BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

5.1 DATA CURAH HUJAN MAKSIMUM

Tabel 5.1 Data Hujan Harian Maksimum

<table>
<thead>
<tr>
<th>No</th>
<th>Tahun</th>
<th>Sta Karanganyar</th>
<th>Wanadadi</th>
<th>Karangrejo</th>
<th>Tugu AR</th>
<th>Kr.Kobar</th>
<th>Bukateja</th>
<th>Serang</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>91</td>
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<td>168</td>
<td>73</td>
<td>150</td>
<td>123</td>
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<td>1987</td>
<td>112</td>
<td>160</td>
<td>120</td>
<td>110</td>
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<td>130</td>
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<td>181</td>
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<td>91</td>
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<tr>
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<td>99</td>
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<td>105</td>
<td>99</td>
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<td>142</td>
<td>155</td>
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<td>97</td>
<td>119</td>
<td>102</td>
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<td>144</td>
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<td>106</td>
<td>200</td>
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<td>1998</td>
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<td>90</td>
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<td>99</td>
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<td>113</td>
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<td>80</td>
<td>200</td>
<td>100</td>
<td>107</td>
<td>118</td>
<td>99</td>
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<tr>
<td>18</td>
<td>2003</td>
<td>140</td>
<td>86</td>
<td>140</td>
<td>95</td>
<td>144</td>
<td>135</td>
<td>97</td>
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<td>2004</td>
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<td>144</td>
<td>160</td>
<td>85</td>
<td>86</td>
<td>105</td>
<td>175</td>
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<tr>
<td>20</td>
<td>2005</td>
<td>123</td>
<td>115</td>
<td>177</td>
<td>106</td>
<td>91</td>
<td>97</td>
<td>177</td>
</tr>
</tbody>
</table>

(Sumber : PSDA Serayu Citandui)

5.2 PERHITUNGAN CURAH HUJAN RATA-RATA

- Perhitungan Hujan Daerah dengan Metode Thiessen

\[ \bar{R} = R_1W_1 + R_2W_2 + \ldots + R_nW_n \]

dimana:

- \( \bar{R} \) = curah hujan rata-rata (mm)
- \( R_1, R_2, \ldots, R_n \) = curah hujan masing-masing stasiun (mm)
- \( W_1, W_2, \ldots, W_n \) = faktor bobot masing-masing stasiun
Gambar 5.1 Pembagian Luas DAS Metode Thiessen
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

Tabel 5.2 Luas DAS dan Koejiesien Thiessen

<table>
<thead>
<tr>
<th>No.</th>
<th>Stasiun</th>
<th>Luas (km²)</th>
<th>Koejiesien Thiessen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Karanganyar</td>
<td>262,556</td>
<td>26,507%</td>
</tr>
<tr>
<td>2</td>
<td>Wanadadi</td>
<td>234,943</td>
<td>23,727%</td>
</tr>
<tr>
<td>3</td>
<td>Karangrejo</td>
<td>73,424</td>
<td>7,466%</td>
</tr>
<tr>
<td>4</td>
<td>Tugu AR</td>
<td>83,496</td>
<td>8,480%</td>
</tr>
<tr>
<td>5</td>
<td>Kr.Kobar</td>
<td>133,071</td>
<td>13,471%</td>
</tr>
<tr>
<td>6</td>
<td>Bukateja</td>
<td>83,099</td>
<td>8,440%</td>
</tr>
<tr>
<td>7</td>
<td>Serang</td>
<td>117,556</td>
<td>11,909%</td>
</tr>
<tr>
<td></td>
<td>Jumlah</td>
<td>993,290</td>
<td>100,000%</td>
</tr>
</tbody>
</table>

(Sumber: Hasil Pengukuran)

Hasil perhitungan hujan daerah metode Thiessen disajikan dalam Tabel 5.3.
5.3 ANALISIS FREKUENSI CURAH HUJAN RENCANA

Dari hasil perhitungan hujan daerah metode Thiessen di atas perlu ditentukan kemungkinan terulangnya curah hujan harian maksimum guna menentukan debit banjir rencana.
5.3.1 Pengukuran Dispersi

Suatu kenyataan bahwa tidak semua nilai dari suatu variabel hidrologi terletak atau sama dengan nilai rata-ratanya, tetapi kemungkinan ada nilai yang lebih besar atau lebih kecil dari nilai rata-ratanya. Besarnya dispersi dapat dilakukan dengan pengukuran dispersi, yakni melalui perhitungan parameter statistik untuk \((X_i - \bar{X})\), \((X_i - \bar{X})^2\), \((X_i - \bar{X})^3\), \((X_i - \bar{X})^4\) terlebih dahulu.

Di mana: 
- \(X_i\) = Besarnya curah hujan maksimum daerah (mm)
- \(\bar{X}\) = Rata-rata curah hujan maksimum daerah (mm)

Perhitungan parameter stasistik dapat dilihat pada Tabel 5.4.

<table>
<thead>
<tr>
<th>No</th>
<th>Tahun</th>
<th>R24 Maks (Xi)</th>
<th>((X_i - \bar{X}))</th>
<th>((X_i - \bar{X})^2)</th>
<th>((X_i - \bar{X})^3)</th>
<th>((X_i - \bar{X})^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1986</td>
<td>116,386</td>
<td>-7,831</td>
<td>61,325</td>
<td>-480,233</td>
<td>3,760,70</td>
</tr>
<tr>
<td>2</td>
<td>1987</td>
<td>121,242</td>
<td>-2,975</td>
<td>8,851</td>
<td>-26,331</td>
<td>78,334</td>
</tr>
<tr>
<td>3</td>
<td>1988</td>
<td>135,328</td>
<td>11,111</td>
<td>123,454</td>
<td>1,371,70</td>
<td>15,240,97</td>
</tr>
<tr>
<td>4</td>
<td>1989</td>
<td>130,057</td>
<td>5,84</td>
<td>34,106</td>
<td>199,177</td>
<td>1,163,19</td>
</tr>
<tr>
<td>5</td>
<td>1990</td>
<td>115,311</td>
<td>-8,906</td>
<td>79,317</td>
<td>-706,396</td>
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<tr>
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<td>9,263</td>
<td>85,803</td>
<td>794,795</td>
<td>7,362,18</td>
</tr>
<tr>
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<td>1992</td>
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<td>-10,105</td>
<td>102,111</td>
<td>-1,03,83</td>
<td>10,426,66</td>
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<tr>
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<td>1993</td>
<td>146,625</td>
<td>22,408</td>
<td>502,118</td>
<td>11,251,47</td>
<td>252,122,95</td>
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<td>120,058</td>
<td>4,859</td>
<td>23,61</td>
<td>-114,72</td>
<td>557,426</td>
</tr>
<tr>
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<td>130,333</td>
<td>5,84</td>
<td>34,106</td>
<td>199,177</td>
<td>1,163,19</td>
</tr>
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<td>1996</td>
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<td>-5,283</td>
<td>27,91</td>
<td>-147,449</td>
<td>778,973</td>
</tr>
<tr>
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<td>132,873</td>
<td>8,656</td>
<td>74,926</td>
<td>648,562</td>
<td>5,613,96</td>
</tr>
<tr>
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<td>1998</td>
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<td>-9,383</td>
<td>88,041</td>
<td>-826,086</td>
<td>7,751,16</td>
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<tr>
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<td>130,013</td>
<td>5,796</td>
<td>33,594</td>
<td>194,709</td>
<td>1,128,53</td>
</tr>
<tr>
<td>16</td>
<td>2001</td>
<td>116,107</td>
<td>-8,11</td>
<td>65,772</td>
<td>-533,412</td>
<td>4,325,97</td>
</tr>
<tr>
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<td>2002</td>
<td>131,571</td>
<td>7,354</td>
<td>54,081</td>
<td>397,714</td>
<td>2,924,79</td>
</tr>
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<td>-5,85</td>
<td>34,222</td>
<td>-200,202</td>
<td>1,171,18</td>
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<tr>
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<td>2004</td>
<td>126,947</td>
<td>2,73</td>
<td>7,453</td>
<td>20,346</td>
<td>55,546</td>
</tr>
<tr>
<td>20</td>
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<td>123,618</td>
<td>-0,599</td>
<td>0,359</td>
<td>-0,215</td>
<td>0,129</td>
</tr>
<tr>
<td>Jumlah</td>
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<td>-0,006</td>
<td>1,690,18</td>
<td>7,275,15</td>
<td>381,444,84</td>
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</tr>
</tbody>
</table>

