

Analysis the Impact of Bridges Existance for the Segamat River Using Infowork RS

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Abstract: Malaysia is experiencing two monsoonal seasons, which have induced heavy rainfall. The increasing of rainfall intensity and longer duration of rainfall has caused a flood. In 2007, Segamat city was hit by the flood due to increasing of rainfall and this has caused a huge damage in term of infrastructure as well as human life. Thus, this study was carried out with the aims to analyze the flood and develop a flood map for the Segamat River. The hydrological data, such as rainfall and streamflow data were retrieved from the Department of Irrigation and Drainage Malaysia (DID). While, for map preparation such as base map, landuse map and river map were delineated based on the topography map. Additionally, contour map was obtained from MACGDI. InfoWork River Simulation (RS) software was used for analysis and develops the flood map. Moreover, two scenarios were carried out to determine the effect of hydraulic structure presence in the waterway. The first scenario is the flood map without a bridge, while the second scenario is the flood map with a bridge. Based on the results, it clearly shows that the flood map with a bridge has higher flow, velocity and water table compared to the flood map without a bridge. In addition, a flood-prone area based on the developed map was identified. Thus, the generated flood map could serve important information to related agency in proposing a suitable design the mitigation works for this area.

Keywords: Infowork RS, flood map, segamat river, flood analyses.

1. Introduction

Flood is a natural disaster that normally occurred due to several factors such as heavy rainfall, poor drainage system, mismanagement of land use and so forth. The increasing of temperature and a warmer climate globally may lead to unstable pressure in the atmosphere that has caused more frequent and intense floods for many areas around the world. Changes in world climatic could affecting the hydrological water balance and geomorphologic right to complexities in balancing the societal and environmental needs [1].

The flood cannot be avoided since the amount of precipitation is out of the human control. However, as a human, we could control the magnitude of the flood by mitigating it by using several approaches such as structural or non-structural measures. The mitigation works normally will be carried out with the aim to find a determined development and application of new tools and knowledge to limit the possibility and effects of floods. During a flood, a few hours can make all difference between disaster and massive disaster. The development of approaches to manage flood risks could lead to optimal utilization of the available mean for preventing flooding and optimizing the mitigation of the flood consequences. The selection of the flood mitigation either by structure or non-structural measures based on the purposes and aims of the project. The



example of structural measures for flood mitigation could be a river bund, flap gate, pump house and many more. While, flood modeling, education and laws are non-structural measures that could be carried out.

Based on a report from the Department of Irrigation and Drainage, Malaysia [2] has stated that about 29,000 km² or 9% of total land area and more than 4.82 million people, which is 22% is affected by flood annually with the damage caused by a flood is estimated about RM915 million. Residents who lived in low land, close to river bank and flood prone areas were identified as most vulnerable to flood hazard. The low land area suffers from severe flood damages every year, it has resulted in loss of life, damage to property and had negative impacts on human welfare.

The advanced technology in computer simulation has become a powerful tool in model the flood map. Computer model could give major advantages to the modeler since it likely to produce more accurate results, designs with cost saving by avoiding over and under sizing. The application of computer model in producing flood map was well recognized. Until today, many kinds of flood related maps were developed and produced such as flood map, flood risk map, inundation map, flood prone area and many more. Jones [3] from USGS has mentioned the important of flood map in minimizing the consequences of floods. He has stated that the maps generally available today are maps used for planning. They are maps of theoretical floods, not maps of flooding forecast for an approaching storm. The U.S. Geological Survey (USGS) and the National Weather Service (NWS) have developed a way to bring flood forecasting and flood mapping together, producing flood maps for tomorrow's flood today and getting them on the Internet in time for those in harm's way to react.

Effective modelling and mapping solutions are critical to our improved understanding of flood risks. Flood maps that represent information in graphs, the visualization can be supplemented with numerical data such as data of water level, flow. The accuracy of the results depends on the validity of the equations used to describe the physical processes and the quality and detail of the input data to which the equations are applied [4]. They also mentioned that DEM resolution has significant effect on simulation results. Flood simulation characteristics that are affected are inundation extent, flow velocity, flow depth and flow patterns across the model domain.

