier Water Quality Control and Management Study report (Kumpulan Perunding Kota Bistari, 1997).

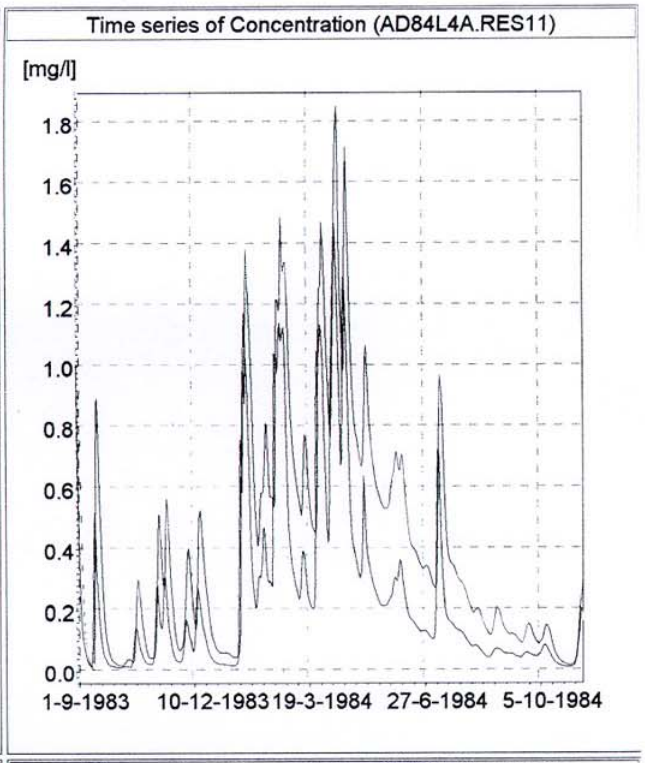
For high flow scenario, phosphorus levels were higher. It was supposed that this was due to particulate BOD and phosphorus being be carried in suspension by the faster stream flow and short-circuiting of processes in each cell will occur. To prevent such occurrence, the placement of vegetation and the planting density must be able to reduce flow and trap a reasonable amount of these particulates at regular high run-off. In addition, there should be land management measures to reduce high runoff flow velocities. However, as high flow is only intermittent and pollutant dilution will occur, high flow condition is not regarded to be a major problem.

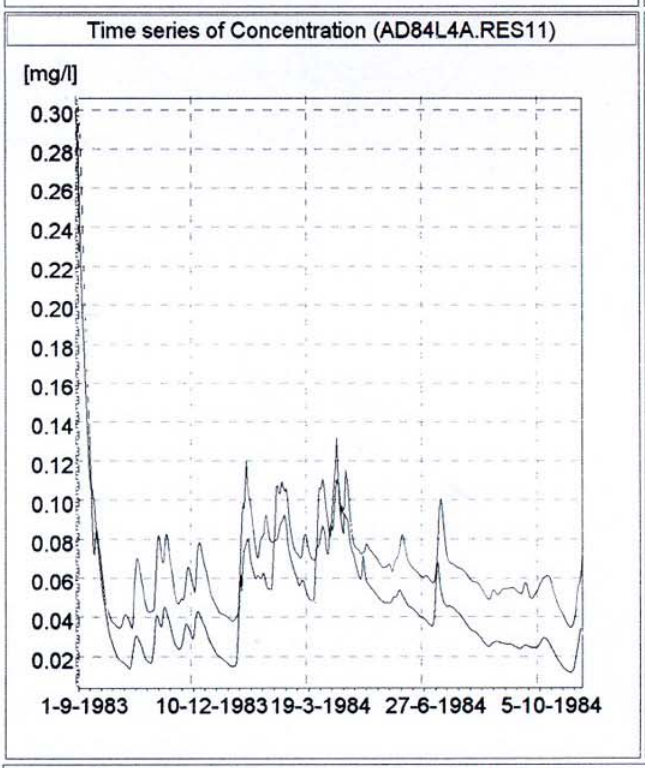
At low flow, as in the dry season, the model predicted that the water quality better water quality conditions in general. The Dissolved Oxygen levels were reduced, however, probably due to the low flow conditions and degradation of organic waste inside the cells. At such conditions, the water quality may deteriorate if there were sewage inflow into the wetland cells. The higher organic load would require more oxygen for degradation. The water may then become septic and regular pump-back or recirculation from the lake will be needed at dry season to increase flow and aerate the water plants.

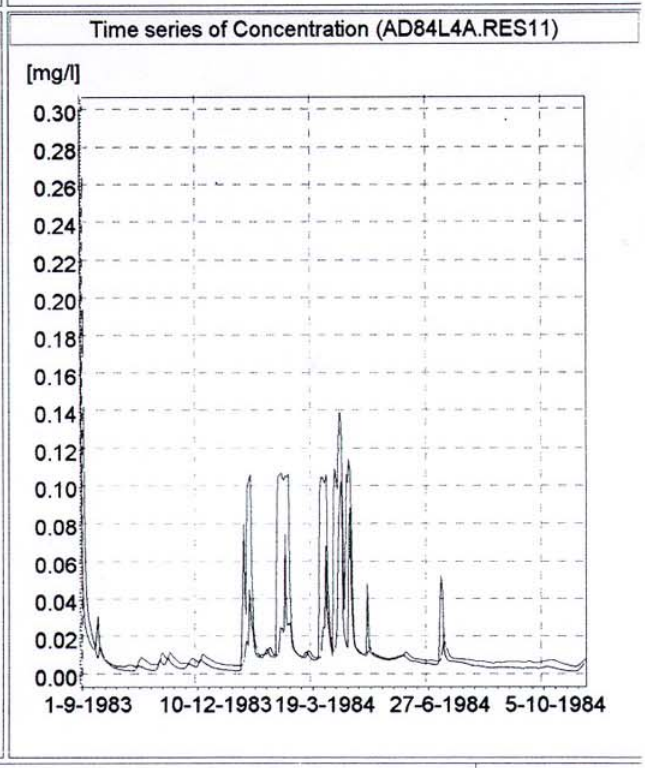
APPENDIX 2.5

TIME SERIES OF CONCENTRATION FOR THE 1984-RUN

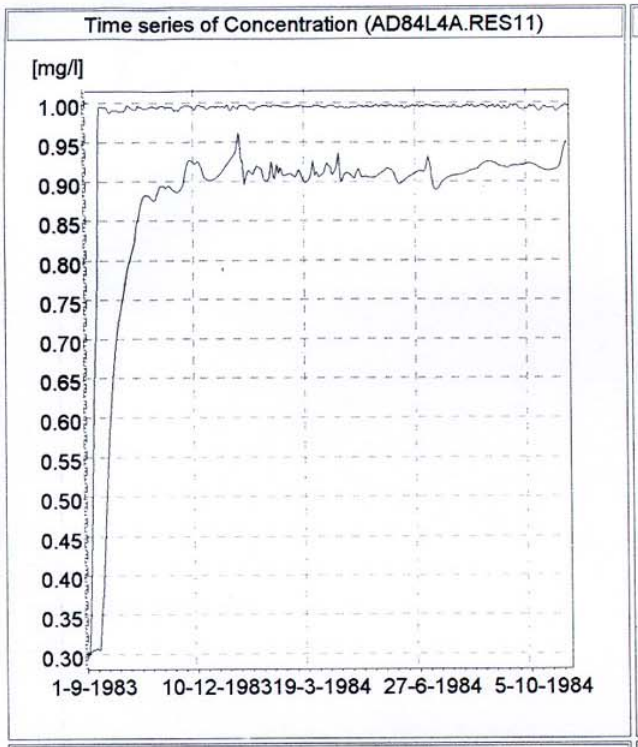


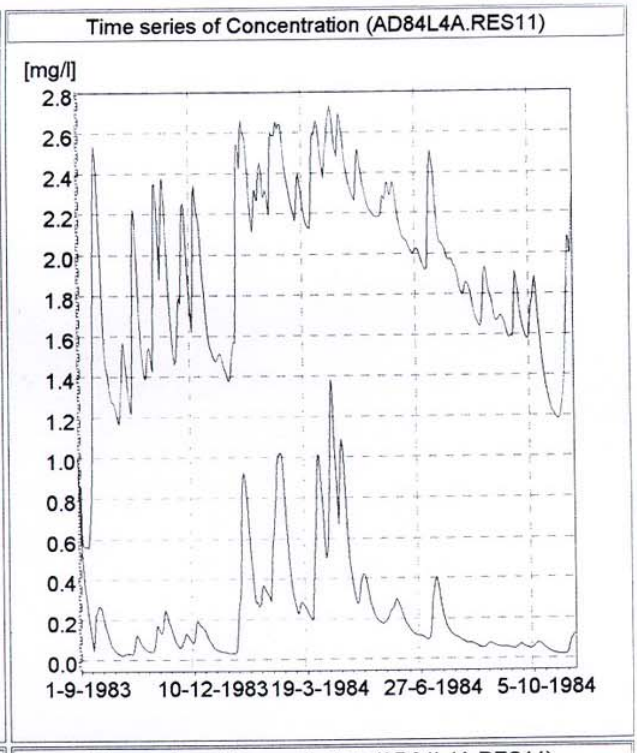


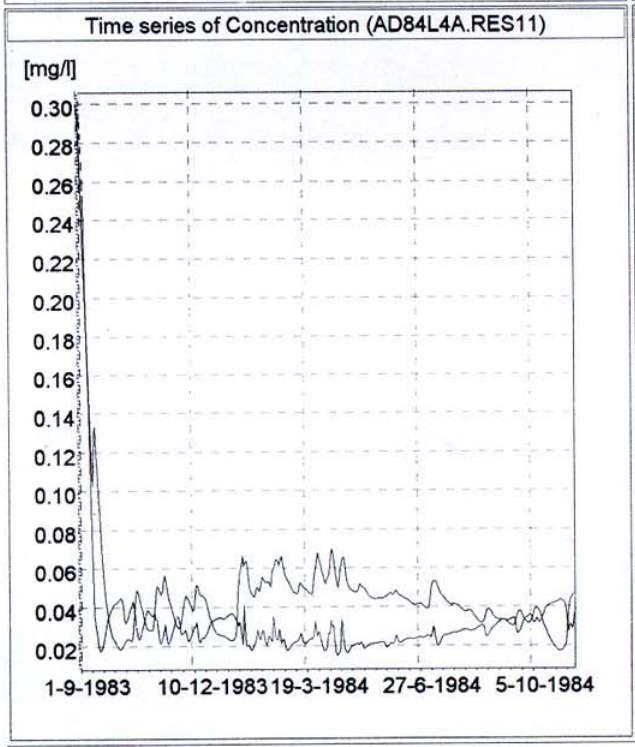


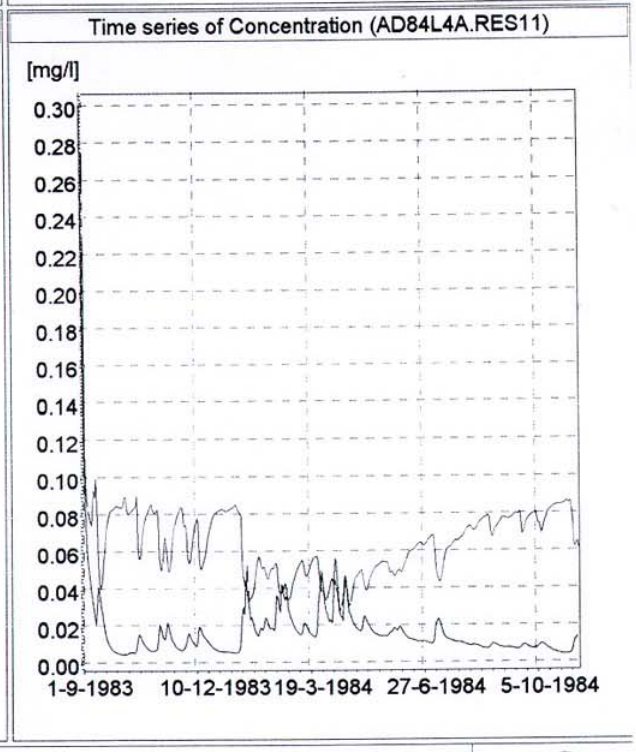


Time Series of Concentrations (1984 run)
for Upper-West wetland Top and Last Cell
NH3, BOD
Dis.P, Par.P

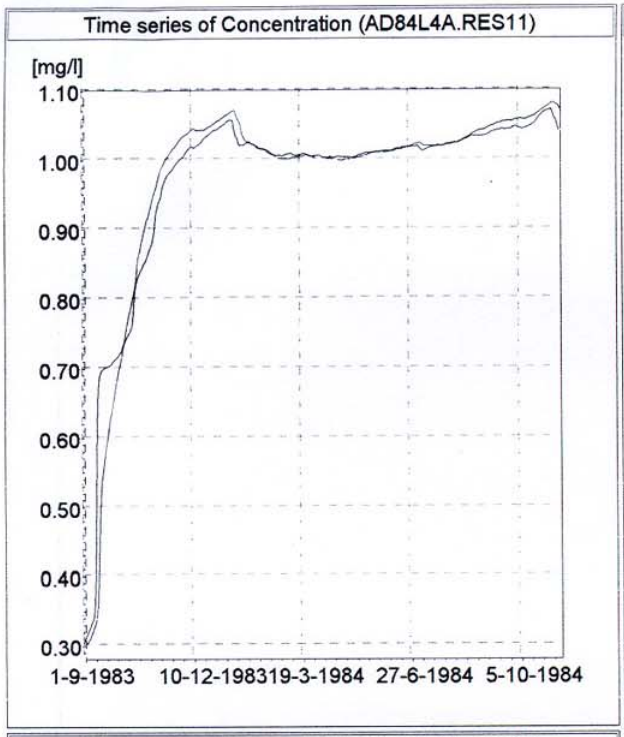


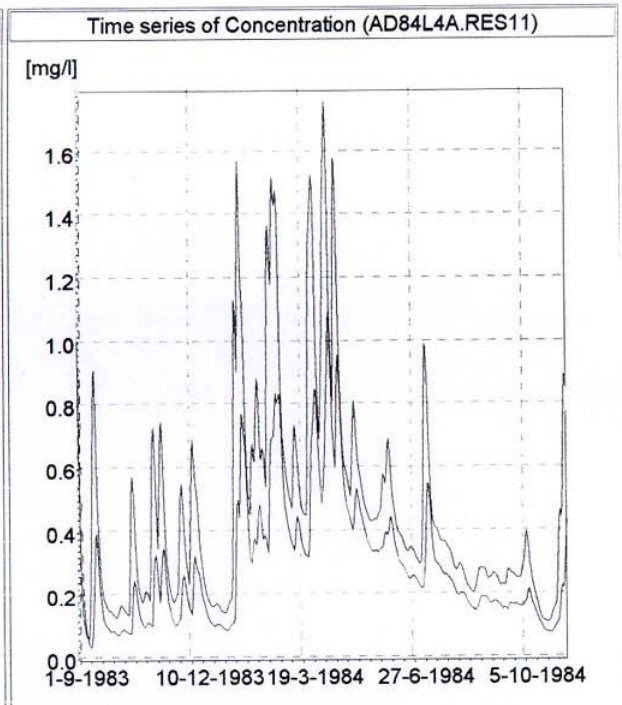


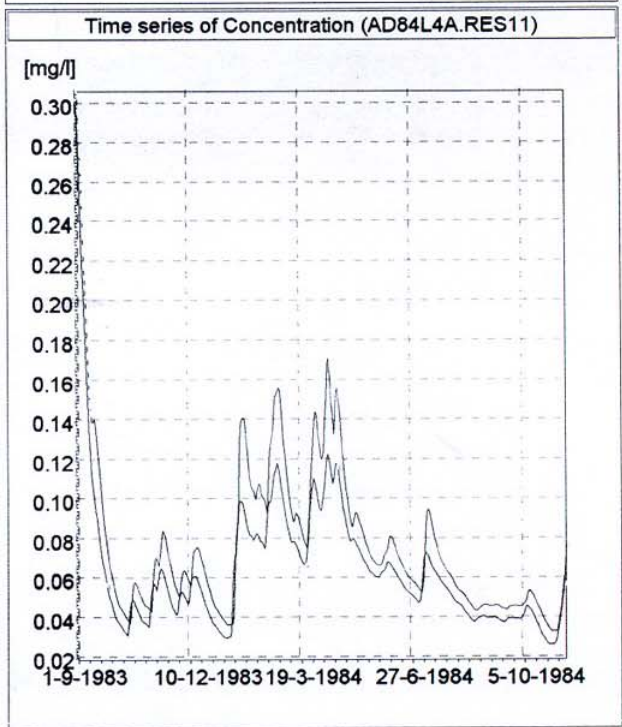


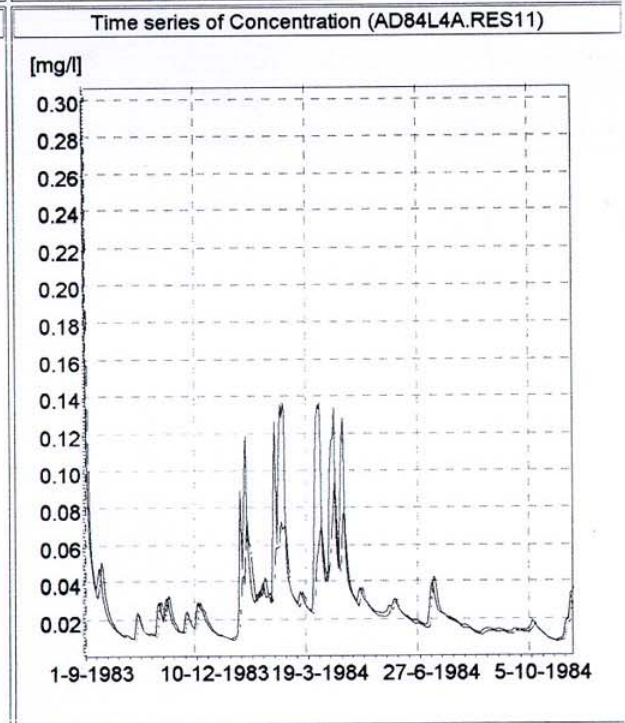


Time Series of Concentrations (1984 run)
for Upper-North wetland Top and Last Cell
NH3, BOD
Dis.P, Par.P

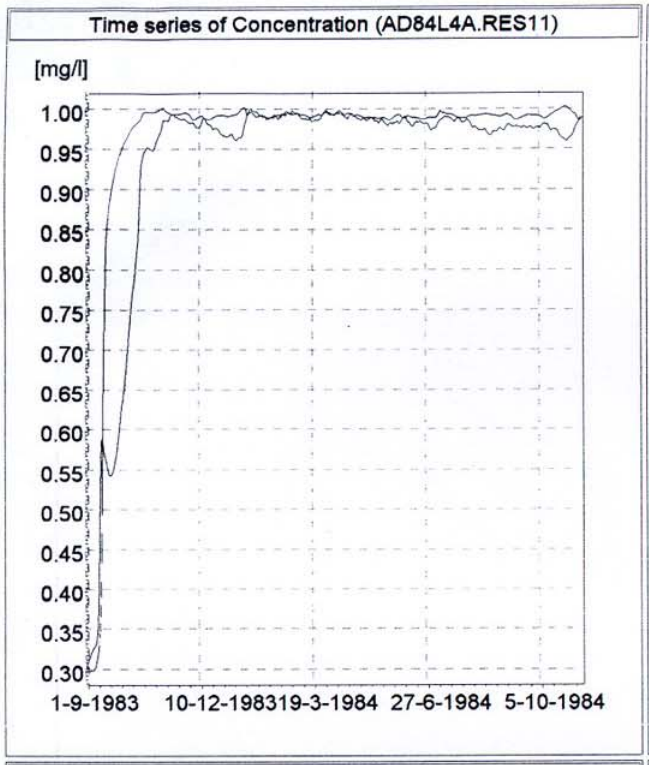


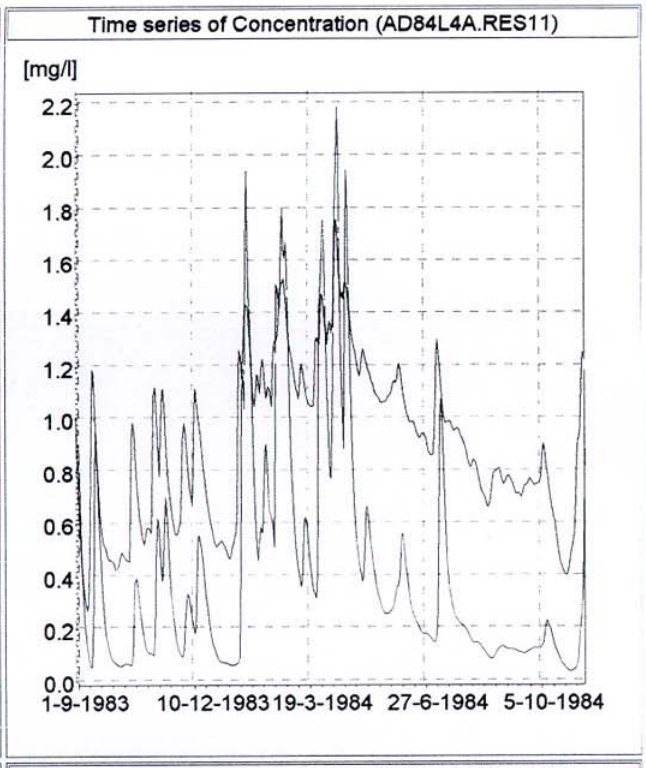


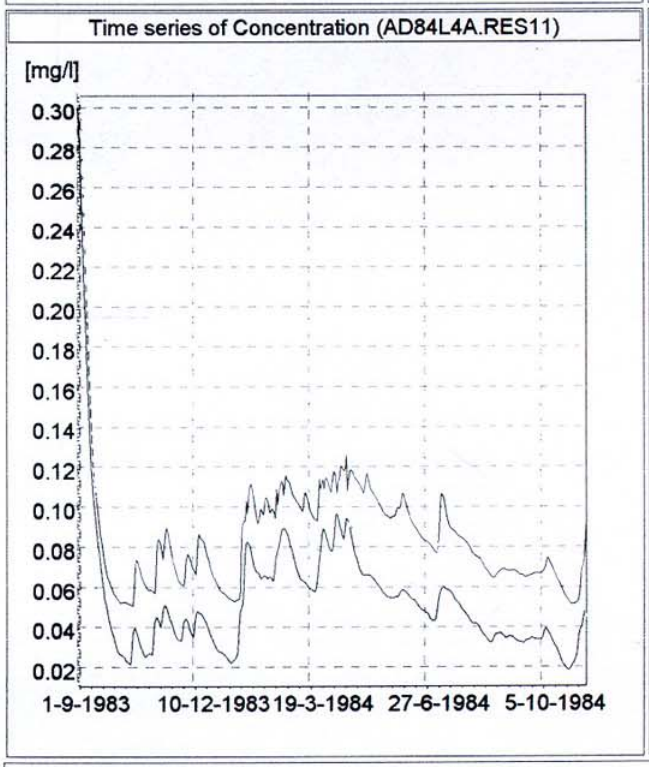


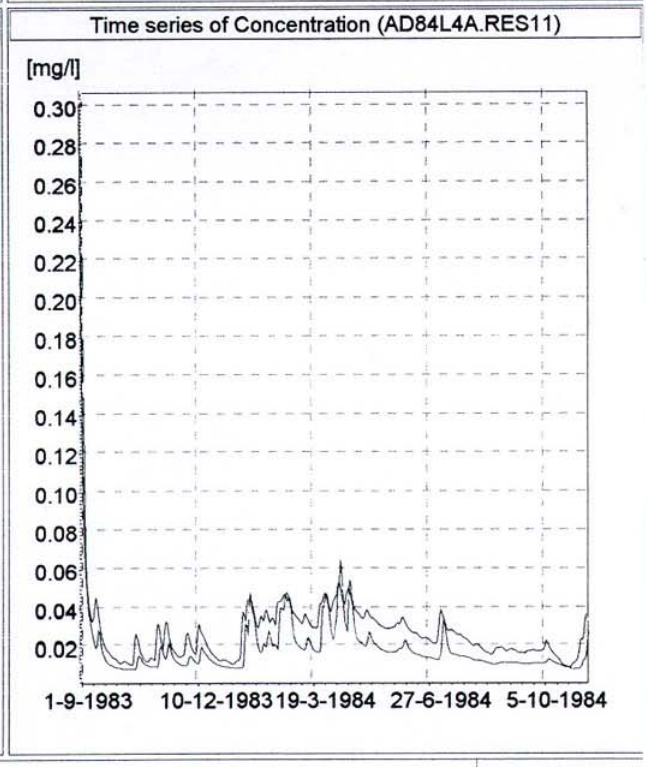


Time Series of Concentrations (1984 run)
for Upper-East wetland Top and Last Cell
NH3, BOD
Dis.P, Par.P

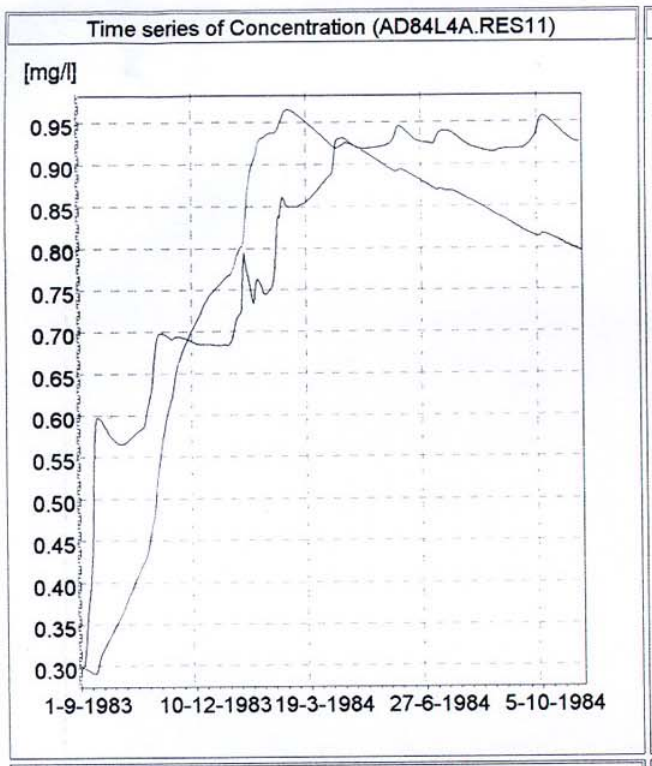


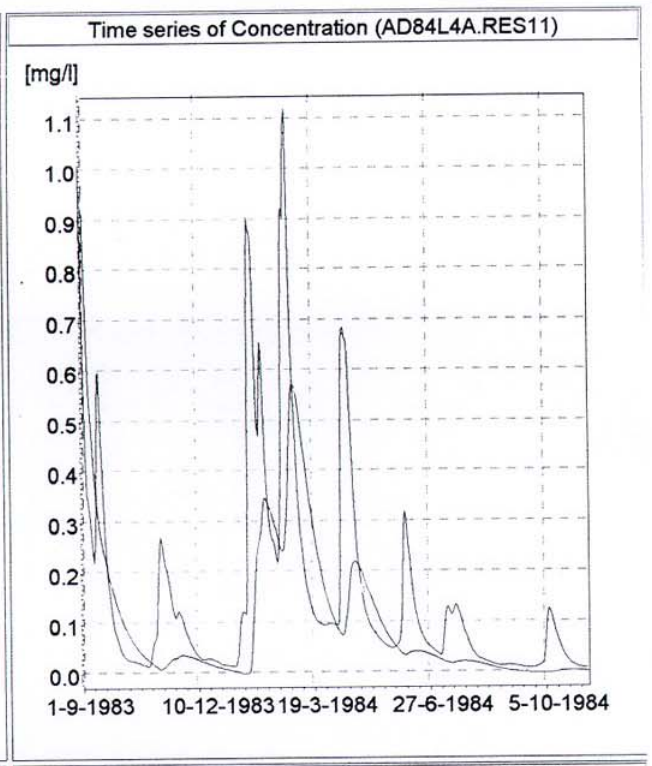


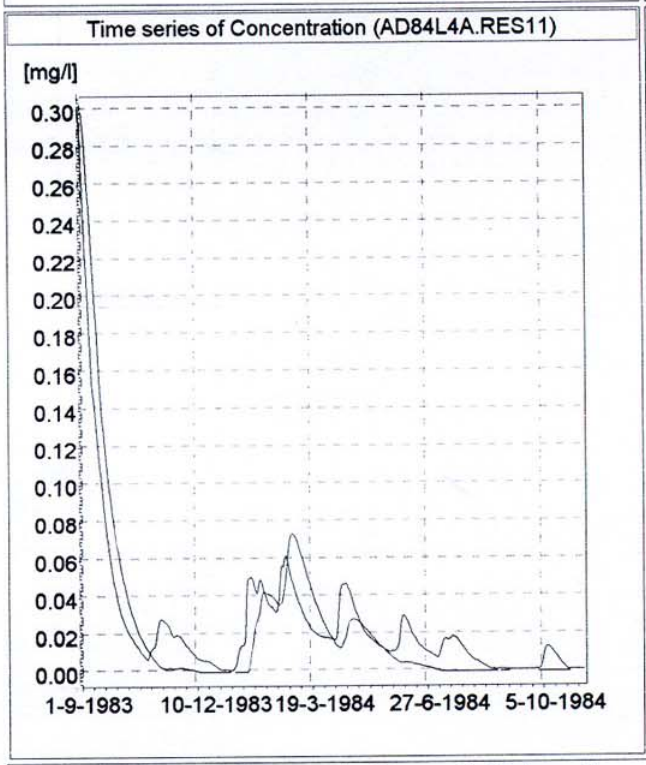


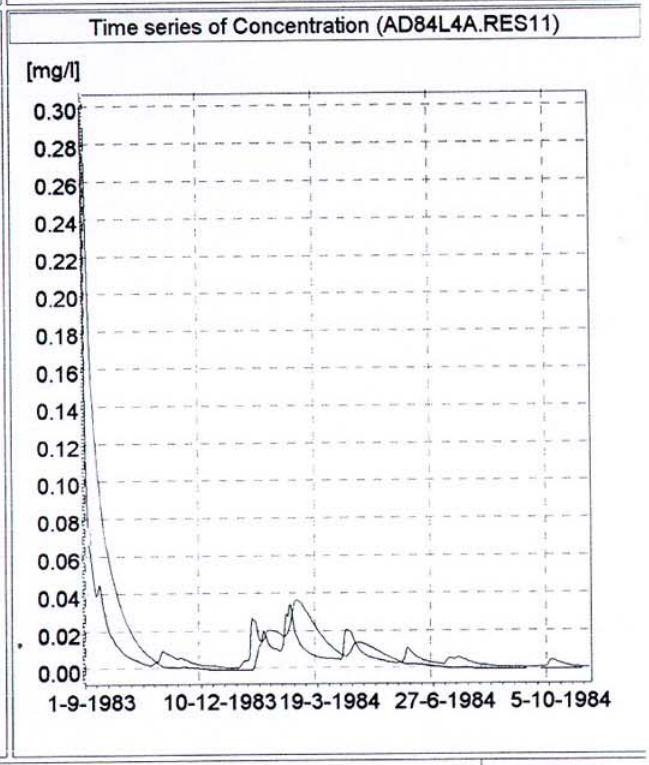


Time Series of Concentrations (1984 run)
for Lower-East wetland Top and Last Cell
NH3, BOD
Dis.P, Par.P

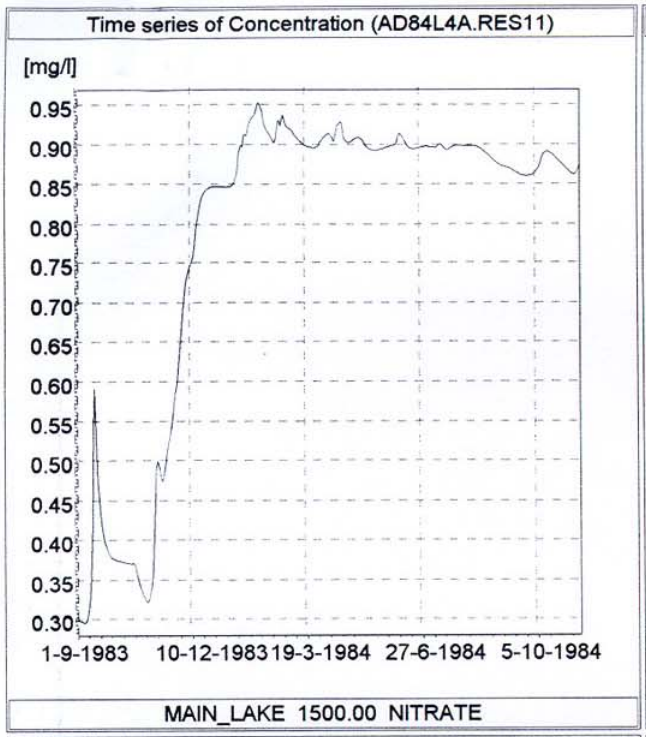


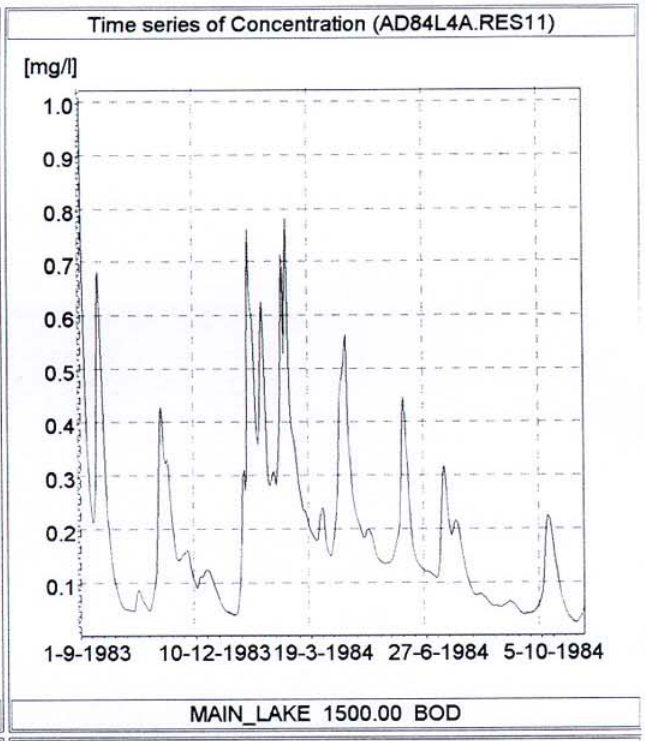


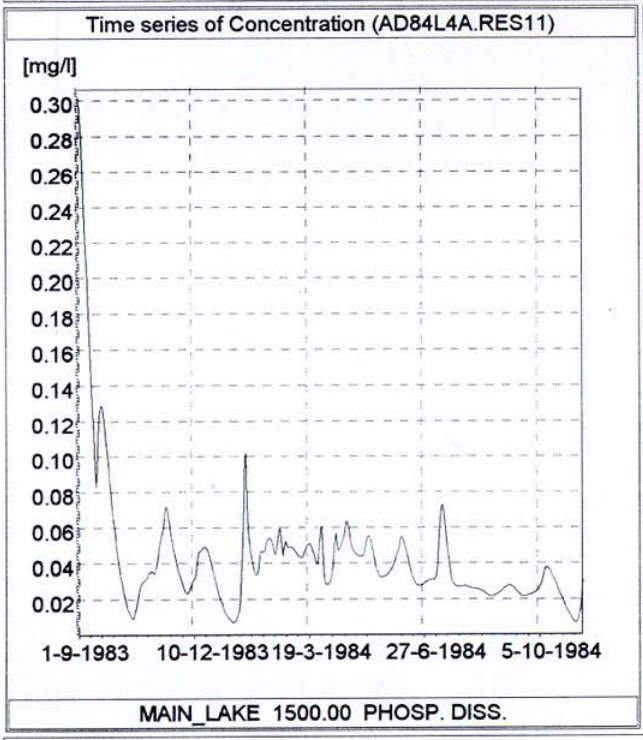


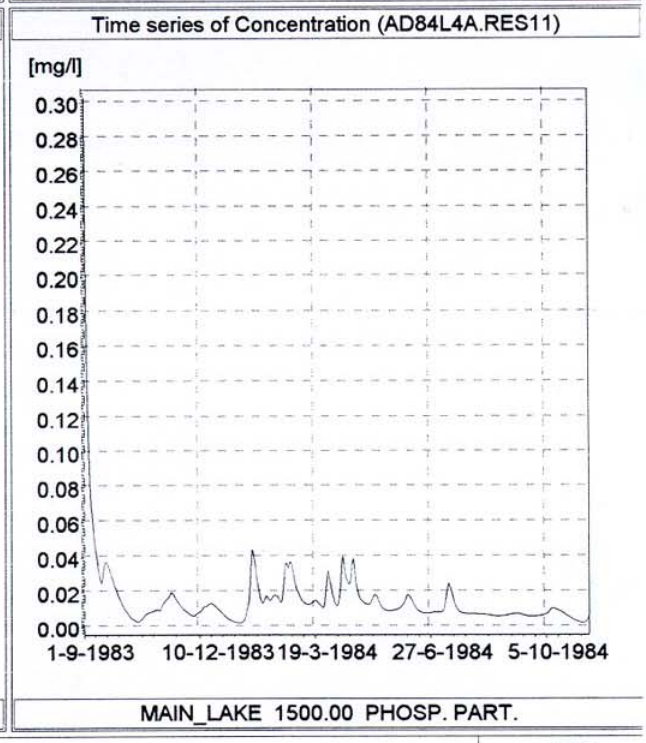


Time Series of Concentrations (1984 run)
for Upper-Bisa wetland Top and Last Cell
NH3, BOD
Dis.P, Par.P









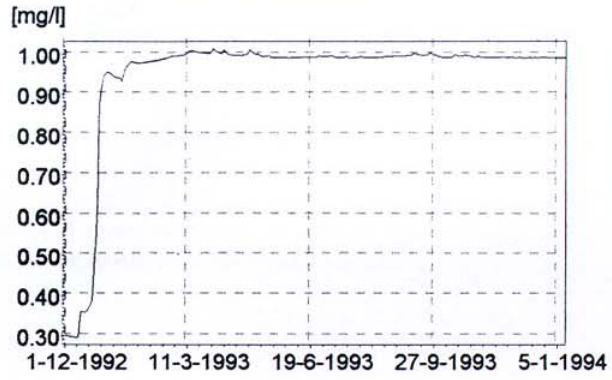
Time Series of Concentrations (1984 run)
for Primary Lake
NH3, BOD
Dis.P, Par.P

Figure 26.7

APPENDIX 2.6

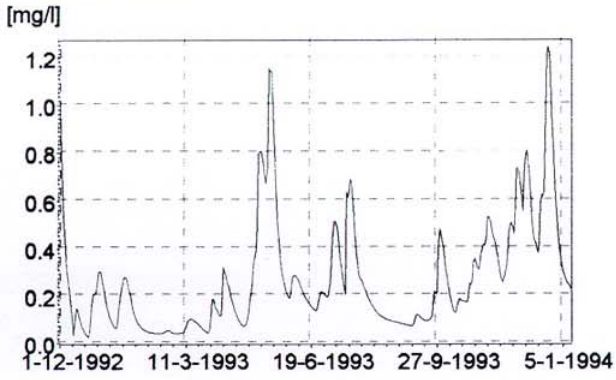
TIME SERIES OF CONCENTRATION FOR THE 1993-RUN

Time series of Concentration (AD93L4A.RES11)



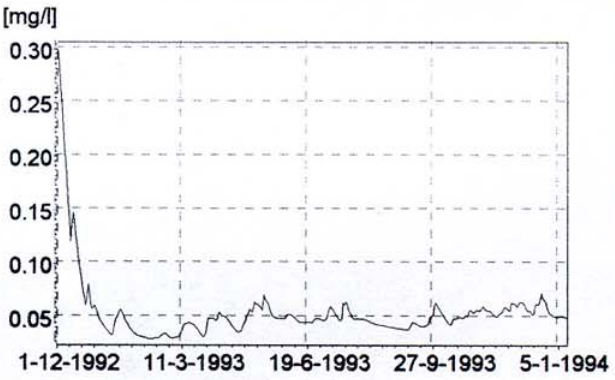
UN 3137.50 NITRATE

Time series of Concentration (AD93L4A.RES11)



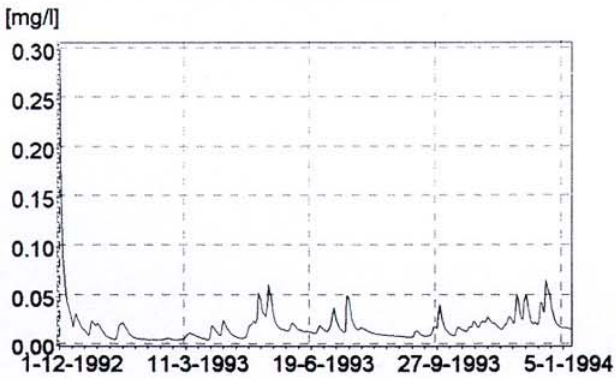
UN 3137.50 BOD

Time series of Concentration (AD93L4A.RES11)



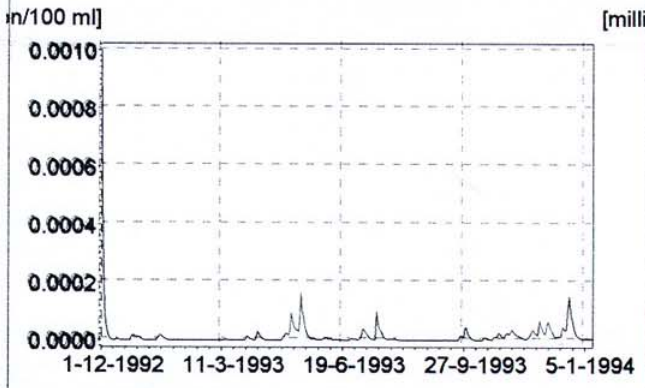
UN 3137.50 PHOSP. DISS.

Time series of Concentration (AD93L4A.RES11)



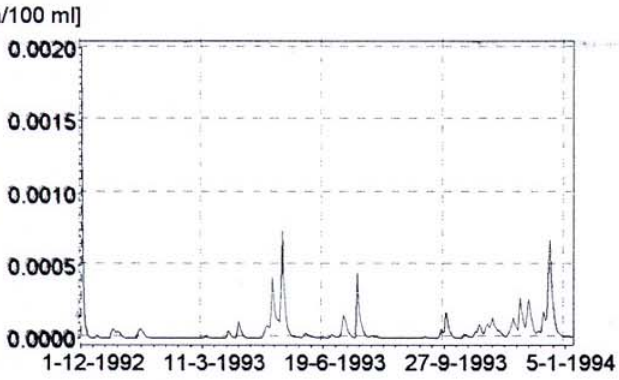
UN 3137.50 PHOSP. PART.

Time series of Bacteria concentration (AD93L4A.RES11)



UN 3137.50 COLI FAECAL

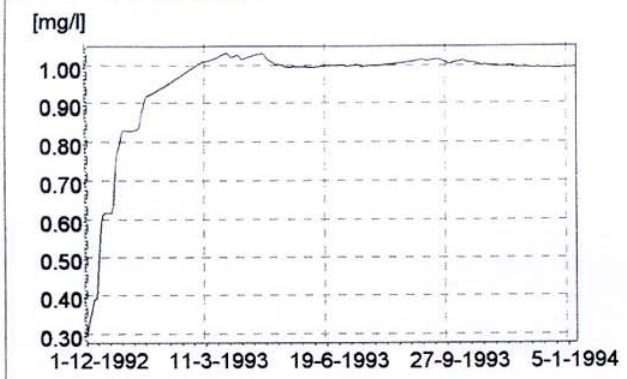
Time series of Bacteria concentration (AD93L4A.RES11)



UN 3137.50 COLI TOTAL

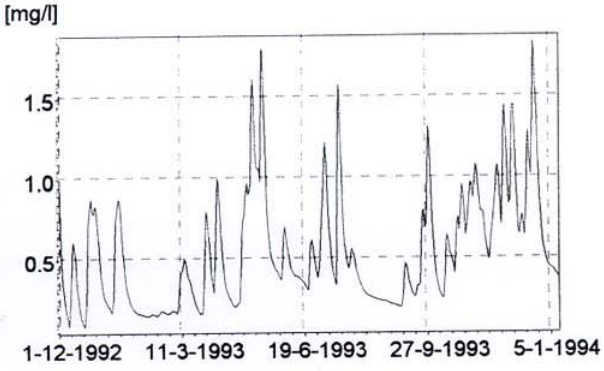
Time Series of Concentrations (1993 run)
for Upper-North wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD93L4A.RES11)



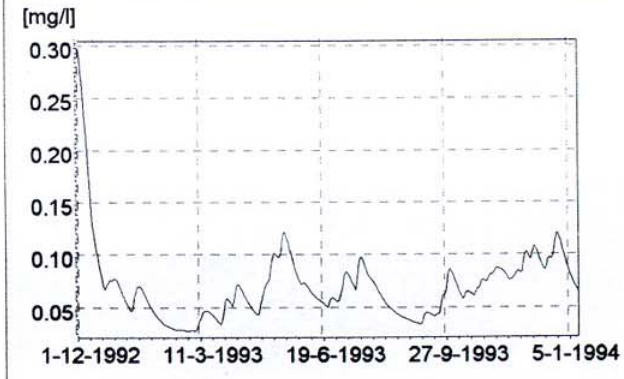
UE 700.00 NITRATE

Time series of Concentration (AD93L4A.RES11)



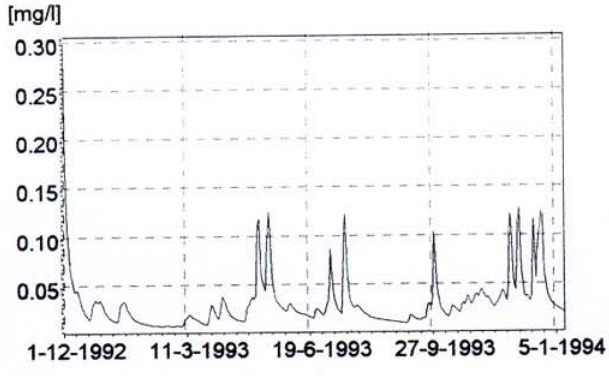
UE 700.00 BOD

Time series of Concentration (AD93L4A.RES11)



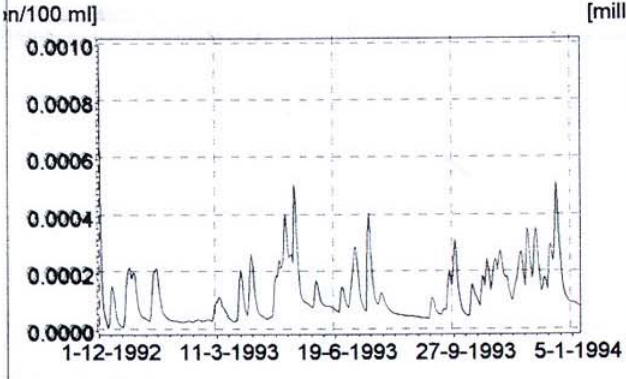
UE 700.00 PHOSP. DISS.

Time series of Concentration (AD93L4A.RES11)



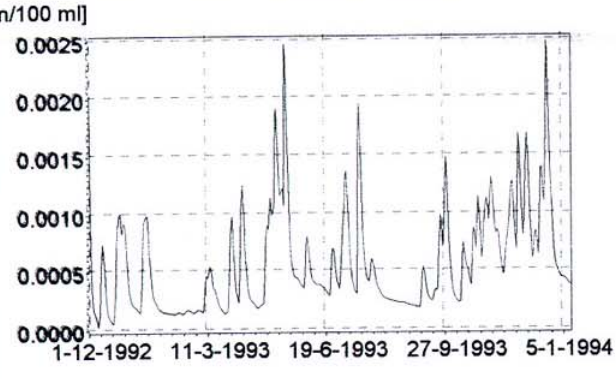
UE 700.00 PHOSP. PART.

Time series of Bacteria concentration (AD93L4A.RES11)



UE 700.00 COLI FAECAL

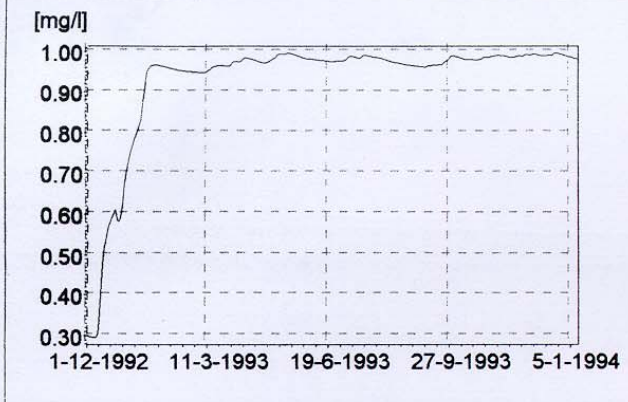
Time series of Bacteria concentration (AD93L4A.RES11)



UE 700.00 COLI TOTAL

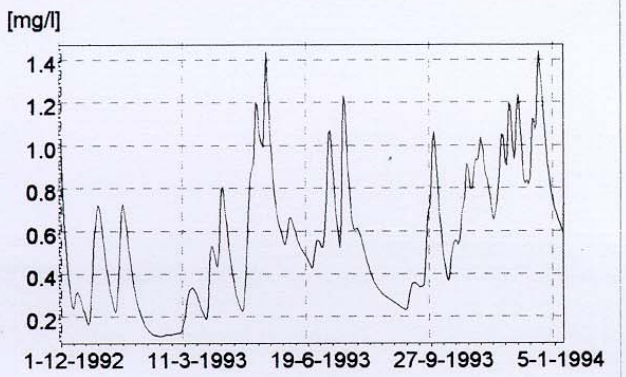
Time Series of Concentrations (1993 run)
for Upper-East wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD93L4A.RES11)



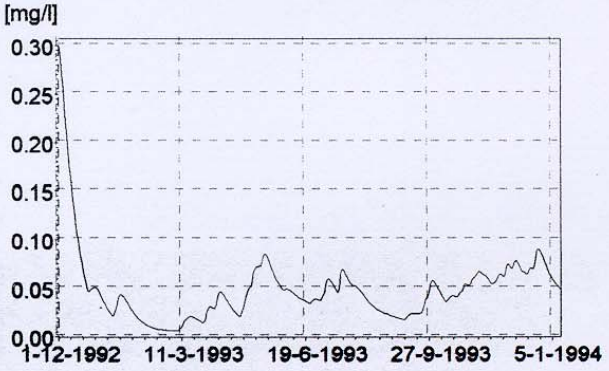
LE 1170.00 NITRATE

Time series of Concentration (AD93L4A.RES11)



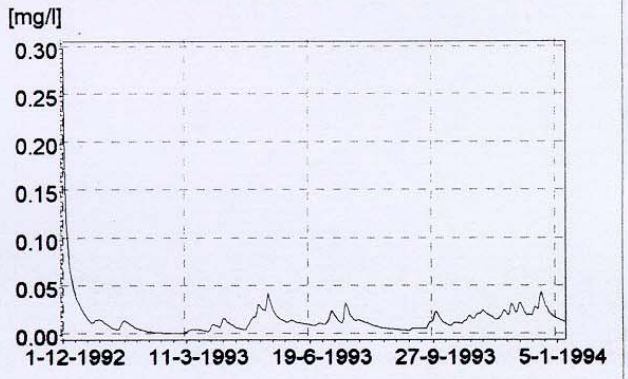
LE 1170.00 BOD

Time series of Concentration (AD93L4A.RES11)



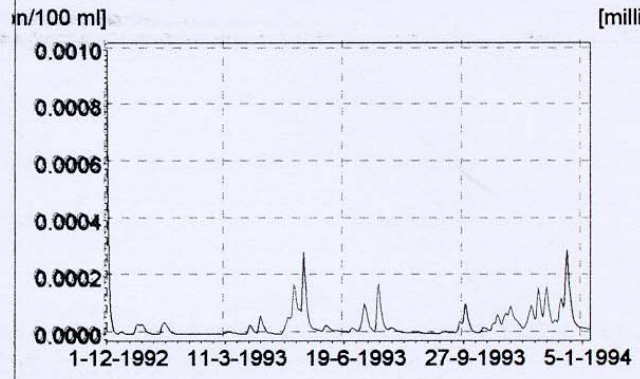
LE 1170.00 PHOSP. DISS.

Time series of Concentration (AD93L4A.RES11)



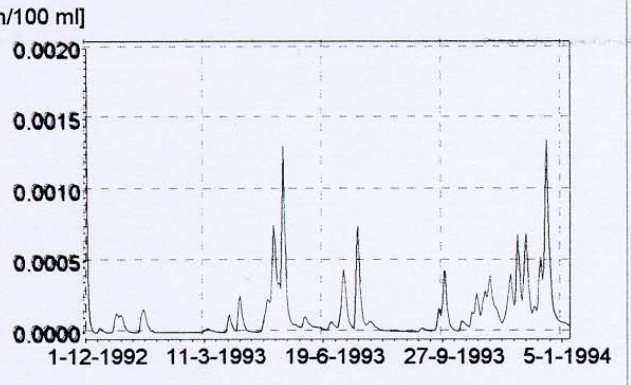
LE 1170.00 PHOSP. PART.

Time series of Bacteria concentration (AD93L4A.RES11)



LE 1170.00 COLI FAECAL

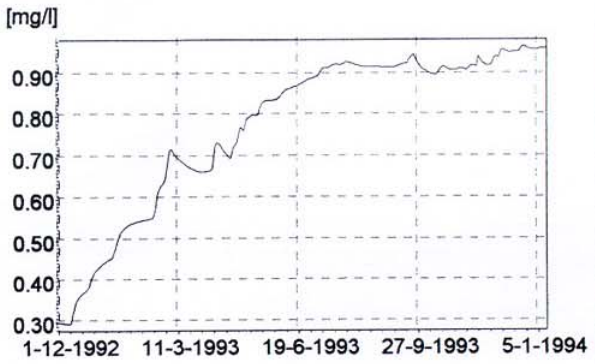
Time series of Bacteria concentration (AD93L4A.RES11)



LE 1170.00 COLI TOTAL

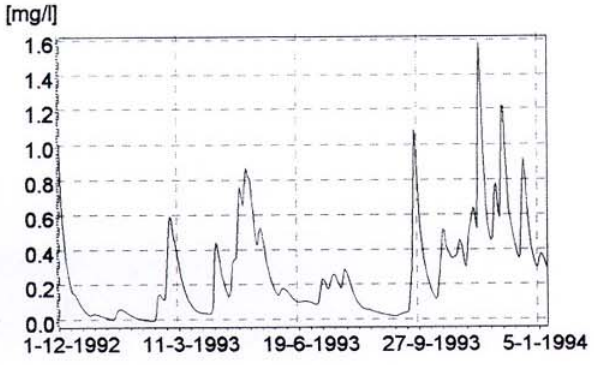
Time Series of Concentrations (1993 run)
for Lower-East wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD93L4A.RES11)



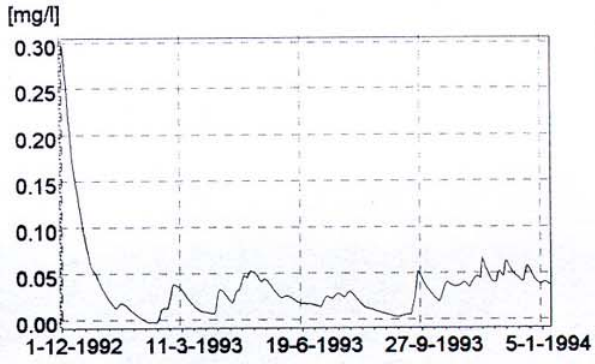
UB 1523.00 NITRATE

Time series of Concentration (AD93L4A.RES11)



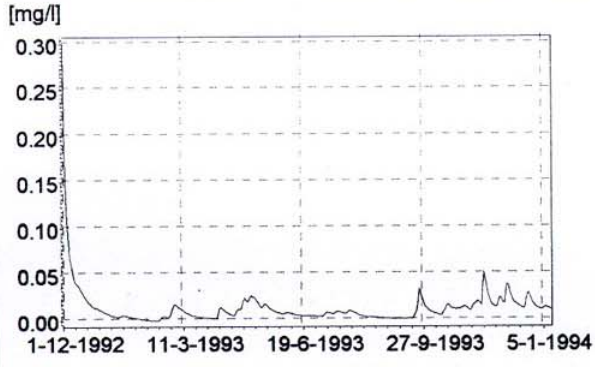
UB 1523.00 BOD

Time series of Concentration (AD93L4A.RES11)



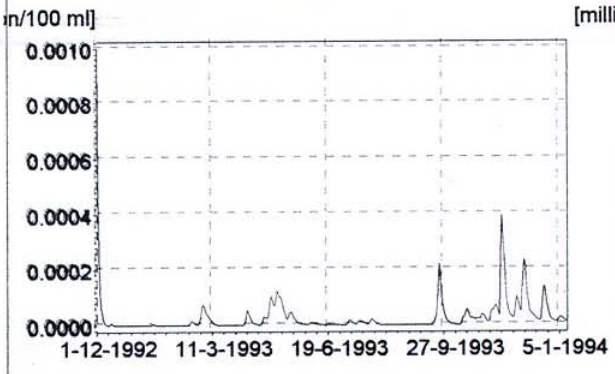
UB 1523.00 PHOSP. DISS.

Time series of Concentration (AD93L4A.RES11)



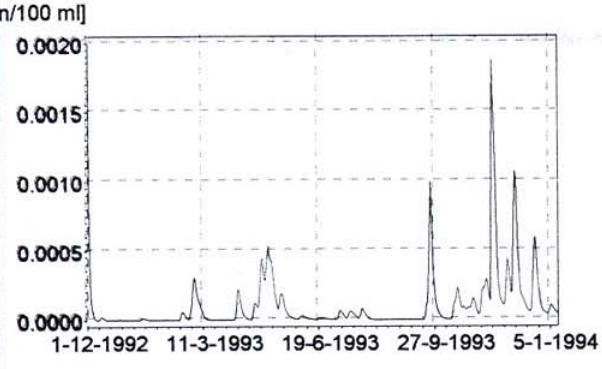
UB 1523.00 PHOSP. PART.

Time series of Bacteria concentration (AD93L4A.RES11)



UB 1523.00 COLI FAECAL

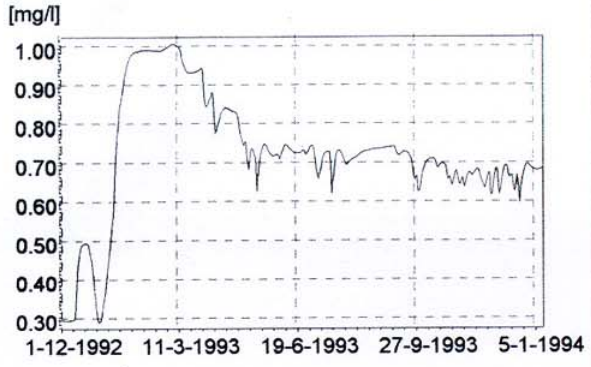
Time series of Bacteria concentration (AD93L4A.RES11)



UB 1523.00 COLI TOTAL

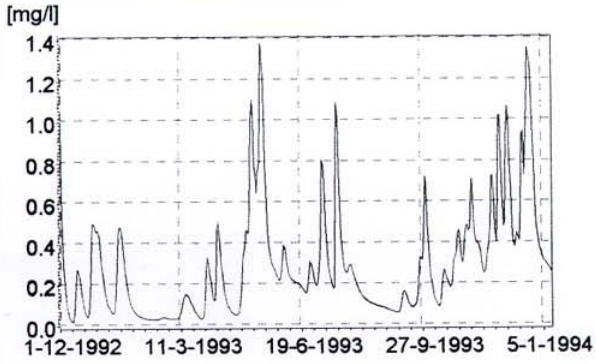
Time Series of Concentrations (1993 run)
for Upper-Bisa wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD93L4A.RES11)



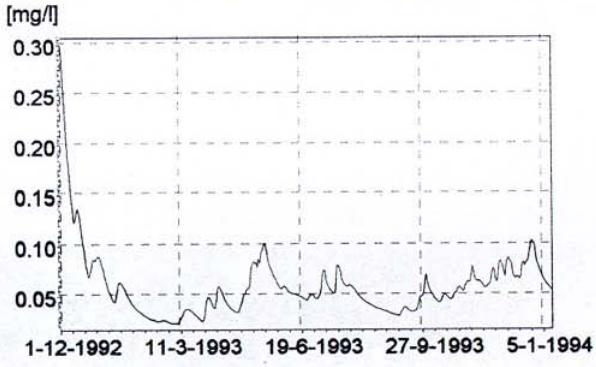
UW 2175.00 NITRATE

Time series of Concentration (AD93L4A.RES11)



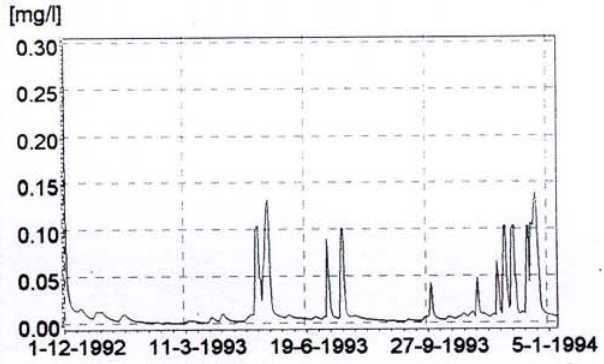
UW 2175.00 BOD

Time series of Concentration (AD93L4A.RES11)



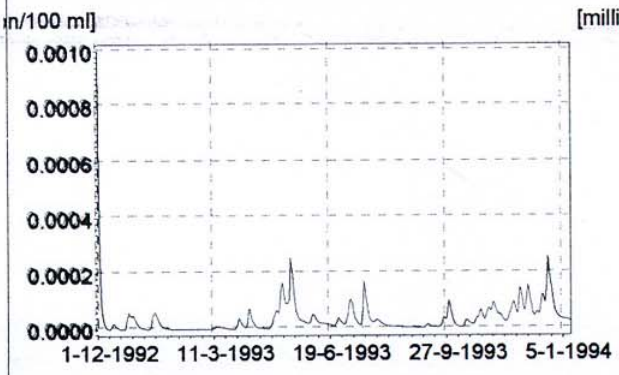
UW 2175.00 PHOSP. DISS.

Time series of Concentration (AD93L4A.RES11)



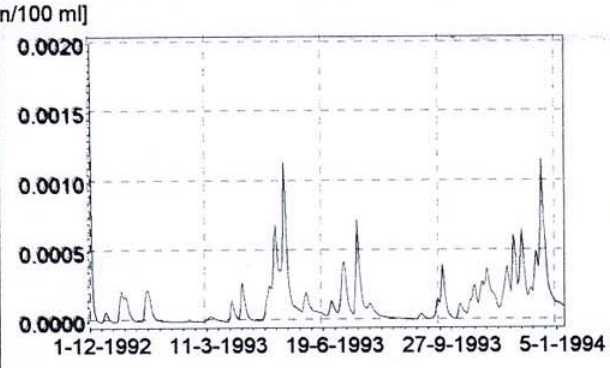
UW 2175.00 PHOSP. PART.

Time series of Bacteria concentration (AD93L4A.RES11)



UW 2175.00 COLI FAECAL

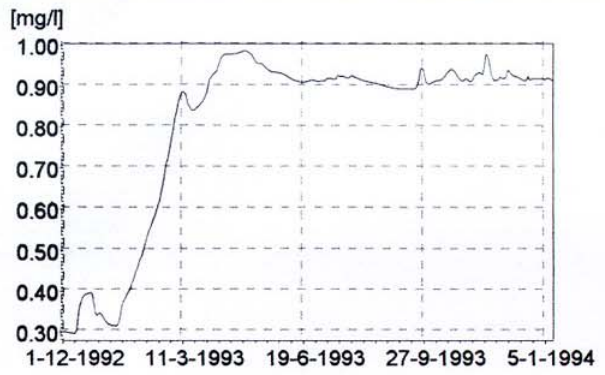
Time series of Bacteria concentration (AD93L4A.RES11)



UW 2175.00 COLI TOTAL

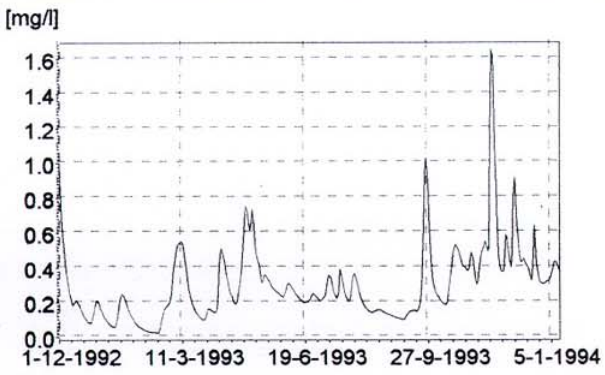
Time Series of Concentrations (1993 run)
for Upper-West wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD93L4A.RES11)



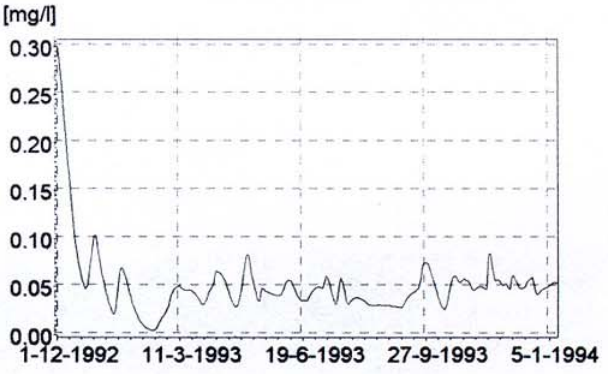
MAIN_LAKE 1500.00 NITRATE

Time series of Concentration (AD93L4A.RES11)



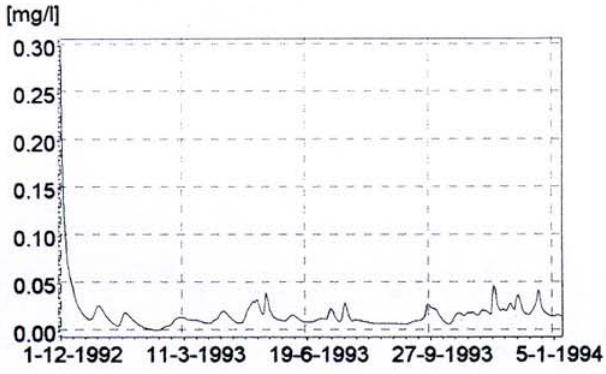
MAIN_LAKE 1500.00 BOD

Time series of Concentration (AD93L4A.RES11)



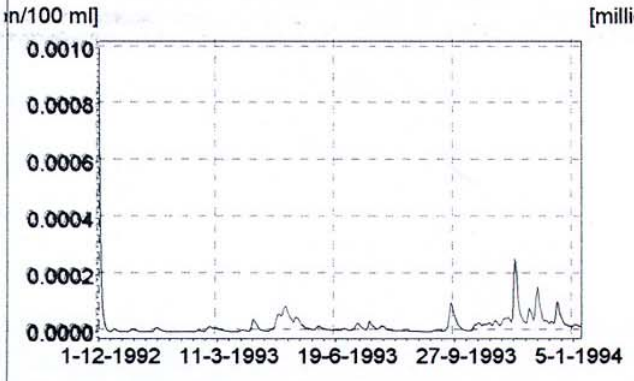
MAIN_LAKE 1500.00 PHOSP. DISS.

Time series of Concentration (AD93L4A.RES11)



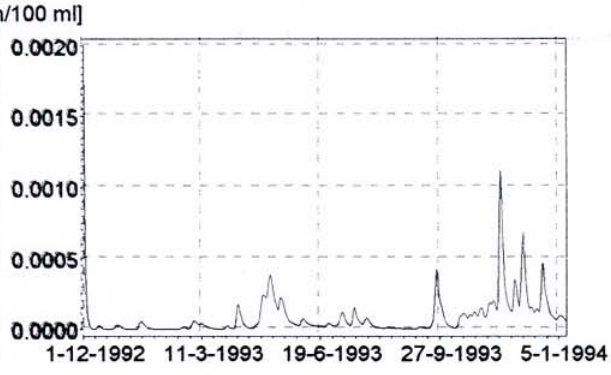
MAIN_LAKE 1500.00 PHOSP. PART.

Time series of Bacteria concentration (AD93L4A.RES11)



MAIN_LAKE 1500.00 COLI FAECAL

Time series of Bacteria concentration (AD93L4A.RES11)



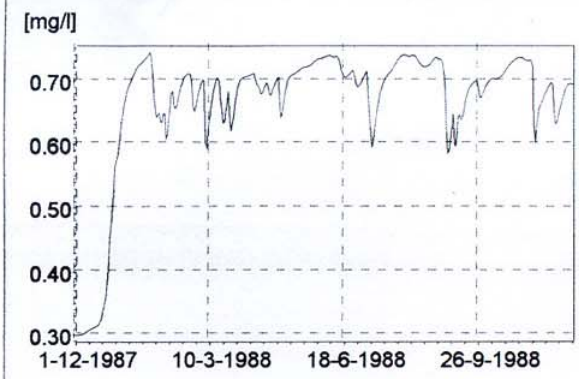
MAIN_LAKE 1500.00 COLI TOTAL

Time Series of Concentrations (1993 run)
for Primary Lake
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

APPENDIX 2.7

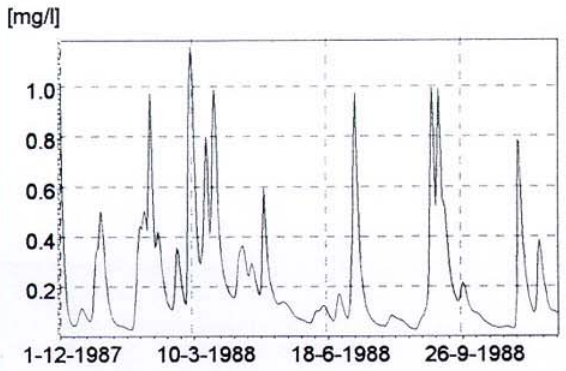
TIME SERIES OF CONCENTRATION FOR THE 1988-RUN

Time series of Concentration (AD88L4.RES11)



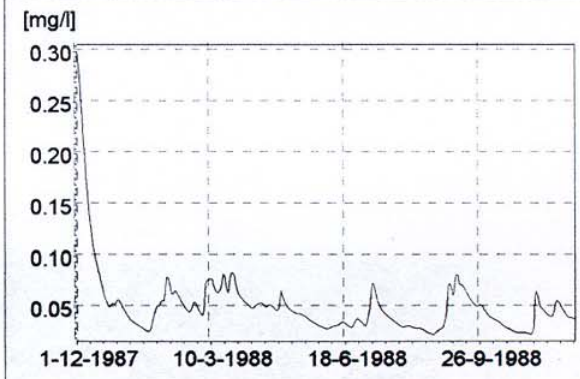
UW 2175.00 NITRATE

Time series of Concentration (AD88L4.RES11)



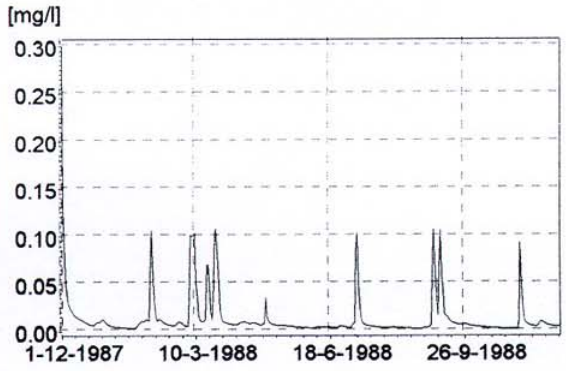
UW 2175.00 BOD

Time series of Concentration (AD88L4.RES11)



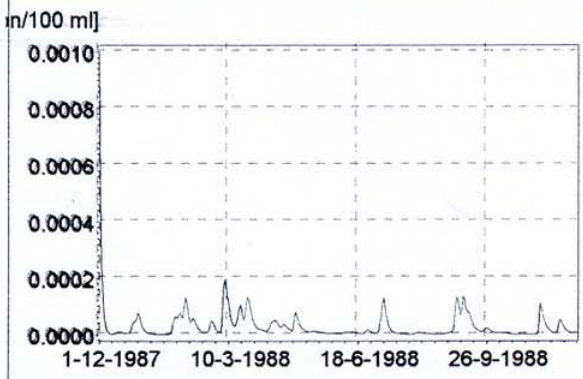
UW 2175.00 PHOSP. DISS.

Time series of Concentration (AD88L4.RES11)



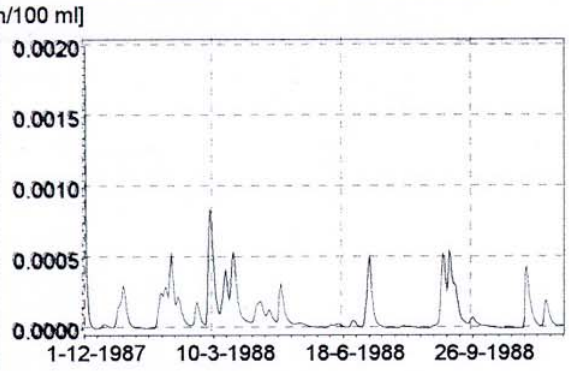
UW 2175.00 PHOSP. PART.

Time series of Bacteria concentration (AD88L4.RES11)



UW 2175.00 COLI FAECAL

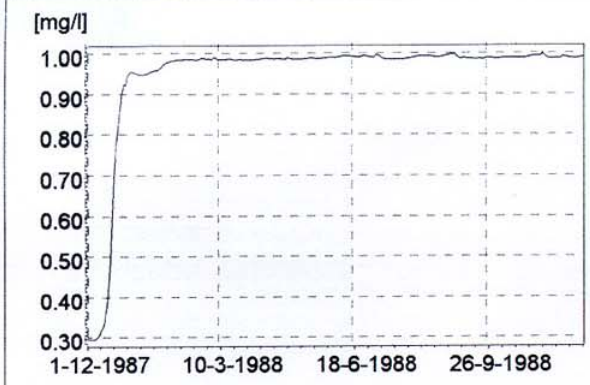
Time series of Bacteria concentration (AD88L4.RES11)



UW 2175.00 COLI TOTAL

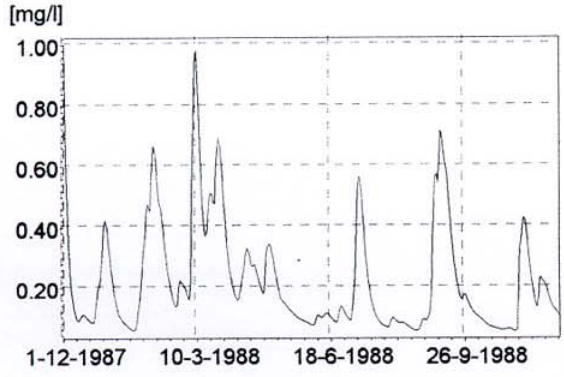
Time Series of Concentration (1988 run)
for Upper-West wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD88L4.RES11)



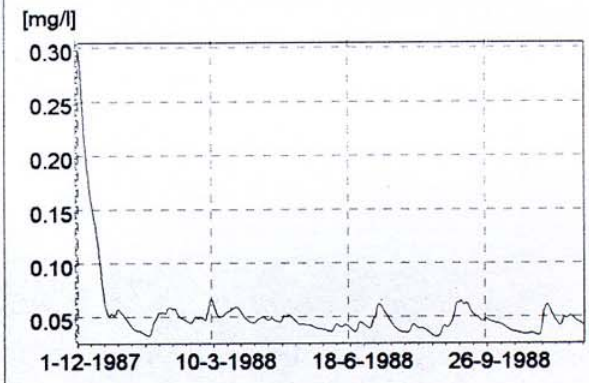
UN 3137.50 NITRATE

Time series of Concentration (AD88L4.RES11)



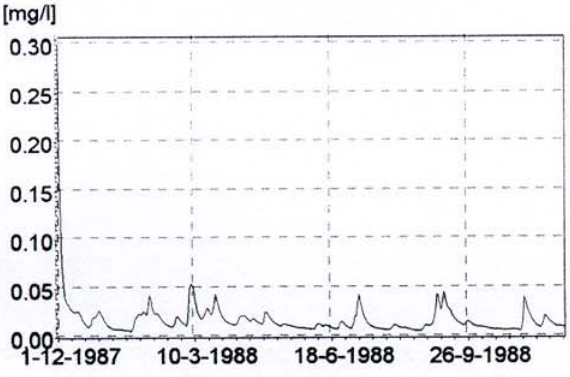
UN 3137.50 BOD

Time series of Concentration (AD88L4.RES11)



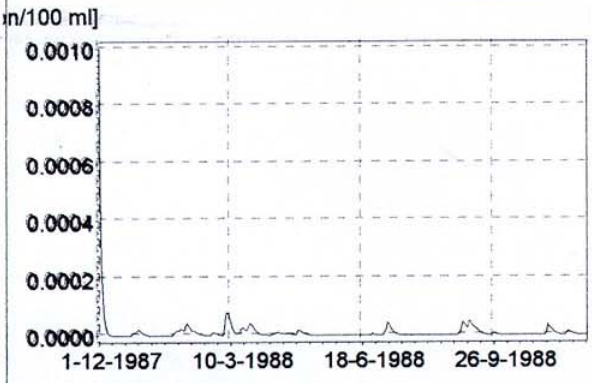
UN 3137.50 PHOSP. DISS.

Time series of Concentration (AD88L4.RES11)



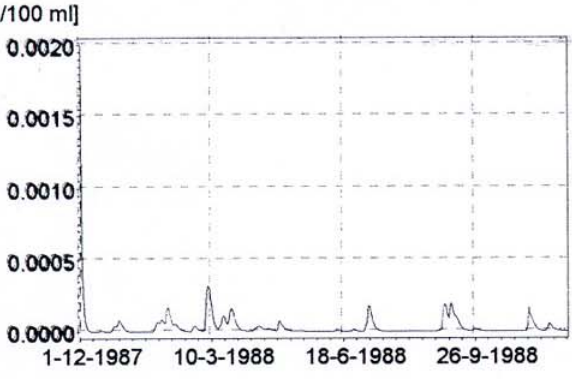
UN 3137.50 PHOSP. PART.

Time series of Bacteria concentration (AD88L4.RES11)



UN 3137.50 COLI FAECAL

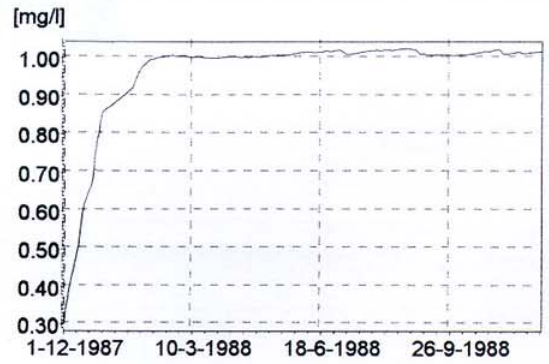
Time series of Bacteria concentration (AD88L4.RES11)



UN 3137.50 COLI TOTAL

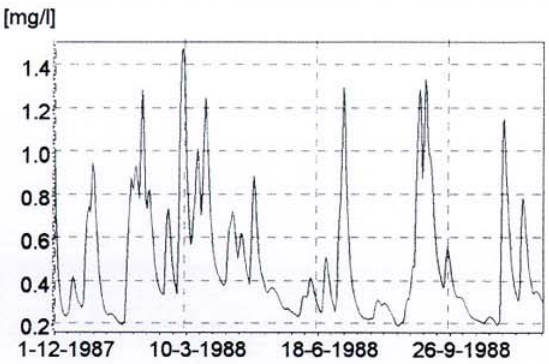
Time Series of Concentration (1988 run)
for Upper-North wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD88L4.RES11)



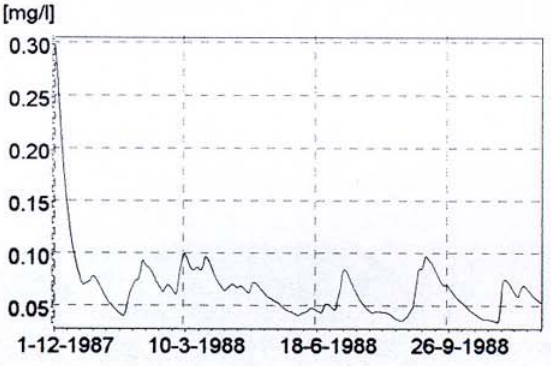
UE 700.00 NITRATE

Time series of Concentration (AD88L4.RES11)



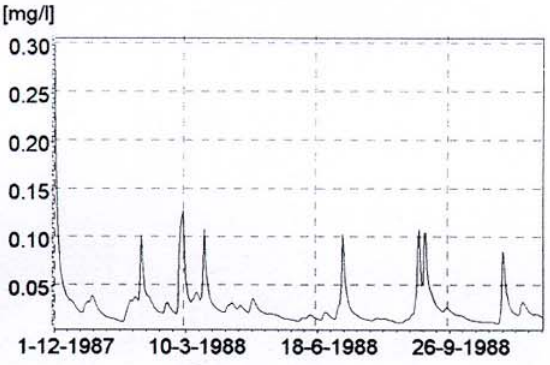
UE 700.00 BOD

Time series of Concentration (AD88L4.RES11)



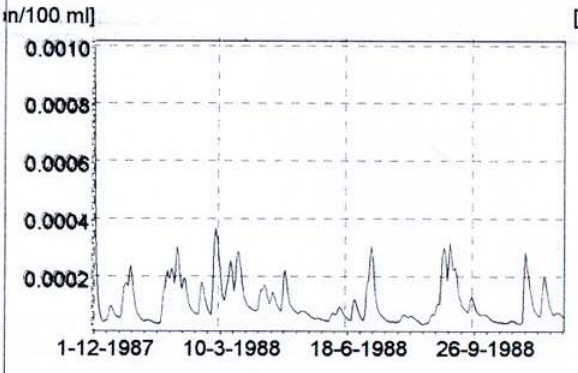
UE 700.00 PHOSP. DISS.

Time series of Concentration (AD88L4.RES11)



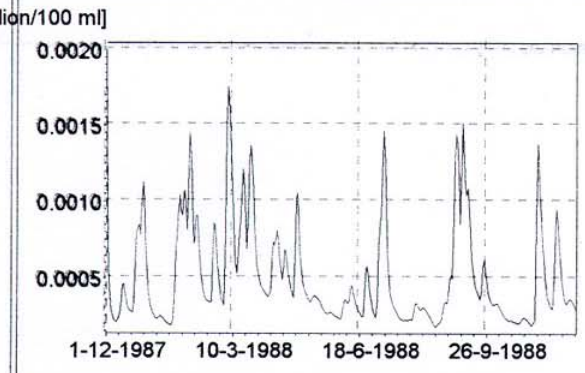
UE 700.00 PHOSP. PART.

Time series of Bacteria concentration (AD88L4.RES11)



UE 700.00 COLI FAECAL

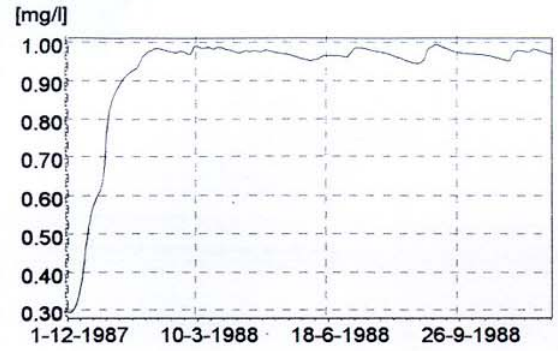
Time series of Bacteria concentration (AD88L4.RES11)



UE 700.00 COLI TOTAL

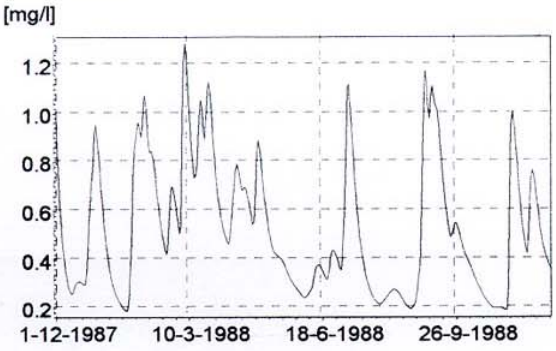
Time Series of Concentration (1988 run)
for Upper-East wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD88L4.RES11)



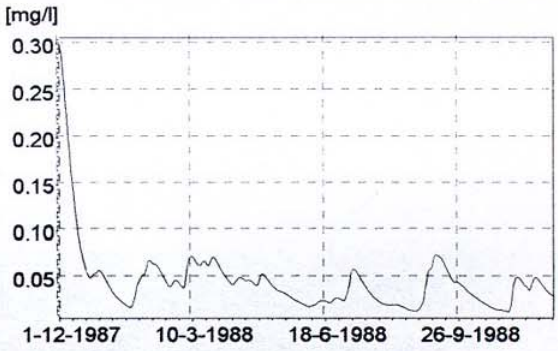
LE 1170.00 NITRATE

Time series of Concentration (AD88L4.RES11)



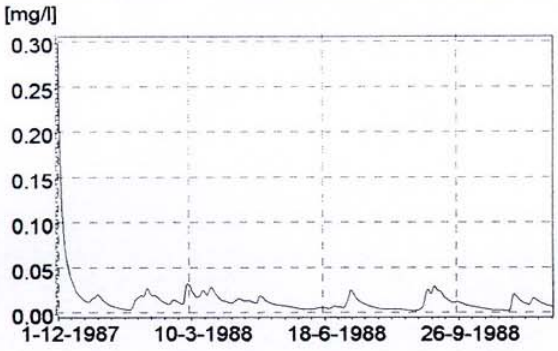
LE 1170.00 BOD

Time series of Concentration (AD88L4.RES11)



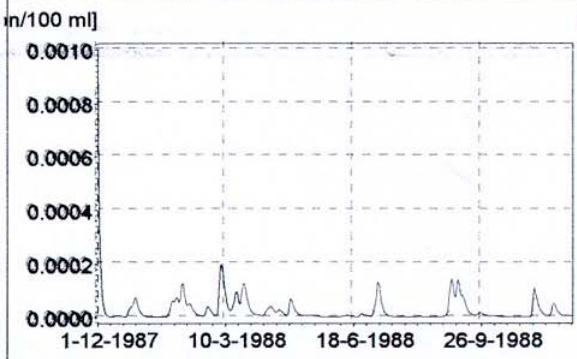
LE 1170.00 PHOSP. DISS.

Time series of Concentration (AD88L4.RES11)



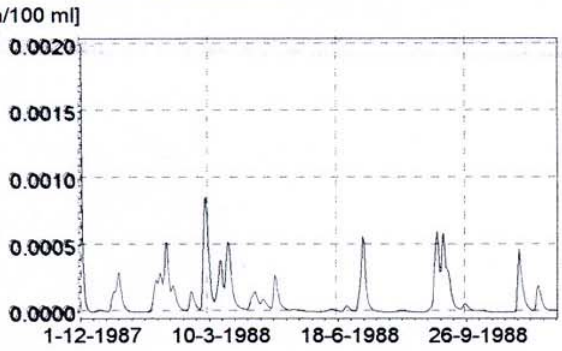
LE 1170.00 PHOSP. PART.

Time series of Bacteria concentration (AD88L4.RES11)



LE 1170.00 COLI FAECAL

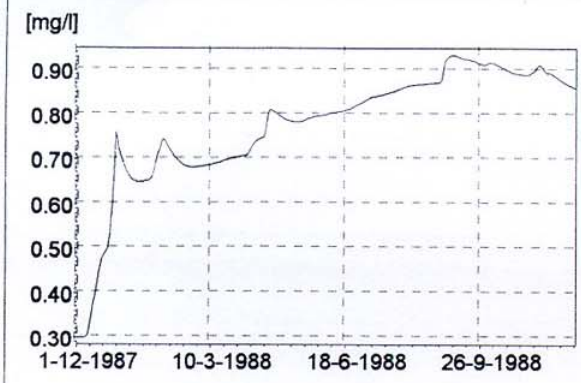
Time series of Bacteria concentration (AD88L4.RES11)



LE 1170.00 COLI TOTAL

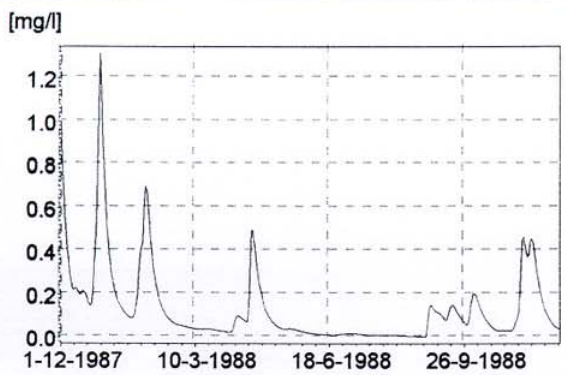
Time Series of Concentration (1988 run)
for Lower-East wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Time series of Concentration (AD88L4.RES11)



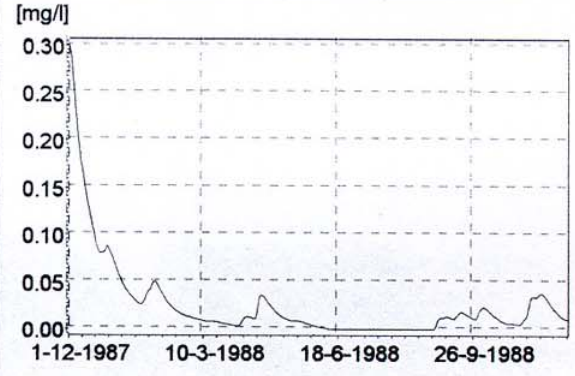
UB 1523.00 NITRATE

Time series of Concentration (AD88L4.RES11)



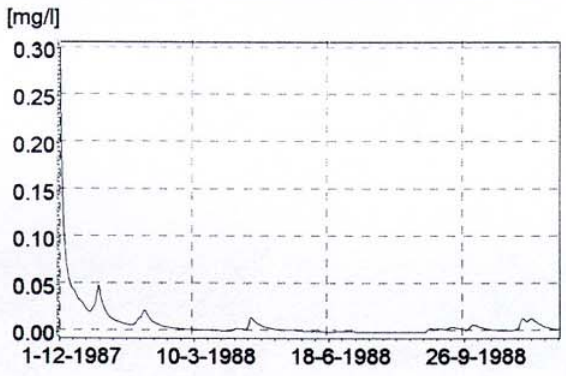
UB 1523.00 BOD

Time series of Concentration (AD88L4.RES11)



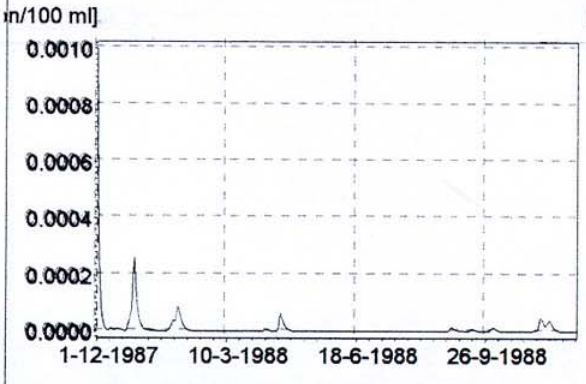
UB 1523.00 PHOSP. DISS.

Time series of Concentration (AD88L4.RES11)



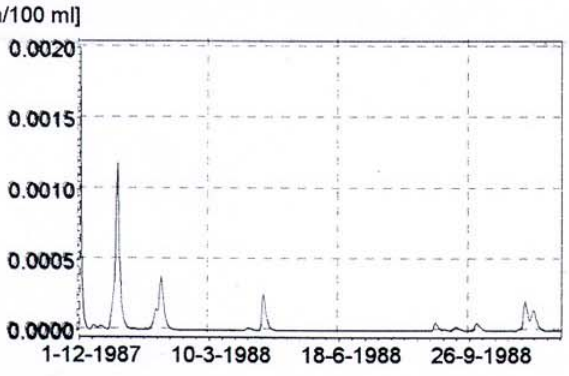
UB 1523.00 PHOSP. PART.

Time series of Bacteria concentration (AD88L4.RES11)



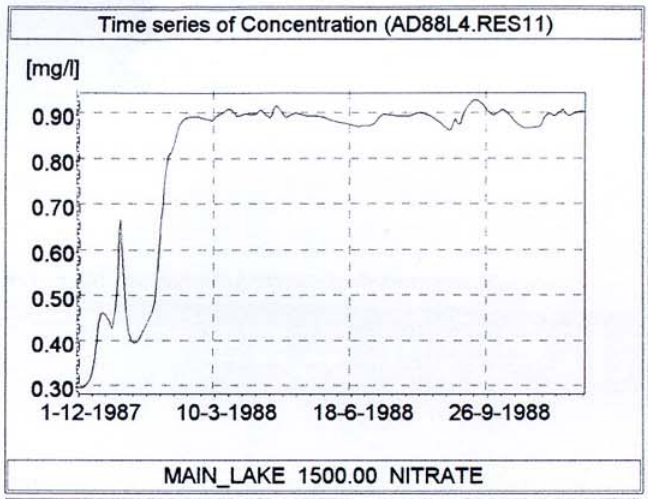
UB 1523.00 COLI FAECAL

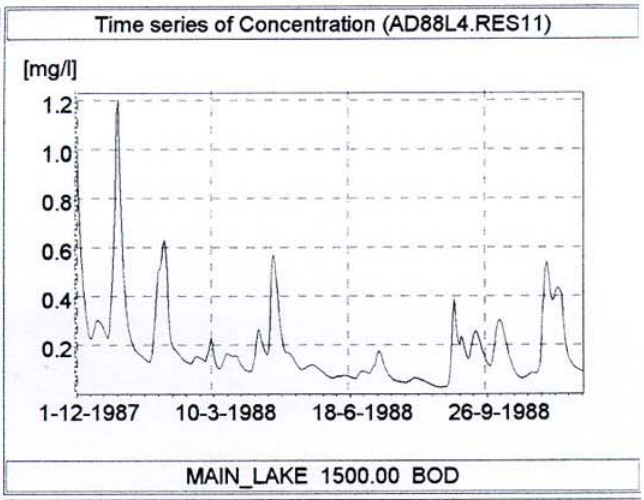
Time series of Bacteria concentration (AD88L4.RES11)

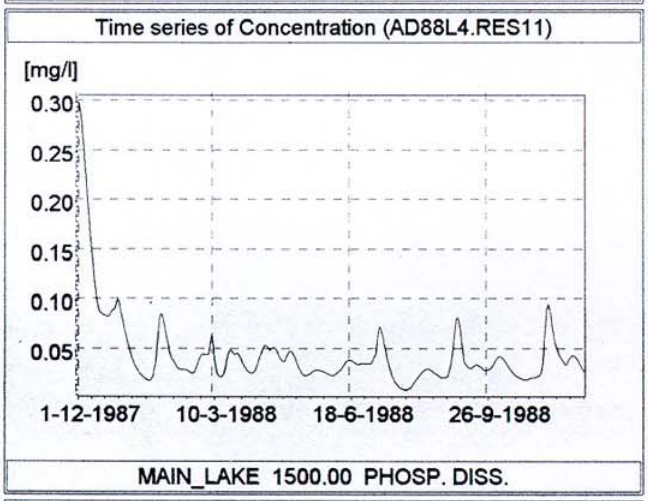


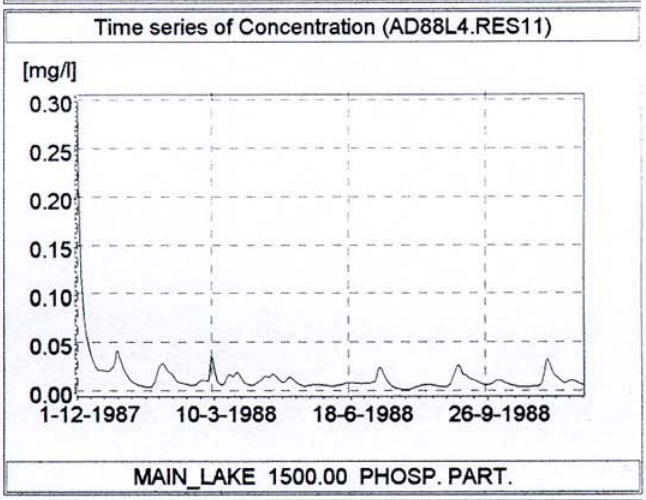
UB 1523.00 COLI TOTAL

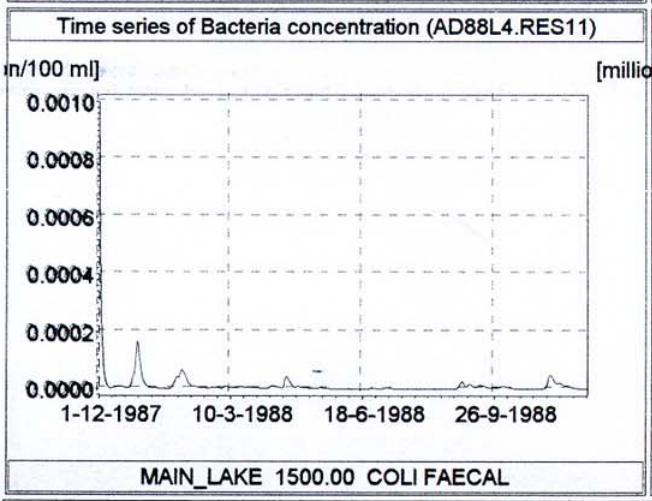
Time Series of Concentration (1988 run)
for Upper-Bisa wetland Last Cell
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

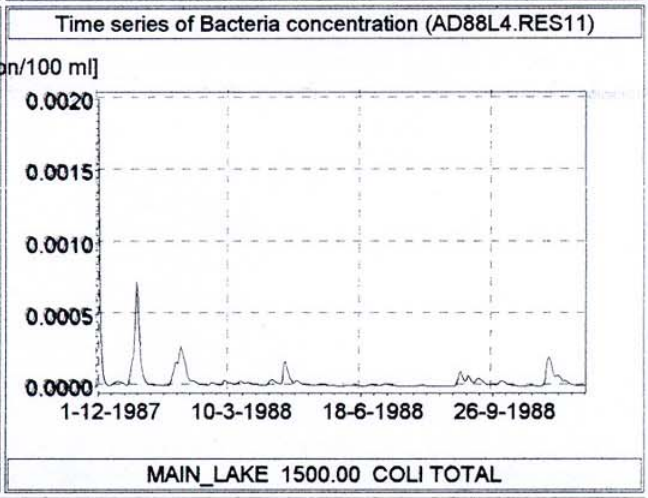












Time Series of Concentration (1988 run)
for Primary Lake
NH3, BOD
Dis.P, Par.P
Fcoli, Tcoli

Figure 2.6.9

APPENDIX A

PUTRAJAYA LAKE CATCHMENT

FERTILIZER USE GUIDELINES

APPENDIX A

PUTRAJAYA LAKE CATCHMENT FERTILIZER USE GUIDELINES

1.0 FERTILIZERS

1.1 GENERAL INFORMATION

1.1.1 Fertilizers are substances that are added to the soil to increase its fertility for plant growth. There are 18 elements essential to plant growth. They may be divided into macronutrients and micronutrients (Table 1). If plants lack any of these nutrients, they will exhibit signs of nutrient deficiency.

Table 1 Plant nutrient requirements

Macronutrients		Micronutrients
Primary	**Secondary**	
Carbon (C) Hydrogen (H) Oxygen (O) Nitrogen (N) Phosphorous (P) Potassium (K)	Calcium (Ca) Magnesium (Mg) Sulfur (S) Chlorine (Cl) Sodium (Na)	Iron (Fe) Zinc (Zn) Manganese Mn) Copper (Cu) Molybdenum (Mo) Boron (B) Cobalt Co)

1.1.2 Most plants receive a natural supply of nitrogen, phosphorus and potassium from organic matter and soil minerals, but this is not usually sufficient to satisfy the demands of crop plants, including ornamental plants.

1.1.3 The primary nutrients are most likely to be present in inadequate amounts and therefore are frequently added through use of fertilizers.

1.1.4 The amount of a nutrient element present in a fertilizer formulation is based on percentage of weight and is normally given as a ratio of three numbers: The percentage by weight of nitrogen (N), phosphate (P2O5), and potash (K2O) respectively. These numbers are said to represent nitrogen, phosphorus, and potassium, or N-P-K. Sometimes there is a fourth number, which represents the amount of sulfur (S) in the mix. The rest of the fertilizer's weight is filler which allows even spreading of the fertilizer.

1.1.5 The best fertilizer to use depends on many factors, such as the nutrients needed, soil structure, soil chemistry, and method of applying the fertilizer.

1.2 TYPES OF FERTILIZERS

1.2.1 Complete vs Incomplete

1.2.1.1 A fertilizer is said to be complete when it contains nitrogen, phosphorus, and potassium. Examples of commonly used fertilizers are 10-10-10, 16-16-16, and 20-10-5.

1.2.1.2 An incomplete fertilizer will be missing at least one of the major components. Incomplete fertilizers can be blended together to make complete fertilizers.

1.2.1.3 The specific fertilizer ratio needed depends on the soil nutrient level. For example, a 1-1-1 ratio (10-10-10, 15-15-15, 20-20-20, etc.) is widely used at the time of lawn establishment, but established lawns generally respond better to fertilizer ratios high in nitrogen. Two of the more common complete fertilizers used by homeowners for flowers and vegetables are 10-10-10 and 5-10-10.

1.2.2 Slow-Release Fertilizers

1.2.2.1 Plants can absorb nutrients continuously, so it is beneficial to provide them with a balance of nutrients throughout their growth. An efficient way to achieve this is to apply a slow-release fertilizer, which releases nutrients at a rate that makes them available to the plants over a long period. Slow-release fertilizers contain one or more nutrients. Slow-release fertilizers can be categorized according to their release mechanism. The three major types of nutrient release mechanisms are:

1) materials that dissolve slowly,
2) materials which must be decomposed by soil microorganisms in order to release nitrogen, and
3) granular materials with coatings made of resin or sulfur to control the rate of nutrient release into the soil.

1.2.2.2 Sulphur-coated urea is a slow-release nitrogen fertilizer with a covering of sulfur around each urea particle. Different thicknesses of sulfur control the rate of nitrogen release, which increases with temperature. Watering does not affect its release rate. Sulfur-coated urea applied to the soil's surface releases nitrogen more slowly than if incorporated into the soil. This material generally costs less than other slow-release fertilizers, and it also supplies the second nutrient, sulfur.

1.2.2.3 When fertilizer products coated with multiple layers of resin come into contact with water, the layers swell and increase the pore size in the resin so that the dissolved fertilizer can move into the soil. Release rate depends on the coating thickness, temperature, and water content of the soil. There is often a large release of fertilizer during the first two or three days after application. Release timing can be from 0 to 6 months, depending on the coating.

1.2.2.4 Slow-release fertilizers need not be applied as frequently as other fertilizers, and higher amounts can be applied without danger of burning. Plants may use the nitrogen in slow-release fertilizers more efficiently than nitrogen in other forms, since it is released over a longer period of time and in smaller quantities. Slow-release fertilizers are generally more expensive than other types. The real benefit, however, is the frequency of application, which is much lower than conventional fertilizers.

1.2.2.5 Urea formaldehyde and sulfur-coated urea have been used as turf fertilizer, while resin-coated fertilizers are predominantly used in container growing.

Table 2 Comparison of Fertilizers

Advantages	Disadvantages
Conventional Fertilizers	
1. Fast acting. 2. Some are acid-forming. 3. Low cost.	1. Greater burn potential. 2. Solidifies in the bag when wet. 3. Nitrogen leaches readily.
Slow-Release Fertilizers	
1. Fewer applications. 2. Low burn potential. 3. Release rate varies depending on fertilizer characteristics. 4.Comparatively slow release rate.	1. Unit cost is high. 2. Availability is limited. 3. Release rate governed by factors other than plant need
Manures or Sewage Sludge	
1. Low burn potential. 2. Relatively slow release. 3. Contain micronutrients. 4. Conditions the soil.	1. Salt could be a problem. 2. Bulky, difficult to handle. 3. Odou.r 4. Expensive per pound of actual nutrient. 5. Weed seeds can be a problem. 6. Heavy metals may be present in sewage sludge.

1.2.3 Organic Fertilizers

1.2.3.1 The word organic, applied to fertilizers, simply means that the nutrients contained in the product are derived solely from the remains or by-products of a once-living organism. Urea is a synthetic organic fertilizer, an organic substance manufactured from inorganic materials (although urea is also, as the name implies, a constituent of urine). Cottonseed meal, blood meal, bone meal, hoof and horn meal, and all manures are examples of organic fertilizers. When packaged as fertilizers, these products will have the fertilizer ratios stated on the labels.

1.2.3.2 Some organic materials, particularly composted manures and sludges, are sold as soil conditioners and do not have a nutrient guarantee, although small amounts of nutrients are present. Most are high in one of the three

major nutrients and low in the other two, although you may find some fortified with nitrogen, phosphorus, or potash for a higher analysis. Many are low in all three.

1.2.3.3 In general, organic fertilizers release nutrients over a fairly long period; the potential drawback is that they may not release enough of their principal nutrient at a time to give the plant what it needs for best growth. Because organic fertilizers depend on soil organisms to break them down to release nutrients, most of them are effective only when soil is moist and soil temperature is warm enough for the soil organisms to be active. Cottonseed meal is a by-product of cotton manufacturing. As a fertilizer, it is somewhat acidic in reaction. Formulas vary slightly, but generally contain 7 percent nitrogen, 3 percent P2O5, and 2 percent K2O. Cottonseed meal is readily available to plants in warm soils, and there is little danger of burn. Cottonseed meal is frequently used for fertilizing acid-loving plants such as azaleas, camellias, and rhododendrons.

1.2.3.4 Sewage sludge is a recycled product of municipal sewage treatment plants. Two forms are commonly available: activated and composted. Activated sludge has higher concentrations of nutrients (approximately 6-3-0) than composted sludge, and is usually sold in a dry, granular form for use as a general purpose, long-lasting, non-burning fertilizer. Composted sludge is used primarily as a soil amendment and has a lower nutrient content (approximately 1-2-0). There is some question about the long-term effects of using sewage sludge products in the garden, because heavy metals, such as cadmium, are sometimes present in the sludge. However, all sewage sludge must be analyzed for heavy metals and meet a regulatory standard, such as US EPA standards before it can be sold for soil applications.

1.2.3.5 Compared to synthetic fertilizer formulations, organic fertilizers contain relatively low concentrations of actual nutrients, but they perform other important functions which the synthetic formulations do not. Some of these functions are: increasing organic content of the soil; improving physical structure of the soil; and increasing bacterial and fungal activity.

1.2.3.1 Fertilizers Combined with Pesticides

(1) The major reason for buying a fertilizer combined with a pesticide is convenience. It is very convenient to combine everything you need in one application, but it is also very expensive. The problem is that the timing for a fertilizer application often does not coincide with the appearance of a disease or an insect problem. And, in the case of a number of turf grass diseases, a primary cause of disease infestation is merely a lack of proper fertilizer.

(2) A fertilizer-insecticide combination, when applied at the proper stage of a pest's life-cycle, can do an adequate job of controlling the turf pest while also giving the grass "a shot in the arm" to help its recovery. However, fertilizers with pesticides intended for use with turf or ornamentals should

not be used in the vegetable garden where it may contaminate food crops. Always read the label carefully.

1.2.4 Fertilizer Formulation

1.2.4.1 Fertilizers come in many forms. Different formulations are made to facilitate types of situations in which fertilizer is needed. Packaging on all formulations must show the amount of nutrients contained, and sometimes it tells how quickly a nutrient is available. Some of the formulations available to the homeowner are: water-soluble powders, slow-release pellets, slow-release collars or spikes, liquids, tablets, and granular solids.

1.2.4.2 Liquid fertilizers come in a variety of different formulations, including complete formulas and special types that offer just one or two nutrients. All are made to be diluted with water; some are concentrated liquids themselves, others are powder or pellets. Growers of container plants often use liquid fertilizers at half the recommended dilution twice as frequently as recommended so that the plants receive a more continuous supply of nutrients.

1.2.5 Applying Fertilizer

Computing the amount of fertilizer needed for a given area is rather tricky at first, but after a few times, this becomes second nature.

2.0 FERTILIZER APPLICATION

2.1 FACTORS

Soil type dictates the frequency of fertilizer application. Sandy soils require more frequent applications of nitrogen and other nutrients than do clay-type soils. Other factors affecting frequency of application include the type of crop, the level of crop productivity required, frequency and amount of water applied, and type of fertilizer applied and its release rate.

2.1.1 Timing

2.1.1.1 The type of crop influences timing and frequency of application since some crops are heavier feeders of particular nutrients than others. A general rule of thumb is that nitrogen is for leafy top growth; phosphorus is for root and fruit production; and potassium is for hardiness, disease resistance, and general durability.

2.1.1.2 Proper use of nutrients can control plant growth rate and character. Nitrogen is the most critical nutrient in this regard. If tomatoes or squash are fertilized heavily with a nitrogen fertilizer into the summer, the plants may be all vine and no fruit. If slow-release fertilizers or heavy amounts of manure are used on crops that form fruit or vegetables, leaf and vine growth will continue into late summer, and fruit and vegetable development will occur very late in the season.

2.1.1.3 The following suggestions about groups of garden plants are given as general guides. Gardeners should be aware that individual species within

these groups vary considerably. After each group of plants, the need for the primary nutrients (nitrogen, phosphorus, and potassium) is indicated as high, medium, or low.

Table 3 Primary Nutrient Need by Plants

Plant Group	Primary Nutrient (N-P-K) Need
Vegetables	High
Herbs	Medium to Low
Lawns	Medium to High
Fruits	Medium
Annual flowers	Medium
Perennial flowers	Medium to Low
Deciduous shrubs	Medium to Low
Evergreen shrubs	Low
Deciduous shade trees	Medium to Low
Evergreen shade trees	Low

2.2 APPLICATION METHODS

2.2.1 There are different methods of applying fertilizer depending on its formulation and the plant needs.

(a) Broadcasting

2.2.2 A recommended rate of fertilizer is evenly spread over the growing area and left to filter into the soil or is incorporated into the soil with a rototiller, or spade, with irrigation water. Broadcasting can be used over large garden areas or when time or labor is limited.

