



Redesigning Of Drainage Channels In The Griya Ampera Complex On Ujung Pandang II Street, Pontianak City

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Received : 22 September 2026 Revised : 12 Oktober 2026 Accepted : 28 Oktober 2026

Abstract

The drainage channels in the Griya Ampera Complex on Ujung Pandang II Street in Pontianak City are facing water pooling and flooding problems due to the small size of the existing channels and sand or mud sedimentation blocking the channels at several end points. Therefore, this study aims to reorganize the drainage channels to handle the total flow. This research uses primary data from field surveys and secondary data in the form of maximum daily rainfall over 14 years (2011–2024) from BWSK I Pontianak. The data is analyzed using the Log Pearson Type III distribution method to obtain design rainfall. Rainfall runoff is calculated using the rational method, and the channel dimensions are planned in a rectangular shape. Unlike previous studies that used the best hydraulic cross-section, this study designs the channel dimensions based on field conditions. The study found a catchment area of 0.0196 km², a concentration time of 0.2050 hours, The rainfall intensity is 143.8000 mm/hour, the runoff coefficient is 0.4700, the rainfall runoff discharge is 0.4290 m³/s, the wastewater discharge is 0.0004 m³/s, and the total discharge is 0.4294 m³/s. The existing front channel has a discharge of 0.0244 m³/s and the back channel 0.1521 m³/s, so they cannot handle the total discharge. The new planned channel is rectangular with a width of 0.5000 m, a flow depth of 0.6000 m, and a freeboard height of 0.4000 m, which meets the required standards.

Keywords: Rainfall, Channel Dimensions, Flow Coefficient, Drainage Layout

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INTRODUCTION

The presence of a well-functioning drainage system is very necessary to channel rainwater and runoff water to disposal areas, so that water accumulation that can disrupt people's activities or damage infrastructure does not occur. Every drainage system has a certain capacity or flow rate that must be able to accommodate the incoming water flow. If the incoming water flow exceeds the channel's capacity, flooding can occur, even leading to major floods.

One area that experiences this problem is the Griya Ampera Housing Complex on Ujung Pandang II Street in Pontianak City. Based on

observations at the location, it is known that this area always experiences water accumulation during heavy rain in the rainy season. According to residents living in the Griya Ampera Complex, water accumulation can last for 2–3 days with a height of around 30–35 cm before it starts to recede. This situation obviously disrupts the daily activities of the people in the area. Around the Griya Ampera Complex. Therefore, it is necessary to conduct an analysis and evaluation of the drainage channels in that area to understand and determine the optimal drainage channel capacity. In addition, the novelty of this research lies in the channel dimension planning approach, which sets the width (B) based on existing field conditions as a fixed variable,

unlike the conventional best hydraulic cross-section approach that optimizes both the width and depth of the channel simultaneously.

METHOD

The research method uses direct field observation to get data on the existing drainage channels in the area, which is then correlated with rainfall data obtained from BMKG. To analyze this data, a rational method approach is used to calculate surface runoff, and the Log Pearson Type 3 distribution method is used as a statistical approach to calculate rainfall distribution. From this analysis, a hydraulic cross-section method is used to calculate the optimal drainage channels in the area.

This research was conducted in a densely populated residential area. For this study, it was carried out in the Griya Ampera housing complex on Ujung Pandang II Street, Pontianak City. The location of this area can be seen in the following image:



Figure 1. Location Map of Griya Ampera Complex Pontianak

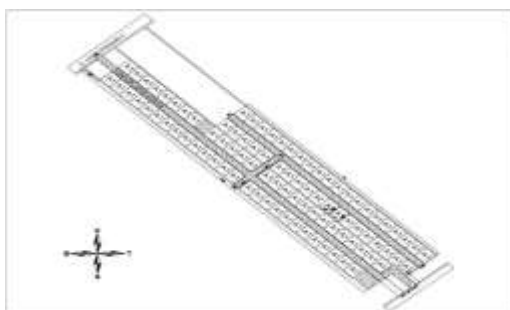


Figure 2. Plot Layout with Street and House Sizes of Griya Ampera Complex Pontianak

At the location of the residential complex, data was collected through direct measurement in the field, with the primary data used as follows:

1. The length of Road 1 in the Griya Ampera complex is 670.2 m.
2. The length of Road 2 in the Griya Ampera complex is 14.31 m.