InfoWorks RS is one of the available commercial software that could model the flood map. This hydrodynamic modeling software could be used to analyze the flow in open channels, floodplains, hydraulic structure and embankment. This application is good enough in giving some thought to the related agencies and person involved in flood mitigation project to evaluate the potential impacts prior implementing prevention measures to avoid the anticipated adverse. Thus, in this paper, the application of InfoWork RS in modeling and analyzing the flood occurrence will be discussed. In addition, two scenarios were simulated to understand differences in water level as well as the flow if there is a hydraulic structure and no hydraulic structure in the study area.

2. Methodology

2.1 Description of Study Area

Segamat River is one of the Muar River tributary that flow passing through the Segamat Town. The total length of this river approximately about 23 km with typically 14m wide and 14 m above the sea level (Figure 1). This river originates from Gunung Besar and joining Muar River at Kampung Tebing Tinggi. Segamat River catchment areas comprise of 685 km² and an average annual rainfall of 1813 mm, but can reach up to 600 mm per day during the monsoon season, between November through March [5]. During 2006-2007 floods, the water level has risen dramatically beyond the danger level in less than 72 hours and cause of 13 roads that connect the Bandar Segamat were closed due this catastrophic flood.

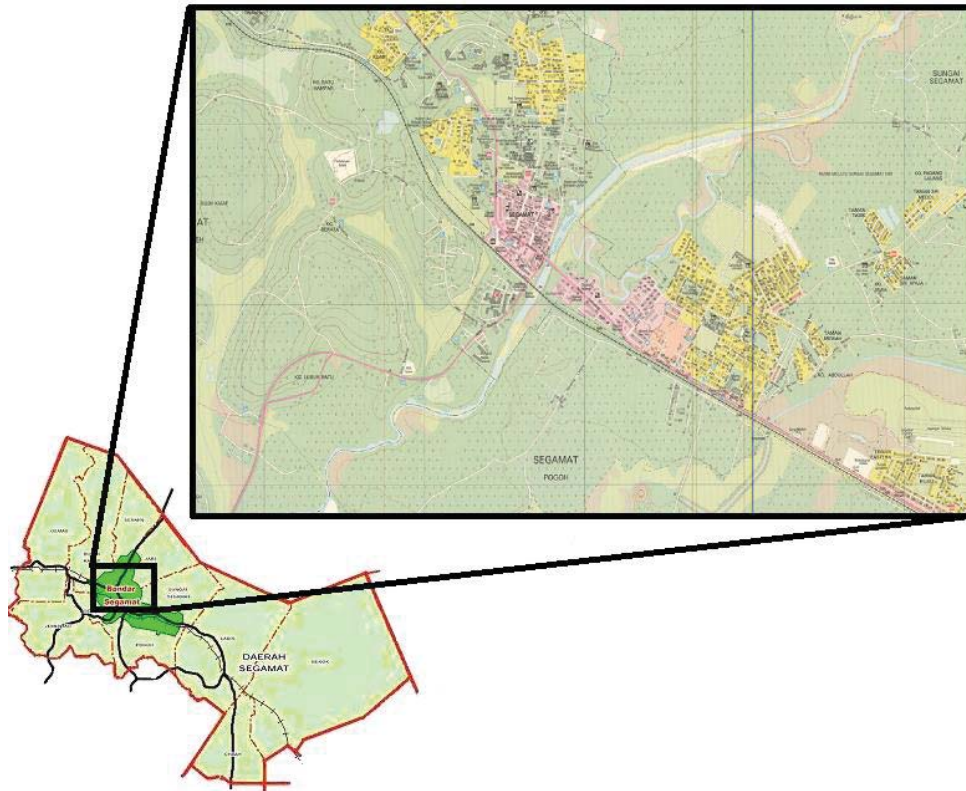


Figure 1. Location of the study area.

2.2 History of Flood in Johor

Johor state has been hit by major floods in 19-31 December 2006 the first flood of 12-17 January 2007 and the second flooded involving district of Johor Bahru, Kota Tinggi, Batu Pahat, Muar, Segamat, Kluang, Pontian and Mersing. The floods caused by series of storm events generated by Northeast Monsoon that caused heavy rains that fell in continuous and comprehensive for several days in Peninsular Malaysia especially in the state of Johor.

During this time, heavy rain has resulted in a massive increase of water level, which results in flood that has paralyzed almost all the daily activities which involved eight districts. It was reported that, most of the areas were observed to be under water due to the increasing of water, which resulted in more than 103,000 populations have to be evacuated to evacuation centers. Unfortunately, this flood event also killed at least 17 lives during the second flood occurred where when the people began to move back home after the first flood from was receded. Figure 2 shows the flood affected area in Segamat Town during the flood event.

