

PUTRAJAYA LAKE AND WETLANDS – CURRENT STATUS AND LESSON LEARNED¹

By

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1.0 INTRODUCTION

Putrajaya, being developed as the Federal Government Administrative Centre and the first ‘Intelligent City’ in Malaysia is located at the heart of the planned Multimedia Super Corridor (MSC) as shown in *Figure 1*.

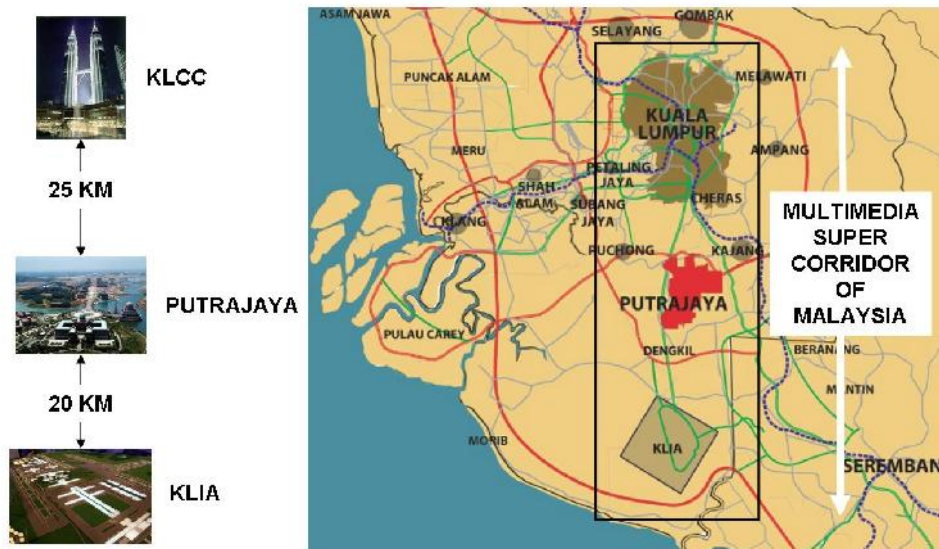


Figure 1: The Location of Putrajaya

The development involves the opening of large land area of up to 4500 hectares. The undulating hill land was formerly rubber and palm oil plantation. The cutting off the plantation trees would also increase the surface runoff velocity, which can cause flooding in downstream areas.

In addition, the clearing activities has exposed the land to the day time heat without enough shade for the first few years after the construction, resulting in a higher temperature in the new urban areas before the full re-vegetation.

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In view of the impacts on its surroundings and future situation, Putrajaya has adopted an innovative approach by allocating a comparatively large area within its boundaries to be converted into water body in the form of wetland and lake.

The Development Concept for Putrajaya

The Masterplan for the development of Putrajaya covered the core area, peripheral residential areas and parklands. It incorporated a comprehensive set of policies and guidelines for land use planning, transportation systems, utilities and infrastructure, residential areas, public amenities, information technology, parks, gardens and landscaped areas. The Masterplan is shown in **Figure 2**. The Masterplan emphasises the creating, preserving and the enhancing of its eco-culture while promoting an active, lively and caring society.

The design has also incorporated the infrastructure that will ease the pressure and stress of modern living. It reinforces the concept of a “City-in-a-Garden” by proposing “an integrated system of parks, water courses, wetlands, forest and open spaces”. This concept will provide the green image control while maintaining its flexibility as an ‘Intelligent City’ that meets the administrative functions of the Federal Government.

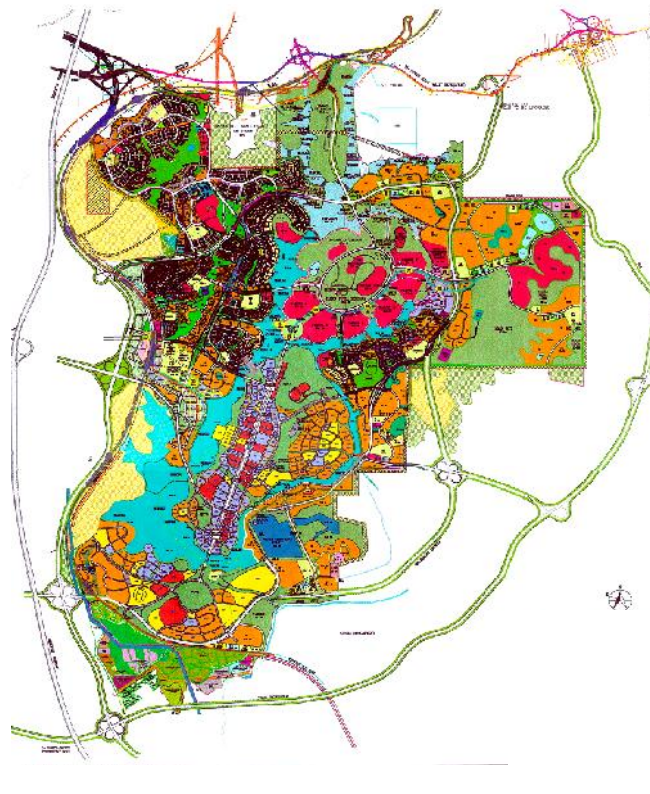


Figure 2: Putrajaya Masterplan incorporate the creation of parks, garden and landscape areas including water

A critical component of Putrajaya is the lake and wetland, which is located in the central area of the city. Apart from other necessary functions of the lake and wetland, the quality of the lake water is to be maintained to a certain level of quality that will allow for body contact. This vision for the lake is to ensure that the lake will always be available for all type of activities especially for the non-motorised sports and recreational boating.

2.0 DESCRIPTION OF THE LAKE

Putrajaya Lake Catchment

The size of Putrajaya lake catchment area is 51.0 km² which is partly in the state of Selangor and only 70% in Putrajaya. This catchment (watershed) is only a small part of the bigger 2350 km² Sungai Langat Basin (Ranhill, 2009) as shown in **Figure 3**. The location of this catchment is within a fairly urbanized area with rapid development going on all around it, at the southern part of Kuala Lumpur.

