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Flood Modelling in Muar Town using HEC-RAS

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Abstract: Muar town has experienced seasonal floods for the last five years. This incident has caused damages to most public property and government property such as houses, buildings, roads, and many others. The behavior of floods, the impact on the local population, and the effectiveness of man-made drainage systems in the city of Muar and the production of flood models are the major objectives of the study. The study is conducted to upgrade the existed man-made drainage system in Muar town based on the modeling that will be done with the hydrology software that is Hydrologic Engineering Centre's River Analysis System HEC-RAS. The study is conducted by a collection of the data in the study area before performing HEC-RAS simulation and hydraulic analysis. Terrain data, geometric data, cross-section data, and flow data will be conducted one by one in the HEC-RAS before simulate the existing conditions. The study discovered increasing rainfall trends, which are one of the most important factors in flooding from year to year. As a result, the current drainage system will be ineffective in the future. The flood modelling is a tool to predict the flood event for existing and future conditions of the drainage. The analysis of the drainage will be done in order to avoid factors that contributing to the flooding.

Keywords: Flood, Modelling, HEC-RAS

1. Introduction

Natural hazards, as one of the elements of global Eco dynamics, that is caused by natural processes that are unrelated to human existence. Weather patterns such as (tornadoes, storms, floods, and hurricanes), changes in the Earth's crust such as (earthquakes, volcanoes, and landslides), and climatic conditions can all cause natural disasters (such as droughts, bush fires, cold snaps, etc.). When humans are exposed to natural hazards, natural risks arise [1]. Natural disasters have been described by humans since the dawn of civilization on Earth, such as Noah's flood in The Holy Quran. Flood disasters,

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whether caused by natural or man-made forces, make up roughly a third of all natural disasters in terms of number and economic losses, as well as more than half of all deaths worldwide [2]. Flood disasters remain the dominant cause of death in Asia's poor and highly populated regions. Population growth, land use force, climate change, and insurance industry response are all global factors that can affect potential flooding. As fast-developing Asian countries face population growth pressures and demand for more floodplain development, flood management is expected to continue for the sake.

This study comes up with a better solution to avoid factors that contributing to the flood occurring in Kg Sabak Awur, Muar. Kg Sabak Awur is known as a lowland area that is flood easily occurred, especially in the monsoon changes. Flash floods are also a common occurrence on the study site [3]. The main purpose of the study is to upgrade man-made drainage systems by using the modelling that has been done with channel modifications. This is critical to prevent the urban floods from getting worse year after year. This could occur if urban drainage systems are managed and upgraded to a better system that can clearly control an excessive amount of filtration during monsoon changes. Aside from that, to avoid natural disasters such as floods, which are destroying Muar's property. Floods have destroyed property in the past, and the worst-case scenario is a loss of life. The flood can be prevented by upgrading the drainage system by developing the flood modelling using HEC-RAS, and the flood behavior pattern and the risk can be determined.

2. Literature Review

Kampung Sabak Awor is one of the areas that experiences flooding almost every year in the Muar town, particularly in low-lying areas. Furthermore, two hours of heavy rain can result in flash floods in several areas of Muar town, including Kampung Sabak Awor, Muar. Some homes were inundated in 0.3 metre deep waters, according to the Muar District Disaster Management Committee [3]. This occurs as man-made irrigation systems cannot hold vast volumes of water because of annual monsoon changes. This situation can be seen as a example at the 300 meter long Sungai Abong’s road that is related to the concrete drain is only 300 millimetres in size and it is cannot hold a high volume of water. Besides, floods inundated some areas with water in Muar town because of the poor effluent system, due to the blocked drainage and sewers [6].

