**The Serok River Catchment Flood Hydrograph**

**Herlianda**, Nurhayati, Eko Yulianto

1Department of Civil Engineering, University of Tanjungpura, Pontianak

Abstract

Global climate change is expected to cause an increase in the intensity and duration of extreme rainfall events that occur today. The leading cause of flooding in various world regions, including flat coastal areas such as the Serok River catchment in Kota Pontianak, influenced by tides, is excessive rainfall. This article presents the results of an analysis of the impact of extreme precipitation on the peak discharge of flood hydrographs in the Serok River catchment, Kota Pontianak. Maximum daily rainfall data for 2009-2020 recorded at PTK-11 Pontianak Station were selected using the Annual Maximum Series Method. Frequency analysis was conducted using the best distribution method selected from Normal, Log Normal, Log Pearson Type III, and Gumbel Type I to obtain the design rainfall. The design rainfall was transformed into flood hydrographs at the next stage using the Snyder Synthetic Unit Hydrograph based on several return periods.

The results of the analysis show that there are changes in flood discharge in the Serok River catchment area for each return period. The location of land use and the value of rain intensity significantly affect the calculation of plan discharge; the more significant the land area and the higher the rain intensity, the greater the resulting release. The most considerable flood discharge (Qmax) in the 2, 5, and 10 years return occurs at STA 1 + 100, w.290 m^3/s, 0.347 m^3/s, and 0.377 m^3/s, respectively. Thus, this causes periodic flooding/inundation conditions, especially in areas that have low elevations.

1. Introduction

One of the most common natural disasters in West Kalimantan is flooding (Soeryamassoeka et al., 2018), as in the Serok River catchment area, Kota Pontianak. This area is flat and influenced by the tides. Due to rapid development in this area since 2009, this area has become one of the areas prone to flooding. Floods are catastrophic occurrences that result in extensive destruction (Soeryamassoeka et al., 2018). In contemporary flood hazard and risk analysis, crucial for designing flood mitigation infrastructure, it is essential to rely on accurate information regarding peak flow values, hydrograph volume, and shape (Ganora et al., 2023). At the same time, the estimation of design flood peaks has a long-standing history with various operational models available; methods for estimating flood volumes and hydrograph shapes still need to be expanded and lack comprehensive consolidation, particularly for catchments or watersheds that lack measured discharge data (Barid et al., 2022; Ganora et al., 2023). There are two alternatives for predicting flood discharge: indirect methods based on rainfall input and rainfall-runoff transformation to generate hydrographs or regional statistical methods to transfer information (e.g., hydrograph shape parameters) from measured to unmeasured sites (Blöschl et al., 2013). This research studies flood hydrograph patterns in the Serok River catchment area, with the data
used being 1-day maximum rainfall data. In this study, no separation was made between the maximum daily rainfall data with extreme events and the maximum daily rainfall data without extreme circumstances.

Extreme rainfall is rainfall with a depth of more than 100 mm/day. Daily rainfall in Indonesia is generally less than 100 mm in depth (I G Tunas et al., 2021). Despite multiple regions experiencing high annual rainfall exceeding 3000 mm/year, the daily rainfall depth remains within the range of average precipitation (Brotowiryatmo, 2000). However, Indonesia is currently witnessing an increase in the frequency of extreme rainfall events due to the pervasive effects of global climate change (Alfaro et al., 2023).

This study aims to determine the pattern of flood hydrographs in the Serok River catchment area so that it can be used as one of the reference parameters in minimizing floods that often occur in the area.

2. Material and Methods

2.1 Theoretical Frame Work

High-resolution flood event data play a crucial role in various aspects, including the design of hydraulic structures, flood frequency analysis, flood risk assessment, and reservoir operations (Lee, J et al., 2021). For hydraulic design and risk assessments, it is necessary to determine design flood estimates for a specific return period in both gauged and ungauged catchments. Unlike traditional design estimates, synthetic design hydrographs offer valuable insights into the peak intensity of events, the associated hydrograph volumes, and the shapes of the hydrographs. These artificial design hydrographs provide comprehensive information for the above purposes (Brunner et al., 2018).

