FLOOD FLOW REDUCTION VIA OPTIMIZATION OF OUTLET CONTROL STRUCTURE AT SETAPAK JAYA POND

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Specially dedicated to *Mak* and *Abah,my husband, my daughter and son,*
*my boss and all my friend.*
Thank you for your support

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# ABSTRACT

Flooding has been one of the most costly disasters in terms of both property damage and human casualties. Floods cannot be fully controlled if the storage ponds constructed without the outlet control structure. Storage ponds are required to store water during rainy season to control flood. It is can reduce the peak volume of runoff from a catchment which can reduce the frequency and extent of downstream flooding. The main objective of the study is to analyse the flood flow reduction trough outlet control structure geometry optimization at difference scenario using Infoworks ICM model. This case study is conducted at Setapak Jaya Pond which is one of the upstream Sungai Bunus tributaries. There are six scenario combination of 3 number orifices and broad crested weir to identify the lowest peak flow to control the discharge water from Setapak Jaya catchment. Scenario 5 and scenario 3 is the best solution for low flow and scenario 2 for high flow. The result for scenario 5 is 4.559$m^3/s$ which the water was discharge trough overflow broad crested weir and closed all the existing orifices with the control gate valve. Outflow for scenario 3 is 9.797$m^3/s$ which the water discharge through 2 numbers orifice and rubber dam at 1.5m high mounted on the board crested weir. Scenario 2 is the best flow rates attenuation for 10 ARI is 14.77$m^3/s$ ,20 ARI is 21.80$m^3/s$ ,50 ARI is 32.90$m^3/s$ and 100 year ARI is 42.19$m^3/s$. It was achieved using a combination of 3 nos orifice pipe discharge outlet of 1.0m and an inflatable rubber dam place at various high above the water level. Therefore, scenario 2 is the best solution for Setapak Jaya Pond.

# ABSTRAK

Banjir merupakan salah satu bencana yang paling mahal dari segi kemusnahan harta benda dan korban manusia. Banjir tidak boleh dikawal sepenuhnya sekiranya kolam takungan yang dibina tanpa kawalan salur keluar. Kolam takungan diperlukan bagi menyimpan air semasa musim hujan untuk mengawal banjir. Ianya boleh mengurangkan kapasiti air larian dari kawasan tadahan dimana ia boleh mengurangkan frekuensi dan melambatkan kadar banjir dikawasan hiliran. Tujuan utama kajian ini adalah untuk menganalisa pengurangan aliran banjir melalui pengotimuman geometri struktur kawalan keluar pada scenario yang berbeza menggunakan model ICM. Kajian ini dibuat di kolam Setapak Jaya yang merupakan salah satu cabang di hulu Sungai Bunus. Terdapat enam senario yang mengabungkan 3 buah paip keluar dengan menggunakan tebing alur keluar untuk menentukan aliran puncak yang paling rendah bagi mengawal air keluar dari kolam Setapak Jaya. Senario 5 dan 3 adalah tebaik untuk aliran yang rendah dan senario 2 untuk aliran yang tinggi. Keputusan untuk scenario 5 ialah 4.559m$^3$/s dimana air keluar melalui alir limpah tebing kawalan dan menutup kesemua salur keluar dengan menggunakan pintu kawalan. Aliran keluar untuk senario 3 adalah 9.797m$^3$/s dimana air keluar melalui 2 buah paip dan Rubberdam pada ketinggian 1.5m yang dipasang pada tebing alur keluar. Scenario 2 adalah terbaik untuk pengecilan kadar aliran untuk 10 ARI iaitu 14.77m$^3$/s ,20 ARI iaitu 21.80m$^3$/s ,50 ARI ialah 32.90m$^3$/s and 100 year ARI adalah 42.19m$^3$/s Ianya di capai dengan menggunakan gabungan 3 buah paip keluar bersaiz 1.0m dan menempatkan empangan getah kembung (Rubberdam) sehingga paras atas air. Oleh itu senario 2 adalah cara tebaik untuk Kolam Setapak Jaya.

