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The Evaluation of Water Level Elevation Design of Sei Batang Serangan Toll Bridge on Sei Batang Serangan Riverside

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ABSTRACT

Hydrological analysis is conducted to determine the rainfall discharge that can be accommodated by the river with various specific return periods and hydraulic analysis to examine the water level that impacts the toll bridge that passes through the Sei Batang Serangan river. Therefore, this research was conducted to calculate the design flood discharge for the return period of 2, 5, 10, 25, and 50 years; and the water level elevation of Sei Batang Serangan toll bridge in the Sei Batang Serangan riverside. Based on hydraulic analysis using the HEC-RAS 5.0 program from steady flow data, the maximum water level elevation is at River Sta 5+00 of 10.52 m in a 50-year return period, and the minimum water level elevation is at River Sta 2+00 of 4.45 m in a 2-year return period. Thus, based on the flood water level of 12.691 meters, the Sei Wampu toll bridge area does not have flood inundation because the water level elevation value does not exceed the flood water level value (TMA < MAB). Meanwhile, from the results of the steady flow data analysis, it can be concluded that no flooding occurred at the Sei Batang Serangan toll bridge in the Sei Batang Serangan riverside at a known return period.

Keywords: *Hydraulic Analysis, Hydrological Analysis, Water Level Elevation*

INTRODUCTION

A river is a place to accommodate and drain rainwater from upstream to downstream and a source of water for human needs, including clean water for drinking water, irrigation, electricity, industry, transportation and so on (Kapantow et al., 2017). Watershed (DAS) is generally defined as an area bounded by topographic boundaries that have a function to receive, collect rainwater, sediment, nutrients and drain them through tributaries and out at one point (Fredrik et al., 2021). Watersheds have an important role in maintaining the environment including maintaining water quality, preventing floods and droughts during the rainy and dry seasons, reducing mass flow (soil) from upstream to downstream. One of the efforts to maintain watershed function is maintaining regular monitoring and evaluation of watershed conditions (Lisa, 2016). In this research, hydrological analysis is conducted to determine the rainfall discharge that can be accommodated by the river with various specific return periods and hydraulic analysis to examine the water level that impacts the toll bridge that passes through the Sei Batang Serangan river.

Sei Batang Serangan River is classified as a large river with a width of more than 80 meters; and is one of the most frequently flooded areas. Sei Batang Serangan River crosses Padang Tualang subdistrict, Sawit Sebrang and Tanjung Pura, Langkat district. The construction of two bridges, that is, the Sei Batang Serangan bridge and the Sei Wampu bridge on the Trans Sumatra Toll Road for the Binjai-Pangkalan Brandan section, which was undertaken by PT Hutama Karya through its subsidiary PT Hutama Karya Infrastruktur, has been completed. Along with the construction of the toll road project, it can participate in efforts to prevent flooding in that area. Based on those previous background, this research is conducted to calculate the design flood discharge for the return period of 2, 5, 10, 25, and 50 years; and the water level elevation of Sei Batang Serangan toll bridge in the Sei Batang Serangan riverside.

In addition, this research also reviewed several previous studies as a reference and additional information on topics related to this research. First, Kapantow et al (2017) in their research's result titled *Analisis Debit dan Tinggi Muka Air Sungai Paniki di Kawasan Holland Village*, indicated that the 5-year rainfall is 162,486 mm/hr, 10-year is 182,587, 25-year is 208,135, 50-year is 227,358 mm/hr, 100-year is 246,581 mm/hr. Meanwhile, the models used in this research are HEC-HMS 3.5 and HEC-RAS 5.0.2, the planned flood discharge at the 5-year return period is 49.2 m^3/s, 10 years is 56.1 m^3/s, 25 years is 64.9 m^3/s, 50 years is 71.4 m^3/s, 100 years is 78 m^3/s. Overflow occurs at sta 340 for return periods of 5, 10, 25, 50 and 100 years.

Second, the research of Nurzanah et al (2022) indicated that the amount of maximum rainfall drawn from the Sampali climatological rainfall station, at the Bandar Sidoras Rubber Dam for four return periods amounted to: 2-year return period = 125.04 mm, 10-year return period = 169.77 mm, 25-year return period = 186.66 mm and 50-year return period = 197.51 mm. AWLR Tembung station water discharge data obtained maximum discharge Q50 of 304.59 m3/sec. The results of flood discharge analysis with Nakayasu method for the return period of 2, 10, 25, and 50 years are 323.71m3/det, 401.51m3/det, 483.24m3/det, 1008.40 m3/det. The results of flood discharge analysis using the rational method for the return periods of 2, 10, 25, and 50 years are 648.166 m3/det, 879.993 m3/det, 967.579 m3/det, and 1023.788 m3/det. The results of the flood discharge analysis of the two synthetic methods using the same river data obtained synthetic unit hydrographs that can be applied to obtain relevant results are the Nakayasu Synthetic Unit Hydrograph method.