The artificial design hydrograph is sustainable hydrological modeling that is a natural evolution of the event-based design approach in modern hydrology. It improves rainfall-runoff transformation and gives practitioners more effective hydrologic output information for risk assessment (Grimaldi et al., 2022).

The Synthetic Unit Hydrograph (SUH) method has been widely applied in Indonesia’s watersheds, especially watersheds that do not have discharge data. SUH assumes rainfall occurs evenly throughout the watershed (Irawan & Hidayat, 2020). One of the commonly used models is the Snyder unit hydrograph model.

2.2 Research Location

The research location is in Serok River Catchment, Jalan Karet, Kota Pontianak, Kalimantan Barat Province, Indonesia. The area is 1.9 km long and geographically located at coordinates 0°00’50.44” North Latitude and 109°17’53.52” East Longitude.

![Fig 1. The Serok River Catchment, Jalan Karet, Kota Pontianak](image)

2.3 Data

The data used to create the Flood Hydrograph of the Serok River Catchment Area is the 1-day maximum rainfall data for 2009-2020 recorded at the PTK-11 Pontianak station. This data was inventoried from Balai Wilayah Sungai Kalimantan (BWSK) I Kalimantan Barat and the catchment area map of the Serok River.

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall (mm)</th>
<th>Year</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>133</td>
<td>2015</td>
<td>79</td>
</tr>
<tr>
<td>2010</td>
<td>159</td>
<td>2016</td>
<td>85</td>
</tr>
<tr>
<td>2011</td>
<td>100</td>
<td>2017</td>
<td>165</td>
</tr>
<tr>
<td>2012</td>
<td>118</td>
<td>2018</td>
<td>115</td>
</tr>
<tr>
<td>2013</td>
<td>112</td>
<td>2019</td>
<td>112</td>
</tr>
<tr>
<td>2014</td>
<td>155</td>
<td>2020</td>
<td>154</td>
</tr>
</tbody>
</table>

2.4 Analysis Method

The Flood Hydrograph Study of Serok River Watershed was conducted with the following steps:

a. Maximum rainfall data recapitulation
b. Determine the type of distribution of rainfall with statistical parameters
c. Fit test with Chi-Square between data distribution and theoretical distribution in choosing the type of rainfall distribution
d. Determine the planned rainfall intensity for return periods of 2, 5, and 10 years using the Mononobe method
e. Determine flood design using the Snyder method
In summary, the course of the research is like the research flow chart presented in Figure 2.

![Research Flow Chart](image)

**Fig 2. Research Flow Chart**

### 2.4.1 Determine the type of distribution of rainfall with statistical parameters

Statistical parameter test is intended to obtain a method that will be used to analyze the frequency of rainfall in the study location. Tests were carried out on the value of the skewness coefficient (Cs), the kurtosis coefficient (Ck), and the coefficient of variation (Cv).

The test results of the Cs, Ck, and Cv values were then compared with the Cs, Ck, and Cv values (Normal, Gumbel, Normal Log, and Type III Pearson Log).

If the results obtained are close to most of the statistical parameter values of one of the methods, then that method will be used for frequency analysis purposes.

<table>
<thead>
<tr>
<th>Table 2. Statistical Parameter Values of Normal, Gumbel Type I, Log Normal 3 Parameter Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statistic Parameter</strong></td>
</tr>
<tr>
<td>Cs</td>
</tr>
<tr>
<td>Ck</td>
</tr>
<tr>
<td>Cv</td>
</tr>
</tbody>
</table>

### 2.4.2 Fit test with Chi-Square Compilation Of Matrix

The Chi-squared test is intended to determine whether the odds distribution equation that has been selected can represent the statistical distribution of the data sample being analyzed.