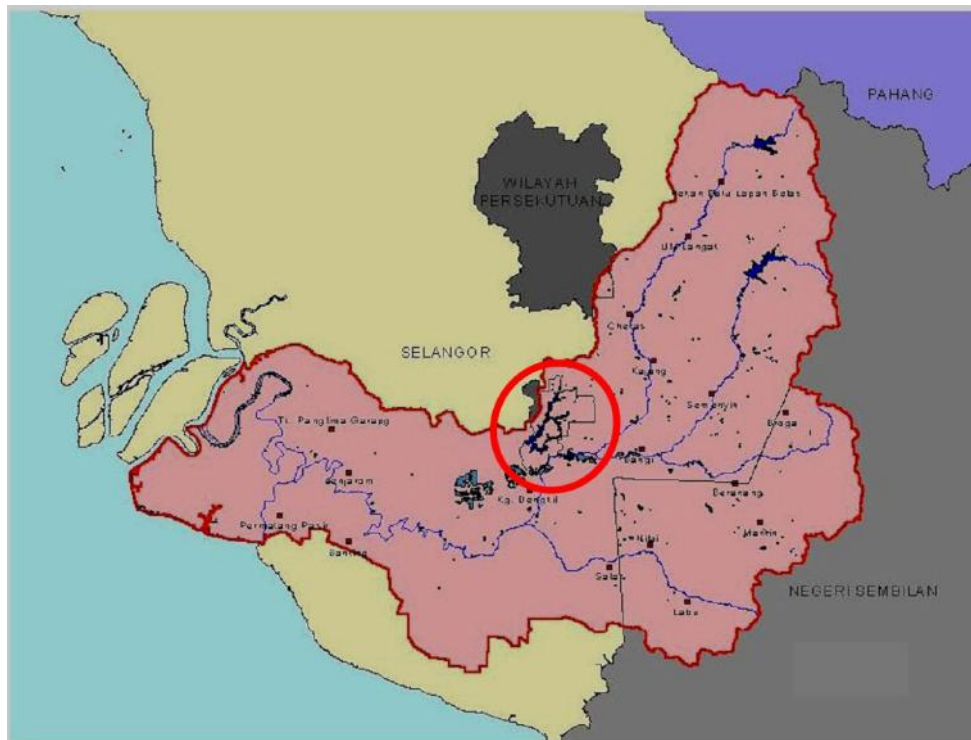


Figure 3: The Putrajaya Lake Catchments as part o the bigger Sungai Langat Basin

Hydrological Processes

There are three identified major effects of urban areas on hydrology (Leopold, 1968): -

- Changes in total runoff;
- Changes in peak flow characteristics; and
- Changes in water quality (Chandler (1976); Hough (1984))

As cities grow in size and more surfaces are paved, there is a growing concern for the water channelling effect of runoffs on watercourses and lack of water penetration into the ground to replenish water tables. The speed of runoff causes problems of erosion in watercourses and oil from parking lots raises the pollution levels of water, and consequently, affects the aquatic life. The actual effects vary from city to city, but the overall impact of the high degree of hard surfaces in cities is to increase flood discharges by as much as 50 percent in areas with highly pervious surfaces, and up to 400 percent in cities with 80 percent impervious surfaces and whose areas are 80 percent storm-sewered (Chandler, 1976).

Not only does the total discharge increase, but also does the speed of runoff, leading to erosion and the scouring of riverbeds. The changes to patterns of vegetation and aquatic life diminish the ability of rivers to cleanse themselves naturally over time, causing the loss of aquatic and riverbank habitats, native plants and wildlife populations.

The design of the Putrajaya Wetland and Lake has taken into consideration of this hydrological impact. The Lower Sungai Langat River Basin will not be able to absorb the increase in runoff volume, velocity and the pollutant resulting from the massive development in Putrajaya area without an integrated management and engineering approach to tackle the problem.

The designed Hydraulics Loading Rate for the Putrajaya Wetland is as shown in ***Table I*** below. 13 years of daily rainfall records at Prang Besar rainfall gauging station from period 1981 to 1994 are used in the design of the present and future flow rates. Typical hydraulic loading rates for artificial wetlands are extremely variable, ranging from 2 – 40 cm/day as suggested by Huat, K.C., 1995.

Table 1: Hydraulic Loading Rate

	Upper West	Upper North	Upper East	Lower East	Upper Bisa	Central Wetland
Design Inflow Rate (ML/d)	18.80	37.60	11.40	5.90	13.70	79.50
Mean Residence Time (d)	12.20	8.20	11.40	25.40	31.40	15.10
Hydraulic Loading Rate (cm/d)	7.30	11.10	8.90	6.20	6.70	15.10

Putrajaya Wetlands

Putrajaya wetland is the first man-made wetland in Malaysia and the largest constructed freshwater wetland in the tropics. The construction began in March 1997 and was completed in August 1998. The 197 hectare project resulted in transforming an oil palm and rubber estate site into a wetland ecosystem with the helps of modern technology and stringent environmental management methods in design and construction.

The Putrajaya Wetland straddle the water courses of Sungai Chuau, Sungai Bisa and three other small tributaries. Their primary function is to filter, absorbing the nutrients and cleansing the surface run-off from its catchment, ensuring that the water quality is improved before entering the lake at the downstream area meets the standard set by Perbadanan Putrajaya.

To achieve this, the wetland have been planted with many species of aquatic plants that will be able to treat and act as a natural filtration system, removing nutrients and pollutants from the run-off water from the catchment.

The Putrajaya constructed wetland system comprises of six arms with 23 cells as described in **Figure 4**. All the arms (except of Upper Bisa) eventually discharge to the Central Wetland, which make the 24 cells in all, before the water flows down into the Putrajaya Lake. Although all the six arms are connected, they differ in size, depths, plant communities and pollutant loads that it is designed to handle.

The physical features of the wetland are shown below:

Table 2: Features of Putrajaya Wetlands (Area in hectares)					
Total Area	Planted Area	Open Water	Weirs & Islands	Zone of Intermittent Inundation	Maintenance Tracks
197.20	77.70	76.80	9.60	23.70	9.40

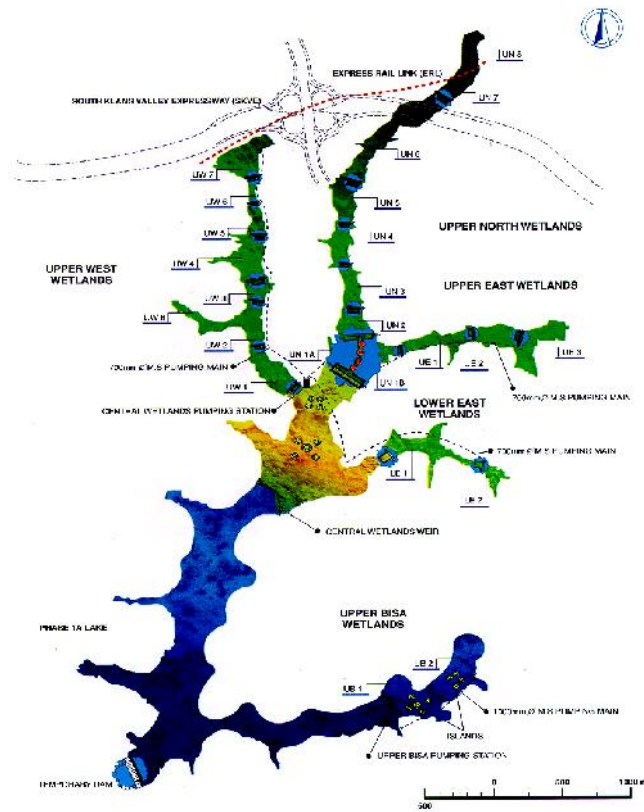


Figure 4: Layout of Putrajaya Wetlands

In addition to being a water cleansing and filtration system, the wetland also help in flood mitigation, nature consevation, ecotourism, recreation, research and education and protection against soil erosion as listed in *Table 3* below.

Table 3: Functions of Putrajaya Wetland

ASPECTS	FUNCTIONS
HYDROLOGICAL	<ul style="list-style-type: none"> • flood mitigation • storm and flood storage • reducing peak discharge • groundwater recharge
BIOCHEMICAL	<ul style="list-style-type: none"> • sediment trapping • nutrient removal • biogeochemical cycle (many biogeochemical cycles are closed by reducing N, C, S, Fe etc in anaerobic mud) • influence atmospheric and climatic fluctuations
ECOLOGICAL	<ul style="list-style-type: none"> • habitats and nursery grounds for wildlife • maintenance of biodiversity
GEOMORPHOLOGICAL	<ul style="list-style-type: none"> • erosion protection
SOCIAL/RECREATIONAL& EDUCATION	<ul style="list-style-type: none"> • recreational value; • open space and aesthetics; • scientific and research opportunities.

