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Evaluation of Lembang Urban Drainage System Using Drains Application

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ABSTRACT

Flood is one of the main problems faced by urban areas, including Lembang. This condition often results in material losses and disrupts social and economic activities of the community. Flooding in urban areas generally occurs due to water overflow that cannot be contained by the urban drainage system such as rivers, culverts, ditches, and other water channels. Lembang, which is located in a highland area with high rainfall, is often inundated every time there is heavy rain, especially around Jalan Panorama, Lembang. Therefore, analysis and evaluation are needed to determine the causes of flooding on Jalan Panorama, Lembang based on flood discharge analysis and hydraulic analysis. From the analysis and evaluation of the urban drainage system in Lembang, it was found that at the design flood discharge for a 5-year return period (Q5), there are 10 segments of channels that cannot accommodate the flood discharge. To address this capacity issue, an improvement plan was developed through two proposed recommendations. The first recommendation is enlarging the channel dimensions using a U-ditch while maintaining the existing channel slope. The second recommendation is increasing the channel slope by deepening the channel and applying a cement plaster lining. Following the redesign process implementing these approaches, it is proven that the channels are now capable of accommodating the 5-year design flood discharge (Q5).

Key Words: Flood, Rainfall, Lembang Urban Drainage System

INTRODUCTION

Indonesia, as a tropical country, has only two seasons: the rainy season and the dry season. Based on data from the Meteorology, Climatology, and Geophysical Agency (BMKG, 2023), the rainy season is determined by rainfall that reaches or exceeds 50 millimeters in one dasarian (a 10-day period) and is followed by several subsequent 10-day periods. The rainy season in Indonesia is often associated with flooding in urban areas, which is exacerbated by inadequate drainage system conditions. The word "drainage" comes from a term meaning to control, drain, or discharge water. It refers to a system designed to handle unwanted excess water, whether flowing on the ground surface or underground. Urban drainage is a crucial aspect in the management of the environment and infrastructure within a residential area. A good drainage system is expected to effectively channel rainwater and domestic wastewater, thereby reducing negative impacts such as waterlogging and flooding.

One of the main challenges faced by urban areas is flooding, including in Lembang. This condition often results in material losses and disrupts the social and economic activities of the community. Therefore, a comprehensive understanding of the condition and performance of the drainage system is highly essential in preparing follow-up plans and flood mitigation measures. Waterlogging in urban areas usually occurs due to water overflow that cannot be accommodated by drainage systems such as rivers, culverts, ditches, and other waterways. According to Birhanu (2016), urban flooding is worsened by heavy rainfall and extreme climate events, as well as significant changes in land use. During the rainy season, high rainfall causes the volume of water entering the drainage system, such as rivers, to exceed its planned capacity. If the water volume overtops the riverbanks, flooding or waterlogging will occur, including the possibility of river embankment breaches.

Waterlogging that occurs in urban areas during the rainy season causes massive losses, both materially and in the form of disrupted business and social activities. The causes of this inundation vary, including the degradation of urban drainage system service quality over time and failures in its management. Therefore, it is necessary to improve the function of the urban drainage system so that it can return to or approach its original condition to reduce waterlogging (Andayani & Yuwono, 2012).

Lembang, which is located at a high altitude with high rainfall, faces challenges related to its drainage system. Kartiko (2018) stated that high rainfall intensity can cause existing drainage systems to be unable to accommodate the excess water volume, resulting in floods and waterlogging. This condition is aggravated by uncontrolled development, which reduces water catchment areas. According to Palawa'ae et al. (2024), an effective urban drainage system must be able to manage surface runoff while minimizing the risks of flooding and waterlogging. An analysis of drainage channel capacity must be conducted to determine whether the channels are still capable of accommodating the water flow generated by high rainfall or if they require repairs and capacity upgrades. This research aims to determine the causes of waterlogging on Jalan Panorama, Lembang, based on flood discharge analysis and hydraulic analysis.

Similar research has been conducted previously, such as by Setiawan (2016) in Garut, Lukman (2018) in Medan, Budiman (2021) in Surabaya, Widodo (2015) and Jifa (2019) in Malang, Indriani (2022) in Bojonegoro, Adhari (2023) in Sleman, Hapsha and Juwana (2023) in Margaasih, Nifen (2023) in Padang, Sabono (2024) in Ambon, Imamuddin (2021) in North Jakarta, Yulius (2018) in South Tangerang, Dwijaya (2018) in Lamandau, Arifin (2018) in Purwokerto, Putri (2019) in Tarakan, Kurniawan (2023) in Tegal, Alfin (2025) in Tasikmalaya, and Cahyono (2025) in Mojokerto.

