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EVALUATION OF DRAINAGE CHANNEL CAPACITY ON JALAN BUDI KARYA, PONTIANAK SELATAN SUB-DISTRICT

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Abstrak

Urban flooding is flooding land or property in the built environment, especially in more densely populated areas, caused by rainfall that exceeds the drainage system's capacity. Like other areas with flat topography, several regions of Pontianak often experience flooding, one of which is the Waduk Permai Housing, Jalan Budi Karya area. The Budi Karya drainage channel cannot accommodate the discharge of the 2 and 5 Year return period plans ($Q_C < Q2$ or $Q_C < Q_5$), according to the analytical results utilizing the HEC-RAS software tools. As a result, drainage must be improved by channel normalization. In solving the existing inundation problem, it is necessary to evaluate the capacity of the drainage channel using primary data (long sections and cross sections of the channel) and secondary data (location map, tidal data, and rainfall data).

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1. Introduction

Drainage means to drain, move, and dispose of excess water not to cause various problems that are detrimental to humans. Poor drainage in some places and inadequate drainage in some streets or alleyways are the two leading causes of flooding. The Waduk Permai residential area on Jalan Budi Karya, Pontianak Selatan, is an area that often floods when it rains. In flat, tidal-influenced areas such as Pontianak, flooding or inundation will occur when the intensity of rainfall and tides are high, and the impact is worse when rain is increased along with tides.

The development of facilities and infrastructure affects land use change. Land that was originally an open area with a function as a permeable area eventually becomes land into an impermeable area, which of course, can interfere with water absorption during the rainy season.

Surface runoff has effects in addition to other problems. It limits land utilization for constructing channels. The development of facilities and infrastructure affects land use change. Land that was originally an open area with a function as a permeable area eventually becomes an impermeable area, which of course, can interfere with water absorption during the rainy season. The conditions in the Jalan Budi Karya region limit the land area designated for the construction of drainage channels, as seen from the description above. Accordingly, it is necessary to undertake a drainage optimization study by the relevant legislation.

The objectives of this research are:

a) Assessing the existing condition of drainage channels in the Jalan Budi Karya area.
b) Reviewing the optimization of drainage channels on Jalan Budi Karya.

2. Materials and Methods

This research is a study to evaluate the capacity of drainage channels in an area using primary and secondary data.

2.1 Preliminary Survey

In the preparation stage for the survey in the field, several tools will be used in the research. Primary data is obtained from the results of field surveys, namely topographic data, ground level, channel dimensions, flow velocity, and water level. Primary data, such as topography information, ground level, channel dimensions, flow velocity, and water level, are gathered from the findings of field surveys. The equipment for collecting field data is theodolite, GPS (Global Positioning System), distance meter, and current meter. The secondary data used in this study is rainfall data, which will be processed using statistical methods.

2.2. Research Location

This research was conducted on the drainage channel in the area of Jl. Budi Karya, precisely at the Waduk Permai Housing, Pontianak Selatan.

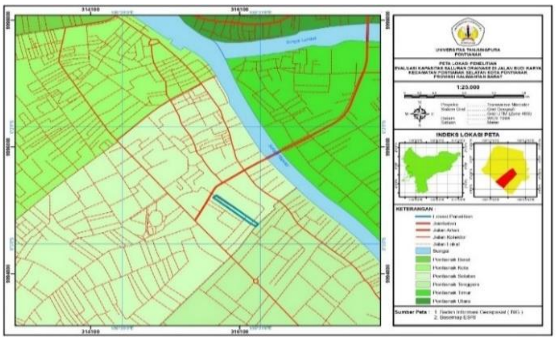

Fig 1. Map of Research Locations

Fig 2. Research Locations

2.3. Data Analysis

For this research, the data analysis consists of the analysis of maximum rainfall with statistical methods, analysis of rain intensity with the Mononobe method, analysis of rainfall return periods using HSS Snyder, and analysis of hydraulic channel models with HEC-RAS tools.

2.4. HEC-RAS Modeling

HEC-RAS is an integrated software system for interactive use in a multi-tasking environment was created by the Hydrologic Engineering Center (HEC), which is one of the divisions within the Institute for Water Resources (IWR) under the US Army Corps of Engineers (USACE). A graphical user interface (GUI), independent analysis components, data management and storage capabilities, visuals, mapping, and reporting tools are all included in the system.

