International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 21, Issue 4 (April 2025), PP 242-250

Flood Hydrograph Analysis in the Sekanak Sub-Watersheed, Palembang City

Achmad Syarifudin[1]; Bagus Dwi Hidayat[2]
[1]*Professor of Civil Engineering, Faculty of Engineering*
[2]*Post Graduate of Civil Engineering, Faculty of Engineering*
Bina University, Palembang, Indonesia
[1]*Corresponding Author*

Abstract
This study aims to obtain the magnitude of the comparison of Qdesign with Qbankfull and the flood hydrograph pattern or a description of the movement of flow discharge in the Sekanak Watersheed with a return period of 5 years, 10 years, 25 years, 50 years and 100 years. This study is located in the Sekanak Sub-DAS Area of Palembang City with secondary data collection in the form of rainfall data for 19 years and primary data obtained directly from field surveys, namely in the Sekanak Sub-DAS. The results of the study on the Sekanak sub-watershed showed that there was an overflow at a return period of 5 years, 10 years, 25 years, 50 years and 100 years. This can be seen from the capacity of the river channel Qbankfull = 42.01 m3/sec <flood discharge with a return period of 5 years Q5 = 69.145 m3/sec. Likewise for the return periods of 10 years (Q10), 25 years (Q25), 50 years (Q50) and 100 years (Q100). The movement of the flow discharge for each return period for a certain time with a return period of 5 years (Q5) for 2 hours of 20.04 m3/sec, and so on can be known during the time and flood return period of 10 years, 25 years, 50 years and 100 years.

Keywords*: Sekanak river, flow capasity, flood hydrograph, flood analysis*

Date of Submission: 12-04-2025 Date of acceptance: 26-04-2025

I. INTRODUCTION

Palembang City is crossed by 108 river branches. Of all these rivers, the four largest are Musi, Komering, Ogan, and Keramasan. The Musi River is the widest river among them, with an average width of around 504 meters and reaching up to 1,350 meters in the area near Kemaro Island. (Syarifudin A, 2018). Only 18 of the 21 sub-districts in Palembang City actually end in the Musi River according to the DAS category. The following sub-districts are included in the map: Rengas Lacak, Gandus, Lambidaro, Boang, Sekanak, Bendung, Lawang Kidul, Buah, Juaro, Batang, Sei Lincah, Keramasan, Kertapati, Kedukan Ulu, Aur, Sriguna, Jakabaring, and Plaju.

The government is facing difficulties in evaluating drainage infrastructure due to flooding in Palembang City. Reassessment and further development are needed, although drainage channels are already available. The Sekanak River, with a watershed area of 11.78 km², functions as a vital drainage channel in Palembang City. This river used to be a natural channel, now it has turned into an artificial system that flows into the Musi River. Simulations with various scenarios show seven locations that are classified as flooded under current conditions.

Because of its position in the center of Palembang City, the Sekanak River plays an important role. In 2021, research on flood control of the Sekanak-Lambidaro River in Palembang City was partially completed by the Sumatra VIII River Basin Center (BBWS Sumatra VIII) of the Directorate General of Water Resources, part of the Ministry of Public Works and Public Housing (PUPR). Among the various retention ponds along the Sekanak River sub-watershed is the Siti Khadijah Retention Pond.

In addition to rainfall data, surface runoff is one of the important factors in the transport system of various materials that will be carried into river flow. If the intensity of rainfall exceeds the infiltration rate, then excess water begins to accumulate as surface reserves. If the surface reserve capacity is exceeded, then surface runoff begins as a thin layer flow. Surface runoff is the part of the runoff that passes above the land surface towards the river channel. (Achmad Syarifudin, 2018).

