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Article

Evaluation of Drainage Systems Based on River Basins (Case Study: The Intersection of Jalan Jenderal Sudirman and Jalan D.I. Panjaitan)

Tasya[1*], Beny Setiawan[2,] Agus Alisa Putra[3]

[1,2,3] Civil Engineering Study Program, Faculty of Engineering, Universitas Pahlawan Tuanku Tambusai

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E-mail: tasyan657@gmail.com (Corresponding Author)

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A B S T R A C T

This study evaluates the drainage system at the intersection of D.I. Panjaitan Street and Jendral Sudirman Street in Bangkinang Kota District, Kampar Regency, Riau Province. The area frequently experiences waterlogging and flooding during periods of high rainfall intensity, which are suspected to be caused by sedimentation, channel blockages, and land-use changes that increase surface runoff. A quantitative descriptive method was employed through field surveys, drainage channel measurements, community interviews, and hydrological and hydraulic analyses. The data used consisted of 10 years of rainfall records from the Silam Rainfall Station and existing drainage channel data. Rainfall frequency analysis was carried out using the Normal, Gumbel, and Log Pearson Type III distributions, while the design discharge was calculated using the Rational Method. The capacity of the existing drainage channels was analyzed using Manning's equation. The results indicate that the existing drainage system experiences several problems, including sediment accumulation, waste blockages, and structural deterioration in certain channel sections, which hinder water flow. The analysis shows that the total existing channel capacity is 66.68 m^3/s, while the total design discharge is 47.77 m^3/s, indicating that the drainage system is generally capable of conveying the runoff. However, one of the eight analyzed channels does not meet the required design discharge capacity and therefore requires improvement. This study provides recommendations for channel normalization, routine cleaning, and periodic maintenance to enhance drainage performance and reduce the risk of flooding in the study area.

1. Introduction

Flooding and waterlogging are hydrometeorological issues that continue to pose challenges in urban area management. Urban growth has led to an increased need for drainage infrastructure to channel stormwater runoff quickly and safely. Problems arise when the capacity of drainage channels is no longer sufficient to handle the runoff volume resulting from increased rainfall, changes in land use, sedimentation, trash, or the limited dimensions of the channels. Therefore, a properly functioning drainage system is essential for reducing the risk of waterlogging and flooding and ensuring the continuity of community activities in urban areas. (Hutagaol et al., 2025).

This issue is becoming increasingly important because hydrometeorological disasters continue to account for the majority of disasters in Indonesia. Data from the National Disaster Management Agency (BNPB) show that between January and March 2025, there were 814 disaster events in Indonesia, 99.39% of which were hydrometeorological disasters (Lubis, 2016). Floods were the most prevalent type of disaster, accounting for 555 incidents or approximately 68% of all disaster incidents during that period. This situation indicates that flooding is not only related to extreme rainfall events but also to a region's ability to manage and channel stormwater runoff. Therefore, evaluating the capacity of drainage systems based on actual hydrological and hydraulic conditions is crucial as part of flood risk reduction efforts.

Flooding also continued to occur in various regions of Indonesia throughout 2025. The National Disaster Management Agency (BNPB) reported that in March 2025, flooding in the city of Pekanbaru affected 3,923 households, or 10,139 people, while flooding in Kampar Regency affected 1,319 households, or 4,857 people. BNPB also noted that wet hydrometeorological conditions were the main factor in various disaster events during that period. These facts demonstrate that the Riau Province is vulnerable to flooding and waterlogging issues; therefore, the management of drainage systems in urban areas and community activity centers requires attention based on rainfall characteristics, watersheds, and available channel capacity. Drainage is also basic facilities designed as a system to meet the needs of the community and the city's infrastructure (Yunianta et al., 2022)