The last is research from Wijayanto & Helda (2022) indicated that based on ArcGIS 10.8 modeling, the total length of the river studied was 2052.57 m and the area of the sub-watershed studied was 0.31 km^2. Modeling of sub-watersheds can also be identified if the land around the research sub-watershed is mostly used as agricultural land or rice fields and along the banks of the research river is filled with residential areas. In addition, based on the simulation results of unsteady flow flood modeling with HEC-RAS 5.0.7, the maximum flood discharge is 34.84 m3/s (5-year return period), 33.99 m3/s (50-year return period), and 142.64 m3/s (100-year return period). Maximum flood water elevations of 3.8 m (5-year return period), 5.2 m (50-year return period), and 9.6 m (100-year return period) were obtained. It can be concluded that if the design rainfall with the Log Pearson Type III method for the 2010-2021 period can cause flood inundation along the sub-watershed rivers of the research.

LITERATURE REVIEW

Hydrological Analysis

Hydrology is a branch of science that studies the occurrence, circulation, or distribution of water on earth which includes hydrological processes, movement, distribution, and others (Martiani & Prayoto, 2020). The hydrological cycle is the process of water being regenerated in a cycle (renewable), where surface water in rivers, lakes, and the sea evaporates into the air, then the condensation process occurs, changing the water points in the form of clouds, then falling to the ground again as rain or other forms of precipitation, and then flows back to the sea (Ambarwati, 2017). Hydrological data is one of the data that serves to analyze the amount of rainwater discharge sorted according to the function and sequence of the data collected (Zulianto et al., 2022).

Hydraulic Analysis

Hydraulic analysis is also used to determine the channel capacity by considering the hydraulics properties that occur in the pacal river basin. These properties include the type of flow (steady or unsteady), roughness number (manning) and the nature of the flow (critical, subcritical, and supercritical) (Harjono & Widhiastuti, 2013). The purpose of hydraulics is to assist and solve problems in life such as utilizing water energy and water traffic. In this research, the hydraulic analysis used supporting software, named HEC-RAS (Hydarulic Engineering Center-River Analysis System) which is a hydraulic analysis program to simulate the flow based on certain known data for the flood discharge of the 5, 10, 25, and 50-year return plans (Fredrik et al., 2021).

RESEARCH METHODOLOGY

The research location was conducted at the Sei Batang Serangan toll bridge in the Sei Batang Serangan river area with a watershed area of 748.54 km^2. The geographical location and conditions include (1) Besitang, Sei Lapan, and Sebrang sub-districts on the north; (2) Bahorok sub-district on the south; (3) Aceh province on the west; and (4) Padang Tualang and Wampu sub-districts on the east. There are two sources of research data, such as (1) primary data are the results of research site surveys and the results of discussions with experts related to the research topic; and (2) secondary data include maximum daily rainfall data for the last 10 years at Batang Serangan Station, Bahorok Station, and Sawit Seberang Station, river profile data/watershed maps, cross section data, river discharge data, and topographic data of the Sei Batang Serangan riverside.

The research design that will be used in this research is a literature study from various sources such as books, journals, papers, lecture notes, or articles related to relevant research from gathering to analyzing and discussing them. The research location was conducted about 150 meters to the right and 150 meters to the left of the Sei Batang Serangan toll bridge in the Sei Batang Serangan riverside area. The analysis methods used are hydrological analysis and hydraulics analysis. The software used is a Lenovo Core I3 Laptop and software such as HEC-RAS 5.0 (Hydrologic Engineering Center-River Analysis System), Microsoft Word 2010, Microsoft Exel 2010, Microsoft Power Point 2010, and AutoCAD Civil 3D 2018.

RESULT AND DISCUSSION

Hydrological Analysis

Data Analysis of Regional Rainfall

There are 3 stations that are used as benchmarks in this research, such following below:

Table 1. The Location of Rainfall Stations

Description				
No.	**Station name**	**Data**	**X**	**Y**
1.	Batang Serangan station	2013-2022	39249.3	398412.7
2.	Bahorok station	2012-2021	403366.4	386904.8
3.	Sawit Seberang station	2012-2021	412062.7	398412.7

Source: Public Works and Spatial Planning Department of North Sumatra (2023)

After determining the rainfall station that will be used as a basis for the calculation of regional rainfall using the Thiessen Polygon Method.

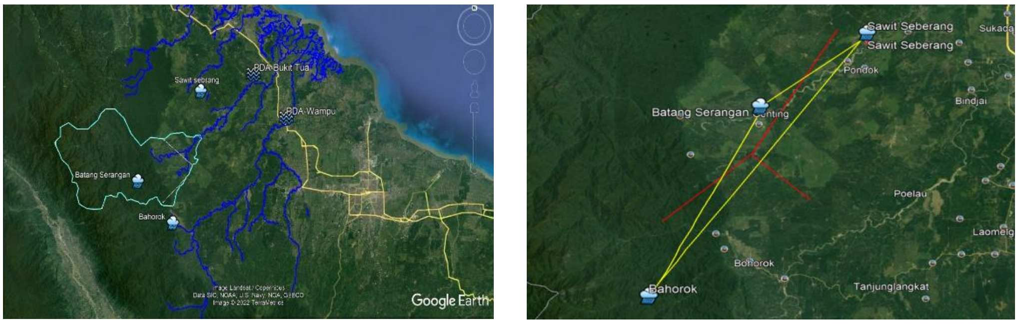


Figure 1. The Location of Three Rainfall Stations
Source: Google Earth (2023)

Based on the calculation of the formula, the average rainfall value obtained by calculating the Polygon Thiessen Method is 95.76 mm.

