ENGINEERED WETLAND FOR SUSTAINABLE URBAN ENVIRONMENT

by

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Dissertation submitted in partial fulfillment of
the requirements for the
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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(Tham Kuan Jian)

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Program
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In partial fulfillment for the requirement of the
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TABLE OF CONTENT

LIST OF FIGURE

L IST OF TABLE

ACKNOWLEDGEMENT

Initially Final Year Project appears to be tough and hard work to be complete. Design Of Wetland to Sustained Urban Environment is my FYP topic. During the early days, I am not attached to environmental engineering before. It is such a new study on wetland that not many people have done. I have to start from zero. However over the period of time I have slowly understand the topic and built up my interest to it. This is due to the immense support from various parties that have provided guidance throughout this internship duration.

First and foremost, it would befitting to extend my outstretched gratitude to **Dr Nasiman Sapari,** who is my academic supervisor. He has provided support and guidance throughout the whole year which help me successfully complete the research and design project. It was really a privilege to be under his supervision. Opportunities given showed that he has great confidence in student. His caring nature gave a sense of belonging in the community of education.

Heartfelt appreciation is extended to **Miss Koh** (FYP coordinater). Her effort and guidance to me is very much appreciated. The advice and supervision given during the whole semester will be very useful for me to continue the project. Without her consent the success today would not be a reality.

The success of the internship program is attributed to the patient of the KLCC staff to accept my interview. **Mr Farid,** as the KLCC engineer instilled his knowledge towards completing this thesis. Besides that, the advice by UTP lecturer, **Ms Zahirah** is very much appreciated. Their kindness and patience in attending to questions whenever there is a doubt will always be remembered.

Last but not least great big thanks goes to my parents who have given immense support in one way or another contributed to the success of this project.

I would like to take this opportunity to express my appreciation to those who had assisted me in completing my thesis and promise will use the knowledge I have learn through out this project period fruitfully in my future career.

ABSTRACT

Although wetlands are often wet, a wetland might not be wet year round. In fact, some of the most important wetlands are only seasonally wet. Wetlands are the link between the land and the water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils and vegetation-making these areas very important features of a watershed.

Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs. An immense variety of species of microbes, plants, insects, amphibian, reptiles, birds, fish and mammals can be a part of the wetland system. Physical and chemical features such as climate, landscape shape, geology and the movement and abundance of water help to determine the plants and animals that inhabit each wetland.

The objective of this project is to develop studies on the principle of engineered wetland that can be applied for sustainable urban environment. Wetland is mainly design for landscaping purpose and the criteria on environment and ecological issues have often been neglected. To an engineer a wetland may be a place that will require a specialized construction design to accommodate poorly drained soils. The scientist likely has a functional perspective, defining a wetland as a place where anaerobic processes occur, and plants are adapted especially for living in saturated or inundated conditions. Therefore, the objective of this project is to study the appropriate design of engineered wetlands that can fulfil the requirements from engineering and also the scientific perspectives. The solution is to design a wetland to become an ecological wetland besides of landscaping purpose. The scope of study of this project covers a wide range of engineering and biological scopes, including water turbidity test, BOD, COD experiments, site surveying, water flow measuring (weir), study of landscape drawing, engineering documentation and engineering ethics.

In short, the result of this project will include a design of a wetland for sustainable urban environment.

Chapter 1

1.0 Introduction

1.1 Background of Study

As part of the overall development of the University Technology Petronas (UTP) campus, the open channel main drain is to be diverted into the existing lake system. There are 8 lakes all together in the Taman Tasik UTP Master Concept Plan approved by the UTP Board. In this study, only one lake is taken into account. The purpose of the UTP Concept Plan is to reduce the maintenance cost for the main drain and minimise land for construction of the main drain.

The diversion of surface runoff into a lake resulted in concern over potential poor water quality in the lake more so with the development of the Mosque. One of the purpose of this project is to carry out a lake water quality study for the lake to assess the extent of pollutant and to identify and recommend a feasible water pollution control scheme. In addition, this also enables the lakes to be utilised for peak flow attenuation as required by JPS.

1.2 Problem Statement

Flooding in urban areas after heavy rainfall events is very common in Malaysia. One of the ways in controlling the flood is by retaining the water in wetland. However, even though the wetland has achieved the purpose of controling flood, the criteria of ecological system in the wetland has often been mistreated. Wetlands, are supposed to have a functional perspective, namely as a place where anaerobic process occur, and plants are adapted specially for living in saturated conditions. Wetlands also need to be designed properly so they can achieve the specified parameter, on water quality for ecosystem and water quantity to control flood. The design of the wetland must meet the requirement set by the JPS (Jabatan Pengairan Saliran) and maintain the ecology of the wetland system. Flora and fauna is one of the important aspects to focus on.

1.3 Objective of Study

The main objective of the project is to revise the design of the wetland so that it meets the objective of flood control and ecological purpose. It is to create a more systematic system to make the engineered wetland not only to attach important to flood control, but also ecological as well.

A detail study will be conducted on the catchment area of the wetland and the maximum volume of water that can be contained in the wetland. One of the objectives of the study is to come out with a design for the hydrological control of the lake near the UTP mosque.

The study will also research on water quality for constructed wetland that have the potential for stormwater treatment. The main objectives of this study are

a) This project will examine the use of engineered wetland as stormwater control in terms of the flow and water quality. The water quality will focus on mainly suspended solids.

b) To evaluate the currently recommended procedures for estimating engineered wetland water balance under tropical climate.

1.4 Scope of Work

This study consists of catchment analysis and the water quality investigation, lake water quality and the planning of pollution control wetlands. The targeted water quality in the lake is the Class IIB standard (Appendix 1) of the Department of Environment (DOE). The scope of the study includes:-

- Collection and review of data
- Site inspection and assessment of water quality sampling locations
- Water quality analysis (Inclusive of Turbidity, TSS, pH, Jar Test and etc)
- Assessment of the catchment water quality characteristic and identification of pollution types and sources

Based on the manual by JPS, design of wetlands requires data on

- Catchment area;
- Hydrology of inflows;
- Survey details, including depths of existing ponds;
- Hydraulic conditions at the outlet, which may create tailwater;
- Estimates of sediment loads and other pollutant loads from the catchment; Chemical analysis of the existing pond water and sediment, if there is risk of chemical contamination.

Chapter 2

LITERATURE REVIEW AND THEORY

2.1 Wetland

Natural wetland can be divided into four general categories-marshes, swamps, bogs, and fens. Marshes are wetlands dominated by soft-stemmed vegetation, while swamps have mostly woody plants. Bogs are freshwater wetlands, often formed in old glacial lakes, characterized by spongy peat deposits, evergreen trees and shrubs, and a floor covered by a thick carpet of sphagnum moss. Fens are freshwater peat-forming wetlands covered mostly by grasses, sedges, reeds and wildflowers *(US EPA, 2005).*

Wetland provide habitat for thousands of species of aquatic and terrestrial plants and animals. Although wetlands are best known for being home to water lilies, turtles, frogs, snakes, alligators and crocodiles, they also provide important habitat for waterfowl, fish and mammals. Migrating birds use wetlands to rest and feed during their cross-continental journeys and as nesting sites when they are at home. As a result, wetland loss has a serious impact on these species *(Donald M.Kent, 2000).*

Wetland do more than provide habitat for plants and animals in the watershed. When rivers overflow, wetlands help to absorb and slow floodwaters. This ability to control floods can alleviate property damage and loss and can even save lives. Wetlands also absorb excess nutrients, sediment and other pollutants before they reach rivers, lakes and other waterbodies. They are great spots for fishing, canoeing, hiking and bird-watching, and they make wonderful outdoor classrooms for people for all ages.

Despite all the benefits provided by wetlands, our world is losing wetland due to the advance of construction. In United State, each year they lose about 60,000 acres of wetlands*(US EPA, 2005).* The runoff that wetlands help to clean can overload and contaminate these fragile ecosystems. In addition, non native species of plants and animals and global climate change contribute to wetland loss and degradation.

In short, natural wetland should be conserve, restore and monitor. Certain regulation must be enforced to protect the wetlands. Environment standards should be established for reviewing permits for discharges that affect wetlands, such as residential development, roads, and levees.

In addition to providing regulatory protection for wetland, local governments, the private sector and citizen organization to monitor, protect and restore these valuable habitats. More wetland should be constructed to treat storm water and sewage, but the point is how many of the wetlands can maintain the ecosystem? This vision will only be succeeded with the coordination and cooperation from all parties, from local government to every one human being.

2.2 Constructed Wetland

Constructed wetland system incorporates the natural function of wetland to aid pollutant removal from stormwater. Constructed wetlands can also to certain extent, remove suspended solids particularly for frequent events, by the provision of storage above the permanent pool water level. Constructed wetland is particularly appropriate in area where there is higher groundwater level as the availability continuous supply of water necessary to sustain the wetland system. A wetland is designed to develop dense wetland vegetation and with sufficient retention time to effectively treat the stormwaters *(Urbronas & Strecher, 1996).* Constructed wetland can be defined as an engineered system designed to simulate natural wetland to exploit the water purification functional value for human use and benefit *(Sidek, 2001; Hammer, 1986).* Constructed wetland consists of former upland environment that have been modified to create poorly drained soil and wetland's flora and fauna for primary purpose of contaminant or pollutant removal from wastewater or runoff.

Constructed wetland for the water treatment, normally can be divided into two categories which consist of Subsurface Flow System and Free Water Surface System. The Subsurface Flow System (SF) consists of permeable medium with a porous substrate of rock and gravel. This system is also known as root-zone system, rock feed filter and vegetated submerged bed system. The Subsurface Flow System used the gravel to ensure better porosity with the depth typically ranging between 0.3-0.6m. This system is similar to Free Water Surface System but they may have difference water depths. A layer of lining is also used to ensure that there is no seepage. The advantages of Subsurface Flow

System are greater assimilation potential for pollutant removal per unit area and also for pest control. The disadvantages of Subsurface Flow system are more expensive to construct, higher cost for maintenance and repair, facing the problem of clogging and unintended surface flow.

The Free Water Surface (FWS) mimics the natural wetland with the water surface is exposed to the atmosphere. It also consists of shallow basin to support the vegetation and a shallow depth of water is maintained through its hydraulic control structure. The water depth can range from a few centimetres to 0.8m or more. A typical operating water depth is 0.3m. The basin normally contained a combination of gravel, clay or peat based soils and crushed rock that is planted with macrophytes. The advantage of FWS is a lower capital and operating cost and their construction, maintenance and also operation are straightforward. The main disadvantage of this system is that it required a larger land area compare to the other system.

Among the two types of constructed wetland, the frequent type that is normally constructed in Malaysia is Free Water Surface System (FWS) due to their advantages and in term of their construction cost. The constructed wetland (FWS) treatment system has been successfully used in Malaysia. For example the Putrajaya and Pandan Indah wetlands that were designed based on Free Water Surface System. The constructed wetland is designed to include not only water quality treatment aspect and also the other functions as flood storage, habitat for fish and wild life, active recreation, education, research and aesthetics enhancement *(Selamat, 2001).*

Research that have been done in mid-80's by Schueler on the used of constructed wetland for urban stormwater treatment, suggested that constructed wetland is able to improve the water quality of surface runoff. From the research on twenty stormwater wetland sites in the mid Atlantics region United State of America, showed that the long term pollutant removal rates were found to be 75% for total suspended solids, 45% of total phosphorus, 25% total nitrogen, 15% organics carbon, 75% lead and 50% zinc *(Schueler, 1992).* The results obtained from the monitoring Putrajaya Wetlands in Malaysia, indicate that the average water index is between 82 to 92 which is in the second category where the water status is good *(Selamat, 2001).*

2.3 JPS Requirement for Design of Wetland

Water quality control ponds ("wetland") can have both water quality control and flood control functions. It is economically advantageous to combine both functions in a single pond.

Wetlands must be protected be upstream sediment traps and gross pollutant traps or other devices to reduce sediment load. In general, Gross Pollutant Traps (GPT) is required for urban drains where there are a range of pollutants possibly including litter, oil and chemicals. Ponds receiving runoff from highways, parking areas or heavy industrial areas are particularly vulnerable. Proprietary traps may also be suitable for some applications *(Volume 13, Chapter 35.2).*

Sediment traps may be suitable for ponds that are being used as off-line flood storage and water quality control for rivers with mainly non-urban catchments. Sediment traps are to be designed to maximize deposition of coarse sediments.

Wetlands can have multiple uses *(Volume13, Chapter 35.2).* They provide:-

a) flood management – temporary flood storage to reduce downstream flow peaks;
b) water quality improvement – by sedimentation and natural biological processes;
c) landscape and recreational value;
d) Water supply – wetland water may be suitable for lawn watering, irrigation, landscaping work and other purposes.
e) Conservation- restoration or provision of habitats for flora and fauna.