One area facing this problem is the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street, Bangkinang Kota Subdistrict, Kampar Regency, Riau Province. Based on preliminary observations documented in this study, the drainage system at this location has issues that could potentially impair its ability to carry water, particularly during heavy rainfall. The condition of the channels is also affected by accumulated trash and physical damage that can obstruct flow. These problems could lead to water stagnation and flooding in the area surrounding the intersection. These conditions highlight the need for an evaluation based not only on visual observations but also supported by quantitative calculations of runoff discharge and channel capacity. The volume of runoff will subsequently place a load on the existing drainage network Pahude et al. (2022) An evaluation of the drainage system's function in residential areas highlights the importance of having a drainage system capable of effectively managing water flow in these areas. Therefore, changes in the area's conditions must be accompanied by an evaluation of the drainage system's capacity to ensure that the channels' capacity remains adequate to meet drainage needs.

Drainage system issues at the study site are also related to changes in the area's conditions over time. According to research documents, the drainage channels at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street were constructed around 2010 in tandem with the development of road infrastructure and the urban area. At the start of construction, the system was designed based on land-use conditions that featured larger infiltration areas. The expansion of residential and commercial areas subsequently altered the surface characteristics of the area and has the potential to increase surface runoff. These conditions are important to consider because changes in land use can increase the volume of water that must be carried by the drainage network; therefore, the capacity of the existing channels needs to be reassessed against the design flow rate based on current area conditions.

Hydrologically, the amount of runoff is determined not only by rainfall intensity, but also by the size of the catchment area and the characteristics of the area's surface. A

catchment area is the region that collects runoff into a specific watercourse, and its definition must take into account the direction of surface flow, topography, land use, and the boundaries of the area draining into the watercourse in question (Tallar, 2023). Therefore, an evaluation of the drainage system in the study area must integrate analyses of rainfall, catchment area, runoff discharge, and the hydraulic capacity of the channels. This approach provides a more objective basis for determining whether the existing channels are still capable of conveying the discharge that occurs during a specific return period.

Previous research has shown that channel capacity assessment is an important approach to understanding urban flooding issues. Yunianta et al.(2022) This study examined the drainage system in the Hamadi Rawa area of Jayapura City using surveys, field observations, flood discharge analysis, and an evaluation of the existing drainage system. The results indicate that the topography—which consists of depressions—is one of the causes of flooding, and that a redesign of the channel dimensions and the implementation of infiltration wells are necessary as part of a sustainable drainage system. The study demonstrates that drainage evaluations must take into account the relationship between regional characteristics, runoff discharge, and channel capacity.

Another study by Hutagaol et al.(2025) A study on the drainage system in Depok City shows that rapid urbanization is placing pressure on the drainage infrastructure. The study analyzed rainfall data, the physical condition of the channels, and flood events to gain an understanding of the drainage system's condition and the factors affecting its effectiveness. The study's results underscore the importance of drainage management based on actual conditions and field data in supporting urban planning and flood mitigation. These findings are relevant to this study because both studies use the physical condition of drainage channels and hydrological characteristics as the basis for evaluating drainage system performance.

A more technical study was conducted by (Akbar & Harahap, 2022) through research on the performance of urban drainage systems using the Mononobe and Manning equations. The study showed that urban flooding can be evaluated by correlating rainfall intensity, design flood discharge, and channel capacity to determine the drainage system's ability to handle runoff. These hydrological and hydraulic approaches are consistent with this study, particularly in the use of rainfall analysis to determine design discharge and the Manning equation to determine the capacity of existing channels.

A study on urban drainage planning on Kavling Baru Nato Street in Batam City also highlights the importance of comparing the design flow rate with the channel capacity. The study utilized a probability analysis of rainfall, the Rational Method to calculate the design flood flow rate, and channel capacity calculations to determine appropriate dimensions. The results show that the existing channels are insufficient to handle the design discharge, necessitating the planning of larger channel dimensions. These findings reinforce the notion that comparing the design discharge with existing capacity is a crucial basis for determining whether a channel remains adequate or requires technical measures. (Kamandani et al., 2024).