Another term for surface runoff that is often used by some experts is runoff on land or runoff water. The duration of rain, intensity and distribution of rain affect the rate and volume of surface runoff. The total surface runoff for a rain is directly related to the duration of rain for a certain rainfall intensity. Rain with the same intensity and for a longer time will produce greater surface runoff. Rain intensity will affect the rate and volume of surface runoff. (Achmad Syarifudin, 2018)

In high intensity rain, the total volume of surface runoff will be greater than with low intensity even though the total rainfall received is the same. Topographic forms such as land slope will affect surface runoff. Watersheds with high slopes will produce greater surface runoff. The presence of vegetation can increase the amount of water retained on the surface, thereby reducing the rate of surface runoff. (Achmad Syarifudin, 2018).

II. MATERIAL AND METHODS

This research is located in the Sekanak Sub-DAS Area of Palembang City with secondary data collection in the form of rainfall data for 19 years and primary data obtained directly from field surveys, namely in the Sekanak Sub-DAS which consists of 4 Sub-DAS.

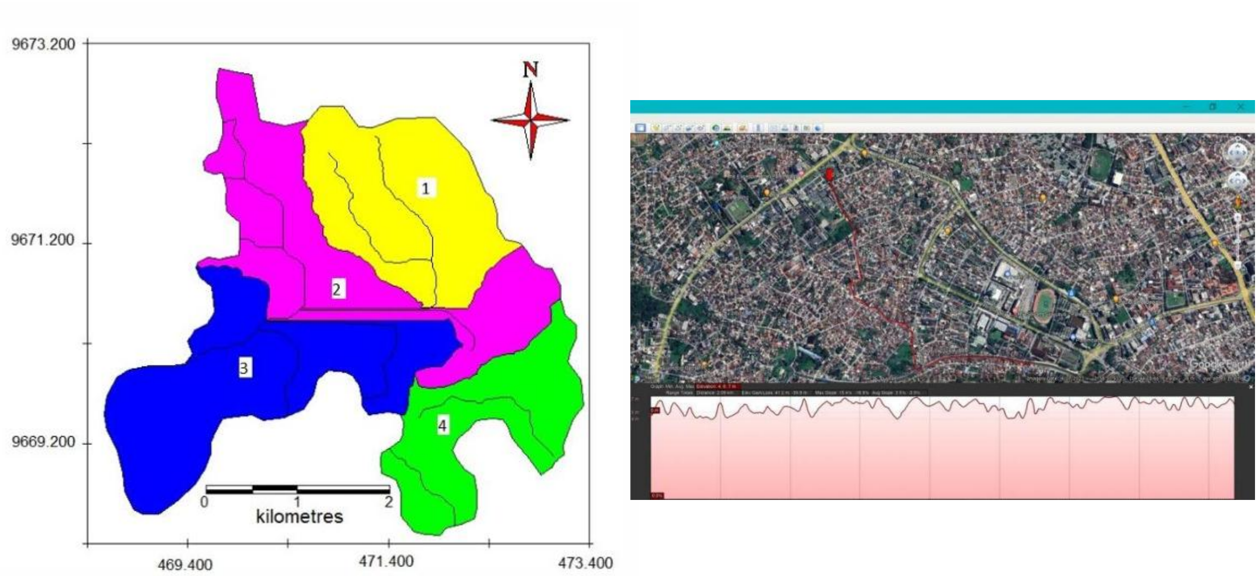

Figure 1: Research location

2.1. Research Tools and Materials

The tools that will be used in this research include those in table 1.

Table 1: List of tools used in the research

No.	Name of tools	Number	Of Uses
1	Meter	1 unit	Measures distance manually
2	Water pass (WP)	1 unit	Measures vertical and horizontal distances for channel surveys
3	Peil-Scale	2 units	Measures water level in channels
4	Computer (RAM 2 GB)	1 unit	Performs general modeling
5	Printer	1 unit	Displays writing in the form of a report
6	Laptop	1 unit	Helps in making reports

