Effective Government Management of Flood Discharge in Drainage Channels using HEC-RAS 6.3.1 Application

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ABSTRACT

Flooding remains one of the most significant natural disasters affecting communities around the world. Proper management of flood discharge in drainage channels is essential to mitigate its impacts on public safety, infrastructure, and the environment. In recent years, advancements in hydrodynamic modeling tools, such as the Hydraulic Engineering Center's River Analysis System (HEC-RAS) 6.3.1, have provided governments with powerful tools to analyze and manage flood discharges effectively. This research aims to investigate the role of government-led management strategies in handling flood discharge within drainage channels using the HEC-RAS 6.3.1 application. The study assesses how the application's features and capabilities can be harnessed by governmental agencies to make informed decisions and implement effective flood management plans. The research methodology involves a combination of field surveys, data collection, and computer simulations using the HEC-RAS 6.3.1 software. Geographic information systems (GIS) data, topographical surveys, and historical flood records are utilized to calibrate and validate the model's accuracy. Various flood scenarios are simulated to assess the performance of different government-led management strategies. The findings of this study reveal that the integration of HEC-RAS 6.3.1 with government-led management approaches enhances the understanding of flood dynamics within drainage channels. The application facilitates the identification of critical flood-prone areas, prediction of potential flood events, and evaluation of flood mitigation measures. The government can utilize this valuable information to formulate more effective flood management policies and allocate resources efficiently.

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1. INTRODUCTION

Floods are natural disasters that have the potential to cause catastrophic impacts on communities, resulting in loss of life, damage to infrastructure, and disruption of essential services. With the increasing frequency and severity of flooding events worldwide, effective flood management has become a top priority for governments seeking to safeguard their populations and reduce the vulnerability of flood-prone areas[1]. One crucial aspect of flood management is the proper control and regulation of flood discharge in drainage channels, which play a critical role in diverting and managing water flow during flood events. In the past, flood management Primarily focused on structural measures such as levees, dams, and drainage systems. While these interventions can provide significant protection, they are often costly and may not address all aspects of flood management[2]. Moreover, reliance solely on structural measures can lead to a false sense of security, overlooking the importance of non-structural measures like early warning systems, land-use planning, and community engagement[3][4].

In recent years, there has been a paradigm shift towards integrated and risk-based flood management approaches. Governments are increasingly recognizing the need to adopt a holistic strategy that combines structural and non-structural measures, as well as utilizing advanced technology for accurate flood modeling and forecasting[5]. HEC-RAS 6.3.1, with its enhanced capabilities for modeling complex hydraulic scenarios, offers governments an invaluable tool to make informed decisions and optimize flood management efforts. However, the successful integration of HEC-RAS 6.3.1 and other hydrodynamic modeling tools into government flood management practices requires careful consideration of various factors[6]. Technical expertise, availability of quality data, financial resources, and interagency coordination are among the critical aspects that can impact the effectiveness of such an approach[7].

Therefore, this research aims to explore the role of government-led management strategies in effectively utilizing the HEC-RAS 6.3.1 application for flood discharge management in drainage channels[8][9]. By addressing the technical, financial, and organizational challenges, the research endeavors to demonstrate how governments can harness the full potential of HEC-RAS 6.3.1 to develop proactive and adaptive flood management plans[10]. By integrating advanced technology with informed decision-making, governments can enhance flood resilience, protect communities, and promote sustainable development in flood-prone regions. Along with the frequent occurrence of heavy rains, it results in high inundation on Jl. Cut Mutia which is located in Bekasi City. As quoted from the "GoBekasi.ID" page, in 2019 the rain which continued to flush until the afternoon resulted in puddles which caused many motorized vehicles, both 2-wheeled and 4-wheeled, to die when passing through them. It should be noted that based on several articles on social media that puddles only occur when it rains, you need to know that puddles are also due to overflow from the Bekasi River, which aggravates the situation. Therefore, the authors have reviewed the place in dry and rainy conditions[11]. When it doesn't rain, the research site is free from puddles, and when it rains, the research site will experience inundation. For channels on Jl. Cut Mutia using a U-ditch measuring 1m x 1m. The subsequent sections of this study will delve into the research methodology, data sources, analysis, and findings, all geared towards providing valuable insights to policymakers and water resource managers seeking to optimize flood discharge management using the HEC-RAS 6.3.1 application[12]. Through the identification of best practices and potential areas for improvement, this research aims to contribute to the advancement of effective flood management strategies at the government level[13].