Putrajaya Lake

The 400 hectares Putrajaya Lake was created by inundating the lower part of the valleys of Sungai Chuau and Sungai Bisa. The construction was started in 1998 and fully completed in the year 2002. The lake has been primarily designed to enhance the aesthetic appeal of Putrajaya. It is also planned to be used for water sport and recreational activities, as well as a tourist attraction.

The lake is at the southern part of the wetland. About 60% of the lake water flows from the wetland and the remaining 40% is the direct discharge from bordering lake shorelines or promenade. The 20-meter width promenade is the buffer feature along the lake shorelines. The length of the shorelines is about 38 km. The total volume of the whole lake water is about 23.5 million cubic meters and the water depth is in the range of 3 to 14 meters. The lake has been planned to cater for multi-functional uses, including recreational, angling (fishing), water sports and water transport.

The lake and its foreshores also form Putrajaya's most popular resource for informal recreation as a waterfront city. This will eventually maximise the property values all along the areas.

As the vision of Putrajaya is to have a beautiful lake located in the heart of the city, it is of paramount important that its water quality is maintained at the best quality possible. The lake is also have been designate as the centre of water sports excellence of Malaysia. This will further demand the assurance of highest quality of the lake water.

The principle features of the lake are shown below.

Catchments Area	Water Level	Surface Area	Storage Volume	Average Depth	Average Catchments Inflow	Average Retention Time
51.0 KM ²	RL 21.00 M	400 ha (4 KM ²)	23.50 mil. M ³	6.60 M	200 million liters	132 days

Environmental Information

The whole Putrajaya Lake & Wetland catchment area is in the tropical climate condition with average daytime temperature of about 30⁰C and average night temperature is 22⁰C throughout the year. The yearly average rainfall is 2700 mm.

Being tropical, the high average rainfall of 2700 mm ensures the wetland and lake with enough surface water flow throughout the year. The month of August to January will experience the heaviest rainfall with the biggest volume of water. The March to July rainfall is very minimal and it is envisaged that a longer dry spell during the months will make activities in the lake impossible.

The rock weirs in the wetlands were designed to allow over topping over its crest for the flood return period of 5 years. The adjacent land of the cells that consist of the maintenance track area will be flooded during the occurrence of 100 years flood return period. All other development area such as the residential and green parklands is designed to be located above this level.

The lake promenade is provided with minimum level of 22.5 m that allow it to be flooded only for heavy rainfall of more than 100 years return period. The dam crest however, is expected to overtop by water for the flood return period of 1000 years.

The average of the Water Quality Index (WQI) within the Putrajaya Lake in 2009 is 93.4, which is of Class I of the WQI. Out of 204 samples, 67% falls into the Class I category while the balance of 33% is in the Class II range. This shows that the Putrajaya Lake vision to maintain the water quality of Class II B (76.5) is achievable all the time. Achieving this water quality standard will allow the user of the lake to be in contact with the water without any adverse or negative impact. This water quality standard will also ensure a high level of clarity of the water within the newly developed city centre.

Biology

The planted vegetation within the constructed wetland cells is enhancing the wetland areas, which were originally small river tributaries in the rubber and palm oil plantation. Aquatic plants are an important part of the artificial freshwater treatment system. In 2009, 19 species out of 23 species originally planted in 1996 are still growing vigorously in the Putrajaya Wetland.

The phytoplankton communities in the lake and wetland are low in terms of its densities and diversity as recorded by the biological monitoring exercises. Chlorophyta, Bacillariophyta and Cyanophyta were the important components of phytoplankton communities in this wetland system. On the average, as shown in **Figure 5**, phytoplankton densities of Putrajaya Lake and Wetland is between 100 – 1000 cells/ml which shows that it is in an oligo-mesotrophic status.

In relation to the water quality and trophic status of the tropical wetland and lake, it is necessary to clearly determine the acceptable trophic level to this system. The trapping of nutrients in the cells will make the system rich in algae. Varieties and abundance of algae will enhance fish diversity and population. On the other hand, nutrient rich water body will influence the trophic status of the system. The mesotrophic state in the wetland and oligo-mesotrophic state in the lake will be more reasonable in relation to the need of the present management requirement.

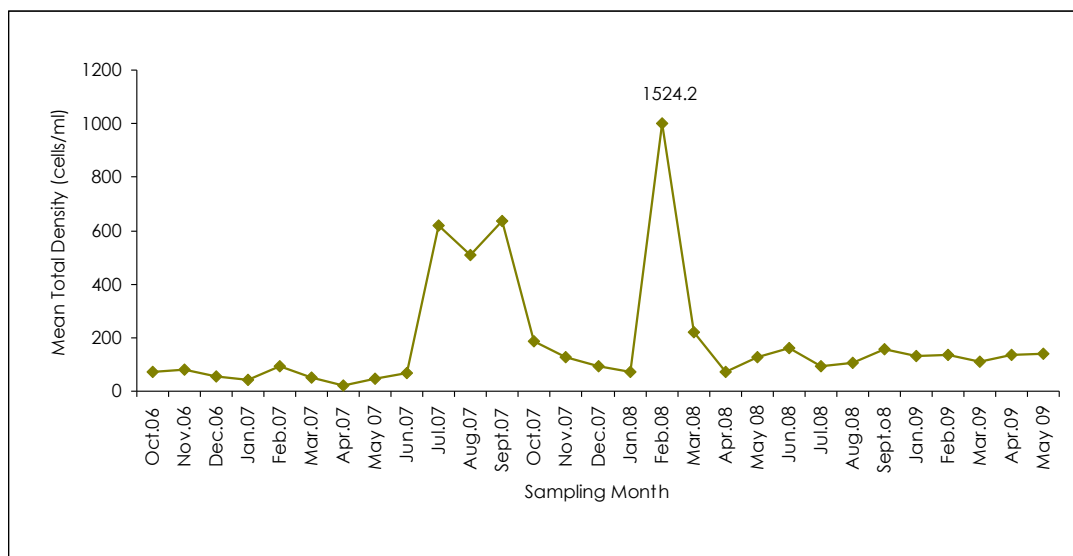


Figure 5: Changes of mean total densities of phytoplankton at Putrajaya Lake and Wetland stations between October 2006 and May 2009.

Flora

Many vegetation species are planted across the flow of the water in the wetland cells. The plant is playing the major role in trapping the silt, particles and nutrients that passing through its area. At the same time, the biological and assimilation process will take place within the planting system to extract the nutrients from the trapped particles at the cells bed.

In the year of 1998, there are 27 species of wetland plants were planted in the wetland cells. In 2009 the most suitable 19 species of wetland plants were identified in the wetland cells due to favourable condition to certain species such as the type of sediment and water level. *Hanguana malayana* sp (**Figure 6**) is found to be the fast spreading wetland plants in Putrajaya Wetland. It easily occupies most of the vicinity of the wetland cells after reaching a certain level of growth. From the monitoring and observation, *Phragmites karka* (**Figure 7**) also seemed growing vigorously in most of the wetland cells. This species survived best at shallow areas, mostly along the edge of the cells.



Figure 6: *Hanguana malayana* sp of the cell



Figure 7: *Phragmites karka* at the edge dominating the cell

The wetland plant species or vegetation is located in different location within the wetland cell as listed in **Table 5**.