The difference between previous research and what will be conducted in this study lies in the flood calculation, which utilizes the DRAINS application during the analysis process. This evaluation will consider factors such as design, drainage infrastructure capacity, and rainfall intensity, which will then be analyzed using the DRAINS application. Thus, the results of this research are expected to provide concrete recommendations and solutions for sustainable urban drainage improvements, especially in Lembang.

LITERATURE REVIEW

The word "drainase" originates from the English word "drainage," which refers to a facility or means to remove excess water or waste. According to the Kamus Besar Bahasa Indonesia (Great Dictionary of the Indonesian Language), drainage is defined as the draining or channeling of water. Suripin (2004:7) defines drainage as a technical measure to reduce excess water in a specific area so that the area can function properly. This excess water can originate from rainfall, seepage, or surplus irrigation water. The removal of this excess water can be conducted through surface or subsurface channels.

According to Kodoatie (2008:102), drainage is a system that channels surface rainwater through collection channels into larger waterways. Similarly, Suripin (2004:8) states that drainage constitutes a series of hydraulic structures functioning to reduce or discharge excess water from an area or land, enabling the land to function optimally.

According to Suripin (2004), flooding occurs when water cannot be accommodated within drainage channels, causing the flow to be obstructed and inundating the surrounding areas. In such cases, water can submerge parts of, or even entire, plains that are normally dry.

Furthermore, Suripin (2004) defines a flood as a condition in which water exceeds the capacity of a drainage channel (riverbed) or the water flow is impeded within the channel, causing it to overflow and inundate adjacent areas (floodplains).

According to Kodoatie and Sugiyanto (2002), the causes of flooding can be categorized into two types: natural flooding and human-induced flooding. Several factors influence natural flooding, including physiography, erosion and sedimentation, river and drainage capacities, and tidal influences. On the other hand, human-induced flooding is driven by factors such as land-use changes, indiscriminate waste disposal, and improper flood control system planning.

DRAINS is a hydrological and hydraulic modeling software developed by Watercom, used for designing and analyzing urban drainage systems. This software is capable of simulating rainfall patterns into 2D surface runoff hydrographs across various catchment scales. By integrating standard methods such as the rational method, ARR (Australian Rainfall and Runoff), and ILSAX, DRAINS can model water flow routing through pipe networks, open channels, culverts, and retention ponds. Furthermore, the application supports integration with CAD and GIS software, making it a comprehensive tool for water infrastructure design.

RESEARCH METHODOLOGY

Lembang is a sub-district located at geographical coordinates spanning from latitude 6°1.031' to 7°3.73' South and longitude 107°1.10' to 107°4.40' East, situated within West Bandung Regency. Rainfall data was obtained from three rainfall stations, namely the Bandung Geophysics Station, the Dago Pakar Rainfall Post, and the Margahayu I – Lembang Rainfall Post.

This study utilized a quantitative descriptive research method. Quantitative descriptive research uses quantitative data such as numbers, statistics, or other measurement results to objectively depict, describe, and explain a phenomenon.

The data utilized in this study consist of primary and secondary data. Primary data, comprising channel conditions and dimensions, were obtained through direct field surveys. Secondary data, consisting of topographic maps and rainfall data, were acquired from various data sources. Data sources refer to the origins or institutions from which data can be obtained based on the type of data required to solve the research problem. The data sources in this study include the Geospatial Information Agency (BIG), the Meteorology, Climatology, and Geophysical Agency (BMKG), and the Citarum River Basin Organization (BBWS Citarum). The rainfall data used represents the highest daily rainfall over the past ten years, specifically spanning from 2013 to 2022.

To determine the highest amount of rainfall at the study location, daily rainfall data were collected from the BMKG Bandung rainfall station and the BBWS Citarum rainfall post. Subsequently, the Thiessen Polygon method was used to calculate the areal rainfall from the maximum rainfall data, an illustration of which can be seen in Figure 1.

To generate the design rainfall, frequency distribution analysis was conducted using statistical parameters to calculate the coefficients of skewness and kurtosis. The frequency distribution methods used included the Gumbel Distribution Method, Normal Distribution Method, Log-Normal Distribution Method, and Log-Pearson Type III Distribution Method. These distribution methods were applied after the rainfall data passed the consistency test. This distribution analysis was performed to calculate the design rainfall values.