This method should not be used in areas close to the Lake and wetland shoreline.

(b) Banding

2.2.3 Narrow bands of fertilizer are applied in furrows several inches from the seeds or plants. Banding is one way to satisfy the needs of many plants phosphorus as the first roots develop. When fertilizers are broadcast and worked into soil, much of the phosphorus is locked up by the soil and is not immediately available to the plant. By concentrating the phosphorus in a band, the plant is given what it needs even though much of the phosphorus stays locked up.

(c) Side-Dressing

2.2.4 Dry fertilizer is applied as a side dressing after plants are up and growing. Scatter fertilizer on both sides of the row 6 to 8 inches from the plants. Rake it into the soil and water thoroughly.

(d) Foliar Feeding

2.2.5 Foliar feeding is used when insufficient fertilizer was used before planting; a quick growth response is wanted; micronutrients (such as iron or zinc) are locked into the soil; or when the soil is too cold for the plants to use the fertilizer applied to the soil. Foliar-applied nutrients are absorbed and used by the plant quite rapidly.

3.0 GUIDELINES

3.1 Landscaping design considerations should site plants according to their fertilizer demand:

- High demand plants should be located further away from lake/wetland edges.
- High demand plants should not be located on slopes to minimise fertilizer loss by runoff. Alternatively, the area for fertilizer application of such plants should be depressed to contain fertilizer applications.
- Slow-release fertilizers should be preferred over other types of fertilizers. It is recommended that the soluble Phosphorus should not be used within the Catchment area. Instead the insoluble form of Phosphorus should be used if necessary.
- Correct fertilizer loadings should be applied through calculation, to prevent wastage and subsequent loss through runoff.
- Frequent, small applications are preferred to few, large applications.
- Grass clippings should be left on the turf to recycle nutrients instead of being swept away.

4.0 REFERENCES

1. Arizona Cooperative Extension (1998), Arizona Master Gardener Manual. College of Agriculture, The University of Arizona.

APPENDIX B

PUTRAJAYA LAKE CATCHMENT

PESTICIDE USE GUIDELINES

APPENDIX B

PUTRAJAYA LAKE CATCHMENT
PESTICIDE USE GUIDELINES

1.0 THE PESTICIDE REGISTER

1.1 The proper use of pesticides will ensure their effectiveness while ensuring minimum impact to safety and the environment.

1.2 A register of pesticides used, the amount and area of application, and the persons applying the pesticide should be maintained.

1.3 This will allow for monitoring of the amount and area the pesticides are being applied.

1.4 The **Pesticide Register** should be given to two parts:

a. Information on the pesticide characteristics
b. Information on application

1.5 The Register should contain the following information:

a. Pesticide characteristics
Pesticide name and formulation
Manufacturer
Safety precautions
Environmental hazard/precautions
Toxicity Class
Storage Location
Person responsible for application control

b. Application information
Area applied
Quantity applied
Date applied

1.6 The pesticide label can provide information on the pesticide characteristics. The label information should be recorded and normally carries the following type of information:

1. Brand name
Type of formulation

2. Ingredient statement
List of the names and amounts of the active and inert ingredients.

3. Common name and chemical name

4. Net contents
   Volume in the container.

5. Name and address of manufacturer
   The maker or distributor of a product, the name and address of the company on the label.

6. Registration number
   A registration number must be on every pesticide label.

7. Precautionary statements
   A warning or hazard section or a title like "Hazards to Humans and Domestic Animals" will explain the ways in which the product may be poisonous to man and animals. It should describe any special steps necessary to avoid poisoning, such as the kind of protective equipment needed. If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

8. Environmental Hazards
   This section should tell how to avoid damage to the environment. Some examples are: "This product is highly toxic to bees exposed to direct treatment or residues on crops." "Do not contaminate water when cleaning equipment or when disposing of wastes," and "Do not apply where runoff is likely to occur."

9. Physical and Chemical Hazards
   Lists other specific fire, explosion, or chemical hazards that the product may have.

10. Toxicity Class, Signal Words and Symbols
    Some pesticides may be hazardous to people. A Signal Word and Symbol (Table 1) is often used on the label. Some toxicity doses are given in Table 2.

11. Statement of practical treatment
    If swallowing or inhaling the product or getting it in the eyes or on the skin would be harmful, the label should contain emergency first aid measures and states types of exposure requiring medical attention. The pesticide label is the most important information you can take to the physician when someone has been poisoned. Without the label, it is difficult for the physician to help.

12. Directions for use
    The instructions will explain several important items.
    - The pests the product will control
    - The crops, animals, or other item the product can be used on safely
    - How the product should be applied
    - How much to use

Where and when the material should be applied
Application to harvest periods

13. Storage and disposal directions
Every pesticide should be stored and disposed of correctly. This section will tell you how to store and dispose of the product.

Table 1 Signal Words and Symbols

Word	Toxicity	Human Lethal Dosage	Symbol
Danger	High	taste to a teaspoon	skull and crossbones; Poison
Warning	Moderate	teaspoon to a tablespoon	none
Caution	Low	ounce to more than a pint	none

2.0 TOXICITY AND PERSISTENCE OF PESTICIDES

2.1 The least toxic and least persistent chemicals should be used for any job. The selection must be based on the nature and extent of infestation.

2.2 Some pesticide toxicity information is given in Table 2.

2.3 Herbicide persistence information based on temperate climate conditions are given in Table 3.

3.0 PESTICIDES AND WATER QUALITY

3.1 The use of pesticides affect water quality through the introduction of non-natural materials, even in small doses. An important factor to water quality is the potential for the pesticide to be washed off the applied plants. Therefore the selection of chemical to use would prefer the one least likely to run off during rain events.

3.2 Runoff potential of herbicides, insecticides and fungicides are given in Tables 4, 5, and 6.

Table 2 **Pesticide Toxicities** *(from Pesticide Information and Training Office, copyright University of Arizona, January 1996)*

Trade Name	Class	Active Ingredient	LD_{50} (rat, oral, mg/kg)
Toxicity Level I B Danger (Oral LD_{50} up to 50 mg/ml)			
Rodine	ROD	red squill	0.7
Temik	I	aldicarb	1
Phosdrin	I	mevinphos	3 - 12
Vydate	I	oxamyl	5.4
Penncap-M	I	methyl parathion	6
Cymag	ROD	sodium cyanide	6.4
Endrin	I	endrin	7 - 15
Furadan 4F	I	carbofuran	8
Dyfonate	I	fonofos	8 - 17.5
Hybrex	ROD	fenrazidon-potassium	25
Aldrin	I	aldrin	38 - 67
Nicotine	I	nicotine	50 - 60
Toxicity Level II B Warning (Oral LD_{50} from 50 to 500 mg/kg)			
Methyl bromide	FUM	methyl bromide	65
DDT	I	DDT	113
Derris	I	rotenone	132-1500
Gramoxone Extra	H	paraquat	150
Lorsban	I	chlorpyrifos	163
Caffeine		caffeine	192
Pyrocide	I	pyrethrum	200
Dimethoate	I	dimethoate	235
Sevin	I	carbaryl	246 - 283
Ammo	I	cypermethrin	250
Capture	I	bifenthrin	375
Copper-Z 4/4	F	copper sulfate	472

Table 3 **Persistence of biological activity at the usual rate of herbicide application in a temperate climate with moist, fertile soils and summer temperatures** *(Water Quality Handbook for Nurseries, E-951, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University Ch 6)*

1 Month or Less		1-3 Months		3-12 Months		Over 12 Months[3]
Acifluorfen	Fluorodifen	Bifenox	Metolachlor	Alachlor	Fluometuron	Borates
Acrolein	Glyphosate	Bromoxynil	Naptalam	Ametryn	Fluridone[4]	Bromacil
Amitrol	Fluazifop	Butachlor	Pebulate	Atrazine	Hexazinone	Chlorates
AMS	Fenoxaprop	Butylate	Prometryn	Benefin	Isopropalin	Chlorsulfuron
Barban	Metham	Chloramben	Propachlor	Bensulide	Imazamethabenz	Fenac
Bentazon	Methyl bromide	Chlorpropham	Proham	Buthidazole	Imazaquin	Fluridone[5]
Benzadox	MCPA	Cycloate	Pyrazon	Chlorimuron	Imazethapyr	Hexaflurate
Cacodylic Acid	MCPB	Desmedipham	Siduron	Clomazone	Metribuzin	Imazapyr
Chloroxuron	Molinate	Diallate	TCA	Clopyralid	Monuron	Karbutilate
Dalapon	MSMA	Diphenamid	Terbutryn	Cyanazine	Napropamide	Picloram
2,4-D	Nitrofen	EPTC	Thiobencarb	Cyprazine	Norflurazon	Prometon
2,4-DB	Paraquat[6]	Linuron	Triallate	DCPA	Oryzalin	Tebuthiuron
Diclofop	Phenmedipham	Mecoprop	Vernolate	Dicamba	Oxyfluorfen	Terbacil
Diquat6	Propanil	Methazole		Dichlobenil	Pendimethalin	2,3,6-TBA
DSMA	Sethoxydim			Difenzoquat	Perfluidone	
Endothal				Dinitramine	Pronamide	
				Diuron	Propazine	
				Ethalfluralin	Simazine	
				Fenuron	Sulfometuron	
				Fluchloralin	Trifluralin	

[1]These are approximate values and will vary.
[2] At higher rates of application, some of these chemicals may persist at biologically active levels more than 12 months.
[3]At lower rates of application, some of these chemicals may persist at biologically active levels for less than 12 months.
[4] In water.
[5] In soil.
[6] Although diquat and paraquat molecules may remain unchanged in soils, they are absorbed so tightly they become biologically inactive.

Table 4 **Herbicide water quality data** *(Water Quality Handbook for Nurseries, E-951, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University Ch 6)*

Herbicide Common Name	Relative Runoff Potential	Relative Ground Water Leaching Potential	Half-Life in Days
Diquat	Small	Small	N/A
Glyphosate	Large	Small	47
Pendimethalin	Large	Small	90
Napropamide	Large	Medium	70

Table 5 **Insecticide water quality data** *(Water Quality Handbook for Nurseries, E-951, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University).*

Systemic Insecticide Common Name	Relative Runoff Potential	Relative Ground Water Leaching Potential	Half- Life in Days
Malathion	Small	Small	1
Acephate	Low	Low	3
Dimethoate	Small	Medium	7
Carbaryl	Medium	Small	10
Diazinon	Medium	Large	30
Chlorpyrifos	Large	Small	30
Dicofol	Large	Small	60
Propargite	Large	Small	l56

Table 6 **Fungicide water quality data** *(Water Quality Handbook for Nurseries, E-951, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University).*

Fungicide Common Name	Relative Runoff Potential	Relative Ground Water Leaching Potential	Half-Life in Days
Thiophanate-methyl	Small	Medium	10
Ferbam	Medium	Medium	17
Vinclozolin	Medium	Medium	20
PCNB	Large	Small	21
Triforine	Medium	Small	21
Triadimefon	Medium	Medium	26
Chlorothalonil	Large	Small	30
Manozeb	Large	Small	70
Metalaxyl	Small	Medium	70
Propiconazole	Medium	Medium	100
Etridiazole	Large	Small	103
Fenarimol	Medium	Small	360

4.0 HOME AND GARDEN

4.1 A large proportion of pesticide application may come from residents with gardens. To reduce incorrect or inappropriate use of pesticides information on garden management should be made available and importance of control must be stressed to residents.

4.2 There are many books and manuals available for the home gardener. The recommendations given here have been adapted from Water Quality Handbook for Nurseries, E-951, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University. It should be the minimum advice given the home owner.

Best Management Practices for Home & Garden Pesticide Use

A. When selecting pesticide/herbicide to purchase:

1. Use a pest control method only when that method will prevent the pest from causing more damage than is reasonable to accept.

2. Consider other pest control methods

   Cultural
   - Keep the turf vigorous to compete against weeds.
   - Practice careful water management.
   - Use tillage to remove weeds if possible.

   Mechanical
   - Hand remove individual weeds/other pests.

   Sanitation
   - Plant weed free seed.

   Host resistance
   - Plant disease-resistant turf grass and trees.

   Integrated Pest Management
   - observe, monitor, decide

3. Buy only in small quantities that will be used in a short period of time.

4. Choose the least toxic pesticide. Note the signal word on the label (in increasing toxicity): caution, warning, or danger.

B. Mixing and application:

1. Read and follow pesticide label instructions.

2. Apply pesticides only to sites identified on the label. Label sites where pesticides are being applied.

3. Always measure accurately and calibrate. Use only the amount needed. Do not prepare excess amounts. The whole mixture should be used in a single application.

4. Mix pesticides together only when allowed on the label.

5. Keep children and pets away from treated areas until sprays are dry or dusts/granules have settled.

6. Avoid spray drift, do not apply sprays on windy days.

7. Don't eat or smoke while applying pesticides.

8. Keep application equipment in good condition.

9. See the label for appropriate pesticide protective clothing and/or equipment.

10. Do not allow runoff or drift into storm sewers or water.

11. Follow label directions for cleanup of equipment.

12. Rinse sprayers and empty liquid pesticide containers with water, apply rinse water to the labelled application site. Do not rinse down the drain.

13. Be aware that irrigation water can carry pesticides (and fertilizers) down through the soil, especially sandy soils, and into the ground water. Do not over-water.

C. Pesticide storage:

1. Store pesticides only in the original, labeled containers. Do not store in empty unlabelled bottles or containers.

2. Store in a secure, locked, ventilated area away from children and pets.
3. Store pesticides separate from food, feed or eating/cooking utensils.

4. Protect pesticides from extremes in temperature and keep them dry.

5. When storing on shelves, store dry products above liquid pesticides.

D. Disposal and spills:

1. The best disposal method is to use the pesticide according to the label.

2. Never re-use pesticide containers for any purpose.

3. Never pour pesticides down the drain or into the toilet.

4. Follow additional guidelines as printed on the label.

5. If a spill occurs, soak it up immediately with soil or vermiculite. Spread these materials over a wide area to a labelled application site. Do not wash with water if spilled on concrete, it spreads the spill.

E. Personal safety:

1. Be aware that pesticide exposure can occur through the skin (includes eyes), by mouth, and by inhalation. Exposure by skin is the most common and easiest to prevent.

2. Wear long sleeved shirt and trousers when applying pesticides.

3. Wear pesticide gloves (nitrile, neoprene, or rubber) as guided by the label. Do not wear latex gloves. These may dissolve in the pesticide base.

4. Goggles prevent eye exposure, especially during measuring and mixing operations.

5. Wash immediately after each application.

6. Launder pesticide-contaminated clothing separately from regular laundry in hot water with heavy duty liquid detergent. After washing, run the washing machine a second time with detergent without clothes.

When Applying Pesticides

- Consider the vulnerability of the site; be sure that weather and irrigation will not increase the risk of water contamination.
- Evaluate the location of water sources.
- Read and follow pesticide label directions.
- When possible, use the pesticide with the least potential for surface runoff and leaching.
- Store pesticides properly.
- Make sure pesticide containers do not leak.
- Use IPM practices.
- Calibrate all pesticide application equipment after at least every third use.
- Prevent backflow during mixing operations by use of a mechanical anti-siphoning device or an air gap.
- Triple or pressure rinse pesticide containers upon emptying and pour rinsing water into spray tank.
- Always mix, handle, and store pesticides at least 30 m from water wells, water bodies.
- Do not apply pesticides when conditions are likely to produce runoff or excessive leaching; for example before rain is likely to occur, or before watering.
- Do not spray pesticides on windy days (winds in excess of 10 mph).
- Prevent pesticide spills and leaks from application equipment.
- Leave buffer zones around sensitive areas such as wells, irrigation ditches, ponds, streams, drainage ditches, septic tanks, and other areas that lead to ground or surface water.
- Do not water pesticide-treated areas immediately after application unless indicated on label instructions.
- Dispose of excess pesticides by applying them to labeled pesticide application sites.

5.0 REFERENCES

1. Oklahoma Cooperative Extension Service (1998). Water Quality Handbook for Nurseries, E-951, Division of Agricultural Sciences and Natural Resources, Oklahoma State University.

2. Arizona Cooperative Extension (1998). Arizona Master Gardener Manual, College of Agriculture, The University of Arizona.

APPENDIX C

PUTRAJAYA LAKE CATCHMENT GUIDELINES FOR THE DEVELOPMENT OF MINI WETLANDS

APPENDIX C

PUTRAJAYA LAKE CATCHMENT
GUIDELINES FOR THE DEVELOPMENT OF MINI WETLANDS

1.0 PURPOSE OF GUIDE

The purpose of this guideline is to assist in the creation or conversion of detention ponds in the Putrajaya Catchment into mini-wetlands.

2.0 FUNCTIONS OF MINI-WETLANDS

2.1 The primary intended function of the creation of mini-wetlands is to improve water quality by invoking conditions for natural water treatment processes. Mini-wetlands can be intended as public open spaces but the public should have limited access to them to ensure ecological preservation. By virtue of limited access, the wetland will also become a refuge for nature.

2.2 In the Putrajaya Catchment, the function and usefulness of mini-wetlands are almost the same as for riparian parks, lake valley parks and retention ponds to be provided within the Putrajaya Federal Government Administrative Centre Peripheral areas (refer to Urban Design Analysis and Strategy). Nonetheless, there will be differences in the physical shape, size and depth of mini-wetlands with those of parks and retention ponds proposed in the Urban Design Masterplan. Despite these physical spatial differences, the basis of species selection and planting strategy at various zones of wetlands can be based on the guidelines spelt out in the Putrajaya Urban Design Masterplan.

3.0 DESIGN FACTORS

3.1 A number of factors affect the functions of wetlands for water quality treatment. They are:

1. Mini-wetlands are generally shallow water bodies, of 1 to 4 m depth, compared to detention ponds.

2. Longer water retention times in the ponds allow for increased treatment capacity.

3. The vegetation type selected should be indigenous species that are suitable for the substrates at the bottom of the pond and its littoral zone. Both functional and structural features should be considered in the selection. Examples of the functional features are the nutrient uptake demand and capacity by the plants and trees and their microbiological carrying capacity. Examples of the structural attributes are the height and shade efficiency and their refuge value for fish and other invertebrates.

4. When creating artificial ponds, land-based biomass and topsoil has to be removed from the detention pond. Care should be taken to ensure that no

such biomass are left at the bottom of the pond otherwise they will degrade under anaerobic conditions and result in noxious smells and poor water quality as nutrients are released.

5. A heterogeneous system, with more than one habitat and associated vegetation types is necessary to improve the treatment capacity of the mini-wetlands. Mini-wetland systems are temporally and spatially dynamic. As such the uniformity of vegetation may not provide the resilience required to cope with the variability in the environment of the waters in the ponds.

3.2 The recommended habitat types, vegetation and fish species for the mini-wetlands are described below.

4.0 DEVELOPMENT RECOMMENDATIONS

4.1 Habitat Types

4.1.1 Detention ponds are usually deep. Figure C.1 shows the typical cross section of a wetland. There are three distinct habitat types within it. To create a mini-wetland in a detention pond it is necessary to create the three habitat types within the pond. They are the :

- main pond habitat, deeper than 3 m;
- deep and shallow marsh zones, between 1-3 m;
- swamp forest zone, i.e. the terrestrial habitat at the land-water interface, where the soil is moist and saturated.

4.1.2 The presence of the three zones will allow a heterogeneous system to be established, allowing for sedimentation processes in the deep pond, nutrient uptake and habitat formation in the wet marsh and moist forest zones.

4.2 Vegetation Types

4.2.1 Species selection for the swamp forest zone or high shore line (permanently moist ground) of the mini-wetland shall be such as to comprise of mixed tree species of various characters such as large coloured foliage, domed and umbrella shaped canopies, fragrant and flowering trees. They range from lower-storey species, middle-storey species and upper climax species. They will provide characteristics such as shade zone, wildlife refuge, woodland, good buffer/screening and water edging. The planting shall be of a woodland character.

4.2.2 The species to be selected should have the following characteristics:

- Compatible with immediate upland land use and guidelines of Urban Design Masterplan for Putrajaya;
- Vegetation to be of indigenous origin having ornamental value;
- Ability to absorb nutrients;
- Grow and propagate without fertiliser;

- Oxygenate water and sediments;
- Provide suitable aquatic fauna habitat, their potential for sustainability over time and their ornamental value;
- Provide water shading, cooling and diversity of habitat types for water birds;
- Create a natural transition of vegetation types.

4.2.3 In the Perbadanan Putrajaya area, the species selected should be compatible with any adjoining riparian parks, lake valley parks, and retention ponds, as proposed in the Urban Design Analysis and Strategy.

4.2.4 Tree species with coloured foliage could include *Eleocarpus*, *Erythrina*. Species like *Alstonia* can provide large foliage character. *Enterolobium* can provide shade with its umbrella-shaped crown. Suitable trees or shrubs with fragrant flowers include *Michelia* and *Gardenia.*

4.2.5 To ensure effective pollutant treatment by the vegetation (through biofiltration) in the mini-wetlands, careful selection of the vegetation is necessary. Table C.1 gives the recommended vegetation types and species for the various zones in a mini-wetland.

4.2.6 Even though free floating and submergent aquatics can achieve excellent nutrient removal efficiencies due to their fast growth and high biomass turnover they are not recommended because their fast growth can choke off the entire mini-wetland in a very short time. Thus, rooted emergent aquatic macrophytes are recommended since they possess the following positive characteristics:

i. High biomass carrying capacity
ii. High nutrient uptake capacity
iii. Provide refuge for fish, aquatic invertebrates and birds
iv. High microbial decomposition

4.2.7 The forested swamp is recommended because it provides a long term nutrient sink in the mini-wetland due to its biomass size and low rate of litter decomposition. It also provide shading benefits to the open water zones reducing light attenuation, promotes phytoplankton growth and water cooling which are beneficial to fishes and other aquatic organisms. Also, structurally the forested swamp provides an attractive visual height and critical habitats for a wide range of fauna and birds.

4.2.8 Phytoplankton biomass may increase after the construction of the mini-wetland. Thus, control of the phytoplankton biomass is important and can be carried out through the appropriate selection of fish and zooplankton feeders.

Table C.1 Recommended Vegetation Types and Species for the Mini-Wetlands

Mini-Wetland Zone	Vegetation Types	Nature of zone	Key Species
Forest Swamp	Trees	Permanently Moist to Water Logged Soils, Zone of Intermittent Flooding	*Alstonia spatulat* *Dipterocarpus* Spp *Dipterocarpus hasselti* *Eugenia* Spp. *Eugenia chloroleuca* *Eleocarpus* sp. *Erythrina* sp. *Enterolobium* sp. *Ficus microcorpa* *Gardenia carinata* *Ixora javanica* *Melaleuca* Spp. *Saraca thaipingiensis* *Shorea macroptera* *Shorea* Spp.
Shallow Macro-phyte Zone	Rooted Emergent Macro-phyte	Shallow Permanent Water/ Shallow Marsh	*Cypera* Spp. *Eleocharis* Spp. *Lepironia* Spp. *Lepironia articulata* *Saccharum* sp. *Scirpus grossus* *Scleria* sp *Phragmites karka*
Open Water	Rooted Emergent	Deep Water >3m	*Ipomoea reptans*/*aquatica* *Nelumbo nucifera* (Lotus) *Nymphnea lotus*

4.3 Fish Species

4.3.1 Fish should be introduced into the mini-wetland to contribute to the maintenance of good water quality in the mini-wetland. The following criteria should be followed when selecting the fish species:

- Indigenous species
- Pelagic species
- Rare and endangered/threatened species
- Sport fish
- Carnivorous and insectivorous species

4.3.2 The recommended fish species for the mini-wetlands is given in Table C.2

Table C.2 Recommended Fish Species for the Mini-Wetlands

Species	Ecological Attributes
Puntius tetrazona (Tiger Berb)	Predate mosquito and zooplankton feeder. High ornamental value
P. gonionotus	Same as above
P. schwanenfeldii	Good sport and ornamental fish
Betta splendens	Feed on phyto- and zooplankto, good ornamental value
Rasbora Spp.	Predate mosquito larvae, insects and some aquatic plants
Trichogaster pectoralis	Control algal production
Leptobarbus hoevenii	Phytoplankton feeder also feeds on aquatic plants. Ornamental fish species
Channa striata	Carnivorous and predate mosquito larvae.

5.0 WETLANDS MANAGEMENT

5.1 Best Management Practices

Recommendations of the Best Management Practices (BMP) to sustain the desired ecological balance for the Putrajaya Lake and its associated wetlands are given below.

5.2 Wetland Plants

5.2.1 For the wetland plants the following factors need to be considered:

- Plant harvesting for die-off, overcrowding and disease to plug further damage to health plants;
- Planting density (to replenish the harvested plants) to be low to very moderate to prevent excessive growth and reaching carrying capacity;
- Pest attacks to be eliminated by applying environmentally friendly pesticide and biological control;
- Unwanted aquatic weeds must be uprooted from the cells. This will be done by manual weeding, applying herbicide (environmentally friendly) and maintaining required water level in the wetland cells;
- Optimum water level (as designed) must be maintained in the wetland cells to control unwanted aquatic weeds and make available adequate nutrients and pollutants to wetland plants;
- For replanting *Scleria* sp., which is less foliaceous and resistant to fluctuating environment can be given priority. However, the planting density

will be less than 6 sp/m^2;

- The colour of the plant leaves should be monitored for chlorosis and growth;

- Water circulation from upstream to downstream to be maintained to reduce plant litter at the substratum. To reduce plant litter, stocking of detritivorous and omnivorous fish species are recommended;

- Planting of rare and endangered wetland/terrestrial plants should be encouraged;

- Weekly monitoring of wetland plants and take immediate appropriate action to prevent further damage or secondary infection to wetland plants;

- Monthly management meeting to review effectiveness of measures taken to maintain healthy plants in wetland cells.

5.2.1 Plant Harvesting

5.2.1.1 Plant die-off, due to overcrowding, pest infestation and weed's invasion in the wetland cells, is common and expected. It should not interrupt the ecological cycle as each wetland cell has its own microbial carrying capacity. However, if the die-off is significant involving large planting area, there will be need for harvesting. Thus, routine harvesting of senescent plants due to disease or overcrowding or to reasons unexplained, is very appropriate and this exercise to be completed during drought period rather than monsoon.

5.2.1.2 Plant harvesting will have environmental impacts on water quality and fish and invertebrates and it must be addressed properly. One of the options to maintain the water quality, is to raise temporarily the stop logs in the weir to increase retention time by increasing volume. This will allow for the sediments to settle at the bottom. The rise in the stop logs will temporarily stop water flow into the downstream.

5.2.2 Planting Density

Planting density is to be as low as possible so as to allow for plant growth and natural propagation. The recommended density for transplanting the harvested cells is as follows:

Scleria sp. - <6 plants/m^2

Others, such as *Phragmites* sp. *Lepironia* sp. and *Scirpus* sp. - <10 plants./m^2

5.2.3 Species Selection

5.2.3.1 Currently there is limited information on the ability of an individual wetland species to uptake of particular nutrients at a particular aquatic habitat type. The

wetlands at Putrajaya represent an excellent opportunity for research into this area.

5.2.3.2 It is generally known that Nitrogen, Phosphorus and Potassium are the three major nutrient elements required for the growth and propagation of plant species including those of wetland plants. But the intricate physiology of nutrient uptake and cellular absorption are little known. Especially very little is known particularly on the tropical and equatorial wetland plants with some information available from temperate regions. However, the information available on the temperate wetland plants may be of little relevance to the tropical wetland species because of the different rates and annual pattern of growth, and the temperature difference which may affect the rates of the biochemical processes themselves. Nevertheless, some general information which may be applicable of the tropical wetlands which are shown in Table C.3.

Table C.3 Plant species and nutrient uptake

Species	Information Available
Phragmites karka	Ability to polish sewage effluents
Lepironia articulata	High nutrient absorber
Saccharum sp.	Good nutrient absorber, shading and refuge for fish
Scirpus grossus	Good nutrient absorber

5.2.3.3 Although other wetland plant species are well known to have ability in nutrient uptake in cleaning up of euthrophicated lakes, ponds, reservoirs and marshland, quantitative field experiments have not been done yet. As such precise information are not available.

5.2.3.4 For the shoreline, *Scleria* sp. is less foliaceous and fast growing. It is relatively more resistant than other species and withstands more water level fluctuation in the cells. As a replacement of harvested species, it can be given priority.

5.2.4 Control of Unwanted Aquatic Weeds

5.2.4.1 Weeds are the major problems in the non-inundated or improperly inundated cells than in the inundated ones. Weeds are competitive and fast growing compared to wetland plants. They are resistant to harsh environment. Common weeds in the wetland are Mimosa, *Pudica* sp. *Galinsoga* sp. *Rhyncospora* sp. *Fimbristylis* sp. and *Limnocharis* sp.

5.2.4.2 The following steps are to be taken:

- Continuous monitoring
- Manual weeding to be done periodically and consistently in all wetland

cells. The exercise has to be limited to noxious and exotic species.

- Maintain the required water level so that weeds are submerged under water. This will prevent further germination of seeds and seedlings.
- Manual weeding of oil palm seedlings.

5.2.4.3 A successful way of removal of unwanted aquatic weeds is by the use of biodegradable herbicides which would have little effect on fish and other invertebrates. The pesticide BMP can be consulted for appropriate herbicides. Regular manual weeding is the best non-polluting method.

5.2.5 Pest Infestation

5.2.5.1 Pest problems have been documented at early stage in the Putrajaya Wetlands (Putrajaya Constructed Wetlands, Advisory Report #8, Wetland International - Asia Pacific). Disease attacks on some wetland plants in UN and UW cells are also found in the present study. *Phragmites karka* and *Scirpus grossus* were found to have been attacked by aphids and stem borer respectively. This was found sporadically in some cells. The problems are, however localised and can be addressed effectively. The following steps are to be considered for action immediately.

1. To develop an Integrated Pest Management Techniques (IPM). IPM is a well-established pest management system whereby pests are killed at a threshold level without having any impact on non-target organisms.

2. Immediate harvesting of the infected plants and transplanting with new plants. Planting density must not exceed 10 sp./m^2 for species other than Elephant Grass. *Scleria* can be planted more than *Phragmites karka* due to latter's resistance to environmental constraints.

3. Biological control method using natural predators of pest and insects. Biopesticide, *Bacillus thuringinesis* can control the pests namely caterpiller leaf rollers (*Craphalocrocis medinalis*) and rice step borer, *Scirpophaga incertulas*.

5.2.6 Water Level Management

Maintenance of required water level is extremely important for survival and propagation of wetland plants. Water level varies with rate of establishment of wetland plants. Shortage or lack of water can put wetland plants under stress and reduced plant vigour. It increases the chance of secondary attack by pests. In such cases water levels should be increased to control unwanted aquatic weeds at the fringe of the marsh zone and to make available adequate nutrients and pollutants to a variety of wetland plants.

5.2.7 Monitoring Plant Performance

5.2.7.1 It is expected that a plant biologist/botanist or horticulturist will be involved in the vegetation monitoring. The following points have to be considered and provide

biological indicators of plant health:

1. The colour of plant leaves should be monitored;
2. Leaves should be observed for chlorosis;
3. Removal of plant litter manually. Plant litter deposited at the bottom of the wetland arms can be removed by suction dredging. The disadvantage, however, is that it can dislodge the roots of the wetland plants.

5.2.7.2 Removal of plant litter at the substratum can be achieved by ensuring the following:

1. Water circulation from upstream to downstream via wetland cells and primary lake;
2. Establishment of roots of wetland plants into the substratum;
3. Stocking more detritivorous, and omnivorous fish species in the wetland cells.

5.2.8 Plant Nursery

Supply wetland plants as, and when, necessary, to replenish the harvested plants is crucial to operation and management of wetland system. The outdoor nursery should be ideally located within the Putrajaya wetland at a strategic location so that they can be supplied readily in any affected wetland arms. The wetland nursery used by the wetland contractors is suitable.

5.2.9 Wetland Plant Monitoring

Long term monitoring and management are important for maintenance of a healthy wetland system. Weekly supervision of general health of all dominant plant species in the wetland cells is to be undertaken. Immediate actions are to be taken for remedy if incidences of any of the following are apparent:

1. Lack/shortage of water in any of the wetland cells; water levels should be in the region of 0.3 to 2 m for aquatic plant growth;
2. Overcrowding of any of the species in the cells that have caused stress, pest infestation and reduced plant vigour resulting in the stunting of growth;
3. Insect attack of significant proportion in any of the species in the wetland cells;
4. Illegal poaching on wetland plants for hunting purpose.

5.3 Fish Community

The objective of fish stocking is to control mosquito larvae, maintain good water quality and support sport and recreational fishery. Nevertheless, the overgrowth of species like Tilapia can be a cause of concern as it will dominate other species present. The following control measures are necessary:

5.3.1 Control of Undesirable Species

5.3.1.1 Species of Tilapia is always a nuisance to the aquatic system for its fast growing nature which if not controlled will affect other fish species. They can be controlled by:

1. Fish sampling using netting (cast and gill netting) and scooping
2. Angling and sport fishing
3. Biological control by introducing more predatory sport and game fish.

5.3.1.2 Some species need to be controlled at the early stage. Generally, the Grass carp, *Ctenopharyngodon idellas*, is the herbivore of concern. Its daily intake of grass is expected to be three times its body weight. Thus it should not be stocked in the initial 2-3 years. Other members of the carp family are not herbivores. Once the wetland plants are established, the Grass Carp can be introduced in deeper waters, at low numbers, so as not to destroy the plant leaves of the Primary Lake and Central Wetlands. In addition, cut grass leaves can be a food source for the Grass Carp population in the water body.

5.3.2 Routine Fish Sampling and Restocking

Routine fish sampling is to be conducted to realise the level of fish recruitment and adaptability to a new habitat. Exact density and availability (comprehensive inventory) will not be known at this stage. However, based on the approximate data, some crude idea will be formed which will be suffice to plan a new stocking exercise. The general aim is to establish a food chain where fish can thrive well without much external feeding and naturally propagate to establish a breeding population. Special emphasis on stocking of Cyprinid species, prawn, *Macrobrachium lancestri* and other invertebates is to be given. The reason is that they form the food of many carnivorous and omnivorous fish species. Care is to be taken so that sampling exercise does not cause problems to ambient water quality, wetland plants and fish stocks. Once established few carp species can be released into main lake and wetlands.

5.3.3 Stocking of Endangered and Rare Species

Stocking of endangered and rare species can be one of the important stocking programmes because the wetland's unique feature and ecological characteristics. The potential species are *Oxyleotris marmoratus*, *Leptobarbus hoevenii*, *Probarbus jullieni* and *Tor tambroides* and *Osphronemus goramy* and *Scalophagus formosus*.

5.3.4 Illegal Fishing

5.3.4.1 Illegal fishing will be difficult to stop once the wetland system is established when a variety of fish species occupy the productive habitat. Prohibition of illegal fishing can be done by enacting new laws and legislation.

5.3.4.2 In summary, the fish community need to be managed through a fish management plan and the following factors need to be considered.

- Routine sampling to determine the adaptability and recruitment of fish stocked into the wetland system. Evaluate the rate of establishment of fish species to support successful sport and recreational fishery;

- Design restocking plan based on the periodic fish sampling exercise. The type of fish and its stocking density must focus on eliminating undesirable fish species, eg. exotic Tilapia sp. and mosquito larvae;

- Ensure water level optimum for all types of fish to move throughout the water column;

- Enact legislation to protect fish from illegal and destructive catch;

- Promote educational and environmental awareness to protect and promote fish, which are rare and endangered;

- Long-term management and monitoring of fish health and their performance to control water quality control, support sport and recreational fishery and reduce mosquito larvae and other noxious materials in water.

5.4 Birds

5.4.1 The presence of birds need to be monitored to ensure that their presence does not unduly affect the wetlands system and lake water quality. The following actions and factors need to be considered:

- Enact legislation to protect bird from illegal hunting;

- Promote educational and environmental awareness to conserve protected birds;

- Develop an outline plan to for management of the wetland and swamp system for use by resident and migratory birds;

- Catchment management committee to met every month to review the effectiveness of measures undertaken to enhance colonization of birds;

- Identify and declare “unique” any areas inhabited by uncommon birds.

5.4.2 Once the wetland plants and its associated swamp forest are well-established, a diversity of terrestrial and water birds will colonize the habitat. A variety of resident and migratory birds are commonly expected to colonize the habitat. To encourage this, the following steps can be taken:

1. Monitoring of birds during the period of migration to assess population impact;
2. Establishment of sheltered sites for for birds to graze, perch and roost.

Floating rafts anchored to the bottom for example, can provide nesting and protection from disturbance.

5.4.3 The impact of the birds also need to be monitored to ensure the population numbers and type of birds do not compromise water quality.

5.4.4 Community awareness and education programme can be undertaken amongst local residents, school and university students and community leaders and other interested groups to encourage public participation in bird watch and their conservation. A warden service needs to be established to provide public liaison and education on water bird watching.

5.5 Wildlife

5.5.1 Undisturbed forest cover will encourage animal (wildlife) colonization. Once the vegetation cover of the riparian park (swamp strip) of the wetland is established, wildlife colonization will be widely expected.

5.5.2 Similar to the concern for bird life in the wetlands and Lake, wildlife also need to be monitored:

- Enact legislation to protect wildlife from poaching and hunting.
- Promote educational and environmental awareness to conserve wildlife, which are either protected or endangered.

6.0 COMMUNITY AWARENESS AND EDUCATION

Apart from the bio-chemical and other physical controls, community awareness and education amongst common people to appreciate wetlands and its associated plants and fauna are important in promoting their conservation and management. In this respect the NIC in Putrajaya can play an important role in disseminating information.

APPENDIX D

PUTRAJAYA LAKE CATCHMENT

GUIDELINES FOR DEVELOPMENT OF RIPARIAN MANAGEMENT ZONES (RMZ)

APPENDIX D

PUTRAJAYA LAKE CATCHMENT
GUIDELINES FOR DEVELOPMENT OF RIPARIAN MANAGEMENT ZONES (RMZ)

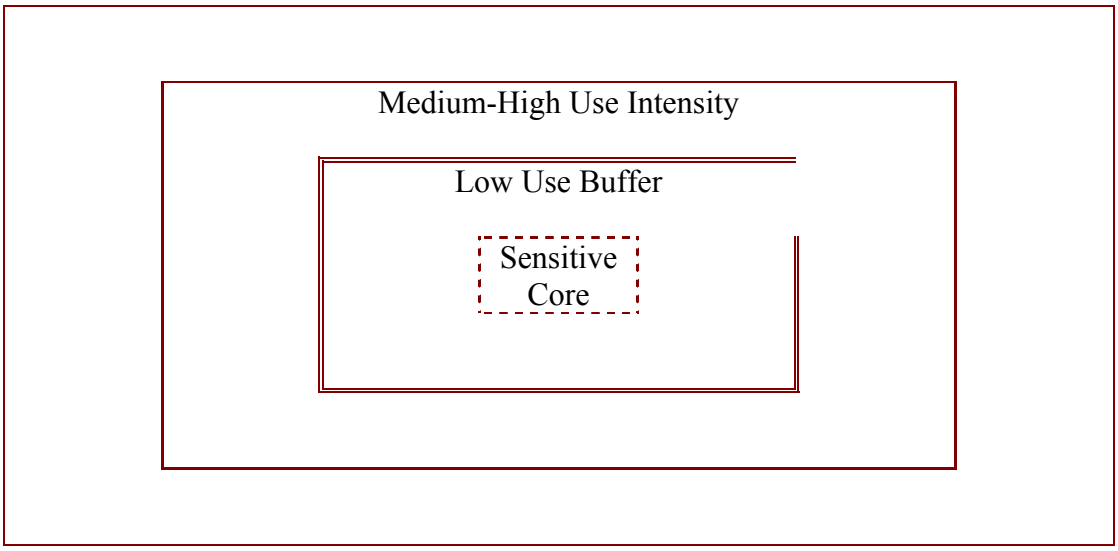
1.0 PURPOSE OF GUIDE

The purpose of this guide to assist in the design of buffers or Riparian Management Zones along drainage lines and water bodies in the Putrajaya Lake Catchment.

2.0 CORE ZONE CONCEPT

In land use design, the identification of sensitive areas may be based on the use of zones. In conservation practice, the ”core zone” principle is used in developing management plans. The central core of a management area is normally considered most sensitive and is most protected from development. This is fringed by a intermediate buffer zone of low intensity use, with increasing intensity use located in the outer fringe to the central core (Figure D.1).

Figure D.1 Core Zone Concept in Conservation



3.0 RIPARIAN MANAGEMENT ZONE CONCEPT

3.1 Within the catchment, the wetlands and natural streams may be considered the most sensitive.

3.2 Management of non-point pollutant input into waters is normally carried out by different management practices based on observations, experimentation and experience. Generally the best management practices for pollutant reduction tries to mimic the natural environment which has been disturbed by man. Thus the more natural-looking an environment the less likely is the pollutant input that might be expected.

3.3 Based on such premise, therefore, there should be as much an abundance of vegetation as

possible without it being detrimental to human activities. Within the Putrajaya Lake Catchment the best example of this enforced 'naturalness' is the Sungai Kyok sub-catchment in MARDI. Here the streams and ponds are lined with tall grassess and trees. What might be regarded as an overgrowth of grasses in the streams actually serve multiple functions.

3.4 They

1. increase channel, reduce flow velocity, and carrying erosive or load carrying capacity;
2. trap particulates, and encourage sedimentation;
3. reduce sunlight penetration in the water column, discouraging algal growth, even in excess of nutrients;
4. uptake nutrients in the water column and store in plant materials;
5. provide stable habitats for aquatic ecological systems.

3.5 The development of the Putrajaya Cacthment area therefore should try to simulate such stream or riparian environments along the natural water courses, ponds and even storm drains. Riparian Management Zones (RMZ) should be established following the practice in forestry management.

3.6 Therefore,

1. low use buffer zones comprising riparian management zones or buffer strips (see below) of 30 to 10 m width on each side should be maintained;

2. higher intensity development should be located further away from the water courses.

4.0 RIPARIAN MANAGEMENT ZONE DESIGN

4.1 Components in the RMZ

4.1.1 Riparian Management Zones comprise of three components:

1. a tree-lined corridor along the stream/pond banks which act to provide shade and reduce water temperatures, provide large organic detritus loads to support aquatic ecological system growth, provide a long-term storage for nutrients taken up by its deep and extensive root system, protect the stream from disturbance;
2. a shrub corridor next to the trees as a transitional zone, to the adjacent grassed edge, to provide habitat for birds and small animals, to provide medium term nutrient uptake storage through its moderate-depth root system, to stabilise the soil structure, to act as barrier to control access to the stream;

3. a grassed edge leading away from the shrubs with tall stands to reduce and regularise overland flow runoff, filter sediments in runoff from reaching the stream, provide rapid uptake of nutrients through its fine and shallow rooting system, provide habitat for very small animals and insects, as well as being the transition to more frequently cut traditional lawns and park landscape.

4.1.2 In addition to land zoning, there must also be monitoring and control of chemical use in the catchment. A Pesticide Register should be instituted in the catchment. The BMPs for fertilizer and pesticide use is given in Appendix A and B.

4.1.3 The guidelines for the buffer zone widths based on land slope is given in Table D.1.

Table D.1 Recommended Total RMZ Widths based on Percent Slope for areas with high potential for ground or soil disturbance. (from www.bloomington.in.us/~mjump/Bmp.htm)

Watershed RMZ Slope Characteristic / **Stram Type**	**0-5%**	**5-10%**	**10-20%**	**20-40%**	**>40%**	**Primary Habitat**
Perennial >40' wide	200'	200'	200'	200'	200'	200'
Perennial 20-40' wide	75'	75'	75'	105'	105-165'	75'
Perennial <20' wide	50'	50'	65'	105'	105-165'	35'
Intermittent	25'	45'	65'	105'	105-165'	-
Sinkholes	25'	45'	65'	105'	105-165'	-
Water Supply Reservoirs	75'	90'	130'	210'	210-300'	75'
Other Lakes & Ponds	35'	45'	65'	105'	105-165'	35'

Note: widths are expressed in feet on each side of the watercourse.

4.1.4 The total width of the buffer strip depends in large part on its major functions and the slope and use of the adjacent land. If the major purpose of the buffer strip is sediment removal from surface runoff, a width of 15 m may be sufficient on slopes of 0-5%. If excess nutrient removal also is an important function, a width of 15-30 m might be necessary depending on the kind and quantity of agricultural chemicals applied and the soil and cultivation system used.

4.1.5 As the slope, intensity of land use, or total area of the land producing non-point pollutants increases, or as soil permeability decreases, a wider buffer is required. Buffer strips of 10-60 m wide are recommended for sediment removal, 5-90 m wide for nutrient removal, 5-100 m wide for species diversity and 15-30 m wide for stream water temperature moderation. Studies on buffer strips indicate that the buffer strip widths could be 20% of the total non-point pollutant area.

4.2 Examples of RMZ design

4.2.1 Multi-Species Riparian Buffer Strip (MSRBS) System

4.2.1.1 The Agroecology Issue Team (AIT) of the Leopold Center for Sustainable Agriculture located in Ames, Iowa, U.S.A. and the Iowa State University Agroforestry Research Team (IStART) have developed multi-species riparian buffer strip (MSRBS) system for application in the Midwestern and Great Plains agroecosystem.

4.2.1.2 From the streambank edge,

the first zone of the MSRBS is 10 m wide and contains 4-5 rows of rapidly growing trees. This provides perennial root systems and long-term nutrient storage close to the stream;

the second zone is 4 m wide and contains 1-2 rows of shrubs. The shrubs add more woody stems near the ground to slow flood flows and provide a more diversified wildlife habitat; and

the third zone is a 7 m wide zone of native, warm-season grasses. The grasses provide the high density of stems needed to dissipate the energy of surface runoff and the deep and dense annual root systems act to increase soil infiltration capacities and provide organic matter for large microbial populations.

4.2.1.3 If the area is barren then fast-growing trees are needed to develop a functioning MSRBS in the shortest possible time. It is especially important that rows 1-3 (the first row is the closest to the streambank edge) in the tree zone (zone 1) include fast-growing, riparian species such as willow (Salix spp) species. If, throughout the year, the rooting zone along the streambank is more than 1.2 m above normal stream flow and soils are well drained, then upland trees and even coniferous trees and shrub species can be planted in rows 4 and 5. The slower growing species will not begin to function as nutrient sinks as quickly as faster growing species but are often considered to be better quality trees.

4.2.1.4 Shrubs are included in the design because their permanent roots help maintain soil stability, their multiple stems help slow flood flows and they add biodiversity and provide wildlife habitat. Many local shrubs can be used and selected based on their desirable wildlife and aesthetic values.

4.2.1.5 The grasses function to intercept and dissipate the energy of surface runoff, trap sediment and agricultural chemicals in the surface runoff, and improve soil quality by increasing infiltration capacity and microbial activity as a result of their annually high turnover of roots. Tall grasses are better suited to the MSRBS than shorter grasses that are usually used for lawns because of their taller and stiffer stems and their more deeply distributed roots. A minimum grass zone width of 7 m is recommended to dissipate the surface runoff, trap sediment, and promote significant infiltration.

4.2.2 Other Systems

4.2.2.1 The three zone MSRBS model of trees, shrubs, and prairie grasses is well suited to the agro-ecosystems of the Midwest and eastern Great Plains. Other combinations of flora types can also be effective. These might include combinations with more trees or shrubs or without any trees or shrubs, except for those used for streambank stabilization.

4.2.2.2 The grass zone is the most critical of the three zones in the MSRBS. Site conditions, major buffer strip biological and physical functions, cost and maintenance requirements need to be considered in specifying species combinations.

CHAPTER 3

WATER RESOURCES STUDIES

3.0 WATER RESOURCES STUDIES

3.1 HYDROLOGICAL STUDY

3.1.1 Introduction

3.1.1.1 The Putrajaya Lake system was created by the impoundment of the Sg. Chuau. Its catchment is predominantly that of the Sg. Chuau's, except for a small section on the South East corner (part of Sg. Limau Manis), which was added to it due to the shaping of the natural terrain by the construction of a canal linking two sections of the Sg. Chuau (see Figure 2.7.1, Chapter 2). Thus, the amount of water in the Lake will depend predominantly on the amount of runoff from the Sg. Chuau catchment. The lack of runoff entering into the Lake or significant losses of water from the Lake will result in the deterioration of the water quality in the Lake, through the increase of pollutant concentration in the Lake. Hence, it is critical that all possible runoff arising from the Lake catchment should enter into the Lake system.

3.1.1.2 In order to quantify the discharge from the catchment entering into the Lake system at different time periods, and for different possible land-use scenarios in the catchment, a hydrological model of the catchment has to be set-up and calibrated for use. The outputs from the model simulations can then be fed into the water quality model of the Lake system to evaluate its water quality for the various land-use scenarios.

3.1.1.3 The hydrological model adopted for use in this study is the NAM conceptual rainfall-runoff model, which is part of a package of hydrological, hydraulic and water quality modelling software developed by the Danish Hydraulic Institute. For the purpose of modelling the water quality in the Lake system a daily simulation time interval is considered adequate and has been used in this study. The modelling exercise involved collection and preparation of the pertinent hydrological input data, model set-up and calibration, and simulation for the discharge outputs for the various proposed land-use scenarios for the catchment.

3.1.2 Hydrological input data

3.1.2.1 The Drainage and Irrigation Department is collecting hydrological data in the area. There are four rainfall stations and one pan evaporation station in the vicinity of the study area. A streamflow station was established at the Phase 1A temporary dam site for several months in 1994. The details on the location and recording period at each of the stations are given in Table 3.1.1.

Table 3.1.1 Details of Hydrological Stations located in the vicinity of the Study Area

Item	Type of Station	Station No.	Name of Stations	Latitude	Longitude	Date Installed Manual/Auto	Date closed
1.	Rainfall	2816 112	Ladang Galloway	02°53'45"	101°39'50"	10/24 (M)	08/94
2.	Rainfall	2916 001	Prang Besar	02°54'17"	101°41'50"	1/81 (A)	10/94*
3.	Rainfall	2916 002	Puncak Niaga	02°55'40"	101°41'18"	1/95 (A)	
4.	Rainfall	2917 106	Ladang West Country	02°58'35"	101°43'40"	1/24 (M)	3/95
5.	Rainfall	2917 001	Stor JPS Kajang	02°59'30"	101°47'50"	4/75(A)	
6.	Streamflow		Temporary Dam			3/94	11/94
7.	Evaporation	2916 301	Prang Besar	02°55'40"	101°41'50"	1/81	10/94

* Station shifted to Puncak Niaga (Treatment Plant)

3.1.2.1 Rainfall data

(1) The availability of the rainfall records were first studied. The records for Ladang West Country and Ladang Galloway were excellent with no missing data gaps in the record at all. The records at Stor JPS Kajang is also good but there were some minor gaps while that at Prang Besar were also good, except for a big gap in 1988.

(2) The consistency of the rainfall records from three stations i.e. Prang Besar, Ladang West Country and Ladang Galloway, were subjected to a double mass curve analysis, with the reference station at Stor JPS Kajang. The exercise involves the

plotting of the cumulative annual rainfalls at each of the 3 stations against the cumulative annual rainfall at Stor JPS Kajang, which is a principal station operated by DID. The curves are given in Figure 3.1.1. It can be seen from the double mass curve plots (all three plots exhibit approximately constant slopes) that the rainfall records at Prang Besar, Ladang West Country and Ladang Galloway were all consistent with that at Stor JPS Kajang.

(3) The range in the annual rainfall is not great, ranging from 2087 mm at Ladang Galloway at the Southern tip of the catchment, 2148 mm at Prang Besar in the middle part of the catchment to 2319 mm at Ladang West Country in the upper reaches of the catchment. According to McCuen (1989), when the annual catch at the rain gauges differ by less than 10%, then the Station-Average Method for estimating missing rainfall, P_m can be used which is given as

$$P_m = 1/n \sum_{i=1}^{n} P_i$$

where P_i is the catch at gauge i

(4) As the difference in annual catch between the rain gauges is ±11 %, the Normal-Ratio Method which uses the annual catch in deriving weights, is therefore employed in this Study in estimating missing rainfall data. The general formula for computing P_m is then

$$P_m = \sum_{i=1}^{n} w_i P_i$$

(5) The weight for station is computed by $w_i = A_x / nA_i$

Where A_i is average annual catch at gauge i
A_x is average annual catch at station x
n is number of stations

(6) Figure 3.1.2 shows the monthly rainfall distributions at the 4 stations. It can be seen that all 4 stations exhibit similar monthly distribution, with periods of heavy rainfall during the inter-monsoon months of March to May, with monthly rainfalls

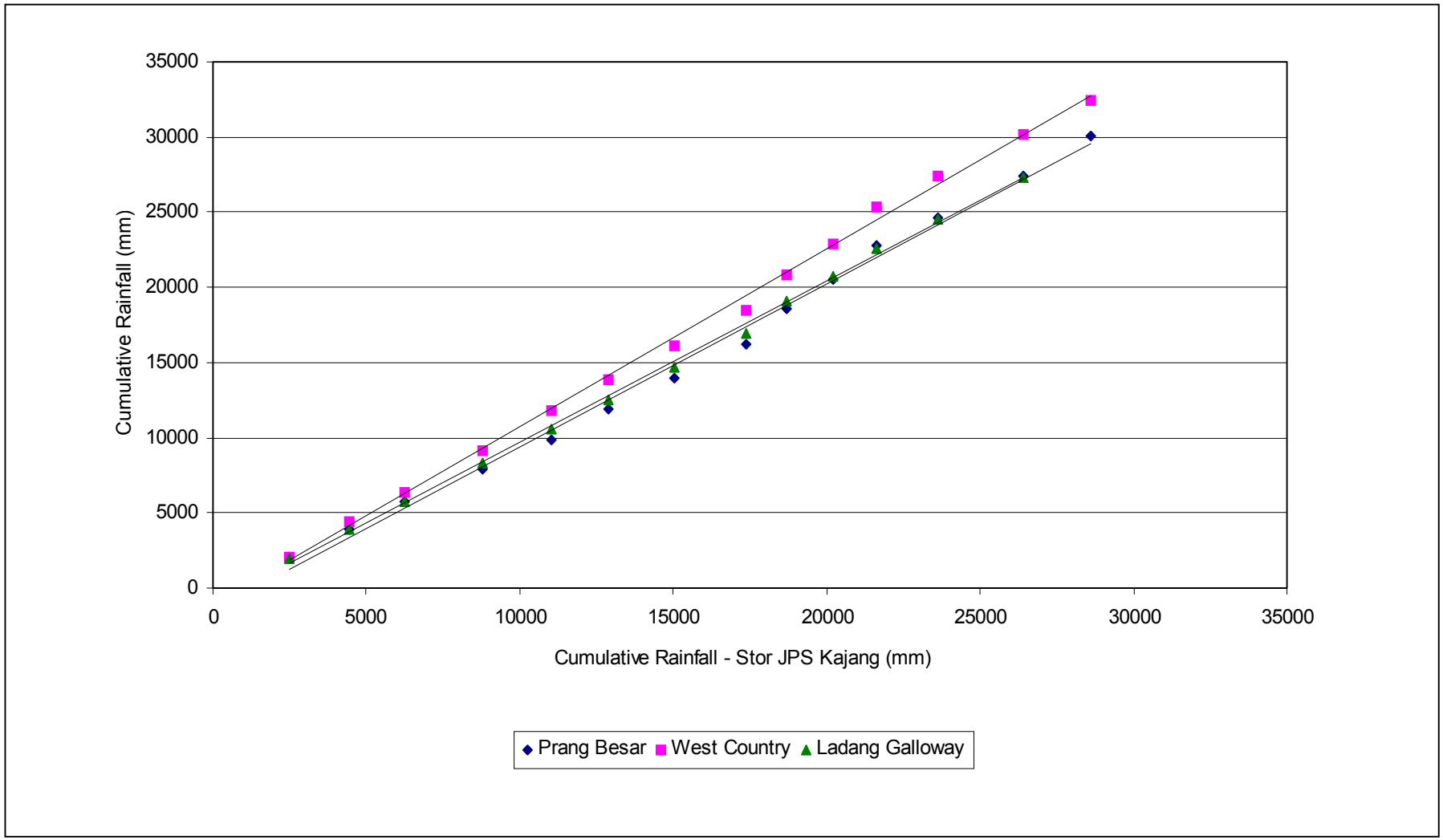


Figure 3.1.1 : Double-mass Curve Analysis of Rainfall Data (1981 - 1994)

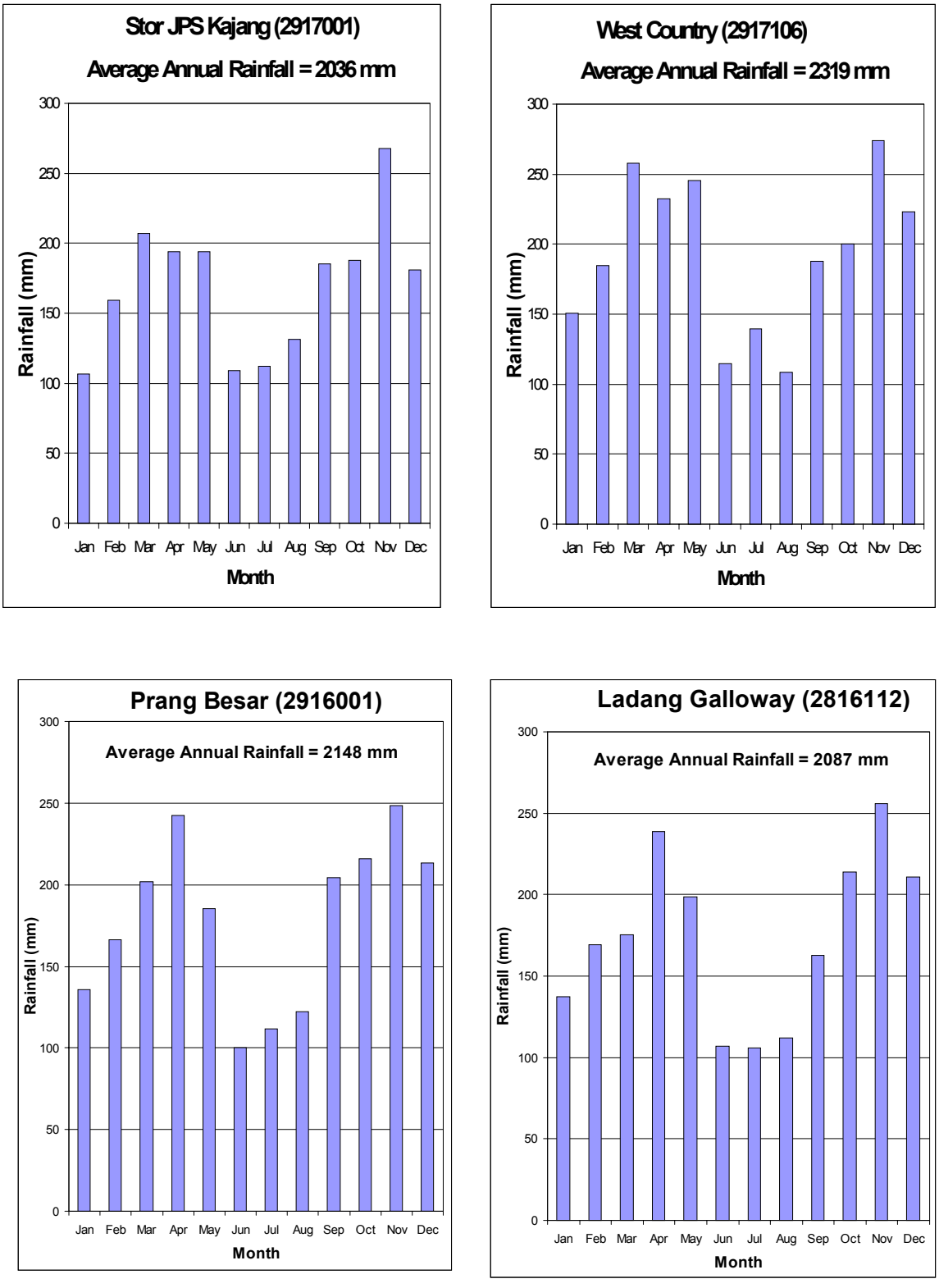


Figure 3.1.2 : Monthly Rainfall Distributions at the 4 Stations (1981 – 1994)

of 150-250mm and also during the North-East monsoon months of October to December, with monthly rainfalls of 200-250mm. The periods from January to February and June to August are relatively drier, with moderate rainfalls of 100-150mm. The monthly rainfall data of the above mentioned rainfall stations for the period 1981-1994 are as tabulated in Tables 3.1.2a and 3.1.2b.

3.1.2.2 Evaporation data

(1) The accuracy of the pan evaporation data is moderate due to operational difficulties associated with the frequent and high intensity rainfall. The method of quality control adopted by DID, as described in the DID Water Resources Publication No. 5 (1976), has been used.

(2) The average annual pan evaporation at Prang Besar is 1720mm. The monthly distribution of the pan evaporation is given in Figure 3.1.3. It can be seen that the range is small, ranging from 130mm in November to December to 155mm in February and July to August. The monthly pan evaporation data at Prang Besar for the period 1981-1992 are as tabulated in Table 3.1.3.

3.1.2.3 Streamflow data

(1) The processed daily streamflow data (Pressure Bulb Recorder) from DID is available for the months of March 1994 to November 1994. The daily mean discharge ranges from a low of 0.21 m^3/s to 2.2 m^3/s. It should be noted here that the data quality from the Pressure Bulb Recorder is however, somewhat lower compared to DID principal streamflow stations which employ more expensive higher accuracy water level recorders. The daily streamflow data at Temporary Dam for the period March to November 1994 are as shown in Table 3.1.4.

3.1.3 Rainfall Runoff Model

3.1.3.1 Method of approach and model selection

(1) In order to produce estimates of monthly streamflows at the gauged site only, any of the following approaches could be adopted:

(i) use of a daily catchment model (rainfall runoff model) which is calibrated using daily data from which monthly data are then extracted

Table 3.1.2a : Monthly Rainfall (1981 – 1994)

Prang Besar (2916001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1981	121	150	63	411	390	50	60	50	175	258	201	171	2097
1982	18	118	147	303	237	130	103	89	52	198	315	135	1843
1983	82	66	134	131	248	74	133	202	273	148	173	113	1774
1984	322	345	112	190	106	130	128	77	111	91	306	237	2153
1985	94	217	169	170	234	8	159	47	123	289	165	274	1948
1986	258	85	259	382	156	28	90	61	115	268	231	120	2050
1987	131	23	136	237	173	92	92	156	240	293	118	371	2059
1988	220	209	354	212	69	150	211	193	234	80	268	94	2294
1989	142	280	351	145	171	140	38	210	226	261	270	176	2407
1990	96	151	199	224	138	98	141	97	255	166	189	195	1946
1991	86	60	79	307	195	74	3	86	176	399	300	448	2211
1992	44	255	189	131	191	41	103	200	147	66	223	286	1872
1993	123	191	189	325	234	150	188	69	285	247	449	284	2730
1994	167	179	450	231	59	240	114	176	450	259	274	89	2685
Mean	136	166	202	243	185	100	112	122	204	216	248	213	2148

Ladang Galloway (2816112)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1981	76	129	86	414	250	42	49	81	155	207	215	228	1929
1982	55	92	115	291	217	128	117	118	44	181	338	260	1953
1983	54	47	227	177	328	118	172	246	176	130	111	58	1841
1984	321	408	108	323	123	116	147	125	137	126	452	255	2639
1985	74	240	193	135	343	0	192	45	151	425	259	151	2204
1986	227	97	258	226	283	17	71	103	109	190	179	157	1915
1987	90	26	12	294	85	184	87	144	290	345	192	374	2120
1988	266	221	270	340	80	107	158	149	177	127	269	104	2267
1989	200	314	348	128	75	118	43	107	242	237	229	130	2169
1990	67	98	116	148	149	47	116	45	146	187	236	214	1566
1991	116	66	98	231	196	120	3	68	214	178	198	402	1888
1992	59	266	69	225	234	85	61	229	160	66	220	264	1935
1993	167	199	214	236	320	158	164	77	197	339	411	271	2751
1994	153	174	342	175	100	261	106	35	82	259	274	89	2049
Mean	137	170	175	239	199	107	106	112	163	214	256	211	2087

Table 3.1.2b : Monthly Rainfall (1981 – 1994)

Ladang West Country (2917106)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1981	119	219	101	201	463	103	56	26	145	189	252	140	2014
1982	25	175	217	308	291	228	111	98	159	150	402	216	2378
1983	139	60	198	105	283	109	156	162	256	185	202	154	2009
1984	327	400	277	337	161	94	182	101	147	100	454	201	2781
1985	64	332	317	250	364	32	167	90	158	267	259	348	2648
1986	260	45	388	321	218	46	122	46	62	183	234	120	2045
1987	141	105	220	211	171	39	153	290	211	274	180	242	2237
1988	299	209	354	212	69	150	211	193	234	80	268	94	2373
1989	140	227	312	127	200	90	44	180	374	258	233	196	2381
1990	96	110	179	216	202	104	227	81	206	214	182	192	2009
1991	140	65	247	346	320	83	24	71	179	307	385	342	2509
1992	104	291	170	162	187	42	132	125	178	68	176	428	2063
1993	155	100	216	222	382	185	265	20	243	266	331	362	2747
1994	101	249	418	237	123	301	106	35	82	259	274	89	2274
Mean	151	185	258	233	245	115	140	108	188	200	274	223	2319

Stor JPS Kajang (2917001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1981	234	361	82	403	513	26	68	43	190	158	139	196	2411
1982	12	101	152	82	214	189	102	81	122	204	450	226	1932
1983	71	83	185	107	175	111	159	320	200	194	129	79	1810
1984	152	437	188	213	159	136	183	82	165	136	459	213	2522
1985	22	174	284	184	154	11	140	106	188	284	334	370	2249
1986	186	56	367	326	180	71	95	62	84	225	144	69	1862
1987	67	111	154	161	167	128	98	426	164	276	177	200	2127
1988	144	193	360	223	76	209	214	164	356	60	349	26	2371
1989	117	83	206	72	104	119	3	37	233	92	78	163	1304
1990	67	72	228	66	54	92	118	86	180	246	182	117	1506
1991	64	24	95	166	129	78	52	105	91	184	300	161	1447
1992	12	216	121	251	211	28	126	159	255	99	323	212	2011
1993	217	155	225	264	310	102	173	71	271	218	406	346	2754
1994	133	168	259	202	269	228	42	104	95	259	282	163	2202
Mean	107	159	207	194	194	109	112	132	185	188	268	181	2036

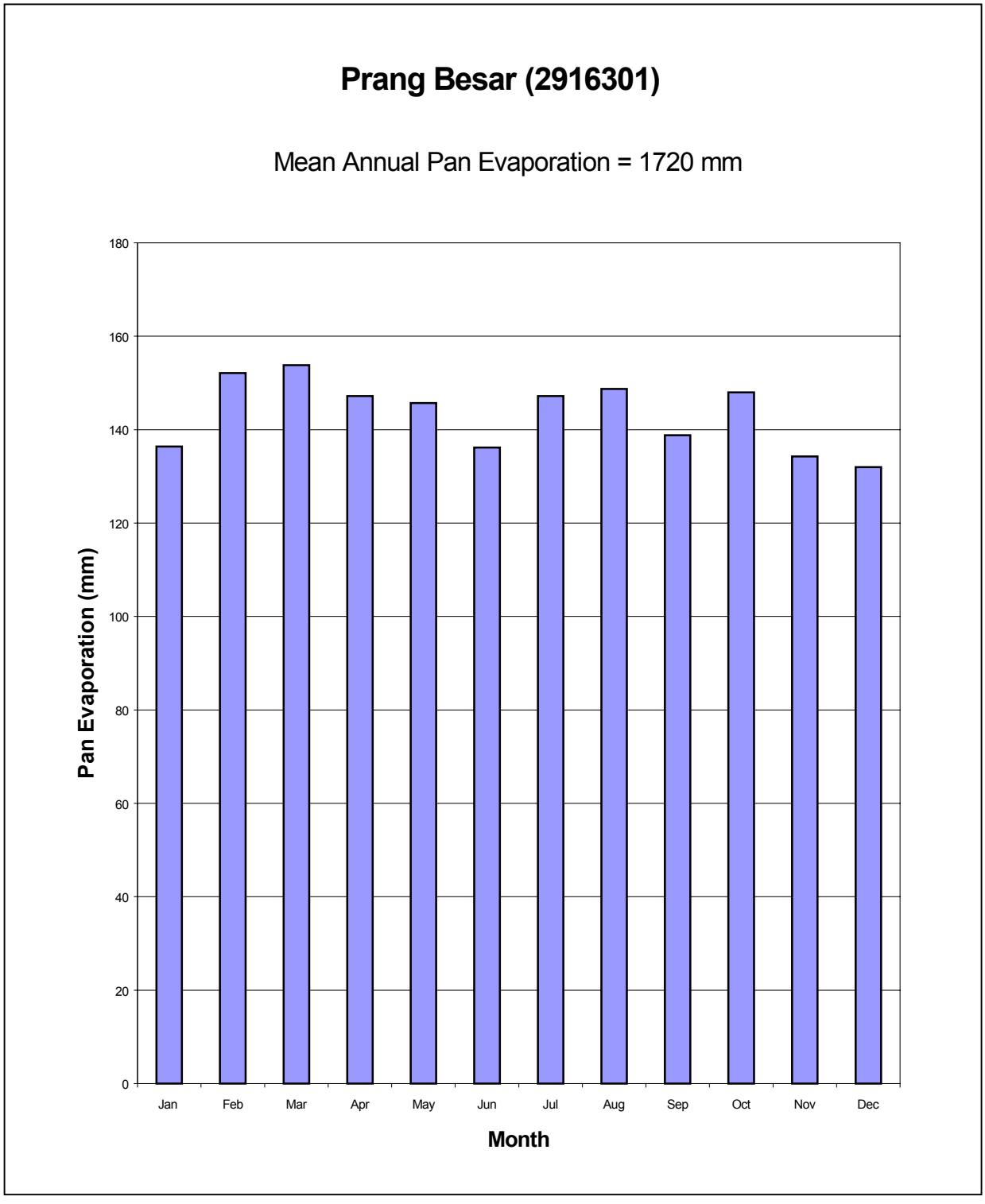


Figure 3.1.3 : Monthly Distribution of Pan Evaporation at Prang Besar Station (1981 1992)

Table 3.1.3 : Monthly Pan Evaporation at Prang Besar (2916301) for 1981 – 1992

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1981	114	144	181	158	134	140	189	189	133	149	132	137	1799
1982	131	139	147	150	138	123	149	133	140	159	140	140	1688
1983	140	134	125	122	127	124	137	136	128	152	158	104	1585
1984	113	94	134	146	144	126	121	125	120	119	149	143	1533
1985	142	137	121	107	126	122	153	180	148	133	110	130	1608
1986	120	140	148	146	166	158	164	154	141	151	123	142	1753
1987	124	169	189	151	151	136	147	156	149	180	124	130	1806
1988	153	165	150	161	147	142	145	142	146	158	138	136	1781
1989	154	171	147	154	152	133	144	149	144	147	151	147	1792
1990	145	226	165	165	153	140	139	144	139	153	127	154	1850
1991	157	149	165	155	157	167	151	147	151	123	132	93	1747
1992	146	156	175	153	152	123	128	131	128	152	129	127	1699
Mean	136	152	154	147	146	136	147	149	139	148	134	132	1720

	March	April	May	Jun	July	August	September	October	November
1	0.01	1.50	0.69	1.36	0.66	0.52	0.47	0.38	1.12
2	0.17	3.46	0.69	1.02	2.05	0.51	0.46	0.40	0.74
3	0.17	1.98	0.69	2.01	1.67	0.50	0.45	0.43	0.57
4	0.19	0.93	0.67	1.70	0.84	0.50	0.45	0.40	0.52
5	0.26	0.72	1.81	1.25	0.66	0.49	0.45	0.60	0.50
6	0.51	0.68	1.62	0.78	0.62	0.49	0.44	0.87	0.49
7	0.68	0.66	0.88	0.68	0.61	0.48	0.51	0.62	0.65
8	0.89	0.65	0.72	0.67	0.61	0.48	0.51	0.44	0.76
9	0.49	0.64	0.68	0.66	0.60	0.48	0.47	0.40	0.80
10	3.71	0.64	0.67	0.64	0.60	0.48	0.48	0.39	0.68
11	2.64	1.17	0.66	0.63	0.59	0.48	0.45	2.16	0.55
12	0.87	0.94	0.66	0.63	0.58	0.47	0.43	1.65	0.51
13	0.55	0.89	0.65	0.62	0.58	0.92	0.43	0.70	0.49
14	0.86	0.89	0.64	0.61	0.57	0.85	0.42	0.50	0.48
15	0.79	0.71	0.64	0.60	0.57	0.84	0.42	1.15	2.04
16	1.00	0.66	0.63	0.60	0.60	0.65	0.42	1.70	1.67
17	1.56	0.70	0.90	0.59	0.58	0.62	0.41	1.35	0.86
18	1.30	0.78	0.98	0.59	0.56	0.60	0.51	0.84	1.19
19	0.77	0.68	0.71	0.58	1.18	0.53	0.59	0.60	0.91
20	0.52	1.74	0.64	0.57	1.10	0.49	0.59	0.85	1.14
21	0.46	1.47	0.67	0.57	0.69	0.48	0.46	0.88	2.19
22	0.44	0.83	0.78	0.97	0.59	0.47	0.42	0.63	2.65
23	0.44	1.14	0.66	0.81	0.57	0.46	0.42	0.57	2.01
24	0.66	1.41	0.81	0.62	0.56	0.46	0.46	0.55	1.16
25	2.19	1.49	0.74	0.58	0.56	0.45	0.42	0.53	0.82
26	2.58	1.19	0.64	0.57	0.55	0.45	0.40	0.52	2.35
27	1.38	0.96	0.61	0.81	0.54	0.51	0.40	0.51	1.84
28	0.73	0.75	0.59	0.78	0.53	0.61	0.39	0.50	0.98
29	0.71	0.70	0.59	1.10	0.53	1.11	0.39	0.50	0.79
30	0.73	0.68	0.59	0.96	0.53	0.76	0.39	0.49	0.76
31	0.60		0.58		0.53	0.52		0.88	
Mean	**0.93**	**1.05**	**0.76**	**0.82**	**0.71**	**0.57**	**0.45**	**0.74**	**1.07**

Table 3.1.4 : Daily Streamflow Data at Temporary Dam for March - November 1994 (m3/s)

(ii) use of a monthly water balance model
(iii) use of a statistical model (regression model)

(2) Due to the short record period available for calibration, methods (ii) and (iii) could not be expected to produce good estimates.

(3) Also neither of methods (ii) and (iii) could be used directly to obtain discharge estimates at points other than the calibration sites, whereas this is possible with current daily flow models which is subdivided into a number of subcatchments.

(4) The model selected is the NAM Model which is one of the modules in MIKE 11. As the water quality module of MIKE 11 is also used for this study it is possible for the simulated runoff from NAM Model to be inputted automatically for the water quality modelling.

3.1.3.2 NAM Model

(1) The NAM Rainfall Runoff Model is a set of linked mathematical statements describing the behaviour of the land phase of the hydrological cycle. It is a deterministic, conceptual, lumped type of model requiring only moderate data input requirements.

(2) The model simulates the rainfall-runoff process in a catchment by means of 4 different and mutually interrelated storages. Figure 3.1.4 shows the model structure. The 4 storages were used to represent the hydrologically important physical elements in the catchment, such as the average soil moisture content and surface storages in the catchment. They are used to continuously account for the changes in the moisture content of the modelled physical elements in the catchment.

(3) A brief description of the pertinent model parameters are given below:

(i) θ_{WP} = Soil moisture at wilting point

(ii) θ_{FC} = Soil moisture at field capacity

(iii) θ_{SAT} = Soil moisture at saturation point

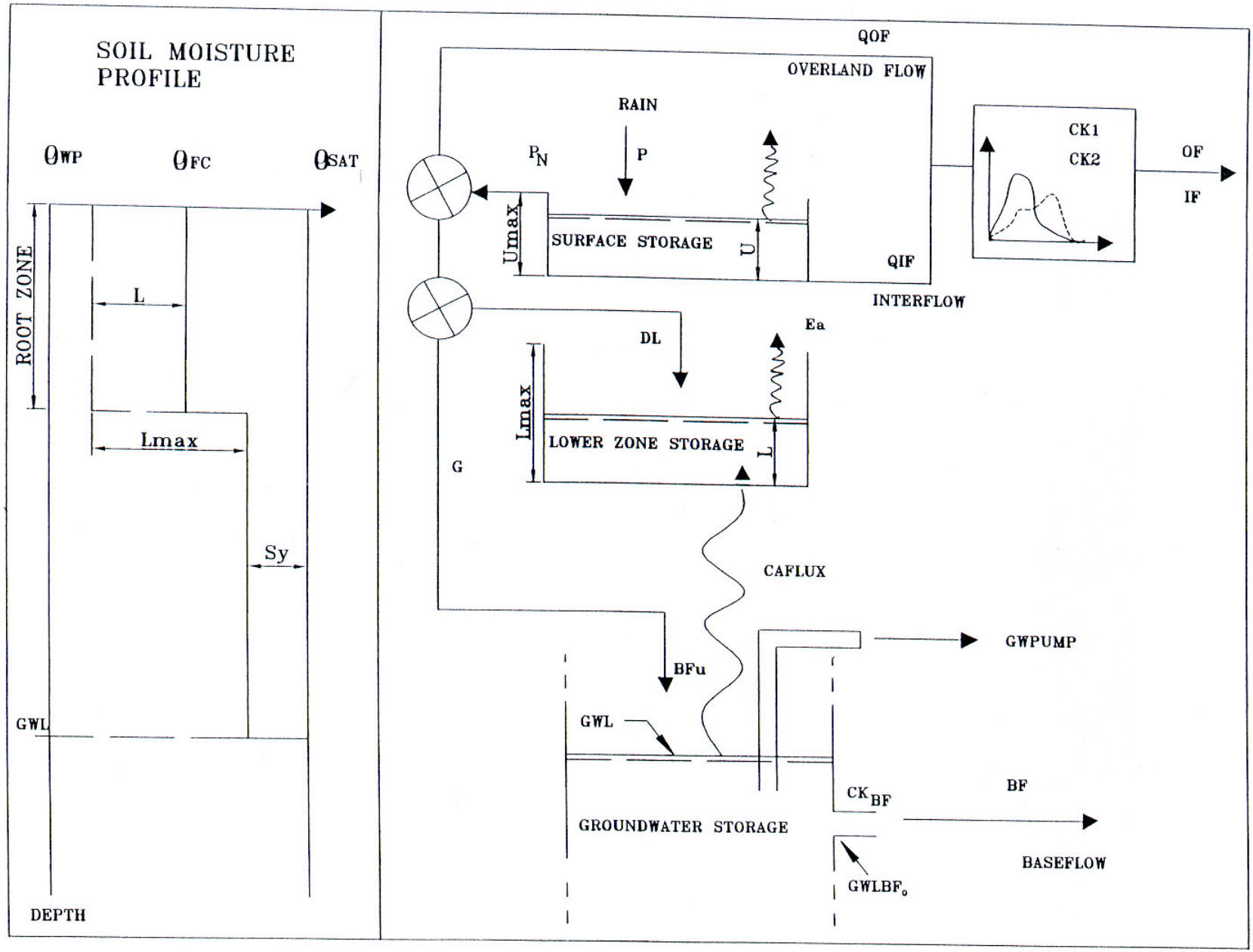


Figure 3.1.4 The Structure of the NAM Model

(iv) L = Moisture content at lower zone storage

(v) L_{max} = Maximum moisture content at lower zone storage

(vi) Sy = Specific yield

(vii) GWL = Ground water level

(viii) P = Precipitation

(ix) P_N = Excess precipitation

(x) U = Amount of water in surface storage

(xi) U_{max} = Maximum amount of water in surface storage

(xii) DL = Amount of infiltration that increase moisture content, L, in lower zone storage

(xiii) G = Excess infiltration moisture that percolate deeper and recharge ground water storage

(xiv) Q_{OF} = Overland flow

(xv) Q_{IF} = Interflow

(xvi) Ea = Evapo transpiration

(xvii) CK1, CK2 = time constants for routing interflow and overland flow.

(xviii) CQ_{OF} = overland flow runoff coefficient

(xix) CK_{BF} = time constant for baseflow.

(xx) CAPFLUX = capillary flux

(xxi) $GWLBF_o$ = maximum groundwater table depth causing baseflow

(xxii) BF = baseflow

(xxiii) GWPUMP = net groundwater abstraction

(4) The input data to the model are rainfall and potential evapotranspiration. The model main outputs are the runoff, groundwater level values, as well as information about other elements of the land phase of the hydrological cycle, such as the temporal variation of the soil moisture content and groundwater recharge.

3.1.3.3 Specification of subcatchments

The Sg. Chuau catchment up to the Temporary Dam Site was divided into a number of subcatchments so that runoff into the five wetlands can be modelled. This resulted in 15 subcatchments and these are shown in Figure 3.1.5.

3.1.4 Model Calibration

3.1.4.1 Data used for Calibration

Daily streamflows at the temporary dam site from March to November 1994 (this period cover the wet intermonsoon months of March to May and September to October and the relatively drier months of June, July and August) were available though with some gaps in parts of April and May. Daily rainfall data from Prang Besar, Ladang West Country and Ladang Galloway (rain gauge representation of subcatchments determined using Thiessen Method) and also monthly pan evaporation (adopting a pan coefficient of 0.8, as in DID Water Resources Publication No. 5 1976) data from Prang Besar were used. The quality of these data will limit the goodness of fit of the model.

3.1.4.2 Rationale for Model Calibration

(1) Initial model parameters for all subcatchments were taken from the calibration run considering the catchment as a whole with the outlet at Temporary Dam Site. Parameter values are selected after a number of program runs with varying parameters using the following criteria:

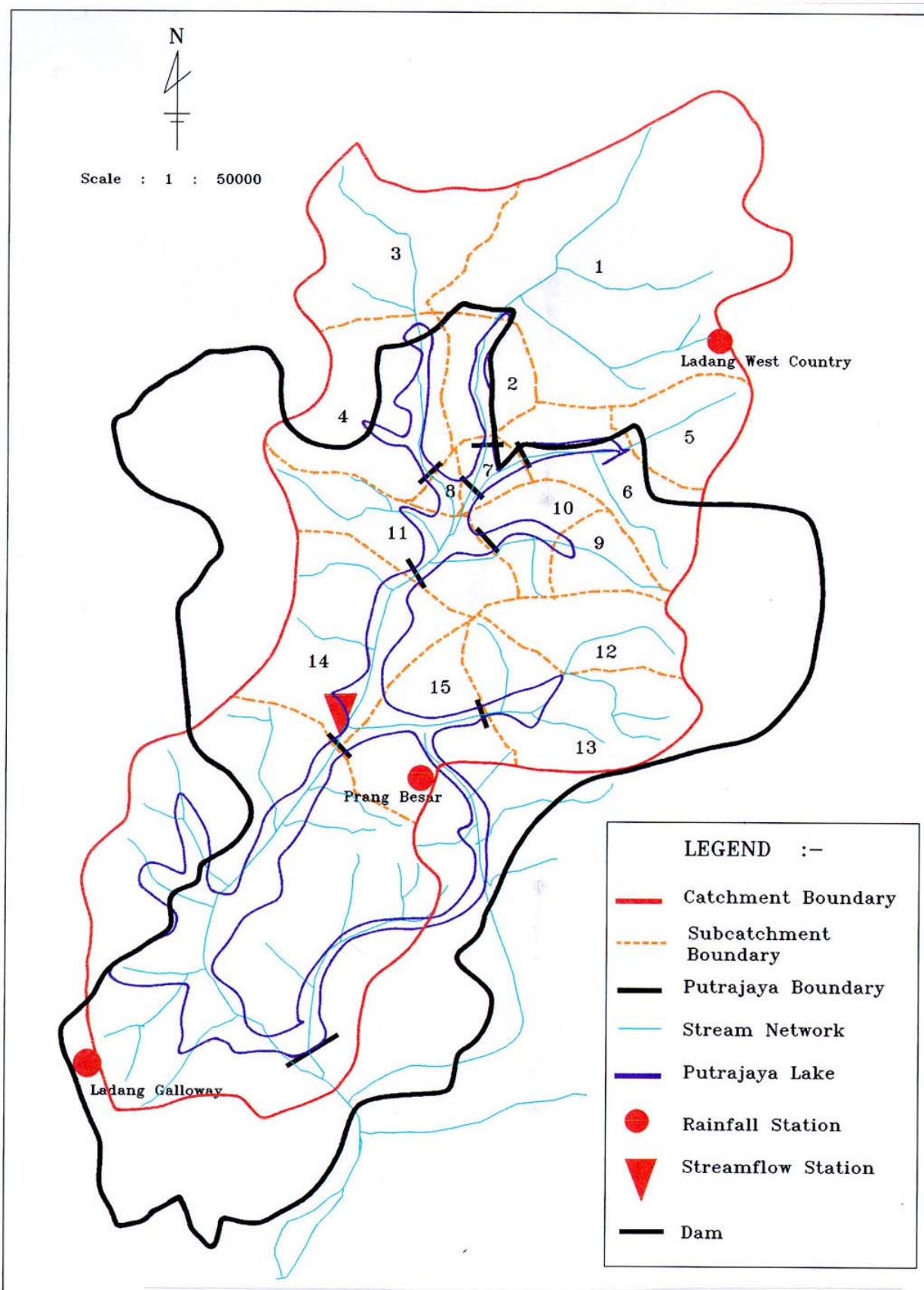


FIGURE 3.1.5 SUB-CATCHMENT BOUNDARIES FOR RAINFALL-RUNOFF MODELLING

(i) best agreement with observed flow sequences by statistics of daily flow
(ii) by reproduction of high flow events and recession shape

(2) It cannot be expected that exact sequences of the observed daily flows can be reproduced when there is significant spatial variability especially during convective thunderstorm activity. The model should however produce sequence of flows adequately representing the catchment response to incident rainfall.

(3) The parameters selected for each subcatchment, as a result of the calibration procedure, and the test statistics used are given in Tables 3.1.5 and 3.1.6. Figure 3.1.6 shows the results of the comparison between the simulated and observed runoff. The simulated daily flows at Temporary Dam for March to November 1994 are given in Table 3.1.7.

(4) The difference between the mean observed and mean simulated discharges is fair at 14 %. The variance as expressed by the coefficient of variation is well preserved at 0.524 for the observed discharge and 0.523 for the simulated discharge. The coefficient of determination (an index of overall model fit) is rather low at 0.418. The low value is attributed to instances of very low catches at the rainfall stations but high flows at the streamflow station and also conversely instances of high catches at the rainfall stations but moderate flows at the streamflow station (as discussed due to highly localised convective storms in the catchment). Considering all these indicators together, it is concluded that these parameters represent a reasonable fit for the daily flows.

Table 3.1.5: Selected Parameter Values for NAM Model

	Description	Units	Sub catchment No.													
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1. U max	Maximum water content in surface storage	mm	25	37.5	25	37.5	37.5	37.5	37.5	37.5	40	37.5	37.5	40	40	40	40
2. L max	Maximum water content in roof zone storage	mm	250	375	250	375	375	375	375	375	400	375	375	400	400	400	400
3. CQ_{of}	Overland flow runoff coefficient (Calibration based on 1994 Landuse)		0.35	0.3	0.3	0.35	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Overland flow runoff coefficient (Current Landuse, 1999)		0.4	0.35	0.3	0.4	0.35	0.3	0.4	0.35	0.3	0.3	0.4	0.3	0.3	0.3	0.4
	Overland flow runoff coefficient (Future Landuse as Proposed in Masterplan)		0.6	0.5	0.3	0.45	0.6	0.75	0.8	0.7	0.75	0.5	0.8	0.7	0.7	0.8	0.7
4. CKIF	Time constant for inter flow	hour	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5. CK_1, CK_2	Time constant for routing inter and overland flow	hour	26	24	35	20	35	20	10	10	20	20	20	25	25	22	20
6. Sy	Specific yield		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7. A	Catchment area	Km^2	8.10	1.54	2.78	2.84	1.41	2.31	0.60	0.15	0.70	1.03	2.05	1.33	2.63	3.17	1.73

Table 3.1.6: Error Statistics for NAM Model

Mean	Observed (m^3/s)	0.43
	Simulated (m^3/s)	0.49
	Difference (%)	14
Coefficient of Variation	Observed	0.524
	Simulated	0.523
Coefficient of Determination		0.418

Figure 3.1.6 **Simulated Discharge versus Observed Discharge (Mac – Nov 1994) at Temporary Dam Site**

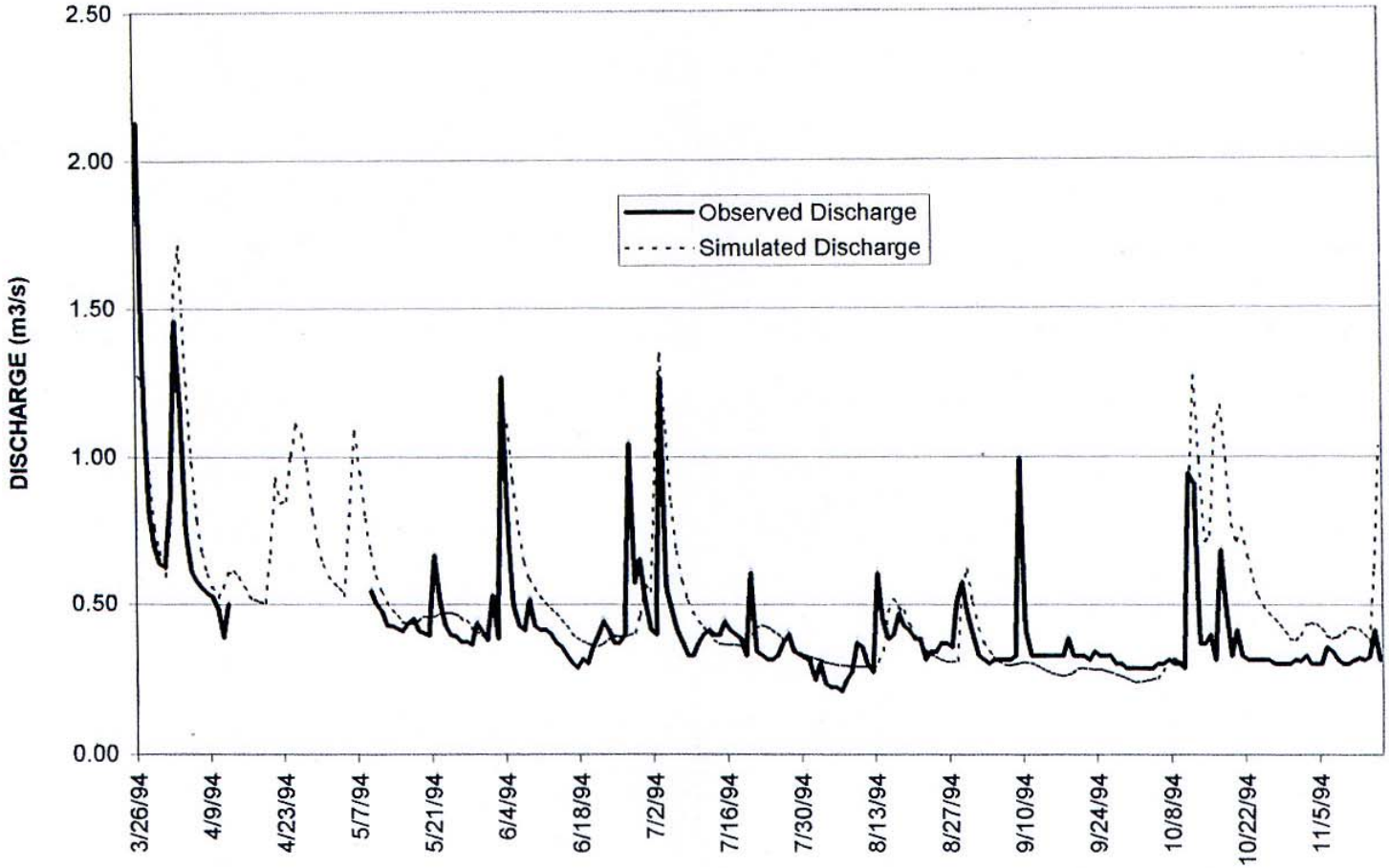


Table 3.1.7 : Simulated Daily Streamflow Data at Temporary Dam for March - November 1994 (m3/s)

	March	April	May	Jun	July	August	September	October	November
1	0.01	0.77	0.59	0.47	0.55	0.32	0.42	0.24	0.40
2	0.14	1.59	0.57	0.58	1.01	0.31	0.37	0.24	0.43
3	0.12	1.71	0.55	1.02	1.35	0.31	0.34	0.24	0.44
4	0.12	1.30	0.53	1.11	1.09	0.30	0.32	0.25	0.43
5	0.12	0.97	0.80	0.92	0.84	0.30	0.31	0.25	0.41
6	0.16	0.78	1.09	0.75	0.68	0.29	0.30	0.28	0.39
7	0.23	0.67	0.95	0.64	0.58	0.29	0.30	0.31	0.39
8	0.36	0.60	0.79	0.58	0.51	0.29	0.30	0.32	0.39
9	0.34	0.56	0.67	0.55	0.47	0.29	0.30	0.31	0.41
10	0.74	0.53	0.60	0.52	0.44	0.29	0.31	0.30	0.42
11	1.45	0.56	0.54	0.50	0.42	0.29	0.30	0.82	0.42
12	1.17	0.61	0.50	0.48	0.39	0.29	0.30	1.27	0.41
13	0.84	0.61	0.48	0.46	0.38	0.31	0.29	0.98	0.39
14	0.73	0.59	0.46	0.44	0.37	0.34	0.28	0.72	0.37
15	0.68	0.56	0.44	0.42	0.36	0.48	0.27	0.74	0.63
16	0.70	0.53	0.43	0.40	0.36	0.52	0.26	1.10	1.03
17	0.89	0.52	0.43	0.39	0.36	0.49	0.26	1.17	0.89
18	0.96	0.51	0.45	0.37	0.36	0.48	0.26	0.99	0.94
19	0.82	0.51	0.46	0.37	0.37	0.43	0.27	0.77	0.89
20	0.65	0.67	0.46	0.36	0.40	0.39	0.28	0.71	0.89
21	0.53	0.93	0.46	0.36	0.42	0.36	0.29	0.76	1.36
22	0.46	0.84	0.47	0.37	0.43	0.35	0.28	0.66	1.86
23	0.41	0.85	0.47	0.38	0.42	0.33	0.28	0.59	1.90
24	0.38	1.01	0.47	0.39	0.41	0.32	0.28	0.53	1.53
25	0.72	1.11	0.47	0.39	0.40	0.31	0.28	0.50	1.15
26	1.27	1.08	0.46	0.39	0.39	0.31	0.27	0.47	1.47
27	1.25	0.96	0.44	0.39	0.37	0.31	0.27	0.45	1.65
28	0.95	0.81	0.42	0.40	0.35	0.31	0.26	0.43	1.31
29	0.76	0.70	0.41	0.47	0.34	0.55	0.25	0.41	1.02
30	0.68	0.63	0.40	0.56	0.33	0.62	0.24	0.38	0.85
31	0.60		0.39		0.32	0.51		0.38	
Mean	**0.62**	**0.80**	**0.54**	**0.51**	**0.50**	**0.36**	**0.29**	**0.57**	**0.84**

3.1.5 Streamflow Extension for Current and Future Landuse

3.1.5.1 After a satisfactory calibration of the NAM Model, the next stage was to input the 14 years rainfall data at Prang Besar, Ladang West Country and Ladang Galloway i.e from 1981 to 1994 into the model to simulate the runoff into the wetlands for Current (1999 Landuse) and Future Landuse (as proposed in Landuse Masterplan). A CQ_{OF} value of 0.8 was adopted for built up areas and for open space covered with trees and grass, CQ_{OF} is taken as 0.3. A weighted CQ_{OF} was then computed for each Subcatchment as given in Table 3.1.5 for both Current and Future Landuse. These simulated runoffs into the wetlands for Current and Future Landuse scenarios are in turn used as inputs for water quality modelling purposes.

3.1.5.2 Figures 3.1.7a to 3.1.7e illustrate the simulated runoffs into the wetlands for Current and Future Landuse respectively. For the Future Landuse scenario, it can be seen that the daily peak runoff increases are significant for Upper East, Lower East and Sg. Bisa Wetlands and with slight increase and insignificant change in daily peak runoff into Upper North and Upper West Wetlands respectively. It can be also seen that there are slight to moderate decreases in the daily baseflows into Upper East, Lower East and Sg. Bisa Wetlands.

3.1.5.3 This phenomena tally well with increase in impervious areas (which causes increase in surface runoff and corresponding decrease in infiltration and baseflow) as a result of housing developments earmarked in the catchments of Upper East, Lower East and Sg. Bisa.

3.1.6 Compensation Flow

3.1.6.1 The design lake water level is at RL 21.0 m which is ensured by setting the main dam spillway crest level at RL 21.0 m. The dam is in effect acting like a weir on a stream such that any inflow, less any losses mainly through open water evaporation, into the lake will spill through the spillway into Sg. Chuau downstream of the dam.

3.1.6.2 To ascertain the quantity of flow spilling via the spillway the discharge at the Main Dam was simulated for the period 1981-1994. The long term discharge at Main Dam was then checked

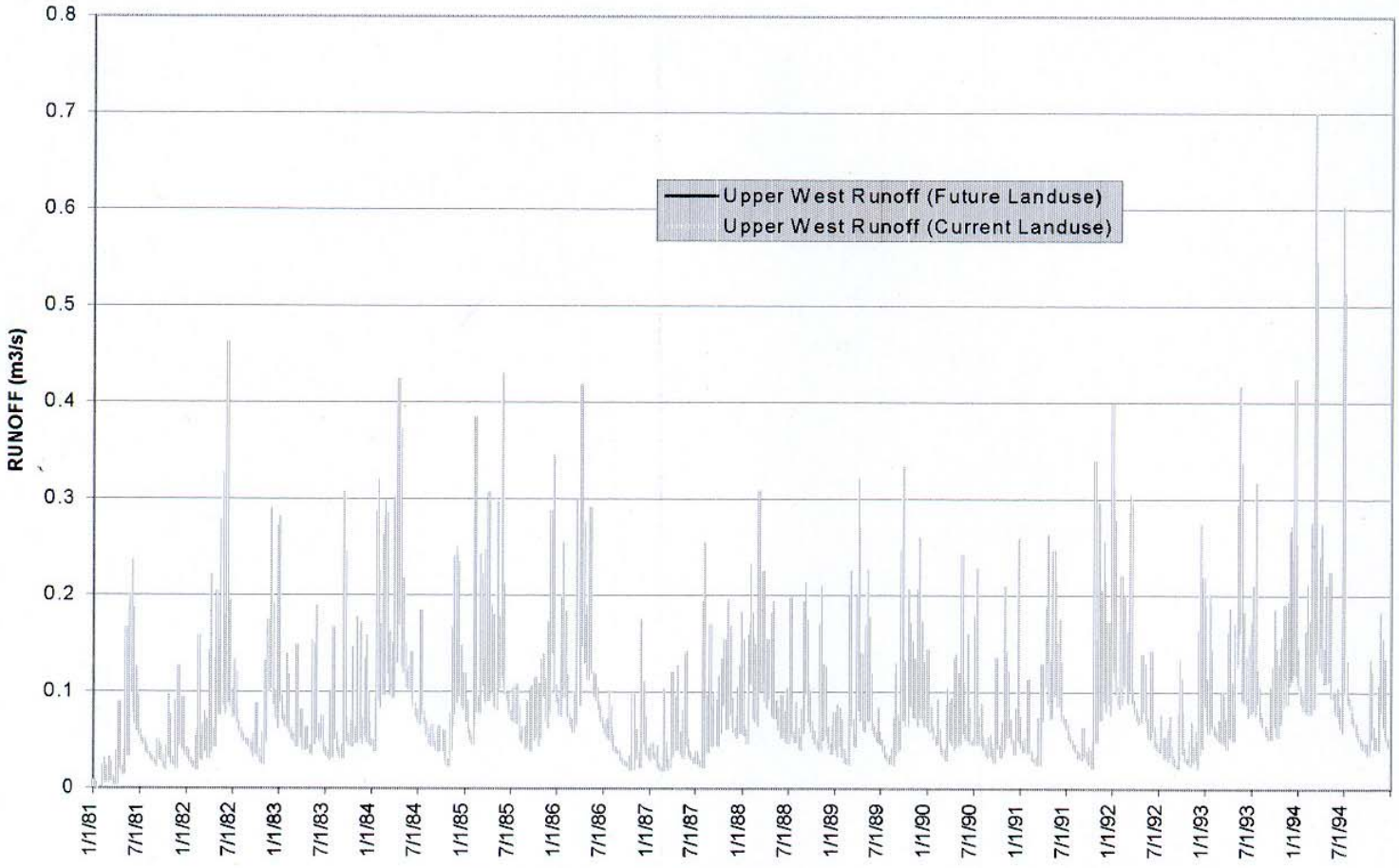


Figure 3.1.7a : Runoff into upper West Wetland

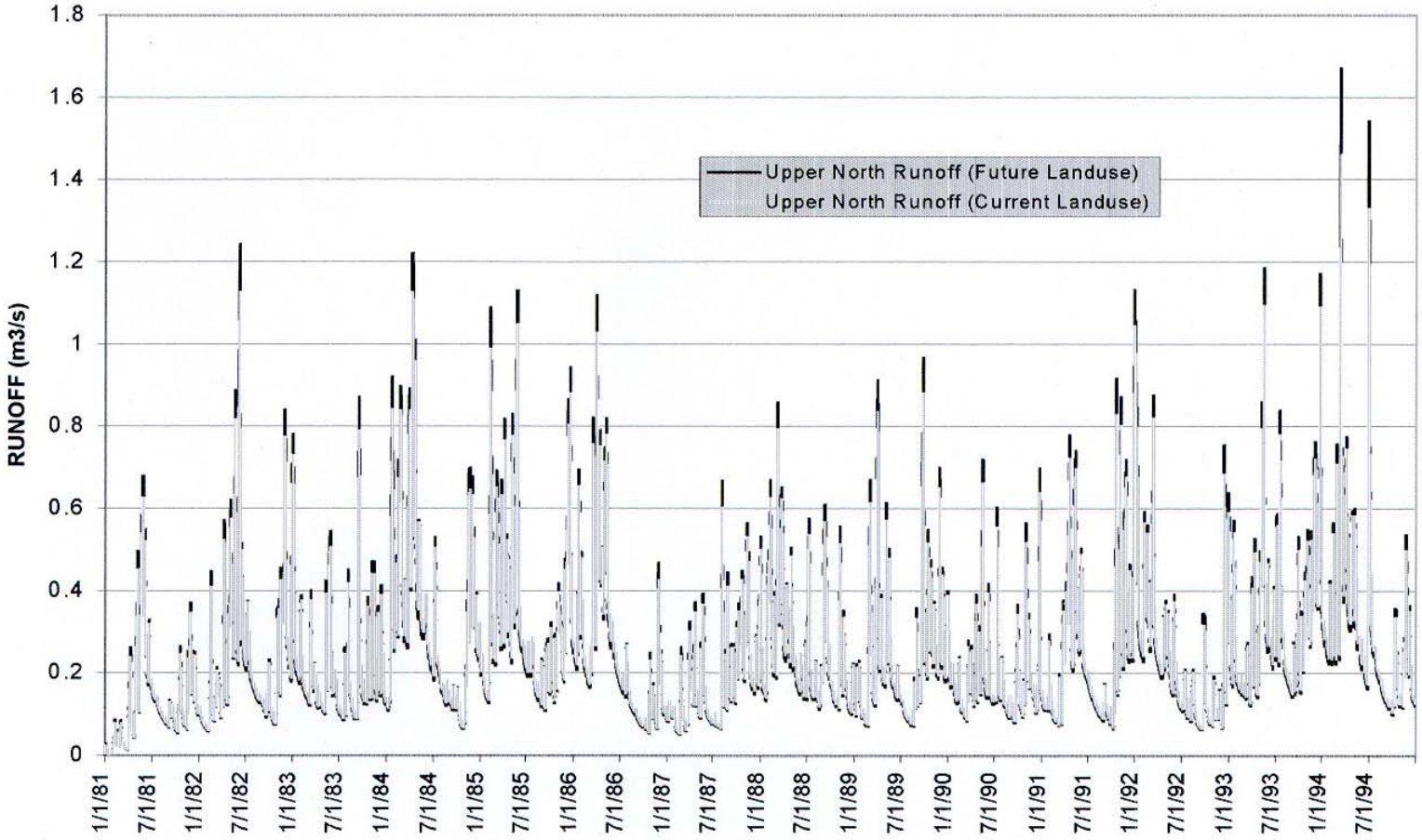


Figure 3.1.7b : Runoff into Upper North Wetland

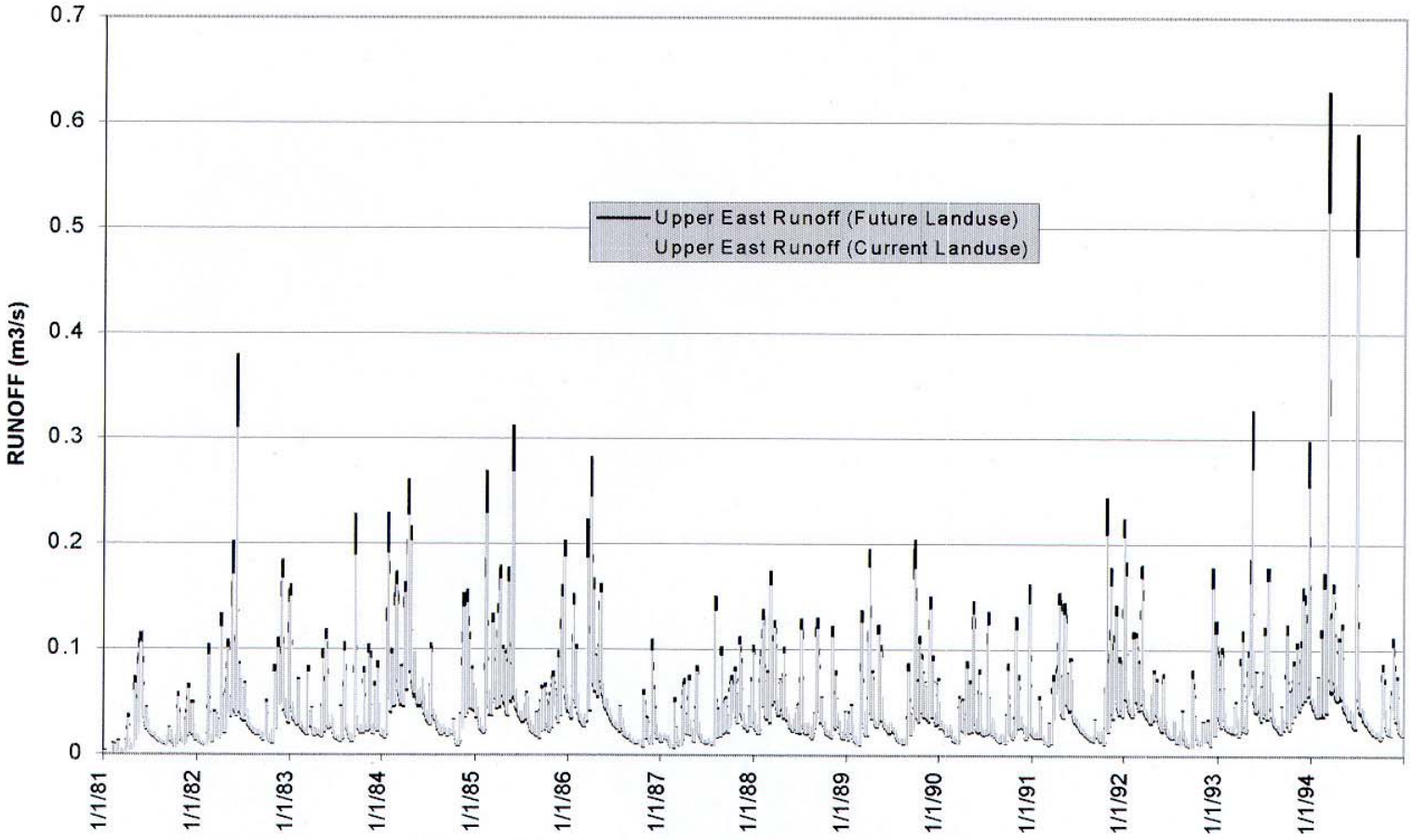


Figure 3.1.7c : Runoff into Upper East Wetland

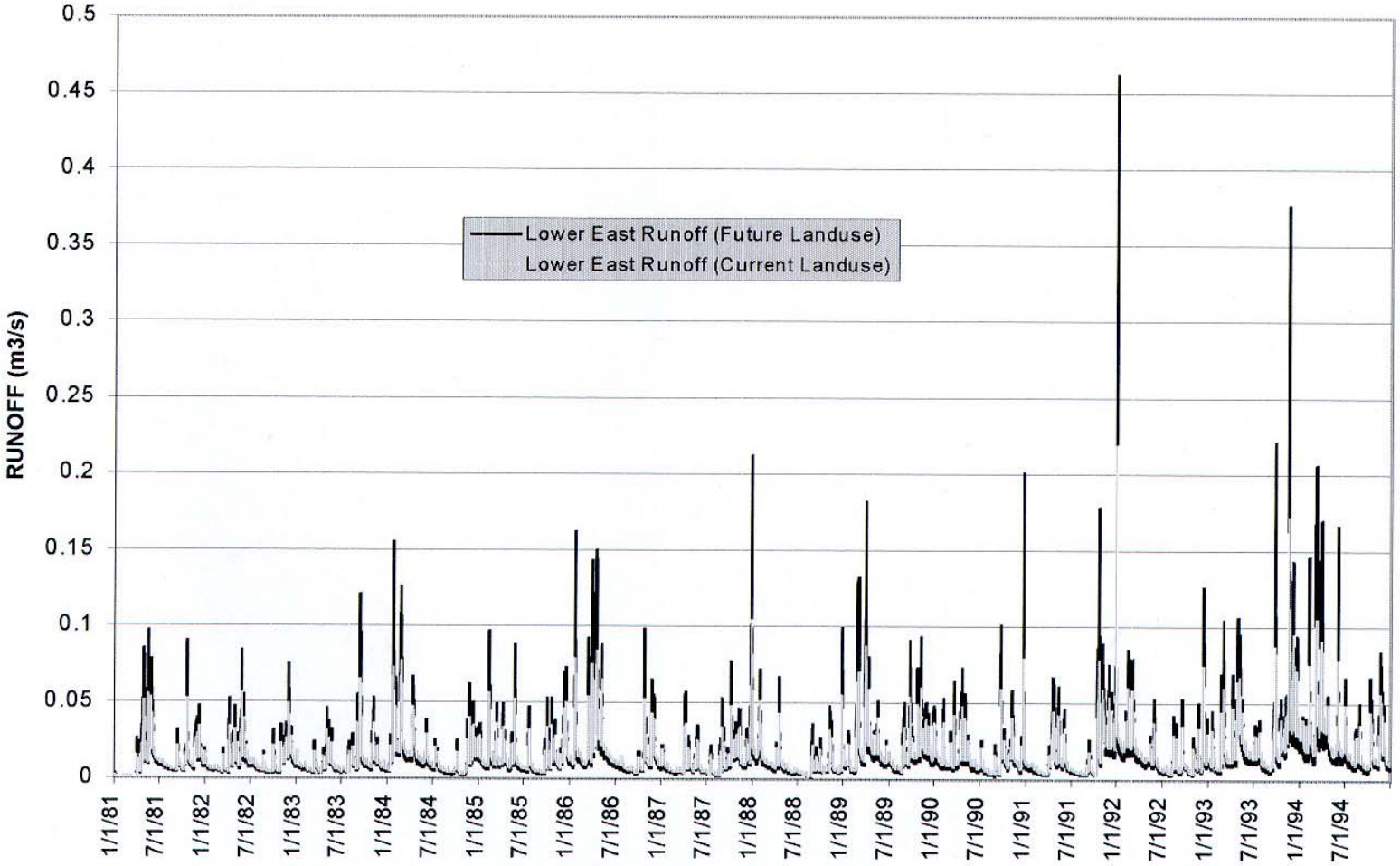


Figure 3.1.7d : Runoff into Lower East Wetland

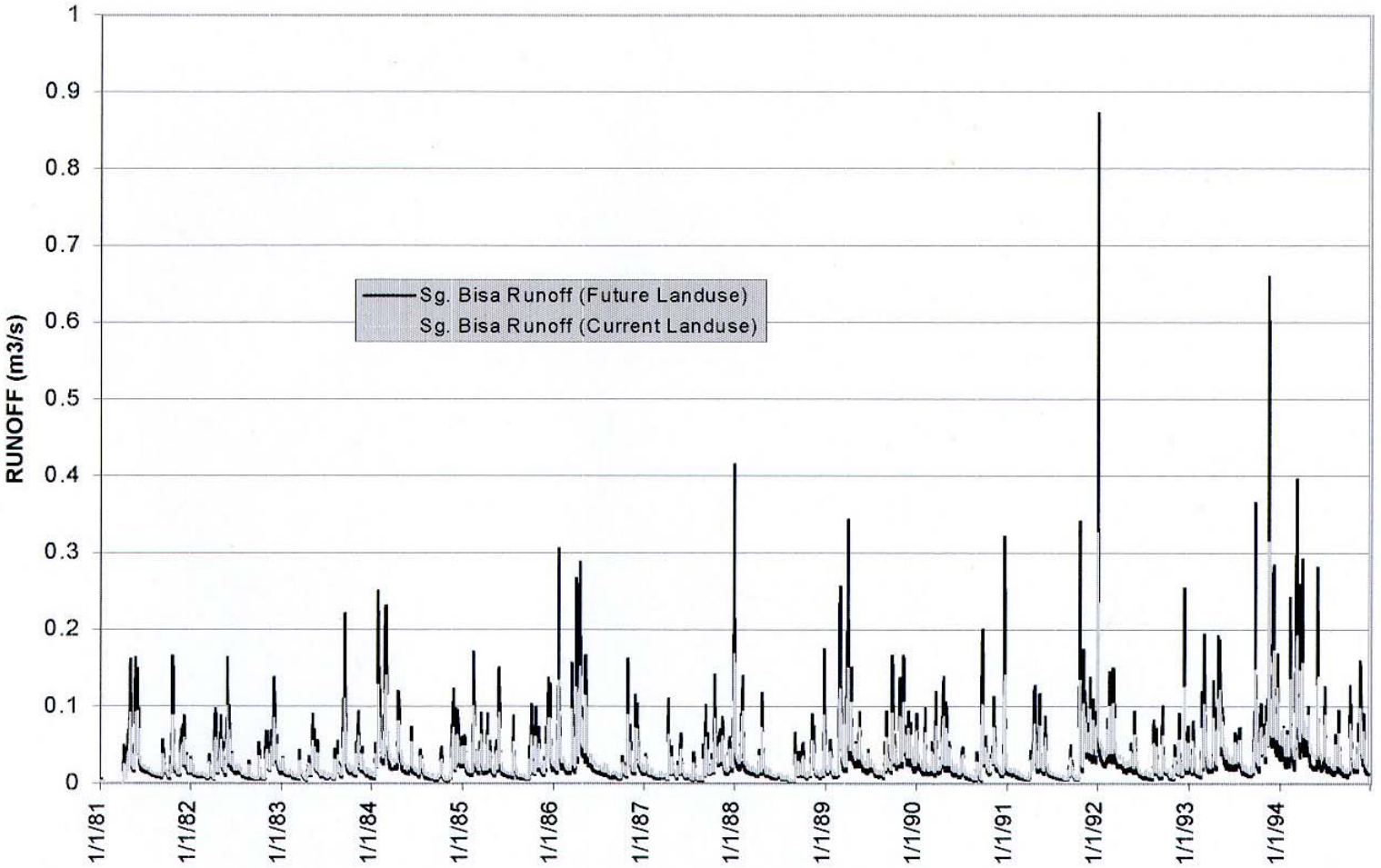


Figure 3.1.7e : Runoff into Sg. Bisa Wetland

using regional low flow relationships developed for the National Water Resources Study (NWRS, 1999).