Based on records and statistics from DID, most of the water level of major rivers in the state of Johor was recorded a significant increase of water and was categorized as dangerous level. Based on the record for Segamat River at Segamat Town, the maximum recorded water level is about 11.7 m which is above the alert level at 8.53. While for others gauge stations like Buloh Kasap and Bukit Kepong also had shown an increase of water level above a dangerous level at 11.2 m and 4.69 m respectively [6].

2.3 Data Management

Data management is one of the most important issues in producing good and acceptable results in modeling. Thus, in this study, combination of both approaches which are primary and secondary data collection were conducted to ascertain the data is enough and available to carry out the task. The data collection was divided into two parts which are (i) hydrology and hydraulic data and (ii) related maps. For hydrology and hydraulic data, the data was retrieved from DID which is the respective agency to monitor and collect the data such as rainfall, temperature, streamflow and sediment. While for map, the map was provided by Malaysian Centre for Geospatial Data Infrastructure (MaCGDI) and delineation based on paper map.

Hydrological model development involves with two main processes which are GIS application and hydrological data. In GIS data processes, the related map were developed and produced such as river network, contour, road and landuse maps. While, for hydrological data the maximum and minimum of annual rainfall as well as flood events are needed. On the other hand, river cross sections, river basin maps, sub-catchment maps, water level and sediment yield are being prepared. Moreover, latest data was collected by conducting a test and measurement at site which was used for calibration and validation purposes.

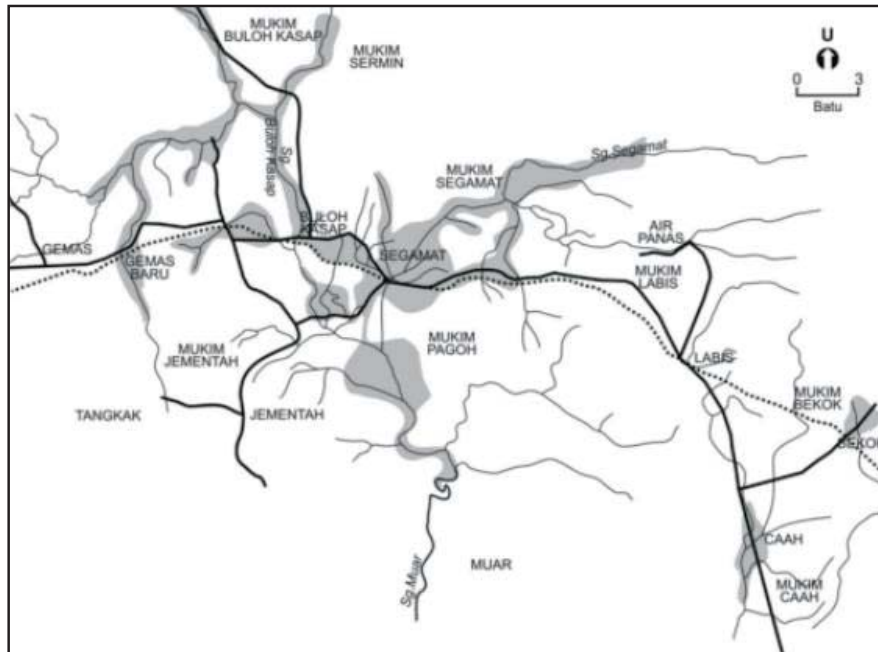


Figure 2. Flooded areas in Bandar Segamat (DID, 2007).

2.4 InfoWorks RS

InfoWorks River Simulation (RS) is one of the modeling programs that combine the advanced flow simulation engine, both hydrological and hydraulic models, GIS functionality and database storage within one single environment. The basic system architecture is an “Integrated Network Model” links data storage using a GIS to hydrologic or hydraulic modeling software suite embedded in InfoWorks RS. It will allow planners and engineers to carry out fast, precise modeling of the key elements of river and channel systems and to view the model data and results in new ways. InfoWorks RS also brings full model management in the water engineering field, allowing a full check trail to be maintained by the modeling process from source data to final outputs.

InfoWorks RS provides the ability to review present and historical model network versions and attribute data by storing information within a database environment. As well as providing full information of each alteration made to the network, it also provides version one dimension, date stamps, and modeler details. The data views show the assurance levels that have been attached to each asset data attribute within the system. A compare function allows the assessment of two model versions and the creation of a highly detailed report outlining the differences, including changes to the data flags recitation poise and source of all data items [7].