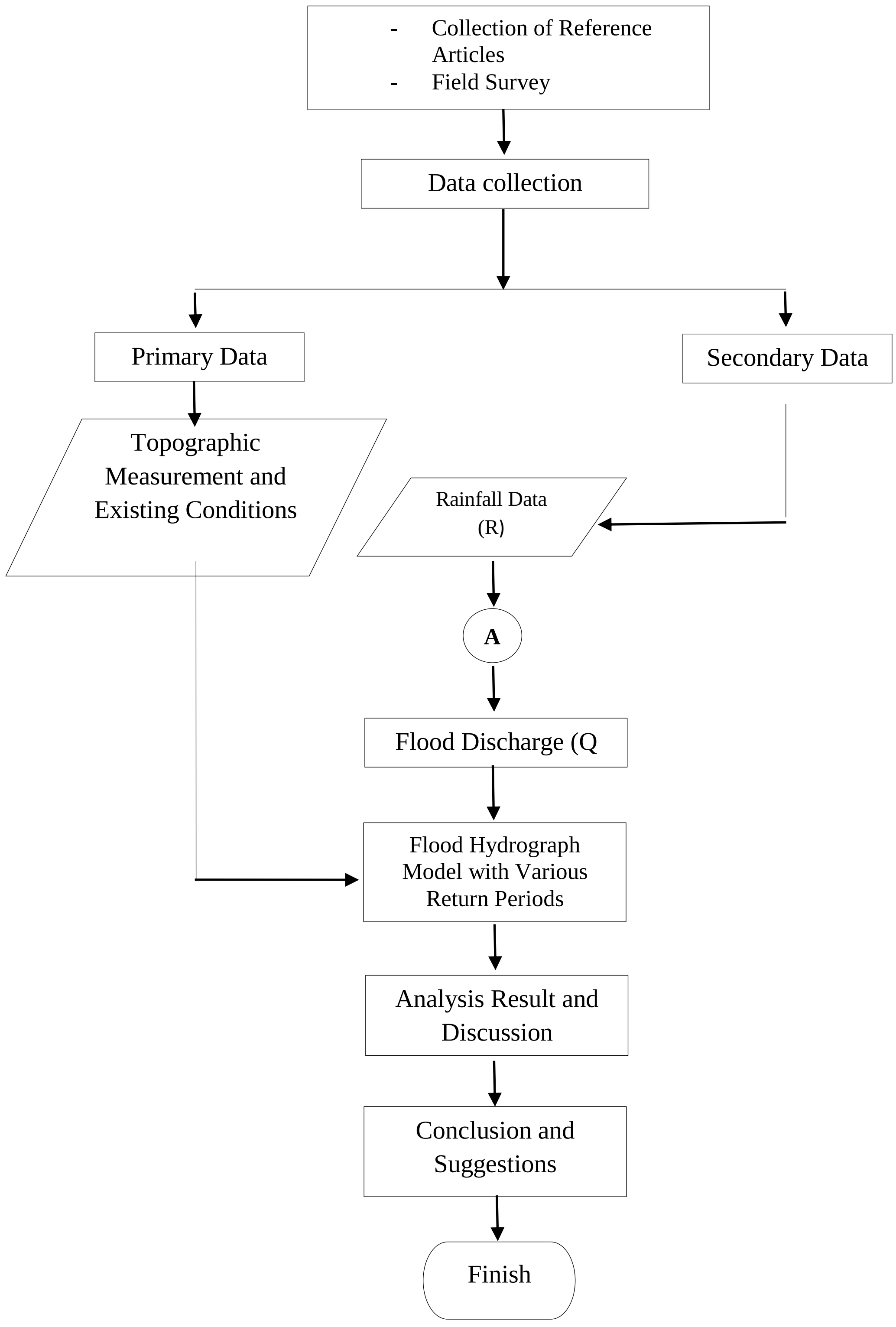

Figure 2: The flowchart of the methodology

III. RESULTSAND DISCUSSION

3.1. Selection of Return Period

Determination of return period based on the method:

1. Empirical Method

Past event observation data to predict future events with the same magnitude. The probability of extreme events in "N" years will recur in the next "n" years is expressed as:

P (N,n) = n / N + n .... (1)

2. Risk Analysis

The risk of failure of the planned building is a risk analysis expressed in the equation:

R = 1 - 1 - 1/T n .... (2)

with:

R = Probability where Q Qt occurs at least once in n years.