(Sumber: Hasil Perhitungan)
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

\[ X \text{ rata - rata } X = \frac{\sum_{i=1}^{n} Xi}{20} \]

\[ = 124,217 \text{ mm} \]

\[ \text{Standar Deviasi : } S = \sqrt{\frac{\sum_{i=1}^{n} (Xi - X)^2}{n - 1}} \]

\[ = \sqrt{\frac{1690,176}{(20 - 1)}} \]

\[ = 9,432 \]

\[ \text{Koefisien Skewness : } Cs = \frac{n \sum_{i=1}^{n} (Xi - X)^3}{(n-1)(n-2)S^3} \]

\[ = \frac{20 \times 7275,147}{(20 - 1) \times (20 - 2) \times 9,432^3} \]

\[ = 0,507 \]

\[ \text{Koefisien Kurtosis : } Ck = \frac{n^2 \sum_{i=1}^{n} (Xi - X)^4}{(n-1)(n-2)(n-3)S^4} \]

\[ = \frac{20^2 \times 381444,641}{(20 - 1) \times (20 - 2) \times (20 - 3) \times 9,432^4} \]

\[ = 3,316 \]

\[ \text{Koefesien Variasi : } Cv = \frac{S}{X} \]

\[ = \frac{9,432}{124,217} \]

\[ = 0,076 \]
5.3.2 Perhitungan Distribusi Logaritma

Hasil perhitungan distribusi logaritma disajikan pada Tabel 5.5.

Tabel 5.5 Parameter Distribusi Logaritma

<table>
<thead>
<tr>
<th>No</th>
<th>Tahun</th>
<th>Xi</th>
<th>log Xi</th>
<th>log X</th>
<th>log Xi - log X</th>
<th>(log Xi – log X)²</th>
<th>(log Xi – log X)³</th>
<th>(log Xi – log X)⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1986</td>
<td>116,386</td>
<td>2,066</td>
<td>1,673</td>
<td>0,393</td>
<td>0,1544</td>
<td>0,0607</td>
<td>0,0238</td>
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<tr>
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<td>1987</td>
<td>121,242</td>
<td>2,084</td>
<td>1,673</td>
<td>0,411</td>
<td>0,1686</td>
<td>0,0693</td>
<td>0,0284</td>
</tr>
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<td>135,328</td>
<td>2,131</td>
<td>1,673</td>
<td>0,458</td>
<td>0,2101</td>
<td>0,0963</td>
<td>0,0442</td>
</tr>
<tr>
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<td>1989</td>
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<td>2,114</td>
<td>1,673</td>
<td>0,441</td>
<td>0,1946</td>
<td>0,0858</td>
<td>0,0379</td>
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<tr>
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<td>2,062</td>
<td>1,673</td>
<td>0,389</td>
<td>0,1512</td>
<td>0,0588</td>
<td>0,0229</td>
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<td>0,2047</td>
<td>0,0926</td>
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<td>0,1477</td>
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<td>0,2433</td>
<td>0,1200</td>
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<td>130,545</td>
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<td>1,673</td>
<td>0,443</td>
<td>0,1960</td>
<td>0,0868</td>
<td>0,0384</td>
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<td>2,075</td>
<td>1,673</td>
<td>0,402</td>
<td>0,1619</td>
<td>0,0651</td>
<td>0,0262</td>
</tr>
<tr>
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<td>132,873</td>
<td>2,123</td>
<td>1,673</td>
<td>0,450</td>
<td>0,2029</td>
<td>0,0914</td>
<td>0,0412</td>
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<td>2,060</td>
<td>1,673</td>
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<td>0,0224</td>
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<tr>
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<td>2,036</td>
<td>1,673</td>
<td>0,363</td>
<td>0,1317</td>
<td>0,0478</td>
<td>0,0174</td>
</tr>
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<td>2001</td>
<td>116,107</td>
<td>2,065</td>
<td>1,673</td>
<td>0,392</td>
<td>0,1536</td>
<td>0,0602</td>
<td>0,0236</td>
</tr>
<tr>
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<td>2,119</td>
<td>1,673</td>
<td>0,446</td>
<td>0,1991</td>
<td>0,0888</td>
<td>0,0396</td>
</tr>
<tr>
<td>18</td>
<td>2003</td>
<td>118,367</td>
<td>2,073</td>
<td>1,673</td>
<td>0,400</td>
<td>0,1602</td>
<td>0,0641</td>
<td>0,0257</td>
</tr>
<tr>
<td>19</td>
<td>2004</td>
<td>126,947</td>
<td>2,104</td>
<td>1,673</td>
<td>0,431</td>
<td>0,1854</td>
<td>0,0799</td>
<td>0,0344</td>
</tr>
<tr>
<td>20</td>
<td>2005</td>
<td>123,618</td>
<td>2,092</td>
<td>1,673</td>
<td>0,419</td>
<td>0,1756</td>
<td>0,0736</td>
<td>0,0308</td>
</tr>
<tr>
<td>Jumlah</td>
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<td>3,5483</td>
<td>1,5075</td>
<td>0,6441</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

\[
\bar{\log X} = \frac{\sum_{i=1}^{n} \log X_i}{n} = \frac{33,465}{20} = 1,673
\]

\[
S_{\log X} = \sqrt{\frac{\sum_{i=1}^{n} (\log X_i - \bar{\log X})^2}{n-1}} = \sqrt{\frac{3,5483}{20-1}} = 0,4321
\]
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\[
Cs = \frac{n \sum (\log X_i - \log X)^3}{(n-1)(n-2) S_{\log x}^3}
\]

\[
= \frac{(20)1,5075}{(20-1)(20-2)0,4321^3}
= 1,093
\]

\[
Ck = \frac{n^2 \sum (\log X_i - \log X)^4}{(n-1)(n-2)(n-3) S_{\log x}^4}
\]

\[
= \frac{(400)0,6441}{(20-1)(20-2)(20-3)0,4321^3}
= 1,271
\]

\[
Cv = \frac{S_{\log x}}{( \log X )}
\]

\[
= 0,4321 / 1,673
= 0,258
\]

Tabel 5.6 Penentuan Jenis Sebaran

<table>
<thead>
<tr>
<th>Jenis Sebaran</th>
<th>Syarat</th>
<th>Hasil Perhitungan</th>
<th>Keterangan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Cs = 0  Ck = 3</td>
<td>Cs = 0,507 Ck =3,316</td>
<td>Tidak Memenuhi</td>
</tr>
<tr>
<td>Log Normal</td>
<td>Cs = 1,104  Ck = 5,24</td>
<td>Cs = 1,093 Ck = 1,271</td>
<td>Tidak Memenuhi</td>
</tr>
<tr>
<td>Log Pearson III</td>
<td>Cs ≠ 0  Cv = 0,3</td>
<td>Cs = 1,093 Cv = 0,258</td>
<td>Memenuhi</td>
</tr>
<tr>
<td>Gumbel</td>
<td>Cs =1,14  Ck = 5,4</td>
<td>Cs = 0,507 Ck =3,316</td>
<td>Tidak Memenuhi</td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

Dari hasil perhitungan di atas maka model distribusi yang digunakan adalah Log Pearson Tipe III karena hasil Cs dan Cv paling mendekati parameter yang disyaratkan.