The Wallingford Software’s InfoWorks RS is an example of a one-dimensional hydrodynamic model used for prediction of discharge and water level for a wide range of rivers, reservoirs, complex floodplains and narrow estuaries under both steady and unsteady conditions. In additional, data from a wide range of sources can be brought together within the software in a rapid and flexible way. InfoWorks computes flow depths and discharges using a method based on the equations for shallow water waves in open channels the Saint-Venant equations [8].

2.5 Development of Flood Map for the Segamat River

Geographical Information System (GIS) is a powerful tool in assisting a modeler to create a base map and others maps that can be put into a series of layer for comprehensive analysis. Soil and Water Assessment Tool

(SWAT) was coupled with GIS to delineate the catchment area. The Triangular Irregular Network (TIN) is a digital data structure for the representation of a surface as shown in Figure 3. TIN is a vector based representation of the physical land surface, and often derived from the elevation data such as a contour. TIN is made up of irregularly distributed nodes and lines with three dimensional coordinates (x-axis, y-axis, and z-axis). The digital data of contour and river are used for the formation of TIN for this study area. The TIN formation is through 3D analysis extension which is provided in ArcMap.



Figure 3. TIN of Bandar Segamat.

TIN model which was developed earlier was used to produce a DEM. Through the ArcToolbox that has been provided by ArcMap, TIN model is converted to DEM in raster format. The Digital Elevation Model is the simplest form of digital representation of topography and the most common. This data is used as input to quantify the characteristics of the land surface and formed the basis for dynamic flood mapping. There are several different methods have been used to create DEM series. A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. DEM is the main data required in the develop watershed. The formation of the watershed is important to identify the inlet and outlet of a catchment, as well as the amount of rainfall received by a river. In ArcMap there are special extensions for producing the watershed, which is using ArcSWAT. Through the ArcSWAT and raster data from the DEM, watershed can be determined.

The main input for the hydraulic model is the river cross section and floodplain, it also depicts the shape of the channel in which a river flows. The cross sectional area is the wet area of the river normal to the direction of flow. Even among different types of the rivers, common characteristics of cross sections are observable from headwaters to the river mouth [9]. Eventhough this river is 23km long, the analyzes that will discussed in this paper only covered 4.3 km which covered the area close to Segamat Township area (Figure 4). The selection of this area is primarily due to objective of this study which is to determine the most impact area at this town to avoid the losses and saving a life. Moreover, two scenarios will be discussed the impact of flood if there are a hydraulic structures and no structure in the waterway during a peak discharge.

3. Results and Discussions

Based on the rainfall analysis for the Segamat Basin, annual rainfall is about 1800 mm/yr. The hydrological data of 2007 were used to validate the results. As mentioned earlier, two scenarios will be discussed to determine the differences between having hydraulic structure and no hydraulic structure. Within 4.3 km reach, there are three (3) bridges were observed as shown in Figure 4.