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| | |
|---|---|
| ICM | Integrated Catchment Modeling |
| DID | Department of Irrigation Department |
| iFFRM | Integrated Flood and Rainfall Management |
| MSMA | Manual aliran Mesra Alam |
| DBKL | Dewan Bandaraya Kuala Lumpur |
| GIS | Geographic Information Systems |
| LIDAR | Light Detection and Ranging |
| DTM | Digital Terrain Data |
| Tc | Time Concentration |
| ARI | Average Recurrence Interval |
| IDF | Intensity Duration Frequency Curve |

# LIST OF SYMBOLS

| | |
|---|---|
| m | Metre |
| mm | Milimetre |
| $t$ | Time |
| $Q$ | Discharge |
| $S$ | Storage |
| $h$ | Height of water level |
| $A_r$ | Surface of storage pond |
| $h_{up}$ | Depth upstream |
| $h_{down}$ | Depth downstream |
| $dS$ | Change of storage volume |
| $dh$ | variation of water level |
| $dt$ | Change of time |

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

A flood is an overflow of water that submerges land which is usually dry. Flooding may occur as an overflow of water from water bodies, such as a river or lake, in which the water overtops or breaks levees, resulting in some of that water escaping its usual boundaries. Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers.

Flooding is a natural part of a river's cycles and the major disaster, affecting many regions around the world year after year. It is an inevitable natural phenomena occurring from time in all rivers and natural drainage system, which not only damages natural resources and environment, but also causes the loss of lives, economy and health. Nowadays, floods are disasters causing untold property loss every year. (Smith,1997: Baumann,1999).Flood is a most common natural disaster in Malaysia. There are two types of flood in Malaysia are monsoon flood and flash flood.

Storage ponds are required to reduce flood damage. It is can reduce the peak volume of runoff from a catchment which can reduce the frequency and extent of downstream flooding. The reduce post-development runoff hydrograph is mean the peak flow is equal to or less than predevelopment peak flow rate. Detention is commonly sized to provide only a reduction in the volume of stormwater runoff generated from an urban area. Peak flow reduction can also achieve in minor storm event if the storage volume is large enough to capture the peak flow before the storage is filled.

Detention ponds are stormwater Best Management Practices (BMPs) used for the control and treatment of urban stormwater. They are treatment technologies used for the control of urban stormwater quantity as well as quality problems (Paine and Akan, 2004, Guo, 1999, Färm, 2002). Over the last two decades, there have been an increase in the number of stormwater detention ponds designed and constructed for the treatment and control stormwater in Malaysia (DID, 2000). Most of these ponds are designed based on design storm concept, in which only the flood control aspect is given attention during design and the pollution control aspect is relegated to the background. Also design storm assumes that the recurrence interval of runoff is the same as that of rainfall producing it thus neglecting the storm separation time between two events. There is the need to better explore the benefits of these systems in such a way that they can serve the dual purposes as flood and pollution control. This can be achieved by extending the detention time long enough for the suspended particles carried by the stormwater to settle (Shammaa *et al.*, 2002, Comings *et al.*, 2000). However, if the detention time is too long, there will be little storage for subsequent storms to fill in, which means there is the tendency that the pond may be overwhelmed by subsequent storms (Guo, 2002).

The study area is Sg. Peran, one of major Sungai Bunus tributaries. The total catchment is about 420.5 hectares (or 4.20 $km^2$). One part of Sg. Bunus originates from WangsaMaju sub-catchment at Bukit Wangsa Mas and passes through Air Leleh pond, Pulapol, Kg. Boyan pond and Kg. Baru before joining into Sg. Klang and the river is about 7.0 km length. Sungai Bunus have three existing pond and one of the ponds is Setapak Jaya pond located at near downstream Sg. Peran. The total ponds area is about 56,000$m^2$ and the volume pond storage about 228,490$m^3$. The Bed level is arranging 42.5m to 43.8m and ground level about 48.5m. Setapak Jaya is a online storage pond and the pond was design to store the runoff for a period of 24 hours.