The Hydrologic Engineering Centre (HEC) of the US Army Engineering Corps initiated flood hazard mapping in 1988 in the United States [4]. Flow over or exceed the natural riverbanks is defined as a high flow river [4]. Results of flooding Overflowing channels or unusual high tides streams from excessive rain on the land or coastal area waves. Some of the main factors determining the characteristics of flows are characteristics of precipitation events, flood depth, flow speed and the rainfall event duration. Intensive precipitation and other factors such as the melting of snow, the inadequate drainage, water-saturated ground or unusually high tides or waves are the cause of most floods. Flooding is the most damaging phenomenon for the social and economic effects of people [4]. There are a variety of flood types. River flows, blazing flows, coastal floods, urban floods and ice jams are the most common types.

The mapping of the river flood is the process by comparing the river water levels to the surface elevation to identify flood levels and flood depth. The process requires an insight into fluid dynamics, topographical relations, and the modeler's sound assessments [5]. The flood hazard maps may contain depth of water, extent of flooding, flow speeds and duration of flooding. This is a fundamental and important indicator for the development and regulation on the floodplain land use. The study mainly aims to produce flood risk map for the national insurance programmed (NFIP) because private insurance companies are reluctant to provide insurance policies as a consequence of disastrous losses [4].

3. Methodology

The main purpose of this study are to prevent the urban floods occur with advancement of technology that made it feasible to do even though such disasters cannot be prevented. Since years ago, floods are the one of the common natural disasters that causing significant economic and property destruction as well as the loss of human life. The advances in technology such as Hydrologic Engineering Centre - River Analysis System (HEC-RAS) can make it possible to identify flood susceptible areas, prospective inundation depths, and areal extents which may then be utilized to build flood risk maps for specific places. The risk maps that have been created can be used to identify vital zones, send out early warnings to individuals in the event of a potential incident, and assist in making administrative choices in the event of an emergency [7]. Figure 1 shown is the flowchart of the studies.

