WATER LEVEL PROFILE IN PARIT BERKAT DRAINAGE CHANNEL OF PUNGGUR BESAR

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<table>
<thead>
<tr>
<th>Abstract</th>
<th>Article history:</th>
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</table>
| Floods are common natural catastrophes in Indonesia, particularly during the rainy season. The Parit Berkat water catchment region is one of the locations that frequently experience flooding. The channel's capacity must be increased to accommodate the current water discharge, resulting in this condition. Several reasons are responsible for the diminished capacity of the canal. For instance, inhabitants' activities along canal banks might contribute to the siltation of channels. This research aimed to evaluate the influence of tides and rainfall on the flow of the Parit Berkat Canal. This research provided the use of both primary and secondary data. The leading information consists of measurements of the cross-section and length of the channel and the elevation of the tidal water level over 15 days. Secondary data consists of the maximum daily rainfall data received from Balai Wilayah Sungai Kalimantan I (BWSK I) and the location map for the research. The flow profile is simulated using HEC-RAS. The findings demonstrate that when maximum rainfall and low tides coincide, 13 stations are safe in the 2-year return period of rain, eight stations are safe in the 5-year return period, and six stations are safe in the 10-year return period. | Submitted 11-02-2023
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1. introduction
Floods rank among the most severe natural disasters globally (Salvati et al., 2023), including in West Kalimantan (Soeryamassoek et al., 2018; 2020), especially during the rainy season, as practically all places in Indonesia are susceptible to flooding. River water that spills into the surrounding area after heavy rains is typically the source of flooding. Some sites are accessible to flooding during high tides. The Punggur Besar Village Area in the Sungai Kakap District is vulnerable to floods due to waves (Yohana, 2017).

The Parit Berkat region, namely the Parit Berkat estuary, is significantly impacted by tides. At high tide, the Pinang River's water level rises and causes a significant increase in water flowing into the Parit Berkat drainage channel. In conjunction with severe precipitation, puddles may form along the Parit Berkat drainage channel. It is possible for puddles to form when the quantity of water exceeds the capacity of the channels.

As a result of urban growth, a portion of the land that was once classified as green space has been transformed into residential property. One of the regions affected by this is the Parit Berkat region. Originally a swamp and plantation region, Parit Berkat is a residential neighborhood with homes on both the left and right sides of the Parit Berkat drainage canal. The majority of residents' activities occur in the Parit Berkat canal, therefore influencing the cross-section of the Parit Berkat drainage canal, which in turn influences the water level profile of the Parit Berkat canal (Resmani, 2017).

This research aimed to detect flooding issues by evaluating the capacity of the Parit Berkat
drainage canal under conditions of excessive rainfall and high tides. Additionally, this research is valuable for determining the influence of tides in the Parit Berkat canal and for determining the cross-sectional conditions of the Parit Berkat drainage channel so that it may be utilized as a guide for future channel designs in the Parit Berkat Water Catchment region.

2. Materials and Methods
2.1 Theoretical Frame Work
Essentially, floods reflect natural phenomena and the accelerated damage to the Earth's surface caused by human actions, resulting in a heightened susceptibility to flooding in specific areas (Alfaro et al., 2023). Due to Indonesia's archipelagic nature, it has numerous small rivers and drainage channels that transport water, including the study location. These water channels redirect water back to rivers and the sea during rainfall. Each channel has its capacity or ability to carry water. A channel is designed based on its intended capacity function. A drainage channel is typically constructed to handle high rainfall and wastewater from residential areas, including tidal water in certain regions. If the drainage channels cannot contain water effectively, excessive rainfall or tidal surges can cause water to overflow onto higher ground and reach residential areas.

This article presents the results of a capacity test analysis on the drainage channel of Parit Berkat in the village of Punggur Besar, Kubu Raya Regency, West Kalimantan Province. Many similar studies have been conducted on capacity tests of drainage channels, but research has yet to be done on Parit Berkat, an area influenced by tidal surges.

In summary, the course of the research is shown in the flow chart in Figure 1.

2.2 Research Location
The research was carried out on the drainage channels of Parit Berkat, which are located on Parit Berkat road, Punggur Besar village, Sungai Kakap Prefecture, Kubu Raya district, West Borneo Province.