Table 5: ZII plants and Wetland plants

Zone Intermittent Inundation (ZII)		Shallow marsh (<0.3m)	Marsh (0.3-0.6m)	Deep Marsh (0.6-1.0m)
ZII Swamp Forest –the highest part of ZII	<i>Eugenia longiflora</i>	<i>Eleocharis variegata</i>	<i>Eleocharis dulcis</i>	<i>Lepironia articulata</i>
	<i>Fragrea fragrans</i>	<i>Eriocaulon longifolium</i>	<i>Fureina umbellata</i>	<i>Phragmites karka</i>
	<i>Saraca thaipingiensis</i>	<i>Fimbristylis globulosa</i>	<i>Lepironia articulata</i>	<i>Scirpus grossus</i>
	<i>Cyrtostachys renda</i>	<i>Fimbristylis miliacea</i>	<i>Phylidrum lanuginosum</i>	<i>Scirpus mucronatus</i>
	<i>Caryota mitis</i>	<i>Hanguana malayana</i>	<i>Scirpus grossus</i>	<i>Typha angustifolia</i>
	<i>Ixora umbellata</i>	<i>Ludwigia adscendens</i>	<i>Scirpus mucronatus</i>	
	<i>Alocasia machorriza</i>	<i>Ludwigia octalvis</i>	<i>Scleria sumatrensis</i>	
	<i>Crinum defixum</i>	<i>Monocharia hastata</i>	<i>Typha angustifolia</i>	
	<i>Arundina spp</i>	<i>Phylidrum lanuginosum</i>		

The wetland varies in size from 50 hectares (the biggest of the Central Wetland) to the smallest of about only 3.0 ha. Each cell is planted with predetermined vegetation species of about 40% to 60% of its surface area. **Figure 8** shows the typical plan layout of a cell.

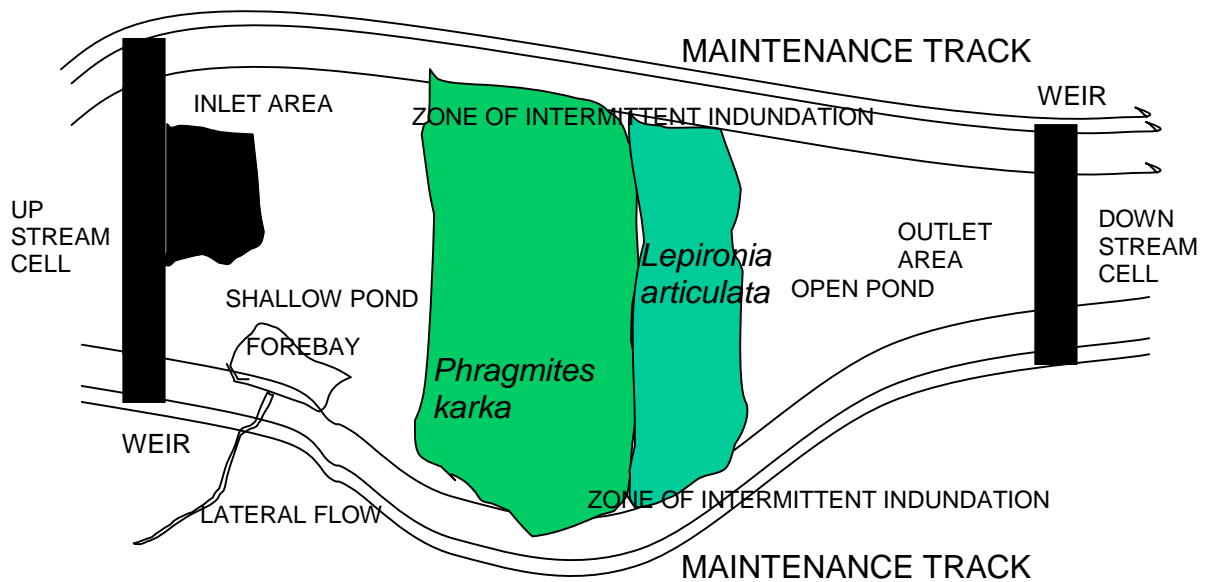


Figure 8: Typical Layout of A Wetland Cell

Fauna

There are seven species of mammals that were still commonly seen in the wetland area. They are the Common palm civet, Leopard cat, Short-nosed fruit bat, Plainain squirrel, House rat, Common tree shrew and Dusky leaf monkey. However, most of the mammals are spotted in a very small numbers at only few areas. The Short-nosed fruit bat was captured through mist netting activity at Upper West and Upper North. The twelve numbers of mammal species that were recorded in June 2009 terrestrial fauna surveys is half less than the number of mammals found in 1995 (EIA). The present urbanized area is not suitable anymore for jungle mammal species such as tiger (*Panthera tigris*) or sun bear (*Helarctos malayanus*) to survive.

Generally, all the wetland arms having good collection of insects from the order of Hymenoptera, Odonata, and Lepidoptera. Among the orders collected are Odonata (dragonfly and damselflies), Hymenoptera (bee, wasp and ants), Lepidoptera (butterfly,

skipper and moth), Coleoptera (beetle), Orthoptera (grasshopper and cricket), Hemiptera (bug), Diptera (flies and mosquito) and Trichoptera (caddis fly).

It was found in 1995 survey (EIA), the number of bird species was only 24. In June 2009 survey, about 10 years after the construction of Putrajaya Wetland, the number of species shows tremendous increase. There are 82 species of birds recorded of which 28 species are migratory birds. Out of the total number of species, 62 species are terrestrial birds, 16 species are water birds, and 4 species are raptor birds. There are only five species, however, were spotted commonly in all the wetland arms most of the time. They are spotted dove (*Streptopelia chinensis*), yellow-vented bulbul (*Pycnonotus goiavier*), black-naped oriole (*Oriolus chinensis*), jungle myna (*Acridotheres fuscus*) and baya weaver (*Ploceus philippinus*).

Fish, including those that feed on mosquito larvae, such as pelaga (*Beta pugnax*) and sepat siam (*Trichogaster pectoralis*), were naturally present in all the wetland cells. Some of the fish species come from the upstream ponds and streams. The species found in the lake are different from that is found in the wetland. The reason for this are: -

- i. Different species of 'game fish' were introduced into the lake such as tenggalan (*Puntioplites bulu*), jelawat (*Leptobarous hoevenil*), and temoleh (*Probarbus julienii*) as part of the management measures exercise of fish stocking.
- ii. The different condition of the habitat of the wetland, which is shaded and shallow, is the best place for breeding of small fish, while the lake is large and open area, which is hotter, that allow for more predator fish such as toman (*Channa micropeltes*) and sebarau (*Hampala macrolepidota*) to survive.

3.0 MANAGEMENT OF THE LAKE AND ITS BASIN

The Vision

It is the policy of the Perbadanan Putrajaya to manage the lake in order to ensure its aesthetics viability, sustain good water quality while providing different recreational uses, including primary and secondary water contact activities. It is also the vision of Putrajaya to ensure the environmental functions and the diversity of the biological and aquatic life is enhanced to ensure the sustainability of the lake and wetland. For that reason, the management of Putrajaya Wetland and Lake is working on an integrated management of both, the lake and its catchment.