3.2. Hydrology

Considering the availability of hydrometric data is not yet available properly, rainfall data is used as the basis for hydrological calculations. The rainfall data used is rainfall data recorded by several stations in the planning area and has quite long data, namely from 2011 to 2021 and the average rainfall value is taken from the maximum monthly rainfall data.

For the planned rainfall estimate, frequency analysis is used by reviewing the commonly used distribution:

1. Planned Rain Estimate

a. For Return Periods above 1 year

The planned rainfall estimate is carried out by analyzing the frequency of the annual maximum rainfall data (annual series). There are several distributions in statistics and those commonly used in frequency analysis are 4 (four) types, namely:

1). Normal

2). Gumbel type I

3). Log normal 2 parameters

4). Pearson type III log

Each distribution has its own statistical properties. By calculating the statistical parameters of the analyzed data series, it can be estimated which distribution is appropriate for the data series. The statistical parameters in question are as follows:

$$X = \frac{\Sigma\, x\, i}{n} \qquad \text{...} \qquad (3)$$

$$S = \sqrt{\frac{(xi - xr)^2}{(n-1)}} \qquad \text{...} \qquad (4)$$

$$Cs = \frac{n}{(n-1)(n-2)S^3} \sum (xi - xr)3 \qquad \text{...} \qquad (5)$$

$$Ck = \frac{n}{(n-1)(n-2)(n-3)S^4} \sum (xi - xr)4 \qquad \text{...} \qquad (6)$$

with:

xr = Mean value

S = Standard deviation

Cs = Skewness coefficient

Ck = Curtosis coefficient

xi = rainfall data
n = amount of data
The typical statistical properties of each distribution can be explained as follows:

1). Normal Distribution: Cs = O
Typical characteristics: Cs = 0
Probability P (x-S) = 15.87%
P (x) = 50.00%
P(x+s) = 84.14%
The possibility of a variable in the interval x – S and X + S = 68.27% and in the interval X – 2S and X + 2S = 95.44%.

2). Log normal distribution (2 parameters)
Characteristics: Cs = 3 Cv
Cs is always positive
Probability line equation: x(t) = x + K
With x(t) = rainfall depth with recurrence period t (years) K = Frequency factor

3). Gumbel distribution type I
Characteristics: Cs = 1.3960 cv and Ck = 5.4002
Probability line equation:

$$X(t) = x + \frac{\sigma}{\sigma n}(y - yn) \qquad (7)$$

with: Y = reduced variated
yn and n = Mean value and standard deviation of reduced variated.

4). Pearson Log Distribution type III
The statistical data does not approach the characteristics of the three previous distributions. The rainfall data is transformed into its natural logarithm value so that the xi values change to ln xi. Then the average value, standard deviation and skewness coefficient are calculated as follows:

$$\overline{ln\frac{\sum_{i=1}^{n} ln\, xi}{n}} \qquad (8)$$

$$S = \sqrt{\frac{\sum_{i=1}^{n}(ln\, xi - \overline{ln}\quad x)^2}{(n-1)}} \qquad (9)$$

$$Cs = \frac{n}{(n-1)(n-2)S^3}\sum_{i=1}^{n}(\ln xi - \overline{\ln}\, x)^3 \qquad (10)$$

Probability line equation:

$$\ln x(t) = \overline{\ln}\, x + K\, S \qquad (11)$$

K is the frequency factor. based on the Cs value calculated in equation 11, the depth of rainfall with a return period of t years is obtained by finding the antilogarithm of the ln (t) value.