![Fig.2 Location of Research](image)

2.3 Data
Data collection is carried out by requesting data from the service and related agencies, learning books, collections of journals, or other literature related to the title to be discussed, which will later be needed as a reference. The data used consists of primary data and secondary data.

a. Primary Data
The primary data used in this research was obtained through field surveys. The first data is the penetration of the lengthy and cross-channel Parit Berkat for each segment carried out over nine days. The second data is the height of the surface of the tide that occurs in the estuary of Parit Berkat channel, which is observed for 15 days with a time interval of 1 hour.

b. Secondary Data
The secondary data used in the research is a map of the research location and daily rainfall data for the last 15 years. Parit Berkat's research area map was obtained from the BAPPEDA Kubu Raya office. In contrast, the daily rainfall data for the last 15 years (2007-2021) was obtained from the office of Balai Wilayah Sungai Kalimantan I (BWSK I).

2.4 Analysis Method
After all the data is collected, the data analysis is conducted to conclude. Data Analysis consists of the maximum rainfall analysis consisting of a consistency test using the Worsley Likelihood Ratio method, a matching test using statistical and square chi parameters, and a rainfall distribution analysis using the Pearson Log Type III method. The method of calculating rain intensity using the Mononobe approach was analyzed. Rainfall return period
analysis with Snyder's HSS and Hydraulic model analysis with HEC-RAS software tools.

3. Result and Discussion

The rainfall data used in this research is the maximum daily rainfall recorded in the last 15 years, namely 2007 – 2021 PTK-12 Sungai Kakap station obtained from Balai Wilayah Sungai Kalimantan I (BWSK I). Maximum daily rainfall can be seen in Table 1.

Table 1. Maximum Day Rainfall

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Maximum Daily Rainfall (mm)</th>
<th>YEAR</th>
<th>Maximum Daily Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>106</td>
<td>2016</td>
<td>152</td>
</tr>
<tr>
<td>2008</td>
<td>184</td>
<td>2017</td>
<td>175</td>
</tr>
<tr>
<td>2009</td>
<td>156</td>
<td>2018</td>
<td>82</td>
</tr>
<tr>
<td>2010</td>
<td>112</td>
<td>2019</td>
<td>80</td>
</tr>
<tr>
<td>2011</td>
<td>258</td>
<td>2020</td>
<td>95</td>
</tr>
<tr>
<td>2012</td>
<td>244</td>
<td>2021</td>
<td>100</td>
</tr>
<tr>
<td>2013</td>
<td>156</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>2014</td>
<td>74</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>2015</td>
<td>130</td>
<td></td>
<td>140.27</td>
</tr>
<tr>
<td></td>
<td>Total 2104</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After the 1-day maximum rainfall data were inventoried, a series of tests were carried out on the data, namely testing data consistency with the Worsley Likelihood Ratio Method and goodness of fit tests using statistical descriptor tests and chi-square statistical tests. The purpose of these tests is to make the analysis results valid.

Table 2. The Result of Consistency Testing

<table>
<thead>
<tr>
<th>Wvalue</th>
<th>Wtabel</th>
<th>Wcount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>2,37</td>
</tr>
<tr>
<td></td>
<td>3,36</td>
<td>&lt;</td>
</tr>
<tr>
<td>Wcount &lt; Wtabel = CONSISTENT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the W value obtained in the table above, the W count value 2.37 is smaller than the W table value 3.36, so it can be understood that the rainfall data obtained from the Balai Wilayah Sungai Kalimantan I for the PTK-12 station is consistent.

Table 3. The result of statistical parameter testing

<table>
<thead>
<tr>
<th>No</th>
<th>Distribution</th>
<th>Condition</th>
<th>Result</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
<td>X = 0</td>
<td>0</td>
<td>0.668</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X = 3</td>
<td>3</td>
<td>3.057</td>
</tr>
<tr>
<td>2</td>
<td>Log Normal</td>
<td>X = 0 + 3X</td>
<td>0.243</td>
<td>0.252</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X = 0 + 6X + 15X^2 + 15X^3 + 3</td>
<td>3.105</td>
<td>3.255</td>
</tr>
<tr>
<td>3</td>
<td>Gumbel</td>
<td>X ≤ 5.14</td>
<td>1.159</td>
<td>0.668</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X &gt; 5.4</td>
<td>5.4</td>
<td>3.057</td>
</tr>
<tr>
<td>4</td>
<td>Log Pearson</td>
<td>Other than zero value</td>
<td>0.252</td>
<td>Accepted</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td></td>
<td></td>
<td>2.225</td>
</tr>
</tbody>
</table>

From the results of the statistical parameter test of rainfall data from each method to be used, as presented in Table 3, the appropriate way to be used in rainfall frequency analysis is the Gumbel and Log Pearson type III methods. However, these results were validated again with the goodness of fit test using the chi-squared test.

