**Engineered Wetland in University Teknologi Petronas Core Park**

By

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Dissertation submitted in partial fulfillment
of the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

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# CERTIFICATION APPROVAL

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A project dissertation submitted to the Civil Engineering Program Universiti Teknologi PETRONAS in partial fulfillment for the requirements of the BACHELOR OF CIVIL ENGINEERING (Hons)

Approved by,

______________________

(Assoc. Prof. Dr. Nasiman Sapari)

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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.

(Haw Seng Poh)

# ABSTRACT

The objective of the project is to design and implement a new wetland which can provide stable flood mitigation system and balance ecological system. The new design is based on the combination of wetland, orifices and spillway with the purpose to improve the existing UTP Core Park wetland. UTP wetland was initially designed for landscaping purpose. Improvement of the wetland is proposed for the sustainability of the wetland with suitable flora and fauna to be located in the wetland.

Without any experience on designing a wetland system, the hydraulic calculations, biological system, and laboratory tests, varied tasks are very challenging to complete. Information from internet and book and the advice from lecturers are the important factors that lead to the completion of this project.

The scope of study of this project covers a wide range of engineering and biological scopes. The engineering scope included in the study covers the existing wetland design capacity, engineering landscape design, calculation of the orifices sizing, calculations of pipe culvert, and calculation of spillway sizing. The study also include ecological scope namely study on flora and fauna and water quality. With this project; student can understand about the concept and application of wetland design.

In the calculation part, all the important parameters will be discussed in more detail for better understanding of the design, considerations. A new design will proposed and the discussion is included in this report to meet the objective of the project

At the end of the report, recommendations were suggested for further improvement about the new design. The suggestions were made for future improvement in the design. The whole finding of this project is concluded at the last section as the conclusion of this thesis.

## Acknowledgement

I would like to take this opportunity to express my appreciation to those who had assisted me in completing my Final Year Project (FYP) report.

First of all, I would like to thank **Dr. Nasiman Sapari** (my FYP supervisor) for giving me the opportunity to go through this interesting and challenging topic. The advise and supervise given by him during the process of preceding my FYP was very useful for me not only for completing my report but also during my working life in the future. From the beginning, I have no idea to start the report and research, with the guidance of Dr. Nasiman Sapari, the time given and willingness to advice, taught me a lot of extra knowledge about the wetland, and helps me to complete this report. Thus the first sincere appreciation is give to him, my supervisor; Dr.Nasiman.

I would also like to take this opportunity to thank **En. Faril,** from KLCC, who is in charged in the design of UTP wetland. I did interview him for more than 3 times and during the interview; he briefly describe to me the design of the UTP wetland. He has helped me a lot to be able to complete this report, my appreciation and thanks also goes to him. My appreciation also goes to the lab assistant who help me and teach me to do various types of laboratory tests and last, I would like to thank Dr. Saied Saiedi and Miss Zahirah who giving me advice in the calculation part

Last but not least, I would also like to thank all of my friends and seniors who had also helped me directly or indirectly throughout this training. I appreciate the help they have given, including all the extra photos and information.



**Haw Seng Poh**

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# Chapter 1

# INTRODUCTION

## 1.1 Project Background

The wetland in UTP core park is a man made wetland and it was designed with reference to two parameters namely water quality and landscaping purpose. The core park of UTP wetland was initially a pond and the pond level is the lowest point around the academic complex area where the ground at the pond is below the water table. Plants are planted in and around the pond for decoration purposes. The pond is connected to three underground culverts namely from building 13, pocket C and building 17 to the pond (refer to figure 1).

The location of the culverts is at the upstream of the wetland. Besides that, drains constructed surrounding the building and core park are connected to the wetland prior to discharge. During rainfall, storm water from the upstream will flow into the wetland through the underground culverts and the storm water from the surface of the land is flowing into the drains that finally discharge into the wetland.

A big underground drain connects the wetland to a downstream lake locate at the South-East of UTP campus. If the water in the wetland exceeds the design flood attenuation water level, the water in the wetland will spill over into the drain and flow out to the lake at the South-Eastern of UTP. The existence of vegetation and the criteria that is used to retain water from upstream and discharge water to outside make the pond in the UTP core park to become a wetland which is used as provision of aquatic life and retention of water, flood attenuation and groundwater recharge.

The purpose of this project is to study and examine the sustainability of the existing wetland capacity. If the wetland capacity is adequate for retaining storm water base on the design criteria from Department of Irrigation and Drainage (JPS), no improvement is needed. On the other hand, if the existing wetland sustainability does not fulfill the requirement of JPS, the new design is proposed with the aim to improve the sustainability of the wetland.

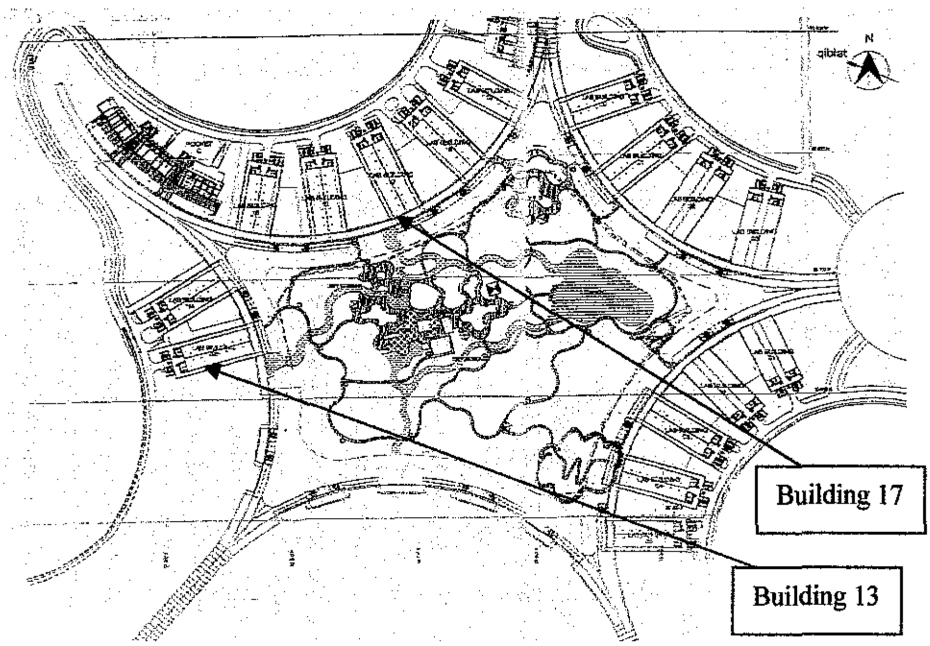



**Figure 1: UTP Core Park Wetland**

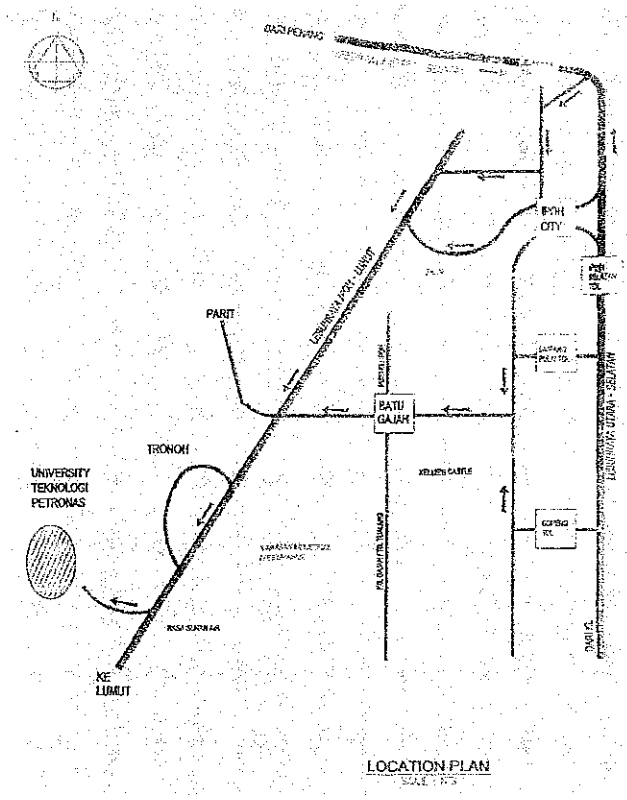



**Figure 2: Location of UTP Campus**

## 1.2 Problem Statement

UTP Core Park is a constructed wetland and it is unlikely to have a functional perspective, considering wetland is a place where bio-ecological processes occur, and plants are adapted especially for living in saturated conditions. On the water aspects, wetland should be designed based on two parameters; water quality and water quantity.

UTP wetland is a man made wetland; therefore, water quality is another important parameter to consider, besides the landscaping purpose. Water quality in the wetland is a serious problem, the turbidity is too high and very hard to see any fauna living or appear at the water surface. The use of the water pump at the wetland is risking the life of living form in the wetland where fauna will be sucked into the pump when it is operating. The water quality in the UTP core park wetland should be clean and suitable for bio-ecological processes to occur, nevertheless, the construction activities which are proceeding beside the wetland has cause mud, silt and others debris entered the wetland

and consequently pollute the water in the wetland. Accordingly, the water turbidity, has achieved a critical level in the condition which is not suitable for living organism.

The water control design of the existing wetland needs further improvement. There was an incident happen in last year whereby the UTP core park was flooded. One of the reasons of this incident was because some of the pipe culverts connecting to the outlet of the wetland were clogged by sediments. Luckily, this incident was happened at midnight after heavy rainfall and no students or lecturers were directly affected by the incident. The main reason of this incident was because the wetland has only one route to discharge the storm runoff from UTP Core Park to the outside lakes. There is no other emergency exit for the storm runoff in the wetland. The second reason due to the capacity of the wetland was limited. The UTP Core Park wetland is designed mainly for landscaping purpose and not for controlling flood. Therefore, the capacity in the wetland is actually not enough to retain the heavy storm water. The calculation of the existing wetland capacity, that was suppose to be based on 100yrs return period with rainfall duration of 60minutes, could not sustain water capacity for a storm period of 45minutes and 100yrs return period.

For the conservation purpose, the flora species existing in the wetland is not enough and other adequate flora species should be planted in order to achieve a balance ecosystem.

## 1.3 Objective of Study

The main objective of the project is to improve the existing man made wetland from a landscaping wetland to become an ecological wetland. It is to create a more sustainable system to make the UTP wetland not only for landscaping but also to ecological purpose. During the first semester, literature review and data collection were carried out to increase the understanding of the whole UTP Core Park wetland system.

The studies include:

- Site survey around the whole UTP Core Park wetland by using total station to understand the area of the wetland
- Water quality analysis using the method in the wastewater engineering book by Metcalf and Eddy, 2003.
- Carry out the conceptual and calculation of the water quantity and the control measures such as orifices calculations, embankment recommendation and spillways design.
- Analyze the flora species in the Core Park wetland.
- Study on wetland function to mitigate the breeding of mosquitoes.
- Jar test laboratory tests to analyze the optimum alum dosage to improve water turbidity
- Recommendation on flora species that need to be plant in the wetland to provide a balance ecological system

## 1.4 Scope of Work

The scope of this study is limited to the research of the wetland ecological system and the study of water quality. Therefore, the task will cover various water quality analysis and other activities as below:

1. BOD analysis
2. COD analysis
3. Turbidity Test
4. TSS (Total Suspended) Laboratory Analysis
5. Documentation
6. Collection and review of data
7. Site inspection and assessment of water quality sampling locations
8. Review of water quality from laboratory tests
9. Jar Test
10. Collecting and analyzing information about orifices, spillways and wetland
11. Proposed calculations of every part base on the design procedure
12. Study the existing flora species in the wetland
13. Propose adequate flora species to be located in the wetland

## 1.5 Gantt Chart

Please refer to Appendix A for the Gantt chart of the project

# Chapter 2
# LITERATURE REVIEW

The literature review of this study was done by collecting information from various sources such as internet and books and reports. The sources and information were analyzed and sort out according to several topics related to the research.. All the findings, guidelines, and references were used as the basis complete the design.

## 2.1 Natural Wetland Background Study

Wetland exhibit a wide range of functional attributes, including provision of aquatic and wildlife habitat, retention of sediments and toxicants, flood attenuation, nutrient metabolism and groundwater recharge(*Kent D.M, 2002*). It can be defined directly or implicitly in a variety of ways. Several factors, including personal perspective, position in the landscape, and wetland diversity and function, are linked to the nature of the definition. The definition of wetland established three parameters essential for a habitat to be wetland (*Kent D.M., 2002*). The first is the presence of surface water, the second is the development of moist soil vegetation and the third parameter is hydroid soils. The ability of the previous definition of wetland can be expended to include not only those habitats with surface water but also those having saturated soils.

The treatment systems described tend to be either predominantly open water systems ("ponds") with associated macrophyte zones, or predominantly macrophyte systems ("wetlands") with some open water. Extended detention basins, which are not strictly ponds at all, are also described. The choice of one of these measures reflects differences in pollutant forms and flow and loading conditions (*JPS, 2000*).

Water quality control ponds ("wet ponds") can have both water quality control and flood control functions. It is economically advantageous to combine both functions in a single pond. This Chapter covers the design principles for the water quality component of the pond or wetland. The designer should refer to the relevant sections of Chapter 20 of the

For large catchments, the size of the necessary outlet structure and spillway generally makes an on-line design very costly. For this reason, an off-line design is preferred. However, there are also exceptions, such as where it is desired to build a pond in a river valley to make use of the natural topography. In this case, the outlet will normally be in the form of a small dam. Where there is, a risk of occasional high-discharge events, constructed wetlands should be located off-line (*JPS, 2000*).

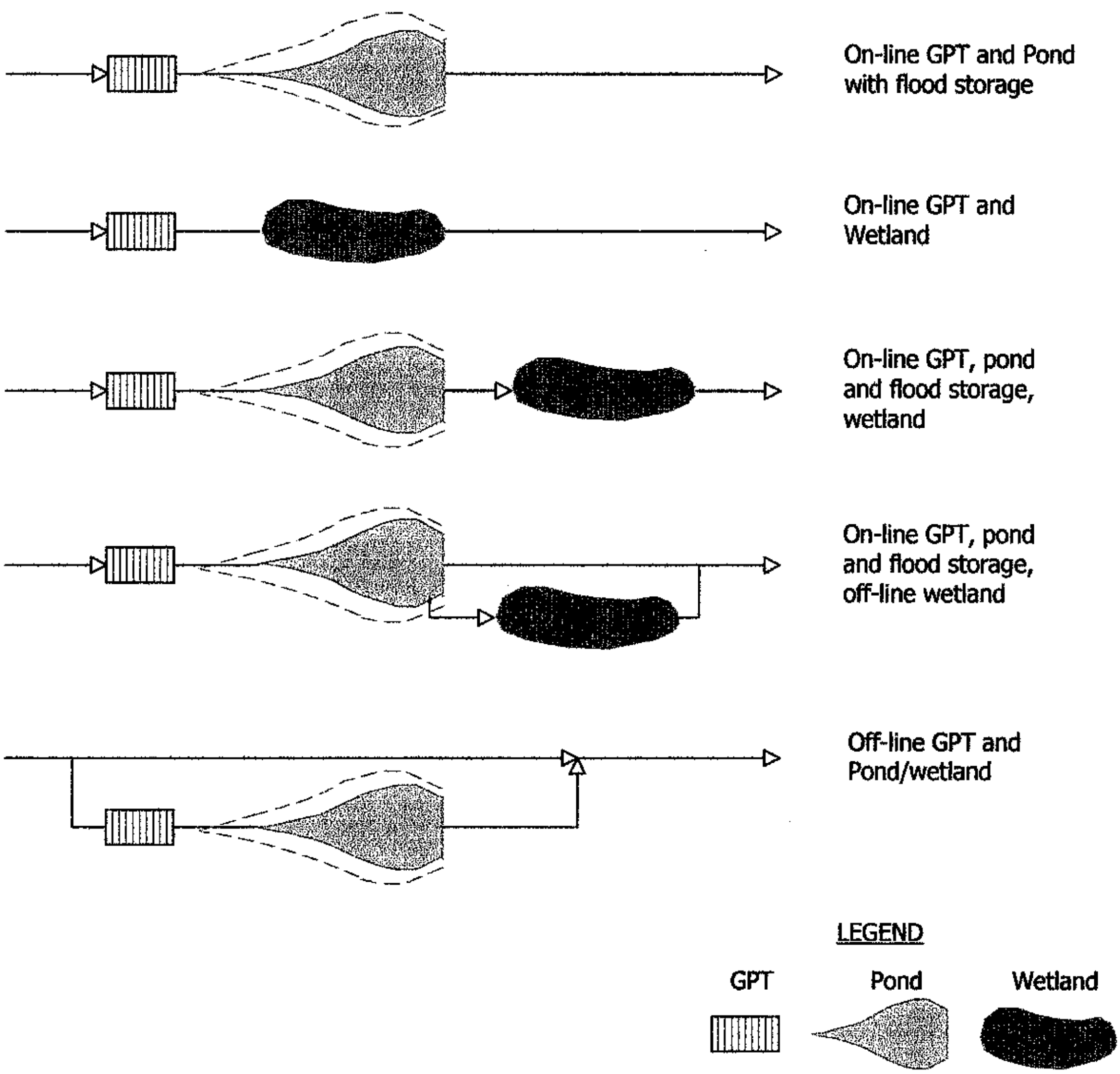



**Figure 3: Alternative Pond and Wetland Layouts**

### 2.1.3 Zone:

Ponds should be designed with a combination of deep and shallow water. The design concept involves three main zones in which different assimilation processes dominate, and different design conditions apply(*JPS, 2000*).

#### (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 GPTs helps in the function of this zone(*JPS, 2000*).

#### (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 should be provided around the pond 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 pond area. Plantings should be on the perimeter, arranged so that there is opportunity for water in the open pond zone to circulate through the macrophyte zone(*JPS, 2000*).

#### (c) Open Water Zone

An open water zone is a deeper area that allows time for fine particles to flocculate and settle to the bottom bed, and allows sunlight to kill bacteria. Decomposition and grazing 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 bottom bed of the pond.

A minimum depth of 2.4 m is recommended for open water zones. The open water zone has the potential for some recreational activity, especially in the larger ponds and urban lakes. Water quality however will generally be unsuitable for body contact recreation.

### 2.1.4 Wet Ponds

Wet ponds remains permanently full with water. The ponds are generally vegetated by islands and wetland vegetation around the fringes. Wet ponds is likely to be widely used in Malaysia due to the soil types and aesthetic appeal. Difficulties will arise in obtaining sufficient land in areas that have already been developed.

When sized adequately, wet ponds can provide good sediment removal (up to 75% of load, on an annual basis). Aquatic plants and microbiota improve the treatment performance, especially with regard to nutrients.

Ponds can be provided with different outflow controls to also promote flow attenuation. Slotted or v-notched weirs and multi-staged outlets are common practice in overseas countries(*JPS, 2000*). These types of devices provide a smooth transition from the case where attenuation is only provided for the water quality design storm, to also providing a measure of flood control in frequent events. This transition is required in order to protect the downstream ecosystem from the increased peak flows in frequent events (small ARIs). If maintained properly, wet ponds is attractive and socially acceptable. They are likely to enhance the appeal of surrounding properties and to serve as a focus for recreation. Wet ponds can provide a habitat for birds and fish. The wetland plants themselves are an environmental amenity.

A permanent pond cannot be maintained with very permeable soils (e.g. sandy soils) unless in area of high water table or else a liner is used. In the initial establishment period, cares in planting and regular maintenance are required in order to encourage plant growth. After this period, pond vegetation and the surrounding areas must be maintained and sediment must be removed periodically from the pre-settling trap or GPT. Maintenance requirements are in general, no greater than for other storm water systems (*JPS, 2000*).

## 2.2 Constructed Wetland

Constructed wetlands require small changes in pond elevation, to drive flow over the outlet structures. Wet ponds therefore provides minimal flow attenuation.

Issues to consider when choosing constructed wetlands include the following (*JPS, 2000*):

- Wetlands have a mostly limited depth, ranging from zero at the shore to 1.0 m in the deepest areas. The average depth of the emergent vegetation zone is typically 0.5 m.
- The change in water level is usually kept small (less than 0.6 m) as most wetland plants are not tolerant of greater changes. These figures are for the water quality design storm. Wetlands which are associated with ponds that are also used for flood control can tolerate submergence to depths between 1 m and 2 m, provided that velocities are low enough to avoid flattening and that the duration of submergence is not more than a few hours.
- 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 transfers 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.
- Although the water level changes are usually small, the large areas provide some volume for attenuation of small storm flows. In general, wetlands should not be used for extreme flood attenuation due to the potential damage to the wetland plants.
- Wetland areas provide educational benefits and some passive recreation (e.g. walking track) benefits. They can have a high visual appeal, and add to the natural landscape. Wetlands provide a good habitat for birds and fish. In wetlands in particular, mosquitoes are likely to be a concern of the public. The control of mosquitoes is discussed later in this Chapter.
- Wetland planting, establishment and maintenance is usually necessary and can be costly

### 2.2.1 Data Collection

Design of water quality control ponds (wet ponds) requires data on:

- Catchments area;
- Hydrology of inflows;
- Survey details, including depths, of existing ponds;
- Hydraulic conditions at the pond outlet, which may create tail-water;
- Soil type;
- Estimates of sediment loads and other pollutant loads from the catchments; and
- Chemical analysis of the existing pond water and sediment, if there is a risk of chemical contamination. This task is essential when an ex-mining pond is proposed to be used.

### 2.2.2 Design Criteria

In Malaysia, the design of wetland should refer to the design criteria listed in JPS Manual, year 2000, and there are five major design criteria; Biochemical, ecological, hydrological, social/recreational/education and geomorphologic. The details of the design criteria are listed as below:

**Biochemical**

- Sediment trapping
- Pollution trapping
- Removal of Toxic substance
- Nutrient removal
- Water processing
- Net oxygen production
- Biochemical storage
- Influence atmospheric and climatic fluctuations

**Ecological**

- Habits and nursery grounds for wildlife including fishes, bird rookeries and refuges for animal, pests and predators
- Gene banks for plant and species
- Maintenance of biodiversity
- Wildlife corridors
- Primary productivity and biomass production

**Hydrological**

- Flood mitigation
- Storm and flood storage
- Base flow and estuarine flow modification
- Recharging aquifers and ground water storage and discharge

**Social/Recreational/Education**

- Commercial use
- Recreational value
- Open space and aesthetics
- Scientific and research opportunities

**Geomorphologic**

- Erosion protection
- Coastal protection from storm, tides and wind

The criteria for design of a water quality control pond (wet pond) will usually take one of the following forms:

1. a requirement to remove a specified percentage removal of pollutants, and/or
2. a requirement to include flood storage, and/or
3. To suit an available site area or utilise an existing pond.