TUGAS AKHIR

58
5.3.3 Pengujian Kecocokan Sebaran

Pengujian kecocokan sebaran digunakan untuk menguji sebaran data apakah memenuhi syarat untuk data perencanaan. Pengujian kecocokan sebaran menggunakan metode chi-kuadrat dengan rumus:

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

Di mana:
\(x^2\) = harga chi kuadrat.
\(O_i\) = frekuansi yang terbaca pada kelas yang sama.
\(E_i\) = frekuensi yang diharapkan sesuai pembagian kelasnya.
\(G\) = jumlah sub kelompok.
\(G = 1 + 3,322 \log n\)
\(= 1 + 3,322 \log 20\)
\(= 5,322 \approx 5 kelas\)
dk = n - 3
dk = 20 - 3
\(= 17\)
\(E_1 = \frac{N}{G}\)
\(= 20 / 5\)
\(= 4\)
\(\Delta \log X = (\log X maks - \log X min) / (G-1)\)
\(= (2,166 - 2,036) / (5-1)\)
\(= 0,033\)
\(\log X awal = \log X min - \frac{1}{2} \Delta \log X\)
\(= 2,036 - \frac{1}{2} 0,033\)
\(= 2,019\)
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

Tabel 5.7 Data Log Xi yang Disusun Secara Urut

<table>
<thead>
<tr>
<th>Tahun</th>
<th>log Xi</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>2,036</td>
</tr>
<tr>
<td>1992</td>
<td>2,057</td>
</tr>
<tr>
<td>1998</td>
<td>2,06</td>
</tr>
<tr>
<td>1990</td>
<td>2,062</td>
</tr>
<tr>
<td>2001</td>
<td>2,065</td>
</tr>
<tr>
<td>1986</td>
<td>2,066</td>
</tr>
<tr>
<td>2003</td>
<td>2,073</td>
</tr>
<tr>
<td>1996</td>
<td>2,075</td>
</tr>
<tr>
<td>1994</td>
<td>2,077</td>
</tr>
<tr>
<td>1986</td>
<td>2,084</td>
</tr>
<tr>
<td>2005</td>
<td>2,092</td>
</tr>
<tr>
<td>2004</td>
<td>2,104</td>
</tr>
<tr>
<td>1989</td>
<td>2,114</td>
</tr>
<tr>
<td>1999</td>
<td>2,114</td>
</tr>
<tr>
<td>1995</td>
<td>2,116</td>
</tr>
<tr>
<td>2002</td>
<td>2,119</td>
</tr>
<tr>
<td>1997</td>
<td>2,123</td>
</tr>
<tr>
<td>1991</td>
<td>2,125</td>
</tr>
<tr>
<td>1988</td>
<td>2,131</td>
</tr>
<tr>
<td>1993</td>
<td>2,166</td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

Tabel 5.8 Uji Chi-Kuadrat

<table>
<thead>
<tr>
<th>No</th>
<th>Kemungkinan</th>
<th>Ei</th>
<th>Oi</th>
<th>Oi - Ei</th>
<th>(Oi - Ei)²</th>
<th>(Oi - Ei)²/Ei</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,019 &lt; X &lt; 2,052</td>
<td>4</td>
<td>1</td>
<td>-3</td>
<td>9</td>
<td>2,25</td>
</tr>
<tr>
<td>2</td>
<td>2,052 &lt; X &lt; 2,085</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>25</td>
<td>6,25</td>
</tr>
<tr>
<td>3</td>
<td>2,085 &lt; X &lt; 2,118</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0,25</td>
</tr>
<tr>
<td>4</td>
<td>2,118 &lt; X &lt; 2,151</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2,151 &lt; X &lt; 2,184</td>
<td>4</td>
<td>1</td>
<td>-3</td>
<td>9</td>
<td>2,25</td>
</tr>
<tr>
<td>Jumlah</td>
<td></td>
<td>20</td>
<td>20</td>
<td></td>
<td>11,00</td>
<td></td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)
Tabel 5.9 Nilai Chi-Kuadrat Kritis dengan $\alpha = 5\%$

<table>
<thead>
<tr>
<th>dk</th>
<th>$\chi^2_{cr}$</th>
<th>dk</th>
<th>$\chi^2_{cr}$</th>
<th>dk</th>
<th>$\chi^2_{cr}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,841</td>
<td>11</td>
<td>19,675</td>
<td>21</td>
<td>32,671</td>
</tr>
<tr>
<td>2</td>
<td>5,991</td>
<td>12</td>
<td>21,026</td>
<td>22</td>
<td>33,924</td>
</tr>
<tr>
<td>3</td>
<td>7,815</td>
<td>13</td>
<td>22,362</td>
<td>23</td>
<td>35,172</td>
</tr>
<tr>
<td>4</td>
<td>9,451</td>
<td>14</td>
<td>23,605</td>
<td>24</td>
<td>36,415</td>
</tr>
<tr>
<td>5</td>
<td>11,070</td>
<td>15</td>
<td>24,996</td>
<td>25</td>
<td>37,652</td>
</tr>
<tr>
<td>6</td>
<td>12,592</td>
<td>16</td>
<td>26,296</td>
<td>26</td>
<td>40,005</td>
</tr>
<tr>
<td>7</td>
<td>14,067</td>
<td>17</td>
<td>27,587</td>
<td>27</td>
<td>40,113</td>
</tr>
<tr>
<td>8</td>
<td>15,507</td>
<td>18</td>
<td>28,869</td>
<td>28</td>
<td>41,007</td>
</tr>
<tr>
<td>9</td>
<td>16,616</td>
<td>19</td>
<td>30,144</td>
<td>29</td>
<td>42,557</td>
</tr>
<tr>
<td>10</td>
<td>18,307</td>
<td>20</td>
<td>31,410</td>
<td>30</td>
<td>43,773</td>
</tr>
</tbody>
</table>

(Sumber: Hidrologi Tehnik, CD Sumarto)

Dari perhitungan diatas diperoleh nilai $\chi^2 = 11,000$. Nilai ini lebih kecil jika dibandingkan dengan nilai $\chi^2$ kritis yang tercantum dalam Tabel 5.9. Dengan nilai derajat kebebasan (dk) = 17 maka nilai $\chi^2_{cr} = 25,587$ Ini berarti bahwa distribusi Log Pearson III yang digunakan dapat diterima.
5.4 PERHITUNGAN CURAH HUJAN RENCANA

Berdasarkan hasil uji sebaran, maka digunakan metode Log Pearson Tipe III untuk menghitung curah hujan rencana, hasil perhitungannya dapat dilihat pada Tabel 5.12.

Rumus:

\[ \log X_r = \bar{\log}X + k \cdot S_{\log x} \]

Dimana:
- \( X_r \) = nilai curah hujan rencana periode ulang T tahun
- \( k \) = harga yang diperoleh berdasarkan nilai Cs dari Tabel 5.1
- \( \bar{\log}X \) = nilai rata-rata logaritma dari hujan areal tiap tahun
- \( S_{\log x} \) = standar deviasi

Dari hasil perhitungan distribusi logaritma didapatkan nilai Cs = 1,093.
### Tabel 5.10 Harga k untuk Distribusi Log Pearson III