To determine whether the applied distribution is acceptable or not, a goodness-of-fit test must be conducted throughout the distribution analysis process. This goodness-of-fit test utilized the Chi-Square test

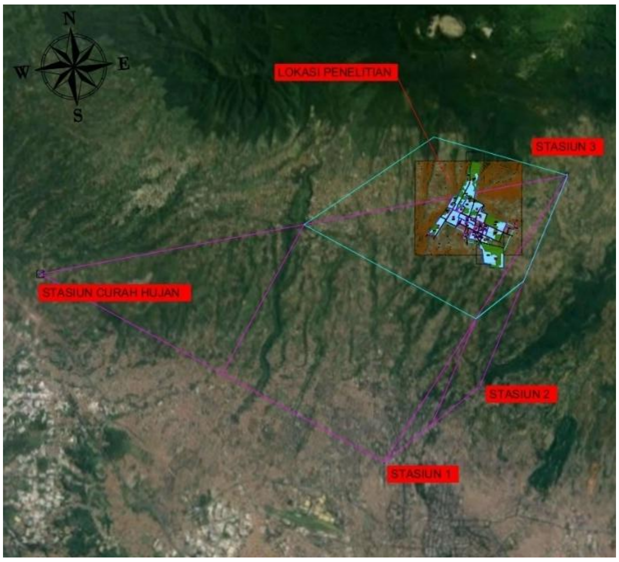

Figure 1. Research Location and Thiessen Polygons

After the design rainfall data passes the goodness-of-fit test, the calculation or analysis of hourly rainfall using the Mononobe method is conducted to determine the characteristics or pattern of rainfall intensity. Once the characteristics or pattern of rainfall intensity are identified, the subsequent step is the analysis of the design flood discharge using a non-hydrograph method. The magnitude of the flood discharge is calculated using the Modified Rational Method.

$$Q = 0.00278 \times Cs \times C \times I \times A$$

Where,

Q = peak discharge (m^3/s)

I = rainfall intensity (mm/hour)

A = catchment area (ha)

Cs = storage coefficient

C = runoff coefficient

To calculate the storage capacity of a drainage channel, formulas involving channel dimensions, runoff coefficients, and land slope are utilized. The process of determining the drainage channel capacity includes calculating the design discharge, the actual discharge, and comparing the two. The channel capacity can be calculated using the following formula:

$$Q = A \times v$$

where,

Q = flow discharge (m^3/s)

v = average velocity in the channel (m/s)

A = wetted cross-sectional area (m^2)

The average flow velocity can be calculated using the following formula:

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

where,

V = average flow velocity

n = Manning's roughness coefficient

R = hydraulic radius

S = channel bed slope

After the planning and approach analysis are completed, the DRAINS application is utilized to model the data in accordance with the design. Subsequently, to observe the conditions of the specific sections under review, an analysis of the DRAINS simulation results is conducted. The final stage involves performing the evaluation calculations for the drainage system.

