

# Analysis of the effectiveness of existing pond to accommodate storm water runoff in UTHM

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Received 01 January 2018; accepted 15 April 2018, available online 07 May 2018

**Abstract:** Rapid development within UTHM campus has changed the existing earth surface from pervious to impervious layer thus increasing the surface runoff. This study describe the application of XP SWMM software in determining the effectiveness of existing pond to accommodate the increase of storm water runoff based on designated rainfall event. Through this approach, the past studies, related journals, and Storm-water Management Manual (SWMM) are used as a reference for this study. Land and hydrographic survey is carried out in order to determine pond profile. The selected study principle using XPSWMM software is based on Rational Method as the catchment area is less than 80 ha and Manning Equation. The existing pond is designed to receive storm water runoff from two different catchments which are area around University Health Centre (PKU) and area starting from Centre for Diploma Studies (PPD) until Information Technology Centre (PTM). The input rainfall data is for 10 years rainfall event (2006-2016). It was found that there are no overflow from the pond, thus the volume for the pond ( $12356.39\text{m}^3$ ) is effective to accommodate increasing storm water runoff from both catchment area.

**Keywords:** Renewable fuel, ethanol, numerical simulation, auto ignition, single-step mechanism

## 1. Introduction

In recent years, due to the serious threats from the storm water disasters to the traffic, commerce, production and lives and properties of citizens, it is very important to establish scientific methods for urban stormwater disaster prevention and control. As the urban areas continue to develop, these problems become more severe and required a proper and holistic approaches to treat such problems [1]. The launching of a New Urban Drainage Manual known as Urban Storm Water Management Manual for Malaysia (SWMM) emphasizes the implementation of Best Management Practices (BMPs) concepts such as wet ponds, grass swales, wetlands, sand filter dry pond and etc [2]. Conventionally, stormwater management practices considered runoff as a waste to be removed and disposed quickly from developments. Thus, the runoff from urban and suburban developments, and municipalities used to be collected and conveyed by drainage system and is directly discharged into lakes and streams. The result is apart from impacts on water quality, was the increase of the occurrence of flooding, a rise in flood elevations, and spread of flood prone areas that adversely affected properties along and adjacent to streams and lakes [3]. There are two classes of storm water systems, which are major and minor. Components in the minor quantity

system are designed to manage runoff generated by the more frequent short-duration storm events. Meanwhile, the components for major storm water system are natural streams, channels, ponds, lakes, wetland, large pipes and culverts. Design criteria for the major system refer to significant amounts of rainfall produced by the less frequent long-duration storms [4]. The minor and major systems are closely interrelated and the integrated design each of the component should comply with the standards and guidelines by the authorities [5]. SWMM tracks the quantity and quality of runoff made within each sub catchment. It tracks the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period made up of multiple time step [6]. A detention pond is a type of storm water Best Management Practice (BMP) aimed to protect against flooding has the capability to attenuate the peak flow discharge and is typically designed to empty within 6 to 12 hours after the storm [7]. A dry pond is capable to retain and store storm water runoff in an average typical duration of 24 hour before draining into other storm water system [8]. Several of studies indicate that peak rates of discharge increased from seventy to ninety percent from pre-development to post-development and the total annual volume of runoff increased approximately 300 percent. Ponds, when properly sized,

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can be a primary water quantity control in a stormwater management system [9].

## 2. Methods

The location of study is at the UTHM existing pond which receive storm water runoff from catchment area 1 and catchment area 2 as shown in Figure 1. The area within catchment consists of structures and infrastructures that prevent water from infiltrating the ground. Nowadays, more than 50% of these areas are covered with impervious surface.