3.1.6.3 The simulated discharge at the Main Dam for the period 1981-1994 is shown in Figure 3.1.8. Throughout the simulation period, spilling occurs at the Main Dam following closely the rainfall pattern in the Putrajaya Lake Catchment i.e. low flows ranging from 0.2 - 0.3 m^3/s in the drier months of June to August and high flows in the months of March to May and September to December. The mean flow for the simulation period was 1.28 m^3/s.

3.1.6.4 Using regional low flow relationships developed for NWRS, 1999 two conditions were evaluated, i.e

(i) when the inflow is the Average Annual Flow (AAF)
(ii) when the inflow is the Mean Annual Minimum of one day mean discharge (MAM)

3.1.6.5 The AAF was determined according to the following relationship developed for the National Water Resources Study (NWRS, 1999).

$$AAF = e^{-6.3638} \times AREA^{0.9416} \times (MAR - AE)^{0.5033}$$

Where AREA - catchment area at Main Dam
MAR – Mean Annual Rainfall
AE – Actual Evaporation

Putting AREA = 45.3 km^2
MAR = 2150 mm
AE = 1300 mm

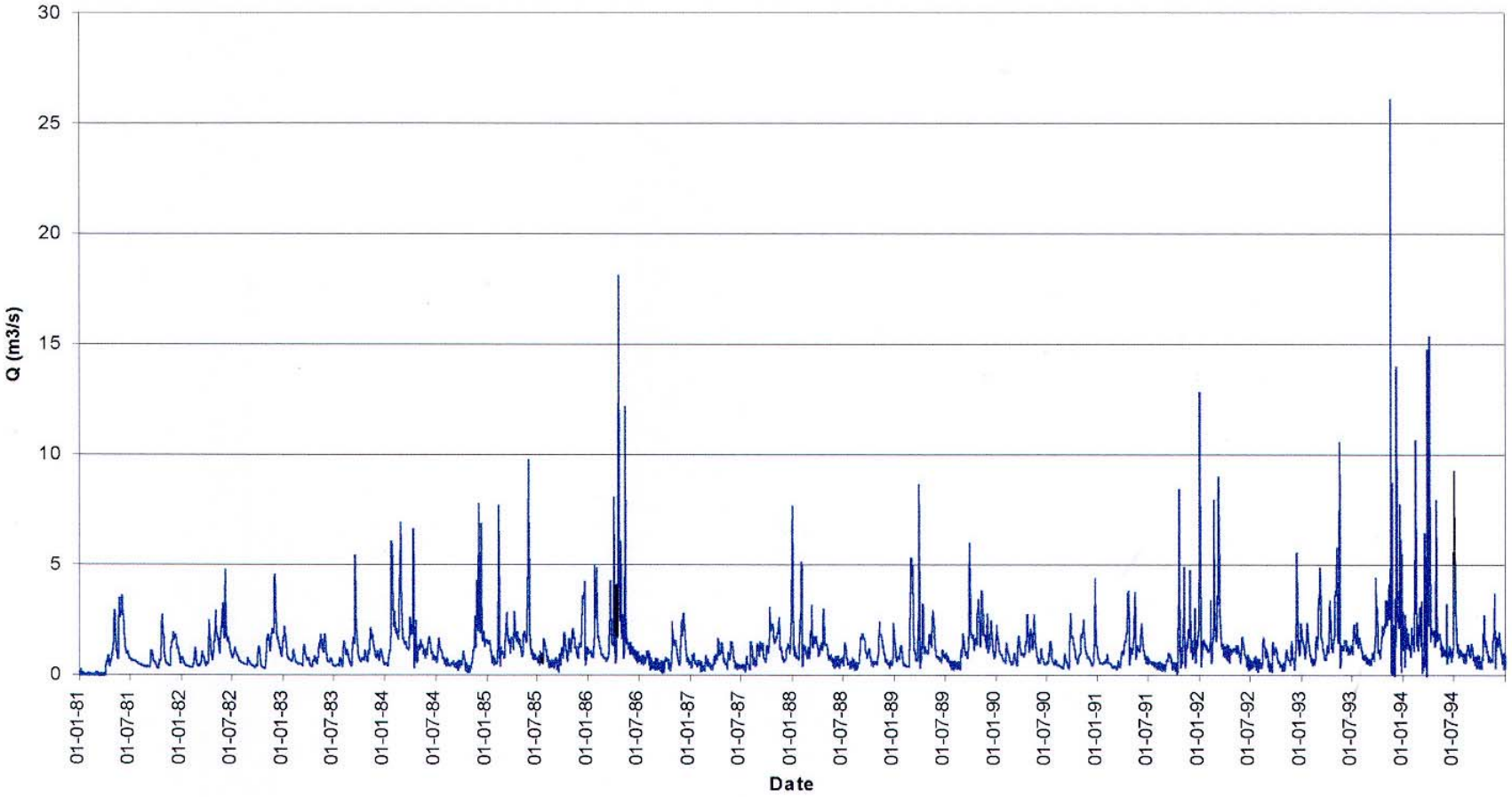
We get AAF = 1.86 m^3/s

3.1.6.6 The mean annual minimum of one day mean discharge (MAM) was computed based on the following relationship developed for the NWRS (1999).

$$MAM = e^{-15.3} \times AREA^{1.009} \times (MAR - AE)^{1.58}$$

Where AREA - catchment area at Main Dam
MAR – Mean Annual Rainfall

Figure 3.1.8 : Simulated Discharge at Putrajaya Main Dam (1981-1994)



AE – Actual Evaporation

Inputting the same AREA, MAR and AE as above,

We get MAM = 0.332 m^3/s

3.1.6.7 Hence, with net evaporation over the lake area of 650 ha amounting to 0.053 m^3/s, about 97% of AAF or 1.81 m^3/s will flow via the spillway into Sg. Chuau downstream of the dam. Similarly, with MAM as inflow and deducting net evaporation over the lake, 84% of MAM or 0.279 m^3/s will flow through the spillway.

A check was made to ascertain whether there will be any spill from the lake during a severe drought of 50-year return period. The 7 day 50 year return period low flow ($Q_{7,50}$) was estimated at 0.183 m3/s ($Q_{7,50}$ computed using the expression given below developed by NWRS).

$$\mathbf{Q_{D,T}/\ MAM = -0.018(-LN(LN(T/(T-1))))^3 + 0.1519(-LN(LN(T/(T-1))))^2 - 0.5058(-LN(LN(T/(T-1)))) + 1.1346)}$$

Deducting net evaporation losses from the lake at 0.7 mm/ day or 0.053 m^3/s, the lake will still spill 0.13 m^3/s of flow downstream of the dam.

3.1.6.8 Unlike a direct supply reservoir where water impounded is taken to supply necessitating releases in the form of compensation flows, the Putrajaya Lake as demonstrated above will spill water downstream ranging from 0.279 - 1.81 m^3/s for mean annual minimum and average annual flow conditions.

3.1.6.9 According to NWRS, the recommended compensation flow downstream of a direct supply reservoir is 10 % of AAF. In the case of Putrajaya Lake as shown in Figure 3.1.8, spilling at the Main Dam occurs throughout the simulation period (1981-1994) and from regional low flow analysis above, the flows through the spillway exceed 0.186 m^3/s (10 % of AAF) which is therefore more than adequate to meet compensation flow requirements. The compensation flow of 0.186 m^3/s, however needs to be checked with observed flows before it is implemented at Putrajaya Main Dam.

3.1.6.10 Based on a previous Report on Preliminary Design of Drainage, Lake Development and Temporary Dam, December 1995, prepared by HKA Hydrology and Water Resources Consultant, it was estimated that the lake will fill up in about 10 months (without any compensation flow) for the case of a 1 in 10 year dry (probability that a given flow is equalled or exceeded is 90%) minimum flow. When compensation flow of 0.186 m^3/s is provided for downstream users it was found that the infilling of the lake took about 11 months (see Figure 3.1.9).

3.1.6.11 Therefore it is still possible to provide compensation flow during infilling of the lake, though complete filling is only delayed by about one month which is acceptable.

3.1.7 Rainwater Harvesting and Utilisation

3.1.7.1 Rainwater harvesting and utilisation for domestic, industrial and other uses is consumptive in nature i.e the bulk of the rainwater harvested and utilised will be lost from the catchment. Consequently, widespread rainwater harvesting in the Putrajaya lake catchment can lead to reduced inflows to the streams feeding the lake.

3.1.7.2 Detail studies on rainwater harvesting and utilisation, taking into consideration aspects such as total roof areas and water demand requirements in the Putrajaya lake catchment, need to be done to determine

(i) impact of rainwater harvesting on the inflows into the Putrajaya lake
(ii) policy prescriptions and regulations to be incorporated into existing By Laws, for controlling rainwater harvesting and utilisation in the Putrajaya lake catchment

3.1.7.3 It is therefore recommended that during infilling of the lake no rainwater harvesting should be allowed except where the quantities involved are small and that too with the permission of Perbadanan Putrajaya.

3.1.7.4 Any rainwater harvesting after lake infilling could only be considered pending the outcome and recommendations of the

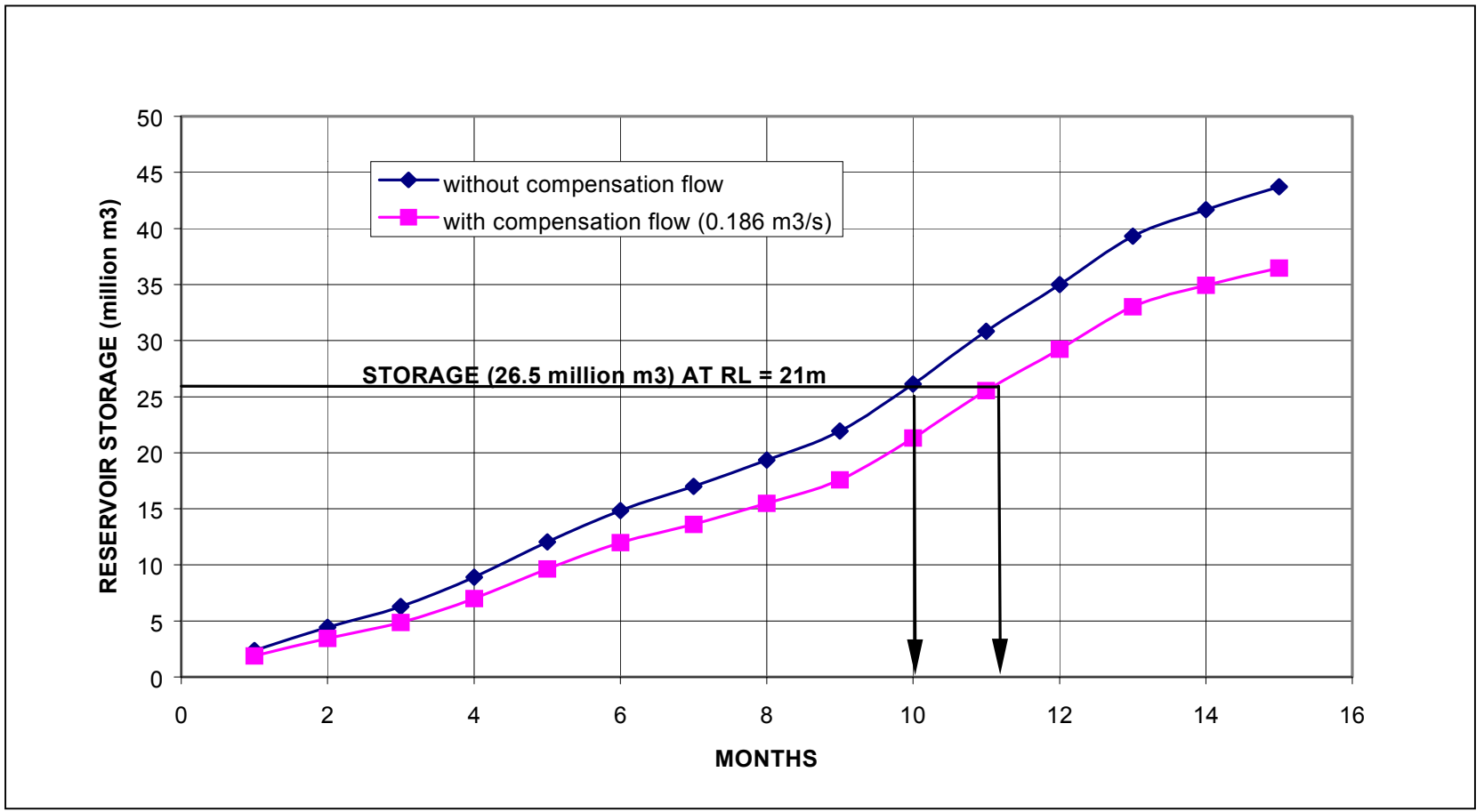


Figure 3.1.9 **Predicted Filling Times for Putrajaya Lake with and without Compensation Flow at 90% Probability (1 in 10 year dry minimum flow)**

detail rainwater harvesting and utilisation study mentioned above.

3.1.8 Proposed Hydrological Stations Network

3.1.8.1 The proposed hydrological stations network is shown in Figure 3.1.10. Two rainfall stations are proposed on two subcatchments in the upstream part of the lake catchment. Another three rainfall stations are proposed at the Central Wetlands, downstream of Upper Bisa Wetlands and at Cyberjaya. The existing rainfall station at Puncak Niaga has to be maintained.

3.1.8.2 Seven streamflow stations are proposed one each at Upper West Wetlands, Upper North Wetlands, Upper East Wetlands, Lower East Wetlands, Upper Bisa Wetlands, Cyber Jaya and Putrajaya Commercial Precinct. Five water level stations are proposed at the downstream weirs of Upper West, Upper North, Upper East and Central Wetlands and one water level station at the Main Dam.

3.1.8.3 Six groundwater stations are proposed one each at Upper West Subcatchment (near MARDI), and Upper North (near UPM Hostels), two at the Central Wetlands, one at downstream of Upper Bisa Wetlands and one at Cyberjaya.

3.1.8.4 The estimated cost of the hydrological stations network are tabulated in Table 3.1.8.

3.1.8.5 Using data from the proposed hydrological stations the rainfall runoff processes in the Putrajaya Lake catchment can be better calibrated and the simulations from the current NAM Rainfall Runoff Model improved. This would also aid in the better and efficient management of the catchment's water resources.

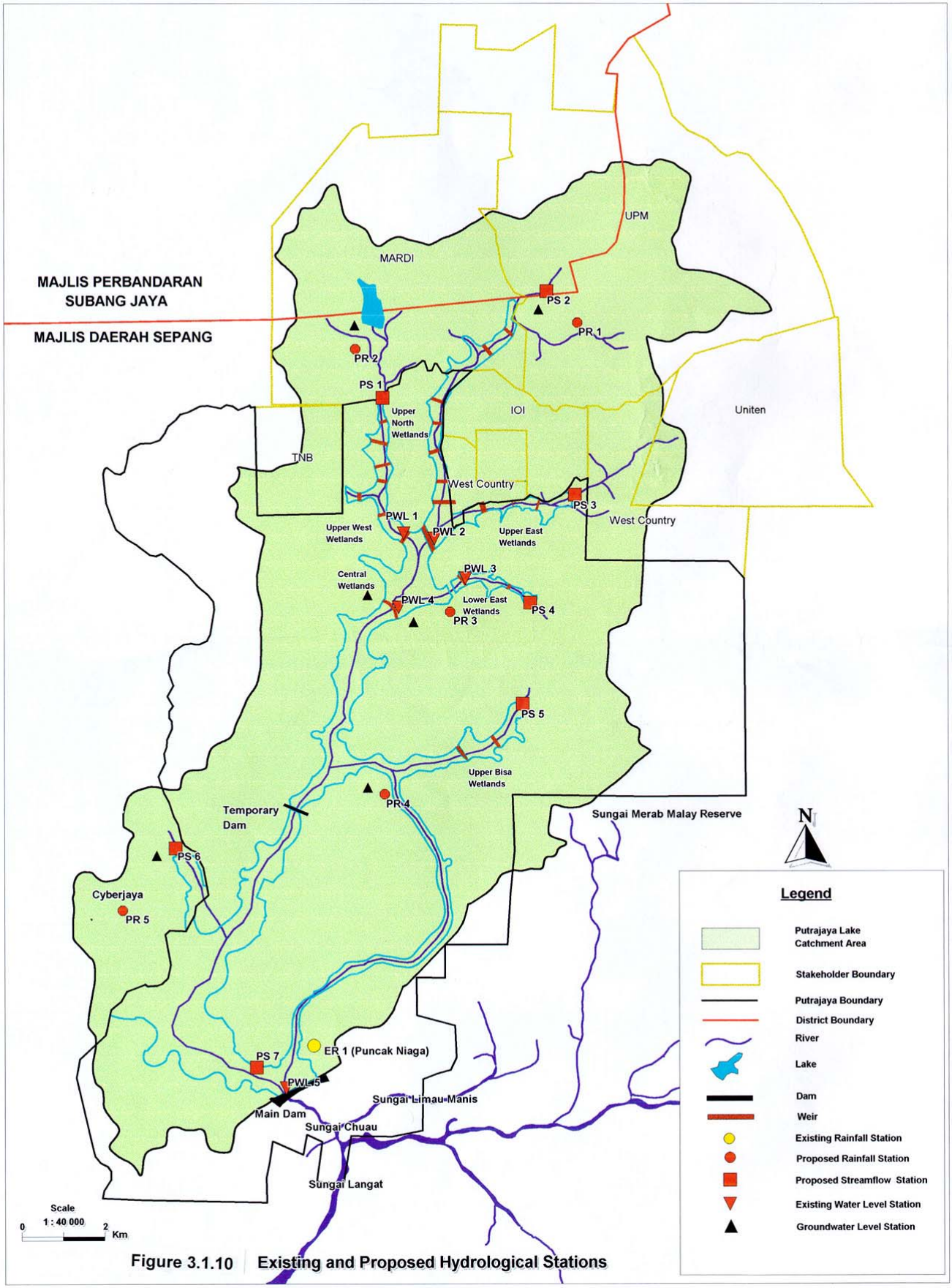


Figure 3.1.10 Existing and Proposed Hydrological Stations

Table 3.1.8 : Cost of Hydrological Stations

Item		No. of Station	Rate (RM)	Total Cost (RM)
1 Setting up of Rainfall Recorder Station				
i. Continuous Rainfall Sensor			10,000.00	
ii. Housing (Civil Works)			5,000.00	
iii. Data Logger			6,000.00	
iv. Commissioning			4,000.00	
v. Maintenance (1 Year)			3,000.00	
	Total (RM)	**5**	**28,000.00**	**140,000.00**
2 Setting up of Automatic Streamflow Station				
i. Area Velocity Flow Meter (Water Level and Velocity Sensor)			20,000.00	
ii. Housing (Civil Works)			20,000.00	
iii. Data Logger			6,000.00	
iv. Commissioning			5,000.00	
v. Maintenance (1 Year)			3,000.00	
	Total (RM)	**7**	**54,000.00**	**378,000.00**
3 Setting up Automatic Water Level Station				
i. Water Level Sensor			13,000.00	
ii. Housing (Civil Works)			15,000.00	
iii. Data Logger			6,000.00	
iv. Commissioning			5,000.00	
v. Maintenance (1 Year)			3,000.00	
	Total (RM)	**5**	**42,000.00**	**210,000.00**
4 Setting up Automatic Groundwater Level Station				
i. Water Level Sensor			13,000.00	
ii. Housing (Civil Works)			10,000.00	
iii. Data Logger			6,000.00	
iv. Commissioning			5,000.00	
v. Maintenance (1 Year)			3,000.00	
	Total (RM)	**6**	**37,000.00**	**222,000.00**
			GRAND TOTAL (RM)	**950,000.00**

3.2 SOIL EROSION AND SEDIMENTATION STUDY

3.2.1 Introduction

3.2.1.1 Soil erosion arising from the land clearing and earthworks activities, associated with development in the catchment, has been identified as a major threat to the water quality of Putrajaya Lake. Thus, there is a need to identify and map the areas in the catchment with high soil erosion potential to facilitate land-use planning in the catchment. There is also a need to define the guidelines for the control of soil erosion and sedimentation in the catchment arising from the development activities in the catchment.

3.2.1.2 Soil erosion is defined as the detachment, entrainment and transport of soil particles from their place of origin by the agents of erosion, such as water, wind and gravity. It is a form of land degradation and can be categorised as either *geological or accelerated* erosion. Geological erosion is part of the natural wearing down of the earth's land surface and occurs at rates ranging from virtually imperceptible soil creep to dramatic sudden landslides. Accelerated erosion results from human activities exposing the soil surface and thus enabling erosive agents such as rain to wash away topsoil and the underlying weathered rock. The rate of erosion and sedimentation in a catchment is a function of changes in the surface drainage patterns, terrain roughness, vegetation and climatic conditions.

3.2.1.3 In order to map the soil erosion potential in the catchment a soil erosion model, CALSITE, is used in this study. The CALSITE (Calibrated Simulation of Transported Erosion) model uses the Universal Soil Loss Equation and the IDRISI GIS to define the soil erosion potential map of a catchment. It requires rainfall, soil, topography and land-use maps of the catchment as inputs. The modelling exercise will involve collection and preparation of the pertinent input maps, model set-up and calibration, and simulation for the soil erosion potential maps associated with the various proposed land-use scenarios for the catchment.

3.2.2 The CALSITE Model

3.2.2.1 The CALSITE Model uses a combination of the Universal Soil Loss Equation (USLE) and a delivery ratio function to determine the soil erosion and sediment yield from a catchment. The equation for the estimated average annual soil erosion loss, in tonnes/ha/year, is given in Equation 3.1.

$$\mathbf{SE = R \times K \times LS \times CP} \qquad (3.1)$$

Where,

SE = Estimated average annual soil erosion loss (tonnes/ha/year)
R = Rainfall Erosivity Factor
K = Soil Erodibility Factor
LS = Slope Length and Steepness Factor
CP = Combined Crop Cover and Conservation Practice Factor

3.2.2.2 LS and CP are dimensionless, whereas the dimension for R and K varies but their product will be equal to the dimension of SE.

3.2.2.3 The Sediment Yield (SY) is calculated based on Equation 3.2

$$\mathbf{SY = DR \times SE} \qquad (3.2)$$

Where,

SY = Sediment yield (tonnes/ha)
DR = Delivery ratio (a calibrated value from 0 – 1)

3.2.2.4 The latest version of the CALSITE model allow the analysis of spatial variation in the erosion and sediment in a catchment, through the use of a raster GIS, IDRISI.

3.2.2.5 The input digital data and maps have to be pre-processed into digital images of rainfall, land use, land cover and slope, before they can be used by the CALSITE model. An elevation image, produced by the pre-processing task is used to determine the delivery ratio, which is then inputted into the model. Map information on topography, soils, land use and rainfall were digitised using AutoCad software, which are then converted to the raster format.

3.2.3 Preparation of input data

3.2.3.1 The following information and maps pertinent to the study were obtained from various government departments and agencies:

- Topographical maps of the catchment, with a scale of 1:50,000, from the Survey and Mapping Department, 1993.
- Soil Map and Erodibility Factor map for Peninsular Malaysia, with a scale of 1:1,000,000, published by the Kementerian Pertanian Malaysia
- Rainfall data from the Hydrology Division, Drainage and Irrigation Department
- Land-use map of Selangor and the Wilayah Persekutuan, with a scale of 1:125,000, published by the Kementerian Pertanian Malaysia, 1995
- Future Land-use map for Putrajaya.

3.2.3.2 The information collected were pre-processed as follows:

(a) Rainfall map

The pre-processing task is to create an annual isohyet contour map showing the spatial distribution of rainfall in the study area, using the annual rainfall depth data of the year to be modelled. The map can be interpolated and drawn using the annual rainfall data from the rainfall stations, described in Section 3.1.2. Figure 3.2.1 shows the image of the average annual rainfall map after the interpolation process.

(b) Soil map

The information on the soil type in the catchment, was obtained from soil characteristics investigation and analysis carried out by Universiti Putra Malaysia.

(c) Elevation and slope map

The topographic map was used to define the elevation differences in the catchment for subsequent computation of slopes and flow paths in the catchment. The contours obtained from the topographic map, with a scale of 1 : 50,000, are digitised and other points are interpolated using IDRISI's Intercom component. Based on the digitised topographic contours the elevation map (Figure

3.2.2) was generated. The slope map (Figure 3.2.3) is then derived from the elevation map using IDRISI's Surface component.

(d) Land-use map

(1) In the Preliminary Report, for present land-use map, digitising was only for Putrajaya catchment only, resulting in the creation of soil erosion potential for Putrajaya catchment only. Soil erosion potential covering the whole Perbadanan Putrajaya area and Putrajaya catchment is included in the Draft Final Report. As for future Land-use, digitising was done for the Perbadanan Putrajaya area as well the Putrajaya Lake Catchment area.

(2) The above processed maps were then geometrically rectified to a common map base and scale so that they can be subsequently overlain to create the soil erosion potential map.

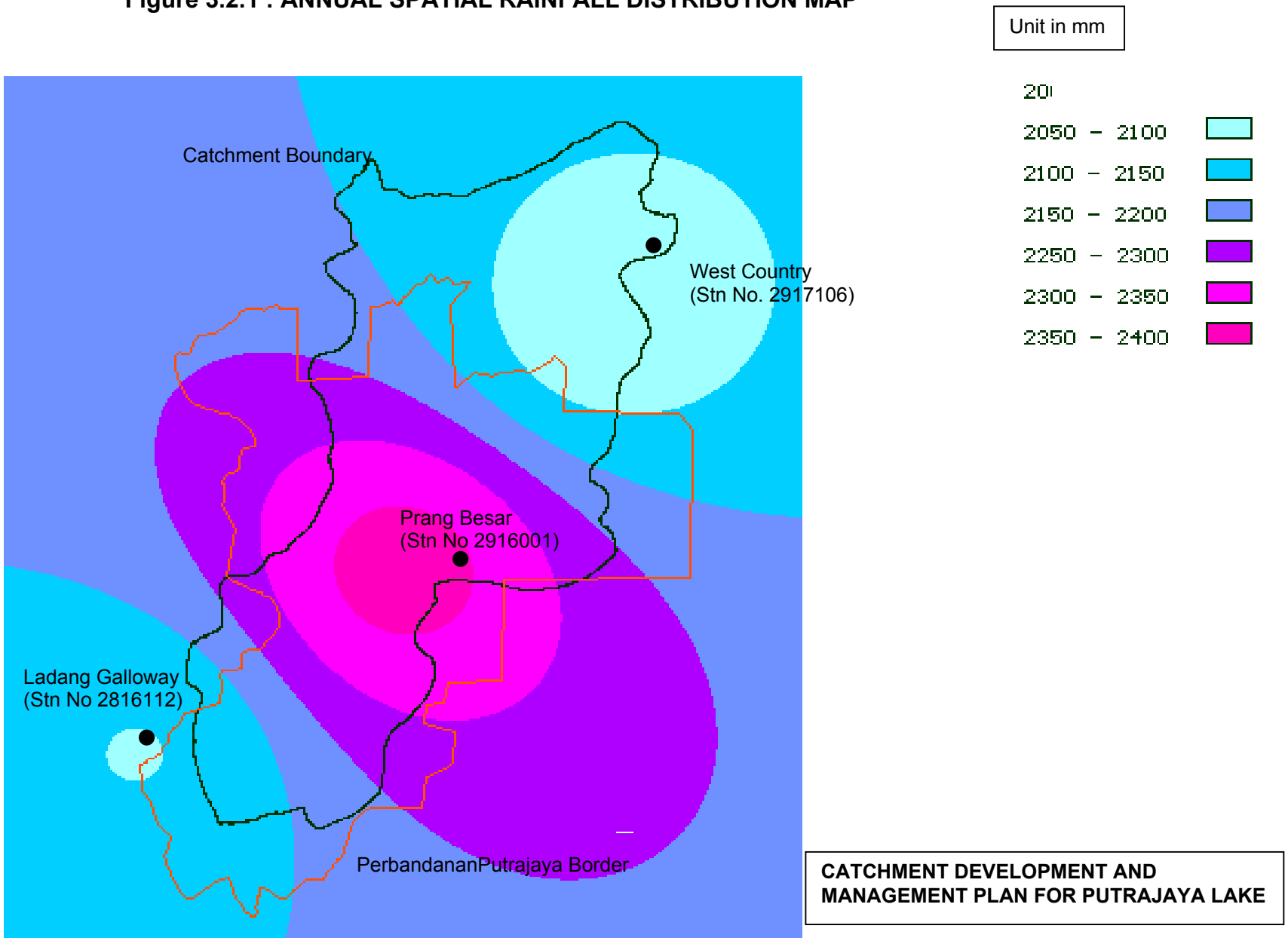
3.2.4 Model calibration and set-up

3.2.4.1 For the calibration of the CALSITE model it is important that data on the observed sediment yield from the catchment be obtained. The most reliable and accurate data are those collected from hydrographic surveys in the catchment. Thus, surveys to collect the required data for the calibration will carried out.

3.2.4.2 From Equation (3.1), it can be seen that the estimated annual soil erosion loss is the product of four parameters. They are the rainfall erosivity factor (R-factor), soil erodibility factor (K-factor), slope length and steepness factor (LS-factor) and conservation practice factor (CP-factor). The image files containing the information on the four factors were pre-processed, as described in Section 3.2.3 above.

3.2.4.3 Among the four factors, the K-factor and the LS-factor are assumed to have insignificant changes throughout the catchment. However, since the R-factor and the CP-factor are related to the rainfall and land-use in the catchment they are expected to vary with time. This implies that the R-factor and CP-factor images are dependent on the year being considered.

Figure 3.2.1 : ANNUAL SPATIAL RAINFALL DISTRIBUTION MAP



CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

Figure 3.2.2 : ELEVATION MAP

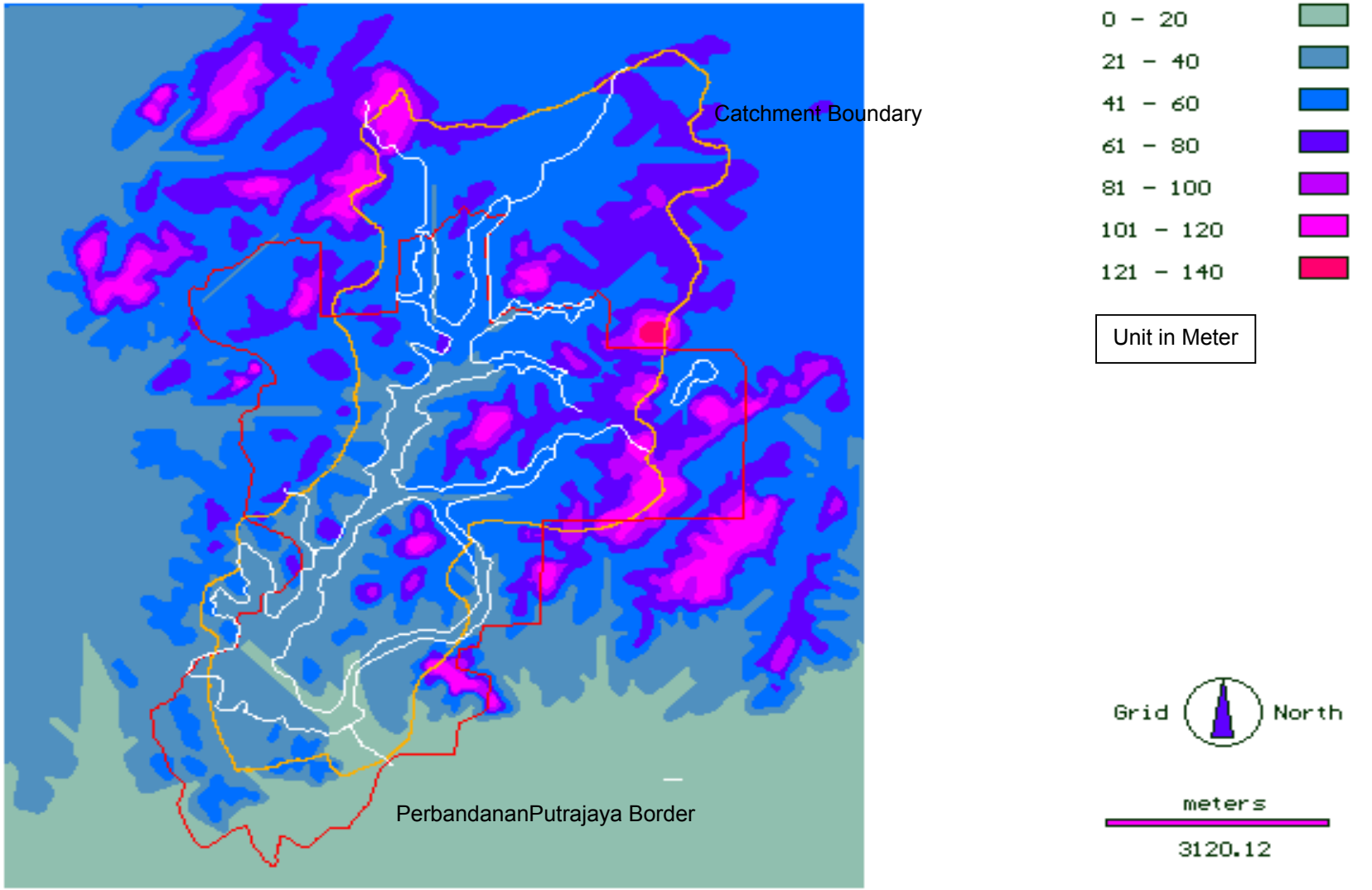
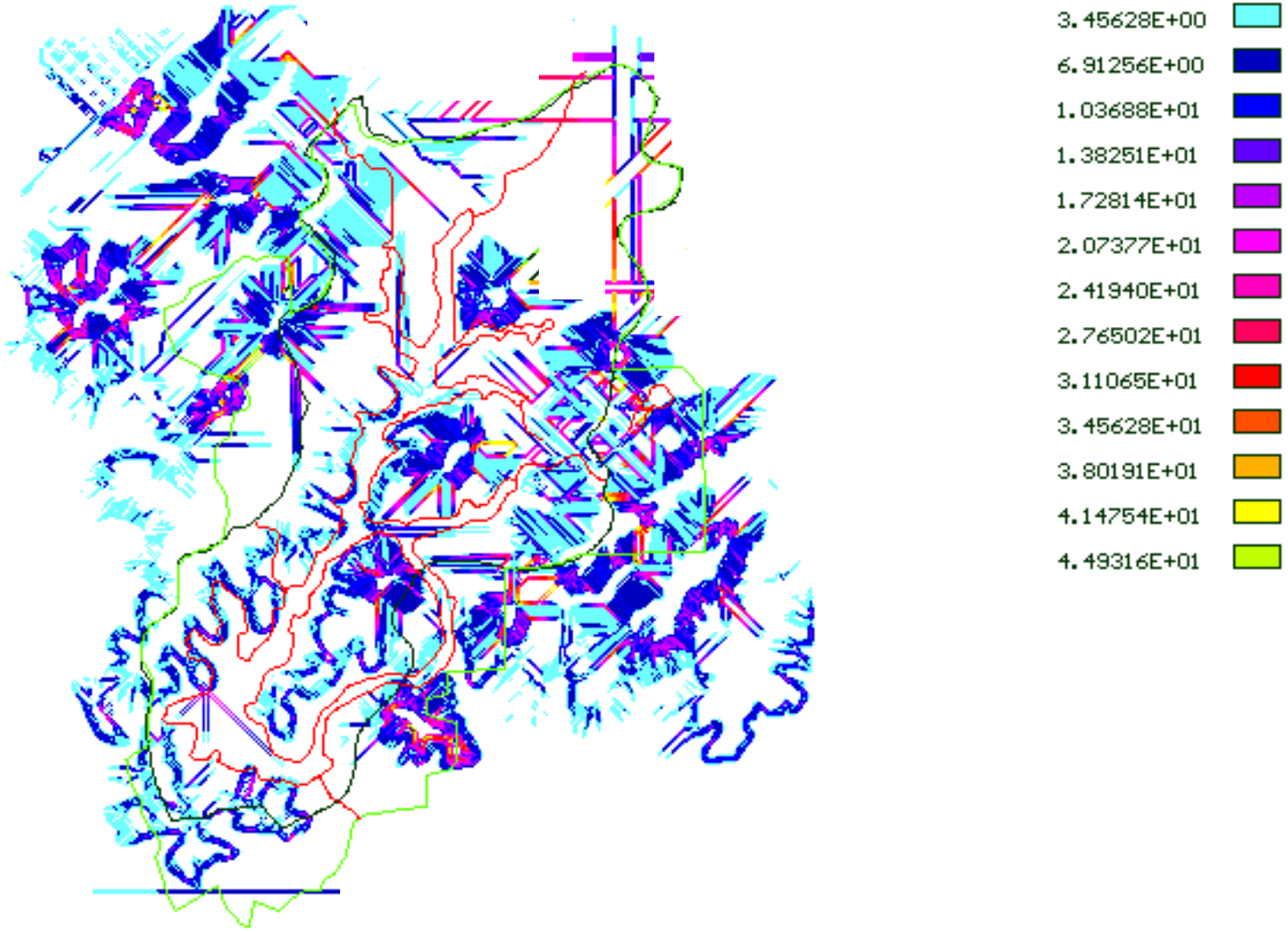


FIGURE 3.2.3: SLOPE MAP



3.2.4.4 The following assumptions have been made in the derivation of the images associated with the four factors used in this study.

(a) Rainfall erosivity factor (R-factor)

(1) The USLE measures rainfall erosivity as the product of the annual kinetic energy of rainfall (E) and the greatest intensity of a 30-min storm (I_{30}). Normally, this method is impractical. It is because the prediction for potential soil erosion is on annual basis (ton/ha/yr). The Model offers two options for deriving R-factor from annual rainfall based on empirical methods. The first is an equation by Bols which has been derived from data collected in Indonesia and has been applied in the Philippines. The other is a regression equation derived by Harper based on the analysis of Hawaii data and has been modified for use in Thailand.

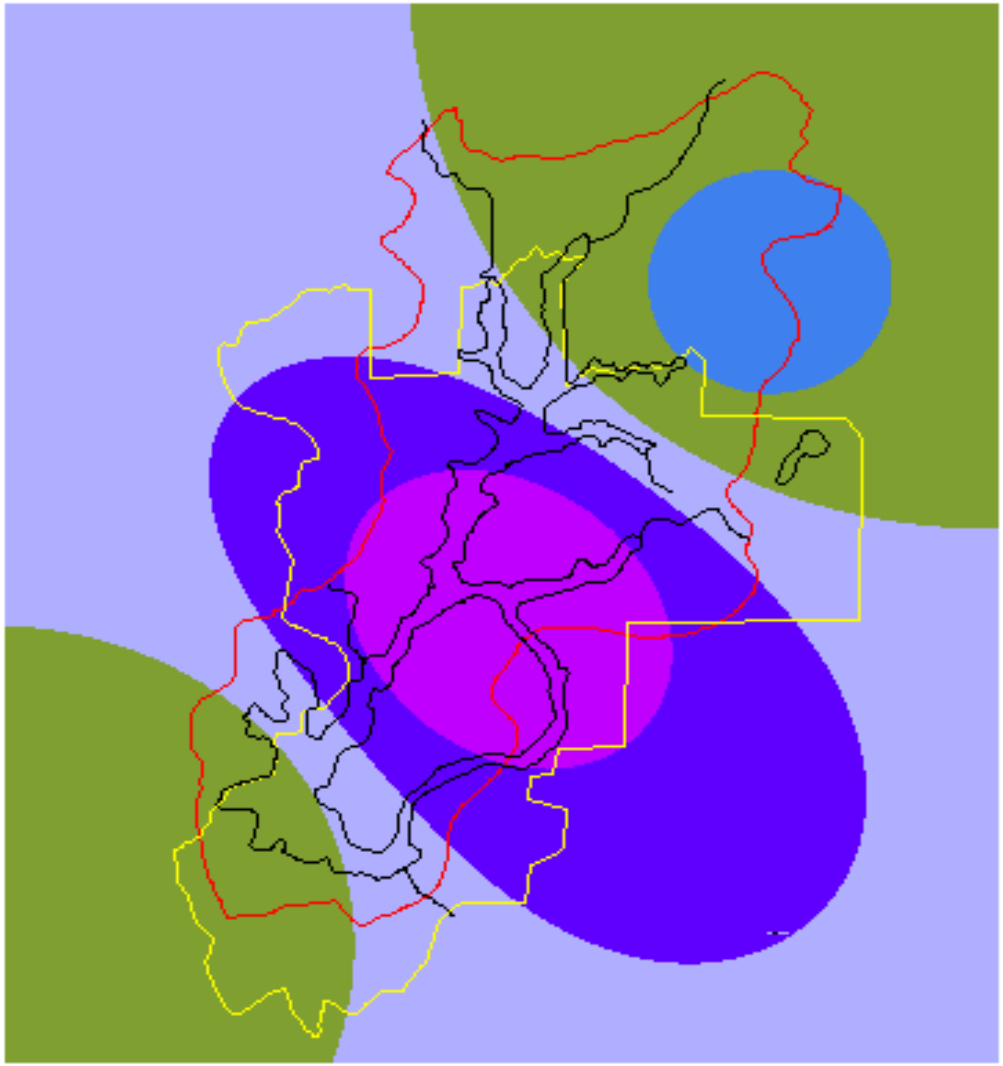
(2) However, for Peninsular Malaysia, Morgan tried to overcome the lack of data to derive the erosivity factor by making use of total daily rainfalls to predict the daily erosivity values. The annual erosivity factors derived from the sum of the daily erosivity values were found to correlate well with the annual rainfall. This relationship was also found in studies carried out at UPM. Figure 3.2.4 shows R-Factor for Perbadanan Putrajaya Lake Catchment Area.

(3) In view of the absence of better information it has been assumed in this study that the annual rainfall depth shall be used in place of the rainfall erosivity factor. This implies that the R-factor has a dimension of mm and thus the dimension of the soil erodibility factor (K-factor) has to be modified to tonnes/ha/mm to ensure dimensional consistency.

(b) Soil Erodibility Factor (K-factor)

The K-factor relates soil erodibility to the texture, organic matter content, structure and permeability of a soil type. Each soil type in the image can be assigned a K-value in the model to generate the soil erodibility image. The Ministry of Agriculture, Malaysia has considered the above method to get the R-factor to be acceptable and has adopted it for use in the Ministry of Agriculture. Thus, it

FIGURE 3.2.4 : R- FACTOR MAP



CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

has prepared K-factors map for the different types of soils in Malaysia for use with the method. For this study, K-Factor map (Figure 3.2.5) were produced based on soil investigation characteristics carried out by University Putra Malaysia.

(c) Slope length factor (LS-factor)

The derivation of the slope-length image requires two images - the slope image and the length-of-slope image. The slope image is obtained from the elevation image as explained earlier. The length-of-slope image (L-value) is generated by the model through the processes of determining the aspects and flow accumulation at each pixel of the image, based on the information in the elevation image.

(d) Conservation Practice factor (CP-factor)

The surface management factor, CP, is a ratio that compares the soil loss from a field cultivated with a particular crop type or vegetation cover with that from a field with bare soil. It has a value of zero, when the soil is completely protected, to a value of one for bare soil. The CP-factor image is generated based on the land-use images produced from the land-use map, by assigning pertinent CP-factors for the various types of land cover in the catchment as shown in Figure 3.2.6**.**

3.2.5 Model simulation

3.2.5.1 Based on the above R, K, LS and CP factor image inputs the simulated output of the CALSITE model is the soil erosion loss image. The R-factor image was produced using the average annual rainfall image from Prang Besar, Ladang Galloway and Ladang West Country. The simulated soil erosion loss map, based on the 4 images above were generated from the available information and were based on three (3) scenarios:

1. Current Landuse
2. Future Landuse
3. Without Cover (worst case scenario)

FIGURE 3.2.5 : K – FACTOR MAP

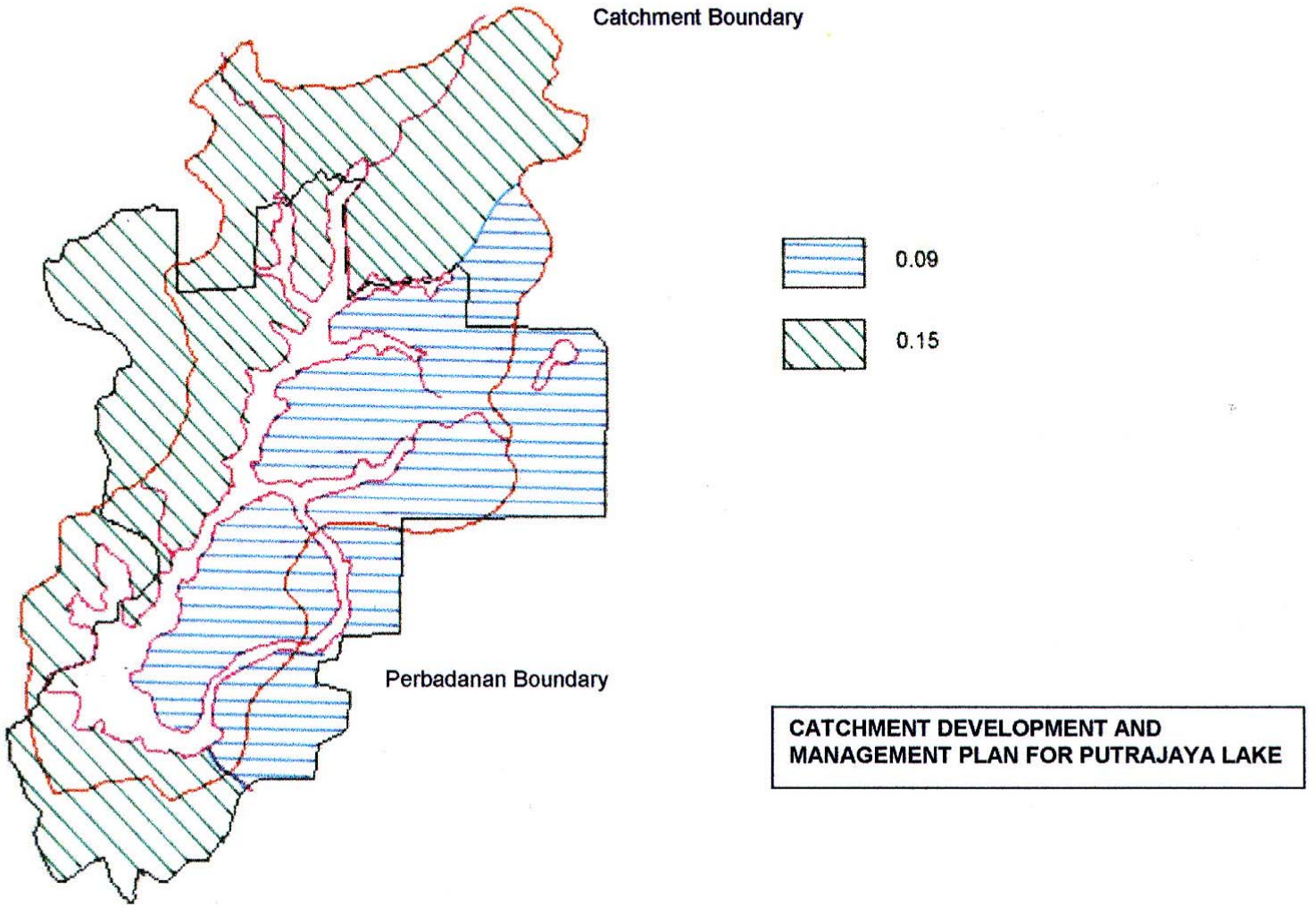
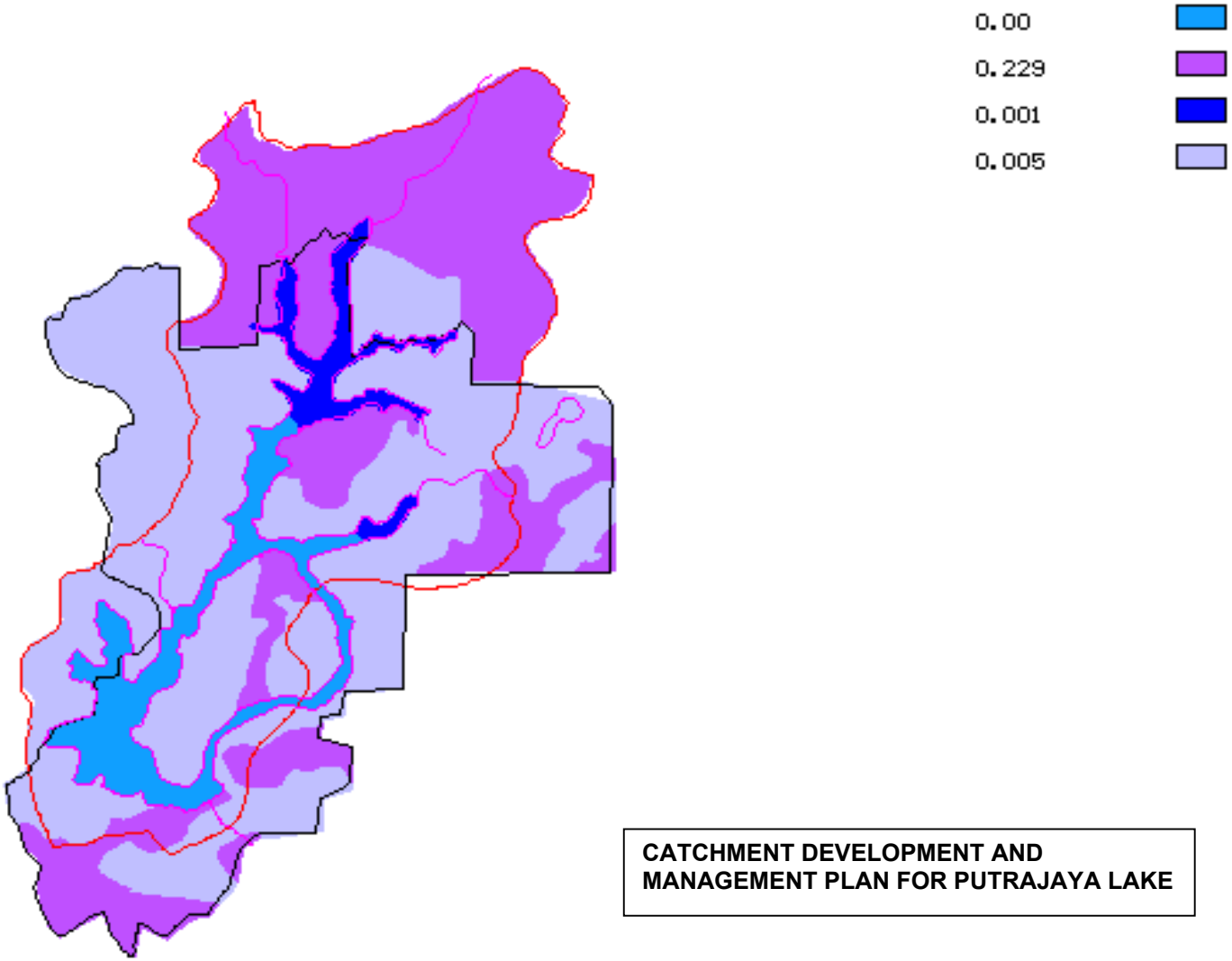


FIGURE 3.2.6: CP – FACTOR MAP



CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

(2) The worst case scenario with a CP value of 1 was used to generate the soil erosion loss map. The worst case scenario consider that soil surface is totally bare and without any cover. This scenario will only be significant when considering any new developments involving major earthworks. From this map, it can be predicted and determined the location where erosion will occur most. Preliminary preventive measures to minimise soil erosion then can be taken during earlier stage of the projects.

3.2.5.1 Soil Investigation Characteristics by UPM

(1) Soil expert from Universiti Putra Malaysia has been appointed on 23 July, 1999 to carry out soil investigation characteristics to determine the properties of soil within Perbadanan Putrajaya area and the area within Putrajaya Lake Catchment.

(2) The objective of the soil investigation is to determine parameters required for the refinement of data input to the CALSITE model. The result of the investigation also can be used for future study.

(3) Scope of the investigation include the following:-

1. Soil Texture
2. Particle Size Distribution (USDA Particle Size Class)
   i. Hydrometer Sedimentation
   ii. Sieve Analysis
   iii. Percent organic matter
   iv. Percent rock content
3. Permeability Test
4. Soil Structure
   - Very fine granular
   - Fine granular
   - Moderate or coarse granular
5. Moisture Content
6. Soil Erodibility Factor, K
7. Soil Description
8. Soil Erodibility Map

3.2.6 CALSITE Modelling results

3.2.6.1 Based on the CALSITE model, soil erosion for Perbadanan Putrajaya is low compared to other studies that have been carried out in other areas. Table 3.2.1 shows the comparison of the estimated erosion rate for various studies.

Table 3.2.1 : Erosion Rate from Selected Watershed in Malaysia and Singapore

Location	Area (km2)	Estimated Erosion Rate (ton/ha/yr)			References
		Forest	Agriculture	Construction	
1. Sg. Tekam Forest Reserve	0.57	0.27			Peh (1981)
2. Sg. Telom, Cameron Highland	77.0	0.3	26		Shallow (1956)
3. Sg. Kial, Cameron Highland	21.0	0.3	25		Shallow (1956)
4. Sg. Bertam, Cameron Highland	73	0.3	22		Shallow (1956)
5. Upper Sg. Anak Air Batu	5.9			11,000	Leigh (1982)
6. Denuded Plot, Upper Sg. Anak Air Batu	0.06			6,000	Leigh (1982)
7. Erosion Grid Plot, NUS, Singapore	$2.5x10^{-6}$			1,300	Chatterjea (1989)
9. Sg. Kurau, Perak			500 (agriculture and urbanising areas)		DID (1997)
10. Putrajaya Lake Catchment	60.7		50 (Current Landuse) 150 (Future Landuse)	300 (Average) 600 (Max)	

3.2.6.2 From Table 3.2.1, the erosion rate for Putrajaya Lake Catchment is very well below the construction rate and slightly above the agriculture rate. Compared to other studies, the erosion rate was very much lower. This is due to the

topography of the Putrajaya Lake Catchment area which is gently undulating.

3.2.6.3 From Figure 3.2.7, it can be observed that soil erosion rates (Current Landuse) for the major part of Putrajaya Lake Catchment area is below 50 ton/ha/yr, which is considered low. Only small pockets of hilly terrain in the Putrajaya Lake Catchment have erosion rates of between 51 to 200 ton/ha/yr.

3.2.6.4 From Figure 3.2.8 (current landuse), for major part of Putrajaya Lake Catchment area, sediment yield is well below 10 Ton/ha/yr. On some parts of the catchment boundary (hilly area) covering the eastern part of Upper Bisa Wetland have a value of between 50 to 60 ton/ha/yr.

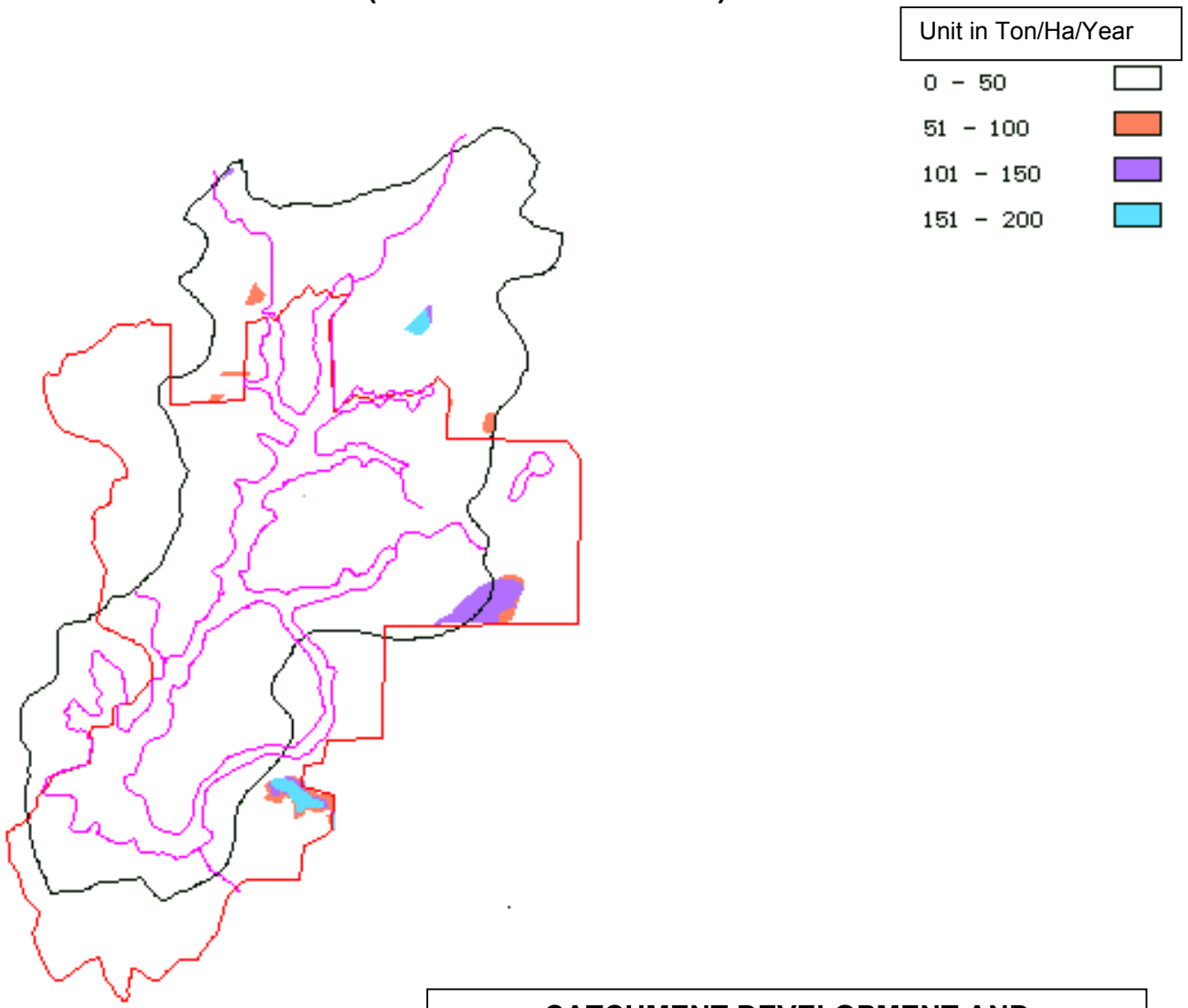
3.2.6.5 For Future Landuse (Figure 3.2.9) the major part of Putrajaya Lake Catchment has a soil erosion rate of below 150 ton/ha/yr. In the north-western fringes near MARDI and eastern fringes near West Country and Upper Bisa wetlands the soil erosion rates goes up to 200-300 ton/ha/yr.

3.2.6.6 From Figure 3.2.10, for major part of Putrajaya Lake Catchment area the sediment yield is up to 50 ton/ha/yr. On some parts on upper north catchment area (MARDI and UPM site) and on the fringes of Upper Bisa Wetland, it register sediment yield of between 60 to 80 ton/ha/yr. On the West Country site, due to hilly terrain the sediment yield is between 80 to 100 ton/ha/yr.

3.2.6.7 For worst case scenario i.e. without cover (Figure 3.2.11) the major part of Putrajaya Lake Catchment has a soil erosion rate of about 300 ton/ha/yr. In the north-western fringes near MARDI and eastern fringes near West Country and Upper Bisa wetlands the soil erosion rate goes up to 400-600 ton/ha/yr.

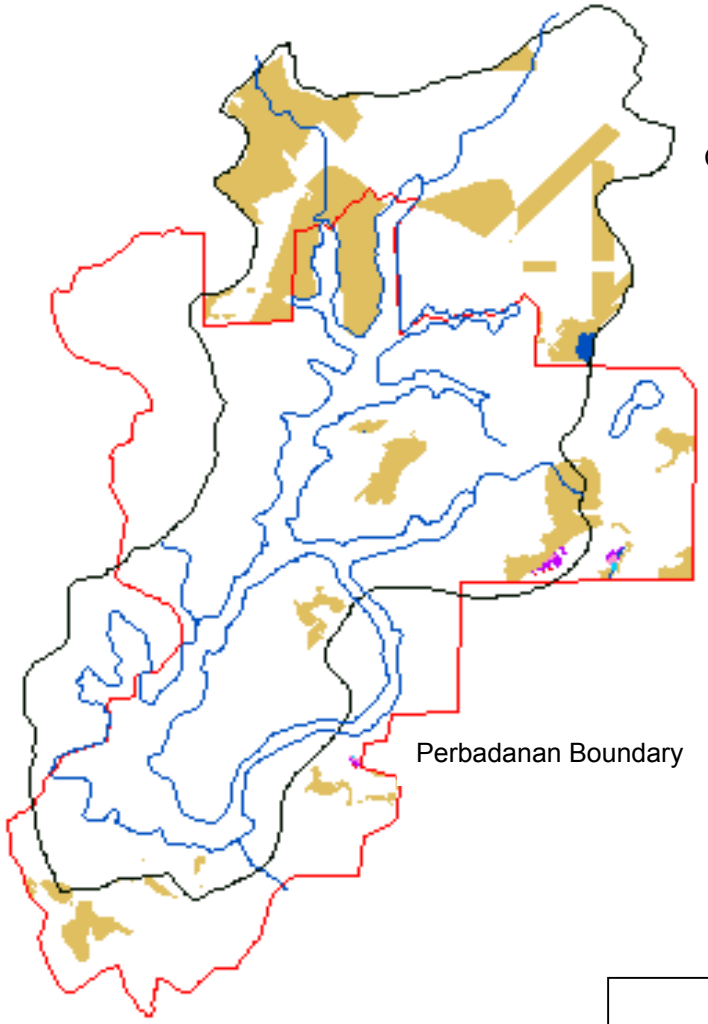
3.2.6.8 From Figure 3.2.12, sediment yield for major part of Putrajaya Lake Catchment is between 50 to 100 ton/ha/yr. On the Upper North catchment area and on the eastern part of Upper East and Lower East Wetland, sediment yield is between 200 to 250 ton/ha/yr.

FIGURE 3.2.7 : SOIL EROSION (CURRENT LANDUSE)



CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

FIGURE : 3.2.8 : SEDIMENT YIELD (CURRENT LANDUSE)

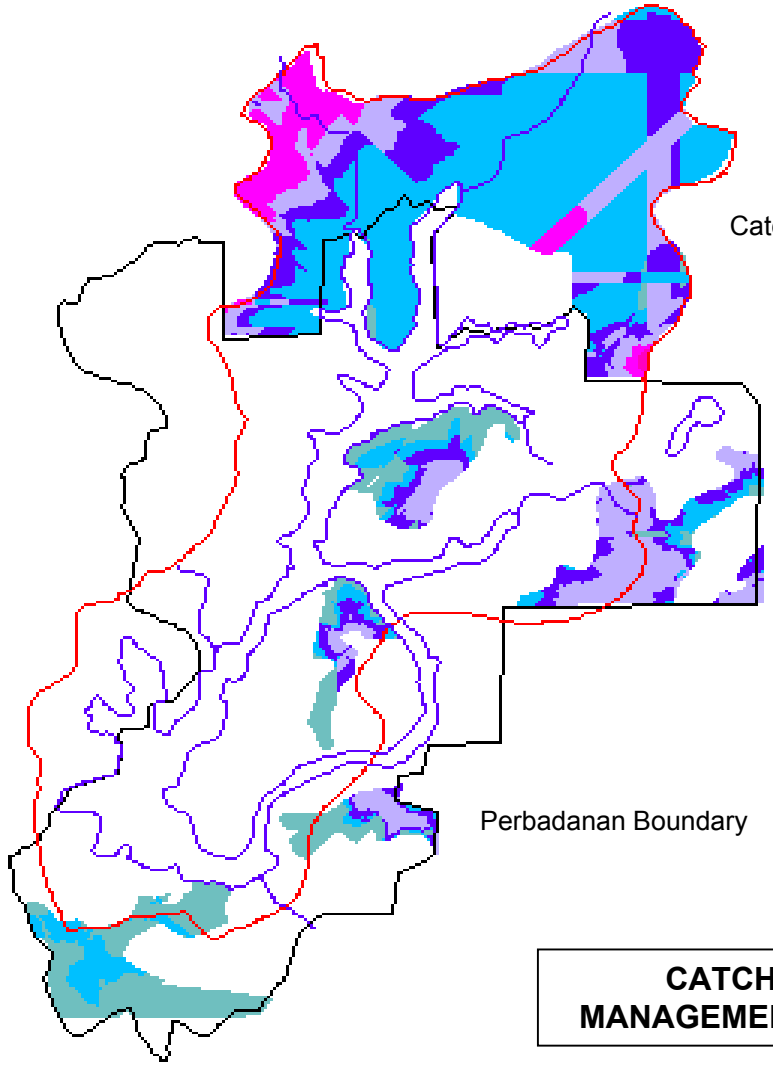


0 - 10	
11 - 20	
21 - 30	
31 - 40	
41 - 50	
51 - 60	

UNIT IN TON/HA/YR

CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

FIGURE 3.2.9: SOIL EROSION MAP (FUTURE LANDUSE)

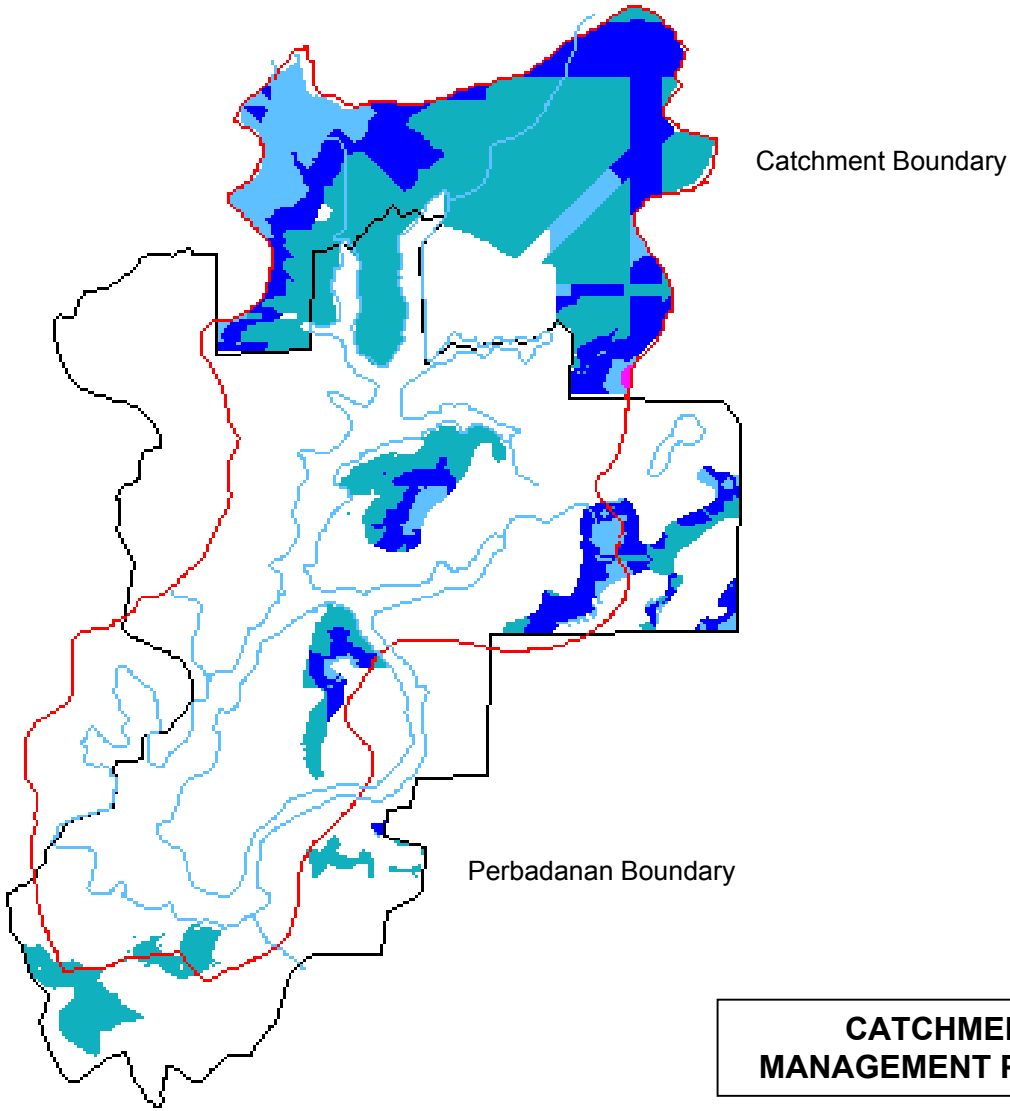


Unit in Ton/Ha/Yr

0 - 50	
51 - 100	
101 - 150	
151 - 200	
201 - 250	
251 - 300	
OVER 301	

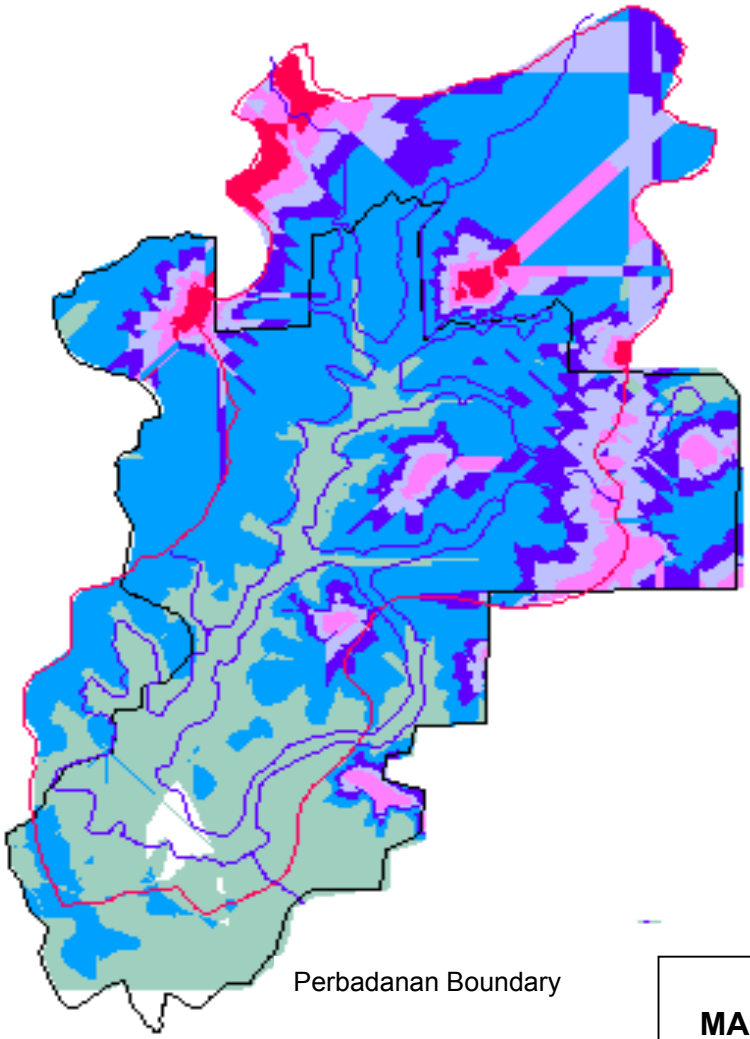
CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

FIGURE 3.2.10 : SEDIMENT YIELD (FUTURE LANDUSE)



CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

FIGURE 3.2.11 : SOIL EROSION (WITHOUT COVER)

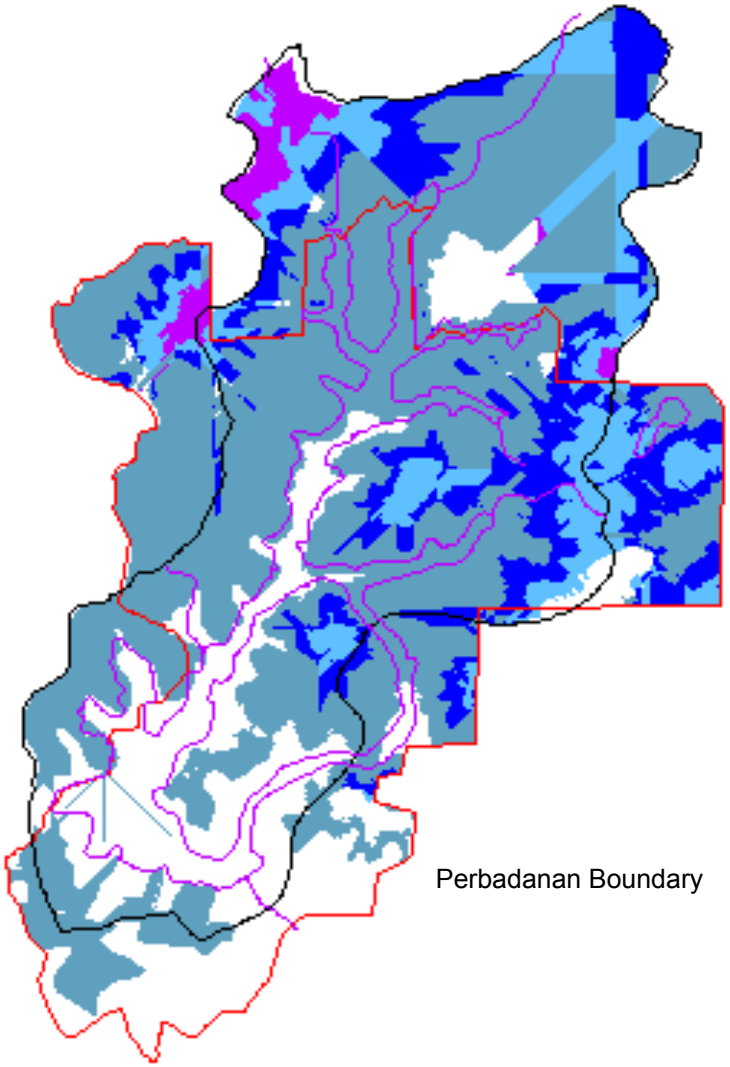


Unit in Ton/Ha/Yr

0 – 100	
101 – 200	
210 – 300	
301 – 400	
401 – 500	
501 – 600	
OVER 601	

CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

FIGURE 3.2.12: SEDIMENT YIELD (WITHOUT COVER)



Unit in Ton/Ha/Yr

0 - 50	
51 - 100	
101 - 150	
151 - 200	
201 - 250	

CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

3.2.6.9 Based from this result, for future Land-use scenario soil erosion problems is expected to be rather mild in the Putrajaya Lake Catchment area provided on-site erosion controls, continuous monitoring, and regular maintenance are carried out.

3.2.6.10 However, at the area with higher erosion rate especially near the eastern and northern boundary of Putrajaya Lake Catchment, on-site erosion and sediment controls should be implemented and monitored closely during any development works to prevent sediment entering the wetlands and Putrajaya Lake.

3.2.7 Review of Existing Guidelines and Legislation on Erosion and Sediment Control

3.2.7.1 Environmental Legislation and Guidelines

(i) Putrajaya Environmental Management Guide

Based on the report on "Putrajaya Environmental Management Guide", Matter pertaining Erosion and Sediment was mentioned in Chapter 2.10: Environment Management Plan (EMP) of the report "Putrajaya Environmental Management Guide".

2.10.6.4(ii)	- Environmental Management–Construction Stages
2.10.7.3.1	- Environmental Management – Operation Stages Attachment (Table A7.2 in Appendix 7)
2.10.8(7)	- Audit Requirements Attachment (Table A7.3 in Appendix 7)

(ii) "Guidelines for Prevention and Control of Soil Erosion and Siltation in Malaysia", Department of Environment (DOE), October 1996

The guideline is recommending various measures for the control of soil erosion and river sedimentation to adopted when undertaking site clearing and earthworks. It outlines the principles for sound practices required to minimise soil

erosion and sedimentation and should be considered as basis for practicable measures to prevent serious soil degradation.

(iii) Land Conservation Act 1960, Revision 1989

Part III of the act – Control of silt and erosion.

The act empower State Land Administrator to serve notice to the land owners or occupiers of any land regarding the movement of soils or stone that likely to cause damage to other land.

(iv) Street, Drainage and Building Act 1974
Earthworks (Perbadanan Putrajaya) By-Laws 1996

(1) Erosion protection were mentioned and covered in some parts of the above mentioned by-laws:-

Part II 6(d)(vii)	- protection to the earthworks against erosion, including protection during the continuance of the earthworks.
Part IV 18(b)	- that silt traps and sediment control facilities are adequately provided and properly maintained.
Part IV 18(d)	- that slopes are adequately protected against erosion.

(2) As mentioned and commented in the Chapter 8.1.5.4 (1) *Drainage, Building and Earthworks* in Putrajaya Environmental Management Guide, although there were sufficient power within Perbadanan Putrajaya to address the erosion and sedimentation issues, it appeared that the approach were not adequate. In order to address the issues, specific task and more focus should be given regarding control or erosion and sedimentation.

(3) As for area outside of the jurisdiction of Perbadanan Putrajaya, the respective Majlis Daerah should adhere to the existing By-laws, act and guidelines.

3.2.10 Recommendations for Soil Erosion and Sediment Control

3.2.10.1 'Erosion and Sediment Control By Law'

(1) In view of the importance and sensitivity of the study area, and the effect of erosion and sedimentation to the wetland and Putrajaya Lake, it make sense for erosion and sedimentation control to be regulated separately at Perbadanan Putrajaya level. Although erosion and sediment control were mentioned briefly in the Street, Drainage and Building Act 1974 Earthworks (Perbadanan Putrajaya) By Laws 1996, a new By Law entitled 'Erosion and Sediment Control By Law' is recommended for Perbadanan Putrajaya and the Local Authorities within Putrajaya Lake Catchment Area as it is the most effective way in implementing and enforcing erosion and sediment control.

(2) Among key features of an effective erosion and sediment control By Laws are the following:

i. Since erosion and sedimentation control will be directly affecting the wetland and lake, persons or contractor that involved in the earthworks must be informed that maintaining water quality in the lake is the paramount objectives and must be maintained at required level. The By Laws will provides a legal basis for Perbadanan to prosecute the offender if water pollution occurs due to their negligence.

ii. All earthworks that may result in a significant erosion and sedimentation should require permit or approval. Other activities involving very minor earthwork may be exempted.

iii. Temporary and permanent erosion and sediment control plan must be submitted for approval. This provision is the most important and provide strong enforcement tools. The consultant or contractor must specify the erosion and sediment control measures for approval by Putrajaya.

iv. Provision should include timetables for regular reporting, site inspection and schedules when the consultant or contractor will start the earthworks. This will enable

Perbadanan to make necessary arrangement to inspect and monitor the progress of the works.

v. Perbadanan also may require modification of an erosion and sedimentation control plan when they feel that such plan is not adequate or ineffective. This provision will provide legal basis for requiring plan changes after initial plan approval.

vi. Strong enforcement should be made available to Perbadanan. A sequence of progressive provisions, such as suspension or revocation of permit, fine and imprisonment should be included in the by-law. The penalties must be severe enough for the offender to comply to the By Laws.

vii. Contractor is required to provide security in the form of deposit or performance bond to finance the remedial works in case the works is not satisfactory and need repair.

(3) There are many other provision that can be incorporated in the By Laws to make it more effective. However, enforcement also played the key part to ensure that erosion and sediment control measures can be implemented successfully. Even though there are punitive provision in the By Laws, using them meant that implementation of the project plans has been unsuccessful. There were many stages before actual action can be taken against the contractors.

3.2.10.2 Standards for Erosion and Sediment Control

(1) It is recommended that a 'Standards for Erosion and Sediment Control' detailing design and specifications for erosion and sediment control works and plan be developed to support the 'Erosion and Sediment Control By Law'.

(2) Developers and engineers involved in earthworks need to comply with the 'Standards for Erosion and Sediment Control' in order for their Erosion and Sediment Control Plan submission (which is mandatory under the new By Law) to be approved by the Perbadanan Putrajaya and other Local Authorities within the Putrajaya Lake Catchment.

3.3 GEOLOGICAL/HYDROGEOLOGICAL STUDY

3.3.1 Introduction

3.3.1.1 The groundwater recharge into and seepage loss from the Putrajaya Lake system is an important management issue, related to the water quantity in the Lake.

3.3.1.2 Also an understanding of the groundwater flow regime is essential for the management of non-point sources pollutant entry into the Lake system through infiltration and groundwater seepage.

3.3.1.3 An adequate understanding of the geological and hydrological setting in the catchment is essential for the identification of any potential problems related to the above issues and for the formulation of appropriate management strategies to address them.

3.3.2 The Geological Setting

3.3.2.1 The catchment area has an undulating topography with low hills rising up to over 100m above sea level.

3.3.2.2 The geology of the catchment is found in the Geological Survey of Malaysia (GSM) report entitled *"Geologi dan Sumber Mineral Kawasan Sepang-Telok Datok, Selangor"* by Abdullah Sani bin Hashim (in manuscript).

3.3.2.3 Figure 3.3.1 shows the geological structures and distribution of the rock formation in the catchment.

3.3.2.4 Rock Formation

(1) The following geological formations are present and outcrop within the catchment area.

- Quaternary - River Alluvium
- Carboniferous-Permian - Kenny Hill Formation
- Silurian - Hawthornden Formation

(2) The alluviums are found in the flat and low-lying areas in the Central and Southern part of the catchment. They overlie the Hawthornden and Kenny Hill Formations. The thickest

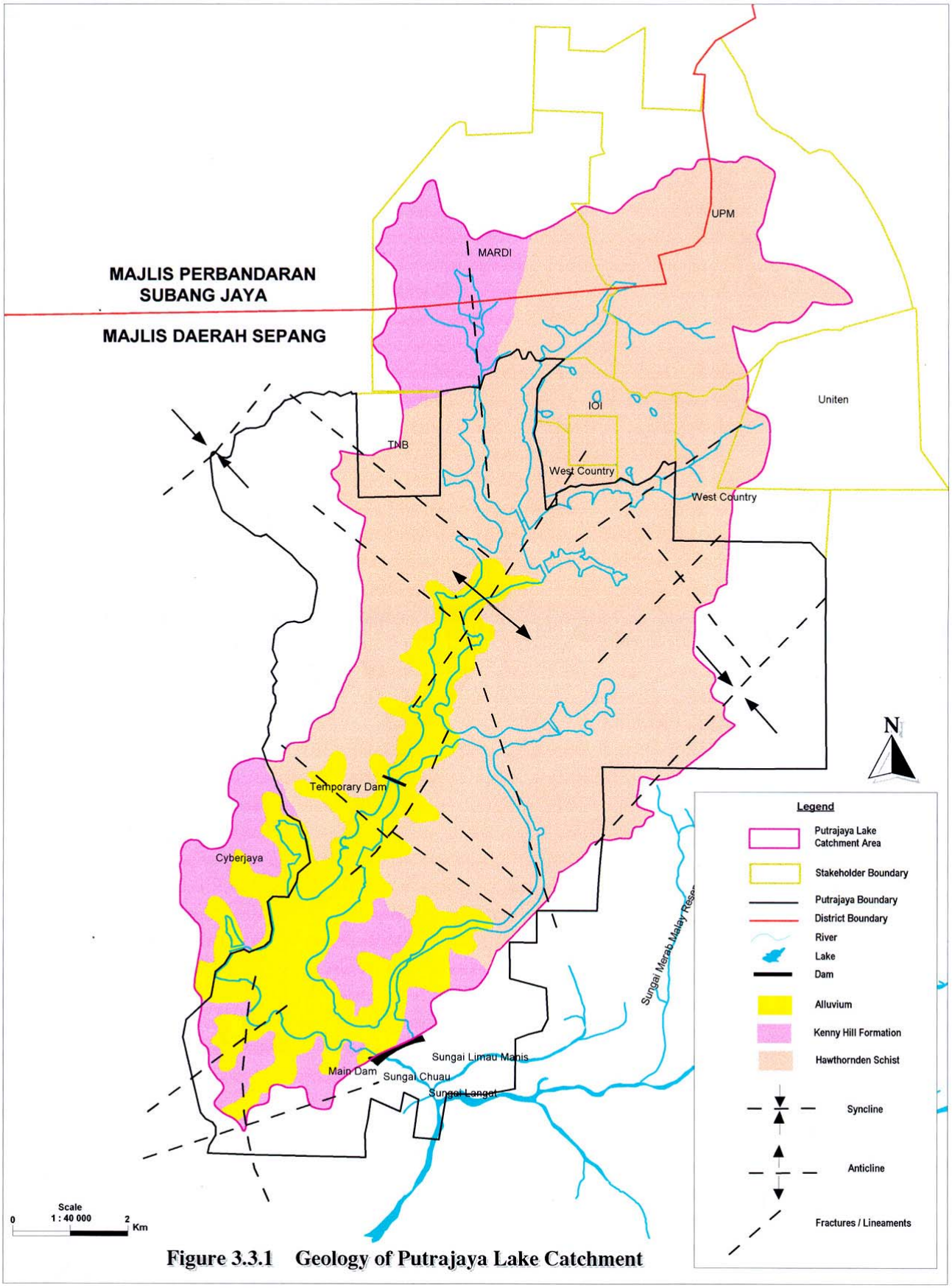


Figure 3.3.1 Geology of Putrajaya Lake Catchment

sequence is developed along the plains and the lower reaches of the Sungai Chuau and Sungai Limau Manis, and their tributaries.

(3) The Kenny Hill Formation is found in the West and Northwest and consists of sandstone and shale which have undergone some degree of regional metamorphism.

(4) The Hawthornden Formation occupies about 70% of the area. This unit is made up of metamorphosed rocks i.e. quartz-mica schist, quartz schist and graphitic schist. This Formation is the oldest rock unit outcropping in the catchment area.

3.3.2.5 Structure

(1) From aerial photographs and satellite imagery analysis studies conducted by the GSM, the geological environment in and around the catchment is regionally folded along the NE-SW axis resulting in the development of broad anticlines and synclines. Within the study area an anticline is demarcated to run along Sungai Chuau.

(2) In addition to the folding, the tectonic movement has also resulted in fracturing and the development of joints in the incompetent metamorphosed rocks. Major fractures and joints seen as lineaments can be pick up in the aerial photographs. In the study the presence of 3 sets of lineaments trending NNE-SSW, NW-SE and NE-SW have been recognised.

3.3.3 The Hydrogeological Setting

3.3.3.1 In any catchment area groundwater is a component of the total water resources available from rainfall. This is illustrated in Figure 3.3.2, which gives a schematic diagram of the hydrological flow components in a catchment. Part of the rain that falls onto the ground moves as surface runoff into the rivers and streams. However, a certain portion enters the subsurface through infiltration. The infiltrated water then moves downwards through the unsaturated zone under the action of gravity and through the saturated zone in a direction determined by the surrounding hydraulic situation. They will subsequently emerge from the ground as discharges into surface bodies such as streams, rivers and lakes.

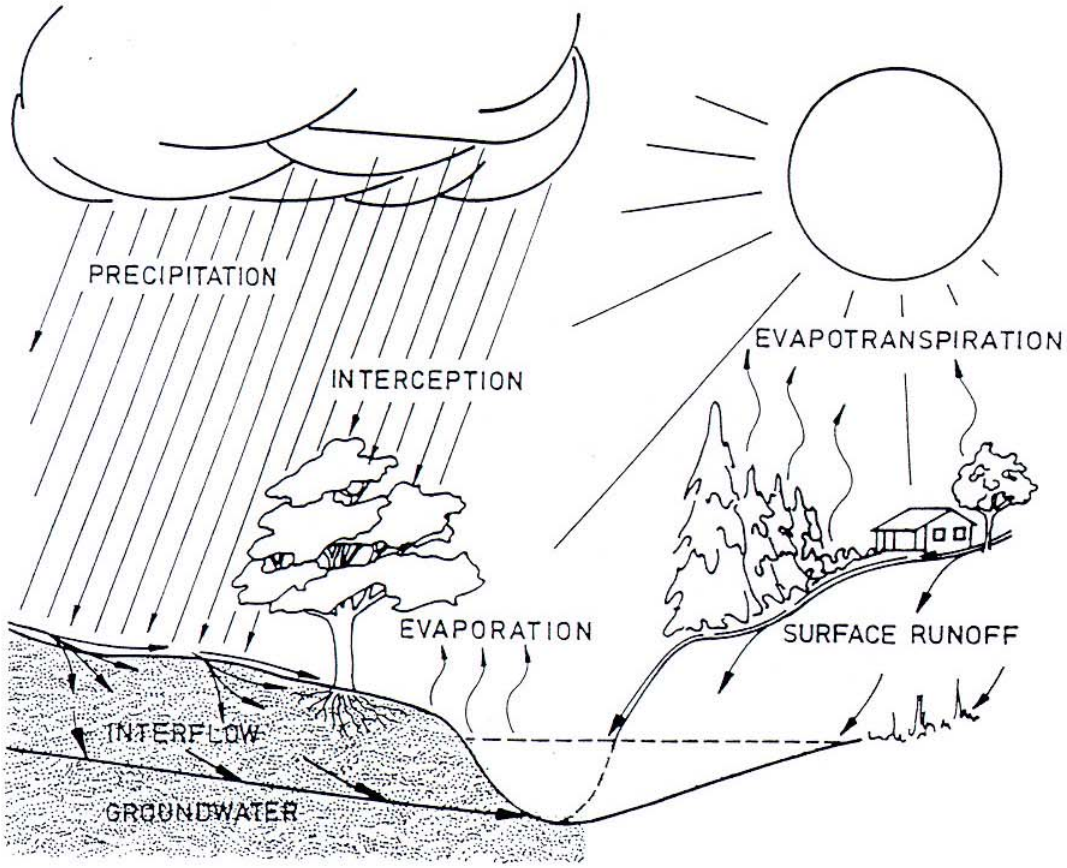


Figure 3.3.2 Hydrological Cycle

3.3.3.2 For the study area the groundwater catchment basin is similar in shape and size to that which has been established for the surface water catchment, and is the area demarcated by the basin's watershed boundary.

3.3.3.3 The regional groundwater flow system within the basin will register flow directions towards the low-lying areas i.e. the valleys, rivers, streams and lakes. This has been confirmed by the GSM through their analysis of the levels in the groundwater piezometric heads recorded in the tube wells carried out during their investigation for groundwater in the Perang Besar area.

3.3.3.4 The GSM report on the groundwater investigation for Perang Besar also discussed the aquifer systems in the Sungai Chuau catchment. Aquifers are found in the Kenny Hill and Hawthornden Formations. They are also found in the alluvium.

3.3.3.1 Aquifer in the Kenny Hill and Hawthornden Formations

(1) The Kenny Hill and the Hawthornden have suffered regional metamorphism and are dense and indurated. The primary porosity of the rocks in these formations is low and not significant. Water bearing zones, commonly described as hard rock aquifer, are related to secondary features such as joints and fractures. Joints and fractures increase the storage capacity and facilitate greater mobility of groundwater. The azimuth and distribution of the major joints and fractures are shown in Figure 3.3.1.

(2) Some characteristics of the hard rock aquifer in the Sungai Chuau catchment are recorded from 2 well localities as indicated in Figure 3.3.3.

(3) In the area previously occupied by Perang Besar Estate, located in the central part of the basin, two wells were constructed by Pacific Industrial & Mining and Drilco Sendirian Berhad. The wells, TWC-1 and TWC-2, built to reach depths of 137 meters and 53 meters, respectively gave an optimum yield of 16 cubic meters/hour/well (3520 gallons/hour/well). It was noted that the initial discharge rate was higher, 22 cubic meters/hour/well (4840 gallons/hour/well), indicating that the fracture system is local in extent and the aquifer is restrictive and irregular in size.

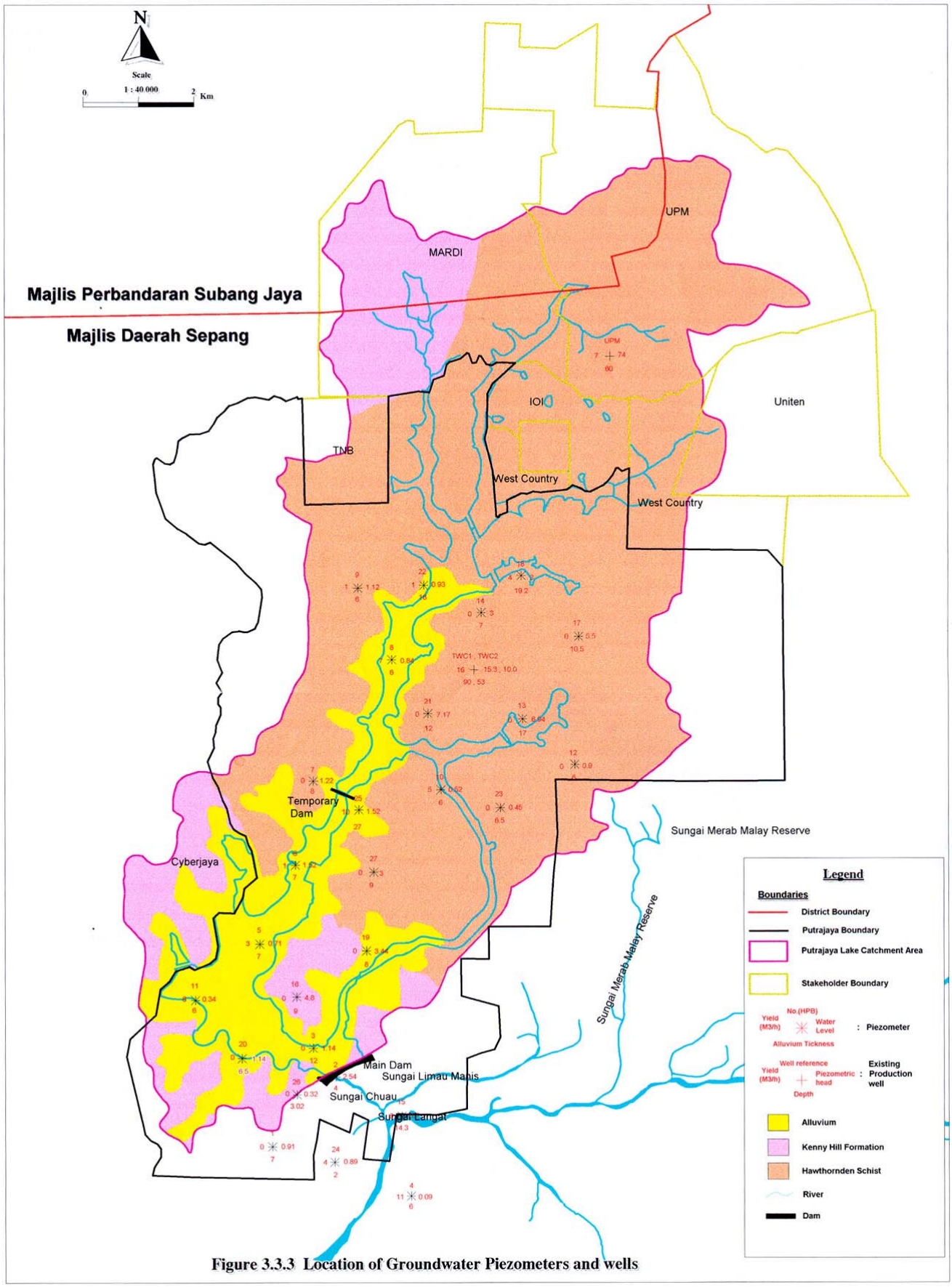


Figure 3.3.3 Location of Groundwater Piezometers and wells

(4) At the UPM, located in the North-Western end of the catchment, one well (UPM) was constructed by Soilmec and Drill Equip Supply Company close to the Sungai Chuau. The well reaches a depth of 60 metres and intercepted a fractured zone between 42 metres to 54 metres below ground surface in the metamorphic rocks. Again the optimum yield computed is lower than the initial discharge, 6 cubic meters/hour (1320 gallons/hour) and 7 cubic meters/hour (1540 gallons/hour), respectively confirming that the aquifer system in the hard rock is local in extent.

3.3.3.2 Aquifer in the Alluvium

(1) The groundwater potential of the Alluvium in the catchment has been investigated by the GSM (Nazan et al., 1994). Table 3.3.1 gives the results of the yield from the 27 piezometers and wells constructed in the Alluvium. The Alluvium was found to comprise of clay, sand, fine gravel, silt and peat and varies from 4 to 14.3 metres in thickness. Bore hole records show that coarse sediments (aquifer zone) of sand and gravel generally form the lower layers while finer components of clay and silt constitute the upper parts. Sand and gravel layers are thicker closer to the river, particularly along the flood plains and near the lower reaches of Sungai Chuau, and peat layers were recorded in several bore holes and vary in thickness from 20 cm to 213 cm. The lithologic logs for HPB 4, 8, and 10 (see Figures 3.3.4, 3.3.5 & 3.3.6) give an insight on the geologic profile of the Alluvium in areas where aquifer is present. Wells sunk in these layers give yields up to 6.8 cubic meters/hour (1500 gallons/hour).

(2) Pumping test analysis conducted by the GSM shows the Transmissivity (T) and storage coefficient (S) of the Alluvium aquifer range from 84 to 163 m^2/day and $4.8x10^{-4}$ to $4.9x10^{-3}$, respectively.

3.3.3.3 Groundwater Quality

(1) Groundwater samples analysed by the GSM show that the pH of the water in the Alluvium ranges from 6.1 – 7.1. The water in the hard rock is slightly more alkaline. TWC-1 gives a pH value of 7.3 while a figure of 7.2 is recorded in the UPM well. The hard rock water is higher in bicarbonate and hence low in iron content, whereas the Alluvium water is lower in bicarbonate and accordingly higher in iron content.

Table 3.3.1 Hydrologeological information from piezometers and wells

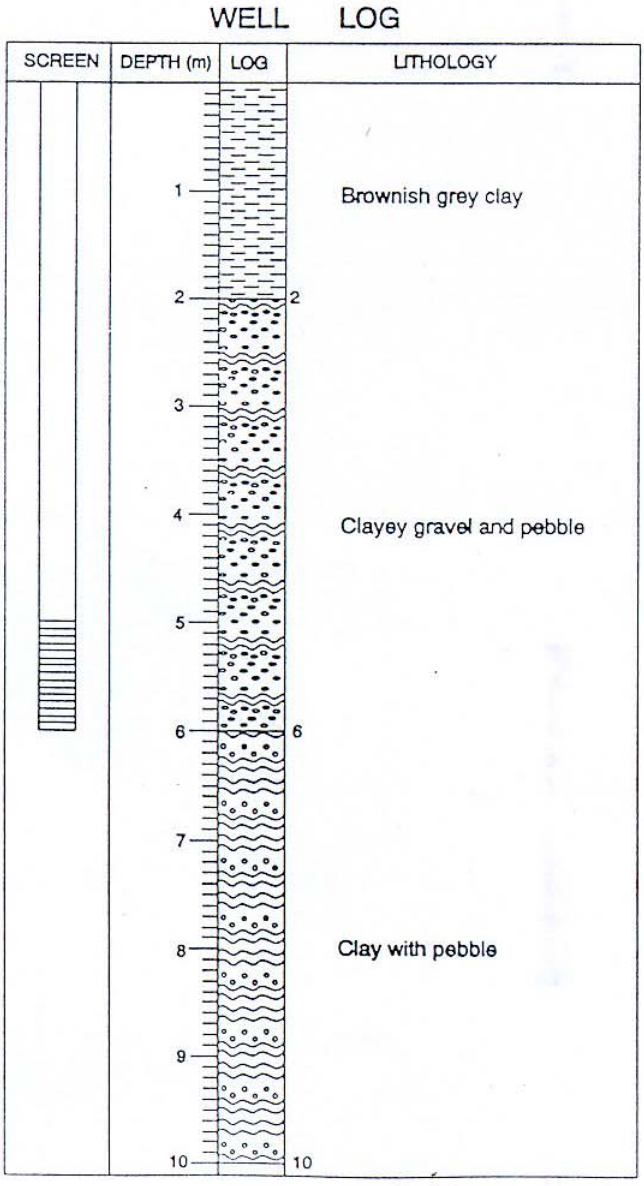
Ref.No (HPB)	Depth (m)	Alluvium thickness (m)	Water level (m). {B.G.L}*	Yield (m^3/hour)
1	6	6	0.91	0
2	6	4	2.54	7
3	12	12	1.14	0
4	6	8	0.09	11
5	7	6	0.71	3
6	7	6	1.52	11
7	6	8	1.22	0
8	6	6	0.84	7
9	6	6	1.12	1
10	6	6	0.57	5
11	6	6	0.34	6
12	6	6	0.90	0
13	6	7	6.94	0
14	6	7	3.0	0
15	6	14.3	0.70	6
16	6	9	4.80	4.8
17	6	10.5	5.5	0
18	6	19.2	3.0	4
19	6	8	3.44	0
20	6	6.5	1.14	0
21	8	12	7.17	0
22	6	18.45	0.93	1
23	6	6.5	0.45	0
24	6	12.0	0.89	4
25	6	9	1.52	10
26	3	3.02	0.32	0
27	6	9	3.0	0
TWC I	137	-	15.3	16
TWC 2	53	-	10.5	16
UPM	60	-	7.4	7

Mohd. Nazan et al 1994

Note: B.G.L: Below Ground Level

Figure 3.3.4 Geological Profile of HPB 4

No. HPB 4	Location : PERANG BESAR
Elevation : 12.21m	X= 4108 Y= 3195
Method of Drilling : Straight Flushing	
Drilling Date : 23. 4. 94	
Total Depth : 10.00m	
Comments : Piezometer diameter 40mm. Good aquifer for shallow well.	



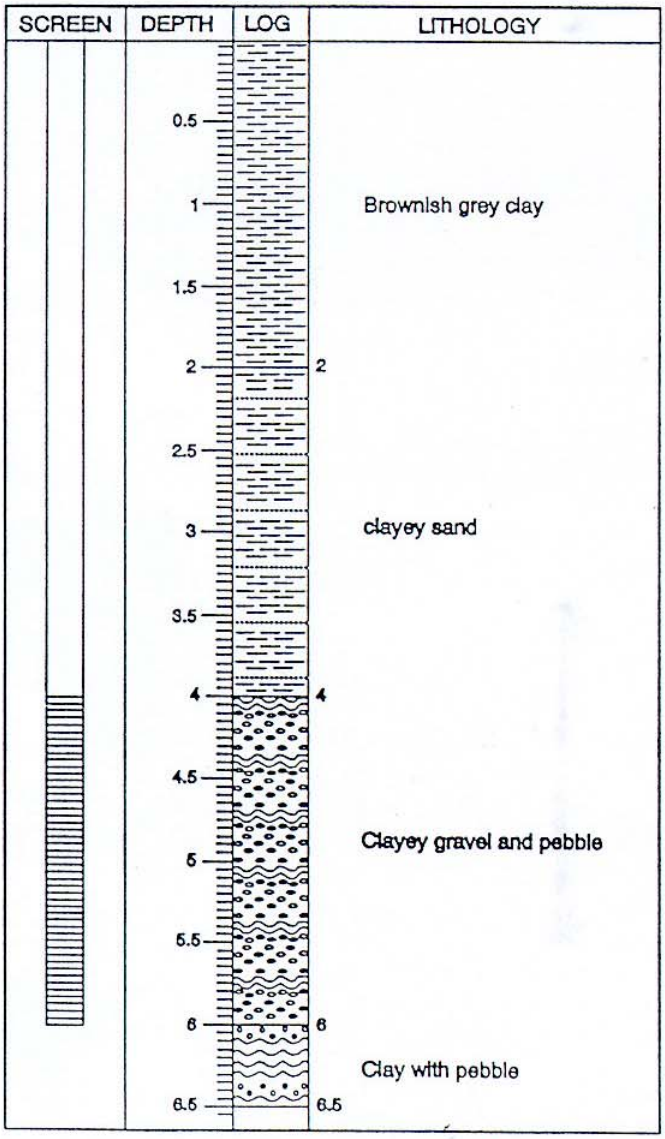
Date : 23. 4. 94
Capacity : 6.8m³/hour
Duration : 360 minutes
Transmissivity : 93m²/day
Method : Theis
Storage Coefficient : 0.00049
Static water level : 0.09m
Drawdown : 0.89m

Mohd. Nazan et al 1994

Figure 3.3.5 Geological Profile of HPB 8

No. HPB 8	Location : PERANG BESAR
Elevation : 11.32m	X = 4103 Y= 3258
Method of Drilling : Stralght Flushing	
Drilling Date : 23. 4. 94	
Total Depth : 6.50m	
Comments : Piezometer diameter 40mm. Good aquifer for shallow well.	

