

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

CHEOK HOU SENG

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Universiti Teknologi Malaysia

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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 hidrologi 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.

TABLE OF CONTENT

CONTENTS	PAGE
TITLE	i
STATEMENT	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS/ABBREVIATIONS	xiv
LIST OF APPENDICES	xv

CHAPTER	TITLE	PAGE
1	INTRODUCTION	
	1.1 Background of Study	1
	1.2 Statement of Problem	4
	1.3 Objective of Study	4
	1.4 Scope and Limitation of Study	5
	1.5 Importance of Study	6
2	LITERATURE REVIEW	7
	2.1 Introduction	7
	2.1 Hydrological and Hydraulic Model Selection	8
	2.2 Hydrological Tank Model	10

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	2.3 Standard Step Method	14
	2.4 Software and Internet Programming Technologies	17
	2.4.1 HTTP Web Request	17
	2.4.2 Ms Excel Web Query	19
	2.4.3 Microsoft Visual Basic for Application	22
	2.4.4 Microsoft Office Automation	23
	2.4.5 ActiveX Controls	24
	2.4.6 Windows API	24
3	RESEARCH METHODOLOGY	27
	3.1 Project Design and Approach	27
	3.2 The Upper Klang Study Catchment	28
	3.3 Subjects and Data Sources	30
	3.4 Model Calibration and Verification	32
	3.5 System Architecture	34
	3.6 Automated Flood Forecasting Operation	37
4	RESULTS ANALYSIS AND DISCUSSION	40
	4.1 Tank Model Calibration Results	40
	4.2 Tank Model Accuracy	45
	4.3 Verification of Tank Model	46
	4.4 Hydraulic Model Results Analysis	47
5	CONCLUSIONS	48
	5.1 Model Accuracy	48
	5.2 Assumptions and Limitations	49
	5.3 Advantages of the System	51
	5.4 Overall Flood Forecasting System	52

CONTENTS

CHAPTER	TITLE	PAGE
5.5	Recommendations for Future Improvements	52
REFERENCES	Reference and Bibliography	54
APPENDIX A	Detail Calculation of the Standard Step Method in Simulating th Water Level Profiles for the 10 th July 2005 Storm Event	56
APPENDIX B	Example of the Tank Model Worksheet Used to Simulate the Discharge Hydrograph of the Upper Klang Catchment.	58
APPENDIX C	Example of Infobanjir HTML web Page Displaying Real-time Hydrological Data for Jambatan Tun Perak Station.	59
APPENDIX D	Example of the Real-Time Data Acquisition Worksheet Used to Acquire Hydrological Data from Infobanjir at Every 5 Minutes Interval.	60
APPENDIX E	Example of Thiessen Polygon Analysis to Obtain the Mean Areal Rainfall for the Upper Klang Catchment	61
APPENDIX F	Example of the Cross Sectional Plot Showing the Current Water Level and the 45 Minutes Lead Time Forecasted Water Level	62

LIST OF TABLES

TABLE NO.	TITLE	PAGE
4.1	Calibrated parameters of the Tank Model for the Upper Klang catchment.	41
4.2	Mean absolute error and model efficiency for all historical storm events used for model calibration	45

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Flash Flood Occurrence in the Kuala Lumpur City Center due to a Heavy Downpour on the 26 th April 2001.	2
1.2	Photos showing the damage caused by the 10 th June 2003 Flash flood event at the Kuala Lumpur City Center.	2
1.3	Budget allocated for flood mitigation projects by the government for past Malaysian Plans.	3
2.1	Concept of the Tank Model to simulate the physical hydrological processes using a series of storage tanks.	11
2.2	Typical configuration of a Tank model.	13
2.3	Definition sketch of the energy grade line used to determine the flow depth at a specified location.	15
2.4	HTTP request-response between a client computer and the web server.	18
2.5	Screen shot showing the use of web query in acquiring real-time rainfall data from JPS Ampang station which is used as input for the Tank-SStep Model	20
2.6	Screen shot showing the option settings for the web query used for the real-time data acquisition module of the Tank-SStep Flood Forecasting system.	21
2.7	Screen shot showing the built-in Visual Basic editor used to program macros for automating the real-time data acquisition module.	22

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.8	Project break-down of the development of a real-time PC-based flood forecasting system for the Upper Klang catchment.	28
3.2	Catchment map showing the Upper Klang catchment.	29
3.3	Rainfall and water level used for the development of the Tank-SStep Flood Forecasting System for the Upper Klang Catchment.	31
3.4	Rating curve for Klang River at Jambatan Tun Perak	32
3.5	System architecture for the Tank-SStep Flood Forecasting System.	34
3.6	Each module in the Tank-SStep system is programmed as an individual Excel worksheet. All the modules are contained within the same Excel workbook.	35
3.7	Automated processes involved in the operation of the Tank-SStep PC-based, real-time flood forecasting system.	38
4.1	Observed and simulated water level hydrograph for the 02 July 2005 storm event.	41
4.1	Observed and simulated water level hydrograph for the 02 July 2005 storm event.	41
4.2	Observed and simulated water level hydrograph for the 28 April 2005 storm event.	42
4.3	Observed and simulated water level hydrograph for the 23 March 2005 storm event.	42