Ponds should form part of a treatment system for storm water. For a complete treatment system serving new development, the overall objective is removal of 70% of suspended solids load. Some of the removal will occur in the settling trap or GPT, and some in the pond or wetland. Where the pond or wetland is being installed as part of land redevelopment, the suggested design target for the pond or wetland is a reduction of 50% of the existing pre-development Suspended Solids load. In existing developed areas, site constraints and economic considerations will govern the size of the pond and the degree of pollutant removal achievable. In some locations, existing mining ponds may be able to be used (*JPS, 2000*).

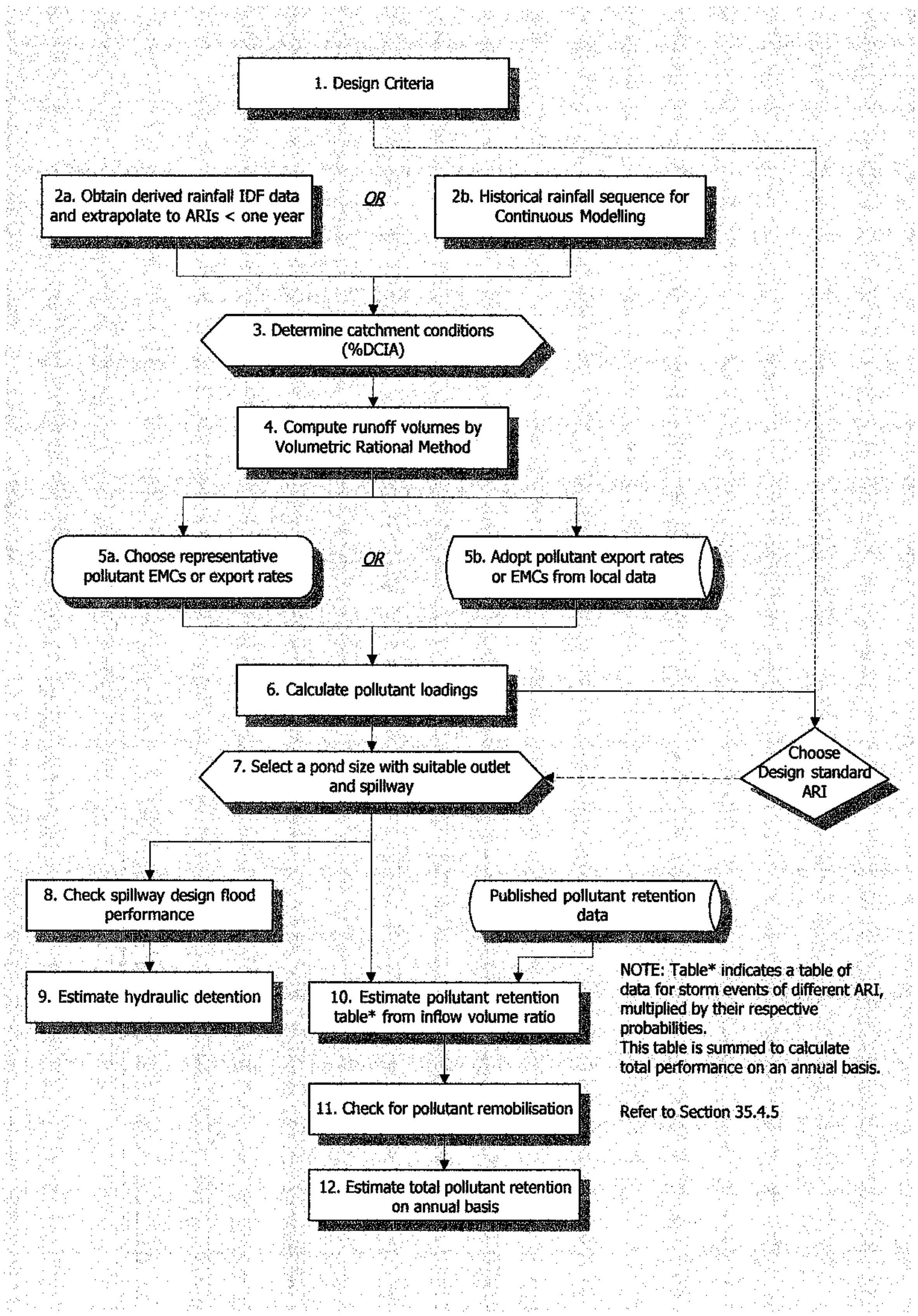



**Figure 4: Flowchart for Preliminary Pollutant Retention Pond Sizing**

### 2.2.3 Embankment

Normally, the design will include an embankment to impound the permanent pond and create flood storage. In some cases where an existing mining pond is being used, an embankment may not be required. The actual subsurface conditions for the particular site and the fill materials intended for use as the embankment must be tested for bearing capacity, seepage, and stability. The structural integrity should not arbitrarily be assumed just because of the proximity or superficial similarities to another pond. In most cases, professional geotechnical advice must be obtained.

The selection of construction materials should take into account the range of immersion depths and flow velocities that is predicted to occur. Embankments are typically constructed from roller-compacted earth. Suitable material must be selected so that it can be compacted to the required standard, so that it will provide an impermeable barrier, and to provide the stability needed to resist hydraulic forces under the design storm.

The embankment should be constructed to control the amount of seepage through the dam in order to prevent piping, which could lead to dam failure. Depending on the availability of suitable material, the dam may be designed as either a homogeneous or a zoned embankment. Figure 5 below shows the typical embankment drawing.

As the name implies, a homogeneous dam embankment is constructed entirely of one type of fill material. Preferably, the material will be sufficiently impervious to inhibit seepage. Because some seepage can be expected for wet pond earth fill dams, homogeneous dams should not be constructed of highly erotic materials, such as silts or fine sands, which could be carried away by water seeping through the embankment (piping).

A zoned type embankment may be preferred if sufficient impervious material is not available to construct the entire embankment, or if the material requires additional measures to prevent slope failure or erosion. For this alternative, two or more zones of different fill material are used to construct the embankment, with one zone, called the dam core, constructed of impervious material. More pervious materials, such as sand, gravel, and cobbles, may provide structural stability for the embankment.

If impervious material is not available, an impervious liner may be placed over the embankment to prevent seepage. The liner may consist of clay, possibly mixed with bentonite, or it may be a manufactured synthetic liner. Special care must be taken to ensure that the liner does not crack or puncture. The liner should extend from above the normal pool of the pond to the pond bottom and some additional distance upstream that depends on the imperviousness of the foundation. For very pervious foundation materials, the entire pond may require a liner (*JPS, 2000*).

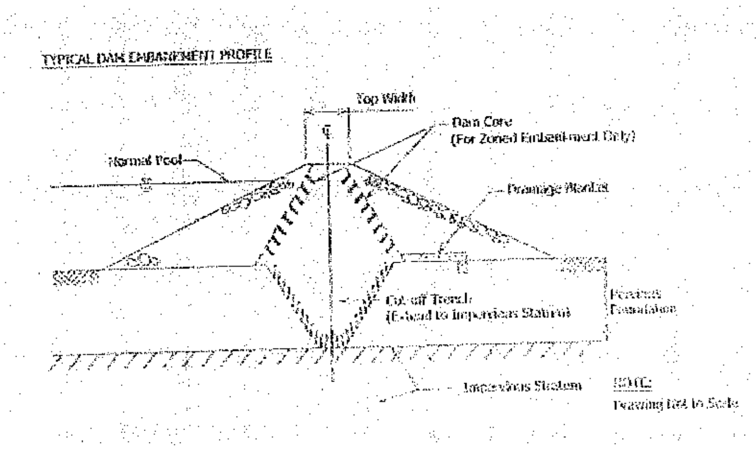



**Figure 5: Typical Dam Embankment Profile**

**Table 1: Recommended Top Widths for Earth Embankments (USDA, 1982)**

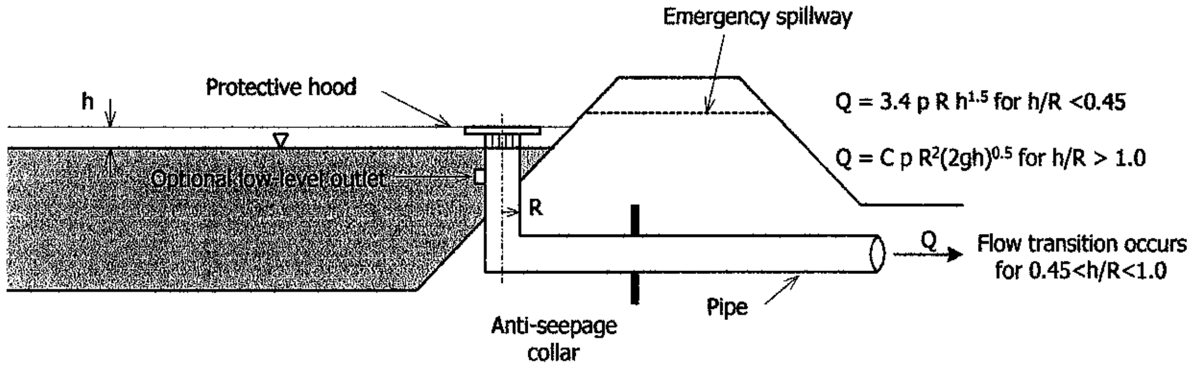
| Height of Embankment (m) | Top width (m) |
|---|---|
| < 3 | 2.4 |
| 3 to 4.5 | 3.0 |
| 4.5 to 6 | 3.6 |
| 6 to 7.5 | 4.2 |

### 2.2.4 Outlet Design Works

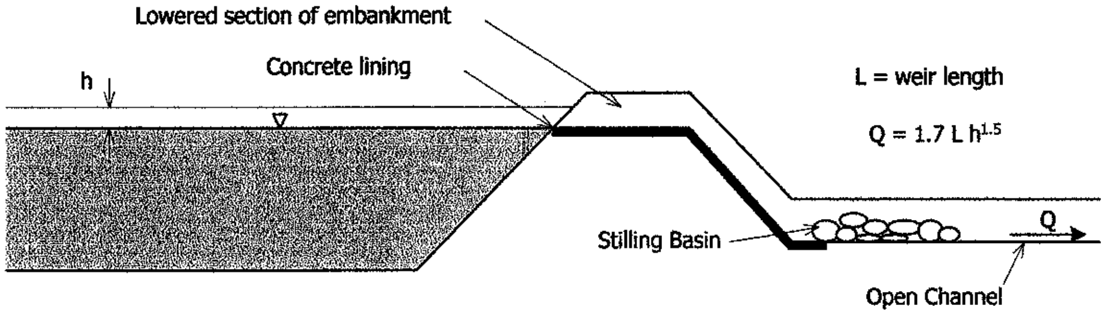
A normal outlet is provided in order to regulate flows from the pond, and to control water levels. In many cases, it is also necessary to maintain a regular base flow downstream. The designer should investigate whether there are any downstream water users, and the amount of base flow they require. In environmentally sensitive areas, consideration should be given to providing an environmental base flow to meet the needs of fish, plants and wildlife. The design of outlets for flood control is discussed in Chapter 20.

The outlet should be arranged to drain the design flood event within 24 hours. This should ensure that the active flood storage is empty before the next storm event.

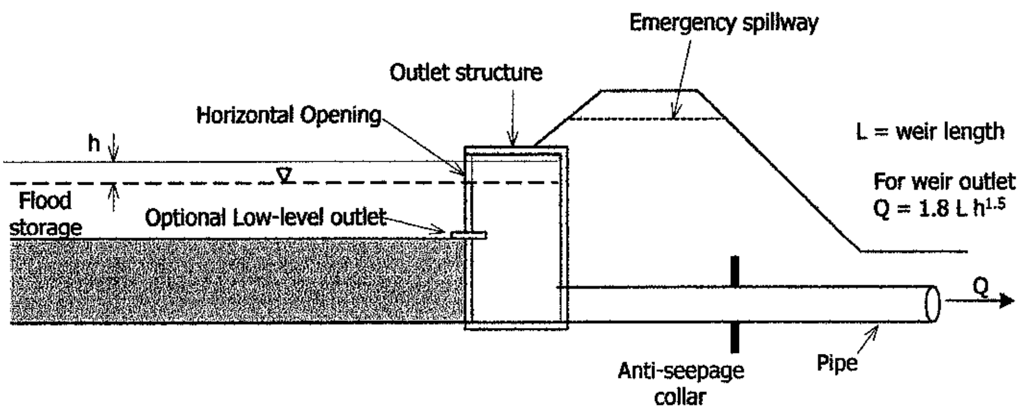
Some of the possible outlet arrangements and the applicable discharge equations are shown in Figure 1. (Based on Auckland Regional Council, 1992)




(a) Drop Outlet




(b) Broad-crested Weir Outlet




(c) Letter-box Outlet

**Figure 6: Alternative Pond Outlet Arrangements and Discharge Equations**

### 2.2.5 Protection of Outlet Pipe

A potential seepage path is along the contact between the outside surface of an outlet pipe and the embankment. The compaction of the embankment fill around an outlet pipe must be at least equivalent to that elsewhere in the embankment.

Anti-seepage collars have been used extensively in the past to lengthen the seepage path along the pipe. If they are used, it is essential that proper compaction around the collars is achieved. An alternative to anti-seepage collars is a "drainage diaphragm", which is a layer of drainage material such as sand or gravel surrounded by a filter layer. The diaphragm is designed to allow water to drain out of the embankment but trap any soil particles and prevent them from being washed away. If a drainage blanket is also used, the drainage diaphragm should be designed in conjunction with the blanket.
Extended detention is normally achieved by modifying the pond outlet to reduce the discharge at low heads. Typical extended-detention outlets include small-diameter pipes, a series of pipes at different levels, or a vertical slot. Care must be taken to ensure that the resulting outlets are not prone to blockage. They must be protected by screens, hoods or other devices (*JPS, 2000*).

### 2.2.6 Outflow and Emergency Spillways

Spillways are required to accommodate the design flood, whether or not the pond is intended to provide flood control. Spillways provide a controlled discharge, protecting the earth embankment from being overtopped and washed away by the flood.

For large ponds, spillway safety is a major consideration and designs need to be checked for rare floods. In Malaysia DID (1975) requires that all embankments be checked for stability in the inflow flood resulting from the Probable Maximum Precipitation (PMP). Overseas practices vary depending on the height of the embankment, the volume of the storage and the risk to downstream residents and property. For example in Australia ponds with embankments that are > 10 m in height and hold 20,000 $m^3$ storage; or are > 5 m high and hold 50,000 $m^3$ storage, are classified as large dams and must be referred to the state or territory's dam safety officer for assessment (*JPS, 2000*).

All ponds should be provided with a spillway to safely discharge the water safety at least for the 1 in 100 year ARI flood. For on-line ponds, this will be the flood in the river after taking into account storage routing caused by the flood storage in the pond. For off-line ponds, the emergency spillway need only cater for the diversion flow plus any local catchments inflow. One of the advantages of off-line ponds is that the emergency spillway requirements are much smaller and simpler than an in-line pond.

If the pond is also intended to have a flood storage component, the form of the emergency spillway becomes important as it will affect the stage-discharge relationship. In this case, the spillway should be designed as part of the normal outlet. A fixed weir set at the permanent pond water level provides a suitable outlet. Preliminary spillway calculations are carried out using the weir formula,

$$Q = C \times L \times d^{1.5}$$

Where the coefficient of discharge $C$ =1.7.

The weir length should be calculated so that it can discharge the design flood discharge allowing for storage routing, at the design flood storage level. Because the weir characteristic affects the storage routing, the design calculations must be checked using a storage-routing computer model.

Some other items to be considered in designing a spillway structure include the following (*JPS, 2000*):

- Reinforced concrete outlet pipes are recommended, and must be of sufficient strength to support the embankment fill.
- All joints in the riser and outlet pipe should be made watertight. This is especially important for a wet pond, but also good practice for a dry pond.
- The riser should be designed to withstand buoyant forces, with a minimum safety factor of 1.3.
- Vortex action at the top of riser should be controlled. An anti-vortex plate or a headwall may be used to prevent a vortex from forming as the water enters the riser. Anti-vortex devices can often be incorporated with a trash rack.

- Trash racks or other debris control devices should be used to prevent the spillway from becoming clogged. Trash racks can also be used to discourage children from playing inside risers and pipes. The trash rack should be designed such that, for the range of design flows, the average velocity of flow through the trash rack is 1.0 m/s maximum. An alternative criterion is to design the trash rack with a surface area of ten times the cross-sectional area of the riser or outlet pipe opening.
- The outfall channel downstream of the spillway should be protected from erosive velocities of flow exiting the spillway. Riprap lining or energy dissipaters may be necessary.

### 2.2.7 Dam Safety

Regardless of how careful a dam is designed and how well it is built, there is always the potential for a dam to be breached, either due to overtopping or to erosion from seepage or piping through or around the embankment. One of the important considerations in pond design is the potential for a failure of the dam embankment, and the potential hazard to downstream features if such an event occurs. If a dam fails, the volume of water stored in the reservoir can be released downstream, posing a risk to roads, buildings, homes and other property, as well as human lives.

Many overseas regulatory agencies have developed classifications systems regarding the hazard potential for damages due to a dam failure. The Soil Conservation Service's classification system is presented below (excerpted from TR-60, *Earth Dams and Reservoirs*, revised October 1985).

*Class (a)*

Dams located in rural or agricultural areas, where failure may damage farm buildings, agricultural land, or township and country roads.

*Class (b)*

Dams located in predominantly rural or agricultural areas, where failure may damage isolated homes, main highway or minor railways, or cause interruption of use or service of relatively important public utilities.

*Class (c)*

Dams located where failure may cause loss of life and serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railways.

To assist in determining the dam classification, a dam breach analysis may be necessary. This is a procedure where the outflow hydrograph resulting from a dam breach is routed down the river valley below the dam to determine the area that may be inundated.

Two types of analysis may be required. The first is sometimes called a "sunny day" dam failure, where the dam is assumed to fail due to water seeping or piping through the embankment, with no additional precipitation. The normal pond water volume is then routed downstream to determine the breach floodplain. The second type of analysis assumes the dam failure occurs as a result of being overtopped by a large storm (that exceeds the spillway capacity). Once the pond water level reaches a specified depth above the top of the dam, the dam is assumed to be breached and the total pond water volume is routed downstream (*JPS, 2000*).

### 2.2.8 Landscaping and Planting

Urban ponds and wetlands represent important open space and recreation facilities in urban areas, and are greatly valued by local communities.

If the ponds or wetlands are provided primarily for storm water management, recreation will normally be limited to secondary uses such as fishing and boating, and passive recreation. The designer will need to accommodate water quality and habitat requirements for fish and other freshwater species such as turtles, as well as aesthetic values (freedom from rubbish, odor and scum).

The pond surroundings should be planted with suitable selected species as quickly as possible, to reduce erosion and provide shade. Local advice should be obtained from, for example, the IPOH City Hall (DBI) on suitable species (*JPS, 2000*).

### 2.2.9 Health and Safety

According to the law, the owner of the pond is responsible for ensuring that it does not cause any risk to public health or safety.

Mosquito-borne diseases are a serious concern in tropical areas. The pond design should minimise the risk that mosquitoes will breed there. Mosquito control strategies include:

- Interception of water-borne rubbish which creates a mosquito breeding environment;
- Selection of plants, which provide a breeding ground for predator insects, such as dragonflies that feed on mosquitoes;
- Encouragement of fish breeding;
- Shaping of ponds to avoid stagnant areas with poor circulation;
- Shaping of pond edges to avoid the trapping of water in depressions as the pond water level changes;
- Providing a mechanism to regulate pond levels in order to disturb any breeding larvae; and
- Selection and control of aquatic plants to avoid the creation of habitats favoured for mosquito breeding.

The pond itself can present a hazard to small children. The designer should concentrate on avoiding serious safety hazards such as:

- Sudden drops into deep water
- Sudden changes in flow velocities or water levels; and
- Raised structures that children can fall off.

Inlet and outlet structures can be particularly dangerous because of the high flow velocities that occur there. It may be desirable to fence off the inlet and outlet structures. Such fencing should be designed so that it does not interfere with the hydraulics of the flow structure (*JPS, 2000*).

### 2.2.10 Design Principle

For the design principles, the sizing of wetlands depends on the flow conditions, there are five types of flow conditions with different sizes are discusses as below (*JPS, 2000*):

a. Steady or Attenuated Flows

This condition applies when upstream flows are constant or only slightly variation, due to the wetland being offline or downstream of a detention storage or wet pond. The basic equation applying for the size of design wetland is shown below:

$$A = 100 \cdot Q \cdot C_{in} \cdot \frac{R}{(r_b \cdot t_r)}$$

Where,

A = wetland area (ha)

Q = volume of event discharge (ML)

Cin = inflow concentration of the target pollutant (mg/L)

R = level of reduction (interception) required (%)

rb = daily adsorption rate of the largest pollutant by biofilm

$t_r$ = retention time or average time between storm events (days)

b. Ephemeral Wetlands

The ephemeral wetlands are design to collect runoff only infrequently and then dry out. Pollutants in ephemeral wetland are intercepted mainly by adhesion to vegetation surfaces, sedimentation, and retention (infiltration and evaporation). The wetting and drying are central to the pollutant removal processes in ephemeral wetlands. There is little published research on which to base a model for determining the size of ephemeral wetlands. Size is related to the volume of the storm event to be captured and, in general, should be such as to fully capture the chosen design storm.

c. Combined Wetland Facility

A combined facility means that the design is able to handle or sustain both steady inflow and high flows due to storm water runoff. Under high flow conditions, the large volume of fast-flowing water and reduced light will place at risk the fragile epiphytes and biofilm systems that are fundamental to treatment of colloids and dissolved pollutants (*JPS, 2000*)

The frequency of storm events and peak discharge rates are guidance of designer, and the volume, cross section area of the wetland should be determine such that the velocities do not exceed 0.05 to 0.1 m/s more than once per year. For a wetland design project, if the land availability is limited, the design of combined facilities with involve a series of compromise is the only viable option for the project.

d. Use of Ephemeral Wetland in Pond or Wetland

This option is essentially a combination of flow condition option 'a' and 'b'. The shallow ephemeral zones tend to have greater species diversity and to have more plant surface per unit area than permanent wetlands, they also help to improve performance by acting as hydraulic controls, allowing high flows to spread out and reduce velocity. Sizing principles for the permanent and ephemeral wetland zones correspond to those listed in 'a' and 'b' above respectively. Ephemeral wetland zones should not be continuously wet, but should have well defined wet and dry periods. A low flow bypass may be necessary to achieve this variation.

e. Recycling of Pond Water through an Off-line Wetland

As an alternative to the composite design, the designer can arrange to recycle water through a separate wetland compartment or a physically embayment of a pond. This allows better control of the treatment processes. The recirculation can be by means of a pump, which has the benefit of inducing mixing to reduce stratification.

