HYDRODYNAMIC ANALYSIS OF THE PROPOSED FLOOD BYPASS CHANNEL UPSTREAM OF KUCHING CITY

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Bachelor of Engineering with Honours
(Civil Engineering)
2009
For my beloved family.
ACKNOWLEDGEMENT

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And lastly not forgetting all my friends and all those involved directly or indirectly in the completion of this thesis, thank you very much. May Allah Bless you all.
ABSTRAK

ABSTRACT

Sarawak River had experienced several disastrous flood events over the past 50 years, with the worst being in 1963, followed by February 2003, January 2004 and January 2009 flood. A flood bypass channel had been suggested as a flood mitigation measure to reduce the flooding effects along the Sarawak River. The proposed flood bypass channel is 8 km long with 250 m base width man-made channel starting from Kampong Paroh to divert a significant portion of flood waters from Sarawak River away from Kuching city to Batang Salak. The main purpose of this project was to review the flooding problems in flood-prone areas of Sarawak River basin and to carry out hydrodynamic analysis on the Sarawak River together with the impacts of the upcoming flood bypass channel. Sarawak River and its floodplains were modeled using one-dimensional hydrodynamic modeling approach, by utilising the Wallingford Software model - InfoWorks River Simulation (RS), coupled with its embedded GIS applications, to obtain the flood hydrographs of the river and its floodplains in extreme flooding condition of January 2004 flood. The simulated results of January 2004 flood obtained showed that the flood bypass channel had been diverting significant portion of flood waters from Sarawak River. Results taken from Batu Kawa showed an average water level reduction of 48.45% which reflects the effectiveness of the flood bypass channel.
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<td>A</td>
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</tr>
<tr>
<td>$A_1$</td>
<td>Catchment area</td>
</tr>
<tr>
<td>B</td>
<td>Water surface width</td>
</tr>
<tr>
<td>C</td>
<td>Runoff coefficient representing a ratio of runoff to rainfall</td>
</tr>
<tr>
<td>$C_s$</td>
<td>Channel Storage Coefficient</td>
</tr>
<tr>
<td>g</td>
<td>Gravitational acceleration</td>
</tr>
<tr>
<td>H</td>
<td>Water surface elevation above datum</td>
</tr>
<tr>
<td>I</td>
<td>Average rainfall intensity for a duration equal to the time of concentration, for selected return period</td>
</tr>
<tr>
<td>K</td>
<td>Channel conveyance</td>
</tr>
<tr>
<td>km</td>
<td>kilometre</td>
</tr>
<tr>
<td>mm</td>
<td>milimetre</td>
</tr>
<tr>
<td>m</td>
<td>metre</td>
</tr>
<tr>
<td>n</td>
<td>Manning's roughness coefficient</td>
</tr>
<tr>
<td>P</td>
<td>Wetted perimeter</td>
</tr>
<tr>
<td>Q</td>
<td>Flow</td>
</tr>
<tr>
<td>$Q_p$</td>
<td>Peak flow</td>
</tr>
<tr>
<td>q</td>
<td>Lateral inflow per unit length of channel</td>
</tr>
<tr>
<td>R</td>
<td>Hydraulic radius</td>
</tr>
<tr>
<td>$S_f$</td>
<td>Friction slope</td>
</tr>
<tr>
<td>$S_o$</td>
<td>Channel bed slope</td>
</tr>
<tr>
<td>t</td>
<td>Time</td>
</tr>
<tr>
<td>Symbol</td>
<td>Definition</td>
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<td>--------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>V</td>
<td>Average velocity of water</td>
</tr>
<tr>
<td>x</td>
<td>Longitudinal channel distance</td>
</tr>
<tr>
<td>y</td>
<td>Depth of water</td>
</tr>
<tr>
<td>β</td>
<td>Momentum correction coefficient</td>
</tr>
<tr>
<td>α</td>
<td>Angle of inflow</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>ARI</td>
<td>Average Recurrence Interval</td>
</tr>
<tr>
<td>DID</td>
<td>Department of Drainage and Irrigation</td>
</tr>
<tr>
<td>DTM</td>
<td>Digital terrain Model</td>
</tr>
<tr>
<td>ESRI</td>
<td>Environmental Systems Research Institute</td>
</tr>
<tr>
<td>etc.</td>
<td>et cetera</td>
</tr>
<tr>
<td>FCP</td>
<td>Flood Control Project</td>
</tr>
<tr>
<td>i.e.</td>
<td>in example</td>
</tr>
<tr>
<td>IRBM</td>
<td>Integrated River Basin Management</td>
</tr>
<tr>
<td>LSD</td>
<td>Land Survey Datum</td>
</tr>
<tr>
<td>MASMA</td>
<td>Urban Stormwater Management Manual</td>
</tr>
<tr>
<td>RS</td>
<td>River Simulation</td>
</tr>
<tr>
<td>SSBM</td>
<td>Sarawak River Barrage Management</td>
</tr>
<tr>
<td>SSRS</td>
<td>Sarawak River Regulation Scheme</td>
</tr>
<tr>
<td>TIN</td>
<td>Triangulated Irregular Network</td>
</tr>
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CHAPTER 1