<table>
<thead>
<tr>
<th>Kemencengan</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>25</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>(CS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-0.396</td>
<td>0.42</td>
<td>1.18</td>
<td>2.278</td>
<td>3.152</td>
<td>4.051</td>
<td>4.97</td>
<td>7.25</td>
</tr>
<tr>
<td>2.5</td>
<td>-0.36</td>
<td>0.518</td>
<td>1.25</td>
<td>2.262</td>
<td>3.048</td>
<td>3.845</td>
<td>4.652</td>
<td>6.6</td>
</tr>
<tr>
<td>2.2</td>
<td>-0.33</td>
<td>0.574</td>
<td>1.84</td>
<td>2.24</td>
<td>2.97</td>
<td>3.705</td>
<td>4.444</td>
<td>6.2</td>
</tr>
<tr>
<td>2</td>
<td>-0.307</td>
<td>0.609</td>
<td>1.302</td>
<td>2.219</td>
<td>2.912</td>
<td>3.605</td>
<td>4.298</td>
<td>5.91</td>
</tr>
<tr>
<td>1.8</td>
<td>-0.282</td>
<td>0.643</td>
<td>1.318</td>
<td>2.193</td>
<td>2.848</td>
<td>3.499</td>
<td>4.147</td>
<td>5.66</td>
</tr>
<tr>
<td>1.6</td>
<td>-0.254</td>
<td>0.675</td>
<td>1.329</td>
<td>2.163</td>
<td>2.78</td>
<td>3.388</td>
<td>6.99</td>
<td>5.39</td>
</tr>
<tr>
<td>1.4</td>
<td>-0.225</td>
<td>0.705</td>
<td>1.337</td>
<td>2.128</td>
<td>2.706</td>
<td>3.271</td>
<td>3.828</td>
<td>5.11</td>
</tr>
<tr>
<td>1.2</td>
<td>-0.195</td>
<td>0.732</td>
<td>1.34</td>
<td>2.087</td>
<td>2.626</td>
<td>3.149</td>
<td>3.661</td>
<td>4.82</td>
</tr>
<tr>
<td>1</td>
<td>-0.164</td>
<td>0.758</td>
<td>1.34</td>
<td>2.043</td>
<td>2.542</td>
<td>3.022</td>
<td>3.489</td>
<td>4.54</td>
</tr>
<tr>
<td>0.9</td>
<td>-0.148</td>
<td>0.769</td>
<td>1.39</td>
<td>2.018</td>
<td>2.498</td>
<td>2.957</td>
<td>3.401</td>
<td>4.395</td>
</tr>
<tr>
<td>0.8</td>
<td>-0.132</td>
<td>0.78</td>
<td>1.366</td>
<td>1.998</td>
<td>2.453</td>
<td>2.891</td>
<td>3.312</td>
<td>4.25</td>
</tr>
<tr>
<td>0.7</td>
<td>-0.116</td>
<td>0.79</td>
<td>1.333</td>
<td>1.967</td>
<td>2.407</td>
<td>2.824</td>
<td>3.223</td>
<td>4.105</td>
</tr>
<tr>
<td>0.6</td>
<td>-0.099</td>
<td>0.8</td>
<td>1.328</td>
<td>1.939</td>
<td>2.359</td>
<td>2.755</td>
<td>3.132</td>
<td>3.96</td>
</tr>
<tr>
<td>0.5</td>
<td>-0.083</td>
<td>0.808</td>
<td>1.323</td>
<td>1.91</td>
<td>2.311</td>
<td>2.686</td>
<td>3.041</td>
<td>3.815</td>
</tr>
<tr>
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<td>-0.066</td>
<td>0.816</td>
<td>1.317</td>
<td>1.88</td>
<td>2.261</td>
<td>2.615</td>
<td>2.949</td>
<td>3.67</td>
</tr>
<tr>
<td>0.3</td>
<td>-0.05</td>
<td>0.824</td>
<td>1.309</td>
<td>1.849</td>
<td>2.211</td>
<td>2.544</td>
<td>2.856</td>
<td>5.525</td>
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<tr>
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<td>-0.033</td>
<td>0.831</td>
<td>1.301</td>
<td>1.818</td>
<td>2.159</td>
<td>2.472</td>
<td>2.763</td>
<td>3.38</td>
</tr>
<tr>
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<td>-0.017</td>
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<td>1.292</td>
<td>1.785</td>
<td>2.107</td>
<td>2.4</td>
<td>2.67</td>
<td>3.235</td>
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<td>2.326</td>
<td>2.576</td>
<td>3.09</td>
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<td>2.252</td>
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<td>2.81</td>
</tr>
<tr>
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<td>0.05</td>
<td>0.83</td>
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<td>1.643</td>
<td>1.89</td>
<td>2.104</td>
<td>2.294</td>
<td>2.675</td>
</tr>
<tr>
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<td>0.066</td>
<td>0.855</td>
<td>1.231</td>
<td>1.606</td>
<td>1.834</td>
<td>2.029</td>
<td>2.201</td>
<td>2.54</td>
</tr>
<tr>
<td>-0.5</td>
<td>0.083</td>
<td>0.856</td>
<td>1.216</td>
<td>1.567</td>
<td>1.777</td>
<td>1.955</td>
<td>2.108</td>
<td>2.4</td>
</tr>
<tr>
<td>-0.6</td>
<td>0.099</td>
<td>0.857</td>
<td>1.2</td>
<td>1.528</td>
<td>1.72</td>
<td>1.88</td>
<td>2.016</td>
<td>2.275</td>
</tr>
<tr>
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<td>0.116</td>
<td>0.857</td>
<td>1.183</td>
<td>1.488</td>
<td>1.663</td>
<td>1.806</td>
<td>1.926</td>
<td>2.15</td>
</tr>
<tr>
<td>-0.8</td>
<td>0.132</td>
<td>0.856</td>
<td>1.166</td>
<td>1.488</td>
<td>1.606</td>
<td>1.733</td>
<td>1.837</td>
<td>2.035</td>
</tr>
<tr>
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<td>0.148</td>
<td>0.854</td>
<td>1.147</td>
<td>1.407</td>
<td>1.549</td>
<td>1.66</td>
<td>1.749</td>
<td>1.91</td>
</tr>
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<td>0.852</td>
<td>1.128</td>
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<td>1.492</td>
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<td>1.664</td>
<td>1.8</td>
</tr>
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<td>0.195</td>
<td>0.844</td>
<td>1.086</td>
<td>1.282</td>
<td>1.379</td>
<td>1.449</td>
<td>1.501</td>
<td>1.625</td>
</tr>
<tr>
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<td>0.832</td>
<td>1.041</td>
<td>1.198</td>
<td>1.27</td>
<td>1.318</td>
<td>1.351</td>
<td>1.465</td>
</tr>
<tr>
<td>-1.6</td>
<td>0.254</td>
<td>0.817</td>
<td>0.994</td>
<td>1.116</td>
<td>1.166</td>
<td>1.2</td>
<td>1.216</td>
<td>1.28</td>
</tr>
<tr>
<td>-1.8</td>
<td>0.282</td>
<td>0.799</td>
<td>0.945</td>
<td>1.035</td>
<td>1.069</td>
<td>1.089</td>
<td>1.097</td>
<td>1.13</td>
</tr>
<tr>
<td>-2</td>
<td>0.307</td>
<td>0.777</td>
<td>0.895</td>
<td>0.959</td>
<td>0.98</td>
<td>0.99</td>
<td>1.995</td>
<td>1</td>
</tr>
<tr>
<td>-2.2</td>
<td>0.33</td>
<td>0.752</td>
<td>0.844</td>
<td>0.888</td>
<td>0.9</td>
<td>0.905</td>
<td>0.907</td>
<td>0.91</td>
</tr>
<tr>
<td>-2.5</td>
<td>0.36</td>
<td>0.711</td>
<td>0.771</td>
<td>0.793</td>
<td>0.798</td>
<td>0.799</td>
<td>0.8</td>
<td>0.802</td>
</tr>
<tr>
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<td>0.396</td>
<td>0.636</td>
<td>0.666</td>
<td>0.666</td>
<td>0.667</td>
<td>0.667</td>
<td>0.667</td>
<td>0.668</td>
</tr>
</tbody>
</table>

(Sumber: Hidrologi Teknik, CD Soemarto, 1995)
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ANALISIS HIDROLOGI DAN SEDIMENTASI

Tabel 5.11 Nilai Faktor $k$ Beberapa Periode Ulang

untuk Nilai Cs =1,093

<table>
<thead>
<tr>
<th>Periode Ulang (tahun)</th>
<th>$k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-0,180</td>
</tr>
<tr>
<td>5</td>
<td>0,745</td>
</tr>
<tr>
<td>10</td>
<td>1,34</td>
</tr>
<tr>
<td>25</td>
<td>2,065</td>
</tr>
<tr>
<td>50</td>
<td>2,584</td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

Hasil perhitungan curah hujan rencana untuk periode ulang $T$ tahun disajikan dalam Tabel 5.12.

