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Evaluation of The Drainage System on Jalan Gunung Guntur, Harjamukti District, Cirebon City

Ajeng Nanda Pitriani*, Ohan Farhan
Universitas Swadaya Gunung Jati, Cirebon, Indonesia
Email: fitrianiajeng10@gmail.com

Abstract

Residential drainage systems play a crucial role in controlling rainwater runoff to prevent localized flooding and puddles. The development of residential areas along Jalan Gunung Guntur, Harjamukti District, Cirebon City, has led to significant changes in land use, resulting in increased surface runoff. Based on field observations, this area frequently experiences puddles during medium- to high-intensity rainfall. This phenomenon is suspected to be caused by inadequate drainage channel capacity, sedimentation, and lack of routine maintenance. This study aims to determine rainfall intensity and design flood discharge based on the time of concentration, evaluate the capacity of existing drainage channels, and identify the causes of puddle formation. The research method employed is a quantitative descriptive approach with hydrological and hydraulic analyses. The hydrological analysis includes calculating design rainfall, rainfall intensity, time of concentration, and flood discharge using the rational method. Hydraulic analysis is conducted to determine the channel cross-sectional capacity using the Manning formula. The evaluation results indicate that several existing drainage channels are unable to accommodate the runoff discharge occurring within a specific return period, potentially causing puddle formation. Therefore, redesigning or normalizing the channel dimensions is necessary to increase capacity, ensuring the optimal functioning of the drainage system and minimizing the risk of flooding.

Keywords: residential drainage; channel evaluation; planned flood discharge; hydrological analysis; channel capacity

INTRODUCTION

Drainage is a system designed to manage the problem of excess water flow, both above and below the ground surface. Harjamukti District, particularly the residential area along Jalan Gunung Guntur in Cirebon City, is frequently affected by flooding during the rainy season, especially under high rainfall intensity (Sahgal, 2024). This condition is caused by several factors, including inadequate channel capacity, sedimentation, channel narrowing, land use changes, and insufficient drainage infrastructure maintenance. Furthermore, population growth and urban development have led to an increase in the runoff coefficient, thereby increasing the volume of surface runoff and placing additional load on the drainage channels (Wilson, 1993).

This research is urgent because recurring waterlogging in the Jalan Gunung Guntur area has caused significant negative impacts across social, economic, and environmental dimensions. From a social perspective, waterlogging disrupts residents' daily activities, including transportation access and mobility (Noneng, 2021). Economically, inundation can damage road infrastructure and residents' property, resulting in material losses. Environmentally, stagnant water that persists for extended periods can become a breeding ground for diseases and reduce the quality of the residential environment. Field observations indicate that this area often experiences flooding during moderate- to high-intensity rainfall, highlighting the need for a thorough evaluation of the existing drainage system to identify the main causes and provide appropriate solutions (Suripin, 2004).

Extensive research has been conducted on the evaluation of drainage systems. For instance, Widodo and Ningrum (2015) found that most drainage systems are no longer able to accommodate current flow rates. Similarly, Aqsha and Harahap (2022) reported that concave-shaped drainage channels are insufficient to manage rainwater flow. Further research by Darmawan et al. (2025) showed that the highest rainfall intensity occurs in the second hour, and redesigned channels could accommodate the projected discharge (Eckart, McPhee, & Bolisetti, 2018). This study differs from previous research by not only analyzing channel capacity but also integrating existing conditions and maintenance aspects to produce a more comprehensive evaluation. The results are expected to provide actionable recommendations to improve drainage effectiveness along Jalan Gunung Guntur, Harjamukti District, Cirebon City (Macdonald, Redfern, Miller, Hess, & Knox, 2022).

Based on previous research, several gaps need to be addressed. First, most studies focused solely on the technical analysis of channel capacity, without considering existing maintenance conditions or social factors in the field. Second, no prior research has specifically evaluated the drainage system in the residential area of Jalan Gunung Guntur, Harjamukti District. Third, previous studies generally did not combine hydrological and hydraulic analysis simultaneously with maintenance and sedimentation considerations. Fourth, recommendations from prior studies are often general and not tailored to the local characteristics of specific regions.