Table 2. Rainfall Area using Thiessen Polygon Method

Year	Rainfall (mm)			Area (km^2)			rainfall area (mm)
	Batang Serangan	Sawit Seberang	Bahorok	Batang Serangan	Sawit Seberang	Bahorok	
1	87	117	128	680.98	54.91	12.65	89.89
2	103	90	126	680.98	54.91	12.65	102.44
3	48	137	85	680.98	54.91	12.65	55.15
4	234	96	96	680.98	54.91	12.65	221.54
5	58	111	75	680.98	54.91	12.65	62.18
6	58	125	70	680.98	54.91	12.65	63.12
7	58	126	79	680.98	54.91	12.65	63.34
8	134	92	67	680.98	54.91	12.65	129.79
9	87	174	60	680.98	54.91	12.65	92.93
10	71	161	50	680.98	54.91	12.65	77.25
Average							95.76

Source: Processed Data of Researchers (2023)

Frequency Distribution Analysis

Based on the distribution of four frequency discussions, the calculations are conducted on each method to obtain the XT value (return period rainfall in mm/day).

Table 3. Design Rainfall Result of Gumbel Distribution Analysis

T	$\overline{x}$	Y	Yn	S	Sn	K_T	X_T (mm)
2	95.76	0.3668	0.50	49.78	0.95	-0.14	89.03
5	95.76	1.5004	0.50	49.78	0.95	1.06	148.49

10	95.76	2.251	0.50	49.78	0.95	1.85	187.86
25	95.76	3.1993	0.50	49.78	0.95	2.85	237.61
50	95.76	3.9028	0.50	49.78	0.95	3.59	274.51

Source: Processed Data of Researchers (2023)

Table 4. Design Rainfall Normal Distribution Analysis Result

T	$\bar{x}$	**K_T**	**S**	**X_T (mm)**
2	95.76	0.000	49.78	95.76
5	95.76	0.840	49.78	137.58
10	95.76	1.280	49.78	159.48
25	95.76	1.708	49.78	180.80
50	95.76	2.050	49.78	197.81

Source: Processed Data of Researchers (2023)

Table 5. Design Rainfall from Log Normal Distribution Analysis

T	$\overline{\text{Log X}}$	K_T	$S_{LOG}X$	X_T (mm)
2	1.942	0.000	0.183	87.42
5	1.942	0.840	0.183	124.62
10	1.942	1.280	0.183	150.06
20	1.942	1.708	0.183	179.80
25	1.942	2.050	0.183	207.70

Source: Processed Data of Researchers (2023)

Table 6. Design Rainfall Result of Log Pearson Type III Distribution Analysis

T	$\overline{\text{Log X}}$	**K_T**	**$S_{LOG}X$**	**Log XT + $\overline{\text{Log X}}$ + KT. S**	**X_T (mm)**
2	1.942	-0.254	0.183	1.895	78.53
5	1.942	0.675	0.183	2.065	116.24
10	1.942	1.329	0.183	2.185	153.20
20	1.942	2.163	0.183	2.338	217.85
25	1.942	2.780	0.183	2.451	282.67

Source: Processed Data of Researchers (2023)

After calculating the four frequency distribution analyses, the recapitulated rainfall values using the various methods previously described are as follows:

Table 7. Recapitulation of Frequency Distribution Analysis with Various Methods

T	X_T (mm)			
	Normal	Log Normal	Log Pearson III	Gumbel
2	95.76	87.42	78.53	89.03
5	137.58	124.62	116.24	148.49
10	159.48	150.06	153.20	187.86
25	180.80	179.80	217.85	237.61

50	197.81	207.70	282.67	274.51

Source: Processed Data of Researchers (2023)

Table 8. Determination of Distribution Type

Distribution type	Requirements		Calculation result		Comparison	
	Cs	Ck	Cs	Ck	Cs	Ck
Normal	0.00	3.00	2.08	8.34	does not fulfill the requirements	does not fulfill the requirements
Log Normal	0.76	3.00	1.22	5.33	does not fulfill the requirements	does not fulfill the requirements
Log Pearson III	as opposed to others		1.22	5.33	fulfill the requirements	fulfill the requirements
Gumbel	1.14	5.40	2.08	8.34	does not fulfill the requirements	does not fulfill the requirements

Source: Processed Data of Researchers (2023)

In accordance with the parameters of the distribution type, the type of distribution that meets the requirements and is used by researchers is Log Pearson Type III Method.

Rainfall Intensity

The calculation was conducted with return periods of 2, 5, 10, 25, and 50 years to measure rainfall intensity.

Table 9. Rainfall Intensity and Effective Rainfall

T (minutes)	T (hours)	Return Period				
		2	5	10	25	50
15	0.25	68.60	101.54	133.83	190.31	246.94
30	0.50	43.22	63.97	84.31	119.89	155.56
45	0.75	32.98	48.82	64.34	91.49	118.71
60	1.00	27.22	40.30	53.11	75.52	98.00
75	1.25	23.46	34.73	45.77	65.09	84.45
90	1.50	20.78	30.75	40.53	57.64	74.79
105	1.75	18.75	27.75	36.57	52.01	67.48
120	2.00	17.15	25.39	33.46	47.58	61.73
135	2.25	15.85	23.47	30.93	43.98	57.07
150	2.50	14.78	21.88	28.83	41.00	53.20
165	2.75	13.87	20.53	27.06	38.48	49.93
180	3.00	13.09	19.37	25.53	36.31	47.11
195	3.25	12.41	18.37	24.21	34.42	44.66
210	3.50	11.81	17.48	23.04	32.76	42.51
225	3.75	11.28	16.70	22.00	31.29	40.60
240	4.00	10.80	15.99	21.08	29.97	38.89
255	4.25	10.38	15.36	20.24	28.78	37.35
270	4.50	9.99	14.78	19.49	27.71	35.95