To find out whether the existing data is in accordance with the selected theoretical distribution, a goodness of fit test is carried out using the Smirnov Kolmogorov and chi-square tests.

a. For Return Period Less than 1 year

The estimated planned rainfall with a return period of less than 1 year cannot be done using the frequency analysis above. Determining the depth of rainfall with a probability of being equaled or exceeded one or more times in a year can be done using the approach below.

1. The length of the rainfall data series is determined (for example n years).
2. Data in each year is broken down from large to small.
3. In each year, the data is taken (k + 1) largest data, where k is the number of events equaled or exceeded in the desired year. So that during n years n x (k + 1) data are obtained.
4. This new data series is sorted from large to small.
5. Rainfall with a probability of being equaled or exceeded k times in a year is data in the order (n x k + 10).

Table 2: Analysis of Design Rain Analysis Results

Return Period (T)	Design Rainfall Frequency Analysis (mm)			
	Normal	Log Normal	Log Pearson Type III	Gumbel
5	117,613	139,711	43,783	120,761
10	128,465	153,019	50,529	138,901
25	138,824	166,901	61,078	161,817
50	147,456	179,428	70,488	178,818
100	154,362	190,123	81,348	195,696

Source: Analysis results, 2024

Based on the results of the rainfall frequency analysis, the ones that meet the design rainfall are based on Gumbel distribution with return periods of 5, 10, 25, 50 and 100 years respectively.

By using the Mononobe formula and design rainfall with Gumbel Distribution, the rainfall intensity is obtained as in table 3.

Table 3: Rainfall intensity with various return periods

T (Year)	R_{24} (mm)	I (mm/jam)
5	114	45,0343
10	155	60,9973
25	182	71,8987
50	212	83,5867
100	218	86,1431

The intensity calculation for return periods of 5, 10, 25, 50 and 100 years in a time span of 10 minutes can be seen in Table 4 below:

Table 4: Rainfall Intensity with Rain Recurrence Period and Duration

t		**Return Period**				
Minute	**hour**	**5**	**10**	**25**	**50**	**100**
5	0.083	228.928	263.736	307.713	340.337	372.724
10	0.167	144.216	166.143	193.847	214.399	234.801
20	0.333	90.850	104.664	122.116	135.063	147.916
30	0.500	69.332	79.873	93.192	103.072	112.881
40	0.667	57.232	65.934	76.928	85.084	93.181
50	0.833	49.321	56.820	66.295	73.323	80.301
60	1.000	43.676	50.317	58.707	64.931	71.110
70	1.167	39.411	45.403	52.974	58.590	64.166
80	1.333	36.054	41.536	48.462	53.600	58.700
90	1.500	33.331	38.399	44.802	49.552	54.267
100	1.667	31.070	35.795	41.763	46.191	50.586
110	1.833	29.158	33.591	39.192	43.347	47.472
120	2.000	27.514	31.698	36.983	40.904	44.797
130	2.167	26.085	30.051	35.061	38.779	42.469
140	2.333	24.827	28.602	33.371	36.909	40.422

150	2.500	23.711	27.316	31.871	35.250	38.605
160	2.667	22.713	26.166	30.529	33.766	36.979
170	2.833	21.813	25.130	29.320	32.428	35.514
180	3.000	20.997	24.190	28.223	31.216	34.186
190	3.167	20.254	23.334	27.224	30.111	32.976
200	3.333	19.573	22.549	26.309	29.098	31.867
210	3.500	18.947	21.827	25.467	28.167	30.848
220	3.667	18.368	21.161	24.689	27.307	29.906
230	3.833	17.832	20.543	23.968	26.510	29.032
240	4.000	17.333	19.968	23.298	25.768	28.220
250	4.167	16.868	19.432	22.672	25.076	27.463
260	4.333	16.432	18.931	22.087	24.429	26.754
270	4.500	16.024	18.460	21.539	23.822	26.089
280	4.667	15.640	18.018	21.023	23.251	25.464
290	4.833	15.278	17.602	20.537	22.714	24.875
300	5.000	14.937	17.208	20.078	22.206	24.319
310	5.167	14.614	16.836	19.643	21.726	23.794
320	5.333	14.308	16.484	19.232	21.271	23.295
330	5.500	14.017	16.149	18.842	20.839	22.822
340	5.667	13.741	15.831	18.470	20.428	22.373
350	5.833	13.478	15.528	18.117	20.037	21.944
360	6.000	13.227	15.239	17.780	19.665	21.536