The novelty of this study lies in its emphasis on the integration of advanced hydrodynamic modeling technology, specifically the HEC-RAS 6.3.1 application, with government-led flood management strategies. While the significance of hydrodynamic modeling in flood control is recognized, the research aims to bridge the gap between cutting-edge technology and effective government decision-making[14]. By investigating the role of HEC-RAS 6.3.1 within the context of government flood management, this study will provide unique insights into how policymakers and water resource managers can harness the capabilities of this powerful tool to optimize flood discharge management in drainage channels[15][16].

2. LITERATURE REVIEW

2.1 Hydrological Analysis

Hydrological analysis begins by determining the closest train station to the research location and havingdaily maximum rainfall data[17]. Then test the consistency of the data using the RAPS (Rescaled Adjusted Partial Sums) method. Rain data that has been consistent is followed by statistical parameter tests to determine parameter values at the next stage, then proceed with calculations of the planned rainfall distribution to determine the distribution method used[18]. These distribution methods are known as the Gumble, Normal, Normal Log, and Pearson III Log Methods. Of the four methods, only one method was selected[19][20].

After selecting one of the methods used, the next step is the frequency distribution fit test, the methods used in this study are Chi-Square and Smirnov-Kolmogorov[21]. The Chi Square formula used can be seen in Equation 1.

$$X^2 = \sum_{i=1}^{n} \frac{(Ei-Ri)^2}{No} \quad (1)$$

Where:
X^2 = Chi value – squared
n = Number of data
Ri = Data from measurement results
Ei = Data calculated from the theoretical frequency curve

As for Smirnov-Kolmogorov do a comparison:

$$\Delta pmax < \Delta p \text{ critical} \quad (2)$$

Where:

Δpmax : Δp maximum from calculation
critical Δp : Δp obtained from the critical Δp table

2.2 Concentration Time

The concentration time has the meaning of the time it takes for rain to flow from the farthest point to the outlet/final disposal point being observed[22][23]. The formula used is the SNI T-02-2006-B Method formula: Road Drainage. Because it's on the road

$$Tc = ti + td \quad (3)$$

$$(\frac{2}{3}\ x\ 3.28\ x\ l\ x\ \frac{nd}{\sqrt{s}})^{0,467} \quad (4)$$

$$Td = \frac{L}{60\ x\ V} \quad (5)$$

Information:
Tc = concentration time (minutes)
Of = inlet time (minutes)
This = distance *in let* the *outlet* (m)
Nd = Barrier Coefficient
S = channel slope
L = Main channel length (m)
IN = allowable flow rate (m/s)

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2.3 Rain Intensity

Rain intensity based on time of concentration in the drainage basin under review, the formula used to calculate rain intensity is the mononobe formula in equation 6.

$$I = \frac{R_{24}}{24}\ x\ (\frac{24}{tc})^{\frac{2}{3}} \quad (6)$$

Information:

I = Rain intensity (mm/hour)
R_{24} = Maximum daily rainfall in 24 hours (mm)
tc = Concentration time (hours)

2.4 Planned Debit

The design debit is the maximum discharge that will be channeled by the drainage channel to prevent flooding. The flood discharge formula used is the rational method in equation 7.

$$Q = 0{,}00278 \text{ x } C \text{ x } I \text{ x } A \quad (7)$$

Information:

Q = Rational Plan Debit
C = Flow Coefficient
A = Area (Ha)

2.5 Hec-Ras 6.3.1

After calculating the design discharge, a simulation is carried out on the Hec-Ras 6.3.1 application to obtain data on the water level during a flood.

3. STUDY RESULT

3.1 Problem

The problem encountered when wanting to process the data was when collecting daily rainfall data and working drawings, due to having to wait for approval from the relevant agencies for the required data to be processed.