285	4.75	9.63	14.26	18.80	26.73	34.68
300	5.00	9.31	13.78	18.16	25.83	33.51
315	5.25	9.01	13.34	17.58	25.00	32.44
330	5.50	8.74	12.93	17.05	24.24	31.45
345	5.75	8.48	12.56	16.55	23.53	30.53
360	6.00	8.24	12.20	16.08	22.87	29.68

Source: Processed Data of Researchers (2023)

Table 10. Hourly Rainfall Ratio (Over 6 Hours)

Hour to (t)	Rain Distribution (R_T)		Rainfall		Ratio	Cumulative
	1 hour		Hour to-		%	%
1	0.550	R_{24}	0.550	R_{24}	55.03%	55.03%
2	0.347	R_{24}	0.143	R_{24}	14.30%	69.34%
3	0.265	R_{24}	0.100	R_{24}	10.03%	79.37%
4	0.218	R_{24}	0.080	R_{24}	7.99%	87.36%
5	0.188	R_{24}	0.067	R_{24}	6.75%	94.10%
6	0.167	R_{24}	0.059	R_{24}	5.90%	100.00%

Source: Processed Data of Researchers (2023)

Table 11. Hourly Rainfall (Over 6 Hours) and Effective Rainfall

Recurrence time	**Year**	**2**	**5**	**10**	**25**	**50**
Rain designation	mm	78.53	116.24	153.20	217.85	282.67
Coefficient of flow c		0.79	0.79	0.79	0.79	0.79
Net rainfall	mm	62.02	91.80	120.99	172.06	223.25

No.	**Hour to (t)**	**Hourly Rain Percentage**	**Net Rainfall in One Hour (mm/hour)**				
			2 Year	**5 Year**	**10 Year**	**25 Year**	**50 Year**
1.	**1**	55.03%	34.13	50.52	66.59	94.69	122.86
2.	**2**	14.30%	8.87	13.13	17.31	24.61	31.93
3.	**3**	10.03%	6.22	9.21	12.14	17.26	22.40
4.	**4**	7.99%	4.95	7.33	9.67	13.74	17.83
5.	**5**	6.75%	4.18	6.19	8.16	11.61	15.06
6.	**6**	5.90%	3.66	5.41	7.13	10.15	13.16
		100.00%					
Net Rainfall (Effective Rain)		**mm/day**	**62.02**	**91.80**	**120.99**	**172.06**	**223.25**

Source: Processed Data of Researchers (2023)

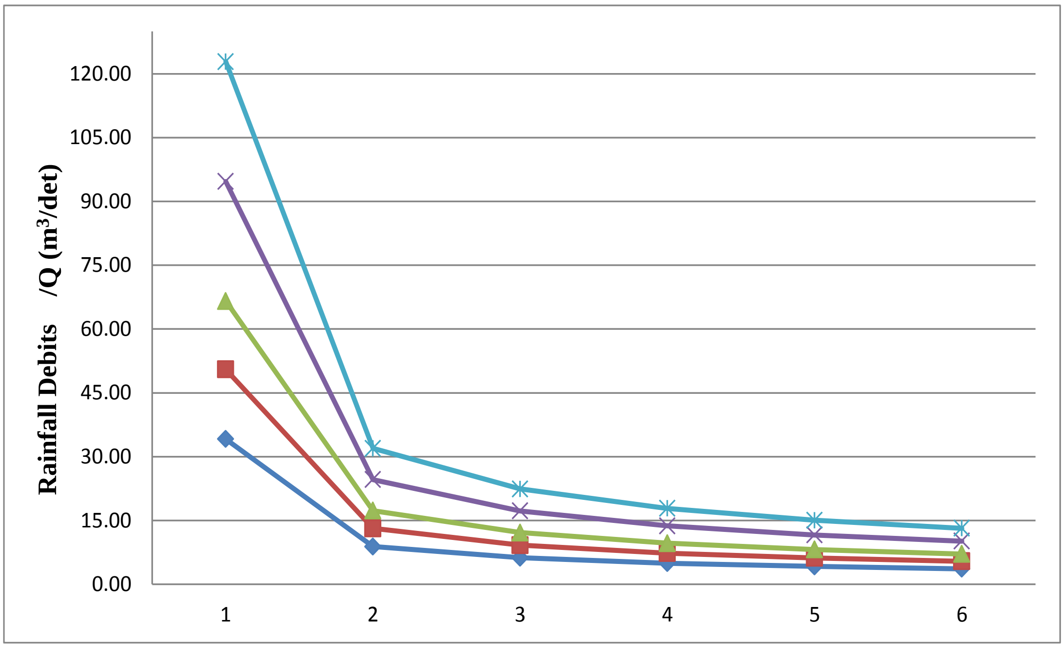


Figure 2. Hourly Rain Output Result
Source: Processed Data of Researchers (2023)

Based on table 11, the hourly rainfall (for 6 hours) and effective rainfall values are obtained, which will be included in the calculation of design flood discharge.