WELL LOG



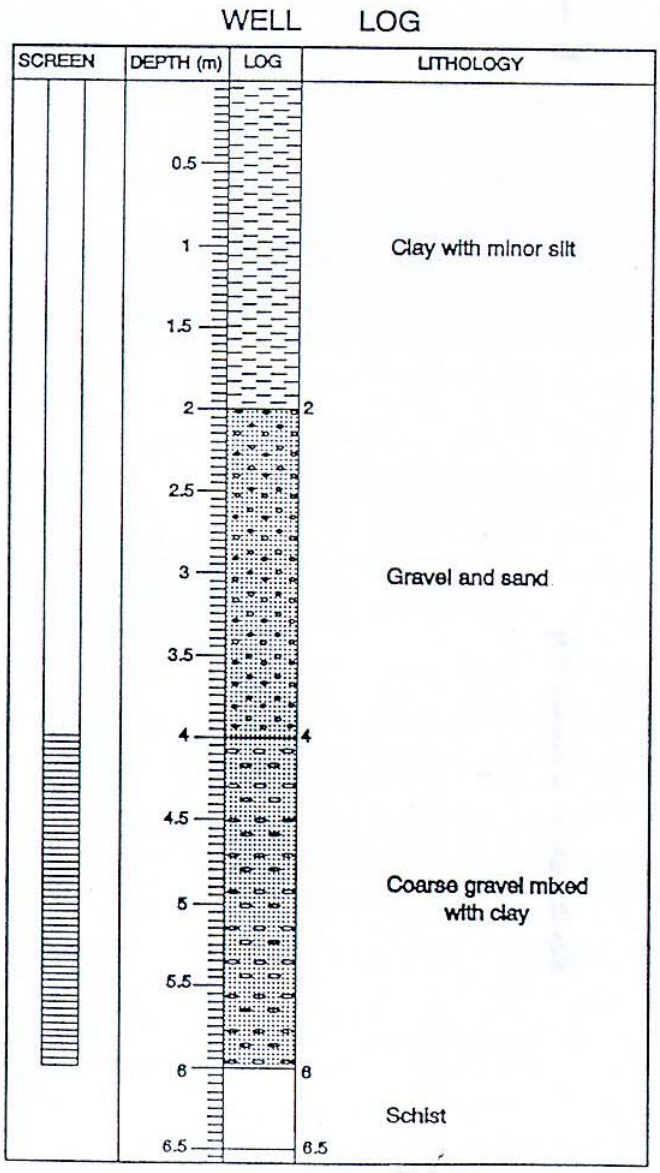
Date : 23. 4. 94
Capacity : 6.8m³/hour
Static water level : 0.84m

No pumping test

Mohd. Nazan et al 1994

Figure 3.3.6 Geological Profile of HPB 10

No. HPB 10	Location : PERANG BESAR
Elevation : 13.91m	X = 4103 Y = 3258
Method of Drilling : Straight Flushing	
Drilling Date : 23. 4. 94	
Total Depth : 6.50m	
Comments : Piezometer in alluvium overlying the Hawthornden Schist. Diameter 40mm. Yield is not good.	



Date : 25. 4. 94
Capacity : 5.5m³/hour
Duration : 300 minutes
Transmissivity : 156m²/day
Method : Theis
Storage Coefficient : 0.0005
Static water level : 0.52m
Drawdown : 0.40m

Mohd. Nazan et al 1994

(2) Nitrate, sulphate and ammonia are low in all the samples. *This suggests that the groundwater was relatively unpolluted at the time of the investigation*. It is also noted that the water samples registered only trace amounts of heavy metals.

(3) Table 3.3.2 gives the chemistry of the groundwater in area. The data in the table constitutes an important base line reference on the quality of the groundwater in the catchment.

3.3.4 Water Quantity Management Issues

Two water quantity management issues, related to the hydrogeology of the catchment, have been identified. They are:

- Groundwater recharge to the Lake
- Groundwater seepage losses from the Lake

3.3.4.1 Groundwater recharge to the Lake

(1) Other than the emergence of infiltration water to streams which subsequently discharged into the Lake, the geological and hydrogeological setting of the Sungai Chuau catchment reveals no other natural contribution of water, such as the presence of artesian water from the subsurface. However, through artificial means, using mechanical pumping, groundwater from the Alluvium aquifer can be abstracted for use as an emergency contingency during periods of prolonged drought, even though the quantity may not be very large.

(2) To avoid disturbing the hydrological regime of the Lake the location of the wells are to be located down stream to the Lake. It is proposed that a well field consisting of 6 wells designed for a total of ½ cusec (10,000g/hour) be built for the above purpose. The proposed well design is shown in Figure 3.3.7. If approved the wells are to be constructed after the dam and lake has been completed.

(3) It is anticipated that since the volume of water abstracted is small, there will be little or no implication on downstream water quantity. In addition, it is pertinent to note that this volume is less than the designed seepage of the dam (see Section 3.3.4.2 (c))

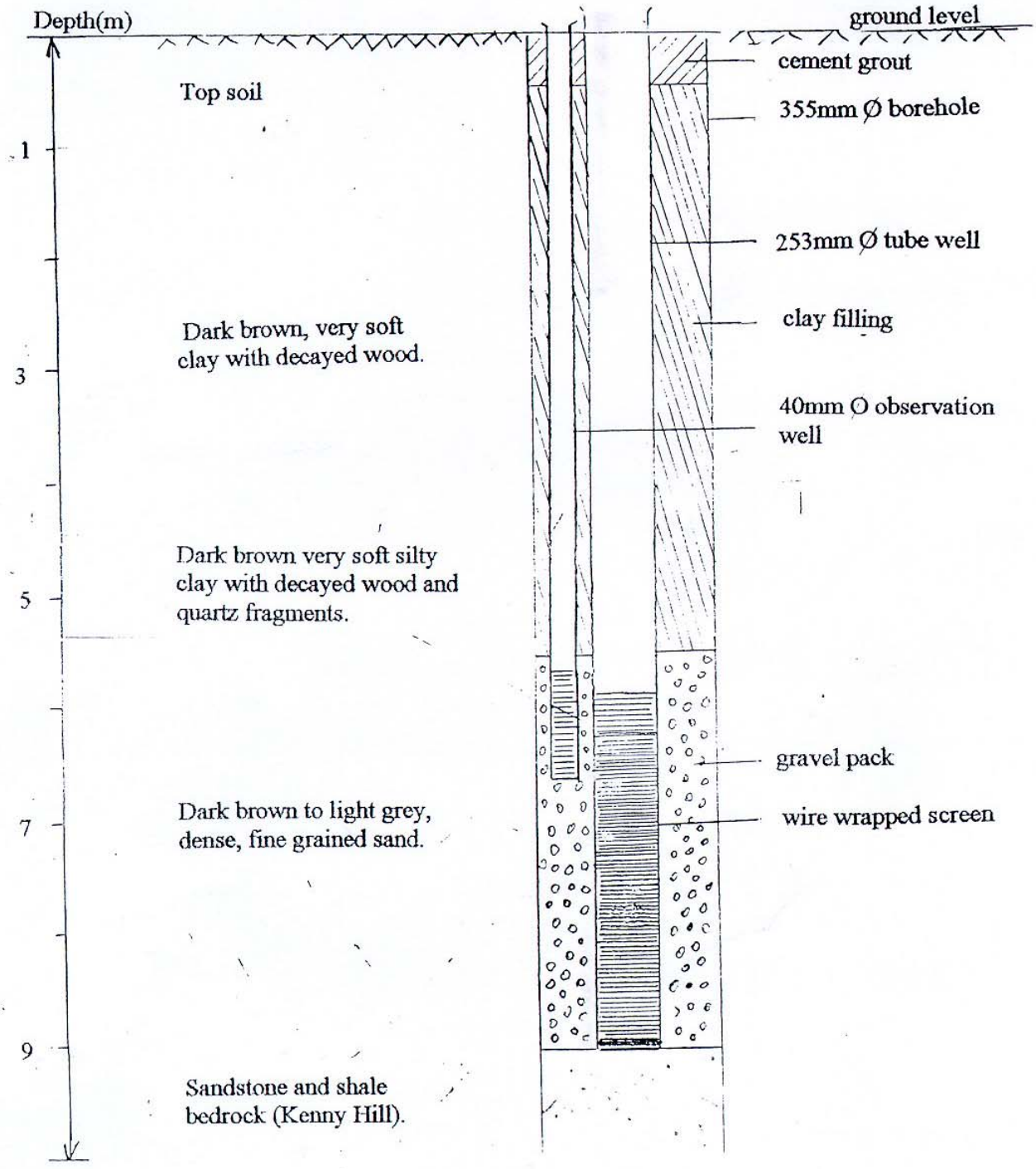
Table 3.3.2 Chemistry of Groundwater in the Sungai Chuau Basin

Sample No.		HPB 4	HPB 5	HPB 6	HPB 8	HPB 10	HPB 11	HPB 12	HPB 20	HPB 25	TWC 1	UPM	WHO (1984)
Parameter													
Ca	ppm	7.5	5.4	5.5	3.0	2.0	1.1	3.2	3.2	8.5	24	51	-
Mg	ppm	0.8	1.4	1.4	1.4	0.6	0.5	1.6	1.5	2.7	4.6	3.8	-
Na	ppm	2.0	26	24	7.6	23	25	8.4	8.2	6.4	27	6.1	200
K	ppm	0.9	2.1	1.6	1.6	1.7	1.7	1.4	1.4	0.9	2.2	2.4	-
CO3	ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
HCO3	ppm	22	79	59	37	60	62	40	37	65	166	170	-
Cl	ppm	6	7	2	2	2	2	2	1	2	2	6	200
SO4	ppm	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	5.00	400
NO3	ppm	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
NO2	ppm	<0.005	0.170	0.205	0.010	0.120	0.109	<0.005	<0.005	<0.005	<0.005	<0.005	-
NH3	ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-
NH4	ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-
F	ppm	<0.5	4.4	4.0	<0.5	4.1	4.2	<0.5	<0.5	<0.5	3.1	<0.5	-
P	ppm	0.03	0.93	0.15	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.5
As	ppm	<0.005	<0.005	0.009	0.010	0.009	0.011	<0.005	0.005	0.006	<0.005	<0.005	0.05
Al	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	-
Fe	ppm	<0.1	7.2	7.3	2.4	5.4	<0.1	10	9.9	8.8	0.8	<0.1	0.3
Mn	ppm	<0.1	0.2	0.2	0.2	0.2	<0.1	0.2	0.2	0.2	0.1	<0.1	0.1
Cu	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Pb	ppm	<0.01	<0.01	0.04	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Zn	ppm	<0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1	<0.1	-
Co	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
No	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Ni	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Cd	ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Sr	ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Ba	ppm	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Se	ppm	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-
B	ppm	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-
Cr	ppm	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	-
Hg	ppb	0.2	2.7	<0.2	<0.2	<0.2	<0.2	1.0	<0.2	1.1	<0.2	<0.2	-
pH		6.1	7.0	6.9	6.4	7.1	7.0	6.1	6.1	6.7	7.3	7.2	6.8 - 9.2
Colour	H.U.	5	5	15	5	10	5	5	5	5	10	5	5
Turb.	N.T.U.	<1	246	292	3.4	259	244	2.4	1.6	7.4	<1	214	5
Cond.	umhos/cm	63	172	115	69	120	123	69	68	107	270	250	-
SIO2	ppm	11	15	16	8.9	16	15	11	9.3	28	56	24	-
Total Solid	ppm	96	598	738	88	652	766	70	108	150	222	230	-
Diss. Solid	ppm	54	132	108	70	100	106	62	64	100	208	210	-
Hardness	ppm	22	19	20	13	7.5	4.8	15	14	32	79	143	-

[Mohd. Nazan et al 1994

Notes : Values for all parameters are in parts per million (ppm),
except for pH, turbidity in Nephelometric Colour Units (N.T.U.),
colour in Hazen Unit (H.U.), conductivity in umhos/cm and
Hg in parts per billion (ppb)
Turb. = Turbidity.
Cond. = Conductivity.
Diss. = Dissolved.

Figure 3.3.7 Proposed Well Design



3.3.4.2 Groundwater seepage losses from the Lake

The geological and hydrogeological setting of the basin presents three possible situations for water seepage losses. They are:

- Losses through the hard rock
- Losses through the peat layers
- Losses through the Alluvium aquifer

(1) Losses through the hard rock

Although the catchment is resting on top of an anticline and is criss-crossed by 3 sets of fracture lineaments, water loss through the bedrock is not expected to be large. This is because the primary porosity and permeability of the metamorphosed Hawthornden schist and the Kenny Hill are low and water movement is confined along joints and fractured zones. Evaluation of wells constructed in these zones indicated that these joints and fracture systems are localised and lack regional connection.

In addition, the residual soil developed over the Hawthornden Schist and the Kenny Hill are 3 to 8m and 5 to 10m in thickness, respectively.

The soil are described as:

Hawthornden Schist: Yellowish red to red sandy to silty clay with subordinate amount of fine lateritic gravels. Consistency varies from soft to stiff.

Kenny Hill: Yellowish brown to red soft to stiff clayey silt/sand with subordinate amounts of lateritic sand, gravel and iron concretions.

The estimated coefficient of permeability of the residual soil is 10^{-8} m/sec and thus movement of groundwater through the above soils is low.

(2) Losses through the peat layers

Within the catchment, peat is found only in the Alluvium and is located on lower grounds. In the area occupied by Cyberjaya, the peat layers outside the catchment are not connected with the peat inside the catchment. Thus, there is no hydraulic

conductivity between them. No groundwater is expected to flow out of the catchment at the South-Eastern edge.

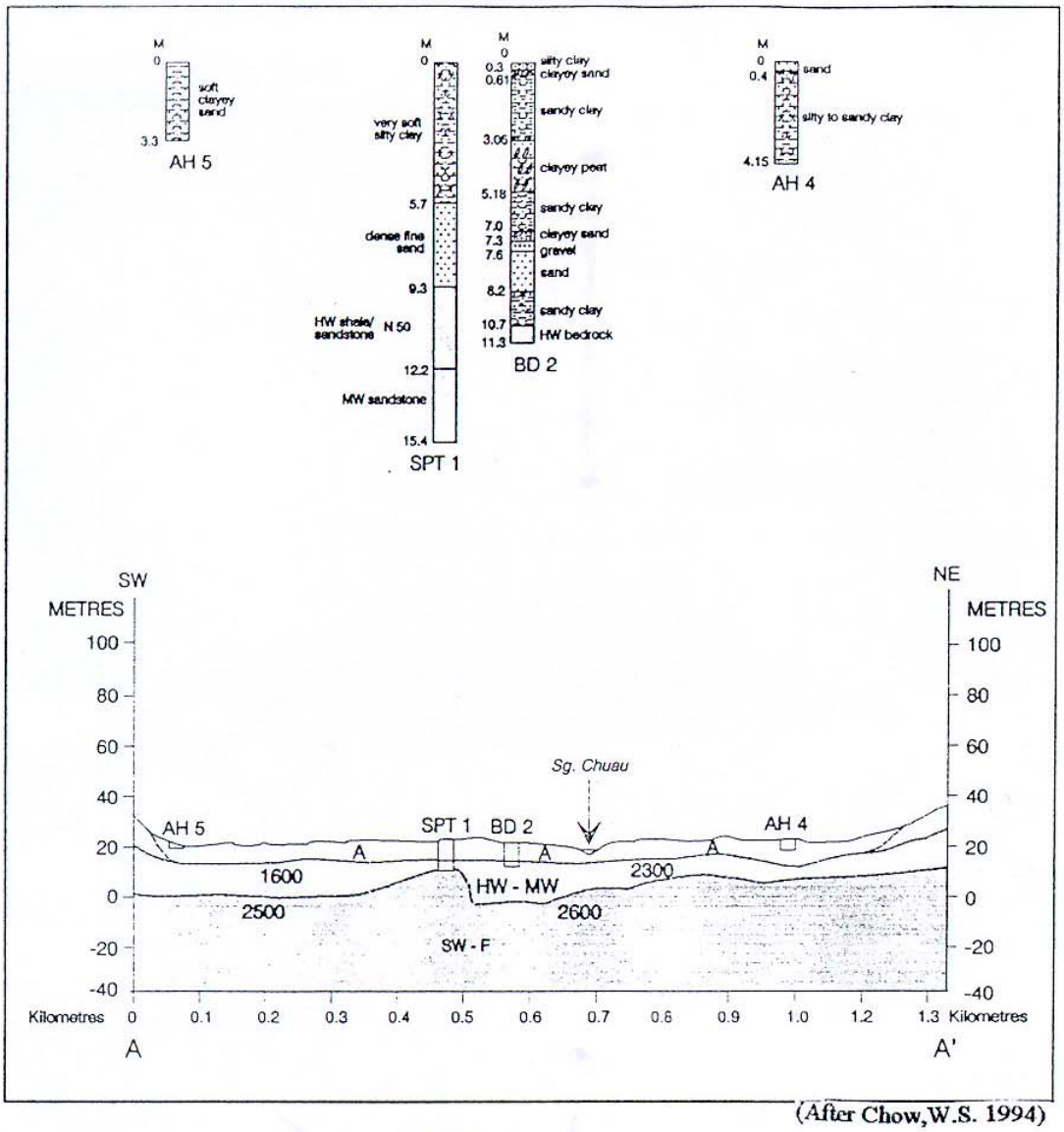
However, peat is found in the Alluvium in the proposed site of the main dam in the South and it is anticipated that water in the Lake can be lost there through the peat layers. Angkasa GHD Engineers Sdn. Bhd., the consultant for the design and construction of the dam has taken cognisance of the situation and it is noted in their report that in the construction of the dam all clay and peat layers are to be removed.

(3) Losses through the Alluvium aquifer

The nature of the alluvium at the lower reaches of Sungai Chuau is illustrated in the geological cross section (Figure 3.3.8) across the proposed dam site. Bore log SPT1 shows an upper most sequence of silty to sandy clay with decayed wood of about 5.7m thick. Beneath the clay is a 3.3m aquifer layer of fine-grained sand. The borehole bottomed on sandstone with interbeds of shale of the Kenny Hill Formation. Water loss through the alluvium aquifer may be an issue here. Angkasa GHD Engineer Sdn. Bhd. has taken note of this and has stated in their report that all sandy and pervious foundation materials are to be removed. The dam is to be embedded 1000mm into the residual soil (grade-4 rock material) with a designed seepage of not more than 100m^3 per day through the dam and its foundation.

The Alluvium at the locality where the flow of the upper reaches of Sungai Limau Manis is diverted towards the Putrajaya area comprises 2m of sandy clay. No distinct aquifer is present. As such water loss through the Alluvium here may not be significant.

Figure 3.3.8 Geological Cross-section at Proposed Main Dam site



(After Chow, W.S. 1994)

LEGEND

Clay	AH	-	Auger hole
Silt	BD	-	Banka drillhole
Peat	SPT	-	Standard Penetration test-hole
Sand	A	-	Alluvium
Gravel	RS - CW	-	Residual soil-completely weathered
Bedrock	HW - MW	-	Highly to moderately weathered
	SW - F	-	Slightly weathered to fresh bedrock
	2000	-	Projected seismic velocity in metres per second

3.4 REFERENCES

1. Abdullah Sani, H. (unpublished), *Geologi dan Sumber Mineral Kawasan Sepang-Telok Datok, Selangor*, Geological Survey Department.

2. Angkasa GHD Engineers Sdn. Bhd. (1999) *Kerja-Kerja Pembinaan Empangan Utama Fasa 1B Pusat Pentadbiran Kerajaan Persekutaan, Putrajaya.*

3. Charng Ning Chen, "Methodology For Erosion Control in Urbanizing Watershed"

4. Chow, W.S. (1994), *Geotechical investigation of the proposed Pusat Pentadbiran Persekutuan Perang Besar Report No. 2*, Geological Survey Department.

5. Jabatan Alam Sekitar "Guidelines for Prevention and Control of Soil Erosion and Siltation in Malaysia", October, 1996.

6. KTA Tenaga Sendirian Berhad "Putrajaya Environmental Management Guide" November, 1998

7. Mohd. Nazan, A., et al. (1994), *Hydrogeological investigation of the proposed Pusat Pentadbiran Persekutuan Perang Besar Sectoral Report No.3*, Geological Survey Department.

8. Department of Irrigation and Drainage, Malaysia, "Erosion and Sediment Study for Sungai Kurau, Perak Darul Ridzwan" December, 1997

9. Roslan Zainal Abidin, Tew Kia Hui, "Soil Erosion Study at Jalan Indah 1/1, Taman Universiti Endah, Seri Kembangan, Selangor Darul Ehsan". December, 1997.

10. Steven J. Goldman, Katherine Jackson, T.A Burswtynsky "Erosion & Sediment Control Handbook" McGraw-Hill. 1986.

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.

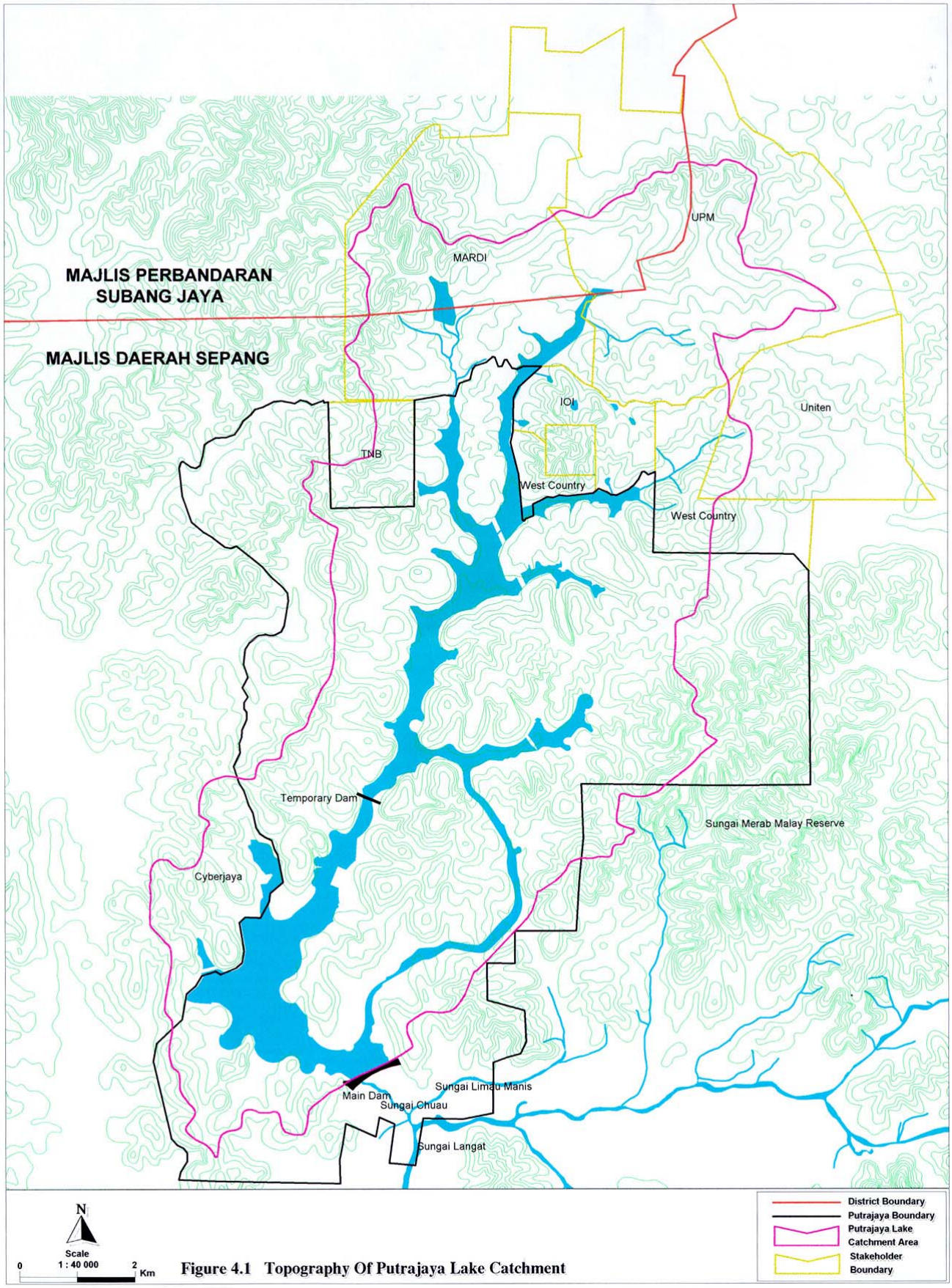


Figure 4.1 Topography Of Putrajaya Lake Catchment

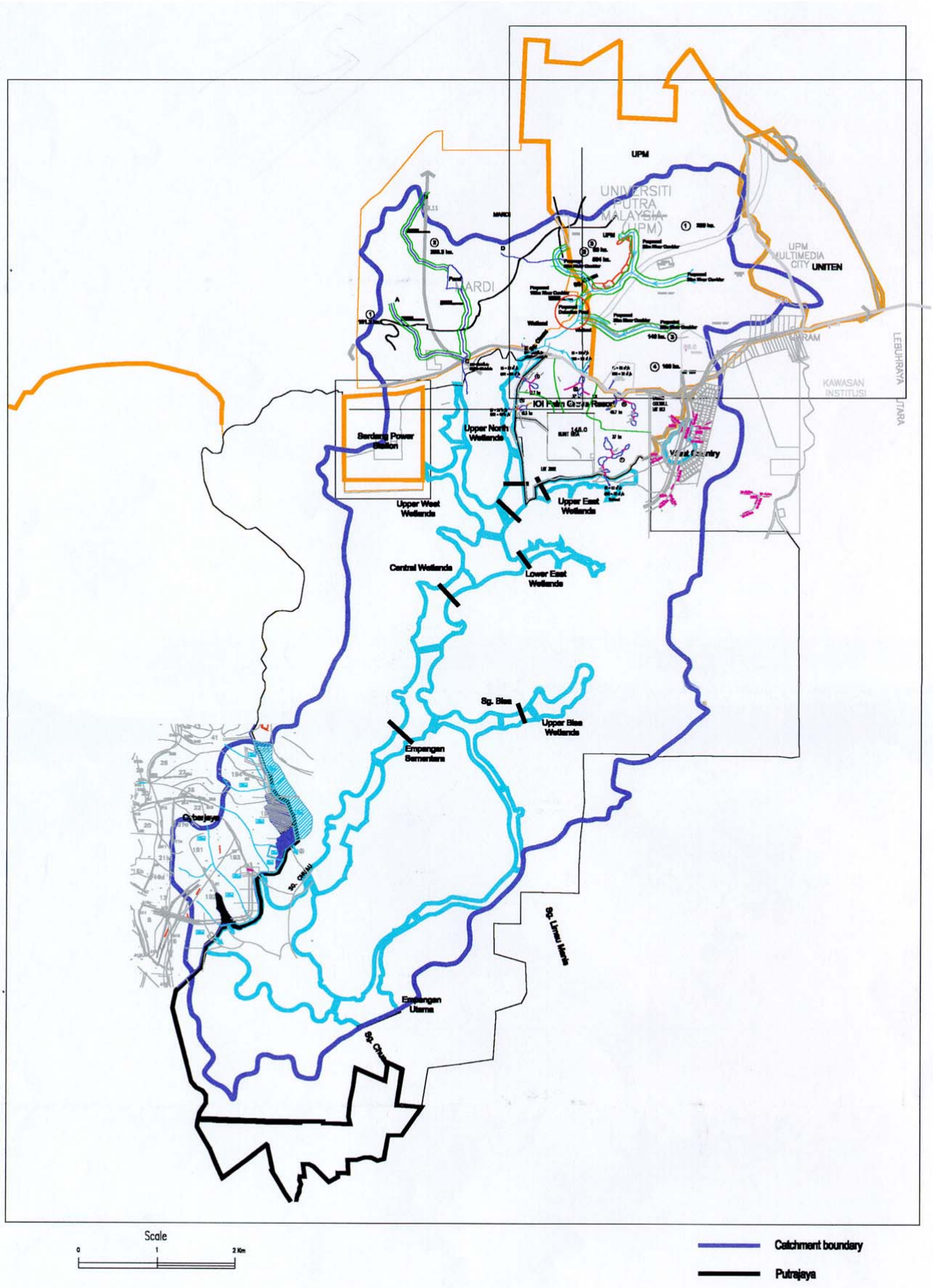


Figure 4.2 Drainage Systems for Areas Outside Putrajaya

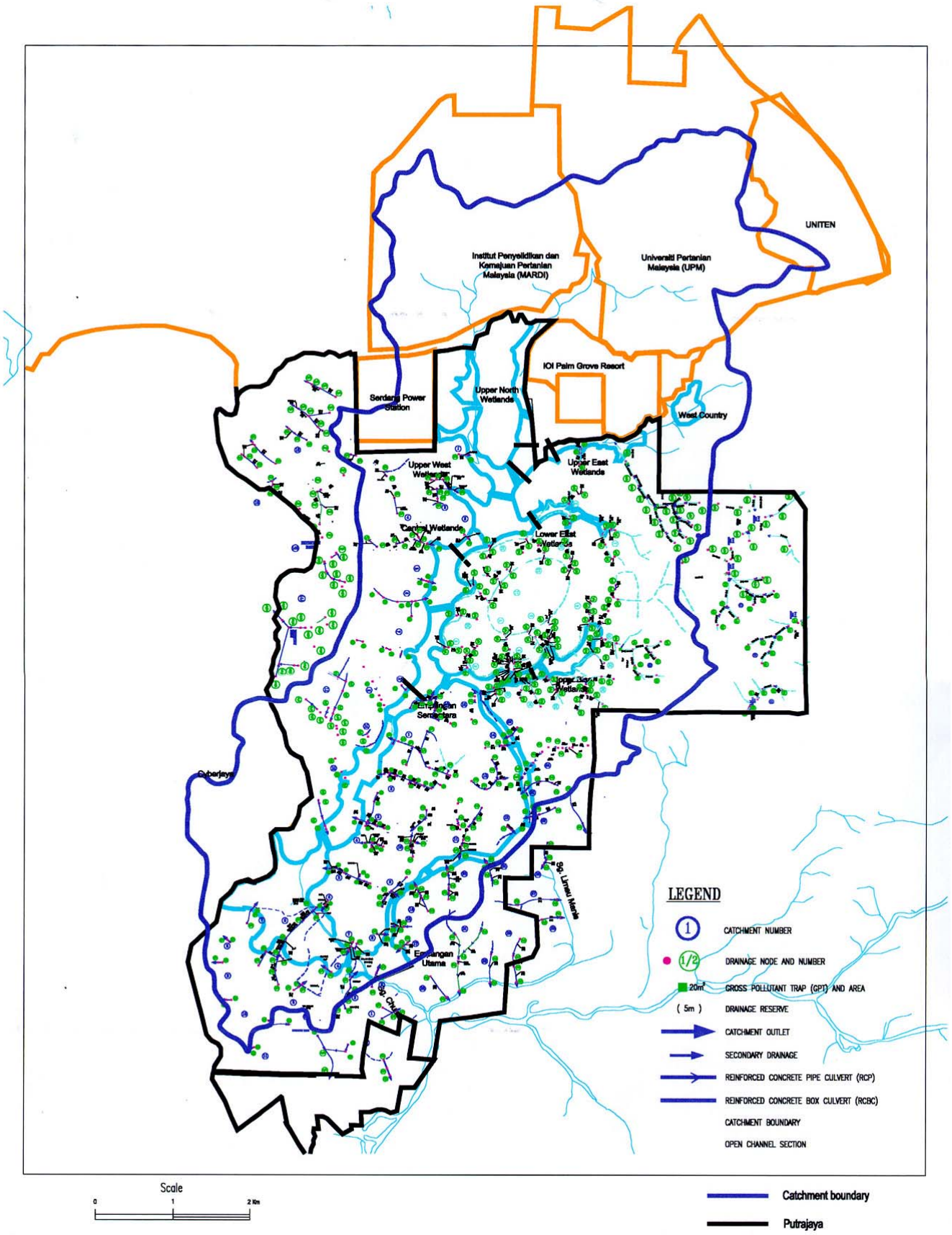


Figure 4.3 Drainage System for Putrajaya

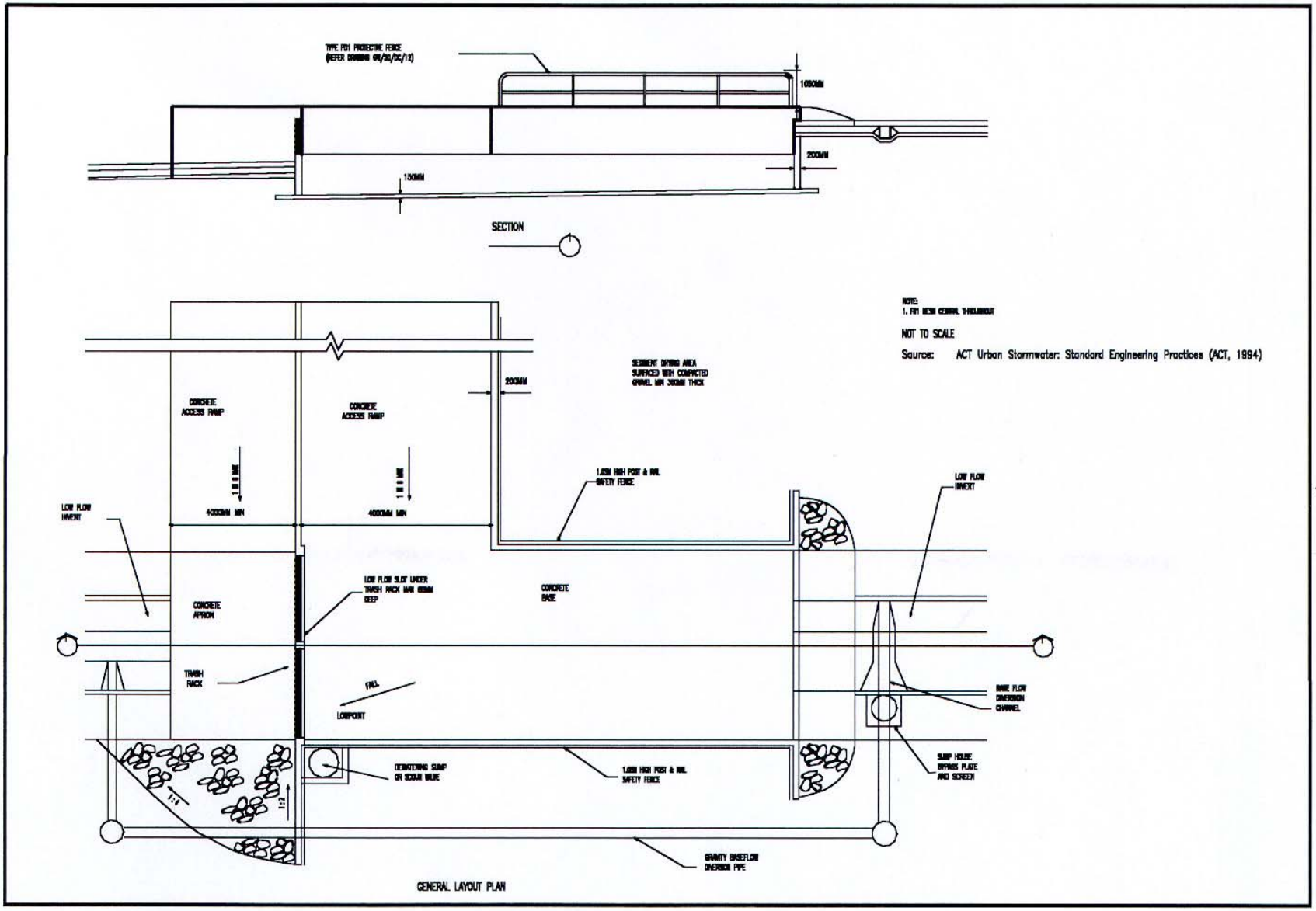


Figure 4.4 Standard Drawing of Major GPT (ST-033)

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)	Hydrauli cRadius (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)

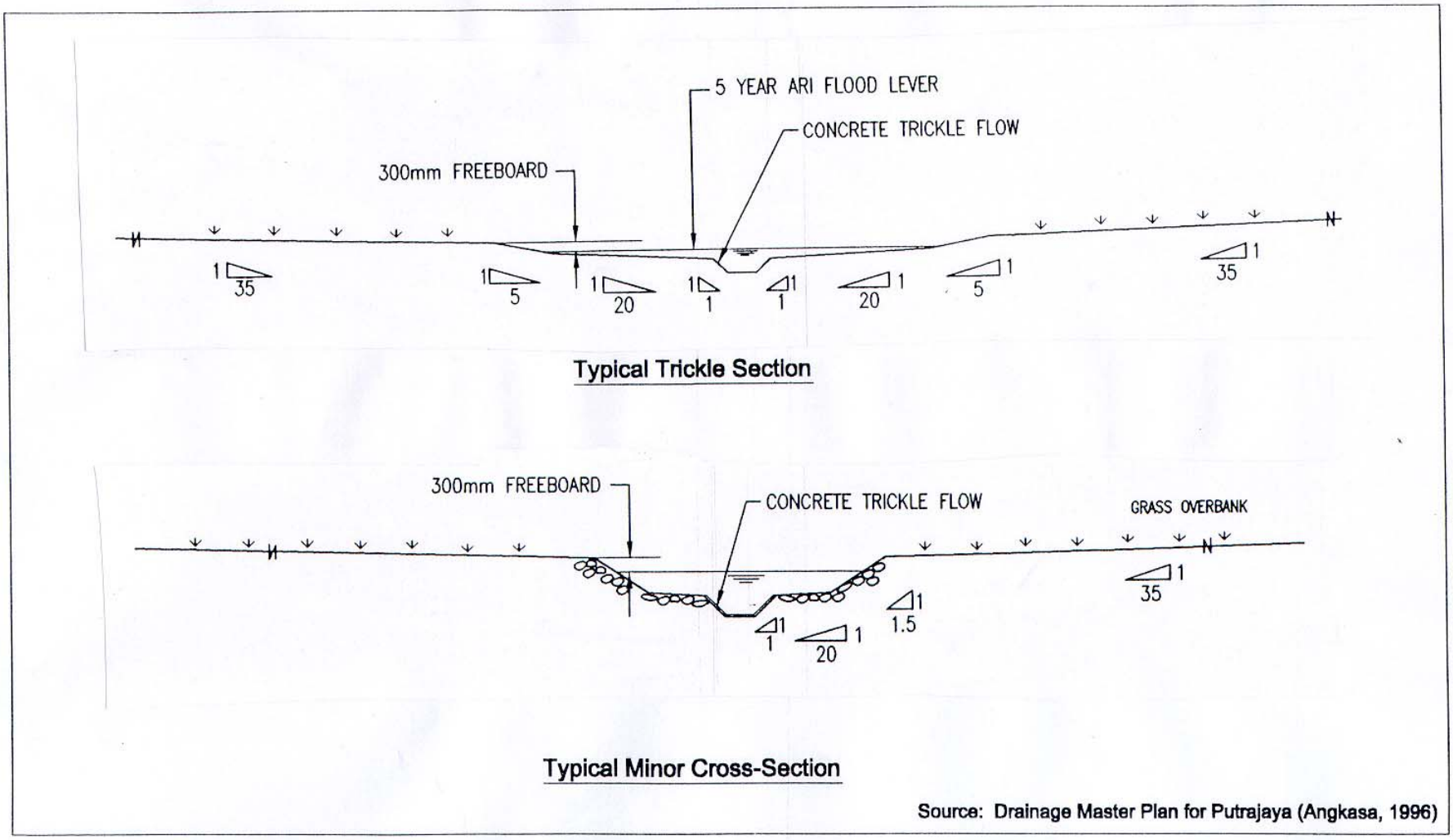


Figure 4-5 Typical Drain Types and Dimensions for Putrajaya

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	Runoff Coeff.	Equiv. Area	Overland time	Drain time	Sub-Area TOC	Design Return Period	Total Equiv. Area	Critical Time of Concn.	Total Time in Drain	Storage Coeff.	Rainfall Intensity	Disch. Q= 0.00278*	Design Return Period	Rainfal Intensity	Discharge Q= 0.00278*	Velocity	Length	Time of Flow in Section
		(A) Ha	(C)	(C*A) Ha	Min	Min	Min	Years	(C*A) Ha	(tc) Min	(td) Min	(Cs)	(i) mm/hr	(C*A)*i*Cs Cumec	Years	(i) mm/hr	(C*A)*i*Cs Cumec	m/s	m	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

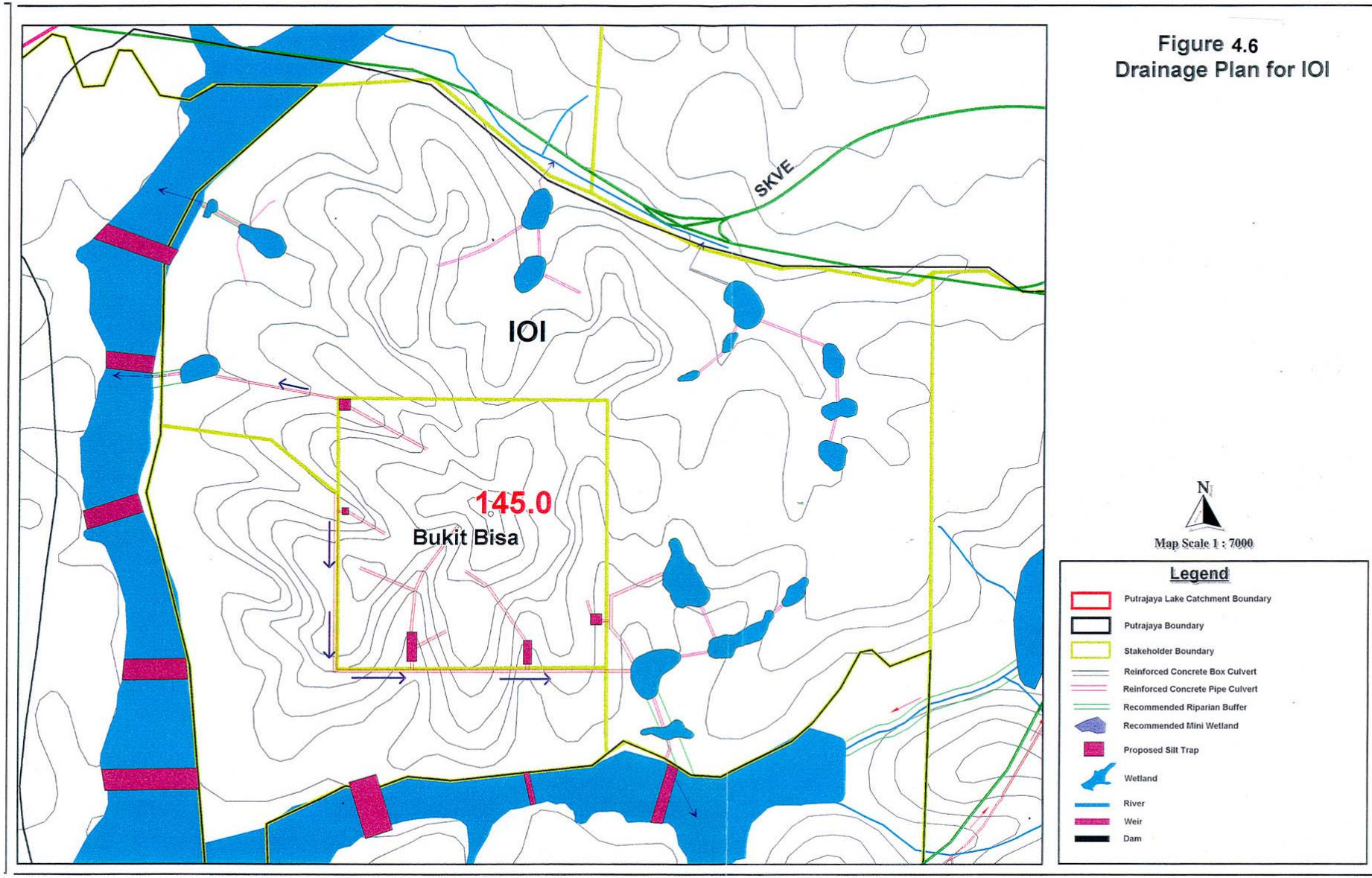


Figure 4.6
Drainage Plan for IOI

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	Runoff Coeff.	Equiv.Area	Overland time	Drain time	Sun- Area TOC	Design Return Period	Total Equiv. Area	Critical Time of Conc.	Total Time in Drain	Storage Coeff.	Rainfall Intensity	Disch. Q= 0.00278* (C*A)*i*Cs	Design Return Period	Rainfall Intensity	Discharge Q= 0.00278* (C*A)*i*Cs	Velocity	Length	Time of Flow in Section
		(A) Ha	(C)	(C*A) Ha	Min	Min	Min	Years	(C*A) Ha	(tc) Min	(td) Min	(Cs)	(i) mm/hr	Cumec	Years	(i) mm/hr	Cumec	m/s	m	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.

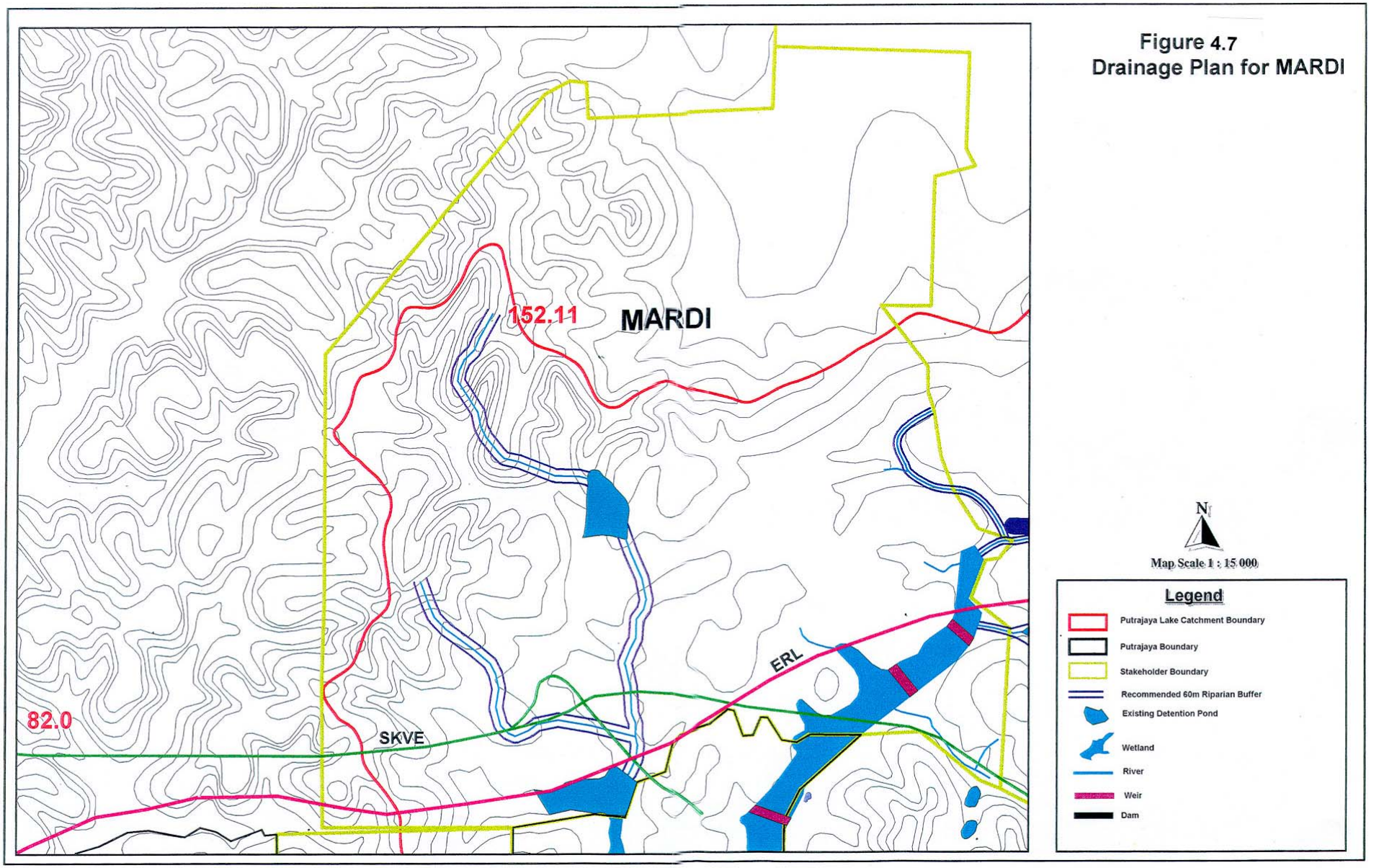


Figure 4.7
Drainage Plan for MARDI

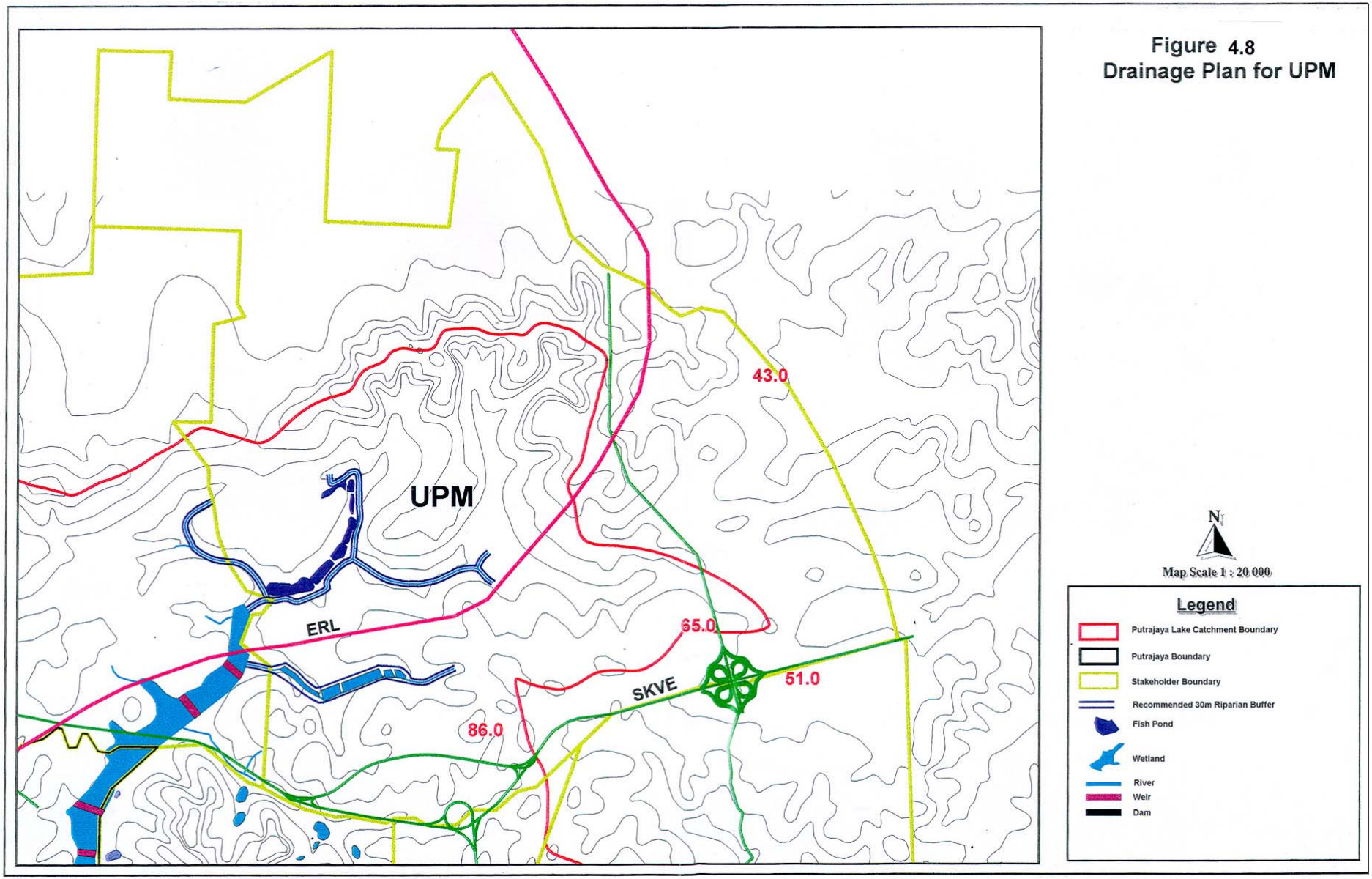


Figure 4.8
Drainage Plan for UPM

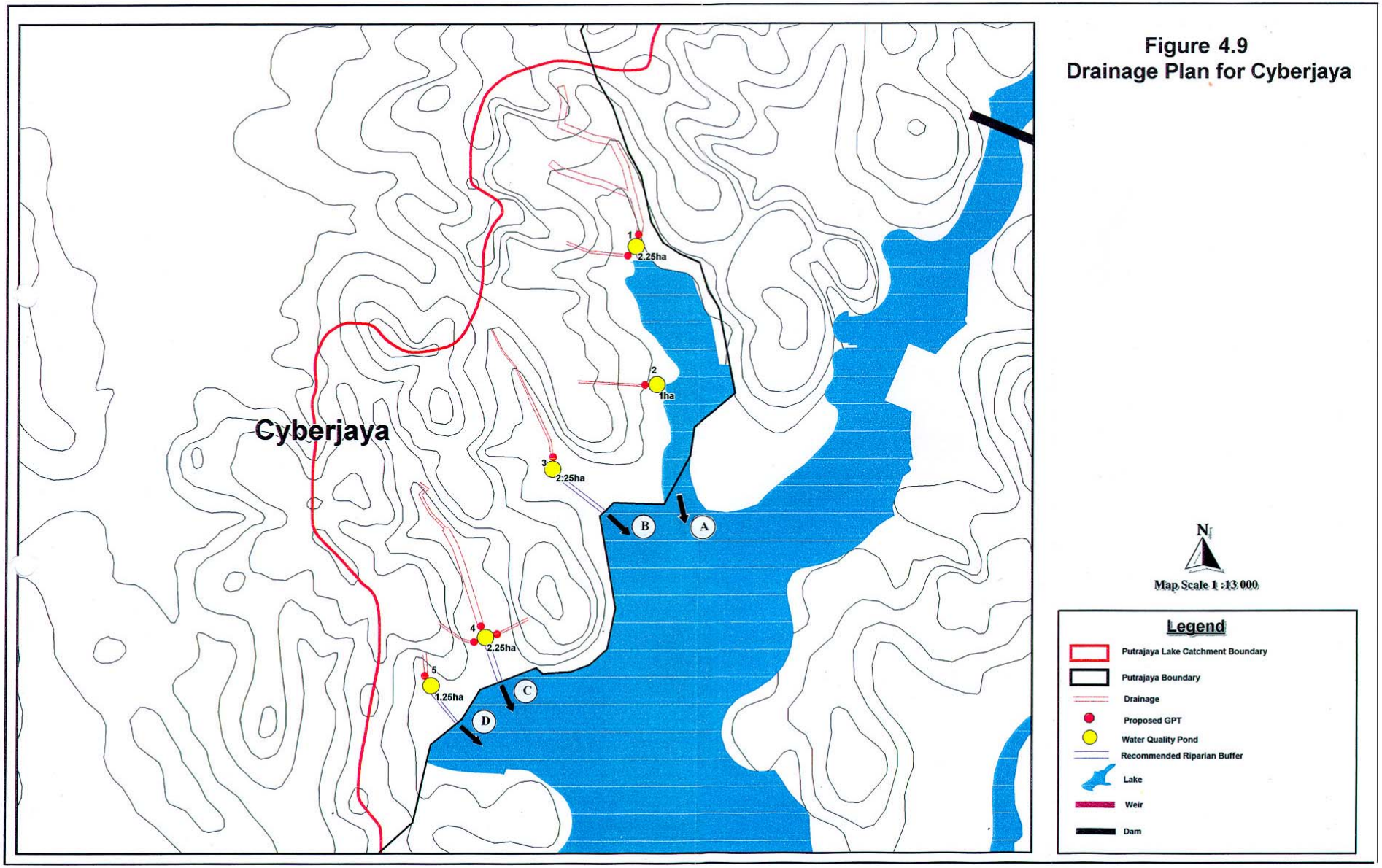


Figure 4.9
Drainage Plan for Cyberjaya

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."

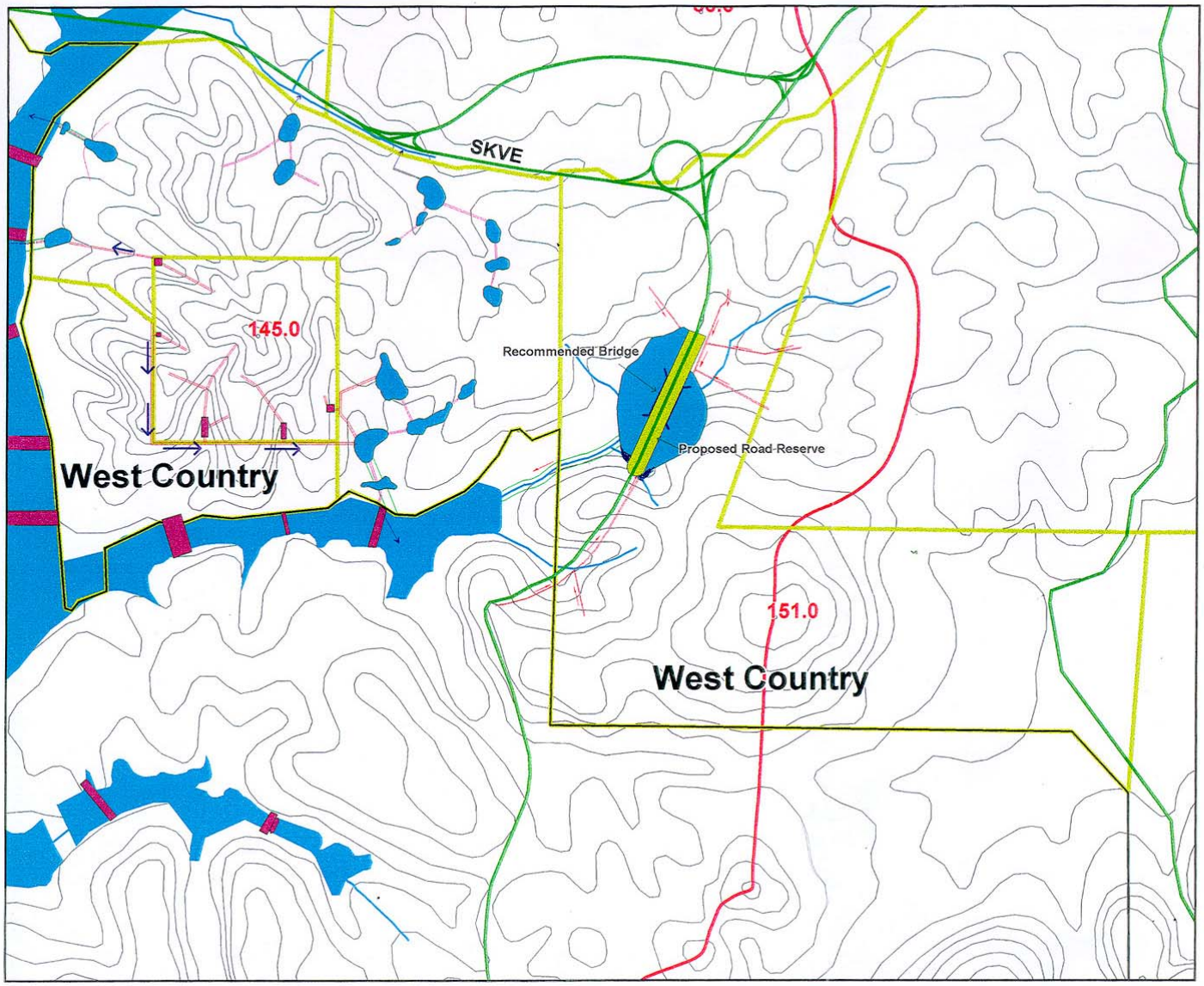


Figure 4.10
Drainage Plan for West Country

N

Map Scale 1 :13 000

Legend

- Putrajaya Lake Catchment Boundary
- Putrajaya Boundary
- Stakeholder Boundary
- Recommended Riparian Buffer
- Proposed Silt Trap
- Wetland
- River
- Weir
- Dam

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;

$$Q = C_s CiA$$

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

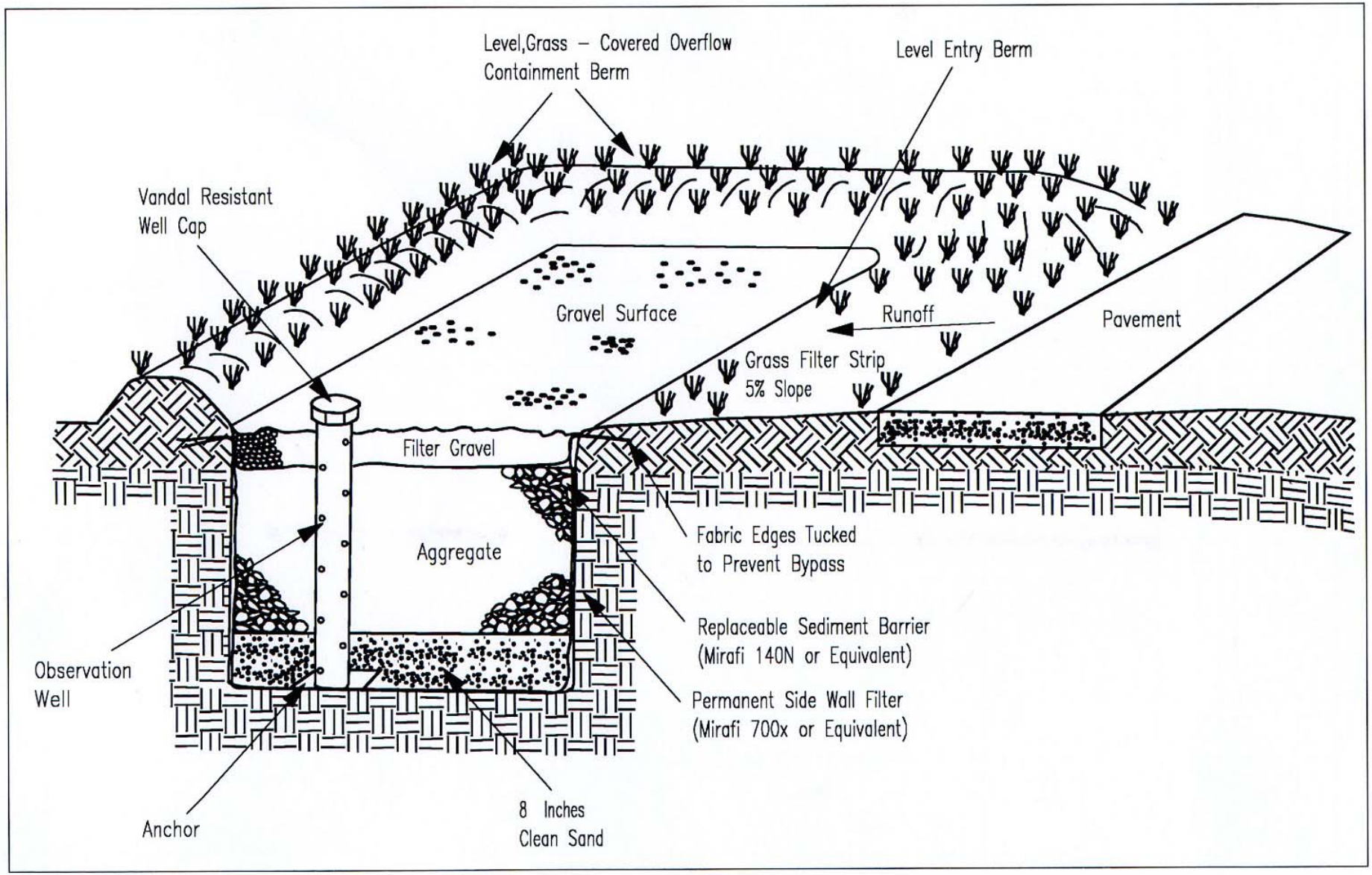


Figure 4.11 Typical infiltration trench.
(Source: Engineers & Surveyors Institute and Northern Virginia District Planning District Commision)

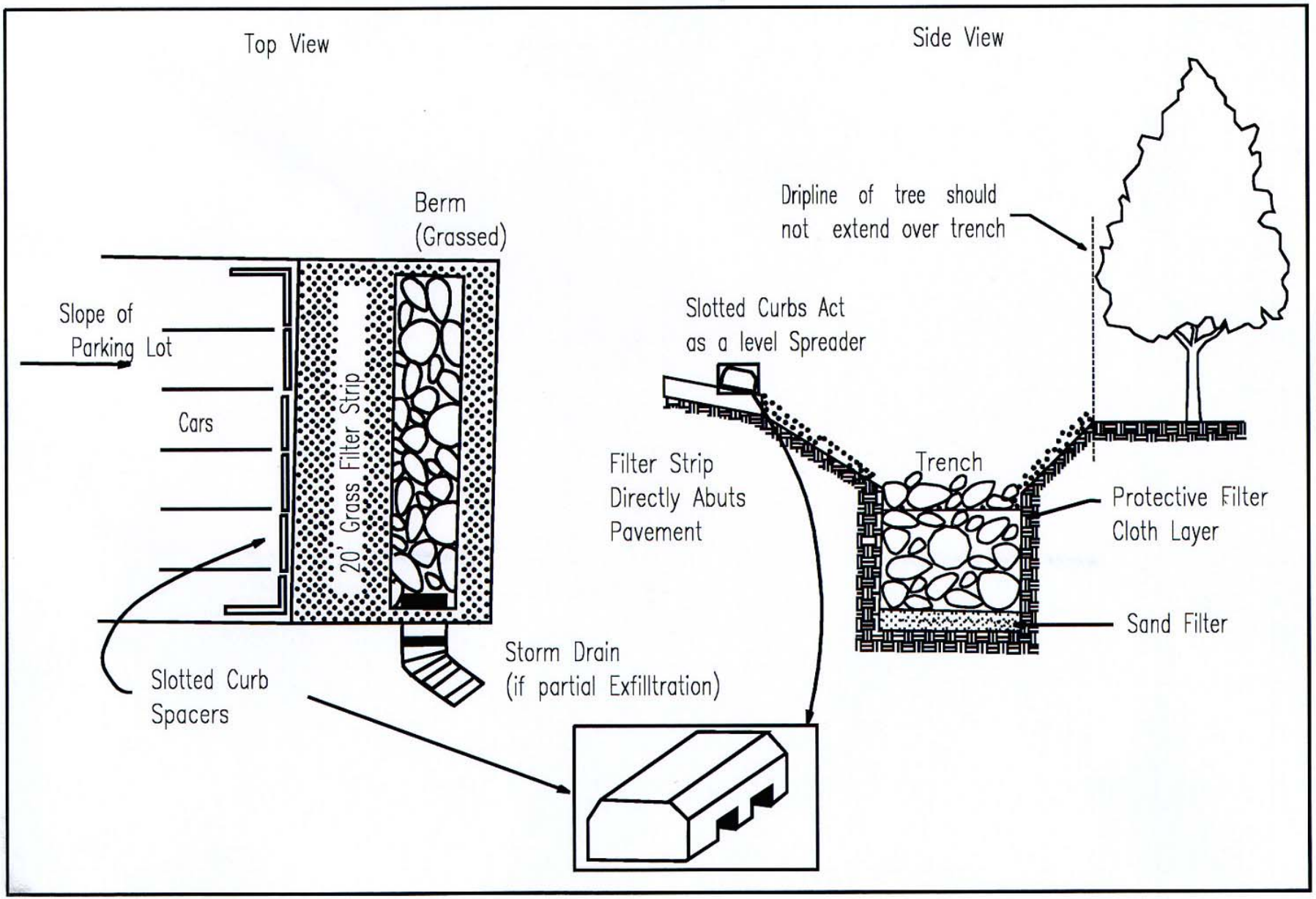
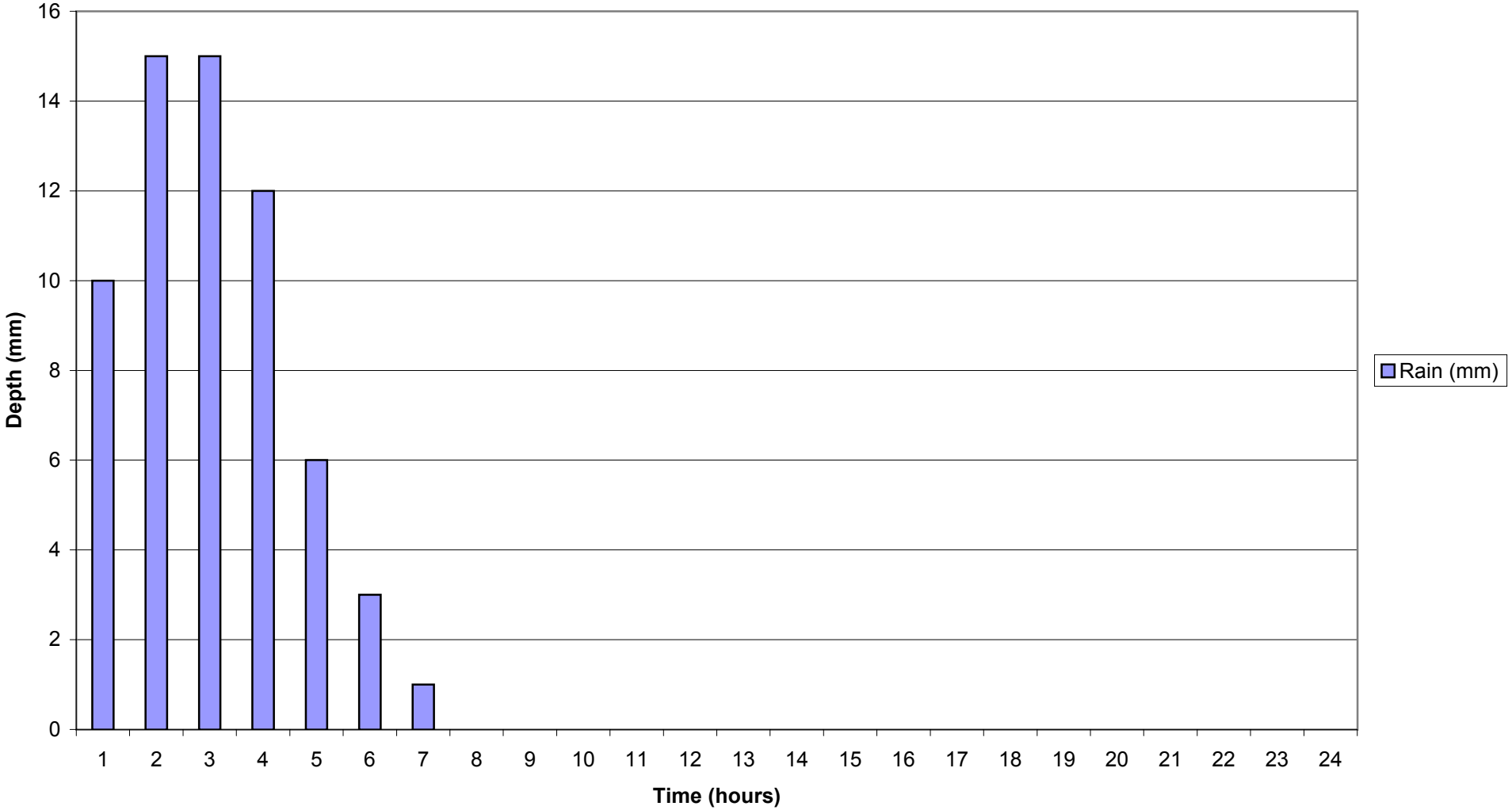


Figure 4.12 **Parking lot perimeter trench. (Source: Schuler, 1987)**

Figure 4.13 Rainfall Distribution



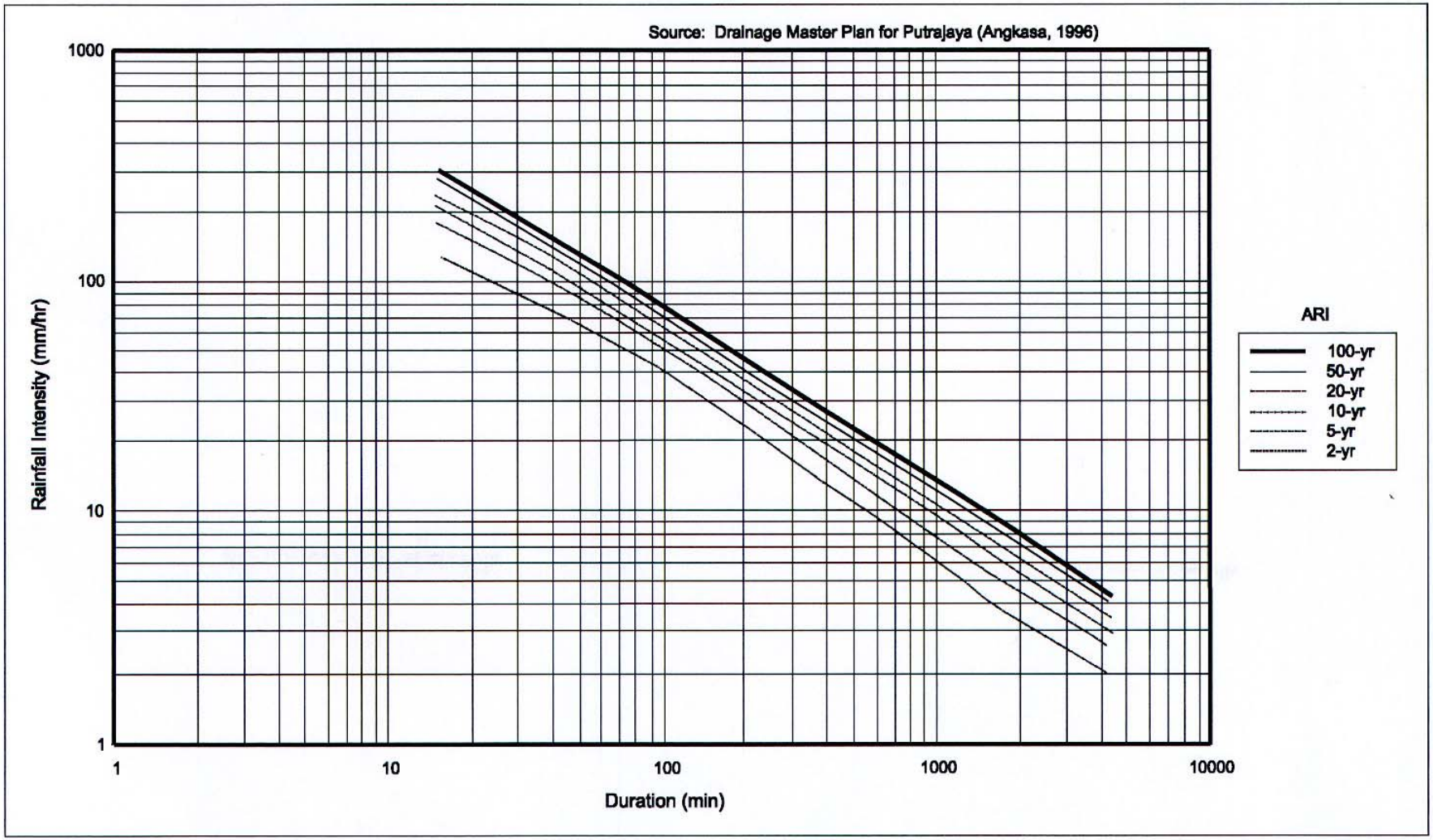


Figure 4.14 Design Rainfall IDF Curves for Putrajaya

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

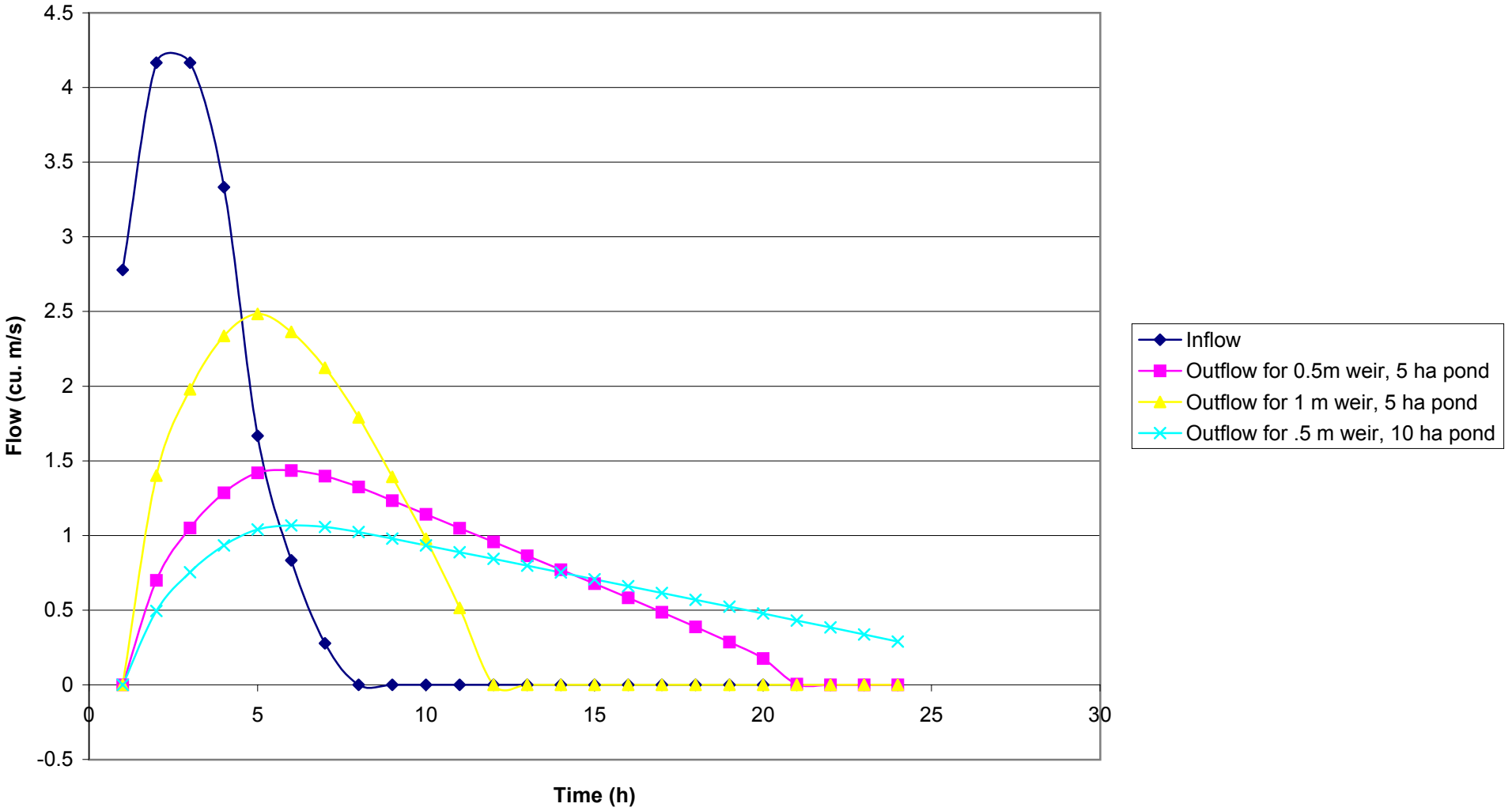
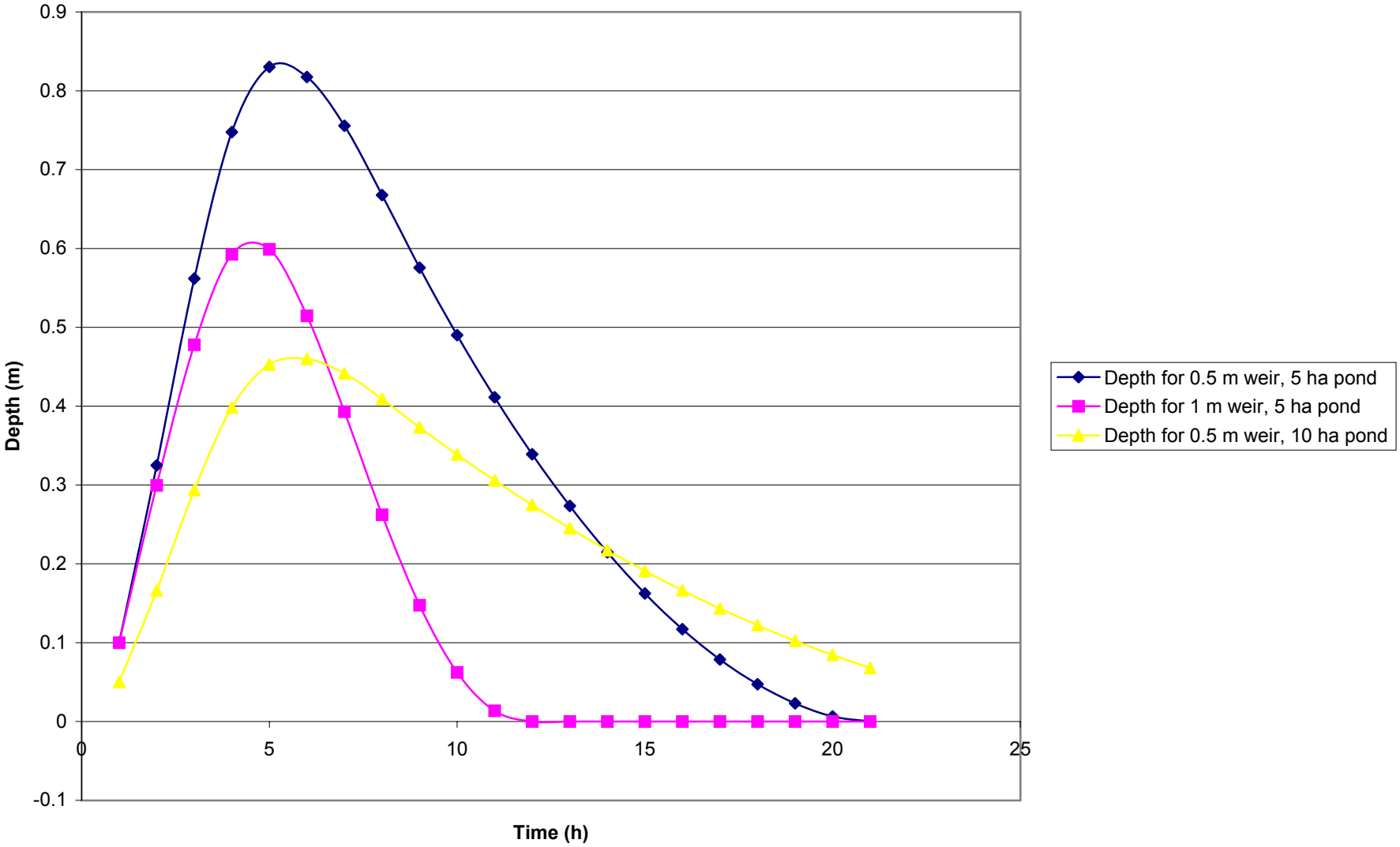


Figure 4.16 **Depth of water in pond**



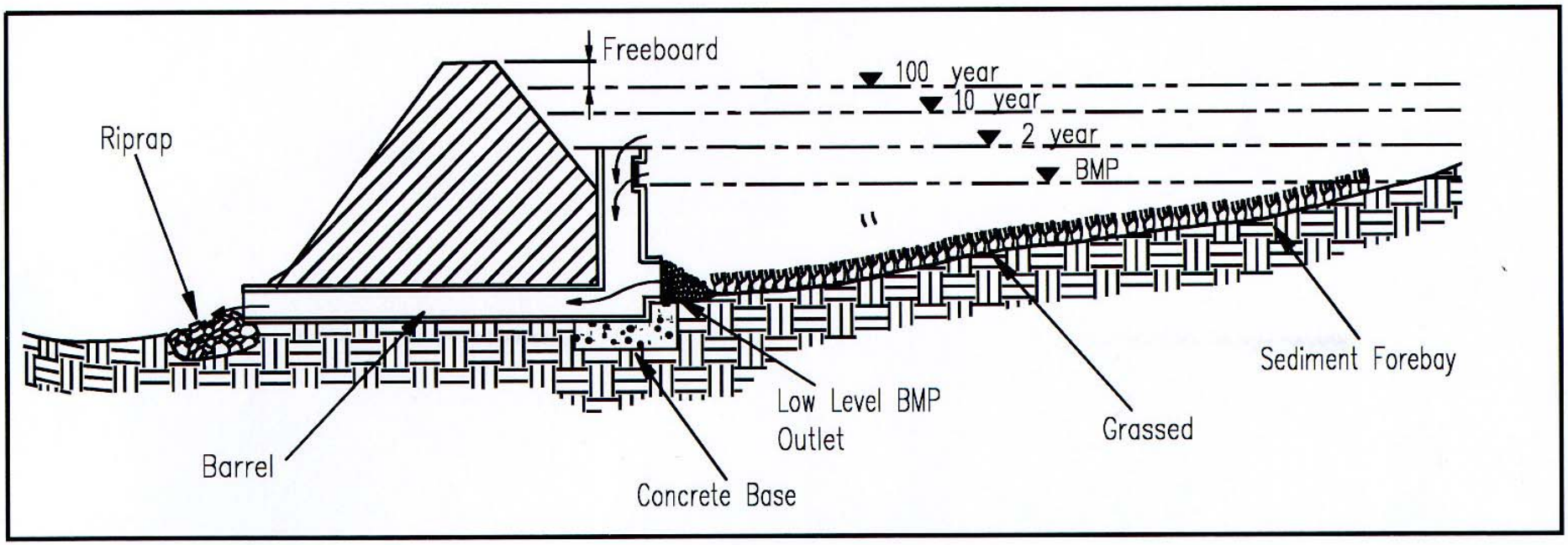


Figure 4.17 Typical Extended Detention (ED) pond.
(Source: Engineers & Surveyors Institute and Northern Virginia District Planning District Commision)

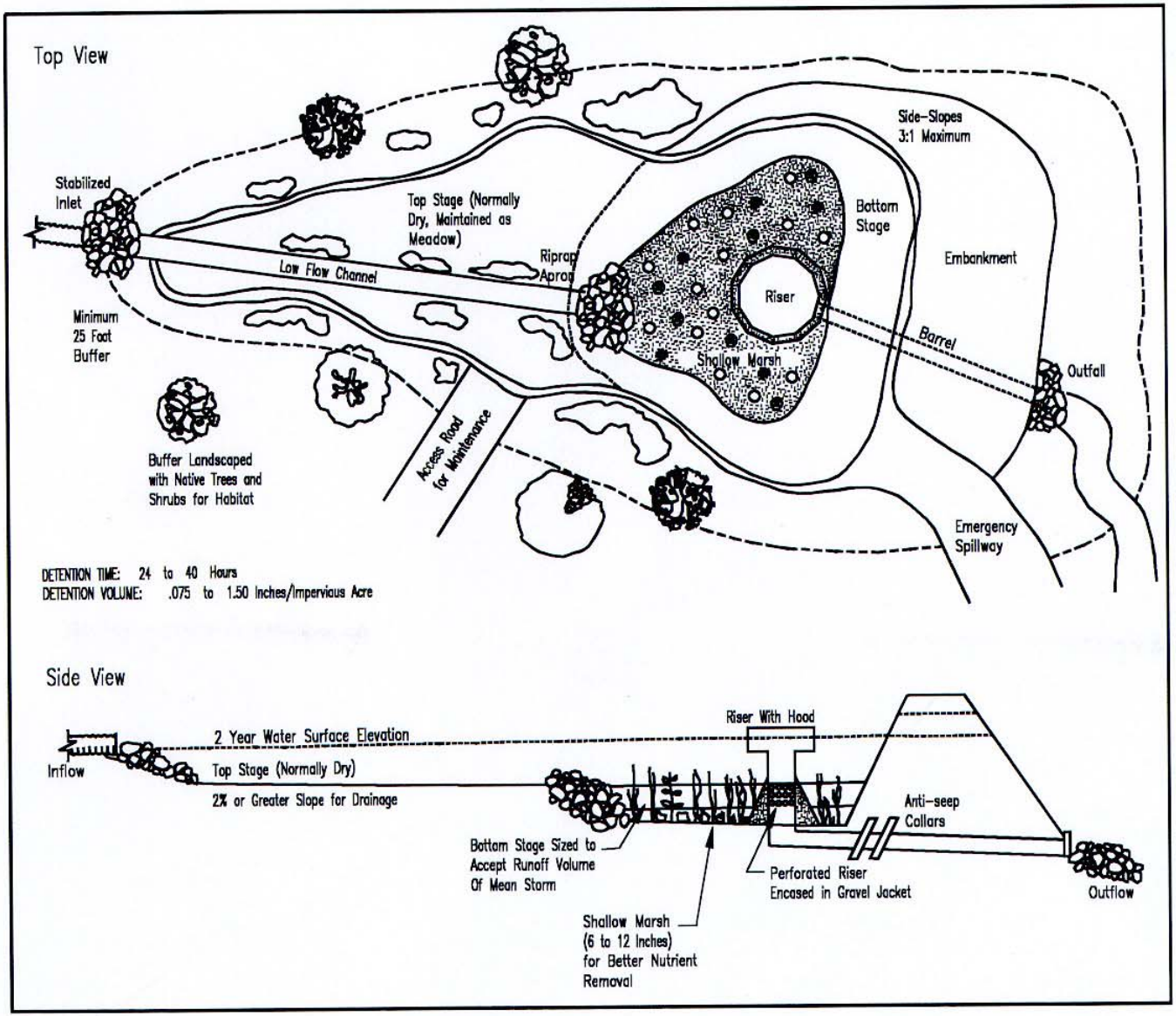


Figure 4.18 Schematic of ED pond design features. (Source: Schueler, 1987)

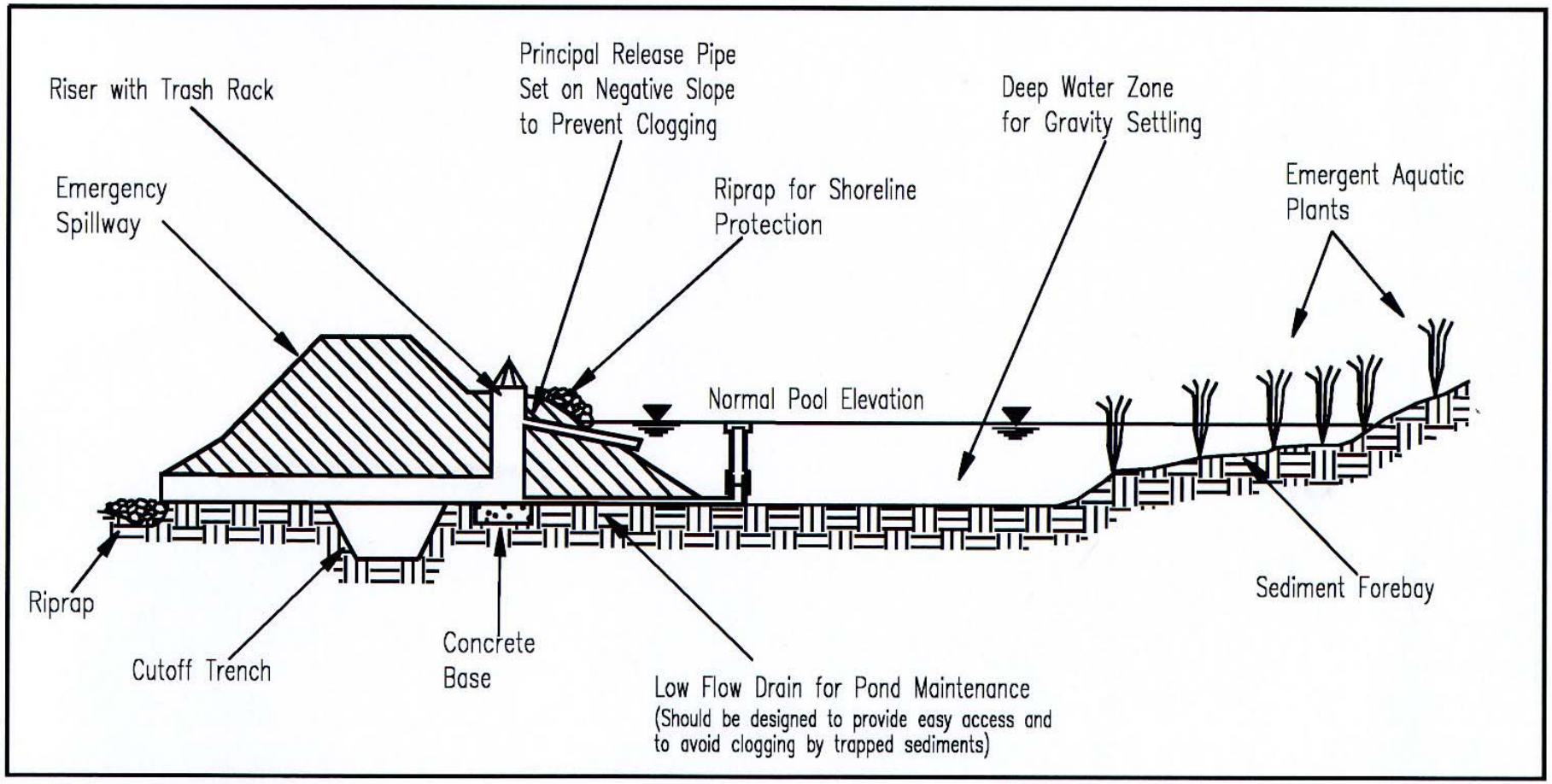


Figure 4.19 Typical wet pond profile.
(Source: Engineers & Surveyors Institute and Northern Virginia District Planning District Commision)

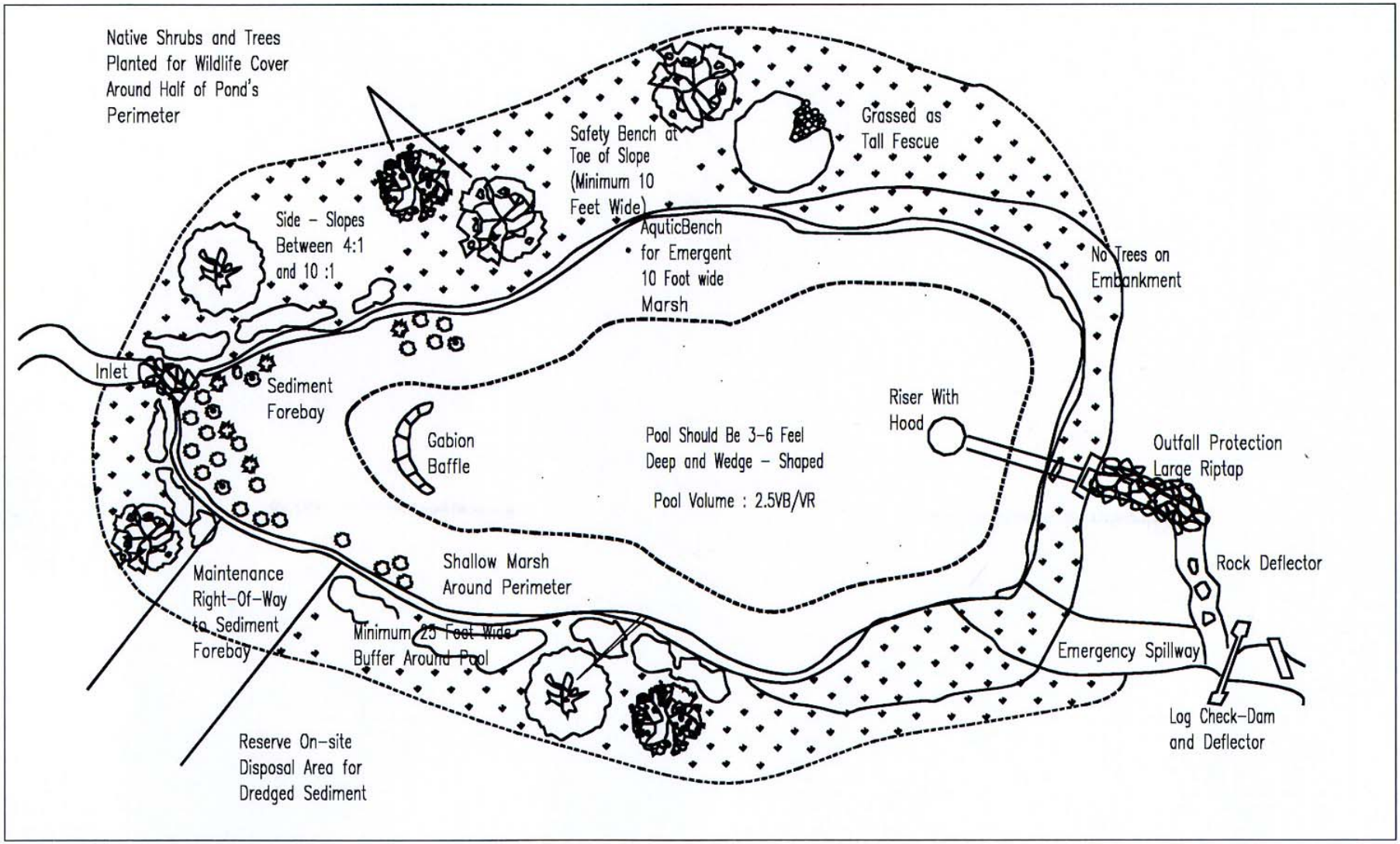


Figure 4.20 Design schematic of a wet pond. (Source: Schueler, 1987)

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.

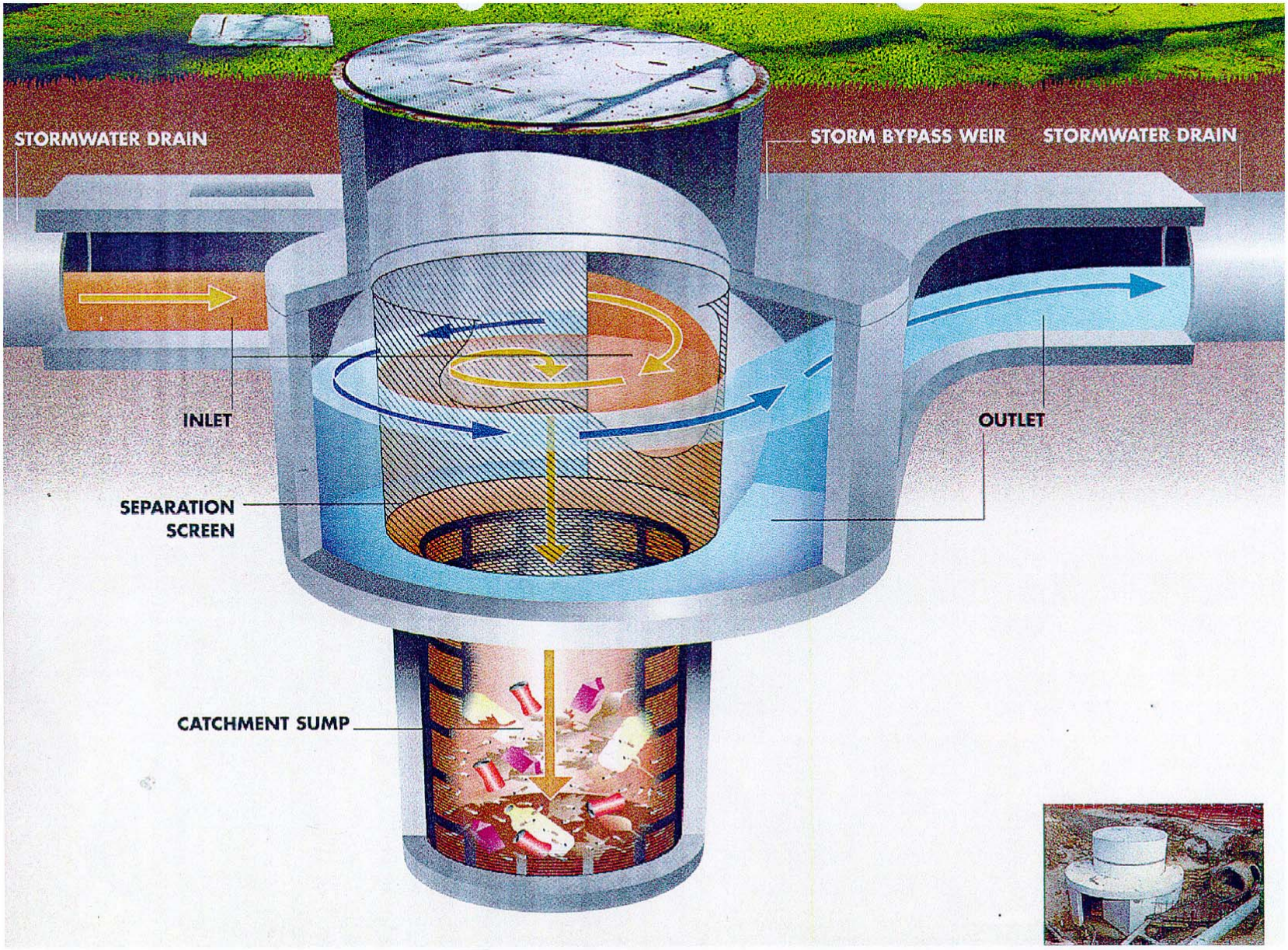


Figure 4.21 : Typical CDS Structure

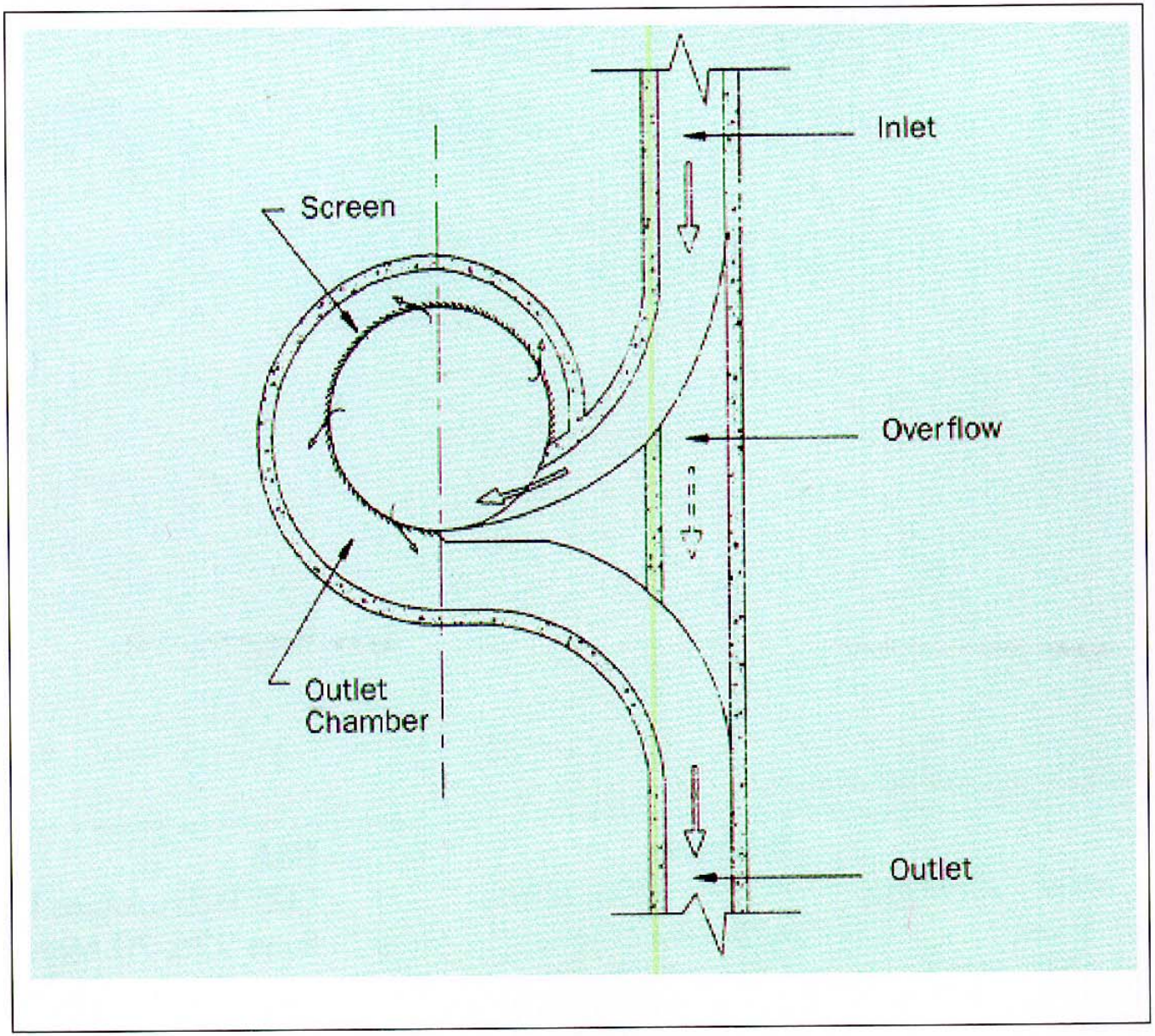


Figure 4.22 : Schematic Representative of the CDS structrure

(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.

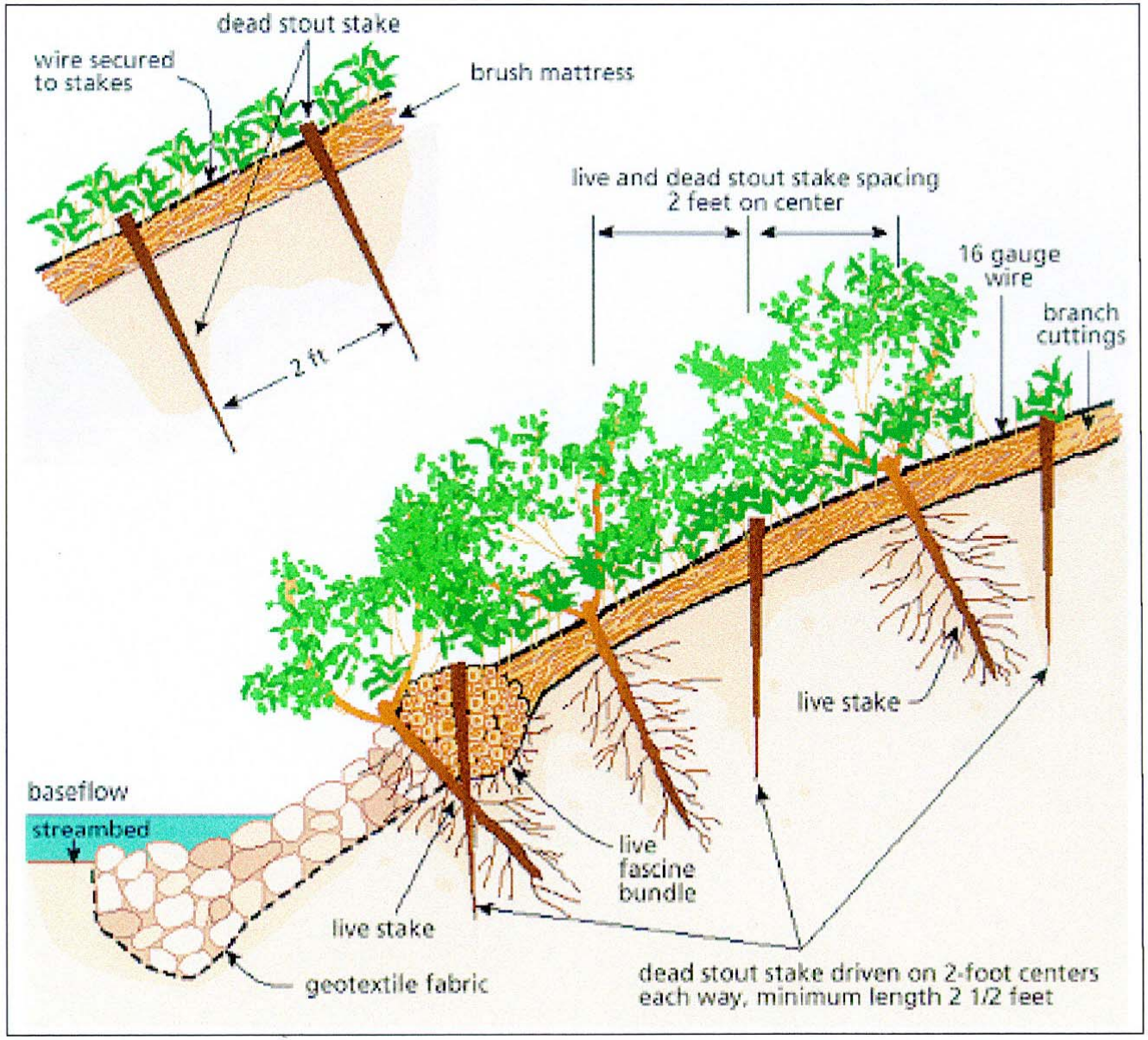


Figure 4.23 Typical details of brush matress technique for streambank.

(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).

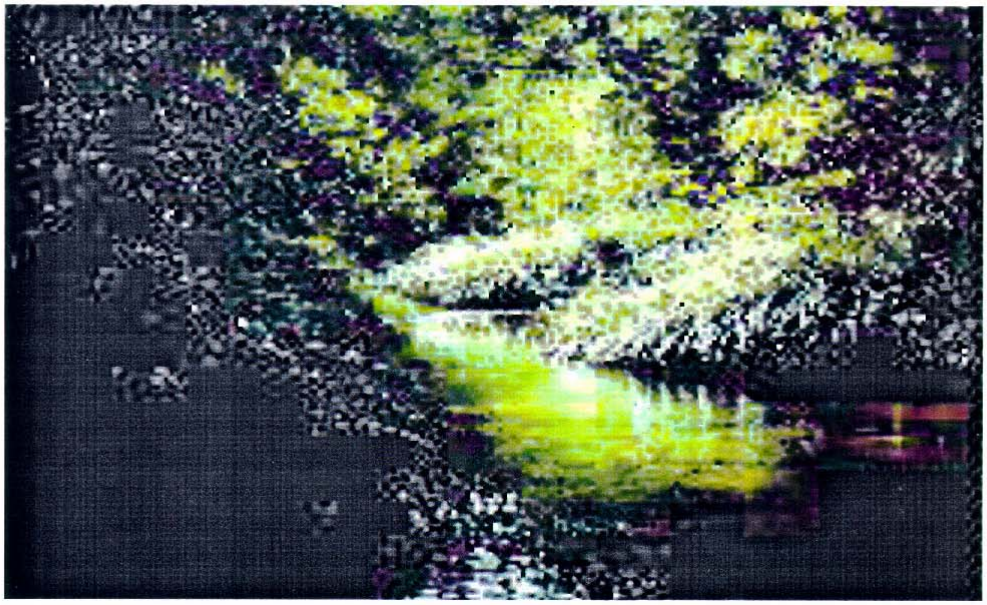


Figure 4.24 Using natural materials in the development of waterbodies.