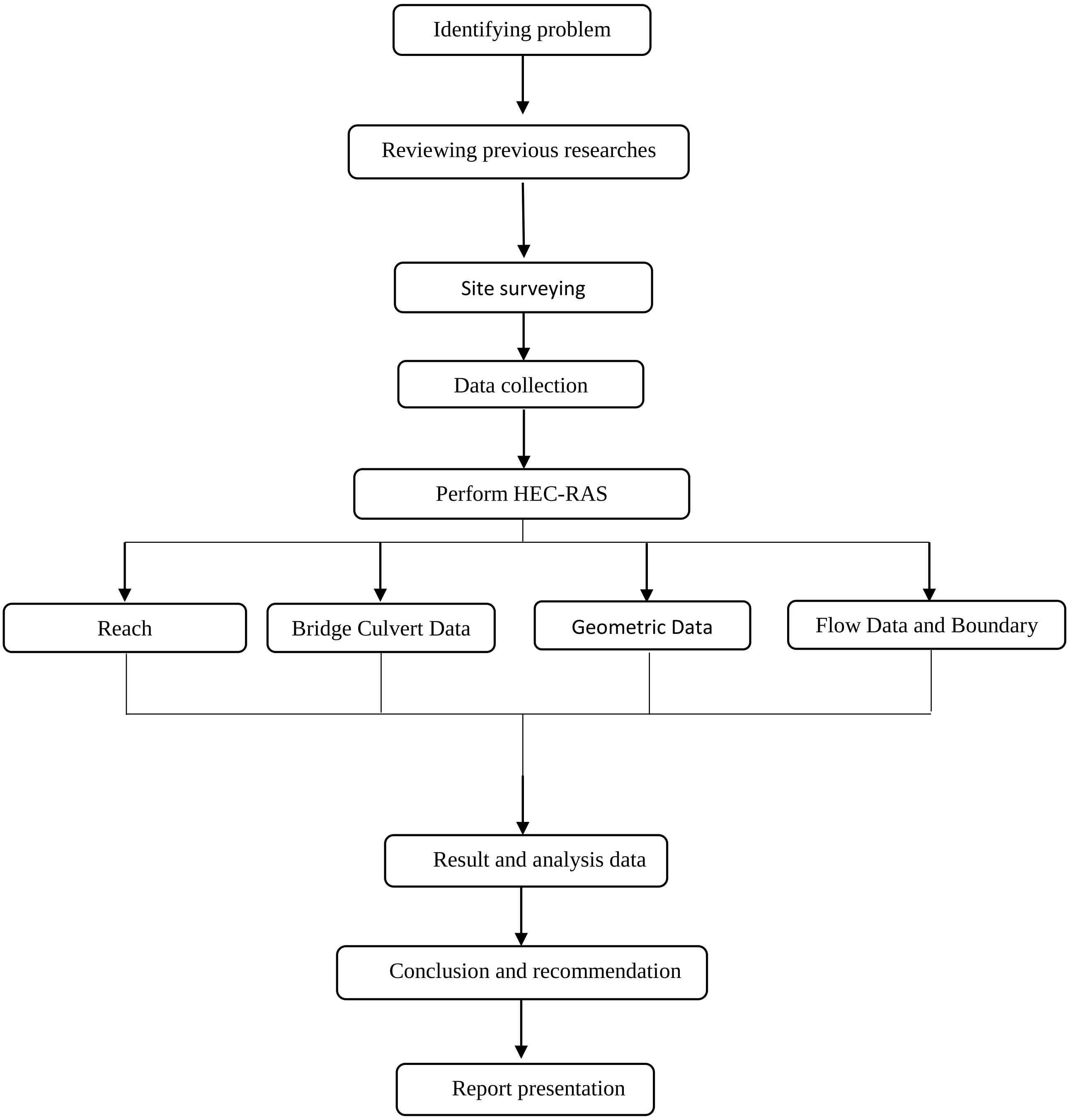

Figure 1: Flowchart of the studies

3.1 Survey data

The CSI (Consortium for spatial information) Web site has digital elevation models (DEMs) for the entire globe, covering all the world's countries. These data were made as a result of the Shuttle Radar Topography Mission (SRTM), an international effort that resulted in the world's most comprehensive high-resolution digital topographic database [8].

The river and floodplain geometry were determined using the SRTM-DEM as well as manual collection in the study area. Land uses were classified with the help of Google hybrid, and these classes were then used to estimate Manning's n values, which were required by HEC-RAS for hydraulic computations. The annual maximum daily rainfall data also has been observed near the study area as shown in figure 2 [8].