Flood Discharge

After analyzing the available rainfall, the next calculation is the calculation of flow coefficient at Sei Batang Serangan are as follows:

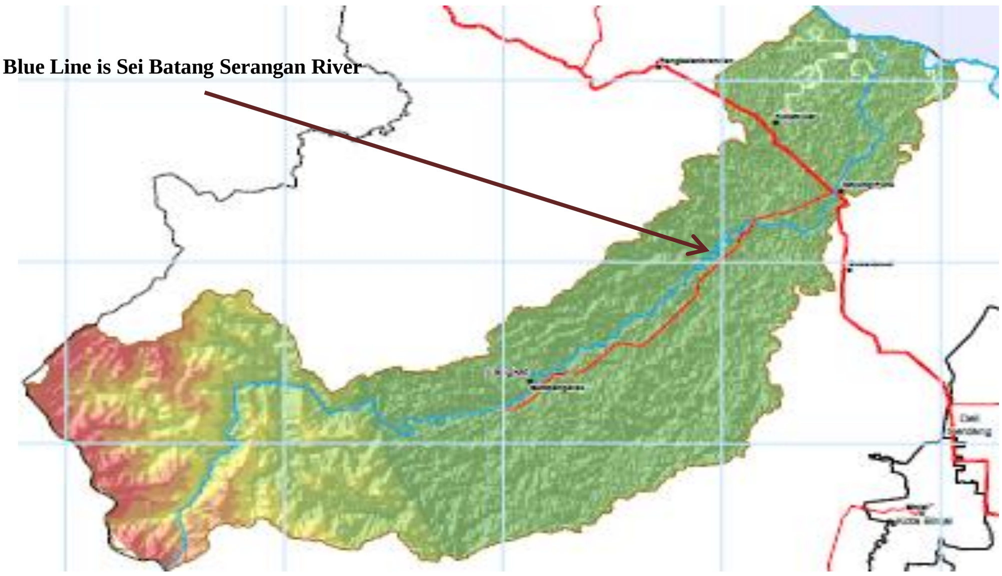


Figure 3. Catchment Area
Source: Public Works and Spatial Planning Department of North Sumatra (2023)

Table 12. Table of Runoff Coefficient Values on Batang Serangan River

Parameter	A (H_a)	C	Ai x Ci	∑ (Ai x Ci) /A
River	11.20	0.50	5.60	**0.790**
Shrubs	29.69	0.20	5.94	
Forest	577.31	0.15	86.60	
Developed land	56.96	0.60	34.18	
Plantation	940.53	0.48	446.75	
Agriculture	19.08	0.50	9.54	
Stagnant waters	12.97	0.20	2.59	

Source: Processed Data of Researchers (2023)

In accordance with the availability of data obtained by researchers, the calculation of flood discharge in this research uses the Nakayasu Synthetic Unit Hydograph (Nakayasu HSS) with the following calculation results:

1. The Characteristics of Watershed
   The following is a description of the characteristics of watershed:
   a. Watershed Area (A): 748.54 km^2
   b. River Length (L): 133.40 km
   c. Flow Coefficient (C): 0.79
   d. Watershed coefficient (α): 1.03
   e. Specific Rainfall (R_0): 1 mm
   f. Basic Flow (Q_b): 6.65 m^3/sec/mm
2. Nakayasu Synthetic Unit Hydrograph Parameters
   The following is the calculation of the parameter values in the Nakayasu Synthetic Unit Hydrograph:
   Parameter Tg (Time Lag)
   Tg = 0.4 + (0.058 x L)
   Tg = 8.14 Hours
   Parameter Tr (Rain Time Unit)
   Tr = 0.75 x Tg
   Tr = 6.10 Hours
   Parameter Tp (Time Peak)
   Tp = Tg + 0.8 Tr
   Tp = 13.02 Hours
   Parameter $T_{0.3}$
   T0.3 = α x Tg = 8.35 Hours
   0.5 $T_{0.3}$ = 4.18 Hours
   1.5 $T_{0.3}$= 12.53 Hours
   2 $T_{0.3}$ = 16.71 Hours
   2.5 $T_{0.3}$ = 20.89 Hours
   Parameter Qp (Peak Discharge)
   $Qp = C.A.R_0 / 3.6 (0.3\ Tp + T_{0.3}) = 13.77$ m^3/det/mm
3. Required Time Duration

Rising Curve Section
Interval $0 \leq t \leq Tp$
$0 \leq t \leq 13.02$
$Qa = Qp\ (t/Tp)^{2.4}$

Descending Curved Section
Interval $Tp \leq t \leq (Tp + T_{0.3})$
$13.02 \leq t \leq 23.20$
$Q_{d1} = Qp \times 0.3^{((t-Tp)/\ T0.3))}$

Interval $(Tp + T_{0.3}) \leq t \leq (Tp + 2.5\ T_{0.3})$
$23.20 \leq t \leq 38.46$
$Q_{d2} = Qp \times 0.3^{((t-Tp + 0.5\ T0.3)/1.5\ T0.3))}$

Interval $t \geq (Tp + T_{0.3})$
$t \geq 38.46$
$Q_{d3} = Qp \times 0.3^{((t-Tp + 1.5\ T0.3)/2\ T0.3))}$