Figure 4.25 Providing easy/direct access to waterbodies.

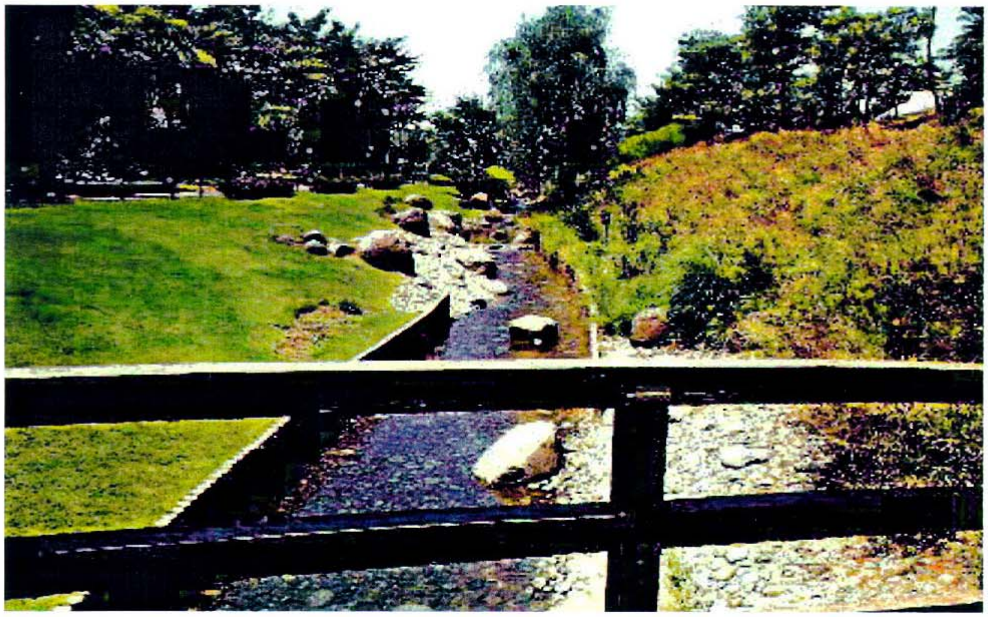


Figure 4.26 Providing more varied profile for water courses.

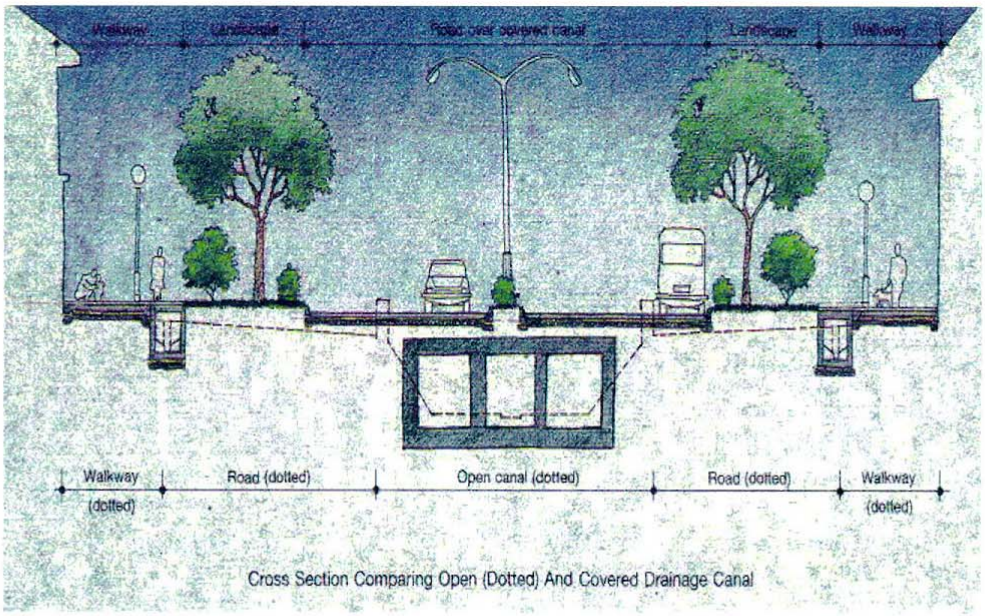


Figure 4.27 Covering water courses.

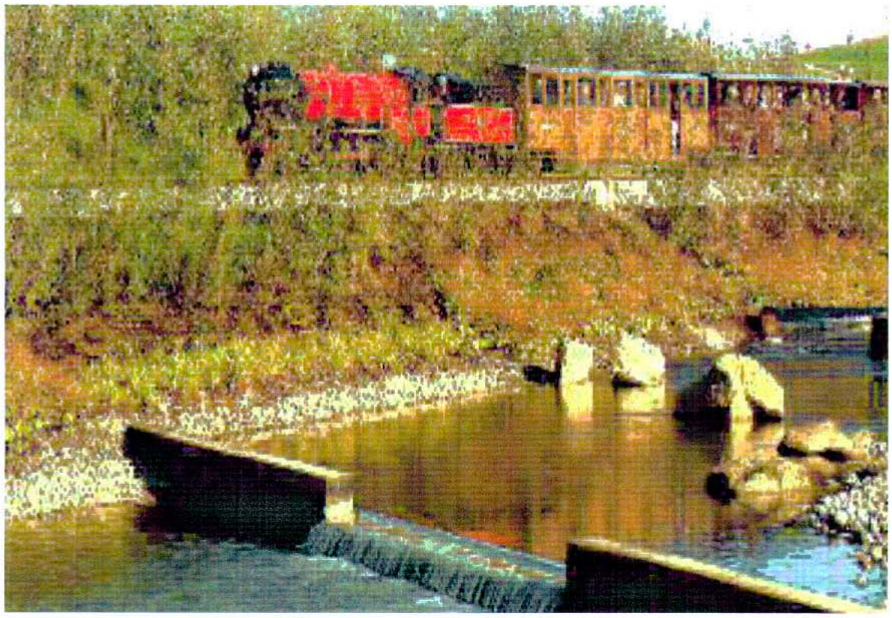


Figure 4.28 Maintaining a permanent body of water.

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.

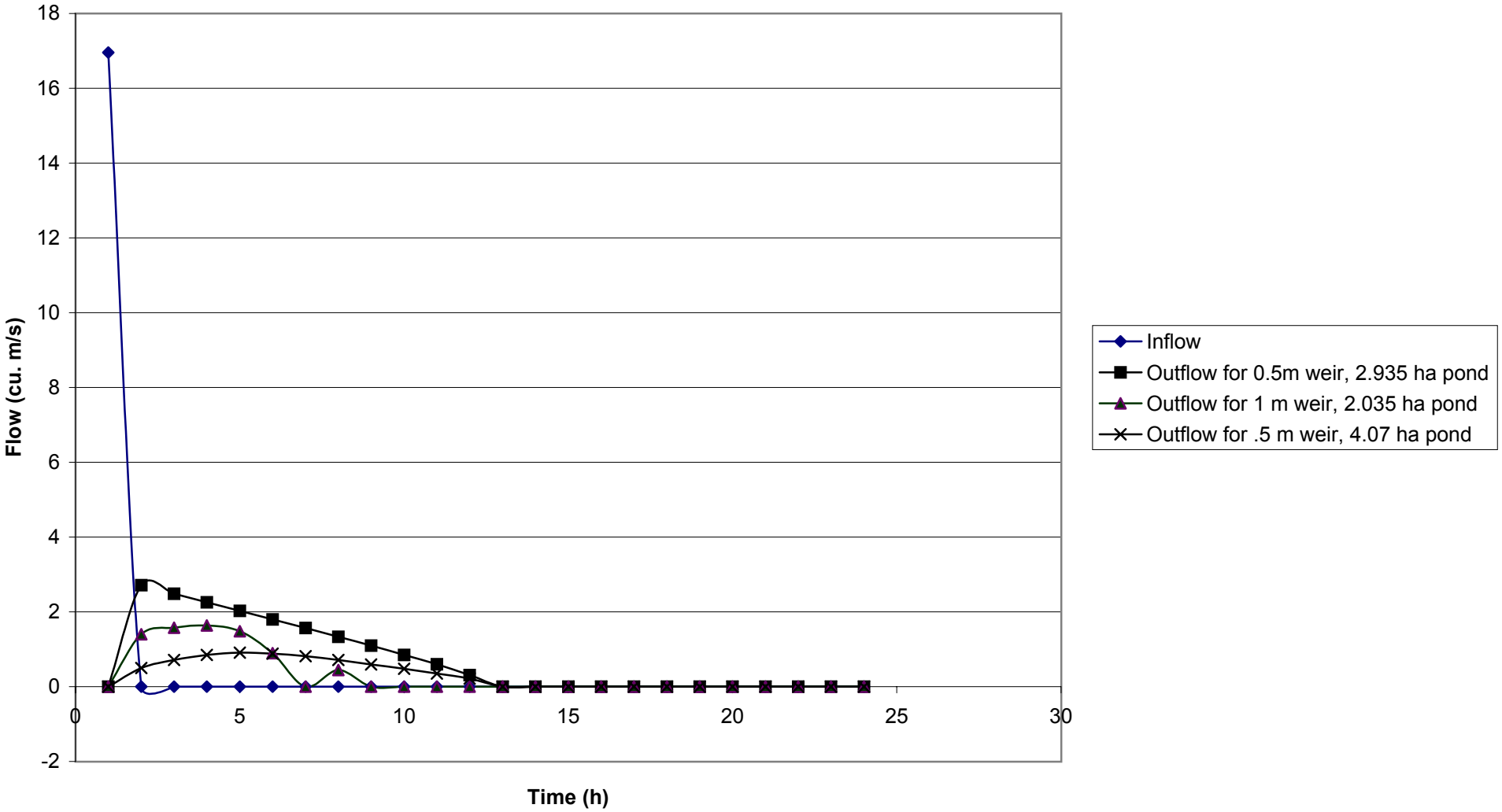
(5) Figures 4.29 and 4.30 shows the results of the flood routing analysis for the ponds.

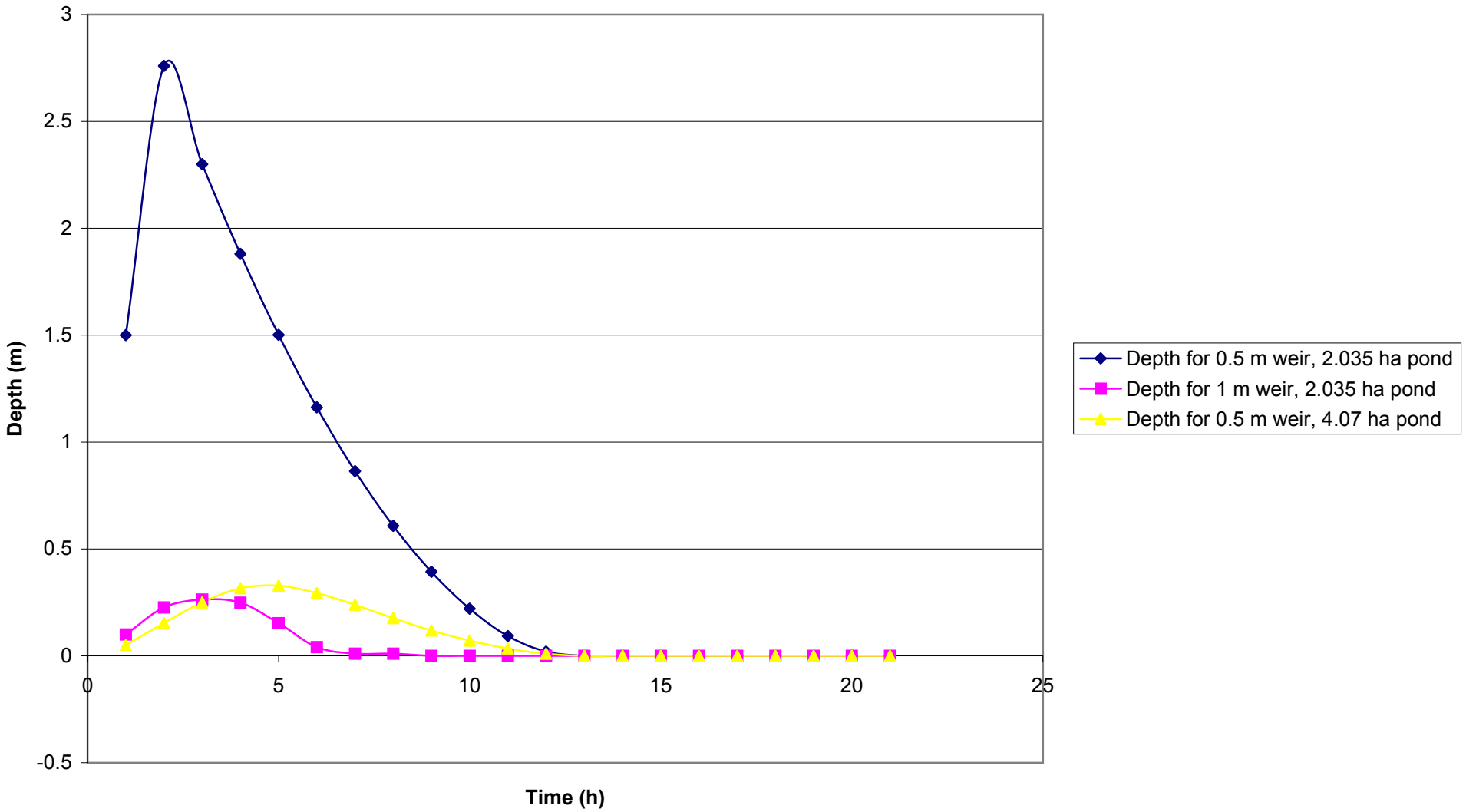
4.6.2.2 MARDI

(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.

Table 4.8 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

1. ACT Government (1994), Urban Stormwater: Standard Engineering Practices, Edition 1, Department of Urban Services, Canberra.
2. American Society of Civil Engineers (1992), Manual and Reports of Engineering Practice No. 77: Design and Construction of Urban Stormwater Management Systems, ASCE, New York.
3. Angkasa GHD Engineers Sdn. Bhd. (1996), Drainage Master Plan Study Report for Putrajaya Development Project.
4. Angkasa GHD Engineers Sdn. Bhd. (1998), Putrajaya Stormwater Management Design Guidelines.
5. Drainage and Irrigation Division (1975), Urban Drainage Design Standards and Procedures for Peninsular Malaysia: Planning and Design Procedure No. 1, Ministry of Agriculture, Malaysia.
6. Drewbury and Davies (1996), Land Development Handbook: Planning, Engineering, and Surveying, McGraw-Hill, New York.
7. Minconsult Sdn. Bhd. (1995), Putrajaya Lake Development: Report on Preliminary Design of Drainage, Lake Development and Temporary Dam.
8. Schueler, T. R. (1987), Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments, Washington D.C.
9. Soil Conservation Service (1998), Stream Corridor Restoration – Principles, Practices, and Processes, USDA.

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.

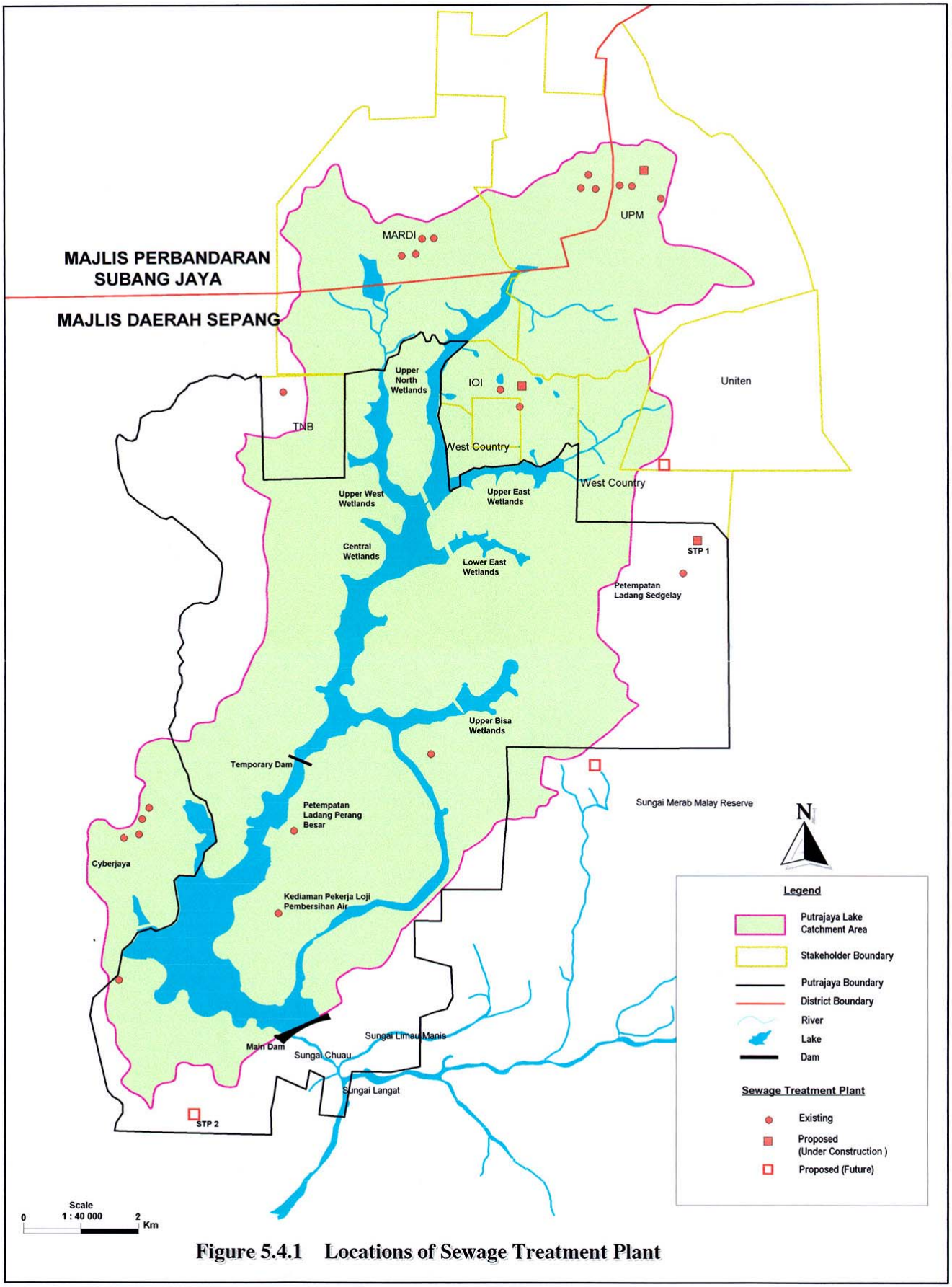


Figure 5.4.1 Locations of Sewage Treatment Plant

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
PUSAT PENTADBIRAN PERSEKUTUAN
PUTRAJAYA
62000 PUTRAJAYA
SELANGOR DARUL EHSAN
TEL : 03-88850225

FIGURE 5.4.2

OVERALL LAYOUT OF PROPOSED PUTRAJAYA DEVELOPMENT SEWERAGE PLAN

1 INCH = 1 UNIT

SCALE 1 : 20,000

SOURCE : ENGINEERING AND ENVIRONMENTAL CONSULTANTS SDN. BHD.
DRG. NO. EEC 9612/PLAN/3

R:\PROJECTS\P-JAYA\M7A

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

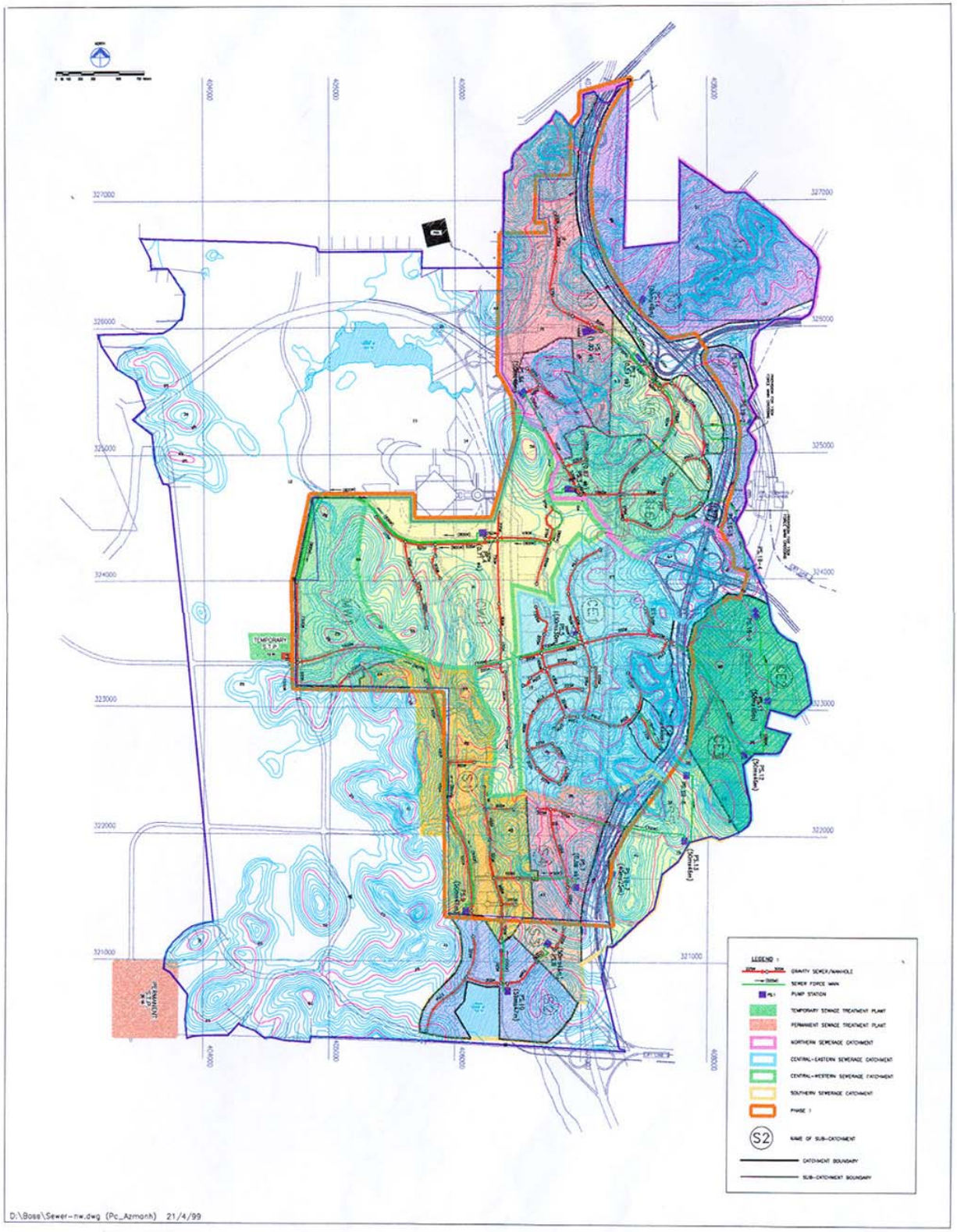


FIGURE 5.4.3 **CYBERJAYA FLAGSHIP ZONE – PHASE 1A PROPOSED SEWERAGE SYSTEM**

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.

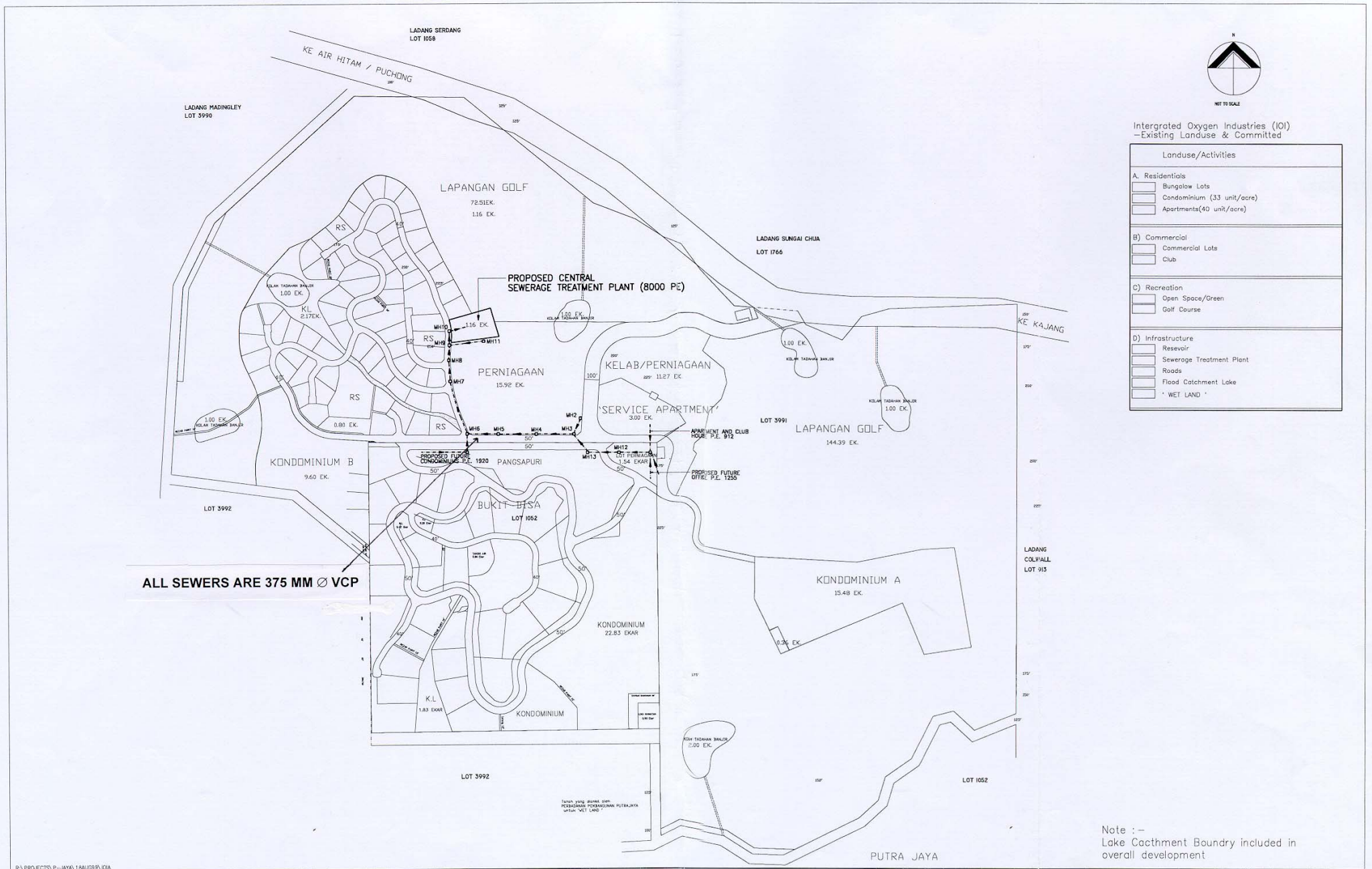
5.4.6 IOI Palm Garden Resort Development

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.



N

NOT TO SCALE

Intergrated Oxygen Industries (IOI)
–Existing Landuse & Committed

Landuse/Activities
A. Residentials
Bungalow Lots
Condominium (33 unit/acre)
Apartments(40 unit/acre)
B) Commercial
Commercial Lots
Club
C) Recreation
Open Space/Green
Golf Course
D) Infrastructure
Resevoir
Sewerage Treatment Plant
Roads
Flood Catchment Lake
' WET LAND '

Note :–
Lake Cacthment Boundry included in overall development

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 :

<u>Suspended Growth System</u>

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

<u>Fixed Film Growth System</u>

(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

CHAPTER 6

LANDUSE MASTERPLAN STUDY

6.0 LAND-USE MASTERPLAN STUDY

6.1 INTRODUCTION

6.1.1 The Putrajaya Lake system is a man-made system. For it to perform as envisaged there is a need to develop an integrated land-use masterplan for the catchment, based on an adequate understanding of the natural system supporting it.

6.1.2 To develop the masterplan there is a need to review the existing land-use policies and land-use situation in the catchment. Based on the review and the land-use controls, recommended by the various specialists in the study team to ensure the success and sustainability of the Lake, an integrated land-use masterplan can then be develop to guide the future development in the catchment.

6.2 REVIEW OF LAND-USE POLICIES AND GUIDELINES

6.2.1 The Structure Plans

6.2.1.1 The current land-use policy in the catchment is governed by two district Structure Plans. They are:

- The Structure Plan for Putrajaya and part of Sepang District
- The Structure Plan for Petaling District and part of Klang District

6.2.1.2 The Structure Plan for Putrajaya and part of Sepang District has defined a set of policies for the planning and development of Putrajaya. The policies governing the planning and management of the area in the Putrajaya Lake Catchment are supposed to create a city possessing the following characteristics:

- an “intelligent City”
- a “City-in-a-Garden”
- a city that meets the administrative needs of the federal government
- a city with a carefully monitored physical and ambient environment
- a city with a high quality living environment
- a city that gives priority to public transport

6.2.1.3 The Structure Plan also supported preservation of the existing development surrounding Putrajaya. They are;

- *Golf Course & Country Homes (IOI)*
  - The activities must be control
  - High management standard of environment, with centralised sewage treatment system

- *Gas Turbine Power Station (TNB)*
  - expansion of existing capacity are not allowed
  - Water pollutant must be controlled

- *West Country Estate*
  - Can be developed for low-density development, such as institution, recreation and green area.

- *Bukit Bisa*
  - Can be developed for low density development

- *Kawasan Rezab Melayu*
  - Land conversion from agriculture to industry is strictly prohibited. The developments in this area are to be encouraged for housing. However, other developments such as commercial, recreation, golf course, tourism etc. have to be screened thoroughly to ensure the development concept for the Putrajaya and Sepang Structure Plan are in line with each other.

6.2.1.4 Basically, the existing and committed developments within the catchment is in line with the general policies of the Structure Plan. The developments are compatible for developing such low-density development and are environmental friendly and integrated with the Putrajaya development concepts.

6.2.1.5 The Structure Plan for the Petaling District and part of Klang District also emphasises on the need to preserve the environment, wherever possible, and to create a green landscape. The pertinent policies are:

- Development without negative impact to the environment
- Preservation of forest reserve and water catchment area

- Future development must have reservation for recreation and open space
- Preservation of water sources
- Utilities reserve must be landscaped.

6.2.1.6 The Consultant has carefully reviewed the policies and objectives described in the above two Structure Plans. The thrust of the policies in the two Plans is to balance rapid development growth in the area with the preservation of the natural environment through low density development. Thus, in the development of the integrated land-use masterplan for the catchment the Consultant will be guided by that concept.

6.2.2 The Putrajaya Land-use Masterplan

6.2.2.1 The land-use Masterplan for Putrajaya (see Figure 6.1), also known as the 'Master Plan', was approved by the Perbadanan Putrajaya on 31st March 1997.

6.2.2.2 The Master Plan reaffirms the concepts of an "intelligent City" and a "City-in-a-Garden" as defined in the Structure Plan. The Master Plan reinforces the concept of a "City-in-a-Garden" by proposing "an integrated system of parks, water courses, wetlands, forest and open spaces…"

6.2.3 The Putrajaya Urban Design Guidelines (UDG)

6.2.3.1 To support and ensure the successful attainment of the vision for Putrajaya and its Lake system, a set of detailed Urban Design Guidelines (UDG) has been prepared. The UDG provides detail guidelines on the design parameters and control for different land parcels in the Putrajaya area.

6.2.3.2 A review of the UDG was also carried out with the objective of incorporating pertinent elements of the UDG in the development guidelines for the catchment areas outside of the Putrajaya area. The following are a few pertinent UDG which were adopted by the Consultants to guide their preparation for the development guidelines at the catchment areas outside of the Putrajaya area.

- Urban Design Guidelines (Vol. 1 – Rationale and Strategies)
- Urban Design Guidelines (Vol. 2 – Development Controls)

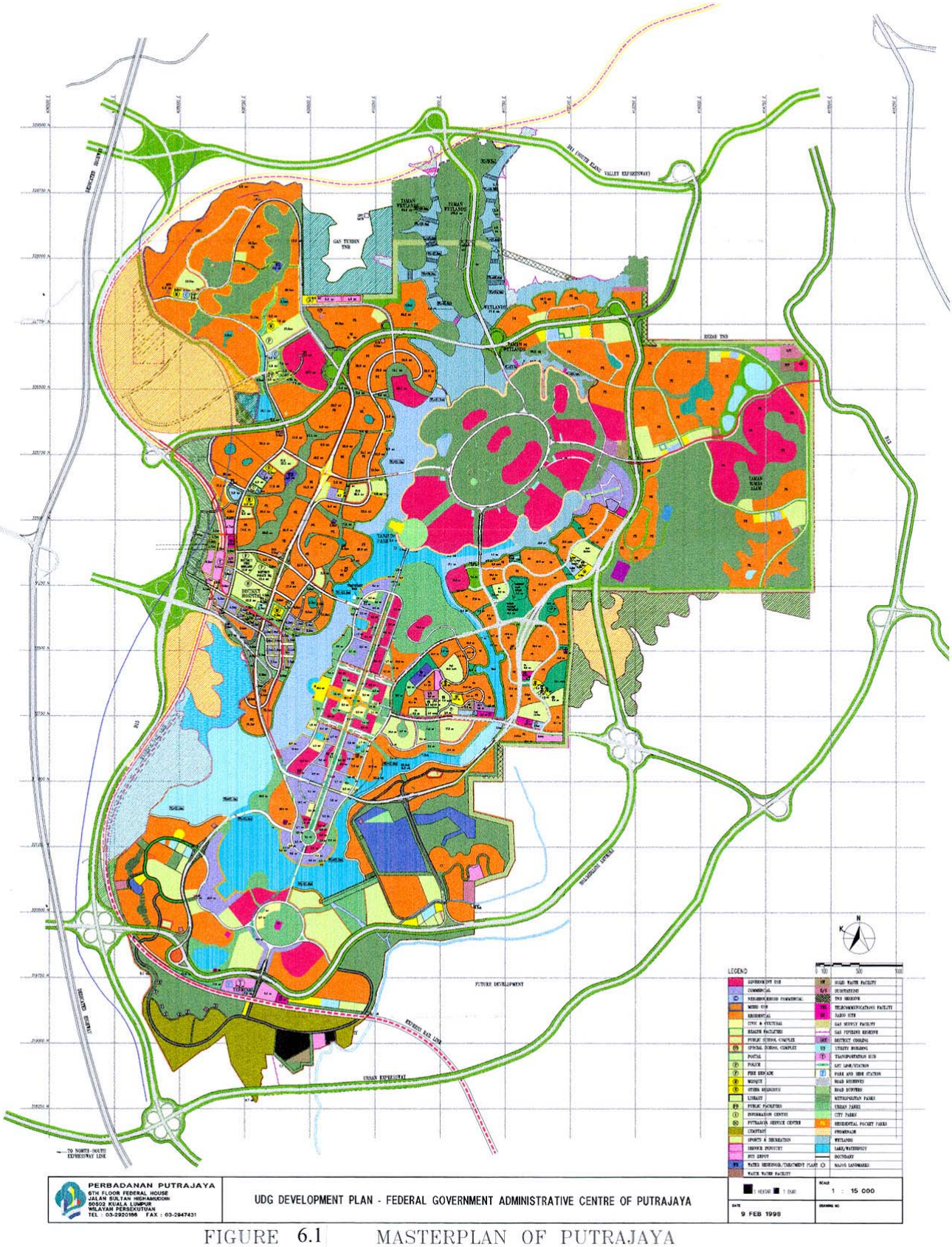


FIGURE 6.1 MASTERPLAN OF PUTRAJAYA

- Urban Design Analysis and Strategies (Vol. 1 – Rationale and Strategies)
- Urban Design Analysis and Strategies (Vol. 2A – Precincts Analysis and Development Plan. Precinct 7, 8, 9 and 10)
- Urban Design Analysis and Strategies (Vol. 3 – Part 1: Residential and Residential Centres)
- Urban Design Analysis and Strategies (Vol. 3 – Part 4: Service Industry, Transport and Public Utilities)
- Urban Design Analysis and Strategies (Vol. 3 – Part 5a & 5b: Landscape, etc.)

6.2.3.3 The UDG also give emphasis on the preservation of greenery with low density development. Therefore, planning for future developments in the catchment areas outside of Putrajaya needs to adhere will follow closely to the guidelines defined in the UDG.

6.2.4 Multimedia Super Corridor (MSC) Guidelines

6.2.4.1 The MSC Guidelines were prepared to facilitate local authorities and developers in the planning and development of the MSC. This is in line with the vision of the government to achieve the desired environment for multimedia and IT development. There are seven planning areas within the MSC where this set of guidelines are applicable. Only three planning areas are pertinent to this study. They are as follows;

- Cyberjaya
- Tele-suburb
- Research and Development (R&D) Centre

6.2.4.2 The basic planning of the MSC is based on the following development principles;

1. Human oriented intelligent city in harmony with nature.
2. Harmonious relation between Man and His Creator, Man and Man, Man and Technology and Man and Environment.
3. Low density living environment.
4. Ecological and environmental planning with lush tropical landscape.
5. Human focus design with 'barrier free' living.
6. Advanced telecommunication infrastructure for the multimedia/IT industries.
7. Comfortable and efficient urban infrastructure.

6.3 EXISTING AND COMMITTED LAND-USE SITUATION

6.3.1 Introduction

6.3.1.1 The Putrajaya Lake catchment has a total area of 14,982 acres or 6,066 ha. It can be divided into two distinct areas – the Putrajaya area with a size of 10,600 acres (4,291 ha.) and the areas outside of it with a size of 4,382 acres (1,774ha.)

6.3.1.2 The existing and future land-use in the Putrajaya area is governed by the Putrajaya Masterplan. The land-use in the 20 precincts of Putrajaya is made-up of various types. The residential areas, comprising of various housing types and densities, are located mostly in the Northern part of the Lake. The Southern part of the Lake will be dominated by mixed development, i.e. a mixture of government offices, commercial buildings and high-density residential developments.

6.3.1.3 The existing land-use in the catchment areas outside of the Putrajaya area can generally be categorised as follows:

- Agricultural production
- Forest reserve
- Low density housing
- Institutional
- Corporate centre

6.3.1.4 The major land owners in the areas are:

- Universiti Putra Malaysia (UPM)
- MARDI
- Integrated Oxygen Industries (IOI)
- Tenaga Nasional Berhad (TNB)
- West Country Berhad
- Cyberjaya
- Sungai Merab Malay Reserve
- Universiti Tenaga Nasional (UNITEN)

6.3.1.5 The existing and committed land-use plan in the catchment has been prepared and is given in Table 6.1 and Figure 6.2. Details on the existing land-use for each of the major landowners are described below.

FIGURE 6.2
EXISTING & COMMITTED LANDUSE MASTERPLAN

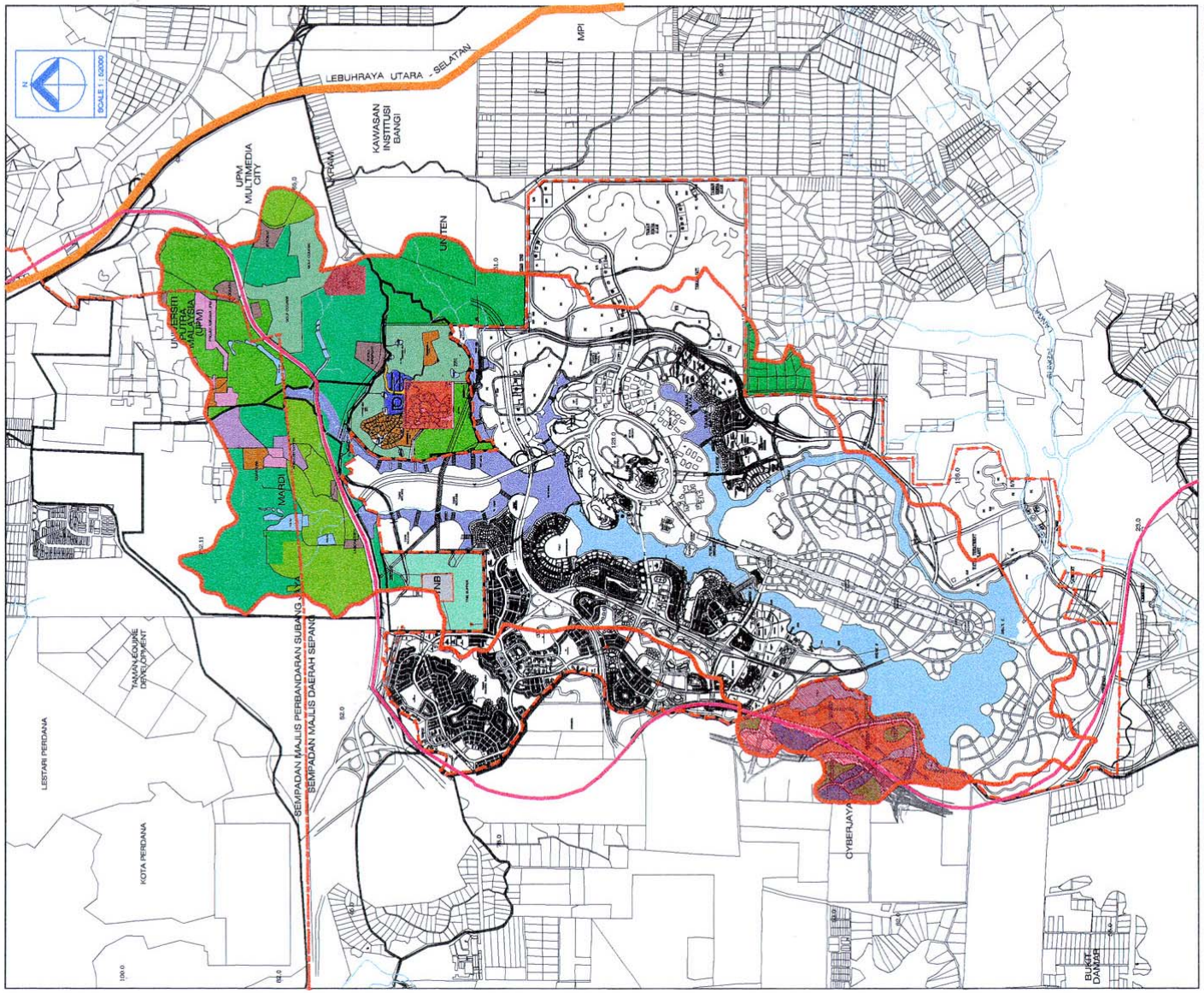


FIGURE :	TITLE : EXISTING & COMMITTED LANDUSE MASTERPLAN

CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

LEGEND :-

BUILDINGS	EXISTING ACRE	COMMITTED ACRE
HOUSING / QUARTERS	101.47	197.47
COMMERCIAL	17.46	12.15
HOSTELS/COLLEGE	59.76	-
TNB POWER STATION	28.95	-
ADMINISTRATION/OFFICE	71.12	66.45
ACADEMIC/R & D	-	-
FACILITIES	92.35	86.06
TOTAL	371.11	359.13
GREEN		
AGRICULTURE	543.33	-
GOLF COURSE	403.41	-
BUFFER ZONE	194.03	-
ORCHARDS	742.96	-
FARMS	723.96	-
OPEN SPACE/RECREATION	363.52	117.29
TOTAL	2970.23	117.29
WATER BODIES		
LAKE/POND	63.28	51.03
WETLAND	46.99	
TOTAL	110.27	51.03
OTHERS		
ROAD/DRAINAGE	242.65	-
EXPRESS RAIL LINK	-	157.95
HIGHWAY	-	313.81
OTHERS	34.48	-
TOTAL	277.33	471.76
GRAND TOTAL		4382.08

BOUNDARY	ACRE	HECTAR
PUTRAJAYA	10,600	4,289.67
SURROUNDING PUTRAJAYA	4,382.08	1,773.37
TOTAL LAKE CATCHMENT	14,982.08	6,063.04

6.3.2 Universiti Putra Malaysia (UPM)

UPM is located at the North of the catchment. It has an area of 2,887 acres (1,168 ha.), however the area within the catchment is 1,390 acres (562 ha.) and most of it is zoned for institutional activities. UPM has been set up as an agricultural and environmental tertiary education centre.

6.3.2.1 Existing and Committed Development

(1) Figure 6.3 shows a plan of the existing land-use in UPM (within Lake catchment) and the boundary of Putrajaya Lake Catchment. Details on the acreage and percentage of the existing and committed land-use in the Lake Catchment are given in Table 6.2. From Table 6.2 it can be seen that the two major land uses in the Lake Catchment are for:

- Sports activities (field, stadium and golf courses) – 28.52%
- Farms and orchards – 46.73%

(2) Currently, the development of UPM is in line with the Putrajaya development concept, i.e. preservation of the environment and greenery. However, the committed development of UPM Hospital located at the edge of the northern side boundary has to take measures to control their waste discharge into the Putrajaya Lake.

(3) Besides the above development, the plans for the future includes a games village for Asia Games 2006 next to the existing stadium, faculty at the northern site of the proposed ERL or next to the Project College and staff quarters within the catchment. Certain areas zoned as 'Flexible Zone' by UPM need careful consideration in order to control its development.

FIGURE 6.3
EXISTING LANDUSE
UNIVERSITI PUTRA MALAYSIA

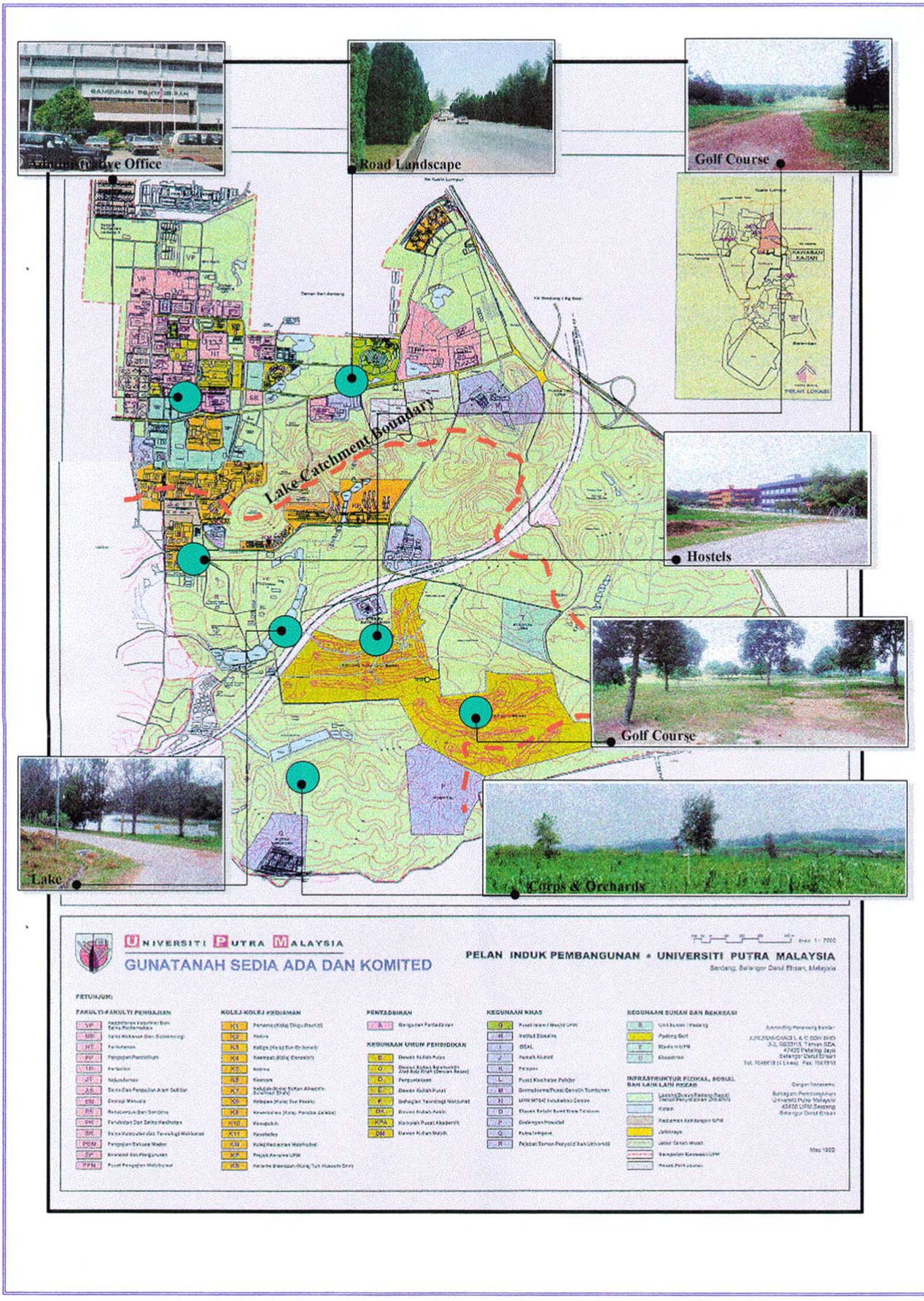


Table 6.2 Existing and Committed Land-use for UPM (Within Catchment)

Landuse/Activities	Area (acre)	Percentage (%)
A. BUILDINGS		
- **Hostels**	59.76	36.87
- **Quarters**	3.59	2.21
- **Hospital (committed)**	43.58	26.89
- **Putra Infoport**	29.68	18.31
- **Others**	25.48	15.72
Total	***162.09***	***10.05***
B. GREEN AREAS		
- **Golf Course**	186.51	15.08
- **Open space/recreation**	209.85	16.97
- **Stadium**	20.19	1.63
- **Farms**	321.65	26.01
- **Orchards**	518.50	40.31
Total	***1,236.51***	***76.56***
C. WATER BODIES		
- **Lake**	24.18	41.20
- **Wetland**	34.51	58.80
Total	***58.69***	***3.63***
D. INFRASTRUCTURE		
- **Roads & Drainage**	61.57	39.07
- **Express Rail Link (Committed)**	73.86	46.87
- **Kajang Ring Highway**	22.17	14.06
Total	***157.60***	***9.76***
Grand Total	***1,614.89***	***100.00***

6.3.2.1 Physical Characteristics

The topography of UPM is hilly and ranges between 75 to 85 meters, especially at the centre of UPM, with slopes down to the east and south. There are a few lakes/ponds located at the western and southern side with a total area of 24.18 acre (10 ha.)

6.3.2.2 Site Potential & Constraints

(1) A review of the existing and committed future land-use development of the UPM indicates that they are in line with the development concept of Putrajaya. The preservation of greenery and low-density development meets the requirements of an 'intelligent city' and 'a-City-in-a-Garden' theme.

(2) The Structure Plan has zoned UPM under 'Institutional' with green and low density mixed development. Therefore, UPM should be developed to preserve the greens within a low-density development accordingly.

(3) The MSC guideline also stated that the UPM is the R&D Centre and will be a collaborative cluster of academic institutions which offer courses on information technology. On the other hand the corporate R&D centres which undertake research and development oriented industries require close co-operation with the academic and research institutions which are equipped with facilities for laboratory testing, R&D, and skill training centres. An example of such collaboration is the MTDC-UPM Incubation Centre.

6.3.3 MARDI

MARDI is located next to the UPM on the North of Putrajaya. It has a total area of 1,858 acres or 752 ha., and only 1,148 acre (465 ha.) is in the Putrajaya Lake catchment.

6.3.3.1 Existing and Committed Development

(1) To support the development objectives of Putrajaya, MARDI has relocated most of its live stocks rearing activities, which are potential pollutant sources, and are keeping the land as a green area. Currently, there are only a few farms operating on a small scale (20%), rearing chicken, sheep, duck, ostrich, cow, etc. in MARDI's area. There is no committed development around the area except the proposed Express Rail Link (ERL) and South Klang Valley Express (SKVE) at the northern side.

(2) Figure 6.4 shows a plan of the existing land-use in MARDI. Details on the acreage and percentage of the existing land-use in the MARDI are given in Table 6.3. From Table 6.3 it can be seen that MARDI has preserved 74% of its total area as green areas.

FIGURE 6.4
MARDI LANDUSE

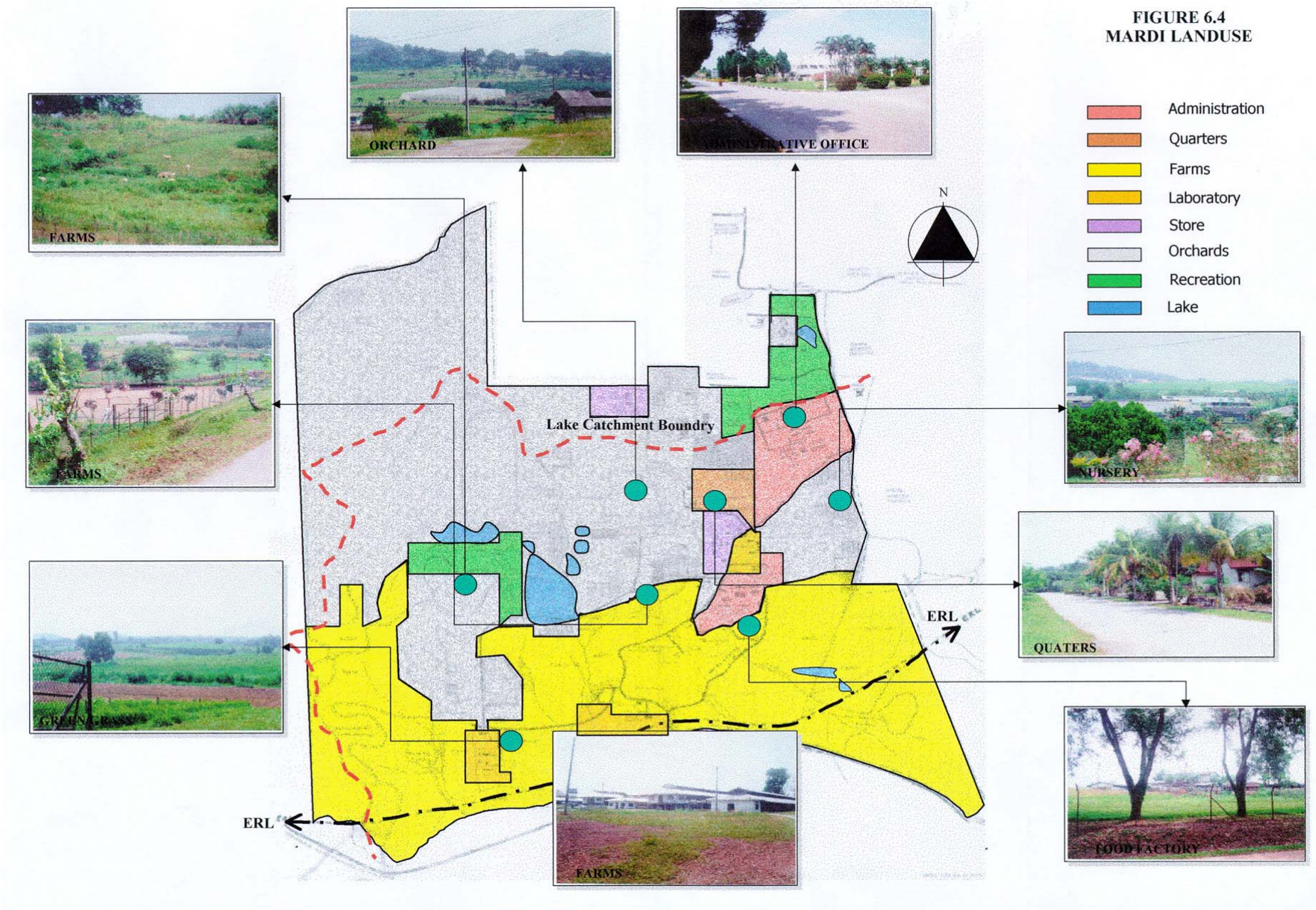


Table 6.3 Existing and Committed Land-use for MARDI

Landuse/Activities	Area (acre)	Percentage (%)
A. BUILDINGS		
- **Administration**	***71.12***	***61.13***
- **Laboratory**	***16.04***	***13.79***
- **Quarters**	***19.30***	***16.59***
- **Others**	***9.88***	***8.49***
Total	***116.34***	***10.13***
B. GREEN AREAS		
- **Farms**	***487.35***	***58.06***
- **Orchards**	***321.47***	***38.30***
- **Open Space/Recreation**	***30.56***	***3.64***
Total	***839.38***	***73.08***
C. WATER BODY		
- **Pond/lake**	***32.10***	***72.00***
- **Wetland**	***12.48***	***28.00***
Total	***44.58***	***3.88***
D. INFRASTRUCTURE		
- **Road**	***53.32***	***35.97***
- **Express Rail Link (ERL)**	***48.32***	***32.60***
- **South Klang Valley Highway**	***46.58***	***31.43***
Total	***148.22***	***12.91***
Total Lake Catchment Area	***1,148.52***	***100.00***

6.3.3.2 Physical Characteristic

(1) This area is characterised by undulating hills, which ranges from 70 to 80 meters and with slopes to the southern area. The dominant land-use is for agricultural research activities, such as farms and orchards. There are also a few ponds scattered around the area and a lake is also located in the centre of MARDI.

(2) Basically, the dominant land-use can be categorised into two, which is

- Orchards at the northern part (58%)
- Farms at the southern part (38%)

6.3.3.3 Site Potentials and Constraints

(1) A review of the existing and committed future land-use development of the MARDI indicates that they are in line with the development concept of Putrajaya. The preservation of greenery with their Research & Development activities in the

future will meets the requirements of an 'intelligent city' and 'a-City-in-a-Garden' theme. The environmental friendly concept that MARDI is proposing for it's Farms, Orchards Complexes and ponds are in line with the Structure Plans and the Putrajaya concept.

6.3.4 Integrated Oxygen Industries (IOI)

The IOI development, with a size of 418 acres or 170 ha, is located next to the North-Eastern wetlands. Basically, the overall development is in the catchment area, including Bukit Bisa.

6.3.4.1 Existing & Committed Development

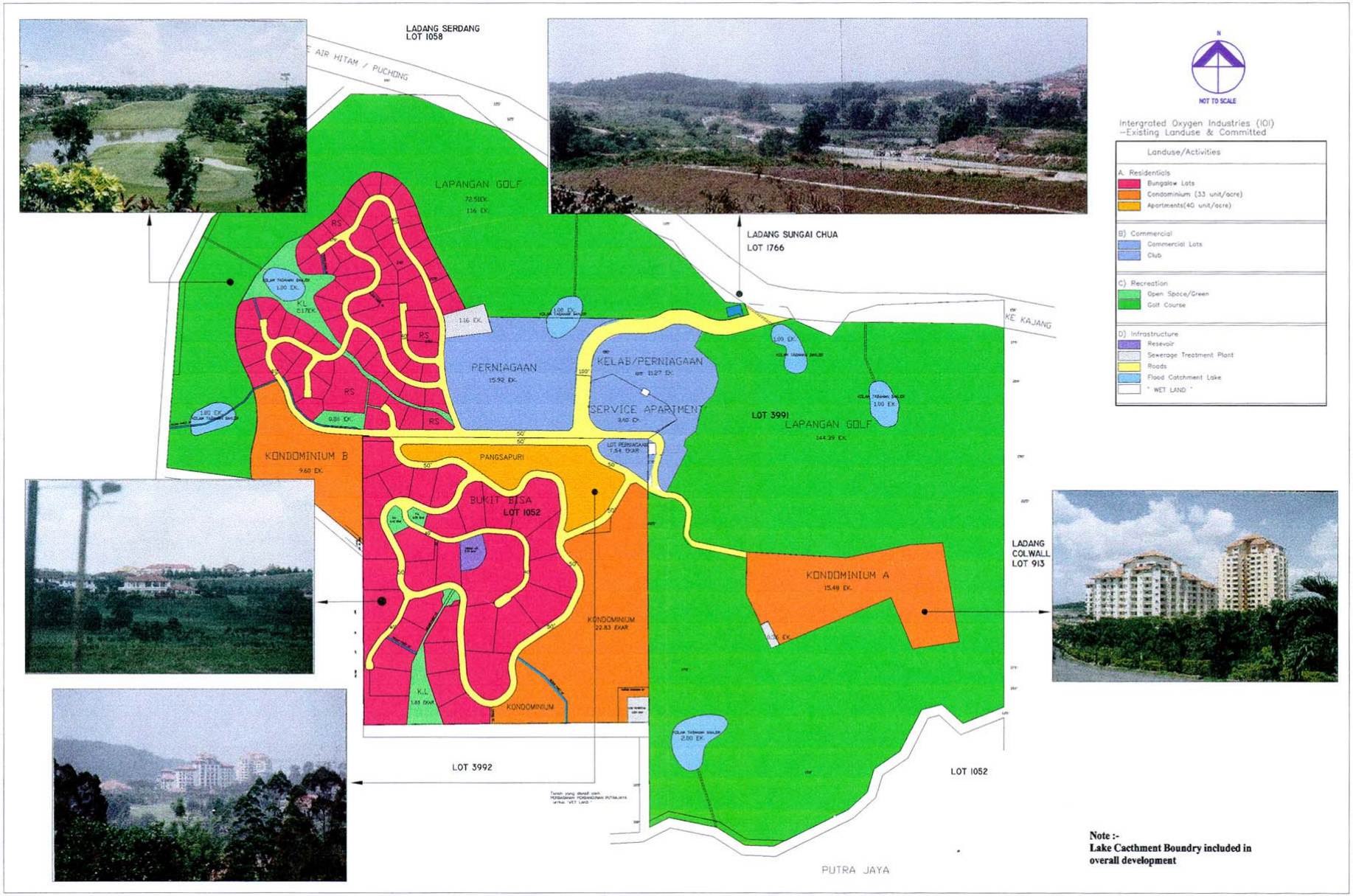
(1) IOI is being developed as a low-density residential area with an average density of 12 units/acre for bungalow and 50 units/acre for condominium, together with commercial lots and a golf course.

(2) Figure 6.5 shows a plan of the existing land-use in the IOI development. Details on the acreage and percentage of the existing and committed land-use in the IOI development are given in Table 6.4. From Table 6.4 it can be seen that the total percentage of the green area of the development is 42%.

6.3.4.2 Physical Characteristic

The development is located in a hilly area, which ranges between 150 to 225 feet. The highest point of the area is Bukit Bisa (145 meter or 430 feet) (see Figure 6.6). The physical character (hilly) has encouraged the development of low-density condominiums and apartments with bungalow lots. There are 6 ponds with a total area of 7 acres. They act as flood retention ponds at the lowest part of the development.

FIGURE 6.5
EXISTING LANDUSE
IOI



Note :-
Lake Cacthment Boundry included in overall development

Figure 6.6 : Northern part of Bukit Bisa - with the development of low density mixed housing

Table 6.4 Existing and Committed Land-use for IOI

Landuse/Activities	Unit	Area (acre)	Percentage (%)
A. BUILDINGS			
- **Bungalow Lots**	*101*	*72.39*	*44.98*
- **Condominium (33 unit/acre)**	*1,737*	*47.91*	*29.77*
- **Apartments (40 unit/acre)**	*487*	*11.9*	*7.39*
- **Commercial Lots**	*1*	***17.46***	*10.86*
- **Club**	*1*	***11.27***	*7.00*
Total		***160.93***	***30.77***
B. GREEN AREAS			
- **Open Space/Green**		*5.82*	*2.61*
- **Golf Course**		*216.90*	*97.39*
Total	**-**	***222.72***	***42.59***
C. WATER BODY			
- **Flood Catchment Lake**		***7.00***	*100.00*
Total	**-**	***7.00***	***1.34***
D. INFRASTRUCTURE			
- **Reservoir**		***0.84***	*3.08*
- **Sewerage Treatment Plant**		***1.99***	*7.29*
- **Roads**		***24.47***	*89.63*
Total	**-**	***27.30***	***25.30***
Total Lake Catchment Area	**-**	***522.91***	***100.00***

6.3.4.3 Site Potentials and Constraints

The development is compatible with that of Putrajaya and follows the Structure Plan. The concept of 'country homes', which is a low density residential development and a golf course, is in harmony with the spacious and green living concept emphasised in the Putrajaya development. Basically, the development is already committed and currently the discharge of water into the Putrajaya Lake is under control.

6.3.5 Tenaga Nasional Berhad (TNB)

This site is currently occupied by the Serdang Gas Turbine Power Plant by TNB (see Figure 6.7) with an area of 297 acre (120 ha). However the catchment boundary only takes 75% of the site with the area of 223 acre (90 ha.).

Figure 6.7: TNB Serdang Gas Turbine Power Plant

6.3.5.1 Existing & Committed Development

There are significant stores of chemicals and fuel at this site. Thus, there are potential risks from chemical and fuel spills or explosions. In the event of such an environmental-related emergency at the power plant, there could be significant impacts on the adjacent developments, i.e. the residential and commercial areas.

6.3.5.2 Physical Characteristic

It is located at the northern part of Putrajaya and adjacent to the Taman Wetland and committed mixed housing development in Putrajaya. However, the buffer zone provided around the power station helps to reduce the risk of emergencies.

6.3.5.3 Site Potentials & Constraints

(1) The impact on the wetlands and the Lake arises primarily from hazardous chemical and fuel spills. Although the risk of such an occurrence is small the impact of such an occurrence could be immense. TNB has to develop emergency response plans to cope with such potential environmental-related emergencies.

(2) The other possible environmental impacts maybe the fallout from any explosions and the release of toxic gases. The wind direction has generally been observed to be from the North Westerly direction. This has implications on the land uses to the South of the power plant. The land use zoning should take this into consideration.

6.3.6 West Country Berhad

This area is located at the north-eastern edge of Putrajaya and is adjacent to the Wetland and IOI (Bukit Bisa). The existing land-use is oil palm and rubber tree cultivation (see Figure 6.8). However, plans are being made to develop the area at the north-eastern end into a mixed development. The land area is 423 acres (171 ha.). The total land area within the Lake Catchment is 381 acres 9154 ha).

Figure 6.8 : Western part of West Country with proposed low density housing – Bungalow lots, located adjacent to IOI golf course.

6.3.6.1 Existing and Committed Development

Currently there is an oil palm estate with slopes of 5 – 20 degrees. West Country Berhad have tentatively proposed mixed development on their 289 acre land, with low density housing developments on the western part which lies within the lake Catchment.

6.3.6.2 Physical Characteristic

The site is undulating and ranges from 100 – 250 feet. The northern site is sloping to the Putrajaya Lake.

6.3.6.3 Site Potentials & Constraints

There is a proposed highway from Putrajaya cutting through the site at the Western end. Tentatively, this area was proposed for mixed development, i.e. bungalow lots, terrace house, commercial, facilities (school, mosque) etc. This development is still in line with that of the Putrajaya Structure Plan. The proposed lake at the middle of the northern side will help to control the runoff discharge into Putrajaya.

6.3.7 Cyberjaya

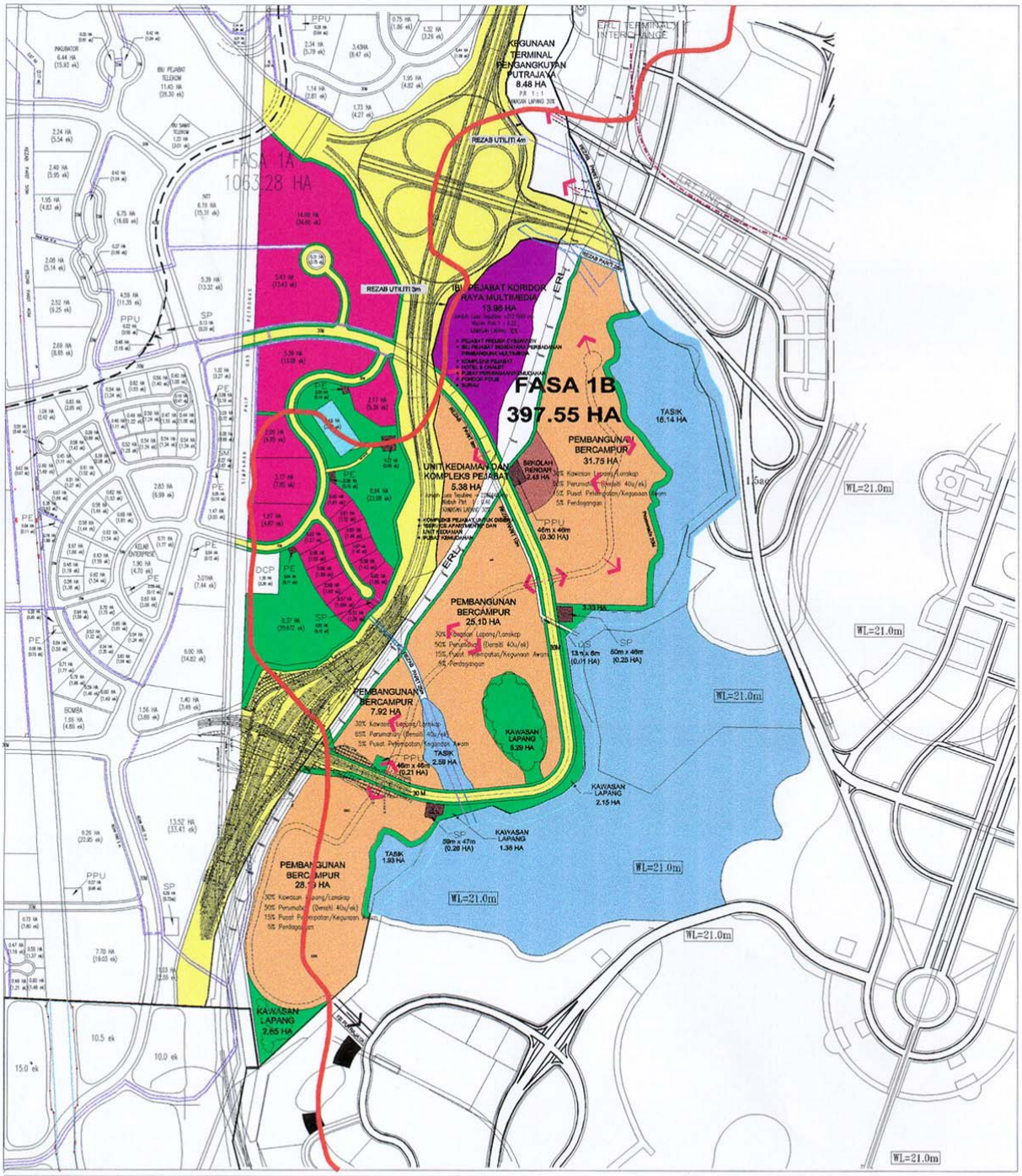
The Cyberjaya Flagship Development Zone (Phase 1B), also known as 'Kawasan Persyarikatan' in the Structure Plan of Putrajaya and part of Sepang District covers an area of 18,300 acres or 7,589 ha. The development in this area is governed by the policies described in the Structure Plan for the area. Only 607 acres (225 ha) of the total area lies within the Putrajaya Lake Catchment. The overall development concept of the area has to be in line with the planning concept for Putrajaya, i.e. development to create an 'Intelligent City' and a 'City In A Garden'. All private and individual land owners in the vicinity of Cyberjaya are required to develop their land in accordance with the overall development concept. Figure 6.9 shows a plan of the Cyberjaya Flagship Development Zone phase 1B.

6.3.7.1 The Existing and Committed Development

(1) The concept of the Cyberjaya development emphasises the following characteristics:

- Intelligent City
- City In A Garden
- Neighbourhood Concept

FIGURE 6.9
COMMITTED LANDUSE
CYBERJAYA



LEGEND :-

- ADMINISTRATION/OFFICE
- ENTERPRISE
- MIXED DEVELOPMEND
- OPEN SPACE/RECREATION
- LAKE/POND
- OTHERS
- ROAD RESERVE
- LAKE CATCHMENT BOUNDRY

N

SCALE 1 : 14000

TITLE :-
CYBERJAYA LANDUSE
CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

- Environmental Friendly
- Efficient Transportation System
- Effective Public Utility
- Green Belt Concept

(2) The land-use of this area are for housing, commercial, administration centre etc. with emphasis on open space, which is more than 30%. The breakdown of land-uses is shown in Table 6.5.

6.3.7.2 Physical Characteristic

The site is hilly towards the Putrajaya lake and ranges between 25 to 50 meter. There is also provision for 51 acres of Lake in the development, complete with gross pollutant traps.

6.3.7.3 Site Potentials and Constraints

(1) The site has been committed with low density mixed development, which is in line with the Putrajaya development and policies underlined in the Putrajaya and Sepang Structure Plan. The development principles of Cyberjaya in terms of environmental considerations are;

- Low density development, well landscaped features and environmentally-friendly,
- Development emphasis on free standing buildings,
- Energy saving, clean and pollutant free activities.

(2) The MSC guideline also stated that Cyberjaya should follow the world-class environmental standards and guideline, and only R&D activities are allowed. Industries are strictly prohibited.

Table 6.5 Existing and Committed Land-use for Cyberjaya

Landuse/Activities	Area (acre)	Percentage (%)
B. BUILDINGS		
- **Offices**	*66.45*	*27.40*
- **Housing**	*121.45*	*50.08*
- **School**	*6.05*	*2.49*
- **Commercial**	*12.15*	*5.01*
- **Other Public Facilities**	*36.43*	*15.02*
Total	***242.53***	***39.96***
B. GREEN AREAS		
- **Open Space/Green**	***104.22***	*88.86*
- **Recreation**	***13.07***	*11.14*
Total	***117.29***	***19.32***
D. WATER BODY		
- **Lake**	*51.03*	*100.00*
Total	***51.03***	***8.40***
D. INFRASTRUCTURE		
- **Express Rail Link (ERL)**	***35.77***	*18.23*
- **Highway**	***81.85***	*41.72*
- **Roads & Drainage**	***48.22***	*24.58*
- **Others**	***30.35***	*15.47*
Total	***196.19***	***32.32***
Total Lake Catchment Area	***607.04***	***100.00***

6.3.8 Sungai Merab Malay Reserve

The Sungai Merab Malay Reserve is located on the eastern side of Putrajaya (adjacent to Putrajaya housing development) at Kampung Tengah which covers only 89.60 acres of agriculture lands.

6.3.8.1 Existing and Committed Development

Currently, there is no development around this area. The existing land-use is rubber tree cultivation and 5 numbers of village houses.

6.3.8.2 Physical Characteristic

17 lots are affected within the catchment. The topography of this area is sloping down towards Precinct 15 of Taman Jati and Precinct 16 (Putrajaya). The highest point is about 100 feet.

6.3.8.3 Site Potentials & Constraints

Sungai Merab Malay Reserve is predominantly residential zones where smart homes and smart schools will be located as stated in the MSC guideline. This area will also be the test-bed for electronic innovations and information technology. All Malay Reserve, especially the Sg. Merab Village are deemed approved for enterprise, residential, commercial and social facilities development, as stated in the Structure Plan policy, Putrajaya and MSC guidelines. They are required to support the Putrajaya development and preserve it's environment.

6.3.9 Universiti Tenaga Nasional (UNITEN)

This area is located at the north-eastern edge of the lake catchment adjacent to West Country. The existing land-use is rubber tree cultivation. The area within the catchment is only 93.80 acres.

6.3.9.1 Existing and Committed Development

Currently there is a rubber tree estate with slopes of 5 – 20 degrees. UNITEN has been zoned as institutional with academic and R&D development.

6.3.9.2 Physical Characteristic

The topography of UNITEN is hilly and ranges between 70 to 80 meter and slopes to the western area. The dominant land use is agriculture.

6.3.9.3 Site Potentials & Constraints

The Structure Plan has zoned UNITEN under Sungai Merab, Bangi Institutional Area with green and low-density development. Therefore, UNITEN should be developed along the same concept as UPM, which is to preserve the greens within a low-density development.

As the institutional zone, UNITEN will be developed as a collaborative cluster of academic institutions and R&D Centre.

6.3.10 Comments on the existing developments

6.3.10.1 The following are the Consultants comments on the existing developments, based on the information compiled todate.

- The stakeholders in general follow the concept of the Putrajaya development, which emphasises the preservation of the green and environmental friendly environment.
- Some of the stakeholders are in the process of developing their land or are in the process of applying for development planning approval for land.
- Most of the highway network and rail link have been committed on the stakeholder land.

6.3.10.2 Generally, the existing land-use of the lake catchment is still under control and in line with the concept proposed by Putrajaya development and within the policies of the Structure Plan and existing Guidelines. However, expansion of development or future plans from the stakeholder especially MARDI, UPM, West Country and in the Sg. Merab Malay Reserve (others are committed) need to be taken into consideration. They are as follows;

UPM

- It's masterplan has indicated plans for the expansion for sports complexes, hospital, faculty complexes and flexible development zones.

MARDI

- To develop into an effective Research & Development Centre on agriculture, with farms and orchards complex.

TNB

- There are no proposed development for this area. It has been fully utilised and there is a buffer zone of green areas to cater for emergency events.

IOI

- This site has been fully committed with low-density development. The development is in line with the Putrajaya development concept.

West Country Berhad

- It has plans for low-density housing developments in the areas within the lake catchment.

Cyberjaya

- The areas within the Lake Catchment have been committed with mixed development. The development is in line with the overall concept of Putrajaya.

Sungai Merab

- The development of Malay Reserve areas is to be encouraged for housing. However, other developments such as commercial, recreation, golf course, tourism etc. have to be screened thoroughly to ensure the development concept for the Putrajaya and Sepang Structure Plan and to support the Putrajaya development and preserve it's environment.

UNITEN

- The future development will be academic and R&D purposes as have been zoned in the development plan.

6.4 THE DEVELOPMENT STRATEGY AND CONCEPT

6.4.1 Introduction

6.4.1.1 The development strategy for the Putrajaya Lake Catchment is based on the concept of a harmonious relationship between Man and His Creator, Man and Man, Man and Technology, and Man and the Environment.

6.4.1.2 The development concept has taken into consideration all factors that has risen in the preparation of the development forms based on planning principles. Figure 6.10 shows the concept for the lake catchment development.

6.4.2 Development Component

6.4.2.1 Generally the development component for the lake catchment can be described as follows;

- Institutional Use
- Low Density Housing
- Park & recreation
- Farm & Orchards
- Lake/pond

Institutional

- Academic Use
- Sport & Recreation
- R & D Centre
- Hospital
- Other Facilities

Buffer zone

- 30m Buffer Along The Utilities

Utilities

- TNB Station
- Buffer Zone

Low Density Housing

- Bungalow
- Semi-Detached
- Resort
- Golf Course
- Commercial

Mixed Development

- Housing
- Office
- Commercial
- Green & Recreation

Low Density Housing

- Low Density Housing (6 Unit Per Acre)

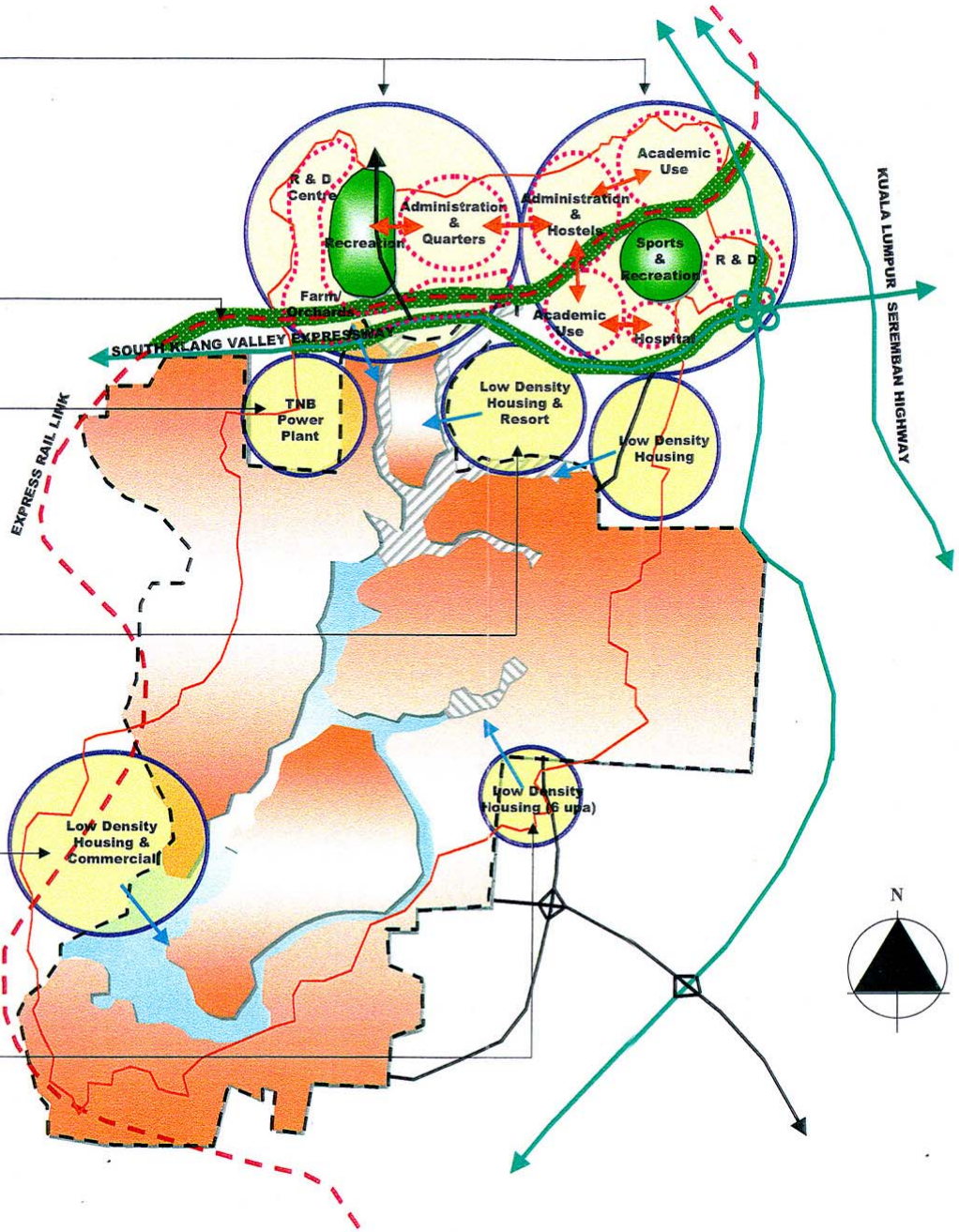


FIGURE 6.10
CONCEPT PLAN

- Inter Network Linkages
- Water Discharge
- Expressway
- Express Rail Link
- Road
- Lake Catchment Boundary
- Buffer Strip

6.4.2.2 Institutional Use

In line with the MSC and Putrajaya development, the lake catchment was proposed as a collaborative cluster of research institutions concentrating on IT research and learning within an R&D Centre. The development is to be concentrated to the North of the Lake Catchment.

6.4.2.3 Low Density Housing

Development with high-tech infrastructure and social facilities to create an excellent living environment with clean and pollutant free activities. The development also gives emphasis on well-landscaped features and is to be environmental-friendly.

6.4.2.4 Park & Recreation

In line with the objective to create and harmonise the development with the environment, parks and recreation areas have also been proposed e.g. cyber park, forest park, golf course and sport complexes.

6.4.2.5 Farms & Orchard

The development of MARDI will be based on the concept of green lung so as to support the development of Putrajaya. The development will be focussed on introducing to the public a love for nature. The emphasis of the developments will be on education, upgrading of the environment, public recreation (forest park) and encouragement of agro-based entrepreneur.

6.4.2.6 Lake/pond

Development within the lake catchment areas will be based on these water bodies which are the essential elements that will create the natural environment in the area. It will also be used for water recreational activities, e.g. canoeing, fishing, boating etc.

6.4.3 Rationale & Justification

6.4.3.1 The factors that form the development strategy and concept are as follows;

- The Structure Plan policies states that low-density development which is in line with the Putrajaya development concepts are to be carried out. The Plan also emphasizes the need to preserve the environment and create a green landscape. The pertinent policies are;

  - Development without negative impact to the environment.
  - Preservation of forest reserve and water catchment areas.
  - Recreation and open space reservation in future developments.
  - Preservation of water sources.
  - Landscaped utility reserves.

- Potential land that can be developed is about 2,098 acres (850 ha) (48%), which gives space to various scales of development.

- Natural assets e.g. hills, rivers, ponds and agriculture can be created to achieve the "World Class Environment".

- Infrastructure Plans, e.g. Express Rail Link (ERL), South Klang Valley Expressway (SKVE) and main roads that pass through the study area can be used to encourage and facilitate future development.

- Existing developments, e.g. the Institutional Zone, R&D and green areas have given a unique identity to the area which are in line with the Putrajaya development.

6.5 THE PROPOSED LAND-USE MASTERPLAN

6.5.1 Introduction

6.5.1.1 The integrated land-use masterplan for the catchment is described under the analysis for the zoning plan below. The analysis is based on the results from the various studies, such as existing and committed development, physical characteristic, environmental or sensitive area, drainage and geology. Furthermore, the Putrajaya and MSC guidelines and the Structure Plan policies have also been incorporated to form the Lake catchment masterplan.

6.5.1.2 The Lake catchment masterplan gives emphasis on integrated and sustainable development. It is shown in Figure 6.11 and the land-use tabulated in Table 6.6. Basically the future development in the lake catchment will be concentrated in the areas of UPM, MARDI and in the Sungai Merab Malay Reserve. The other stakeholders have already committed their developments and there is only a need to monitor their development implementations.

6.5.2 Zoning Plan

6.5.2.1 UPM

(1) UPM is zoned under Institutional with ample green area and low density mixed development. Therefore UPM can be developed in a manner to preserve the greens with low-density development.

(2) It is proposed that UPM will serve as the R&D Centre and will be a collaborative cluster of academic institutions which offer courses on information technology and corporate R&D centres as shown in Figure 6.12. UPM will undertake research and development oriented industries which require close co-operation with academic and research institution equipped with facilities for laboratory testing, R&D, and skill training centres. An example of such collaboration is the MTDC-UPM Incubation Centre. The existing pond/lake can also be upgraded as a recreational centre for public use, as illustrated in Illustration 6.1.

TABLE 6.6 : PROPOSED LANDUSE MASTERPLAN FOR PUTRAJAYA LAKE CATCHMENT (ACRE)

LAKE CATCHMENT AREA (Acre)	UPM	%	MARDI	%	IOI	%	TNB	%	WEST COUNTRY	%	CYBER JAYA	%	SUNGAI MERAB	%	UNITEN	%	TOTAL	%
A. BUILDINGS																		
Administration/Offices	-	-	151.38	57.48	-	-	-	-	-	-	66.45	27.40	-	-	-	-	217.83	11.84
Hostels/College	213.68	29.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	213.68	11.62
Housing/Quarters	-	-	19.30	7.33	132.20	82.14	-	-	236.26	100.00	121.45	50.00	89.60	100.00	-	-	598.81	32.56
Commercial	-	-	-	-	17.46	10.86	-	-	-	-	12.15	5.01	-	-	-	-	29.61	1.61
Academic/R&D	312.89	43.23	-	-	-	-	-	-	-	-	-	-	-	-	93.80	100.00	406.69	22.11
Power Station	-	-	-	-	-	-	28.95	100.00	-	-	-	-	-	-	-	-	28.95	1.57
Facilities	197.25	27.25	92.68	35.19	11.27	7.00	-	-	-	-	42.48	15.02	-	-	-	-	343.68	18.69
TOTAL	723.82	50.94	263.36	22.93	160.93	30.77	28.95	12.98	236.26	61.96	242.53	39.96	89.60	100.00	93.80	100.00	1,839.25	41.97
B. GREEN AREAS																		
Open Space/Field Recreation	189.66	49.28	183.49	26.82	5.82	2.61	-	-	17.66	-	110.06	100.00	-	-	-	-	506.69	31.16
Golf Course	186.51	48.46	-	-	216.90	97.39	-	-	-	-	-	-	-	-	-	-	403.41	24.81
Farms	-	-	141.21	20.64	-	-	-	-	-	-	-	-	-	-	-	-	141.21	8.68
Orchards	-	-	354.96	51.88	-	-	-	-	-	-	-	-	-	-	-	-	354.96	21.83
Buffer Zone	8.67	2.25	4.51	0.66	-	-	194.03	100.00	5.34	23.22	7.23	-	-	-	-	-	219.78	13.52
TOTAL	384.84	27.09	684.17	59.57	222.72	42.59	194.03	87.02	23.00	6.03	117.29	19.32	-	-	-	-	1,626.05	37.11
C. WATER BODIES																		
Pond/Lake	24.18	100.00	56.02	81.78	7.00	14.29	-	-	18.30	100.00	51.03	100.00	-	-	-	-	156.53	76.91
Wetland	34.51	-	12.48	-	-	85.71	-	-	-	-	-	-	-	-	-	-	46.99	23.09
TOTAL	58.69	4.13	68.50	5.96	7.00	21.41	-	-	18.30	4.80	51.03	8.40	-	-	-	-	203.52	4.64
D. INFRASTRUCTURE																		
Roads/Drainage	61.57	24.29	53.32	40.24	24.47	89.63	-	-	55.27	53.26	48.22	24.58	-	-	-	-	242.85	34.05
Express Rail Link	73.86	29.13	48.32	36.47	-	-	-	-	-	-	35.77	18.23	-	-	-	-	157.95	22.14
Highway	118.08	46.58	30.85	23.28	-	-	-	-	47.20	45.49	81.85	41.72	-	-	-	-	277.98	38.97
Others	-	-	-	-	2.83	10.37	-	-	1.30	1.25	30.35	15.47	-	-	-	-	34.48	4.83
TOTAL	253.51	17.84	132.49	11.54	27.30	5.23	-	-	103.77	27.21	196.19	32.32	-	-	-	-	713.26	16.28
GRAND TOTAL	1,420.86	100.00	1,148.52	100.00	417.95	100.00	222.98	100.00	381.33	100.00	607.04	100.00	89.60	100.00	93.80	100.00	4,382.08	100.00

FIGURE 6.11
PROPOSED INTEGRATED LANDUSE MASTERPLAN

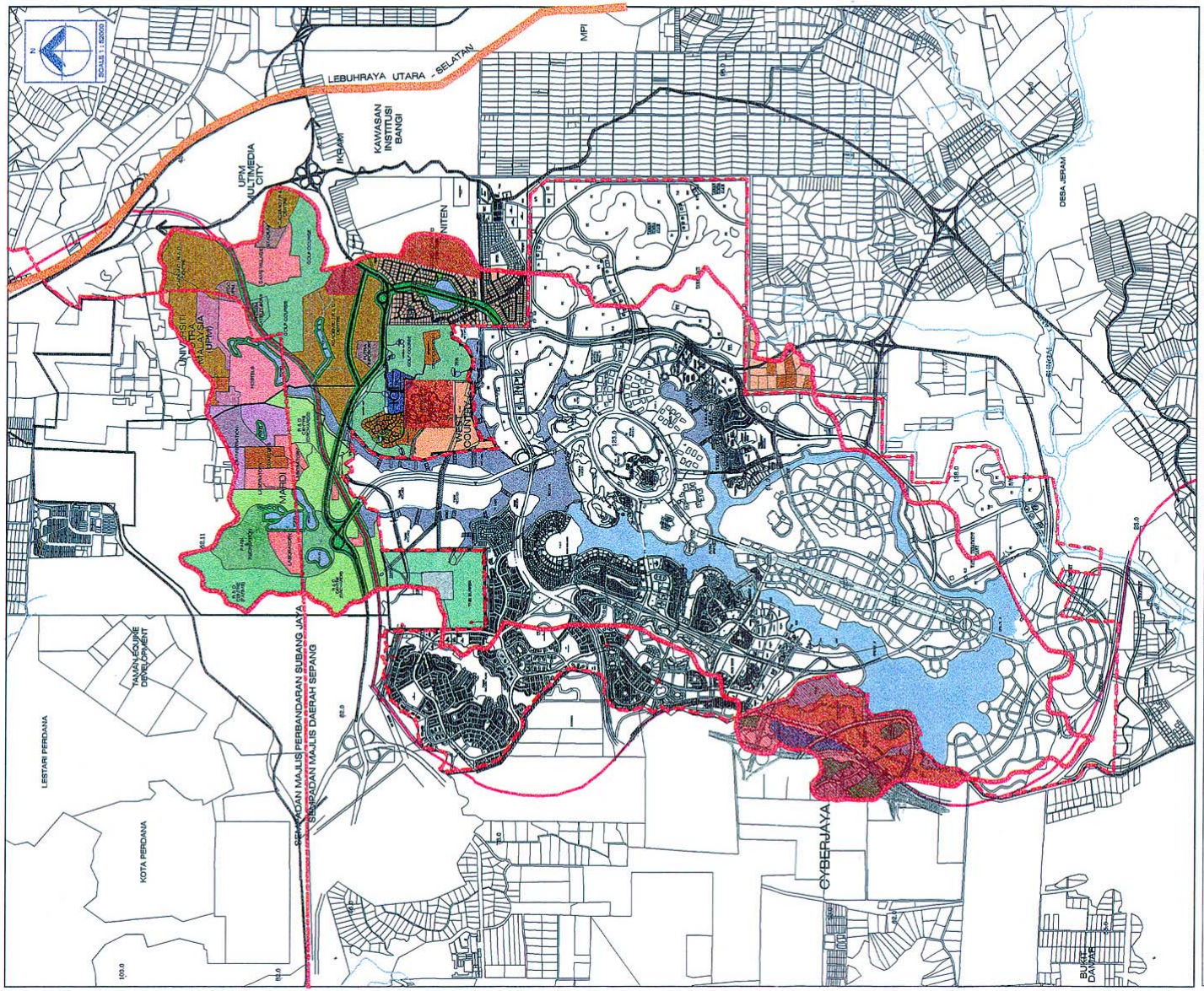


FIGURE : PROPOSED INTEGRATED LANDUSE MASTERPLAN

CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN FOR PUTRAJAYA LAKE

LEGEND :-

BUILDINGS	EXISTING ACRE	COMMITTED ACRE	PROPOSED ACRE	FUTURE LANDUSE	%
HOUSING / QUARTERS	161.47	197.47	303.46	596.61	32.71
COMMERCIAL	17.46	12.15	-	29.61	1.62
HOSTELS/COLLEGE	59.76	-	153.82	213.58	11.87
TNB POWER STATION	28.95	-	-	28.95	1.58
ADMINISTRATION/OFFICE	71.12	66.45	80.26	217.83	11.93
ACADEMIC/R & D	-	-	406.69	406.69	22.22
FACILITIES	92.35	66.06	165.27	343.68	18.29
TOTAL	371.11	369.13	1109.74	1830.96	41.77
GREEN					
AGRICULTURE	542.33	-	-	-	
GOLF COURSE	403.41	-	403.41	403.41	26.23
BUFFER ZONE	194.03	-	25.75	219.78	13.84
ORCHARDS	742.96	-	354.96	354.96	22.20
FARMS	723.58	-	141.21	141.21	8.83
OPEN SPACE/RECREATION	246.23	117.29	163.36	506.89	29.91
TOTAL	2970.53	117.29	1061.72	1599.06	36.40
WATER BODIES					
LAKE/POND	63.29	51.03	42.22	156.53	76.91
WETLAND	46.98	-	-	46.98	23.09
TOTAL	110.27	51.03	42.22	203.52	4.64
OTHERS					
ROAD/DRAINAGE	242.85	-	-	242.85	32.42
EXPRESS RAIL LINK	-	157.95	-	157.95	21.09
HIGHWAY	-	277.96	-	277.96	41.86
OTHERS	34.48	-	-	34.48	4.60
TOTAL	277.33	471.76		749.09	17.09
GRAND TOTAL				4382.06	100.00

BOUNDARY	ACRE	HECTAR
PUTRAJAYA	10,600	4,289.67
SURROUNDING PUTRAJAYA	4,382.06	1,773.37
TOTAL LAKE CATCHMENT	14,982.06	6,063.04

FIGURE 6.12
UNIVERSITI PUTRA MALAYSIA
LANDUSE ZONING

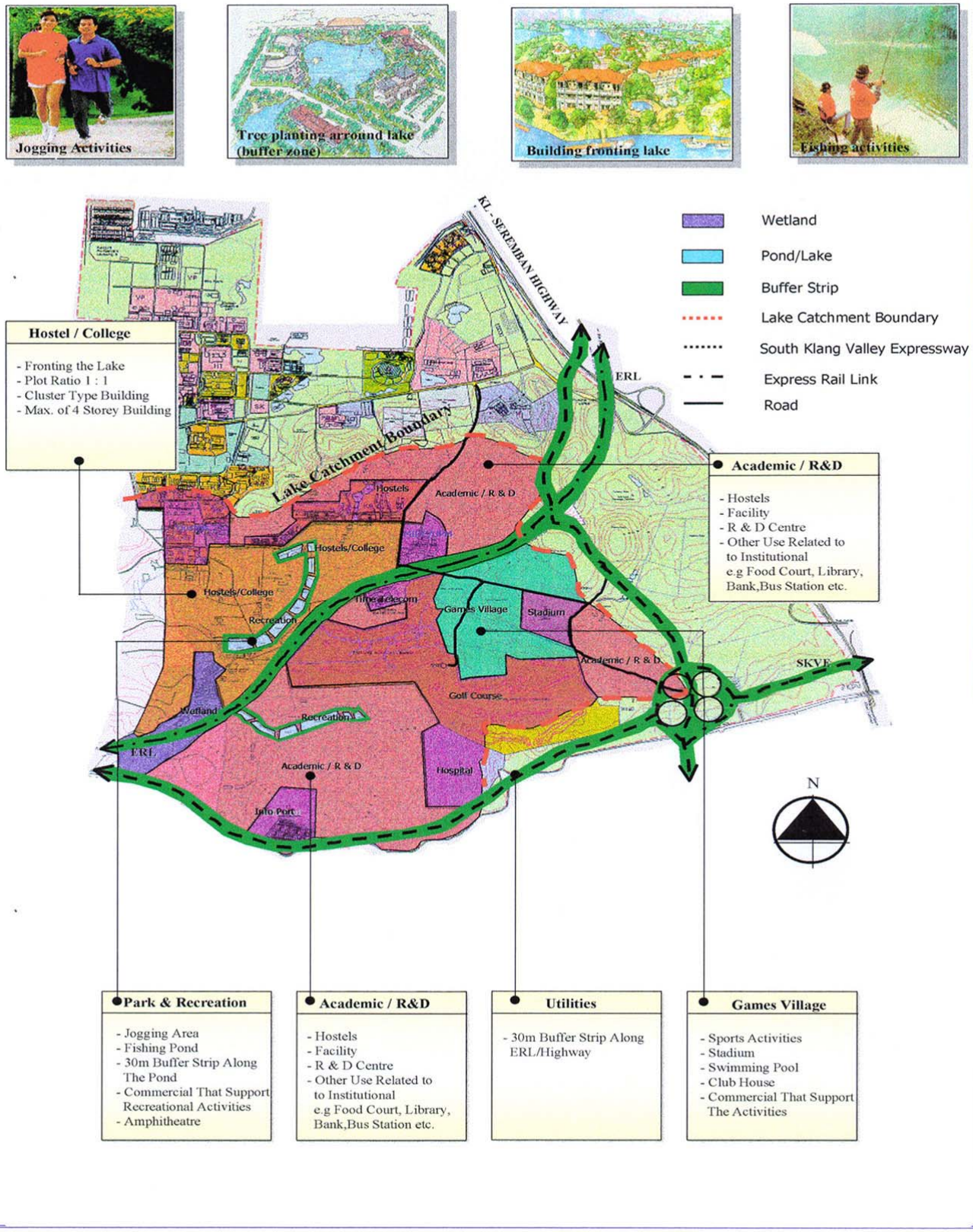


ILLUSTRATION 6.1 :
UPM RECREATION
LAKE & PARK

6.5.2.2 MARDI

MARDI will also be zoned under R&D centres with green lung concept for agriculture with complexes of farms, orchards complex for agricultural education and experimental, public forest park purposes as shown in Figure 6.13. Illustration 6.2 also shows the types of activities at the forest park..

6.5.2.3 Sungai Merab

The section of the Sungai Merab Malay Reserve areas that lies within the catchment are proposed for enterprise, residential, commercial and social facilities development to support the Putrajaya development and preserve the environment with minimal pollution.

6.5.3 Use Class Order

The development in the lake catchment should also be controlled under the use class order listed in Table 6.7.

6.6 LAND-USE CONTROL GUIDELINES

6.6.1 Introduction

The land-use control guidelines are as follows;

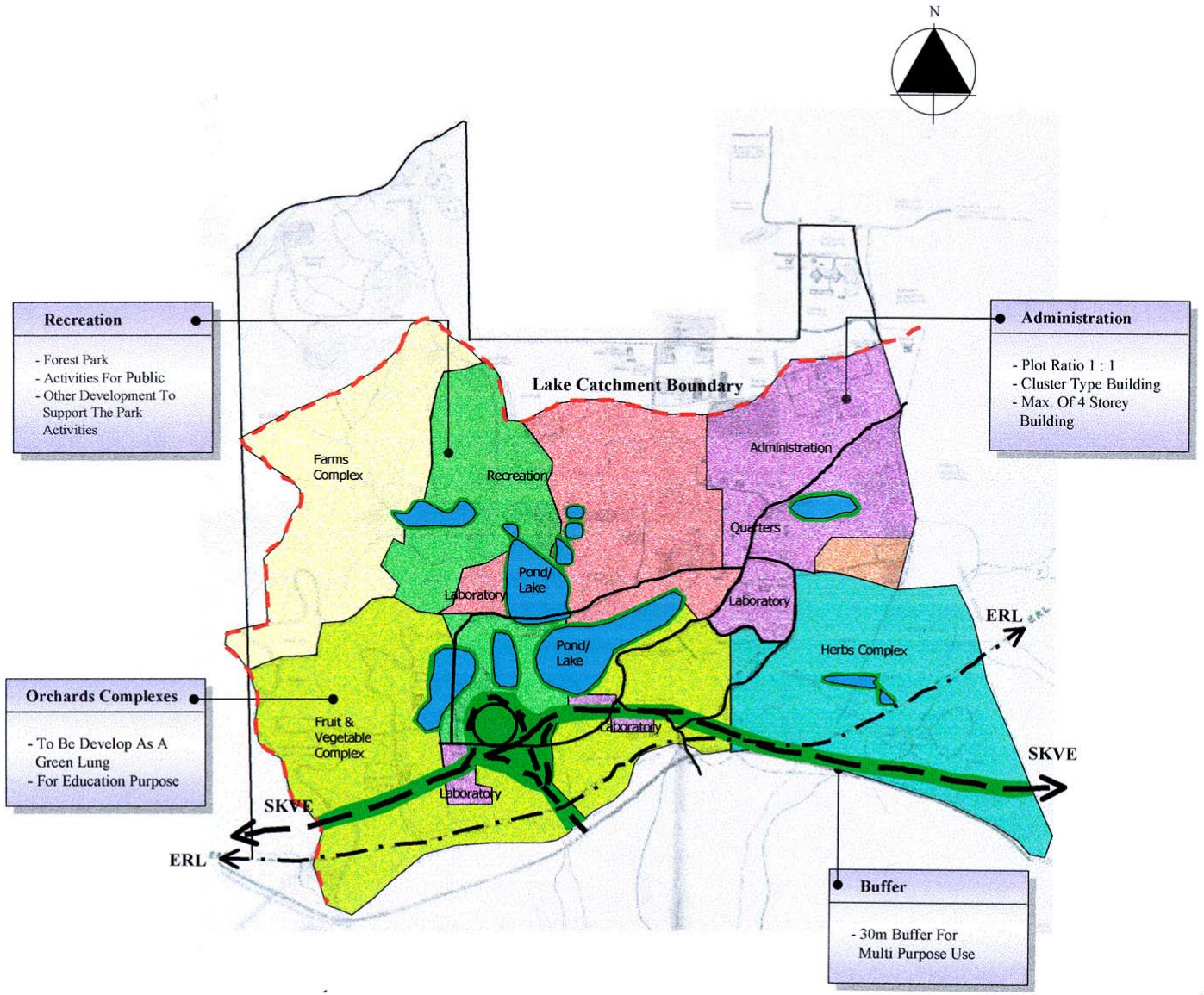
- Preservation and Conservation of Environmentally Sensitive Areas
- Protection of rare, endemic and endangered species
- Pollution Prevention and Minimisation
- Water Conservation

6.6.2 Existing Guidelines

The following generic guidelines should be adopted for any development proposals within the catchment, namely;

- The Environmental Quality Act, 1974 and all regulations made thereunder
- Guidelines on Environmental Impact Assessment: Procedure and Requirement in Malaysia, Department of Environment (1995)
- 'Garis Panduan Konsep Pembangunan berhadapan Sungai', Jabatan pengairan dan Saliran (1995)
- Guidelines for Prevention and Control of Soil Erosion and Siltation, Final Draft, Department of Environment (1996)

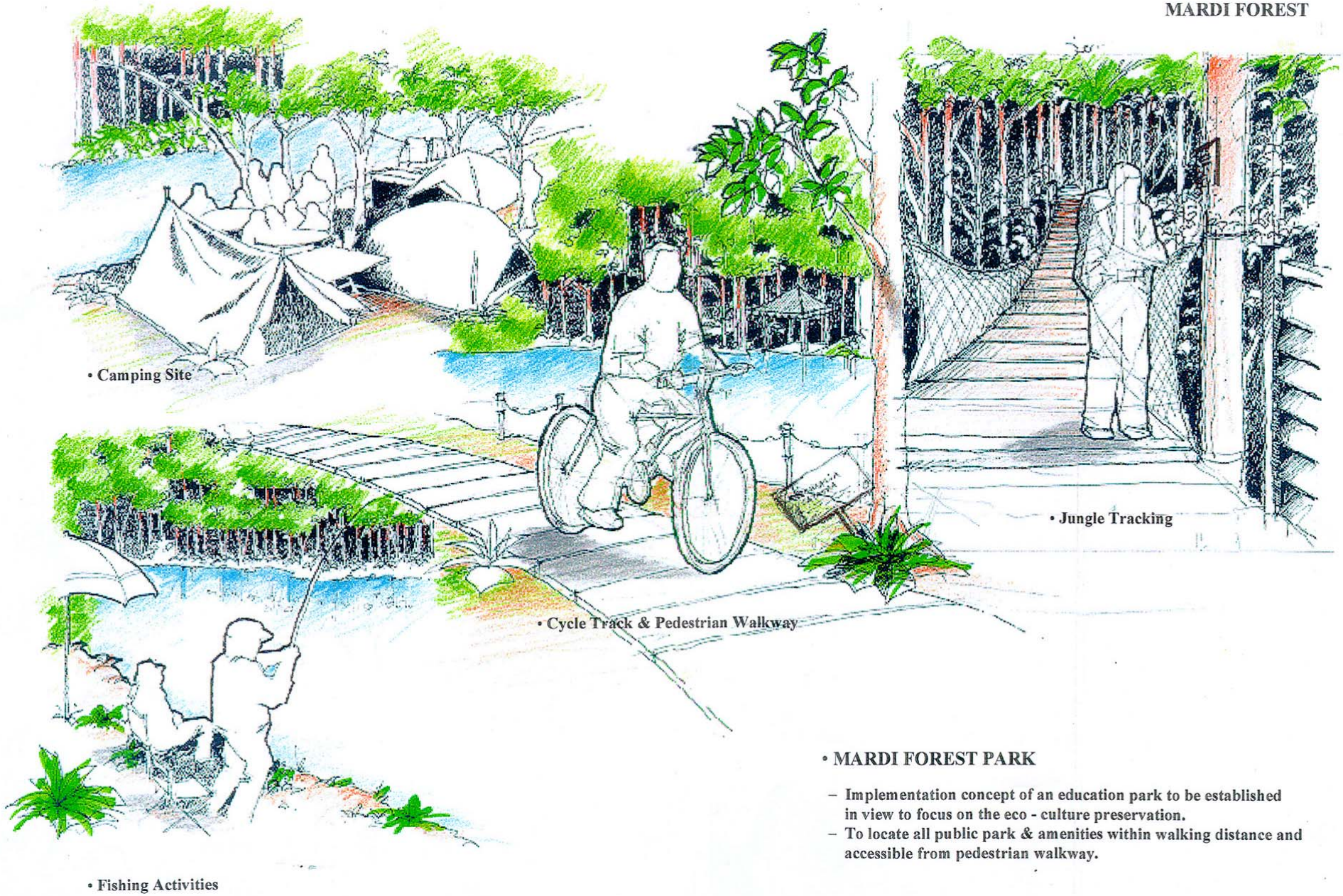
FIGURE 6.13
MARDI
LANDUSE ZONING



- R & D Institutional
- Committed Development
- Farms Complex
- Fruit and Vegetable Complex
- Herbs Complex
- Flowers Complex
- Agro Forestry Park
- Pond/Lake
- Buffer Strip
- South Klang Valley Expressway
- Express Rail Link
- Road
- Lake Catchment Boundary

ILLUSTRATION 6.2 :

MARDI FOREST



• **MARDI FOREST PARK**

- Implementation concept of an education park to be established in view to focus on the eco - culture preservation.
- To locate all public park & amenities within walking distance and accessible from pedestrian walkway.

