DEVELOPMENT OF A PC-BASED TANK MODEL REAL-TIME FLOOD FORECASTING SYSTEM.

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This project is dedicated to my family, my supervisors and
to those who had given me tremendous support to contribute to
the betterment of the society.

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ABSTRACT

The Upper Klang catchment has been under-going rapid development which instigated many flash flood occurrences within the catchment, especially at the Kuala Lumpur City. A reliable and timely flood forecasting system is necessary to provide early warning to minimize the destruction caused by flash floods. Utilizing the publicly available online hydrological data combined with the most recent programming technologies, a PC-based a real-time flood forecasting system is developed for this purpose. The Tank Model is used as the hydrological model to simulate the catchment discharge while the Standard Step Method applied as the hydraulic model to simulate the water level profile of Klang River starting from the confluence of Klang and Ampang River to Jambatan Tun Perak. Integration of both models into a complete real-time hydro-dynamic flood forecasting system is programmed using the Microsoft Excel and Visual Basic For Application. Calibration and Verification of the model has proven that forecast generated by the system is highly reliable with an average Model Efficiency of 89.37% and a Mean Absolute Error of 0.23m. The system acquires real-time hydrological data from the Infobanjir server maintained by Department of Irrigation and Drainage Malaysia at 5 minutes intervals and is therefore able to provide a reliable and timely warning at 40 minutes before the flood peak reaches the city center.

ABSTRAK

Proses urbanisasi yang berlaku dengan pesat di kawasan tadahan Upper Klang telah menyebabkan kejadian banjir kilat melanda pusat bandar Kuala Lumpur yang terletak di bahagian hilir kawasan tadahan tersebut. Untuk mengurangkan kemysnahan akibat banjir kilat yang berlaku, satu sistem peramalan banjir "real-time" berasaskan computer peribadi harus dibangunkan untuk memberi amaran awal tentang kejadian banjir kepada penduduk-penduduk di kawasan pusat bandar. Dengan gabungan teknologi aturcara dan data hydrologi on-line yang disediakan oleh Jabatan Pengairan dan Saliran (JPS), suatu sistem peramalan banjir telah dibangunkan bagi tujuan tersebut. Dalam sistem yang dibangunkan, Model Tangki telah digunakan sebagai model hidrologi untuk meramalkan hidrograf discas dari kawasan kajian. Kaedah "Standard Step" pula digunakan untuk mensimulasikan aras air bagi sungai kajian iaitu Sungai Klang, bermula dari pertemuan Sungai Klang dan Sungai Ampang ke pertemuan Sungai Klang dan Sungai Gombak. Kedua-dua model ini kemudian diintegrasikan menjadi satu sistem peramalan banjir yang lengkap dengan menggunakan Microsoft Excel dan Aturcara Visual Basic For Application. Kalibrasi dan verifikasi model tersebut telah membuktikan bahawa ketepatan ramalan yang dihasilkan oleh sistem ini adalah memuaskan, dengan keberkesanan model sebanyak 89.67% dan purata perbezaan mutlak sebanyak 0.23mm. Sistem peramalan ini akan mengambil data hidrologi melalui internet pada sela masa setiap 5 minit dari server Infobanjir yang disediakan oleh JPS. Maka sistem ini boleh memberi ramalan banjir yang memuaskan 40 minit sebelum puncak banjir hidrograf sampai ke pusat bandar Kuala Lumpur.

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DID	-	Department of Irrigaion and Drainage, Malaysia
JPS	-	Jabatan Pengairan dan Saliran, Malaysia
RF	-	Rainfall
Q	-	Flood Discharge
WL	-	Water Level
m R.L.	-	Meters Reduced Level
Ms Excel	-	Microsoft Excel
VB	-	Visual Basic
BASIC	-	Beginner's All-Purpose Symbolic Instruction Code
GVF	-	Gradually Varied Flow
HTTP	-	HyperText Transfer Protocol
URL	-	Uniform Resource Locator
RFC	-	Request for Comments
PC	-	Personal Computer
WWW	-	World Wide Web
HTML	-	HyperText Marked-up Language
VBA	-	Microsoft Visual Basic for Application
GUI	-	Graphical User Interface
GIF	-	Graphic Interchange Format
API	-	Application Programming Interface

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Upper Klang Catchment covers a total area of 108km^2 (excluding the Klang Gate catchment), which extends from the tip of Klang River until the confluence of Klang and Gombak River. The downstream of the catchment, which includes part of the Kuala Lumpur City Center is fully developed while the upstream part like Taman Melati, Wangsa Maju and Ulu Klang are being rapidly developed to accommodate the drastic increase in the capital's population.

With the rapid development, many areas have been paved impervious by roads and building which eventually reduces the amount of rainfall infiltrated into the ground and caused an increase in surface runoff (MASMA, 2000). Besides that, impervious areas like roads and concrete pavements have smoother surfaces compared to the undeveloped vegetation. This causes the reduction in the time of concentration of the catchment, which literally means that the rainfall will discharge much faster into the river, causing the water level in the river system to rise drastically during storm events. The combined effects due to the rapid development has contributed to an increase in the river discharge and thus caused many flash flood occurrences in the catchment for the past few years (refer Figure 1.1 and Figure 1.2).

Figure 1.1 flash flood occurrence in the Kuala Lumpur City Center due to a heavy downpour on the 26th April 2001

Figure 1.2 Photos showing the damages caused by the 10th June 2003 flash flood event at the Kuala Lumpur City Center.