Although previous studies have extensively addressed drainage evaluation through hydrological analysis, the physical condition of channels, design flow rates, and hydraulic capacity, there remains scope for research at a more specific local scale. The study by Yunianta et al. (2022) emphasized sustainable drainage in the Hamadi Rawa area, while Hutagaol et al. (2025) discussed drainage systems in the context of the city of Depok. These previous studies have not specifically evaluated the drainage system at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street in Bangkinang Kota Subdistrict by integrating channel physical conditions, catchment area, rainfall frequency analysis, design discharge using the Rational Method, and channel capacity using Manning's equation. This gap in the specific location and the integration of these parameters serves as a key basis for conducting this study. The research document also identifies that no study has been found that specifically evaluates this location using the combination of hydrological and hydraulic analyses as described.

Based on this gap, this study aims to produce a quantitative evaluation of the drainage system's performance at the study site. The evaluation was conducted by

analyzing rainfall data, determining design rainfall based on an appropriate probability distribution, defining the stormwater catchment area, calculating design flow using the Rational Method, and calculating the capacity of existing channels using Manning's equation. Next, the design flow was compared with the capacity of each channel to determine which channels met and which did not meet the flow requirements. This procedure aligns with the research design of this thesis, which uses primary and secondary data as the basis for analyzing channel conditions, calculating flow rates, determining capacity, and comparing existing conditions with design conditions.

Thus, the primary objective of this study is to determine the current condition of the drainage system at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street. Furthermore, the study aims to identify points in the drainage system that do not meet the required discharge capacity based on rainfall data. This study is not intended to test causal relationships between variables but rather to provide an empirical and quantitative description of the condition and capacity of the drainage system based on hydrological and hydraulic parameters. Based on these objectives, the research questions posed are: (1) what is the design flow rate for the stormwater catchment area at the study site; (2) what is the capacity of the existing drainage channels; (3) which channels are capable of and which are incapable of accommodating the design flow rate; and (4) what technical measures are required for channels whose capacity does not meet the design flow rate? With this approach, the study is expected to provide empirical contributions to the evaluation and planning of drainage systems in developing urban areas, particularly in Bangkinang City.

2. Literature Riview

Drainage is a system designed to reduce and/or remove excess water from an area so that the land can be used optimally. In an urban context, drainage serves to channel rainwater and surface water toward water bodies, thereby reducing the potential for puddles and flooding. Pahude et al.,(2022) explains that drainage is a series of water structures used to reduce or remove excess water from an area, whereas Hutagaol et al. (2025) Urban drainage is viewed as a network that functions to channel rainwater and surface water to prevent flooding. Thus, drainage systems in urban areas are not merely regarded as a network of channels, but as part of the water management infrastructure that must be able to adjust its flow capacity to the characteristics of the area's runoff.

The function of a drainage system is closely related to protecting areas from standing water, erosion, and flooding, as well as supporting public health and safety. A well-functioning drainage system allows water to flow smoothly, thereby reducing the risk of damage to roads, buildings, and the environment caused by standing water. In this research document, the functions of drainage include protecting densely populated areas from waterlogging, erosion, and flooding; reducing environmental health risks; optimizing land use; and protecting infrastructure. In the context of this study, these functions serve as the basis for evaluating whether the drainage channels at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street are still capable of optimally discharging water.

Based on their flow systems, drainage systems can be classified into separate systems, combined systems, and mixed systems. Additionally, based on their physical form, drainage systems can be either open channels or closed channels. Open channels are generally used to drain stormwater in areas with sufficient space, while closed channels are widely used in urban areas or locations that require control over flow and the surrounding environment. Understanding these types of channels is important in this study because the physical characteristics of existing channels serve as a basis for determining hydraulic capacity and evaluating their suitability for design flow rates. (Fairizi, 2015).

Drainage systems can also be classified based on their network patterns, including L-shaped, parallel, grid-iron, natural, and mesh networks.