Wetlands can be designed with a combination of deep and shallow water. The design concept involves three main zones in which different assimilation process dominate, and different designs conditions apply *(Volume 13, Chapter 35.3).*

a) Inlet Zone – The function of the inlet zone is to remove larger particles including sediment, and to distribute flow across the pond. The installation of sediment traps or Gross Pollutant Traps (GPT) helps in the function of this zone.
b) Macrophyte Zone – Macrophytes are large aquatic plants. Beds of macrophytes filter out finer particles, and directly take up contaminants. They enhance sedimentation and the absorption of pollutants onto sediments. The macrophyte zone can be provided around the wetland edges downstream of the main inlets to filter out sediment, nutrients and toxicants, to disperse the inflowing waters and to reduce its velocity. Macrophyte zones should be from 25-50% of the total wetland area. Planting should be on the perimeter, arranged so that there is opportunity for water in the open zone to circulate through the macrophyte zone.
c) Open Water Zone – An open water zone is a deeper area that allows time for fine particles to flocculate and settle to the bed. Decomposition and assimilation of organic matter will occur in this zone. Periodic algal growth may occur here and this will also trap dissolved nutrients and allow them to enter the food chain or to settle to the bed of the wetland. A minimum depth of 2.4m is recommended for open water zones by JPS.

There are only small changes in pond elevation, to drive flow over the outlet structures. Wet ponds therefore provide minimal flow attenuation. Issues that need to be considered when designing constructed wetlands include the following *(Volume 13, Chapter 35.3):*

a) Wetlands are mostly having limited depth, ranging from zero at the shore to 1.0m in the deepest areas. The average depth of the emergent vegetation zone is typically 0.5m.
b) The change in water level is usually small (less than 0.6m) as most wetland plants are not tolerant to greater changes. These figures are for the storm water quality design. Wetlands which are associated with ponds that are also used for flood control can tolerate submergence to depths between 1m and 2m, provided that velocities are low enough to avoid flattening and that the duration of submergence is not more than few hours.

c) Wetlands differ from ponds in having greater biological uptake. Well designed perennial wetlands intercept dissolved and colloidal forms of pollutants. The benthic biofilm adsorbs pollutants and transfer them to the sediments, while dissolved nutrients are primarily taken up by benthic and epiphytic algae. Adhesion of fine particles onto vegetative surfaces may also play a part in pollutant interception.

d) Although the water level changes are usually small, the large areas provide some volume for attenuation of small storm flows. In general, wetlands shall not be used for extreme flood attenuation due to the potential damage to the wetland plants.

e) Wetland areas may provide educational benefits and some passive recreational benefits. They can have a high visual appeal, and add to the natural landscape. Wetlands provide a good habitat for birds and fish. In all ponds and in wetlands in particular, mosquitoes are likely to be a concern of the public.

f) Wetland planting, establishment and maintenance is usually necessary and can be costly

2.4 Health and Safety

In is the requirement of the law that the owner of the wetland is responsible for ensuring that it does not cause any risk to public health or safety.

Mosquito-borne disease such as Dengue is a serious concern in tropical areas. In Malaysia, Dengue cases are at alarming rate recently. The Aedes mosquito, the source of the dengue fever across the country, has evolved into a super resistant menace. The eggs can survive for a long period in very harsh and tough conditions without water. Based on the findings by University Science Malaysia entomologist, Prof Abu Hassan Ahmad showed the eggs of the Aedes mosquito can withstand extremely dry conditions and they are able to survive in these conditions for up to six months *(The Star 13/10/2005, pg 3).*

To counter this issue in Malaysia, JPS has come out with some strategies to control the breeding of mosquito. Mosquito control strategies include *(Volume 13, Chapter 35.7):*

a) Interception of water borne rubbish which creates a mosquito breeding environment.

b) Selection of plants, which provide a breeding ground for predator insects, such as dragonflies that feed on mosquitoes.

c) Encouragement of fish breeding.

d) Shaping of wetlands to avoid stagnant areas with poor circulation.

e) Shaping of wetland edges to avoid trapping of water in depressions as the wetland water level changes.

f) Providing a mechanism to regulate water levels in order to disturb any breeding larvae

g) Selection and control of aquatic plants to avoid the creation of habitats favored for mosquito breeding.

The wetland itself can become a hazard to small children. The design of wetland should concentrate on avoiding serious safety hazards such as sudden drops into deep water. The slop of the wetland must not be too big. Wetlands can be a recreational area for small children, so it can be dangerous if it has a sudden drop into deep water. Besides that, sudden changes in flow velocities or water levels are not encouraged. Wetlands are encouraged to have some structures surrounding it, to prevent children from falling off.

Inlet and outlet structures can be particularly dangerous because of the high flow velocities. It may be desirable to fence off the inlet and outlet structures. However, such fencing should be designed so that it does not interfere with the hydraulics of the flow structure. *(Urban Stormwater Management Manual Volume 13, Chapter 35.7)*

2.5 Integrating Wetland with Ecological and Landscape Setting

The primary objective for engineered wetlands is to provide stormwater flow control and treatment. However, where possible the secondary benefits, such as landscape setting or habitat creation should be explored. It is important to note that sometimes the primary objective can compromise the ecological value as the impacts of catchment derived pollutants maybe deleterious to the wetland ecology*(Melbourne Water,2005)*.

If carefully designed there may be options to integrate the two objectives, for example, small off-line wetlands filled seasonally by direct rainfall and local catchments of open space can be provided adjacent to the main water quality treatment wetland. Such ephemeral wetlands can attenuate high pollutant loads from a storm event and provide breeding opportunity for species that are susceptible to predation from mosquito fish.

It should be noted that constructed waterbodies near an airport may be a concern to the airport authority due to the potential of attracting birds. Further information should be sought from the relevant airport and planning authority.

The following points can be considered in the design of constructed wetlands to maximise their landscape setting and ecological value within the constraints presented by their water quality treatment function*(Melbourne Water,2005)*.

- Retention, enhancement and interpretation of existing ecological, landscape and cultural values, such as trees and other native vegetation and sites of archeological significance should be considered. These are valuable assets that will be of interest to the local community and help to create a unique sense of place.
- Water bodies should be created that simulate important physical characteristics of natural wetlands such as shape, depth, edge gradients and wetting/drying cycles. The shaping and gradient of wetland edges are very important in creating good habitats for plant growth. Shallow edge gradients maximize the width of planting benches and also provide natural conditions when water levels draw down over summer.

- The use of locally indigenous species in wetland plantings ensures that plants are adapted to local environmental conditions and that the character of the wetland is 'in keeping' with the surrounding landscape.
- Creation of structural complexity in riparian and wetland vegetation is important for ecological diversity and landscape amenity. A range of plant life forms should be included in the planting schedule. These life forms include emergent, submerged and floating plants.
- Terrestrial planting of appropriate indigenous tree, shrub and groundcover species provide additional habitat requirements necessary for some wetland animals, such as nesting sites for birds and over-wintering shelter for frogs.
- Sensitive placement of paths, roads, power-lines and other infrastructure should be considered. Power-lines in particular pose a serious threat to water birds when they are taking off or landing. If a wetland must be placed near power-lines it should oriented to be parallel to them. Dense screening vegetation should be planted between the wetland and the power-lines to discourage birds from using this area as a flight path.
- The impact of domestic animals, especially dogs need to be managed. In habitat wetlands, unleashed dogs can have significant direct and indirect impacts on native wildlife. Fencing and/or regulatory signage may be required.

2.6 Wetlands and Flood Control

Wetlands can have multiple purposes. One of main purpose is for flood management. Wetland is temporary flood storage to reduce downstream flow peaks. It requires a good design for a wetland to meet the function of flood management. A general procedure to analysis and design a wetland is recommended as below:

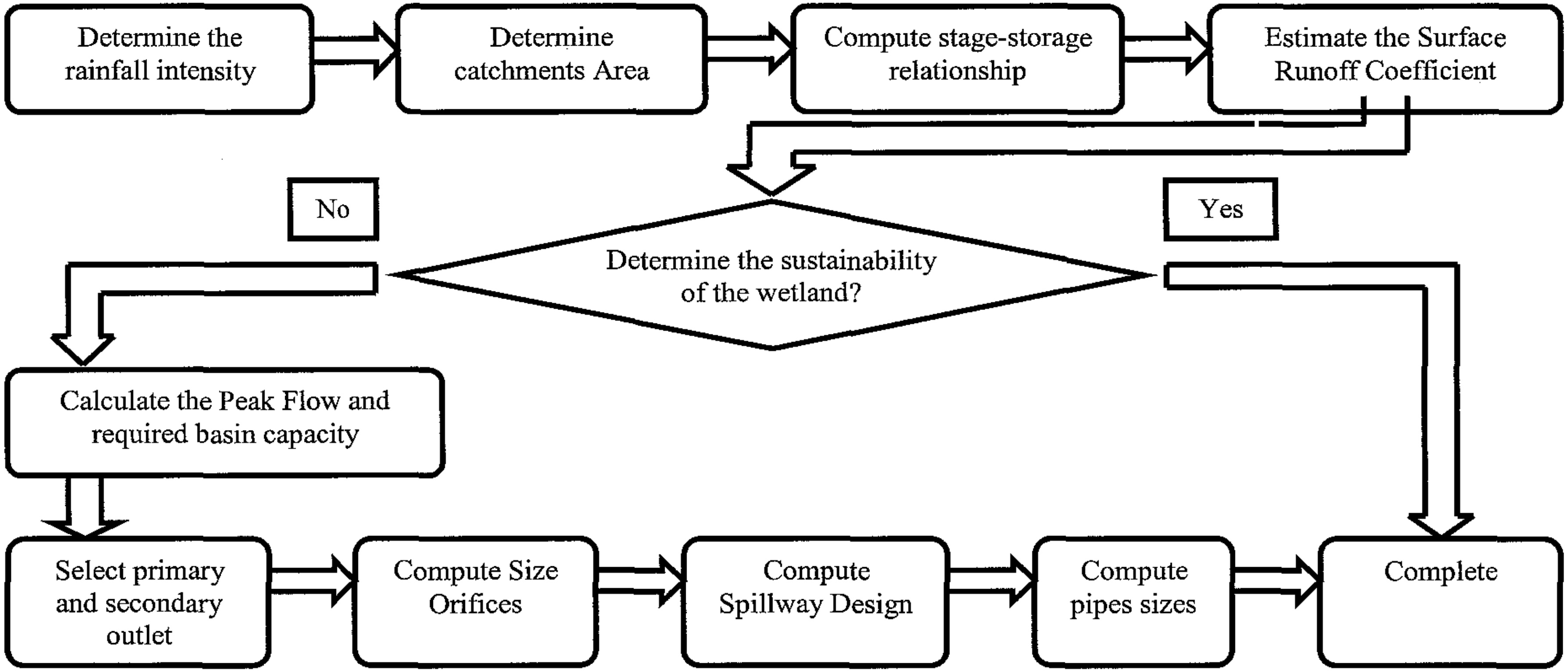


Figure 1 Procedure to Study and Design a Wetland for Flood Control

Chapter 3

3.0 Existing Lake Condition and Design Improvement

3.1 Catchment Area and Volume of Lake

Figure 3.1 shows a plan view of the existing lakes configuration, sequence of flow, normal water level (NWL) and bottom water level (BWL). Lake 1 is where this project is concern.

The catchment area boundary was determined on side by observing the contour of the area. The drainage system of UTP also gives some clues to determining the size of the catchment area. Total size of the catchment area is estimated to be 400000m^2. The estimation is based on some surveying work on site using total station and step counting method. This value is further justified by referring to the value provided by KLCC which is more or less the same 394900m^2.

The size of the wetland area is also determined using total station and step counting method. The estimated 35000m^2 is quite accurate as the information provided by KLCC is 3.4ha. The maximum water depth provided by KLCC is 2.9m depth. The Bottom Water Level is 20.0 RL m whereas the Highest Water Level of the water is 22.9 RL m. The average water depth of the wetland is around 2m.

Based on the different depth of the wetland at different storm event, a study has been done to estimate the total volume of water that the wetland can contain. Geometic survey has been done using theodolite, considering the topography of the area to identify the surface area of various depth for the wetland. The result of the survey is show in figure 1 and figure 2.