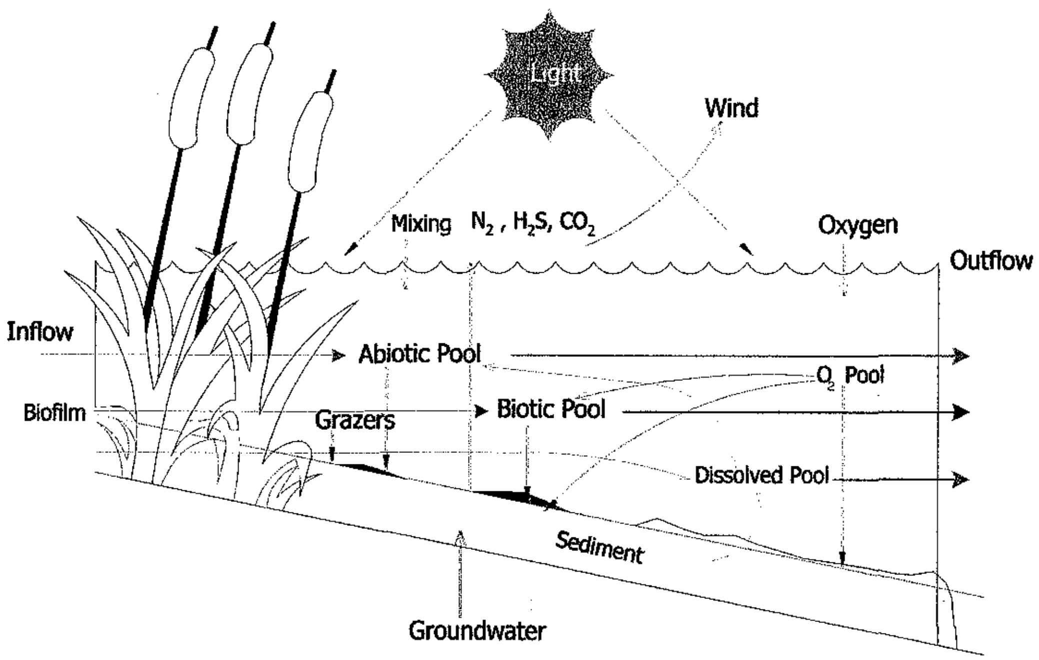



**Figure 7: Water Quality Processes in Ponds and Wetlands (CRCFE, 1998)**

### 2.2.11 Hydrologic Regime

The principal function of the storage in a constructed wetland is to provide a variable wetting cycle, which encourages growth and diversity of plants. A depth range of 0.5m to 1.0m and a hydraulic residence time of less than 3-5 days for a design storm may be suitable (EPA NSW 1997). This depth range is tolerated by most emergent macrophysics vegetation.

An important aspect of the hydrologic regime of the wetland is the frequency of inundation at different depths. This is a function of the outlet design as well as of local climatic conditions. Water depth is a fundamental factor controlling the growth of plants. Different species will have preferences for different depth and inundation regimes. The designed should evaluate the hydrologic regime by means such as a continuous simulation computer model (*JPS, 2000*).

### 2.2.12 Wetland Outlet Design

The use of a riser type outlet is generally more suitable for controlling the water level regime in a wetland than a weir because it gives more control over the stage discharge relationship. However, there is a scope for the design of innovation outlet arrangements such as proportional weirs to suit Malaysian conditions.

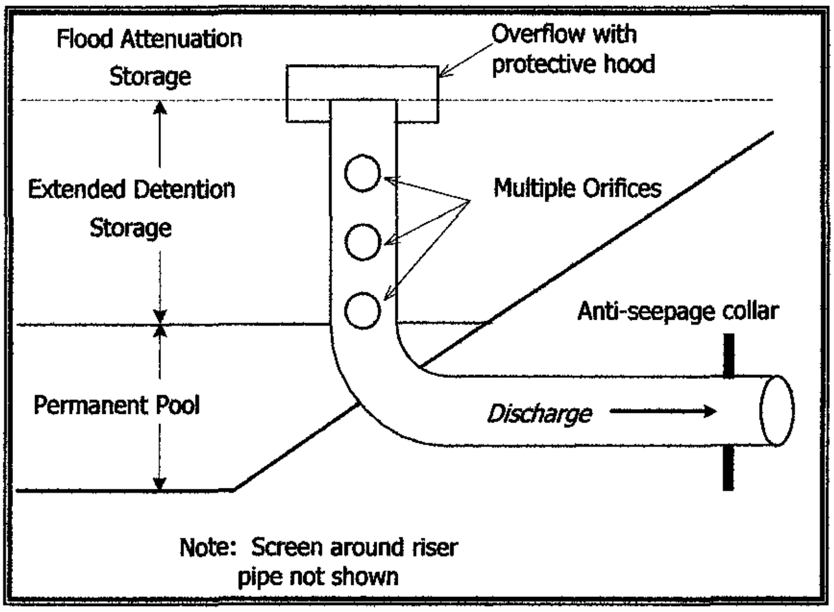



**Figure 8: Schematic view of a typical riser pipe outlet design for a constructed wetland**

Figure 8.0 shows a schematic view of a typical riser pipe outlet design for a constructed wetland. In this example, the riser pipe has a hood and screen to prevent blockage by the floating materials which is commonly found in wetlands. Anti seepage, collars should be installed along outlet conduits passing through or under the dam embankment. It is desirable to provide an adjustable outlet so that the water depth can be adjusted if necessary. This is particularly so during the early of plant establishment. Some examples of adjustable outlets can be wooden weirs, which can be mounted at different levels and removed when not required; or piped low flow outlets, which can be capped off when not required. An emergency spillway must be provided to protect the embankment surrounding the wetland. For the flow distribution, wetland must be designed to provide an even flow distribution and avoid short circuiting (direct flow from inlet to outlet). A long, narrow shape is recommended for this reason. Urbonas and Stahre (1993) proposed that the ideal shape is an extended oval, with inlet and outlet at opposite ends. Inlet structure should be designed to spread the flow as much as possible. This may involve providing flow baffles or a weir. (*JPS Manual, volume 13, Chapter 35*)

### 2.2.13 Planting

The following criteria should be used when selecting plants for a particular pond site:

- The proposed plant must be able to establish and grow at the site
- The plant should be unlikely to spread outside or downstream of the pond
- The maximum height of plants must be consistent with the desired visual characteristic of the pond
- Plants must not grow to a density that provides habitats for mosquito or other pest breeding.

### 2.2.14 Operation and Maintenance

As with constructed facility, wetlands require regular ongoing operation and maintenance. General maintenance including lawn mowing, rubbish removal, and inspection should be carried out at regular intervals not exceeding once every two weeks, Structures such GPTs, embankments, inlets, outlets, spillways and culverts must be routinely inspected for serviceability, safety and cleaning and removal of trapped rubbish and sediment. Safety measures such as fences, booms and warning notices must routinely be inspected to ensure that they are in working order (*JPS, 2000*).

### 2.2.15 Aquatic Vegetation

Maintenance during the plant establishment phase is critical because it is during this phase that plants are most vulnerable to damages. Low water level, weed invasion, and damage by animals are possible causes of problems. Plants should be inspected at least weekly during the initial phase in order to detect any damage and allow corrective action. Aquatic plants should be inspected periodically to control pest species and to promote the desired mix of plants for conservation and landscaping purposes. Occasional replanting may be necessary to maintain the desired mix of species. The consensus of scientific opinion is that it is not appropriate to regularly harvest by the harvesting process introduces the risk of remobilizing sediments and nutrients, and introducing weed species. The validity of this conclusion in tropical countries such as Malaysia needs to be established by further research (*JPS, 2000*).

## 2.2.16 Eutrophication and other Problems

Under climatic conditions, nutrients enrichment of pond water can cause abundant plant and algae growth. The resulting algae blooms are unsightly and damaging to public health and can cause fish kills and episodes of poor water quality. The following conditions are most likely to encourage eutrophication:

1. Excessive nutrient loading in inflows
2. High average temperatures and abundant sunshine
3. Still water, and
4. Clear water (low turbidity)

Pond or wetland designer should try to avoid these conditions. For example, it may be inappropriate to locate a pond or wetland downstream of an oxidation pond discharge, which is rich of nutrients. In many parts of Malaysia, the high turbidity of surface waters helps to prevent eutrophication by preventing sunlight penetration.

However, high turbidity promotes another problem, which is water column stratification. Heated surface waters become lighter than the bottom waters, effectively preventing any mixing. The resulting physical barriers prevent oxygen transfer to the bottom layers, which typically become deoxygenated. Deep mining ponds may be prone to stratification. There is a rapidly increasing body of scientific knowledge of both of these problems and there are methods, such as mechanical mixing, to overcome them. If any ponds are found to be subject to these problems specialized technical advice should be sought.

### 2.2.17 Water Quality

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 issues of water quality need to be considered from the following aspects:

- Aesthetic: this shall consider the turbidity, nutrient, concentrations (potential impact on algae bloom), oil, grease, and pollution from gross pollutant.
- Odors: Sources of odors are from decaying biomass and deoxygenated lakes sediments.
- Public health issue: This relates to bacterial pollution and presence of toxic substances.

5 Classes of water have been proposed by DOE (EPA NSW 1997)

- Class I: Conservation of natural environment water supply I(no treatment of necessary), Fishery I -very sensitive aquatic species
- Class 1IA : Water supply II -conventional treatment required, Fishery 11 - sensitive aquatic
- Class IIB : Recreational use with body contact
- Class III: Water Supply III -extensive treatment required, Fishery III - common economic value and tolerant species live stock drinking.
- Class IV : irrigation
- Class V: none of the above

The target water quality of the lakes and wetland should ideally Class 1IB, suitable for body contact. Principal features of this class of water are as follow:

- No visible floatable materials or debris
- No objectionable odor and taste
- Relatively low suspended solids (50mg/LO, turbidity (50NTU)
- Modest oxygen demand as measured by BOD(3mg/L) and COD(25mg/L)
- Bacterial contamination of less than 5000 MPN/100ml
- Ammoniac nitrogen less than 0.3mg/L

### 2.2.18 Water Balance Model Parameters

The model requires estimates of the upper soil and groundwater store depths as well as recession and store runoff coefficients. Initial model parameters were based on calibration to two urban catchments in Austria. These parameters were later modified to reflect the runoff volumes estimated in Malaysia conditions. The runoff coefficient for non-urban areas was estimated to be 0.35. A runoff coefficient of 7 was estimated for fully urbanized areas. The value has been adopted in order to show consistency with the Design Report of Main Drain and Flood Detention Pond for Tasik UTP.

### 2.2.19 Evaporation Data

Evaporation data were based on averaged monthly values provided by the JPS evaporation station in Perak Ujian at Tg. Piandang, Perak. The annual evaporation rate is 1816mm. A pan evaporation factor of 0.7 was used to estimate evapo-transpiration from the catchments areas. A pan evaporation factor of 1 was chosen for open water surfaces (JPS 2000).

### 2.2.20 Rainfall data

The rainfall data are obtained from Jabatan Pengaliran Dan Saliran (JPS) Hygrology and Water Resources Department, Nalla rainfall recording station at Tronoh Perak. Daily values from year 1930 to 1995 inclusive were available. Refering to the 66 years of data available, some of the data are incomplete. Rainfall data from year 1988 to 1995 have been chosen for analysis. Out of the 8 years data, 1992 was determined to be the driest year, while 1995 was the wettest year. In water quality modeling, driest year will normally create higher pollutant concentration, while wettest year carried higher pollutant loading by storm water runoff.

### 2.2.21 Mosquitoes

'Aedes aegypti' and 'Aedes albopictus' are difficult scientific Latin names to remember, but the local population has come to know them, as they are used non-stop by TV and local newspapers. Referring to the newspaper "New Strait Time" (*September 3, 2005*), Malaysia was the last country to declare a dengue state of emergency. Kuala Lumpur reports 28,592 infected people, 1,480 of which in the form that can result in death. The victims in the country total 73. "The epidemic is reaching its peak, the situation might last several weeks," Ramlee Rahmat, from the Malaysian health ministry, told the New Strait Times, confirming more than 1000 new hospitalizations in recent days. The situation is even worse in neighboring Singapore where, paradoxically the extreme cleanness may have helped the disease spread. "Precisely because Singapore has in the past vanquished dengue, the new generations, born in the last 20 years, has a low immunity level," said Professor Paul Reiter, who works at the prestigious Pasteur medical institute, specialized in the treatments and prevention of epidemics. Reiter is part of a team of international experts who are studying Singapore's dengue outbreak, with 11,000 confirmed infection cases, and 12 deaths. In Indonesia, in mid September, there were reports of 650 victims and 48,000 infected people. Last year the victims were 800 and the cases 80,000. At the end of summer, in Thailand the victims were 50 with more than 31,000 cases. In the Philippines, the mosquitoes had infected 19,000 people, killing 259. In Vietnam, 22 victims and 38 in Cambodia. The actual figures could be sensibly higher.

## 2.3 Introduction of Various Laboratory Tests

### pH

The term pH is referred to the hydrogen ion activity in a given solution and has been expressed as the logarithm to the base 10 of the reciprocal (negative logarithm) of the activity of hydrogen ions at a given temperature. It measures the concentration of hydrogen ions in a solution. The equation of pH term is:

$$pH = \log 1/[H^+] = -lo_g[H^+]$$

Whereby; $[H^+]$ = concentration of hydrogen ions in moles/L

The pH scale ranges from 1 to 14; in which pH from 1 to 6 indicates that the solution is acidic, while pH from 8 to 14 indicates that the solution is basic. Solutions that have pH 7.0 are said to be neutral.

### Turbidity

Turbidity is a measure of suspended matter that interferes (absorption or scattering) with the passage of the light through water. Thus, the factor that affects the scattering of the light would affect its measurement. The influential factors include:

- Number, size and shapes of the particles
- Refractive index of particles
- Wavelength of the incident ray from the instrument
- Characteristic and the quality of the measuring device

Turbidity measurements are very important as a guide to quality as well as an essential parameter for proper control and operation of treatment plants. As, colloidal particles have dimensions greater than the average wavelength of white light, they interfere with the passage of light.

**Chemical Oxygen Demand (COD)**

Chemical oxygen demand is widely used to characterize the organic strength of wastewaters and pollution of natural waters. It is the amount of oxygen that is required to oxidize an organic compound (biodegradable and non-biodegradable) to COD and the water is under the influence of a strong oxidant ($K_2Cr_2O_7$) in an acid environment (silver nitrate used as a catalyst). Compared to the BOD test, the major advantage of this test is that it requires a shorter time which is approximately 3 hours. The relationship between COD and BOD can be established so that the BOD value can be estimated quickly. The common relationship between these two parameters can be obtained by $BOD_5$ / COD for municipal wastewater ~ 0.5

**Total Suspended Solids**

Wastewater contains a variety of solid materials varying from rags to colloidal material. In the characterization of wastewater, coarse materials are usually removed before the sample is analyzed for solids. Total solids are obtained by evaporating a sample of wastewater to dryness and measuring the mass of the residue. A filtration step is used to separate the total suspended solids (TSS) from the total dissolved solids (TDS). As a filter is used to separate the TSS from the TDS, the TSS test is somewhat arbitrary, depending on the pore size of the filter paper used for the test. Filters with nominal pore sizes varying from 0.45μm to about 2.0um have been used for the TSS test. More TSS will be measured as the pore size of the filter used is reduced. Thus, it is important to note the pore size of the filter paper used, when comparing reported TSS value.

**Biochemical Oxygen Demand**

The most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day BOD ($BOD_5$). This determination involves the measurement of the dissolved oxygen used by the microorganisms in the biochemical oxidation of organic matter. The results from the BOD test are now used (1) to determine the approximate quantity of oxygen that will be required to biologically stabilize the organic matter present, (2) to determine the size of waste treatment facilities, (3) to measure the efficiency of some treatment processes, and (4) to determine compliance with wastewater discharge permits. The actual BOD test involves placing a sample of waste in a test bottle that includes bacteria (seed), nutrients and dissolved oxygen. The test bottle is incubated for 5 days at a constant temperature of 20°C. The amount of dissolved oxygen used under these conditions is known as the 5 day biochemical oxygen demand.

The presence of BOD in wastewater can be removed by two methods, which is oxidation reaction and synthesis in the activated sludge or aeration tank.

Oxidation:

$$COHNS + O_2 + \text{bacteria} \longrightarrow CO_2 + H_2O + NH_3 + \text{other end products} + \text{energy}$$

Synthesis:

$$COHNS + O_2 + \text{bacteria} + \text{energy} \longrightarrow C_5H_7NO_2$$

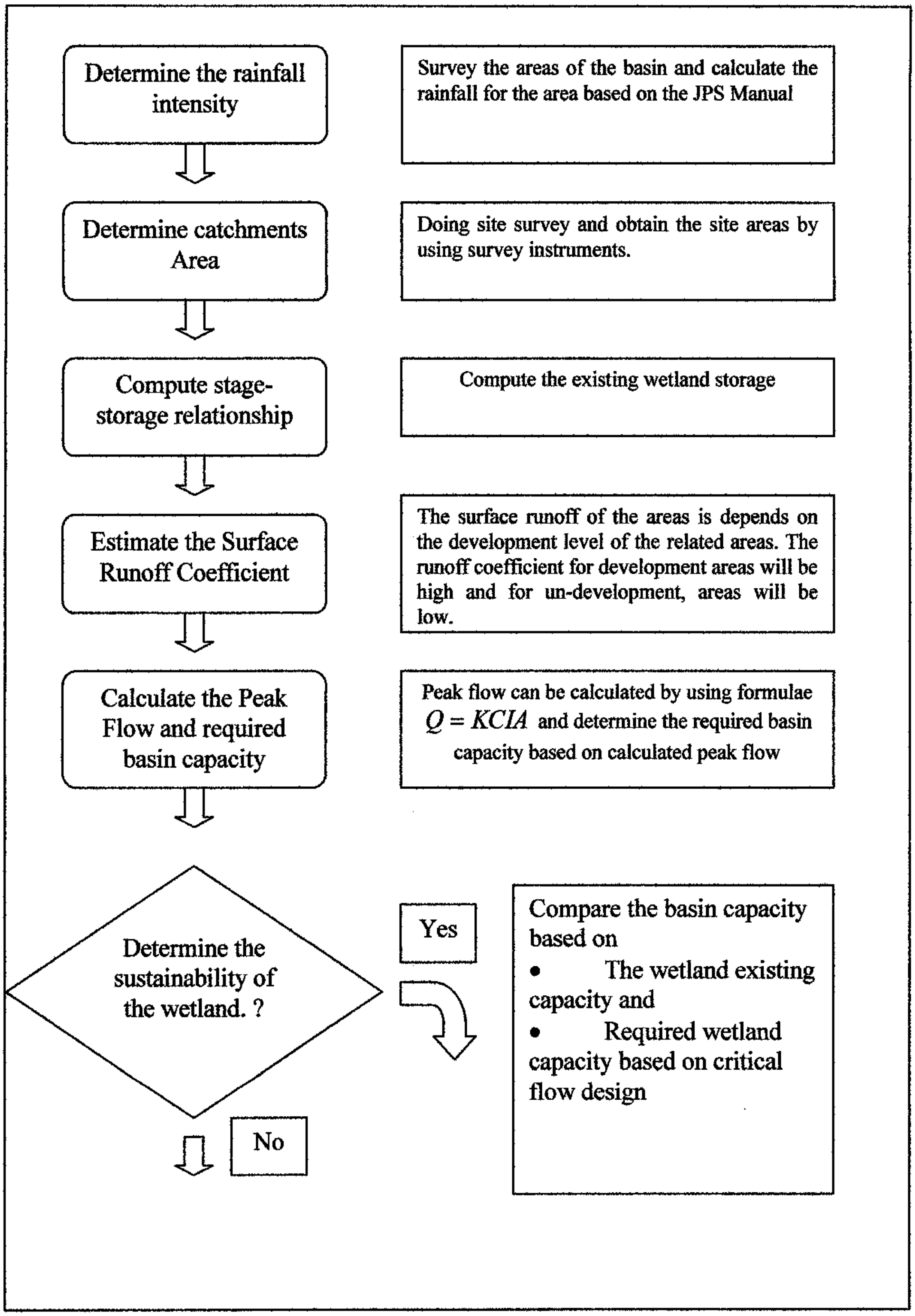
# Chapter 3
# METHODOLOGY

## 3.1 Introduction

The methods used in this study are wetland volume calculation and the water quality laboratory tests. The calculation part includes the rainfall intensity calculation for IPOH (Appendix C). Secondly, the area of UTP was divided into seven catchments area and each of them has different values of runoff coefficient. The volume capacity calculation is based on the peak flow of the catchments area. The water quality is based on various type of laboratory test to examine the level pollution of the water samples. Information about flora was collected from the KLCC office in UTP campus. Around 70 types of flora species are planted surround the wetland and 35 types of flora species are listed in the report.

## 3.2 Wetland Design Calculation Procedures

The calculation of the wetland capacity was according to the calculation of the rainfall intensity in UTP. UTP is near IPOH town, so the rainfall data which is required for the calculation was based on the rainfall data from IPOH city. After the rainfall intensity for UTP was calculated, the next step was to proceed with calculating the peak flow of various catchments area in UTP. The whole UTP campus was divided into seven catchments area and the concern catchments area is the catchments area A4 (*refer to Figure 9*). Finally, the wetland volume capacity can be calculated based on the peak flow value calculated from the catchments area.