Tabel 5.12 Curah Hujan Rencana Metode Log Pearson III

untuk Periode Ulang $T$ Tahun

<table>
<thead>
<tr>
<th>Periode Ulang (Th)</th>
<th>$k$</th>
<th>$\log X_r$</th>
<th>$X_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-0,18</td>
<td>1,595</td>
<td>39,355</td>
</tr>
<tr>
<td>5</td>
<td>0,745</td>
<td>1,995</td>
<td>98,855</td>
</tr>
<tr>
<td>10</td>
<td>1,34</td>
<td>2,252</td>
<td>178,649</td>
</tr>
<tr>
<td>25</td>
<td>2,065</td>
<td>2,565</td>
<td>367,282</td>
</tr>
<tr>
<td>50</td>
<td>2,584</td>
<td>2,790</td>
<td>616,595</td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

5.5 PERHITUNGAN DEBIT BANJIR RENCANA

Dalam perhitungan debit banjir rencana pada perencanaan *ground sill* ini digunakan metode sebagai berikut :

1. Metode *Hapers*
2. Metode Manual Jawa Sumatra
3. Metode *Gamma I*
4. Metode *Passing Capacity*
5.5.1 Perhitungan Debit Banjir Rencana Metode Haspers

Rumus: \( Q_T = \alpha \cdot \beta \cdot q_T \cdot A \)

Koefisien Run off (\( \alpha \))
\[
\alpha = \frac{1 + 0,012 \cdot A^{0.70}}{1 + 0,075 \cdot A^{0.70}}
\]

Koefisien Reduksi (\( \beta \))
\[
\frac{1}{\beta} = 1 + \frac{t + 3,70 \cdot 10^{-0.40t}}{t^2 + 15} \cdot A^{0.75}
\]

Hujan maksimum (\( q_n \))
\[
q_T = \frac{R_T}{3.6 \cdot t}
\]

Waktu konsentrasi (\( t \))
\[
t = 0,10 \cdot L^{0.80} \cdot i^{-0.30}
\]

Curah hujan harian maksimum (\( R_n \)) untuk 2 jam < \( t < 19 \) jam
\[
R_T = \frac{t \cdot R_{24}}{t + 1}
\]

Didapat:
- \( A = 993,29 \) km\(^2\)
- \( \alpha = 0,241 \)
- \( \beta = 0,474 \)
- \( L = 59,48 \) km
- \( i = 0,00622 \)
- \( t = 12,060 \)

Hasil perhitungan debit banjir rencana dengan menggunakan metode Haspers disajikan dalam Tabel 5.13.
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

Tabel 5.13 Debit banjir rencana dengan metode Hapers

<table>
<thead>
<tr>
<th>Periode Ulang</th>
<th>R24</th>
<th>t</th>
<th>RT</th>
<th>QT</th>
<th>QT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(tahun)</td>
<td>(mm)</td>
<td>(jam)</td>
<td>(mm)</td>
<td>(m/km/dt)</td>
<td>(m/dt)</td>
</tr>
<tr>
<td>2</td>
<td>39,355</td>
<td>12,060</td>
<td>36,342</td>
<td>0,906</td>
<td>102,854</td>
</tr>
<tr>
<td>5</td>
<td>98,855</td>
<td>12,060</td>
<td>91,286</td>
<td>2,277</td>
<td>258,357</td>
</tr>
<tr>
<td>10</td>
<td>178,649</td>
<td>12,060</td>
<td>164,970</td>
<td>4,115</td>
<td>466,898</td>
</tr>
<tr>
<td>25</td>
<td>367,282</td>
<td>12,060</td>
<td>339,159</td>
<td>8,460</td>
<td>959,890</td>
</tr>
<tr>
<td>50</td>
<td>616,595</td>
<td>12,060</td>
<td>569,383</td>
<td>14,202</td>
<td>1,611,468</td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

5.5.2 Perhitungan Debit Banjir Rencana Metode Jawa Sumatra

- Luas Daerah Aliran (AREA) = 993,29 km²
- Faktor Reduksi Area (ARF) = 1,152 – 0,123 log A
  = 1,152 – 0,123 log 993,29
  = 0,782
- Panjang sungai (MSL) = 59,48 km
- LAKE = 0 (untuk bendung)
- Elevasi hulu = +480,00 m
- Elevasi hilir = +30,00 m
- Indeks kemiringan (SIMS) = 0,00622
- V = 1,02 – 0,0275 log AREA
  = 0,938

Rata-rata tahunan hujan terbesar APBAR = PBAR x ARF

Di mana PBAR (hujan terpusat maks R24) dapat dilihat dalam Tabel 5.12.

Rata-rata banjir tahunan :

MAF = 8 x 10⁻⁶ x AREA⁰⁵ x APBAR².⁴⁴⁵ x SIMS⁰.¹¹⁷ x (1 + LAKE)⁻⁰.⁸⁵

Q = GF x MAF
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI


<table>
<thead>
<tr>
<th>TH</th>
<th>PBAR mm</th>
<th>APBAR mm</th>
<th>AREA SIMS km$^2$</th>
<th>LAKE</th>
<th>V</th>
<th>GF</th>
<th>MAF</th>
<th>$Q_T$ m$^3$/dt</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>39,355</td>
<td>0,782</td>
<td>0,006993,290</td>
<td>0,000</td>
<td>0,938</td>
<td>1,000</td>
<td>12,437</td>
<td>12,437</td>
</tr>
<tr>
<td>5</td>
<td>98,855</td>
<td>0,782</td>
<td>0,006993,290</td>
<td>0,000</td>
<td>0,938</td>
<td>1,211</td>
<td>118,228</td>
<td>143,174</td>
</tr>
<tr>
<td>10</td>
<td>178,649</td>
<td>0,782</td>
<td>0,006993,290</td>
<td>0,000</td>
<td>0,938</td>
<td>1,484</td>
<td>502,446</td>
<td>745,629</td>
</tr>
<tr>
<td>25</td>
<td>367,282</td>
<td>0,782</td>
<td>0,006993,290</td>
<td>0,000</td>
<td>0,938</td>
<td>1,747</td>
<td>2.926,657</td>
<td>5.112,870</td>
</tr>
<tr>
<td>50</td>
<td>616,595</td>
<td>0,782</td>
<td>0,006993,290</td>
<td>0,000</td>
<td>0,938</td>
<td>2,078</td>
<td>10.387,180</td>
<td>21.584,561</td>
</tr>
</tbody>
</table>

(Sumber: Hasil Perhitungan)

5.5.3 Perhitungan Debit Banjir Rencana Metode Gamma I

Data-data yang diketahui dari peta topografi:

Panjang sungai utama = 59,48 km

Panjang sungai semua tingkat = 420 km

Panjang sungai tingkat I = 165 km

Jumlah sungai semua tingkat = 303 buah

Jumlah sungai tingkat I = 233 buah

$WU$ = lebar DAS diukur di titik sungai berjarak 0,75 L dari titik kontrol

= 18,62 km

$WL$ = lebar DAS diukur di titik sungai berjarak 0,25 L dari titik kontrol

= 38,19 km

$DAS$ = Luas Daerah Aliran Sungai

= 993,29 km$^2$

$AU$ = Luas DAS dihulu garis yang ditarik tegak lurus garis hubung antara titik kontrol dengan stasiun pengukuran dekat titik berat DAS
= 610,33 km\(^2\)

Perhitungan resesi unit hidrograf

S = kemiringan sungai
= 0,00622

JN = jumlah pertemuan anak sungai di dalam DAS
= 119

SF = faktor sumber yaitu perbandingan antara jumlah panjang sungai tingkat I dengan jumlah panjang sungai semua tingkat
= 165 / 420 = 0,393

WF = faktor lebar
= WU / WL = 18,62 / 38,19 = 0,488

RUA = perbandingan luas DAS sebelah hulu dengan jarak titik berat DAS ke stasiun hidrometri.
= AU / DAS = 610,33 / 993,29 = 0,614

SIM = faktor simetri
= WF x RUA = 0.488 x 0.614 = 0,300

TR = waktu puncak
= 0,43 x (L/100xSF)\(^3\) + (1,0665 x SIM) + 1,2775
= 0,43 x (59,48/100x0,393)\(^3\) + (1,0665x0,300) + 1,2775
= 3,089 jam

Qp = debit puncak
= 0,1836 x DAS\(^{0,5886}\) x JN\(^{0,2381}\) x TR\(^{-0,4008}\)
= 0,1836 x 993,29\(^{0,5886}\) x 119\(^{0,2381}\) x 3,089\(^{-0,4008}\)
= 21,174 m\(^3\)/dt
D = kerapatan jaringan
= panjang sungai semua tingkat / DAS
= 420 / 993,29
= 0,423

K = koefisien tampungan
= 0,5617x(DAS$^{0,1798}$)x(S$^{-0,1446}$)x(SF$^{-1,0897}$)x(D$^{0,0452}$)
= 0,5617x(993,29$^{0,1798}$)x(0,00622$^{-0,1446}$)x(0,393$^{-1,0897}$)x(0,423$^{0,0452}$)
= 62,212
Perhitungan Resesi Unit Hidrograf \( (Q_t) \) selanjutnya ditampilkan dalam Tabel 5.15 dengan menggunakan rumus:

\[
Q_t = Q_p \times e^{-t/k}
\]

