FLOOD MAPPING OF SUNGAI SKUDAI USING INFOWORKS RS

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To my beloved parents, my dearest sisters, my family

And

To all my friends.

My God shower them with healthiness and happiness.

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ABSTRACT

Flooding is a natural part of a river's life cycle but it is a major disaster affecting many regions around the world, year after year. Malaysia is among the countries that faces potential flooding problems due to rapid development, improper river systems and climate change. The Skudai river basin covers an area of 293.7 km^2 in the south-western part of Johor. The Skudai River has come under the spotlight due to its potential impacts on nearby future development projects. Based on recorded data from previous flooding events, hydrological and hydraulic analyses needed to be done. The objectives of this study are to evaluate a hydraulic analysis for flood mapping at Skudai River basin using InfoWorks RS software and produce a flood map of Skudai River before comparing the results with the results obtained using XP SWMM software. One hundred and forty cross-sections have been used to model the Skudai River. The manning coefficient values of 0.03 and 0.05 have been chosen to model the river after calibration. Results from the hydrodynamic modeling indicated water surface profiles that showed river bank overflows along with some of the hydrodynamic parameters such as flow, velocity and flood extent map for various ARIs along the Skudai River. Eighteen locations will be effected by flood disaster based on 100 ARI at Skudai River. The flood map that was generated with this model showed good comparison with the observed flood prone area map published by the DID. The water levels from InfoWorks at various ARI are approximately ninety percent similar to the results obtained from XPSWMM simulation. Thus InfoWorks RS-2D is recommended for evaluation of flood disasters as well as their impact to infrastructures and villages along the banks of the Skudai River.

ABSTRAK

Banjir adalah sebahagian daripada kitaran semulajadi sebuah sungai dan merupakan bencana besar yang mempengaruhi banyak tempat di seluruh dunia setiap tahun. Malaysia merupakan salah sebuah negara yang menghadapi masalah banjir besar akibat pembangunan yang pesat, sistem sungai yang tidak elok dan perubahan iklim. Cekungan Sungai Skudai meliputi kawasan sebesar 293.7 km^2 di bahagian barat daya negeri Johor. Sungai Skudai dititik beratkan kerana ianya mempunyai pengaruh yang besar terhadap projek-projek pembangunan di masa depan. Berdasarkan maklumat yang telah dirakam mengenai peristiwa-peristiwa banjir yang pernah berlaku, analisis hidraulik dan hidrologi amat diperlukan. Tujuan kajian ini ialah menilai analisis hidraulik pemetaan banjir di cekungan Sungai Skudai menggunakan perisian RS InfoWorks dan menghasilkan peta banjir Sungai Skudai serta membandingkan keputusan pemodelan Sungai Skudai dari penggunaan perisian InfoWorks dengan keputusan menggunakan perisian XP SWMM. Pekali Manning 0.03 dan 0.05 telah dipilih untuk memodelkan sungai. Melalui profil permukaan sungai, hasil daripada pemodelan hidrodinamik menunjukkan bahawa terdapat beberapa tempat di sepanjang Sungai Skudai yang mengalami aliran limpah melepasi tebing sungai. Peta takat banjir serta beberapa parameter hidrodinamik seperti aliran dan kelajuan turut dipaparkan oleh model tersebut berdasarkan ARI yang diperlukan. Untuk ARI 100, terdapat lapan belas lokasi yang akan dilanda bencana banjir. Peta banjir yang dihasilkan melalui model ini menunjukkan perbandingan yang baik dengan peta ramalan banjir yang diterbitkan oleh Jabatan Pengairan dan Saliran. Aras air yang didapati untuk ARI yang berlainan menggunakan InfoWorks menunjukkan hampir 90 peratus persamaan dengan keputusan simulasi XPSWMM. Untuk menilai bencana banjir yang mungkin melanda infrastruktur serta kawasan penempatan di sepanjang Sungai Skudai, adalah disyorkan agar perisian InfoWorks RS digunakan untuk pemodelan 2D sungai tersebut.

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HR	-	Flood hazard
d	-	Depth of flooding
V	-	Velocity of flood water
DF	-	Debris factor
g	-	Gravity
S_0	-	Slope of river
S_f	-	Loss of friction
q	-	Lateral inflow
K	-	Channel conveyance
R	-	Hydraulic radius
P	-	The length of the wetted perimeter
n	-	Manning's roughness coefficient

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

There are several important parameters involved in the hydrological system such as precipitation or rainfall, runoff, interception, evapotranspiration, groundwater and many more. The relationship of these parameters can be represent by the hydrologic cycle as shown in Figure1.1 below. The hydrologic cycle is the continuous, unsteady circulation of water from the atmosphere to and under the land surface and back to the atmosphere by various processes (MASMA, 2001).