INTRODUCTION

1.1 Background

Kuching city is the most developed area in Sarawak, known to be the biggest state in Malaysia. It serves as the state capital of Sarawak. As the largest city in the state, Kuching is now a rapidly developing city, boasting a population of almost half a million. Kuching city was built in the floodplains of Sarawak River, thus large parts of the Kuching city is sited in very flat and low lying areas.

Due to rapid development and urbanisation, flooding problems in the Kuching city have turn to be of a very much concern as those parts of very flat and low lying areas are susceptible to river flooding and significant tidal events.

The average annual rainfall in the catchment area is about 3800mm. During the wet season, from October to March, Kuching city has mean monthly rainfall between 400mm to 500mm. However, during the drier season, typical rainfall is between 200mm to 300mm per month.
1.2 The Sarawak River Basin

The Sarawak River (Sungai Sarawak) basin encompasses an area of approximately 2375 km² and the length is about 120 km. Sarawak River divides on the eastern of Kuching city, and prior to 1998 exits to the sea were via Sarawak River which is around 30km to the South China Sea and on the Santubong River which is around 20km to the South China Sea. Sarawak River has two main tributaries, namely Sarawak Kiri and Sarawak Kanan where they converge near Batu Kitang area, about 34km upstream of Kuching city.

Kuching City is located in tidal influence zone with highest tidal range of approximately 6 meters, or better known as King Tide. In order to control upstream water level in Sarawak River, a barrage was constructed in 1988, i.e. Sarawak Barrage to regulate river water from draining out and to prevent seawater from flooding in. Two causeways were also constructed over Santubong and Sarawak
Rivers. The barrage structure consists of 5 radial gates (25 meters in width each) to prevent saline intrusion and to regulate water levels upstream of Sarawak River (Law, 2001).

Buan Bidi and Kpg Git are located upstream of Sarawak River, which is about 73km upstream of Kuching barrage. Buan Bidi and Kpg Git are far beyond the tidal limit. Downstream of Kuching barrage is Pending, located about 20km from the sea, thus it is extremely affected by tidal action.

1.3 Flooding occurrence in Sarawak River

![Figure 1.2: Flood affected areas in Kuching (DID, 2004)](image)
Malaysia bears an equatorial climate with invariant high temperatures and a high relative humidity. The climate is influenced by the northeast and southwest monsoons. The former, persisting between November and February, brings heavy rainfall as much as 600 mm in 24 hours in extreme cases.

The east coast and the southern part of Peninsular Malaysia, Sabah and Sarawak are mainly affected by floods during December to January when the northeast monsoon is dominating. Flooding occurs due to widespread prolonged heavy rainfall resulting in a large concentration of runoff which is very much in excess of the capacities of streams and river.

Table 1.1: Some historical Flood Events Recorded involving Sarawak River and Kuching City (DID, 2008)