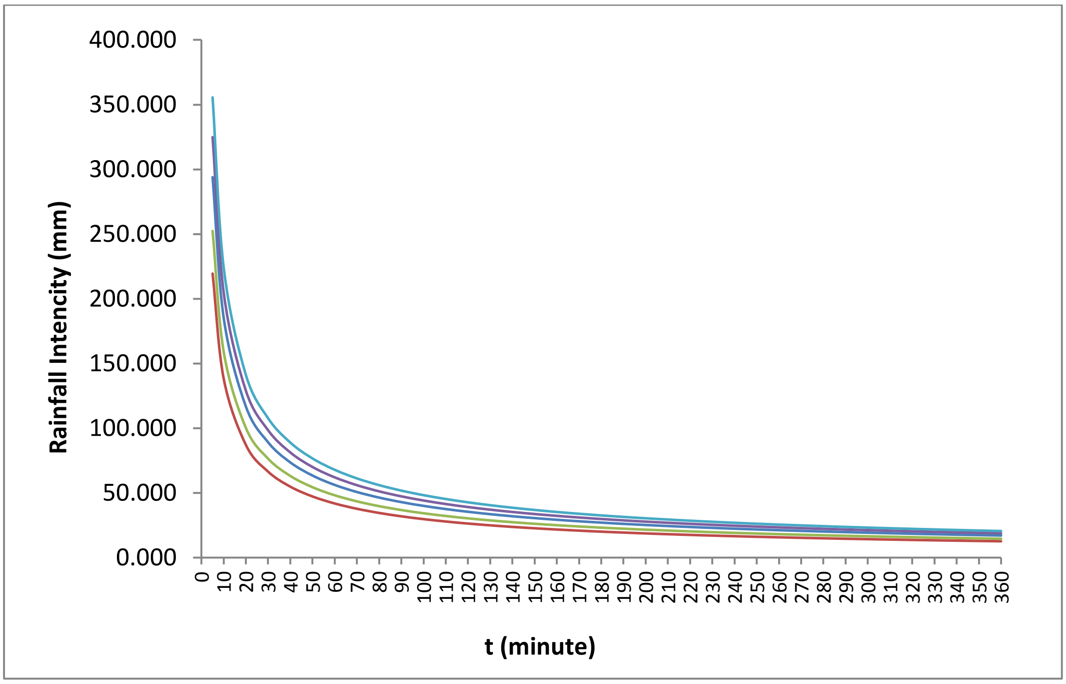

Figure 3: *Intencity Duration Frequency* (IDF) Curve

3.3. Time of Concentration

According to Suripin (2004), Triatmodjo (2008), and Syarifudin A (2018), concentration time is the duration required for water particles to reach the exit point of a watershed after traveling from the furthest point. Meanwhile, the period between the center of mass of effective rainfall and the peak of the unit hydrograph is known as lag time or basin lag. Table 5 presents the results for the upstream Sekanak sub-watershed, where the concentration time analysis was recorded at 0.1524 hours, while the results for the other sub-watersheds are as follows.