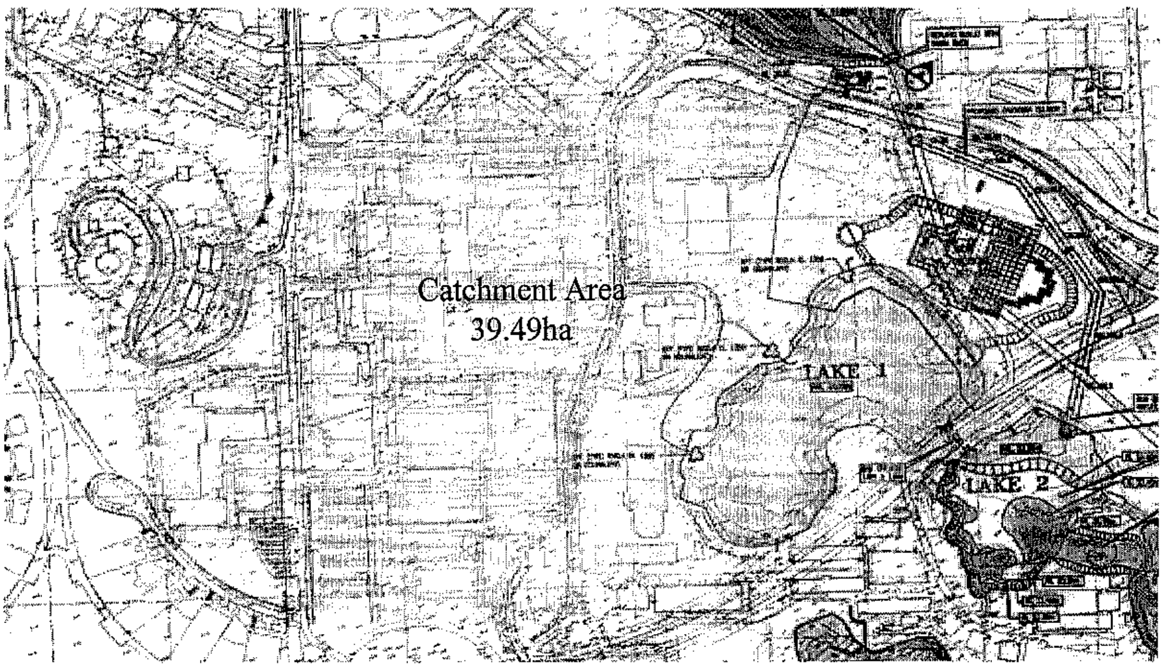


Figure 2 Catchment Area of Wetland

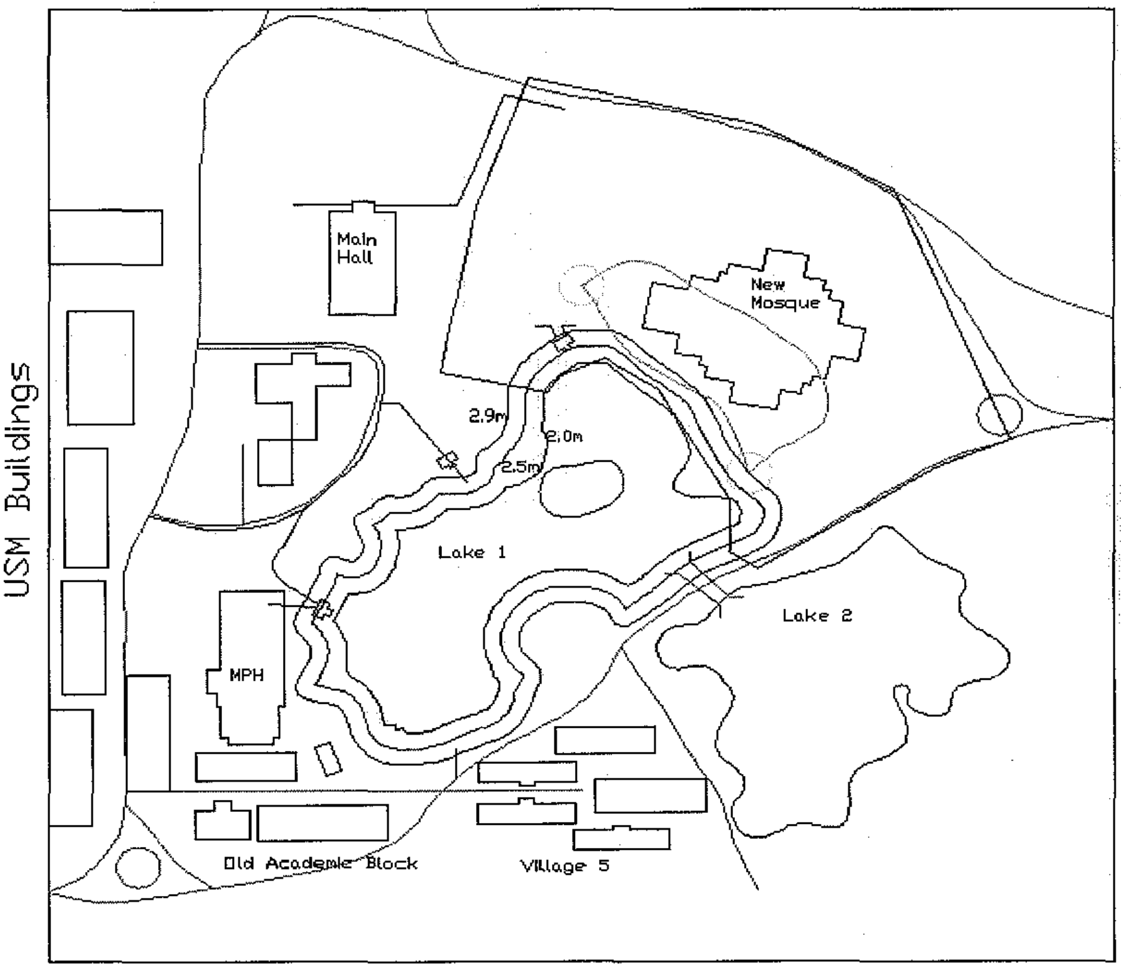


Figure 3: Layout of Wetland

Table 1: Surface Area of Wetland at Different Depth.

Depth of Wetland	Surface Area
2.9m	3.4 ha
2.5m	3.31ha
2.0m	3.25ha
1.5m	3.22ha

Based on the result obtain, total volume of water that contain in wetland based on different depth and surface area can be calculated. However, the topography of the wetland base has to be identified in order to get a more accurate result. Due to some limitation, the wetland is assume to be rectangular shape for this calculation. Result of calculation is show below:

For 2.9m, Top of water level 22.9 RL m, surface area is 3.4ha

Total Volume : 2.9m x 3.4ha x 10000 = 98600m^3

For 2.5m, water level 22.5 RL m, surface area 3.31ha

Total Volume : 2.5m x 3.31ha x 10000 = 77500m^3

For 2m, water level 22.0 RL m, surface area 3.25ha

Total Volume : 2m x 3.25ha x 10000 = 65000m^3

For 1m, water level 21.5 RL m, surface area 3.22ha

Total Volume : 1.5m x 3.22ha x 10000 = 48300m^3

The result shows that minimum water that contain in the wetland is 65000m^3 and the maximum volume is 98600m^3. The allowable fluctuation of water is around 35600m^3. However, the accuracy of the result is doubted as it can only give a rough guideline of the volume that contain in the wetland. Further study has been done to identify the peak flow of the wetland and minimum storage volume that the wetland should have.

Table 2: Catchment Area and Runoff Coefficient in UTP Boundary

Item	Catchments	Area (ha)	Inflow Hydrograph	Runoff Coefficient	Land Use	
					Pre Development	Post Development
1	A1	159.34	1	0.35	Undeveloped	Undeveloped
2	A2	75.70	1	0.75	Undeveloped	Developed
3	A3	39.49	3	0.75	Undeveloped	Developed
4	A4	73.92	2	0.75	Undeveloped	Developed
5	A5	42.65	4	0.55	Undeveloped	Developed
6	A6	17.05	5	0.35	Undeveloped	Developed
7	A7	11.81	5	0.35	Undeveloped	Developed
	Total	419.96				

Refer to the table, we can estimate the total catchment area of UTP boundary. Different Sub-catchment will have different inflow hydrograph and runoff coefficient based on the land usage. However, our focus will only at catchment A3, where the wetland is located. Refer to the Table of Catchments Area and Runoff Coefficient; table of Intensity – Duration – Frequency relationship for Ipoh, the peak flow can be determined from the result above:

3.2 Peak Flow

Calculation for Qp (peak flow);

Qp = KCIA,

Qp = peak flow volume in ft^3/s or m^3/s

K = K is 1.0 in U.S, customary units 0.28 for SI units

C = runoff coefficient

I = average rainfall intensity in in/hr or mm/hr (0.129 m/hr in Ipoh) *Refer Appendix*

A = Area of the concern area in acres or km^2

Example for ARI = 100yrs and rainfall duration is 1 hour or 60 minutes, for coefficient for catchment area A3 = 0.75, catchment area = 39.49ha:

Qp = 0.28 (0.75) (0.129m/hr) ($3.949 \times 10^5 m^2$)

Qp = $10697.841 m^3/hr$

= $2.97\ m^3/s$

The peak flow into the wetland at catchment area A3 is calculated to be $2.97m^3/s$ for rainfall duration of 60minutes. Peak flow value might vary with different rainfall duration. As a result, a series of peak flow is calculated and illustrated in the table below based on different rainfall duration within an hour.

Table 3: Peak flow for return period 100 years with different rainfall duration

Item	Area (ha)	Runoff Coefficient	T, Duration (minutes)	Intensity (m/hr)	Qp, m^3/s (peak flow volume)
1	39.49	0.75	10	0.339	7.81
2	39.49	0.75	20	0.242	5.57
3	39.49	0.75	30	0.195	4.50
4	39.49	0.75	40	0.165	3.80
5	39.49	0.75	50	0.145	3.34
6	39.49	0.75	60	0.129	2.97

The total area is 14.17 ha. Assume that the wetland can reduce the peak flow by 30%. The peak flow volume is $4.5 m^3/s$, (Refer to table 3)

Assume $Tp = 30min$

$Tb = 22.5min$

$$Vs/Vtr = 1.291 \times \frac{(1 - Qo/Qi)^{0.153}}{(Ti/Tp)^{0.411}}$$

Vs = storage volume

Vr = runoff volume

Q_0 = peak outflow = ($0.7 \times 4.5 = 3.15 m^3/s$)

Q_i = peak inflow = $4.5 m^3/s$

t_b = base time of the inflow hydrograph = 29.25minutes

t_p = the time to the peak of the inflow hydrograph = 15minutes

$Vr = 0.5(t_b)(Q_P)$

$= 0.5 \times (29.25 \times 60) \times 4.5$

$= 3948.75 m^3$

$(Vs/Vr) = (1.29(1-(1.127/1.61))^{\wedge 0.153}) / (29.25/15)^{\wedge 0.411}$

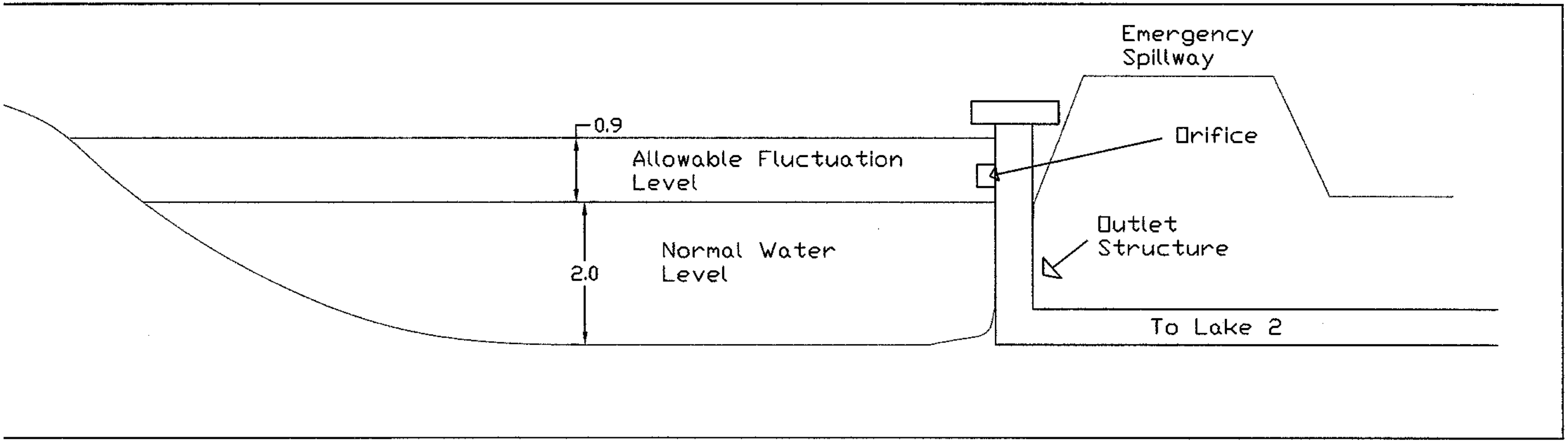
$= 1.073 / 1.316$

$= 0.815$

$Vs = 0.815 \times 3948.75$

$= 3218 m^3$

Based on the calculation above, the minimum storage volume of the wetland should be at least $3218 m^3$. The result show that the actual volume of the wetland which is $35600m^3$ (calculated in section 3.1) is greater than the minimum storage required of the wetland. In other word, the wetland is sufficiently enough to retain water that goes into it meet the flood control requirement.



PROPOSED WETLAND OUTLET STRUCTURE

3.3 Proposed Design for Outlet

Outlet structures are designed to release controlled volumes of water from the wetland into the downstream. This structure is divided to 2 parts which is the primary outlet and secondary outlet. Primary outlet will be design for water to flow through the orifice. Secondary outlet will allow water to discharge through a emergency spillway.

Based on the calculation in section 3.1, the maximum depth of the wetland is 2.9m and the average depth is 2m. The allowable fluctuation of water level is 0.9m.