Dengan \( e = 2,718281828 \)

**Tabel 5.15 Perhitungan resesi unit hidrograf**

<table>
<thead>
<tr>
<th>( t ) (jam)</th>
<th>( Q_p ) (m³/dt)</th>
<th>( t/k ) (m³/dt)</th>
<th>( Q_t ) (m³/dt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>21,174</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3,089</td>
<td>21,174</td>
<td>0,049653</td>
<td>21,174</td>
</tr>
<tr>
<td>4</td>
<td>21,174</td>
<td>0,064296</td>
<td>19,8554</td>
</tr>
<tr>
<td>5</td>
<td>21,174</td>
<td>0,080370</td>
<td>19,5388</td>
</tr>
<tr>
<td>6</td>
<td>21,174</td>
<td>0,096444</td>
<td>19,2273</td>
</tr>
<tr>
<td>7</td>
<td>21,174</td>
<td>0,112518</td>
<td>18,9207</td>
</tr>
<tr>
<td>8</td>
<td>21,174</td>
<td>0,128593</td>
<td>18,619</td>
</tr>
<tr>
<td>9</td>
<td>21,174</td>
<td>0,144667</td>
<td>18,3221</td>
</tr>
<tr>
<td>10</td>
<td>21,174</td>
<td>0,160741</td>
<td>18,0299</td>
</tr>
<tr>
<td>11</td>
<td>21,174</td>
<td>0,176815</td>
<td>17,7424</td>
</tr>
<tr>
<td>12</td>
<td>21,174</td>
<td>0,192889</td>
<td>17,4595</td>
</tr>
</tbody>
</table>
Perhitungan intensitas curah hujan

Rumus yang digunakan adalah, rumus dari Dr. Mononobe yaitu :

\[ I = \left( \frac{R_{24}}{24} \right) \times \left( \frac{24}{t} \right)^{2/3} \]

Dimana :

- \( I \) = Intensitas ( mm/jam )
- \( R_{24} \) = Curah hujan maksimum dalam 1 hari ( mm )
- \( t \) = waktu konsentrasi ( jam )

Hasil perhitungan intensitas curah hujan jam-jaman disajikan dalam Tabel 5.1
### Tabel 5.16 Intensitas Curah Hujan Jam-Jaman

<table>
<thead>
<tr>
<th>Periode</th>
<th>2 th</th>
<th>5 th</th>
<th>10 th</th>
<th>25 th</th>
<th>50 th</th>
</tr>
</thead>
<tbody>
<tr>
<td>R24 (mm)</td>
<td>39,355</td>
<td>98,855</td>
<td>178,649</td>
<td>367,282</td>
<td>616,595</td>
</tr>
<tr>
<td>t (mm/jam)</td>
<td>13,644</td>
<td>34,271</td>
<td>61,934</td>
<td>127,330</td>
<td>213,762</td>
</tr>
<tr>
<td>1</td>
<td>8,595</td>
<td>21,589</td>
<td>39,016</td>
<td>80,213</td>
<td>134,661</td>
</tr>
<tr>
<td>2</td>
<td>6,559</td>
<td>16,476</td>
<td>29,775</td>
<td>61,214</td>
<td>102,766</td>
</tr>
<tr>
<td>3,089</td>
<td>6,433</td>
<td>16,158</td>
<td>29,200</td>
<td>60,032</td>
<td>100,782</td>
</tr>
<tr>
<td>4</td>
<td>5,414</td>
<td>13,601</td>
<td>24,579</td>
<td>50,531</td>
<td>84,831</td>
</tr>
<tr>
<td>5</td>
<td>4,666</td>
<td>11,721</td>
<td>21,181</td>
<td>43,546</td>
<td>73,105</td>
</tr>
<tr>
<td>6</td>
<td>4,132</td>
<td>10,379</td>
<td>18,757</td>
<td>38,562</td>
<td>64,738</td>
</tr>
<tr>
<td>7</td>
<td>3,728</td>
<td>9,365</td>
<td>16,925</td>
<td>34,796</td>
<td>58,416</td>
</tr>
<tr>
<td>8</td>
<td>3,411</td>
<td>8,568</td>
<td>15,484</td>
<td>31,832</td>
<td>53,440</td>
</tr>
<tr>
<td>9</td>
<td>3,153</td>
<td>7,921</td>
<td>14,314</td>
<td>29,428</td>
<td>49,405</td>
</tr>
<tr>
<td>10</td>
<td>2,939</td>
<td>7,383</td>
<td>13,343</td>
<td>27,432</td>
<td>46,054</td>
</tr>
<tr>
<td>11</td>
<td>2,758</td>
<td>6,929</td>
<td>12,522</td>
<td>25,743</td>
<td>43,218</td>
</tr>
<tr>
<td>12</td>
<td>2,603</td>
<td>6,538</td>
<td>11,816</td>
<td>24,293</td>
<td>40,783</td>
</tr>
<tr>
<td>13</td>
<td>2,468</td>
<td>6,199</td>
<td>11,202</td>
<td>23,030</td>
<td>38,663</td>
</tr>
<tr>
<td>14</td>
<td>2,349</td>
<td>5,900</td>
<td>10,662</td>
<td>21,920</td>
<td>36,800</td>
</tr>
<tr>
<td>15</td>
<td>2,243</td>
<td>5,635</td>
<td>10,183</td>
<td>20,935</td>
<td>35,145</td>
</tr>
<tr>
<td>16</td>
<td>2,149</td>
<td>5,397</td>
<td>9,754</td>
<td>20,053</td>
<td>33,665</td>
</tr>
<tr>
<td>17</td>
<td>2,064</td>
<td>5,184</td>
<td>9,368</td>
<td>19,259</td>
<td>32,332</td>
</tr>
<tr>
<td>18</td>
<td>1,986</td>
<td>4,990</td>
<td>9,017</td>
<td>18,539</td>
<td>31,123</td>
</tr>
<tr>
<td>19</td>
<td>1,916</td>
<td>4,813</td>
<td>8,698</td>
<td>17,882</td>
<td>30,021</td>
</tr>
<tr>
<td>20</td>
<td>1,852</td>
<td>4,651</td>
<td>8,406</td>
<td>17,281</td>
<td>29,012</td>
</tr>
<tr>
<td>21</td>
<td>1,792</td>
<td>4,502</td>
<td>8,137</td>
<td>16,728</td>
<td>28,083</td>
</tr>
<tr>
<td>22</td>
<td>1,738</td>
<td>4,365</td>
<td>7,888</td>
<td>16,217</td>
<td>27,226</td>
</tr>
<tr>
<td>23</td>
<td>1,687</td>
<td>4,237</td>
<td>7,658</td>
<td>15,744</td>
<td>26,431</td>
</tr>
<tr>
<td>24</td>
<td>1,640</td>
<td>4,119</td>
<td>7,444</td>
<td>15,303</td>
<td>25,691</td>
</tr>
</tbody>
</table>

(Sumber: Hasil Perhitungan)