The novelty of this research lies in several aspects. First, it analyzes drainage channel capacity while integrating existing conditions, maintenance, and sedimentation factors for a more comprehensive evaluation. Second, the study focuses specifically on Jalan Gunung Guntur, Harjamukti District, which has not been previously researched. Third, it simultaneously combines hydrological analysis (design rainfall, rainfall intensity, time of concentration, projected flood discharge) and hydraulic analysis (channel cross-sectional capacity using the Manning formula) while considering maintenance factors. Fourth, it provides recommendations for the redesign or normalization of channel dimensions based on local conditions, enabling direct application by relevant authorities.

This study aims to analyze rainfall intensity and planned flood discharge based on time of concentration in the research area, evaluate the capacity of existing drainage channels in accommodating design flood discharge, and identify the main causes of waterlogging along Jalan Gunung Guntur, Harjamukti District, Cirebon City. The research is expected to offer both theoretical and practical benefits. Theoretically, it enriches the body of knowledge in civil engineering, particularly in the evaluation of residential drainage systems using an integrated hydrological and hydraulic approach. Practically, the results can inform the Cirebon City Government, particularly the Public Works and Spatial Planning Office, in formulating policies for the improvement and maintenance of drainage systems in densely populated residential areas. For the community, this study provides recommendations to improve safety and comfort concerning waterlogging and flooding risks. Finally, it serves as a reference for future researchers in developing sustainable urban drainage systems.

METHOD

This study employs a quantitative descriptive research design. Descriptive research aims to systematically describe the existing conditions of the drainage system at the research site, while the quantitative approach is used to measure and analyze hydrological and hydraulic data numerically. This research design was chosen because it aligns with the study's objectives, which are to evaluate the capacity of existing drainage channels based on the calculation of design flood discharge and to identify the causes of waterlogging. The residential drainage system evaluation was conducted along Jalan Gunung Guntur, Harjamukti District, Cirebon City, from December 16, 2025, to March 3, 2026.

The data collection methods in this study comprised two types: primary data and secondary data. Primary data were obtained through field surveys and direct interviews. These data included measurements of drainage channels and identification of causes of channel blockages. Secondary data were collected from relevant agencies, such as the Cimanuk-Cisanggarung Watershed Center in Cirebon City and the Cirebon City Public Works and Spatial Planning Agency. These included rainfall data from 2016 to 2025 for Harjamukti District, Cirebon City, drainage channel data for Jalan Gunung Guntur, and the Kalijaga Watershed Map.

Data analysis was conducted using a descriptive quantitative approach through several systematic stages. The first stage involved hydrological analysis, which aimed to determine the design rainfall, rainfall intensity, time of concentration, and planned flood discharge for the research area.

RESULTS AND DISCUSSION

Research Location

This research was conducted in the residential area of Jalan Gunung Guntur, Harjamukti District, Cirebon City, West Java Province. The research area is a densely populated residential area with land use dominated by residential homes, public facilities, and a network of neighborhood roads. The research was conducted from December 16, 2025, to March 3, 2026, and included data collection, data processing, data analysis, and report preparation. A map of the residential area along Jalan Gunung Guntur, Harjamukti District, Cirebon City can be seen in **Figure 1.**

Figure 1. Administrative Map of Gunung Guntur Street Settlement
Source: Screenshot from Google Earth, accessed in 2025

Drainage Channel Condition

Based on a field survey conducted on Jalan Gunung Guntur, Harjamukti District, it was found that the existing drainage system consists of open channels made of mixed materials and some soil. The drainage channels function to channel rainwater from residential areas and roads to drainage channels. However, in several locations, these channels were found to be poorly maintained, with sedimentation, wild vegetation growth, and piles of garbage obstructing the flow of water (Yang & Zhang, 2021).

The dimensions of the existing channels vary, both in width and depth, resulting in uneven flow capacity. Furthermore, the channel bed slope is relatively small because the study area is located on flat topography. This condition results in low flow velocities and tends to trap rainwater within the channels. During heavy rain, the drainage channels often overflow, causing water to pool on the road and surrounding residential areas. The dimensions of the existing drainage channels in the residential area on Jalan Gunung Guntur, Harjamukti District, Cirebon City, are 0.75 m wide and 0.5 m high (Hardjosuprapto, 1998).

Figure 2. shows the drainage channels that function as rainwater and surface runoff channels. The existence of these drainage channels is very important to prevent water pooling on surfaces and roads and to ensure that the air conditioning system in the surrounding area functions properly.