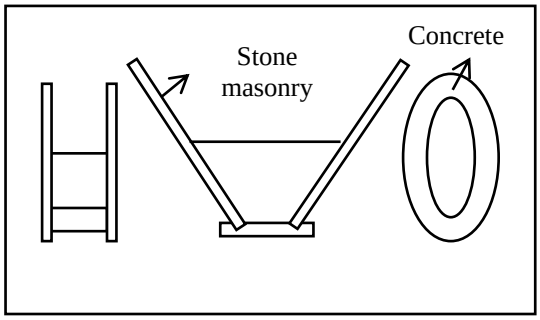


Figure 1. Artificial Drainage (Putri, 2023)

The drainage network pattern illustrates the relationships between main channels, branch channels, catchment areas, and the direction of flow toward the final discharge point. Kamandani et al.. (2024) explains several of these drainage network patterns as adaptations of the drainage system to the topographic characteristics and conditions of urban areas. In this study, network patterns and flow directions were taken into account in determining the catchment areas that contribute runoff to each of the channels under review.

Hydrological concepts form an important foundation for the analysis of drainage systems because rainwater that falls in a given area undergoes processes that result in surface runoff (Indriani, 2025). The hydrological cycle describes the circulation of water from the atmosphere to the Earth's surface and back to the atmosphere through the processes of evaporation, condensation, precipitation, and transpiration (Ratna Musa et al., 2025). explains that the hydrological cycle is the continuous circulation of water between the atmosphere and the Earth. In the context of drainage, precipitation in the form of rain is the primary component that generates surface runoff, which must then be channeled through the drainage system. Rainfall is a key parameter in hydrological analysis for determining the design rainfall. Historical rainfall data can be analyzed using frequency analysis to determine rainfall with a specific return period. Limantara et al. (2024) discusses design rainfall analysis as part of hydrological analysis, while Astrid and Ayudia (2024) using frequency analysis in flood studies. Based on the research framework in the file, the rainfall data used were obtained from the Silam Station, with a 10-year observation period, and were subsequently analyzed to determine the design rainfall.

Therefore, the results of the rainfall frequency analysis serve as a key input in determining the design discharge of the drainage system. A watershed is an area that contributes runoff to a specific channel or discharge point. The area of the watershed is one of the key parameters in determining the magnitude of runoff discharge; the larger the area contributing to the flow, the greater the potential volume of runoff entering the drainage system. (Manibuy & P Perangin-Angin, 2021). specifically examines the size of the catchment area and the design dimensions of open channels. In this study, the determination of the catchment area is used to identify the runoff contribution to each channel so that the design flow can be calculated more specifically based on the channel's service area. Ameto and Valderama (2024) examined runoff calculations as a basis for determining the amount of flow generated by a given area, whereas Kamandani et al..(2024) using hydrological analysis in urban drainage system planning. Thus, the design discharge in this study was used as a benchmark to assess the capacity of existing channels to convey runoff.

Hydraulic capacity is the ability of a channel to convey water flow based on its geometric characteristics and physical conditions. Parameters that influence this capacity include the shape and dimensions of the cross-section, the wet cross-sectional area, the wet perimeter, the hydraulic radius, the channel bed slope, and the roughness coefficient. In this study, channel capacity was calculated using the Manning equation and then compared with the design flow rate. This comparison served as the basis for determining whether the existing channel capacity was sufficient or not. The approach of evaluating channel capacity based on existing conditions was also used in the study by Akbar and Harahap (Akbar & Harahap, 2022)

Based on these studies, there remains scope for further research to specifically evaluate the drainage system at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street in Bangkinang Kota Subdistrict, by integrating existing conditions, the watershed, design rainfall, runoff discharge, and channel capacity. Therefore, the conceptual framework of this study uses rainfall and catchment characteristics as the basis for determining the design discharge, which is then compared with the hydraulic capacity of the existing channels. The results of this comparison are used to identify channels that meet and do not meet capacity requirements and serve as the basis for formulating technical recommendations. This framework aligns with the research objectives outlined in this document, namely to determine the existing drainage conditions and identify points in the drainage system that do not meet discharge capacity based on rainfall data.