The peak inflow is $4.5m^3/s$. The outlet is designed using flow through orifice and spillway. When peak flow occurs, period to fill up the wetland is estimated based on different outflow rate.

Estimated allowable fluctuation for volume of water : $0.9m \times 34000m^2 = 30600m^3$

Period to fill up the wetland without outflow : $30600m^3 / 4.5m^3/s = 6800s$

$= 1.9$ hrs

Proposed flow through the Outlet $2.5m^3/s$

Amount of water that will remain in wetland $4.5\ m^3/s - 2.5\ m^3/s = 2\ m^3/s$

Period to fill up the wetland with inflow of $2\ m^3/s$: $30600m^3 / 2\ m^3/s = 15300s$

$= 4.25$ hours

Proposed flow through the Outlet $3m^3/s$

Amount of water that will remain in wetland : $4.5\ m^3/s - 3\ m^3/s = 1.5\ m^3/s$

Period to fill up the wetland with inflow of $1.5m^3/s$: $30600m^3 / 1.5m^3/s = 20400s$

$= 5.67$ hours

Proposed flow through the Outlet $3.5\ m^3/s$

Amount of water that will remain in wetland : $4.5\ m^3/s - 3.5\ m^3/s = 1\ m^3/s$

Period to fill up the wetland with inflow of $1m^3/s$: $30600m^3 / 1m^3/s = 30600s$

$= 8.5$ hours

Proposed flow through the Outlet $4m^3/s$

Amount of water that will remain in wetland : $4.5\ m^3/s - 4.0\ m^3/s = 0.5\ m^3/s$

Period to fill up the wetland with inflow of $0.5m^3/s$: $30600m^3 / 0.5m^3/s = 61200s$

$= 17$ hours

Table 4: Time taken to fill up the wetland during peak flow using different outlet design

Outflow Rate	Flow remain in wetland	Period to fill up the wetland
Without outflow	$4.5m^3/s$	1.90 hours
$2.5\ m^3/s$	$2\ m^3/s$	4.25 hours
$3\ m^3/s$	$1.5\ m^3/s$	5.67 hours
$3.5\ m^3/s$	$1\ m^3/s$	8.50 hours
$4\ m^3/s$	$0.5\ m^3/s$	17.0 hours

3.4 Base Flow

Vee notch weir

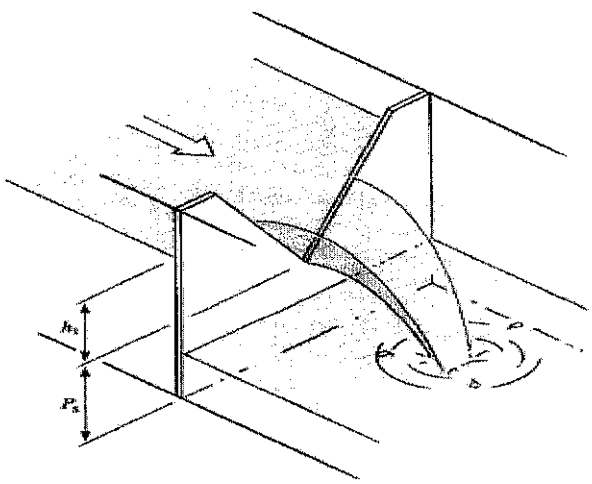


Figure 4: V-Notch Weir

A study was conducted on site to understand the base flow rate of the wetland. A Vee notch weir was constructed by using polystyrene box. The angle of the weir was set to be 90 degrees. Using the weir, the height of the water was determined during dry days. Calculation of the base flow was done from this measurement.

The experiment has been conducted 3 times to obtain the average value. The result of the experiment is as follow:

Table 5 : Result of V-notch Weir Experiment

Experiment / day	Weather	Height of water, H (meter)
1. 21-3-2006	Clear	0.23
2. 22-3-2006	Clear	0.24
3. 23-3-2006	Rain (Ignore)	-
4. 24-3-2006	Clear	0.28

The average of the height (**h**) of water indicated by the weir is 0.25m. This value is taken as the low flow of the wetland. Experiment 3 is ignored as the result does not indicate the low flow of the wetland. The average flow rate for the low flow can be calculated using the formula given below:

$Q = 8/15 \times (2g)^{1/2} \times \tan(\theta/2) \times h^{5/2}$

Q = base flow of wetland (m^3/s)

G = Gravitational force ($9.81 m^2/s$)

θ = Angle of weir

h = Height of water indicated at weir (m)

$Q = 8/15 \times (2g)^{1/2} \times \tan(\theta/2) \times h^{5/2}$

$Q = 8/15 \times (2 \times 9.81)^{1/2} \times \tan(90/2) \times 0.25^{5/2}$

$Q = 0.533 \times 4.43 \times 1 \times 0.031$

Q = 0.074 m^3/s

From the result, base flow rate of the wetland was calculated to be $0.074 m^3/s$.

3.5 PRIMARY DESIGN - Orifice Design

In this design, base flow was used, for the design of orifice. Three orifices will be proposed for the outlet structure arranged vertically with spacing between the orifice around 0.12m. Using this concept, outflow rate can be determined by observing water flowing through how many orifices.

$Q = Cc \times A \times (2gh)^{1/2}$

Q is the flowrate, Cc is the Coefficient of Contraction, assume to be 0.62 for pipe diameter more than 50mm. A is the area, g is the gravitational force and h is the fluctuation height. The require flow rate, Q is $0.074m^3/s$ base on the result of section 3.4. Each orifice will be design to the capacity of $0.074m^3/s$.

$Q \quad = Cc \times A \times (2gh)^{1/2}$

$0.074 \quad = 0.62 \times A \times (2 \times 9.81 \times 0.9)^{1/2}$

$A \quad = 0.028m^2$

$\Pi d^2/4 \quad = 0.028m^2$

$d \quad = 0.19m$

The diameter for each orifice is designed to be 0.19m. The discharge rate from the orifice can be determined by observing how many orifices is flow through with water.

Energy Equation

Energy equation is used to determine the minimum diameter pipeline for the outlet structure that can withstand the pressure and velocity of the flow through water from the orifices. The equation is as follow:

$P_1/Pg + V_1^2/ 2g + Z_1 = P_2/Pg + V_2^2/ 2g + Z_2 +$

Where $P_{1/2}$ = Pressure at point 1 and point 2

Pg = density of fluid

$V_{1/2}$ = Velocity at point 1 and point 2

$Z_{1/2}$ = Height of point 1 and point 2

h_f = minor lost (friction)

For this calculation, we will set 2 point for our studies, which will be the highest point of the wetland and the lowest point at the outlet of the pipe. P_1 and V_1 will be 0 as it is located at open channel. Z_1 will be 2.9m. P_2 and Z_2 will be 0, but V_2 will be the unknown. h_f is the frictional lost of the outlet pipe. Assume h_f as 0.3.

$2.9 = V_2^2 / 2(9.81) + 0.3$

$V_2 = 7.54 m^3/s$

$Q = AV$

$0.032 = \Pi d^2/4 \times 7.54$

$d = 0.15m$

Based on the result, the minimum diameter of pipe is 0.15m.

3.6 Pipeline Design

The water flow out through orifice will pass through a pipeline and into a downstream. The pipeline design is essential as it can determine continuous outflow of the outlet. Pipeline design is based on the *Charts for the Hydraulic Design of Channels and Pipes (Chadwick and Morfett, 1998)*. Three dependant engineering variables (flow rate, Hydraulic gradient and Diameter) are required.

Flow rate, $Q = 0.74 \times 3 m^3/s = 0.222 m^3/s = 222 l/s$

Proposed Hydraulic Gradient, $S_f = 1/100$

$100S_f = 1$

From the chart, D = 0.38m.

Based on the result from the energy equation and Hydraulic Design chart, the pipe diameter recommended for this outlet is 0.38m.

3.7 SECONDARY DESIGN - Spillway Design

The purpose of a secondary outlet (emergency spillway) is to provide a controlled overflow for flows in excess of the maximum design storm Average Return Interval (ARI) for the storage facility. The emergency spillway is proportioned to pass flows in excess of the design flood without allowing overtopping of the embankment. Flow in the emergency spill way is open channel flow. Assume that the critical depth occurs at the control section. Calculation of spillway design is as below:

100 years return period peak flow	= 4.5 m^3/s
Base flow taken by orifice	= 0.074 m^3/s
Flow Rate to be manage	= 4.5 – 0.074
	= 4.426 m^3/s

$Q = CbH^{3/2}$

Typically spillway design, $1.6 < C < 2.3$

Assume the width of the spillway is b = 2.5m, and C = 1.6

$Q = CbH^{3/2}$

$4.426 = 1.6 \times 2.5 \times H^{3/2}$

$H^{3/2} = 1.107m$

$H = 1.16\ m$

Therefore, the height of the spillway will be 1.16m and the width will be 2.5m.

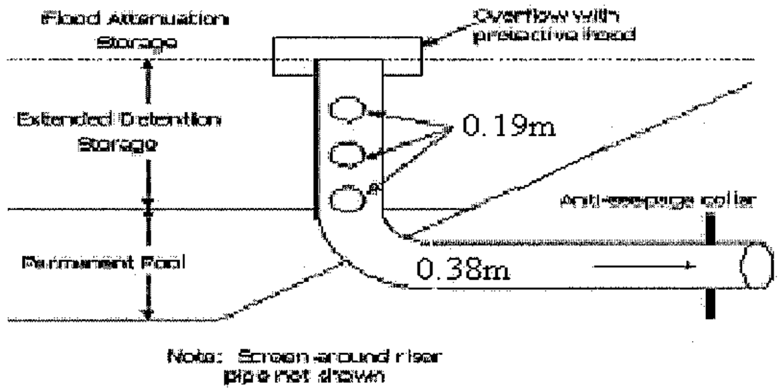


Figure 5: Orifice Design

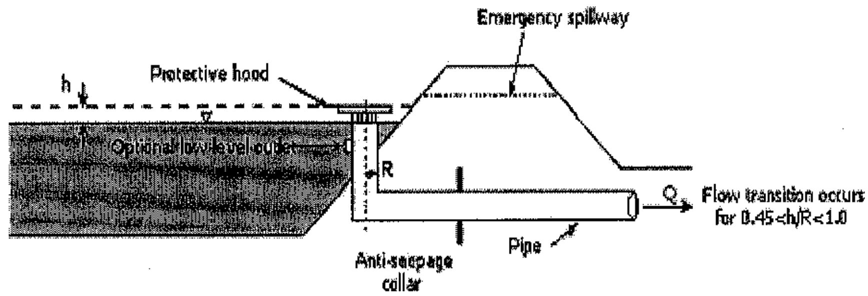


Figure 6: Outlet Design with Emergency Spillway

CHAPTER 4

4.0 Water Quality and Water Treatment

4.1 Objective

a) General

As part of the UTP redevelopment, the existing lakes are to be rehabilitated to provide for public amenity, recreational and aesthetic usage. For this purpose it is essential that the lake water quality be of acceptable standards.

The issue of water quality needs to be considered from the following aspects:

- Aesthetic. This shall consider the turbidity, nutrient concentrations (the potential impact on algal bloom), and pollution from solid waste (especially those of the floatable types)
- Odours. Sources of odours from decaying biomass and deoxygenated lakes sediments.
- Public Health issue. This relates to bacterial population in the water.

b) Interim National Water Quality Standards

Under the Department of Environment's (DOE) Interim National Water Quality Standards for fresh surface water, 5 classification of water is proposed *(KLCC, 2004)*. They are:

- Class I - Conservation of natural environment water supply I (practically no treatment is necessary)
  - Fishery I - very sensitive aquatic species
- Class IIA - water supply II - conventional treatment required
  - Fishery II - sensitive aquatic species
- Class IIB - Recreational use with body contact
- Class III - Water Supply III - Extensive treatment required
  - Fishery III - common economic value and tolerant species livestock drinking

- Class IV - Irrigation
- Class V - none of the above

The full list of parameters and their limits for each class of water quality is provided in Appendix

The target water quality of the lakes should ideally be Class IIB i.e. suitable for body contact. Principal features of this class of water is as follows:

1. No visible floatable materials or debris
2. No objectionable odour and taste
3. Relatively low suspended solids (50mg/l), turbidity (50NTU)
4. Modest oxygen demand as measured by BOD (3mg/l) and COD (25mg/l)
5. Bacterial contamination of less than 5000 MPN/ 100ml
6. Ammoniacal nitrogen less than 0.3 mg/l

4.2 Water Quality Management Strategy

a) General

In order to ensure a long-term self sustaining and healthy lake system for UTP a controlled strategy of managing surface drainage and wastewater within the drainage catchment is required. An interview was conducted with the staff of KLCC to discuss on this issue. Some of the recommendation and strategies has been highlighted by the KLCC staff. Key aspects of this strategy include the followings (*KLCC 2004*):

1) Control of drainage because many drainage outlets are diverted into the wetland.
2) Management of landscaping and irrigation activities such that fertilizers and pesticides do not enter the surface drains that flow to the lake.
3) Management of lake activities such as recreation, boating, etc.