The Management Objectives

The objectives of Putrajaya Lake and Wetland management are to:

- i. Ensure the water quality in the lake meets certain quality standard (The Putrajaya Lake Water Quality Standards), which allow it to be used for recreational and suitable for body contact;
- ii. Achieving habitat enhancement and ecological functions improvement of the open space resources (biodiversity) of the lake and wetland as well as the urban setting surrounding it - attractive to biological, aquatic life and human.

The Management Elements

The management phases are illustrated in the diagram in *Figure 9* below. However, the implementation of the phases is not in relation to time, rather to the mechanisms involved.



Figure 9: The Three Phases of Wetland Management Elements

Catchment Management and Control

The urban stormwater management involves the control of pollutant loading and the control of runoff hydrological aspects (water volume, speed and flow rate). Naturally, the pollutant coming into the Putrajaya Lake system will continuously coming not only from within its boundaries but also from the whole catchment which lies outside its boundary and jurisdiction. That is the reason why the management and control approach of the lake system should be seen from the overall management system within the catchment area.

Apart from the hydrological control processes (stormwater quantity) and the pollutant loading rate and its source control measures (water quality), the management focus will be in the following areas of concern, which become the basis for other management decisions and actions that will have to be undertaken to fulfil the integrated management requirements of the lake system: -

- The emergency preparedness, security and navigation plan within the area;
- Public awareness and participation;
- The water quality assessment and its impact to the surroundings; and
- Groundwater quantity – and applicability.

Although the wetland and the buffer zones within the city are functioning as the ‘natural treatment facilities’, which will be able to treat the runoff water and improve its quality, the quality of water entering the wetland and lake system must also be controlled. The cleansing capacity of this ‘natural treatment facilities’ of the wetland is very limited. To ensure of this situation, the water quality of the incoming water from the upstream areas must be monitored and the functioning of the wetland and the buffer zones in filtering the pollutant passing through it must be properly observed all the time to estimate of its optimum cleansing capacity.

The reality of the situation requires us to observe at the response and interactions between the lake and the wetlands and the wetlands with the catchment.

The Catchment Control

The implementation mechanisms used is within a comprehensive legislative framework of the catchment management and will involve the control of: -

- incoming pollutant;
- the management of the surface runoff;
- the hydrological control factors;
- the land use control; and
- the activities control.

All the management components and control measures mentioned above is enforceable for areas within Putrajaya. However, for areas outside Putrajaya there is generally a need to encourage all the stakeholders to: -

- Improve the land use planning;
- Upgrade sewage treatment facilities;
- Stringent control of pesticide and fertilizer use;
- Develop riparian buffer strips or management zones along streams; and
- Utilisation/development of existing and proposed ponds as mini-wetlands.

Land use planning

Within the Putrajaya Catchment, the wetland and the lake is designed in the manner that it is the most sensitive and is most protected from development. The planning will carry through the concept of fringing intermediate buffer zone of low intensity use with increasing intensity use located in the outer fringes.

This concept is carried through by having the riparian management zones or buffer strips of 10 to 30 m width on each side should be maintained and the higher intensity development should be located further away from the sensitive and the protected areas.

Central sewage treatment systems and septic tank systems

Total Phosphorus loading of 2.0 mg/l at the design discharge will be the highest concentration that can be handled by the Putrajaya Wetland system. This is to ensure a lake target value of 0.05 mg/l or less. For that reason, sewage treatment systems which could treat and discharge an effluent of this concentration would be compulsory for the catchment in the upstream areas.

There are several septic tank systems already existing in the catchment. The effluent from these systems needs to be redesigned into the recommended new centralised sewage treatment facilities prior to discharging into the Upper-West or Upper-North wetlands.

Best management practices (BMP)

The best management practices recommended to be applied by all stakeholders in the catchment covers three important aspects to ensure better run-off pollutant control.

- Best construction site management practice
- Best pesticide control practice
- Best fertilizer type and application methods

In addition to land use planning and zoning, there must also be the monitoring and control of construction and development activities in the area. All construction sites within the catchment will have to apply the best construction site management practices that will ensure the acceptable level of pollution discharge from within any work areas.

Monitoring and control of chemical use in the catchment is also a new approach that should be seriously considered within the catchment areas. A Pesticide Register should be instituted in the catchment. The BMPs for pesticide use is being applied for all landscaping activities in Putrajaya.

This will also applicable in the use and application of fertilizers. The type and application methods of fertilizer will be monitored and controlled so that, there will be no unnecessary application which will overflow into the lake system.

Stakeholders Management

The catchment area of the Putrajaya Lake lies within the administrative jurisdiction of the Majlis Perbandaran Sepang (MPSP) and Majlis Perbandaran Subang Jaya (MPSJ), both in the state of Selangor and Perbadanan Putrajaya (PPj).

There are seven (7) areas with stakeholders of different corporation and individuals as shown in *Figure 10* below, including areas within the Perbadanan Putrajaya jurisdiction. The other stakeholders are UPM, MARDI, IOI, West Country (Mayang Development), TNB, UNITEN, Cyberjaya and a small Sungai Merab area, which is under individual's ownership.

The source of pollutant coming into the Putrajaya Wetland and Lake system will continuously coming not only from within Putrajaya boundaries but also from the whole catchment which lies outside its boundaries and jurisdiction. This means that the management approach of the lake system should be seen from the overall capability of all the management system within the catchment area including that of the stakeholders. Perbadanan Putrajaya has done a number of research / studies on the catchment in order to streamline a common development approach for all stakeholders.

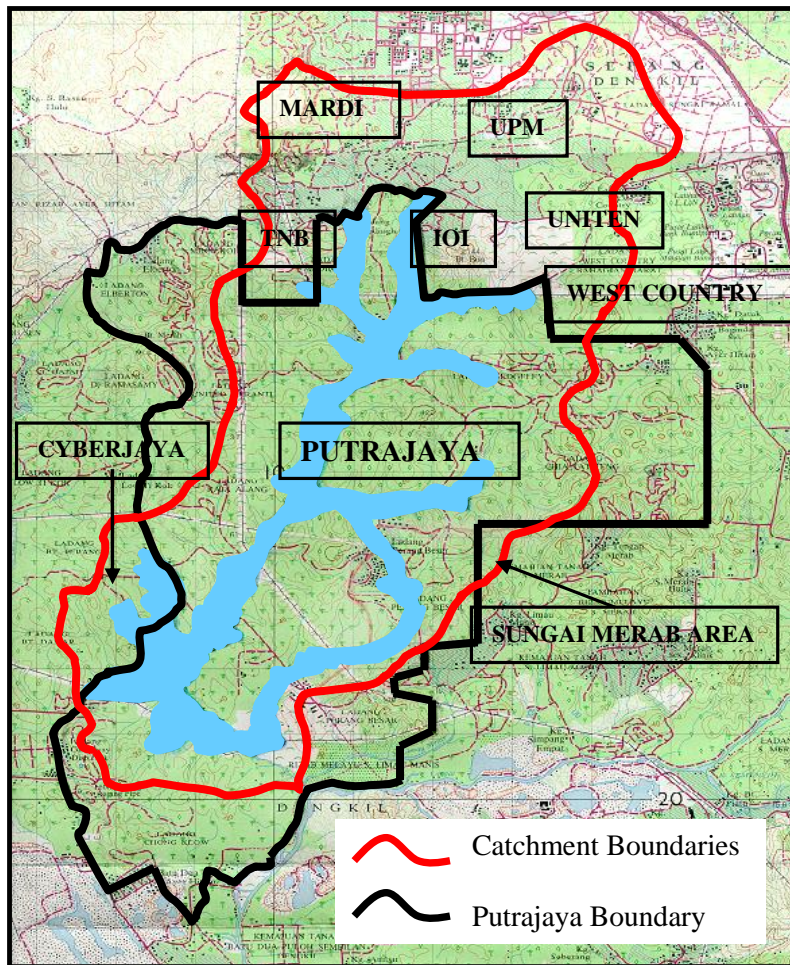


Figure 10: The Putrajaya Lake and Wetland Catchment Area

The Overall Management of Putrajaya Lake and Wetland

The overall management of the Putrajaya Lake and Wetland involves various elements. Proper planning, operation and control measures are essentials for the effective and efficient implementation of the management elements. Besides, the management and control of its catchment, there are other management elements involved as follow: -