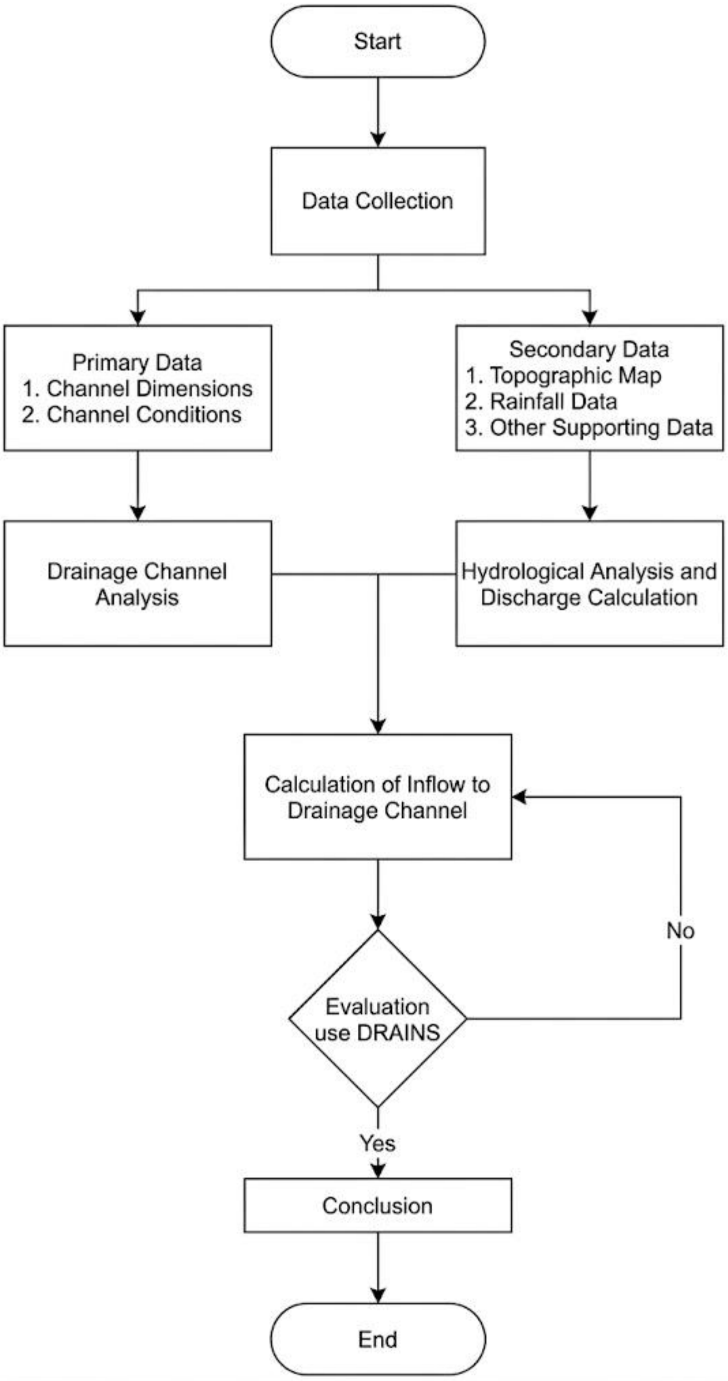

Figure 2. Flowchart

ANALYSIS AND DISCUSSION

Rainfall Data

Table 1. Maximum Annual Rainfall Data

Year	Bandung Geophysics Station	Dago Pakar Rainfall Post	Margahayu I - Lembang Rainfall Post
2013	68	83	87
2014	62	79	56
2015	78	85	39
2016	113	86	33
2017	74	187	80
2018	85	55	52
2019	83	81	45
2020	160	85	50
2021	77	75	44
2022	71	44	42
Max	160	187	87

Source: BMKG and BBWS Citarum

Catchment Area Delineation

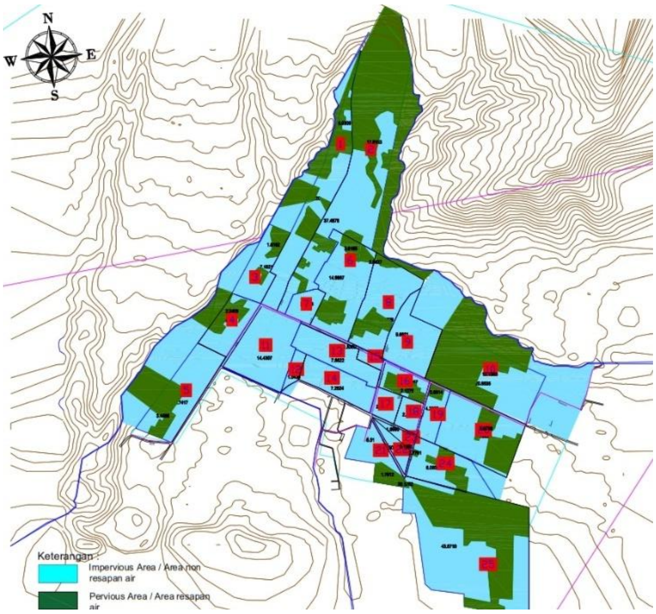

Figure 3. Sub-Catchment Division

Average Areal Rainfall Analysis

The Thiessen method is utilized to calculate the average areal rainfall. The area of influence of each observation point is taken into account. This approach is carried out by incorporating the regional influence factor represented by the rain gauge station, which is known as the Thiessen coefficient or weighting factor.

Rainfall Frequency Analysis

Table 2.Summary of Rainfall Frequency Parameter Calculations

Parameter	Value
Mean Value ($\bar{X}$)	52.54
Standard deviation (S)	17.559
Coefficient of variation (Cv)	0.334
Coefficient of skewness (Cs)	1.682
Coefficient of kurtosis (Ck)	4.502

Design Rainfall Calculation

Table 3. Summary of Rainfall Calculation Result

No.	Methode Type	Return Period (year)					
		2 mm	5 mm	10 mm	25 mm	50 mm	100 mm
1	Gumbel	50.16	71.11	84.99	102.52	115.53	128.44
2	Normal	52.54	67.29	75.01	82.56	88.53	93.45
3	Log Normal	50.24	64.99	74.37	84.85	94.16	102.60
4	Log Person III	48.38	63.92	75.62	92.12	105.70	120.45

Based on the calculated statistical parameters, the data accepted are the results from the Log Pearson Type III distribution method. Consequently, for subsequent calculations, the data used are the results obtained from the Log Pearson Type III distribution method.