3.2 Results Hydrological Analysis

Hydrological analysis results were carried out by collecting daily rainfall data for 10 years at the research location and then processing it into maximum daily rainfall data[24][25]. Rainfall data was obtained through Perum Jasa Tirta II at Bendung Bekasi Station. The following is the maximum daily rainfall data in table 1.

Table 1. Maximum Daily Rainfall Data at Bendung Bekasi Station

Year	Rainfall
	mm
2013	120
2014	190
2015	112
2016	70
2017	135
2018	78
2019	101
2020	155
2021	108
2022	118

(Source: PJT II)

Data consistency test was carried out using RAPS (Rescaled Adjusted Partial Sums) and it was found that the Bekasi Bendung Station data is consistent. Followed by the calculation of the planned rainfall, the planned rainfall with a return period of 2 and 5 years can be seen in table 2.

Table 2. Calculation of Planned Rainfall

CALCULATION OF PLANNING RAINFALL				
Time Repeat	Distribution (mm)			
	Gumbel	Log Pearson III	Normal	Log Normal
2	113.936	114.396	118.700	114.147
5	155.992	146.55	148.293	146.344

(Source: Personal Calculation)

The next step is to determine the distribution test used. Based on the Chi Square and Smirnov-Kolmogorov tests, it was found that the Log Pearson III distribution test was used to calculate the design rainfall intensity based on Tables 3 and 4 with regard to the smallest Chi Square and Smirnov-Kolmogorov values.

Table 3. Chi Square Calculation Results

WHO SQUARES			
REQUIREMENT	**X SQUARE**	<	**X CRITICAL SQUARE**
Gumbel	**5**	**ok**	**5.991**
Normal	**1**	**ok**	**5.991**
Log Normal	**3**	**ok**	**5.991**
Pearson III	**1**	**ok**	**5.991**

(Source: Personal Calculation)

Table 4. Smirnov-Kolmogorov Calculation Results

SMIRNOV KOLMOGOROV			
METHOD	COUNT	CRITICAL	INFORMATION
GUMBLE	0.10	0.41	OK
NORMAL	0.12	0.41	OK
LOG NORMAL	0.08	0.41	OK
LOG PEARSON III	0.08	0.41	OK

(Source: Personal Calculation)

3.3 Calculation of Planned Debt

In order to calculate the design discharge in this study, a runoff coefficient is required which is determined based on the land function in the study area. The magnitude of the flow coefficient value chosen is 0.75 – 0.95. In this study there are 10 channels which are the research boundaries and have 2 inlets, namely the Jl.Cut Mutia Left & Right Channels, and each outlet that flows towards the channel leading to the Rawalumbu Watershed. The amount of discharge with a return period of 2 and 5 years can be seen in table 5.

Table 5. Discharge Entering the Left and Right Cut Mutia Channels

channel	Q2 (m^3/s)	Q5 (m^3/s)
Jl. Cut Mutia Left	3.841	4.920
Jl. Right Cut Pearl	4.473	5.731

(Source: Personal Calculation)

3.4 Hec-Ras

To start Hec-Ras, the first thing to do is to create geometric data, to create geometric data you need coordinates obtained from Autocad as shown below.

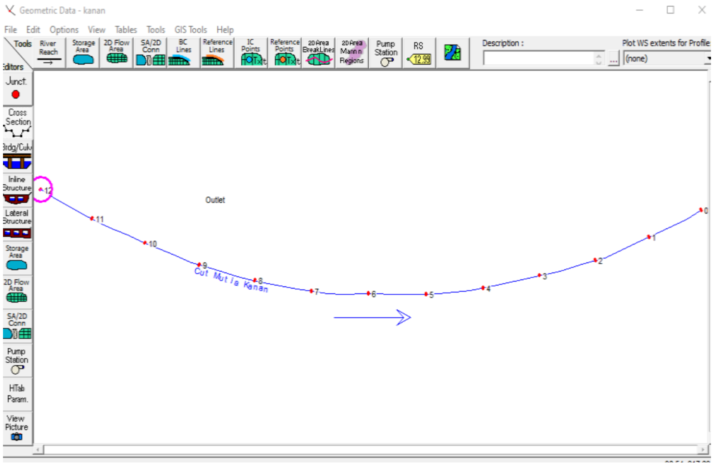

Figure 1. Geometric Data

After entering the geometric data, the next step is to enter the cross section data as shown below which is the existing cross section of 0+200 and 0+800 from Jl. Cut Mutia Right and left.