Figure 2. Condition of existing drainage channels
Source: Research Results, 2025

Drainage Channel Capacity Evaluation

The evaluation was conducted by comparing the planned flood discharge from the hydrological analysis with the existing channel capacity from the hydraulic analysis. The comparison revealed that some of the drainage channels on Jalan Gunung Guntur were unable to accommodate the planned discharge. This indicates that the existing drainage system is not functioning optimally (Jamali, Bach, & Deletic, 2020).

Factors contributing to the channel's inability to accommodate air discharge include small channel dimensions, lack of routine maintenance, and changes in land use around the study site that increase surface runoff. Therefore, improvements and capacity improvements are necessary to ensure the drainage system functions properly (Piadeh, Behzadian, & Alani, 2022).

Rainfall data for the Harjamukti District area was taken from the Cimanuk-Cisanggarung River Basin Center, Cirebon City with an observation period of the last 10 years starting from 2016 - 2025. Meanwhile, rainfall data for the Harjamukti District can be seen in **Table 1.**

Table 1. Maximum Daily Rainfall

Year	Maximum Rainfall (mm/day) Daily
2016	92
2017	111.5
2018	127
2019	71
2020	141.5
2021	139.5
2022	148.5
2023	135.5
2024	102
2025	210
Average	1278,5

Source: (Cimanuk-Cisanggarung Regional Center Cirebon City)

Based on the maximum daily rainfall calculation data above, the maximum daily rainfall amount above for the last 10 years is 120.45 so for the calculation of the planned rainfall data below, the largest figure is taken each year.

Table 2. Calculation of Planned Rainfall Using the Gumbel Distribution Method

Year	Rainfall Max / xi (mm)	Deviasi (xi-x)^2
2016	1.964	0.015625
2017	2.048	0.001681
2018	2.104	0.000225
2019	1.851	0.056644
2020	2.151	0.003844
2021	2.145	0.003136
2022	2.172	0.006889
2023	2.132	0.001849
2024	2.009	0.0064
2025	2.322	0.054289
Average	20.898	0.137782

Source: Researcher's Results

Gumbel Distribution Method

From the table above, the calculation of projected rainfall for the last 10 years using the Gumbel distribution method yielded an average rainfall of 2,052 mm.

1. Average maximum daily rainfall

$\bar{X}$ Log $= \frac{\sum Log\ Xi}{n}$

$\bar{X}$ Log = 20.898/10

$\bar{X}$ Log = 2.089 mm

2. calculate standard deviation

$Sd = \sqrt{\frac{1 \sum_{i}^{n}=1\ (log\ Xi - log\ \bar{X})^2}{n-1}}$

Sd = 0.137782/9

Sd = 0.015 mm

3. calculating the coefficient of skewness

$Cs = \frac{n\ \sum_{i}^{n} -1\ (\ Log\ Xi - Log\ X)^3}{(n-1)(n-2)sd^3}$

$Cs = \frac{10X(-0.022)}{(9)(8)(0.015)^3}$

Cs = -0.00000010648/0.000243

Cs = -0.00044

4. Calculate the planned rainfall for a 5-year return period.

Log X_T = Log $\bar{X}r$ +(Sx . G)

$X_T = 10^{(Log\ X_T)}$

Log X_T = Log $\bar{X}r$ +(Sx . G)

Log X_T = 2.089+ (0.015. 0.84)

Log X_T = 2.101

Log $X_T = 10^{2.101}$

Log X_T = 126 mm

So the planned rainfall for 5 years is = 126 mm

Time of Concentration is the time required for rainwater to flow from a distant point in the river flow to a designated control point downstream of the channel. To calculate the Time of Concentration, the author uses the Kirpich Formula as follows :

$Tc = 0.0195 \times L^{0.77} \times S^{-0.385}$

answer :

$Tc = 0.0195 \times 225^{0.77} \times 0.002^{-0.385}$

Tc = 18,2 minute

Rain Intensity Analysis

Rain intensity is the height or depth of rainwater per unit time. The general characteristic of rain is that the shorter the rainfall, the higher the intensity tends to be. The longer the recurrence period, the higher the intensity.

