# RISK BASED ANALYSIS FOR DETENTION POND OVERFLOW AT ISKANDAR MALAYSIA (NUSAJAYA), JOHOR

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*Dedicated especially to my beloved father, mother and family.*
*Thank you for their unlimited patient, loving inspiration and care*
*May Allah bless us.*

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# ABSTRACT

Overflow risk of detention pond is defined as the probability of having a rainfall event that produces a runoff volume more than the available storage capacity of detention pond. Overflow risk analysis depends on the waiting period (elapse time) and draining time. This study dealt with risk analysis of detention pond overflow at Ledang Heights, Nusajaya, Johor Bahru. Monte Carlo simulation the simplest application to estimate the probability of occurrence of the 10 year rainfall interevent timeswas applied during this study. The maximum value for interevent time was 8 hr and 6 hr occurred with probability 24.18% and 28.39% after 5000 and 10000 trials respectively using Gamma distribution. The most likely range for interevent time were 2 to 18 hr (1.34%-1%) and 2 to 22 hr (3.84%-0.05%). The equation by Guo (2002) was applied during this study. The highest overflow risk obtained was 0.425 for the longest drain time of 71.75 minutes and for shortest elapse time. The overflow risk increases as the drain time increases and the elapse time decreases. Therefore, the selection of a proper drain time (recession time) is very important for reducing risk of overflow. Size of detention pond at the site is 70 m length x 70 m width x 3 m depth. The new size suggested was 82 m length x 70 m width x 3 m depth. The storage capacity of detention pond was larger than the volume of maximum rainfall data. The new size of detention pond is appropriate at the area because it could collect the maximum volume of runoff over a longer time period at the lowest overflow risk. It is suggested to design at lower elapse and drain time to minimize the overflow risk.

# ABSTRAK

Risiko air limpah adalah kebarangkalian mempunyai hujan yang menghasilkan isipadu airlarian permukaan melebihi kapasiti kolam tahanan. Analisis risiko air limpah bergantung kepada masa ke puncak (*elapse time*) dan masa pengosongan. Kajian ini membincangkan tentang analisis risiko kolam tahanan di Ledang Heights, Nusajaya, Johor Bahru. Simulasi Monte Carlo telah digunakan di dalam pengiraan kebarangkalian berlakunya *interevent time* bagi data hujan 10 tahun. Nilai maksimum *interevent time* adalah 8 dan 6 jam dengan kebarangkalian berlaku adalah 24.18% dan 28.39% selepas 5000 dan 10000 cubaan menggunakan taburan Gamma. Julat anggaran untuk berlaku *interevent time* adalah antara 2 hingga 18 jam (1.34%-1%) dan 2 hingga 22 jam (3.84%-0.05%). Di dalam kajian ini, persamaan Guo (2002) telah digunakan dalam pengiraan risiko air limpah. Risiko air limpah yang paling tinggi ialah 0.425 pada masa pengosongan yang paling tinggi iaitu 71.75 minit dan pada elapse time yang paling rendah. Risiko air limpah meningkat apabila masa pengosongan meningkat manakala elapse time menurun. Oleh itu, dalam rekabentuk kolam tahanan adalah penting untuk mengetahui nilai risiko untuk masa pengosongan yang dipilih bagi mengurangkan risiko air limpah. Saiz kolam tahanan sedia ada di tapak adalah 70 m panjang x 70 m lebar x 3 m dalam. Manakala saiz kolam tahanan yang dicadangkan adalah 82 m panjang x 70 m lebar x 3 m dalam. Isipadu kolam tahanan lebih besar daripada isipadu maksimum hujan rekabentuk daripada data hujan. Saiz kolam tahanan yang dicadangkan adalah sesuai kerana ia boleh menampung isipadu maksimum air larian permukaan bagi jangka masa yang panjang iaitu pada masa risiko air limpah yang paling rendah. Oleh itu dicadangkan, pemilihan elapse time dan masa pengosongan yang rendah digunakan dalam rekabentuk bagi meminimakan risiko air limpah.

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| | |
|---|---|
| $Q_p$ | Peak Flow, $m^3/s$ |
| C | Surface Runoff Coefficient |
| i | Rainfall Intensity, mm/hr |
| A | Catchment Area |
| $t_c$ | Time of Concentration, minute |
| R | Average Return Period, year |
| $P_d$ | Design Rainfall Depth |
| $P_{30}$ | 30 Minute Duration Rainfall Depth |
| $P_{60}$ | 60 Minute Duration Rainfall Depth |
| $F_d$ | Adjustment Factor for Storm Duration |
| $F_c$ | Conversion Factor |
| L | Length of Flow Path from Catchment Divide to Outlet |
| S | Slope of Stream Flow Path |
| $V_0$ | Capacity In Channel |
| Dm | Average Rainfall Depth, mm |
| Di | Incipient Runoff Depth, mm |
| q | Average Release |
| T | Elapse Time, minute |
| $T_r$ | Drain Time, minute |
| Tm | Average Interevent Time, minute |
| Cd | Outflow Coefficient |
| H | Effective Head on Measured From The Centroid of Culvert To Surface Outflow |
| Re | Inherent Overflow Risk |
| Rd | Operational Overflow Risk |
| R(T) | Overflow Risk |

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# CHAPTER 1

# INTRODUCTION

## 1.1 General

Nowadays, construction process is rapid because of human necessity for better life and comfort. Rapid construction and uncontrolled plan will changed the condition of the earth. This can cause to topographic changes and disturb the hydrology cycle.