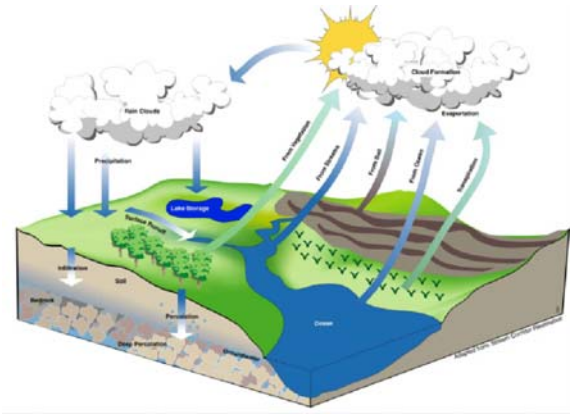

Figure 1.1: Hydrologic Cycle (Richard H. McCuen, 1998)

Solar energy influences the hydrological cycle more directly in the tropics than in other regions of the planet. In tropical areas, rainfall is the main factor that

determines the seasons, and therefore, the quantity and temporal distribution of rainfall are important criteria to distinguish sub-climatic zone. Wet (N1800 mm), wet–dry (700–1800 mm) and dry (b700 mm) as shown in (Figure 1.2).

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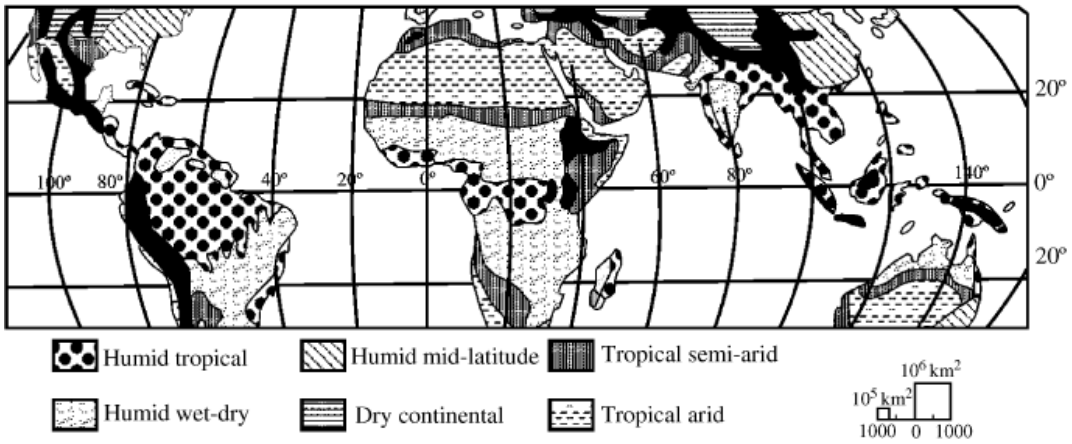

Figure 1.2: Climatic zones in the tropics (Latrubesse, 2005)

Malaysian has an equatorial climate with constant high temperature and a high relative humidity through at the year. The climate is influence by the northeast and southwest monsoons. The northeast monsoon prevailing between November and February brings heavy rainfall which could persist for several days. In addition, there are two transitional periods between the monsoons (inter monsoon) when convectional thunderstorms are common.

River is a natural watercourse, usually freshwater, flowing toward an ocean or another river. All land is part of river basin and all is shaped by the water it flows over it and through it. Rivers derive their water from precipitation, in the form of rain either directly from surface runoff, or indirectly from springs and marshes. The roles of rivers are very wide to the earth and its mankind.

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 to 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. Human activity, however, has upset the natural way flooding occurs by walling off rivers and straightening their courses. Removal of bogs, swamps and other wetlands in order to produce farmland has reduced the absorption zones for excess water and made floods into sudden disasters rather than gradual increases in water flow. Nowadays, floods are disasters, causing untold property loss each year. Accurate information on the extent of water bodies is important for flood prediction, monitoring, and relief (Smith, 1997; Baumann, 1999).