From the calculation of the curved section up to down, the Qt value is obtained based on the calculations that have been carried out and the Qp (Peak Discharge) value of 13.40 m^3/sec is obtained. The graphic is presented as follows:

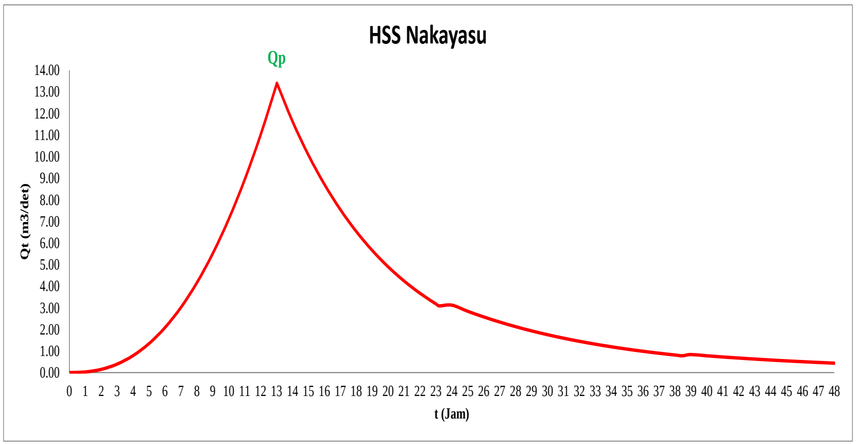


Figure 4. Nakayasu Synthetic Unit Hydrograph
Source: Processed Data of Researchers (2023)

After calculations based on known parameters, the calculated discharge data mm/day is entered into various return times of 2, 5, 10, 25, and 50 years which are presented in the table below:

Table 13. Recapitulation of Flood Discharge at Various Return Periods

T (year)	Q peak (m^3/sec)
2	745.03
5	1099.61
10	1447.14
25	2055.06
50	2664.55

Source: Processed Data of Researchers (2023)

Based on the results of the flood discharge analysis of various return periods, the peak Q value for year is obtained. It also identifies that Tp (Peak Time) value becomes Qp (Peak Flow) value. Thus, the following is a graph of the output results based on the calculation of flood discharge of Nakayasu synthetic unit hydrograph from 2-year, 5-year, 10-year, 25-year, and 50-year return periods.

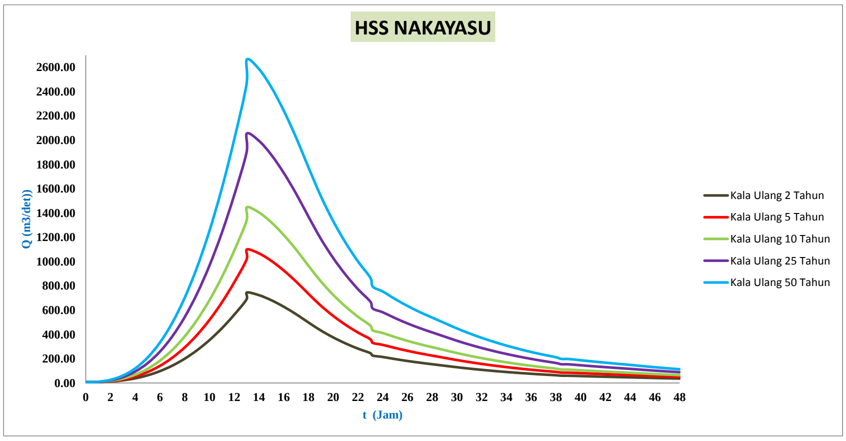


Figure 5. 50-year Return Period Flood Discharge Chart
Source: Processed Data of Researchers (2023)

Hydraulic Analysis

Hydraulic analysis was conducted through HEC-RAS 5.0 software with the following calculation analysis:

Figure 6. Aerial View of Sei Batang Serangan Toll Bridge and River Profile
Source: Public Works and Spatial Planning Department of North Sumatra (2023)

Making Project Plan

First open the application then create a project name, then save it to the specified folder.

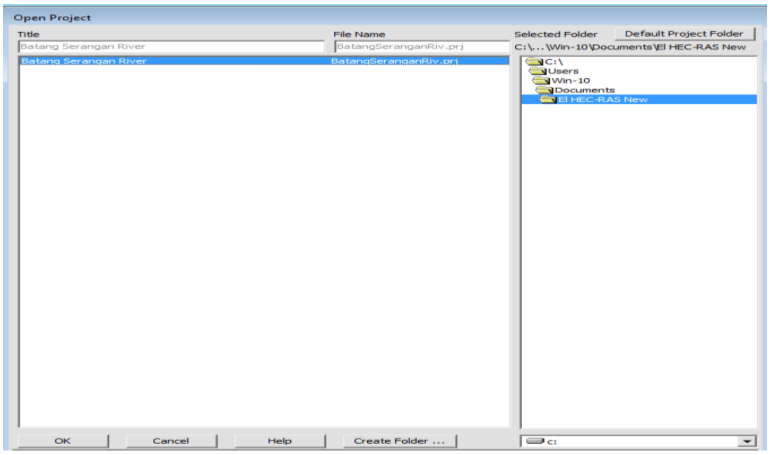
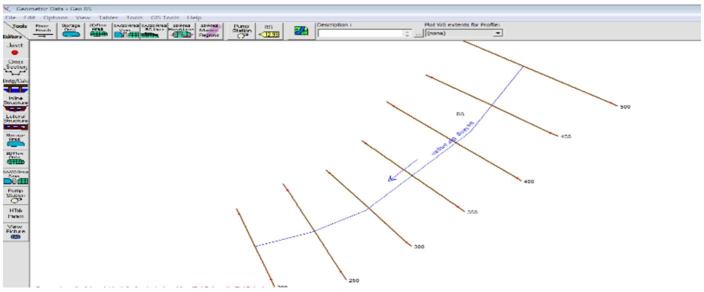