Table 4. Chi-Square Test Results

<table>
<thead>
<tr>
<th>Frequency Distribution</th>
<th>X²</th>
<th>X²cr</th>
<th>Keterangan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gumbel</td>
<td>3.333</td>
<td>5.991</td>
<td>Accepted</td>
</tr>
<tr>
<td>Log Pearson Type III</td>
<td>0.667</td>
<td>5.991</td>
<td>Accepted</td>
</tr>
</tbody>
</table>

Based on the table of computation of the suitability test with the Chi-Square method above, the results show that both approaches have X² < X² count, so it can be interpreted that both rainfall distribution methods are acceptable. Based on the smallest X² value, the Log Pearson Type III Distribution Analysis is the most suitable method for analyzing the frequency of rainfall in the Parit Berkat.

The form of the frequency curve equation obtained from the Log Pearson type III Method is as follows:

Log X_T = Log X_{RT} + K_T × S log X

Log X_T = Log 2,115 + 0,84518 × 0,171

Log X_S = 2,1149

R_5 = Log 2,1149

R_5 = 181,728 mm

The re-period plan rainfall analysis is intended to estimate the maximum or higher rainfall that may occur in a given period.

Table 5. The results of recurring period rainfall analysis

<table>
<thead>
<tr>
<th>No</th>
<th>Return Period</th>
<th>Log Xrt</th>
<th>Kt</th>
<th>S Log X</th>
<th>Log X_t</th>
<th>X_T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>2.12</td>
<td>0.60</td>
<td>0.17</td>
<td>2.11</td>
<td>130.30</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>2.12</td>
<td>0.85</td>
<td>0.17</td>
<td>2.26</td>
<td>181.73</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>2.12</td>
<td>1.28</td>
<td>0.17</td>
<td>2.33</td>
<td>215.82</td>
</tr>
</tbody>
</table>

From the rainfall return period analysis, the rainfall intensity in Parit Berkat was analyzed. The analysis of rainfall intensity was carried out using the Mononobe equation.

\[
I = \left[\frac{R_{24}}{24}\right]^{m} \left[\frac{24}{\frac{I_C}{60}}\right]^m \\
\]

\[m = 0.4\]  (1)

Wcount < Wtabel = CONSISTENT
With $L = 9.6$, $S = .0477$, the obtained $t_c$ value is

$$t_c = \left( \frac{0.87 \times L^2}{1000 \times S} \right)^{0.385}$$

(2)

$t_c = 1,2283$ hour

$= 1,2283 \times 60$ minute $= 73,29$ minute

With $t_c = 73,29$ minutes, the intensity for each return period are

$$I_2 = \left( \frac{130.30}{24} \right) \left( \frac{24}{73.29/60} \right)^{0.4} = 17.868 \text{ mm/hr}$$

$$I_5 = \left( \frac{181.73}{24} \right) \left( \frac{24}{73.29/60} \right)^{0.4} = 24.920 \text{ mm/hr}$$

$$I_{10} = \left( \frac{215.82}{24} \right) \left( \frac{24}{73.29/60} \right)^{0.4} = 29.595 \text{ mm/hr}$$

Analysis of the planned flood discharge for each return period is carried out using the Snyder Synthetic Unit Hydrograph. After obtaining the amount of rainfall intensity for each return period, the amount of planned flood discharge for each return period is obtained. The flood discharge hydrograph is calculated in three segments:

- the descending segment for stations 0000 - 3301
- the middle part for stations 3301 - 6319
- the upstream component for stations 6319 - 9600

The total length of the channel is 9600 m.