Calculation of Non-Hydrograph Design Flood Discharge

In the calculation of the non-hydrograph design flood discharge, the modified rational method is utilized. Prior to this, the runoff coefficient for each subcatchment area was calculated. The application of this runoff coefficient is subsequently divided into two categories: areas where rainwater can infiltrate the soil (pervious areas) and areas where rainwater cannot infiltrate the soil (impervious areas). A runoff coefficient of 0.70 is applied to pervious areas, whereas a runoff coefficient of 0.35 is applied to impervious areas.

Table 4. Calculation of Non-Hydrograph Design Flood Discharge for 2-Year and 5-Year Return Periods

Name Area	A	Cs	C	I_2	I_5	Q_2	Q_5
A1	16.62 Ha	0.82	0.47	16.77	22.16	0.302	0.399
A2	37.49 Ha	0.85	0.52	16.77	22.16	0.769	1.016
A3	7.18 Ha	0.72	0.44	16.77	22.16	0.106	0.140
A4	6.64 Ha	0.91	0.46	16.77	22.16	0.130	0.171
A5	12.74 Ha	0.97	0.44	16.77	22.16	0.256	0.339
A6	14.99 Ha	0.78	0.44	16.77	22.16	0.238	0.315
A7	3.09 Ha	0.45	0.35	16.77	22.16	0.023	0.030
A8	13.17 Ha	0.81	0.43	16.77	22.16	0.213	0.282
A9	9.66 Ha	0.69	0.35	16.77	22.16	0.109	0.144
A10	20.55 Ha	0.92	0.56	16.77	22.16	0.492	0.650
A11	14.43 Ha	0.73	0.35	16.77	22.16	0.171	0.226
A12	1.54 Ha	0.91	0.35	16.77	22.16	0.023	0.030
A13	7.88 Ha	0.68	0.35	16.77	22.16	0.087	0.115
A14	7.26 Ha	0.69	0.35	16.77	22.16	0.082	0.108
A15	1.53 Ha	0.64	0.35	16.77	22.16	0.016	0.021
A16	4.50 Ha	0.86	0.51	16.77	22.16	0.093	0.123

Name Area	A	Cs	C	I_2	I_5	Q_2	Q_5
A17	2.71 Ha	0.70	0.35	16.77	22.16	0.031	0.041
A18	2.53 Ha	0.68	0.35	16.77	22.16	0.028	0.037
A19	4.34 Ha	0.80	0.40	16.77	22.16	0.065	0.086
A20	15.88 Ha	0.89	0.46	16.77	22.16	0.303	0.401
A21	6.51 Ha	0.98	0.44	16.77	22.16	0.131	0.173
A22	2.50 Ha	0.98	0.37	16.77	22.16	0.042	0.056
A23	1.60 Ha	0.68	0.35	16.77	22.16	0.018	0.024
A24	8.08 Ha	0.84	0.47	16.77	22.16	0.149	0.197
A25	43.87 Ha	0.96	0.51	16.77	22.16	1.014	1.339