3. Research Methodology

This study employs a quantitative descriptive approach using a case study design. The quantitative descriptive approach is used to objectively describe the condition of the drainage system based on numerical data from field measurements, rainfall data, and the results of hydrological and hydraulic calculations (Hutagaol et al., 2025). This study was not designed to test causal relationships or the influence between variables, but rather to evaluate the existing conditions and the capacity of the drainage channels to carry stormwater runoff. The study was conducted on the drainage system at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street, Bangkinang Kota Subdistrict, Kampar Regency, Riau Province. The location was selected because the area experiences waterlogging and flooding during heavy rains, and there are indications of sedimentation, trash blockages, and damage to several sections of the drainage channels. The case study location was selected purposefully because it is directly related to the issues that are the focus of the evaluation, namely the physical condition and capacity of the urban drainage system.

The research data consists of primary and secondary data. Primary data was obtained directly through observation and measurement at the research site, as well as through interviews with community members or parties engaged in activities near the site (Winarni, 2021). Data tersebut meliputi kondisi fisik saluran, dimensi saluran, keberadaan sedimentasi dan sampah, kondisi genangan, serta informasi mengenai kejadian banjir. Sementara itu, data sekunder diperoleh dari pihak atau instansi terkait, terutama data curah hujan dan informasi pendukung sistem drainase. data curah hujan diperoleh dari Balai Wilayah Sungai Sumatera III (BWS Sumatera III), sedangkan data yang berkaitan dengan sistem drainase digunakan untuk mendukung analisis arah aliran dan kondisi jaringan drainase. Penggunaan kombinasi data primer dan sekunder juga lazim dalam penelitian evaluasi sistem drainase perkotaan.

3.1 Instruments and Materials

The research instruments consisted of observation sheets, channel dimension measurement tools, documentation tools, interview guidelines, and tools for processing hydrological and hydraulic data. The observation sheets were used to systematically record the physical conditions of each channel, while the measurement tools were used to directly obtain the channel's geometric dimensions. The interview guidelines were used to gather supporting information regarding the frequency of flooding, the timing of flooding events, the duration of flooding, floodwater levels, and factors suspected to cause flooding. The list of interview questions in the thesis covered the community's experiences with flooding, the condition of the channels, the presence of trash or sedimentation, and the history of drainage maintenance.

Table 1. Research Instruments

List of Questions
Since when have you been living or spending time around the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street?
Does this area often experience standing water or flooding?
When does flooding usually occur?
How long does it usually take for standing water to recede?
How high did the floodwaters ever rise?
In your opinion, what is the main cause of the flooding at this location?
Do the drainage channels in the surrounding area appear to be functioning properly?
Is there any trash or sediment clogging the drain?
Have any repairs or cleanings of the drainage system ever been performed?
How does flooding affect your daily activities?
What are your expectations or suggestions regarding improvements to the drainage system at this location?

Since this study is not a survey study with psychometric constructs, validity and reliability tests—such as Cronbach's alpha—were not applied to the instrument. Data reliability was ensured through direct measurements, documentation of field conditions, and cross-checking of primary data with secondary data and hydrological and hydraulic calculation results.

3.2 Data Collection and Analysis

Data collection was conducted through field observations, direct measurements, documentation, interviews, and a review of existing records. Field observations were used to identify the actual condition of the channels, including sedimentation, trash, structural damage, and flooding conditions. Direct measurements were taken to determine the channel dimensions—specifically, width and depth—which were subsequently used in hydraulic capacity calculations. Photographic documentation served as visual evidence of the channel's condition and the locations of standing water. Additionally, interviews were conducted with individuals familiar with the drainage conditions in the vicinity, particularly residents and business owners near the intersection. These data collection techniques are consistent with the research by Yunianta et al..(2022) which uses surveys and field observations in the evaluation of drainage systems.