Table 6. The flood design for each return period results from the Snyder Synthetic Unit Hydrograph analysis

<table>
<thead>
<tr>
<th>STA</th>
<th>Maximum Discharge Q (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Years</td>
</tr>
<tr>
<td>0000 - 3301</td>
<td>2.892</td>
</tr>
<tr>
<td>3301 - 6319</td>
<td>3.249</td>
</tr>
<tr>
<td>6319 - 9600</td>
<td>4.560</td>
</tr>
</tbody>
</table>

The Parit Berkat drainage channel is influenced by the tides at the mouth of the Parit Berkat channel. The tidal observations made for 15 days show that the tidal type in Parit Berkat is mixed tide, prevailing diurnal type, leaning towards single daily.

After obtaining the magnitude of the flood design and the type of tide in Parit Berkat, flood modelling was carried out with the help of HEC-RAS 5.07 software.

This modelling aims to see the results of the analysis of the calculation of the discharge plan with tidal observations that have been processed by the data with predetermined methods.

The flow in the channel under review could be more stable. Model inputs consist of water level in the medium (tides) and 2-year, 5-year, and 10-year planned rainfall discharge.

In tidal conditions without rain, the data entered into the boundary conditions for non-permanent flow analysis is the tidal observation data that
affects the channel according to the observation data carried out without a flood hydrograph plan.

Fig. 7 STA 4186 overlapping profile when installed high without rain

Fig. 8 Profile lengthens the drainage channels of Parit Berkat to the tide conditions without rain.

Figures 7 and 8 show that the water level in Parit Berkat at high tide is above the channel’s lower right-side lip. In addition, more channel segments can hold water at high tide without rain. So, it can be said that even without rain, the drainage capacity in Parit Berkat is close to maximum. Thus, the area around Parit Berkat is prone to flooding.

Furthermore, simulations were carried out again to find out the condition of the drainage capacity in Parit Berkat when the tide and rainfall occur together by including the amount of precipitation for each return period and the wave.

Fig. 9 The overlapping profile of STA 2703 when there is a 2-year rebound period of rain, accompanied by the maximum installation in the estuary

Fig. 10 Profile length drainage channels Parit Berkat condition of tide with rain period 2 years

Fig. 11 The overlapping profile of STA 2703 when there is rain during the 5-year rebound period accompanied by maximum installation in the estuary

Fig. 12 Profile lengthens the drainage canal of Parit Berkat to the conditions of the tide with the rainy period of 5 years

Fig. 13 Transverse profile of STA 2703 when 10 year return period precipitation coincides with the highest tide in the estuary
Fig.14 Profile length drainage channels Parit Berkat condition of the rise with the rain period of 10 years

From the analysis that has been carried out, it can be seen that the capacity of the Parit Berkat drainage channel when tides and rain occur together is overloaded so that it cannot accommodate water, resulting in increased inundation, because the right side of the track has a lower elevation.

From the analysis results, it can be seen that the capacity of the drainage channel in Parit Berkat is already overloaded, so action is needed to improve the performance of the existing drainage so that its power can be optimized again.

4. Conclusion

Based on the results of the analysis, it can be seen that the tides influence the Parit Berkah drainage channel and have varying elevations, where the hill in the upstream section is higher than the elevation in the downstream area so that flooding occurs more often in the downstream section of the channel which is a densely populated settlement compared to the upstream quarter which is still free from payments. Thus, the flooding results from the reduced function of the Parit Berkat drainage channel, which can no longer accommodate the water discharge flowing through it. Based on the simulation results, it is known that six channel sections flow during rain and no rain, and 27 units do not rush.

Simulation results with input data on rainfall for a 2-year return period and sea tides showed that out of 33 segments, there were 16 segments in the Parit Berkat drainage channel where the water overflowed and caused flooding. In comparison, in the 5-year and 10-year return periods, there were 24 segments and 26 segments, respectively. Based on the simulation results, it can be concluded that the Parit Berkat drainage channel needs to be dealt with in anticipation of the expansion of the area affected by flooding due to the drainage channel’s declining performance. Suggested handling actions so that the Parit Berka drainage can function optimally include routine maintenance and channel normalization. With channel normalization, silting can be prevented so water can flow smoothly.

5. Acknowledgement (Arial 10 pt)

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6. Author’s Note

As the author, I certify that there are no conflicts of interest in publishing this journal, that other parties have not published it, and that it is original.

7. References