HEC-RAS is a one-dimensional steady-flow hydraulic model designed to aid hydraulic engineers in channel flow analysis and floodplain determination. The model's findings can be used in studies on flood insurance and floodplain management. If you remember from hydraulics, steady flow refers to situations when depth and velocity at a specific channel site do not alter over time. Slight variations in water depth and velocity from cross-section to cross-section define gradually varying flow.

The direct step approach, the main method used by HEC-RAS to compute water surface profiles, is based on the assumption of a steady, gradually changed flow situation. An iterative solution of the energy equation forms the foundation of the computing process:

$H = Z + Y + \frac{\alpha V^2}{2g}$ which states that the total energy (H) at any given location along the stream is the sum of potential energy (Z + Y) and kinetic energy $\frac{\alpha V^2}{2g}$.

The change in energy between two cross-sections is called head loss (hL). The Fig below shows the parameters of the energy equation.

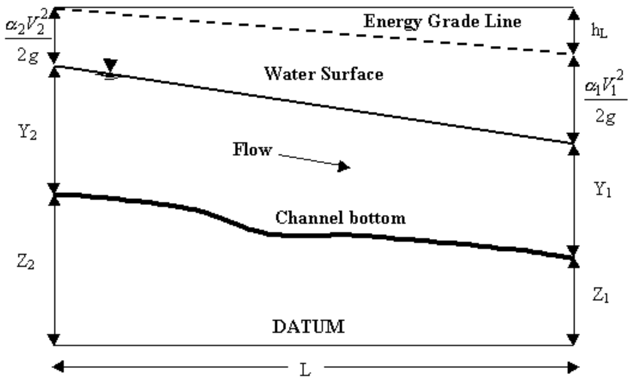

Fig 3. Illustrated the energy equation parameters

In this study, HEC-RAS is a method used to estimate the flow profile of the Jalan Budi Karya drainage channel.

There are three components required in the use of HEC-RAS, namely Geometry data, Flow data, and Plan data. Geometry data consists of a description of the river cross-section's size, shape, and connectivity. Flow data is the maximum discharge value, and plan data is information relating to the specifications of the model run, including a description of the flow regime. Each of these components is explored individually. The boundary condition in the HEC-RAS simulation for this study is the water discharge from upstream entering the channel expressed as inflow and the water level elevation downstream of the channel as outflow. The independent variables used in this study are water discharge from upstream rivers (from hydrological data processing) and elevation in the downstream section of the channel under review. The dependent variable in this study is the elevation of the water level in the channel.

3. Results and Discussion

3.1 Rainfall Data The

Rainfall data used is the maximum daily rainfall data with a recording period from 2011 to 2020 obtained from the Balai Wilayah Sungai

Kalimantan (BWSK) I. The maximum daily rainfall data can be seen in Table 2.

Table 1. Maximum Rainfall

No	Year Of	Rainfall (mm)
1	2020	154.00
2	2019	112.00
3	2018	115.00
4	2017	165.00
5	2016	85.00
6	2015	79.00
7	2014	155.00
8	2013	112.00
9	2012	118.00
10	2011	100.00

Source: Calculation Results, 2022

3.2 Descriptor Test

In testing the statistical data, namely the kurtosis coefficient value, the skewness coefficient value, and the coefficient value to be compared with the values in the table to see whether the data used are the same as the reference statistical parameters have been determined from several existing methods.

The results of calculating statistical parameters for the suitability test using the statistical descriptor method. The value of each method and the error percentage in each method can be seen in Table 3.

Table 2. The result of calculating the percent relative error of each method

Deskriptor Statistik	Normal	Gumbel Tipe I	Log Pearson Tipe III	og Normal 2 Paramete	og Normal 3 Paramete
Cs	0.00%	69.73%	0.00%	115.19%	103.40%
Ck	26.09%	58.95%	0.00%	23.29%	38.55%
Cv	0.00%	0.00%	82.55%	0.00%	0.00%
Rata-rata	8.70%	42.89%	27.52%	46.16%	47.32%

Source: Calculation Results, 2022

3.3 Rainfall Frequency Analysis

From the Statistical Descriptor test which aims to determine the most suitable rain distribution analysis method, it is found that the Normal Method is the most suitable method to be used in finding the return period rain 2, 5, 10 (R2, R5, R10).