Table 5: Recapitulation of Concentration Time Analysis (tc)

Sekanak River Sub-watershed	Height difference (m)	River length (km)	Slope (%)	tc (hour)
1	0.2	0.558	0.0358	0.1524
2	0.1	1.272	0.0079	0.5143
3	0.1	1.007	0.0099	0.3941
4	1.8	1.887	0.0954	0.2671

3.4. Flow Discharge (Q)

Q = 0.2778 C I A
with:
Q = Peak discharge (m^3/sec)
C = Runoff coefficient
I = Rain intensity with duration equal to flood concentration time (mm/hour)
A = Catchment area (km^2)
Q_{10} = 0.2778 . 0.85 . (257.1460 mm/hour) . (2.2341 km^2)
Q_{10} =7,574 m^3/sec

Table 6: Flow rate calculation results

Return Period (year)	C	I (mm/jam)	A (km^2)	Q (m^3/det)
5	0,90	65,219	11,780	6,9145
10	0,90	75,016	11,780	7,9532
25	0,90	87,392	11,780	9,2653
50	0,90	96,574	11,780	10,2388
100	0,90	105,690	11,780	11,2052

Sumber : Analysis result, 2024

3.5. Flood Analysis

Flood analysis is carried out by comparing the capacity of the river channel in a section, obtained from hydraulic calculations, with the planned discharge flowing in the same section, calculated in the hydrological analysis. This calculation provides an overview of whether the existing planned discharge can still be flowed in the river channel or will overflow. A more accurate approach should be carried out with flood tracking analysis if sufficient data availability is available.

Table 6 is the result of the analysis of the planned flood discharge and the capacity of the Sekanak river channel with a certain recurrence period and will be compared between the flood discharge and the capacity of the Sekanak river channel and it will be seen whether the river conditions are still able to accommodate the available flood discharge.

Table 7: Design Flood Discharge and Channel Capacity

No	Return Period (Year)	Design Flood Discharge (m^3/det) Q_{design}	Flow Capacity Of River (Channel) (m^3/det) $Q_{bankfull}$	River Condition
1	5	69.145	42.01	Overflow
2	10	79.532	44.82	Overflow
3	25	92.653	57.97	Overflow
4	50	102.388	65.22	Overflow
5	100	112.052	72.47	Overflow

Sumber: Analysis result, 2024

IV. CONCLUSION

Based on the results and discussions, the following can be concluded:

1. Sub-watershed of Sekanak was occurred overflows occurred at return periods of 5 years, 10 years, 25 years, 50 years and 100 years. This can be seen from the river channel capacity Qbankfull = 42.01 m^3/sec <flood discharge with a return period of 5 years Q_5 = 69.145 m^3/sec. Likewise for return periods of 10 years (Q_{10}), 25 years (Q_{25}), 50 years (Q_{50}) and 100 years (Q_{100}).
2. The movement of flow discharge for each return period for a certain time with a return period of 5 years (Q_5) for 2 hours of 20.04 m^3/sec, and so on can be known during the time and flood return period of 10 years, 25 years, 50 years and 100 years.

REFERENCES

[1]. Andikha, F., 2017, Penerapan Sistem Ecodrainage Dalam Mengurangi Potensi Banjir (Studi Kasus di Kabupaten Sampang) (Doctoral dissertation, Institut Teknologi Sepuluh Nopember)

[2]. Aureli, F and Mignosa, P., 2001, "Comparison between experimental and numerical results of 2D flows due to levee-breaking," XXIX IAHR Congress Proceedings, Theme C, September 16-21, Beijing, China

[3]. Chow, V.T., Maidment, D.R., and Mays, L.W., 1988, Applied Hydrology. Mc. Graw Hill co. Department of Public Works., Guidance for Landslide Management Planning, SKBI - 2.3.06., 1987, PU Publication Agency Foundation

[4]. Department of Public Works., Guidance for Landslide Management Planning, SKBI - 2.3.06., 1987, PU Publication Agency Foundation Islam M

[5]. Desromi, F., Putri, Y.E., Wijaya, O.E., & Hermawati., 2022. Penggunaan Program Hec-Ras dalam Pengendalian Banjir Sungai., ISSN 2477- 4960, EISSN 2621-7929