Figure 7. Making Project Plan
Source: Processed Data of Researchers (2023)

Input Geometry Data

The data used is cross section sta 2+00 - sta 5+00 meters with a distance of every 50 meters. Then enter the known data as shown below according to the elevation value at the known point.



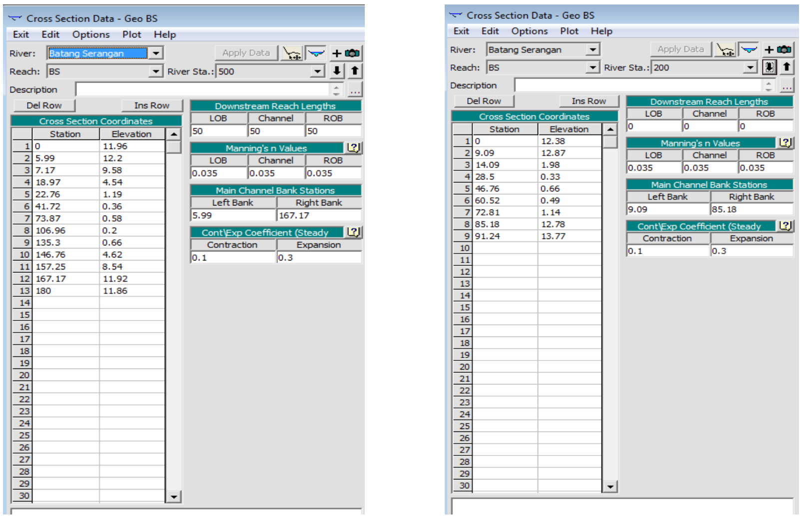


Figure 8. Input Geometry Data
Source: Processed Data of Researchers (2023)

Input Steady Flow Data

The data entered is taken from the 5 discharge data calculated in the previous table, which are for Q2 Year, Q5 Year, Q10 Year, Q25 Year, and Q50 Year with the values listed in the figure below:

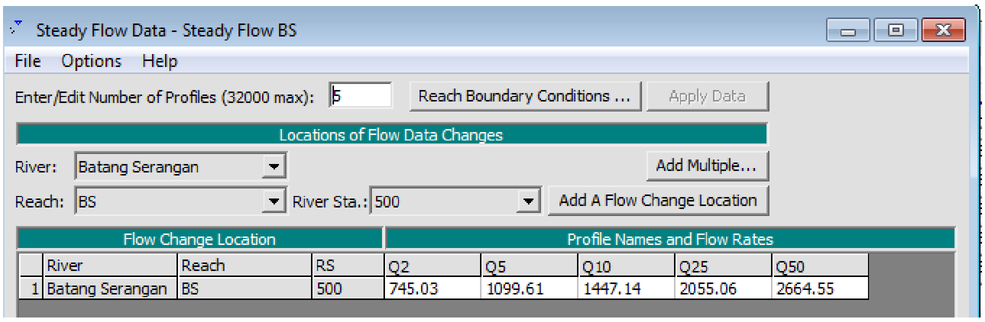


Figure 9. Input Steady Flow Data
Source: Processed Data of Researchers (2023)

Running Steady Flow Data

After entering the discharge data, then running steady flow data is conducted and the output is generated as follows:

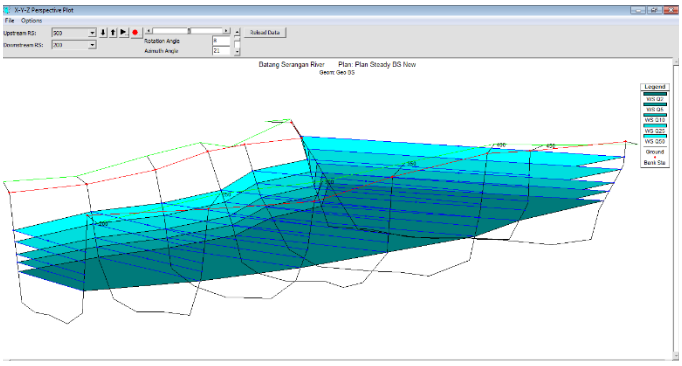


Figure 10. 3D Display of Steady Flow Data Output Results
Source: Processed Data of Researchers (2023)