There are about 200 rivers system in Malaysia include 150 rivers system in Peninsular while 50 rivers system in Sabah and Sarawak. So flood is one of the main disasters in Malaysia. Major floods recorded are in 1926, 1931, 1947, 1957, 1967, 1971, 1973, 1979, 1983, 1995, 1998, 2003 and 2005 (Abdullah, 2006) and most recently in December 2006 and January 2007 which occurred in Johor. The January 1971 flood that hit Kuala Lumpur and many other states had resulted in a loss of more than RM 200 million then and the death of 61 persons. In fact, during the recent Johor 2006-2007 flood due to a couple of “abnormally” heavy rainfall events which caused massive floods, the estimated total cost of these flood disasters is RM 1.5 billion, and estimating damages to infrastructure due to the 2006 flood for Johor were estimate at RM 237.1 million considered as the most costly flood events in Malaysian history.

Wilayah Pembangunan Iskandar (WPI) which is located in Southern Johor covers an area of 2,216.341 sq. km. (Figure 1.3). The region experienced two major floods late 2006 and early 2007 in Johor. The first one occurred between the 18th to 21st December 2006 with total rainfall of 350mm within three days. The second flood occurred between 11th to 17th January 2007 with total rainfall of 400mm within the three days. The worst hit areas include catchments of Sg. Sekudai, Sg. Tebrau, Sg. Plentong, Sg. Tiram, Sg. Pulai, Sg. Pendas, Sg. Melayu, Sg. Masai, Sg. Kim- Kim and Sg. Kong-Kong.

Figure 1.3: Location of Wilayah Pembangunan Iskandar WPI (Perunding Teknik Padu Sdn. Bhd, 2009)

Computer models use the computational power of computer to automate the tedious and time-consuming manual calculations. Most models also include input and output procedures, and possibly including graphics and statistical capabilities. The analytical power of computer methods gives them major advantages over manual techniques. This is likely to result in more accurate designs, with cost saving s by avoiding over or under-sizing. A very important factor is that almost all computer models can fully account for storage in all stages of the hydrology/hydraulic routing.

InfoWorks RS includes full solution modeling of open channels, floodplains, embankments and hydraulic structures. Rainfall-runoff simulation is available using both event based and conceptual hydrological methods. Full interactive views of data are available using geographical plan views, sectional view, long sections, spreadsheet and time varying graphical data. The underlying data can be accessed from any graphical or geographical view. Animated presentation of results in geographical plan, long section and cross section views is standard, together with results reporting and analysis using tables and graphs. Full flood-mapping capability is provided based on a sophisticated flood-interpolation model overlaid onto an imported groundmodel. An optional fully-dynamic, 2D surface flood simulation, integrated with the surface-channel hydraulic simulation, is also available. Some Features & Benefits of InfoWorks RS are Workgroup Model Management ,Model Building Tools ,Results Interpretation ,Powerful Hydraulic, Water Quality & Sediment Transport Simulation ,Dynamic Flood Mapping Model, Data Integration .

1.2 Objective

The objectives of this study are:

1. To evaluate hydraulic and hydrology analysis using hydrodynamic modeling
2. To develop hydrodynamic modeling in Sg. Skudai river basin
3. To produce flood map of Sg Skudai for various ARIs using InfoWorks RS
4. To compare the results of modeling Sg Skudai with InfoWorks software and XP SWMM software

1.3 Scope of study

The scopes of this study are:

1. Study area at Sg.Skudai river basin (293.7 km^2)
2. To collat hydrological data such as rainfall and stream flow
3. To collat hydraulic data such as survey map, river alignment, river cross section, roughness coefficient, tide and etc.
4. To compute hydraulic modeling using Infoworks RS-1D
5. To produce water level for different Average Recurrence Interval (ARI) for 100, 50, 20, 10, 5 and 2 years
6. To produce some parameters like: flow, velocity, max flow, min flow, and min velocity, max velocity for different ARI for 100, 50, 20, 10, 5 and 2 years
7. To produce which locations have flood influence for different ARI for 100, 50, 20, 10, 5 and 2 years
8. To compare the water level has measured with XP SWMM and InfoWorks for different ARI for 100, 50, 20, 10, 5 and 2 years

1.4 Problem statement

The December 2006 flood recorded a total of 11,724 victims being evacuated in Johor Baharu district (January 2007 flood had 7,915 victims evacuated). This indicates an estimated 2,373households being directly subjected to flooding in this flood (1,615 households in January 2007 flood). The December 2006 flood inflicted heavy damage to the manufacturing activities. An estimated 381 establishments of all sizes were affected. Total estimated losses were estimated at RM 25.2 million. The Total economic losses due to the floods in Malaysia were estimated at RM 1.5 billion. Estimated damages to infrastructure due to the 2006 flood for Johor were estimated at RM 237.1 million.