4.3 Recommendation for Inflow Structure

Constructed wetland system have been the most common treatment measure used to reduce concentrations of fine particulate and dissolve pollutants, they should be considered as one component within a treatment of water sensitive urban design option. In many situations, they are not the most cost effective method of mitigating stormwater pollution.

Consideration must be given to ease of maintenance with allowance for access to ponds and structures when laying out the wetland system. The wetland system should be able to be taken offline to enable critical maintenance actives. Figure 7 provide a conceptual design of a wetland system indicating the main elements in their order.

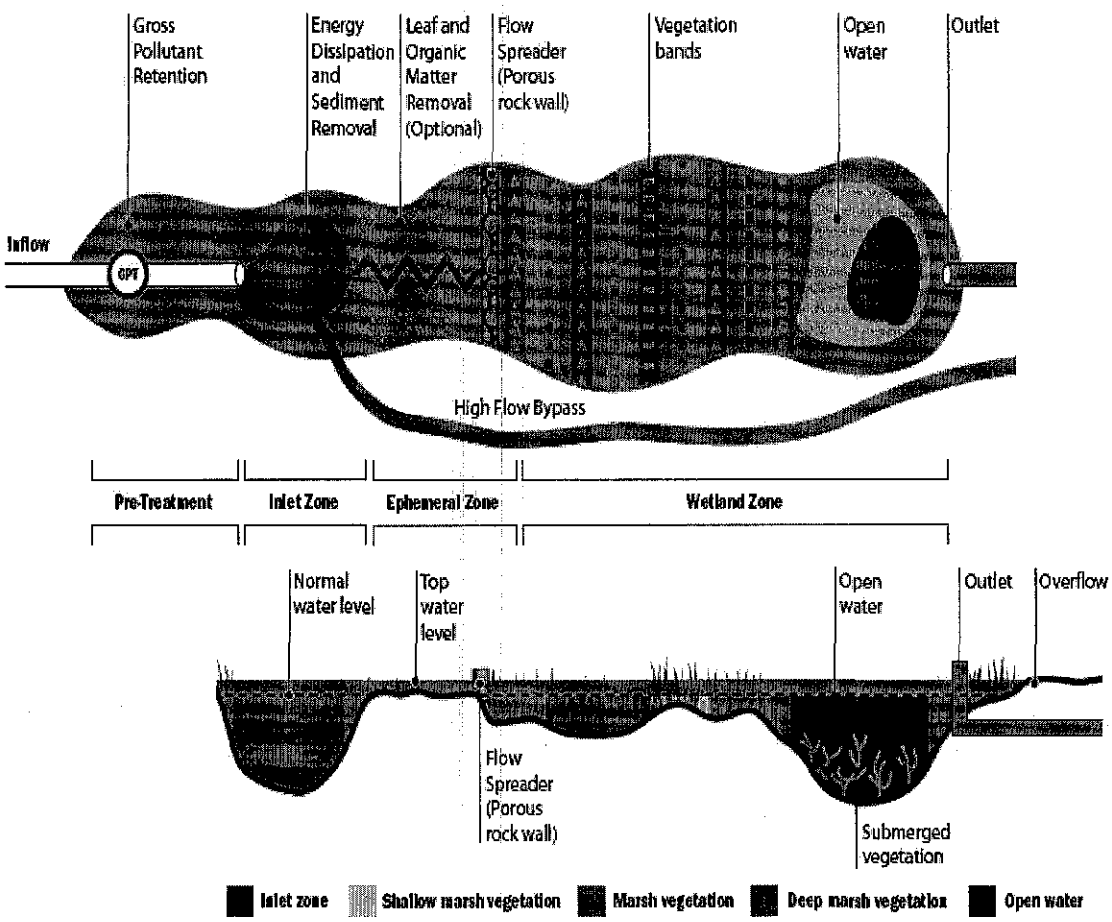


Figure 7: Recommended Engineered Wetland

Pre-Treatment Zone (Solid waste trap)

To minimize the onerous task of removing litter from vegetation throughout the wetland, a litter trapping capability is required upstream of the wetland. The intention of the litter trap is to remove litter and coarse organic matter from inflows to allow simple collection by maintenance crews. By having the traps, the solid sediment that go into the wetland will be greatly reduce and minimize the contamination of water.

Inlet Zone

Coarse sediment and excessive velocities can damage, smother or dislodge sensitive wetland vegetation. Sediment trap is recommended for the purpose of removing coarse sediment. The inlet zone pond can also be used as the pre-treatment coarse sediment trap. Regardless of which method, it is recommended that 95% of all suspended sediment down to a particle size of at least 125μm shall be removed for peak design flows.

Ephemeral Zone (leaf/organic matter trap)

An ephemeral marsh leaf trap may be considered to trap leaf and other organic material prior to entering the wetland zone where the litter trap device cannot meet the design flow. Ephemeral zones may be more useful in areas where significant carbon loads such as residential catchments with established deciduous tress. The ephemeral zone enhances the likelihood of the aerobic decomposition of organic matter in the wetland. This zone can reduce the leaf and organic matter to goes into the wetland.

Wetland Zone

The wetland zone is where the water will retain in. The wetland is design properly to ensure no small reservoir in the wetland to allow breeding habitat for mosquitoes. Wetland vegetation and animals is introduced in this zone.

4.4 Water Quality Test

JAR test

Jar test was conducted of determining the optimum coagulant dosage and operating pH for given water sample. The pH of several water samples was adjusted to pre-selected value. Coagulation reactions and the initial particle aggregation occur under slow mixing where particles grow through flocculation process.

pH

The pH test was taken for each of the samples. The required standard for class IIB for the pH test result should between 5 and 9. However, pH level near neutral is desirable. That means, the optimum pH should be around near 7. For adjusting pH, sodium hydroxide was recommended. However, other common chemicals can be used- such as soda ash and lime. For some applications magnesium hydroxide is an effective agent.

Turbidity

Turbidity is a measure of the suspended matter that interferes with the passage of the light through water. Thus, the factors that affect the scattering of the light would affect its measurement. The influencing factors might include

- The number, size and shape of the particles
- Refractive index of the particles
- Wavelength of the incident ray from the instrument
- Characteristic and quality of the measuring device

The standard value for turbidity for Class IIB as recommended by JPS is below 50NTU.

JAR Test Equipment

Jar test was conducting using 1000ml beaker, Hydro lab multi tester, stopwatch/timer, syringes, pH meter, Turbid meter, Distill water, Alum (Aluminium Sulfate with concentration of 30%), Sodium Hydroxide (10% of concentration) and water samples from the site of the wetland.

Procedure

1. 6 samples of water were taken from different location of the lake, The water samples were transferred into 1000ml beaker and label it.
2. The turbidity, pH and colour of the water samples were measured by using the hydro lab multi testing.
3. The sample were mixed at a high speed of 100rpm
4. 2ml of Alum of 30% concentration were added to each of the water sameple.
5. Sodium Hydroxide was added to each of the sample while mixing. Volume of the Sodium Hydroxide in each sample is vary from 0.5ml to 2.5ml. One sample was kept blank without adding in Sodium Hydroxide
6. The speed was reduced to 40rpm for 10minutes to allow flocculation process.
7. Stop the stirrer and allows the flock to settle for not more than 30 minutes.
8. The pH, turbidity and colour of the samples were taken again. Special care was observed to collect the sample free from floating and settle flock.
9. Plot the graph of Turbidity vs pH and the optimum pH was obtained from the lowest point in the plotted graph.
10. Repeat the experiment by adding in the optimum dosage of Sodium Hydroxide for each of the samples and varies the Alum dosage from 1ml – 5ml.
11. Plot the graph of Turbidity vs Alum Dosage. Obtain the optimum Alum Dosage from the graph
12. Repeat the experiment for 3 times to obtain a more accurate result.

Result

Before coagulation and flocculation process:

Table 6: Water quality result before coagulation and flocculation process

Sample	**pH**	**Turbidity**	**TSS**	**Colour**
1	6.87	85	72.8	White Brown
2	6.59	87	74.8	White Brown
3	6.78	90	80.9	White Brown
4	6.35	75	65.8	White Brown
5	6.82	85	74	White Brown
6	6.68	88	81	White Brown

Experiment One

a) Fixed the dose 2ml of Alum and vary the Sodium Hydroxide (concentration 10%)

Table 7: Jar Test Result 1

Alkaline	pH	NTU	TSS
blank	4.9	36	33.6
0.5ml Sodium Hydroxide	5.8	25	20.2
1ml Sodium Hydroxide	6.7	12	8.5
1.5ml Sodium Hydroxide	7.5	19	16.2
2ml Sodium Hydroxide	8.0	28	25.3
2.5ml Sodium Hydroxide	8.4	40	34.6

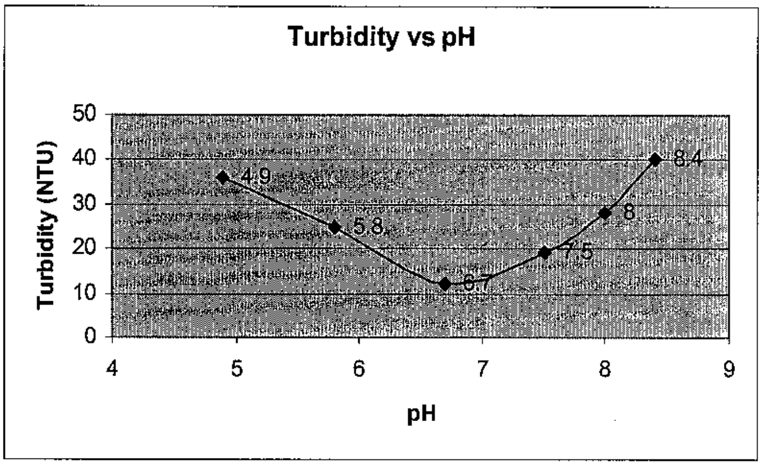


Figure 8: Jar Test Result 1(Turbidity vs pH)

b) Vary the volume of alum with a constant 1ml of Sodium Hydroxide (concentration 10%). Constant pH value of 6.7 was used in the experiment.

Table 8: Jar Test Result 1 (Volume of Alum vs Turbidity)

Volume of Alum	NTU
1	20
2	12
3	25
4	30
5	35

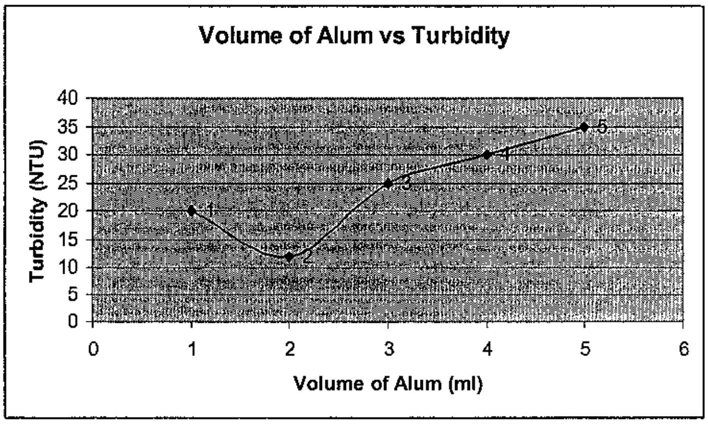


Figure 9: Jar Test Result 1(Volume of Alum vs Turbidity)

Experiment Two

a) Fixed the dose 2ml of Alum and varies the Sodium Hydroxide (concentration 10%)

Table 9: Jar Test Result 2

Alkaline	pH	NTU	TSS
blank	5.2	39	34.5
0.5ml Sodium Hydroxide	6.0	25	20.2
1ml Sodium Hydroxide	6.7	17	8.5
1.5ml Sodium Hydroxide	7.4	26	16.2
2ml Sodium Hydroxide	8.1	33	25.3
2.5ml Sodium Hydroxide	8.5	36	34.6

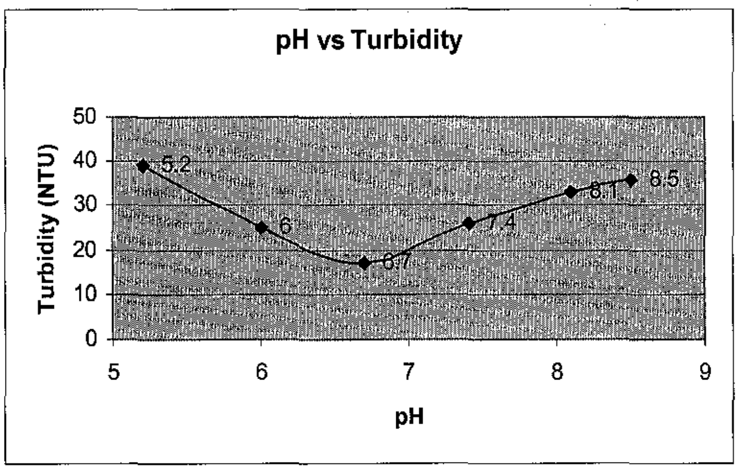


Figure 10: Jar Test Result 2 (pH vs Turbidity)

b) Varies the volume of alum with a constant 1ml of Sodium Hydroxide (concentration 10%). Constant pH value 6.7 was used in the experiment.