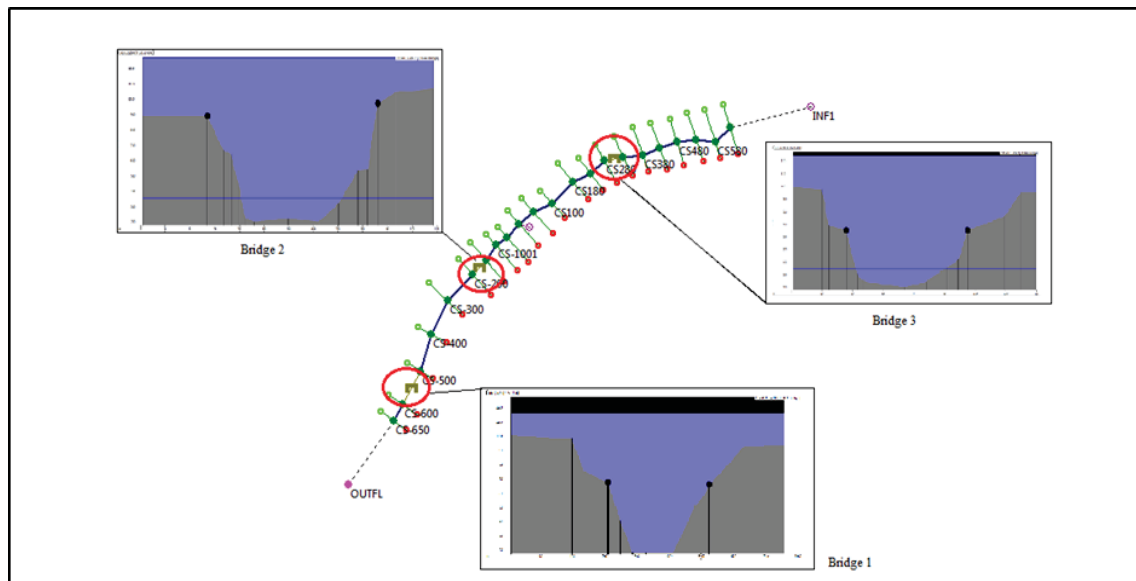


Figure 4. Location of bridges in study area (Segamat Town).

3.1 With a bridge

By having the bridge in the river has caused a flow disruption as shown in Figure 5. The hydrograph shows that the water level was significantly increased during this event and the increment within a range of 5 – 15 meter from normal depth. The water level start to increase since 6th Dec 2007 and reach the first peak on 7th Dec 2007 with a water level is 16.175 m. The second peak was recorded 4 days after which is on 11th Dec 2007 with a water level reading about 20.543 m. Both of water level reading is above the danger level based on DID historical data. While Figure 6 shows the longitudinal cross section from upstream to downstream during the peak flow. Based on this figure, it clearly shows that during the peak flow, the water level has surpassed the left and right river bank that caused the water flow to the lowland area on the surface.

Table 1 shows the value of maximum water level, flow and velocity for every bridge during peak hours. Based on this result, it shows that the existing of the bridge in waterway could trigger the increasing of water level and slow down the flow. Bridge number 3 shows the highest water level which is 20.467m, while bridge number 1 recorded the lowest water level. In terms of flow and discharge, the highest flow value is 2048.414 m³/s for bridge number 1 while the lowest value was calculated at bridge number 3. This could give some important information to us, the water level and flow was influenced by the existing of the bridge and the condition of river width. This condition correlates with the shape and width of the river. It was observed that the upstream area the terrestrial and the terrain of this river are uneven and the width is narrower compared to downstream areas. This finding corresponding with the study conducted by [10] in Jhalem River. They had mentioned that the increase in valley slope, discharge increases and the water level decreases. On the other hand, with the increase in valley width (in terms of entrenchment ratio) both discharge and water level decrease. It is also concluded that with an increase in valley slope, the overall flood severity in a river valley would increase due to fast flooding. The existing of bridges in the river has become an obstacle for flood flow to get through since the river width was narrow down and there are might be debris that was flowing together that block the flow when this debris stuck at the bridge piers.

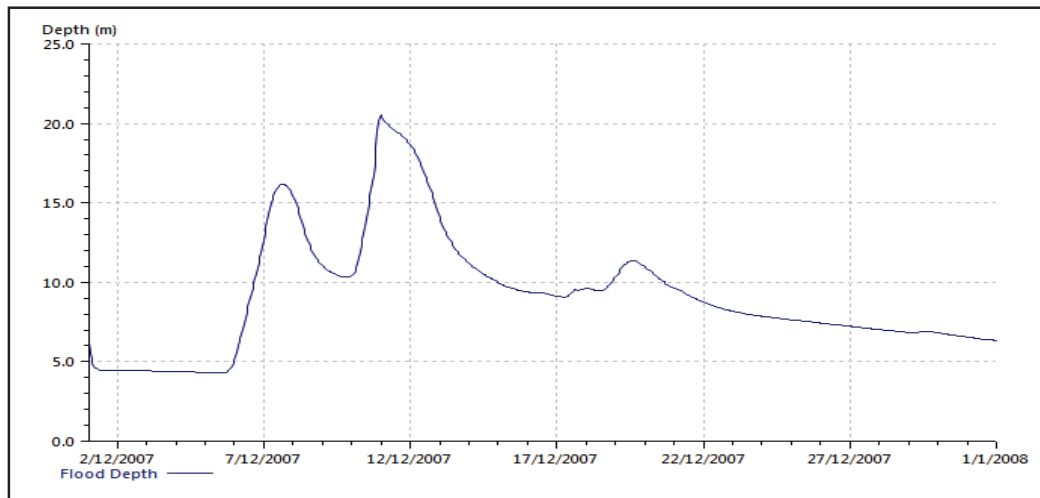


Figure 5. Water level of Segamat River at Segamat Town for event with bridge.