[6]. Ikhsan, C., 2017, Pengaruh variasi debit aliran pada dasar saluran terbuka dengan aliran seragam, Media Teknik Sipil

[7]. Ikhsan, M., Refiyanni, M. & Nazimi, D., 2018. Studi Penelusuran Aliran Pada Sungai Krueng Meureubo Kecamatan Meurebo Kabupaten Aceh Barat. Vol. 4 No.1 April 2018, p. 53

[8]. Istiarto., 2012, Teknik Sungai, Transpor Sedimen, Universitas Gadjahmada, Yogyakarta

[9]. Istiarto., 2012, Teknik Sungai, Universitas Gadjahmada, Yogyakarta

[10]. Harisuseno, D., & Bisri, M., 2017, Limpasan Permukaan secara Keruangan: Spatial Runoff. Universitas Brawijaya Press

[11]. Kustamar., 2017. Pengendalian Limpasan Permukaan, Penerbit Mitra Gajayana, Malang, hal. 1

[12]. Loebis, J., 2008. Banjir Rencana Untuk Bangunan Air. Yayasan Badan Penerbit Pekerjaan Umum. Jakarta

[13]. Mc. Cuen R.H., 1982, A Guide to hydrologic analyses using SCS methods. Prentice Hall Publication

[14]. Narulita, I., 2016, Distribusi spasial dan temporal Curah Hujan di DAS Cerucuk, Pulau Belitung. Jurnal Riset dan Pertambangan, Vol. 26 No. 2: 141 – 154

[15]. Okubo K, Muramoto Y, and Morikawa H, 1994, "Experimental Study on Sedimentation over the Floodplain due to River Embankment Failure," Bulletin of the Disaster Prevention Research Institute, Kyoto University, 44 (2), pp. 69-92

[16]. Paimin et al., 2012, Sistem Perencanaan Pengelolaan Daerah Aliran Sungai, Pusat Penelitian dan Pengembangan Konservasi dan Rehabilitasi (P3KR), Bogor, Indonesia

[17]. Robert. J. Kodoatie, Sugiyanto., 2002, Flood causes and methods of control in an environmental perspective, Yogyakarta

[18]. Sunu Tikno., 2002, Penerapan metode penelusuran banjir (flood routing) untuk program pengendalian dan sistem peringatan dini banjir kasus : sungai ciliwung jurnal sains & teknologi modifikasi cuaca, vol. 3, no. 1, 2002: 53- 61

[19]. Suripin., 2004, Sistem Drainase Perkotaan Berkelanjutan, Penerbit Andi, hal. 176-179

[20]. Syarifudin, A., 2018, Hidrologi Terapan, Penerbit Andi, Yogyakarta, hal. 45-48

[21]. Syarifudin, A., 2018, Sistem Drainase Perkotaan Berwawasan Lingkungan, Penerbit Bening's, hal. 38-42

[22]. Syarifudin, A., 2017, The influence of Musi River Sedimentation to The Aquatic Environment DOI: 10.1051/matecconf/201710104026, MATEC Web Conf, 101, 04026, , [published online 09 March 2017]

[23]. Achmad Syarifudin A and Dewi Sartika, A Scouring Patterns Around Pillars of Sekanak River Bridge, Journal of Physics: IOP Conference Series, volume 1167, 2019, IOP Publishing

[24]. Cahyono Ikhsan., 2017, Pengaruh variasi debit aliran pada dasar saluran terbuka dengan aliran seragam, Media Teknik Sipil.

[25]. Robert. J. Kodoatie, Sugiyanto., 2002,Flood causes and methods of control in an environmental perspective, Yogyakarta

[26]. Syarifudin A, HR Destania., IDF Curve Patterns for Flood Control of Air Lakitan river of Musi Rawas Regency,IOP Conference Series: Earth and Environmental ScienceVolume 448, 2020, The 1st International Conference on Environment, Sustainability Issues and Community Development 23 - 24 October 2019, Central Java Province, Indonesia