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Operation & Maintenance (OM) Model of the Channel in the Kampung Sawah Area, Martapura District, East OKU Regency

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Abstract
This study aims to obtain the magnitude of flood discharge as well as the Operation and Maintenance (OM) model for the magnitude of discharge that occurs during operations without OM (25%) and OM (50%) without floodgates and OM (75%) with floodgates on the Water Catchment Area channel in Sawah village, Martapura Sub-Watershed, East OKU.
Some modeling scenarios of Operation and Maintenance (OM) 25% with manning coefficient (n) is 0.025 operation without floodgate; OM 50% with n = 0.033 without floodgate and OM 75% with n = 0.035 operation with floodgate.
The results of the study obtained a flood discharge with a 10-year return period (Q_{10}) of Q_10 = 32.178 m^3/sec. The 10-year return period is taken as a benchmark that the flood will occur for 10 years or exceeded for 10 years and with the discharge that occurs when without OM (25%) water gate operation of 8 m^3/sec and OM (50%) of 16 m^3/sec also without water gate operation, while OM (75%) with opening and closing the water gate produces a discharge of 24 m^3/sec.

***Keywords**: Rainfall data, IDF-Curve, Discharge, Operation and Maintenance (OM)*

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I. INTRODUCTION

OKU TIMUR Regency is geographically located at 103º 40'– 104º 33' East Longitude and 3º 45'– 4º 55' South Latitude. In accordance with Law Number 37 of 2003, the area of Ogan Komering Ulu Timur Regency (OKU TIMUR) is 3,370 km², where most of the area is lowland and tends to be flat except in the Martapura District and its surroundings which tend to be hilly. (OKUT in figures, 2017) The topography of OKU TIMUR Regency can be classified into flat areas (Peneplain Zone), undulating (Piedmont Zone), and some are hilly areas that have varying elevations, namely between 42 meters to the highest elevation reaching 87 meters above sea level (asl) and slope gradients vary between 0-2% and 2-15%. Flat areas are found in Belitang District and Buay Madang District, while hilly areas are found in part of Martapura District. (OKUT in figures, 2017)

Meanwhile, in terms of physiography, OKU TIMUR Regency is part of the Barisan Mountains Zone and the Basin Zone. The Barisan Mountains Zone is characterized by a landscape of volcanic cones, mountains and undulating hills formed by intrusive rocks with andesitic-granite composition, pyroclastic and Tertiary sedimentary rocks; while the Basin Zone is characterized by a landscape of low and gentle undulating plains which are mostly formed by river alluvial deposits; in some places there are Tertiary sedimentary rocks and local swamp deposits and reef limestone. (Satria Jaya Priatna et al., 2011). In high intensity rain, the total volume of surface runoff will be greater than in 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).

The Komering River flows in the southern part of the island of Sumatra which has a tropical rainforest climate. The average annual temperature is around 24°C. The hottest month is October, with an average temperature of 26°C, and the coldest is January, around 22°C. The average annual rainfall is 2902 mm. The month with the highest rainfall is November, with an average of 435 mm, and the lowest is August, with an average of 83 mm. The Komering Sub-DAS is one of the Sub-DAS of the Nine Musi Sub-Catchment area and is located in the southern part of the island of Sumatra which has an area of 915,375.820 ha. The Komering Sub-Catchment area is one of the priority Sub-Catchment area that requires immediate handling, because in line with the development of society in the Komering Sub River Basin area, various life systems change rapidly following the various needs of the community. (https://id.wikipedia.org/wiki/Sungai_Komering)

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).

For this reason, a study is needed on how the Operation and Maintenance model of channels/rivers can be used as a standard in anticipating flooding and inundation caused by sediment movement in channels/rivers.

II. MATERIAL AND METHODS

This research took place in The Kampung Sawah Water Catchment Area (WCA) Martapura District in The East OKU, Regency area. (Figure 1)

The Ssecondary data, namely by collecting rainfall data to conduct frequency analysis and cross-sections and lengths taken from previous research conducted by Lanosin (2023).

Primary data, namely by conducting a hydrodynamic flow survey to determine the flow speed in the river/channel of the Sawah Village area in the Water Catchment Area as in the map in Figure 2.