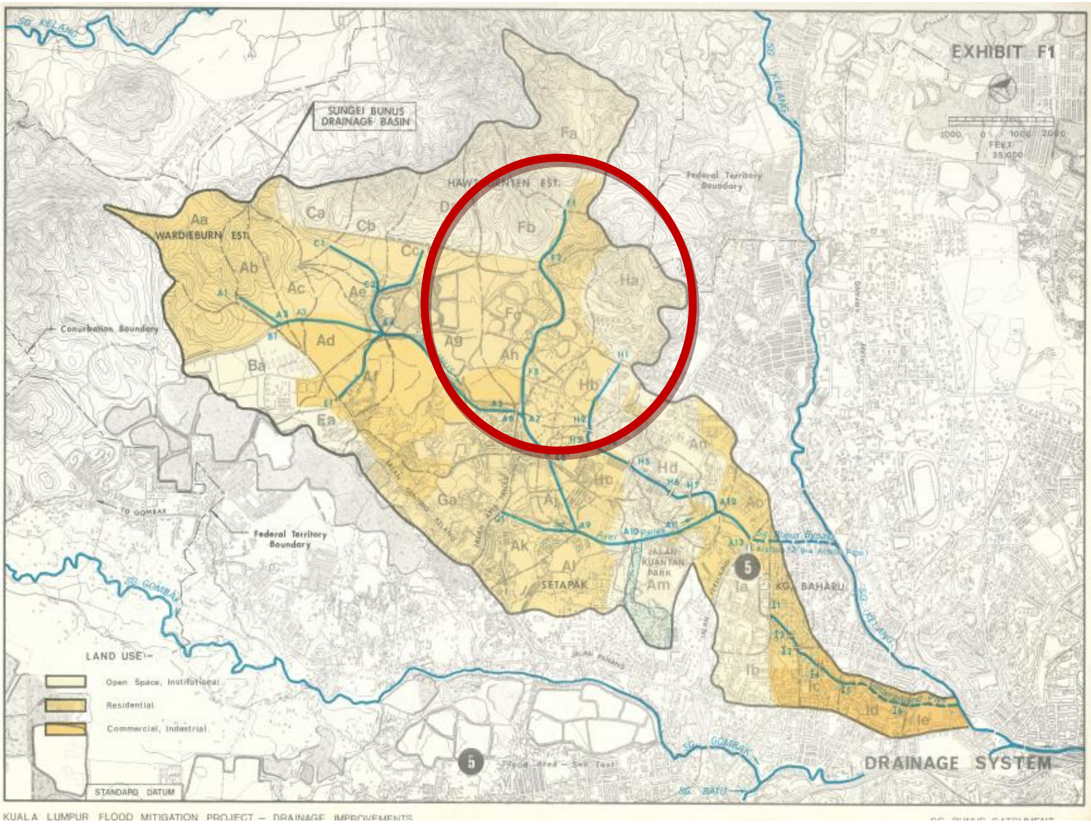


**Figure 1.1:** Catchment area of Setapak Jaya Pond

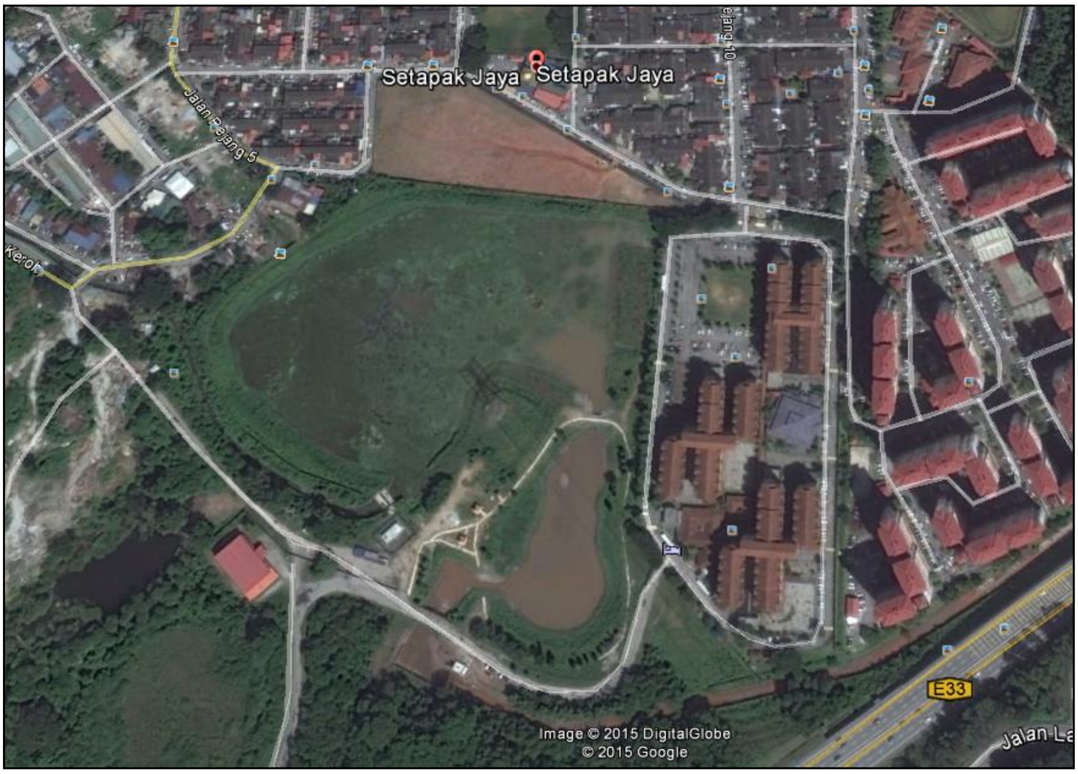


**Figure 1.2:** Location of Setapak Jaya Pond from Google Earth

**Figure 1.3:** View at Setapak Jaya Pond

## 1.2 Problem Statement

In January1971 Kuala Lumpur was a major flash flood disaster in Malaysia. The flooding was the result of heavy monsoon rains, which swelled the Klang, batuand Gombak rivers. 32 people were killed and 180,000 people were affected. Over the past decade, incidences of major flooding have become more frequent and effected. Table 1 shows the history flooding incidences in Kuala Lumpur.

**Table 1.1:** History Flooding in Kuala Lumpur.

| Period | No. of Times | Year |
|---|---|---|
| 1970s | 1 | 1971 |
| 1980s | 3 | 1982, 1986, 1988 |
| 1990s | 4 | 1993, 1995, 1996, 1997 |
| 2000 | 5 | 2000, 2001, 2002, 2003, 2007 |
| 2010 to date | 11 | 2011 (4 times) 1012 (3 times) 2013 (4 times) |

The recent flash flood of Sg. Bunus at Jalan Tun Razak in 2011 ($24^{th}$ Feb 2011, $14^{th}$ April 2011, $16^{th}$ April 2011 and $13^{th}$ December 2011) has prompted the Government to accelerate the plan towards finding solution for this problem as this is the major road to the city center. The peak discharge recorded about 223 $m^3/s$ at Jalan Tun Razak on $24^{th}$ February 2011, which is larger than the existing conveyance capacity of about 60 $m^3/s$ (Kg. Baru). Figure 1.4 shows the flooding situation at Jalan Tun Razak.


