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Article

Flood Overflow Identification in Parit Indah Using HEC-RAS Model

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ABSTRACT

Flooding is an annual problem and has a major impact on the condition of society both economically, socially and environmentally. Flooding generally occurs due to overflowing rivers or the inability of rivers to accommodate excess river water due to high rainfall. The purpose of the study was to see how flood overflow in Parit Indah is simulated into a model so that it can be visualized and planned for appropriate and efficient control or mitigation efforts. The results of the analysis with the HEC-RAS model with input data of the maximum value of rainfall intensity in the last 10 years and the planned discharge of 2, 4, 6, 8 and 10 years, the results of the model exceeded the volume of the drainage channel and caused flood overflow around the beautiful ditch when the maximum rainfall intensity occurred.

1. BACKGROUND

1.1 Introduction

Floods are one of the natural disasters that often occur in most parts of Indonesia, including the city of Pekanbaru. The factors that cause floods also vary, such as the level of urbanization which causes the reduction in water catchment areas (Nugroho & Handayani, 2021). In addition, floods can also be caused by overflowing rivers or the inability of rivers to accommodate excess river water due to high rainfall (Sholikha et al., 2022).

Parit Indah is one of the largest drainage channels in Pekanbaru city and is a dense area of vehicle traffic both towards the city center and towards the Sumatra highway connecting Pekanbaru city with the surrounding districts, thus the Parit Indah area is included in the important transportation access area plus around Parit Indah there are many residential areas and campuses. The overflow of the Parit Indah channel which occurs due to heavy rain and the decreasing absorption capacity causes flooding problems that hamper community activities in terms of transportation and economy. In addition, flooding generally has negative impacts such as disease for the community and damages buildings and public infrastructure available.

Therefore, an effort is needed to control the overflow of the Indah Ditch channel so that it does not exceed the channel's capacity by carrying out planning and then inputting it into a model so that a visualization of the appropriate form of action to be taken is obtained.

1.2 Research Purposes

ObjectiveThe purpose of the research is to see how flood overflows are then simulated into a model so that appropriate and efficient control or mitigation efforts can be visualized and planned. The results of the HEC-RAS model show a 2-dimensional picture of flood overflows and the areas that will be affected..

2. LITERATURE REVIEW

2.1 HEC-RAS Model

An important approach in the study of water resources management, especially in flood risk mitigation. One of the widely used software for river flow and flood overflow simulation is HEC-RAS (Hydrologic Engineering Center River Analysis System), developed by the US Army Corps of Engineers. HEC-RAS allows one-dimensional (1D) and two-dimensional (2D) flow analysis, so it can simulate water flow behavior more realistically, including the identification of areas that are potentially inundated.

Theoretically, the HEC-RAS model is based on the mass and momentum conservation equations, namely the Saint-Venant equations. In the context of a two-dimensional simulation, these equations are solved numerically to calculate the water level and flow velocity on each grid or mesh element that represents the land surface. The integration of surface topography (DEM - Digital Elevation Model), rainfall data, and river boundary conditions allows the model to provide a fairly accurate spatial projection of flood impacts.

2.2 Hydraulics

Hydraulic theory is used to understand the characteristics of water flow. HEC-RAS uses the Saint-Venant equation as the basis for its calculations, which is a system of partial differential equations representing the conservation of mass (continuity) and conservation of momentum.

For one-dimensional (1D) flow, the main assumption is that the flow occurs along one centerline of the flow, and the flow variation in the transverse direction is ignored. While for two-dimensional (2D) flow, HEC-RAS considers the distribution of water velocity and depth in the horizontal direction, so it can describe flood overflow more realistically.

Understanding the hydraulic parameters is essential in building an accurate flow simulation model, such as that done with HEC-RAS. Each parameter has a significant influence on the final result of the simulation, both in terms of water level, inundation area, and flow velocity.

3. METHODOLOGY

The model used in the flood distribution simulation is a hydrodynamic model integrated with HEC-RAS software for pre-processing and post-processing purposes.