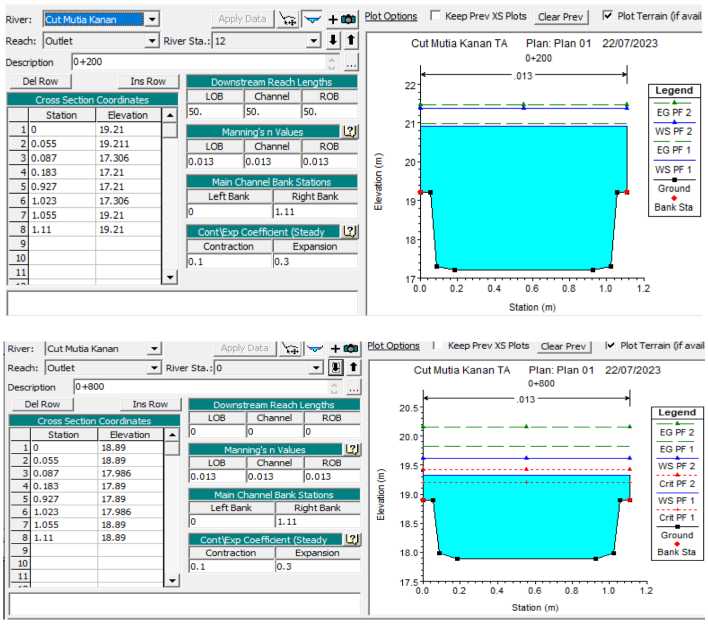

Figure 2. Crossection Data Right

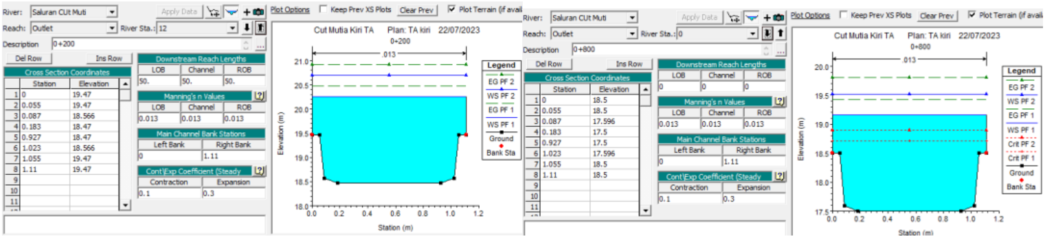

Figure 3. Cross Section Data Skin
(Source: Personal Calculation)

After entering data cross section, next is enter Steady Flow Data which contains the discharge obtained from the calculation of the rational discharge and the slope of the channel. slope using Normal Depth.

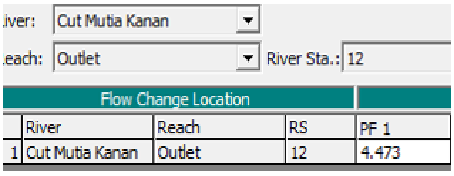

Figure 4. Debit On Steady Flow

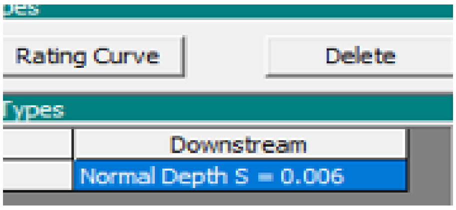

Figure 5. Slope Data on Steady Flow

After obtaining the design discharge, a simulation is carried out on the Hec-Ras 6.3.1 application in order to obtain the flood water level in the Jl. Cut Mutia with results as shown in tables 6 and 7.