**Perhitungan hujan efektif**

\[ \Phi = 10,4903 - 3,859 \times 10^{-6} \cdot A^2 + 1,6985 \times 10^{-13} \cdot (A/SN)^4 \]

\[ \Phi = 7,1557 \]

\[ \text{Re} = I - \Phi \]
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

Hasil perhitungan curah hujan efektif disajikan dalam Tabel 5.17

**Tabel 5.17 Curah Hujan Efektif dengan Φ Indeks**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>2th</th>
<th>5th</th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>i</td>
<td>Re</td>
<td>i</td>
<td>Re</td>
<td>i</td>
<td>Re</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>1</td>
<td>13,644</td>
<td>6,488</td>
<td>34,271</td>
<td>27,115</td>
<td>61,934</td>
<td>54,778</td>
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<td>8,595</td>
<td>1,439</td>
<td>21,589</td>
<td>14,433</td>
<td>39,016</td>
<td>31,860</td>
</tr>
<tr>
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<td>16,476</td>
<td>9,320</td>
<td>29,775</td>
<td>22,619</td>
<td>61,214</td>
<td>54,058</td>
</tr>
<tr>
<td>4</td>
<td>13,601</td>
<td>6,445</td>
<td>24,579</td>
<td>17,423</td>
<td>40,531</td>
<td>33,375</td>
</tr>
<tr>
<td>5</td>
<td>11,721</td>
<td>4,565</td>
<td>21,181</td>
<td>14,025</td>
<td>43,546</td>
<td>36,390</td>
</tr>
<tr>
<td>6</td>
<td>10,379</td>
<td>3,223</td>
<td>18,757</td>
<td>11,601</td>
<td>38,562</td>
<td>31,406</td>
</tr>
<tr>
<td>7</td>
<td>9,365</td>
<td>2,209</td>
<td>16,925</td>
<td>9,769</td>
<td>34,796</td>
<td>27,640</td>
</tr>
<tr>
<td>8</td>
<td>8,568</td>
<td>1,412</td>
<td>15,484</td>
<td>8,328</td>
<td>3,832</td>
<td>24,676</td>
</tr>
<tr>
<td>9</td>
<td>7,921</td>
<td>0,765</td>
<td>14,314</td>
<td>7,158</td>
<td>29,428</td>
<td>22,272</td>
</tr>
<tr>
<td>10</td>
<td>7,383</td>
<td>0,227</td>
<td>13,343</td>
<td>6,187</td>
<td>27,432</td>
<td>20,276</td>
</tr>
<tr>
<td>11</td>
<td>12,522</td>
<td>5,366</td>
<td>25,743</td>
<td>18,578</td>
<td>43,218</td>
<td>36,062</td>
</tr>
<tr>
<td>12</td>
<td>11,816</td>
<td>4,660</td>
<td>24,293</td>
<td>17,137</td>
<td>40,783</td>
<td>33,627</td>
</tr>
<tr>
<td>13</td>
<td>11,202</td>
<td>4,046</td>
<td>23,03</td>
<td>15,874</td>
<td>38,663</td>
<td>31,507</td>
</tr>
<tr>
<td>14</td>
<td>10,662</td>
<td>3,506</td>
<td>21,92</td>
<td>14,764</td>
<td>36,800</td>
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(Sumber: Hasil Perhitungan)
Perhitungan hidrograf banjir

TR = waktu puncak
   = 3,089 jam

S = kemiringan sungai
   = 0,00622

SN = frekuensi sumber
    = jumlah n₁ / jumlah n
    = 233 / 303
    = 0,769

RUA = AU / DAS
    = 610,33 / 993,29
    = 0,614

TB = waktu dasar
    = 27,4132 x ( TR⁰,¹⁴⁵⁷ ) x ( S⁻⁰,⁰⁹⁵⁶ ) x ( SN⁰,⁷³⁴⁴ ) x ( RUA⁻⁰,²⁵⁷⁴ )
    = 27,4132 x ( 3,089⁰,¹⁴⁵⁷ ) x ( 0,00622⁻⁰,⁰⁹⁵⁶ ) x ( 0,769⁰,⁷³⁴⁴ ) x
    ( 0,614⁻⁰,²⁵⁷⁴ )
    = 229,130 jam

QB = 0,4751 x DAS⁰,⁶⁴⁴⁴ x D⁰,⁹⁴³⁰
    = 0,4751 x 993,29⁰,⁶⁴⁴⁴ x 0,423⁰,⁹⁴³⁰
    = 18,013 m³/dt

Hidrograf banjir untuk beberapa periode ulang disajikan dalam Tabel 5.18 sampai Tabel 5.22.
### Tabel 5.18 Perhitungan hidrograf banjir periode ulang 2 tahunan

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(Sumber: Hasil Perhitungan)
### Bab V
Analisis Hidrologi dan Sedimentasi

#### Tabel 5.19 Perhitungan hidrograf banjir periode ulang 5 tahunan

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*(Sumber: Hasil Perhitungan)*

#### BAB V

ANALISIS HIDROLOGI DAN SEDIMENTASI

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<td>1,826,38</td>
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<td>0</td>
<td>18,013</td>
<td>18,013</td>
</tr>
</tbody>
</table>

(Sumber: Hasil Perhitungan)
|     | 0    | 949.47 | 842.42 | 762.08 | 699.26 | 648.65 | 606.89 | 571.73 | 541.76 | 515.83 | 493.22 | 473.21 | 455.45 | 439.57 | 425.22 | 412.06 | 400.45 | 399.64 | 379.74 | 370.6 | 362.16 | 18.013 | 10757.621 |
|-----|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|     | 0    | 829.01 | 749.93 | 688.4 | 638.3 | 597.2 | 562.64 | 533.12 | 507.61 | 485.33 | 465.68 | 448.19 | 432.55 | 418.46 | 405.67 | 394.06 | 383.42 | 373.68 | 364.7 | 356.37 | 18.013 | 9652.059 |
|     | 0    | 737.99 | 677.13 | 628.12 | 587.67 | 553.66 | 524.65 | 499.51 | 477.59 | 458.24 | 441.06 | 425.65 | 411.78 | 399.22 | 387.77 | 377.31 | 367.72 | 358.88 | 350.7 | 343.1 | 18.013 | 8682.67 |
|     | 0    | 466.35 | 438.1 | 578.3 | 544.82 | 516.28 | 491.57 | 469.98 | 450.93 | 434.01 | 418.88 | 405.21 | 392.84 | 381.61 | 361.86 | 355.16 | 345.1 | 336.1 | 325.1 | 18.013 | 7818.294 | 18.013 | 7818.294 |
|     | 0    | 608.26 | 569.08 | 536.13 | 508.04 | 483.73 | 462.51 | 443.74 | 427.09 | 412.18 | 398.76 | 386.58 | 375.51 | 365.39 | 356.08 | 347.53 | 339.6 | 18.013 | 7038.202 | 18.013 | 7038.202 |
|     | 0    | 560.01 | 527.59 | 499.93 | 476.01 | 455.12 | 436.68 | 420.27 | 405.61 | 392.39 | 380.43 | 369.52 | 359.55 | 350.42 | 341.98 | 334.19 | 18.013 | 6327.715 | 18.013 | 6327.715 |
|     | 0    | 519.18 | 491.96 | 468.41 | 447.86 | 429.72 | 413.59 | 399.14 | 386.13 | 374.35 | 363.64 | 353.81 | 344.82 | 336.54 | 328.85 | 18.013 | 5676.029 | 18.013 | 5676.029 |
|     | 0    | 484.13 | 460.95 | 440.72 | 422.86 | 406.99 | 392.8 | 379.97 | 368.38 | 357.83 | 348.18 | 339.32 | 331.16 | 323.62 | 18.013 | 5074.921 | 18.013 | 5074.921 |
|     | 0    | 453.61 | 433.69 | 416.11 | 400.5 | 386.5 | 373.85 | 362.5 | 352.12 | 342.62 | 332.93 | 325.88 | 318.45 | 311.78 | 18.013 | 4517.879 | 18.013 | 4517.879 |
|     | 0    | 426.78 | 409.48 | 394.11 | 380.36 | 367.97 | 356.74 | 346.51 | 337.15 | 328.59 | 320.7 | 313.37 | 18.013 | 3999.765 | 18.013 | 3999.765 |
|     | 0    | 402.96 | 387.83 | 374.29 | 362.69 | 351.05 | 341 | 331.78 | 323.35 | 315.57 | 308.39 | 18.013 | 3516.306 | 18.013 | 3516.306 |
|     | 0    | 381.65 | 368.32 | 356.32 | 345.44 | 335.56 | 326.5 | 318.19 | 310.54 | 303.46 | 18.013 | 3063.992 | 18.013 | 3063.992 |
|     | 0    | 362.46 | 350.64 | 339.93 | 330.2 | 321.29 | 313.13 | 305.59 | 298.62 | 18.013 | 2639.871 | 18.013 | 2639.871 |
|     | 0    | 345.05 | 334.51 | 324.93 | 316.17 | 308.13 | 300.73 | 293.85 | 18.013 | 2241.396 | 18.013 | 2241.396 |
|     | 0    | 329.19 | 319.75 | 311.12 | 303.22 | 295.83 | 289.18 | 18.013 | 1866.405 | 18.013 | 1866.405 |
|     | 0    | 314.66 | 306.16 | 298.38 | 291.21 | 284.57 | 18.013 | 1512.991 | 18.013 | 1512.991 |
|     | 0    | 301.29 | 293.62 | 286.56 | 280.03 | 18.013 | 1179.511 | 18.013 | 1179.511 |
|     | 0    | 288.95 | 281.99 | 275.56 | 18.013 | 864.514 | 18.013 | 864.514 |
|     | 0    | 277.3 | 271.17 | 18.013 | 566.682 | 18.013 | 566.682 |
|     | 0    | 266.95 | 18.013 | 294.861 | 18.013 | 294.861 |
|     | 0    | 18.013 | 18.013 |

(Sumber: Hasil Perhitungan)
Gambar 5.4 Grafik hidrograf banjir metode Gamma I
Rekapitulasi hasil perhitungan debit banjir rencana metode Gamma I dari masing-masing periode ulang disajikan dalam Tabel 5.23.