Data analysis was conducted in stages, beginning with the examination and processing of rainfall data, frequency analysis to determine the design rainfall, delineation of the catchment area, calculation of the design discharge using the Rational Method, and calculation of channel capacity using Manning's equation. The final stage involved comparing the existing Q values with the design Q values for each channel. A channel is categorized as capable of conveying the design flow if its existing capacity is greater than or equal to the design flow, while a channel is categorized as non-compliant if its existing capacity is less than the design flow. If the channel capacity is insufficient, design dimension calculations are performed to serve as the basis for technical recommendations. The analysis flowchart in this thesis also illustrates the stages from the collection of primary and secondary data, analysis of channel conditions, flow and capacity calculations, to the comparison of existing and planned dimensions.

Data analysis techniques using the normal distribution, log-persson III, and Gumbel methods were employed to process rainfall data, followed by a hydraulic analysis using the rational method. The rational method is one of the methods used to determine surface runoff caused by rainfall. If the comparison results show that the capacity of the existing channel is insufficient to handle the design flood discharge, a redesign of the drainage system capable of accommodating the current flood discharge will be carried out.

4. Results and Discussion

4.1 Current Condition of the Drainage System at the Intersection of D.I. Panjaitan Street and Jenderal Sudirman Street

The current condition of the drainage system at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street is causing problems that prevent it from functioning optimally and even pose a risk of waterlogging or flooding. An evaluation and improvement of the drainage infrastructure are needed, taking into account its capacity and maintenance requirements, in order to address these issues and prevent the adverse effects of flooding that could harm the surrounding community,



Figure 2. Condition of the Drainage Channels on D.I. Panjaitan Road During a Flood

The results of the field survey, as shown in Figure 2, indicate that the drainage system at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street consists of eight channel segments that were examined. Physically, all channels have a square cross-section, with a total channel length of 1,640 m. The channel dimensions range from 1.53 to 1.83 m in width and 0.77 to 0.92 m in height. These conditions indicate that, geometrically, the channels are relatively large; however, their physical and operational conditions remain problematic due to the presence of trash and sedimentation in several segments.

Field observations show that drainage problems are not only related to the dimensions of the channels but also to their actual condition. Blockages caused by trash were

found in Channels 1, 4, and 8. Meanwhile, sedimentation was found in Channels 2 and 3 with a thickness of about 5 cm, while Channels 5, 6, and 7 had sediment deposits of about 3–4 cm. This sedimentation reduced the effective height of the channels, thereby decreasing the cross-sectional area available for water flow. In Channels 2 and 3, for example, the sediment depth reached 5 cm, or about 6.25% of the channel's original depth. These findings demonstrate that a channel's theoretical capacity, based on its geometric dimensions, does not necessarily reflect its effective capacity when the channel experiences sedimentation and blockages.

4.2 Analysis of Planned Rainfall

Rainfall frequency analysis is used to determine the likely amount of rainfall in a study area. The distributions used in rainfall frequency analysis are the normal distribution, the log-normal distribution, the Gumbel distribution, and the log-Person III distribution. The hydrological analysis was conducted using 10 years of rainfall data from the Silam Station. Several probability distributions were compared to determine the distribution that best fits the characteristics of the data. The results of the analysis show that the Log-Pearson III distribution was selected to determine the design rainfall. The design rainfall values obtained using this distribution are 112.979 mm for a 2-year return period, 136.280 mm for a 5-year return period, and 150.314 mm for a 10-year return period. These values indicate an increase in design rainfall as the return period increases.

The selection of the Pearson III log-normal distribution is a critical step because the design rainfall values are subsequently used in runoff analysis. Differences in values across return periods indicate that the longer the return period used, the greater the design rainfall that the drainage system must accommodate. In the context of this study, this analysis serves as the basis for determining the hydrological conditions used in evaluating channel capacity. Thus, the assessment of drainage capacity is not based solely on the visual condition of the channel but also takes into account the magnitude of the runoff load that must be conveyed.