<table>
<thead>
<tr>
<th>Events</th>
<th>Affected flood areas</th>
<th>Flood height</th>
<th>History</th>
</tr>
</thead>
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<tr>
<td>January 1985</td>
<td>Sarawak River, Kuching Town</td>
<td>4 feet</td>
<td>Flash flood</td>
</tr>
<tr>
<td>December 1987</td>
<td>Batang Kayan, Sarawak River</td>
<td>4 feet</td>
<td>-</td>
</tr>
<tr>
<td>January 1992</td>
<td>Sarawak River, Lundu areas, Sadong &amp; Samarahan</td>
<td>6 feet</td>
<td>-</td>
</tr>
<tr>
<td>December 1993</td>
<td>Kuching, Lundu, Sibu Town, Selangau, Dalat, Mukah, Matu/Julau &amp; Limbang</td>
<td>1-8 feet</td>
<td>Wide spread flood hit the coastal areas of Sarawak</td>
</tr>
</tbody>
</table>
According to the Department of Irrigation and Drainage (DID) contoured topographical plan, Batu Kitang and Batu Kawa urban centres are both situated in low lying areas within the Sarawak River floodplain with most of the grounds being lower than the five and ten metres contour lines with isolated small hills. Batu Kitang is located near the confluence of the Sarawak Kanan and Sarawak Kiri Rivers while Batu Kawa is 4km downstream of Batu Kitang along the suburban fringe of Kuching city.

The flooding problem for Batu Kitang areas is focussed on Batu Kitang Bazaar as it was classed as ‘high-hazard’ with the estimated flood depth of the 1963 flood at about 4.2 metres and the 1976 flood about 2.7 meters deep. As for Batu Kawa areas, the Batu Kawa Bazaar and nearby Kampung Sinar Budi are taken into consideration. Based on the Sungai Sarawak Flood Mitigation Options Study (2003), the design flood levels at Batu Kitang and Batu Kawa for a 2 year ARI, 10 year ARI, 50 year ARI and 100 year ARI are as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Depth</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1994</td>
<td>Kuching Town</td>
<td>1-2 feet</td>
<td>Flash flood hit Kuching Town only</td>
</tr>
<tr>
<td>February 1995</td>
<td>Sarawak River and Kuching Town</td>
<td>5 feet of water above Batu Kitang shophouses</td>
<td>-</td>
</tr>
</tbody>
</table>
1.4 Flood mitigation

Floods are one of the most disastrous events that occur due to the forces of nature. A total control over the flooding problems is infeasible, thus effective mitigation works can be carried out to minimize the damages. Flood mitigation comes with numerous options, as for structural measures, such as construction of levees and embankments, flood bypass and river diversion, storage dams and flood retention ponds, evacuation centres and channel improvement. The non-structural flood mitigation measures are flood forecasting and warning system, relocation of residents, and restriction of developments at the flood-prone areas.

In order to alleviate the flooding problems in the Kuching city areas, one of the flood mitigation measures desirable at the Sarawak River is through the proposed flood bypass channel. The constructions of bypasses are generally limited by the topography of the valley and availability of low-value land. In the case of Kuching city, excess water would be directed to flow across the land.

Table 1.2: Design Flood Level (Sungai Sarawak Flood Mitigation Options Study 2003)

<table>
<thead>
<tr>
<th>Design ARI</th>
<th>Predicted Flood Level (m LSD)</th>
<th>Batu Kitang</th>
<th>Batu Kawa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Batu Kitang</td>
<td>Batu Kawa</td>
</tr>
<tr>
<td>2</td>
<td>4.91</td>
<td>3.72</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6.55</td>
<td>4.83</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>8.64</td>
<td>6.49</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>9.67</td>
<td>7.26</td>
<td></td>
</tr>
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</table>
This study is focused on the proposal that had been developed, which is to create a 8 km long and 250 m wide bypass channel near Kampung Paroh to Batang Salak, near Matang area (Figure 1.4). The addition of this flood bypass channel is to divert a significant portion of flood waters from Sarawak River away from Kuching city. With the flood bypass channel, it would result in lowering of flood possibilities through the vicinity of city during rainy season. This is believed to be the biggest project of its kind in Malaysia.
A flood bypass’ effectiveness is influenced by a few factors namely; understanding of the flood cause, finding the right location for diversion, finding the right release point, selecting a good route between the two and choosing the correct form for the conveyance (Keizrul, 2006). Flood bypasses are used where channel capacity is limited and it is not feasible to divert flows out of the basin (Petersen, 1986). A controlled (gated) diversion structure is usually used to divert flows from the river into the bypass past a constricted channel reach. A second barrage would be constructed to cut off Sungai Sarawak and flows were forced into the bypass channel.

Catastrophic floods endanger lives and cause human tragedy as well as heavy economic losses. Floods are unavoidable natural phenomena but through the right measures we can reduce their likelihood and limit their impacts.