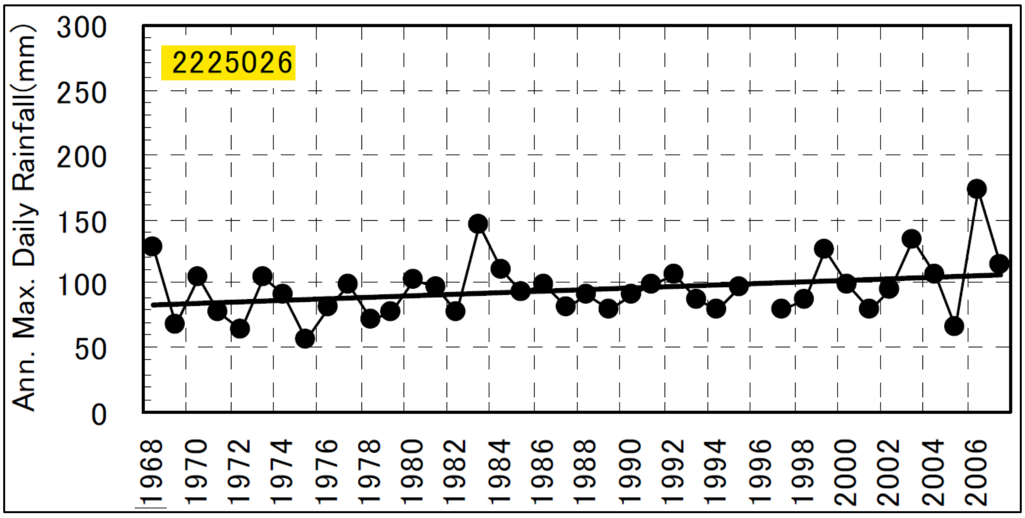

Figure 2: Annual maximum daily rainfall data

3.2 Geometry

The geometry as reach and the cross-section of the drainage in Kg Sabak Awur, Muar was created with the help of Google hybrid and based on the data collection. Figure 3 shows are the reach and cross-section of drainage in the study area. The length of the reach is 500 meters and have 50 meters between each cross section. The selection of the reach is based on the frequent flood occurred of the area. The bridge culvert data was also created using the HEC-RAS software, which involved two circular culverts and four rectangular culverts. The geometry of the channel also shown in the figure 4 as the one of the cross section in the study area reach.

Figure 3: The reach and Cross-section

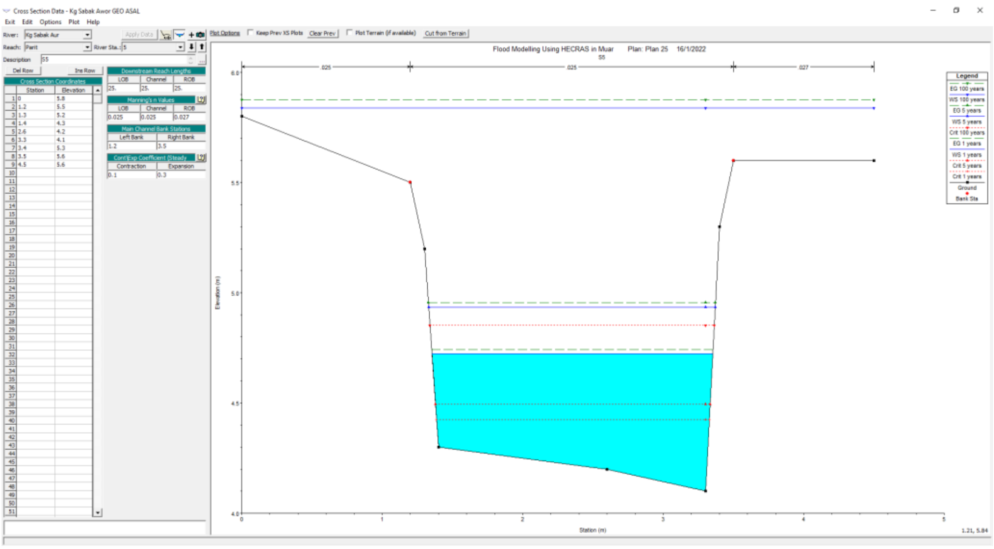

Figure 4: The channel geometry

3.3 Steady flow and the boundary condition

In the steady flow editor of HEC-RAS, two profiles were created, each of which included all the stations. The ARIs 5 years and 100 years were selected based on quantity design storm ARIs from minor and major system shown in the table 2 as a type of development of infrastructure or utility. The data is based on the calculations used to determine the discharge value using equations 1, 2, 3 and 4. Equation 2 is the mean velocity in estimating the value of discharge. The increasing trends in rainfall are also a factor in determining a discharge by estimation method. Steady flow estimation has been made based on the rational method that is involving the catchment area of Kampung Sabak Awur, Muar. The catchment area is 88,887.4m^2 as shown in figure 5 [9]. The peak flow (q) obtained for 100 years is 16.66m^3/s.

Table 1 shown the 5 years and 100 years discharge of the peak flow in the drainage system. The boundary conditions for all the profiles are normal depth and a slope of 0.0025 upstream. The slope determination is based on the general use for the drainage system for the normal depth. While the downstream profile is critical depth for the entire profile.