The form of the frequency curve equation obtained from the Normal Method is as follows:

R = R average + KT.S
R = 119,5 + (KT x 29,564)
R2 = 119,5 + (0 x 29,564) = 119,500 mm
R5 = 119,5 + (0,84 x 29,564) = 144,334 mm
R10 = 119,5 + (1,28 x 29,564) = 157,342 mm

3.4 Analysis of Rainfall Intensity (I)

Furthermore, after getting the value of the frequency of rainfall, an analysis of rainfall intensity was carried out using the Mononobe method with a concentration time (tc) of 0.442 hours;

Since the value of t_c is known, then proceed with calculating the intensity (I_2, I_5, I_{10}) as follows:

- For the calculation of the rainfall intensity for the 2 year return period is:

$$I_2 = \frac{R_2}{24}\left[\frac{24}{t}\right]^m = \frac{119{,}500}{24}\left[\frac{24}{0{,}442}\right]^{2/3} = 71{,}40 \text{ mm/hours}$$

- For the calculation of the rainfall intensity for the 5 year return period is:

$$I_5 = \frac{R_2}{24}\left[\frac{24}{t}\right]^m = \frac{144{,}334}{24}\left[\frac{24}{0{,}442}\right]^{2/3} = 86{,}20 \text{ mm/hours}$$

- For the calculation of the rainfall intensity for the 5 year return period is:

$$I_{10} = \frac{R_2}{24}\left[\frac{24}{t}\right]^m = \frac{157{,}342}{24}\left[\frac{24}{0{,}442}\right]^{2/3} = 94{,}01 \text{ mm/hours}$$

3.5 Analysis of Flood Discharge

Analysis of flood discharge can be carried out using the Synthetic Snyder Unit Hydrograph Method (HSS) for 2, 5 and 10 year rainfall return periods. The following recapitulation of the maximum discharge for various return periods can be seen in Table 4.

Table 3. Maximum Discharge

Sta	Debit (m³/s)		
	Repeat period		
	2	5	10
00+000	0.0420	0.0508	0.0554
00+078	0.0261	0.0315	0.0344
00+102	0.0364	0.0439	0.0479
00+152	0.0370	0.0447	0.0487
00+202	0.0354	0.0427	0.0466
00+253	0.0378	0.0456	0.0497
00+306	0.0357	0.0431	0.0470
00+356	0.0446	0.0539	0.0588
00+438	0.0303	0.0366	0.0400
00+473	0.0416	0.0502	0.0548
00+549	0.0355	0.0429	0.0467
00+599	0.0352	0.0425	0.0464
00+649	0.0362	0.0437	0.0477
00+691	0.0259	0.0313	0.0341

Source: Calculation Results, 2022

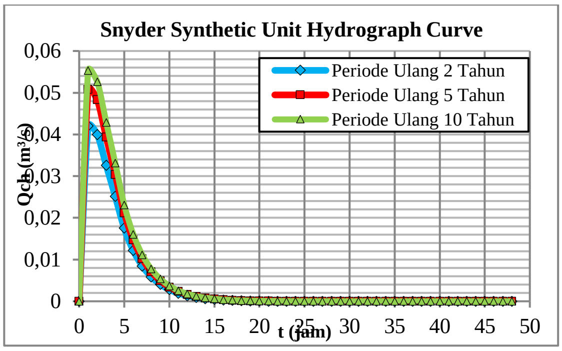

Fig 4. Flood Discharge Hydrograph *(Source: Calculation Results, 2022)*

3.6 Hydraulics Analysis Using HEC-RAS

This hydraulics analysis consists of cross-sectional analysis of the existing drainage channels. Analysis of the existing cross section with the HEC-RAS 6.2.0 program using discharge as input. The length of the Drainage Channel is 691 m, divided into 14 stations under review. 3 Simulations were carried out with different conditions, namely:

a. Simulation of conditions without rain and estuary in high tide conditions.

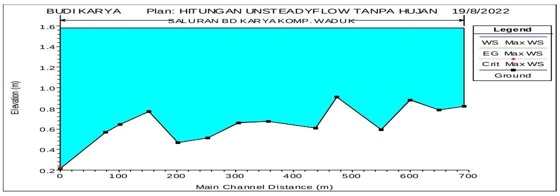

Fig 5. Water level profile along the Cultivation Channel without rain

b. Simulation of rain conditions during the 2-year return period

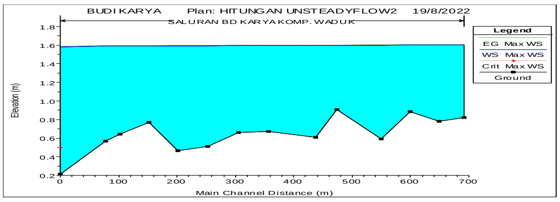

Fig 6. Water level profile along the Budi Karya Channel due to flooding, maximum 2-year return period if the estuary is high tide