Determine the rainfall intensity
Survey the areas of the basin and calculate the rainfall for the area based on the JPS Manual
Determine catchments Area
Doing site survey and obtain the site areas by using survey instruments.
Compute stage-storage relationship
Compute the existing wetland storage
Estimate the Surface Runoff Coefficient
The surface runoff of the areas is depends on the development level of the related areas. The runoff coefficient for development areas will be high and for un-development, areas will be low.
Calculate the Peak Flow and required basin capacity
Peak flow can be calculated by using formulae $Q = KCIA$ and determine the required basin capacity based on calculated peak flow
Determine the sustainability of the wetland. ?
Yes
Compare the basin capacity based on
• The wetland existing capacity and
• Required wetland capacity based on critical flow design
No

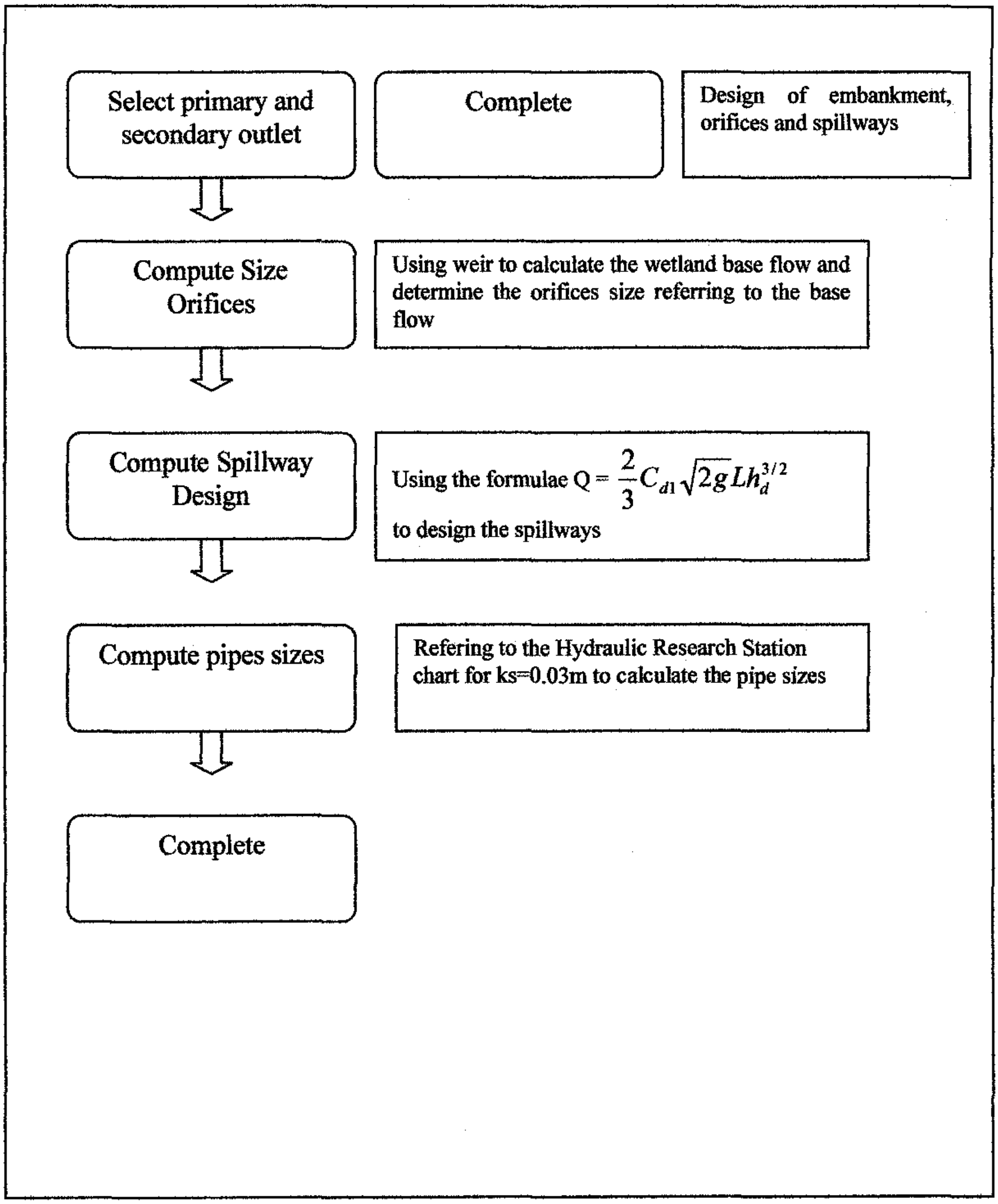



**Figure 9: Wetland Design Procedure**

### 3.2.1 Step 1: The Rainfall Intensity Calculation

The calculation of the rainfall intensity of UTP campus is based on the rainfall data from IPOH city (Appendix C), and the design calculation is for 60 minutes rainfall duration and 100 years return period. The calculation data is based on Table 3, coefficient of the Fitted IDF equation for Perak and the formula applied is $\ln({}^{R}I_t) = a + b\ln(t) + c(\ln(t))^2 + d(\ln(t))^3$ ( *JPS Manual 2000*), and the rainfall data is based on the rainfall data for Malaysia as shown in appendix B

**Table 2: Coefficient of the Fitted IDF Equation for Perak, Ipoh**

| ARI (years) | a | b | c | d |
|---|---|---|---|---|
| 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 |

Explanation: Table 1 was extracted from figure 1 with the concern area is Ipoh Perak. Assumption that Return Period is **100 yrs**, duration = **60minutes**: Refer to the formulae 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 = 5.1068

b = 0.8168

c = -0.2905

d =0.0165

$$\ln({}^{R}I_t) = 5.1068 + 0.8168(\ln 60) + -0.2905(\ln 60)^2 + 0.0165(\ln 60)^3$$

$$\ln({}^{R}I_t) = 4.7133$$

${}^{R}I_t$ (average rainfall intensity) = **111.42mm/hr = 4.39inches/hr**

Therefore, the rainfall intensity of UTP campus is 4.39inches/hr.

### 3.2.2 Step 2: Estimation of the Surface Runoff Coefficient

The area of UTP campus is big enough to have various design criteria vary from each other. Therefore, the whole UTP campus is divided into seven sub-catchments areas and the surface runoff coefficient are estimated based on the development condition on the related area and the surface characteristic. For develop areas, the runoff coefficient will be high and for un-develop areas, the runoff coefficient will be low. According to this design, the surface runoff coefficient is referring to Table 15.2.3 Runoff Coefficients for use in the Rational Method in page 563 (Water Resources Engineering by Larry W. Nays, 2001).

**Table 3: Catchments Area and Coefficient**

| Item | Sub-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 | 34.49 | 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 | | | | |

### 3.2.3 Step 3: The Peak Flow using Rational Methods

Using the rational method, the storm runoff peak is estimated by the rational formulae

**Qp = KCIA,**

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

K = K is 1.0 in U.S, customary units o.28 for SI units

C = runoff coefficient

I = average rainfall intensity in in/hr or mm/hr

A = Area of the concern area in acres or km

For the existing wetlands, the design Return period, ARI = 100yrs and rainfall duration is 1 hour or 60 minutes, for catchments area A4 = 0.75, area = 73.92ha, rainfall intensity =0.111m/hr:

**Qp = KCIA**

$$Qp = 0.28\,(0.75)\,(0.111 m/hr)\,(0.7392\text{^}10^6 m^2)$$

$$Qp = 17230.75 m^3/hr$$

$$= 4.786 m^3/s$$

### 3.2.4 Step 4: Sizing Detention Calculation

The American Association of State Highway Transportation Officials AASHTO(1991) recommended an alternate estimate of storage volume using the regression equation developed by Wycoff and Singh (1986) as

$$(Vs/Vr) = 1.29(1-(Q_A/Qp))^{0.153} / (tb/tp)^{0.411}$$

Where $V_s$ is the volume of storage in inches, $V_r$ is the volume of runoff in inches, $Q_A$ is the peaj outflow in $m^3/s$, $t_b$ is the time base of the inflow hydrograph in hours (determined as the time from the beginning of rise to a point on the recession limb where the flow is 5% of the peak), and tb is the time to peak of the inflow hydrograph in hour.

The concern area: catchments area A4: Assume that the wetland can reduce the peak flow by 35% from the peak flow. Refer to the table above; the peak flow volume is $4.786m^3/s$, Tp =15minutes, Tb= 29.25minutes.

$$(Vs/Vr) = 1.29(1-(Q_A/Qp))^{0.153} / (tb/tp)^{0.411}$$

Vs = storage volume

Vr = runoff volume

$Q_A$ = peak outflow = (0.65x 4.786 = 3.1109 $m^3/s$)

$Q_P$ = peak inflow = $4.786m^3/s$

tb - base time of the inflow hydrograph = 29.25minutes

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

$$Vr = 0.5(t_b X Qp)$$

= 0.5 x (29.25 x 60) x 4.786

$= 4199.72\,m^3$

$(Vs/Vr) = (1.29(1-(3.1109/4.786))^{\wedge 0.153}) / (29.25/15)^{\wedge 0.411} =$

$= 1.09858/1.31584 = 0.8349$

$Vs = 0.8349 \times 4199.72$

$= 3506.29\,m^3$

Therefore, according to the calculation above, the volume of the wetland design in the UTP core park is above 3519.9 $m^3$.

From the survey that was conducted, UTP Core Park Wetland has an area about 3500 sq meter, and the average, depth of the wetland is 1m:

Wetland capacity = 3500 x 1

$= 3500\,m^3$

Therefore, the existing wetland capacity in the UTP Core Park wetland is enough to sustain the 100yrs return period and 60minutes rainfall duration peak flow.

### 3.2.5 Step 5: New Consideration whereby Duration is 45 minutes and 100yrs ARI

### Calculation for Rainfall Intensity (mm/hr), 45minutes

In another situation of the rainfall intensity of UTP campus, calculation can be made based on the rainfall data from IPOH city, and the design calculation will refer to 60 minutes rainfall duration and 100 years return period. The calculation data is based on Table 3, coefficient of the Fitted IDF equation for Perak and the formula applied is

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

**Table 4: Coefficient of the Fitted IDF Equation for Perak**

| ARI (years) | a | b | c | d |
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| 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 |

Based on the assumption that Return Period is **100 yrs**, duration = **45minutes:**

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 = 5.1068

b = 0.8168

c = -0.2905

d =0.0165

$$\ln({}^{R}I_t) = 5.1068 + 0.8168(\ln 45) + -0.2905(\ln 45)^2 + 0.0165(\ln 45)^3$$

$$\ln({}^{R}I_t) = 4.917$$

${}^{R}I_t$ (average rainfall intensity) = **136.66mm/hr**

Therefore, the rainfall intensity of UTP campus is 136.66/hr.

### 3.2.6 Step 7: Qp (peak flow) Calculation for Sub-Catchments Area A4

Using the rational method,

Qp = KCIA,

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

K = K is 1.0 in U.S, customary units o.28 for SI units

C = runoff coefficient

I = average rainfall intensity in in/hr or mm/hr

A = Area of the concern area in acres or km

Example for ARI = 100yrs and rainfall duration is 1 hour or 60 minutes, for catchments area Al = 0.35, area = 159.34ha:

Qp = 0.28 (0.35) (0.1366m/hr) ($1.59^\wedge10^6 m^2$)

Qp = $21294.36 m^3/hr$

= $5.915 m^3/s$

### 3.2.7 Step 8: Calculate the Base Flow using Vee Weir

It has been stated that rectangular weirs suffer from a loss of accuracy at low flows (Hydraulics in Civil and Environmental Engineering, page 403); the Vee weir largely overcomes this problem. The variation of b with height, together with the narrow nappe width in the jet, means that for a given increase in Q, the increase in h1 for a Vee weir will be much greater than for a rectangular weir. Conversely, the greater sensitivity limits the range of discharge for which a Vee weir can be applied. The underlying theory and assumptions are the same as for the rectangular weir excepting, of course, the fact that b is not a constant but a function of z.

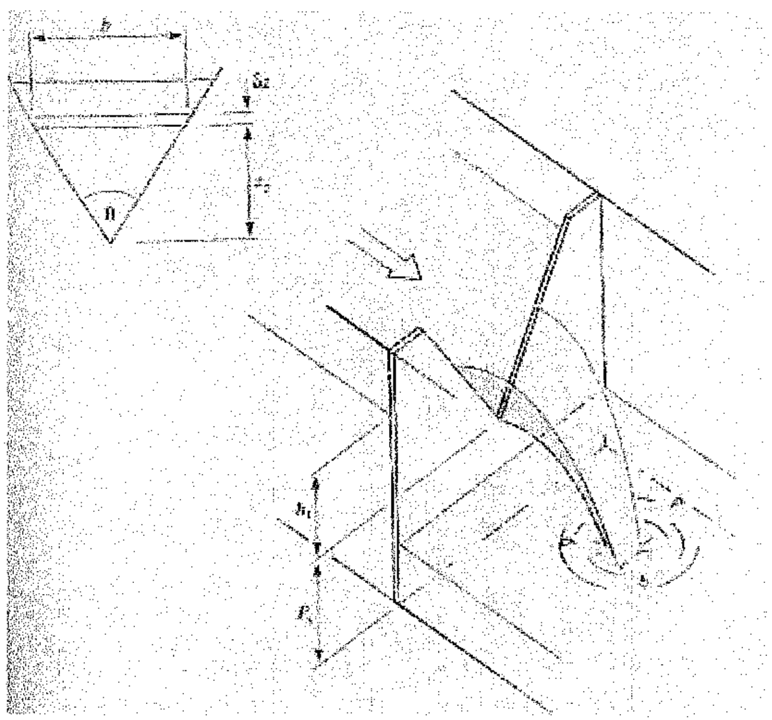

**Figure 10: Vee Weir**

Thus the formulae use for Vee Weir is $Q = \frac{8}{15}\sqrt{2g}\tan(\vartheta/2)h_1^{5/2}$

According to the weir prepared, the weir used to measure the water flow rate
Weir prepared :
Width : 50cm
Height : 30cm
V-notch angle : $90^0$
Ps : 5cm
$h_1$ : 15cm

Experiment date : 13/4/2006 Thursday
Weather : Raining day one Tuesday

| | $h_1$, Water height(cm) |
|---|---|
| First measurement | 15.1 |
| Second measurement | 14.8 |
| Third measurement | 15.1 |
| | Average measurement: 15.0cm |

**For VEE Weir Calculation**

$$Qideal = \frac{8}{15}\sqrt{2g}\tan(\theta/\ 2)h_1^{5/2}$$

Θ = $90^{o}$
h = 10cm to 0.15m
g = 9.81
Q = $\frac{8}{15}\sqrt{2(9.81)}\tan(90/\ 2)0.15^{5/2}$

Q = 0.02 $m^3/s$

### 3.2.8 Step 9: Design of the Orifices Sizes

The orifices sizes was designed based on the base flow in the wetland,of 0.02 $m^3/s$. The formulae used for the design the orifices is Q = Cd Ao $(2gHo)^{1/2}$ . After the calculation of the bottom orifice diameter, the mid and the top orifices will be designed using the same diameter. The volume discharge of mid and top orifices will be calculated and find out the total flow rate for three orifices. Flow rate in different conditions will be shown as below.

Bottom Orifices
Q = Cd Ao $(2gHo)^{1/2}$
Ho = 0.7m
Cd = 0.581
0.02 = 0.5 Ao $(2*9.81*0.7)^{1/2}$
Ao = 0.011
$\frac{\pi d^2}{4}$ = 0.011
D = 0.1172m or 11.17cm
= 12cm

Mid Orifices
Q = Cd Ao $(2gHo)^{1/2}$
Ho = 0.56m
Cd = 0.5
Q = 0.5 0.011 $(2*9.81*0.56)^{1/2}$
= 0.018 $m^3/s$

Top Orifices

| | |
|---|---|
| Q | $= Cd\ Ao\ (2gHo)^{1/2}$ |
| Ho | $= 0.18m$ |
| Cd | $= 0.5$ |
| Q | $= 0.5\ 0.011\ (2*9.81*0.18)^{1/2}$ |
| | $= 0.01\ m^3/s$ |

Total Flow Rate by three Orifices $= (0.02+0.018+0.01)$
$= 0.048\ m^3/s$

The Proposed Orifices Sizes:

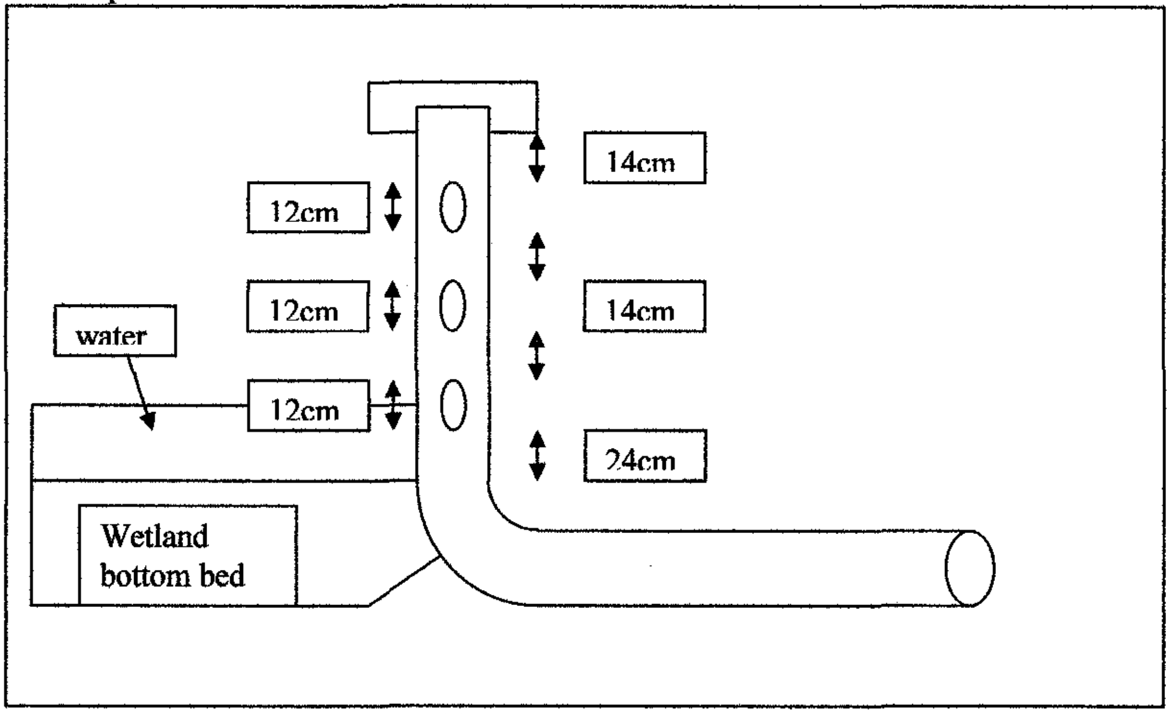


**Figure 11: Proposed Orifices design**

**Flow Rate in different conditions:**

When the bottom orifices has submerged, the water flow rate is $0.02\ m^3/s$,

When the bottom and mid orifices are submerged, the water flow rate is $0.038\ m^3/s$,

When all orifices are submerged, the water flow rate is $0.048 m^3/s$,

Estimation of water capacity in the wetland:

Because the depth of the UTP wetland is 1m, so the estimation of water capacity in wetland can be determined by measuring the water level at the orifices pipe.

When the water has submerged the bottom orifices and the water surface is just reach the top of the bottom orifices, the water capacity is around 36% of the wetland and the capacity is = (0.36 * 3619.9 $m^3$) = 1303.164 $m^3$

When the water has submerged the mid orifices and the water surface is just reach the top of the orifices, the water capacity is around 62% of the wetland and the capacity is = (0.62 * 3619.9 $m^3$) = 2244.338 $m^3$

When the water has submerged the top orifices and the water surface is just reach the top of the orifices, the water capacity is around 88% of the wetland and the capacity is = (0.88 * 3619.9 $m^3$) = 3185.5 $m^3$

### 3.2.9 Step 10: Design the Outlet Pipe Culvert Sizes

**Design of pipes**

By using the equation Q=AV,

The Q under consideration for the volume flow rate of three orifices = 0.048 $m^3/s$

Therefore, convert to L/s = 48L/s

The pipe length used to connect the orifices pipe to pumping house = 3m, and the dropping is 1cm for each 300cm, therefore,

Sf= 1/300, 100Sf= 0.33

Refer to the table 6, Typical ks value, for asbestos cement pipe, the ks value should be 0.03mm and for figure12, Hydraulic Research Station chart for ks=0.03mm

The estimation diameter for the pipe is 0.27m or 27cm, but the proposed pipe diameter will be 30cm.

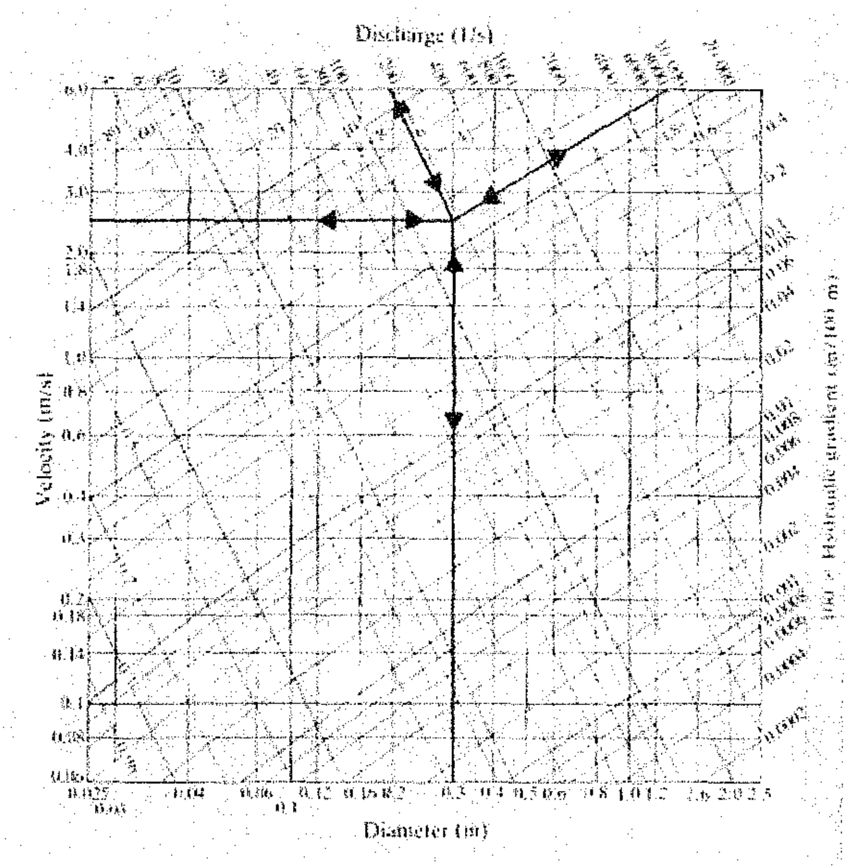


**Figure 12: Hydraulic Research Station chart for ks=0.03mm**

**Table 5: Typical ks value**

Table 4.2 Typical $k_s$ values

| Pipe material | $k_s$ (mm) |
|---|---|
| brass, copper, glass, Perspex | 0.003 |
| asbestos cement | 0.03 |
| wrought iron | 0.06 |
| galvanized iron | 0.15 |
| plastic | 0.03 |
| bitumen-lined ductile iron | 0.03 |
| spun concrete lined ductile iron | 0.03 |
| slimed concrete sewer | 6.0 |

### 3.2.10 Step 11: Design of Embankment

Embankment is a part of the new design and the main function of it is to impound the permanent pond and create flood storage. In some cases where an existing mining pond is being used, an embankment may not be required.

Refer to the recommended top widths for earthen dam embankments are provided in Table 35.2, JPS Manual, Chapter 35.

**Table 6: Recommended Top Widths for Earth Embankments (USDA, 1982)**

| Height of Embankment (m) | Top width (m) |
|---|---|
| < 3 | 2.4 |
| 3 to 4.5 | 3.0 |
| 4.5 to 6 | 3.6 |
| 6 to 7.5 | 4.2 |

Therefore, the recommended embankment is 2.4 meters width and 2 meters height.