Table 1: 5 years and 100 years discharge

Station	5 years discharge (m^3/s)	100 years discharge (m^3/s)
1	0.84	6.32
2	0.88	7.03
3	0.96	7.68
4	1.39	8.34
5	0.75	3.01
6	0.84	3.76
7	0.90	3.11
8	1.15	5.77
9	0.90	3.60
10	1.51	4.59
11	1.87	16.66

$$Area, A = Width \times Depth \; Eq. 1$$

$$Velocity = \frac{Distance(m)}{Time\ taken(s)} Eq. 2$$

$$Discharge, Q = Area(m) \times Velocity(m/s) \; Eq. 3$$

$$q = C_i A \; Eq. 4$$

Table 2: Quantity design storm ARIs

Type of Development (See Note 1)	Minimum ARI (year) (See Note 2)	
	Minor System (See Note 3)	Major System (See Note 3)
Residential		
Bungalow and semi-detached dwellings	5	50
Link house/apartment	10	100
Commercial and business center	10	100
Industry	10	100
Sport field, park and agricultural land	2	20
Infrastructure/utility	5	100
Institutional building/complex	10	100

Figure 5: The catchement area

4. Results and Analysis

The result and the analysis of the study will be present with the references to the purpose of the study, which was to create the flood modelling at the prone inundation area as a one of the medium to avoid flooding. The channel modification for all the station that has been overflowed from the banks also will be present.

4.1 Results

The results obtained after running the model in the HEC-RAS software can be compared in the appendix as a cross-section of a 5-year flood profile and a 100-year flood profile. Figures 6 and 7 depict one of the stations in a 5-year flood profile and a 100-year flood profile, respectively, where the water level has overflowed from the banks. The channel was modified to prevent the water level from rising too high and overflowing the banks.