This test decision-making uses the $\chi^2$ parameter. Therefore, it is called the Chi-square test. The formula can calculate the $\chi^2$ parameter:

$$\chi^2 = \sum_{i=1}^{G} \frac{(O_i - E_i)^2}{E_i}$$

### 2.4.3 Determine the rainfall intensity

The measure of rainfall intensity is the amount of rain that falls during a specific period divided by the duration of that period. This measurement is typically expressed as the rain depth in millimeters per hour (mm/h). In this study, rainfall intensity was calculated using the Mononobe equation.

$$I = \frac{R_{24}}{24} \left[ \frac{24}{tC_{f}/\gamma} \right]^m$$

<table>
<thead>
<tr>
<th>Table 3. Statistical Parameter Values of Log-Normal 2 Parameter Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statistic Parameter</strong></td>
</tr>
<tr>
<td>Cs</td>
</tr>
<tr>
<td>Ck</td>
</tr>
<tr>
<td>Cv</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4. Statistical Parameter Values of Log Pearson Type III Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statistic Parameter</strong></td>
</tr>
<tr>
<td>Cs</td>
</tr>
<tr>
<td>Ck</td>
</tr>
<tr>
<td>Cv</td>
</tr>
</tbody>
</table>
3. Result and Discussion

3.1 Results of statistical descriptor test to determine the type of rainfall distribution of the Sungai Serok Catchment Area

In conducting the statistical descriptor test to determine the type of rainfall distribution with statistical parameters, first calculate the mean value, standard deviation, magnitude of the skewness coefficient, kurtosis coefficient, and coefficient of variation of the 1-day maximum rainfall data for the Normal method and the Gumbel type I method.

Table 6. Calculation Results Number and the average value of 1-day maximum rainfall of PTK-11 Pontianak Station

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall Data (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>133</td>
</tr>
<tr>
<td>2010</td>
<td>159</td>
</tr>
<tr>
<td>2011</td>
<td>100</td>
</tr>
<tr>
<td>2012</td>
<td>118</td>
</tr>
<tr>
<td>2013</td>
<td>112</td>
</tr>
<tr>
<td>2014</td>
<td>155</td>
</tr>
<tr>
<td>2015</td>
<td>79</td>
</tr>
<tr>
<td>2016</td>
<td>85</td>
</tr>
<tr>
<td>2017</td>
<td>165</td>
</tr>
<tr>
<td>2018</td>
<td>115</td>
</tr>
<tr>
<td>2019</td>
<td>112</td>
</tr>
<tr>
<td>2020</td>
<td>154</td>
</tr>
</tbody>
</table>

Sum (X) 1487
Average (X) 123,917

From Table 6, the standard deviation (Sd) value is then calculated, followed by the skewness coefficient (Cs), kurtosis coefficient (Ck), and coefficient of variation (Cv), the results of which are as follows:

\[ S_d = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{9374.917}{12-1}} = 29.194 \]

\[ C_s = \frac{n\sum(x_i - \bar{x})^3}{(n-1)(n-2)s_d^3} = \frac{12 \sum 2990.736}{(12-1)(12-2)29.194^3} = 0.013 \]

\[ C_k = \frac{n^2\sum(x_i - \bar{x})^4}{(n-1)(n-2)(n-3)s_d^4} = \frac{12^2 \sum 12862245.290}{(12-1)(12-2)(12-3)29.194^4} = -1.243 \]

\[ C_v = \frac{s_d}{\bar{x}} = \frac{29.194}{123.917} = 0.236 \]
The statistical descriptors follow the log rule for the log Pearson type III, 2-parameter log-normal, and 3-parameter log-normal methods.

**Table 7.** Calculation Results Number and the average value of 1-day maximum rainfall of PTK-11 Pontianak Station in Log form

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall Data (mm)</th>
<th>Log Xi</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>133</td>
<td>2,12</td>
</tr>
<tr>
<td>2010</td>
<td>159</td>
<td>2,20</td>
</tr>
<tr>
<td>2011</td>
<td>100</td>
<td>2,00</td>
</tr>
<tr>
<td>2012</td>
<td>118</td>
<td>2,07</td>
</tr>
<tr>
<td>2013</td>
<td>112</td>
<td>2,05</td>
</tr>
<tr>
<td>2014</td>
<td>155</td>
<td>2,19</td>
</tr>
<tr>
<td>2015</td>
<td>79</td>
<td>1,90</td>
</tr>
<tr>
<td>2016</td>
<td>85</td>
<td>1,93</td>
</tr>
<tr>
<td>2017</td>
<td>166</td>
<td>2,22</td>
</tr>
<tr>
<td>2018</td>
<td>115</td>
<td>2,06</td>
</tr>
<tr>
<td>2019</td>
<td>112</td>
<td>2,05</td>
</tr>
<tr>
<td>2020</td>
<td>154</td>
<td>2,19</td>
</tr>
<tr>
<td>Sum (X)</td>
<td></td>
<td>1487</td>
</tr>
<tr>
<td>Average ( X )</td>
<td></td>
<td>123.92</td>
</tr>
</tbody>
</table>