In hydrological process, rainfall water will become less because of plants overtake and others will infiltrate into the earth. When new construction area is build, plants will be cut. This will make more rain will moving direct to the drain without going through process of overtake and infiltration.

As urban development occurs, the increase of impervious surface areas increases the volume of surface runoff and decreases infiltration volumes. Installation of storm sewers and realignment and channelization of natural streams result in a more rapid transmission of surface runoff. Without control measures, the increase in peak discharge rate following rainfall event is often an inevitable consequence and may exacerbate flooding (overflow) of downstream areas. (Yiping Guo, 2001). Flood cause loss of live, damage properties and buildings, and disturb human activities such as the aspect of economic and traffic. Incompatible drainage system, unmanageable logging activities, and change land use from rural use to urban development are the reasons that worsen the flood problem.

This is why most urban communities require the use of stormwater detention ponds to reduce peak discharge rates from urban area to avoid hydrological problems; flood or overflow. (Philip and Huber, 1992; Ram, 1989). The drainage systems should be designed taking into consideration water quality and environmental aspects. Athadyde (1976) stated that many studies have revealed that the traditional approach in storm water drainage has increase flooding and stream erosion, affected the balance of a water body and created shock loads of pollutants to the receiving waters.

In manual for rapid discharge method, runoff water will discharge direct into drain system without detention system involved. This can give negative effect at downstream area cause runoff water decrease on rain event. For water flow control, enlarge drain system must be done to support the increasing of the flow. If the enlarged drain system also cannot cover the increasing of the flow, enlargement of the river can be done. Although this alternatives can solved the problem but it just temporary and not practical because it not environment friendly.

In report Cary, Australia (Tery, 1998), effect of the rapid discharge will increase the river flow, eroded to river bank and then, sediment of that erosion can reduced the river depth. Enlarge the river will include the higher cost because if necessary, the additional space are needed if it exceeded the limit of river rizab (JPS, 2000).

Stormwater management in Malaysia has traditionally focused primarily on managing the impacts of flooding by adopting a conveyance-oriented approach. Stormwater systems designed in accordance with this approach provide for the collection of runoff, followed by the immediate and rapid conveyance of the stormwater from the collection area to the point of discharge in order to minimize damage and disruption within the collection area. Stormwater runoff is viewed as a nuisance to be disposed of as quickly and efficiently as possible (MASMA , 2001).

The operational cycle of a stormwater control basin can be divided into the waiting period between events and the filling and draining period during an event. In this study, an inherent overflow risk is defined as the probability of having a large event exceed the basin storage capacity. Such a probability is prescribed by the basin storage capacity and the local distribution of rainfall event depth. An operational risk is defined as the probability of having the basin overwhelmed by subsequent strom event during the draining process. An operational risk is found to be dependent on watershed runoff coefficient, basin drain time, local average rainfall event depth and average rainfall interevent time.

In addition to this new designed concept, risk analysis should be incorporated in the design analysis to effectively addressed flood problems. Risk study would provide a more comprehensive analysis in the environmental and hydrological matters. Recent trends in many design of channel and other structures are towards the use of risk analysis (Warren and Gary, 2003). Risk analysis is an effective procedure or method for proper management of environmental and infrastructure systems. Risk analysis is also important in an uncertainty issues and helps in decision making process (Haimes, 2004).

## 1.2 Problem Statement

As urban development occurs, the increase of impervious surface areas increases the volume of surface runoff and decreases infiltration volumes. Installation of storm sewers and realignment and channelization of natural streams result in a more rapid transmission of surface runoff. Without control measures, the increase in peak discharge rate following a rainfall event is often an inevitable consequence and may exacerbate flooding of downstream areas. This is why the detention pond overflow risk analysis is carried out to reduce peak discharge rates and to avoid hydrological problems to the Nusajaya area.

## 1.3 Objectives of Study

The objectives of this study were:

i. To obtain probability distribution for 10 year interevent time using Monte Carlo simulation combining Gamma and Weibull distribution
ii. To determine elapsed time (Tm) and drain time (tr) for the to be estimated overflow risk
iii. To determine the relationship between overflow risk and elapse time.

## 1.4 Scopes of Study

The scopes of the study are to obtain the rainfall distribution at Ledang Heights, Nusajaya, Johor Bahru. The study is carried out for surface water analysis without the inclusion a groundwater.

## 1.5 The Importance of Study

"Storage detention approach" has been introduced in our country to handle flood problem due to development. This approach is recommended by the Department of Irrigation and Drainage Malaysia in the year 2000 by publishing a guideline name MASMA. Utilization of detention facilities is to control the additional volume and peak flow as well as the content of pollutant due to the additional development in the catchment area. Uncontrolled development and rapid urbanization are the major factors that cause the severity of the local flooding problems especially flash flood. Utilization of detention facilities is to retain the stormwater for certain duration (temporary storage) and control the peak discharge rate.

An operational risk is found to be dependent on watershed runoff coefficient, pond drain time, local average rainfall event depth and average rainfall interevent time. This study presents a design method by which the overflow risk is associated with a pond storage volume evaluated for various drain time. The concepts of the "longer, the better" applies to the sedimentation process, but concern for the overflow risk requires that the pond drain as fast as possible. For instance, a short drain time is preferred in order to reduce the overflow risk while the pond is emptying out. The risk-based approach developed in this study provides a quantifiable basis for making the decision on the operation of a detention pond.

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