Table 10: Jar Test Result 2 (Volume of Alum vs Turbidity)

Volume of Alum	NTU
0.5	28
1	20
1.5	17
2	12
2.5	19
3.0	26

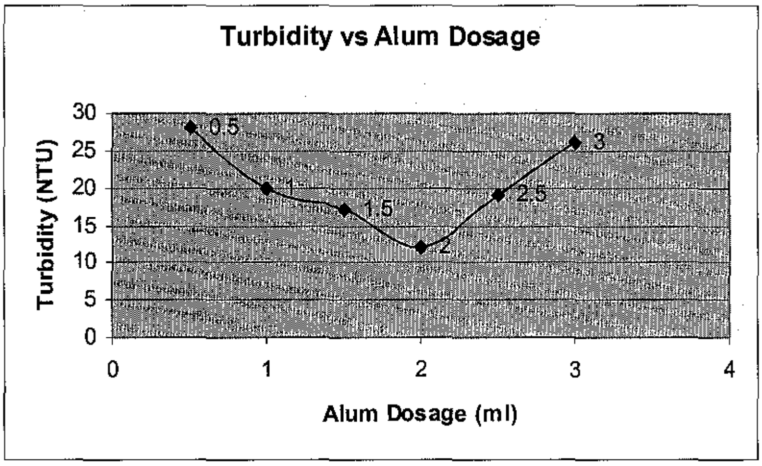


Figure 11: Jar Test Result 2 (Volume of Alum vs Turbidity)

Experiment Three

a) Fixed the dose 2ml of Alum and varies the Sodium Hydroxide (concentration 10%)

Table 11: Jar Test Result 3

Alkaline	pH	NTU	TSS
blank	4.8	42	38
0.5ml Sodium Hydroxide	5.5	31	27
1ml Sodium Hydroxide	6.3	24	16
1.5ml Sodium Hydroxide	7.1	11	8.1
2ml Sodium Hydroxide	7.8	18	16.5
2.5ml Sodium Hydroxide	8.7	28	26

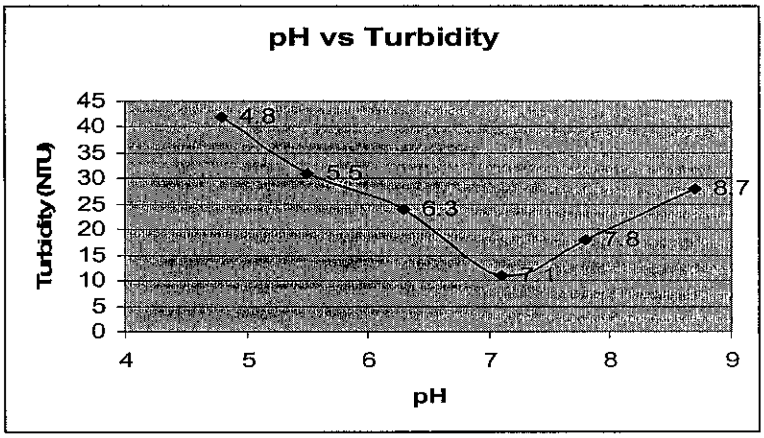


Figure 12: Jar Test Result 3 (pH vs Turbidity)

b) Varies the volume of alum with a constant 1ml of Sodium Hydroxide (concentration 10%). Constant pH value 7.1 was used in the experiment.

Table 12: Jar Test Result 3(Volume of Alum vs Turbidity)

Volume of Alum	NTU
1.8	16
1.9	13
2.0	12
2.1	8
2.2	10
2.3	11

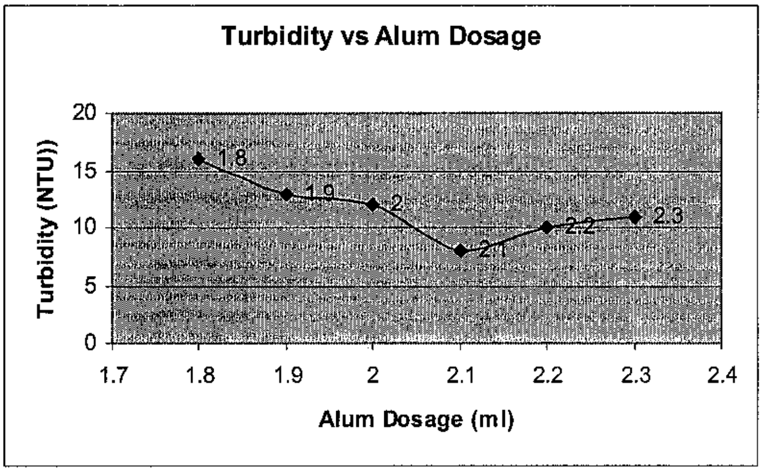


Figure 13: Jar Test Result 3(Volume of Alum vs Turbidity)

Discussion

The dosage of various volume of alum is to find the optimum volume of alum is needed for the coagulation and flocculation process. Based on the results, before the coagulation and flocculation process, the average pH is 6.68, average Turbidity is 84.4 and TSS is 73.66 which is consider very high and not suitable for Recreation purpose. It does not meet the class IIB requirements given by JPS. However, after the JAR test, the results show that the turbidity and TSS were tremendously reduced and could meet the JPA requirement

Based on the result, optimum volume of Alum is 2.1ml to obtain the lowest turbidity. Optimum pH that gives the lowest turbidity is 7.1. This was achieved by adding 1ml of Sodium Hydroxide of 10% concentration to every 1L of water.

2.1 ml of Alum with concentration of 30% requires for 1L of water sample. As the result, we can calculate that 1L of water sample requires 620mg of Aluminum Sulfat for water treatment.

Chapter 5

5.0 Flora and Fauna

5.1 Flora

Basic constructed wetlands should consist of vegetation with the following attributes:

a) Adaptation to the local climate and soils (native species)
b) Tolerance to pollutants in the water or wastewater
c) High biomass production.
d) Perennial species
e) Rapid growth but to avoid usage of noxious species namely *Eichornia crassipes* (keladi bunting), *Limnocharis flava* (yellow bar head), *Salvina molesta* (lukut-lukut), *Mimosa pigra* (kemang gajah), etc
f) Non-weedy, aesthetic habit.
g) Values for wildlife habitat.
h) Broadest possible feasible mixture of plant species to maximize plant diversity and enhance stability of the constructed wetland.

Aquatic plant and riparian trees have important role on the ecology of the ponds. Certain plants improve the water quality by absorbing pollutants using nutrients and providing suitable habitat for micro-organism that help cleanse the water. As plants have different tolerance to inundation, the wetland basin is categorized into six zones, which dictate the particular plants that can survive within each zone. Planting within the stormwater or constructed wetlands requires determining the hydrologic zones or water depth in the new system facilities. Hydrologic zones refer to the degree to which an area is inundated by water. Vegetation within the wetland can be broken up into zones perpendicular to the flow. These zones refer to the depth of water and appropriate species to be selected to optimise the success of the system.

All species used in vegetation, including both aquatic and terrestrial, should be indigenous and local provenance. In areas of predictable low rainfall patterns and where there is also a high evaporative loss due to wind sheer, the wetland should use a vegetation sequence such that there is sustainable water depths in deep and submerged marsh areas during drawn down, as illustrated in figure 11 and 12.

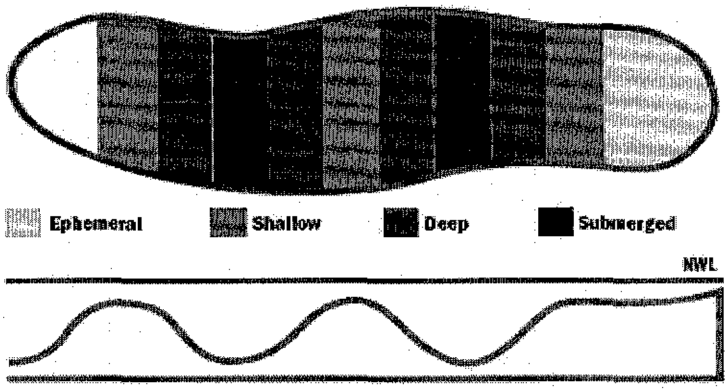


Figure 14: Conceptual Vegetation Sequence in low rainfall areas

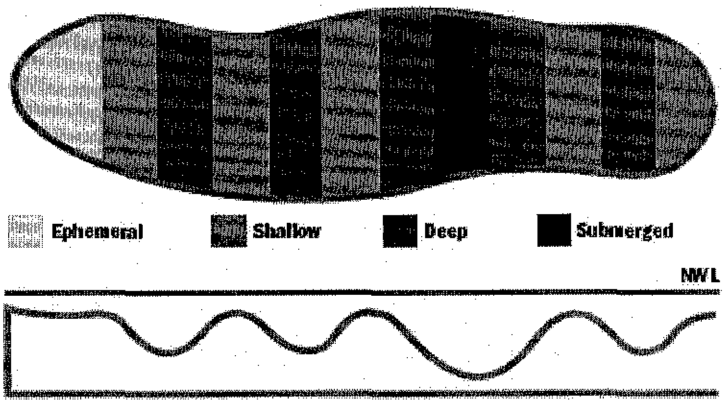


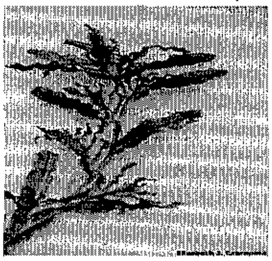
Figure 15: Conceptual Vegetation Sequence in high rainfall area

Suggested Macrophyte Species for Wetland

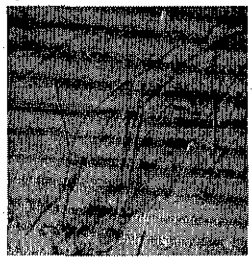
Submerged Marsh 0.4 – 0.9 m below normal top water level

Potamageton crispus	Curly Pondweed
Potamageton ochreatus	Blunt Pondweed
Vallisneria americana	Eel-grass

The recommended plant density is 2 plants per square meter.



Curly Pondweed

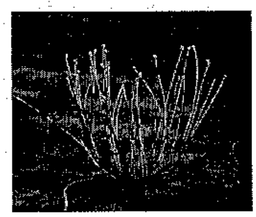


Eel grass

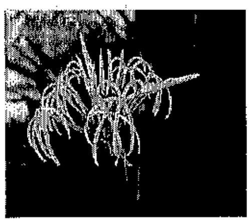
Deep Marsh 0.2 – 0.4 m below normal top water level

Eleocharis sphacelata	Tall Spike-rush
Potamageton tepperi	Floating Pondweed
Potamageton ochreatus	Blunt Pondweed
Schoenoplectus tabernaemontani	River Club-rush
Triglochin procerum	Water Ribbons
Ottelia ovalifolia	Swamp Lily
Vallisneria americana	Eel-grass

The recommended plant density is 4 plants per square meter



Spike Rush



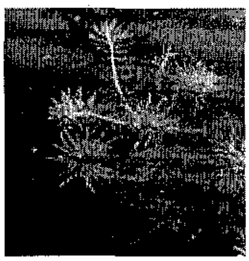
Swamp lilly

Shallow Marsh 0 – 0.2 m below normal top water level

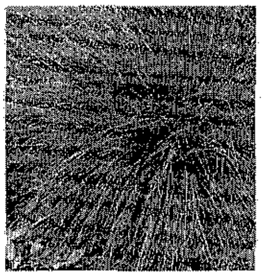
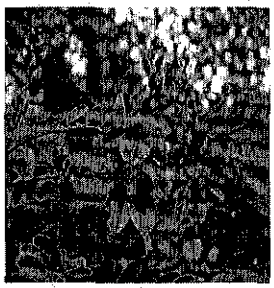
Alisma plantago- aquatica	Water Plantain
Baumea articulate	Jointed Twig-rush
Bolboschoenus medianus	Marsh Club-rush
Cyperus gunnii	Flecked Flat-sedge
Eleocharis acuta	Common Spike-sedge
Juncus procerus	Tall Rush
Glyceria australis	Austral Sweet-grass
Myriphyllum crispatum	Upright Milfoil
Myriphyllum varrifolium	Variable Milfoil
Ranunculus inundatus	River Buttercup
Schoenoplectus tabernaemontani	River Club-rush