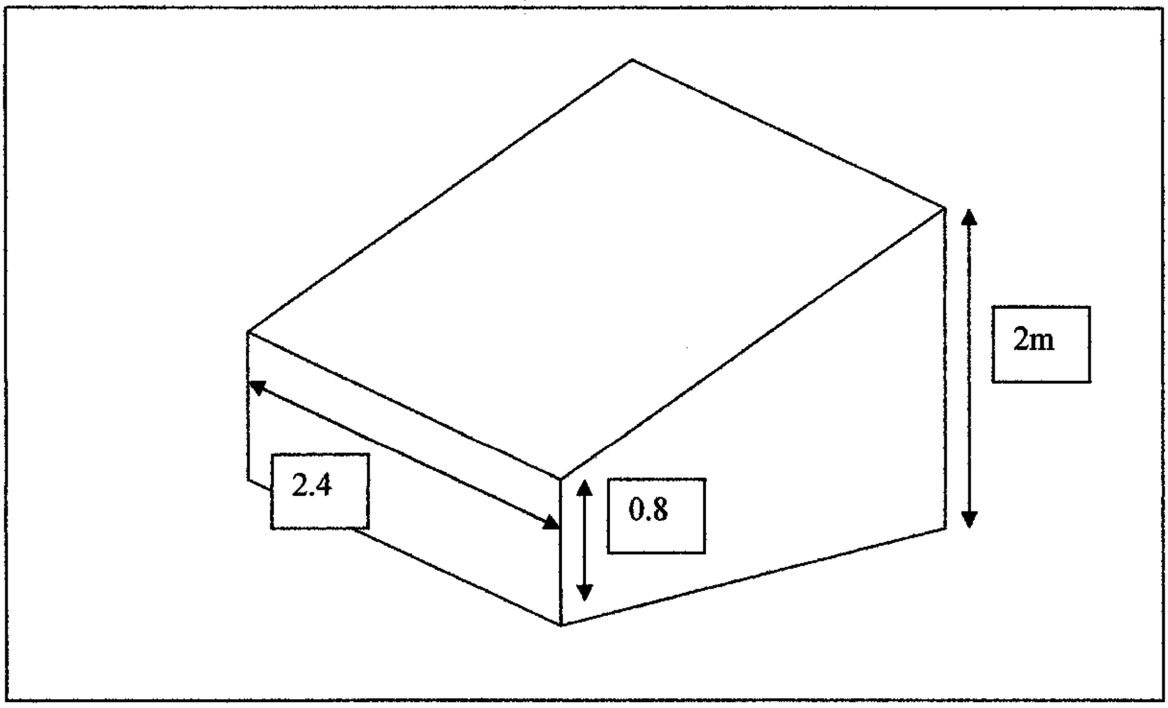


**Figure 13: Proposed Embankment Sizes**

### 3.2.11 Step 12: Calculate the Concern Peak Flow

During Peak flows Condition

Major design storm, $Q_{peak}$ (For 60 minutes), the peak flow which can be sustained by the existing wetland = $4.804 m^3/s$

Minor design storm, $Q_{outflow}$ (For 45 minutes) , the peak flow which the existing wetland can not be sustained = $5.915 m^3/s$

Q to be manage during peak flow = 5.915-4.804 = $1.111 m^3/s$

Wetland Depth = 1.0m

Height of Orifices = 1.0m

### 3.2.12 Step 13: Spillway Design Calculation

The crest profile of the spillway is so chosen as to provide a high discharge coefficient without causing dangerous cavitations conditions and vibrations. The profile is usually made to conform to the lower napped emanating from a well-ventilated sharp-crested rectangular weir. This idea is believed to have been proposed by Muller in 1908. Such a profile assures, for the design head, a high discharge coefficient, and at the same time, atmospheric pressure on the weir. However, heads smaller than the design head cause smaller trajectories and hence result in positive pressures and lower discharge coefficients. Similarly, for heads higher than the design head, the lower napped trajectory tends to pull away from the spillway surface and hence negative pressure and higher discharge coefficients result. For ogre spillway, the formula applying is:

$Q = \frac{2}{3} C_{d1} \sqrt{2g} L h_d^{3/2}$, (Book Flow in Open Channels, second edition, page 333)

Flow Rate to be manage = 1.111 − 0.048
= $1.063 m^3/s$

$$Q = \frac{2}{3} C_{d1} \sqrt{2g} L h_d^{3/2}$$

Cd =0.19, Cds = 1.19(0.50) =0.6

Assume the width of the spillway is 1.3m

$$1.063 m^3/s = \frac{2}{3} 0.6 \sqrt{2(9.81)} (1.3) h_d^{3/2}$$

$h_d^{3/2} = 0.18$

$h_d = 0.6\text{m or } 60\text{cm}$

Therefore, the height of the spillway will be 60cm and the width will be 1.3m.

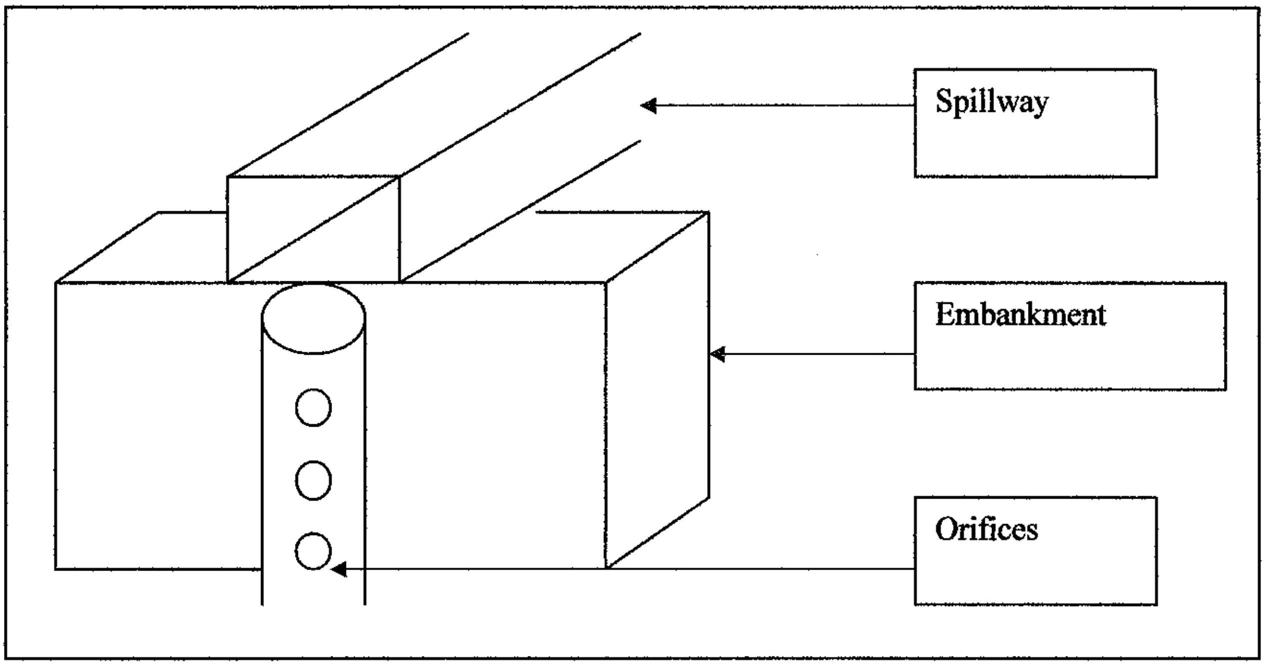


**Figure 14: Proposed Spillway Design**

According to the existing condition of the UTP Core Park Wetland, the downstream of the wetland is facing to Block 02, and there is hard to connect the spillway directly to the lake in the opposite of chancellor hall. Therefore, the spillway proposed will be constructed like drainage but the sizing will be same as the proposed spillway calculation whereby the spillway will be constructed to the edge of the building and make a 90° turn and connected with the another connection part of the spillway. The top of the spillway will be covered by using drainage cover. The route of the spillway will be shown in the figure below:

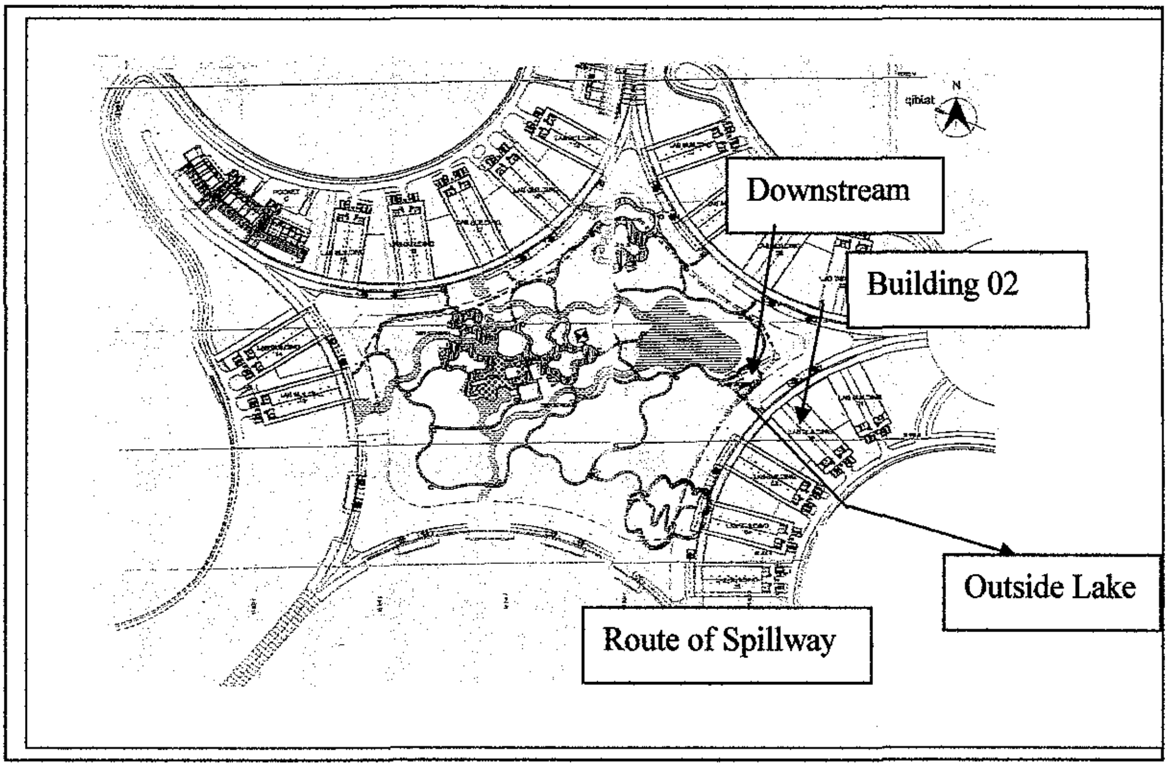


**Figure 15: Routes of the proposed spillway**

## 3.3 Apparatus and Reagents for various Tests

Pictures of various laboratories can refer to appendix H

**pH**

320 pH meters, beakers, magnetic stirrer, bar magnet, phosphate buffer of pH 7.0

**Turbidity**

2100P turbidity meter

**Water samples**

UTP Wetland

**Chemical Oxygen Demand**

Potassium dichromate, influent water sample from UTP wetland

**Total Suspended Solids**

Water samples, filter paper, filter holder, filtering flask, watch glass, drying oven, tweezers and 100ml measuring cylinder

**Biochemical Oxygen Demand**

Water samples from UTP Core Park, distilled water, aerated distilled water, pipette, measuring cylinder, BOD bottles and DO probe.

**Jar Test**

pH meter with electrode to monitor pH, 6 1000 ml Beakers, clear plastic or glass, Magnetic Stirrer or equivalent, Alum, acid sulfuric, Turbidity meter.

### 3.3.1 Procedures of Laboratory Tests

***pH***

1. The phosphate buffer of pH 7.0 is poured into a beaker and the pH meter is calibrated with the phosphate buffer as the indicator.
2. 5mL of samples are poured into a beaker.
3. The beaker is placed on the magnetic stirrer and the electrode is placed in the sample in such a way that the bar magnet will not touch the electrode.
4. The pH reading of the sample is recorded

***Turbidity***

1. Distilled water is used as the blank to calibrate the turbid meter.
2. 5ml samples are poured into the bottles specifically designed to be put into the turbid meter.
3. The readings are recoded down. Dilution is done if readings are over-ranged.

***Chemical Oxygen Demand***

1. 2 mL of water sample was measured and poured into a test tube containing Potassium dichromate.
2. This procedure is repeated another two times to obtain 3 samples of the sample water.
3. The test tubes are then shaken properly. Heat was produced, indicating an exothermic process.
4. The 3 test tubes together with a blank as an indicator were then put into the rotator and left for 2 hours.
5. The readings are taken down.

***Total Suspended Solids***

1. A clean filter pad is weighed and the mass is recorded down.
2. The filter pad with the wrinkled surface upward is placed in the filter holder. A pair of tweezers is always used to handle the filter discs as fingers add moisture content that will cause weighing error.
3. 50 mL of well mixed water sample is filtered by applying vacuum to the flask, followed by washing with distilled water to ensure that all the solids have been filtered.
4. The vacuum is slowly released from the filtering system and the filter pad is gently removed from the holder with a pair of tweezers. The filter pad is then placed on a watch glass.
5. The filter pad on the watch glass is placed into a drying oven at 103°C for half an hour.
6. The filter pad on the watch glass is removed from the oven and allowed to cool to room temperature.
7. The filter pad is then weighed and the mass is recorded down.

***Biochemical Oxygen Demand***

1. Samples were prepared and poured into the BOD bottles according to the volume needed. Blank samples were also prepared. Each of them is 5mL.
2. After all the samples were prepared, the initial DO for each sample was measured by the DO probe that was equipped with a stirring mechanism.
3. The BOD bottles were then placed in the refrigerator at 20°C temperature and left for 5 days.
4. After 5 day's incubation, the final DO is measured by using the DO probe.

***Jar Test***

1. Six water samples were prepared by using 1000ml beakers.
2. Measure the turbidity before adding alum
3. 6 water samples were prepared with equal alum dosage (1ml) and varied with different pH
4. The samples were prepared with pH 5.0, 5.5, 6.0, 6.5, 7.0, and 7.5 by adding acid sulfuric and lime

5. When the water samples were prepared with the required pH and alum dosage, it will be located into a Magnetic Stirrer
6. Samples were mixed with 100rpm for 1o minutes and then mixed with 50 rpm for another 5 minutes. Finally, the samples were stopped for coagulation process and it takes 25 minutes
7. Measured the water samples turbidity and determine the optimum pH
8. preparing 6 water samples with pH value obtained from step 7 and vary alum dosage; 6ml, 8ml, 10ml, 12ml, 14ml
9. Measures the samples turbidity repeated step 5 and 6 to obtain optimum alum dosage

# CHAPTER 4
# RESULTS AND DISCUSSION

## 4.1 Water Quality from the existing UTP Core Park Wetland

Various type of laboratory tests were conducted on the water samples from wetland and the results are shown in the table **13, 14, 15, 16, 17**. Analysis of turbidity, pH, COD, BOD, and TSS analysis of water samples were carried out. Water samples were taken from few places in the UTP Core Park wetland and the locations of sampling are shown in Appendix D.

### 4.1.1 Results & Discussion

## Samples Collection and Results

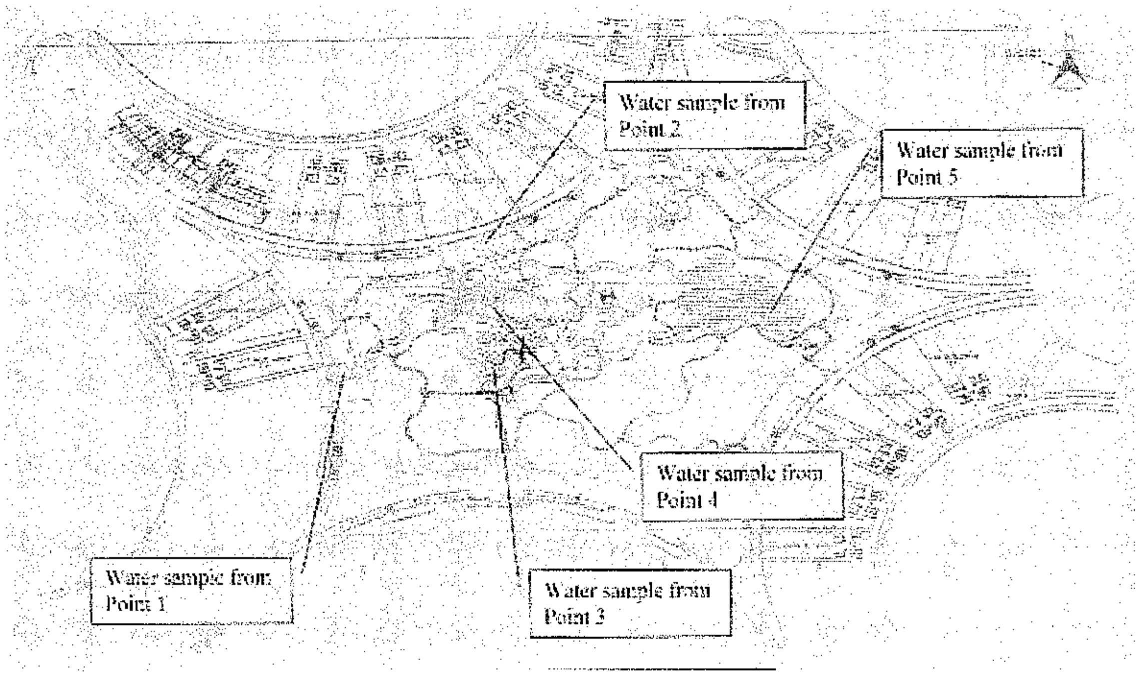


**Figure 16: Location of sampling Points**

**Table 7 Summary of Analysis Results of Water Quality on 30 August 2005**

| Test parameters | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 |
|---|---|---|---|---|---|
| BOD, mg/l | 1.1 | 1.0 | 2.3 | 1.2 | 0.9 |
| COD, mg/l | 1.0 | 0.9 | 2.1 | 1.0 | 1.1 |
| pH | 6.3 | 6.2 | 6.1 | 6.4 | 6.3 |
| TSS, mg/l | 29 | 25 | 70 | 31 | 36 |
| Turbidity, NTU | 30 | 30 | 110 | 40 | 40 |

**Table 8 Summary of Analysis Results of Water Quality on 26 september 2005**

| Test parameters | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 |
|---|---|---|---|---|---|
| BOD, mg/l | 1.1 | 1.2 | 2.0 | 1.2 | 1.3 |
| COD, mg/l | 1.1 | 0.9 | 2.1 | 1.1 | 1.2 |
| pH | 6.1 | 6.1 | 6.5 | 6.4 | 6.5 |
| TSS, mg/l | 21 | 23 | 70 | 28 | 31 |
| Turbidity, NTU | 20 | 20 | 120 | 30 | 30 |

**Table 9 Summary of Analysis Results of Water Quality on 5 OCT 2005**

| Test parameters | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 |
|---|---|---|---|---|---|
| BOD, mg/l | 1.2 | 1.1 | 1.5 | 1.2 | 1.3 |
| COD, mg/l | 0.9 | 0.9 | 1.3 | 1.2 | 1.2 |
| pH | 6.3 | 6.2 | 6.1 | 6.2 | 6.3 |
| TSS, mg/l | 25 | 25 | 60 | 28 | 30 |
| Turbidity, NTU | 30 | 30 | 110 | 30 | 35 |

**Table 10 Summary of Analysis Results of Water Quality on 11 OCT 2005**

| Test parameters | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 |
|---|---|---|---|---|---|
| BOD, mg/l | 1.3 | 1.2 | 1.3 | 1.2 | 1.2 |
| COD, mg/l | 0.9 | 0.9 | 1.2 | 1.1 | 1.1 |
| pH | 6.3 | 6.3 | 6.1 | 6.4 | 6.5 |
| TSS, mg/l | 25 | 30 | 75 | 28 | 31 |
| Turbidity, NTU | 30 | 30 | 120 | 30 | 30 |

**Table 11 Summary of Analysis Results of Water Quality on 18 OCT 2005**

| Test parameters | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 |
|---|---|---|---|---|---|
| BOD, mg/l | 1.1 | 1.2 | 2.0 | 1.2 | 1.3 |
| COD, mg/l | 1.1 | 0.9 | 2.1 | 1.2 | 1.3 |
| pH | 6.1 | 6.1 | 6.4 | 6.2 | 6.3 |
| TSS, mg/l | 21 | 23 | 70 | 28 | 35 |
| Turbidity, NTU | 20 | 25 | 110 | 30 | 30 |

***pH***

The average pH of the water samples measured in this experiment is about 6.4. The recommended value of pH for treated water ranges from 6.5 to 9.0, as specified in the National Water Quality Standard, thus this water samples are considered as good for recreational purpose with body contact and suitable for very sensitive aquatic species to survive.

***Turbidity***

Turbidity reflects the amount of the suspended solid in the water. The theory of light reflection as it collided with particles is used to determine the turbidity of water. Hence, if there are additional particles in the water, the level of reflection would increase because there are more reflectors in the water.

According to the Malaysian Water Association Design Guidelines for water supply system (2000), the maximum allowed turbidity level in drinking water is 5 NTU whereas the maximum acceptable raw water turbidity limit is 1000mg/L.

Based on the result of the water analysis, the average turbidity of the samples is around 30 to 40 NTU, except the samples obtained in Point 3 (refer to figure 21) where high value of 200 NTU was recorded. These readings are consistent with the fact that the water samples appear cloudy. These is because of the water in this area is coming from construction site in UTP. Many development activities are still on going in the UTP Core Park, therefore the silt, debris or sand are mostly flow into the wetland through the drains connected to the wetland. However, turbidity may also be caused by organic impurities that are suspended in water. Stagnant water sources like pond are normally subjected to rapid organism growth, leading towards high turbidity.

***Chemical Oxygen Demand (COD)***

Based on the tables from **table** , the average obtained from the experiments is around 1.2mg/L. the COD value obtained is considered quite low. This is because there is no connection between the wetland and organic components; the second reason is because the water has undergoes sedimentation which settles the suspended solids, the UTP core park wetland is mainly used for flood attenuation and the ecological issue is not considered in the design, therefore, the connection between the wetland and organic content is limited.

***Biochemical Oxygen Demand (BOD)***

Based on the results in table 7, 8, 9, 10 and 11, the average figure obtained is 1.2mg/L. The BOD value obtained as considered quite low. The main reason of this phenomenon is because of the connection between wetland and organic components are blocked. The water sources of wetland come from the surface runoff and the drainage system around the new campus; these sources are not containing any organic components. Secondly, the sediment process is another cause of obtaining low BOD value. The water in the wetland undergoes sedimentation process which settles the suspended solids. The connection between the wetland and organic components is limited due to the design of the wetland which is mainly for flood attenuation and not considered ecological issues.

***Total Suspended Solid (TSS)***

Based on the result obtained from the experiment, the average TSS of the samples 25mg/L, this value is considered low, but the result of samples obtained from point sourse 3 indicated high TSS value around 70mg/L. The reason for high TSS of the water samples is because the water samples were collected near to a development site area. The development activities are still going on in the UTP Core Park, therefore the silt, debris or sand are mostly flow into the wetland through the drains connected to the wetland. These silt and clay which are too fine and can not settle to the bottom of the wetland are suspended in water, thus causing high value of TSS.