\[ S_{\log X} = \sqrt{\frac{\sum (\log x_i - \bar{\log X})^2}{n-1}} = \sqrt{\frac{(0.124)^2}{12-1}} \]
\[ S_{\log X} = 0.106 \]

\[ Cs = \frac{n \sum (\log x_i - \bar{\log X})^3}{(n-1)(n-2)(\sum_x \log x)} \]
\[ Cs = \frac{12 \sum -0.004}{(12-1)(12-2)(-0.001)^3} = -0.326 \]

\[ Ck = \frac{n^2 \sum (\log x_i - \bar{\log X})^4}{(n-1)(n-2)(n-3)(\sum_x \log x)} \]
\[ Ck = \frac{12^2 \sum 0.003}{(12-1)(12-2)(12-3)0.004^4} = -0.876 \]

\[ k = \frac{S_{\log X}}{\log x} = 0.236 \pm 0.4 \]

From the results of testing the statistical parameters of the normal distribution and the statistical parameters of the logarithmic distribution, the most suitable distribution method used in the calculation will be determined by comparing the values of the coefficient of Variation (Cv), the coefficient of Skewness (Cs), and the coefficient of Kurtosis (Ck). Analysis results with the coefficient values for each of the most suitable methods are the method with the relative error value closest to zero.

**Table 8. Statistical Descriptor Testing Analysis Results**

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Cs</th>
<th>Ck</th>
<th>Cv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.01</td>
<td>0.00</td>
<td>3</td>
</tr>
<tr>
<td>Gumbel Type I</td>
<td>1.139</td>
<td>0.013</td>
<td>99%</td>
</tr>
<tr>
<td>Log Pearson</td>
<td>-0.326</td>
<td>-0.326</td>
<td>0%</td>
</tr>
<tr>
<td>Type III</td>
<td>0.051</td>
<td>0.051</td>
<td>90%</td>
</tr>
<tr>
<td>2-Parameter Log Normal</td>
<td>0.153</td>
<td>0.153</td>
<td>313%</td>
</tr>
<tr>
<td>3-Parameter Log Normal</td>
<td>0.702</td>
<td>0.702</td>
<td>144%</td>
</tr>
</tbody>
</table>

For testing with chi-squared (C²), the straight-line equation of each method used is determined, namely the Normal Method, Gumbel Type I, Log Pearson Type III, Log Normal 2 Parameters, and Log Normal 3 Parameters.

The statistical parameters used are mean value and standard deviation (for normal and Gumbel Type I methods), mean value, standard deviation, and skewness coefficient (for Log Pearson Type III, Log Normal 2 Parameter and Log Normal 3 Parameter methods).

Determining the number of opportunities is intended for determining the class interval boundaries. In conducting the Goodness of Fit Test, the number of opportunities is determined. The number of subgroups is divided into 5, so the class interval limit is 5, and the number of opportunities taken is 4, namely: 0.2; 0.4; 0.6; 0.8.

The course of testing for each method is as follows:

**a. Normal Methods.**

In performing the Goodness of fit test for the Normal method, the probability value of K is taken from the Gauss Reduction Variable value table.
The chi-squared is obtained using a K value based on the probability of the rainfall amount occurring.