Table 2. Pearson's Log III

No	Year	Xi	$Log\ Xi$	$Log\ Xi - Log\ \bar{X}$	$(Log\ Xi - Log\ \bar{X})^2$	$(Log\ Xi - Log\ \bar{X})^3$	$(Log\ Xi - Log\ \bar{X})^4$
1	2015	93,000	1,968	-0,0889	0,0079	-0,0007	0,0001
2	2016	90,000	1,954	-0,1032	0,0106	-0,0011	0,0001
3	2017	90,000	1,954	-0,1032	0,0106	-0,0011	0,0001
4	2018	97,000	1,987	-0,0706	0,0050	-0,0004	0,0000
5	2019	110,000	2,041	-0,0160	0,0003	0,0000	0,0000
6	2020	141,500	2,151	0,0933	0,0087	0,0008	0,0001
7	2021	141,500	2,151	0,0933	0,0087	0,0008	0,0001
8	2022	120,000	2,079	0,0218	0,0005	0,0000	0,0000
9	2023	121,000	2,083	0,0254	0,0006	0,0000	0,0000
10	2024	160,500	2,205	0,1481	0,0219	0,0032	0,0005
Jumlah		1164,50	20,57	0,0000	0,0749	0,0016	0,0009
Rerata		116,45	2,057				

Source: Processed research data, 2026

The selection of the Pearson III log-normal distribution is a critical step because the design rainfall values are subsequently used in runoff analysis. Differences in values across return periods indicate that the longer the return period used, the greater the design rainfall that the drainage system must accommodate. In the context of this study, this analysis serves as the basis for determining the hydrological conditions used in evaluating channel capacity.

Thus, the assessment of drainage capacity is not based solely on the visual condition of the channel but also takes into account the magnitude of the runoff load that must be conveyed.

4.3 Analysis of Planned Flow Rates

The design flow rate was calculated using the Rational Method, taking into account the concentration time, rainfall intensity, runoff

coefficient, and catchment area. The calculation results for the eight channels show that the design flow rate ranges from 3,660 to 8,312 m³/sec. The highest design flow rate was found in Channel 6 at 8,312 m³/s, while the lowest was found in Channel 4 at 3,660 m³/s. These differences are influenced by the characteristics of each catchment area, the concentration time, and the rainfall intensity used in the calculations.

More specifically, the analysis results show that Channel 1 has a design flow rate of 4,416 m³/sec, Channel 2 of 6,046 m³/sec, Channel 3 of 6,857 m³/sec, Channel 4 of 3,660 m³/sec, Channel 5 of 5,043 m³/sec, Channel 6 has a design flow rate of 8,312 m³/s, Channel 7 has a design flow rate of 6,376 m³/s, and Channel 8 has a design flow rate of 7,068 m³/s. These data show that Channel 6 receives the largest runoff load, while Channel 4 receives the smallest runoff load. These design flow rate results are then used as the basis for evaluating the hydraulic capacity of each channel.

Meanwhile, the capacity of the existing channel was calculated using Manning's equation, taking into account the wet cross-sectional area, wet perimeter, hydraulic radius, and flow velocity. The calculation results show that the capacity of the existing channel ranges from 6,323 to 11,790 m³/s. The highest capacity is found in Channel 8 at 11,790 m³/s, while the lowest capacity is found in Channel 4 at 6,323 m³/s. The flow velocities obtained range from 4.94 to 7.06 m/s, with the highest velocity in Channel 8 and the lowest in Channel 4.

These results indicate variations in hydraulic capacity among the channel segments. These differences in capacity are primarily influenced by the cross-sectional dimensions and hydraulic characteristics of each channel. Channel 8 has the highest capacity due to its relatively large wet cross-sectional area and high flow velocity, while Channel 4 has the lowest capacity. However, these theoretical capacity values must be considered in conjunction with the physical condition of the channels, as sedimentation and debris can reduce the channels' effective capacity in the field.