Table 6. High Inundation on Jl. Cut Mutia left

Left puddle height	
2 th (m)	5 th (m)
0.78	1.22
1.33	1.76
1.29	1.72
1.4	1.81
1.32	1.73
1.25	1.65
1.2	1.59
1.14	1.53
1.08	1.46
1.01	1.38
0.92	1.28
0.82	1.17
0.66	1.02

(Source: Personal Calculation)

Table 7. High Inundation on Jl. Cut Mutia right

Right Puddle Height	
2 th (m)	5 th (m)
1.7	2.35
1.61	2.05
1.55	1.99
1.49	1.92
1.69	2.11
1.62	2.02
1.54	1.93
1.85	2.23
1.82	2.18
1.95	2.30
0.71	1.03
0.6	0.89
0.43	0.73

(Source: Personal Calculation)

It is known that all canals are flooded, therefore here the author changes the size of the U-ditch which was originally 1m x 1m to 2m x 2m.

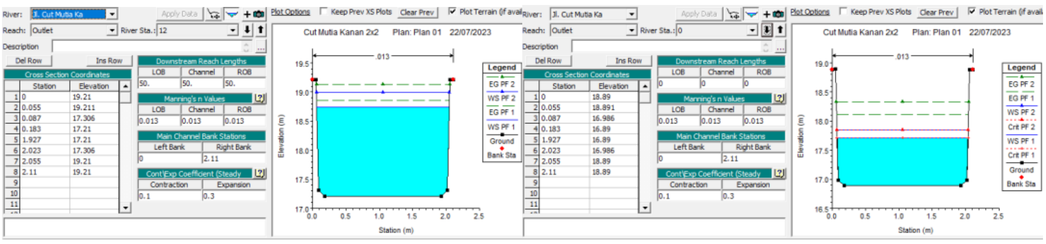

Figure 6. Cross Section Right U-ditch 2m x 2m

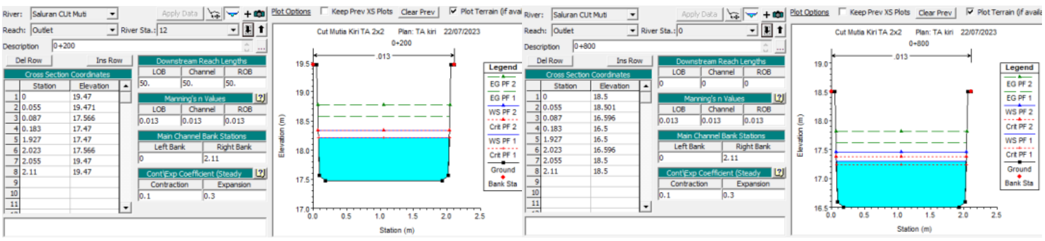

Figure 7. 2m x 2m U-ditch Right Cross Section

After entering the Cross Section data according to the change in U-ditch size, a simulation was carried out on the Hec-Ras 6.3.1 application, and the results were obtained as in tables 8 and 9.

Table 8. Cross Section Kanan U-ditch 2m x 2m

High Puddle right	
Q2 (m)	Q5 (m)
0.48	0.22
0.5	0.24
0.52	0.27
0.54	0.3
0.3	0.06
0.34	0.1
0.37	0.15
0.02	-0.2
0.02	-0.2
-0.15	-0.36
1.07	0.89
1.18	1.04
1.18	1.04

Table 9. Cross Section Kiri U-ditch 2m x 2m

Left Puddle Height	
Q2 (m)	Q5 (m)
1.26	1.13
0.77	0.53
0.79	0.56
0.65	0.43
0.7	0.48
0.76	0.54
0.78	0.57
0.8	0.6
0.84	0.64
0.87	0.68
0.92	0.74
0.99	0.83
1.2	1.04

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4. CONCLUSION

By applying the resulting runoff coefficient based on the type of land use in the research area, we were able to formulate a solution that includes the following, among others:

1. The flood discharge that occurred on Jl. Cut Mutia Right for the return period of 2 years and 5 years is 4.473 m^3/s and 5,731 m^3/s then on Jl. Cut Mutia Left for 2 years and 5 years return period is 3.841 m^3/s and 4,920 m^3/s

2. When the dimensions change, the channel is no longer flooded and the ideal size is a 2m x 2m U-ditch

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