Table 10. The Calculation Goodness of Fit Test To Normal Method Using Chi-Squared

<table>
<thead>
<tr>
<th>Probability</th>
<th>X</th>
<th>Interval</th>
<th>Oi</th>
<th>Ei</th>
<th>(Oi - Ei)²</th>
<th>χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>P = 1 - 0.2 x 0.8</td>
<td>99,39</td>
<td>&lt;99,39</td>
<td>2</td>
<td>2</td>
<td>0.16</td>
<td>0.067</td>
</tr>
<tr>
<td>P = 1 - 0.4</td>
<td>116,62</td>
<td>99,39 - 116,62</td>
<td>4</td>
<td>2,4</td>
<td>2.56</td>
<td>1.067</td>
</tr>
<tr>
<td>P = 1 - 0.6</td>
<td>0.4</td>
<td>131,22 - 131,22</td>
<td>1</td>
<td>2.4</td>
<td>1.96</td>
<td>0.817</td>
</tr>
<tr>
<td>P = 1 - 0.8 x 0.2</td>
<td>148,44</td>
<td>131,22 - 148,44</td>
<td>1</td>
<td>2.4</td>
<td>1.96</td>
<td>0.817</td>
</tr>
<tr>
<td>&gt; 148,44</td>
<td>12</td>
<td>2,4</td>
<td>2.56</td>
<td>1.067</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Jumlah 12 12 3,833

Furthermore, the calculation of the degree of freedom is done by

\[ DF = G-R-1 \]

G = number of classes = 5

\[ R = 2 \]

\[ DF = 5-2-1 = 2 \]

With DF equal to 2, at 95% confidence, the \( \chi^2 \) table value is 5.991. The calculation results show that the amount is 3.833; this value is less than \( \chi^2 \) standard for degree of freedom two is 5.991. Thus, the normal method can be used to analyze rainfall distribution in the Serok River catchment area.

b. Gumbel Type I Methods

The method of testing the Gumbel Type I Method is the same as the Normal Method, what differs is the equation used, and the reference table used. For the Gumbel Type I Method, the equation used is a straight-line equation of the mathematical model of the Gumbel Type I distribution determined using the method of moments.

\[ Y = \alpha (X - X_o) \rightarrow \alpha = \frac{1.283}{\sigma} \rightarrow X_o = \mu - \frac{0.577}{\sigma} \]

or

\[ X_0 = \mu - 0.455 \sigma, \text{with;} \]

\[ \mu = \text{average} \]

\[ \sigma = \text{standard deviation} \]

The value of \( Y \), the type I Gumbell reduction factor, is a function of the probability or return period, as shown in the Gumbel Reduction Variation Values table.

Table 11. The Gumbel Reduction Variation Values

<table>
<thead>
<tr>
<th>Return Period T (Year)</th>
<th>Probability</th>
<th>Y</th>
<th>Return Period T (Year)</th>
<th>Probability</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,001</td>
<td>0.001</td>
<td>-1.93</td>
<td>3,33</td>
<td>0.700</td>
<td>1,030</td>
</tr>
<tr>
<td>1,005</td>
<td>0.005</td>
<td>-1.67</td>
<td>4</td>
<td>0.750</td>
<td>1,240</td>
</tr>
<tr>
<td>1,01</td>
<td>0.010</td>
<td>-1.53</td>
<td>5</td>
<td>0.800</td>
<td>1,510</td>
</tr>
<tr>
<td>1,05</td>
<td>0.050</td>
<td>-1.097</td>
<td>10</td>
<td>0.900</td>
<td>2,250</td>
</tr>
<tr>
<td>1,11</td>
<td>0.100</td>
<td>-0.834</td>
<td>20</td>
<td>0.950</td>
<td>2,970</td>
</tr>
<tr>
<td>1,25</td>
<td>0.200</td>
<td>-0.476</td>
<td>50</td>
<td>0.980</td>
<td>3,900</td>
</tr>
<tr>
<td>1,33</td>
<td>0.250</td>
<td>-0.326</td>
<td>100</td>
<td>0.990</td>
<td>4,600</td>
</tr>
<tr>
<td>1,43</td>
<td>0.300</td>
<td>0.185</td>
<td>200</td>
<td>0.995</td>
<td>5,290</td>
</tr>
<tr>
<td>1,67</td>
<td>0.400</td>
<td>0.087</td>
<td>500</td>
<td>0.998</td>
<td>6,210</td>
</tr>
<tr>
<td>2</td>
<td>0.500</td>
<td>0.366</td>
<td>1000</td>
<td>0.999</td>
<td>6,900</td>
</tr>
<tr>
<td>2.5</td>
<td>0.600</td>
<td>0.671</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the analysis performed in testing the Gumbel Type I Method for rainfall distribution analysis at the study site, the parameter equations based on the rainfall data of Table 7 are;