- Maintenance Activities
- Monitoring Programs
- Management Measures
- Regulations, Enforcement and Control

The Management Areas and scopes

Table 6: Managing the Putrajaya Lake and Wetland

Management Areas	Management Scopes
The Wetland Cells	Flora Fauna Fish Pest Litter Sediments
The Water Supply	Water Quality Monitoring Water Quantity Monitoring Water Quantity Controlling Water Quality Enhancement
The Structures	Shorelines Weirs Inlet/Outlet Pump
The Laboratory	The equipments The Machines Analysis chemicals Apparatus
The Nursery	The Plant Species The Irrigation system The Fertilizers
The Assets	The Pumps The equipments The Machines
The Data	Hydrological Meteorological Water Quality Sediment
The Conditions	Drought Heavy Rain

The Wetland and Lake Operation and Maintenance

The wetland and lake maintenance activities cover a wide portion of the overall management requirements. Although it seems to be enough coverage of the maintenance exercise in fulfilling every aspects of the management demand there is always a clear divisional area that differentiates the two. One good example is while the maintenance activities do monitoring and collecting data and the necessary inventories for certain aspects, the overall management duties is to analyse and managing the massive collection of data and use it for controlling purpose or other future improvement and development programs (for decision making).

Basically the maintenance of the wetland involves a number of main components such as: -

- The management of the wetland cells
- The condition of the wetland at any one time
- The water quality monitoring and investigation
- The plant management

The operation of maintenance activities consist of various aspects in different scopes but very closely related: -

Maintenance	Scope
House keeping	– rubbish collection, litters management, weed,
The civilworks	– v-drain and GPT, wetland cells when required; sediment removal; desilting;GPT, drains, weir and dams, culverts, maintain access; erosion and scouring control
M&E	- pumps, main switch, switch rooms;
Biological	-fish monitoring;fish stocking, removal of unwanted species; fauna monitoring and management;
Weed management	- preventive measures; dewatering or reducing water level; manual weeding; mechanical weeding; biological control; chemical control; catchment's sources
Plant management	- wetland vegetation, the ZII plants, water level control, re-circulation and plant harvesting
The hydrological	– water level control; water quantity observations
Controlling of pest	- including that of birds, insects, reptiles, amphibians; mosquitoes control
Controlling of aquatic pest	- a number of fish species, snails
Security and emergency response	- security and guards; equipment and inventory; chemical spills
Nursery and the laboratory	- support facilities;

Some monitoring exercises are done in the maintenance operation, while some are not. This is mainly so to minimise duplicating activities within the same area or time.

Monitoring Programs

Monitoring programs is part of the management activities. It is undertaken to ensure a fair assessment of the wetland functions in relation to its ecological requirements as well as to confirm the water quality status of the lake. The monitoring data is also important for management decisions and for future development programs. There are many types of monitoring programs that is related to the wetland and lake system functionality as summarised in **Table 7** below.

Table 7: Monitoring activities for the Putrajaya Lake and Wetland Management Purpose

MONITORING TYPE	COMPONENTS	REMARKS
The Wetland and Lake Ecology monitoring	Bird	Include migratory bird, water bird and the existing bird within the wetland and lake. Include the bird family, which is not expected in the area.
	Fauna	Wildlife community, its protection and survival Include pest and other control of Undesirable Species
Biological monitoring	Plant Management	Plant performance - plant nutrient uptake Plant health and density Pest Infestation Weeds – aquatic and on land Fertilizer and herbicides application
	Fish	Control of undesirable species Routine fish sampling and restocking Stocking of endangered and rare species Illegal fishing
	Sediment	The quantity Trace pollutant content
Water Quality monitoring	The Catchment	Water runoff quantity Water runoff quality Ground water quantity and quality
	Putrajaya area	Water Runoff Quantity Water Runoff Quality The Wetland water quality The Lake water quality
Other Management Purpose	Maintenance	Structural integrity – weirs, dam Water Level Management Wetland Plant Nursery
	Education	Research Community Awareness and Education Tourism
	Emergency and Security	Security Safety Emergencies situations
	Assets management	Equipments Pumps Structures Plants
	Data management	Data collection and analysis Data control and usage Inventory and control
	Activities	Activities control Activities network and promotions Business activities

Management Measures

Management measures are set of tools executed in the Putrajaya Lake and Wetland, to achieve (a part of) an operational objective. There are some management measures that have been done such as: -

- habitat enhancement – special tree planting
- installing fish attracting device (FAD) to ensuring the health of aquatic life;

- fish stocking – releasing different type of game fish species;
- catch and release;
- protection of rare and endangered bird species;
- developing an integrated database system of the wetlands and lake management ;
- dredging works – desilting

Regulations and Enforcement

Formal regulations are required to enable Perbadanan Putrajaya to have effective control over the lake en route for maintaining the lake in an acceptable condition as planned. The objectives of the regulations, control and enforcement are to ensure the management objectives will be realised in a systematic and regulated manner.

Guidelines such as Lake Management guidelines, The Putrajaya Lake Use Master Plan, Environmental Management Guidelines, The Catchment Management Guidelines and others, which is related in one way or another to the overall lake and wetland management, had been developed and introduced by management of Perbadanan Putrajaya.

Zoning of the lake and wetlands is an important start to control the possible activities that are permissible in or around the lake. The lake zoning system has been useful, particularly in guiding the appropriate uses and activities.

Activities that might adversely affect the quality and integrity of lake and wetlands, the general amenity of parks and open spaces, residential neighbourhoods and government institutional areas are deemed as prohibited in the lake and wetlands area. Similarly, activities that cause damage to banks (e.g. as a result of wash of fast large craft) and the overall water quality of the lake are forbidden.

The rules provide control of all activities that are envisaged to be undertaken in the lake and wetlands. Several user guidelines such as Guidelines for Licensing of Motorized Leisure boats, Guidelines for Licensing of Fishing and Code of Practice for Boating will be published for public use. Guidelines for the Registration of Non-Motorized Leisure Boats, guidelines for activities requiring permits and approval, such as fishing, will also be published for public use. The user guidelines are meant to supplement the rules and assist users in carrying out the activity within the confines of the law.

4.0 MAJOR “IMPACT STORIES” OF THE LAKE

Negative Impacts

Algae bloom

Isolated algae bloom in localized areas in the lake has become more frequent and this created a negative impact To the water quality of the lake as well as a threat to its aesthetic value. A serious algae bloom event in the wetland (upstream) is the *Euglena sanguinea* bloom that happened in 2003 due to lack of maintenance of the sewage treatment plant of a university’s students hostel. Moreover, every now and then the green algae (*Botryococcus braunii*) bloom occurs due to mostly from the leakage of the underground sewerage lines. Blooms of *Botryococcus braunii* have been shown to be toxic to other micro-organisms and fishes.