3. The width of Road 1 in the Griya Ampera complex is 5.09 m.
4. The width of Road 2 in the Griya Ampera complex is 4.39 m.
5. The road surface type in the Griya Ampera complex is asphalt.
6. The drainage channel width in the Griya Ampera complex is 0.5 m.
7. The drainage channel depth in the Griya Ampera complex is 0.332 m.
8. The plot area of houses in Block A in the Griya Ampera complex is 204.7761 square meters.
9. The plot area of houses in Block B in the Griya Ampera complex is 158.88 square meters.
10. The total number of houses in the area is 91 units.

In evaluating the drainage channels in the area, secondary data is needed as supporting data for this research. As for the secondary data used, it involves taking annual daily rainfall data from 2011-2024 obtained from the West Kalimantan River Basin Agency, location sketches obtained from Google Earth, and related literature such as SNI 02-2406-1991 on General Urban Drainage Planning Procedures. As for the flowchart in this study, it is as follows :

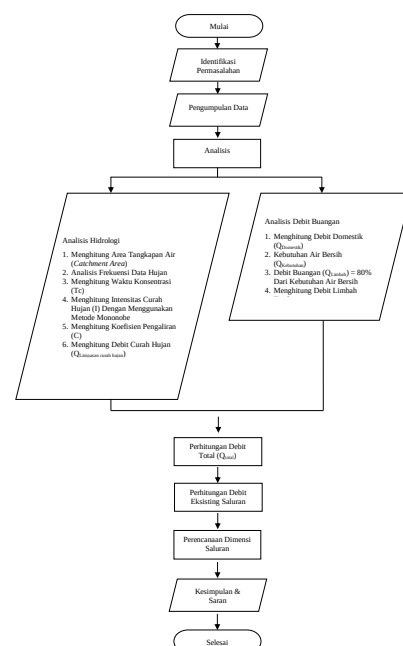


Figure 3. Research Flowchart

RESULT AND DISCUSSION

1. Hydrological Analysis

In evaluating a drainage channel in urban areas, a hydrological analysis needs to be carried out. In this study, the maximum annual daily rainfall data over 14 years from 2011-2024, obtained from the West Kalimantan River Basin Agency, was used. The purpose of this hydrological analysis is to determine the return period that will be used in analyzing the maximum rainfall intensity. In this study, a statistical approach was conducted by looking at the frequency distribution analysis suitable for calculating the return period. As for the rainfall data obtained from BMKG Pontianak City, it is first grouped from the largest annual maximum daily rainfall to the smallest. The highest daily rainfall in Pontianak according to BMKG Pontianak data was in 2022, with a maximum daily rainfall of 256 mm. Meanwhile, the lowest daily rainfall in Pontianak occurred in 2015, with a maximum daily rainfall of 79 mm.

The rainfall data can be seen in the following table.

Tabel 1. Maximum Daily Rainfall Data for Statistical Parameters

NO	Tahun	Tinggi Hujan (x)	(x-x) ²	(x-x) ³	(x-x) ⁴
1	2022	256	12.624,1280	1.418.410,9030	159.368.596,4240
2	2021	200	3.176,1280	178.997,4740	10.087.786,2200
3	2024	185	1.710,4130	70.737,8060	2.925.513,5380
4	2023	175	983,2700	30.832,5510	966.820,6960
5	2017	165	456,1280	9.741,5810	208.052,3430
6	2014	155	128,9850	1.464,8980	16.637,0510
7	2020	154	107,2700	1.111,0150	11.506,9400
8	2012	118	657,5560	-16.861,6180	432.380,0540
9	2018	115	820,4130	-23.498,9800	673.077,9260
10	2013	112	1.001,2700	-31.683,0560	1.002.542,4300
11	2019	112	1.001,2700	-31.683,0560	1.002.542,4300
12	2011	100	1.904,6990	-83.126,5050	3.627.878,2030
13	2016	85	3.438,9850	-20.1671,8880	11.826.615,7250
14	2015	79	4.178,6990	-270.123,0410	17.461.525,1620
n = 14		xi = 2011	32.189,2140	1.052.648,0820	209.611.475,1430

Source : BMKG Kota Pontianak

Next, calculations were done to find the statistical parameter values such as the mean ($\bar{X}$), standard deviation (SX), coefficient of variation (CV), skewness coefficient (CS), and kurtosis coefficient (CK).