### Tabel 5.23 Debit banjir rencana metode Gamma I

<table>
<thead>
<tr>
<th>Periode Ulang (th)</th>
<th>Qt (m³/dt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>177,302</td>
</tr>
<tr>
<td>5</td>
<td>1,444,132</td>
</tr>
<tr>
<td>10</td>
<td>3,849,070</td>
</tr>
<tr>
<td>25</td>
<td>10,433,920</td>
</tr>
<tr>
<td>50</td>
<td>19,339,997</td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

#### 5.5.4 Perhitungan Debit Banjir Rencana Metode Passing Capacity

\[
Q = A \cdot V \\
V = c \cdot \sqrt{R \cdot I} \quad \text{(Rumus Chezy)}
\]

\[
c = \frac{87}{1 + \frac{m}{\sqrt{R}}}
\]

\[
R = \frac{A}{P}
\]

\[
A = \sum_{i=1}^{n} A, \quad P = \sum_{i=1}^{n} P
\]

Di mana :

- \(Q\) = Volume banjir yang melalui tampang (m³/dtk)
- \(A\) = Luas penampang basah (m²)
- \(V\) = Kecepatan aliran (m/dtk)
- \(R\) = Jari – jari hidrolis (m)
- \(I\) = Kemiringan sungai
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

\[ P = \text{Keliling penampang basah sungai (m)} \]
\[ c = \text{Koefisien Chezy} \]

**Tabel 5.24 Harga koefisien Kekasaran Bazin (m)**

<table>
<thead>
<tr>
<th>Jenis Dinding</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinding sangat halus</td>
<td>0,06</td>
</tr>
<tr>
<td>Dinding halus (papan, batu)</td>
<td>0,16</td>
</tr>
<tr>
<td>Dinding bau pecah</td>
<td>0,46</td>
</tr>
<tr>
<td>Dinding tanah sangat teratur</td>
<td>0,85</td>
</tr>
<tr>
<td>Saluran tanah dengan kondisi biasa</td>
<td>1,30</td>
</tr>
<tr>
<td>Saluran tanah dengan dasar batu pecah dan tebing rumput</td>
<td>1,75</td>
</tr>
</tbody>
</table>

(Sumber : Kp – 02 – 1986)

K16

K20
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

K 21

Gambar 5.5 Potongan melintang sungai

K 16

\[ A = \sum_{i=1}^{n} A \]

= 585,326 m²

\[ P = \sum_{i=1}^{n} P \]

= 153,639 m

K 20

\[ A = \sum_{i=1}^{n} A \]

= 548,860 m²

\[ P = \sum_{i=1}^{n} P \]

= 127,214 m

K 21

\[ A = \sum_{i=1}^{n} A \]

= 607,566 m²

\[ P = \sum_{i=1}^{n} P \]
BAB V
ANALISIS HIDROLOGI DAN SEDIMENTASI

\[ A_{rata-rata} = 580,584 \text{ m}^2 \]
\[ P_{rata-rata} = 141,895 \text{ m} \]
\[ R = \frac{A_{rata-rata}}{P_{rata-rata}} = 4,092 \text{ m} \]

\[ V = c \sqrt{R.I} \]
\[ c = \frac{87}{1 + \frac{m}{\sqrt{R}}} = \frac{87}{1 + \frac{1,75}{\sqrt{4,092}}} = 46,646 \]
\[ I = 0,00622 \]
\[ V = 46,646 \cdot \sqrt{4,092} \cdot 0,00622 \]
\[ = 7,442 \text{ m/det} \]
\[ Q = A.V \]
\[ = 580,584 \cdot 7,442 = 4.320,706 \text{ m}^3/\text{det} \]

Tabel 5.25 Perbandingan hasil perhitungan debit banjir rencana (Q)

<table>
<thead>
<tr>
<th>Periode Ulang (th)</th>
<th>Metode Haspers (m(^3/\text{det}))</th>
<th>Metode Manual Jawa Sumatra (m(^3/\text{det}))</th>
<th>Metode Gamma I (m(^3/\text{det}))</th>
<th>Metode Passing Capacity (m(^3/\text{det}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>102,854</td>
<td>12,437</td>
<td>177,302</td>
<td></td>
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<tr>
<td>5</td>
<td>258,357</td>
<td>143,174</td>
<td>1.444,132</td>
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<td>10</td>
<td>466,898</td>
<td>745,629</td>
<td>3.510,284</td>
<td>4.320,706</td>
</tr>
<tr>
<td>25</td>
<td>959,890</td>
<td><strong>5.112,870</strong></td>
<td>10.374,112</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1.611,468</td>
<td>21.584,561</td>
<td>19.339,997</td>
<td></td>
</tr>
</tbody>
</table>

(Sumber : Hasil Perhitungan)

Berdasarkan hasil perhitungan diatas diambil nilai yang mendekati nilai \( Q \) rencana dengan metode passing capacity yaitu Metode Manual Jawa Sumatra dengan periode ulang 25 tahun sebesar 5.112,870 m\(^3\)/det.
5.6 PERHITUNGAN SEDIMENTASI

Untuk perencanaan penampang sungai yang stabil digunakan teori pendekatan “Tractive Force” yang memberikan rumusan sebagai berikut:

- Tegangan geser pada dasar sungai (τc) yang besarnya tergantung diameter butiran:
  \[ τc = (ρs - ρw) \times g \times d \]

Dimana:
- \( τc \) = tegangan geser titik dasar (N/m²)
- \( ρs \) = rapat massa butir (kg/m³)
- \( ρw \) = rapat massa air (kg/m³)
- \( g \) = percepatan gravitasi (m/dt²)
- \( d \) = diameter butiran (m)

Dari data diketahui:
- \( ρs = 1.672 \text{ kg/m}^3 \)
- \( ρw = 1.000 \text{ kg/m}^3 \)
- \( g = 9.8 \text{ m/dt}^2 \)
- \( d = 2 \text{ mm} \)

Maka \( τc = (1.672 - 1.000) \times 9.8 \times 0.002 \)

\[ = 13.1712 \text{ kg/m}^2 \]
\[ = 131.712 \text{ N/m}^2 \]

- Tegangan geser maksimum pada dasar sungai:
  \( τb = ρw \times g \times h \times I \)

Dimana:
- \( τb \) = tegangan geser maksimum di dasar sungai (N/m²)
- \( h \) = ketinggian air banjir (m)
I = kemiringan dasar sungai

Dari data diketahui:

\[ \rho_w = 1.000 \text{ kg/m}^3 \]
\[ g = 9,8 \text{ m/dt}^2 \]
\[ h = 3,0 \text{ m} \]
\[ I = 0,00622 \]

Maka \( \tau_b = 1.000 \times 9,8 \times 3,0 \times 0,00622 \)

\[ = 182,868 \text{ kg/m}^2 \]
\[ = 1.828,68 \text{ N/m}^2 \]

Dari hasil perhitungan di atas ternyata \( \tau_b > \tau_c \), hal ini mengindikasikan bahwa kondisi dasar sungai labil sehingga diperlukan bangunan penjaga kestabilan dasar sungai berupa bangunan *Groundsill*. 