The recommended plant density is 6 plants per square meter

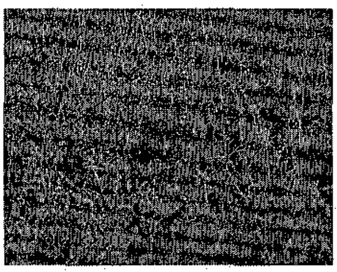
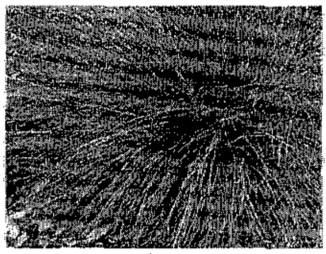
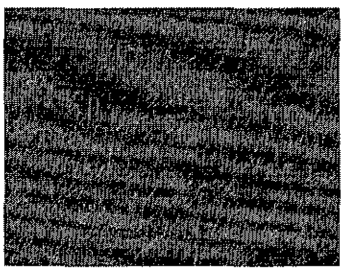
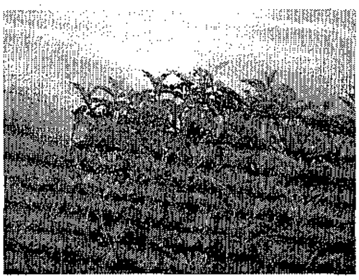
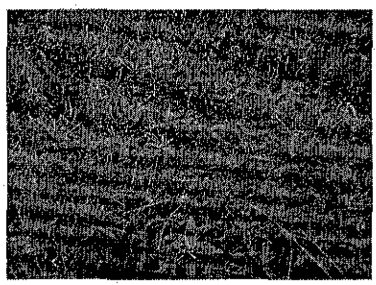
River Buttercup

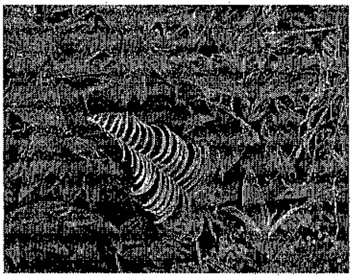
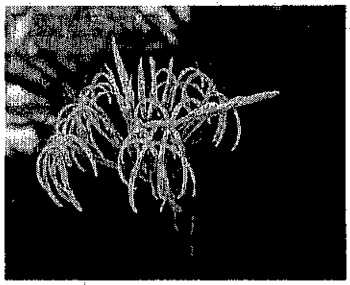


Variable Milfoil

Ephemeral Marsh Above normal water level, temporally inundated during high flows		
Carex appressa	Tall Sedge	 Common Tussock-Grass
Carex gaudichaudiana	Austral Indigo	
Crassula helmsii	Swamp Crassula	
Cyperus lucidius	Leafy Flat-sedge	
Eleocharis acuta	Common Spike-sedge	
Juncus amabilis	Hollow Rush	
Juncus gregiflorus	Green Rush	 Austral Indigo
Juncus sarophorus	Broom Rush	
Melaleuca ericifolia	Swamp Paperbark	
Persicaria decipens	Slender Knotweed	
Poa ensiformis	Sword Tussock-grass	
Poa labillardierei	Common Tussock-grass	
Persicaria praetermissa	Spotted Knotweed	
Gratiola peruviana	Brooklime	
The recommended plant density is 6 plants per square meter.		

Below are some of the plants that are recommended in tropical area and for UTP wetland.

 Cyperus halpan	 Dreffenbachia maculata	 Blue Tussock Grass
 Lepironia articulate	 Ludwiga actovalvis	 Ludwigia adscendens

 Nepholepis sp	 Zephyranthes rosea	 Swamp Lily
 Austral Indigo	 Hollow Rush	 Leafy Flat-sedge

5.2 Fauna

Planting for ponds, wetlands and large waterways such as river shall incorporate opportunities for creation of wildlife habitat. The fundamental of ecological systems, relationship of the flora and fauna and their contribute to the wetland must be understand in order to create a perfect environment. Native wildlife will stay put at the habitat if the environment is suitable for them. (*The Ramsar Convention Manual 1994).* The importance of maintaining the environmental at a wetland is important to maintain its ecology.

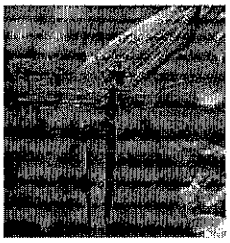
A) A wetland should make as a breeding area for fish and aquatic life. It is encourage by improving the water quality and providing pools and undercuts for the rivers.

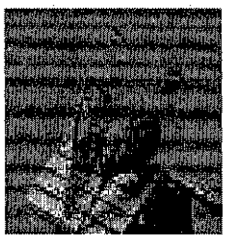
B) A diverse indigenous species are to be provided to ensure ample food supply through flowers, seeds and fruits to attract animals such as birds, squirrels, monkeys and insect (Dragonflies).

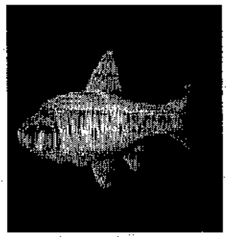
C) Nesting materials such as moss, lichens, feathers, dried grasses and leaves shall be available to create ideal nesting area.

Some of the animals and insects will naturally be coming to the wetland if the ecology appropriate for them in UTP wetland. These include:

a) Dragonflies
b) Fishes
c) Frogs
d) Prawns
e) Birds
f) Reptiles
g) Amphibians
h) Mammals


Dragonfly


Birds


Fish


Frog

5.3 Design of Flora Distribution of UTP Wetland

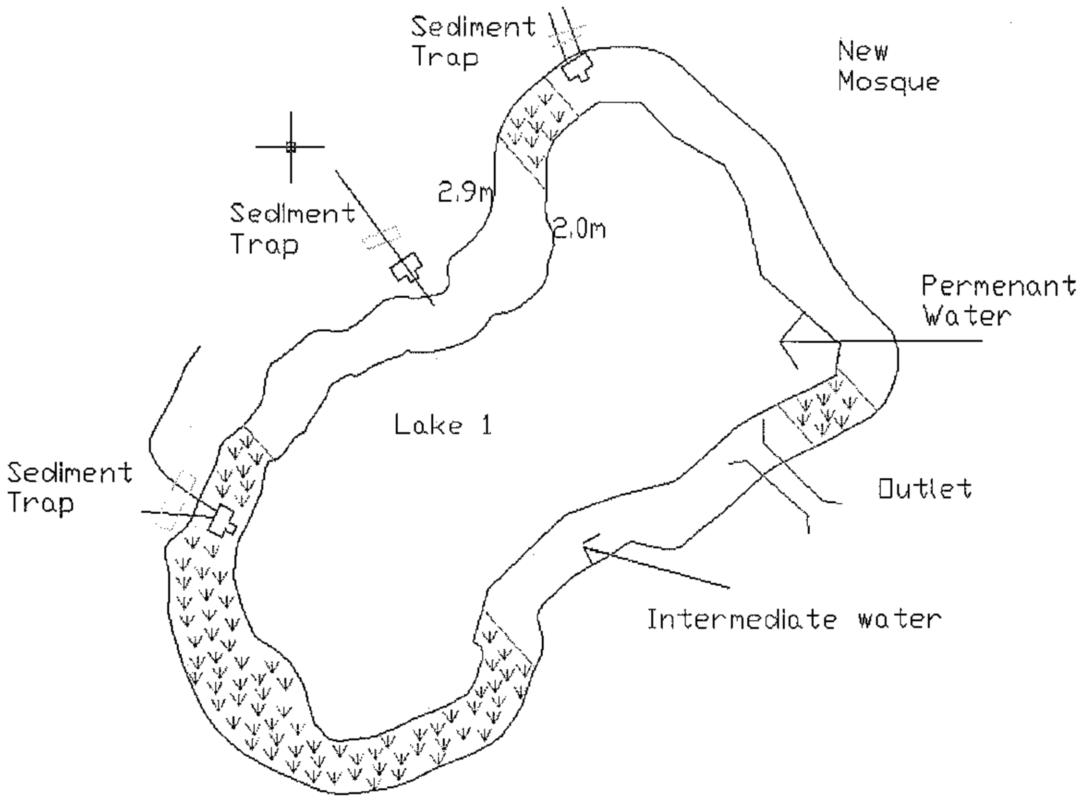


Figure 16 Flora Distribution of UTP Wetland

Area of Intermediate water

Water will cover up the area at certain season based on the rainfall. Some species are recommended to this area:

1) Blue Tussock Grass
2) Leafy Flat – Sedge
3) Hollow Rush
4) Austral Indigo
5) Ludwiga Actovalvis

Area of permanent water

No flora is recommended in this area due to recycling of wetland.

CHAPTER 6

6.0 *SUMMARY AND CONCLUSION*

Constructed Wetland can effectively function as a stormwater treatment plant and as temporary flood storage to reduce downstream flow peaks. The water quality control for urban stormwater can be achieved with the used of appropriate design features and suitable macrophyte plants. In addition, the sufficient maintenance and monitoring may also contribute to achieve this objective. The better designed and constructed system will posses high efficiency in terms of removing contaminants from the inflowing water and reducing the downstream flow rate which may contribute flooding.

The proposed wetland in this case study which is the UTP wetland behind the mosque is designed to be able to retain water during heavy storm and dry season. During low flow the wetland size is approximately 3.25ha with the water depth around 2m. This water will be release slowly at with the rate of $0.075m^3/s$ if the wetland is not full. However, during heavy storm, the size of the lake will increase to 3.4ha with the maximum depth up to 2.9m. The water will flow through the emergency spillway and directly to the downstream. Applying with this design, the wetland can reduce the possible flooding of the downstream area which meets the target of flood management.

Currently the water qualities of the studied wetland fail to meet the JPS requirement for class IIB standard. The average pH is 6.68, Turbidity is 84.4NTU and Total Suspended Solid is 73.66mg is consider very high and not suitable for recreation purpose. However, with the proposed design and improvement of wetland system by adding in rubbish trap and sediment trap, it is believe the water quality will meet the class IIB standard. Water treatment has to be done to improve the water quality in the wetland. Maintaining the ecology system of a wetland is very important to protect the balance of flora and fauna.

To conclude with this report, it is believed that the undertaking of this project has greatly benefit in numerous ways, broadening the knowledge and experience myself on various engineering scopes as well as environmental scopes. I am eager to continue with the research whenever I have a chance in future. I strongly believe that the outcome of the project, which is designing a wetland which can sustained urban environment can be the guideline of all engineered wetland in real industries.

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APPENDIX

Manual Saliran Mesra Alam Malaysia

Volume 13

Appendix 13.A

APPENDIX 13.A FITTED COEFFICIENTS FOR IDF CURVES FOR 35 URBAN CENTRES

Table 13.A1 Coefficients for the IDF Equations for the Different Major Cities and Towns in Malaysia (30 ≤ t ≤ 1000 min)

State	Location	Data Period	ARI (year)	Coefficients of the IDF Polynomial Equations			
				a	b	c	d
Perlis	Kangar	1960-1983	2	4.6800	0.4719	-0.1915	0.0093
			5	5.7949	-0.1944	-0.0413	-0.0008
			10	6.5896	-0.6048	0.0445	-0.0064
			20	6.8710	-0.6670	0.0478	-0.0059
			50	7.1137	-0.7419	0.0621	-0.0067
			100	6.5715	-0.2462	-0.0518	0.0016
Kedah	Alor Setar	1951-1983	2	5.6790	-0.0276	-0.0993	0.0033
			5	4.9709	0.5460	-0.2176	0.0113
			10	5.6422	0.1575	-0.1329	0.0056
			20	5.8203	0.1093	-0.1248	0.0053
			50	5.7420	0.2273	-0.1481	0.0068
			100	6.3202	-0.0778	-0.0849	0.0026
Pulau Pinang	Penang	1951-1990	2	4.5140	0.6729	-0.2311	0.0118
			5	3.9599	1.1284	-0.3240	0.0180
			10	3.7277	1.4393	-0.4023	0.0241
			20	3.3255	1.7689	-0.4703	0.0286
			50	2.8429	2.1456	-0.5469	0.0335
			100	2.7512	2.2417	-0.5610	0.0341
Perak	Ipoh	1951-1990	2	5.2244	0.3853	-0.1970	0.0100
			5	5.0007	0.6149	-0.2406	0.0127
			10	5.0707	0.6515	-0.2522	0.0138
			20	5.1150	0.6895	-0.2631	0.0147
			50	4.9627	0.8489	-0.2966	0.0169
			100	5.1068	0.8168	-0.2905	0.0165
Perak	Bagan Serai	1960-1983	2	4.1689	0.8160	-0.2726	0.0149
			5	4.7867	0.4919	-0.1993	0.0099
			10	5.2760	0.2436	-0.1436	0.0059
			20	5.6661	0.0329	-0.0944	0.0024
			50	5.3431	0.3538	-0.1686	0.0078
			100	5.3299	0.4357	-0.1857	0.0089
Perak	Teluk Intan	1960-1983	2	5.6134	-0.1209	-0.0651	0.00004
			5	6.1025	-0.2240	-0.0484	-0.0008
			10	6.3160	-0.2756	-0.0390	-0.0012
			20	6.3504	-0.2498	-0.0377	-0.0016
			50	6.7638	-0.4595	0.0094	-0.0050
			100	6.7375	-0.3572	-0.0070	-0.0043
Perak	Kuala Kangsar	1960-1983	2	4.2114	0.9483	-0.3154	0.0179
			5	4.7986	0.5803	-0.2202	0.0107
			10	5.3916	0.2993	-0.1640	0.0071
			20	5.7854	0.1175	-0.1244	0.0044
			50	6.5736	-0.2903	-0.0482	0.00002
			100	6.0681	0.1478	-0.1435	0.0065
Perak	Setiawan	1951-1990	2	5.0790	0.3724	-0.1796	0.0081
			5	5.2320	0.3330	-0.1635	0.0068
			10	5.5868	0.0964	-0.1014	0.0021
			20	5.5294	0.2189	-0.1349	0.0051
			50	5.2993	0.4270	-0.1780	0.0082
			100	5.5575	0.3005	-0.1465	0.0058
Selangor	Kuala Kubu Bahru	1970-1990	2	4.2095	0.5056	-0.1551	0.0044
			5	5.1943	-0.0350	-0.0392	-0.0034
			10	5.5074	-0.1637	-0.0116	-0.0053
			20	5.6772	-0.1562	-0.0229	-0.0040
			50	6.0934	-0.3710	0.0239	-0.0073
			100	6.3094	-0.4087	0.0229	-0.0068