The other negative impact when algae bloom happens is the diminishing quantities of dissolve oxygen (DO) in the water. This may cause fish death. It is expected that the growing algae demand more oxygen and this makes the water becoming more turbid and at the same time will cause the DO to be depleted. In that sense, it is of great concern to the management to ensure that this problem could be detected as soon as possible i.e. before major damage done to the overall ecological settings of the lake and wetland.

Online monitoring equipments installed at the incoming water sources can be very helpful since it can activate the alarm system. Algae monitoring for determining its species diversity and indicator species need to be done at least once or twice a year. The dual purpose of this exercise is to observe the diversity of the algae species and the early detection of problematic algae in the system.

Sedimentation / Siltation

The major process happen in the wetland system is the sedimentation and accumulation of the nutrients in the water caused by the filtration capabilities of the various vegetations in the wetland cells. The process will cause accumulated sedimentation in the cells. The sedimentation and trapping of the silt carried along the surface runoff from the upstream and surrounding area by the wetland plants in the wetland cells is a main physical process. Although this is a good indicator of a functioning of the system, the build up sediment will reduce the amount of water volume in the cell. This in turn will reduce the hydraulics retention time of the wetland cells. The cells should be

rectified and turned to its original condition. This is done by implementing the desilting works for the affected wetland cells.

Biological Waste

The silt and surge of biological waste from upstream and lateral flow from adjacent rapid development areas are some of the threats to the capability of the wetland vegetation and system to function to the highest efficiency.

Pesticide and Fertilizer

There is also possibility of overflow of pesticide and fertilizer from the golf courses, parks and other development areas upstream of the wetland system. This threat can, in a way change the behaviour or response of the system and the water quality that is passing through it.

Pest and Weed

The other aspect is the existent or accumulating number of pests or unwanted species around the area. The connectivity of the areas may cause migrating of a number of this kind of pests. Domination by unwanted or other invasion plant species is commonly happen in tropical condition. This situation may affect the other ecological functions of the wetland and should be deal with quickly.

Public Encroachment

Public encroachment into the area for illegal sport fishing is also a threat to this sensitive ecological setting. The sensitivity of the wetland ecological units needs some measures of isolation i.e. by zoning into non-trespassing areas and activities areas or by limiting the use.

Positive Impact

Enhancing the Habitat

Transforming the land from an undulating plantation site to a waterlogged wetlands ecosystem resulted in a radical change in the flora of the area. The propagated wetland vegetation comprises exclusively indigenous species; some classified as endangered which highlight the rich natural heritage of the country.

Before the development of Putrajaya and its wetland, the site was an oil palm and rubber plantations. The vegetations were typical of an old inland oil palm/rubber estate, with *Nephrolepis*, *Stenochlaena ferns* (mainly) and other under-storey plants such as *Clidemia hirta*, *Dillenia suffruticosa*, *borreria latifolia* and *Alstonia angustiloba*.

With the construction of the wetlands and planting of emergent aquatic vegetation, the formerly narrow, swift riverine system was altered into a slow flowing “marsh” with a diversity of plants and open water areas covering about 200 hectares of land. The ecology of the area was enhanced from a terrestrial plantation into a large area of water body that enables the propagation of varieties of aquatic plants (in the wetlands itself) and banks of riparian and littoral vegetation (in the Zone of Intermittent Inundation).

The planted flora of the wetlands comprises only plants indigenous to Peninsular Malaysia. The other plants species are listed out in the **Table 5**. The vegetation are planted along the littoral zone also provide diversity and naturalness to the wetlands. The covers, shrubs, herbs and trees in this zone not only protect the slope but also create a cool and natural environment for that area.

The Fauna

The wetlands with the diverse vegetation lining the littoral zones form a crucial and important part of the ‘green corridor’ linking the numerous parks in Putrajaya (Taman Wetlands, Taman Botani, Taman Jati, Taman Putra Perdana). Development of the “green corridor” is crucial to the concept of biogenic environment for the fauna. The large diversity of plants and insects provide a broad food base for the different families of birds, from insectivorous to frugivorous, granivorous and nectarivorous.

Even with the drastic modification of the landscape and the environment in the Putrajaya development areas, it does not chase away all the fauna found in the area. The only thing that can be noticed here is that it is changing for a better habitat with a number of different families of species.

The most noticeable changes were in the increase in the population of dragonflies and birds such as swifts, moor hens, water hens, wild ducks and kingfishers. The normally airborne black-shouldered kite (*Elanuscaeruleus*) and brahmny kite (*Haliastur indus*) are sometimes seen swooping on their prey. Migratory birds such as the cattle egret (*Bubulcus ibis*), little egret (*Egretta garzetta*) and purple heron (*Ardea purpurea*)

painted stork (*Mycteria leucocephala*) have appeared, attracted by the shelter of the wetland vegetation and abundance of fish.

The fish represent the full spectrum in the food chain – from plankton (including algae) feeders to herbivores, omnivores and carnivores. Monitoring of the fish and mosquito larvae populations is being carried out regularly to ensure that the fishes are able to control the breeding of mosquitoes. Some fishes attract water birds too.

High Level of Water Quality

The water quality-monitoring programme has been implemented since 2000 to assess and ensure suitability of the water for recreational use with body contact as well as to ensure a healthy and diverse ecosystem. The monitoring programmes also form a basis for the assessment of the environmental management efficiency and its control measures and for the formulation of appropriate recommendations when necessary.

Based on the average monthly Putrajaya Lake Water Quality Index (WQI) temporal trend from January 2009 to December 2009 (**Figure 11**), the lake is always well above the Class II limits and at certain months (March, April, May, August, October and November) has even breached the Class I limits. Furthermore, the temporal trend also shows a very consistent WQI values throughout the period and remained satisfactory in terms of water quality classification based on Interim National Water Quality Standard (INWQS).

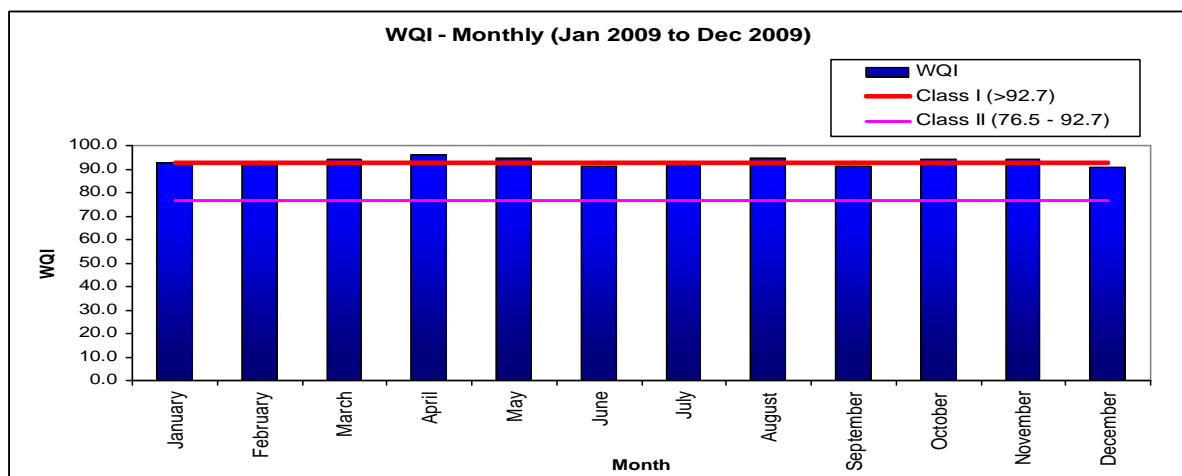


Figure 11: Average WQI Monthly (January 2009 to December 2009)