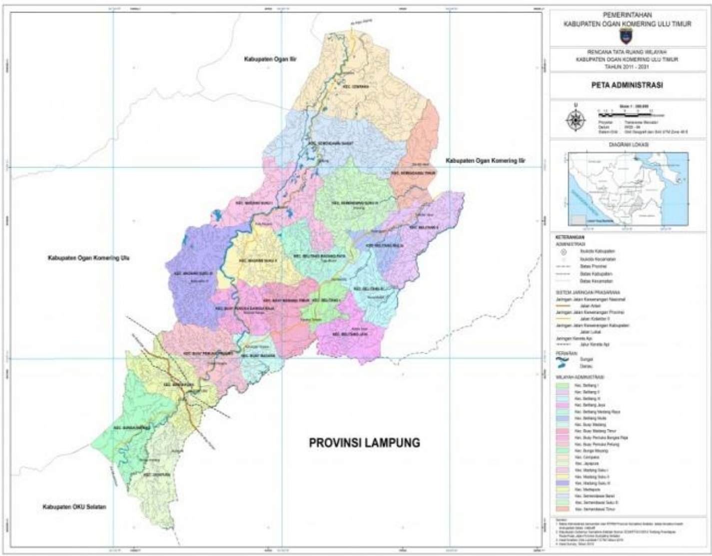

Figure 1: Administrative Map of Research Location

Figure 2: Kampung Sawah area, Tanjung Kemala village, Martapura sub district, East OKU district

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

Several scenarios of Operation and Maintenance (OM) modeling 25% with manning coefficient (n) is 0.025; OM 50% with n=0.033 and OM 75% with n=0.035 as shown in the following table:

Table 2: Simulation scenario model

Scenarios	Manning coefficient "n"	Operation without floodgate	Operation with floodgate
OM (25%)	0,025	√	-
OM (50%)	0,030	√	-
OM (75%)	0,035	-	√

Table 3: Typical Manning's roughness coefficient values for 'n' channels based on OP scenario

Channel Type	**Value of "n"**			**Scenarios OM (%)**
	Minimum	Normal	Maximum	
• The flood plain has short-tall grass	0,025	0,025	0,035	25
• The channel has little bushes	0,033	0,040	0,045	50
• Relatively clean of grass	0,035	0,050	0,070	75

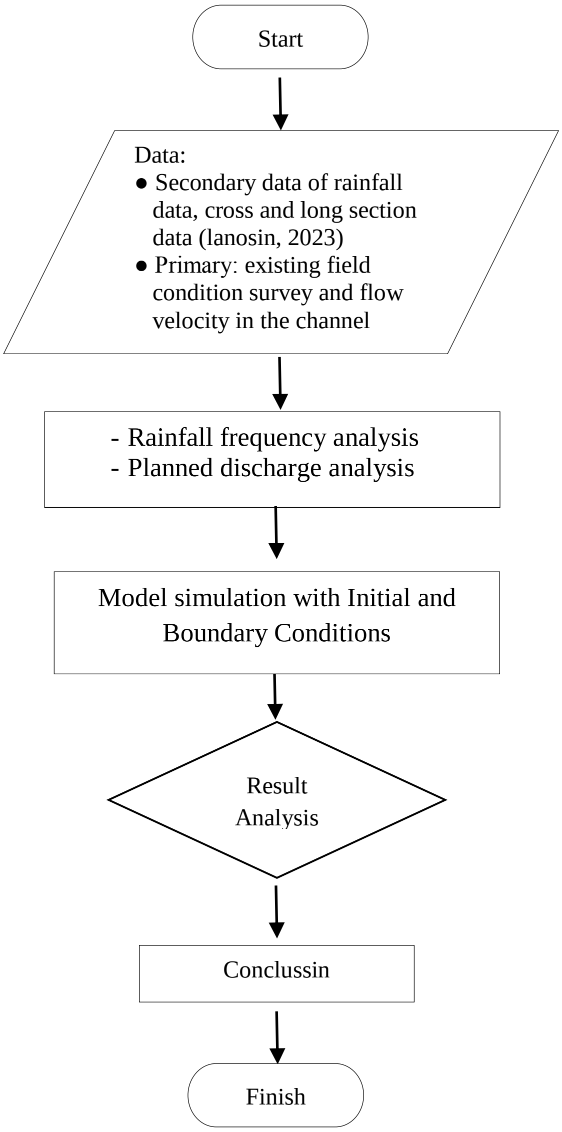

Figure 3: The flow of the methodology

III. RESULTS AND 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:

$$P(N,n) = n / N + n \quad \text{.................................... (1)}$$

2. Risk Analysis

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

$$R = 1 - 1 - 1/T\ n \quad \text{.................................... (2)}$$

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:

$$X = \frac{\Sigma xi}{n} \qquad \text{..} \qquad (3)$$

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

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

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

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:

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

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

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

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 1: Analysis of Design Rain Analysis Results

Return Period (T)	Design Rainfall Frequency Analysis (mm)			
	Normal	Log Normal	Log Pearson Type III	Gumbel
5	188.601	139.711	237.467	193.508
10	205.512	153.019	274.053	221.775
25	221.655	166.901	331.270	257.487
50	235.107	179.428	382.308	283.980
100	245.869	190.123	441.209	310.281