3.1 Pre-Processing

The initial stage in hydraulic modeling aims to build a geometric representation of the river. This process is carried out using software. This data is then exported and used as input in the HEC-RAS software, which functions as a basic framework for defining and identifying the physical characteristics of the river consisting of cross-section data and rainfall data. Cross-section data retrieval is carried out through direct measurements, or using data from digital elevation. The cross-section data required are the dimensions of the beautiful ditch channel, namely the length, width, depth and slope of the channel. Rainfall data for the last 10 years was obtained from the climate chart for the beautiful ditch area of Pekanbaru City.

3.2 Running Model HEC-RAS

Flow simulation is performed on HEC-RAS to determine the water surface profile along the river cross-section. The required data are river geometry data that has been created in the pre-processing stage, discharge data for each return period and discharge on a certain date. The boundary conditions used to determine the initial water surface at each end of the river system (upstream and downstream), consist of four types of boundary conditions, namely Known Water Surface Elevation, Critical Depth, Normal Depth and Rating Curve, flow regime and Manning coefficient (n) for each cross-section that can be obtained.

3.3 Post-Processing

It is the final process in flood modeling, which aims to show the ability of the Indah ditch channel to accommodate the water flow discharge from the maximum rainfall intensity with a rainfall recurrence period of 2, 4, 6, 8 and 10 years based on the results of flow simulations from HEC-RAS.

4. Results and Discussion

4.1 Cross Section Data

Cross section data collection is done through direct measurement, or using data from digital elevation. The cross section data required are the dimensions of the beautiful ditch channel, namely the length, width, depth and slope of the channel.

Table1. Cross Section Measurement Data

No	Data Types	Unit (m)
1	Length of the Beautiful Ditch Channel	3200
2	Beautiful Ditch Channel Width	8
3	Tilt/ Manning	0.0013
4	Total Depth of the Beautiful Ditch Channel	2,294
5	Guide Space	0.264

The measurement data is used as model input to determine the visualization of the cross-sectional shape of the indah ditch channel. The setting of the cross-section data will be divided into two main segments, namely upstream and downstream. . The following is a visualization of the dimensions of the indah ditch channel in the HEC-RAS model.

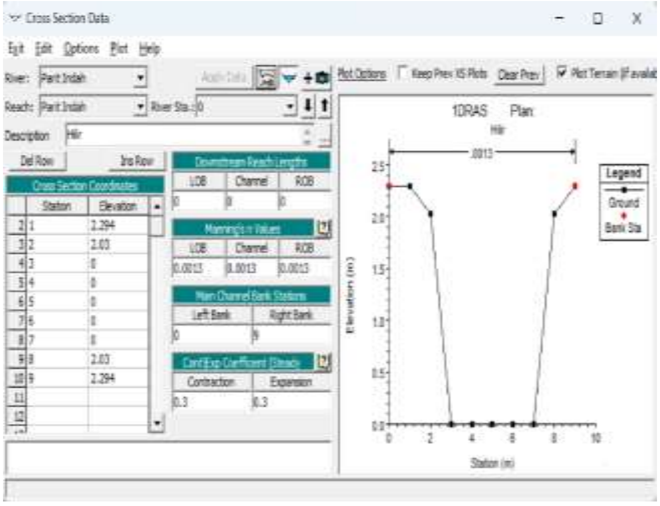


Figure1. Cross Section Data of the Downstream Segment of the Parit Indah Channel

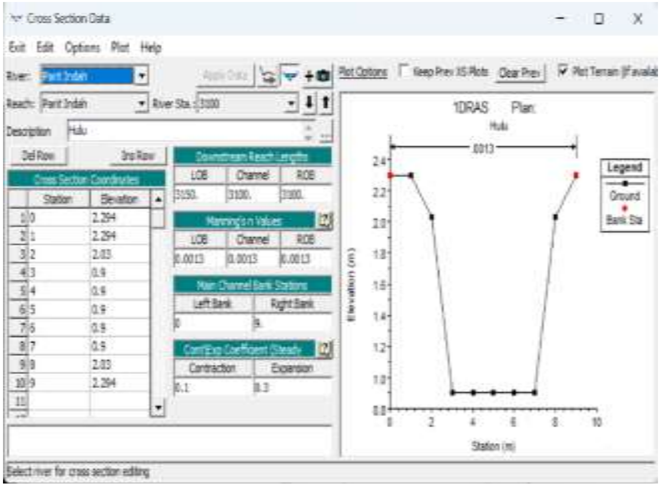


Figure 2. Cross Section Data of the Upstream Segment of the Parit Indah Channel

Based on the image above, the cross section coordinates are divided into station and elevation data as channel dimension data consisting of channel depth data, channel slope data, channel length data and steady coefficient data.