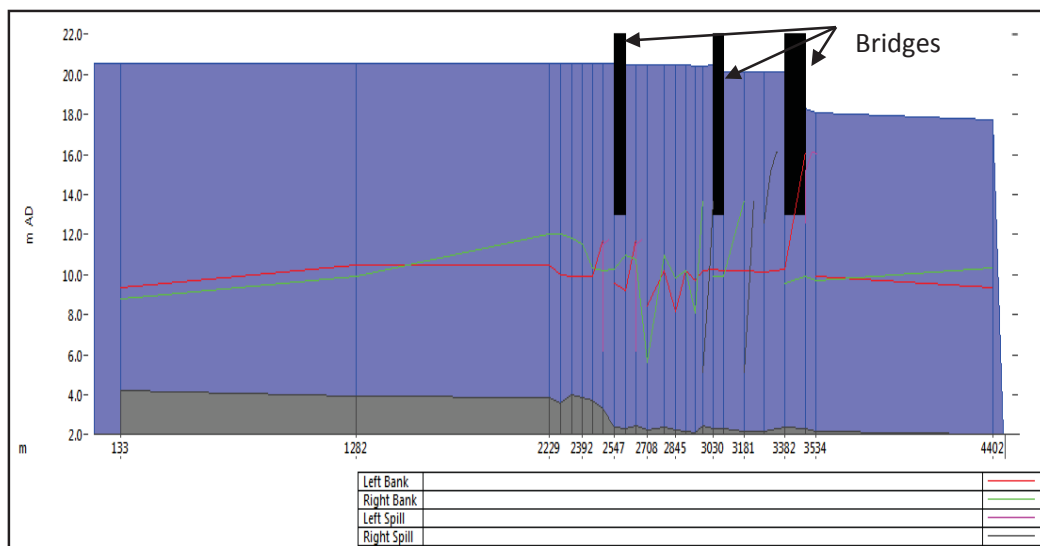


Figure 6. Long section view of the Segamat River for Unsteady event with bridge.

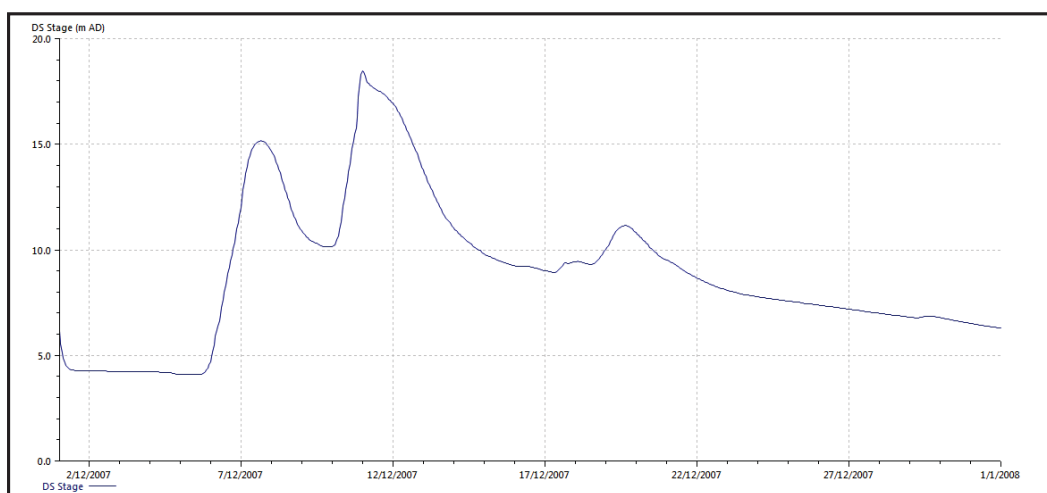


Figure 7. Water level of Segamat River at Segamat Town for event without a bridge.