c. Simulation of rain conditions during the 5-year return period

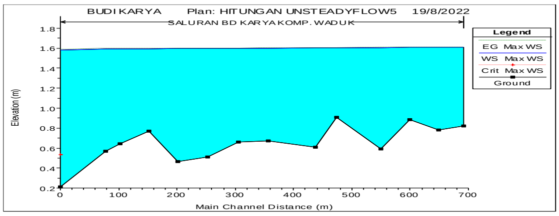

Fig 7. Water level profile along the Budi Karya Channel due to flooding, maximum 5-year return period if the estuary is high tide

The following are perspective plots of channel cross-section during no rain, rainy two years, and five years return periods.

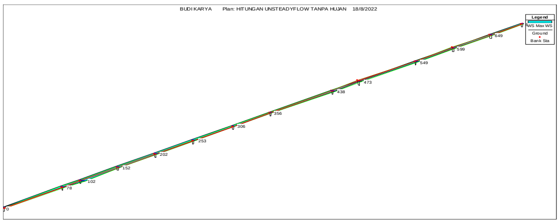

Fig 8. Perspective Plots on the Budi Karya drainage channel without rain

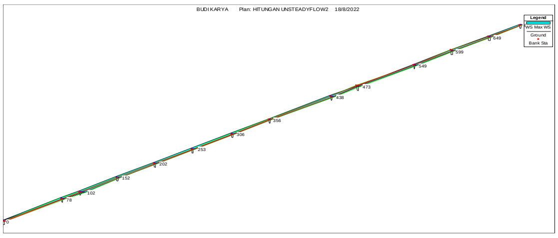

Fig 9. Perspective Plots on the Budi Karya drainage channel for a 2 year

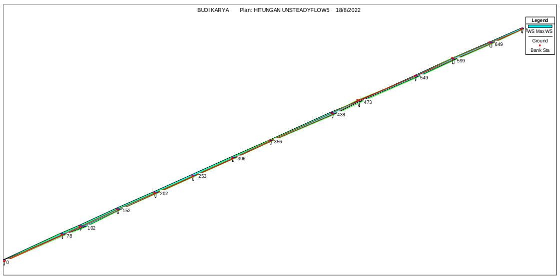

Fig 10. Perspective Plots on the Budi Karya drainage channel for a 5 year

3.7 Conditions of Model Simulation Results

The causes of flooding in Jalan Budi Karya are rainfall in the catchment area and the influence of tides in Parit Media, the channel of Jalan Budi Karya that empties into the Kapuas River. Flooding at the Kapuas River estuary affected the water level in some parts of the Jalan Budi Karya Channel, especially in the downstream area.

Table 4. Maximum Water Level Elevation of Drainage Channel

STA	Base Elevation (m)	Elavasi Muka Air Maksimum (m)		
		Without Rain	R_2	R_5
00+000	0.513	1.58	1.59	1.59
00+078	0.577	1.58	1.60	1.61
00+102	0.652	1.58	1.60	1.60
00+152	0.680	1.58	1.60	1.60
00+202	0.575	1.58	1.60	1.61
00+253	0.521	1.58	1.60	1.61
00+306	0.610	1.58	1.60	1.61
00+356	0.684	1.58	1.60	1.61
00+438	0.607	1.58	1.60	1.61
00+473	0.532	1.58	1.61	1.61
00+549	0.591	1.58	1.61	1.61
00+599	0.670	1.58	1.61	1.61
00+649	0.583	1.58	1.61	1.61
00+691	0.620	1.58	1.61	1.61

Source: Calculation Results, 2022

The following is a cross-sectional image with several measurement points in the reviewed drainage channel;

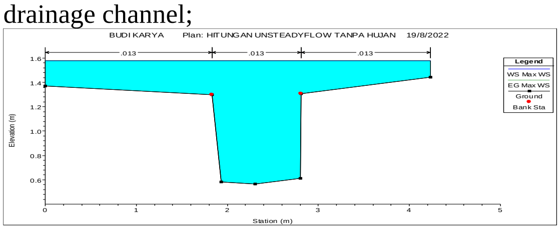

Fig 11. Existing Section of No Rain and Mounting Estuary

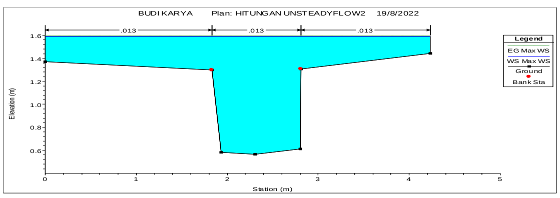

Fig 12. Existing Section of Drainage Channel for 2 Years Return Period if the estuary is in high tide