Channel Data

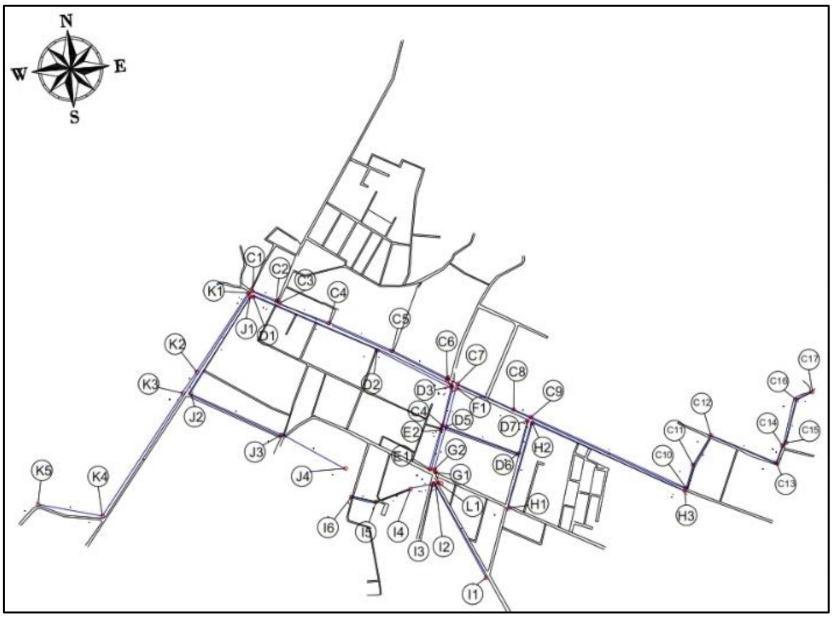

Figure 4. Channel Map and Control Point

Channel Capacity

Table 5. Channel Capacity Calculation

No.	Channel	Cross Sectional Area (m^2)	Average Flow Velocity (m/s)	Channel Capacity (m^3/s)
1	C1-C2	0.64	5.39	3.45
2	C2-C3	0.64	3.81	2.44
3	C3-C4	0.64	4.45	2.85
4	C4-C5	0.64	5.28	3.38
5	C5-C6	0.64	5.08	3.25
6	C6-C7	0.64	3.00	1.92
7	C7-C8	0.63	3.61	2.27
8	C8-C9	0.63	3.15	1.98
9	C9-C10	0.48	3.24	1.55
10	C10-C11	1	4.25	4.25
11	C11-C12	1	6.08	6.08
12	C12-C13	1.6	2.92	4.67
13	C13-C14	1.6	7.97	12.75

No.	Channel	Cross Sectional Area (m^2)	Average Flow Velocity (m/s)	Channel Capacity (m^3/s)
14	C14-C15	1.6	7.27	11.63
15	C15-C16	1.6	12.01	19.21
16	C16-C17	1.6	10.59	16.94
17	D1-D2	0.64	4.83	3.09
18	D2-D3	0.64	5.57	3.56
19	D3-D4	1	3.55	3.55
20	D4-D5	1	3.90	3.90
21	D5-D6	0.64	1.44	0.92
22	D6-D7	1	5.97	5.97
23	D7-C9	1	6.54	6.54
24	E1-E2	1	1.17	1.17
25	E2-D4	1	3.38	3.38
26	F1-D5	1	4.26	4.26
27	G1-G2	1	0.37	0.37
28	G2-D5	1	0.94	0.94
29	H1-H2	0.64	3.17	2.03
30	H2-H3	0.64	3.75	2.40
31	H3-C10	1	0.28	0.28
32	I1-I2	0.24	3.54	0.85
33	I2-I3	0.64	1.06	0.68
34	I3-I4	0.64	0.87	0.55
35	I4-I5	0.64	6.29	4.03
36	I5-I6	10	7.72	77.22
37	L1-I2	0.64	2.18	1.40
38	J1-J2	0.64	4.38	2.80
39	J2-J3	0.48	3.13	1.50
40	J3-J4	0.48	3.72	1.79
41	K1-K2	0.64	4.63	2.96
42	K2-K3	0.64	5.76	3.69
43	K3-K4	0.54	3.13	1.69
44	K4-K5	0.54	4.61	2.49

Drainage Performance Evaluation

Table 6. Comparison Calculation of Existing Channel Capacity and Q5 Design Flood Discharge

No	Channel	Channel Capacity (m^3/s)	Design Flood Discharge Q_5 (m^3/s)	DRAINS Q_5 (m^3/s)	Capacity Differenc with DRAINS Q_5 (m^3/s)	Conclusion Q_5
1	C1-C2	3.45	1.339	0.355	3.10	Sufficient
2	C2-C3	2.44	1.738	0.894	1.54	Sufficient
3	C3-C4	2.85	1.824	1.88	0.97	Sufficient
4	C4-C5	3.38	3.163	2.08	1.30	Sufficient
5	C5-C6	3.25	4.502	2.73	0.52	Sufficient
6	C6-C7	1.92	5.841	1.87	0.05	Sufficient
7	C7-C8	2.27	5.841	1.87	0.40	Sufficient
8	C8-C9	1.98	7.180	2.67	-0.69	Insufficient
9	C9-C10	1.55	7.649	4.36	-2.81	Insufficient
10	C10-C11	4.25	8.731	6.06	-1.81	Insufficient
11	C11-C12	6.08	8.731	6.07	0.01	Sufficient