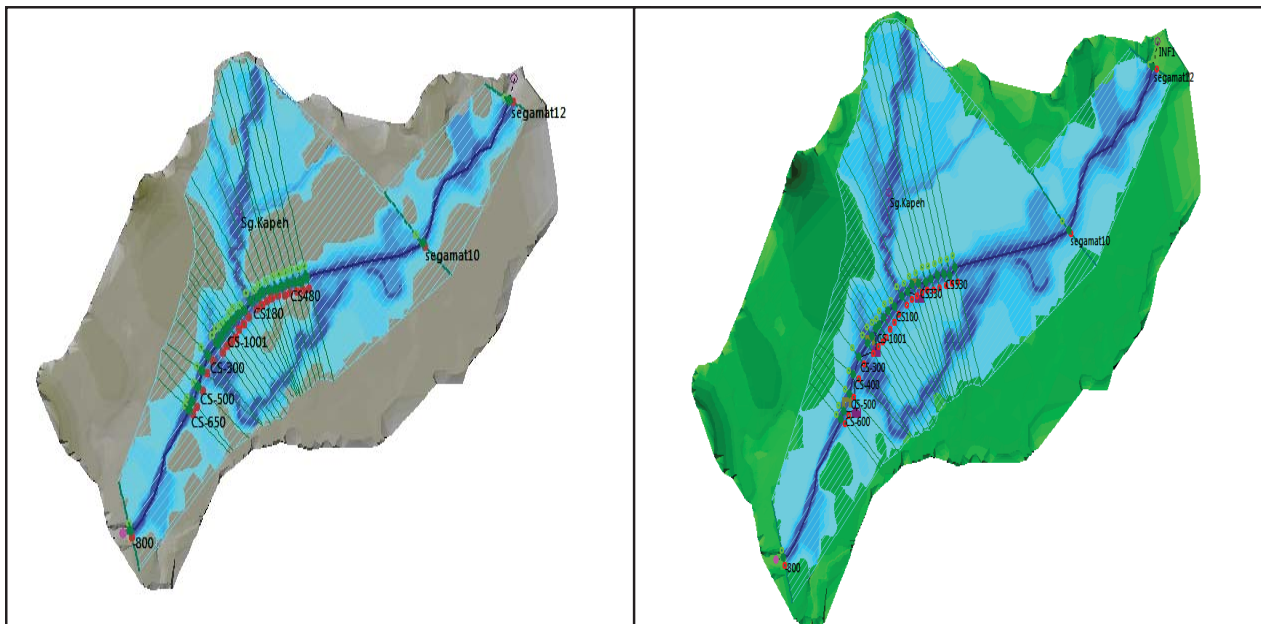
Table 1. Analyses data for each bridge (with bridge).

Bridge No.	Stage (m)	Flow (m ³ /s)	Velocity (m/s)
1	18.321	2048.414	0.711
2	20.154	1870.607	0.241
3	20.467	615.016	0.049

3.2 Without a bridge

For the second scenarios, the assumption was made by stating that there is no bridge was constructed to determine the difference of water level, discharge as well as velocity. The presence of the bridges act as a barrier has caused disruption to the water flow. With the absence of bridges, flood water flow passes the city faster compared with the presence of bridges. This has resulted in lesser effected areas hit by the flood. Based on hydrograph as shown in Figure 7, the maximum water level is about 18.54 m which is lower compared with the water level with the existing of bridges. This has strengthened our finding that the existing of hydraulic structure in the river could increase the water level.

The absence of bridges has also increased the water velocity; reaching 0.962 m/s. Water velocity tends to be increased if there is no obstacle in the river. For verification, the selection of one month simulation was carried out to determine the effect of the bridge on the velocity. Based on the Figure 8, it clearly shows that the velocity was higher for scenario having no bridge. The big difference was observed on 11th December with a difference of 0.227 m/s. A difference of ARI is also being conducted to understand the effect of a difference with the presence of bridge on flood mapping. 100 ARI was selected to model the flood map. Based on the results, it shows that velocity for scenarios without a bridge simulated higher value. Figure 8 clearly shows the affecting area by the two scenarios mentioned earlier. The area of the flood was increased when there is a structure being built in the river. The spreading of water is wider in the map having a bridge compared to no bridge.

**Figure 8.** Flood mapping for both scenarios. (a) without bridge (b) with bridge.

4. Conclusion

This paper investigates the effect of the existence of a bridge for Segamat River at Segamat Town. It is concluded that the existing of bridge in the river influenced the water level, flow discharge, velocity as well as the affected area by the flood. The presence of the bridge has led to the increasing of water level, reduced the flow and velocity and wider affected area compared to no bridge. The flood water tends to spread and dispersed with the presence of the bridge. This can be seen clearly during the high flow especially during flood events. Thus, a finding from this study could be applied by the related agencies to plan flood mitigation project in this basin by identifying the possible locations of flood prone area.

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