TABLE 6.7: LAKE CATCHMENT LANDUSE MASTERPLAN – USE CLASS ORDER

LAKE CATCHMENT AREA (PLOT)	PERMITTED USE	PERMITTED WITH CONDITION		NON PERMITTED USE
UPM	**INSTITUTIONAL**	**Activities**	**Conditions**	
Institutional Centre Total Area: 1,420.86 acre	• Hostels/College • Faculty • Administration Centre • R&D Centre • Farms & Orchards • Open Space/Feild • Library • Laboratory	• Hospital • Staff Quarters • Supporting Commercial - Bank, Shop, Food court, clinic etc. • Mosque • Pedestrian walk • Buffer Zone • Sewage Treatment Plant • Road/Drainage • Highway/ERL	• To comply with Guidelines - Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Enhance and introduce riparian buffer strips (non-point BMP) • Medical/laboratory wastes should be discharged out of the catchment • Shoreline & riparian buffer are planned along drainage lines & the lake. • Install mitigating measures to prevent pollutant input from the roads crossing the wetland • Fetilizer & pesticide use is controlled and monitored. • Stream flow to be preserve • Turfing of cleared land to carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Land earthwork clearing more than 15% of catchment at anyone time • Development with pollution - excess fertilizers, herbicides, and insecticides from agricultural lands and parks - bacteria and nutrients from livestock, wildlife, pet wastes and sewerage system
MARDI	**REASEARCH CENTRE**	**Activities**	**Conditions**	
Research Centre Total Area: 1,148.52 acre	• Administration Office • R&D Centre • Laboratory • Store • Farms & Orchards • Nursery	• Staff Quarters • Hostels • Supporting Commercial - Canteen, Food court, etc. • Buffer zone • Recreation/Open Space • Lake/pond • Road/Drainage • Highway/ERL	• To comply with Guidelines - Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Enhance and introduce riparian buffer strips (non-point BMP) • Utilise constructed ponds to retain drainage and stream flows • Laboratory wastes should be discharged out of the catchment • Shoreline & riparian buffer are planned along drainage lines & the lake. • Install mitigating measures to prevent pollutant input from the roads crossing the wetland • Stream flow to be preserve • Turfing of cleared land to carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Land earthwork clearing more than 15% of catchment at anyone time • Development with pollution - excess fertilizers, herbicides, and insecticides from agricultural lands and parks • bacteria and nutrients from livestock, wildlife, pet wastes and sewerage system

LAKE CATCHMENT AREA (PLOT)	PERMITTED USE	PERMITTED WITH CONDITION		NON PERMITTED USE
IOI	**HOUSING & RECREATION**	**Activities**	**Conditions**	
Country Homes & Golf Course Total Area: 417.95 acre	• Low Density Housing - Bungalow lots • Sports and recreations • Open Space/Feild	• Neighbourhood Commercial - Club House - Nursery Centre - Health Club - Shops - Clinic • Golf Course • Road/Drainage	• To comply with Guidelines - Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Low Medium Density Development • Enhance and introduce riparian buffer strips (non-point BMP) • Development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring and re-evaluation of impacts. • Providing Flood Detention Pond • Fetilizer & pesticide use is controlled and monitored • Stream flow to be preserved • Turfing of cleared land to carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Development with pollution - sediment from improperly managed construction sites and eroding stream banks. • Development on slope with more than 20% (except recreations)
TNB	**FACILITIES**	**Activities**	**Conditions**	
Power Station Total Area: 222.98 acre	• Power Plant • Green Network - Reserve for electric line - Buffer Zone	• Recreation • TNB Facilities • Open Space/Feild	• To comply with Guidelines - Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Enhance and introduce riparian buffer strips (non-point BMP) • Install mitigating measures to prevent pollutant input from the roads crossing the wetland	• Any development accept TNB use
WEST COUNTRY BHD.	**HOUSING**	**Activities**	**Conditions**	
Housing Total Area: 381.33 acre	• Low Density Housing - Bungalow lots • Sports and recreations •	• Neighbourhood Commercial - Shops, Clinic etc. • Institutional • Lake/pond • Sewage Treatment Plant • Road/Drainage • Highway	• To comply with Guidelines – Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Enhance and introduce riparian buffer strips (non-point BMP) • Development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring • Providing Flood Detention Pond • Fetilizer & pesticide use is controlled and monitored • Stream flow to be preserved • Turfing of cleared land to carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Development with pollution - sediment from improperly managed construction sites and eroding stream banks. • Development on slope with more than 20% (accept recreations)

LAKE CATCHMENT AREA (PLOT)	PERMITTED USE	PERMITTED WITH CONDITION		NON PERMITTED USE
CYBERJAYA	**HOUSING & OFFICES**	**Activities**	**Conditions**	
Mixed Housing & Offices Total Area: 607.04 acre	• Low & Medium Density Housing • Commercial - shops, clinic, bank, food court etc. • Offices • Open Space/Feild •	• Institutional • Commercial • Public facilities • Recreation • Lake/pond • Sewage Treatment Plant • Road/Drainage • Highway/ERL	• To comply with Guidelines – Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Enhance and introduce riparian buffer strips (non-point BMP) • Development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring and re-evaluation of impacts. • Providing Flood Detention Pond • Fetilizer & pesticide use is controlled and monitored • Stream flow to be preserved • Turfing of cleared land to carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Development with pollution - sediment from improperly managed construction sites and eroding stream banks. • Development on slope with more than 20% (accept recreations)
UNITEN	**INSTITUTIONAL**	**Activities**	**Conditions**	
Institutional Centre Total Area: 93.80 acre	• Hostels/College • Faculty • Administration Centre • R&D Centre • Farms & Orchards • Open Space/Feild • Library • Laboratory	• Staff Quarters • Supporting Commercial - Bank, Shop, Food court, clinic etc. • Mosque • Pedestrian walk • Buffer Zone • Sewage Treatment Plant • Road/Drainage • Highway/ERL	• To comply with Guidelines – Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Enhance and introduce riparian buffer strips (non-point BMP) • Medical/laboratory wastes should be discharged out of the catchment • Development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring and re-evaluation of impacts. • Install mitigating measuresss to prevent pollutant input from the roads crossing the wetland • Fetilizer & pesticide use is controlled and monitored • Stream flow to be preserved • Turfing of cleared land to be carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Land earthwork clearing more than 15% of catchment at anyone time • Development with pollution - excess fertilizers, herbicides, and insecticides from agricultural lands and parks - bacteria and nutrients from livestock, wildlife, pet wastes and sewerage system

LAKE CATCHMENT AREA (PLOT)	PERMITTED USE	PERMITTED WITH CONDITION		NON PERMITTED USE
SUNGAI MERAB VILLAGE	**HOUSING**	**Activities**	**Conditions**	
Housing Total Area: 89.60 acre	• Low Density Housing - Bungalow lots - Cluster - Semi Detached	• Neighbourhood Commercial - Local Shopping Centre • Enterprise Office • Research Centre/Institutional • Small/medium Enterprise related to IT • Open Space & Recreation • Public Facilities • Golf Course • Tourism • Lake/pond • Sewage Treatment Plant • Road/drainage	• To comply with Guidelines - Planning Standard, Lake Catctment, Putrajaya, MSC Guidelines and Sg. Merab Local Plan. • Structure which are complimentary to recreational activities and environment • Enhance and introduce riparian buffer strips (non-point BMP) • Development should occur in stages, planned to extend over 8 to 10 years to allow for monitoring and re-evaluation of impacts. • Providing Flood Detention Pond • Fetilizer & pesticide use is controlled and monitored • Stream flow to be preserved • Turfing of cleared land to carried out • EMP programme must be implemented - soil erosion management programme to be included	• Industry • Development with pollution - sediment from improperly managed construction sites and eroding stream banks. • Development on slope with more than 20% (accept recreations)

Note;
Non Point BMP - Non Point Source of Best Management Practise (as described in Chapter 2.5)
Detail 'Conditions' can be refer in Chapter 2.5 (Assesment of pollutant impact to Putrajaya Lake System)

- Environmental Requirement: A guide For Investors, Department of Environment (1994)
- 'Garis Panduan kawasan Kolam takungan Sebagai Sebahagian tanah Lapang', JPBD (1997)
- Guideline on Development Proposal Report, JPBD (1996)

6.6.3 Lake Catchment Guidelines

6.6.3.1 Generic Guidelines

The design concept of the lake catchment should observe the following general design guidelines;

1. Urban Design

- Creating design characteristics and building types that are compatible and flexible to the needs of a 'high tech' environment, varied life styles and affordability of the users.
- Creating networks of water bodies, green open spaces, public squares, pedestrian walkways and cycle paths as a basic concept in planning.
- Taking into account the natural topography of the area and blending this with the man-made elements in order to preserve the natural environment and to create attractive viewing points or vistas, serial vision, landmarks, balanced and harmonious skyline, etc.
- Creating urban design elements such as boulevards, landmarks, vistas, silhouettes, walkways, serial visions, public open spaces/squares, nodes, courtyards, theme parks, pedestrian malls, etc.
- Creating harmonious linkages between zones and other planned land-use components/activities.
- Promoting medium and low density developments with low rise buildings (except buildings which are planned as landmarks, subject to site development standards).
- Promoting characteristics of beauty, convenience, harmony, health and safety through combinations of land-use components and activities that are compatible and balanced in scale.
- Consists of elements of flexibility and sustainability to cater for the current and future needs without undermining the original goal and design concept of development.

- Orientation and design of buildings which optimise views or use of water bodies and parks, privacy considerations and design art of adjacent buildings. This is illustrated in Illustration 6.3, 6.4 & 6.5.
- Creation of balanced and attractive building skylines which harmonise with the surrounding natural physical features such as hills, water bodies and parks.

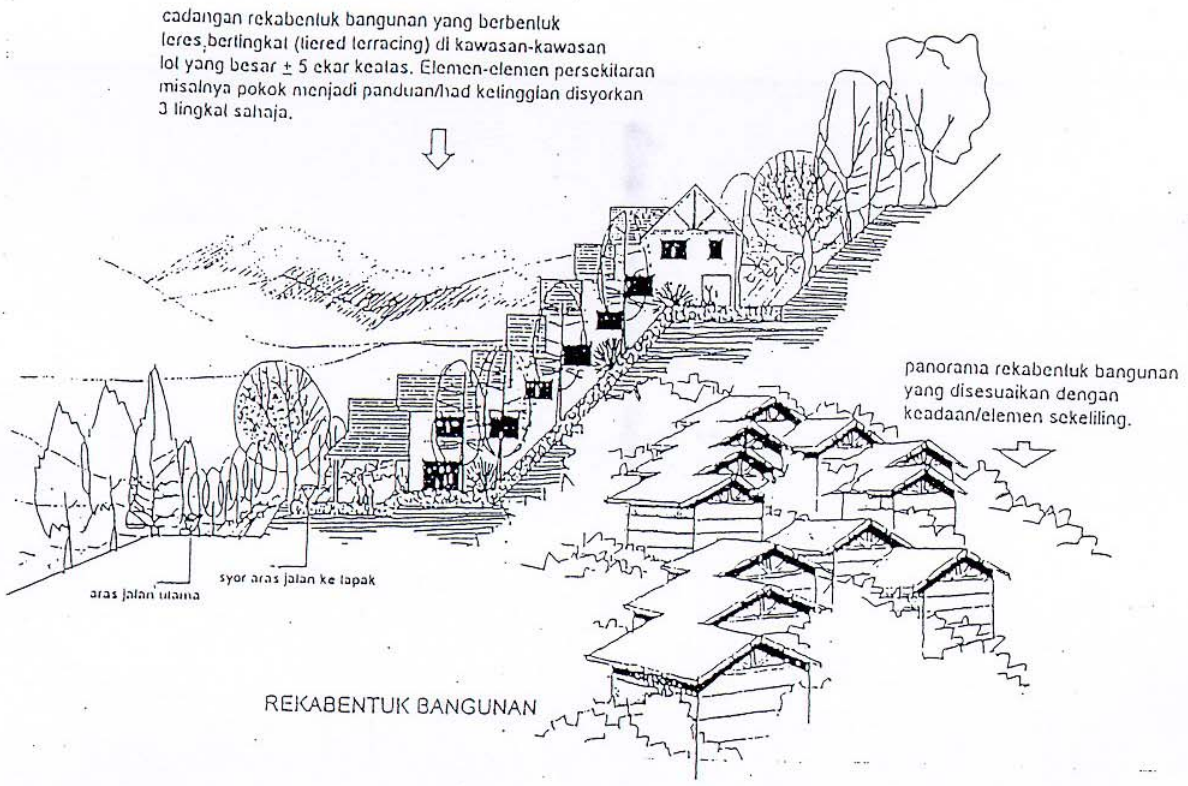
2. Housing

- Residential neighbourhoods shall be based on a residential park concept, and should represent a diverse and user-friendly dwelling types and styles
- Each residential neighbourhood shall be self sufficient in terms of provision of amenities, open space and retail activities as well as having the characteristics of a neighbourly atmosphere.
- Residential developments shall be in harmony with the site conditions, conform to the natural contours of the land and adapt to the surrounding terrain.
- Residential developments shall be designed based on the cluster design to allow for the utilisation of best building sites while preserving environmentally sensitive areas. Monotonous barrack-like layout is not encouraged.
- The orientation of buildings will have to be adapted to the natural vistas of the site to take advantage of the most potential and attractive natural view, sunlight and prevailing breezes.
- Housing development in hill areas would have to observe and abide with the guidelines on Natural Topography Preservation in Physical Planning and Development.

3. Environment

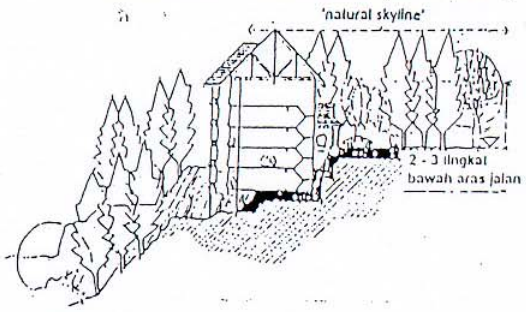
- Enhancement of open spaces, improving ecological functions in terms of biodiversity, wildlife habitats, urban forest and increasing total biomass to act as pollution sinks.
- Priority and greater percentage for public transport, efficient modal integration and maximum use of non-polluting forms of transport, creating more cycling paths and pedestrian-priority areas.

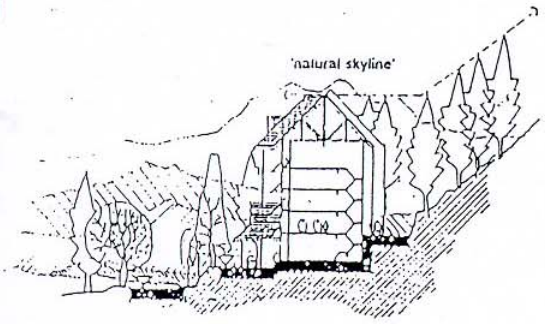
ILLUSTRATION 6.3 : BUILDING OREINTATION AND DESIGN



A. cadangan bangunan dilereng bukit yang curam disyorkan kerja-kerja tanah dihadkan dengan mencadangkan rekabentuk bangunan, teres bertingkat (tiered terracing) dan ketinggian bangunan yang disyor antara 3 hingga 5 tingkat sahaja. Ketinggian bangunan ini disesuaikan dengan elemen persekitaran bagi mengekalkan 'natural skyline'.

B. cadangan bangunan dilereng bukit yang curam, disyorkan kerja tanah dihadkan dgn mencadang rekabentuk bangunan 2 hingga 3 tingkat atas jalan dan 2 hingga 3 tingkat bawah aras jalan, ketinggian bangunan disyorkan 5 hingga 6 tingkat. Bangunan masih disesuaikan dengan elemen persekitaran untuk menjamin 'natural skyline' yang indah.





C cadangan bangunan dilereng kaki bukit atau pun ditanah rata disyorkan bangunan dlantara 3 hingga 5 tingkat sahaja. Ketinggian bangunan disesuaikan dengan elemen persekitaran bagi menguludkan suasana yang berharmoni dengan alam persekitaran.

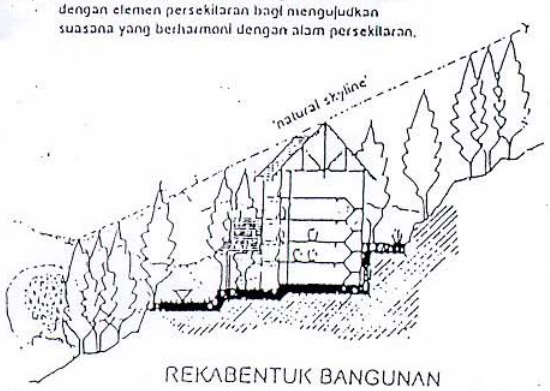
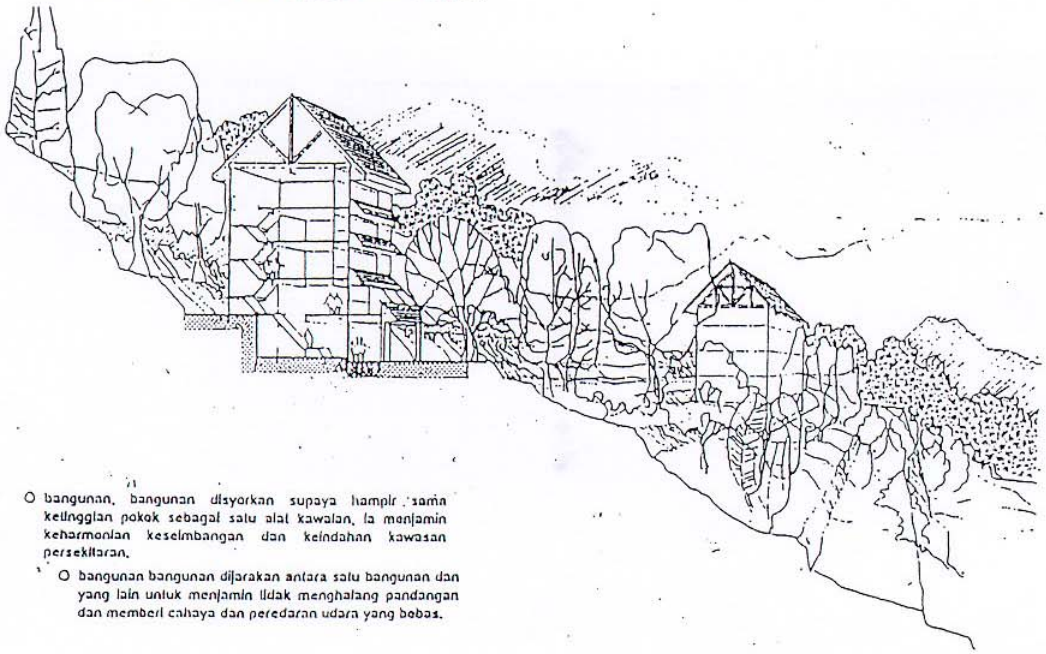


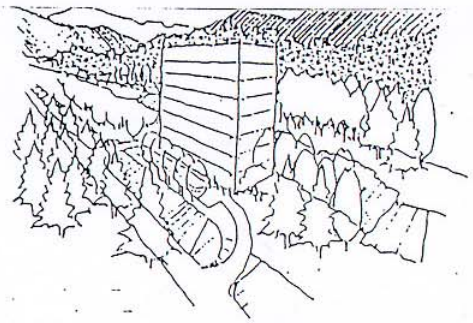
ILLUSTRATION 6.4 : BUILDING OREINTATION AND DESIGN

RAJAH 1d REKABENTUK BANGUNAN

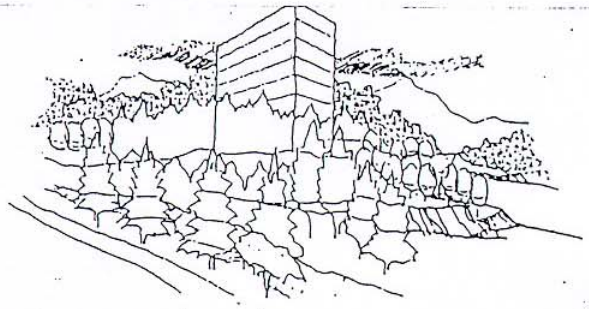


O bangunan, bangunan disyorkan supaya hampir sama ketinggian pokok sebagai satu alat kawalan, ia menjamin keharmonian keseimbangan dan keindahan kawasan persekitaran.

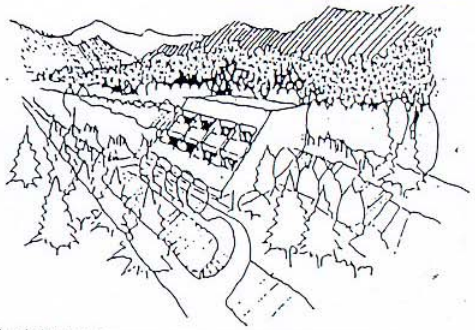
O bangunan bangunan dijarakan antara satu bangunan dan yang lain untuk menjamin tidak menghalang pandangan dan memberi cahaya dan peredaran udara yang bebas.



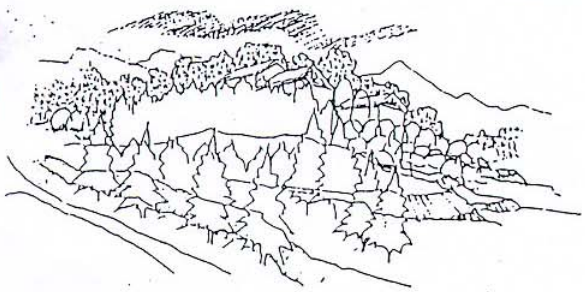
O rekabentuk bangunan yang tidak sesuai di kawasan landai ketinggian bangunan yang tertalu tinggi melebihi ketinggian pokok memberi kesan pandangan 'eye sore'.



O contoh rekabentuk bangunan yang tidak sesuai dikawasan berbukit. Bangunan memuncak kealas melebihi ketinggian menyebabkan kesan yang tidak harmoni dengan keadaan sekeliling.



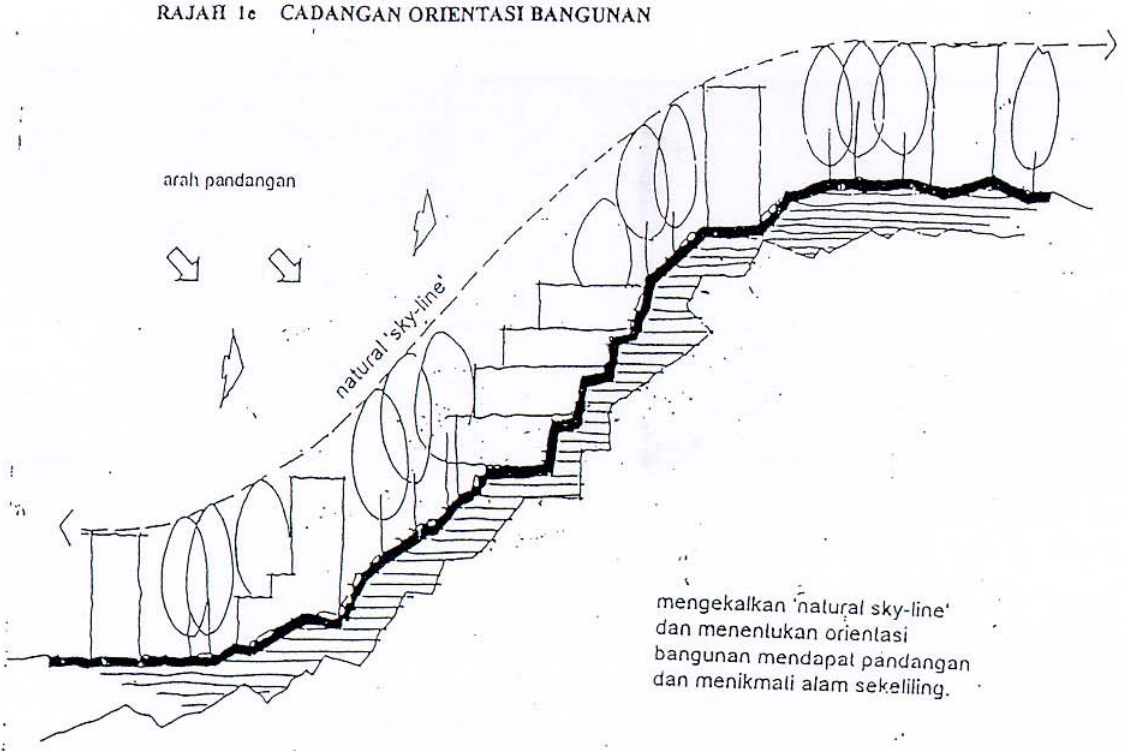
O rekabentuk bangunan yang sesuai dilereng bukit. Aras ketinggian bangunan meningkat mengikut keadaan topografi dan ketinggian bangunan adalah berharmoni/disesuaikan dengan keadaan/elemen sekeliling.



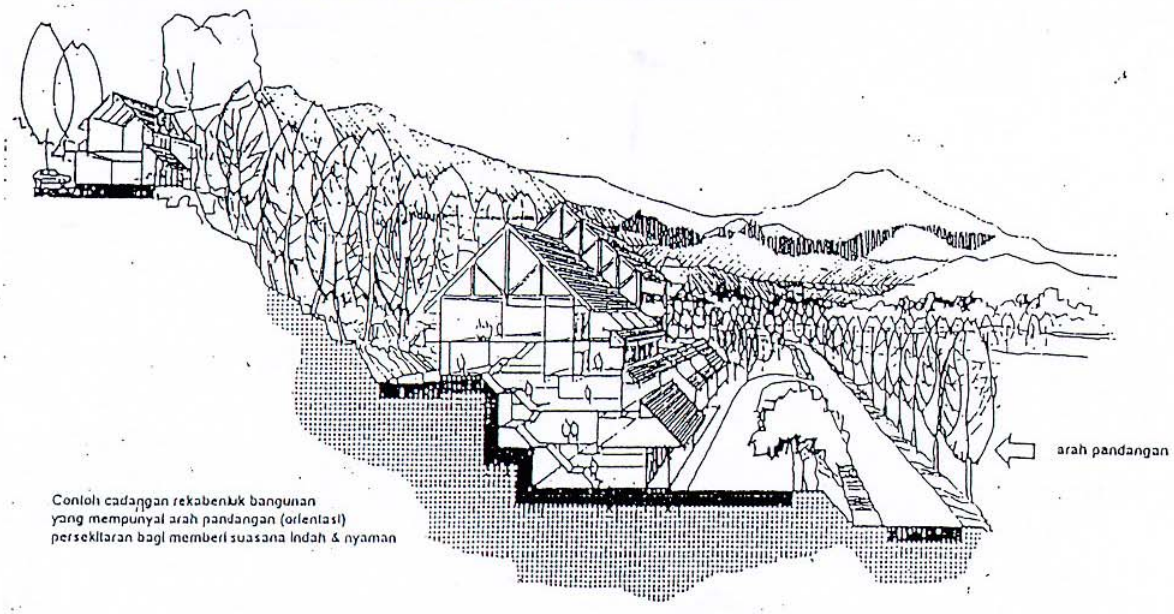
O contoh rekabentuk bangunan dipuncak bukit atau lereng bukit. Bangunan disyorkan supaya disesuaikan dengan pokok-pokok/bukit bagi menjamin 'natural sky line'.

ILLUSTRATION 6.5 : BUILDING OREINTATION AND DESIGN

RAJAH 1e CADANGAN ORIENTASI BANGUNAN



RAJAH 1f CONTOH CADANGAN REKABENTUK ORIENTASI BANGUNAN



- Setback requirements and buffer zones must be incorporated into the planning and design process to reduce adverse environmental impacts.
- Formulate Environmental Management System to continuously monitor and improve quality of air, water and solid waste management.

4. Open Space and Recreation

- Maximising the assets of the natural environment such as the water bodies, particularly ponds and/or lakes, hills and greenery, to create a garden city or Forest Park image wherever relevant.
- Preserve large areas and open spaces sufficient to meet the long-term needs of the lake catchment.
- Develop and maintain a balanced city-wide system of high quality public open space.
- Land for open space and recreational use should not be alienated to any private ownership.
- Open spaces and recreational areas, which can generate economic gains such as Theme Parks, Botanical and Herbal Gardens, should be encouraged.
- Multipurpose open space should be provided for each of the neighbourhood centres. This is mainly to hold public activities such as children's playground or community fairs.
- Other open spaces are reserved for greeneries at the appropriate locations. These may be used as green areas to act as visual barriers and for screening.
- Creating a continuos network of green belts and buffers that run throughout the whole development.
- Functional open spaces should be provided for leisure activities.
- Designs of appropriate open spaces, meeting places, eating areas or place settings such as plazas, promenades, boulevards, open theatre and the like to cater for day to day activities or for festive events, cultural processions or activities.
- Designs to encourage participative, healthy and socio-cultural activities.

- Provide easily accessible and affordable public park amenities, facilities and recreational opportunities for the general public, especially for the under privileged.
- Identify and provide appropriate mechanisms for adequate management and sensitive environmental and ecological areas such as water bodies, wetlands, highlands and steep terrain.

5. Institutional

- Incorporate comprehensive research and educational facilities such as libraries, research centres, information kiosks, educational guides and literatures.
- The institutions within the lake catchment will have a spin-off effect and would benefit supporting Putrajaya development and its environment.
- Preserving and promoting a park-like environment. Intensity in terms of overall gross plot ratios (GPR) with low intensity area with GPR of 0.5 or maximum nett plot ratio of 1:1.
- A minimum requirement of 10% to 15% of total area should be set aside for public open space.
- Plinth area or site coverage permitted to a maximum of 60% of individual site areas.

6. Infrastructure and Utilities

Roads

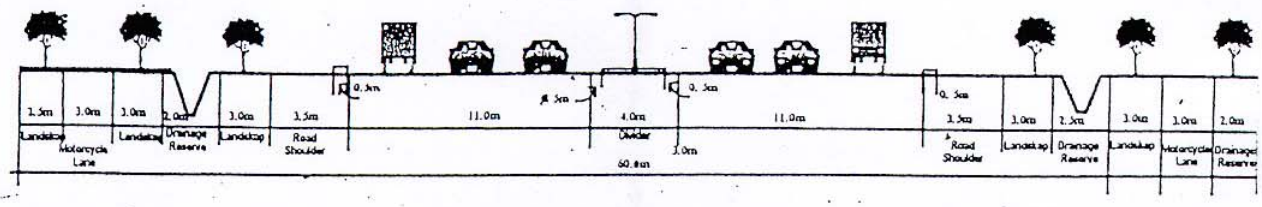
- Throughout the development region, the road networks should consist of the following hierarchy (Illustration 6.6);

  i. Expressways
     - Providing inter-region and inter-state communication linkages.
     - U6 design standard with minimum reserve width of 60 metres.
     - Three-lane, dual-carriageways with provision for an additional lane in the future.
     - All junctions and intersections are grade-separated with full access control.

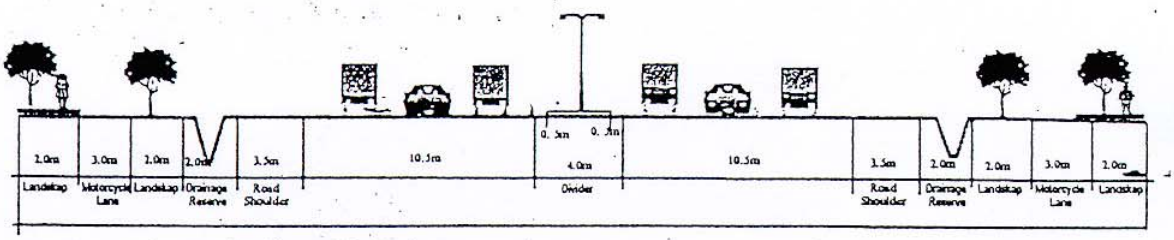
ILLUSTRATION 6.6 : TYPICAL ROAD CROSS SECTIONS

ustration 6.1: Typical Road Cross Sections

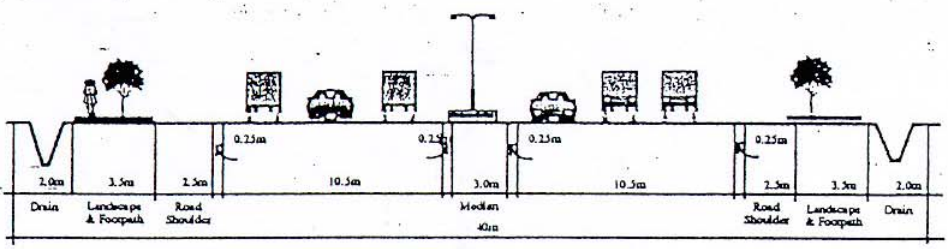
EXPRESSWAY (U 6)



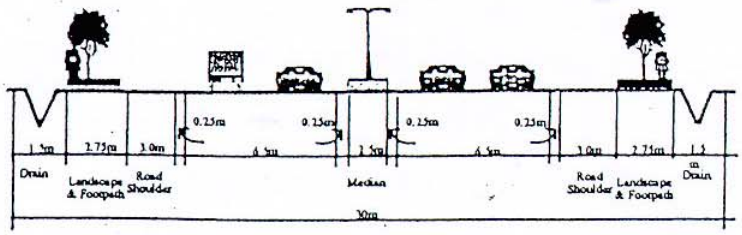
PRIMARY DISTRIBUTOR (U 5)



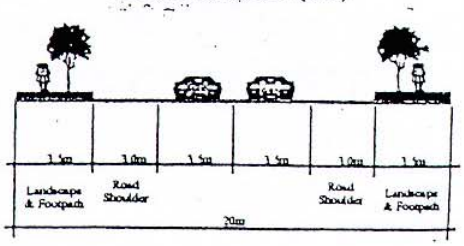
SECONDARY DISTRIBUTOR (U 4)



LOCAL DISTRIBUTOR (U 3)



LOCAL ACCESS (U 2)



ii. Primary Distributors
- Providing linkages between U6 Expressways and the internal areas.
- U5 design standard with a minimum reserve of 50 meters.
- Also three lane dual-carriageways with provision for an additional lane in the future.
- All junctions are to be grade-separated but with partial access control.

iii. Secondary Distributors
- Providing access between development areas within a locality.
- U4 design standard with a minimum reserve of 40 metres.
- Three lane dual-carriageways.
- Junctions are at-grade with partial access control.

iv. Local Distributors
- Connect adjacent landuses.
- 2 lane dual-carriageways of U3 design standard with 30 metre minimum reserve width.
- At grade junctions with partial access control.

v. Local Accesses
- Provide access to individual lots
- U2 design standards with minimum reserves of 20 metres.
- U1 design standards with minimum reserves of 12 metres.
- 2 lane single-carriageways with no access control.

- The pedestrian walkways and bicycle paths should be provided within the landscaping reserves.
- Independent footpath networks for the purpose of facilitating social interaction should be provided in residential, institutional zones, linking them to

neighbourhood centres as well as to public transport station.

- The use of road reserves for utility trenching should be limited to the outer edge of the carriageways.

Drainage

- The storm drains should be connected to a system of trunk and secondary drains which ends at an existing river/waterbody.
- Treated waste water from the Sewage Treatment Plant may be released into rivers or streams only after meeting the Putrajaya Effluent Quality Standards. This level is to be strictly adhered to at all times to prevent water pollution.
- The treated water may also be used for landscaping purposes.
- All drainage design in the catchment are to conform to the Putrajaya Stormwater Management Design Guidelines.
- The drainage reserve requirements in the catchment shall follow those specified in the DID Urban Drainage Design Standards (UDDS).
- The individual land owners and project proponents are to be responsible for the construction of 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.

Sewerage

- Sewerage design will accommodate modern sewage treatment system that will not only meet specific standard as stipulated by the Environmental Quality (Sewerage and Industrial effluents) Regulation 1979 for effluent discharge but also keep the limit for nutrient into the waterbodies to a minimum.

7. Construction

- The working area for various facilities within a construction site should be kept to less than twice the plinths of the building.
- Development schedule must be clearly defined. Completion date for each phase of development shall be indicated and all clearing, grading and stabilisation operations shall be completed before moving onto the next phase.
- Timing of construction activities shall, wherever possible, be spread evenly over the development time-scale to ensure that the deleterious effects arising from construction activities are minimised.
- All known rare and endemic flora and fauna areas or niches within the construction site shall be demarcated and preserved.
- All trees that are rare shall be fenced and preserved or carefully uprooted and transferred to a nursery/another site for replanting.
- Roads and permanent storm drains should be installed as early as possible so that they can control runoff during construction. However, they should be temporarily connected to the sediment basins until stabilisation of graded areas is achieved.

6.6.3.2 Specific Guidelines

(1) Universiti Putra Malaysia (UPM)

- All development must follows Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.
- Faculty, Hostels, Administration and others building planned within the lake catchment area should be clustered as an institutional village.
- The institutional area will comprise of academic uses and R&D centres and other supporting institutional element e.g. laboratories, sports complex, shops, mosque, etc.
- Medical/laboratory development should discharge their waste outside the catchment.

- Maximum number of storeys permissible is 4 storeys for low intensity area and 5 storeys for the medium intensity area.
- Only low and medium intensity development with an overall gross plot ratios (GPR) are permitted as below;
  - Low intensity area with maximum GPR of 1:0.5
  - Medium intensity are with maximum GPR of 1:1
- Conserve and well-balanced reserve of 'green lung' as sources of pollution filters and buffers for the sustenance of the overall development and environment.
- A minimum of 30% of the individual development parcel should be landscaped and be set aside as green area.
- A minimum of 30m riparian buffer should be landscaped along the development parcel, e.g. roads, water bodies, ERL's and highways.
- Maximising the assets of the natural environment such as water bodies, particularly ponds/lakes, hills and greenery and to create a garden city or recreational park image.
- Preserve large areas and open spaces sufficient to meet the long range needs of the lake catchment.
- Other open spaces are reserved for greeneries at appropriate location. These may be used as green areas to act as visual barrier and for screening.
- Creating a continuous network of green belt and buffer that runs throughout the whole development.
- Functional open spaces should be provided to utilise for leisure activities.
- Design of appropriate open spaces, meeting places, eating areas or place settings such as plazas, promenades, boulevards, open theatre and the like to cater for day to day activities or for festive events, cultural processions or activities.
- Provide easily accessible and affordable public parks amenities, facilities and recreational opportunities for the general public with interaction of students, especially for the under privileged.

(2) MARDI

- All development must follows Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.

- Institutional building planned within the lake catchment area should be clustered as an institutional village.
- The institutional area will comprise of R&D centres, laboratories, etc.
- Maximum number of storeys permissible is 4 storeys for low intensity area and 5 storeys for the medium intensity area.
- Only low and medium intensity development with an overall gross plot ratios (GPR) are permitted as below;
  - Low intensity area with maximum GPR of 1:0.5
  - Medium intensity are with maximum GPR of 1:1
- Building setback is to be provided between buildings and roads to provide a green buffer and landscaping within each parcel. The front setback for each individual parcel should be at least 9m while a minimum of 6m setback for all sides.
- A minimum of 30% of the individual development parcel should be landscaped and be set aside as green area.
- A minimum of 30m green buffer should be landscaped along the development parcel, e.g. roads, water bodies, ERL's and highways.
- Conserve and balance well the reserve of 'green lung' as sources of pollution filters and buffers for the sustenance of the overall development and environment.
- Maximising the assets of the natural environment such as water bodies, particularly ponds/lakes, hills and greenery and to create a garden city or forest park image.
- Preserve large areas and open spaces sufficient to meet the long range needs of the lake catchment.
- Open spaces and recreational areas such as Theme Parks, Botanical Garden and Herbal Garden, which can generate economic gains should be encouraged.
- Other open spaces are reserved for greeneries at appropriate location. These may be used as green areas to act as visual barrier and for screening.
- Creating a continuous network of green belt and buffer that runs throughout the whole development.
- Functional open spaces should be provided to utilise for leisure activities.
- Design of appropriate open spaces, meeting places, eating areas or place settings such as plazas, promenades, boulevards, open theatre and the like to cater for day to

day activities or for festive events, cultural processions or activities.

- Provide easily accessible and affordable public parks amenities, facilities and recreational opportunities for the general public, especially for the under privileged.
- Stream buffers shall be retained for rivers, the width of the buffers shall follow the DID regulations.

(3) TNB Serdang Power Plant

- No further development is allowed in this area except, development to reduce the risk due to emergencies related to the operation of the existing TNB Power Station.

(4) IOI

- All development must follow Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.
- Housing layouts shall be cluster type to reduce the total length of roads and the extent of corresponding infrastructure.
- The residential development shall be in harmony with the site conditions and adapted to the surrounding terrain.
- The intensity of housing shall be based on 15 units per hectare.
- Maximising the assets of the natural environment such as water bodies, particularly ponds/lakes, hills and greenery and to create a resort and homestead image.
- Orientation and design of buildings which optimise views, water bodies and parks, respect and consider privacy and design art of adjacent buildings.
- Create a balanced and attractive building skyline which is in harmony with their surrounding natural physical features such as hills, water bodies and parks.
- For hilly land, terracing shall be done and maintained. Cover plants shall be established on the slopes of the platforms and walls of terrace immediately after commencement of earthworks.

(5) West Country

- All development must follows Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.
- Housing layouts shall be cluster type to reduce the total length of roads and the extend of corresponding infrastructure.
- The residential development shall be in harmony with the site conditions and adapted to the surrounding terrain.
- The intensity of housing shall be based on 15 units per hectare.
- Maximising the assets of the natural environment such as water bodies, particularly ponds/lakes, hills and greenery and to create a resort and homestead image.
- Orientation and design of buildings which optimise views, water bodies and parks, respect and consider privacy and design art of adjacent buildings.
- Create a balanced and attractive building skyline which is in harmony with their surrounding natural physical features such as hills, water bodies and parks.
- Terrace type housing layout should be avoided.
- A minimum of 30m green buffer should be landscaped along the development parcel, e.g. roads, water bodies and highways.
- For hilly land, terracing shall be done and maintained. Cover plants shall be established on the slopes of the platforms and walls of terrace immediately after commencement of earthworks.

(6) Universiti Tenaga Nasional (UNITEN)

- All development must follows Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.
- Faculty, Hostels, Administration and other supporting institutional buildings planned within the lake catchment area should be clustered as an institutional village.
- The institutional area will comprise of academic uses and R&D centres and other supporting institutional element, e.g. laboratories, sports complex, shops, mosque etc.

- Maximum number of storeys permissible is 4 storeys for low intensity area and 5 storeys for the medium intensity area.
- Only low and medium intensity development with an overall gross plot ratios (GPR) are permitted as below;
  - Low intensity area with maximum GPR of 1:0.5
  - Medium intensity are with maximum GPR of 1:1
- Conserve and balance well the reserve of 'green lung' as sources of pollution filters and buffers for the sustenance of the overall development and environment.
- Maximising the assets of the natural environment such as water bodies, particularly ponds/lakes, hills and greenery and to create a garden city or forest park image.
- Preserve large areas and open spaces sufficient to meet the long range needs of the lake catchment.
- Other open spaces are reserved for greeneries at appropriate location. These may be used as green areas to act as visual barrier and for screening.
- Creating a continuous network of green belt and buffer that runs throughout the whole development.
- Functional open spaces should be provided to utilise for leisure activities.
- Design of appropriate open spaces, meeting places, eating areas or place settings such as plazas, promenades, boulevards, open theatre and the like to cater for day to day activities or for festive events, cultural processions or activities.
- Provide easily accessible and affordable public parks amenities, facilities and recreational opportunities for the general public, especially for the under privileged.

(7) Sg. Merab Malay Reserve

- All development must follows Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.
- Housing layouts shall be cluster type to reduce the total length of roads and the extend of corresponding infrastructure.
- The residential development shall be in harmony with the site conditions and adapted to the surrounding terrain.

- The intensity of housing shall be based on 15 units per hectare (6 upe).
- Maximising the assets of the natural environment such as water bodies, particularly ponds/lakes, hills and greenery and to create a resort and homestead image.
- Orientation and design of buildings which optimise views, water bodies and parks, respect and consider privacy and design art of adjacent buildings.
- Create balanced and attractive building skyline which is in harmony with their surrounding natural physical features such as hills, water bodies and parks.
- For hilly land, terracing shall be done and maintained. Cover plants shall be established on the slopes of the platforms and walls of terrace immediately after commencement of earthworks.

(8) Utilities Areas

- All development must follows Planning Standard, Lake Catchment Guidelines, Putrajaya Guidelines and MSC Guidelines.
- A minimum of 30m green buffer should be landscaped along the development parcel, e.g. roads, water bodies, ERL's and highways.
- Road shoulders are to be protected mechanically or vegetatively against erosion.
- Roads, permanent storm drains and other utilities should be installed as early as possible so that they can control runoff during construction. However, they should be temporarily connected to the sediment basins until stabilisation of graded areas is achieved.
- Runoff water should be directed so that it does not run across disturbed and unstable areas.
- The storm drains should be connected to the existing water bodies such as ex-mining pools for flood prevention purposes.

CHAPTER 7

DEVELOPMENT OF THE BASIC ICMS

7.0 DEVELOPMENT OF THE BASIC ICMS

7.1 INTRODUCTION

7.1.1 For the successful implementation of the Catchment Development and Management Plan there is a need to develop an information management system that will provide adequate and timely processed information related to the Plan for use by pertinent decision-makers. Thus, the Consultant has proposed that a *basic or low-level* Integrated Catchment Management System (ICMS) be developed as part of this study to support decision-making on the implementation of the Plan.

7.1.2 The complete ICMS is envisaged by the Consultant to be an IT-based decision support system comprising of four components, as illustrated in Figure 7.1. They are:

- Data and information pre-processing
- Information system
- Analytical system
- Graphical user interface (GUI)

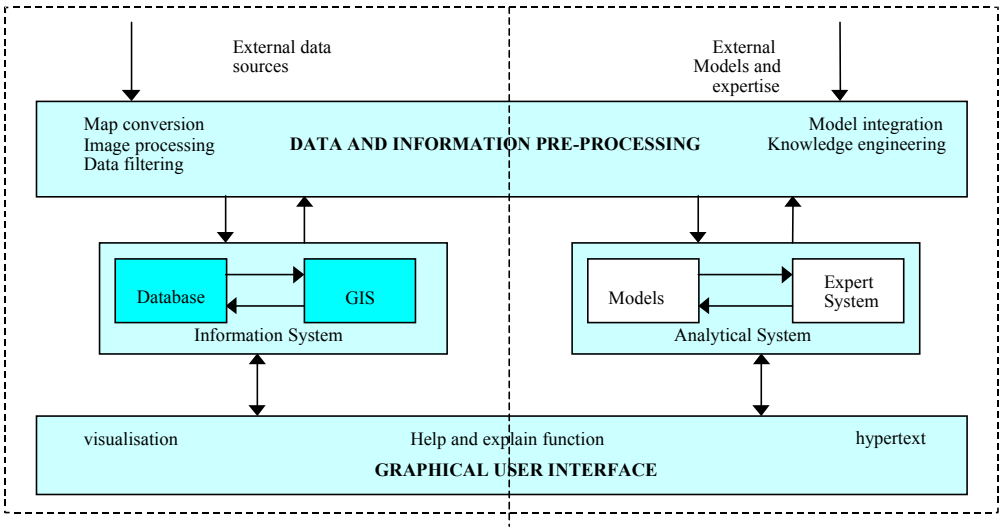


Figure 7.1 The Complete ICMS

7.1.3 At this stage of the study it is only feasible to develop the information system component, comprising of the information database and the Geographical Information System (GIS) used to manage the information in the database. Thus, the low-level ICMS will involve work to develop the Information System

component and its associated data inputs pre-processing and outputs visualisation.

7.1.4 To support the development and maintenance of the ICMS, there is a need to define an Information Management Plan (IMP). The IMP will address all the major issues of information flow within an organisation. It will also highlight the importance of having a management structure for data sharing and the need to classify information.

7.1.5 The system development life cycle for the low-level ICMS is illustrated in Figure 7.2. The steps are as follows:

(a) User requirements study
(b) System design
(c) System development
(d) System implementation
(e) Maintenance and support

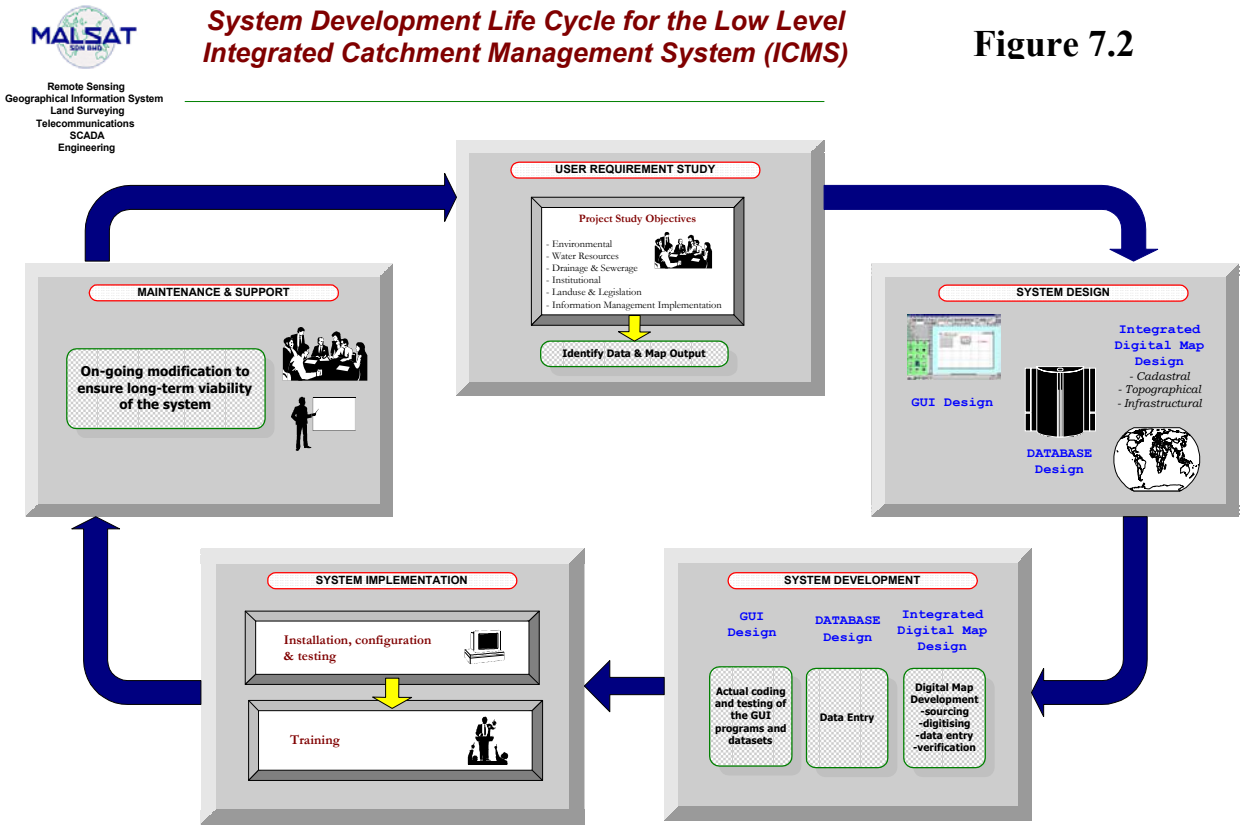


Figure 7.2

NOTE :
- *With each cycle, the ICMS functionality should be enhanced and become more sophisticated*
- *This development life cycle allows for the ICMS to be developed in stages depending on priorities and budget*

7.2 INFORMATION MANAGEMENT PLAN (IMP)

7.2.1 The need for an IMP

7.2.1.1 The basic requirement for integrated catchment management is comprehensive understanding of the catchment, its physical forms and functions. This can only be achieved if data and information on the catchment are sufficient and accurate.

7.2.1.2 Within the Perbadanan Putrajaya, the various technical units must be diligent in the management of the data collected as part of the environmental monitoring programmes. Proper management of data is important to enable it to pass on processed information for decision-making.

7.2.1.3 Whilst data and information are available for areas within the Putrajaya administrative boundary, gaps in information may exist for areas outside it. With data residing and owned by different parties, there is a clear need to have an understanding between the Perbadanan Putrajaya and the other stakeholders in the catchment on the issue of sharing of certain information for mutual development benefits.

7.2.1.4 Thus, an Information Management Plan is necessary to facilitate the handling and management of information related to the management of the Putrajaya catchment. It is an essential component of the study to develop and implement the Integrated Catchment Management System.

7.2.2 Information Sharing

7.2.2.1 Objectives of Information Sharing

(1) Information sharing is important for successful integrated catchment management. It's main purpose is to provide information to all parties with interests in the catchment based on the principle that proper management can only be achieved with continuous growth of knowledge and understanding of the catchment and its issues.

(2) It encompasses all levels of society - from government and local authorities to property developers and landowners, and even to the general public.

(3) For the Putrajaya Lake catchment, information sharing can achieve the following objectives:-

- Avoid duplication of effort in data collection in the catchment
- Co-ordinate approach in obtaining data types that transcend property boundaries
- Prepare plans for individual development based on information from the same source
- Pool information for participatory management of the catchment
- Pave the way for future close co-operation on development and environmental issues

(4) One way to avoid duplication of effort in data collection is by creating a co-ordinated local data resource base. The benefit of this data resource base has been long realised but the implementation of data sharing mechanisms, although attempted at various levels and sectors of Government, are often hampered by bureaucracy and lack of continuity in representation. The ongoing National Land Information System (NALIS), however, proves that concerted effort and planning in data sharing can be successful.

(5) With the formation of the Putrajaya Lake Catchment Management Committee, a platform to discuss major developmental concerns has been created. A Technical Committee has also been formed to address technical issues. Information sharing is one of the agendas of this technical committee and this Plan shall further refine the needs of information sharing.

7.2.2.2 Benefits of Information Sharing

(1) In promoting data sharing amongst multiple stakeholders, one of the most common questions asked by stakeholders is what are the benefits for them? The benefits of information sharing amongst stakeholders can be summarised as follows:

- Access to up-to-date information on the catchment area.

- Conflicting issues on development will manifest earlier allowing time for discussion and solution before permanent changes take place
- Avoids duplication of data collection efforts
- Identification of gaps in information
- Greater awareness of the area as a whole
- Learning from the experience of other stakeholders
- General public appreciation of environment

(2) Information sharing usually paves the way for future two-way co-operation in handling joint concerns. It is critical however; that a consensus is reached by all involved as to the mechanism for data sharing.

7.2.3 Obtaining Information

7.2.3.1 Information sharing between stakeholders requires several issues to be discussed and agreed upon by all. They are described below:

7.2.3.2 Inventory of Information - *Determine what information is held elsewhere and how it can be obtained*

7.2.3.3 Copyrights and Sharing Conditions - *Ownership and copyrights must be respected hence the limitations to the use of information passed on by one stakeholder to another must be stated and agreed upon. For example, the information should not be made available to a third party without the express consent of the original source.*

7.2.3.4 Information requirements - *The information or data to be shared should be clearly defined. The type of information, the format in which it is required and the time period expected for the request to be met. The setting of a deadline for response indicates the seriousness of the request and implies that there will be impending downstream action.*

7.2.3.5 Regular Contact - *Stakeholders must often be in touch with each other in order for information status to be continuously updated. The catchment committee meetings may be spaced too far apart to allow for successful implementation of the information management strategy. Hence a smaller but more technical group may be appropriate. This technical group*

could meet bi-monthly to report on data updates and address other information-related issues.

7.2.4 Assessment of Response to Information Request

7.2.4.1 In the effort to understand stakeholders' concerns, several meetings were held with the stakeholders during the study. Corresponding to this, information management survey questionnaires were distributed. The purpose of the survey is to inquire on the presence of information among the stakeholders and identify general concerns.

7.2.4.2 Only two out of ten stakeholders (including local authority) responded. Most stakeholders however did respond by agreeing to meetings where mutual issues on data were discussed. In most cases, the developers were represented by their engineering consultants. The sectoral experts were quite successful in obtaining information from the stakeholders only after explaining at length the reasons and objectives of the study.

7.2.5 Information Dissemination

7.2.5.1 To encourage stakeholders and the general public's participation in catchment management, correct and accurate information should be periodically made available to the stakeholders and the general public. This can be in various forms and in several levels of detail. For example:

- Reports – technical or management reports on engineering, environment or development status targeted for internal use or academic interest
- Booklets – guidelines to development in the catchment targeted at developers, engineers and environment managers
- Pamphlets/Brochure – summary of information; Putrajaya map of roads and buildings targeted for general public
- Newsletters – summary of study findings, current affairs, warnings of potential hazards, public announcements
- Internet – website on areas of interest in the Putrajaya catchment such as buildings, wetlands and current issues.

7.2.5.2 The release of information by government agencies to the private sector and the general public is usually hampered by the

lack of an official information policy. Thus, there is a need to define an appropriate Information Management Policy.

7.2.5.3 For sharing to be successful, data should be appropriately classified and clearance of data for public use can be co-ordinated by a committee entrusted with the task.

7.2.6 Perbadanan Putrajaya as Lead Agency for Information Management

7.2.6.1 The stakeholder that will benefit most from information sharing is Perbadanan Putrajaya. Thus, it should be the leading stakeholder in this catchment to provide information sharing and must play a proactive role.

7.2.6.2 Perbadanan Putrajaya has the necessary resources to carry out the necessary environmental monitoring operations in the areas of the other stakeholders to support the lake Management. This could include:

- Establishing water quality measuring stations within the areas owned by stakeholders
- Providing data to stakeholders e.g. rainfall, streamflow, water quality
- Providing overall landuse maps of the catchment area
- Advice on environment and development issues
- Central depository for data collected by stakeholders
- Providing digital information
- Commission research activities which encompass the entire catchment

7.2.6.3 However, for any of the services provided above, a reciprocal contribution should be provided by the other stakeholders.

7.2.6.4 A co-ordinated local data resource base should be designed to avoid duplication of effort in data collection. This benefit has been long realised by the Government but the implementation of data sharing mechanisms, although attempted at various levels and sectors, are often hampered by bureaucracy and lack of continuity in representation.

7.2.6.5 Due to its technical and administrative capabilities, Perbadanan Putrajaya is well positioned to take the lead as the data resource base for the Putrajaya catchment.

7.2.6.6 Data held centrally by an agreed organisation facilitates a common mechanism for data sharing. Hence, plans for individual development can be based on information from the same source.

7.2.6.7 Thus, it is recommended that Perbadanan Putrajaya should play the role of data custodian for the catchment and the referral centre for development-related information. Appendix 7.1 gives the details on how the Perbadanan can carry out this function.

7.3 ICMS - USER REQUIREMENTS STUDY

7.3.1 The first step in the development of the low-level ICMS is to identify the information management needs of the end-user of the ICMS. The information to be identified are the monitoring datasets to be collected and processed, and all informative maps that are necessary to support decision-making in the catchment.

7.3.2 Based on the identified information the IT team will design the structure of the database, process into digital form all pertinent maps, and design the necessary linkages between the data and maps, so as to integrate the spatial and attribute data information in the database.

7.3.3 The "enduser" for the *Basic ICMS* will be Perbadanan Putrajaya. However, since the various studies are out-sourced by Perbadanan Putrajaya to Consultants, the User Request Study (URS) was carried out by focussing more on the scope of work of the Consultants, and the expected data and map outputs which will be delivered to the "enduser". Additionally, the URS also took into account the Perbadanan Putrajaya's existing and planned IT infrastructure, objectives and manpower resources.

7.4 SYSTEM DESIGN

7.4.1 Introduction

7.4.1.1 In developing the system design for the low-level ICMS the IT team is guided by the following consideration:

(a) The design should be compatible with Perbadanan Putrajaya's IT system – the *Sumber Putra*.
(b) The design should allow information stored in it to be easily exported to other IT systems.
(c) The design should take into account the level of IT literacy of the potential end-user.

7.4.1.2 Based on the above consideration the IT team has defined the system requirements for the software and hardware for the low-level ICMS. Detail discussion on the Sumber Putra IT system and on the IT team's assessment are described below.

7.4.2 The Perbadanan's IT System

7.4.2.1 The current desktop workstations in the Perbadanan Putrajaya run on Windows NT with a Unix server at the heart of the network. The Unix is opaque to the general users. The desktop software used by the Perbadanan's staff includes the Microsoft Office 98 suite of programmes. All softwares are server-installed and hence a protocol for software usage already exists.

7.4.2.2 AutoCAD release 14 by Autodesk is currently the Perbadanan Putrajaya standard for the development of plans and design drawings. Autocad Map also by Autodesk, is also used by some technical Units to provide the GIS facility.

7.4.3 The Sumber Putra IT System

7.4.3.1 The Sumber Putra IT system represents the core of Perbadanan Putrajaya's IT development. The system is still in the early stages of development and is reported to comprise of five different applications.

7.4.3.2 Work on the first and flagship – the Electronic Submission Standards (ESS) system, is in progress. The following are details on the ESS system provided by the Perbadanan's IT consultant, Mr. Rishipal Singh from Novasprint.

7.4.3.3 Electronic Submission Standards (ESS) System - Introduction

(1) The ESS system is an electronic system for the processing and approval of electronic submissions by project proponents, on all aspects of planning approval to the Perbadanan. It consists of two parts. They are:

- A main processing system at the Perbadanan Putrajaya and,
- A user-end module use by the project proponents to submit his drawing/plans electronically to the Perbadanan.

(2) To submit its plans electronically the project proponent must adhere to a standard digital drawing format, which define details for the thickness of each line entity and the standard icons for point entities.

(3) The ESS is designed to be an intelligent system, i.e. it is supposed to conduct the routine checks on the electronic drawings submitted to ensure compliance to the Perbadanan's standard drawing format. It also includes provision for registration, confidentiality, security and re-submission, in case of non-compliance.

7.4.3.4 ESS System – User-end Module

(1) A project proponent has to purchase the user-end module of the ESS from the Perbadanan. The module contains a software and a guideline that describes the outlines of the hardware requirements to establish an online link with the Perbadanan Putrajaya's ESS.

(2) The hardware required to connect with the ESS is no different from those used normally by a user to connect with the Internet.

(3) The drawing format for submission to the ESS is the AutoCAD - dxf file format, which is the de-facto standard due to its wide application in the local engineering scene. The accompanying database has to be prepared using Microsoft Access.

(4) The user-end ESS module is designed to take advantage of the availability of off-the-shelf software and comprises of a user-friendly graphical user interface that facilitates the entry of submission and drawing information.

(5) Once the entry form is filled, the information can be submitted via a modem through the Internet connection to the Perbadanan Putrajaya.

7.4.3.5 ESS System – System-end Module

(1) At the Perbadanan Putrajaya the ESS is run on a network platform with a UNIX server at its core.

(2) The operating system for the workstations used by the Perbadanan's staff runs on Windows NT.

(3) The system database is Oracle which remains opaque to the workstation users.

7.4.3.6 ESS System – Vetting of submission

(1) There are two levels of vetting of the submitted documents. The first stage is a non-interactive stage and the second stage requires interaction with the staff in the Perbadanan's technical Units.

(2) In the first stage the ESS system screens and analyses the electronic submissions for general compliance to the Perbadanan's procedures and standards. Upon fulfilling the registration requirements the submitted documents undergo an electronic check for drawing format compliance. Only when this stage is cleared will the submission be channelled to the next stage for the interactive vetting by the relevant technical Units in the Perbadanan.

(3) The Perbadanan's technical Units are responsible for assessing the feasibility and technical compliance of the development proposal plans. This vetting exercise is an interactive process with the ESS, where the assigned personnel query the ESS on the various technical aspects of the development plans. They would include an assessment of the proposal's compliance to building by-laws, buffer zone requirements, engineering and technical guidelines requirements.

7.4.4 The Software Requirements

7.4.4.1 The Need

(1) There is a need to define the database and GIS software to be used for the development of the low-level ICMS. After taking

into consideration a number of factors the IT team has decided on the following database and GIS software. They are:

- Database - *Microsoft Access*
- GIS - *ArcView Rel. 3.0*

(2) The reasons for the above choices are described below.

7.4.4.2 Selection of Database Software

The Microsoft Access database program has been chosen for the development of the database in the low-level ICMS for the following reasons:

(a) It is widely available, as it comes bundled with every purchase of the popular Microsoft Office Professional suite.
(b) Microsoft Access is the database program used in the Sumber Putra IT system.
(c) The Program is readily available on most workstations at the Perbadanan Putrajaya.
(d) The database created using the Program is readily read by AutoCadMap, the GIS software currently used by a few technical units in the Perbadanan.
(e) The learning curve for Microsoft Access is not very steep.

7.4.4.3 Selection of GIS software

(1) For the development of the ICMS, there was no necessity for immediate physical integration between the IT team's output and the ongoing Sumber Putra IT system. The developments for both systems can be independent of each other, with the ICMS eventually being subservient to the Sumber Putra. Since the ICMS is a low-level system, containing only digital databases and maps, future convergence with the Sumber Putra IT system or with any other IT system should not be a problem.

(2) Thus, for the development of the low-level ICMS, the IT team recommends that ArcView Rel. 3.0 GIS be used. The program is a simple, Windows-based GIS software.

(3) To familiarise the potential users of the low-level ICMS on its use, before it is incorporated as a component of Phase-2 of the Sumber Putra project, it is recommended that a copy of Arc View and a desktop computer be purchased.

7.5 SYSTEM DEVELOPMENT

The work of developing the low-level ICMS can be divided into 2 distinct components. They are:

- Development of the Integrated Digital Map
- Development of the database structure

7.5.1 Development of the Integrated Digital Map

7.5.1.1 Three groups of maps and their associated data will be generated from this study. They are Cadastral, Topographical and Infrastructure or Development maps. The nature of the map data is described below.

(a) *Cadastral* data deals with information on property parcels, land ownership, size, land valuation, existing land use and zoning categories. Most, if not all, of the cadastral maps and data have already been digitised by the town planner.

(b) *Topographical* data deals with information on the physical layout of the land such as terrain, contours, hills, lakes, rivers, watercourses, roads, buildings, etc.

(c) *Infrastructure* data deals with information on the physical development that have been built or are being planned for the future, such as telecommunication, sewerage, water, electricity, highways and roads, buildings, etc.

7.5.1.2 Most of the topographical and infrastructure data covering Putrajaya is already in digital format, as part of Perbadanan Putrajaya's *Sumber Putra Information System Project*. For areas outside of Putrajaya, topographical and infrastructure maps will have to be obtained from the Survey and Mapping Department and from the other stakeholders within the catchment area.

7.5.1.3 These datasets have been organised into logical GIS layers and integrated into a common MRSO co-ordinate system in a single GIS platform (ArcView). By integrating these *datasets* into a GIS-technology environment in a logical manner and with comprehensive associated databases, the ultimate aim is to ensure that they become useful *information*.

7.5.1.4 Extensive geographical maps and data have and are being collected by the vendors of Sumber Putra as part of the Land Information System module and this has yet to be completed. The creation of the Integrated Digital Map was done progressively with a view to updating certain layers and data from Sumber Putra, as and when they are ready.

7.5.1.5 A common co-ordinate system has to be adopted for integrating the 3 datasets layers into a single GIS. The co-ordinate system to be adopted will logically follow those used in the Sumber Putra IT system, i.e. Cassini, MRSO, Latitude/Longitude or WGS84.

7.5.1.6 Some problems were encountered during the creation of the Integrated Digital Maps: -

- lack of available data outside Putrajaya
- lack of knowledge of what data is available at Putrajaya as part of Sumber Putra
- lack of metadata about the Sumber Putra maps and data
- massive data editing required to convert from CAD to GIS format

7.5.1.7 Appendix 7.2 shows the Data Description for the development of the ICMS

7.5.2 Development of the Database Structure

7.5.2.1 Introduction

(1) The implementation of the monitoring program in the Plan will result in the generation of a number of databases. The format of the digital data and the structure of their database tables have to be defined. Careful design of the table structure is essential to facilitate the design of queries, analysis and subsequently for tie-in with the spatial data in the GIS.

(2) In the design of the datatable structures the IT team has taken into account the procedures for the data sampling and their subsequent processing into useful information. However, it must be noted that the format and design of the datatables presented in this study should be considered as basic. They should be improved as the monitoring programmes are refined and tailored to meet the needs of the pertinent end-user.

(3) The following are detail descriptions on the design of the following databases:

- Monitoring station location
- Water quality monitoring
- Wetlands
- Hydrology
- Drainage
- Sewerage

Appendix 7.3 gives the Database Manual developed for the low-level ICMS.

7.5.2.2 Monitoring Station Location Database

(1) A general structure for the database containing information on any monitoring station location has been developed. The table contains the following information:

- Monitoring station ID number - a unique number that differentiates one monitoring station from another
- Description of a station's location
- Latitude in degrees MRSO - to enable geo-referencing
- Longitude in degrees MRSO - to enable geo-referencing
- Date of first sampling - a historical record of the station's date of commissioning
- Maintained by – specify the ownership of the station and its data

(2) Photographs may also be added into the datatable to provide a visual description of the area.

7.5.2.3 Water Quality Monitoring Database

(1) The water quality monitoring requirements for Putrajaya Lake have been described in the Putrajaya Lake Management Guide. Based on the monitoring requirements four datatables are considered adequate for the water quality monitoring database. The four datatables are:

- Monitoring station location datatable (see Section 8.4.2.1)
- Job identification datatable
- Measurement record datatable

- Threshold datatable

(2) Detail descriptions of the pertinent datatables are described below.

(a) Job identification datatable *WQJob*

The attributes of the data fields in this table are as follows:

- Water quality station ID number – This provides the link to the station location datatable
- Sampling Job Number – This is a unique identifier for each sampling job
- Sampling date
- Weather condition during sampling
- Initials of person doing the sampling
- Notes on any related field activity

The last three fields provide an audit trail for data quality assurance. The notes on any related field activity is a field provided for recording any in-situ observations that may influence the use or interpretation of the data.

(b) Measurement record datatable *WQSample*

The attributes of the data fields in this table are as follows:

- Sampling Job Number - This provides the link to the job identification datatable
- Sample number
- Time of sampling
- Depth of sampling in metres
- One or more fields for each of the measured parameters

Based on discussions with the environmental specialist the following five parameters have been recommended to be measured:

- pH value
- Dissolve Oxygen (DO)
- Suspended Solids (SS)
- Total Phosphorous (RP)

- Reactive Phosphorous (RP)

(c) Threshold datatable

A datatable containing the threshold values for all the water quality parameters listed in the Putrajaya Lake Water Quality Standard (see Appendix 5.3) has also been prepared to complement the other datatables of the water quality database. The threshold data will be useful for comparisons with the measured water quality data to check that they are within permissible levels.

7.5.2.4 Wetlands Database

(1) The wetlands database is an inventory of wetlands identified inside the Putrajaya catchment area including those outside the administrative boundaries of Putrajaya. Information on location, size, flora and fauna are included in the database.

(2) Detail descriptions of the pertinent datatables are described below.

(a) Wetlands datatable *Wetland1*

This datatable holds the location attributes of the wetland and is tied with the digital map. The wetlands of Putrajaya have been identified by the wetlands expert in his report. In this datatable, each wetland is given a unique identifier and key information including a name, size and georeference coordinates.

(b)* Wetland subcells datatable *Wetland2

This datatable holds subcells of Wetland1. It was designed primarily to identify the wetlands plant types in the subcell areas.

(c)* Plant and wildlife datatables *XX_TerPlant, XXX_WetPlant, Fish1, Mammal1 and Bird1

These are simple datatables for plant and wildlife inventory. They can be designed in a few ways but are usually more helpful when a picture is included.

7.5.2.5 Hydrology Database

(1) This database is designed for hydrological information. Hydrological information includes rainfall, streamflow and sediment records. Each hydrological data collection station is identified by coordinates.

(2) Detail descriptions of the pertinent datatables are described below.

(a) Hydrological Station datatable *HydStation*

This is a datatable that identifies the location of hydrological stations i.e. for rainfall, evaporation or streamflow gauging stations. Geographical coordinates in the datatable connect the database with the relevant GIS map. Actual parameter records for any particular station can exist in a different datatable but linked to this.

7.5.2.6 Drainage Plan Database

(1) The drainage database provides the user with information on location and size of drains corresponding to a line feature on the GIS map. This is a drainage structure information database which linked with the proposed drainage master plan drawing. The database will be associated with the line entities representing drainage structures.

(2) Detail descriptions of the pertinent datatables are described below.

(a) Drain datatable *Drain1*

This datatable will complement the final drainage map by displaying information on the drain type, size and maximum discharge including length and slope at the click of a button.

(b) Gross Pollutant Trap datatable *GPT_DControl*

This datatable stores information on the gross pollutant traps designed as part of the drainage plan including design parameters and dimensions. GPTs are man-made structures constructed as part of the drainage system. As the name implies, its function is to trap all visible pollutants including rubbish, sediment and debris. GPTs have to be cleaned and maintained. GPT's are often built based on trial-and-error and may need to be redesigned to

meet efficiency requirements designs. The last record in this data table represents the current design.

(c) Gross Pollutant Trap Water Quality datatable *GPT_WQ1*

This water quality data table is associated with the GPT station. It keeps the records of suspended solids measurements entering and exiting the GPT. The efficiency of the structure based on the measurements recorded here can be calculated manually using the parameters or alternatively, a query can also be designed to calculate it automatically.

(d) Detention Pond datatable *DetPond1*

Eight areas within the Putrajaya area have been designated as permanent flood detention ponds. Outside the Putrajaya area, five areas have been found to be potential sites for flood detention ponds. DetPond1 is a datatable of detention ponds found in the Putrajaya catchment. Information provided therein includes the sub-catchments in which they are located as well as the size and width of the ponds.

7.5.2.7 Sewerage Database

(1) One potential point source pollutant to the Putrajaya Lake is the discharge of untreated or inadequately treated sewage effluent into the catchment drainage system of the lake. Among the information pertinent to manage sewage in Putrajaya is the location and capacity of the existing and proposed sewage treatment plants. This database houses this information and provides an overall view of the major sewage treatment facilities in the area.

(2) Detail descriptions of the pertinent datatables are described below.

(a) Sewage Treatment Plant datatable *STPlant1*

This datatable georeferences the location of all sewage treatment plants in the Putrajaya catchment both inside and outside the Putrajaya administrative boundaries. Records of the capacity of the sewage treatment plant, status of construction and information on the discharge from the plant can be included within STPlant1.

7.6 SYSTEM IMPLEMENTATION

7.6.1 Installation and ICMS Training for Users

The proposed basic stand-alone hardware system will first have to be purchased before training in the low-level ICMS can be conducted. This basic system comprises of one (1) licence ArcView release 3.0 and a desktop PC. Should Perbadanan Putrajaya defer the purchase of the software, the consultant will proceed to transfer the GIS files of the study over to the IT Unit in ESRI .dxf format.

7.6.2 Database Training

A hands-on session on water quality data entry is proposed using the forms and datatables designed by the MIS specialist. The Water Quality Specialist will be called in to conduct a water quality sampling assignment specifically to demonstrate the use of the data entry form and datatable. The session will include post-processing of water quality sample data using the existing datatables and basic analysis. The purpose of the training is to impart to Perbadanan Putrajaya personnel the basic database management skills using tools afforded by Microsoft Access and Excel. The target group will be the technical staff from the Environment, Lake and Hydrology Units of the City Planning Department.

7.7 SYSTEM MAINTENANCE AND SUPPORT

7.7.1 The low-level ICMS is a simple stand-alone system and the IT team do not envisage any difficulty for the Perbadanan's IT staff to carry out the routine maintenance and support tasks for the system.

7.7.2 Based on the IT team's understanding of the management requirements recommended by the various specialists, the IT team envisage the complete ICMS to comprise of the following core technologies :

- Real time monitoring system
- Geographical Information System
- Relational Database Management System
- Satellite Image Processing System
- Aerial Photography

- Web based decision support system

7.7.3 Brief descriptions on the technologies are given in the conceptual proposal for the complete ICMS in Appendix 7.4.

7.8 CONCLUSIONS AND RECOMMENDATIONS

7.8.1 Perbadanan Putrajaya is well positioned to play a leading role in the management of resources and information within the Putrajaya Lake catchment. To do this successfully, it needs up-to-date and accurate information.

7.8.2 The following are the IT Team's recommendations, in order of priority:

(a) Perbadanan to purchase, as soon as possible, a copy of the ArcView GIS software and a stand-alone computer for the installation of the low-level ICMS, developed as part of this Study. The indicative cost of the software and computer are as follows:

- ArcView GIS Software – RM11,500
- Stand-alone computer – RM 9,000

TOTAL: RM20,500

(b) The pertinent Units (Lake & Wetlands, Environment, Hydrology) in the Perbadanan are required to evaluate, over a period of **6 months,** the usefulness of the low-level ICMS in facilitating their management of the Lake catchment and identify the items within the system where further refinements should be carried out to support their work.

(c) Based on the evaluation the Perbadanan shall make a decision on whether to proceed to the next stage of the development of the low-level ICMS. If the Perbadanan decides to proceed with the next stage of the ICMS development it is recommended that the data and information in the low-level ICMS be converted to the SiCAD GIS system that has been adopted by the Perbadanan for its Sumber Putra System.

During the development of the low-level ICMS it was found that a lot of the data are quite "dirty" and it was not possible within the time-constraint and scope of work within the Study to do a thorough data cleaning exercise. Thus, the bulk of the work during the second phase of the ICMS development will be on data editing, data integration, data-clean-up and data verification. It will also involve refinements to the various components and databases in the low-level ICMS, based on the feedback from the respective Units using the low-level ICMS. The indicative consulting services costs for this second-phase is estimated to be about RM200,000.

(d) Further developments of the ICMS system on the SiCAD GIS to include the various technological components, such as real-time water quality and hydrological data monitoring through telemetry, as described in the conceptual proposal for the complete ICMS in Appendix 7.4, can be carried out after another period of use of the refined low-level ICMS on the SiCAD GIS, by the pertinent Units. It is not possible at this stage of the Study to define the indicative cost for this stage of the ICMS development.

(e) The Perbadanan should also consider creating a position for a Geographical Information Officer (GIO) within its IT Unit to handle all issues related to the managing of geo-referenced digital information within the Perbadanan. The Consultant understands that the Perbadanan has plans to recruit such a person in the near future.

(f) To facilitate information sharing among the various government agencies, regulatory bodies and major stakeholders within the catchment it is recommended that the Perbadanan and the proposed Putrajaya Lake Catchment Management Committee agree on a clear set of objectives for data collection, updating and sharing among themselves.

APPENDIX 7.1
INFORMATION MANAGEMENT WITHIN PERBADANAN PUTRAJAYA

1.0 Administrative Structure, Responsibilities and Management

1.1 Within the context of the study, the technical units directly involved are grouped under the Landscape and Environment Division of the City Planning Department. They are:

- Hydrology Unit
- Environment Unit
- Lake Unit
- Horticultural Unit
- Landscape Unit

1.2 These units will be responsible for the environmental monitoring programmes, including data collection and processing. All programmes should have clearly defined management objectives and process paths.

1.3 If data is shared between units, then the procedures for sharing and the format should be stated. This may seem trivial when the units and the department are small, however, as their functions mature and routines are set, procedures become necessary to enable an audit trail.

1.4 The custodian of digital data is the Information Technology Unit (ITU) under the Corporate Services Department. The ITU is responsible for the development and updating of all plans related to the development of Putrajaya. It plays a central role in maintaining electronic data relating to development and management of the city.

1.5 However, it is more appropriate if the Landscape and Environment Division manages its environmental database as the need for information amongst the units of the division are often immediate particularly in response to an environmental emergency.

1.6 Each department and unit of Perbadanan Putrajaya should be responsible for collecting, keying-in and updating their own maps

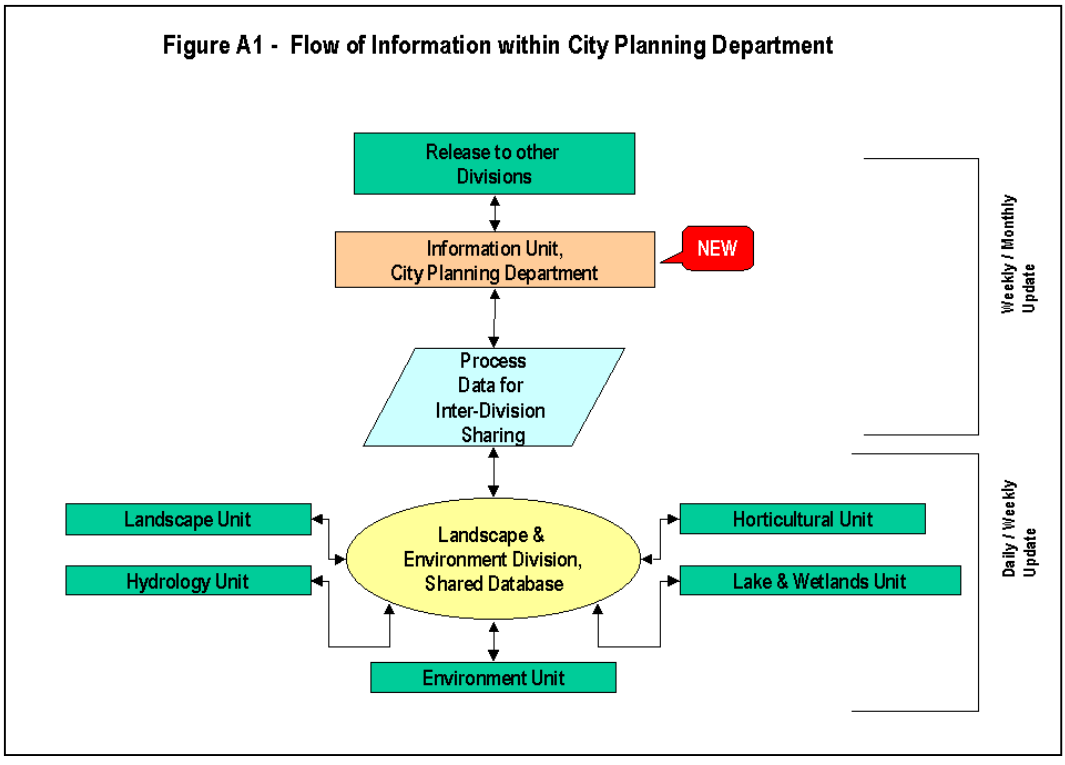
and datasets. However, this should be carried out in a co-ordinated manner so that they are not duplicating each other's efforts.

1.7 For example, the Town Planning Department should be responsible for creating and updating the cadastral and zoning basemaps. However, the valuation data is simply an attribute Oracle database maintained by the Valuation and Property Department, which is linked to the lot parcel maps.

1.8 It may thus be helpful if an Information Unit (IU) be created under each department as the intermediary to the ITU. A Geographic Information Officer (see section 4.1) will play a key role in the proper co-ordination of these efforts.

1.9 In summary, the role of the technical department's is to collect, process and manage their data in an agreed format whilst that of the ITU is to coordinate all relevant information for inter-departmental sharing and to develop official maps of the Putrajaya administrative and catchment area.

Figure A1 - Flow of Information within City Planning Department



2.0 Information flow within the City planning Department

2.1 Figure A7.1 describes a proposed process for data flow between the units of the Landscape and Environment Division. It treats the

department as an independent organisation which contributes a certain level of data to the central ITU.

2.2 Initially, the amount of data and information to be processed may seem overbearing and some effort may be required to identify data/information pertinent to the day-to-day functions of the unit. The following are the proposed exercises:-

2.2.1 General Exercise - Identification of information requirements for

(a) Divisional level – data in both raw and processed format; technical notes and analysis
(b) Departmental level – processed and analysed data; with description of trends, technical reports
(c) Board level – summarised information; statements of problems, alternative solutions and conclusions; management reports
(d) Public level – officially endorsed documents, maps and digital data

2.2.2 Specific Exercises – The specific exercises are as follows:

- Identifying data sources to provide information to management
- Targeting monitoring programmes to produce information that achieve management needs
- Identification of resource persons at unit level and department level for data management and sharing
- Identification of actual data to be shared, its format and frequency of sharing (weekly updates, monthly updates)

2.3 While the nature of work does not permit every information requirement to be anticipated, it is worthwhile to start by first identifying management objectives and subsequently identifying the information required to achieve the said objective. The information requirements will then lead to identification of data needed to be collected.

2.4 Some examples are tabulated below in Table A7.1:

Table A7.1 Management objectives and information requirement

Management Objective	Information Required	Frequency of Submission	Data Source
To maintain water level at X meters in central lake	Water level at key points, Rainfall data, streamflow data	Daily	Hydrological stations (Lake & Wetlands Unit)
To maintain water quality in central lake within permitted levels	Water quality in lake, water quality at monitoring points	Weekly	Water quality monitoring stations, hydrological stations (Hydrology, Environment Unit)
To check pollutant levels from north west Sector	Parameter levels from GPT's along drain X, water quality at station Y,wetland Z	Monthly	Environment Unit, Lake & Wetlands Unit

2.5 The information requirements should later be improved if it does not meet the management objective. Similarly, if information is insufficient, the data collection programme should then be reviewed. Figure A7.2 illustrates the process.

2.6 The sharing of technical data between the various units, divisions and departments of Perbadanan Putrajaya will require control. This will allow each section of Perbadanan Putrajaya to manage information according to its hierarchical position.

2.7 Data sharing within divisions are handled at departmental level whereas inter-departmental sharing is managed by the ITU.

2.8 A data clearance committee can be formed if necessary to serve as a final check before information is released to the public. Figure A7.3 illustrates the structure of levels and controls of data within and outside Perbadanan Putrajaya.

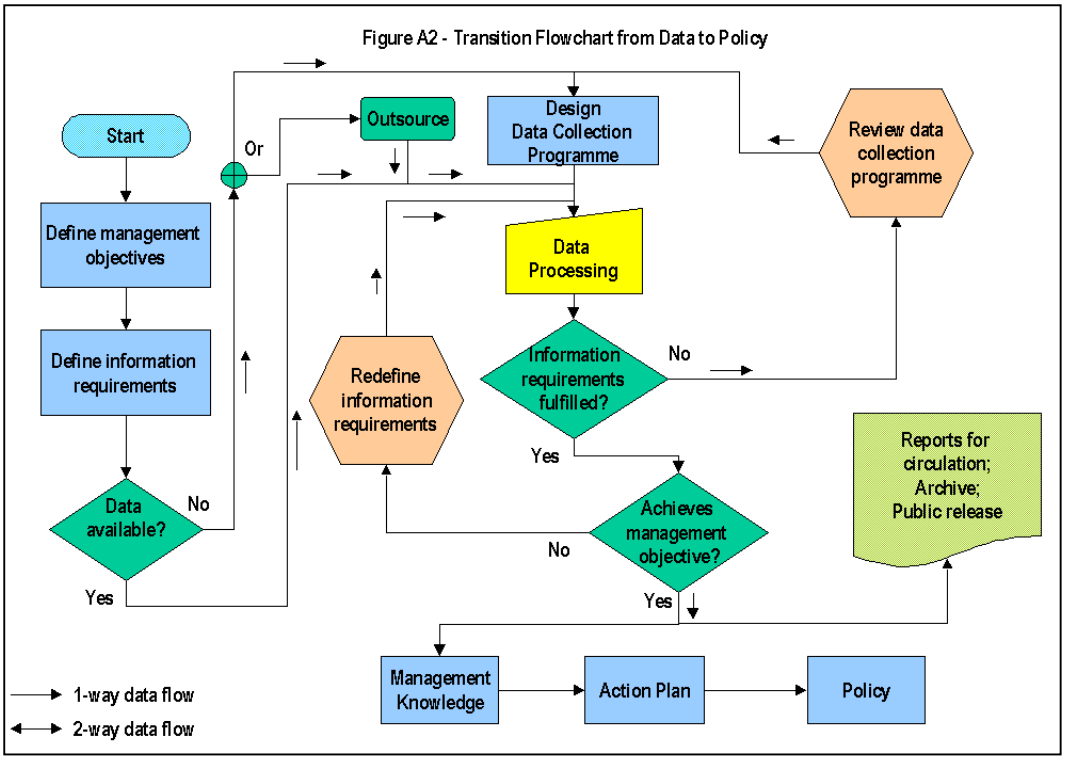


Figure A2 - Transition Flowchart from Data to Policy
Start
Define management objectives
Define information requirements
Data available?
No
Yes
Or
Outsource
Design Data Collection Programme
Review data collection programme
Data Processing
Information requirements fulfilled?
No
Yes
Redefine information requirements
Achieves management objective?
No
Yes
Reports for circulation; Archive; Public release
Management Knowledge
Action Plan
Policy
1-way data flow
2-way data flow

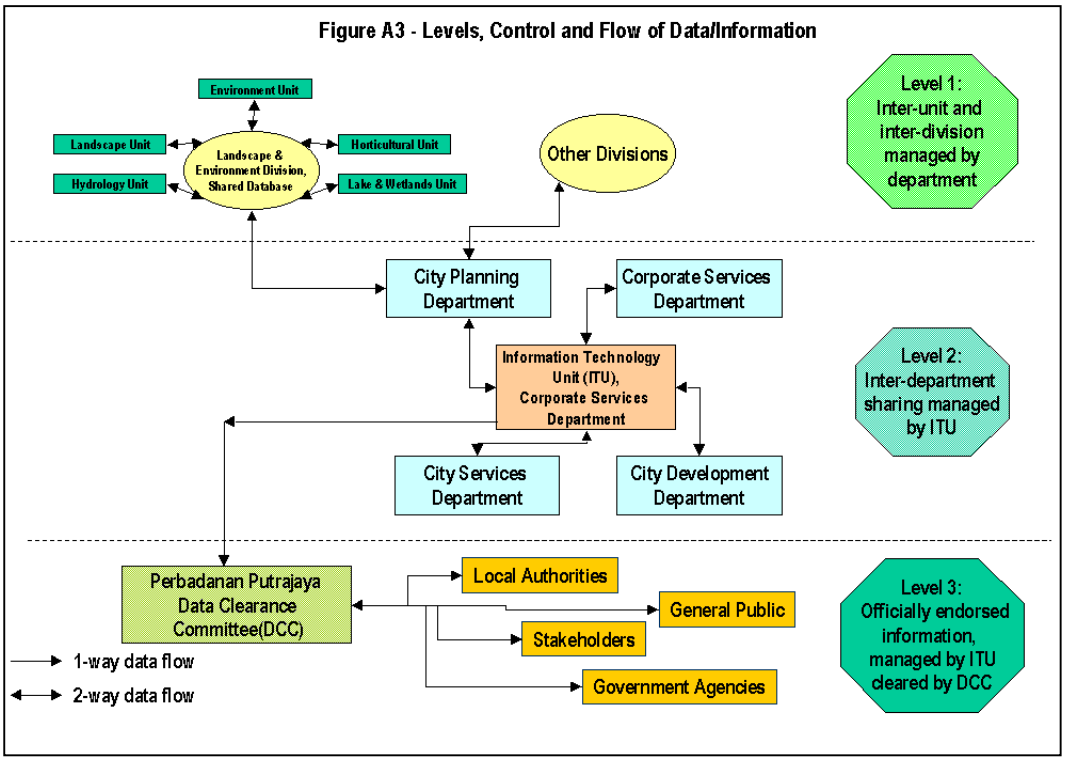


Figure A3 - Levels, Control and Flow of Data/Information
Environment Unit
Landscape Unit
Landscape & Environment Division, Shared Database
Horticultural Unit
Hydrology Unit
Lake & Wetlands Unit
Other Divisions
Level 1: Inter-unit and inter-division managed by department
City Planning Department
Corporate Services Department
Information Technology Unit (ITU), Corporate Services Department
Level 2: Inter-department sharing managed by ITU
City Services Department
City Development Department
Perbadanan Putrajaya Data Clearance Committee(DCC)
Local Authorities
General Public
Stakeholders
Government Agencies
Level 3: Officially endorsed information, managed by ITU cleared by DCC
1-way data flow
2-way data flow

3.0 The Use of Geographical Information Systems (GIS)

3.1 The usefulness of Geographical Information Systems in environmental monitoring have been widely accepted and is one of the reasons why an ICMS is recommended to accompany the Catchment Management and Development Plan.

3.2 SiCad is the GIS software used in Perbadanan Putrajaya's Sumber Putra central data management system. Future GIS applications, if purchased whether at Department or Unit level must ensure cross-compatibility. However, the need of the management must be defined in order to decide as to what level or platform of GIS.

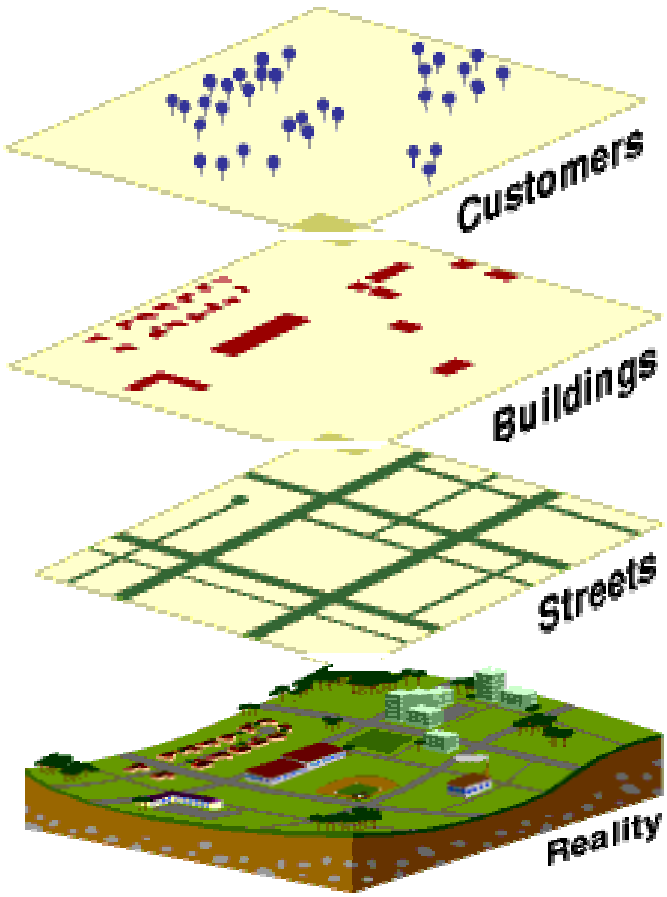
3.3 Costs for GIS systems are expensive particularly, fully-interactive types. A complete Decision-Support System may require administrative adjustments for its proper upkeep and utilisation.

3.4 Most studies carried out as part of this project require maps to carry out its analysis. In a few of the studies, maps are the most important criteria e.g. drainage and sewerage, slope analysis and land use studies, all requires contour maps and land parcel maps.

3.5 By putting all the maps in digital format and keying in the associated data (or attributes as it is referred to in GIS parlance), the GIS becomes a powerful tool for data entry, storage and updates, data query and analysis and for producing hardcopy and softcopy maps and data output.

3.6 Gaining access to the study data from the GIS is also faster and easier, and maps provide a spatial perspective, which is impossible to achieve with spreadsheets and hardcopy reports. GIS technology also promote data sharing by encouraging consultants, decision makers and other endusers to utilise each other's data in order to carry out better and more powerful analysis.

3.7 Figure A7.4 shows the representation of real-world objects in GIS concepts.



- Computer mapping
- Information represented by points, lines, polygons and text
- Linked to multiple layers of databases
- Automated system for
  - Capture
  - Storage
  - Retrieval
  - Analysis
  - Display
  - Output

Figure A7.4 GIS Concepts

3.8 The main concerns in GIS implementation are maps and data, procedures and application development.

3.9 The factors to be considered for selection of a GIS software and system are: -

- The software choices of other parties which have information relevant to environment and catchment monitoring
- The risk of data loss between software types and versions particularly, the loss of topological data which will be time consuming to rectify.
- The availability of skilled personnel in the selected software
- The choice of operating system platform; a UNIX based GIS on a server system although being more powerful than a personal-computer (PC) or desktop system requires

appropriately trained and skilled personnel for support and development work

- The learning curve of the selected software; Unix based systems require longer training time as compared to PC systems.

4.0 Recommendation

4.1 Geographic Information Officer (GIO)

4.1.1 A Geographic Information Officer (GIO) is recommended to be part of Perbadanan Putrajaya's Information Technology management team. The task of the GIO is to formulate strategies that incorporate geographic information technology to improve the organisation's overall performance.

4.1.2 The GIO should be responsible for:

- Development of the geographic information plans and associated policies to achieve the strategic objectives of the organisation.
- Development of organisation-wide information product and technology requirements.
- Directing the investment of information technology funds to maximise organisation benefits and maintaining a managed portfolio of those investments.
- Providing external representation for the organisation on all matters relating to geographic information.
- Supporting the creation and management of the enterprise geographic data model with respect to content, standards, quality, geographic reference, integration, interoperability, and appropriate documentation, including metadata.
- Providing open access to data where appropriate and promoting sharing of commonly needed data resources, within Putrajaya, among other stakeholders in the catchment area and the public at large.

4.1.3 As with the Head of Information Technology, a GIO brings specialised skills to the organisation. A GIO has a comprehensive knowledge of geographically distributed phenomena and the processes that create and modify the geographic landscape. The GIO has knowledge of geographic information technologies and the digital representation of geographic phenomena, and has knowledge of the role of geospatial information in organisation-wide operations such as management, decision-making, and policy formulation.

4.1.4 A GIO should have an advanced degree in geographic information science, geography, remote sensing, computer science or a closely related field and has demonstrated GIS management experience.

4.2 Procedures for handling Digital Maps and Databases

4.2.1 Perbadanan Putrajaya is in a unique position to develop proper procedures for the handling of digital maps and databases as the whole Putrajaya City is being built from scratch.

4.2.2 Proper procedures need to be put in place in terms of:

- Electronic and hardcopy archiving – Who has responsibility? How often? Where? Firewall? Disaster and Recovery Centre? Archiving and circulation of hardcopy maps and documents?
- Responsibilities for maintenance and updates of different databases. This is best addressed by allowing different departments to be responsible for their own datasets whilst not duplicating each other's efforts.
- Access and Security issues need to be properly addressed so that only authorised personnel are given access to sensitive documents, whilst not hindering the promotion of data sharing concept.

4.3 Conversion of CAD datasets to GIS Format

4.3.1 The CAD datasets submitted by various outside parties (developers, planners, and landowners) in the Sumber

Putra Project are recommended to be converted into GIS format. This will allow them to be integrated to the GIS data repository in the GIS Server.

4.3.2 Over time, these integrated GIS digital maps and data will become an invaluable resource to Putrajaya.

4.4 Data Sharing through Intranet (Internal Access) and Internet Map Server (External Access)

4.4.1 Staff within Perbadanan Putrajaya should undergo training not only on GIS software and concepts but also on the maps and datasets in the GIS Server so that they have a deep understanding of available resources. Each department should be given access to the GIS Server (but not necessarily "editing" access) via a corporate Intranet.

4.4.2 Furthermore, certain information, which might be of use and concern to the public, should be made available via the Internet Map Server. These could be the general cadastral, planning, topographical and zoning information, which could be useful to developers, for instance, in their preparation of proposed Development Master Plans or Layout Plans. Currently, they would need to obtain this information over the counter from various public institutions.

4.5 Develop and Integrate Specific GIS Applications for All Departments within Putrajaya

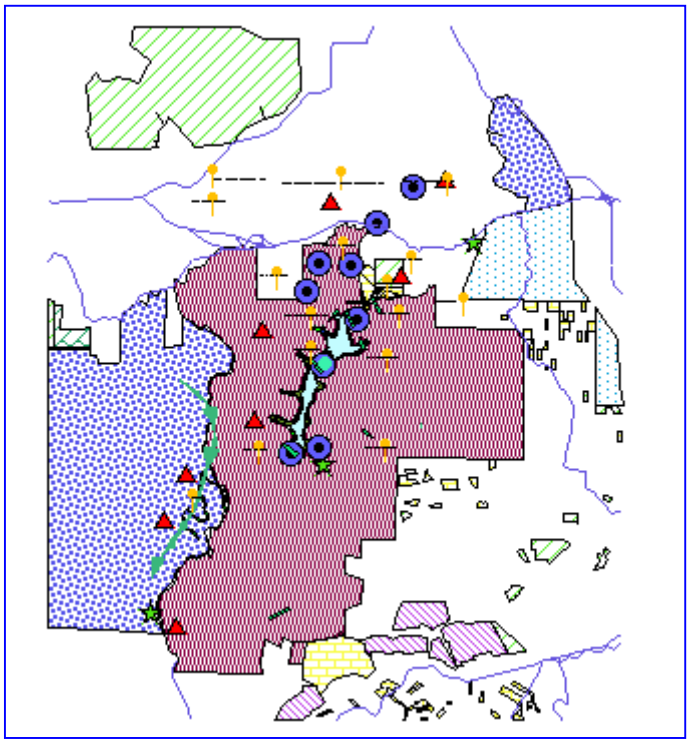
4.5.1 GIS can be utilised by the Town Planning Department, the I.T. Department, the Licensing Department, the Building Department, the Valuation and Property Department, the Engineering Department, the Customer Services Department, the Irrigation and Drainage Department, and the Perbadanan Putrajaya management.

4.5.2 However, most of the time, the endusers do not necessarily want to, or have the time to undergo proper training to become proficient users in GIS. Then there are users who only need to use some basic GIS functionality coupled with their own datasets or maps.

4.5.3 For all these users, the power of GIS technology can be harnessed so that they can utilise fully their maps and databases by developing small, specific applications using a combination of MapObjects, Visual Basic and/or Visual C++, to suit their individual department's requirements.

4.5.4 Finally, document imaging is a widely available and used tool in Malaysia today. However, document imaging linked to the GIS is a new area and requires proper expertise and careful planning before implementation. This can be an extremely useful tool for planners, engineers and managers as they can zoom onto an area using the GIS and retrieve whatever scanned images of engineering plans and drawings available within the area (especially underground utilities).

APPENDIX 7.2
Catchment Development and Management Plan for Putrajaya Lake
Data Description for the ICMS (Version 1)



Produced by:

Head Office:
No: 35, 1st & 2nd Floor
Jalan USJ 10/1
47620 UEP Subang Jaya
Selangor Darul Ehsan, MALAYSIA
Tel: (603) 734 4197
Fax: (603) 733 7142
E-mail: razali@malsat.com.my

Branch Office:
Lot 442, No. 8, 2nd Floor
Jalan Rubber
93400 Kuching
Sarawak, MALAYSIA
Tel: (6082) 236 310
Fax: (6082) 236311

Website: http://www.malsat.com.my

Installation

For your convenience, the data description for the ICMS for the **Catchment Development and Management Plan for Putrajaya Lake** Version 1.0 is delivered to you in the following data formats: -

- ArcView Native Format (*.SHP)

The datasets are stored in a single 100Mb Zip Disk or eight 1.44Mb 3.5" diskettes, or other suitable digital data medium. Where necessary, especially DXF files, they are compressed using the PKZIP.EXE utility. These can be uncompressed using a WINZIP shareware which is included in the Zip Disk or in the 3.5" diskette No. 8. The WINZIP shareware has a PKUNZIP.EXE utility for compressing/decompressing data. Please register the WINZIP shareware with the copyright owner.

Data Delivered

All the data delivered was installed in a GIS Unix Server under logical path **("\database\dg_map\professional\putrajaya").** Under the folder of **\putrajaya**, there are 11 more sub-folders, which indicates the type of features, which is included in this delivery:

1. **\putrajaya \Pollution_Source_Study**
2. **\putrajaya \Mini_Wetland_Study**
3. **\putrajaya \Water_Quality_Study**
4. **\putrajaya \Hydrological_Study**
5. **\putrajaya \Erosion&Sedimentation_Study**
6. **\putrajaya \Geological&Hydrological_Study**
7. **\putrajaya \Drainage_Master_Plan**
8. **\putrajaya \Sewarage_Master_Plan**
9. **\putrajaya \Existing_Landuse**
10. **\putrajaya \Landuse_Master_Plan**
11. **\putrajaya \Features**

Layers

There are 46 ArcView Shape (*.shp) files.

Layer Code	Filename	Description	Entity Type
1	ROAD	Road Network	Polygon
2	RIVERLINE	River	Line
3	RIVERPOLY	River	Polygon
4	DAM	Dam	Polygon
5	LAKE	Lake	Polygon
6	PHIGHWAY	Plus Highway	Line
7	PEXLINK	Proposed Express Link	Line
8	WETLAND	Wetland area	Polygon
10	CONLINE	Contour Lines	Polyline
12	CONTEXT	Contour lines text/description	Text
14	RCASE	Road Case	Polygon
16	MASPLAN	Master Plant (Combination all layers)	Pgon/Pline/Pt/tx
17	LOT	Lots	Polygon
18	PUTLACAT	Putrajaya Lake Catchment	Polygon
20	PUTBOUND	Putrajaya Boundary	Polygon
21	SGCHAUB	Boundary of Sg Chua catchment area	Polygon
22	DISTBOUN	District Boundary	Polygon
23	WEIRCW	Weir in center wetland	Polygon
24	SWAMFZCW	Swamp Forest Zone in center wetland	Polygon
25	PONDCW	Pond in center wetland	Polygon
26	MARSHCW	Marsh in center wetland	Polygon
27	WEIRPL	Weir in center Primary Lake	Polygon
28	SWAMPL	Swamp Forest Zone in center P. Lake	Polygon
29	PONDPL	Pond in center Primary Lake	Polygon
30	MARSHPL	Marsh in center Primary Lake	Polygon
31	SYNCLINE	Geology - Syncline	Point
32	KENNYHF	Geology – Kenny Hill Formation	Polygon
33	HAWTFOR	Geology – Hawthornden Formation	Polygon
34	ALLUVIUM	Geology – Alluvium	Polygon
35	FRACTURE	Geology – Fractures - Lineaments	Line
36	ANTICLIN	Geology - Anticline	Point
37	DETPOND	Detention Ponds	Point
38	VEGEBUF	Vegetation buffer	Point
39	KENNYHI2	Kenny Hill Formation 2	Point
40	HAWTHO2	Hawthornden Formation 2	Point
41	WELLPRO	Existing Production wells	Point
42	ALLUVIU2	Alluvium 2	Point
43	RSTATION	Rainfall Station	Point
44	SFSTATIO	Stream flow station	Point
45	WQSATIO	Water Quality Station	Point
46	STPLANT	Sewerage Treatment Plant	Point

47	SDRAIND	Surface Drainage Direction	Line
48	CATCHA	Putrajaya catchment area	Polygon
49	WETLAND	Wetland	Polygon
50	ERL_CENT	Erl_cent	Line
51	LANDUSE	Land use	Polygon
52	PIEZOME	Piezometer	Point

Accuracy

The expected accuracy is +/- 15 meters. This needs to be verified by collecting GPS points at road intersections or other landmarks.

Map Projection

All data were from various sources with different map projections, i.e. Lat./Long (Malaysia) and MRSO. Additional data were obtained by field GPS Survey in the WGS84 coordinate system but the final digital data products were merged in a single MRSO ((West Malaysia) projection only.

Attributes

Apart from their respective individual attributes, e.g. street name for ROAD, all features or GIS layers has four common attributes:

- Map Source - Coded to reflect either topographical maps, town maps, Aerial Photography, or other sources.
- Map Projection - Of the map source, NOT the projection of the Digital Data.
- Map Scale - Of the map source, NOT the projection of the Digital Data
- Last Updated - Date of last map and data update by MALSAT's Technical Department, NOT the currency of the map sources.

Where certain information is not available, the attributes are entered as "N/A". For example, an attribute for a road with the entry "N/A" means that after field verification the road has no name.

Spatial Database Structure

Layer Code 1: Structure for table ROAD

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 2: Structure for table RIVERLINE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 3: Structure for table RIVERPOLY

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 4: Structure for table DAM

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 5: Structure for table LAKE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	35	
3	Description	Character	25	
4	Map_Source	Character	10	
5	Map_Scale	Character	10	
6	Map_Projection	Character	50	
7	Last_Updated	Character	10	

Layer Code 6: Structure for table PHIGHWAY

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 7: Structure for table PEXLINK

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 8: Structure for table WETLAND

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Map_Source	Character	10	
3	Map_Scale	Character	10	
4	Map_Projection	Character	50	
5	Last_Updated	Character	10	

Layer Code 10: Structure for table CONLINE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Elevation	Number	10	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 12: Structure for table CONTEXT

Field	Field Name	Type	Width	Dec
1	Contour Info	Character	50	

Layer Code 14: Structure for table RCASE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Road_Name	Character	30	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 16: Structure for table MASPLAN

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
4	Map_Source	Character	10	
5	Map_Scale	Character	10	
6	Map_Projection	Character	50	
7	Last_Updated	Character	10	

Layer Code 17: Structure for table LOT

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Lot No	Character	10	
3	Map_Projection	Character	20	
4	Map_Source	Logical		
5	Map_Scale	Character	10	
6	Last_Updated	Character	10	

Layer Code 18: Structure for table PUTLACAT

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 20: Structure for table PUTBOUND

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 21: Structure for table SGCHAUB

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 22: Structure for table DISTBOUN

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 23: Structure for table WEIRCW

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	TCom_Code	Character	2	
4	Map_Source	Character	10	
5	Map_Scale	Character	10	
6	Map_Projection	Character	50	
7	Last_Updated	Character	10	

Layer Code 24: Structure for table SWAMZCW

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	TCom_Code	Character	2	
4	Map_Source	Character	10	
5	Map_Scale	Character	10	
6	Map_Projection	Character	50	
7	Last_Updated	Character	10	

Layer Code 25: Structure for table PONDCW

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 26: Structure for table MARSHCW

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 27: Structure for table WEIRPL

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 28: Structure for table SWAMPL

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 29: Structure for table PONDPL

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 30: Structure for table MARSHPL

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 31: Structure for table SYNCLINE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 32: Structure for table KENNYHF

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 33: Structure for table HAWTFOR

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 34: Structure for table FRACTURE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 35: Structure for table ANTICLIN

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 36: Structure for table ALLUVIUM

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 37: Structure for table DETPOND

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 38: Structure for table VEGEBUF

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 39: Structure for table KENNYHF2

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 40: Structure for table HAWTHO2

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 42: Structure for table ALLIVIU2

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 43: Structure for table RSTATION

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 44: Structure for table SFSTATION

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 45: Structure for table WQSATIO

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 46: Structure for table STPLANT

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 47: Structure for table SDRAIND

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 48: Structure for table CATCHA

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 49: Structure for table WETLAND

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 50: Structure for table ERL_CENT

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 51: Structure for table PIEZOM

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

Layer Code 52: Structure for table LANDUSE

Field	Field Name	Type	Width	Dec
1	Layer_Code	Character	2	
2	Feature_Name	Character	50	
3	Map_Source	Character	10	
4	Map_Scale	Character	10	
5	Map_Projection	Character	50	
6	Last_Updated	Character	10	

APPENDIX 7.3

DATABASE MANUAL FOR LOW-LEVEL ICMS

PREPARED BY

National Hydraulic Research Institute Malaysia (NAHRIM)

Water Quality Database : WaterQuality.mdb

Purpose: **This database is designed for the storage of in-situ water quality data**

End-user: **Environmental Management Unit , Lake Management Unit**

Background

The water quality database and data tables allows for the prompt record of field water quality measurements. The data tables are tailored to accompany the water quality monitoring programme as proposed in the Putrajaya Lake Management Guide. The water quality parameters proposed to be measured are:

1. PH value
2. Dissolve Oxygen (DO)
3. Suspended Solids (SS)
4. Total Phosphorous (TP)
5. Reactive Phosphorous (RP)

Description

The database comprises four tables and is discussed below:

- *Thresh* – the table containing threshold data for effluent parameters based on the Environmental Quality Act, 1974. This table is a table of standards. It is primarily static and updates of this table is expected to accompany legislative changes to the national or local water quality standards. It's function is to provide the facility for queries involving comparisons between field data recorded in the other water quality datatables with the current standards. The structure of this table has been extracted from Appendix 16 of the Putrajaya Environmental Management Guide – *Second Schedule; Environmental Quality Act, 1974; Environmental Quality (Perbadanan Putrajaya) (Water Pollution Control) Regulations, 1998 [Regulations 8(1), 8(2)]; Parameter Limits of Effluent*

- *WQStation* - the table containing information pertaining to the station location, description and management. This data table provides the GIS link to planning maps.