These flash floods nuisance have forced the government to allocate a total of RM 2.7 billion from the Eighth Malaysian Plan to mitigate the problem (refer Figure 1.3). According to a study by The Drainage & Flood Mitigation Division of Drainage and Irrigation Department (DID) Malaysia in 2003, the flood mitigation projects implemented has successfully reduced the flood damages from RM1356 million to RM915 million. However most of these mitigation measures are structural river improvement works. In order to further reduce the flood damages caused, a timely and reliable flood forecasting system is important to provide early warning to evacuate people and properties from the flood-prone areas.

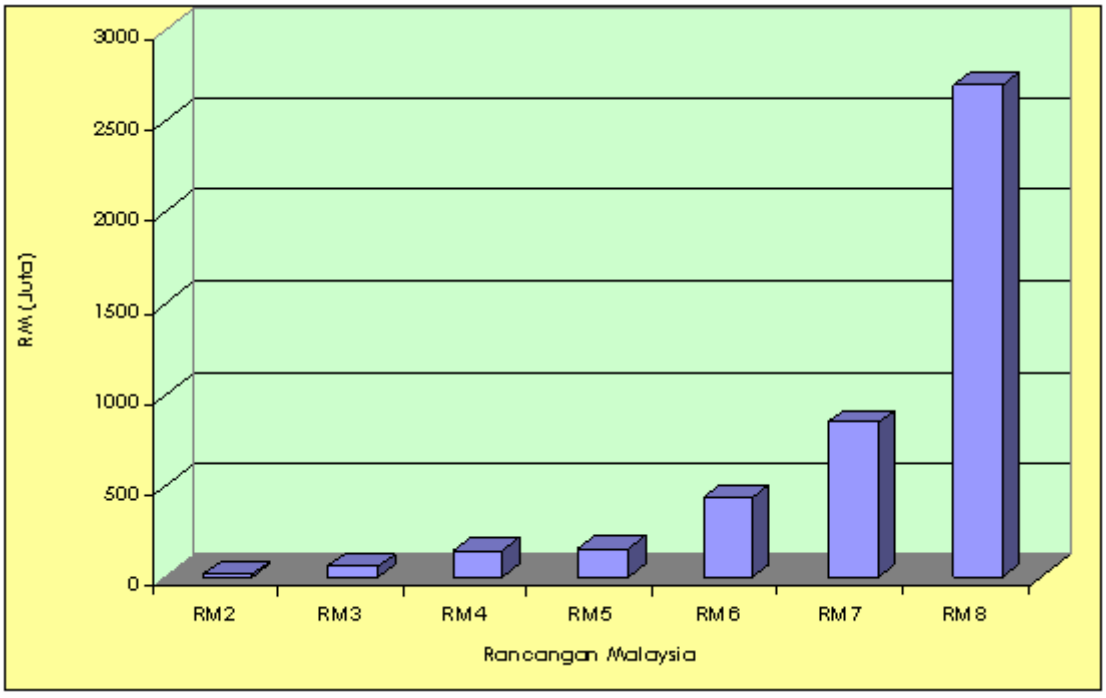

Figure 1.3 Budget allocated for flood mitigation projects by the government for past Malysian Plans.

1.2 Statement of Problem

There are currently 2 flood forecasting models setup for Kuala Lumpur, namely the FloodWatch System and a Unit Hydrograph Model. However both models require cumbersome maintenance and are still being evaluated in their capability to provide reliable real-time flood warnings. Taking advantage of the online hydrological data for the Klang River Basin and utilizing the various programming technologies available, it is time to research into the development of a new personal computer-based flood forecasting model to provide timely and reliable flood forecast to prevent loss of lives and properties within the Kuala Lumpur City Center.

1.3 Objective of Study

The main objectives of the project are:

1. To develop and setup a hydrological Tank Model to simulate the discharge hydrograph of the Upper Klang catchment at Jambatan Tun Perak.
2. To develop and setup a hydraulic model, using the Standard Step Method to simulate the water level profile for Klang River starting from the confluence of Klang and Ampang River until Jambatan Tun Perak.
3. To develop a real-time PC-Based flood forecasting system with user-friendly graphical user interface (GUI) for easy model updating, calibration and flood forecasting operations.

1.4 Scope and Limitation of Study

1. To obtain and process relevant hydrological data of various historical storms which are used for calibration and verification purposes of the developed models.
2. To calibrate the Tank Model based on historical flood events to provide reliable simulation of flood discharges at Jambatan Tun Perak.
3. To obtain and process all relevant hydraulic data which are used for the Standard Step Method Model to simulate the water level profile within the study channel.
4. To develop a PC-based system to integrate both the Tank Model and the Hydraulic Model into a complete Hydro-dynamic model for the Upper-Klang catchment.
5. To develop a software module to acquire hydrological data at 5 minutes interval from the Infobanjir web site to be inputted into the PC-based forecasting system to provide real-time flood forecast at Jambatan Tun Perak.
6. The main limitation of the study is the availability of reliable and error-free hydrological data. Therefore the scope of the study is only limited to the Upper Klang catchment because of the inadequacy of well-established on-line hydrological data in other catchments.
7. The scope of the hydraulic model development is limited to the determination of water level profile for a river channel with one inflow and one outflow. Modelling of complicated river networks with lateral inflow is not covered in this study.
8. The hydraulic model can model river channel without any flow control structures. The modeling of water level profiles regulated by flow control structures are not covered in this study.

1.5 Importance of Study

The developed system synergizes the most recent engineering modeling techniques with the technologies in software and the internet programming in order to achieve the objective of providing an accurate and timely flood forecast to the masses. The developed system, given the name Tank-SStep Model uses the hydrological Tank Model to simulate the catchment discharge hydrograph while the water level profile within the Klang River is generated using the Standard Step Method. It also includes a data acquisition module to continuously acquire rainfall and water level data from the Infobanjir web server as input to the model. The generated output of flood forecast warnings can then be disseminated using various communication technologies like through the internet, cell phones and other wireless devices.