Rain Intensity Formula:

$I = \frac{R24}{24} \text{ x } (\frac{24}{t})^{\frac{2}{4}}$

$I = \frac{126}{24} \text{ x } (\frac{24}{18.2/60})^{2/3}$

I = 97 mm/ jam

Flood Discharge

The rational method is used to determine surface flow caused by rainfall, which is usually the basis for designing discharge in drainage channels. The rational formula used to calculate flood discharge is as follows:

Q = 0,00278 x C x I x A

Q = 0,00278 x 0,50 x 97 x 4,247

Q = 0.573 m^3 /det

Runoff Coefficient

The runoff coefficient is the ratio between the portion of rainfall that forms direct runoff and the total rainfall. This value is influenced by land use, road slope, type, and condition.

The formula for calculating the runoff coefficient is as follows:

$C = \frac{C_1.A_1}{A_1}$

$C = \frac{0.60 \, x 42.47}{42.47}$

C = 0.60

Channel Appearance

A channel cross-section is the cross-section of a channel required to plan and achieve an ideal and efficient cross-section for land use. Efficient land use means taking into account available land. The formula for a channel cross-section is as follows:

$R = \frac{A}{P}$

$V = \frac{1}{n} \text{ x } R^{\frac{2}{3}} \text{ x } S^{\frac{1}{2}}$

Q = A X V

Because in the field the shape of the channel is square, we have to calculate the cross-section of the channel using the formula:

A = b.h
P = b + 2.h
Answer :
Known :

B = 75 cm = 0,75 m
H = 50 cm = 0,5 m
n = 0,030
S = 0,001
V = 0,6 m/det
W = 1
Qbanjir = 0.573 m^3 /det

Answer :

A. cross-sectional area (A)

A = b x h
A = 0,75 x 0,5
A = 0,375 m^2

B. wet surroundings

P = b + 2h
P = 0,75 + (2 x 0,5)
P = 1,75 m

C. Hydraulic spokes (R)

R $= \frac{A}{P}$
R $= \frac{0,375}{1,75}$
R = 0,214 m

D. Calculate speed using manning's formula

V $= \frac{1}{n}\ x\ R^{2/3} x\ S^{1/2}$
V $= \frac{1}{0,030}\ x\ (\ 0,214)^{2/3}\ x\ (0,001)^{1/2}$
V = 0,57 m/det

E. Calculate the existing debit

Q_{eks} = A x V
Q_{eks} = 0,375 x 0,57
Q_{eks} = 0,214 m^3/det

compare values chanel $\boldsymbol{Q_{eksisting}}$ **with** $\boldsymbol{Q_{banjir}}$ **:**

$Q_{eksisting}$ = 0,214 m^3/det
Q_{banjir} = 0.573 m^3 /det

From the comparison above, it can be concluded that the existing channel is not safe in accommodating flood discharge during high rainfall intensity.

Drainage Channel Hydraulic Analysis

A hydraulic analysis was conducted to determine the capacity of existing drainage channels to drain rainwater. Channel capacity calculations were performed using the Manning equation, which takes into account channel cross-sectional dimensions, channel bed slope, and channel roughness coefficient (Hou et al., 2021). The analysis results showed that the capacity of the existing channels in several segments was less than the planned flood discharge. This was due to inadequate channel dimensions, sedimentation that reduced the wetted cross-sectional area, and poor channel maintenance. As a result, during heavy rainfall, the channels were unable to accommodate the incoming water discharge, resulting in overflows and backfilling (dos Santos, Barbassa, & Vasconcelos, 2021).

CONCLUSION

Based on the research results and discussions regarding the evaluation of the residential drainage system on Jalan Gunung Guntur, Harjamukti District, Cirebon City, the following conclusions can be drawn. The hydrological analysis, which included calculations of design rainfall, rainfall intensity, time of concentration, and planned flood discharge, revealed that the rainfall runoff at the study site is considerable and has the potential to cause flooding if not accommodated by adequate channel capacity. The hydraulic analysis indicated that, in several segments, the existing drainage channels along Jalan Gunung Guntur are unable to accommodate the planned flood discharge. This is primarily due to relatively small channel dimensions, sedimentation, and insufficient maintenance. A comparison between the planned flood discharge and the existing channel capacity demonstrates that the drainage system at the study site is not functioning optimally. As a result, water frequently overflows, causing puddling on the roadway and surrounding residential areas during heavy rainfall. Land use conditions around the study site, which are dominated by residential areas and paved surfaces, contribute to increased surface runoff, thereby increasing the flow load that the drainage channels must carry. This evaluation indicates that improvements and capacity enhancements are necessary to ensure that the drainage system on Jalan Gunung Guntur functions effectively and reduces waterlogging during the rainy season.

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