## 4.2 Pumping System Analysis

### 4.2.1 End Suction Pump System

The design of the pond is by overflow system, whereby water from the pond overflow into water holding chamber. The pumps suck the water from the holding chamber and return it to the stream 1, 2 and 3. There are five stream pumps inside the pump room and these pumps are operated automatically whereby they control by a timer in 12 hours turn over period. There are three (Evolution 200x150x320c/w 30kw) pumps serve for stream 2 and 3. Basically, the pump system is design for 2 pumps running, another pump will be on standby, and the timer was set for the first 4 hours, the second 3 hours and third 4 hours. All pumps are controlled with sensor rod. When there is low water level in the starter panel, all the pump operating will be switched off automatically to prevent the machine from malfunction.

### 4.2.2 Submersible Pump

The submersible pump is located inside a sump. The sump size is 1m (Height) x 1m (Width) x 2m (Length) and the volume is equal to 2 $m^3$. Two number of submersible pump are used to suck in the water during cleaning the stainer and also the rain water from outside. The submersible pumps are controlled by using a starter. There are two ways to control the submersible pumps from the starter panel. The first is using either one of the submersible pump or operate both of the pumps. The other alternative solution is using auto system whereby the system is control by sensor rod and the rod will detect the water level which signals to operate the system to operate automatically. The first submersible pump will run when the water reaching 25% of the sump capacity and both of the pumps will operate together when the water level has reached 50% of the sump capacity.

### 4.2.3 Operation of the System

The strainers have to be checked and cleaned before operating the system. The butterfly valve at the suction head has to be closed before opening strainers in anti-clockwise direction. Ensure the water level at the pond and water chamber are meeting the requirement before starting the operating system because the sensor will trip off the start panel if the water level in the chamber is lower than the requirement. The system can be started after checking the water level and cleaning the suction head. The pressure gauge would be checked for the second time after the system start operating and the recommended pressure is around 0 to 20 psi.

### 4.2.4 Precaution to be taken

The pumps have to be checked daily to ensure no leakage and if a particular pump is having problem, the system has to be stopped from operating and technician will be informed for checking and servicing.

Both strainers have to be checked before operating the system to prevent rubbish from setting in the strainer and harm the pipe. Leaking might happen if the inner pipe is requiring services from technician is required immediately to prevent further damage on the pipe.

Skillful workers or staff should be recruited to operate the system

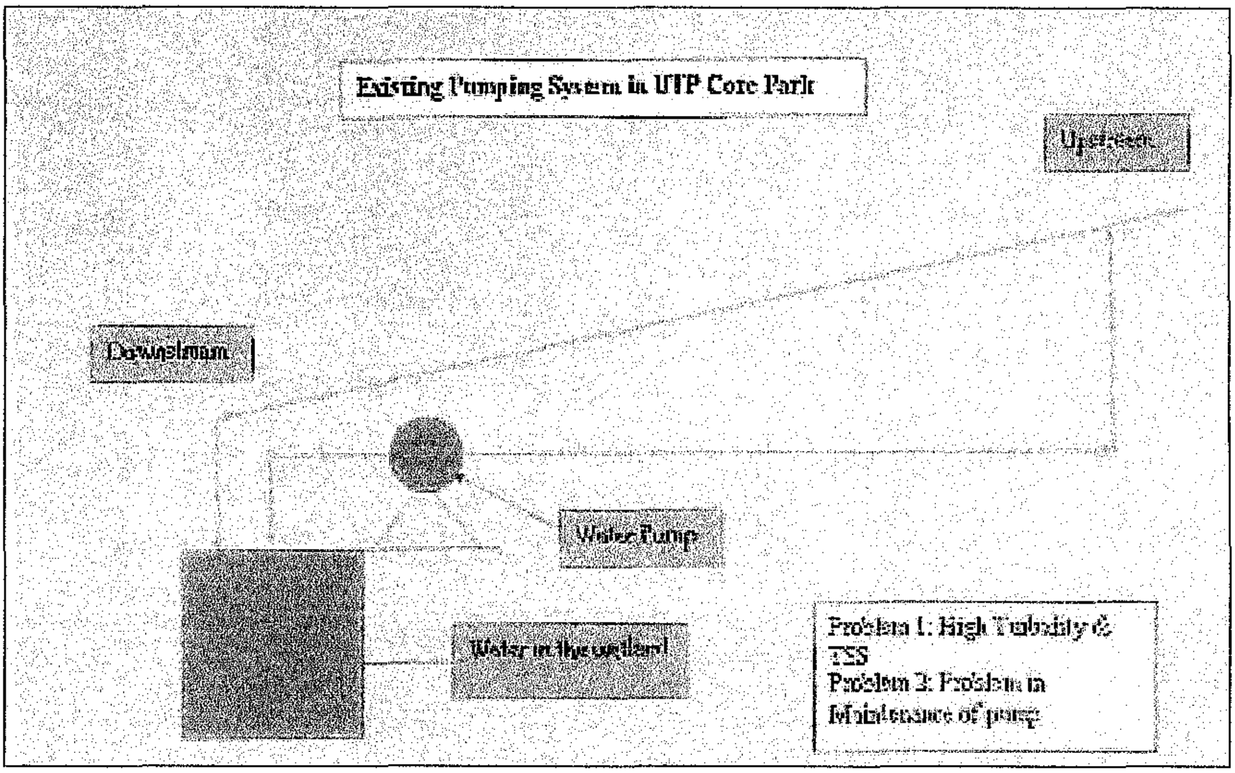


**Figure 17 Existing Pumping System in UTP Wetland**

## 4.3 Results of Jar Test

According to the three experiments of using Jar Test, (refer to Appendix F) the optimum pH for the sedimentation activity is 5.5. Moreover, the average optimum alum dosage for 1000ml water samples is 12ml based on the average value from the three tests.

### 4.3.1 Discussion of Jar Test

For UTP Core Park wetland, the water capacity concern to be treated is the water retain in the pond during base flow and the alum dosage calculated is based on the water capacity in the wetland during base flow condition. During the base flow period, the estimated water capacity is around 24% of the wetland capacity.

Therefore, the water capacity (during base flow condition) estimated to be treated is 24% x wetland capacity

$= 0.24 \times 3500m^3$

$= 840m^3$

Based on the Jar Test experiment, the alum dosage that should be applied for 1000ml water samples is 12ml

The alum dosage should be applied during the base flow condition is:

1 $m^3$= 1000L

840$m^3$= 840000L

1ml = 1mg

Therefore, the required alum dosage = $\frac{840000(12)}{1000}$ mg

= 10080mg

= 10.08kg

The alum dosage can be applied at the upstream of the wetland pond, and the sedimentation will happen during the water flow to the downstream and water turbidity at downstream can be treated well, and the recommended alum dosage base on the design calculation is about 10.08kg of alum.

## 4.4 Discussion of Design

The purpose of this design is based on the combination of wetland, orifices and spillways. For a normal engineered wetland usually the design uses with the combination of wetland and orifices. However this is not enough for the condition when peak flow capacity is more than the existing flow, in other words, the wetland is no longer attenuate the high flow.

Therefore, the new concept of this design is based on the combination of orifices, wetland and spillways that is positioned at a higher level. This design was based on the factors as below:

1. According the existing condition in our country, the industry and construction fields are undergoing rapid growth, and most of the un-development areas are changing to develop areas, so the surface runoff have increased and more engineered wetland are required to solve the flash flood problems.
2. There is a plan that the new airport in Ipoh is going to move to Bandar Seri Iskandar, therefore, the rapid development will take place in the areas surrounding Bandar Seri Iskandar including UTP campus in the future.

Therefore, the existing UTP Wetland will help in attenuating the peak flow due to the increment of surface runoff. Another wetland might need to be constructed or the existing wetland might need to be enlarging to increase the wetland capacity. Therefore, instead of constructing another new wetland to control flood, improvement on the existing wetland by increasing the capacity using orifices, embankment and spillways can be another better choice from the economical point of view.

3. According to the existing structural plan of UTP campus, there is another new block which to be constructed and the location is exactly in the catchments area of A4. Therefore, the future construction activities are other factors which can increase surface runoff and cause the UTP Core Park wetland to be flooded. The new design with a higher capacity can solve this problem by increasing the sustainability of the wetland.
4. Flash flood can visit UTP Core Park campus at any moment. Once there was a flood in the UTP Core Park because of the blockage in culvert connecting the wetland outlet to the lake outside end; the wetland can not sustain the water in the catchments area of A4 thus causing flood. The case was happened at night and no students were affected but many machines in the campus were malfunction because of this case.

**Advantages of the design:**

1. Firstly, most of the natural wetlands which are existed in the environments are polluted by rubbishes and causing health problem. Secondly, the flow of sediment into wetland during raining has caused the reduction of wetland capacity. Therefore, the proposed new design can address these problems by having rubbish trap, regulation and maintenance. The accumulation of sediments in the wetland pond can reduce the wetland capacity and during the critical condition of flash flood, the wetland might not be able to retain storm water, the storm water which can not be sustained by wetland can be discharged to the downstream through spillway. However, off course, in order to provide good

wetland systems, the maintenance of the wetland is another important factor to be focused.

2. The new design of wetland can control the surface runoff from flooding the related areas. The new design can increase the capacity of the wetland by increasing the level of the water in the catchments area.
3. The new design can maintain water level in the wetland and the orifices can discharge extra water in the wetland into downstream and the discharge rate is according to the design of the pipe orifices, by this way, the water flow rate discharge at the wetland outlet is under control.
4. The wetland is a place to retain storm runoff. During the raining, season, storm runoff will flow into the wetland and carried sediments from the ground surface as well. This can reduce the wetland capacity gradually by years in the way that the bed of the wetland is filled with the sediments from the ground. Therefore, the wetland capacity might no longer sustainable in the future. The new design can solve the problem because the emergency spillway can solve the problem during critical condition (flash flood). When the water level has exceed the orifices level, the extra water capacity which can not retain in the wetland will discharge to down stream through spillway.

## 4.5 Final Design

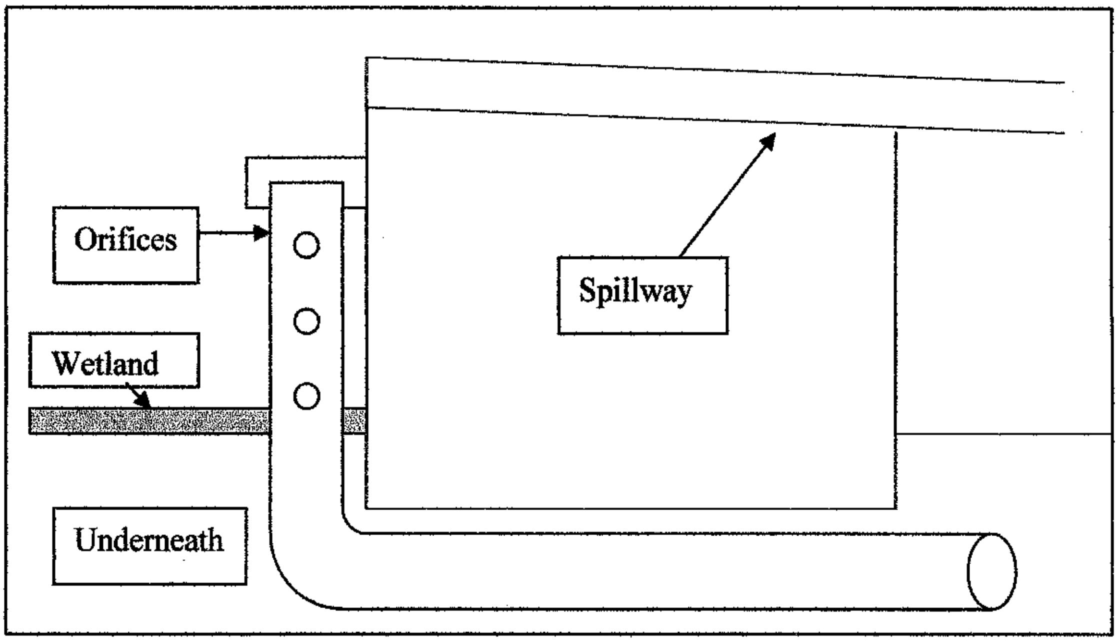


**Figure 18: Final Design Drawing**

## 4.6 Flora Species in UTP Wetland

**The flora species information are obtained through site assessment and please refer to Appendix C**

# CHAPTER 5

# CONCLUSION & RECOMMENDATION

## 5.1 Flora and fauna Species

Referring to the topography of the UTP Core Park wetland, the pond is located at the middle part of wetland with depth more than 1m and the other part of wetland with water depth of 20cm to 30cm. The pond is suitable for flora and fauna species, and another upstream pond is filled with big rock and is not suitable for planting purpose. In order to achieve the conservation purpose of wetland, some flora species with different water depth are recommended in the table below and the pictures are listed in appendix H:

**Table 12: Hydrologic Zones**

| Zone | Area | Hydrologic Conditions |
|---|---|---|
| Zone 1 | Deep-water pool | 0.3 – 1.8 m BWL |
| Zone 2 | Shallow water bench | 0 –0.3 m BWL |
| Zone 3 | Shoreline fringe | 0–0.3 m AWL |
| Zone 4 | Riparian Fringe (Periodically Inundated) | 0.3 –1.2 m AWL |
| Zone 5 | Floodplain Terrace | Infrequently inundated) |
| Zone 6 | Upland Slopes | Seldom or never inundated |

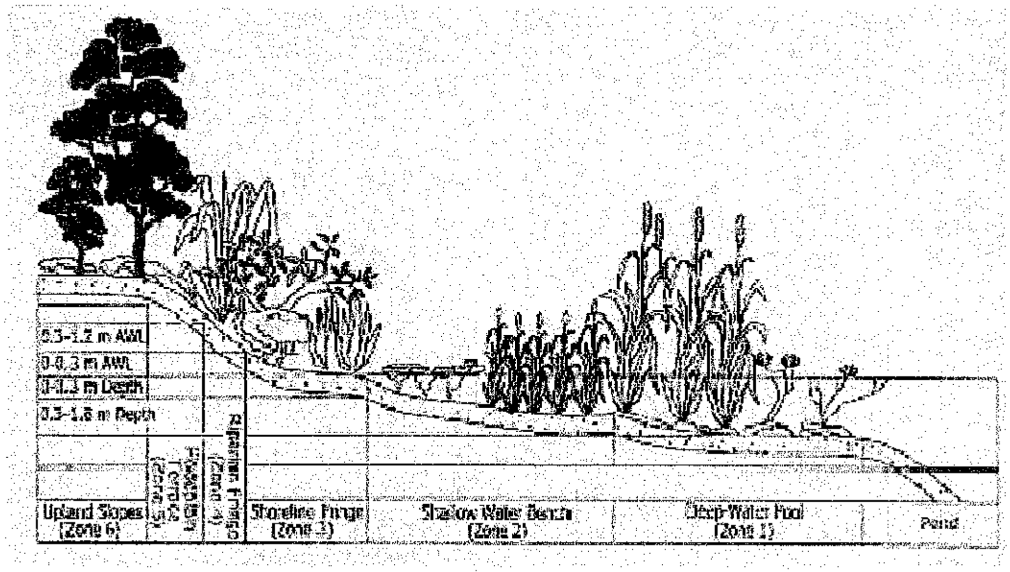


**Figure 19: Typical Plants with Different Water Depths**

Plants from zone 1, 2 3 and 4 are suitable to be planted in the UTP Core Park Wetland and the recommended flora species are listed as in table below and the pictures are shown in Appendix H.

**Table 13 Recommended Plant Species for Zone 1 (Deep-water pool)**

| Botanical Name | Common Name | P | B | E | A | I |
|---|---|---|---|---|---|---|
| *Cyperus compactus* | Para-para | • | | | | |
| *Cyperus digigatus* | Rumput bunga satuan | • | | | | |
| *Cyperus halpan* | Rumput sumbu | • | | • | | |
| *Lepironia articulata* | Puron | • | | • | | |
| *Nasurtium sp.* | - | • | | • | | |
| *Nelumbo nucifera* | Telipok | | | • | • | |
| *Nymphae lotus dentata* | Water lily | | | • | • | |
| *Nymphae nouchali* | Water lily | | | • | • | |
| *Nymphae rubra* | Red water lily | | | • | • | |
| *Nymphae tashkent* | Purple Water lily | | | • | • | |
| *Phragmites karka* | Rumput gedabong | • | | • | | |
| *Phylidrum lanuginosum* | Rumput kipas | • | | • | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Rynchospora corymbosa* | Rusiga | • | | • | | |
| *Scirpus grassus* | Rumput menderong | • | | • | | |
| *Scirpus juncoides* | Rumput bulat | • | | | | |
| *Thalia geniculata* | Water canna | • | | • | • | |
| *Typha latifolia* | Banat | • | | • | • | |
| *Victoria sp.* | Giant Water lily | | | | • | |

P = Pollution control B = Bank/slope protection
E = Ecological A = Aesthetic I = Indigenous

**Table 14: Recommended Plant Species for Zone 2 (Shallow water bench)**

| Botanical Name | Common Name | P | B | E | A | I |
|---|---|---|---|---|---|---|
| *Cleome spinosa* | Maman | | • | • | | |
| *Eleocharis variegata* | Ubi purun | • | | • | | |
| *Eriocaulon longifolium* | Rumput butang | • | | • | | |
| *Fimbristylis globulosa* | Rumput sandang | • | | • | | |
| *Fuirena umbellata* | Rumput kelulut | • | | • | | |
| *Hanguana malayana* | Bakong | | • | | • | |
| *Ludwigia adscendens* | Tinggir bangau | | • | | • | • |
| *Ludwigia octovalis* | Tinggir pasir | | • | • | | |
| *Monocharia hastata* | Keladi agas | • | | • | | |
| *Pandanus immersus* | Pandan rasau | | • | | | • |
| *Pandanus sp.* | Pandan | | • | | • | • |
| *Rynchospora corymbosa* | Rumput sendayan | • | | | | |
| *Sagittaria sagitaefolia* | Arrow head | • | | | | |
| *Scleria sumatrensis* | Rumput kumba | • | | | | |
| *Stachytapheta jamaicensis* | Selasih dendi | | • | • | | |
| *Thalia geniculaia* | Water canna | • | | | • | |
| *Vanda hookeria* | Kinta weed | | | | • | • |
| *Zingiberacae sp.* | Halia hutan | | | • | • | |

P = Pollution control B = Bank/slope protection
E = Ecological A = Aesthetic I = Indigenous

**Table 15: Recommended Plant Species for Zone 3 (Shoreline Fringe)**

| Botanical Name | Common Name | P | B | E | A | I |
|---|---|---|---|---|---|---|
| *Acacia mangium* | Akasia daun lebar | | • | • | | |
| *Alstonia spathulata* | Pulai paya | | | | • | |
| *Artocarpus altilis* | Sukun | | | • | | • |
| *Barringtonia asiatica* | Putat | | • | • | • | • |
| *Caryota mitis* | Tukas | | | • | | • |
| *Cyrtostachys lakka* | Pinang merah | | | | • | |
| *Dillenia suffruticosa* | Simpoh Air | | • | • | • | • |
| *Melaleuca leucadendron* | Gelam | | | • | | • |
| *Pometia pinnata* | Kasai | | • | • | • | • |
| *Salix babylonica* | Weeping willow | | | | • | |
| *Saraca thaipengensis* | Saraka kuning | | | • | • | • |
| *Shorea longifolia* | Damar hitam paya | | | | • | • |
| *Shorea platycarpa* | Meranti paya | | | | • | • |
| *Sindora coriaceae* | Sepetir | | | | • | • |
| *Spathodea campanulata* | African tulip | | • | | • | |

P = Pollution control B = Bank/slope protection
E = Ecological A = Aesthetic I = Indigenous

**Table 16: Recommended Plant Species for Zone 4 (Riparian Fringe)**

| Botanical Name | Common Name | P | B | E | A | I |
|---|---|---|---|---|---|---|
| *Acacia auriculiformis* | Akasia | | • | | • | |
| *Arachis pintoi* | Kekacang | | • | | • | |
| *Asystasia gangetica* | Rumput itik | | | • | • | |
| *Bambusa vulgaris* | Buluh | | • | | | |
| *Barringtonia asiatica* | Putat | | | | • | |
| *Caryota no* | Tukas | | | • | • | |
| *Cleodendron paniculatum* | Pagoda tree | | • | • | • | • |
| *Cocoloba uvifera* | Sea grape | | | • | | |
| *Cratoxylon arborescens* | Geronggong | | • | | | |
| *Dillenia sp.* | Simpoh | | • | • | • | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Elaeocarpus nitidus* | Pinang punai | | | | • | |
| *Ficus benjamina* | Ara | • | • | • | | • |
| *Ficus elastica* | Ara | | • | • | • | |
| *Johannesteijmannia altironis* | Johanna palm | | • | • | • | • |
| *Koompasia malaccensis* | Kempas | | | • | • | • |
| *Licuala spinosa* | Palas | | • | • | • | • |
| *Melia excelsa* | Sentang | | | | • | |
| *Mirabilis jalapa* | Seroja | | | • | • | |
| *Nephrolepis sp.* | Paku | | • | • | • | |

P = Pollution control B = Bank/slope protection
E = Ecological A = Aesthetic I = Indigenous

## 5.2 Maintenance and Services

Maintenance is an important operation to be carried out for the wetland; any great design without maintenance is actually belongs to nothing. For example, the pumping system design operating in the UTP Core Park is a good design to help solving the mosquito's problems and also to pump up water from downstream to upstream for landscaping purpose. But the lack of maintenance in the pumping system has caused some of the upstream pond is drying out with no reasons. The malfunction of the pumping system has caused the mosquito breeding problem because water in the upstream pond is not flowing and providing stagnant water surface for mosquito to breed. Therefore, the pumping system in the Core Park Wetland should be provided with maintenance all the time.

Secondly is the clearance of sedimentation in the upstream. The new design proposed that alum should be applied in the upstream pond to improve the water quality. Therefore, the upstream pond will be filled with sediments and maintenance of the upstream pond is required to improve the wetland.

## 5.3 Conclusion

In short, the UTP Core Park pond as a wetland area covers an area approximately 73.92ha and the size of the pond water body is about 3500m$^2$. The water quality of the water in the pond is; pH = 6.4, highest turbidity value is 200NTU, COD = 1.2mg/L, BOD= 1.2mg/L, TSS= 25mg/L, and the suitable Alum dosage calculated for water treatment at upstream is 10kg. The peak flow volume capacity of the existing UTP wetland is 4.786m$^3$/s, and this design has improved the sustainability of the wetland by increasing the peak flow volume capacity to 5.915m$^3$/s. Flora species recommended as in appendix G.

The final design should be able to improve the wetland flood mitigation system and provide a balance ecosystem.