- *WQJob* – the data table containing information regarding the sampling assignment or job. This table is used to record weather conditions, site notes and dates of sampling. This table can be copied and named after the actual stations once they are established.

- *WQSample* – the sampling data table that is used to record sampling times, depths and readings for the various water quality parameters tested. This table can be copied and named after the actual stations once they are established.

The three data tables can be linked by the primary key fields (i) the Station ID and (ii) the Sampling Job Number. The Station ID (primary key) links table WQStation to WQJob, the former providing the geographical reference to the actual water quality measurements. The Sampling Job Number links the field assignment records in WQJob to the measurements at various depths recorded in WQSample

WATERQUALITY

Datatable: WQStation

Field Name	Data Type	
Sta_ID	Text	Water quality station ID number (unique)
Sta_Desc	Memo	Description of station location
Lat	Number	Latitude of location in degrees MRSO
Long	Number	Longitude of location in degrees MRSO
Sta_Date	Date/Time	Date of station set-up and first sampling
Maint_by	Text	Maintained by
Notes	Memo	

Datatable: WQJob

Field Name	Data Type	
Sta_ID	Text	Station ID
S_JobID	Text	Sampling job number
S_Date	Date/Time	Date of sampling
Wth	Text	Weather condition
S_By	Text	Initial of person doing sampling
Field_N	Memo	Notes of field activity

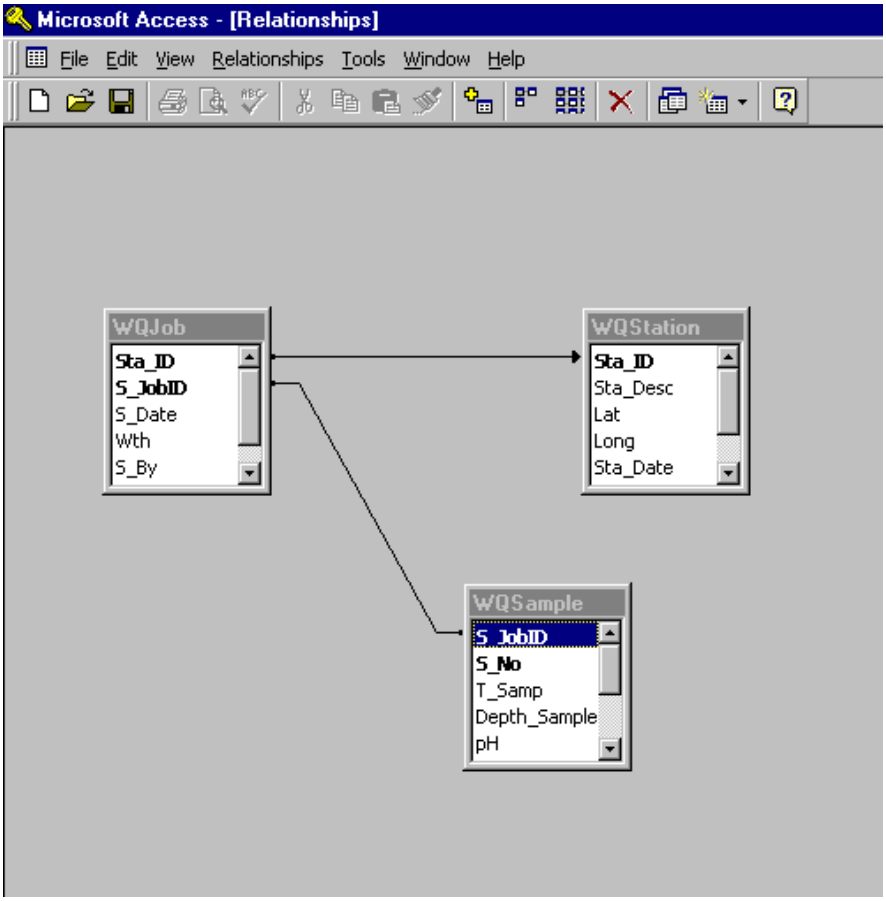
Datatable: WQSample

Field Name	Data Type	
S_JobID	Text	Sampling job number
S_No	Text	Sample number
T_Samp	Date/Time	Time of sampling
Depth_Sample	Number	Depth of sampling in meters
pH	Number	pH value of water sample
DO	Number	Dissolved oxygen, mg/l
TSS	Number	Total Suspended solids, mg/l
TP	Number	Total Phosphorous, mg/l
RP	Number	Reactive Phosphorous, mg/l

Relationship between Datatables in the WaterQuality Database

For field water quality parameter data entry, a form has been designed using the WQJob and WQSample datatables. The form consists of a main form, WQJob, and a subform, WQSample. This form allows data entry into both the datatables whereby each sampling job assignment and each sample can be recorded. It is important that the job ID and the sample ID be unique.

In order for such a form to be designed, the tables WQJob and WQSample must first be connected using the relationships feature in Microsoft Access. The relationships are as shown below.

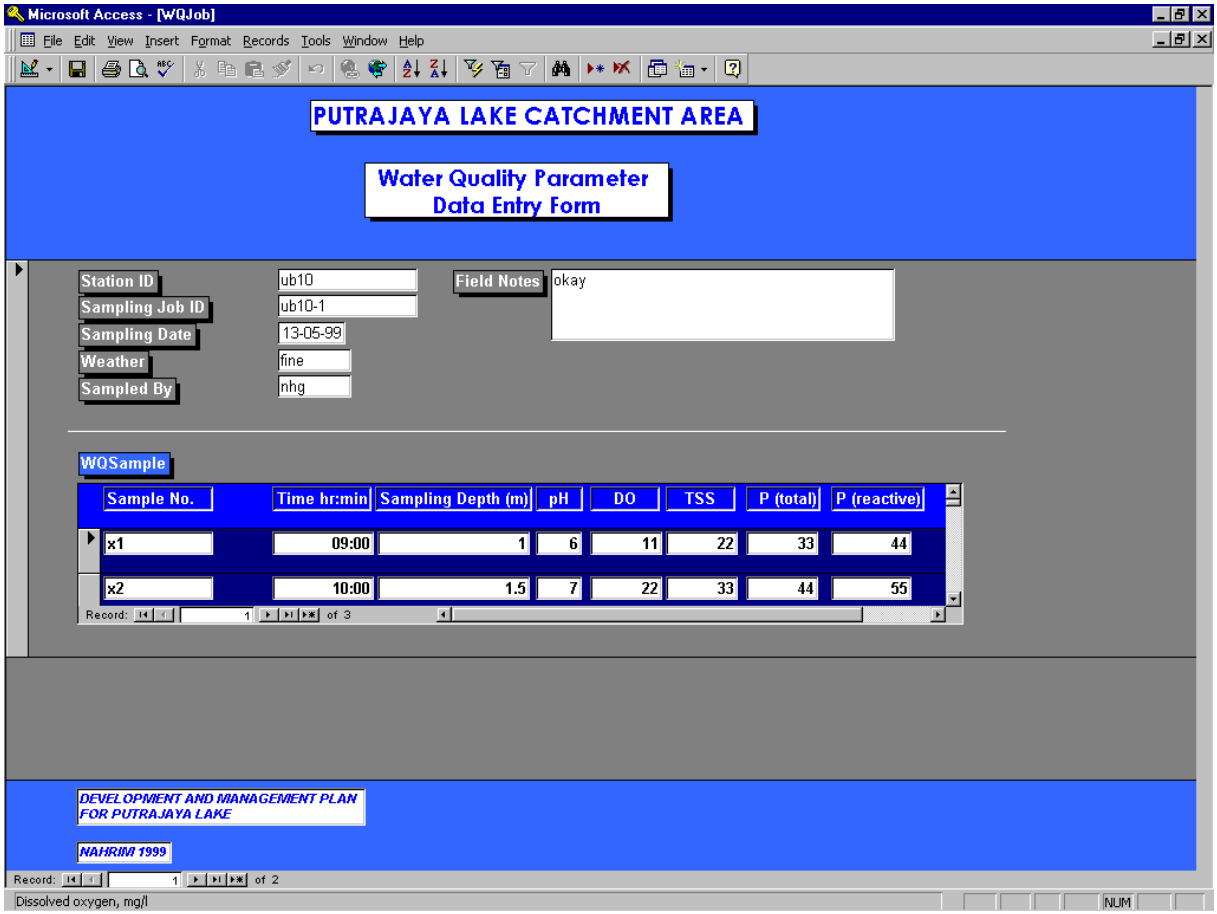


The fields in bold have been designated as primary keys within each datatable. The relationship between WQStation and WQJob and between WQJob and WQSample is termed a “one-to-many” relationship. This means that for each station there can be more than one sampling job assignment and for each sampling job assignment there can be several samples.

Water Quality Parameter Data Entry Form

The Water Quality Parameter Data Entry Form is displayed below:

Form: WQJob



This form actually comprises of the main form WQJob and the subform WQSample. Entry of data will fill both the WQJob and WQSample datatables simultaneously due to the relationship set as explained earlier. Changes to the design of the subform can only be done by opening the subform independently.

Hydrology Database

Purpose: **This database is designed for the storage of hydrological station information**

End-user: **Hydrology Unit**

Background

This database is designed for hydrological information.

Description

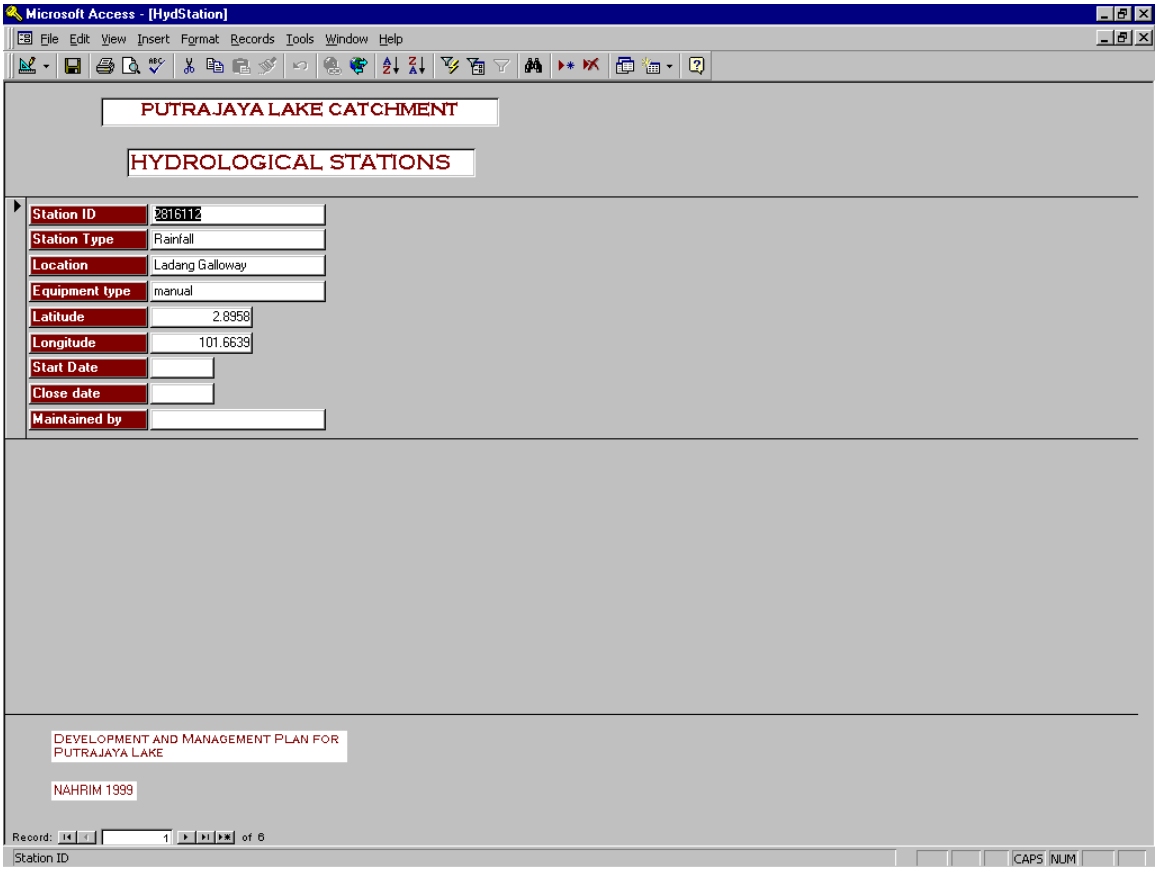
HydStation: Datatable for location of hydrological stations i.e. for rainfall, evaporation or streamflow gauging stations. Geographical coordinates in the datatable connect the database with the relevant GIS map.

The HydStation table structure and form are shown below. The form is an alternative way to enter and also to view data.

Datatable: **HydStation**

Field Name	Data Type	
ID	AutoNumber	
HSta_ID	Text	Station ID
HSta_type	Text	Type of station
HSta_Loca	Text	Location and description of station
Equip_type	Text	Equipment type
Lat	Number	Latitude of location in degrees MRSO
Long	Number	Longitude of location in degrees MRSO
St_Date	Date/Time	Date of station set-up and first sampling
Cl_date	Date/Time	Date of closing station
Maint_by	Text	Maintained by

Form: **HydStation Data Entry/Viewing Form**



Drainage Database

Purpose: ***This is a drainage structure information database. It is to be linked with the proposed drainage master plan drawing. The database will be associated with the line entities representing drainage structures.***

End-user: ***Hydrology Unit, Environmental Unit***

Background

The drainage database provides the user with information on location and size of drains corresponding to a line feature on the GIS map.

Description

A drainage master plan is one of the deliverables of the study and the expected final recommendation presentation will include a drainage plan. The plan will indicate the layout of the proposed drains within the Putrajaya administrative area. The drainage database comprises 5 tables described below.

Drain1: this datatable will complement the final drainage map by displaying information on the drain type, size and maximum discharge including length and slope at the click of a button.

GPT1: this datatable is stores the inventory of gross pollutant traps installed in the drainage system

GPT_DControl: this datatable stores information on the gross pollutant traps designed as part of the drainage plan including design parameters and dimensions. GPTs are man-made structures constructed as part of the drainage system. As the name implies, its function is to trap all visible pollutants including rubbish, sediment and debris. GPTs have to be cleaned and maintained. GPT's are often built based on trial-and-error and may need to be redesigned to meet efficiency requirements designs. The last record in this data table represents the current design.

GPT_WQ1: is the water quality data table associated with the GPT station. It keeps the records of suspended solids measurements entering and exiting the GPT. A query programme can be designed to calculate the efficiency of the structure based on the measurements recorded here and provides a status report of the GPT. This will make fields DesMaxEff and Eff_MinVar fields redundant. Alternatively, the information can be exported to a spreadsheet for further analytical purposes.

DetPond1: Eight areas within the Putrajaya area have been designated as permanent flood detention ponds. Outside the Putrajaya area, five areas have been found to be potential sites for flood detention ponds. DetPond1 is a datatable for detention ponds found in the Putrajaya catchment. Information provided therein includes the sub-catchments in which they are located as well as the size and width of the ponds.

Datatable: Drain1

Field Name	Data Type	
Dr_ID	Text	Drain structure ID (unique)
Dr_type	Text	Type of drain; earth, concrete
Slope	Number	Slope of drain X (horizontal):1(vertical)
Length	Number	Length of drain in meters
Qmax	Number	Maximum discharge in cubic meters per second
Dr_pix	OLE Object	Linked graphic; design cross-section of typical drain

Datatable: GPT1

Field Name	Data Type	
ID	AutoNumber	
GPT_ID	Text	GPT unique identifier
GPT_Desc	Memo	Description of GPT location
Lat	Number	Latitude of location in degrees MRSO
Long	Number	Longitude of location in degrees MRSO
St_Date	Date/Time	Date of GPT construction
Maint_by	Text	Maintained by
Notes	Text	

Datatable: GPT_DControl

Field Name	Data Type	Description
ID	AutoNumber	
GPT_ID	Text	GPT unique identifier
GPT_ModNo	Text	Gross Pollutant Trap Modification ID number (unique)
SubCatch	Text	Subcatchment
Type	Text	Type description
Maint_Per	Number	Maintenance period in months
Date_Built	Date/Time	Date GPT was built
ARI	Number	Design Average Recurrence Interval in years
AreaRatio	Number	Area ratio in sq. meters/ ha.
TrapWidth	Number	Maximum width of trap in meters
TrapDepth	Number	Maximum depth of trap in meters
DepthWeir	Number	Maximum depth to weir in meters
DepthInlet	Number	Maximum depth to invert of inlet pipe, meters
VelMax	Number	Maximum 1 year velocity in m/s
Eff_Max	Number	Maximum efficiency for low discharge 25% quartile
DesMaxEff	Number	Calculated; 40% design maximum efficiency level; Eff_Max x 0.4
Eff_Min	Number	Minimum efficiency for high discharge 75% quartile
Eff_MinVar	Number	Calculated; 10% variation minimum efficiency level; Eff_Min - (Eff_Min x 0.1)

Datatable: GPT_WQ1

Field Name	Data Type	Description
ID	AutoNumber	
GPT_SampNo	Text	GPT water quality sample number
GPT_ModNo	Number	Gross Pollutant Trap Modification ID number in GPT_DControl
Date_S	Date/Time	Sampling Date
In_SS	Number	Inflow suspended solids, mg/l
Out_SS	Number	Outflow suspended solids, mg/l
FlowQ	Number	Flow quartile
FlowEff	Number	Calculated; Flow efficiency; (Inflow SS - Outflow SS)x100 / Inflow SS
Action	Text	Action required after comparing with DesMaxEff in GPT_DControl
Maint_Date	Date/Time	Date on which maintenance work was done

Datatable: DetPond1

Field Name	Data Type	
ID	AutoNumber	
DetPond_ID	Text	Unique detention pond identifier
Lat	Number	Latitude of location in degrees MRSO (central point)
Long	Number	Longitude of location in degrees MRSO (central point)
SubCatch	Text	Subcatchment name
SubCatch_Area	Number	Size of subcatchment area
DetPond_Width	Number	Width of detention pond in meters
Notes	Memo	

Wetlands Database

Purpose: ***Inventory of wetlands, flora and fauna***

End-user: ***Lake and Wetlands Unit, Environment Management Unit***

Background

The wetlands database is an inventory of wetlands identified inside the Putrajaya catchment area including those outside the administrative boundaries Putrajaya. Information on location, size, flora and fauna are included in the database.

Description

Wetland1: The seven wetland areas of Putrajaya have been identified by the wetlands expert in his report. In this datatable, each wetland is given a unique identifier and key information including a name, size and georeference coordinates. The number of subcells identified for wetland plant inventory purposes is also included.

Wetland2: The wetlands have also been subdivided into subcells for the purpose of marking areas where wetland plants are present. There are 22 subcells including the central wetland and the primary lake.

XX_TerPlant: This datatable stores an inventory of the type of terrestrial plants found in each respective wetland and includes a photograph of the item. This datatable can be duplicated and named after each particular wetland cell.

XXX_WetPlant: This is the generic database structure for the wetland plants in each Wetland subcell. This datatable can be duplicated and named after each particular wetland cell.

Fish1: Information from Table 2.7.5 of the report has been transferred into this datatable

Mammal1: Information from Table 2.7.6 of the report has been transferred to this datatable

Birds1: Information from Table 2.7.7 of the report has been transferred to this datatable

Datatable: Wetlands1

Field Name	Data Type	
Wetland_ID	Text	Wetland identifier
Wetland_N	Text	Name of wetland
No_Cell	Text	Number of Subcells
Area	Number	Area in hectares, approximate
Lat	Number	Latitude of location in degrees MRSO (central point)
Long	Number	Longitude of location in degrees MRSO (central point)

Datatable: Wetlands2

Field Name	Data Type	
Wetland_ID	Text	Wetland identifier
WetCell_ID	Text	Wetland cell identifier
Wetland_N	Text	Name of wetland
Area	Number	Area in hectares, approximate
Lat	Number	Latitude of location in degrees MRSO (central point)
Long	Number	Longitude of location in degrees MRSO (central point)

Datatable: XX_TerPlant

This is the generic database structure for the terrestrial plants around each Wetland area. The first 2 letters of the datatable would be the ID initials of the wetland area e.e CW_TerPLant for Central Wetland.

Field Name	Data Type	
Plant_ID	AutoNumber	
Plant_ Sci_Name	Text	Plant scientific name
Vern_Name	Text	Vernacular Name
Plant_Com_Name	Text	Plant common name
Plant_pix	Hyperlink	Hyperlink to pix gallery

Datatable: XXX_WetPlant

This is the generic database structure for the wetland plants in each Wetland subcell. The first 3 letters of the datatable would be the ID initials of the wetland area e.g. UB1_WetPlant for Upper Bisa subcell 1.

Field Name	Data Type	
Plant_ID	Number	Unique plant ID number
Plant_Sci_Name	Text	Scientific name
Plant_Com_Name	Text	Common name
Plant_pix	Hyperlink	Hyperlink to picture gallery

Datatable: Mammals1, Birds1, Fish1

Simple datatable structures for inventory of wildlife. A hyperlink field can be added to link the data with pictures.

Field Name	Data Type	Description
ID	AutoNumber	
Mam_Sci_Name	Text	Scientific name
Mam_Com_Name	Text	Common name English/Malay
Env_Status	Number	Environmental status;1=protected according to Wildlife Protection ACt, 1972
Pix	Hyperlink	Photo of wildlife

Field Name	Data Type	Description
ID	AutoNumber	
Bird_Sci_Name	Text	Scientific name
Bird_Com_Name	Text	Common name English/Malay
Env_Status	Number	Environmental status;1=protected according to Wildlife Protection ACt, 1972

Field Name	Data Type	
ID	AutoNumber	
Fish_Sci_Name	Text	Scientific name
Fish_Com_Name	Text	Common name English/Malay
Pix	Hyperlink	Photo

Picture Gallery

Wildlife inventory datatables can be enhanced by photographs. A picture gallery should be created to store all photographs related to the wetland flora and fauna. The hyperlinked fields in XXX_WetPlant, XX_TerPlant, Fish1, Mammal1 and Bird1 would then be associated with this to access the photographs. The photographs should be in JPG or TIF rather than BMP format to conserve space.

Sewerage Database

Purpose: ***Inventory of sewage treatment plants in Putrajaya Lake Catchment***

End-user: ***Environment Unit***

Background

One potential point source pollutant to the Putrajaya Lake is the discharge of untreated or inadequately treated sewage effluent into the catchment drainage system of the lake. Among the information pertinent to manage sewage in Putrajaya is the location and capacity of the existing and proposed sewage treatment plants. This database houses this information and provides an overall view of the major sewage treatment facilities in the area..

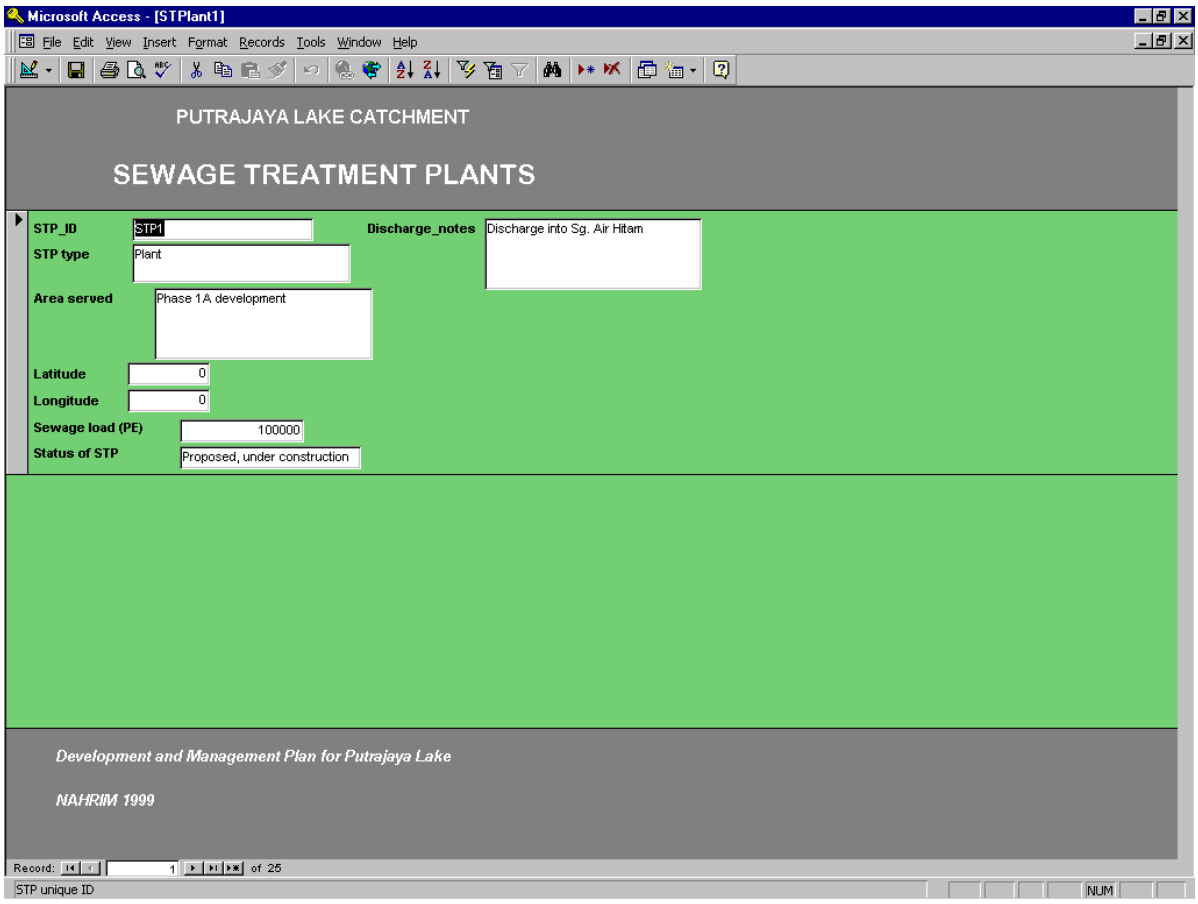
Description

STPlant1: This datatable georeferences the lcoation of all sewage treatment plants in the Putrajaya catchment both inside and outside the Putrajaya administrative boundaries. Records of the capacity of the sewage treatment plant, status of construction and information on the discharge from the plant can be included within STPlant1.

Datatable: **STPlant1**

Field Name	Data Type	
ID	AutoNumber	
STP_ID	Text	STP unique ID
ServArea_Desc	Memo	Description of area served by STP
Lat	Number	Latitude of STP location in degrees MRSO
Long	Number	Longitude of STP location in degrees MRSO
Sew_Load	Number	Sewage load or capacity in population equivalent (PE)
Status	Text	Status of STP; existing, temporary, proposed
Discharge_notes	Memo	Notes on discharge of effluent

Form: STPlant1



APPENDIX 7.4

CONCEPTUAL PROPOSAL FOR COMPLETE ICMS

1. INTRODUCTION

The Kawasan Putrajaya, covering an area of about 4,581 hectares, is being developed by the Malaysian Federal government as a new administrative capital. The city is being developed based on a "City in a Garden" concept, with Putrajaya lake forming the focal point. The lake is being formed by the impoundment of Sg. Chuau and has an Catchment area of about 4,500 hectares. The Putrajaya lake is planned to cater to the needs for multi-purpose uses, such as recreation, boating, fishing, water transport etc. Hence a high water quality standard has to be maintained in the lake.

In view of the above, an efficient system has to be develop to monitor and maintain the water quality level of the lake. As many external parameters are contributing to water quality of the lake an integrated system has to be developed to manage the water quality of the lake as well as the ecosystem around the lake and the catchment.

The success of any environment management plan is largely dependent on the timely collection of critical data, proper processing and prompt dissemination to the users and decision makers. In view of the importance attached to the project and the environment, regular updating of the data both spatial and attribute becomes imperative. With technology growing vertically in many segments with overlapping features between features, the web technology has to be leveraged to its best in passing the information to the decision-makers.

Taking into consideration all the factors the complete Integrated Catchment Management System, ICMS, is envisaged to consists of the following:

- Real time monitoring system
- Geographical Information System
- Relational Database Management System
- Satellite Image Processing System
- Aerial Photography
- Web based decision support system

1.1 REAL TIME MONITORING SYSTEM

The technology of Telemetry and computer networking have made it possible to access data in real-time. Real-time hydrological data like rainfall, surface

runoff, temperature, etc make it possible to analyze and determine what influences daily observations will have on the environment.

The system is proposed to support the following functions:

- Real-time tracking of the hydrological parameters.
- Reservoir (lake) levels & Level Trending.
- Monitoring of water quality parameters like pH, turbidity, BOD etc.
- Warning the users based on user defined threshold.

It is proposed that the real time data collected using the telemetry RTU's be integrated with GIS and RDBMS system.

1.2 GEOGRAPHIC INFORMATION SYSTEM

Geographic Information System (GIS) helps in querying and analyzing the data in a spatial domain. As the definition itself specifies that data plays an important role, the database imparts a major impact on the efficiency of the system. The GIS should be able to support the following functions:

- Easy mode of data entry, retrieval, analysis and output.
- Integrate with other systems like Telemetry and RDBMS.
- Data updating using Aerial photographs.
- Simulation analysis

The GIS is proposed to act as a GIS web server for web related front-end application.

1.3 RELATIONAL DATABASE MANAGEMENT SYSTEM (RDBMS)

A comprehensive and reliable Database Management System is being proposed as part of the system to support attribute database, storage and management of data and data security. The RDBMS not only stores the attribute database, but also manages the related GIS spatial database.

1.4 SATELLITE IMAGE PROCESSING SYSTEM

To assist in Environmental Impact Assessment studies, landuse/landcover patterns etc, a Satellite Image Processing System is being proposed. This system forms as a data source to GIS in the integrated system.

1.5 AERIAL PHOTOGRAPHY

In order to have up-to-date information of the development surrounding Putrajaya and its catchment, frequent collection of large scale data is proposed, either by using aerial photographs or high resolution satellite images.

1.6 WEB BASED DECISION SUPPORT SYSTEM

To facilitate easy access of selected information by the pertinent regulatory agencies, a web-based information and decision support system is proposed.

2. INTEGRATED CATCHMENT MANAGEMENT SYSTEM

The efficiency of the system depends on the type and amount of data collected and managed in all the components. A close look of data criteria along with the proposed applications and the role of the applications is given below.

2.1 TELEMETRY

For monitoring the water quality parameters like pH, turbidity etc. and quantity parameters such as level of the reservoir (lake), surface flow, setting up of RTUs (Remote Testing Units) at important locations is proposed. Constant monitoring of water quality and water quantity is proposed. A predefined threshold is proposed as a benchmark and an alarm system is triggered once the system moves above or below the threshold values. As an example, the following functions are proposed which may require GIS technology to be embeded.

- Inform the lake administrator of heavy flow or anomalies
- Help in locating active pollution zones and identify the possible offenders through GIS
- Collect water quality parameters
- Collect hydrological parameters

All data collected from the RTUs and hydrology stations are proposed to be stored in RDBMS.

2.2 GEOGRAPHIC INFORMATION SYSTEM

A GIS client server environment is proposed for all the GIS related functions. Data creation and related activities are proposed to be performed on the server and viewing & query of data is performed on the client systems.

2.3 LAYERS OF DATA

For the purpose of an effective and efficient system, the base data should be relevant, extensive and accurate. Above which all the related information has to be added. A few of the layers which is a must are given below:

- Geology
- Topography – slope and aspect

- Lot Parcels
- Road Network – different classes
- Land use/ Land Cover
- Settlement details at larger scale (with all the existing details)
- River network
- Drainage patterns and Water bodies
- Location of Hydrological stations, Water quality monitoring stations
- Location of Environmental details
- Location of RTUs

For each of these layers the attribute data has to be prepared and stored in a RDBMS. Following functions are proposed for the GIS within the ICMS. In the system GIS will be getting data from integrated components also.

- Query and Analysis of the data
- Able to access telemetry data

2.4 ENVIRONMENT FUNCTIONS

- Perform analysis to support Environment Impact Assessment studies
- Identify the polluting zones and possible offenders (industries)
- Preparation of environmental zoning mapping
- Potential zones of sedimentation

2.5 WATER RESOURCES FUNCTIONS

- Water quality monitoring
- Watershed management

2.6 PERSPECTIVE VIEWING

- Landscape management in a 3D perspective
- Terrain modeling and Fly through

2.7 MAP UPDATING

- Update the data using high resolution data

2.8 ENVIRONMENTAL ZONE MAPPING

A comprehensive and integrated map is proposed to have up to date zoning map, categorized based on the environmental, geological, landuse/landcover, hydrological parameters.

2.9 SATELLITE IMAGE PROCESSING

This system is proposed to function as a sub-system to GIS and is proposed to perform the following functions

- Landuse/landcover maps
- Reservoir siltation analysis
- Change detection studies
- Updating of details at smaller scale

2.10 MAP UPDATING

To regularly update the details of the Putrajaya area, procurement of aerial photographs or high-resolution satellite images is recommended. A scale of 1:10,000 or larger is recommended.

CHAPTER 8

LEGISLATION AND INSTITUTIONAL STUDIES

8.0 LEGISLATION AND INSTITUTIONAL STUDIES

8.1 LEGISLATION STUDY

8.1.1 Introduction

8.1.1.1 To ensure that the water quality in the Putrajaya Lake can be achieved and maintained there is a need to identify and review the existing legislation, involving catchment management issues, to ensure that they are adequate. Based on the review there may be a need to recommend appropriate amendments to the existing legislation or propose new legislation to address any ambiguities or inadequacies, respectively, in the existing legislation.

8.1.1.2 The adequacy of the legislative controls covering the following areas in the Putrajaya Lake catchment will have to be reviewed.

- Putrajaya Lake System
- Putrajaya Area
- Catchment areas outside the Putrajaya Area

8.1.1.3 The review and adequacy of the legislative controls covering the Putrajaya Lake System is the subject of another Study. It is expected that adequate legal measures will be taken in that Study to address issues pertaining to the sustainable management of the Lake.

8.1.1.4 The management of the catchment area within the Putrajaya Area will be within the control of the Perbadanan Putrajaya and is most probably not an issue. Thus, the focus of the review of the existing legislation will be concentrated largely on the legal issues pertaining to the management of the catchment areas outside of the Putrajaya Area.

8.1.2 Background review

8.1.2.1 The integrated management of the Lake and its catchment is essential to ensure that the Putrajaya development achieves the objective of being a "City in a Garden". The waterfront of the Lake is about 30 km long and adjoins various land uses proposed under the Master Plan. Several minor rivers drain into the Lake of which the main river is the Sungai Chuau. These rivers are tributaries of the Sungai Langat and are part of the larger Langat River Basin. The rapid pace of urbanisation within Putrajaya and in the surrounding areas of Putrajaya will cause immense pressures

on the Authorities in terms of managing the conflicting demands between rapid development and maintaining the desired level of water quality in the Lake.

8.1.2.2 The catchment areas outside Putrajaya fall within the jurisdiction of the Sepang and Subang Jaya Local Councils, both of which lie in the State of Selangor. It is critical that land use in the catchment area is regulated to protect the quality of water flowing into the Lake, to preserve the aquatic habitats and generally to enhance the waterfront environment.

8.1.2.3 In Selangor the statutory framework for the management of waters has been consolidated in the *Selangor Waters Management Authority Enactment 1999 (SWMAE)*. The Selangor Waters Management Authority (SWMA) to be set up under the SWMAE is required to take a multi sectoral and multidisciplinary approach to the management of water resources with controls over pollution, drainage, adjoining lands and catchments.

8.1.2.4 The integrated management of water resources in general and of large water bodies is something new in this country. The adoption by Malaysia of the Ramsar Convention and the designation of Tasik Bera as a wetland site under the Convention is a relatively new initiative but there is certainly an increasing awareness of the need to manage water resources in a much more integrated and holistic manner.

8.1.2.5 The Lake itself is intended to be an integral part of the Putrajaya community. It will be available for the activities of the community. The types of activities that are likely to be allowed in the Lake include fishing, boating (both motorised and non-motorised), floating restaurants, eco-tourism, swimming, construction of floating and fixed structures, and other activities on and along the waterfront. Activities requiring primary contact with the Lake waters imply that the quality of water in the Lake has to be high. This in turn will translate into requirements to be imposed on the quality of waters that will flow from the catchment areas into the Lake and the attendant constraints or restrictions that may have to be considered in undertaking any development or activity that impacts on such flows.

8.1.2.6 Two critical problems that afflict most waterways in the country are silt due to soil erosion and pollution caused by solid and industrial wastes. It is to be expected that these two problems will also be critical to maintaining the water quality in the Lake.

8.1.3 The Status of Perbadanan Putrajaya

8.1.3.1 The creation of the Federal Administrative Capital of Putrajaya was concluded by way of an Agreement between the Federal Government and the State Government of Selangor (hereafter referred to as the "Agreement"). The Agreement delineates the powers of Putrajaya, which essentially includes all powers over local government and to act as the Land Administrator as enumerated in the Second Schedule of the Agreement. Notwithstanding the latter devolution of powers, Article 3, Clause 3(1) and the Third Schedule of the Agreement identifies certain matters that will remain under the jurisdiction of the State. This includes item 7 – *"water and water supply and the revenue collected therefrom."*

8.1.3.2 The term "water supply and the revenues collected therefrom" refers to the supply of treated water. The term "water" is not defined in the Agreement. It could be broadly interpreted to mean the general regulation and control of water in any source including rivers, water bodies and ground water. In so far as matters pertaining to water outside Putrajaya the State has the sole jurisdiction. In so far as "water" within Putrajaya is concerned the matter is a bit more complex and will be discussed in detail in a later part of this Report.

8.1.3.3 The Perbadanan was established as a body corporate by an act of Parliament (Perbadanan Putrajaya Act, 1995) (PPA) with effect from 1996. The Act gave effect to the provisions of the Agreement and in particular placed the Putrajaya area under the sole jurisdiction and control of the Perbadanan. The main objective of the Perbadanan is to "administer and manage" the Putrajaya area. Its detailed duties include the performance of all functions of a local government in the Putrajaya area. Through subsidiary legislation made by the State the powers of a local government has been bestowed on the Perbadanan.

8.1.3.4 The Perbadanan has full powers to implement the provisions of the PPA. The State Authority may further assign certain powers of the State Authority to the Perbadanan. Accordingly, by way of orders

made under the Putrajaya (Performance of Functions) Enactment 1995 the State of Selangor has assigned its powers and functions under the Street, Drainage and Building Act, 1974 (SDBA), Town and Country Planning Act, 1976 (TCPA) and Local Government Act, 1976 (LGA), in so far as the latter legislation apply to Putrajaya, to the Minister (who in this case is the Prime Minister) and the Perbadanan. It has also appointed a Land Administrator in Perbadanan under the National Land Code to undertake administration of land within Putrajaya.

8.1.4 Review of Laws on Catchment Management

8.1.4.1 Introduction

(1) In addressing issues related to catchment management one has to look at laws relating to the following issues within the catchment area:

(a) water which includes rivers, groundwater, lakes, wetlands and other water bodies;
(b) land and the development/exploitation of such land;
(c) municipal administration which is under the authority of the State Authority/local government; and
(d) environmental management.

(2) Other issues such as state/federal/local authority relationships, constitutional jurisdictions and the rights and participation of stakeholders will also be given due consideration.

8.1.4.2 Constitutional Position - Federal/State Jurisdiction

(1) The constitutional position between the Federal and State authorities related to the following issues are discussed below:

- Water
- Land
- Municipal Administration
- Environmental Management

(a) <u>Water</u>

(2) A detailed review of the position of the Federal Government vis-à-vis the State Governments on water has been undertaken elsewhere (Kerajaan Negeri Selangor, 1998) and need not be repeated here. It may be stated that, in general, "water" is a State matter. This would include rivers, lakes, streams, and

water beneath the surface of the land. However water is not exclusively a matter within the sole jurisdiction of the States. The Federal Government has specific powers, for example over federal works including water supplies, rivers and canals, except those which are wholly within one State or are regulated by an agreement between the States concerned. The Federal Government has control over other aspects of water resource utilisation such as hydropower generation, navigation within ports, marine fisheries and mining.

(3) Parliament has powers to make laws with respect to any matter in the State List for the purpose of promoting uniformity of the laws of two or more States. The power to make such laws, however, is subject to restrictions. *Article 78* of the Constitution stipulates that any law made by Parliament that restricts the right of a State to the use of any river wholly within that State, shall not have effect unless it is approved by the State Legislature. Water rates are also deemed to be a source of revenue to the States. Further, the Federal Government cannot exercise executive authority over matters within the Concurrent List unless the Federal or State laws specifically provide for it. Thus, whilst the Federal Government may legislate for uniformity in the country, it must take into consideration the above mentioned restrictions on its powers. The Federal Government, subject to the above restrictions, has enacted legislation on matters that may be considered to occur in the State List. These laws include the Waters Act, Land Conservation Act, Fisheries Act, Streets Drainage and Buildings Act, Local Government Act and National Land Code.

(4) The State Authorities, by virtue of the fact that water and matters relating thereto, and in particular land is within their jurisdiction, would appear to be in a better position to control and regulate matters on the ground pertaining to the effective management of water resources in their respective States. The State of Selangor in particular has enacted the SWMAE that has resulted in the establishment of the SWMA. The latter Authority is expected to regulate and manage all water resources in the State on a sustainable basis.

(b) <u>Land</u>

(5) Pursuant to List II of the Ninth Schedule, item 2, all matters relating to Land is under the State. Consistent with Article 76(4) Parliament enacted the National Land Code for the purpose of uniformity in the administration of land throughout the Federation. The definition of "land" includes land under water. Together with land, related matters such as forestry, agriculture and mining, are also under State jurisdiction. Article 91 also establishes the National Land Council (which comprised of Federal and State representatives chaired by the Minister) which formulates national policies "for the promotion and control of the utilisation of land… for mining, agriculture, forestry or any other purpose…". The Federal Government or any State Government may consult the NLC with respect to any matters relating to the utilisation of land or in respect of any purported legislation dealing with land or the administration of any such law. The Federal and State Governments shall implement the policy so formulated. Article 92 allows the Federal Government to proclaim any area as a "development area". Upon such declaration Parliament may give effect to the "development plan" by making **any laws** necessary to implement the Plan including on matters which are not under the Federal List. *Putrajaya was declared under Article 92.*

(6) The Constitution contains no direct reference to the management or control of catchment areas. Compared to the Federal List however the State List includes matters pertaining to land including colonisation, land improvement and soil conservation, agriculture, forestry and water, including rivers, canals, riparian rights, turtles and riverine fishing. The Concurrent List includes the protection of wild animals, birds, national parks, drainage and irrigation and rehabilitation of land that has suffered soil erosion. It would appear that the State has more powers over catchment management than the Federal Government.

(c) <u>Municipal Administration</u>

(7) Pursuant to List II of the Ninth Schedule, item 4 local government including local government services, local administration, obnoxious trades and public nuisances in local authority areas are under the jurisdiction of the State Governments. Article 95A also establishes the National

Council for Local Government (which comprised of Federal and State representatives chaired by the Minister) which formulates national policies "for the promotion, development and control of local government throughout the Federation and for the administration of any laws relating thereto…" The Federal and State Governments shall implement the policy so formulated. It is also the duty of the Federal and State Governments to consult the Council in respect of any proposed legislation dealing with local government.

(d) <u>Environmental Management</u>

(8) There is no direct reference to the control and regulation of environmental pollution in the Constitution as concern for the environment and control of pollution are relatively new issues. It is necessary therefore to infer the source of authority for environmental matters by examining particular issues. In the Federal List Item 8 "Trade, commerce and industry" - sub-item (k) which relates to "factories, boilers, machinery, and dangerous trades" and sub-item (l) relating to "dangerous and inflammable substances" are the only specific items which may be inferred to impinge on environmental issues.

(9) There are however more items under the State List, such as

- item 2 which relates to "land, land improvement and soil conservation"
- item 4 which relates to "local government, including obnoxious trades and public nuisances in local authority areas and local administration"
- item 6 which relates to "water, control of silt and riparian rights"
- item 12 which relates to "turtles and riverine fishing"

(10) They may all be inferred to relate to environmental concerns. The Concurrent List also includes similar provisions, such as

- item 3 for "the protection of wild animals and birds including national parks"
- item 5 for "town and country planning"
- item 7 includes "public health, sanitation and the prevention of diseases"

- item 8, which relates to drainage and irrigation
- item 9 includes "the rehabilitation of mining land and land which has suffered soil erosion"

(11) All of the above may, in their particular areas, is inferred to include environmental concerns.

(12) It would therefore appear that both the Federal and State Governments have powers over environmental matters depending upon the subject matter under consideration. In the leading case of *Ketua Pengarah Jabatan Alam Sekitar & Anor. V Kajing Tubek & Ors.* (3 MLJ 1997) the Court of Appeal decided that (in the event of conflict between State law and the Federal EQA) environmental law which was to be applied depends on the specific subject matter to which it applies and whether the State or Federal Government had powers on the matter. Environmental matters related to land, water and municipal services for example would be under the State Government. *Article 77* also provides for residual powers whereby the State Legislature may make laws with respect to any matter *not enumerated* in any of the Lists set out in the 9th Schedule, if it is not a matter in respect of which Parliament has powers to make such laws. This Article would be relevant in considering matters that are not clearly delineated in the Constitution, such as for example, matters pertaining to the environment.

(13) *In so far as the constitutional position related to catchment management is concerned therefore it would appear that State Governments have the jurisdiction to play a larger role than the Federal Government.*

8.1.5 Review Of Existing Legislation

8.1.5.1 Introduction

(1) Consistent with the constitutional position whereby both the Federal and State governments appear to have jurisdiction over water it is not surprising that the management of water resources in Malaysia is covered by numerous Federal and State laws. Legislation in Malaysia directly or indirectly related to water, land, municipal government and the environment is itemised in Appendix 8.1.1

8.1.5.2 Ownership of Water and Water Rights

(1) Various legislation relating to water vest ownership of water in the State Governments, particularly in terms of waters that occur in rivers and water bodies within the State. Pursuant to this the Waters Act 1920 provides that "the entire property in and control of all rivers in any State is and shall be vested solely in the Ruler of such State." It defines a "river" to include:

- "a tributary of a river and any other stream or natural water course; and
- any canal declared by the State Authority of the State . . . by notification in the Gazette."

(2) The Waters Act has been repealed and replaced with the SWMAE in Selangor. The SWMAE is a much more comprehensive legislation and it vests far greater powers of control over all waters including wetlands, ground water, lakes and other water bodies and coastal waters.

(3) State ownership of water is further entrenched by the National Land Code that identifies "water" as an integral element of "land," whose disposition is subject principally to State control. The Mining Enactment, 1929 further considers "water" as a property that vests with the Ruler of the State.

(4) The right to use water, whether it is surface or underground, is thus subject to the control of the State Authority. Unlike many other countries such as the USA there is no private ownership rights to water. In practice, the owner or occupier of land may use water for domestic purposes and in this respect is not required to hold a licence to enjoy such usage. The SWMAE however specifically prohibits, except for subsistence agriculture, the diversion of water from any river or the taking of any water except in accordance with the terms of a licence. Licences to divert water from rivers for private, domestic or industrial purposes or for agriculture may be granted by the SWMA. The SWMA is empowered to authorise the licensee to erect, cut or construct and maintain upon any State lands or alienated lands any drain, dam or reservoir and to take and use the water therefrom in such quantities and in such manner as the SWMA may approve under the licence.

(5) The Agreement between Putrajaya and Selangor does appear to reserve all rights over water to the State and a strict application of this Agreement would mean that Putrajaya should obtain the approval of the State for actions related to waters and the Lake. However the SWMAE appears to exclude its application to Putrajaya but under limited circumstances. The exclusion of application of the Enactment is only under circumstances where any river or water body **occurs wholly** within Putrajaya. It would appear that there are no such rivers as all of them originate outside Putrajaya. It also now appears that the Lake itself, in Phase Two of its inundation program, will eventually stretch out of Putrajaya into Cyberjaya. If this does occur then the Lake too would not be exempted from the application of the SWMAE as it would not fall wholly within Putrajaya. *Under the circumstances it would appear that the SWMA would have authority over the whole catchment area including those areas within Putrajaya.*

8.1.5.3 Recreational Activities on Water Bodies

(1) States do have power to enact laws pertaining to local shipping and navigation on rivers, lakes and other inland water bodies outside the limits of ports and harbours. Pursuant to such powers under the Constitution, various states have enacted legislation (some under the colonial administration) which include:

(a) The Waters Enactment, 1920 (adopted, some with amendments, by most States);
(b) The Selangor Waters Management Enactment, 1999;
(c) River Launches (F.M.S.) Cap.177; Pahang (En No. 6/49);
(d) River traffic (Kelantan) En. 2/1955;
(e) River Traffic (Trengganu) En. 3/1988;
(f) Sarawak Rivers Ord., 1993;
(g) Sarawak Water Ord., 1994; and
(h) Lights and Registration of Small Shipping Enactment, 1899 (Selangor), Federated Malay States Enactment XXVII of 1899.

(2) In general such legislation provides for the control of navigation on inland waters and regulates localised traffic within rivers. It provides for the licensing and registration of small boats in local waters. Under the Local Government Act (LGA) the local authorities have enabling municipal powers to control any recreational activity on rivers and other water bodies including navigation, swimming, boating, fishing and any other works

carried out on such water sources. The requisite power of a local government has been delegated to the Perbadanan by the State.

8.1.5.4 Drainage, Buildings and Earthworks

(1) The carrying out of any earthworks and buildings is controlled under the Street, Drainage and Building Act (SDBA). The SDBA provides sufficient powers to local authorities to effect control on all building and earthworks within their jurisdiction. Earthworks include earthworks undertaken on any land that includes land under water. Perbadanan Putrajaya has made Earthworks By-Laws to control all earthworks. Present day approach to the control of earthworks, particularly in respect of prevention of soil loss and erosion and the consequent siltation of rivers, does not seem to be adequately addressed within present by-laws. *There are adequate powers within the SDBA, LGA and TCPA to address this issue and greater attention should be given to this aspect.*

(2) Drainage in municipal areas is the responsibility of the Local Authorities under the LGA and SDBA. Every Local Authority is empowered to make bylaws to provide drains in the interest of public health. None of the authorities have however made any drainage by-laws. Local authorities appear to follow the Urban Drainage Design, Standards and Procedures issued by the DID. The authority is also empowered to impose a drainage rate or fee to defray the construction and maintenance cost of such drainage systems. The SDBA also imposes an obligation on the Local Authority to construct and maintain drains. The cost for construction and maintenance of such drains may be recovered from persons who are "frontagers" to such works. Usually the developer of a housing scheme is required to pay a deposit to enable the local authority to construct drains. Alternatively, the developer is required to construct the drains to standards determined by the Local Authority. The Local Authority has powers under this Act to levy fees or charges to enable it to defray expenses in executing its functions. It also has powers to determine the location, design, flow and other detailed characteristics of drainage in any area within its jurisdiction. The problem of diversion of the flow of waters away from the Lake can be addressed under these laws.

(3) Whilst the SDBA provides adequate powers for the design and layout of drainage it does not however provide for controls over the quality of discharge of such drains. The quality of discharge

may be controlled under other legislation such as the SWMAE and the EQA. The EQA controls largely point sources of discharge originating from prescribed premises such as factories and plants. The SWMAE can control both point and non point sources of discharge into any water source including the connection of urban drains into rivers. Local authorities too, have some limited powers (under the LGA) in terms of controlling discharge of effluents and noxious substances into any drain.

(4) *There will be a need for local authorities, DOE and the SWMAE to work together on determining the quality of discharges into any water source. There is also a need to address the quality of runoff from streets to ensure that its main pollutants such as oil and grease is trapped and removed before it enters rivers and the Lake. Appropriate technical measures will have to be considered for this purpose and the drainage systems appropriately designed.*

8.1.5.5 Flood Mitigation

(1) Traditionally, drainage and flood control works and services have largely been undertaken by the Department of Irrigation and Drainage by virtue of its role in providing drainage and irrigation for agricultural development as provided for in the Concurrent List. The Irrigation Areas Act, 1953 and the Drainage Works Act, 1954, accordingly provides for the control, protection and maintenance of such works and services and appropriate authority is vested with the DID Engineer for this purpose.

(2) Under the Ministerial Functions Act, 1969, the Minister of Agriculture has responsibility for and is entrusted with the responsibility for flood mitigation and river conservancy works. The actual implementation is carried out by the DID, an agency under the Ministry of Agriculture, and which also acts as the Secretariat to the Flood Commission. The Minister of Agriculture is currently the Chairman of the Commission.

(3) The DID obtains large Federal funding for flood mitigation works. In carrying out large scale flood mitigation and agricultural drainage works country-wide, the DID had invariably undertaken urban drainage works as an integral part of such projects (like in Kuala Lumpur, Georgetown, Batu Pahat, Kota Bharu and other major towns).

(4) Urban Drainage Design Standards and Procedures, currently in use by all local authorities, were developed by the DID. The DID continues to provide specialist services in urban drainage to local authorities, wherever such competencies are deficient.

(5) Municipal authorities consider large urban drainage works, particularly those involving flood mitigation and riverine works, as the responsibility of DID, especially since such works invariably involve more than one LA area.

(6) However, from a strictly legal sense, drainage within local authority areas is the sole responsibility of the local authority. The State Governments are responsible for drainage and flood mitigation within the State concerned.

(7) With the implementation of the SWMAE, the SWMA should work with DID as the latter has a macro view of the problem.

8.1.5.6 Catchment Management

(1) In order to minimise, prevent or mitigate potential problems of flooding, ensure adequate flow of waters and maintain water quality, catchment areas must be carefully managed, preserved and protected. The immediate land reserves surrounding rivers and other water sources such as the Lake should be similarly managed. There are various laws pertaining to these matters. The Land Conservation Act 1960 enables the State Authority to declare any area to be "hill land" by notification in the Gazette. Upon such declaration no person can clear such land or interfere with or destroy trees and plants on such land. This is to prevent soil erosion and siltation.

(2) Under the Forest Enactment, State Authorities may also constitute any area as a reserved forest for the purposes of protecting catchment areas. Upon such proclamation all activities within the area are prohibited. Generally, the administration of land is undertaken through the National Land Code and this law can also be used to control development. Detailed urban planning is sanctioned by the State Authorities under the Town and Country Planning Act. Within local authority areas the structure and local plans can play a critical role in controlling and determining appropriate development and compatible land use patterns within the catchment area.

(3) The SWMAE provides for catchment management of river basins within Selangor. Among others it has powers to:

(a) take measures to protect the water from pollution;
(b) take measures to improve the quality of water;
(c) prevent any unauthorised interference with the flow or availability of water;
(d) declare flood zones, river reserves, protection zones and buffer zones;
(e) declare catchment areas; and
(f) control all works within such catchment areas.

(4) The SWMAE makes possible the adoption of a more comprehensive approach and can be a powerful vehicle for the management of the Lake catchment area.

8.1.5.7 Environmental Protection

(1) The Environmental Quality Act of 1974 (EQA), a Federal law, is the principal legislation pertaining to environmental protection. Section 25 of the EQA provides that "no person shall, unless licensed, emit, discharge or deposit any waste into any inland waters in contravention of acceptable conditions." The Minister of Science, Technology and Environment may specify the acceptable conditions for emission or discharge of waste into any area of the environment. Pursuant to this Act, several regulations have been enacted.

(2) The Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 regulate discharges from palm oil refineries. The Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 regulate discharges from rubber operations. The Environmental Quality (Sewerage and Industrial Effluents) Regulations 1979 regulates discharges from the industrial sector.

(3) The EQA has also prescribed catchment areas for water intake points and the classification of such areas for purposes of maintaining water quality. The application of any rules pertaining to water or rivers will however require the prior approval of the State concerned.

(4) The EQA applies to all States in the country. However Sarawak has enacted some of the provisions of the EQA into state

legislation. The Department of Environment (DOE) licences prescribed premises so as to monitor discharges from such premises. It is also supposed to monitor water quality from these sources of discharge so as to ensure that discharges are maintained within the stipulated limits. Section 34(A) of the EQA provides for environmental impact assessment. The Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 has prescribed measures to prevent or mitigate the impact of large projects. The EIA requirement is a preventive measure to ensure that proposed projects take into consideration environmental matters in their implementation. The EQA and in particular the EIA regulations do not cover existing projects or the smaller projects. Further there appears to be problems of enforcement of the EIA conditions and the monitoring of implementation of such conditions. The EQA also does not cover non-point sources of pollution.

(5) Besides the EQA, the SWMAE provides for control of pollution in water sources. The Enactment prohibits the discharge of any poisonous, noxious or polluting matter that will render any water source harmful to public health, safety or welfare, or to animal or plant life or other beneficial uses of such water source. However, discharges may be made by licence approved by the SWMA in line with the SWMA's overall strategy of protection and sustainable management of a water source. Except for the Fisheries Act and the SWMAE, none of the other laws cover the requirement for minimum flow to protect in stream resources.

(6) Part VIII of the LGA also provides for the control of activities or nuisance that may pollute "any stream, channel, public drain or other water course within the local authority area". Local authorities may:

(a) prevent littering or depositing of any wastes or filth;
(b) prevent any waste being allowed to flow or the discharge of any liquid or solid;
(c) regulate bathing, washing or swimming of persons or animals;
(d) prohibit, abate, remove or prevent the occurrence of any nuisance;
(e) control the method of cultivation, irrigation and the use of manure or fertilisers;
(f) control the keeping of fish; and

(g) generally, to do all things necessary for or conducive to safety of the public, health and convenience.

(7) All three local authorities within the Lake catchment area have enacted various rules including anti-litter, control of activities in parks and vandalism (See Appendix 8.1.1 for the full list). None of them have however tackled issues related to pollution in general or non-point sources of pollution as in (e) above which would be an important source of non-point pollution. The authorities, with the exception of Perbadanan, have not made any systematic approaches to manage water sources within their jurisdiction.

(8) Strict control of pollution is a matter vital to the maintenance of the water quality in the Lake. Whilst the EQA is a specific law made to control environmental concerns its approach however has been "national" rather than "local". Its application in localised areas for specific concerns may lead to inadequacies. It is also dependent on the capacity and capability of the DOE on the ground. The DOE certainly does not have the capacity to undertake strict enforcement of the EQA in particular catchment areas. Standards determined by the DOE are meant to apply throughout the country. It may not be adequate for the purposes of the Lake. *The SWMAE provides an alternative in this respect for the integrated management of the catchment area.*

8.1.5.8 Mining

The Mining Enactment, 1929 allows the taking, diversion and discharge of water for the purposes of mining. The National Land Code allows the Land Administrator to allow the mining of rock material (including sand) from rivers. The impact of such mining activities on river regimes would be severe and cause a disruption to the flow of the water including having an adverse impact on the in-stream resources of the water sources. However the SWMAE has now imposed a requirement for consultation and approval prior to any of these activities being undertaken by the authorities.

8.1.5.9 Stakeholder Participation

Participation by the affected parties including consumers, water users, land owners and non government organisations has generally resulted in better compliance with the laws and more effective and less costly implementation in many countries. *Only the SWMAE provides for the participation and encouragement of formation of stakeholder groups*.

8.1.6 Recommendations

8.1.6.1 Based on the above review the following are the main points of some pertinent recommendations. They are discussed in details below.

- Sub-catchment management approach
- SWMAE – the legal vehicle for integrated sub-catchment management
- New rules under the SWMAE

8.1.6.2 ***(a) Sub-catchment management approach***

It would appear that there is a number of enabling legislation that would allow the catchment to be managed by the various authorities. However the profusion of laws may not allow and in fact could be a hindrance to the integrated management of the Lake catchment area. Most of the rivers in the catchment area are also part and parcel of the larger Sg. Langat Catchment. The full application of the SWMAE including the designation of the Sg. Langat Catchment as an integrated river basin management area may take some time. *In the interim it is recommended that a sub-catchment management approach be adopted for the Lake's catchment area.*

8.1.6.3 ***(b) SWMAE – the legal vehicle for integrated sub-catchment management***

The SWMAE presents the best legal vehicle to implement an integrated sub-catchment management plan for the Lake Catchment. *The Enactment is comprehensive and well suited to manage the whole sub-catchment area including the area within Putrajaya.* A detailed review of the SWMAE is included in Appendix 8.1.2. The SWMA has the legal authority to manage the Lake Catchment area. However it would be far better for the SWMA to take the lead but work together with the Perbadanan in managing the catchment area both inside and outside Putrajaya.

A sub-catchment management plan could be drawn up under the SWMAE and jointly implemented by SWMA, Putrajaya, Sepang and Subang local councils. The SWMAE together with the various provisions of the SDBA, LGA and TCPA could then be used to implement the plan. An appropriate institutional framework for such co-operation amongst all stakeholders should be formulated.

8.1.6.4 ***(c) New Rules under the SWMAE***

Having reviewed the recommendations made by the various specialists in the Study Team for the management of the Lake Catchment area the Consultant are of the opinion that it is not necessary to review or make amendments to any existing legislation. At this point in time the Consultant does not see the need for any rules other than that pertaining to the designation of the sub-catchment area. Thy can be done later after the Sub-Catchment Management Committee has been formed and started its work. This is because the Committee would be in a much better position to assess the need for supporting rules and the declaration of the sub-catchment as a designated area under the SWMAE. There are presently sufficient powers within the SWMAE for the Committee to start off with its work.

8.2 INSTITUTIONAL STUDY

8.2.1 Introduction

8.2.1.1 The objective of the institutional component of the study as outlined in item 5 (xiii) of the "Scope of Work" of the Study Terms of Reference, relates to:

"Examining the existing institutional arrangement/set-up and legislation, and recommend improvement for the effective implementation of the proposed catchment and monitoring plan".

8.2.1.2 The study scope covered the following:

(a) Existing Institutional Framework Study

A systematic review of the existing institutional arrangement/set-up and administrative framework of important institutions which in one way or another have responsibilities for water, land and catchment management. It involved an analysis of the role and responsibilities, organisational structure and function of these authorities in relation to the above concerns areas of management.

(b) Recommended Institutional Framework Study

A study to develop and recommend the most effective and appropriate institutional/administrative arrangement or set-up to implement and manage the developed Catchment Development and Management Plan for Putrajaya Lake. It involved examining the legislative provisions for such a set-up and the action programme recommended by the various consultants involved in the project.

(c) Stakeholder's Participation in Catchment Management

A study to determine the strategies for engaging current and future catchment stakeholder’s participation for sustainable management of the catchment.

8.2.2 Existing Institutional and Administrative Framework

8.2.2.1 Introduction

(1) Land and water and the use of such resources represent the most important elements in the management of the Putrajaya Lake catchment. Jurisdiction over the subjects of "land" and "water" is spelt out within the provisions of the Constitution. (Please see Section 8.1.5.2 for a review of this matter). These provisions provide the basis for the formulation of laws for administration of matters related to the two subjects. Associated with the formulation of laws is the requirement that necessary institutions be set up to administer them.

(2) As outlined in the Constitution, "water" and "land" are State matters, which means that jurisdiction for control and use of these two resources rest with the states concerned. In relation to water, ownership of water that occurs in rivers and other water bodies is vested in the State within which the resource is located. Based on these provisions it can be seen that administration of water and land with regards to the right to use rests with the states concerned, except in so far as the state may assign such responsibilities to authorities that the state designates otherwise. Hence any proposal to use these resources or change its use category generally requires the approval of the States.

(3) The catchment of the Putrajaya Lake falls within the two Districts of Sepang and Petaling in the State of Selangor. The two districts are administered by the respective District and Land Offices who have as their head a District Officer.

(4) Within these two districts, three local government administrative areas are to be found within which the Putrajaya Lake catchment lies. The three local authorities administering these areas are:

- Perbadanan Putrajaya,
- Majlis Perbandaran Subang Jaya, and
- Majlis Daerah Sepang

(5) In general, local governments are sub-sets of the State Government who generally have powers to control such matters as the use of land and water within the areas of local

authorities. In the case of Perbadanan Putrajaya, it is a body established by an Act of Parliament to administer and manage the Kawasan Perbadanan Putrajaya on behalf of the Federal Government. The State of Selangor has assigned most of its powers and functions relating to local government to the Perbadanan and the Minister responsible, under the main legislations to which local authorities have jurisdiction, these being the *Street, Drainage and Building Act, 1974* (SDBA), the *Local Government Act, 1976* (LGA) and the *Town and Country Planning Act, 1976* (TCPA). It thus differs from the other two local authorities in that it has powers to act independently of the State in so far as matters related to land use and land use planning are concerned. However, in matters related to land revenue and "water and water supply and the revenue collected therefrom" these remain with the State (see Ramadas, 1999).

(6) The following review briefly describes and discusses the functions and responsibilities of various levels of government and the authorities and departments relevant to the development and management of the catchment of the Putrajaya Lake.

8.2.2.2 State Government of Selangor

(i) ***Administration***

(1) The highest level of government administration, in respect of matters relating to land and water affecting the Putrajaya Lake catchment, is the State Government of Selangor. Changes in land use or the use of water for any purpose requires, in general, the approval of the state. The highest level of authority for decision making is within the purview of the Majlis Mesyuarat Kerajaan Negeri (MMKN) or the State Executive Council, chaired by the Menteri Besar. The MMKN is made up of State Assembly Members who are the chairpersons of various portfolios (equated to that of ministers in a Cabinet).

(2) Various state departments and agencies at state and district level assist in planning and development in the state. Local authorities represent the "lowest" level of government in the implementation of projects and programmes for development. The role and function of these authorities are described later in this report.

(ii) ***Planning And Development***

(3) In relation to planning and development within the state, two important committees have been set up which have powers to plan and approve projects and programmes within the state. These are:

- Majlis Pembangunan Negeri (MPN) or State Development Council , and the
- Jawatankuasa Perancangan Negeri (JPN) or State Planning Committee.

(4) The functions of the MPN include the following:

a) Determine the strategy and programme for implementation of development projects in accordance with the National Development Policy,

b) Monitor and evaluate the implementation strategies for programmes and projects, and

c) Assess the progress of implementation of programmes and projects.

(5) In relation to land use and land use planning, the State Planning Committee (JPN) has the function to advise the State Government on matters relating to protection, use and development of land. The members of the Committee include the following:

Chairman : Menteri Besar
Deputy Chairman : Member of MMKN
State Secretary
State Director (UPEN)
State Director (JKR)
State Director (Lands & Mines)
State Legal Advisor
4 Members who are appointed
Secretary : State Director (JPBD)

(6) The JPN plays an important role in catchment management since matters related to project planning

approval and structure and local plans are referred to the committee for review and endorsement prior to approval by the State.

8.2.2.3 State Agencies And Departments

(1) Various state agencies and departments assist in the planning and implementation of various policies, programmes and projects that are planned and proposed to be undertaken in the state. Of interest to the management of the Putrajaya Lake catchment area, are the following:

- Department of Town and Country Planning (JPBD),
- Department of Drainage and Irrigation (JPS),
- Department of Public Works (JKR), and
- Office of Lands and Mines (PTG).

(i) ***Department of Town and Country Planning (JPBD)***

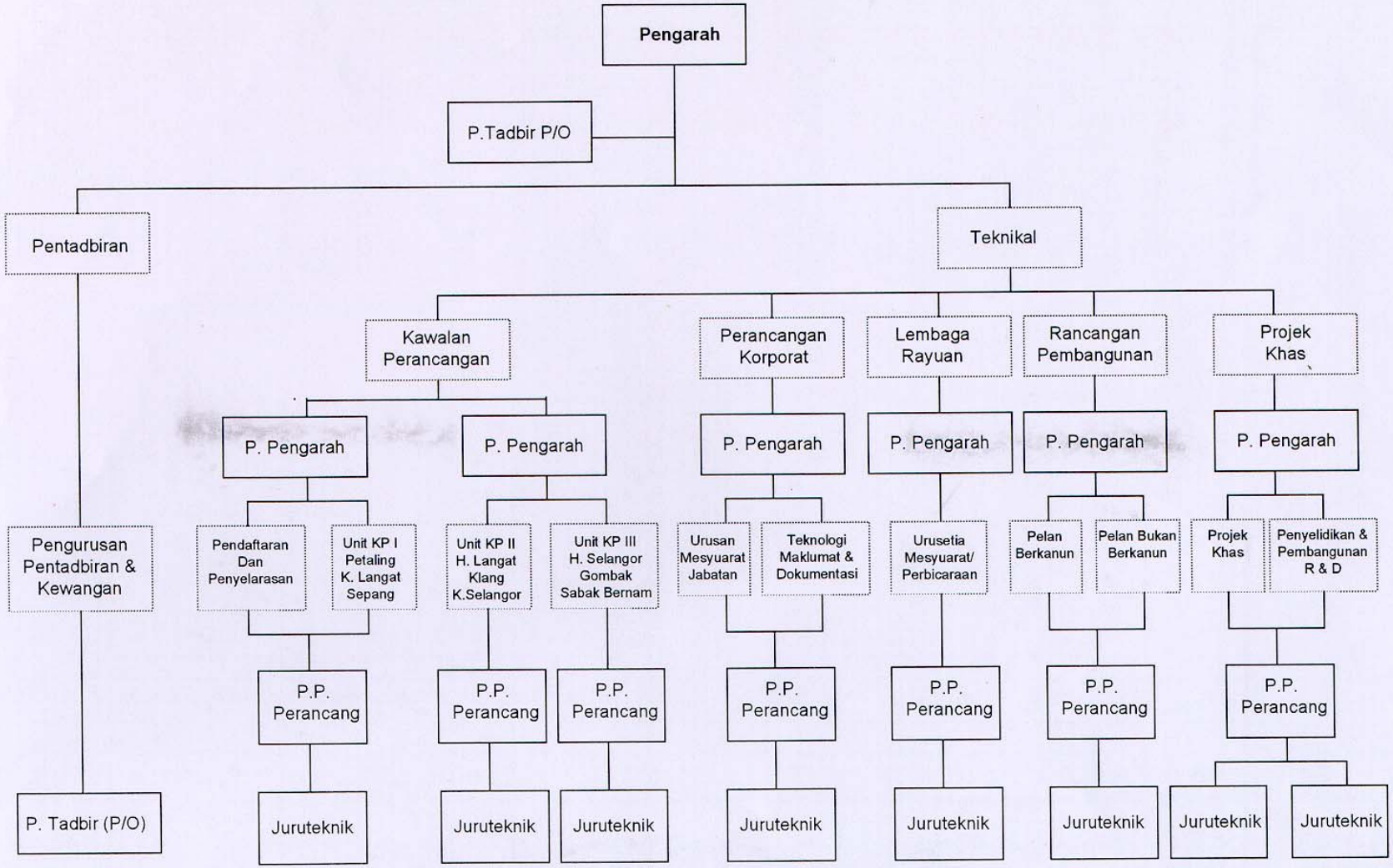
(2) The department has been given powers to advise the State with regards to physical planning and to manage and implement the provisions of the *Town and Country Planning Act, 1976*. The general structure of the department is shown in Figure 8.2.1.

(3) The functions of the department include:

- Advise the State Government and provide feedback to the Federal Government with regards to town and country planning,
- Advise the State Government with regards to policies and controls over the planning of land and buildings,
- Act as Secretariat to the State Planning Committee,
- Collect, collate and analyse data and information for planning, and
- Advise local authorities with regards to policy and control of planning.

(4) JPBD plays an important role in catchment management since it has responsibilities to draft structure and local plans and advise on land use planning and development controls. The type of land use dictates to a large extent the type of activity that would be allowed for a particular

FIGURE 8.2.1 : STRUKTUR ORGANISASI JABATAN PERANCANGAN BANDAR DAN DESA



land area. This has important implications to pollution control and waste management.

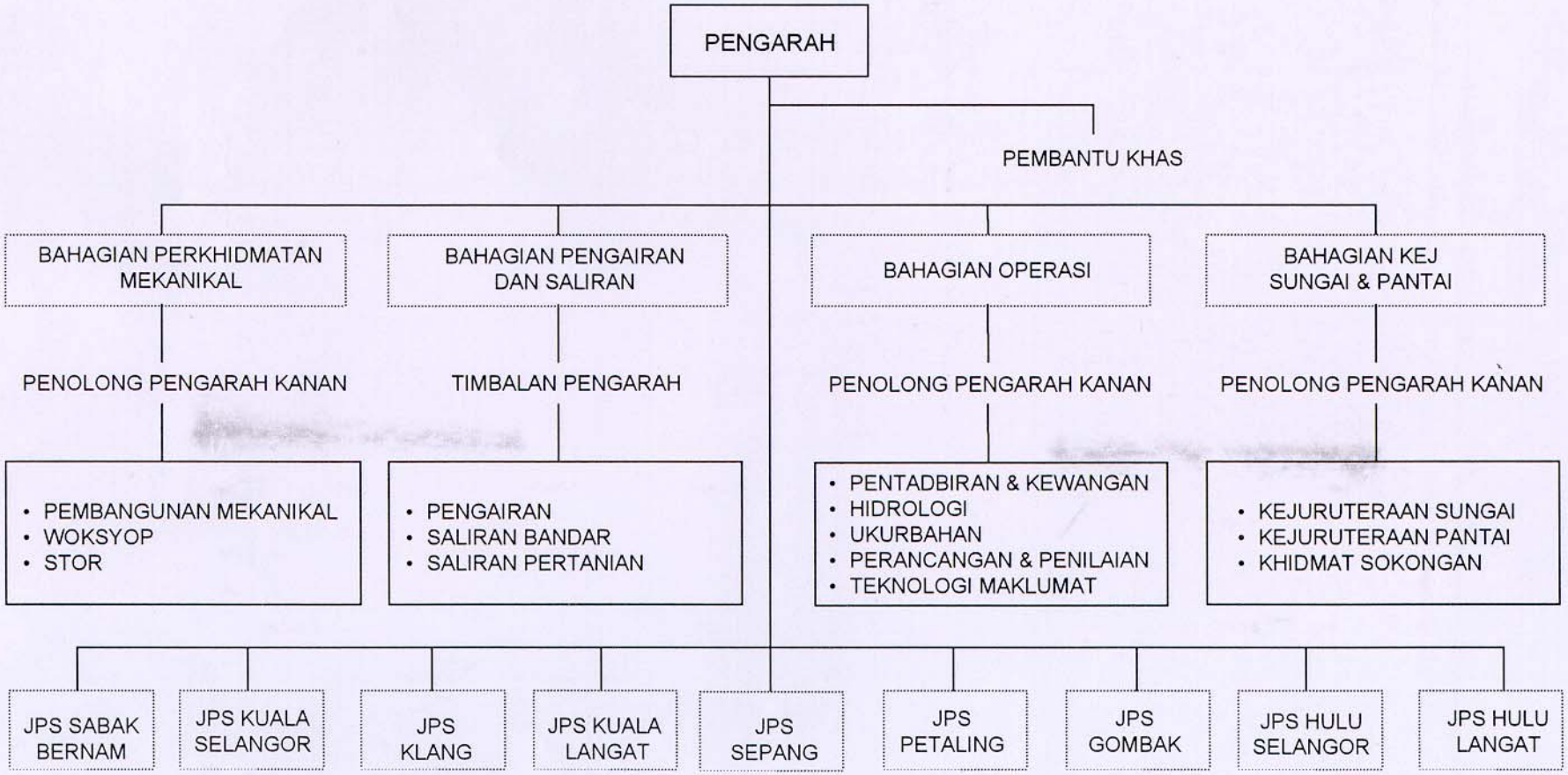
(ii) ***Department of Drainage and Irrigation (JPS)***

(5) The JPS operates both as a federal and a state agency since matters to which it has jurisdiction is a shared responsibility under the provisions of the Constitution. The department at state level has responsibilities for the implementation of projects related to irrigation, drainage, river improvement and coastal protection. The organisational structure and general functions of the department at state level are outlined in Figure 8.2.2.

(6) In general the department has been entrusted with the responsibility for implementation of irrigation, flood mitigation and river conservancy works. It is an important organisation with regards to rivers and catchment management. The department has also been largely responsible for providing advise to the State and Federal Governments with respect to water resource planning, use and exploitation.

(7) It is to be noted that drainage within a local authority area is the sole responsibility of the local authority although in some cases, especially with respect to main drainage systems and rivers, the JPS has taken over responsibility or been consulted for advise. It has also been known that the department provides advise to the State with regards to water use, abstraction and diversion. In this regards, the department plays an important role in water resource management since its recommendations have implications to river hydrology and water availability (see section 8.1.6.5).

FIGURE 8.2.2 : CARTA ORGANISASI JABATAN PENGAIRAN DAN SALIRAN NEGERI SELANGOR DARUL EHSAN



(iii) ***Department of Public Works (JKR)***

(8) The role of JKR in catchment management is small since its responsibilities are related to implementation of works, such as bridges, buildings and roads that have indirect impacts to rivers. The responsibility of water supply, which has traditionally been a function of the JKR, has now been taken over by water authorities or water supply departments. More recently, responsibilities with respect to water treatment and supply have been taken over by private companies under the privatisation scheme. However, this is not of concern to the present study since the use of water for public water supply from the Putrajaya Lake catchment does not arise.

(9) Nevertheless, drainage related to road works is important since runoff from roads and other works such as car parks have potential to carry pollutants such as oils and sediment into rivers. For the Putrajaya Lake catchment, concern has been expressed with regards to main JKR roads that cut across the catchment since these roads are frequently used by tankers that carry petroleum and other chemical products. Spillage of such products onto roads and roadside drains and their subsequent discharge into the river or lake system has serious implications to the lake and its wetlands.

(10) The general structure and areas of responsibilities of the department is shown in Figure 8.2.3.

(iv) ***Office of Land and Mines (PTG)***

(11) Land matters in respect of the *National Land Code, 1965* are the responsibility of the PTG. In general the department has the responsibility to co-ordinate matters related to land conversion and the issuance of land titles, mining leases and the collection of land revenue. The department serves as the co-ordinating body for the transmission of all applications related to land conversion, mining and related land matters to the MMKN for decision.

FIGURE 8.2.3 : CARTA ORGANISASI JKR SELANGOR DARUL EHSAN

(12) With respect to catchment management, the department can play an important role in advising the state where there are proposals for the conversion of land within the catchment.

8.2.2.4 Local Authorities

(1) Local authorities are the lowest level of government within the structure of the government system in the country. The powers of local authorities are vested in the *Local Government Act 1976* (LGA), and the *Street, Drainage and Building Act, 1974* (SDBA). In addition, local authorities have also been vested with powers to implement the *Town and Country Planning Act 1976* (TCPA).

(2) The two local authorities of Sepang and Subang Jaya are subservient to the State Government of Selangor while the Perbadanan is subservient to the Federal Government. In relation to matters concerning local authorities, the powers of the State over local authorities, include:

- Accept or otherwise any legislation relating to local authorities that is formulated by Parliament,
- Control changes to boundary, incorporation of new areas and approve the status of a local authority,
- Appoint Council Members, Mayor or the President of a local authority (the Perbadanan is excluded),
- Approve expenditure of local authority (the Perbadanan is excluded),
- Approve appointments of local authorities (the Perbadanan is excluded), and
- Confirm by-laws made by local authorities.

(3) Local authorities have heavy responsibilities since they look after largely urbanised areas where developmental activities are the most intense and rapid. They have an important role in implementation of decisions on land use determined within Structure and Local plans approved by the State, as well as the

approval of building plans and the development of urban drainage. The control of developmental activities that have potential to impact the physical, biological and human environment as a result of earthworks is also an important function of local authorities.

(i) Perbadanan Putrajaya

(4) Perbadanan Putrajaya ("Perbadanan" in short) was established as a body under the *Perbadanan Putrajaya Act 1995* (Act 536), to administer and manage the Kawasan Perbadanan Putrajaya (KPP) on behalf of the Federal Government. The functions of the Perbadanan are to:

- Perform functions of a local government within the KPP;
- Promote, stimulate, facilitate and undertake economic and social development in the KPP;
- Promote, stimulate, facilitate and undertake commercial development, infrastructure development as well as residential development in the KPP; and
- Control and co-ordinate the performance, in the KPP, of the activities mentioned in (b) and (c).

(5) To undertake the above functions, an organisational structure as shown in Figure 8.2.4 has been implemented. The President is the Chief Executive Officer of the Perbadanan and is assisted by a Director General with a Board overseeing the overall functions of the Perbadanan. The Perbadanan has been organised into 4 departments to perform the functions described above. The main areas of responsibilities of each of these departments is also outlined in Figure 8.2.4.

(6) Environmental matters are managed under the City Planning Department within the Landscape and Environment Division, as shown in Figure 8.2.5. The division presently composes of 4 units, namely the

FIGURE 8.2.4 : ORGANISATIONAL STRUCTURE AND ACTIVITIES OF THE PERBADANAN

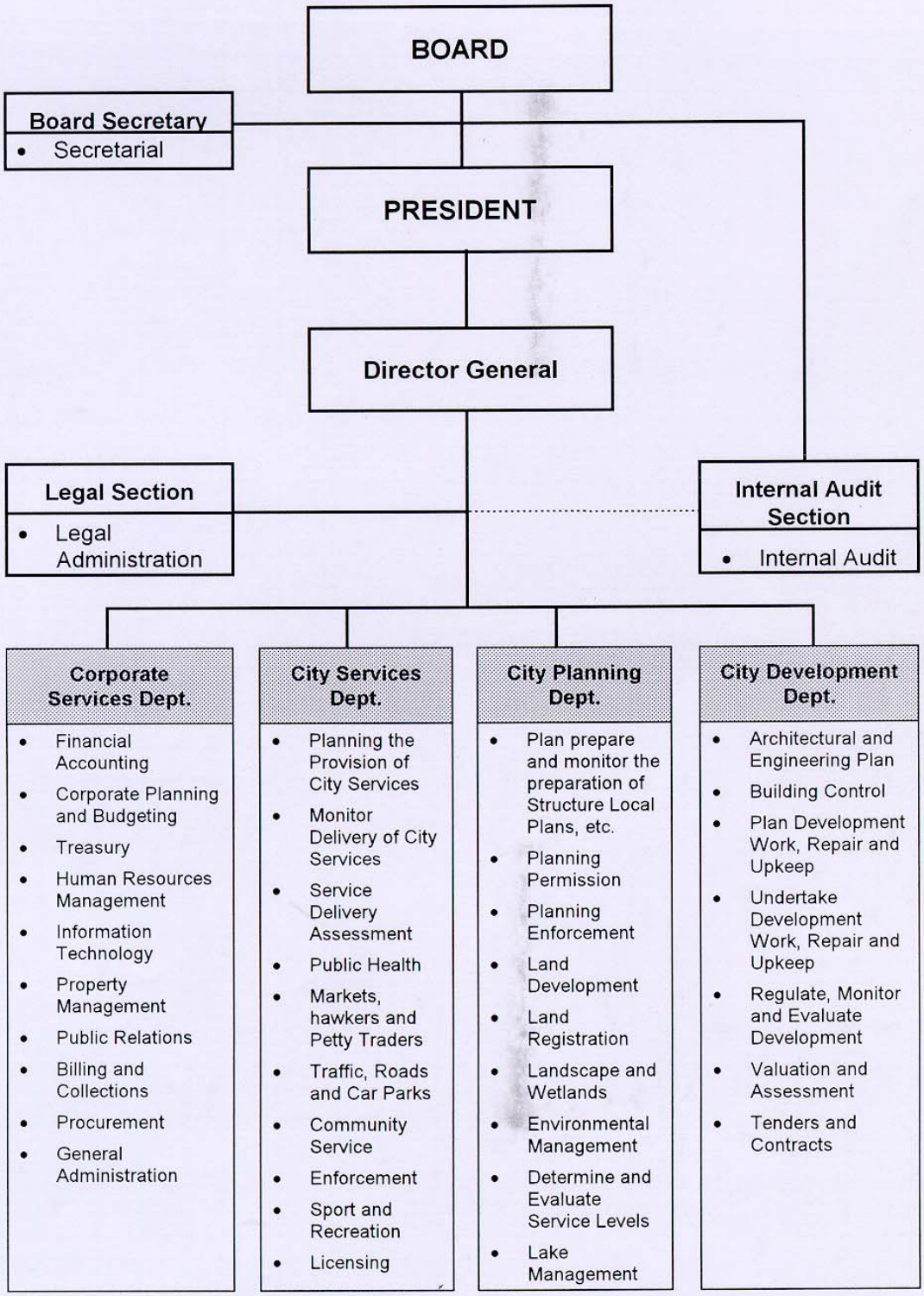
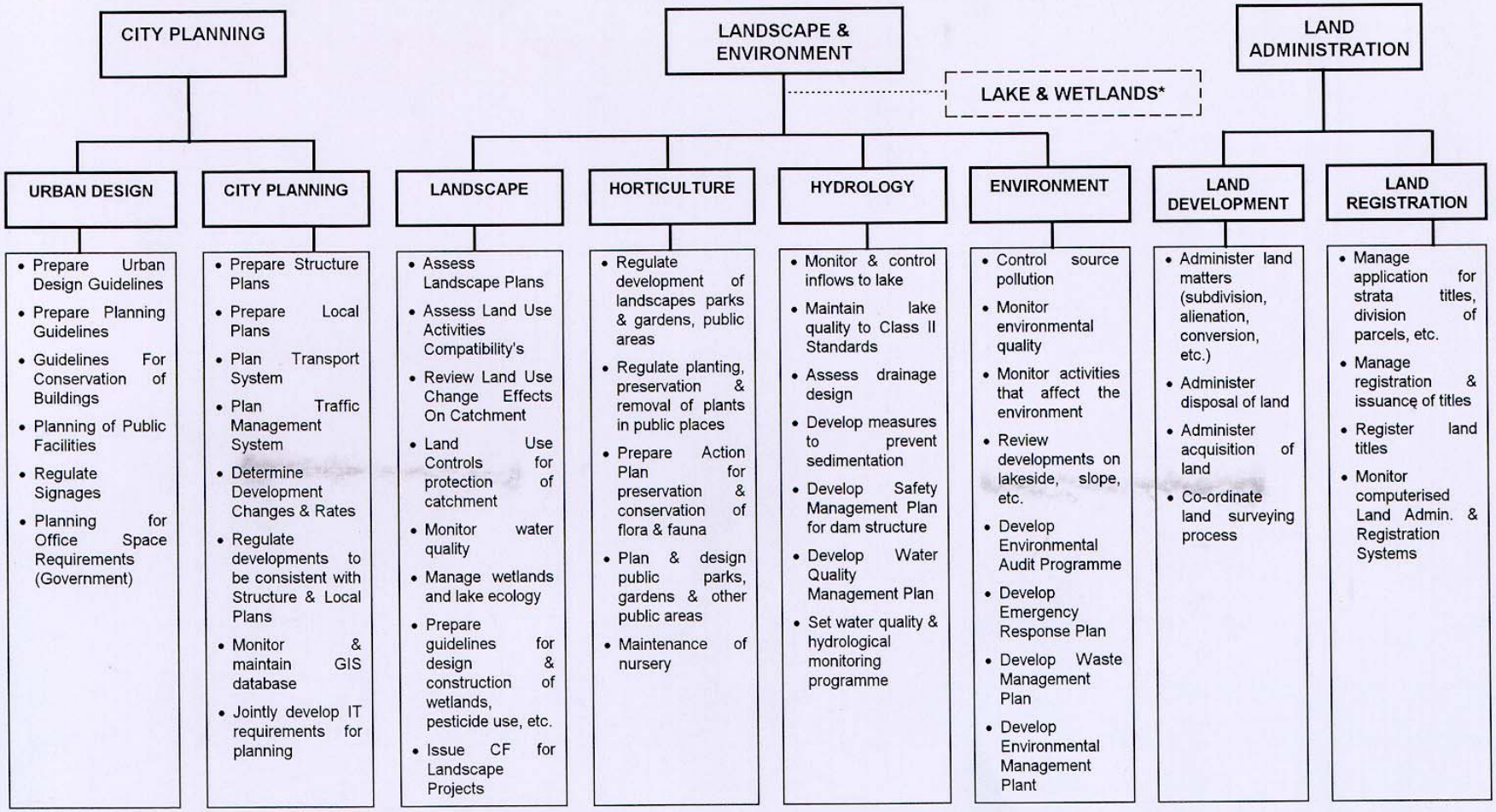


FIGURE 8.2.5 : OUTLINE OF RESPONSIBILITIES OF UNITS IN CITY PLANNING DEPARTMENT



**Proposed new unit for management of the lake and wetlands, (see Figure 8.2.14)*

Landscape Unit, Environment Unit, Horticultural Unit and the Hydrology Unit. Two other units were recommended to be formed, namely the Lake Management Unit and the Wetlands Management Unit (see *Putrajaya Environmental Management Guide, 1998*). Only one new unit, which combines the two functions of lake and wetlands management, has been formed, this being the Lake and Wetlands Unit. The general function and responsibilities of the new unit are described later in Section 8.2.6.2.

(7) Two other Departments which have relevance to lake catchment management include that of the City Development Department and the City Services Department. Within the former department, the Building Control Division is important since the regulation of earthworks and building development falls within its responsibility (see Figure 8.2.6). Besides, monitoring of physical development, project progress and project compliance is the responsibility of the Development Co-ordination Division within the same department.

(8) The responsibility for enforcement with respect to public health, traffic and business establishments is that of the Enforcement Unit of the City Services Department (see Figure 8.2.7). This is besides the enforcement of specific requirements that is undertaken by various units in the other departments.

(ii) ***Local Authorities of Sepang and Subang Jaya***

(9) The status of the two local authorities of Sepang and Subang Jaya differ in that the former operates as a Local Council (Majlis Daerah Sepang or MDS) while the latter as a Municipality (Majlis Perbandaran Subang Jaya or MPSJ). Despite this difference, they share the same functions and responsibilities in the management of their respective areas of control.

(10) The structures of the two local authorities are in general similar, though in the case of MPSJ, it is organised into departments while in the MDS it is organised in the form of divisions (see Figures 8.2.8 and 8.2.9 respectively).

FIGURE 8.2.6 : CITY DEVELOPMENT DEPARTMENT

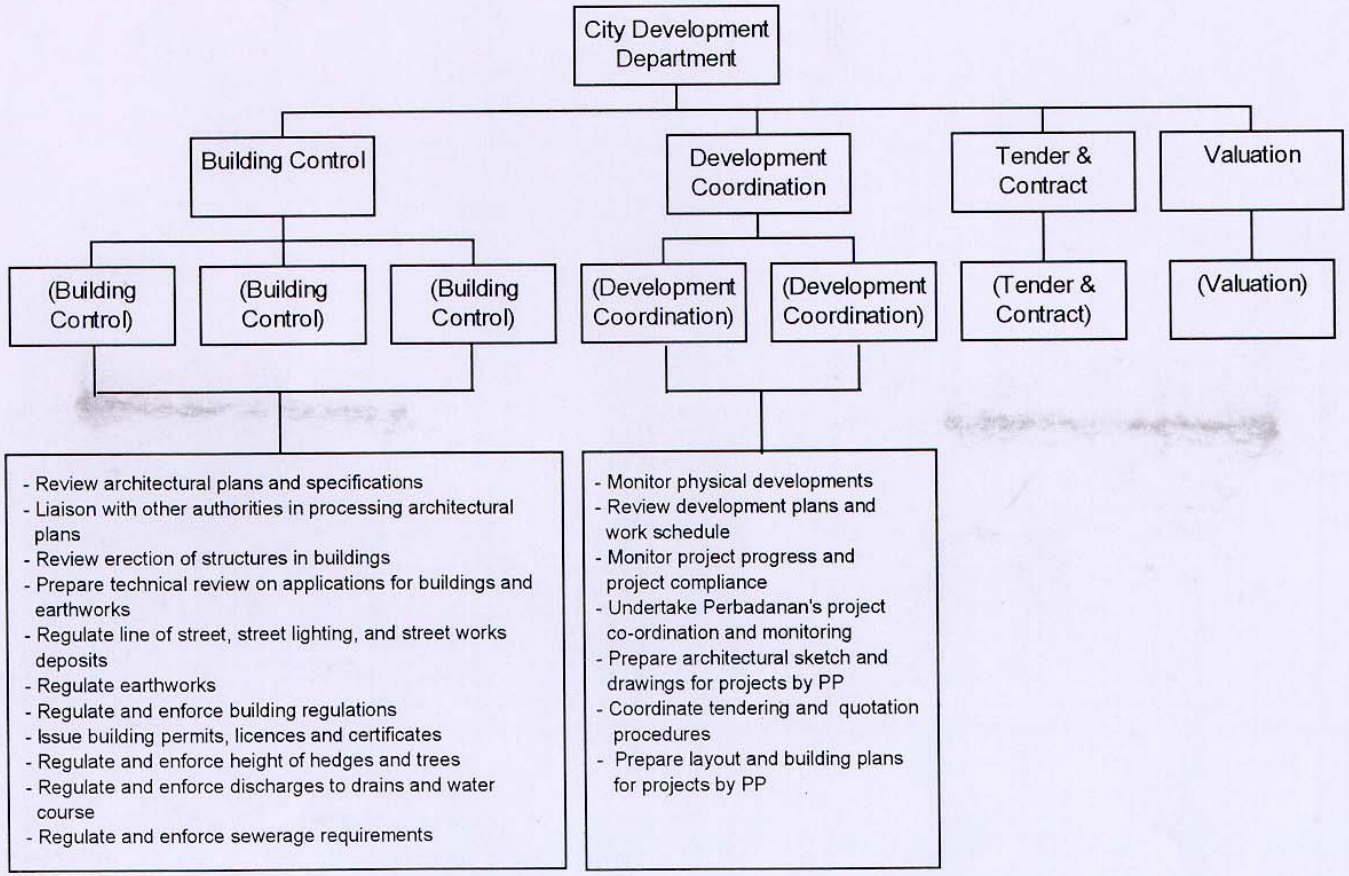


FIGURE 8.2.7 : CITY SERVICES DEPARTMENT

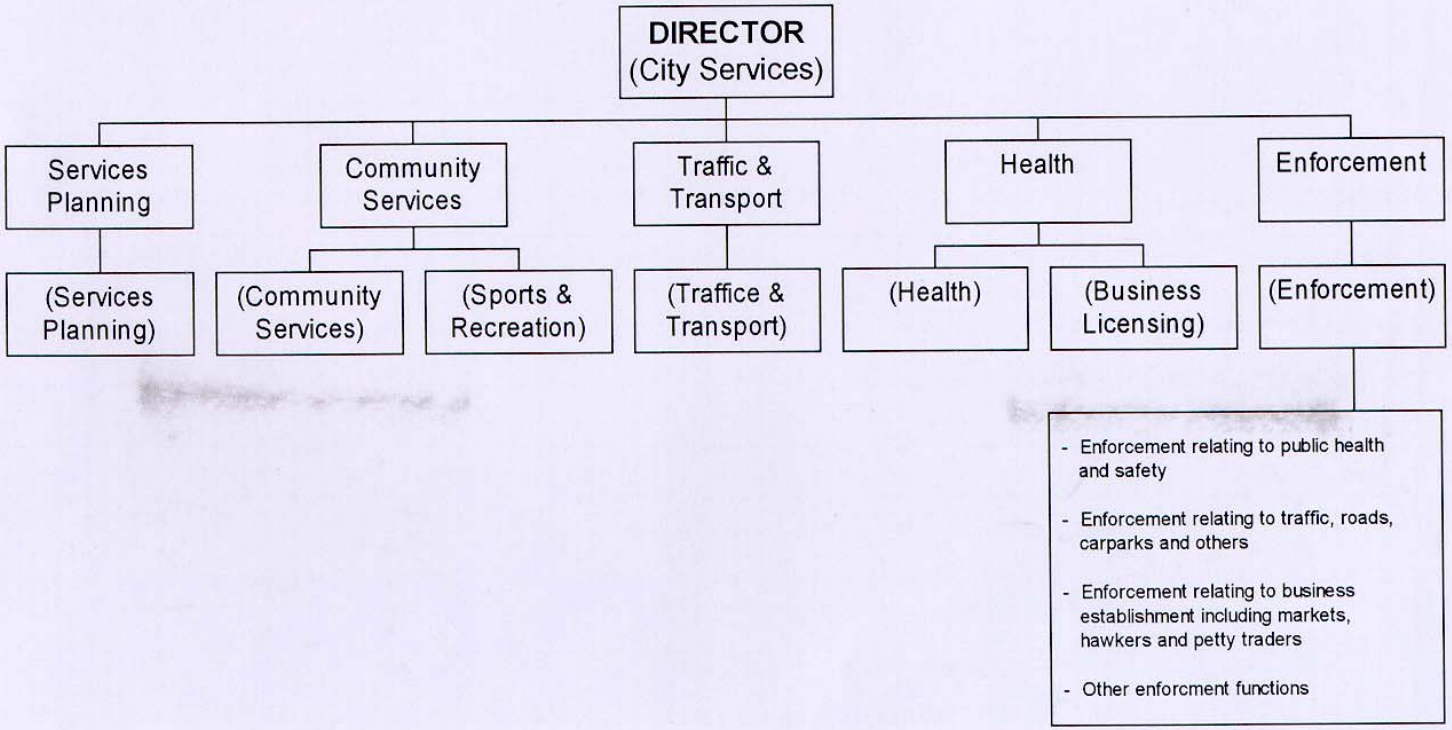


FIGURE 8.2.8 : CARTA ORGANISASI MPSJ

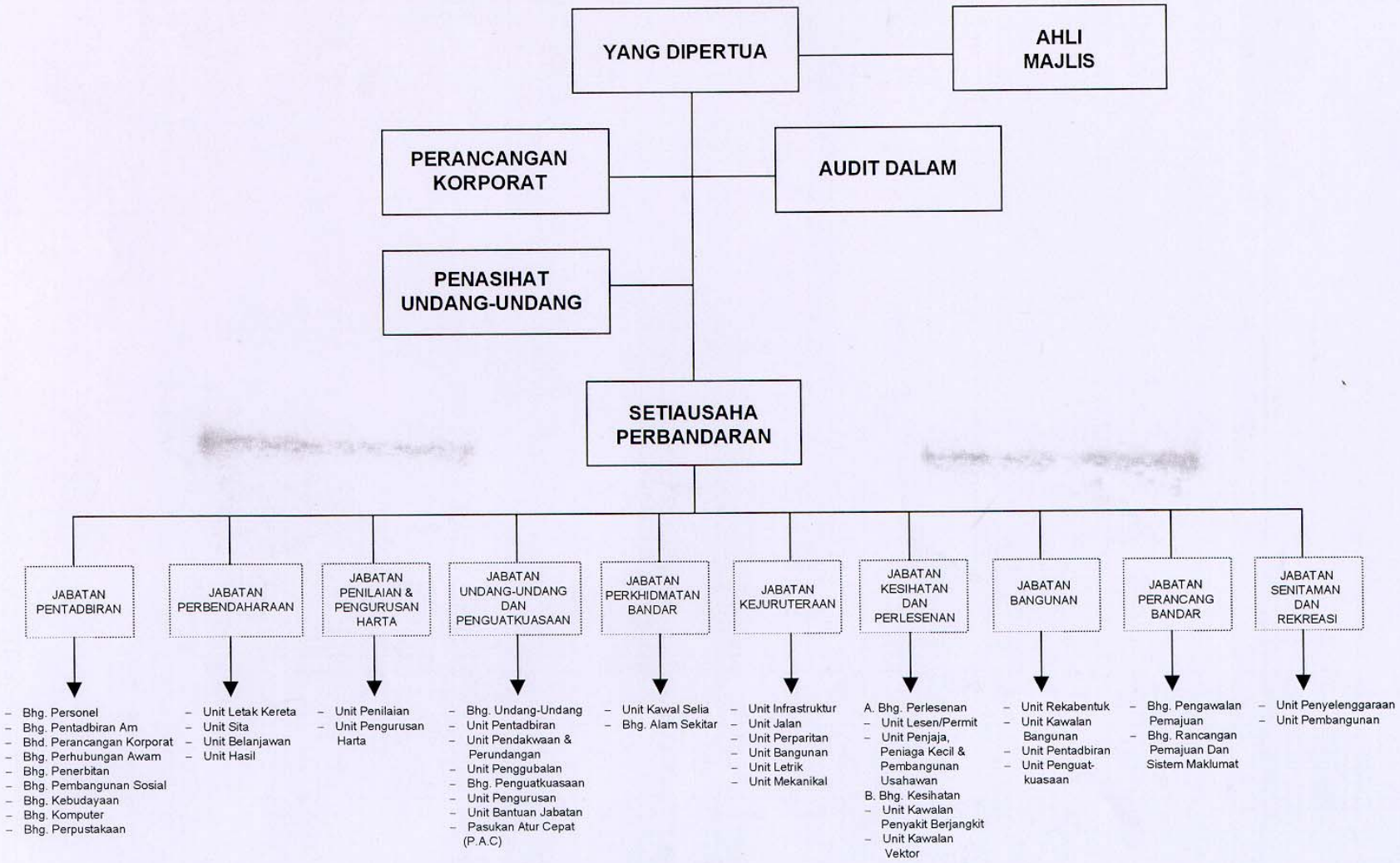
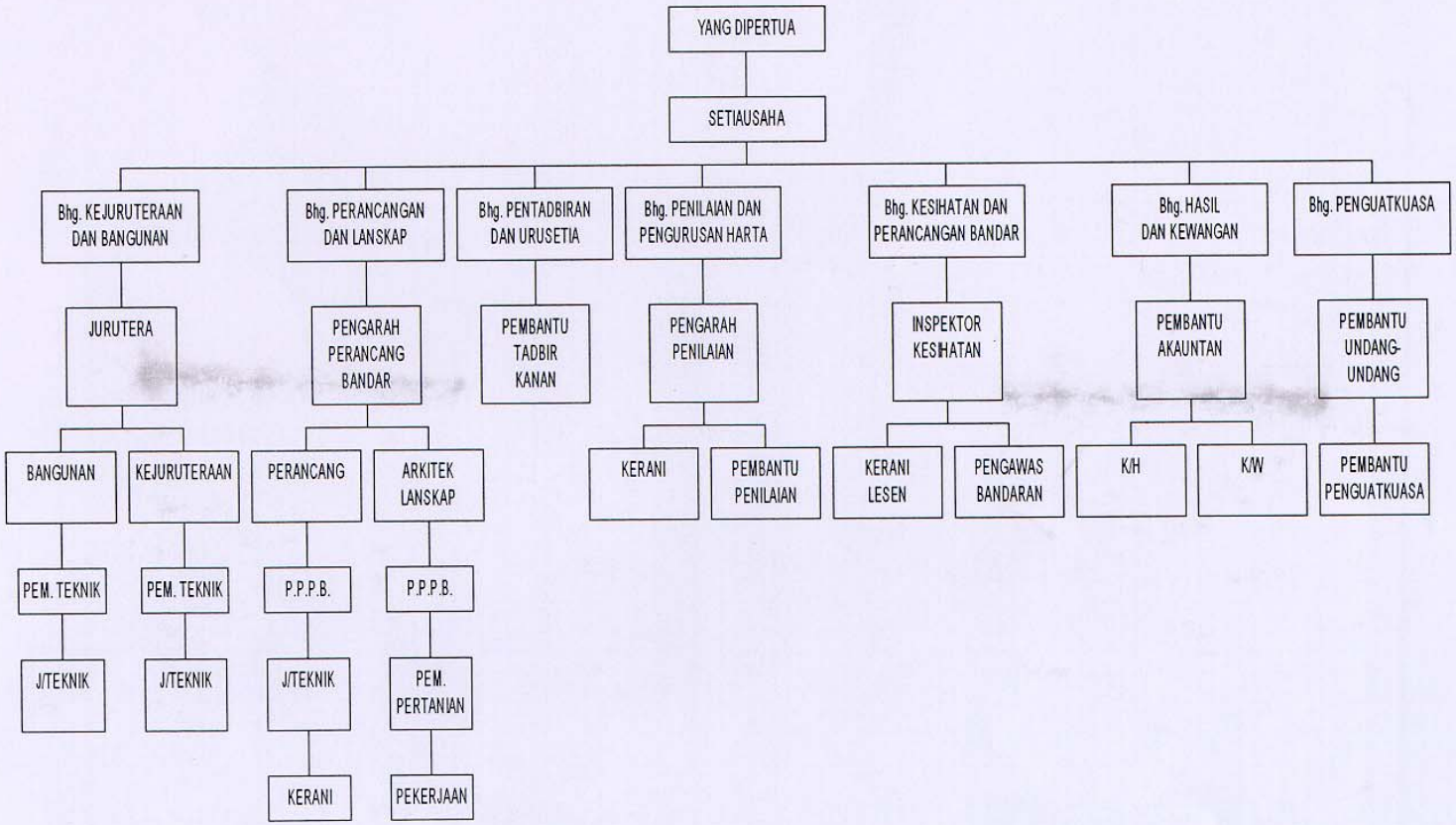


FIGURE 8.2.9 : CARTA ORGANISASI
MAJLIS DAERAH SEPANG



Both are headed by a President nominated by the State Government and assisted by a Secretary. However, in the case of the MDS, the District Officer doubles up as the President of the Council. This means that the President is not full time on the job and the Secretary represents the highest level officer who is full time with the Council.

(11) Both local authorities have similar set ups with basic units looking after planning and building, engineering, public health, valuation and management of property, enforcement, revenue and finance and general administration. Presently, MPSJ is better organised in terms of structure and manpower for management and enforcement of various by-laws that have been made under the LGA, the SDBA and the TCPA. The present management and enforcement capability of the MDS is weak, though there are proposals to increase staff strength significantly in the future.

(12) The area of jurisdiction of the MDS is large and covers the new development areas of the Kuala Lumpur International Airport (KLIA) as well as the new townships of Cyberjaya and Salak Tinggi. Unlike the MDS, MPSJ has jurisdiction over largely urbanised and developed areas with a larger population compared to that of the MDS.

(13) In relation to the Putrajaya Lake Catchment, the area of catchment that lies outside the boundary of the Perbadanan falls within the jurisdiction of the two local authorities, with a larger area falling within the MDS and the remainder under MPSJ. In terms of potential to impact the lake catchment, the former area is more important since these are areas that are privately owned and have high potential to be converted for other land uses. Areas that are presently classified as "institutional", such as those that belong to MARDI and UPM, are less likely to be converted to other land uses since the types of development that are likely to be allowed would not be expected to deviate from that of the institutions concerned, which are for research and teaching.

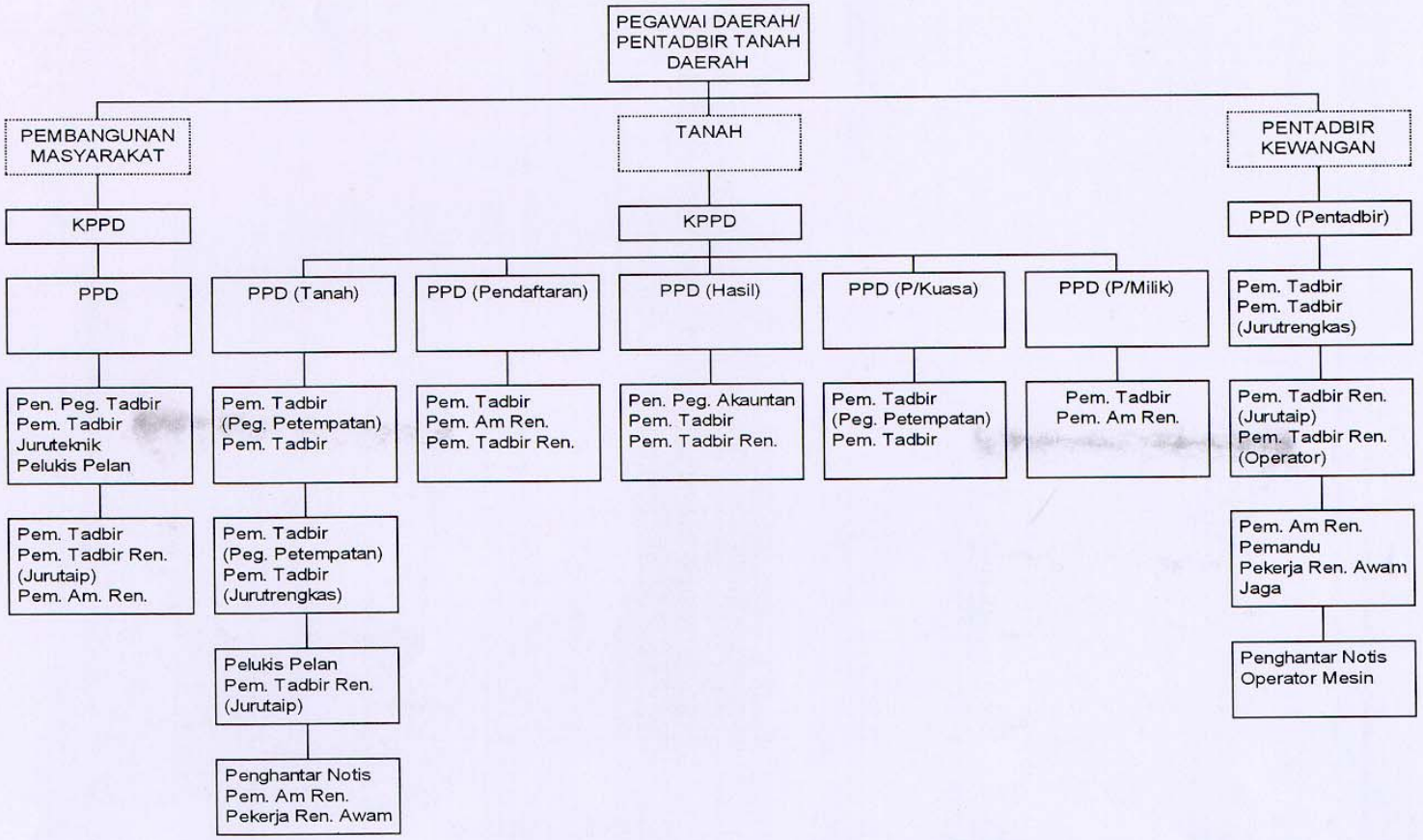
(14) Compared to the Perbadanan, the two local authorities are not as well organised or staffed for the administration of environmental matters. Their present set-up does not provide for a dedicated environmental unit to look after environmental issues such as water quality management, control of pollution and other related matters. Environmental matters within the MPSJ are handled by the Urban Services Department while within the MDS this is not indicated within its structure. Nevertheless, the latter has requested for secondment of an officer from the Department of Environment to assist in the matter but to date this position has not been filled.