4.2 Rainfall Projection Data

The next input data calculation analysis is rainfall data obtained from rainfall intensity data from the Bukit Raya sub-district area. The rainfall data needed is the last 10 years of data where this data is obtained from the climate chart.

The design rainfall projection is needed in determining the design discharge that will be used as input in the HEC-RAS model. The design discharge determination is done by entering the equation of the multiplication of the flow coefficient with the design rainfall intensity then multiplied by the catchment area.

Table 3. Planned Rainfall

Period (year)	Xr	K	Sx	Xt (mm)/hour
2	363.5	-0.13552	48.5618	356.9190414
4	363.5	0.790543	48.5618	401.8901881
6	363.5	1.270833	48.5618	425.213976
8	363.5	1.598798	48.5618	441.1405397
10	363.5	1.848323	48.5618	453.257912

4.3 Model Result Data Analysis

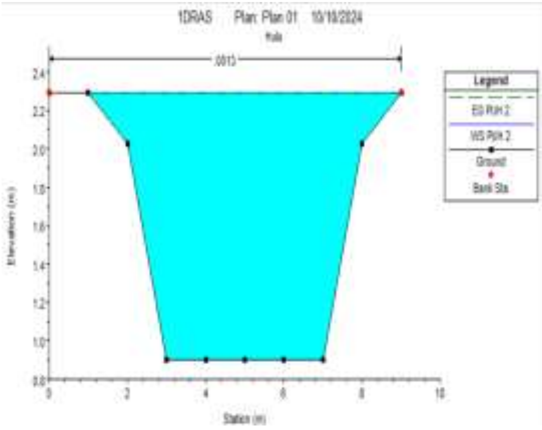
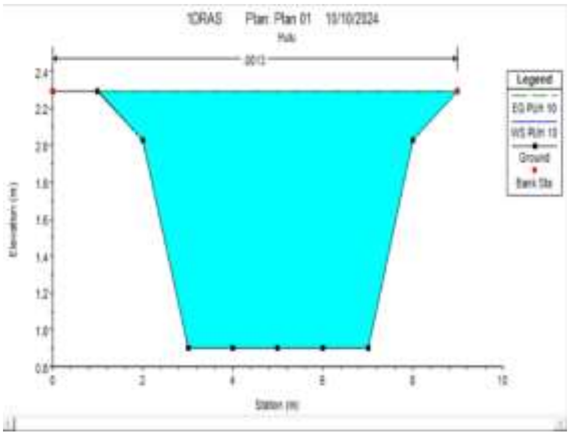


Figure 3. HEC-RAS Model Result Data on PUH 2

The results of running the HEC-RAS model on the PUH 2 projection (2-Year Rainfall Return Period), with a planned discharge of 0.17 m3/second, showed that the water overflow exceeded the drainage channel of the Indah ditch, indicated by the red value on the ground. This water overflow is likely caused by the rainfall intensity data used as input into the model exceeding the capacity of the drainage channel, causing water to seep beyond the drainage channel.



HEC-RAS Model Result Data on PUH 10

Based on the results of running the HEC-RAS model on the PUH 10 projection (2-Year Rainfall Return Period), with a planned discharge of 0.2 m3/second, an increase in water overflow exceeds the drainage channel of the Indah ditch, indicated by the red value on the ground. This water overflow is likely caused by the rainfall intensity data used as input into the model exceeding the capacity of the drainage channel, causing water to seep beyond the drainage channel.

5. CONCLUSION

Analysis of the HEC-RAS model with a planned discharge of 2, 4, 6, 8 and 10 years found that the water discharge exceeded the volume of the drainage channel and caused flooding around the beautiful ditch channel when maximum rainfall intensity occurred. This can be prevented by adding dimensions to the beautiful ditch channel either by digging the channel base or adding slopes to the channel, in addition the difference in height between the upstream and downstream of the channel is also an important factor in the distribution of flow velocity downstream towards the river.

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