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
4.4	Observed and simulated water level hydrograph for the 13 February 2005 storm event.	43
4.5	Observed and simulated water level hydrograph for the 25 February 2004 storm event.	43
4.6	Observed and simulated water level hydrograph for the 02 November 2003 storm event.	44
4.7	Observed and simulated water level hydrograph for the 17 March 2003 storm event.	44
4.8	Water level time series at Jambatan Tun Perak for the 10 th July 2005 storm event.	46
4.9	Longitudinal water level profile for the study channel on 10 th July 2005 at 7:22pm	47
5.1	Figure showing the lag time between the simulated water level and the observed water level captured at Jambatan Tun Perak.	49

LIST OF SYMBOLS/ABBREVIATIONS

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

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A	Detail Calculation of the Standard Step Method in Simulating th Water Level Profiles for the 10 th July 2005 Storm Event	56
APPENDIX B	Example of the Tank Model Worksheet Used to Simulate the Discharge Hydrograph of the Upper Klang Catchment.	58
APPENDIX C	Example of Infobanjir HTML web Page Displaying Real-time Hydrological Data for Jambatan Tun Perak Station.	59
APPENDIX D	Example of the Real-Time Data Acquisition Worksheet Used to Acquire Hydrological Data from Infobanjir at Every 5 Minutes Interval.	60
APPENDIX E	Example of Thiessen Polygon Analysis to Obtain the Mean Areal Rainfall for the Upper Klang Catchment	61
APPENDIX F	Example of the Cross Sectional Plot Showing the Current Water Level and the 45 Minutes Lead Time Forecasted Water Level	62

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Upper Klang Catchment covers a total area of 108km² (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.

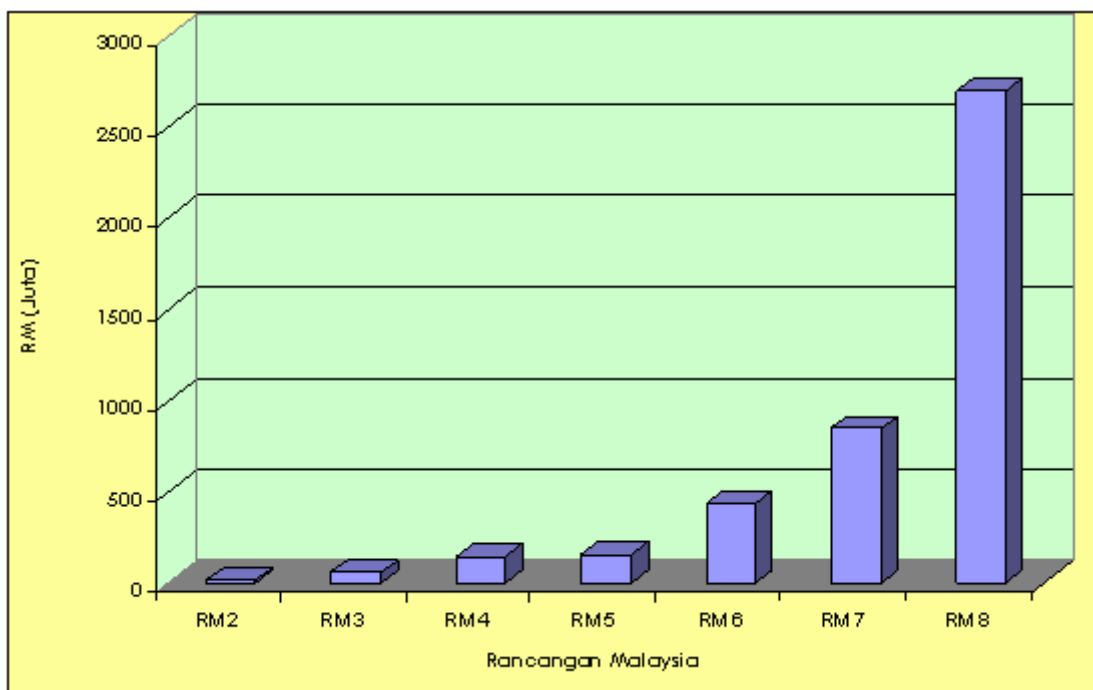


Figure 1.3 Budget allocated for flood mitigation projects by the government for past Malaysian Plans.

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.