**Figure 1.4:** Flooding at Jalan Tun Razak

The occurrence of localized flash floods on 14 April 2011 causes the sink hole at Kg. Bharu and it was reported that 12 houses was affected shows in figure 1.5. Because occurring of the floods, leading to material damages, more complex control and flood mitigation works should be plan in a sustained manner. The study is aimed at reducing the flooding frequency within the Sg. Bunus catchment especially at Jalan Tun Razak.

**Figure 1.5:** Sink Hole at Kg. Bharu

## 1.3 Objectives of the Study

The main objective of the study is to analyse the flood flow reduction through the outlet structure geometry optimization at Setapak Jaya pond. Specific objective include:

i) to produce routing using Infoworks ICM (Integrated Catchment Modeling)

ii) to choose the lowest peak flow to control flood even at downstream for consideration scenario.

iii) to choose the best scenario for standard operating procedure.

## 1.4 Scope of Study

The scope of the study includes the following:

i. Study catchment area of Setapak Jaya Pond included the Sungai Bunus alignment and flood history
ii. Data collection including survey data, Lidar data, soil investigation data, rainfall and others hydraulic data
iii. Model using Infoworks ICM (Integrated Catchment Modeling)
iv. Determine the inflow and outflow hydrograph for difference scenario

## 1.5 Importance of Study

The importance of this study is to control the flood at the downstream and control the flow capacity before the water discharge to Sungai Klang. This analysis will help the operation and maintenance officer to identify their control the flow capacity by SCADA System

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