1. Calculating the mean value ($\bar{x}$)

$$\bar{x} = \frac{\sum X_i}{n} = \frac{2011}{14} = 143,6430$$

2. Calculating the standard deviation (SX)

$$S_x = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}} = \sqrt{\frac{32.189,214}{14-1}} = 49,7600$$

3. Calculating the coefficient of variation (CV)

$$C_v = \frac{S_x}{\bar{X}} = \frac{49,760}{143,643} = 0,3640$$

4. Calculating the skewness coefficient (CS)

$$C_s = \frac{n \cdot \sum (X_i - \bar{X})^3}{(n-1)(n-2)S_x^3} = \frac{14 \cdot 1.052.648,0820}{(14-1) \cdot (14-2) \cdot 49,7600^3} = 0,7670$$

5. Calculating the kurtosis coefficient (CK)

$$C_K = \frac{n^2 \sum (X_i - \bar{X})^4}{(n-1)(n-2)(n-3)S_D^4} = \frac{14^2 \cdot 209.611.475,1430}{(14-1) \cdot (14-2) \cdot (14-3) \cdot 49,7600^4} = 3,9050$$

To decide which distribution method will be used in the rainfall frequency analysis in the next stage, the calculated statistical parameter values are then compared with the characteristics of the frequency distribution

The statistical parameter tests for the frequency distribution analysis are as follows:

Table 2. Statistical Parameter Test Results

Distribution Methods	Requirement	Result	Description
Distribusi Normal	$C_s \approx 0$ $C_K \approx 3$	$C_s = 0,7670$ $C_K = 3,9050$	Fail
Distribusi Gumbel	$C_s = 1,14$ $C_K = 5,4$	$C_s = 0,7670$ $C_K = 3,9050$	Fail
Distribusi Log Normal	$C_s = 1,140$ $C_K = 5,397$	$C_s = 0,7670$ $C_K = 3,9050$	Fail
Distribusi Log Pearson Tipe III	Besides the above values	$C_s = 0,7670$ $C_K = 3,9050$	Succesful

Source : Calculation Data

So from the table above, the log Pearson III distribution method is used to calculate the return period because the Cs and Ck values are met. In the recalculation period for organizing the area in the Griya Ampera Pontianak housing complex using frequency distribution analysis with the Log Pearson III method. The frequency distribution analysis table is as

follows :

Table 3. Frequency Distribution Analysis of Data Using the Log Pearson III Method

NO	Xi	Log Xi	Log (Xi - $\bar{x}$) ²	xi log (Xi - $\bar{x}$) ³
1	256	2,4082	0,0753	0,0206
2	200	2,3010	0,0279	0,0046
3	185	2,2671	0,0177	0,0023
4	175	2,2430	0,0119	0,0013
5	165	2,2174	0,0070	0,0005
6	155	2,1903	0,0032	0,0001
7	154	2,1875	0,0028	0,0001
8	118	2,0718	0,0038	-0,0002
9	115	2,0607	0,0053	-0,0003
10	112	2,0492	0,0071	-0,0006
11	112	2,0492	0,0071	-0,0006
12	100	2,0000	0,0179	-0,0023
13	85	1,9294	0,0417	-0,0085
14	79	1,8976	0,0557	-0,0131
Jumlah Log		29,8728	0,2850	0,0040
Log rata - rata		2,1337		
S Log x		0,1480		
Cs		0,1111		

Source : Calculation Data

2. Renewal Period Criteria

In the hydrological analysis to determine the return period in the calculation of surface runoff discharge in the Griya Ampera Ujung Pandang residential area, a 2-year return period is used. The hydrological analysis to calculate the maximum daily rainfall return period uses the log Pearson II. As for the calculation of the 2-year renewal period, it is as follows:

$$\begin{aligned}\log X_T &= \log \bar{x} + K_T \cdot (S_{\log x}) = \\ &= (2,1340 + 0,1670 \cdot 0,1480) \\ &= \log 2,1590 \\ &= 10^{2,1590} = 144,2110 \text{ mm}\end{aligned}$$

From the calculation of rainfall height (XT) for a 2-year return period (T) using the Log Pearson Type III distribution method, the XT value is 144.2110 mm. This planned rainfall value of 144.2110 mm is an estimate of the maximum daily rainfall that is likely to occur once in a 2-year return period based on the Log Pearson Type III distribution analysis. This value is then used as the basis for calculating the design rainfall intensity in the next stage.