No	Channel	Channel Capacity (m³/s)	Design Flood Discharge Q_5 (m³/s)	DRAINS Q_5 (m³/s)	Capacity Differenc with DRAINS Q_5 (m³/s)	Conclusion Q_5
12	C12-C13	4.67	8.731	6.13	-1.46	Insufficient
13	C13-C14	12.75	8.731	6.12	6.63	Sufficient
14	C14-C15	11.63	8.731	6.1	5.53	Sufficient
15	C15-C16	19.21	8.731	6.27	12.94	Sufficient
16	C16-C17	16.94	8.731	6.65	10.29	Sufficient
17	D1-D2	3.09	0.000	0	3.09	Sufficient
18	D2-D3	3.56	0.000	0	3.56	Sufficient
19	D3-D4	3.55	0.021	0.411	3.14	Sufficient
20	D4-D5	3.90	0.245	1.51	2.39	Sufficient
21	D5-D6	0.92	0.309	1.49	-0.57	Insufficient
22	D6-D7	5.97	0.346	1.7	4.27	Sufficient
23	D7-C9	6.54	0.469	1.76	4.78	Sufficient
24	E1-E2	1.17	0.108	0.56	0.61	Sufficient
25	E2-D4	3.38	0.224	1.2	2.18	Sufficient
26	F1-D5	4.26	0.000	0	4.26	Sufficient
27	G1-G2	0.37	0.024	0.41	-0.04	Insufficient
28	G2-D5	0.94	0.064	0.0535	0.89	Sufficient
29	H1-H2	2.03	0.197	0.294	1.73	Sufficient
30	H2-H3	2.40	0.282	0.518	1.88	Sufficient
31	H3-C10	0.28	0.683	1.21	-0.93	Insufficient
32	I1-I2	0.85	1.339	2.38	-1.53	Insufficient

Based on the calculation results in Table above, ten channel segments are unable to meet the capacity required to accommodate the five-year return period (Q5) design flood discharge from their respective service areas. These channels are:

1. Channel C8-C9 (Road Maribaya)
2. Channel C9-C10 (Road Maribaya)
3. Channel C10-C11 (Road Cendana)
4. Channel C12-C13 (Road Pangragajian)
5. Channel D5-D6 (Road Kp. Gunungsari)
6. Channel G1-G2 (Road Panorama)
7. Channel H3-C10 (Road Maribaya)
8. Channel I1-I2 (Road Adiwarta)
9. Channel I2-I3 (Road Cijeruk)
10. Channel I3-I4 (Road Cijeruk)

The channel segments that currently cannot accommodate storm runoff will result in waterlogging within their service areas.

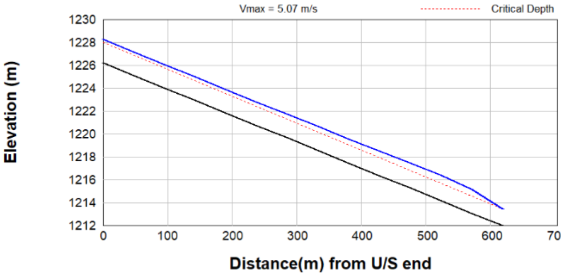

Figure 5. Long Section of Segment C9-C10 Q_5

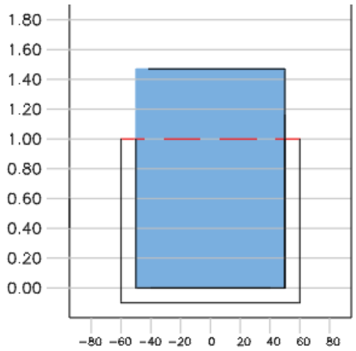

Figure 6. Cross Section at Control Point C10 Q_5

From the long section above, it is evident that the capacity of segment C9-C10 is insufficient for the design flood discharge.

Recommendation 1

In the first recommendation, the design slope of the new channel will follow the existing channel's slope, and the new channel will be designed using a U-ditch with larger dimensions than the existing channel.

Table 7. Calculation of Design Channel Dimensions

Segment	Discharge Q_5 (m^3/s)	Design Width (m)	Design Depth (m)	Design Area (m^2)	Design Capacity (m^3/s)	Excess Capacity (m^3/s)
C8-C9	2,67	1	1	1	4,96	2,29
C9-C10	4,36	1	1	1	5,61	1,25
C10-C11	6,06	1	1,2	1,2	6,92	0,86
C12-C13	6,13	1,2	1,6	1,92	8,01	1,89
D5-D6	1,49	1	1	1	2,18	0,70
G1-G2	0,41	1,2	1,2	1,44	0,60	0,19
H3-C10	1,21	1,6	1,6	2,56	1,29	0,09
I1-I2	2,38	0,8	0,8	0,64	3,97	1,60
I2-I3	2,4	1,2	1,2	1,44	2,60	0,20
I3-I4	1,47	1	1,2	1,2	1,63	0,17

Based on Table above, it can be concluded that the designed channel is capable of accommodating the 5-year design flood discharge (Q5).