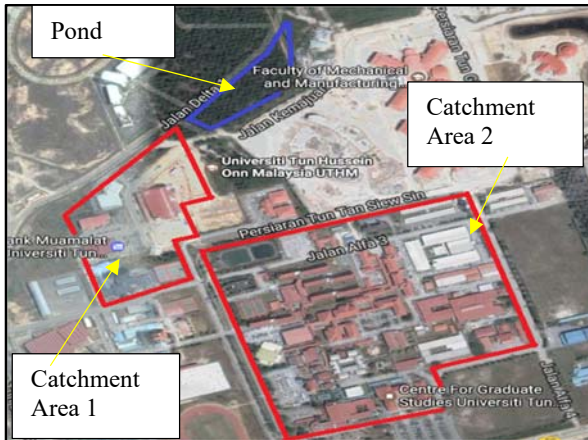


Fig. 1 Catchment area 1 and catchment area 2 for the pond.

In this study, the rainfall intensity data patterns were acquired from the Department of Irrigation and Drainage Malaysia (DID). The obtained precipitation data is in the form of rainfall per hours for 10 years rainfall event in Parit Raja (2006-2016). Any information relating to the dimensions of the pond system for this study was obtained from hydrographic and onshore survey. Basically, XPSWMM and AutoCAD software plays an important role in this study. All the collected data was processed using the software to produce the pond profile as shown in Figure 2.

There are variety of methods which can be used to estimate the peak flow from the catchment. However, the The Rational Method was used in this study to estimate the peak flow discharge as the total area is less than 80 ha. The characteristics of the catchments and pond system components, which include the drainage of inlet and outlet and also the storage capacity of the pond, have been modeled in the XP-SWMM using the link-node concept. The calibration of the model is performed using rainfall storm event provided by DID based on rainfall data from 2006 until 2016. Initial losses, depression storages, infiltration parameters are among the hydraulic and hydrologic parameters used for the calibration process to evaluate the performance of SWMM in modeling the pond.

## 3. Results and discussions

The obtained data from levelling survey, tachymetry survey and hydrographic survey is used to identify the

geometry characteristic of the pond. The survey data was processed to produce detailed pond profile and to identify flood plains within the pond. The hydrographic survey data used to identify the depth of the pond and then, the obtained result is compared with the pond depth studies in 2012. Next, the collection of rainfall data from Department of Irrigation and Drainage (DID) used to design water flow from catchment area in XPSWMM software. Later, the processed data is used to analysis the effectiveness of the pond to accommodate the storm water runoff. From the survey data, the surface area of the existing pond is approximately 12185.52 m<sup>2</sup>.

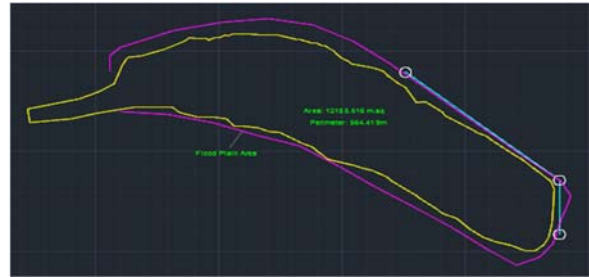


Fig. 2 Area and perimeter of the pond.

The existing pond profile is compared with the previous data (2012) in order to identify the bed changes profile. Hence, the comparison of pond depth profiles were shown in Figure 3 (a), (b) and (c). The depth cross-section position used for comparison is termed as CH 50, CH 100 and CH 200 as it represents the location at the inlet point, an intermediate point and outlet point of the pond.

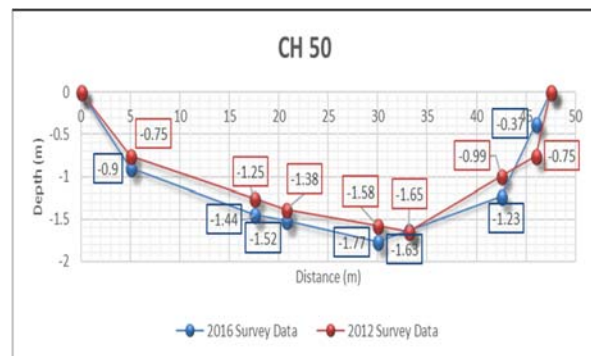


Figure 3 (a) Depth comparison for inlet point of the pond.