3. Calculating the Concentration Time (Tc)

The flow concentration time was taken from the farthest point of the drainage channel in the Griya Ampera Pontianak residential area. The flow concentration time in this area was found to be 9.7520 minutes or 0.1630 hours from the upstream to downstream of the drainage channel.

4 Calculation of Rainfall Intensity (I)

The calculation of rainfall intensity (I) using the Mononobe method. The data used to analyze in this calculation are:

R = Maximum daily rainfall over a 24-hour period (R_{24}) = X_{T10} = 144,2210 mm

Tc = Duration of concentration = 0,1630 hours

Therefore,

$$\begin{aligned}I &= \frac{R_{24}}{24} \times \left(\frac{24}{T_c}\right)^{2/3} \\ &= \frac{144,2110}{24} \times \left(\frac{24}{0,1630}\right)^{2/3} = 167,547 \text{ mm/hours}\end{aligned}$$

A rainfall intensity of 167.5470 mm/hour indicates a fairly high rainfall rate over a concentration time of 0.1630 hours. The shorter the concentration time of a drainage area, the higher the resulting rainfall intensity, because this rainwater is then used as one of the main variables in calculating the design discharge using the Rational Method.

5. Calculation of the Flow Coefficient (C)

Based on observations of the land cover in the residential area of Griya Ampera complex in Pontianak City through direct observation, it was found that the land cover in the area consists of asphalt and concrete. From the field observations, to calculate the runoff coefficient (C), the calculation is carried out as follows:

$$C = \frac{\sum_{i=1}^n A_i C_i}{\sum_{i=1}^n A_i}$$

$$C = 0,4700$$

From the data of the existing study above, an average runoff coefficient (C) of 0.4700 was obtained, which means that the average runoff that occurs is 47%.

6. Rainfall Runoff Calculation Using the Rational Method (Rainfall Runoff Q)

For the calculation of the design discharge (stormwater runoff), it is done after determining the runoff coefficient (C), the rainfall intensity (I) in mm/hour, and the catchment area in km². In this study, the design discharge is calculated using the rational method because this method is suitable for small-scale catchment areas, generally less than 300 hectares. The catchment area of the Griya Ampera Complex, which is only 1,950 hectares, is well below that limit, so the basic assumption of the Rational Method that rainfall intensity occurs evenly across the entire catchment area during the concentration time is still relevant for application at this research site. This rainfall discharge calculation is carried out to find out the amount of rainfall in cubic meters per second. Since the units vary, they are standardized by converting mm/hour and km² into m³/s by multiplying by 0.2780. The rainfall discharge can then be calculated, based on the following equation:

$$Q = 0,2780 \cdot C \cdot I \cdot A$$

$$Q = 0,2780 \cdot 0,4700 \cdot 167,5470 \cdot 0,0196$$

$$Q = 0,4290 \text{ m}^3/\text{detik}$$

From the results of the hydrology analysis to determine the rainfall runoff discharge (Q rainfall runoff) with a 2-year return period, a value of 0.4290 m³/sec was obtained. This rainfall runoff discharge value of 0.4290 m³/sec represents the amount of rainwater that could potentially flow into the drainage system during rainfall with a 2-year return period. This value is then added to the household waste discharge to get the total discharge that the Griya Ampera Complex drainage system must be able to handle.

7. Waste Discharge Flow Calculation (Q Waste)

In determining domestic wastewater flow, it is obtained from the amount of clean water used by taking into account water loss factors. The wastewater flow rate is equal to 80% of the user's clean water consumption. The waste flow rate (Qlimbah) obtained is 0.0004 m³/s, and the reserve flow rate (Qcadangan) is

0.0001 m³/s, with the total waste being 0.0005 m³/s. For the next calculations, Qlimbah will be used based on the assumption that out of 100% of clean water usage, 80% flows into the channels while 20% does not flow into the channels due to reasons like drinking, water absorption, and so on. So, Qlimbah is 0.0004 m³/s.