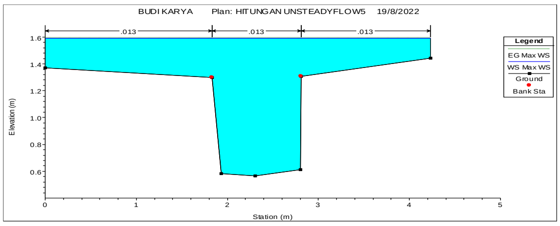

Fig 13. Existing Section of Drainage Channel for 5 Years Return Period if the estuary is in high tide

3.7 Evaluation of Existing Channel Capacity with HEC-RAS Modeling

Evaluation of the capacity of the Jalan Budi Karya drainage channel is carried out to determine the ability of the existing drainage channel to the calculated plan discharge. If the capacity of the existing drainage channel is greater than the planned flood discharge, then the channel is still feasible, and no overflow occurs, so no improvements need to be made. The following is a recapitulation of the evaluation of the existing channel capacity to the planned storage discharge, as seen in Table 5.

Table 5. Recapitulation of Existing Discharge Capacity to Planned Discharge

No	STA	Debit Saluran Eksisiting	Debit Saluran Rencana	Debit Saluran Rencana	Selisih Debit QS & Qr	Selisih Debit QS & Qr	Keterangan
			Q = 2 (m3/s)	Q = 5 (m3/s)	Q = 2 (m3/s)	Q = 5 (m3/s)	
1	00+000	0.153	0.197	0.238	-0.044	-0.085	Tidak Cukup
2	00+078	0.091	0.06	0.072	0.031	0.019	Tidak Cukup
3	00+102	0.079	0.131	0.159	-0.052	-0.08	Tidak Cukup
4	00+152	0.062	0.132	0.159	-0.07	-0.097	Tidak Cukup
5	00+202	0.096	0.129	0.156	-0.033	-0.06	Tidak Cukup
6	00+253	0.137	0.142	0.171	-0.005	-0.034	Tidak Cukup
7	00+306	0.091	0.129	0.156	-0.038	-0.065	Tidak Cukup
8	00+356	0.11	0.128	0.155	-0.018	-0.045	Tidak Cukup
9	00+438	0.082	0.088	0.106	-0.006	-0.024	Tidak Cukup
10	00+473	0.259	0.192	0.232	0.067	0.027	Tidak Cukup
11	00+549	0.072	0.128	0.155	-0.056	-0.083	Tidak Cukup
12	00+599	0.122	0.127	0.154	-0.005	-0.032	Tidak Cukup
13	00+649	0.111	0.117	0.142	-0.006	-0.031	Tidak Cukup
14	00+691	0.064	0.065	0.079	-0.001	-0.015	Tidak Cukup

Source: Calculation Results, 2022

4. Conclusion

Based on the analysis that has been carried out, it can be concluded that;

a) The Jalan Budi Karya area has a reasonably varied topography, which has a low elevation in the downstream section, and the upstream height tends to be high.

b) Based on the analysis using *6.2.0* software using rainfall analysis, field measurements, and tides, it is found that:
- When there is no rain and the highest tide is occurring, the water level already exists, which exceeds the existing cross-sectional capacity of the Jalan Budi Karya drainage channel, especially in the Downstream section, namely at STA.0 to STA. 691.
- When the maximum rain condition is 2 years return period, and the highest tide is occurring, the water level already exists which exceeds the existing cross-sectional capacity of the Jalan Budi Karya drainage channel, especially in the Downstream to Upstream section, namely at STA.0 to STA. 691 on residents' land.
- When the maximum rainfall conditions are 5 years, and the highest tide occurs, the water level already exceeds the existing cross-sectional capacity, namely at STA.0 to STA. 691 with a puddle water level of about 0.08 m – 0.36 m above the highway.

c) The results of the evaluation of the planned discharge of the drainage channel's existing discharge obtained Qs<Qr, namely that there were 14 Jalan Budi Karya drainage channels experiencing relatively low inundation. It can be concluded that there is a need for normalization in some drainage channels.

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