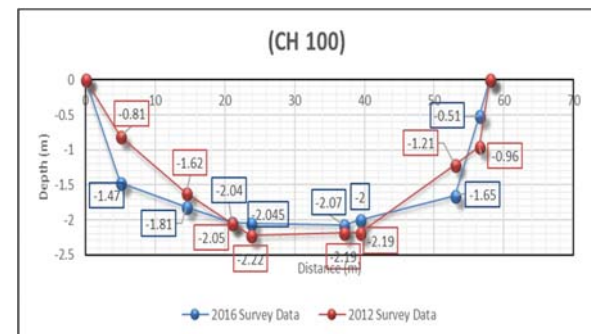


Figure 3 (b) Depth comparison for an intermediate point of the pond.

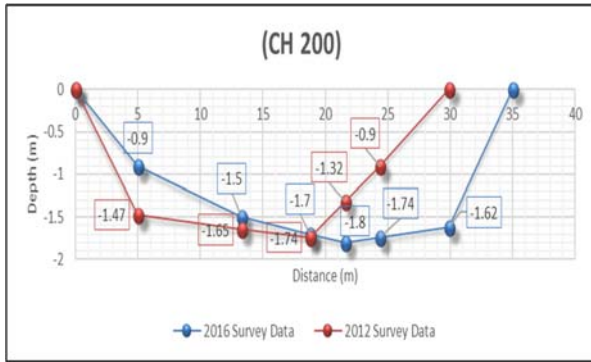


Figure 3 (c) Depth comparison for the outlet point of the pond.

Based on the Figure 3 (a), (b) and (c), it shown that there are change of bed profile between 2012 data and 2016 data reflected the sediment erosion and sedimentation phenomena. At CH 50, it can be seen that the pond profile change from 1.77 m to 1.58 m with the difference of 0.19 m in depth. This situation caused by the high velocity inlet flow from the catchment areas that create an imbalance on the bed profile of the pond. At CH 100, the eroded sediment was deposited at the bottom of the pond as the flow velocity is no longer dominant at this point. The increase of cross-sectional area is attenuated to the free-flowing velocity which reduce the sediment shear stress and affected the sediment transport capacity. Thus, the sediment was deposited at this particular point.

Based on the Figure 3 (c), there is a significant difference of cross-section at CH 200. The distance from side to side of the pond for year 2012 is 29.9 meter but the distance for year 2016 is 35 meter. The pond depth and profile at CH 200 is completely difference as the sedimentation occur at the left bank of cross-section and the erosion occurred at the right bank. The difference is quite significant as the flow velocity at CH 200 is presented in Table 1. From the table, it can be seen that the flow velocity at the right bank is higher compared to the left bank due to the bed change profile.

Table 1. Velocity data for CH 200

Depth, h (m)	Velocity, v (m/s)		
	Left	Center	Right
0.8D	0.011	0.021	0.027
0.2D	0.005	0.012	0.011
Average	0.008	0.017	0.019

From table 1, the flow velocity at left bank of the cross-section is low which is 0.005 m/s for 0.2D and 0.011 m/s for 0.8D. This situation is caused by sediment deposition at the left bank of CH 200 cross-section. By referring to Figure 3(c), the left bank of 2016 cross-section profile is shallow as compared to the right bank. Hence, this condition caused the velocity to be non-uniformly distributed. Non-uniform flow will occur where the area or the depth varies along the conduit. Meanwhile, the

water velocity at the right bank is higher than left bank which is 0.027 m/s for 0.8D and 0.011 m/s for 0.2D.