8.2.2.5 District and Land Office

(1) As outlined earlier, the catchment of the Putrajaya lake is to be found within the two districts of Petaling and Sepang. The District and Land Office (PTD) of these two districts represent the most important agency for administration at the district level and have as their main function the co-ordination of implementation of projects and programmes at the district level and the administration and management of land. This is reflected in the structure of the two PTDs as shown in Figures 8.2.10 and 8.2.11. In general, PTDs are structured to administer the functions of Development, Land Administration and General Administration.

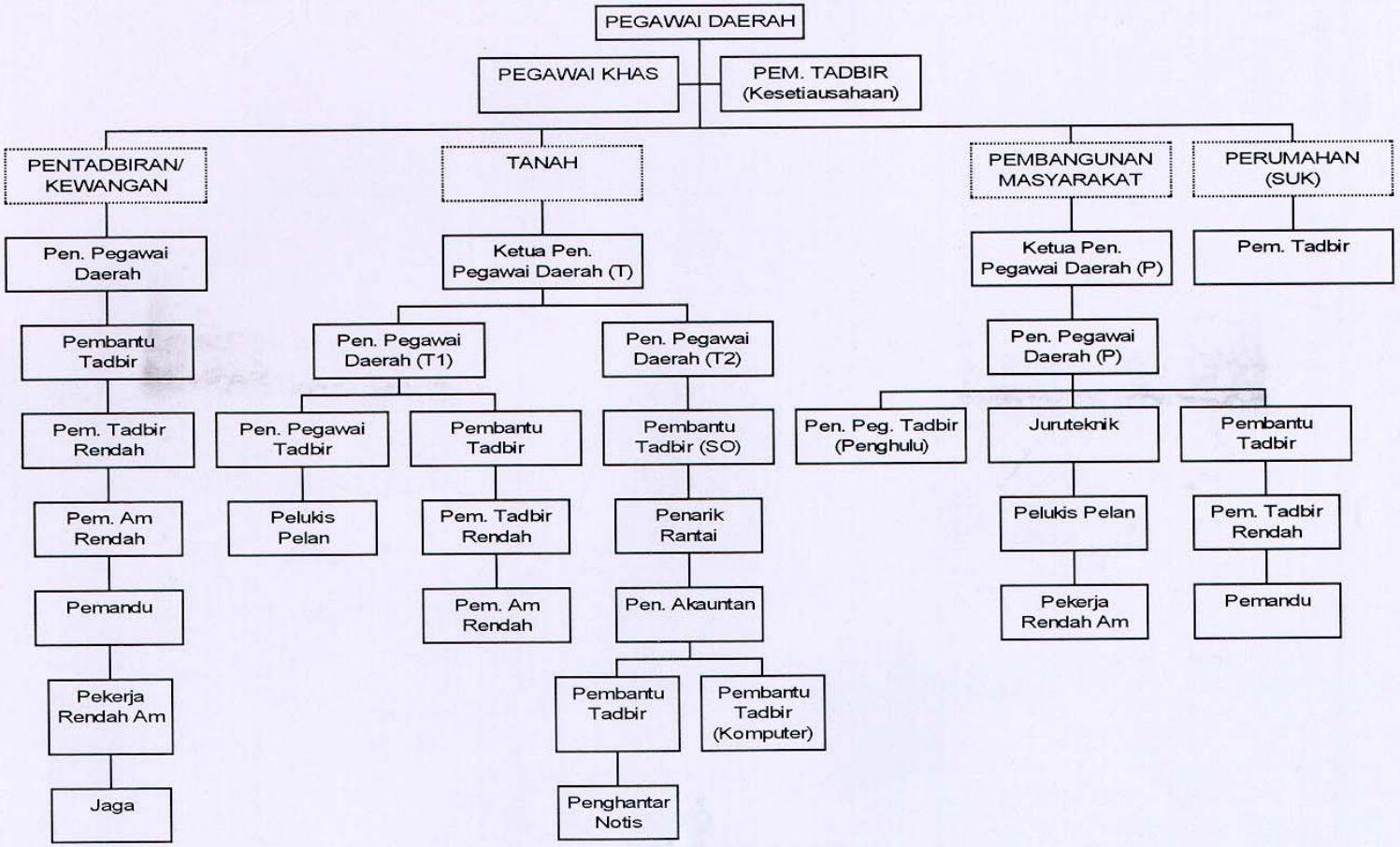
(2) All PTDs come under the purview of the State Secretary and have as one of their main functions, the co-ordination and control of activities and works that have been planned to be implemented by various departments and agencies operating at the district level. The importance of the office is reflected by the fact that although projects may be planned at the state or federal level these are ultimately implemented at the district level. The mechanism for co-ordination of development programmes and projects is through the Jawatankuasa Pembangunan Daerah or District Committee for Development which is Chaired by the District Officer. This Committee has as its members, representatives of Parliament and the State Assembly as well as heads of public agencies and departments at the district level.

FIGURE 8.2.10 : STRUKTUR ORGANISASI PEJABAT DAERAH/TANAH PETALING



Nota : KPPD - Ketua Penolong Pegawai Daerah
PPD - Penolong Pegawai Daerah

FIGURE 8.2.11 : STRUKTUR ORGANISASI PEJABAT DAERAH/TANAH SEPANG



(3) An equally important function of the PTDs is in the administration and management of land. The process of land conversion (involving a change in land use) or application for land, generally goes through the PTDs who act to obtain the views and comments of various public agencies and departments and forward these to the Office of Land and Mines (PTG). The latter has the responsibility to submit such applications to the MMKN which makes the final decision on whether to approve or reject such requests.

(4) In relation to land matters, the PTDs play an important role, since any application for change in land use status or in the application of land is first made known to the office. They are also the "custodian" of state land since they have been given the responsibility to ensure that such land is not illegally used or converted without the permission of the state.

8.2.2.6 Federal Agency at State Level

(1) Various Federal Agencies and Departments operate at state level and one of them, the Department of Environment, has relevance to catchment management by virtue of its role in the protection of the environment. Another agency, the Sewerage Services Department, does not operate at state level but has regional offices which cover more than one state. Its importance in relation to catchment management is in the approval of sewerage services for developments in an area. Related to this is the development and management of sewerage services which has largely been privatised to Indah Water Konsortium for most areas in the country.

(i) ***Department of Environment (JAS)***

(2) An important agency for catchment management, of the Federal Government that also operates at state level, is the Department of Environment (JAS). The department has the function to enforce the provisions of the *Environmental Quality Act 1974* (EQA).

(3) The functions of JAS in the state, includes Prevention (through the requirements for Environmental Impact Assessment or EIA), Enforcement (in relation to contravention of the provisions of the EQA and its subsidiary legislation and to investigate complaints),

Development (covering the assessment and approval of new industrial and related applications, education and others), and General Administration. It has also been proposed that two units be set up to look into matters related to coastal management and river management, the latter being in response to the *Selangor Waters Management Authority Enactment 1999* (Figure 8.2.12).

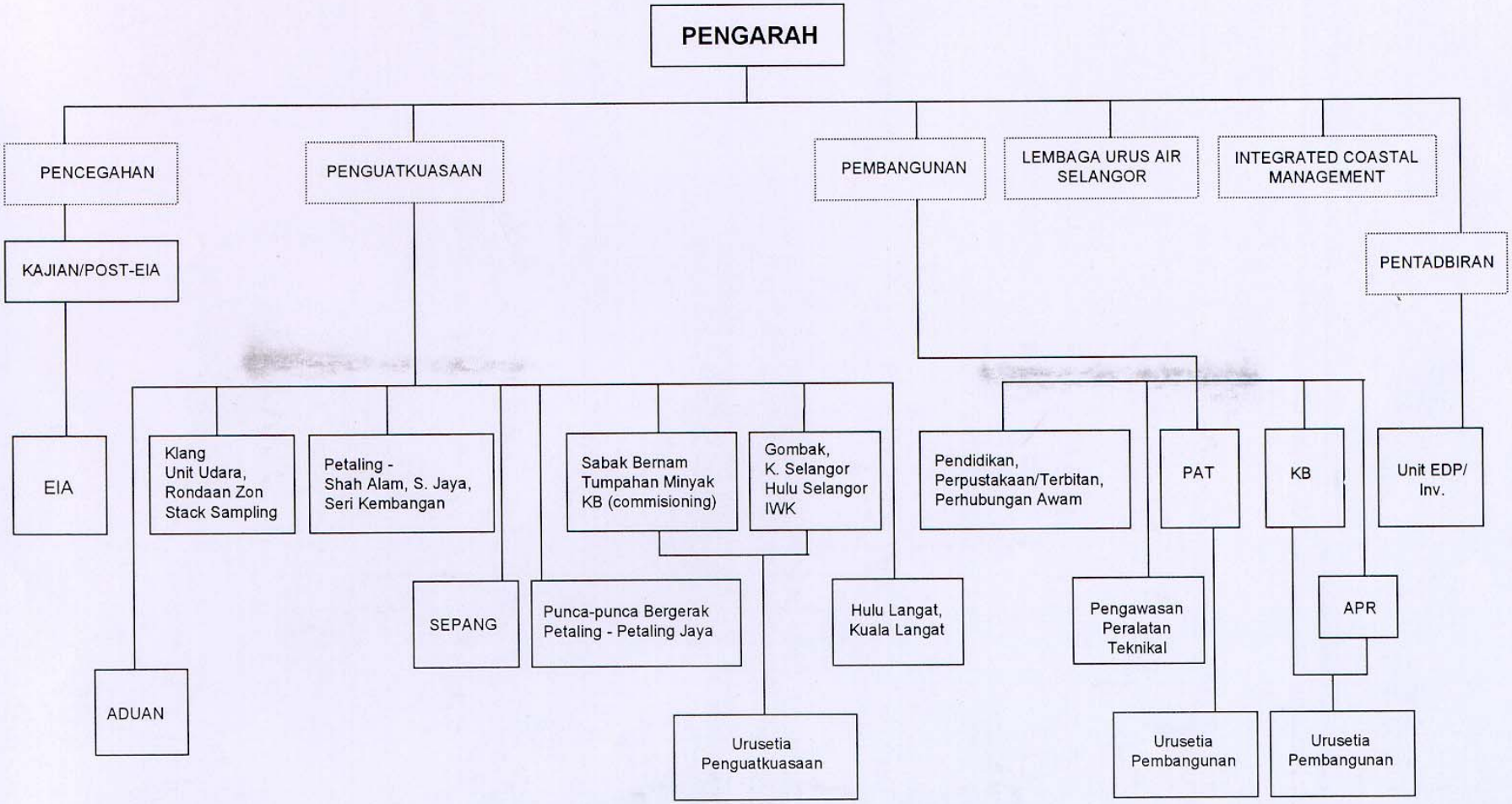
(4) The department does not operate at district level. However, there has been a request for the secondment of an officer to the Majlis Daerah Sepang in view of the rapid development of the area with the operation of the KLIA and Cyberjaya. To date an officer has yet to be seconded. The department itself is facing a shortage of staff as shown by the number of vacancies within its office.

(ii) ***Sewerage Services Department (JPP)***

(5) The JPP has been given the responsibility to co-ordinate and approve the development of sewerage services in the country under the Sewerage Services Act 1993. The actual responsibility of development and management of sewerage works has since been privatised to Indah Water Konsortium (IWK), although in the past sewerage services was a responsibility of local authorities. Except for the areas managed by Perbadanan Putrajaya, IWK has taken over responsibility in the local authority areas of Sepang and Subang Jaya.

(6) Although IWK has taken over the development and management of sewerage works in local authority areas, they have so far not been effective in the implementation of new capital works. Refurbishment of old sewage treatment plants have been undertaken while treatment works for new development areas have generally been borne by private developers. In this regards, the role of the JPP in ensuring that treatment plants approved in the catchment area of the Putrajaya Lake meet standards that are effective for water quality management is crucial.

FIGURE 8.2.12 : CARTA ORGANISASI
JABATAN ALAM SEKITAR NEGERI SELANGOR



8.2.2.7 Putrajaya Lake Catchment Management Committee

(1) The Putrajaya Lake Catchment Management Committee (PLCMC), is an administrative committee that was formed in January 1997 to address the concerns of developments in the catchment outside of the Perbadanan Putrajaya, which have potential to affect water quality of the lake. The Committee has no legal powers since it does not operate under any specific law but the recommendations made by the Committee may be effected through the various responsible government agencies and departments by way of laws in which they have jurisdiction.

(2) The Committee is made up of various government agencies and department, the three local authorities of Sepang, Subang Jaya and Putrajaya as well as two of the major stakeholders, Universiti Putra Malaysia (UPM) and Malaysian Agricultural Research and Development Institute (MARDI). It is chaired by the Secretary General of the Ministry of Agriculture.

(3) The Terms of Reference of the Committee (see Appendix 8.2.1) is as follows:

1. Menyelaras kawalan pembangunan sekitar kawasan tadahan di luar Putrajaya, khususnya yang melibatkan kawasan IOI, UPM, MARDI dan TNB.

   To co-ordinate the control of development in the catchment areas outside Putrajaya, in particular in the areas occupied by IOI, UPM, MARDI and TNB.

2. Memastikan penggunaan tanah sekitar kawasan terlibat adalah bersesuaian bagi menjamin dan memelihara kualiti air di kawasan terlibat termasuk yang akan mengalir masuk ke Tasik Putrajaya.

   To ensure suitable land-use in the areas concerned to safeguard and maintain the desirable water quality in the concerned areas as well as for outflows into Putrajaya Lake.

3. Mengubal dasar dan peruntukan undang-undang berkaitan dengan *drainage discharge* ke kawasan tadahan yang mampu merangka sebarang ancaman pencemaran daripada berlaku; dan

To formulate policies and legislation that can regulate drainage discharge from the catchment area against any potential pollution.

4. Menentukan lain-lain peruntukan dan langkah yang perlu diambil dalam usaha memelihara kualiti air kawasan tadahan dan tasik supaya harus berada ditahap yang tinggi.

   To undertake such other measures and provisions that are necessary to ensure that the water quality is maintained at high standards in the catchment area and the Lake.

(4) The members of the Committee, chaired by the Secretary-General of the Ministry of Agriculture, are as follows:

1. Ketua Setiausaha Kementerian Pertanian (Chairman)
2. Setiausaha Kerajaan Negeri Selangor
3. Unit Perancang Ekonomi
4. Jabatan Perancang Bandar dan Desa, Malaysia
5. Jabatan Perancang Bandar dan Desa, Selangor
6. Jabatan Alam Sekitar, Malaysia
7. Jabatan Alam Sekitar, Selangor
8. Pengarah Tanah dan Galian, Selangor
9. Majlis Perbandaran Subang Jaya
10. Majlis Daerah Sepang
11. Universiti Putra Malaysia
12. Putrajaya Holdings Sdn Bhd
13. Perbadanan Putrajaya
14. Jabatan Pengairan dan Saliran, Malaysia
15. Jabatan Pengairan dan Saliran, Selangor
16. MARDI
17. Penasihat Undang-undang Kementerian Pertanian

(5) The Committee is supported by a Technical Committee chaired by the Director General of JPS (see **Appendix 8.2.2**). This Technical Committee has as its members, representatives of local authorities, state agencies and departments as well as all the major stakeholders within the catchment.

8.2.2.8 Stakeholders

(1) Within the catchment of the Putrajaya Lake are to be found several stakeholders who own land within the catchment and in one way or another have potential to affect the catchment and hence generate impacts to the lake system. The major stakeholders include institutions such as, UPM, MARDI and Tenaga Nasional Berhad (TNB) who own a gas fired power plant and Universiti Tenaga Malaysia (UNITEN) within the catchment.

(2) Private land owners and developers include IOI Berhad (the owners of a recreational, residential and hotel complex), West Country Sdn Bhd (owns land adjacent to Putrajaya with a view to convert this for residential development) and Cyberview Sdn Bhd who are involved in the development of Cyberjaya.

8.2.3 Management and Control Systems

Protection of the water quality of the Putrajaya Lake system requires effective management of its catchment to minimise the generation of pollutants and to prevent the entry of undesirable pollutants in excessive amounts into the lake. In this regards three main areas of management and control may be considered crucial to protect the lake system. These being:

- Planning and land use control,
- Drainage management and control, and
- Environmental management and pollution control.

8.2.3.1 Planning and Land Use Control

(1) Planning and land use control of areas within the catchment of the lake system represents one of the most important mechanisms for protection of water quality of the lake. This is due to the impact that a change in land use has on runoff which affects drainage and the hydrology of the river and lake system. In addition, activities that are undertaken in an area as a result of changes in land use that is allowed, has potential to generate pollutants which affect water quality.

(2) Presently, land use is determined by the State except in Putrajaya. Changes in land use in all other areas require the approval of the State and generally all proposals for land conversion are referred to the MMKN for approval (see Section

8.2.2.2). Co-ordination of such submissions is by the PTG. While various agencies and departments at district and state level are expected to give their views with respect to such applications for conversion of land, the final decision on the application rests with the MMKN. Local authorities like other agencies and departments may present their views and comments. Nevertheless, requirements recommended by the agencies and departments may be imposed as conditions of approval.

(3) Private stakeholders within the catchment of the Putrajaya Lake may be expected to apply for a change in land use if these changes provide commercial and economic gains. For instance, West Country Sdn Bhd owns prime land just adjacent to Putrajaya. Plans are being made to convert the land for mixed residential development. Such changes in land use have implication to the lake catchment and hence lake water quality.

(4) Structure plans for both the MDS and MPSJ have been prepared but for most areas, local plans that detail out the approved land use for the area are being prepared but only for some areas. It is expected that this process will take time to be completed and gazetted. As such these areas are still open to applications for ad-hoc conversion of land which is undesirable since this has the potential to prevent effective land use control and management.

(5) Within the areas of Putrajaya and Cyberjaya, master plans for land use have been prepared. The master plans that have been prepared are very detailed and planning controls are strictly enforced and effectively managed. Local plans are also being made for various development areas within Putrajaya and these are expected to be gazetted and made mandatory for future developments. In this regards, changes to land use to those approved in the local plans are not expected to be a major issue for the two areas.

(6) Based on an analysis of the mechanism of planning control and land use management it is clear that, except for the Putrajaya area, the State is the approving authority for conversion of land and hence the type of land use within the local authority areas of Sepang and Subang Jaya. The absence of local plans within

the two areas precludes effective land use control by the two local authorities since ad-hoc applications for conversion may still be made to the State.

8.2.3.2 Drainage Management and Control

(1) The responsibility for control and management of drainage rests with local authorities (urban drainage), the JPS (main drainage systems and rivers), and the JKR (roadside drains). Each has its own area of responsibility but not necessarily co-ordinated.

(2) With regards to catchment management, the JPS has generally taken the lead for managing rivers where issues of stream flow, water availability and use, and flood management arise, whereas local authorities and the JKR are more concerned about drainage where it affects the local authority area or project (such as road) respectively. Drainage from the latter two are ultimately directed to main drainage systems or rivers which are taken to be the responsibility of the JPS.

(3) Changes in runoff arising as a result of urban development or the implementation of projects, such as roads, affects receiving streams and rivers since large increases in runoff can lead to flooding downstream and land clearing can lead to increase in soil erosion and sediment transport to rivers. Hence controls on developments within a catchment is important. Presently the JPS is consulted where land development projects are proposed. The department imposes conditions for runoff management and flood control and requires that developers submit appropriate plans for its approval.

(4) Even though the JPS has control on runoff and manages flooding, it has no jurisdiction over the quality of water that is discharged. As discussed earlier, runoff generated from local authority areas and from roadside drains of JKR roads, have the potential to carry sediment and other pollutants. Drainage of such pollutants into the river system and ultimately into the lake has potential to affect its water quality. Control of such discharges into main drains and rivers is an issue that needs to be addressed if protection of the Putrajaya Lake is to be achieved.

8.2.3.3 Environmental Management and Pollution Control

(1) Agencies which have direct responsibilities for environmental management and pollution control are essentially the local authorities and JAS. The areas of responsibility of these two authorities and the relevant laws which are enforced have been discussed earlier and in Section 8.1.6 of the Legislative study. Other agencies, such as the JPP and IWK play an indirect role in the planning and implementation of sewerage programmes and works to ensure that sewage is properly treated prior to its discharge.

(2) The control of pollution within the catchment of the Putrajaya Lake may be discussed with respect to point and non-point sources of pollution. Both sources of pollution are to be found within the lake catchment and the present mechanism for the control of these sources is outlined in the following.

(i) ***Points sources***

(3) Point sources of pollution are associated with the discharge of sewage from residential, recreational and institutional developments. There is no significant industrial sources of pollution within the catchment. For new developments, sewage is presently quite well controlled since it is required by the JPP that proper sewerage systems be constructed and operated. Except for Putrajaya, no centralised sewerage system is operated in the area of the catchment outside of Putrajaya. Individual sewerage systems are used which cater to the needs of specific developments.

(4) Within Putrajaya, sewerage systems are presently constructed by the Perbadanan and this could be the case for operation and maintenance. However, the latter may be privatised or managed by IWK. For all other areas that have been taken over by IWK, they are to be operated and managed by the Consortium.

(5) In relation to the quality of discharge, JAS has set standards of discharge for treated effluents under the *Environmental Quality (Sewage and Industrial Effluents) Regulations 1979*. These standards apply to both sewage and industrial effluents. More stringent standards may be

set if this is required to safeguard the quality of lake water.

(6) The Perbadanan is proposing to adopt more stringent standards of discharge to control water pollution of the lake by way of regulations to be made under the EQA 1974.

(7) It is to be noted that the powers to set standards for discharges and water quality is within JAS but the department is a Federal agency and only operates up to state level. It does not have offices at the district or local authority levels and this limits to some extent its effectiveness in enforcement.

(ii) ***Non-Point sources***

(8) Non-point sources of pollution present problems for control as often no specific laws have been made to control them. Following are some of the non-point sources of pollution and the legislative controls that are currently applied.

a) Soil Erosion and Sedimentation

(9) Soil erosion is expected to represent the most important problem that has potential to affect the quality of lake water as a result of silt carried into rivers and the lake. Earthworks and construction activities result in the opening up of land and expose them to erosion. From the legal standpoint, control is mainly through the *Earthworks By-laws* which are enforced by local authorities.

(10) Other agencies such as JAS and the JPS do this administratively. For example, JAS requires project proponents whose EIAs have been approved, to prepare an Environment Management Plan (EMP) as a condition of EIA approval. It has also issued a guideline on the format of the EMP to be prepared (See Appendix 8.2.3).

(11) Based on the legislative analysis undertaken, improvements to the *Earthworks By-laws* is required to

strengthen and make it more effective. In addition, enforcement of the by-laws is important.

b) Pollutants in Runoff

(12) Pollutants in runoff include nutrients from agricultural areas, and sediment and chemicals (such as oils) from roads, car parks and sources from urbanised areas. There are no specific laws governing the control of quality of runoff and this is presently done administratively, such as the requirement for silt traps and sedimentation basins. The responsibility for the management of runoff rests with the local authority and the respective agencies such as the JKR and other developers or owners of the property.

(13) These non-point sources can be significant sources of pollutant inputs into the catchment and represent areas of control that are currently not adequately addressed.

8.2.4 Assessment of Institutional and Administrative Framework for Catchment Management

8.2.4.1 A review of the administrative set-up and institutional arrangements for management of pollution from the Putrajaya Lake Catchment has been made and following are some of the preliminary conclusions that can be drawn:

8.2.4.2 Effective planning and Landuse Control in Putrajaya and Cyberjaya areas

The control of planning and land use management within areas such as Putrajaya and Cyberjaya is expected to be effective since detailed Master Plans have been drawn up for the two areas. In the case of Putrajaya, the mechanism and set-up for control and management of planning is well organised compared to those of the other local authority areas. Although Cyberjaya lies within the MDS it nevertheless is a special case since control of planning and development is within the authority of the Multi Media Development Corporation. Cyberview Sdn Bhd, the developer of Cyberjaya, is bound to adhere to the conditions imposed by the Corporation.

8.2.4.3 No local plans for the areas outside Putrajaya and Cyberjaya

Areas that fall outside of the two areas are managed by the respective local authorities, MDS and MPSJ. Structure Plans have been prepared for the two local council areas but Local Plans have yet to be made and gazetted for those areas within which the Putrajaya Lake Catchment lies. Ad-hoc applications for conversion of land is likely to occur and the final decision to allow such conversions lies with the state and not with the local authority.

8.2.4.4 No integrated approach to drainage

With respect to drainage, there is no integrated approach to the issue since the responsibilities for drainage lies with the JPS, the local authorities and other agencies such as the JKR and other developers. All runoff and discharges into drainage systems ultimately flow into rivers which is the main source of water for the lake. Integrated management of drainage and the river system is important and needs to be addressed. Control of quality of runoff represents one of the issues that need to be given attention.

8.2.4.5 MDS and MPSJ have inadequate set-ups for management of environmental issues

The two local authorities, MDS and MPSJ, have set ups that are similar except that the latter is more organised and better staffed, it being a municipality. However, compared to the Perbadanan, the organisational structure of both local authorities for effective management of environmental issues such as control of water pollution, runoff management and others that have an effect on lake water quality, are generally inadequate. They lack suitable staff for undertaking such responsibilities.

8.2.4.6 No effective control of non-point sources of pollution

The powers of JAS to control pollution are wide but effectively these are mainly directed towards point sources of pollution. Its jurisdiction with respect to non-point sources of pollution, such as soil erosion and siltation, contaminants in runoff and others are limited (see Section 8.1.6.7 of Legislative review). These matters are better addressed by local authorities since these issues relate to activities which fall within their jurisdiction. Hence, local authorities need to be structured to manage and control non-point sources of pollution which are expected to be

important in the management of the Putrajaya Lake Catchment. The enforcement functions of local authorities should not be confined to those related to public health (such as domestic waste or pest management), traffic and businesses but expanded to include environmental quality management.

8.2.5 Proposed Institutional Arrangement For Administration

8.2.5.1 The present arrangements for control of planning and management of land use, control and management of drainage, and environmental management and pollution control suggests that significant improvements to the present arrangement are necessary for effective management of the Putrajaya Lake Catchment.

8.2.5.2 A review of the legislative provisions for management suggests that the *Selangor Waters Management Authority Enactment 1999* (SWMAE) provides a mechanism for integrated management of the catchment (see Section 8.1.7 of the Legislative review). The structure of the Selangor Waters Management Authority (SWMA) has been proposed and is shown in Figure 8.2.13**.** It includes the formation of Regional Offices which are to be responsible for the management of entire river basin systems, such as the Sg. Langat of which the Sg. Chuau is a tributary.

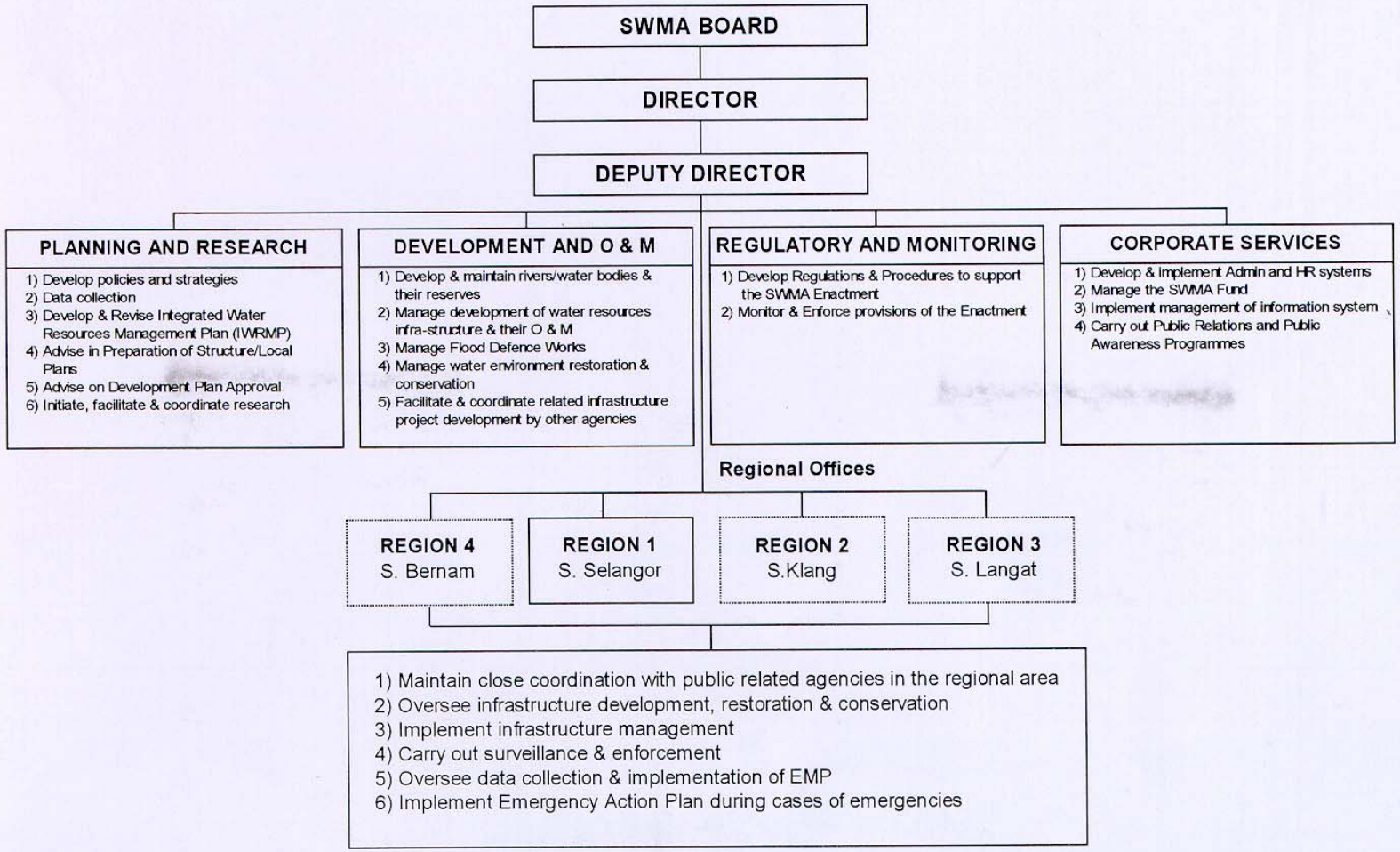
8.2.5.3 Based on an analysis of the powers within the Enactment and the structure of the Authority, the following conclusions can be drawn:

(1) The SWMAE is a comprehensive law and provides the legal basis for management of a catchment since the issue of water is a state matter;

(2) The Enactment provides for the management of water resources on a catchment basis in a sustainable and integrated manner. It allows for a sub-catchment approach to be adopted for the management of the Putrajaya Lake Catchment;

(3) The Enactment provides the best basis for water quality management since it has provision for prescribing water quality standards and the imposition of control on total

FIGURE 8.2.13 : PROPOSED SWMA ORGANISATIONAL STRUCTURE AND FUNCTION



pollutant load discharges into the catchment. It provides the means to control more effectively non-point sources of pollution and complements the provisions under the EQA for point sources;

(4) There are provisions within the Enactment to ensure that land use within a catchment is reviewed by the Authority before approval for conversion is given. The Authority has a Planning role which is to advise on Structure and Local Plans that are prepared;

(5) Drainage planning and development, which is presently not approached in an integrated manner, can be more effectively addressed by the Authority since it has authority over an entire catchment;

8.2.5.4 Based on the above analysis, it can be summarised that the SWMA has both the legal clout and the administrative linkages to undertake overall catchment management effectively. The contribution from other existing agencies to catchment management will continue to complement those of the Authority, since it is expected that the actual exercise of enforcement can remain the function of the local authorities and other existing agencies who already have such powers or can be delegated such powers under the SWMA.

8.2.6 Recommendations

8.2.6.1 The findings from the Institutional Review have shown that catchment management is best undertaken by the SWMA which has the legal powers and institutional set-up for undertaking this. It is thus recommended that overall management of the Putrajaya Lake Catchment be the responsibility of the SWMA in the long term as part and parcel of the overall management scheme for the Sungai Langat River Basin which is to be managed by the proposed Regional office of the SWMA.

8.2.6.2 However, the Authority is at its infancy and although a Director has been appointed, the formation and full functioning of the Authority has yet to be made known. As such interim measures for catchment management are recommended to be taken until such time that the Authority has specific plans and programmes for the management of the Sg. Langat Catchment. It is

anticipated that the Perbadanan and the other local authorities will continue to take lead roles in the management of the catchment.

8.2.6.3 Sub-Catchment Management

(1) Section 46 (1) of the SWMAE allows the SWMA to establish local area management committees and stakeholders' groups to work with the SWMA. In this context, it is proposed that a Sub-Catchment Management Committee (SCMC) be appointed in the interim to advise the Authority on matters relating to the management of the Putrajaya lake catchment, of which the Sg. Chuau, a tributary of the Sg. Langat, is the main river system. The SCMC will operate as a sub-committee of the SWMA Technical Committee.

(2) The members of the Committee is to comprise of technical experts from the various government agencies and departments, and also a representative from the stakeholders. The Committee is suggested to be chaired by the State Secretary or his representative and comprise the following members:

Chairman:	State Secretary/Representative
Members:	SWMA Drainage and Irrigation Department Department of Environment Town and Country Planning Department Perbadanan Putrajaya Majlis Perbandaran Subang Jaya Majlis Daerah Sepang Jabatan Kerja Raya Sewerage Services Department Representative of Stakeholder's Consultative Committee
Secretariat:	SWMA / Perbadanan Putrajaya's Lake & Wetlands Unit

(3) The Perbadanan has the greatest stake in preserving the water quality in the Lake and has all the necessary resources to manage the Putrajaya Area to meet the desired water quality objectives of the Lake. Thus, it is recommended that the

functions of the Committee be confined to the following main issues related to integrated management of the catchment*, for the areas outside Putrajaya*.

- Provide advise relating to land use planning and management in the areas, that are necessary for integrated management of the catchment;
- Provide advise relating to drainage control and management;
- Provide advise relating to pollution control and management;
- Provide advise on the monitoring programme required for the integrated management of the catchment;
- Provide advise on the enforcement action required to be taken; and
- Provide advise on the works required to support the integrated management of the catchment.

A draft TOR for the Committee has been drawn-up (see Appendix 8.2.4). The Committee has to be formalised by the SWMA eventually.

With the above institutional arrangements the micro-management of the catchment areas within Putrajaya will be the responsibility of the Perbadanan, whereas those outside will be the responsibility of the SWMA. *However, from the macro-management perspective of the Langat River Basin, the Perbadanan still has to meet the water quantity and quality requirement, downstream of the Putrajaya Lake catchment, set by the SWMA*.

(4) It is to be noted that the Committee is not intended to override the functions of the various local authorities and other government agencies but to act as a forum for consultative discussions and decisions to ensure integrated catchment management. It is still left to the various local authorities as well as other government agencies to enforce matters related to their areas of jurisdiction.

(5) It is anticipated that the Perbadanan will play a lead role in the Committee since it is the best placed to do so by virtue of its

technical and financial strength and commitment to ensure that the lake is protected. In this context it is proposed that the management of the catchment within Putrajaya be the responsibility of the Perbadanan, while the SWMA be responsible mainly for the catchment outside of the Perbadanan.

(6) The formation of a Lake and Wetlands Unit within the City Planning Department of the Perbadanan is expected to enhance the effectiveness of the Sub-Catchment Management Committee as discussed in the following.

8.2.6.4 Role of Perbadanan Putrajaya's Lake & Wetlands Unit

(1) The Perbadanan Putrajaya has formed a Lake and Wetlands Unit within its City planning Department (see section 8.2.2.4 (6)) with the responsibility for managing and maintaining the lake and the wetlands. It has been assigned the task to plan, co-ordinate and implement programmes for monitoring and undertake research. The general structure and functions that have been assigned to the Unit is outlined in Figure 8.2.14.

(2) The SCMC, has representatives from various government departments and local authorities. The Committee is effectively a co-ordinating body and as such it would not be expected that matters relating to the collection, collation and analyse data (such as water quality, waste inventory, source emissions and other information that is required for integrated catchment management), be undertaken by the Committee. It is best that these be undertaken by a supporting "unit" that has capabilities and facilities to undertake such works. The centralisation of data and information to enable ease of collation, analysis and interpretation is thus recommended.

(3) In this regards it is recommended that the Perbadanan Putrajaya's Lake and Wetlands Unit (PLWU) either wholly or jointly with the SWMA be assigned the overall task of monitoring the implementation of the Catchment Management Plan and acting as the Secretariat to the SCMC. It should be assigned the task to collect, collate, analyse and manage the information that is generated from the monitoring, source inventory and model studies. It would be required to provide technical reports to the SCMC on matters such as:

FIGURE 8.2.14 : CARTA CADANGAN UNIT TASIK DAN WETLAND JABATAN PERANCANGAN BANDAR

PENYELIDIKAN
- Lake and wetlands chemistry
- Lake and wetland biology
- Limnology
- Vegetasi
- Tanah
- Hidupan liar
- Rekreasi
- Kesihatan

INVENTORI DAN 'DATABASE'
- Tanaman
- Kecekapan tasik dan wetland

PEMBANGUNAN
- Sistem pengurusan tasik dan wetland (ISO 14000)
- Garispanduan pengurusan tasik dan wetland

LAPORAN
- Kecekapan tasik dan wetland

PEMANTAUAN
- Kualiti tasik dan wetland
- Kualiti trafik
- Tanaman
- Kecekapan tasik, wetland dll., struktur fizikala dan biologi
- Estetika
- QC/QA

O & M
- Schedule
- Prosedur kecemasan dan keselamatan

INVENTORI DAN 'DATABASE'
- Punca pencemaran
- Kecekapan struktur kawalan

LAPORAN
- Kualiti tasik dan wetland

- trends in water quality and causes of changes,
- source inventory updates (point and non-point), and
- biological changes affecting the lake and wetlands.

(4) Overall co-ordination of monitoring of the catchment is also proposed to be delegated to the Perbadanan and be the responsibility of the Unit. It is to be assisted by the Hydrology Unit of the Perbadanan in providing information on drainage, lake and river hydrology and related hydrogeological information. Agencies such as JAS, JPS, JPP, MPSJ, MDS and other technical departments and various stakeholders are expected to contribute to the information database that is kept by the PLWU.

8.2.6.5 Stakeholders' Participation

(1) The involvement of stakeholders in catchment management is important and a platform for their participation is proposed both at the Sub-Catchment Management Committee as well as the Stakeholders' Group which will be in the form of a Stakeholders' Consultative Committee (SCC). It is recommended that the SCC be chaired by the Director of SWMA or his/her representative.

(2) The SCC is recommended to be formed as it presents a separate forum for members to discuss matters that affect them. The involvement of all stakeholders in the Sub-Catchment Management Committee is too unwieldy and will not provide adequate opportunity for effective discussion of such matters. Awareness and understanding of the decisions of the SCMC is important to ensure that stakeholders will contribute positively to catchment management. The SCC should meet at least annually but also as and when issues are referred to it by the SCMC.

8.2.6.6 Structure For Catchment Management

(1) Figure 8.2.15 outlines the suggested arrangement for catchment management between the Selangor Waters Management Authority (SWMA), the Sub-Catchment Management Committee (SCMC) and the Stakeholders' Consultative Committee (SCC). It is anticipated that these new committees

will replace the present ad-hoc Putrajaya Lake Catchment Management Committee (PLCMC) and its technical arm that has been set up to manage the catchment.

(2) The suggested Terms of Reference for the SCMC and the SCC are outlined in **Appendix 8.2.4 and 8.2.5** of this report.

8.2.6.7 Putrajaya Lake Catchment Management Committee

(1) As outlined earlier, the PLCMC was formed as an ad-hoc committee to co-ordinate the control of development within the catchment with the aim of safeguarding the quality of water in the Putrajaya Lake. Until the formation of the new SCMC by the SWMA, it is suggested that the PLCMC continues with its present function.

(2) Similarly, the Technical Committee assisting the PLCMC, chaired by the Director General of JPS, is to continue its function until such time that the new SCMC is formed by the SWMA. It is then proposed that both these present committees be disbanded upon the coming into operation of the two new committees.

8.2.6.8 Organisational Strengthening

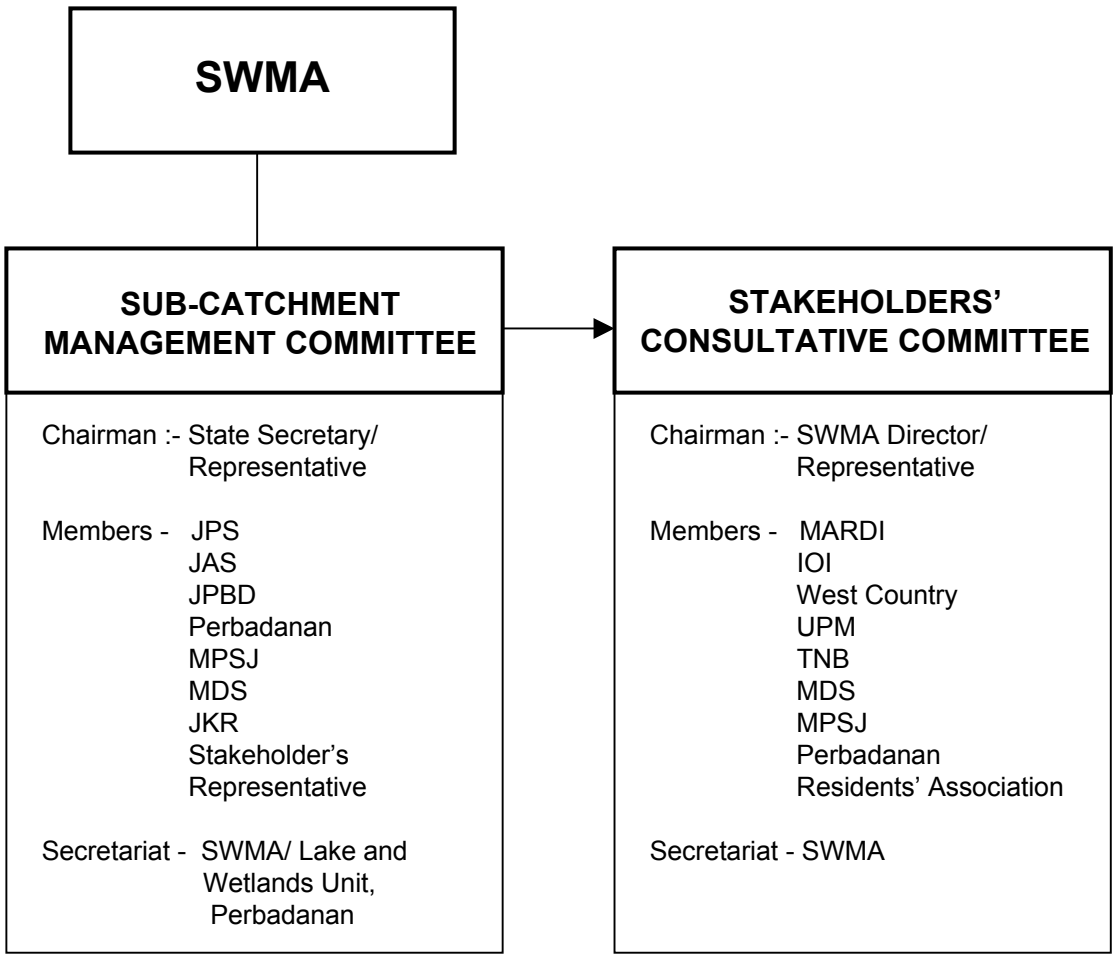
(1) The recommendations for integrated catchment management require that the tasks for management be assigned to various organisations and parties. These relate to planning, operation and implementation of various programmes and projects in the catchment area besides the enforcement of laws within which they have jurisdiction. Some of these works require that certain organisations be strengthened while others may require that new functions be added.

(2) Following are recommendations relating to new functions and manpower requirements for various organisations.

(i) Perbadanan Putrajaya

(3) The additional duties proposed for the Lake and Wetlands Unit of the City Planning Department requires that the Unit be beefed up and reorganised to consist of at least 2 graduate officers (besides the Penolong Pengarah) instead of 1 as presently. At least one of these two officers is to have substantial training in chemistry or chemical

FIGURE 8.2.15 : PROPOSED STRUCTURE FOR PUTRAJAYA LAKE CATCHMENT MANAGEMENT



engineering, while the other is to have substantial training in aquatic science. The rationale for this is change is to ensure effective analysis and interpretation of data and information that is required to support the SCMC.

(4) It is also suggested that the position of the Penolong Pegawai Sains be substituted for an additional position of a Pembantu Teknik since the former is irrelevant in the presence of the latter. These technicians should be in possession of at least a diploma in science or engineering. The role of the technicians in monitoring, collection and collation of data and information is substantial, and unless they are conducted efficiently, the analysis and interpretation of data would not be effectively carried out.

(ii) Majlis Daerah Sepang

(5) The status of MDS should be upgraded to that of a Municipality in view of the large area of jurisdiction and the anticipated increase in development that is expected in the presence of the KLIA, Cyberjaya, Salak Tinggi and other developments in the area. With this status the organisational structure and budget of the local authority can be enhanced and increased.

(6) In view of the importance of land use planning and land use control in catchment management, it is recommended that additional staff be assigned to the Planning Division. An additional Planner and a Technical Assistant is recommended to be added to the present set-up in the MDS in view of the heavy work load in the MDS.

(7) As urban drainage is an important function of the local authority, it is also suggested that an additional Engineer and a Technical Assistant be recruited into the Engineering and Buildings Division of the MDS. The engineer is to give special attention to drainage and earthworks as well as undertake other responsibilities that may be assigned to him/her.

(8) In view of the importance of environmental management in the catchment, it is recommended that an Environmental Unit comprising of a graduate Environmental Officer and

a Technical Assistant be added to the present set-up of the MDS.

(9) In order to shorten the timeframe for operation of these units, it is recommended that trained or experienced staff be given preference. All the above additional staff may be recruited through secondment from other pertinent government agencies and departments.

(iii) Majlis Perbandaran Subang Jaya

(10) The area of catchment which is within the jurisdiction of MPSJ is small and confined to the MARDI area. Although the Municipality is well structured, it still lacks graduate officers to manage its planning and look after its engineering works.

(11) For the purposes of catchment management of the Sg. Chuau, there is no necessity for any increase in staff for the Municipality. However, over the long term if catchment management is to be extended to whole river systems, it is recommended that additional graduate staff be recruited to strengthen the Planning and Engineering Departments of the MPSJ. The formation of an Environmental Department should also be given due consideration.

(iv) Other Government Departments and Agencies

(12) Organisational strengthening of other government departments and agencies is presently not required.

(v) Stakeholders

(13) While stakeholders are expected to be involved in catchment management, such as monitoring of discharges, this is expected to be undertaken by contractors appointed by the stakeholders. Ensuring that there is control on the quality of the monitoring that is undertaken is an important aspect that needs to be given due consideration. Results of the monitoring is expected to be submitted to the Secretariat of the SCMC for collation and analysis.

8.2.7 REFERENCES

1. Ramadas, K. & Associates (1999) - Formulation of Regulations and Guidelines For The Control of Activities And Use of The Lake And Other Water Bodies In Putrajaya. June 1999.

2. Perunding Utama Sdn Bhd (1998) Putrajaya - Legislative Review for Environmental Management. October 1998.

3. Jurutera Perunding Zaaba Sdn Bhd (1999) - Institutional and Legal Study for The Establishment of a State Government River Management Institution. Draft Final Report. June 1999.

4. Kassim Chan Management Consultants (1997) - Organisation Scheme and Compensation Scheme/Salary Structure Study for Perbadanan Putrajaya. Phase 1 Final Report. March 1997.

5. Kassim Chan Management Consultants (undated) - Job Description for the City Planning Department.

6. Kassim Chan Management Consultants (undated) - Job Description for the City Development Department.

7. Kassim Chan Management Consultants (undated) - Job Description for the Top Management Section and the Corporate Services Department.

APPENDIX 8.1.1
LIST OF LEGISLATION RELEVANT TO THE MANAGEMENT OF THE PUTRAJAYA LAKE CATCHMENT AREA

1. Waters Act, 1920
2. Geological Survey Act, 1974
3. Irrigation Areas Act, 1953
4. Street, Drainage and Building Act, 1974
5. The Forest Act, 1984
6. The National Land Code, 1965
7. The Drainage Works Act, 1954
8. The Fisheries Act, 1985
9. Environmental Quality Act, 1974
10. Land Conservation Act, 1960
11. Town and Country Planning Act, 1976
12. Local Government Act, 1976
13. Selangor Waters Management Authority Enactment, 1999
14. Mining Enactment, 1929
15. Sewerage Services Act, 1993

MUNICIPAL RULES

1. Planning Control (General) Rules
2. Earthworks By-Laws
3. Stray Animal By-laws
4. Licensing of Trades, Businesses and Industries By-laws
5. Refuse Collection, Removal and Disposal By-Laws
6. The Public Cleansing By-Laws
7. Anti-Litter By-laws
8. Parks By-laws

APPENDIX 8.1.2
REVIEW OF THE SELANGOR WATERS MANAGEMENT ENACTMENT, 1999

1.0 Introduction

The Selangor Waters Management Authority Enactment, 1999 (SWMA) was passed by the State Legislature in April 1999. The enforcement of the Enactment is pending announcement by the State Authorities. The setting up of the SWMA is being given priority by the State and it is expected that the Authority will be set up by the end of this year. The SWMAE is a comprehensive law that will allow the State of Selangor to manage all its water resources in a sustainable and integrated manner. It applies to all water sources wholly within the State of Selangor, except those which are wholly within Putrajaya.

2.0 Main Objective of the Enactment

The main objective of the Enactment is to enable the State of Selangor to manage all its water resources in a sustainable and integrated manner. Water resources include rivers, wetlands, lakes, coastal waters, ground water and other similar water bodies. The Enactment will be implemented by the establishment of an Authority (the SWMA). The Authority is empowered to act to safeguard water resources and enable utilisation of water resources at a rate that will continuously provide adequate water supply to the State whilst ensuring the continued proliferation of flora and fauna dependant on the water resources. The Menteri Besar is appointed the Chairman of the Authority to reflect the importance of the functions to be undertaken under the Enactment. A Technical Committee shall also be instituted to provide advice to the SWMA and to ensure better coordination with several related agencies.

3.0 Focus of the SWMA

The focus of the SWMA is on the following areas. Details are described below.

(a) Integrated management of water resources
(b) Protection of water sources

(c) Promotion of water use efficiency and conservation
(d) Mitigation of floods
(e) Privatisation
(f) Environmental protection
(g) Increased stakeholder participation
(h) Enforcement

3.1 Integrated Management of Water Resources

The SWMA provides for the integrated management of all water resources in the State. The various sources of water form part and parcel of the total hydrological cycle. They are best managed as an integrated whole. The SWMA is vested with wide ranging powers to develop, control, regulate and manage all water sources in the State. It can also collect, collate and disseminate data and conduct research on water resources. Other public agencies such as the Land Administrator, local authorities and Mining Inspector will have to consult and obtain the approval of the SWMA before commencing any works in a water source.

In order to allow the SWMA sufficient time to build itself up a gradual extension of its powers over water sources is provided by enabling the Authority to designate any water source as a designated water source. Upon such designation the Authority shall draw up and implement an integrated management plan for the sustainable utilisation of the resources therein. The Sg. Langat Catchment does not appear to be a current priority to the SWMA. The need to give greater priority to this catchment in view of the expected accelerated development will have to be impressed upon the SWMA by the Perbadanan.

3.2 Protection of Water Sources

The SWMA can take action to control and regulate any activity that may have an adverse impact on any water source. Such action includes licensing, imposition of safety standards, fitting of approved equipment, monitoring and regulation of any works and the control of activities on the surface of water bodies. Reclamation and coastal works will have to be approved by the SWMA. The SWMA can delineate and control activities on catchment areas, river reserves, flood zones and problem soil areas. Where other public authorities (such as local authorities) have powers vested under

different laws the SWMA may request any of these authorities to consult the SWMA regarding any development proposed within catchment areas or in any river reserves.

3.3 Promotion of Water Use Efficiency and Conservation

The SWMA provides for the development of efficient and best management practices in order to ensure that water is used efficiently and wastage is reduced. Various mechanisms are provided including measures for establishment of realistic water pricing, development of incentives for conservation such as reduced water charges for water conserved, encouragement of water re-cycling in both public and private sectors, resale of conserved water and the control of the exploitation of ground water. The taking of any water including any diversion, abstraction and extraction or the discharge of any substance or return of water into any water source will be subject to the control of the Authority.

3.4 Mitigation of Floods

The SWMA, in consultation with the relevant public authority, which in this case will be the Drainage and Irrigation Department, will take effective steps to prevent and mitigate the impact of disasters caused by flooding. This will include mitigating the impact of drainage discharges in sensitive areas, coordination at the state level between the DID, SWMA and other state and federal authorities to ensure that drainage discharges are minimized and runoff from development and urban schemes is contained on site. The SWMA may impose a charge on any discharge into any water source including a return of water.

3.5 Privatisation

Any services and undertaking of the SWMA may be privatised. The SWMA shall, as far as possible, play a regulatory, promotional and developmental role. The latter role may be undertaken especially when any multi purpose development is undertaken, such as a dam that is built for water, hydro electric power and irrigation. There are sufficient safeguards provided to ensure that the private entity plays its role effectively.

3.6 Environmental Protection

The SWMA, in order to achieve its objective of sustainable use and development of water resources, will play a pro active role in environmental matters. The Environmental Quality Act, 1974 (EQA) will continue to apply. The SWMA will have to coordinate its actions and consult the Department of Environment on EIA's performed in compliance with the EQA. The SWMA may, in areas where the EIA does not apply, require that the project proponents or by itself carry out an EIA so as to allow better control over ongoing activities in river basins and other water sources. Compliance with EIA conditions will be strictly enforced. Rules and regulations including standards and guidelines for reservoir, dams and other activities which would have an impact on water resources, riparian users and river dependent in-stream resources will be formulated.

3.7 Increased Stakeholder Participation

There will be enhanced opportunities for all stakeholders including NGO's and other public agencies to participate in the planning and establishment of river basin management schemes. The SWMA itself will have to encourage the formation and operations of stakeholder groups so as to allow grass roots participation in the management of river basins. This will also encourage better enforcement through self regulation.

3.8 Enforcement

The SWMAE has instituted a system of incentives for compliance and disincentives for noncompliance and self-regulation, as far as possible. In the event that these measures do not work then adequate powers and stiff penalties are provided for enforcement to ensure that the water resources are safe-guarded.

4.0 Conclusion

The Enactment will result in the repeal of the Waters Act, 1920 in so far as the latter Act applies to Selangor. Transitional provisions have been incorporated to allow for smooth implementation. Effective implementation of the Enactment will revolutionise the management of water resources in the State. Selangor will be a pioneer in the better governance of water resources which is facing serious threats from development. Trans-boundary rivers will have to be jointly managed with the other relevant states. The SWMAE provides for detailed rules and regulations to be drawn up that will enable the SWMA to regulate all matters pertaining to the integrated management of water resources in the State.

APPENDIX 8.2.1

Nota Ringkas
Jawatankuasa Khas Pengurusan Kawasan Tadahan Tasik Putrajaya
(Putrajaya Lake Catchment Management Committee)

Bagi menyelaras pengurusan kawasan tadahan Putrajaya untuk menjamin kualiti air yang mengalir ke Tasik Putrajaya, Jawatankuasa Khas Pengurusan Kawasan Tadahan Tasik Putrajaya telah ditubuhkan di Kementerian Pertanian selaras dengan arahan Ketua Setiausaha Negara pada Januari 1997. Jawatankuasa ini, dengan keahliannya seperti di Lampiran A berkembar dipengerusikan oleh Ketua Setiausaha Kementerian.

Syarat-syarat Rujukan Jawatankuasa ini yang telah ditetapkan adalah bagi:-

i. menyelaras kawalan pembangunan sekitar kawasan tadahan di luar Putrajaya, khususnya yang melibatkan kawasan IOI, UPM, MARDI dan TNB;

ii. memastikan pengunaan tanah sekitar kawasan terlibat adalah bersesuaian bagi menjamin dan memelihara kualiti air di kawasan terlibat termasuk yang akan mengalir masuk ke Tasik Putrajaya;

iii. mengubal dasar dan peruntukan undang-undang berkaitan dengan *drainage discharge* ke kawasan tadahan yang mampu merangka sebarang ancaman pencemaran daripada berlaku; dan

iv. menentukan lain-lain peruntukan dan langkah yang perlu diambil dalam usaha memelihara kualiti air kawasan tadahan dan tasik supaya harus berada ditahap yang tinggi.

Dalam hubungan ini, satu Jawatankuasa Teknikal bersabitan juga telah ditubuhkan yang dipengerusikan oleh Ketua Pengarah Jabatan Pengairan dan Saliran.

Bahagian Pembangunan Sumber dan Institusi
Kementerian Pertanian Malaysia

29 Jun 1999

JkTmgP.IvKTA

APPENDIX 8.2.2
MEMBERS OF THE PUTRAJAYA LAKE CATCHMENT MANAGEMENT TECHNICAL COMMITTEE

1. Ketua Pengarah (Chairman)
Jabatan Pengairan dan Saliran Malaysia
Jalan Sultan Salahuddin
50626 Kuala Lumpur

2. Ketua Pengarah
Jabatan Alam Sekitar Malaysia
Tingkat 13, Wisma Sime Darby
]alan Raja laut
Kuata Lumpur
(UP: Puan Wan Ramlah Haji Wan lbrahim)

3. Ketua Pengarah
Jabatan Perancang Bandar dan Desa
Jalan Cenderasari
50646 Kuala Lureput
(UP: Puan Asmi Mustafa)

4. Penasihat Undang-undang
Kementerian Pertanian Malaysia

5. Presiden
Perbadanan Putrajaya
Pusat Pentadbiran Kerajaan Persekutuan Putrajaya
43000 Kajang

6. Yang Di Pertua
Majlis Perbandaran Subang Jaya
USJ 5, Persiaran Perpaduan
47610 Subang Jaya
(UP: En. Alias Miskon)

7. Yang Di Pertua
Majlis Daerah Sepang
Tingkat 1, Bangunan Tun Aziz
43900 Bandar Baru Salak Tinggi
Sepang
(UP: En. Asraruddin Jaafar)

8. Pengarah, Jabatan Pengairan dan Saliran
Negeri Selangor Darul Ehsan
Tingkat 5, Blok Podium Selatan
Bangunan Sultan Salahuddin Abdul Aziz Shah
40626 Shah Alam

9. Pengarah
Jabatan Perancangan Bandar dan Desa
Negeri Selangor Darul Ehsan
Tingkat 5, Blok Podium Selatan
Bangunan Sultan Salahuddin Abdul Aziz Shah
40646 Shah Alam
(UP: En. Che Mohamad Che Idris)

10. Pengarah
Jabatan Alam Sekitar
Negeri Selangor
Tingkat 5, Bangunan Sultan Salahuddin Abdul Aziz Shah
40626 Shah Alam

11. Pengarah Tanah dan Galian
Negeri Selangor
Tingkat Bawah
Bangunan Sultan Salahuddln Abdul Aziz Shah
40626 Shah Alam

12. Pengarah Bahagian Pembangunan
Universiti Putra Malaysia
43400 UPM
Serdang, Selangor
(UP: Hj. Zakaria A. Hamid)

13. Pengurus Besar
MARDITECH Corporation Sdn. Bhd.
19-21-2, SHL Business Centre,
Jalan SR 8/1, Serdang Raya
43300 Seri Kembangan
Selangor
(UP: En. Ibrahim Osman)

14. Pengurus Besar
Putrajaya Holdings Sdn. Bhd.
Pusat Pentadbiran Kerajaan Persekutuan Putraiaya
43000, Kajang
(UP: En. Norazmi Mohamed Nordin)

15. Pengurus Besar Steysen.Janaletrik Serdang
Tenaga Nasional Generation Sdn. Bhd.
Bag Berkunci 211
43009 Kajang
(UP: En. Izam Ismail)

16. Pengurus
Industrial Oxygen Incorporated Bhd.
Bangunan IOI, No. 8, Jalan Kenari 5
Bandar Puchong Jaya
47100 Puchong
(UP: En. David Tan)

17. Pengurus
West Country Sdn. Bhd.
33rd Floor, Menara Multi Purpose
Capital Square
No. 8. Jalan Munshi Abdullah
50100 Kuala Lumpur
(UP: En. Martin Chung)

18. Pengarah Hidrologi
JPS Malaysia
Cawangan]alan Ampang
68000 Jalan Ampang
(UP: En. Azmi Mohd. Jaafri)

19. Ketua Pegawai Eksekutif
Cyberview Sdn. Bhd.
Level 7, Menara 1
Faber Towers
Jalan Desa Bahagia
Taman Desa
58100 Kuala Lumpur

20. Angkasa GHD Engineering Sdn. Bhd.
(UP: Ir. Khor Chai Huat)

APPENDIX 8.2.3
DOE'S GUIDELINE FOR THE PREPARATION OF AN ENVIRONMENT MANAGEMENT PLAN
(Plan, Implement, Check and Review)

I INTRODUCTION
II POLICY
III COMPANY'S ORGANISATION CHART AND RESPONSIBILITIES
IV ENVIRONMENTAL REQUIREMENTS
V MONITORING PROGRAMS
VI SIGNIFICANT IMPACTS AND POLLUTION CONTROL MEASURES
VII ENVIRONMENTAL CONTINGENCY PLAN

I INTRODUCTION

a. Project Concept, which has been approved by Local Authority.
b. Work Implementation Schedule

II POLICY

a. Company's objective in environmental protection.
b. Management's long term commitment in ensuring compliance to the environmental requirements.

III ORGANISATION CHART/ BUDGET

a. List of names of top management and officers responsible for managing the environmental aspects (this list would need to be updated if there are any changes)
b. Name of consultants or accredited labs which conducts the monitoring work or are responsible for carrying out the analysis or preparing the environmental report
c. Frequency and training related to environment and safety which is provided to the staff
d. The estimated financial budget provided for the implementation of the Environmental Management Plan

IV ENVIRONMENTAL REQUIREMENTS

a. Conditions of Approval of EIA and Appeal for Change of Condition (if any)
b. The related standards and regulations
c. Monitoring reports and frequency
d. Copies of any other approvals or written permission which has been issued by DOE

V **MONITORING PROGRAMS**

a. Baseline study of water quality and noise levels before commencement of work as a comparison to the monitoring data which will be submitted later
b. Monitoring stations have to be selected and indicated in the map – justifications of the site selection would have to be given
c. Effluent discharge points would have to be shown
d. Monitoring frequency
e. Sampling Methods

VI **SIGNIFICANT IMPACTS AND POLLUTION CONTROL MEASURES**

a. The significant impacts of the project would have to be submitted, along with the specific control measures such as the proposed location of silt traps, the slopes of which have been identified as erosion – prone and the proposed specific slope protection, selection of air emission control etc.
b. Identification of wastewater treatment systems and air pollution control along with a summary of the concept would have to be submitted
c. "Abandonment Plan" if the project is abandoned

VII **ENVIRONMENTAL CONTINGENCY PLAN**

a. Actions to be taken in the event of an emergency such as land slides, oil spill or hazardous chemical spill and failure of any of the pollution control equipment
b. The organisation that will be involved in managing the plan

APPENDIX 8.2.4
TERMS OF REFERENCE FOR SUB-CATCHMENT MANAGEMENT COMMITTEE

The following is the suggested Terms of Reference for the Sub-Catchment Management Committee:

1. To review land use and development plans in the catchment areas outside Putrajaya and to advise the Selangor Waters Management Authority (SWMA), and such other local and state authorities or agencies, on acceptable land use or development for the areas, so as to support the integrated management of the Lake catchment.

2. To advise the SWMA and such other local and state authorities on acceptable land use for the structure and local plans that are to be prepared for the areas;

3. To review and assess water quality trends in the streams, wetlands and the Lake and to make recommendations for pollution control and enforcement action in the areas, where this is necessary to protect the water quality;

4. To review the monitoring programme and make recommendations for changes in the areas, where they are required to enhance catchment management;

5. To review and advise on acceptable physical and engineering works in the areas, which are necessary for water quality management and catchment protection; and

6. To advise on stakeholders' participation in catchment management and to refer matters that affect stakeholders to the Stakeholders' Consultative Committee for review and feedback.

APPENDIX 8.2.5
TERMS OF REFERENCE FOR STAKEHOLDERS' CONSULTATIVE COMMITTEE

The following are the suggested Terms of Reference for the Stakeholders' Consultative Committee (SCC):

1. To review matters related to management of the Putrajaya Lake Catchment that is referred to the SCC by the Sub-Catchment Management Committee (SCMC);

2. To provide feedback or decisions to the SCMC on matters referred to it where this requires a decision of members of the SCC; and

3. To consult, where necessary, with members of the public, land owners or residents' association and such other individuals or groups on matters (referred by the SCMC) related to management of the Putrajaya Lake Catchment that are likely to affect them.

CHAPTER 9

COSTING, BUDGET AND FUNDING

9.0 COSTING, BUDGET AND FUNDING

9.1 INTRODUCTION

9.1.1 The management and monitoring programs, together with the implementation requirements specified in this Catchment Development and Management Plan will involve financial expenditure. Thus, there is a need to compile the indicative costs associated with the programs for the preparation of an indicative budget for the proposed implementation schedule in the Plan.

9.1.2 There is also a need to identify and assess the possible funding sources and funding options, respectively, so that an equitable funding mechanism, in line with the policy of the Plan, can be agreed upon by all stakeholders in the catchment.

9.2 INDICATIVE COSTS ESTIMATES

9.2.1 Introduction

9.2.1.1 The Consultant has attempted to provide cost estimates under two categories, viz. one-off capital expenditure (development expenditure), and their concomitant operating overheads (operations and maintenance costs). *(NB: Where operating and maintenance costs include salaries, only the basic salary costs have been computed. It is beyond the scope of this study to compute EPF, SOCSO and other employee benefits).*

9.2.1.2 Wherever possible, the specialists have tried to obtain the cost estimates in the case of development expenditure from third party suppliers. Where this was not possible, the specialists have prepared estimates based on their own past experience.

9.2.1.3 The indicative cost estimates for the following study components have been compiled:

- Water quality
- Hydro-geology
- Hydrology
- Drainage
- Sewerage
- ICMS

- Institutional

9.2.2 Water Quality Study

9.2.2.1 The water quality specialist has proposed a ***Water Quality Monitoring Program*** to be implemented, over a 3-year period, upon the implementation of the Lake Catchment Management Plan.

9.2.2.2 The details of the Program are specified in the *Putrajaya Lake Management Guide.* A total of 81 water level recorders and 23 water gauging stations have been proposed to be installed over the 3-year period.

9.2.2.3 Table 9.1 gives the summary of the indicative Capital, Operations & Maintenance (O & M) and water quality sampling costs associated with the Water Quality Monitoring Program over the 3-year period. The details are given in Appendix 9.1.

Table 9.1 Indicative costs associated with the Water Quality Monitoring Program for a 3-year period.

Period	Year-1 (RM)	Year-2 (RM)	Year-3 (RM)	Total (RM)
Capital	335,000	425,000	335,000	1,095,000
O & M	5,000	15,000	20,000	40,000
Sampling	725,000	1,815,000	2,446,400	4,986,400

9.2.3 Hydro-geological Study

9.2.3.1 The hydro-geologist has indicated that a groundwater well field of 6 wells can be developed, downstream of the main dam. The timing for the construction of the well field depends on the needs of Putrajaya for the groundwater.

9.2.3.2 The development of the well field may be implemented as part of the irrigation master plan for Putrajaya.

9.2.3.3 The indicative capital and annual O & M costs associated with the development and operations of the groundwater well field are given below. The details are given in Appendix 9.2.

- Capital cost – RM144,000
- O& M cost – RM16,433/year

9.2.4 Hydrological Study

9.2.4.1 The hydrologist has proposed that a hydrological monitoring station network be installed to support the management of the Putrajaya Lake, upon the implementation of the Lake Catchment Management Plan.

9.2.4.2 A total of five (5) automatic rainfall measuring stations, seven (7) automatic streamflow gauging stations, five (5) automatic water level measuring stations and six (6) automatic groundwater level monitoring stations have been proposed. The locations of the stations are given in Figure 3.1.10 in Chapter 3.

9.2.4.3 The indicative capital and annual O & M costs associated with the setting-up and operations of the hydrological monitoring station network are given below. The details are given in Appendix 9.3.

- Capital cost – RM881,00
- O& M cost – RM69,000 /year

9.2.5 Drainage Masterplan Study

9.2.5.1 The drainage engineer has proposed that mini-wetlands and vegetated landscape drainage corridors be constructed as part of the drainage system improvement in the areas outside Putrajaya.

9.2.5.2 Table 9.2 gives the indicative capital and annual O & M costs associated with the drainage system improvement works for the areas outside Putrajaya, together with pertinent remarks on their respective implementation schedule. The details are given in Appendix 9.4.

Table 9.2 Indicative costs associated with the drainage system improvement works in the areas outside Putrajaya.

Stakeholder Area	Capital Cost	Annual O&M cost	Remarks on implementation schedule
1. MARDI - Drainage corridor improvement (6.9 km)	RM8,942,400	RM56,000	To be implemented as part of the SKVE, ERL and MARDI's development in the area
2. UPM - Drainage corridor improvement (6 km)	RM7,776,000	RM60,000	To be implemented as part of UPM's development
3. IOI - 3 Nos. mini-wetlands	RM72,000	RM14,400	To be implemented as part of the development for the proposed ponds.
4. West Country - 1 No. mini-wetland	RM31,500	RM6,300	To be implemented as part of West Country's development
5. Cyberjaya - 6 water quality enhancement ponds provided with GPTs	RM81,000	RM16,200	To be implemented as part of Cyberjaya's development
Total	RM16,902,900	RM152,900	

9.2.6 Sewerage Masterplan Study

9.2.6.1 The sewerage engineer has proposed that a sewage effluent discharge monitoring program be implemented, upon the implementation of the Lake Management Plan. He has also proposed that the existing sewerage treatment plants for two student hostels in UPM, Kolej 8 (1097 PE) and Kolej 9 (1038 PE), be upgraded as soon as possible.

9.2.6.2 The indicative cost for the upgrading works for the two student hostels in UPM is **RM854, 000** at RM400/PE.

9.2.6.3 The monitoring program will require the carrying out of sampling and testing of the sewage effluent discharge by the following four stakeholders in the catchment – MARDI, UPM, IOI and Cyberjaya.

9.2.6.4 The indicative annual operational costs associated with the operations of the sewage effluent discharge monitoring program, for the 4 stakeholders, are given below. The details are given in Appendix 9.5.

- UPM – RM55,800/year
- MARDI – RM37,200/year
- IOI – RM9,300/year
- Cyberjaya – RM37,200/year

Total: RM139, 500/year

9.2.7 ICMS Study

9.2.7.1 The ICMS team has recommended the purchase of a GIS program and a personal computer for the installation and training in the use of the low-level ICMS, developed as part of this study, *upon the completion of the study.*

9.2.7.2 The team also recommended that a decision be made*, after a trial period of 6 months*, on the refinement of the low-level ICMS and conversion to the Perbadanan's SiCAD GIS.

9.2.7.3 The indicative cost associated with the above two recommendations are as follows:

(a) Installation and Training in the use of low-level ICMS

- GIS program (ArcView) – RM11,500
- Personal Computer – RM 9,000

Total RM20, 500

(b) Refinement and conversion to SiCAD GIS

- Consulting cost – **RM200,000** (see Appendix 9.6 for details)

9.2.8 Institutional Study

9.2.8.1 The institutional specialist has recommended the recruitment of additional 6 staff for the Majlis Daerah Sepang (MDS), as part of the institutional strengthening exercise, upon the implementation of the Lake Catchment Management Plan.

9.2.8.2 He has also indicated that there are expenses associated with the holding of meetings of the Lake Management Committee and Stakeholders Consultative Committee.

9.2.8.3 The indicative costs associated with the above two items are as follows. The details are given in Appendix 9.7.

- Staff recruitment for the MDS – RM141,000/year
- Meeting expenses – RM 26,000/year

Total RM167, 000/year

9.3 INDICATIVE IMPLEMENTATION BUDGET

9.3.1 Table 9.3 gives the indicative implementation schedule and budget for the various programs recommended by the respective specialists for an implementation period of 3 years.

9.3.2 From Table 9.3 it can be seen that the total indicative 3-year total cost of the recommended programs is about RM 26.6 million, made up of about RM20.3 million for capital expenditure and about RM6.3 million for O&M expenditure. The bulk of the capital expenditure, about 83%, is for drainage improvement

PUTRAJAYA LAKE CATCHMENT DEVELOPMENT AND MANAGEMENT PLAN

	CAPITAL COSTS (RM)					O & M COSTS (RM)					REMARKS
PROGRAMS	**Year 1**	**Year 2**	**Year 3**	**Unscheduled**	**Total**	**Year 1**	**Year 2**	**Year 3**	**Unscheduled**	**Total**	
1. Water Quality Monitoring Network	335,000	425,000	335,000		**1,095,000**	725,000	1,815,000	2,446,400		**4,986,400**	O & M Cost includes
(Refer App. 9.1 for details)											sampling costs
2. Development of groundwater well field				144,000	**144,000**				16,433	**16,433**	To be implemented
(Refer App. 9.2 for details)											when needed
3. Hydrological Monitoring Network	881,000	0	0	881,000	**881,000**	69,000	69,000	69,000		**207,000**	
(Refer App. 9.3 for details)											
4. Drainage Improvement Cost											To be implemented
(a) MARDI				8,942,400	8,942,400				56,000	56,000	as part of each
(b) UPM				7,776,000	7,776,000				60,000	60,000	stakeholder's
(c) IOI				72,000	72,000				14,400	14,400	development program
(d) West Country				31,500	31,500				6,300	6,300	
(e) Cyberjaya				81,000	81,000				16,200	16,200	
(Refer App. 9.4 for details)					**16,902,900**					**152,900**	
5. Sewerage Improvement/Monitoring Cost											
(a) UPM	854,000				854,000	55,800	55,800	55,800		167,400	
(b) MARDI	240,000				240,000	37,200	37,200	37,200		111,600	
(c) IOI	0				0	9,300	9,300	9,300		27,900	
(d) Cyberjaya	0				0	37,200	37,200	37,200		111,600	
(Refer App. 9.5 for details)					**1,094,000**	139,500	139,500	139,500		**418,500**	
6. ICMS Installation and Improvement	20,500	200,000			**220,500**						
(Refer App. 9.6 for details)											
7. Institutional Strengthening (manpower)						167,000	167,000	167,000		**501,000**	
(Refer App. 9.7 for details)											
TOTAL COSTS	**2,330,500**	**625,000**	**335,000**	**17,927,900**	**20,337,400**	**1,100,500**	**2,190,500**	**2,821,900**	**169,333**	**6,282,233**	

which cost about RM16.9 million. Also, the bulk of the O&M expenditure, about 81%, comes from the water quality sampling costs over the 3-year period.

9.3.3 The following programs are recommended to be implemented in the first year upon approval of the Lake Catchment Management Plan:

- Water quality monitoring network
- Hydrological monitoring network
- Sewerage effluent discharge monitoring
- Sewerage improvement at UPM
- ICMS Installation
- Institutional Strengthening (additional manpower for MDS)

9.3.4 The total indicative capital expenditure in the first year is about RM2,330,500 and that for O&M expenditure is about RM1,100,500. 74.5% of the capital expenditure in the first year, i.e. RM1,735,000 has been estimated for the upgrading of the sewerage treatment facilities for the two student hostels in UPM (RM854,000) and for the hydrological monitoring network (RM881,000). 69% of the O&M expenditure in the first year, i.e. RM725, 000, is for the cost of the water quality sampling.

9.4 FUNDING

9.4.1 Funding Sources

9.4.1.1 The three main sources of funding for the successful implementation of the Consultant's recommendations are:

- The Federal Government
- The Selangor State Government
- The individual stakeholders

9.4.1.2 The Federal Government, through Perbadanan Putrajaya as the main stakeholder in the catchment, will have to bear most of the cost associated with the implementation of the recommended programs within the 70% of the catchment where Putrajaya lies.

9.4.1.3 The Selangor State Government, through its respective agencies and local authorities, will have to bear additional costs arising

from increased regulatory supervision and maintenance in the 30% of the Lake catchment area that lies within the State, to meet the desired environmental objectives for the catchment.

9.4.1.4 The individual stakeholders in the catchment will have to bear additional costs as a result of complying with the additional regulatory requirements imposed in the catchment to meet the desired environmental objectives for the catchment.

9.4.2 Funding Principles

9.4.2.1 The Federal Government, as the main project proponent for the development of Putrajaya, and the primary beneficiary from the development will most probably have to bear all additional costs arising from the implementation of the recommended programs in the Lake Catchment Management Plan, that would not normally have been expended by the Selangor State Government and the individual stakeholders under normal circumstances.

9.4.2.2 However, the Selangor State Government and the individual stakeholders also benefit from the development of Putrajaya, through increased economic activities and appreciation of property values due to their proximity to Putrajaya and its high quality living environment. Thus, it is not unfair to expect the Selangor State Government and the individual stakeholders in the catchment to bear part of the additional costs arising from the implementation of the recommended programs and compliance with the high regulatory requirements set to meet the desired environmental objectives for the Putrajaya Lake and its catchment.

9.4.2.3 An equitable approach has to be found through negotiations between the Federal and State Government of Selangor. As for the individual stakeholders in the catchment the following approach maybe acceptable:

(a) For *existing and committed developments* in the catchment it would be fair to compensate the respective affected stakeholders for the additional costs burden incurred by them as a result of complying with the requirements of the programs in the Lake Catchment Management Plan.

(b) For all uncommitted developments the additional cost associated with complying with the requirements of the programs in the Lake Catchment Management Plan shall be borne by the respective stakeholders, as part of compliance with the regulatory requirements. *The regulatory provisions for the management of the development in the Lake catchment will be further strengthened by the designation of the Putrajaya Lake Catchment as a designated sub-catchment under the SWMA Enactment, as recommended by the Consultant.*

9.4.3 Funding For The Recommended Programs

9.4.3.1 Based upon the above funding principles the Consultant has identified the possible funding sources for the recommended programs. They are given in Table 9.4 and are discussed below.

9.4.3.2 Water Quality Monitoring Network

The Perbadanan Putrajaya is the primary stakeholder of Putrajaya Lake and is also the body responsible for the monitoring of the water quality in the Lake. Thus, the most likely funding source for this program is the Perbadanan Putrajaya.

9.4.3.3 Development of groundwater well field

The groundwater well field can be developed by the Perbadanan Putrajaya if required to meet the irrigation and other water needs in Putrajaya. Thus, the funding source for this program will be the Perbadanan Putrajaya.

9.4.3.4 Hydrological Monitoring Network

Similar to the water quality monitoring network the hydrological monitoring network is an essential requirement for the management of the Putrajaya Lake. Thus, the most likely funding source for this program is the Perbadanan Putrajaya.

TABLE 9.4 POSSIBLE FUNDING SOURCES

FUNDING SOURCE	PROGRAMS	CAPITAL COSTS (RM)	O & M COSTS (RM)	REMARKS
Perbadanan Putrajaya	1. Water Quality Monitoring Network	1,095,000	4,986,400	To be implemented in Year 1 over a 3-year period
	2. Development of groundwater well field	144,000	16,433	To be implemented when needed
	3. Hydrological Monitoring Network	881,000	207,000	To be implemented in Year 1
	4. Sewerage Effluent Monitoring		418,500	To be implemented in Year 1 over a 3-year period
	5. ICMS Installation	20,500		To be implemented in Year 1 for a trial period of 6 months
	6. ICMS Improvement	200,000		To be decided based on 6 months trial
TOTAL COST TO BE BORNED BY PERBADANAN PUTRAJAYA		**2,340,500**	**5,628,333**	
Federal Government	1. Sewerage Improvement Cost	1,094,000		Sewerage Improvement in UPM and MARDI to be implemented in Year 1 (subject to negotiation with UPM and MARDI)
	2. Institutional Strengthening		167,000	1. Annual O & M cost 2. To be implemented in Year 1 3. Subject to negotiation with the Selangor State Government
	3. Drainage Maintenance Cost		152,900	Federal Government to fund maintenance program in areas outside Putrajaya
TOTAL COST TO BE BORNED BY FEDERAL GOVERNMENT		**1,094,000**	**319,900**	
Selangor State Government	Institutional Strengthening		167,000	1. Annual O & M cost 2. To be implemented in Year 1 3. Subject to negotiation with the Federal Government
TOTAL COST TO BE BORNED BY SELANGOR STATE GOVERNMENT			**167,000**	
MARDI	1. Drainage Improvement Cost	8,942,400		To be implemented as part of MARDI's development program
	2. Sewerage Improvement Cost	240,000		Subject to negotiation with Federal Government (to be implemented in Year 1)
TOTAL COST TO BE BORNED BY MARDI		**9,182,400**		
IOI	Drainage Improvement Cost	**72,000**		
TOTAL COST TO BE BORNED BY IOI		**72,000**		
West Country	Drainage Improvement Cost	**31,500**		To be implemented as part of each stakeholder's development program
TOTAL COST TO BE BORNED BY WEST COUNTRY		**31,500**		
Cyberjaya	Drainage Improvement Cost	**81,000**		
TOTAL COST TO BE BORNED BY CYBERJAYA		**81,000**		
SKVE	Drainage Improvement Cost**			
TOTAL COST TO BE BORNED BY SKVE PROJECT		**		To carry out drainage improvement in UPM and MARDI areas which are affected by the respective project
ERL	Drainage Improvement Cost**			** Costs cannot be ascertained
TOTAL COST TO BE BORNED BY ERL PROJECT		**		
UPM	1. Drainage Improvement Cost	7,776,000		To be implemented as part of UPM's development program
	2. Sewerage Improvement Cost	854,000		Subject to negotiation with Federal Government (to be implemented in Year 1)
TOTAL COST TO BE BORNED BY UPM		**8,630,000**		

9.4.3.5 Drainage Improvement Program

(1) There is no immediate need for the improvement of the existing drainage systems outside Putrajaya. All of the recommended drainage improvements for the following stakeholders are to be implemented by them, as part of their normal development cost:

- MARDI
- UPM
- IOI
- West Country
- Cyberjaya

(2) There is a need to ensure that the respective project proponents for the SKVE and ERL implement the recommended vegetated landscape drainage corridor in the MARDI and UPM areas, where the SKVE and ERL passes through. There is also a need to ensure that the drainage inlets from the SKVE and ERL to the vegetated landscape drainage corridor are provided with GPTs. The costs for complying with the recommended requirements will most probably be the responsibility of the respective project proponents.

(3) The responsibility for the maintenance of the drainage corridors and mini-wetlands in the public areas lies with the pertinent local authorities, whereas those in the individual stakeholder's areas, such as MARDI, UPM and IOI, should be borne by the respective stakeholders. Since the maintenance funds of local authorities are limited the Federal Government may have to develop and fund specific maintenance programs for identified areas outside Putrajaya.

9.4.3.6 Sewerage Improvement/Monitoring Program

(1) There is an immediate need to upgrade the sewage treatment facilities of two student hostels in UPM. IWK has identified the MARDI and UPM areas as part of the sewerage catchment area to be served by its proposed Kota Perdana/Listari central sewerage treatment plant. However, the exact date of the implementation of the central sewerage treatment plant is not certain. Thus, in the interim there may be a need to upgrade the sewage treatment facilities of the two student hostels in UPM. The cost for the upgrading will most probably have to be borne by both the Federal Government and UPM.

(2) There is a need to conduct additional monitoring of the quality of the sewage effluent discharge coming from the UPM, MARDI, IOI and Cyberjaya, beyond those required by the DOE. The monitoring can be carried out as an additional part of the water quality monitoring program. The cost for this monitoring program will have to be borne by the Perbadanan Putrajaya.

9.4.3.7 ICMS Installation and Improvement Program

(1) There is an immediate need to purchase the ArcView GIS software and a personal computer for the installation and training in the use of the low-level ICMS, developed as part of this study. The cost for the purchase has to be borne by the Perbadanan Putrajaya. The SWMA may also wish to make the same purchase, and send its staff for the training in the use of the low-level ICMS.

(2) After a recommended trial period of 6 months, the Perbadanan Putrajaya may be able to make a decision on whether to proceed with further improvement of the ICMS. The next-stage improvement cost for the low-level ICMS will also have to be borne by the Perbadanan Putrajaya.

9.4.3.8 Institutional Strengthening Program (Additional Manpower)

There is an immediate need to strengthen the existing institutional structure in the Majlis Daerah Sepang to cope with the additional recommended regulatory responsibilities for developments in the areas outside Putrajaya. The costs associated with this program will have to be borne by both the Federal and Selangor State Government.

9.5 COST RECOVERY

9.5.1 The capital expenditure associated with the programs to achieve the environmental objectives and desired living environment for the Lake catchment is not expected to be recovered. However, there is a need for the respective Local, State and Federal authorities to consider the option of implementing a means of cost recovery for the *funding of the maintenance programs* in the Lake catchment area.

9.5.2 A detailed review of the various possible funding options has to be carried out, which is beyond the scope of the current study. The following are two possible equitable policy options for cost recovery:

- Adopt and implement the policy of *"the polluter pays"*
- Adopt and implement the policy of "*the direct beneficiaries pays"*

9.5.3 The *"polluter pays"* policy option will require the respective regulatory authorities to diligently enforce all pertinent legislative provisions for the imposition of fines and penalties for causing pollution in the catchment. This would help to encourage regulatory compliance, in addition to being a source of funds for the maintenance programs. The SWMA Enactment provides for quite drastic fines and penalties for causing pollution in a designated catchment.

9.5.4 The *"direct beneficiary pays"* policy option will require the respective regulatory authorities to find ways to collect funds from direct beneficiaries of the enhanced living environment in the Lake catchment. One such way is to put a surcharge on the assessment rates of the property owners in the Lake catchment areas.

APPENDIX 9.1
DETAILS OF INDICATIVE COST ESTIMATES FOR WATER QUALITY STUDY

1. CAPITAL EXPENDITURE

Setting up Physical Measurement Stations

Year 1 (2000)

(a)	*Installation of 25 Water Level Recorders at GPTs @ RM 5,000.00 each*	*RM 125,000.00*
(b)	*Construction of 7 Gauging Stations (including recorder)@ RM 30,000.00*	*RM 210,000.00*
	Estimated Capital Expenditure in Year 1	***RM 335,000.00***

Year 2 (2001)

(a)	*Installation of 31 Water Level Recorders at GPTs @ RM 5,000.00 each*	*RM 155,000.00*
(b)	*Construction of 9 Gauging Stations (including recorder)@ RM 30,000.00*	*RM 270,000.00*
	Estimated Capital Expenditure in Year 2	***RM 425,000.00***

Year 3 (2002)

(a)	*Installation of 25 Water Level Recorders at GPTs @ RM 5,000.00 each*	*RM 125,000.00*
(b)	*Construction of 7 Gauging Stations (including recorder)@ RM 30,000.00*	*RM 210,000.00*
	Estimated Capital Expenditure in Year 3	***RM 335,000.00***

Total Estimated Capital Expenditure For 3 years	**RM 1,095,000.00**

2. OPERATIONS/MAINTENANCE AND SAMPLING/ ANALYSIS COSTS

A. Operating Costs of Physical Measurement Stations:

Year 1	*RM 5,000.00*
Year 2	*RM 15,000.00*
Year 3	*RM 20,000.00*
Total Operating Costs for 3 years	**RM40,000.00**

B. Water Quality Sampling /Analysis Cost

	Per Month	*Per Annum*
Year 1 (2000)		
100 samples/month @ RM 600.00	*RM 60,000.00*	*RM 720,000.00*
Year 2 (2001)		
250 samples/month @ RM 600.00	*RM 150,000.00*	*RM 1,800,000.00*
Year 3 (2002)		
337 samples/month @ RM 600.00	*RM 202,200.00*	*RM 2,426,400.00*

APPENDIX 9.2
DETAILS OF INDICATIVE COST ESTIMATES FOR HYDROGEOLOGICAL STUDY

1. Capital Expenditure

(1) *Well field development cost*

Construction cost per well

	RM
Mobilisation & Demobilisation	500.00
Drilling/bailing 11½ in dia to 30 ft below ground level	5,500.00
PVC 10 in dia class D x 2 lengths inclusive of installation	1,200.00
Stainless steel screen 10 in dia slot size 0.020 x 3m inclusive installation	3,300.00
Gravel packing-graded 3-6mm quartz sand inclusive of installation	500.00
Well development min 8 hrs	2,500.00
Pumping Test	2,500.00
TOTAL	16,000.00

Construction costs of 6 wells (including one test well) = *RM96,000.00*

Supply and Installation of submersible pump set per well

	RM
SP5 A4 SUBMERSIBLE PUMP	3,180.00
G. 1.2 in dia class B x 1 length plus fittings	100.00
Dip pipe ¾ in dia class B x 1½ lengths	60.00
4 core cable for power supply	700.00
Control panel	2,600.00
Well clamp cap	160.00
Installation service	1,200.00
TOTAL	8,000.00

Supply and Installation of 6 submersible pump sets RM8,000.00 x 6 = *RM48,000.00*

Total **RM144,000.00**

(2) *Schedule for completion of works:*

Completion of test well	*7 days*
Completion of 6 production wells	*30 days*
Delivery and installation of pumps	*84 days*

2. Operations and Maintenance Costs

Salary for 1 pump operator
RM800.00 per month = *RM 9,600.00 per annum*

Energy costs (24 hrs. pumping)
RM15.98 per day, = *RM 5,833 per annum*

Well and Pump maintenance = *RM1,000.00 per annum*

Total Annual Maintenance Costs **RM16,433.00 per annum**

(NB: The above maintenance costs will cover the whole well field)

APPENDIX 9.3
DETAILS OF INDICATIVE COST ESTIMATES OF HYDROLOGICAL MONITORING STATIONS

Item		Capital Expenditure (RM)	Annual Operation and Maintenance Costs (RM)
1. Setting up of Automatic Rainfall Station (5 stations)			
i. Continuous Rainfall Sensor	RM 10,000 x 5	RM 50,000	
ii. Housing (Civil Works)	RM 5,000 x 5	RM 25,000	
iii. Data Logger	RM 6,000 x 5	RM 30,000	
iv. Commissioning	RM 4,000 x 5	RM 20,000	
v. Maintenance (1 year)	RM 3,000 x 5		RM 15,000
	Sub Total	RM 125,000	RM 15,000
2. Setting up of Automatic Streamflow Station (7 stations)			
i. Area Velocity Flow Meter (Water Level and Velocity Sensor)	RM 20,000 x 7	RM 140,000	
ii. Housing (Civil Works)	RM 20,000 x 7	RM 140,000	
iii. Data Logger	RM 6,000 x 7	RM 42,000	
iv. Commissioning	RM 5,000 x 7	RM 35,000	
v. Maintenance (1 year)	RM 3,000 x 7		RM 21,000
	Sub Total	RM 357,000	RM 21,000
3. Setting up of Automatic Water Level Station (5 stations)			
i. Water Level Sensor	RM 13,000 x 5	RM 65,000	
ii Housing (Civil Works)	RM 15,000 x 5	RM 75,000	
iii Data Logger	RM 6,000 x 5	RM 30,000	
iv. Commissioning	RM 5,000 x 5	RM 25,000	
v. Maintenance (1 year)	RM 3,000 x 5		RM 15,000
	Sub Total	RM 195,000	RM 15,000
4. Setting up of Automatic Groundwater Level Station (6 stations)			
i. Water Level Sensor	RM 13,000 x 6	RM 78,000	
ii. Housing (Civil Works)	RM 10,000 x 6	RM 60,000	
iii. Data Logger	RM 6,000 x 6	RM 36,000	
iv. Commissioning	RM 5,000 x 6	RM 30,000	
v. Maintenance (1 year)	RM 3,000 x 6		RM 18,000
	Sub Total	RM 204,000	RM 18,000
	GRAND TOTAL	**RM 881,000**	**RM 69,000**

APPENDIX 9.4
DRAINAGE MASTER PLAN

1.0 CAPITAL COSTS ESTIMATES

Cost basis :

i. Planting cost of mini-wetland

Planting of various species of wetland plants, viz. Phragmites Karka, Lepinoria, Eleocharia, Cyperas, Sceleria.

The recommended **planting volume** is 6 plants per sq. metre @ RM1.50 per plant.

ii. Landscaping cost of riparian buffer zone

The per metre/run cost estimates for landscaping the 30 metre riparian buffer zone for the drain corridor improvement are estimated as follows:

Cost of planting 2 rows of shaded trees with materials @ 0.5 metres apart 6 x RM 30 per tree	*RM 180.00 per metre/run*
Cost of planting 3 rows of shrub hedges@ 6 ins. apart with raw materials	*RM 108.00 per metre/run*
Lump turfing: 24 sq. metre/metre run @ RM 15.00 per sq. metre	*RM 360.00 per metre/run*
Total landscaping capital costs	**RM648.00 per metre/run**

The following are the estimated capital costs:

a) Cyberjaya (Flagship Zone)

Planting of wetland
Total pond area to be vegetated = 9,000 sq.m
6 plants/m.sq x 9,000 = 54,000 plants @RM1.50/plant **=RM81,000**

b) I0I Palm Garden Resort Area

Planting of wetland
Total pond area to be vegetated = 8,000 sq.m
6 plants/m.sq x 8,800 = 48,000 plants @RM1.50/plant **=RM72,000**

c) **West Country Area**

Planting of wetland
Total pond area to be vegetated = 3,500 sq.m
6 plants/m.sq x 3,500 = 21,000 plants @RM1.50/plant =**RM31,500**

d) MARDI

Drain Corridor Improvement
Total length of stream = 6.9 km
Length of streams for riparian buffer zone=6.9x2=13.8km
Total cost =13,800m x RM648/m** run =**RM8.9Million**

e) UPM

Drain Corridor Improvement
Total length of stream = 6 km
Length of streams for riparian buffer zone=6x2=12km
Total cost =12000m x RM648/m** run =**RM7.8Million**

2.0 OPERATIONS AND MAINTENANCE COSTS

1. IOI

Item	Descriptions		Per Annum (RM)
a.	Replanting (Assume 20% replanting of the total plants required per year)	20% x 48,000 plant @ RM1.50/plant	14,400

2. WEST COUNTRY

Item	Descriptions		Per Annum (RM)
a.	Replanting (Assume 20% replanting of the total plants required per year)	20% x 21,000 plant @ RM1.50/plant	6,300

3. CYBERJAYA

Item	Descriptions		Per Annum (RM)
a.	Replanting (Assume 20% replanting of the total plants required per year)	20% x 54,000 plant @ RM1.50/plant	16,200

4. UPM

Item	Descriptions		Per Annum (RM)
a.	Grass cutting	RM1000/km @ 6 km @ 2 time/yr	12,000
b.	Desilting (once a year)	6 km @ 1.5m^3/m-run @ RM8/-	48,000
	Total Annual Maintenance Cost		60,000

5. MARDI

	Description		Per Annum (RM)
a.	Grass cutting	RM1000/km @ 7km @ 2 time/yr	14,000
b.	Desilting (Once a year)	7 km @ 1m^3/m-run @ RM6/-	42,000
	Total Annual Maintenance Cost		56,000

APPENDIX 9.5
DETAILS OF INDICATIVE COST ESTIMATES OF SEWERAGE MASTERPLAN STUDY

1. CAPITAL EXPENDITURE

The capital expenditure budget for UPM is based on the following estimated combined flows:

		PE	Cost
i.	Kolej 8	1097 PE	438,800
ii.	Kolej 9	1038 PE	415,200
	Total	**2,135 PE**	**854,000**

@ RM 400.00 per PE

2. OPERATING AND MAINTENANCE COSTS

The monitoring programme as recommended by the Sewerage specialist will necessitate carrying out testing and sampling by the following stakeholders with their attached estimated cost burdens on a 4 monthly basis.

SET A : Sampling and Testing RM300/sample SET B :Sampling and Testing RM550/sample								
Development	Nos. Of Location	Month					RM	
		1		2	3	4		
		SET A	SET B	SET A	SET A	SET B	Set A	Set B
MARDI	4	8	8	4	4	4	3600	8800
UPM	6	12	12	6	6	6	5400	13200
IOI	1	2	2	1	1	1	900	2200
CYBERJAYA	4	8	8	4	4	4	3600	8800
TOTAL	15	30	30	15	15	15		
ESTIMATED COST (RM)		25500		4500	4500	8250		

	RM (4-monthly basis)	RM (per Annum)
MARDI	*12,400.00*	*37,200.00*
UPM	*18,600.00*	*55,800.00*
IOI	*3,100.00*	*9,300.00*
Cyberjaya	*12,400.00*	*37,200.00*
Total	**46,500.00**	**139,500.00**

NB: No cost estimates are shown for West Country as they have not yet constructed any treatment plants.

APPENDIX 9.6

DETAIL INDICATIVE COST ESTIMATES FOR THE DATA CONVERSION TO SiCAD AND REFINEMENT PHASE OF THE LOW-LEVEL ICMS

Item	Station	Description	Duration	Unit	Amount (RM)	Remarks 1	Remarks 2	Pricing Sou	Data Sources
A	**Consultation Fee**								
A1	Mohamed Razali Mohamed	Consultation for developing ICMS	8 months	L/S	$ 14,080.00	10% loading	RM8,000 per month	MALSAT	
A2	Steve McCrone	Consultation for developing ICMS	8 months	L/S	$ 79,200.00	30% loading	RM15,000 per mont	MALSAT	
A3	Ghazaly Yeop Zainuddin	Project Manager	8 months	L/S	$ 22,000.00	50% loading	RM2,500 per month	MALSAT	
		Sub - total			**$ 115,280.00**				
B	**Data Conversion for Integrated Digital Maps**								
	Scope of work include :-								
	- Sourcing from Perbadanan Putrajaya, other								
	Stakeholders, and Government agencies								
	- Conversion fron SiCAD and AutoCAD into GIS format								
	- Conversion of coordinates								
	- Registration of coordinates								
	- Digitising								
	- Polygonisation								
	- Topology								
	- Database creation								
	- Data entry								
	- Draft Plotting								
	- Field Survey for detailed verification								
	- Field GPS Survey for accuracy verification								
	- Final Editing and Data Entry								
	- Final Plotting								
B1	***Topographical Maps***	- Contours (1 meter and 5 metres)	6 months	L/S	$ 39,600.00	2 GIS Technicians	@RM1,500 per mon	MALSAT	Perbadanan Putrajaya
		- Spot Heights			$ 26,400.00	1 GIS Specialist	@RM2,000 per month		
		- Rivers							
		- Lakes							
		- Digital Terrain Model							
		- Aerial Photographs	1 month	L/S	$ 3,300.00	1 GIS Technician	@RM1,500 per mon	MALSAT	Perbadanan Putrajaya
									Jurukur Perunding

APPENDIX 9.6

B2	***Infrastructural/Physical Maps***	- Buildings	4 months	L/S	$ 26,400.00	2 GIS Technicians	@RM1,500 per mon	MALSAT	Perbadanan Putrajaya
		- Roads and Highways							
		- Drainage							
		- LRT line & LRT station							
		- Emergency Services (police,fire brigade,hospitals)							
		- Telecomunication infrastructure							
		- Electricity Infrastructure							
		- Water Infrastructure							
		- Gas Infrastructure							
		- Public services (schools, postal)							
		- Other Landmarks							
B3	***Cadastral Maps***	- Lot Parcels	3 months	L/S	$ 19,800.00	2 GIS Technicians	@RM1,500 per mon	MALSAT	Perbadanan Putrajaya
B4	***Catchment Study Map Output***								
	Pollutant Sources Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Ecological Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Mini Wetland Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Water Quality Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Hydrological Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Erosion and Sedimentation		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Geological / Hydrogeological Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Drainage Masterplan Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Sewerage Masterplan Study		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Existing Landuse		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
	Landuse Master Plan		3 Weeks	L/S	$ 7,425.00	2 GIS Technicians, 1 Survey Techni	@RM1,500 per mon	MALSAT	Consultants
		Sub - total			**$ 197,175.00**				

APPENDIX 9.7
DETAILS OF INDICATIVE COST ESTIMATES OF THE INSTITUTIONAL STUDY

The Institutional Specialist's recommendations would necessitate an increase in staff costs as follows:

Majlis Daerah Sepang

1 Planner	*RM 26,000.00 per annum*
1 Environmental Officer	*RM 26,000.00 per annum*
1 Engineer	*RM 26,000.00 per annum*
1 Planning Assistant	*RM 21,000.00 per annum*
2 Technical Assistant	*RM 42,000.00 per annum*
Total	***RM141,000.00 per annum***

In addition to the above additional staff costs, an operational budget has to be allocated to support the "*Sub-Catchment Management Committee"* and the *"Stakeholders Consultative Committee"*

The costs are as follows :

(a)	*Travel & communication*	*RM 20,000.00 per annum*
(b)	*Purchases*	*RM 4,000.00 per annum*
(c)	*Refreshment*	*RM 2,000.00 per annum*
Total		***RM 26,000.00 per annum***
Total annual additional operating budget		**RM167,000.00 per annum**

GLOSSARY

GLOSSARY OF TERMS

A

Activated sludge process
A sewage treatment process in which the sludge in the secondary stage is put into aeration tank to facilitate aerobic decomposition by micro-organisms

Aeration
Exposing to the action of air or oxygen

Aerobic
Living in present of free oxygen (gaseous or dissolved).

Algae
Simple, photosynthetic plants with unicellular organs of reproduction.

Anaerobic
Living in absence of free oxygen (gaseous or dissolved).

Attribute
A trait, quality or property describing a geographical feature such as location co-ordinates, features, name and colour. It can also be depicted as a fact describing an entity in a relational data model, equivalent to the column in a relational table.

B

Base Map
A set of topographic data displayed in map form providing a frame of reference or contextual information to the user.

Biomass
The weight of all the organisms forming a given population or trophic level, or inhabiting a given region.

Biotype
Naturally occurring group of individuals having the same genetic composition.

Buffer
In spatial information systems, a buffer zone or simply buffer, is a polygon enclosing an area within a specified distance from a point, line or polygon. Accordingly, there are point buffers, line buffers and polygon buffers. Buffers are useful for proximity analysis, for example, find all stream segments within 300 feet of a proposed logging area.

C

CAD - Computer Aided Design
The design activities, including drafting and illustrating, in which information processing systems are used to carry out functions such as designing or improving a part or a product.

Carnivorous
Fish that feeds on mainly small insects and small fish.

Chlorination
Introduction of chlorine into effluent for disinfecting purposes.

Chlorophyll
Green pigment found in all algae and higher plants, responsible for light capture in photosynthetic. Several chlorophyll exits, with chlorophyll a being the only one common to all.

Clean Data
Data that is devoid of errors for GIS application. For example is a coverage that is without topological errors.

Coliform
Colon bacilli bacteria

Concept Plan
Illustration that show the proposed zone for development in general incoporate the land-use and circulation system.

Contour
A set of points representing the same value of a selected attribute and forming an imaginary line. The terms contour or contour line is most commonly used for lines connecting points on the ground having the same elevation.

Conversion of land
Land that have change the activity or restricted use for other use or development.

D

Database
A collection of data organized according to a conceptual structure describing the characteristics of the data and the relationships among their corresponding entities, supporting applications areas. For example, a GIS database includes data about the position and characteristics of geographical features.

Data Capture
The encoding of data. In the context of digital mapping this includes digitising, direct recording by electronic survey instruments, and the encoding of text and attributes.

Data Conversion
The translation of data from one format to another. Often, when data is moved from one system to another, some form of data conversion is required to convert the data to a format the receiving system can interpret. Sometimes it may be necessary to have an intermediate format. Many GIS supports conversion algorithms that enable them to accepts data in other formats.

Data Format
A specification that defines the order in which data is stored or a description of the way data is held in a file or record.

Denitrification
Reduction of nitrate to gaseous products such as nitrogen gas brought about by denitrifying bacteria

Dentritus
Organic debris from decomposing plants and animals.

Detrivorous
Fish that feeds on dead organisms and detrual materials.

Digitising
A method of data capture that involves the conversion of data in analogue form, such as maps and aerial photographs, into a digital form that is directly readable by a computer. This is normally achieved manually by a human operator using a digitizer, although methods of automated digitising and semi-automated digitising also exist. The result of digitising is a digital map in vector form.

DXF - Digital Exchange Format
A format for transferring drawings between Computer Aided Design systems widely used as a de facto standard in the engineering and construction industries.

E

Ecology
Study of the relations of animals and plants, particularly of animal and plant communities, to their surroundings.

Ecosystem
A community of organisms, interacting with one another, plus the environment in which they live and with which they also interact.

Effluent
Treated sewage discharge

Expert System
A computer system that provides for solving problems in a particular application area by drawing inferences from a knowledge base acquired by human expertise, it is a form of artificial intelligence. Knowledge based systems, or more commonly, expert systems have been used for purposes of automated map generalisation. This is an area that they have particular application within the field of Geographic Information Systems.

F

File Structure
The organisation imposed on a file to facilitate processing.

Fixed film growth processes
Active microorganisms are developed by passing organic sewage over a solid covered in a biomass (slime).

G

GIS - Geographical Information System - Geographic Information System
A computer system for capturing, storing, checking, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System (or Spatial Information System) is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map.

Layers of data are organised to be studied and to perform statistical analysis. Uses are primarily government related, town planning, local authority and public utility management, environmental, resource management, engineering, business, marketing, and distribution.

H

Habitat
Place with particular kind of environment inhabited by organism(s)

Hard Copy
A print or plot of output data on paper or some other tangible medium.

Herbivorous
Fish that feed predominantly on plant leaves and small grasses.

I

Integrated Planning
The planning that integrate all aspect of politic, social, economy, physical and involved various related agency.

L

Layer
A usable subdivision of a dataset, generally containing objects of certain classes, for example rivers, roads or geology.

Littoral Zone
Refers to the edge of the closed water body particularly pond, lake and reservoir.

M

Map
A graphic representation of features of the earth's surface or other geographically distributed phenomena. Examples are topographic maps, road maps, and weather maps.

Master plan
Overall strategic planning for the area, that shows the land-use zoning and main acessibility, and normally its in the form of written report with illustration and diagram.

Microbial Carrying Capacity
Refers to limit beyond which decomposition of organic materials by microbes is generally not possible.

N

Network
An interconnected set of arcs or lines representing possible paths for the movement of resources from one location to another. A group of computers that are linked, and are able to share peripherals, software and data. The Internet is probably the most well known example of a computer network. A type of database structure. A network data model is based upon the idea of explicit links between related entities. The most well known example of the network model is the CODASYL data model.

Nitrification
Conversion by bacteria of organic compounds of nitrogen, unavailable to green plants, into available nitrates.

O

Oligotrophic
(Of lakes) poorly productive in terms of organic matter formed, nutrient supply low.

Omnivorous
Fish that feeds on wide variety of organisms from plant to animals.

One-off capital expenditure
These are expenditure that will occur once, especially on the setting up of a facility or system initially, and which expenditure may be incurred again after several years at the end of its depreciated life. Common examples of such capital items are plant and machinery, computer hardware and software, software development costs, laboratory equipment, etc.

One-off establishment costs
These are expenditure that again may occur only once, as opposed to being of a recurring type that would be expended in every financial period. Examples would be professional legal fees for the drafting of new laws, professional consultants' fees for specific one-off studies, the setting up a laboratory building, etc.

P

Photosynthetic
In green plants, synthetic of organic compounds from water and carbon dioxide using energy absorbed by chlorophyll from sunlight.

Polygon
A feature used to represent areas. A polygon is defined by the lines that make up its boundary and a point inside its boundary for identification. Polygons have attributes that describe the geographic feature they represent.

Population Equivalent (PE)
Unit as person or capital for sewage loading estimation. One PE contributes 225l per day of raw sewage

Q

Query
A statement expressing a set of conditions that form the basis for the retrieval of information from a database. Queries are often written in a standardized language such as SQL.

R

Recurring direct costs of operations
These are costs that would need to be incurred every financial period to enable an activity to be maintained or sustained. Examples would be the staff's salaries, the utilities (electricity, water, etc,), repairs and renewal expenditure that would need to be incurred after the setting up of a laboratory. (Such a lab may be set up to implement a monitoring programme, for instance).

Rhizome
Underground stem, bearing buds in axils of reduced scale-like leaves, serving as means of perennation and vegetative propagation.

Riparian Park
Refers to vegetable area of the edge of stream, river or tributary.

S

Sequencing batch reactor
A fill-and-draw activated-sludge treatment system having five steps in sequence: fill, react (aeration) settle (sedimentation/clarification), draw (decant)

Sewage Treatment
Processes for purification of wastewater or sewage flow

Sewer
An underground pipe for carrying sewage

Sludge
Semiliquid residual waste from the treatment of sewage

Spatial Data
Any information about the location and shape of, and relationships among, geographic features. This includes remotely sensed data as well as map data.

Standing Crop
The production of plant material water existing condition.

Structure Plan
Written document with illustration and diagram. The document explained the policies and general proposal for local authority in term of preservation, development, land-uses etc. in their area.

Suspended growth processes
Micro-organisms remain in suspension in the sewage and are aerated over a period to remove the organics

U

Use Class Order
Regulations under written laws that allowed type or activities in the use class to develop for other purpose in the same classes without any development order.

User Requirements Analysis
A study of the needs of a user of a system conducted prior to system development.

V

Vector Data Model
An abstraction of the real world where positional data is represented in the form of co-ordinates. In vector data, the basic units of spatial information are points, lines and polygons. Each of these units is composed simply as a series of one or more co-ordinate points, for example, a line is a collection of related points, and a polygon is a collection of related lines.

W

Wastewater or Sewage
Fluid discharge from domestic sanitary appliances.

Z

Zoning Plan
Distribution plan that show the land-uses and density for the purpose of planning and development control.