In summary, 67 % of the total 204 samples collected for the year 2009, recorded WQI value of more than 92.7 (Class I based on INWQS) while the remaining 33% registered a Class II (Figure 12). Water quality classified as Class I are normally found at the most upstream part of rivers, inhabited areas, which remain clean and pristine. Therefore, maintaining the water quality of Class I and Class II for the Putrajaya Lake, which is surrounded by a rapidly developing area and an urbanised area, is a commendable achievement. Furthermore, the health of the water body for the year 2009 remained highly suitable for sensitive aquatic species and fishes and, at the same time it is useable for sports and recreational activities with body contacts.

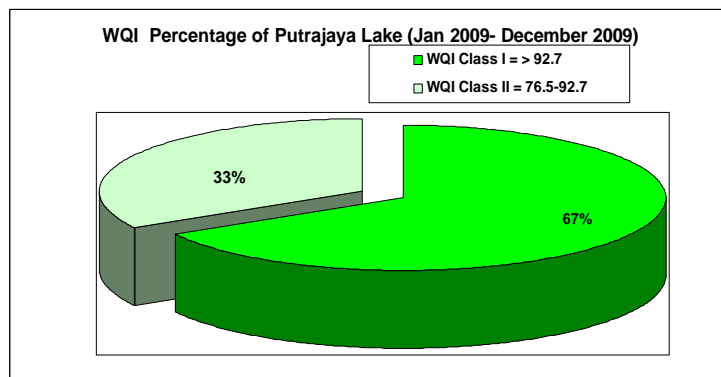


Figure 12: WQI Percentage of Putrajaya Lake (January 2009 to December 2009)

The Recreational and Ecotourism Destination

The Putrajaya Wetland also attracts of eco-friendly recreational activities. Among other, the ‘wetland trail’ is ideal for bush-walking, bird watching, jogging, cycling and relaxing. The waterfront facilities include picnic and barbecue sites, lookout points and restaurants.

Much space has been dedicated to public parks, gardens and water bodies in Putrajaya – centre of tranquillity for those seeking refuge from the pressures of modern urban living. The ecotourism appeal of Putrajaya lies in the development of a series of green areas and buffer zones complementing the water body that have merged to form a unique ecosystem, which is a vibrant corridor of local wildlife and vegetation.

The riparian parks, which are the low-lying (surface run-off) buffer zones with a number of different (natural and constructed) levels – some submerged with different water depth, in residential areas along the lakefront. The attractive landscape features will make them an ideal habitat for some flora and fauna. This will make it more attractive to visitors and tourists alike.

The lake is being used for the water related activities such as rowing, canoeing and boating. It was also designed to cater the international sports events such as rowing and canoeing. The waterfront and facilities provided will be adequate for such events. There are also boating services, passenger ferry and sightseeing boats that are plying from one jetty to another within the interesting locations in the lake.

Field Research

The construction of the wetland brings about a unique wildlife habitat. Yet, another branch of the sciences can undertake studies on the varieties of flora and fauna, their behaviour and habits. Migratory birds, even mammals, can be tagged to study their movements. It would be interesting and useful to study the succession of wetlands plants species and the mosaic pattern of the flora.

5.0 MAJOR LAKE BASIN GOVERNANCE ISSUES

About 30% of the upstream areas of the Putrajaya Lake Catchment lies inside Selangor, where the level of enforcement and control of surface run-off quality is not as integrated and focused as that carried out by the Perbadanan Putrajaya - for the catchment areas within Putrajaya. Thus, there is a need to enhance the enforcement and monitoring of the 30% of the Putrajaya Lake Catchment that lies within Selangor, through new institutional development and increased legal enforcement mechanisms using the provisions in the LUAS Enactment (1999).

There are limits of authority and trans-boundaries issues that are complicated and cannot be easily resolved by any one party. This is one of the main challenges faced by the management of Putrajaya Lake and Wetland. The trans-boundaries matter is summarised as follows:

- i. Putrajaya Lake Catchment lies both in the Putrajaya administrative area (70%), and in the State of Selangor (30%), thus both authorities have to gazette their

- respective parts of their catchment areas for the same purpose of controlling the water quality.
- ii. Future development within the catchment is expected to increase the water runoff and the pollutant concentration. Therefore a standard method of enforcing the limit of pollutant discharge in both areas within the catchment should be formulated.
 - iii. There is a need to determine the feasible mechanism where strategic intervention can be made to mitigate the impacts to Putrajaya Lake via catchments protection and control.

To reinforce the technical intervention in Lake Basin management, formal regulations are required to enable Perbadanan Putrajaya and LUAS on behalf of the Selangor State Government, to have an effective control over the Putrajaya Lake Catchment in order to maintain the desired condition.

6.0 KEY CHALLENGES TO LAKE GOVERNANCE

It is clear that the management of Perbadanan Putrajaya want the water quality of the Putrajaya Lake and Wetland to be kept at a very high level and complying with the Putrajaya Lake Water Quality Standard (PLWQS). Apart from the goal to achieve the high water quality, it is also necessary to have a self-sustaining and balanced lake ecosystem. This operational objective involves the creating, enhancing and preserving the best and optimal habitat for ecological diversity of the flora and fauna within the system (as good as the one found in the natural wetland of its kind).

For the purpose of biodiversity condition for this wetland, there is a site reference, which will be used for comparison. In terms of algae composition, comparison can be made with the Tasik Bera condition. Tasik Bera is one of Malaysian Ramsar wetland site. On the other ecological processes and vegetation species (depending on the condition of the area), Tasik Bera will always be good comparison. In any situation, other site references with similar condition and ecological units need to be compared.

For the overall situation of this man-made wetland, the management of Putrajaya Wetland cannot be seen separately from the overall management of the lake and its catchments' area. The threats or disturbances expected from upstream areas need constant management intervention. The coordination with all parties involve in

discharging water into the system should be consistently being done in a systematic and positive manner.

The ecological values of the wetland and lake located in the middle of a city will be very crucial in creating the natural ambiance of the city itself. The direct implication of this situation is the total involvement of the management in the operation and maintenance of the wetland.

While it is critical to protect the lake from surface water pollution, we have to balance the need for community to interact with the lake in line with Putrajaya's policy that lake has to be an integral part of the community. With proper control, some active and extreme activities for the communities can be held in the lake.

Integrated approach of managing the lake and wetland introduced in Putrajaya has never been done anywhere else in Malaysia. An integrated and comprehensive management approach will avoid duplicating of actions or responsibilities. The key challenge to lake governance is to establish an integrated management team of multidiscipline professionals to undertake the various management tasks. Perbadanan Putrajaya as a local authority has been able to implement this management tasks by having such a multidiscipline team and taking custodian over the whole of Putrajaya Wetland and Lake. This management approach implemented by Perbadanan Putrajaya should be a good example for other local authorities or government agencies to undertake the management of lakes and wetlands in their areas.

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