For modelling analysis, the runoff mode was used to analyse rainfall data in order to determine flow rate from the catchment area. From the analysis of rainfall data, it was found that the flow rates from catchment 1 to Node 1 is 1.3876 m<sup>3</sup>/s and from catchment 2 to Node 5 is 2.3367 m<sup>3</sup>/s. Meanwhile, hydraulics mode is used to simulate the storage and transport of water through a drainage network. The water flow characteristic in node and link can be determined by reviewing results in hydraulics mode. Figure 4 and Figure 5 show the link profile from catchment 1 to Node 12 (pond). The magenta line shows the maximum hydraulic grade line occurring during simulation process and the blue line shows the water grade line according to time step. In Figure 4, there is wave shape at early phase for Link 11, it is means there is overflow occur on that section.

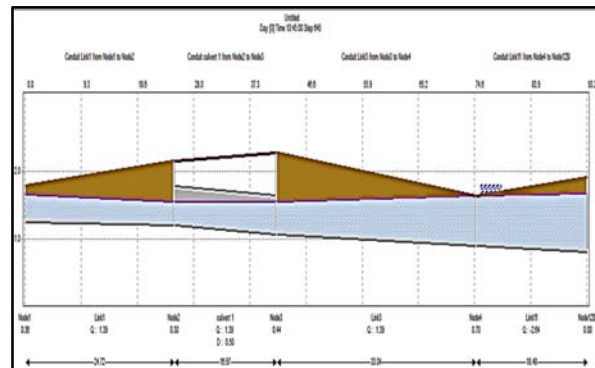


Figure 4. Link profile from Node 1 to Node 12.

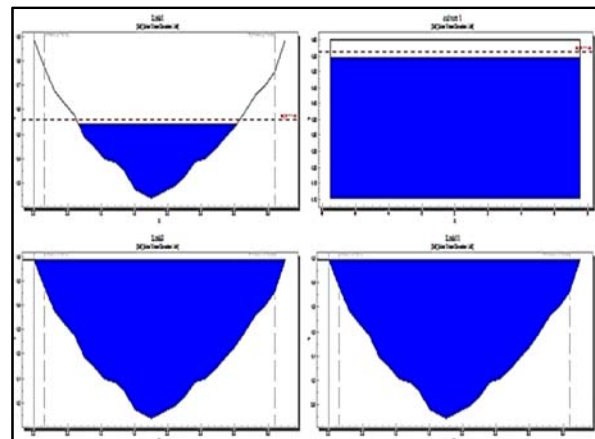


Figure 5. Links cross-section from Node 1 to Node 12.

Based on Figure 6, the overflow value result for Node 12 (pond) is 0 m<sup>3</sup>, hence, it is means there is no overflow from the pond and the pond is capable to store the stormwater. It can be concluded that the present volume of the pond (12356.39 m<sup>3</sup>) is sufficient and effective to accommodate storm water runoff from both catchment area.

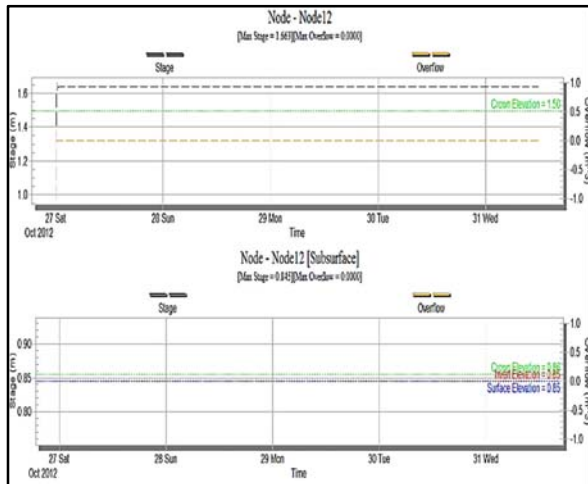


Figure 6. Hydraulics (HDR) mode result for Node 12.

#### 4. Conclusions

Based on the pond depth and pond profile, it can be concluded that there are sediment deposition and erosion phenomena occur at the pond bed. Meanwhile, the analysis model using XP SWMM software show that the maximum overflow for the pond is 0 m<sup>3</sup>. Hence, it is proved that the pond is effective to accommodate existing storm water runoff from catchment area 1 and 2.

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