\[ Y = \alpha (X - X_o) \rightarrow \alpha = \frac{1.283}{\sigma} \rightarrow X_o = \mu - \frac{0.577}{\sigma} \]

\[ \therefore Y = \alpha (X - X_o) \rightarrow Y = 0.044 (X - 110.79) \]

\[ Y = 0.044 X - 4.869 \rightarrow X = 0.044 \]

Next, the Y value for each probability is determined based on Gumbel Reduction Variable Value Table;

At a chance of 0.2, the value of \( Y = -0.476 \) 0.4, Y value = 0.087 0.6, Y value = 0.671 0.8, Y value = 1.510

In the same way as testing the normal method, the calculated \( \chi^2 \) value of the Gumbel type I method is 3.833, less than the \( \chi^2 \) table. Thus, the Gumbel Type I method can be used to analyze rainfall distribution in the Serok River catchment area.

c. Log Pearson Type III Methods

This form transforms the Pearson type III distribution by replacing the variate with a logarithmic value.

The K value is obtained from the Pearson Type III and Log Pearson Type III Distribution K Value tables in testing the Log Pearson Type III method.
Table 12. The Pearson Type III and Log Pearson Type III Distribution K Value

<table>
<thead>
<tr>
<th>Skewness (Cs)</th>
<th>Return Period (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Probability (%)</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>3.05</td>
</tr>
<tr>
<td>1.25</td>
<td>0.25</td>
</tr>
<tr>
<td>2.5</td>
<td>0.50</td>
</tr>
<tr>
<td>3.0</td>
<td>0.50</td>
</tr>
</tbody>
</table>

The calculation steps performed for the chi-squared test of the Log Pearson Type III Method are the same as those for the Normal and Gumbel type I methods above. What is different is the value of the data used, the Log value of the rainfall tested, and the value of k, which is determined based on the chance value in Table 12 based on the Skewness Coefficient (Cs) value.

Based on the value of Cs, the frequency factor K for each probability is obtained:

- 0.2, K value = -2.642
- 0.4, K value = -0.531
- 0.6, K value = 0.654
- 0.8, K value = 0.912

In the same way as testing the normal method and Gumbel Type I method, the calculated \( \chi^2 \) value of the Log Pearson type III method is 8.833, which is greater than the \( \chi^2 \) table. Thus, the Log Pearson Type I method cannot be used to analyze rainfall distribution in the Serok River catchment area.

From the results of the statistical descriptor test and goodness of fit test that have been carried out, it can be seen that the Normal method is a suitable method used for analyzing the frequency of rainfall distribution in the Serok River catchment area because during the statistical descriptor test the percentage error value is less than 50%. The goodness of fit test results is accepted.

3.3. Rainfall Intensity Analysis Results

The goodness of fit test results shows that the Normal method is the most suitable rainfall distribution frequency analysis. So by using the Normal method, the amount of rainfall in the 2, 5, and 10-year periods is obtained as follows:

\[
\begin{align*}
R_2 &= \bar{X} + k \cdot S = 123.92 + 0 \times 29.19 \\
R_5 &= 123.92, \text{ mm} \\
R_{10} &= 148.44, \text{ mm} \\
R_{100} &= 161.29, \text{ mm}
\end{align*}
\]

After obtaining the amount of rainfall at a return period of 2, 5, and 10 years, the intensity of rainfall for each return period was analyzed.

The equation used is the Mononobe equation, as presented in Equation 2. It is known that the length of the main channel of the Serok River from upstream to the sewer (L) is 1.9 km = 1900 m, and the average slope of the main channel (m) (S) of the Serok River is 0.000585, then by using equation 3, the magnitude of tc is equal to 1.96 hour = 117.53 minute, so the amount of rainfall intensity per return period are \( I_2 \) is equal 27.44 mm/hour, \( I_5 \) is equal 32.87 mm/hour and \( I_{10} \) is equal 35.72 mm/hour.