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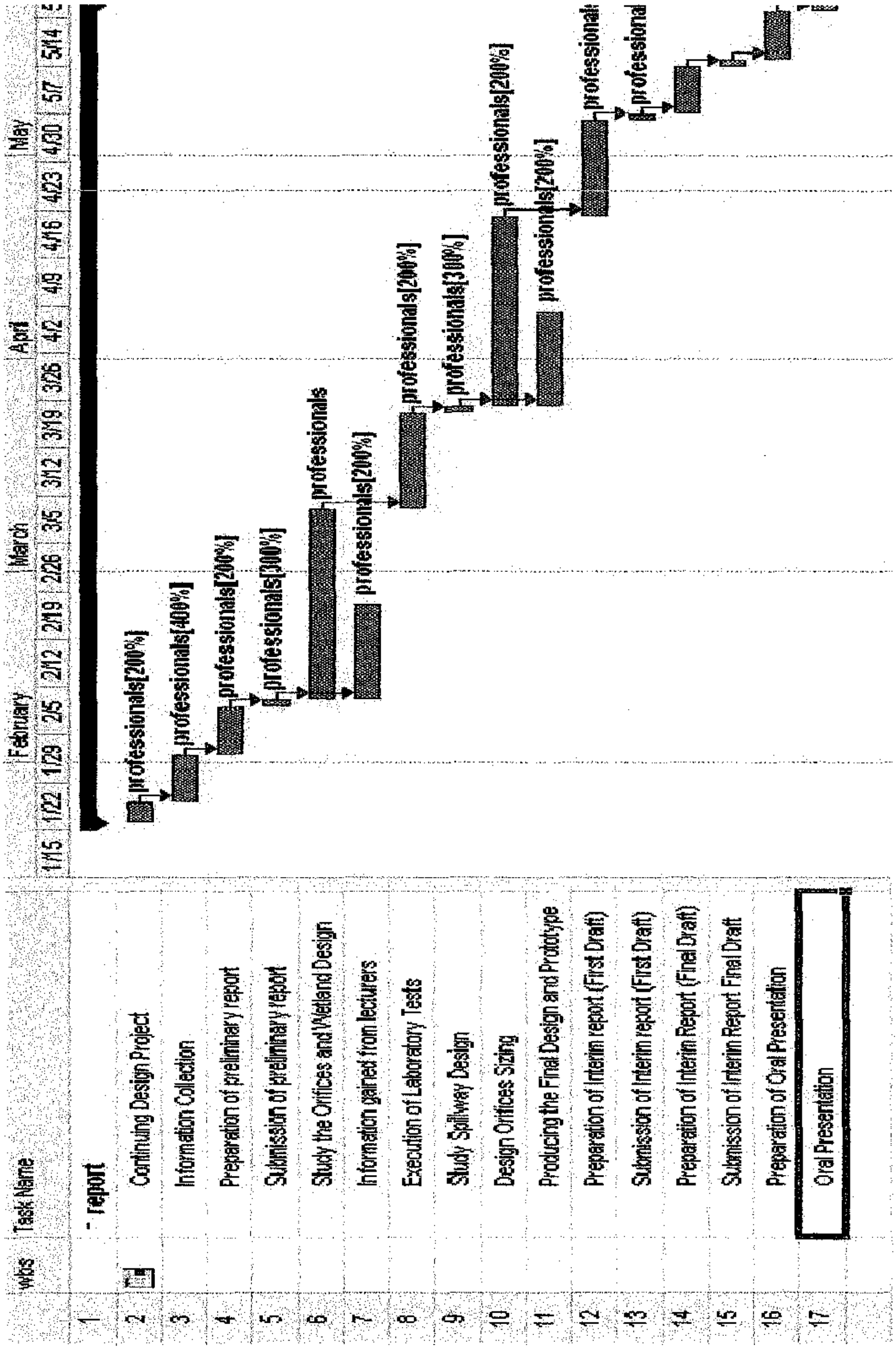
# APPENDICES

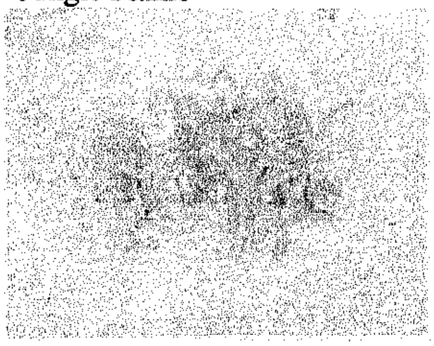
## APPENDIX A: Gantt chart



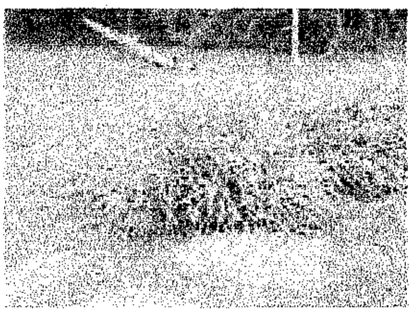
# Appendix B: Flora Species in UTP Wetland

"Green Pandan"

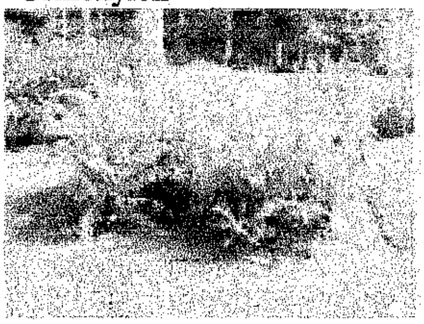
"Jungle Flame"



"Screw Pine"



"Osmoxylon"



# Appendix C: Rainfall Intensity Figure

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

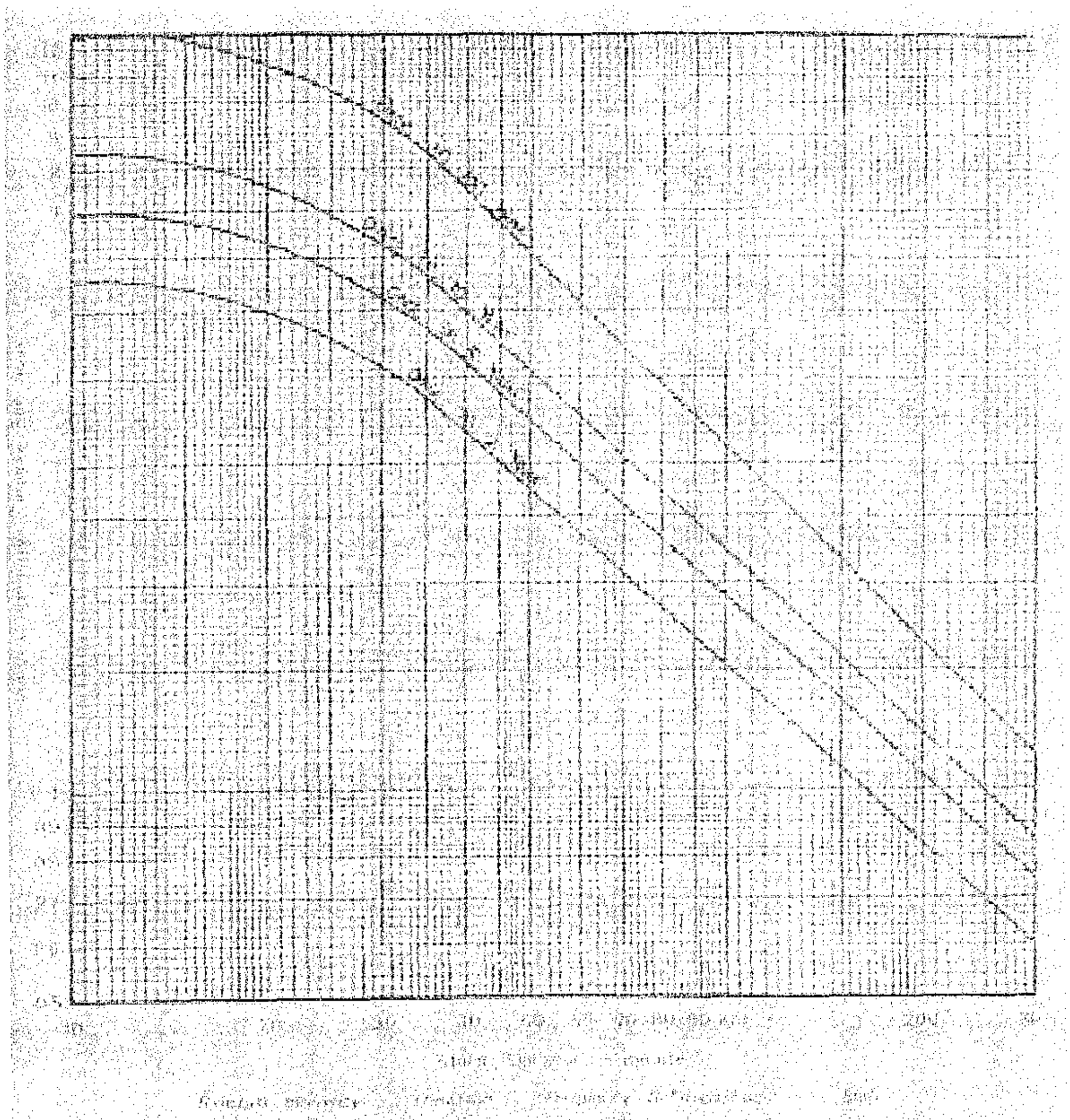
Table 13.A1 Coefficients for the IDF Equations for the Different Major Cities and Towns in Malaysia (30 ≤ t ≤ 1000 min)

| State | Location | Data Period | ARI (year) | Coefficients of the IDF Polynomial Equations | | | |
|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d |
| Perlis | Kangar | 1960-1983 | 2 | 4.5800 | 0.4729 | -0.1915 | 0.0093 |
| | | | 5 | 5.7949 | -0.2044 | -0.0413 | -0.0008 |
| | | | 10 | 6.5856 | -0.6048 | 0.0445 | -0.0044 |
| | | | 20 | 6.8710 | -0.6620 | 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 | 1951-1993 | 2 | 5.6790 | -0.0276 | -0.0993 | 0.0033 |
| | | | 5 | 4.5709 | 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 | 4.5146 | 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 | 5.3068 | 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 | 0.2536 | -0.1686 | 0.0078 |
| | | | 100 | 5.3299 | 0.4357 | -0.1857 | 0.0089 |
| Perak | Teluk Intan | 1960-1987 | 2 | 5.6134 | -0.1700 | -0.0651 | 0.0004 |
| | | | 5 | 6.1025 | -0.2249 | -0.0484 | -0.0036 |
| | | | 10 | 6.3160 | -0.2756 | -0.0390 | 0.0032 |
| | | | 20 | 6.3504 | -0.2498 | -0.0377 | -0.0016 |
| | | | 50 | 6.7638 | -0.4595 | 0.0054 | -0.0020 |
| | | | 100 | 6.7375 | -0.3572 | -0.0070 | -0.0013 |
| Perak | Kuala Kangsar | 1960-1983 | 2 | 4.2114 | 0.9483 | -0.3154 | 0.0179 |
| | | | 5 | 4.2986 | 0.5803 | -0.2202 | 0.0102 |
| | | | 10 | 5.3916 | 0.2997 | -0.1640 | 0.0071 |
| | | | 20 | 5.7854 | 0.1175 | -0.1244 | 0.0044 |
| | | | 50 | 5.5236 | 0.2903 | -0.0482 | 0.00002 |
| | | | 100 | 5.9051 | 0.1478 | -0.1435 | 0.0065 |
| Perak | Setiawan | 1951-1990 | 2 | 5.0790 | 0.3724 | -0.1796 | 0.0081 |
| | | | 5 | 5.2320 | 0.3330 | -0.1535 | 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 | 0.3805 | -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 | 6.0234 | -0.3710 | 0.0239 | -0.0073 |
| | | | 100 | 6.3094 | -0.4087 | 0.0229 | -0.0068 |

*(Continued)*

**Figure 20: Coefficient for the IDF Equation for the Different Major Cities and Towns in Malaysia (JPS)**

# Appendix D: Intensity – Duration – Frequency relationship for IPOH



# Appendix E: Flora Species Planted in UTP Wetland

**Table 17: List of Flora Planted in UTP Core Park Wetland**

| Number | Botanic Name | Common Name |
|---|---|---|
| 1 | Hymenociallis caribea | Spider Lily |
| 2 | Ixora Macrothysa | Jungle Flame |
| 3 | Ixora Compacta Orangeana | Orange Ixora |
| 4 | Jatropa pandurifolia | Jetropa |
| 5 | Jatropa Podogrica | Jetropa |
| 6 | Melastoma Sanguineum | Senduduk |
| 7 | Monstera Deliciosa | Ceriman |
| 8 | Nepholepsis Bisserata | Paku uban |
| 9 | Nephrolepsis exaltata | Paku, Boston fern |
| 10 | Neomorica bicolor | Walking iris |
| 11 | Neomorica longifolia | Fan iris |
| 12 | Nymphaea lotus | White lotus |
| 13 | Nymphaea capensis | Blue water lily |
| 14 | Nymphaes Mexicana | Yellow water lily |
| 15 | Pandanus utilis | Screw pine |
| 16 | Philodendron selloum | Lacy tree philodendrom |
| 17 | Phormium tenax variegatum | Variegated flax |

| | | |
|---|---|---|
| 18 | Pandarous amary lifolius | Green pandan |
| 19 | Phyllostochus sulphurea | Yellow Bamboo |
| 20 | Psederanthemum reticulum | Golden psederanthemum |
| 21 | Ptesis asperula | Fern |
| 22 | Pandanus Pygmen "Green" | Dwarf Green Pandanus |
| 23 | Ochna kirkii | Mickey mouse plant |
| 24 | Osmoxylon geelvinkianum | Osmoxylon |
| 25 | Rhapis excelsa | Large lady plan |
| 26 | Ophiopogon jaburan | Mondo grass |
| 27 | Rheo discolor | Dwarf shell plant |
| 28 | Rubia ornamentable | Charpaleo |
| 29 | Spathiphyllum "Maunna Loa" | Dwarf Spathiphyllum |
| 30 | Spathiphyllum sensation | Giant Spathyllum |
| 31 | Spathyllum cannafolium | Spathiphyllum |
| 32 | Spathoglottis plicata | Dwarf Ground Orchird |
| 33 | Trimeza caribaea | Trimeza |
| 34 | Typha angustifolia | Cat tail |
| 35 | Tristellateia australasiae | Galphimia Vine |

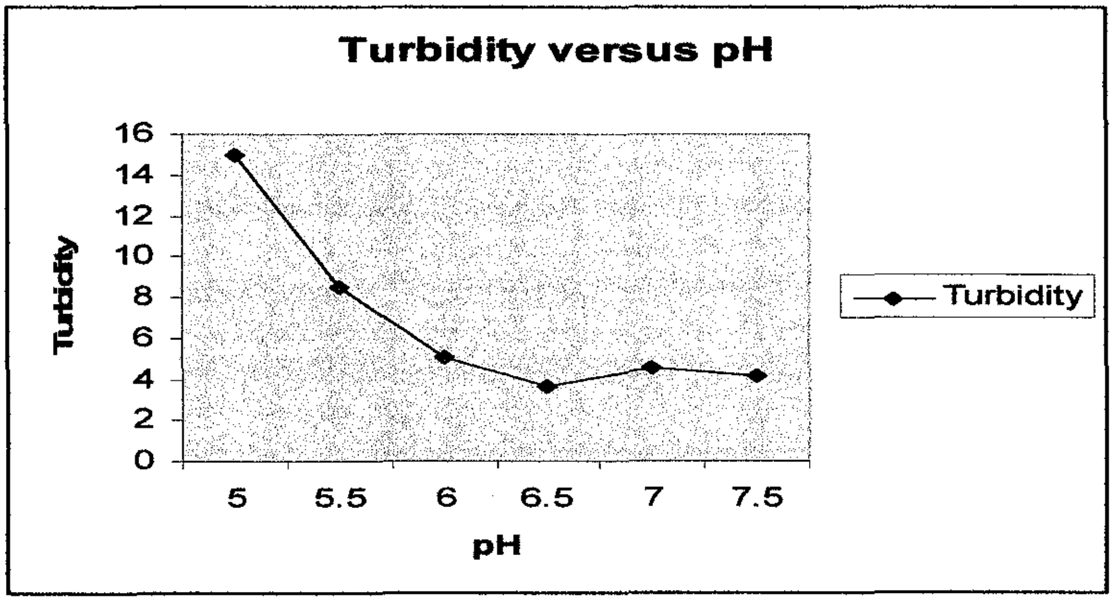
# Appendix F: Jar Test Experiment Results

## Result of Jar Test

### Experiment 1: Finding Optimum pH with same alum dosage (1ml)

- Alum dosage used is 1ml (1000mg/L)
- Turbidity water samples before treatment is 19NTU
- Samples with different pH value and constant alum dosage

| Sample | pH | Turbidity(NTU) |
|---|---|---|
| 1 | 5.0 | 15 |
| 2 | 5.5 | 8.5 |
| 3 | 6.0 | 5.1 |
| 4 | 6.5 | 3.6 |
| 5 | 7.0 | 4.6 |
| 6 | 7.5 | 4.2 |

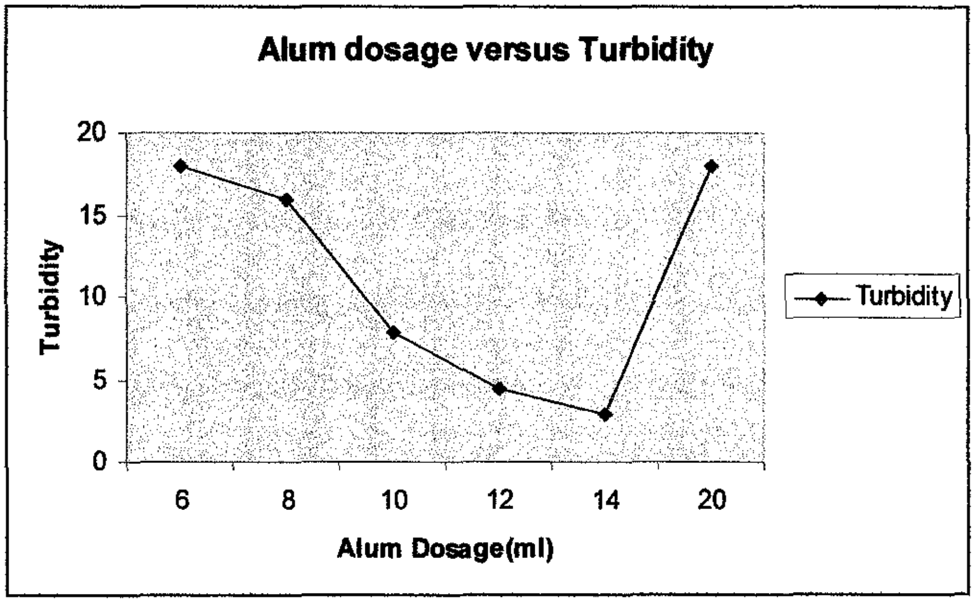



Results: According to the result above, the optimum pH to obtain optimum alum dosage is 5.5.

**Experiment 1: Finding Optimum Alum dosage with constant pH value**

- pH for water samples are 6.5
- Turbidity water samples before treatment is 20NTU
- Samples with constant pH value and varies alum dosage

| Sample | Alum Dosage(ml) | Turbidity(NTU) |
|---|---|---|
| 1 | 6 | 18 |
| 2 | 8 | 16 |
| 3 | 10 | 7.9 |
| 4 | 12 | 4.4 |
| 5 | 14 | 2.9 |
| 6 | 20 | 18 |

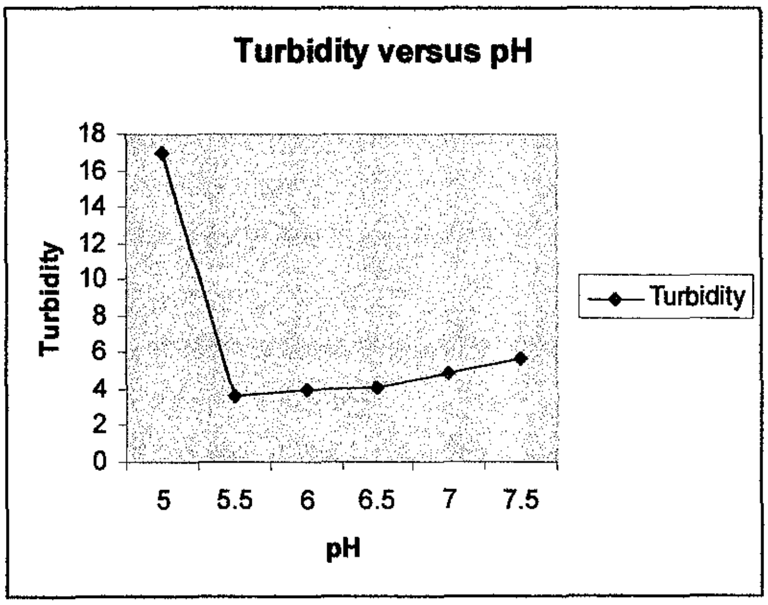



Results: According to the result above, the optimum Alum dosage with pH 6.5 is 14ml

**Experiment 2: Finding Optimum pH with same alum dosage (1ml)**

- Alum dosage used is 1ml (1000mg/L)
- Turbidity water samples before treatment is 20NTU
- Samples with different pH value and constant alum dosage

| Sample | pH | Turbidity(NTU) |
|---|---|---|
| 1 | 5.0 | 17 |
| 2 | 5.5 | 3.6 |
| 3 | 6.0 | 4.0 |
| 4 | 6.5 | 4.1 |
| 5 | 7.0 | 4.9 |
| 6 | 7.5 | 5.7 |

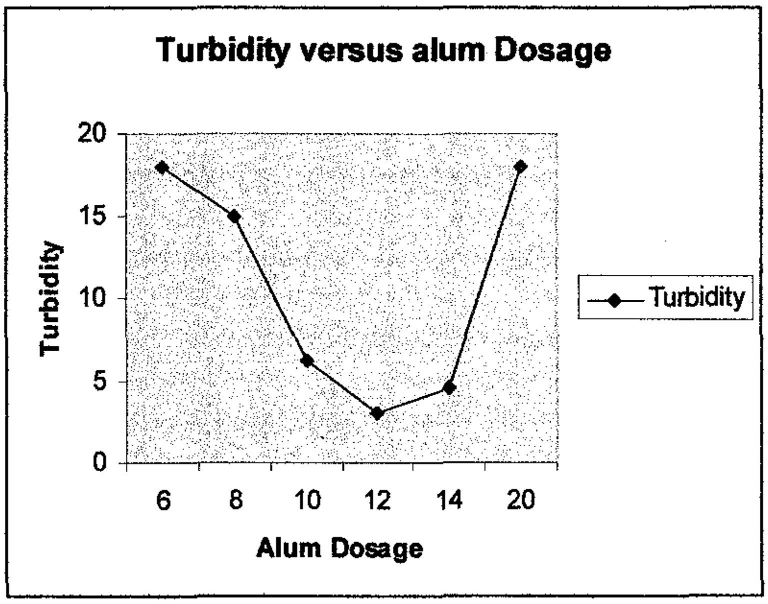



Results: According to the result above, the optimum pH to obtain optimum alum dosage is 5.5.