Reach	River Sta	Profile	Q Total (m^3/s)	W.S. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # chl
BS	500	Q2	745.03	5.54	0.000238	1.21	614.55	132.6	0.18
BS	500	Q5	1099.61	6.64	0.000267	1.44	763.78	138.14	0.2
BS	500	Q10	1447.14	7.62	0.00028	1.61	900.87	143.03	0.2
BS	500	Q25	2055.06	9.15	0.00029	1.83	1125.23	150.85	0.21
BS	500	Q50	2664.55	10.52	0.00029	1.99	1335.99	156.3	0.22
BS	450	Q2	745.03	4.96	0.004702	3.37	221.28	97.14	0.71
BS	450	Q5	1099.61	6.14	0.00265	3.25	338.85	101.73	0.57
BS	450	Q10	1447.14	7.13	0.001996	3.28	441.82	105.22	0.51
BS	450	Q25	2055.06	8.66	0.001491	3.4	603.85	107.35	0.46
BS	450	Q50	2664.55	10.01	0.001268	3.55	749.77	109.07	0.43
BS	400	Q2	745.03	5.2	0.000539	1.7	438.82	105.29	0.27
BS	400	Q5	1099.61	6.33	0.000553	1.96	559.81	109.38	0.28
BS	400	Q10	1447.14	7.3	0.000557	2.17	668.23	112.91	0.28
BS	400	Q25	2055.06	8.81	0.000549	2.44	842.14	116.54	0.29
BS	400	Q50	2664.55	10.16	0.000541	2.66	1001.21	119.37	0.29
BS	350	Q2	745.03	4.97	0.001413	2.48	299.87	83.6	0.42
BS	350	Q5	1099.61	6.06	0.001323	2.81	391.66	85.41	0.42
BS	350	Q10	1447.14	7	0.001276	3.06	472.78	87.36	0.42
BS	350	Q25	2055.06	8.46	0.001223	3.41	602.41	90.38	0.42
BS	350	Q50	2664.55	9.76	0.001188	3.69	721.74	93.08	0.42
BS	300	Q2	745.03	4.86	0.001635	2.63	283.68	81.08	0.45
BS	300	Q5	1099.61	5.94	0.001511	2.94	373.61	84.12	0.45
BS	300	Q10	1447.14	6.89	0.001436	3.19	454.06	86.76	0.44
BS	300	Q25	2055.06	8.35	0.001333	3.53	582.89	89.3	0.44
BS	300	Q50	2664.55	9.65	0.001277	3.8	700.67	91.78	0.44

BS	250	Q2	745.03	4.85	0.001097	2.31	322.76	83.08	0.37
BS	250	Q5	1099.61	5.94	0.001088	2.65	415.3	85.72	0.38
BS	250	Q10	1447.14	6.88	0.001077	2.91	497.15	87.57	0.39
BS	250	Q25	2055.06	8.35	0.00106	3.27	627.6	90.43	0.4
BS	250	Q50	2664.55	9.65	0.001048	3.57	747.16	92.98	0.4
BS	200	Q2	745.03	4.45	0.00265	3.32	224.67	63.37	0.56
BS	200	Q5	1099.61	5.43	0.002651	3.82	288.05	64.87	0.58
BS	200	Q10	1447.14	6.29	0.002654	4.21	343.78	66.16	0.59
BS	200	Q25	2055.06	7.61	0.00265	4.75	432.44	68.17	0.6
BS	200	Q50	2664.55	8.78	0.00265	5.19	513.39	69.96	0.61

From the running results above, it is found that there is no flooding in river area, because it is known that MAB around the Bridge is 12.691 m (2.171 m below the bridge). In other words, Sei Batang Serangan Toll Bridge area in Sei Batang Serangan River Area is not flooded.

CONCLUSION AND SUGGESTION

Conclusion

The calculation of regional rainfall through Polygon Thiessen Method with an average rainfall obtained of 95.76 mm. Moreover, the frequency distribution analysis using Log Pearson Type III with rainfall values in various return periods obtained the result, such as: (1) 2-year return period = 78.53 mm; (2) 5-year return period = 116.24 mm; (3) 10-year return period = 153.20 mm; (4) 25-year return period = 217.85 mm; (5) 50-year return period = 282.67 mm. Meanwhile, flood hydograph calculations using the Nakayasu HSS Method obtained plan discharge with various return periods, such as: (1) 2-year return period = 745.03 m^3/second; (2) 5-year return period = 1099.61 m^3/second; (3) 10-year return period = 1447.14 m^3/second; (4) 25-year return period = 2055.06 m^3/second; (5) 50-year return period = 2644.55 m^3/second. Then, based on the hydraulic analysis using the HEC-RAS 5.0 program from steady flow data, the maximum water level elevation is at River Sta 5+00 of 10.52 m in a 50-year return period, and the minimum water level elevation is at River Sta 2+00 of 4.45 m in a 2-year return period. Then, based on flood water level of 12.691 meters, Sei Wampu Toll Bridge area does not experience flooding because the water level elevation value does not exceed the flood water level value (TMA < MAB). From the results of steady flow data analysis, it can be concluded that no flooding occurs at Sei Batang Serangan Toll Bridge in Sei Batang Serangan River Area at return times.

Suggestion

For more accurate results, the latest rainfall station data is needed to determine the plan flood discharge and more data is needed at river cross section points to obtain the water level elevation. In addition, it aims to provide information for the community, institutions, or agencies related to the parties concerned in order to plan good, strategic, and integrated flood control in conducting studies on the evaluation of water level elevation on flood discharge at the Sei Batang Serangan toll bridge in the Sei Batang Serangan riverside.

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