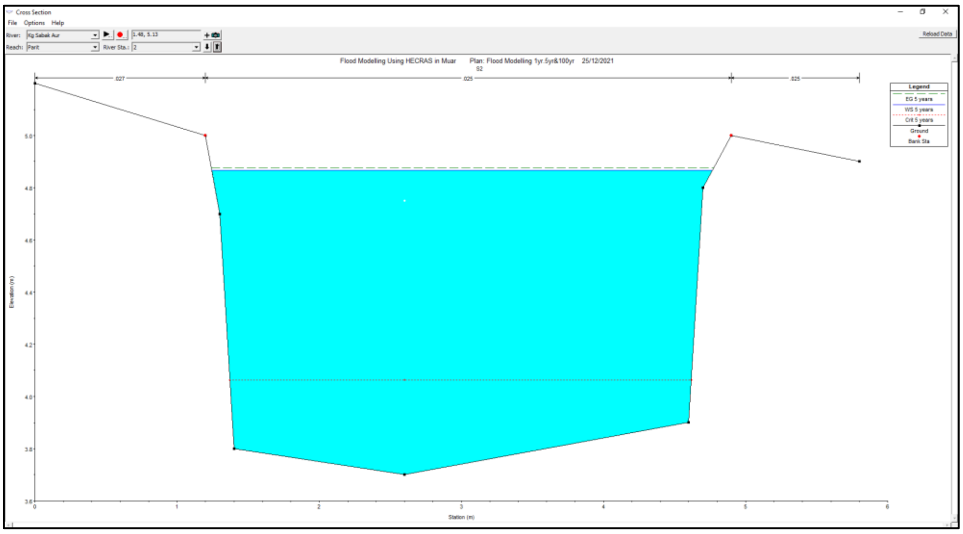

Figure 6: 5 years flood profile of station 2

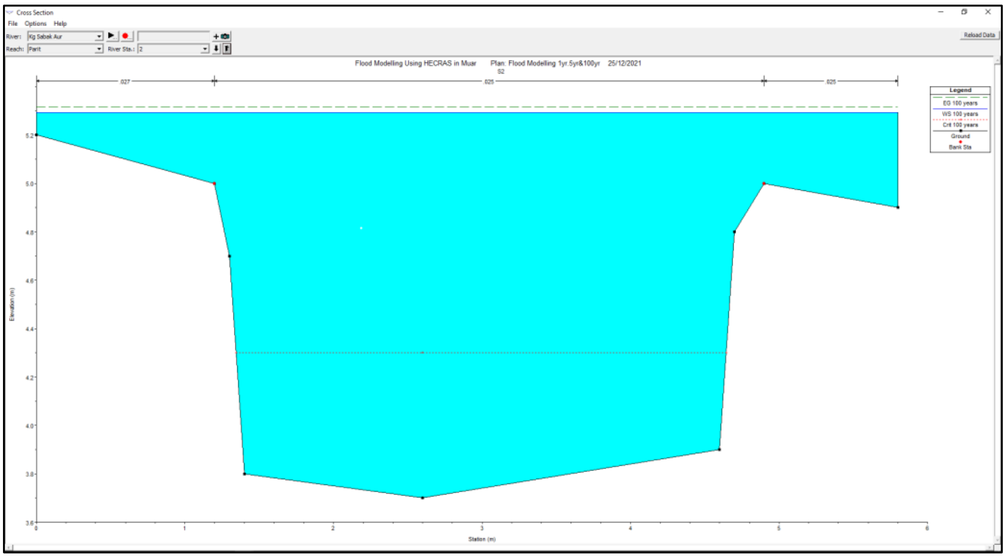

Figure 7: 100 years flood profile of station 2

4.2 Analysis data

The existing drainage system in the study area has been triggered by the increase in rainfall trends from year to year as the water level has increased, especially during monsoon change. This is depicted in Figure 2 as rainfall data collected near the research area [10]. The increase in precipitation will have resulted in an ineffective existing drainage system because of an increase in the amount of water that will overflow the banks and flooding will occur. After the model has been developed in the HEC-RAS software, channel modifications can be made to ensure that the drainage system can handle the excessive amount of water during monsoon changes. Figure 8 shows the channel that has been changed for station 2. The channel cross-section can be changed in the software and applied in a real-world situation to prevent future floods.