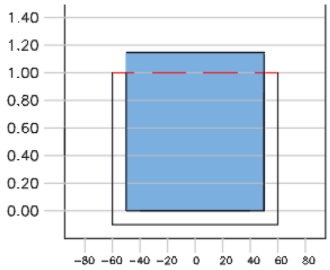

Figure 7. Existing Cross Section at Control Point C11

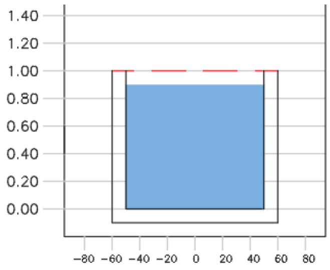

Figure 8. Redesigned Cross Section at Control Point C11

From the figure ABOVE, the difference in the channel's water level after recalculation is evident, demonstrating that the redesigned channel can accommodate the 5-year design flood discharge (Q5).

Recommendation 2

In the second recommendation, the channel slope will be increased from the existing slope by deepening the channel, and the proposed channel is designed with a cement plaster lining.

Table 8. Calculation of Design Channel Dimensions

Segment	Discharge Q_5 (m^3/s)	Existing Width (m)	Design Depth (m)	Channel Velocity (m/s)	Design Capacity (m^3/s)	Excess Capacity (m^3/s)
C8-C9	2,67	0.7	1.9	4,961489	4,961489	2,29
C9-C10	4,36	0.6	1.8	5,613282	5,613282	1,25
C10-C11	6,06	1	2	5,767076	6,920491	0,86
C12-C13	6,13	1	1.6	4,175184	8,016353	1,89
D5-D6	1,49	0.8	1.6	2,187942	2,187942	0,70
G1-G2	0,41	1	1.05	0,417603	0,601348	0,19
H3-C10	1,21	1	1.05	0,50589	1,295078	0,09
I1-I2	2,38	0.8	0.8	6,215468	3,9779	1,60
I2-I3	2,4	0.8	2.4	1,808838	2,604727	0,20
I3-I4	1,47	0.8	2.6	1,364232	1,637079	0,17

Based on Table above, it can be concluded that the designed channel is capable of accommodating the 5-year design flood discharge (Q5).

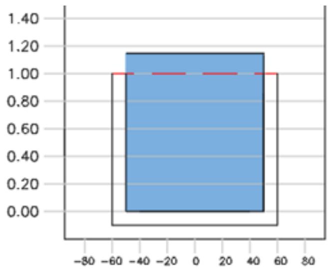

Figure 9. Existing Cross Section at Control Point C11

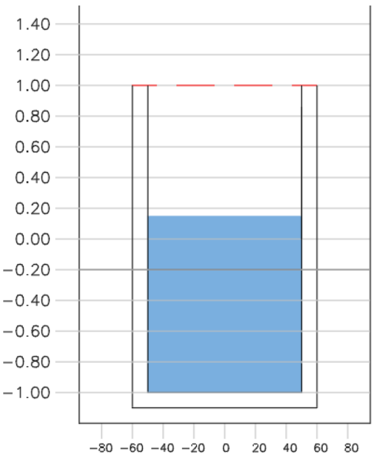

Figure 10. Figure 8. Redesigned Cross Section at Control Point C11

From the figure above, the difference in the channel's water level after the redesign is evident, indicating that it can now accommodate the 5-year design flood discharge (Q5).

CONCLUSION

Based on the analysis and evaluation of the urban drainage system in Lembang, the following conclusions were drawn: at the 5-year return period design flood discharge (Q5), 10 channel segments are unable to accommodate the design flood discharge. Consequently, an upgrade in channel capacity is required for these 10 segments. The channel capacity improvement plan was developed utilizing the 5-year design flood discharge (Q5) through two proposed design recommendations. The first recommendation involves upgrading the channels using larger U-ditches while maintaining the existing channel slope. Alternatively, the second recommendation involves steepening the channel slope by deepening the channel and applying a cement plaster lining. Following the redesign process using these approaches, the channels are now capable of accommodating the design flood discharge.

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