Table 3. Comparison of Existing Capacity and Planned Flow Rate

Channel	Q Existing (m³/det)	Q Plan (m³/det)	Difference Q (m³/sec)	Status
1	9,729	4,416	+5,313	To fulfill
2	6,937	6,046	+0,891	To fulfill
3	6,606	6,857	−0,251	**Does Not Meet**
4	6,323	3,660	+2,663	To fulfill
5	6,827	5,043	+1,784	To fulfill
6	9,073	8,312	+0,761	To fulfill
7	9,402	6,376	+3,026	To fulfill
8	11,790	7,068	+4,722	To fulfill
Total	**66,68**	**47,77**	**+18,91**	**Generally meets**

Source: Research analysis results, 2026.

Based on Table 1, the total existing capacity recorded in the study is 66.68 m³/s, while the total planned flow rate is 47.77 m³/s. However, an evaluation based solely on these totals is insufficient, as the capacity of each channel segment must be examined individually. The results of the individual evaluations show that 7 out of 8 channels, or 87.5%, meet the capacity requirements, while 1 channel, or 12.5%, does not. Channel 3 is the critical point because its capacity is smaller than the planned discharge. These results indicate that, in general, the system has a capacity that memadai, However, there are still areas where water flow disruptions could occur.

3.3 Discussion of Results

The research findings indicate that the hydraulic capacity and physical conditions of the channels present a contrasting picture. Hydraulically, most channels have a capacity greater than the design flow rate, so they are theoretically still capable of conveying runoff. However, field observations reveal blockages caused by trash and sedimentation that can reduce the effectiveness of flow. Debris was found in Channels 1, 4, and 8, while sedimentation was present in Channels 2, 3, 5, 6, and 7. Thus, the flooding that occurred at the study site was not solely caused by insufficient channel dimensions but also by the operational and maintenance conditions of the channels.

The research findings also indicate that the occurrence of flooding at the site cannot be explained solely by comparing the geometric capacity to the design flow rate. Interviews

with community members revealed that flooding frequently occurs during heavy rains, lasting approximately 1–3 hours, with water levels ranging from 10 to 30 cm. Community members identified trash blockages, sedimentation, and channel capacity as factors contributing to the flooding. These interview findings are consistent with the results of observations and hydraulic analyses, which indicate that one channel does not meet the design flow rate and that several channels are experiencing physical obstructions..

The findings of this study are consistent with previous research highlighting the importance of comparing design flow rates with channel capacity. Kamandani et al. (2024), for example, identified situations where the design flood flow rate exceeds the capacity of existing channels, necessitating a redesign of the channel dimensions. Research by Yunianta et al. (2022) also indicates that flooding issues can occur when the area's runoff discharge exceeds the available flow capacity. In contrast, this study shows that, overall, the channel capacity at the study site is still greater than the design flow, but there is one segment that serves as a critical point. This indicates that a segment-by-segment evaluation is necessary so that problem areas are not masked by the aggregate results of the entire system.

4. Conclusion

Based on the results of the hydrological and hydraulic analyses—which served as the basis for evaluating the drainage system as part of flood mitigation efforts at the intersection of D.I. Panjaitan Street and Jenderal Sudirman Street—the researchers have reached the following conclusions:

a. The existing drainage system is generally still capable of handling the design flow rate, with an existing capacity of 66.68 and a design flow rate of 47.77. However, of the 8 channels analyzed, 1 channel—Channel 3—does not meet the design flow rate. Flooding is also influenced by sedimentation and debris blockages.

b. Recommended mitigation measures include periodic channel normalization and maintenance, adjusting the dimensions of Channel 3 in accordance with the planning results, and constructing or replacing culverts at locations prone to ponding or flooding.

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