(Continued)

Table 13.A1 Coefficient for the IDF Equation for the Different Major Cities and Towns and Towns in Malaysia

Table 13.2 Coefficients of the Fitted IDF Equation for Perak

ARI (years)	**a**	**b**	**c**	**d**
2	5.6134	-0.1209	-0.0651	0.00004
5	6.1025	-0.2240	-0.0484	-0.0008
10	6.3160	-0.2756	-0.0390	-0.0012
20	6.3504	-0.2498	-0.0377	-0.0016
50	6.7638	-0.4595	0.0094	-0.0050
100	6.7375	-0.3572	-0.0070	-0.0043

Calculation for Rainfall Intensity (mm/hr) for IPOH with the assumption that Return Period is 100 yrs, duration = 60minutes:

Refer to the formula 13.2 from JPS manual,

$\ln(^{R}I_{t}) = a + b\ln(t) + c(\ln(t))^{2} + d(\ln(t))^{3}$

$^{R}I_{t}$ = the average rainfall intensity (mm/hr) for ARI and Duration t

R = average return interval (years)

t = duration (minutes)

a to d are fitting constant dependent on ARI

With ARI = 100yrs,

a = 6.7375

b = -0.3572

$c = -0.0070$

$d = -0.0043$

$$\ln ({}^{R}I_t) = 6.7375 + -0.3572(\ln 60) + -0.0070(\ln 60)^2 + -0.0043(\ln 60)^3$$

$$\ln ({}^{R}I_t) = 4.8625$$

${}^{R}I_t$ (average rainfall intensity) = **129.35mm/hr = 5.17inches/hr**

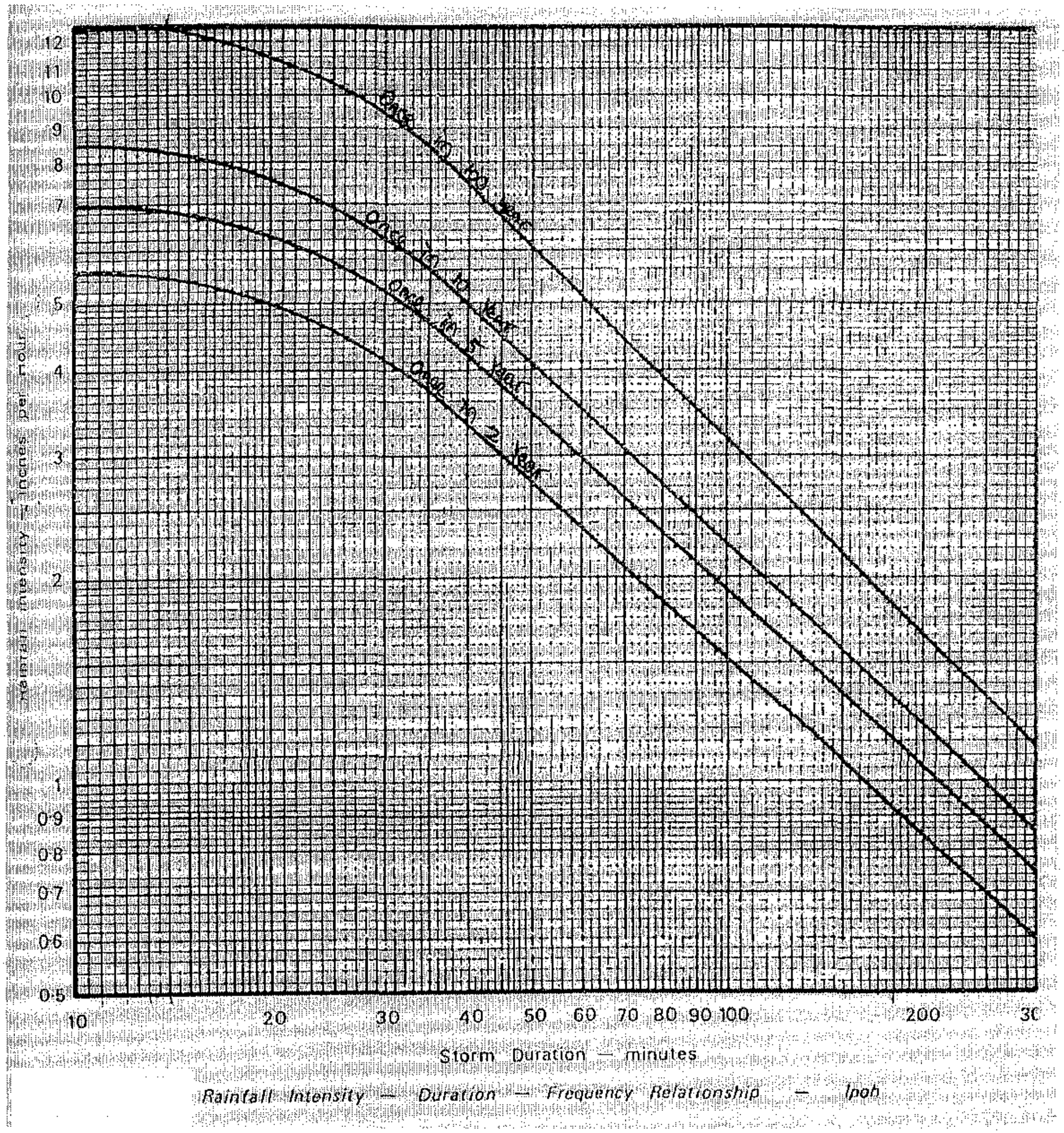
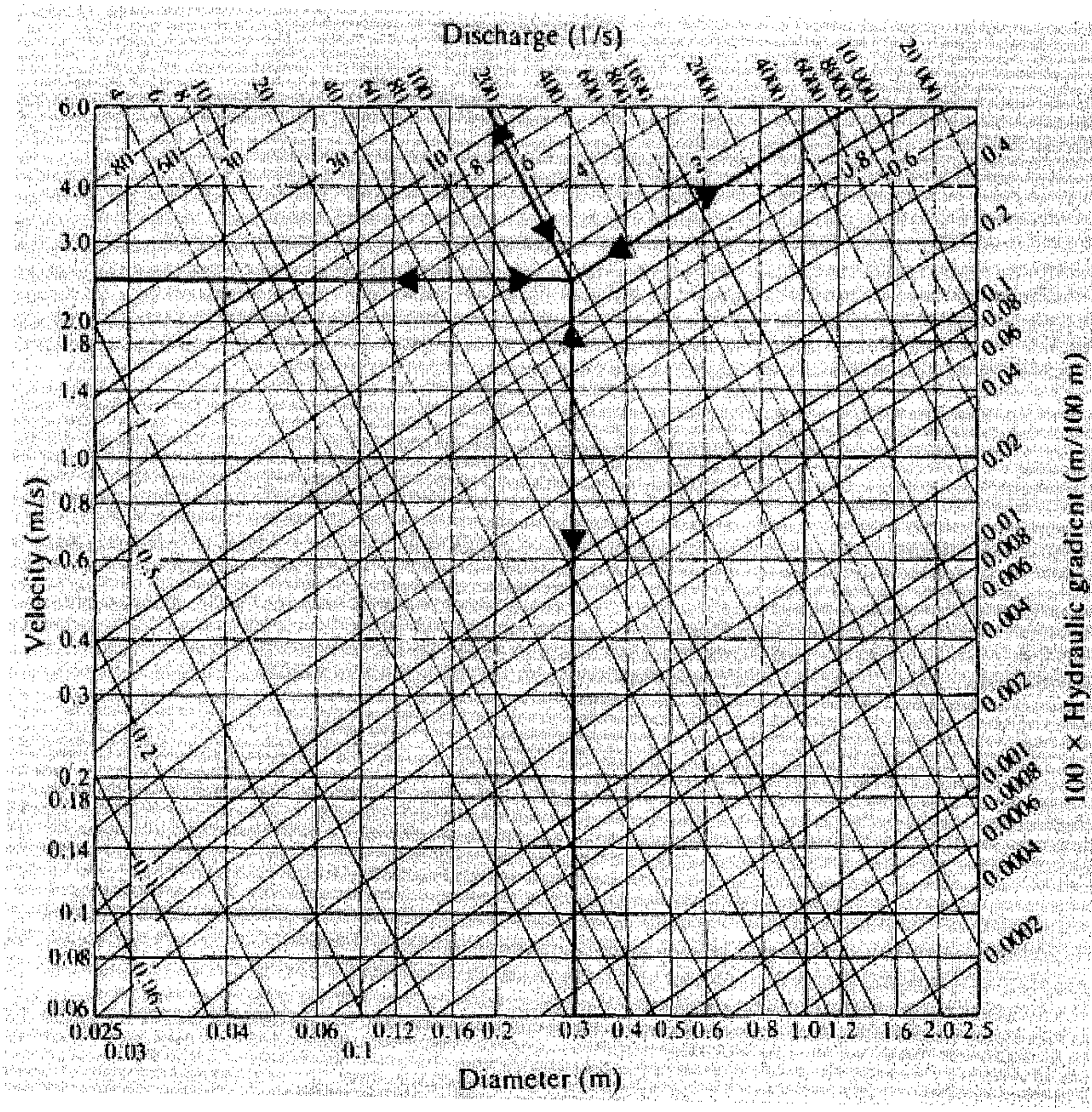


Table of Intensity – Duration – Frequency relationship for Ipoh



Hydraulics Research Station Chart for $k_s = 0.03$ mm

ΞD INTERIM NATIONAL
ⲒUALITY STANDARDS FOR MALAYSIA

RAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
:al Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
	mg/l	1	3	3	6	12	>12
	mg/l	10	25	25	50	100	>100
	mg/l	7	5-7	5-7	3-5	<3	<1
	6.5-8.5	6-9	6-9	5.9	5-9	-	
	TCU	15	150	150	-	-	-
ıd.*	μ mhos/cm	1,000	1,000	-	-	6,000	-
;		N	N	N	-	-	-
		N	N	N	-	-	-
	$^{0}/_{00}$	0.5	1	-	-	2	-
		N	N	N	-	-	-
. Solid*	mg/l	500	1,000	-	-	4,000	-
). Solids	mg/l	25	50	50	150	300	>300
ure	°C	-	Normal ± 2	-	Normal ± 2	-	-
	NTU	5	50	50	-	-	-
	counts/100 ml	10	100	400	5,000 (20,000)'	5,000 (20,000)'	
	counts/100 ml	100	5,000	5,000	50,000	50,000	>50,000

visible floatable materials/debris
ⅰo objectionable odour
ⅰo objectionable taste
ated parameters, only one recommended for use
metric mean
ːimum not to be exceeded

PARAMETER	UNIT	CLASS					
		I	IIA / IIB	III@		IV	V
CCE	μg/l	↑	500	-		-	-
MBAS/BAS	μg/l	N	500	5000	(200)	-	-
O&G (mineral)	μg/l	A	40;N	N		-	-
O&G (emulsified edible)	μg/l	T	7000;N	N		-	-
PCB	μg/l	L	0.1	6	(0.05)	-	-
Phenol	μg/l	E	10	-		-	-
		V					
Aldrin / Dieldrin	μg/l	E L	0.02	0.2	(0.01)	-	-
BHC	μg/l	S	2	9	(0.1)	-	-
Chlordane	μg/l		0.08	2	(0.02)	-	-
t-DDT	μg/l	O	0.1	1	(0.01)	-	-
Endosulfan	μg/l	R	10	-		-	-
Heptachlor/ Epoxide	μg/l	A B	0.05	0.9	(0.06)	-	-
Lindane	μg/l	S	2	3	(0.4)	-	-
2, 4-D	μg/l	E	70	450		-	-
2, 4, 5-T	μg/l	N	10	160		-	-
2, 4, 5-TP	μg/l	T	4	850		-	-
Paraquat	μg/l	↓	10	1800		-	-

N = Free from visible film, sheen, discoloration and deposits
@ = Maximum (unbracketed) and 24-hr average (bracketed) concentration

Class **Uses**

I Conservation of natural environment
Water supply I - practically no treatment necessary (except by disinfection or boiling only)
Fishery I - very sensitive aquatic species

IIA Water supply II - conventional treatment required
Fishery II - very sensitive aquatic species

IIB Recreational use with body contact

III Water supply II - extensive treatment required
Fishery III - common, of economic value, and tolerant species

IV Irrigation

V None of the above