In this area there are many studding have started because of formulating an integrated Flood Mitigation Master Plan for Wilayah Pembangunan Iskandar (WPI) as shown in Figure 1.4, to formulate a comprehensive short term and long term solution for the flooding problems in order to reduce the adverse impacts and protect the existing and future developments by providing an appropriate level of affordable flood protection. The proposed flood mitigation measures shall incorporate the concept of integrated stormwater management, comprising best-mix strategies using both structural and non-structural measures. To optimize the effectiveness of the existing flood mitigation/stormwater management infrastructure network and drainage facilities within the Study Area, taking into account the environmental impacts and public expectations and To formulate appropriate Flood Hazard Management Plan for handling unexpected events such as floods, bund breach, breach of flood detention facilities, etc. Sg Skudai catchment has a total area of about 1,707.4 hectares of which 37.8 percent (644.7 hectares) are classified as development area whilst the larger remaining area of 62.2 percent (1,062.7 hectares) as non-development area. The largest land uses is road/transportation with 13.9 percent (237.7 hectares). This is followed by planned housing/residential land use with 8.5 percent (144.5 hectares). The third largest is traditional kampung housing land use with 5.8 percent (99.8 hectares). The largest land use is agricultural

representing 32.8 percent (559.7 hectares), followed by vacant land with 29.2 percent (497.8 hectares) and river/pond with 0.3 percent (5.2 hectares).

As shows above, this catchment is an important unite in WPI, and until now there isn't any flood mapping detected for Sg Skudai excepted of flood prone area shows in figure 1.4. The government need to plan for prohibiting disaster of flood (human, industry and infra structure) to use some common ways to control the flood. So flood mapping will be done to help policy of this problem. Actually develop planning (identify flood porn affected area with different ARI, identify flood depth) and flood insurance because some information that mentioned the first of this part, are two reasons of this thesis.

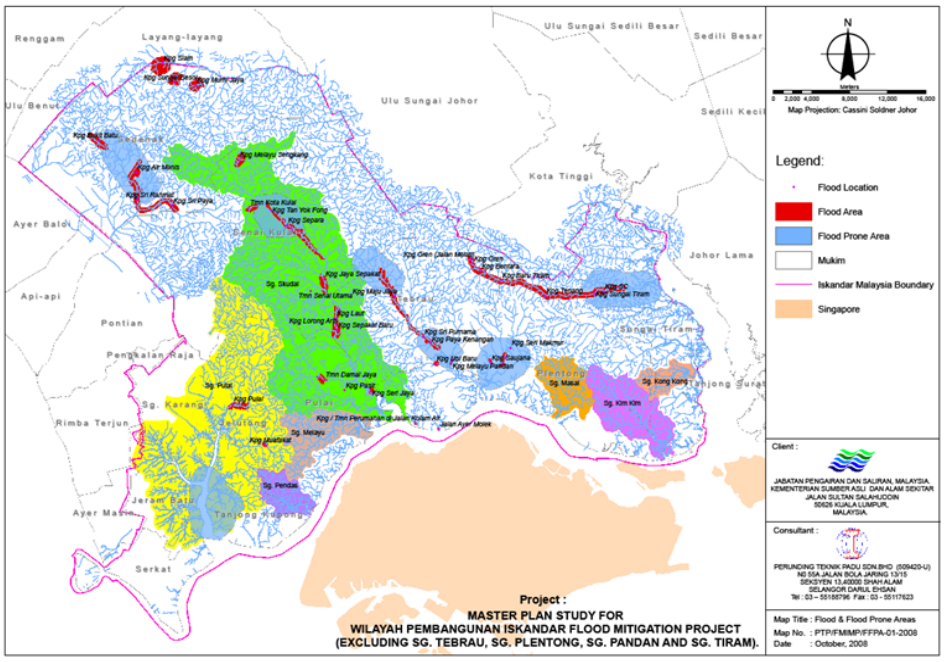

Figure 1.4: Flood Prone Areas WPI (Perunding Teknik Padu Sdn. Bhd, 2009)