8. Total Runoff and Waste Discharge (Q tot)

Because the drainage in the Griya Ampera Complex serves to carry several types of discharge, the total flow calculation involves adding the wastewater flow at an 80% service level of 0.0004 m³/s and the rainfall flow of 0.4290 m³/s, so the total flow that the drainage in the Griya Ampera Complex must handle is $Q_{\text{Total}} = Q_{\text{rain runoff}} + Q_{\text{wastewater}} = (0.4290 \text{ m}^3/\text{s} + 0.0004 \text{ m}^3/\text{s}) = 0.4294 \text{ m}^3/\text{s}$. This total flow of 0.4294 m³/s is the accumulation of two runoff sources that go into the same drainage channel, namely rainwater and household wastewater. This value is the main reference to assess whether the existing channel can still accommodate the current flow and also serves as the basis for planning the dimensions of a new channel if the existing one is found unable to handle it.

9. Existing Channel Flow Calculation

The discharge of the existing flow is calculated to determine the discharge of the capacity of the existing channel, which can be calculated after knowing the wet area (A) with the channel speed (V) where the larger the wet area and the flow speed, the greater the flow discharge and vice versa. The calculation of the existing flow discharge (Q) can be calculated using the equation:

$$Q = A \cdot V$$

From the calculation of the existing discharge that can be handled by the drainage channels in the Griya Ampera Complex, it is obtained that the front drainage with a width of 33 cm can handle 0.0244 m³/s, and the back drainage with a width of 50 cm can handle 0.1521 m³/s. So, when compared to the total discharge that has been calculated at 0.4294 m³/s, it can be concluded that the drainage in the Griya Ampera Complex is not capable of handling the total discharge. This is the main reason for the flooding in the Griya Ampera Complex.

Therefore, the drainage channel dimensions in the Griya Ampera Complex need to be reorganized.

10. Reorganizing Drainage Channels

Because the existing flow of the old channel in the Griya Ampera Complex on Ujung Pandang II Street can't handle the total flow, the channel dimensions will be rearranged. The channel chosen for planning is rectangular, and the width of the drainage channel will follow the width of the back drainage, which is 50 cm. This width adjustment is based on the consideration that the back drainage is an existing channel that can't be widened due to land limitations. So from the calculations above, we get that the optimal drainage channels on both sides of the Griya Ampera Pontianak complex road to handle runoff rainfall are as follows:

Table 4. Recap of the calculation results and the optimal drainage channel dimensions at Griya Ampera Pontianak Complex

Qr (Runoff Discharge)	0,4294 m^3/s
A square (Cross-sectional area of a square channel)	0,7794 m^2
B (channel width)	0,5 meters
H (channel depth)	0,6 meters
W (Channel head height)	0,4 meters

Based on the results of the channel dimension planning, it can be concluded that the drainage dimensions meet the required standards. Therefore, the arrangement of the drainage channel dimensions at Griya Ampera Complex on Ujung Pandang II Street is considered safe, capable of functioning well, and suitable to be built on the site. For the cross-sectional image of the drainage channel in the Griya Ampera complex in Pontianak, it is as follows:

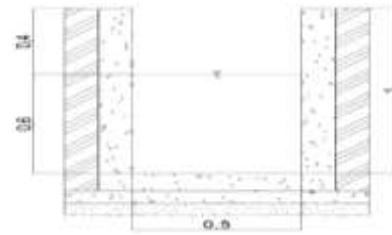


Figure 4 Optimal Drainage Channel Cross-Section for Griya Ampera Complex Pontianak

As for the drainage channel material used for the drainage arrangement in the Griya Ampera Ujung Pandang complex in Pontianak, it is reinforced concrete with a rectangular cross-section.

CONCLUSION

Based on the research results, the existing channel capacity is proven to be smaller than the planned flow, so it cannot convey runoff optimally. The planned dimensions can meet the hydraulic capacity, so they can be used as an alternative for organizing drainage channels in the study area by changing the channel cross-section to a rectangular shape with a width of 0.5 m, a depth of 0.6 m, and a freeboard height of 0.4 m. With this change in the drainage channel cross-section, the amount of surface runoff that can be accommodated and conveyed through the drainage channel is 0.4294 cubic meters per second.

ACKNOWLEDGMENTS

A thank you as a form of appreciation to the Department of Civil Engineering at Pontianak State Polytechnic for supporting this research.

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