**Experiment 2: Finding Optimum Alum dosage with constant pH value**

- pH for water samples are 5.5
- Turbidity water samples before treatment is 20NTU
- Samples with constant pH value and varies alum dosage

| Sample | Alum Dosage(ml) | Turbidity(NTU) |
|---|---|---|
| 1 | 6 | 18 |
| 2 | 8 | 15 |
| 3 | 10 | 6.2 |
| 4 | 12 | 3.0 |
| 5 | 14 | 4.6 |
| 6 | 20 | 18 |

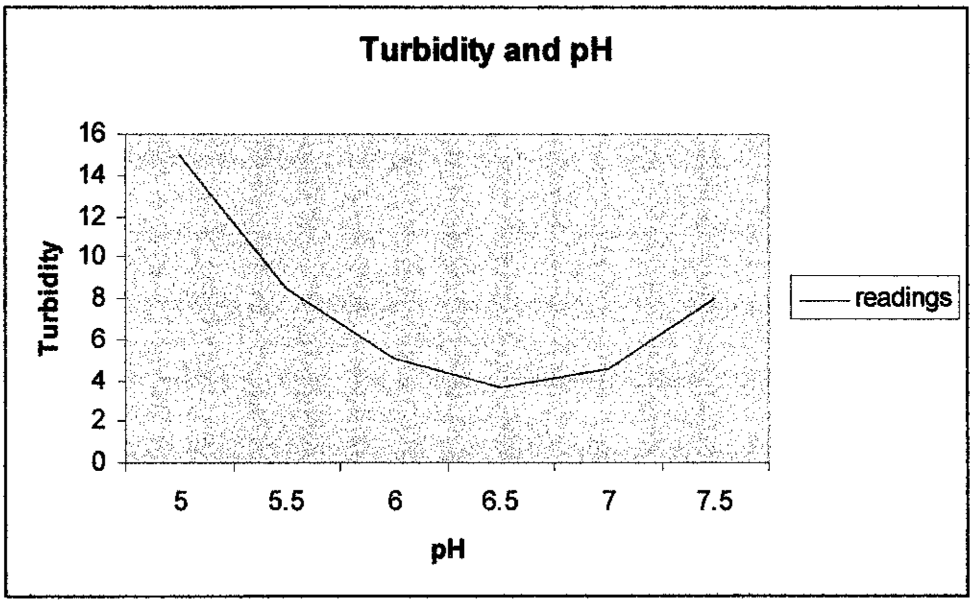



Results: According to the result above, the optimum Alum dosage with pH 5.5 is 12ml

**Experiment 3: Finding Optimum pH with same alum dosage (1ml)**

- Alum dosage used is 1ml (1000mg/L)
- Turbidity water samples before treatment is 19NTU
- Samples with different pH value and constant alum dosage

| Sample | pH | Turbidity(NTU) |
|---|---|---|
| 1 | 5.0 | 15 |
| 2 | 5.5 | 8.5 |
| 3 | 6.0 | 5.1 |
| 4 | 6.5 | 3.6 |
| 5 | 7.0 | 4.6 |
| 6 | 7.5 | 8 |

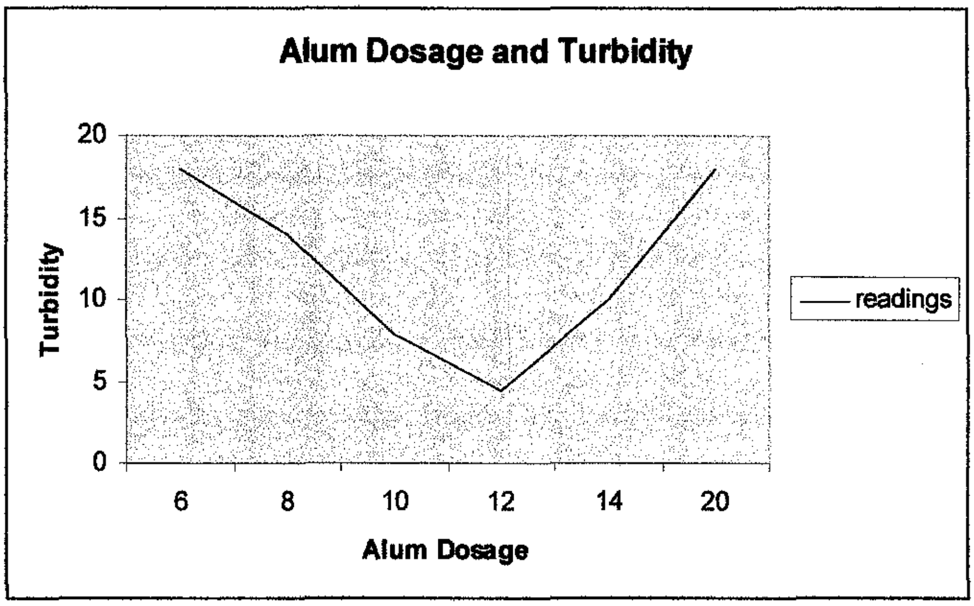



Results: According to the result above, the optimum pH to obtain optimum alum dosage is 6.5.

**Experiment 3: Finding Optimum Alum dosage with constant pH value**

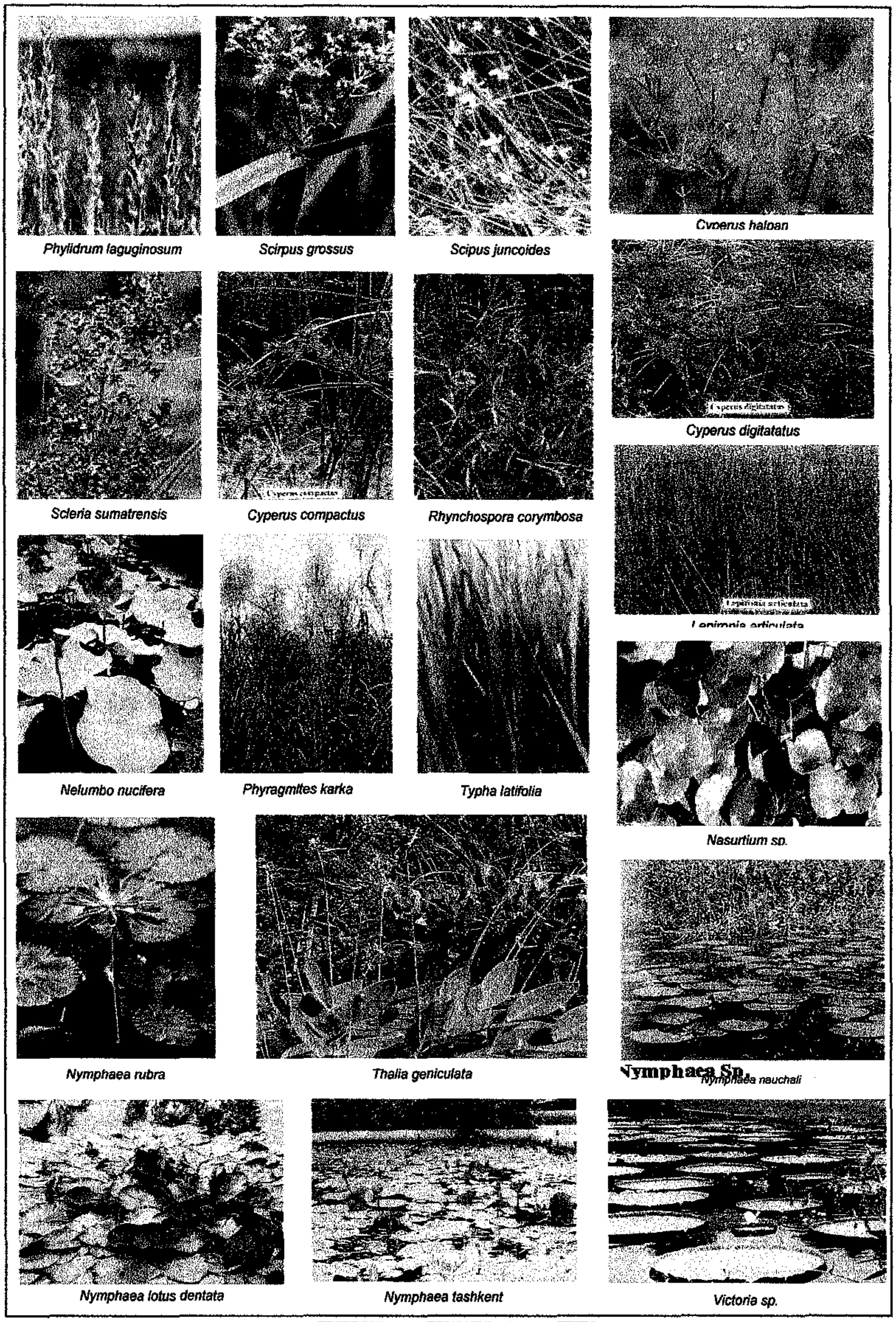
- pH for water samples are 6.5
- Turbidity water samples before treatment is 20NTU
- Samples with constant pH value and varies alum dosage

| Sample | Alum Dosage(ml) | Turbidity(NTU) |
|---|---|---|
| 1 | 6 | 18 |
| 2 | 8 | 14 |
| 3 | 10 | 7.9 |
| 4 | 12 | 4.4 |
| 5 | 14 | 10 |
| 6 | 20 | 18 |



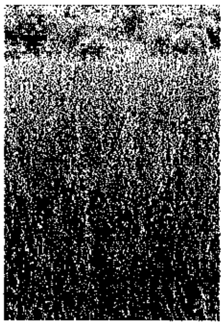

Results: According to the result above, the optimum Alum dosage with pH 6.5 is 12ml

# Appendix G: Recommended Flora Species in Zone 1, Zone 2, Zone 3, and Zone 4




Flora Species for Zone 1

*Zingiberaceae sp.*



*Lepironia articulata*

*Pandanus sp.*

**Pandanus Immersus**

*Vanda hookeriana*

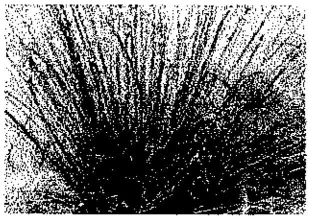
*Hanguana malayana*

*Caladium hortulanum 'hybrid'*

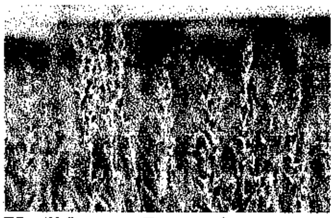
*Dreffenbachia maculata*

*Eleocharis variegata*

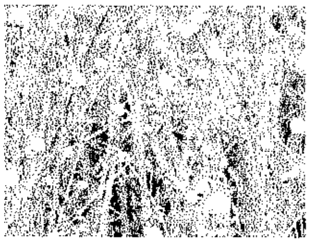
*Sagittaria sp.*



*Fimbristylis glabulosa*

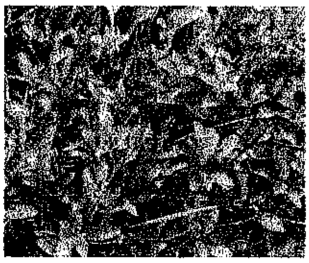


**Phylidrums Lanuginosum**
*Phylidrum lanuginosum*



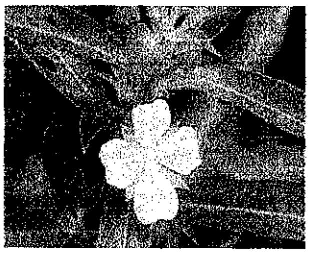
*Eriocaulon longifolium*

*Fuirena umbellata*

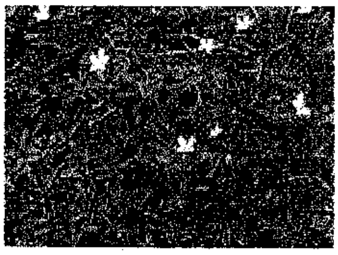


*Stachhytapheta jamaicersis*

*Cleome spinosa*



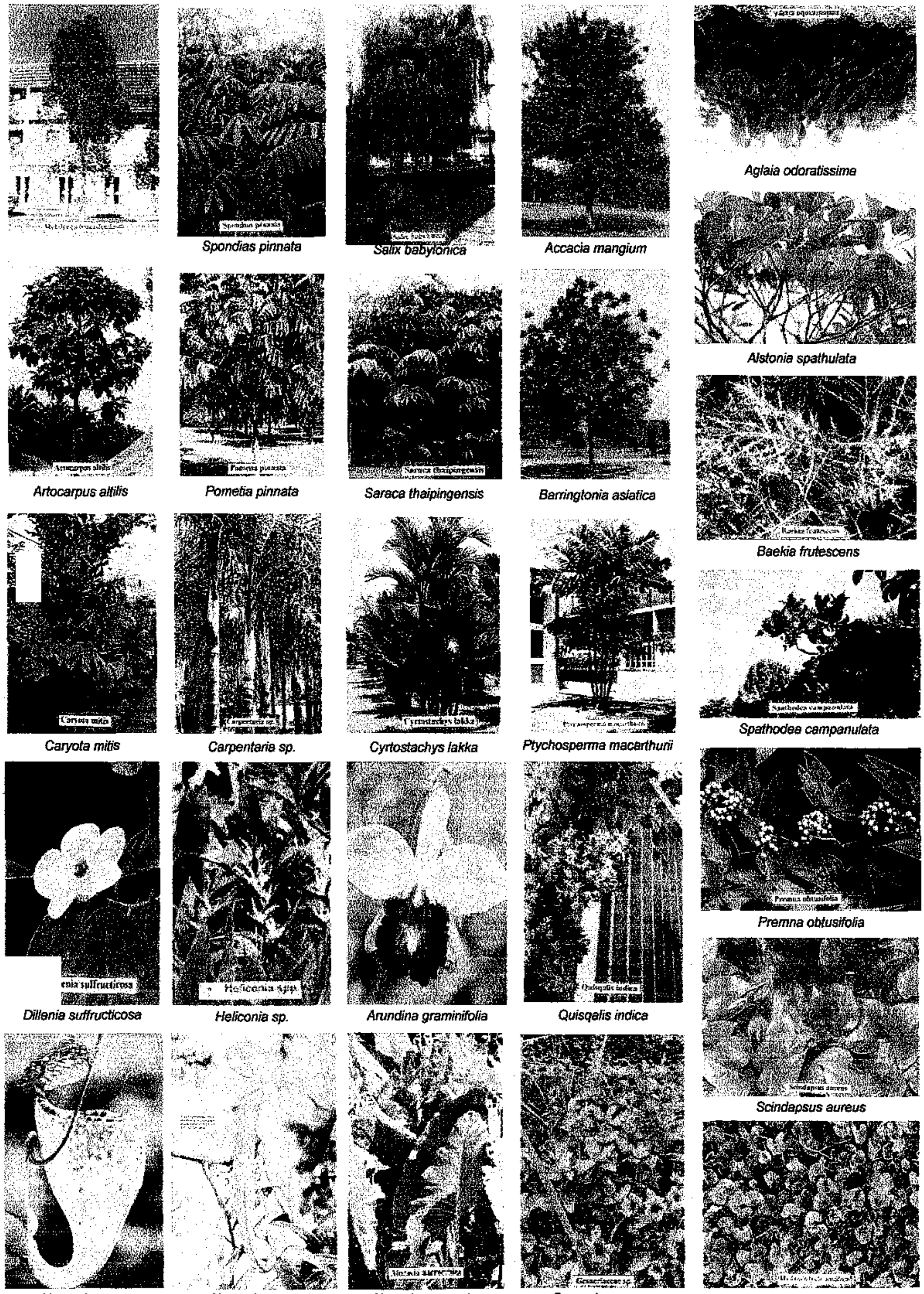
*Lugwigia actovalvis*



*Ludwigia adscendens*

*Limnocharis flava*

Flora Species for Zone 2



*Spondias pinnata* | *Salix babylonica* | *Accacia mangium* | *Aglaia odoratissima*

*Artocarpus altilis* | *Pometia pinnata* | *Saraca thaipingensis* | *Barringtonia asiatica* | *Alstonia spathulata*

*Caryota mitis* | *Carpentaria sp.* | *Cyrtostachys lakka* | *Ptychosperma macarthurii* | *Baekia frutescens* | *Spathodea campanulata*

*Dillenia suffructicosa* | *Heliconia sp.* | *Arundina graminifolia* | *Quisqalis indica* | *Premna obtusifolia* | *Scindapsus aureus*

*Nepenthes sp.* | *Nepenthes sp.* | *Alocasia accorrhiza* | *Gesneriaceae sp.* | *Hydrocutycle asiatica*

Flora Species for Zone 3

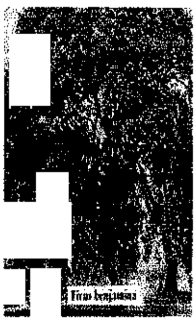

*Celia petandra*


*Elaeocarpus nitidus*


*Melia excelsa*


*Cocoloba uvifera*


*Ficus sp.*


*Ficus benjamina*


*Caryoto no*


*Cratoxylon arborescens*


*Licuala spinosa*


*Dillenia sp.*


*Clerodendron paniculatum*


*Bambusa sp.*


*Bambusa sp.'broad leaves'*


*Johannesteijsmannia altifrons*

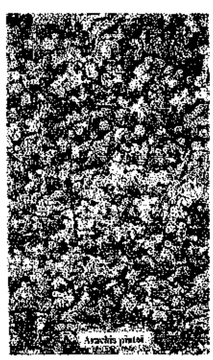

*Cassia alata*

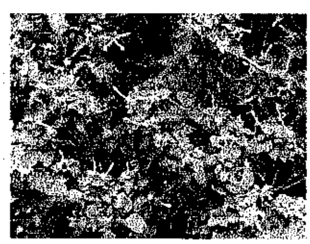

*Ixora javanica*

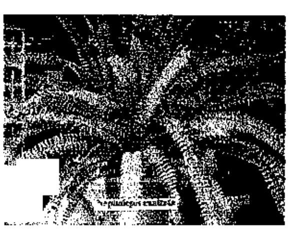

*Nepholepis sp.*


*Pandanus sp. 'green dwarf'*


*Pandanus utilis*


*Arachis pintoi*


*Mirabilis jalapa*


*Nepholepis exalata*


*Turnera almifolia*


*Asystasia gangetica*


*Nephrolepis sp.*

Flora Species for Zone 4

# Appendix H: Pictures of Laboratory Works

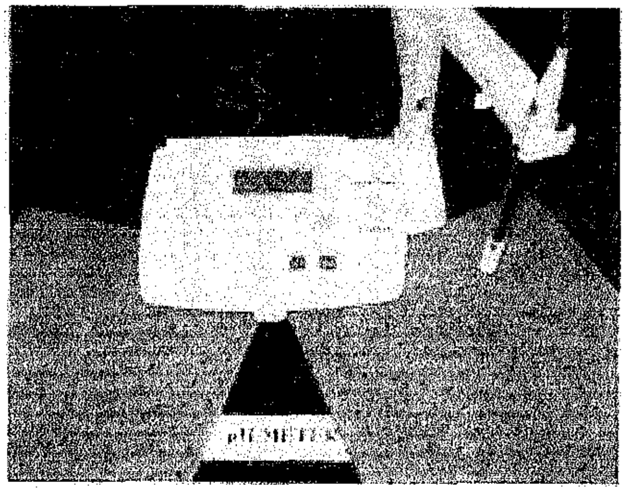


**Figure 21: pH meter use to check pH**

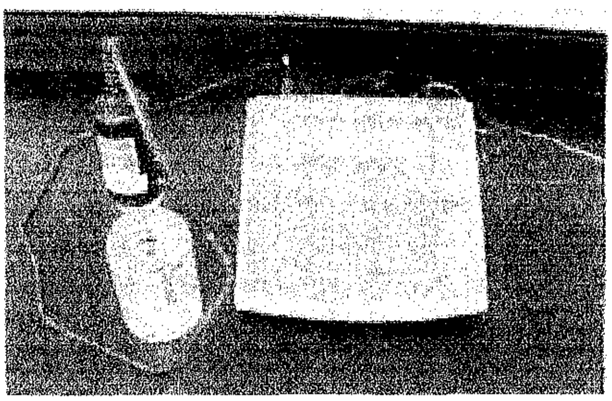


**Figure 22: Dissolved Oxygen Meter use to measure BOD**

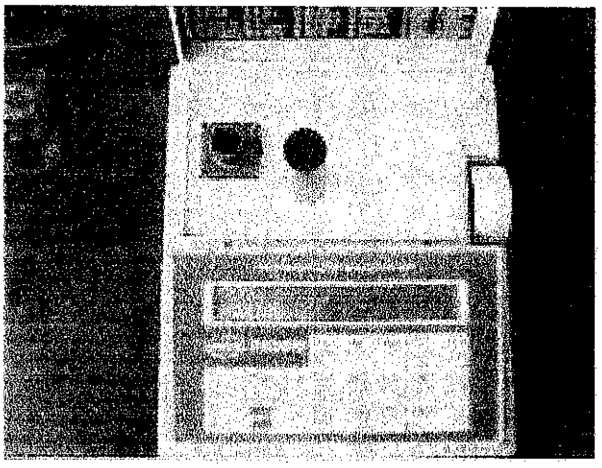


**Figure 23: Portable Data logging Spectrophotometer**

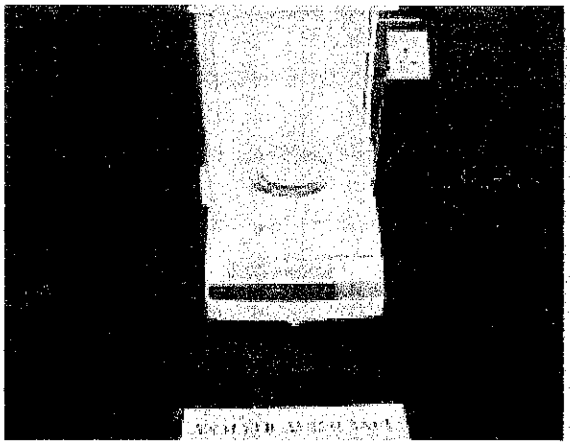


**Figure 24: Equipment used to weight filter paper with suspended solids**

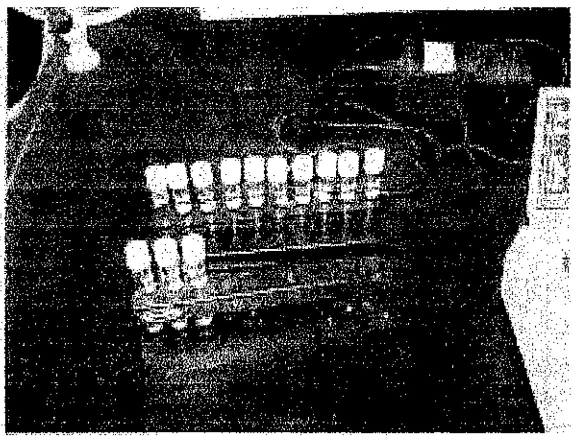


**Figure 25: HACH used as samples containers**

**Figure 26: Photo during testing the pH of water samples**