By knowing the rainfall and rainfall intensity for each return period, flood design analysis is then carried out for each return period, the results of which are used to create a flow hydrograph.
3.4 Flood Design Analysis Result

By using the results of rainfall analysis and rainfall intensity for each return period, a flood design analysis using SUH Snyder can be conducted. The analysis follows equations 4 and 5 to obtain the results of flood design and flow hydrographs for each return period. The analysis was conducted in each segment of the 1.9 km long Serok River, with a distance of 100 m between segments.

<table>
<thead>
<tr>
<th>Sta</th>
<th>Catchment area</th>
<th>Channel length</th>
<th>Q Return period</th>
</tr>
</thead>
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<tr>
<td>0</td>
<td>0.0469</td>
<td>0.1</td>
<td>0.26, 0.31, 0.33</td>
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<tr>
<td>200</td>
<td>0.0459</td>
<td>0.1</td>
<td>0.25, 0.30, 0.33</td>
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<td>300</td>
<td>0.0401</td>
<td>0.1</td>
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<td>400</td>
<td>0.0411</td>
<td>0.1</td>
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<tr>
<td>500</td>
<td>0.0475</td>
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<tr>
<td>600</td>
<td>0.0526</td>
<td>0.1</td>
<td>0.29, 0.35, 0.38</td>
</tr>
<tr>
<td>700</td>
<td>0.0382</td>
<td>0.1</td>
<td>0.21, 0.25, 0.27</td>
</tr>
<tr>
<td>800</td>
<td>0.0438</td>
<td>0.1</td>
<td>0.24, 0.29, 0.31</td>
</tr>
<tr>
<td>900</td>
<td>0.0429</td>
<td>0.1</td>
<td>0.24, 0.28, 0.31</td>
</tr>
<tr>
<td>1000</td>
<td>0.039</td>
<td>0.1</td>
<td>0.21, 0.26, 0.28</td>
</tr>
<tr>
<td>1100</td>
<td>0.0529</td>
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<td>0.29, 0.35, 0.38</td>
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<td>0.26, 0.31, 0.33</td>
</tr>
<tr>
<td>1300</td>
<td>0.0421</td>
<td>0.1</td>
<td>0.23, 0.28, 0.30</td>
</tr>
<tr>
<td>1400</td>
<td>0.0421</td>
<td>0.1</td>
<td>0.23, 0.28, 0.30</td>
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<tr>
<td>1500</td>
<td>0.039</td>
<td>0.1</td>
<td>0.21, 0.26, 0.28</td>
</tr>
<tr>
<td>1600</td>
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<td>0.1</td>
<td>0.27, 0.32, 0.35</td>
</tr>
<tr>
<td>1700</td>
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<tr>
<td>1900</td>
<td>0.0092</td>
<td>0.1</td>
<td>0.05, 0.06, 0.07</td>
</tr>
</tbody>
</table>

The results of the Snyder Synthetic Unit Hydrograph graph show that each annual return period takes the same time to reach the peak of the maximum rainfall discharge and proves that the longer the annual return period, the greater the possibility of flood discharge.

4. Conclusion

Based on the results of the analysis, it is known that there are changes in flood discharge in the Serok River catchment area for each return period. The area of land use dramatically affects the magnitude of the discharge plan; the more land area, the greater the resulting discharge. The value of rain intensity is also very influential on the amount of flood discharge because the higher the rain intensity, the greater the resulting discharge.

This research is an early stage research, so it opens up opportunities for more in-depth studies with complete data, one of which is by calibrating the coefficients Ct and Cp so that it will be seen how much influence land use change has on the amount of discharge that occurs in the Serok River catchment area.

5. Acknowledgement

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6. Author’s Note

The author now declares that this article is an original work and does not plagiarize any research, as it has successfully passed the examination to obtain a bachelor’s degree in engineering at the Faculty of Engineering, Tanjungpura University, on January 3, 2023.

7. References


Barid, B., & Afanda, B. O. (2022). Increasing Peak Flow of Snyder Synthetic Hydrograph Units in the Serenan Sub-