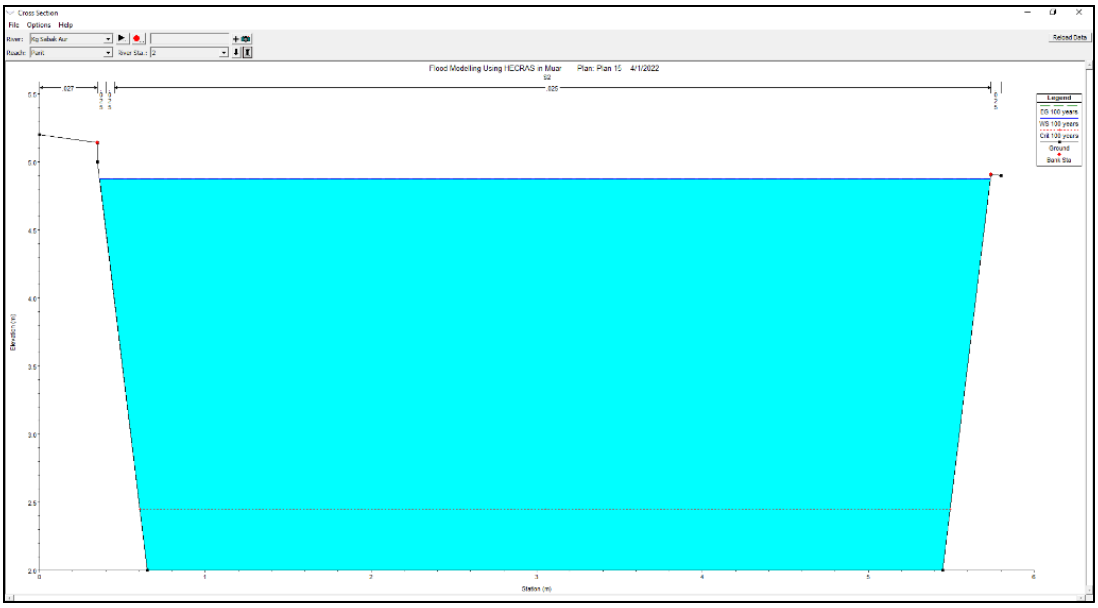

Figure 8: 100 years flood after modification of station 2

4.3 Floodplain map

The map for flood plain can be obtain in the RAS Mapper in HEC-RAS software that allowed to see affected area from 5 year flood events to 100 years flood event so that early alert for the flood can be obtained in the future. Figure 9 and figure 10 shown are the 5 years flood event and 100 years flood events that are obtained from the HEC-RAS analysis at Kg Sabak Awor, Muar.

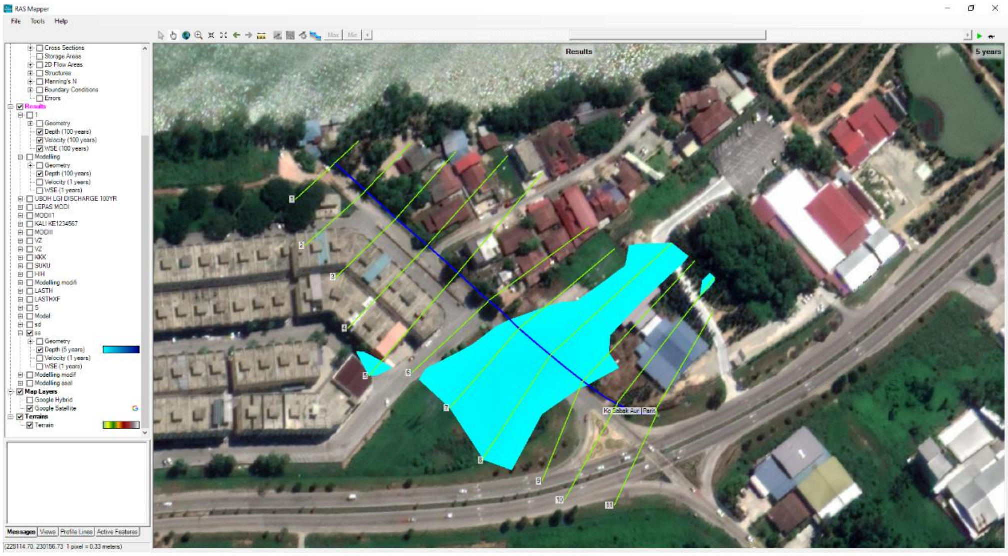

Figure 9: 5 years flood event at Kg Sabak Aur, Muar

Figure 10: 100 years flood event at Kg Sabak Aur, Muar

5. Conclusion

The Hydrologic Engineering Centre's River Analysis System, also known as HEC-RAS, is one of the best software programs for developing flood modelling wherever we want, regardless of how big or small the stream is or how many discharges, culverts, and other features, it has. This is demonstrated by the creation of well-constructed flood modelling at Kg Sabak Awur in Muar. We can see a clear comparison of the flood that will occur in a 5-year flood event versus a 100-year flood event in the study area as a result of the findings. Not just that, but we can also foresee how effective the existing drainage system will be in the future. This was an excellent way to meet the study's objectives. Furthermore, using the HEC-RAS software, we can assess flood behavior patterns and their risk to a community as an early warning system prior to flooding.

The study's findings revealed that rainfall trends have an effect on flood behavior patterns. More flooding will occur if rainfall trends continue to increase, particularly in low-lying areas. As a result of this result, a flood event in 100 years will be worse than a flood event in 5 years, or even in the current year.

The channel modification can be used in real-world situations based on what has been done in the HEC-RAS software to prevent flooding from becoming even worse, especially in lowland areas. The drainage system should be upgraded to ensure that it can accommodate a well of water in the future, as this is the most important factor for flooding.

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