Source: Analysis results, 2024

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

Table 2: Design Rainfall

Return Period (T)	YT	R_{24}
5	2.145	139.711
10	2.185	153.019
25	2.222	166.901
50	2.254	179.428
100	2.279	190.123

By using the Mononobe formula and design rainfall with Log Normal 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

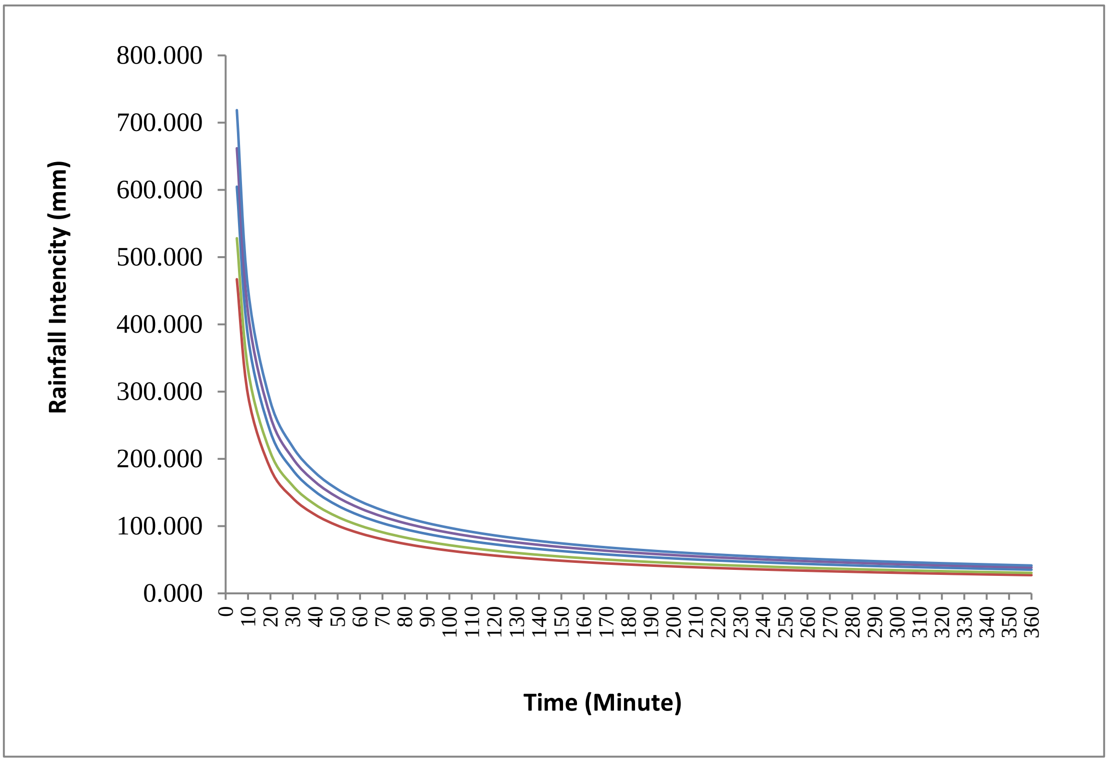

Figure 4: ***Intencity Duration Frequency*** **(IDF) Curve**

3.3. Flood Discharge (Q design)

Qdesign = 0.2778 C I A
with:
Qdesign = Peak discharge (m^3/sec)
C = Runoff coefficient
I = Rain intensity with duration equal to flood concentration time

(mm/hour)
A = Water catchment area (km^2)
Q_{10} = 0.2778 . 0.85 . (60.9973 mm/hour) . (2.2341 km^2)
Q_{10} = 32,178 m^3/sec

3.4. Operation and Maintenance (OM)

Based on the analysis of flood discharge with a 10-year return period (Q_{10}), a value of Q_{10} = 32,178 m3/sec was obtained. With the scenario for Operation and Maintenance on the channel as in the following table

Table 4: Flow Capacity Results with Operation and Maintenance Scenarios

Scenario	Manning Coefficient "n"	Q used Operation without floodgates (m^3/sec)	Q used Operation with floodgates (m^3/sec)
OP (25%)	0,025	8	-
OP (50%)	0,030	16	-
OP (75%)	0,035	-	24

So it can be explained that the discharge that occurs during operation without floodgates for OM 25% is 8 m^3/sec and the discharge for OM (50%) is 16 m^3/sec without gate operation, while for OM (75%) with floodgate openings it produces a discharge of 24 m^3/sec.

IV. CONCLUSION

This study can be concluded as follows:

1. Flood discharge with a 10-year return period (Q_{10}) of Q_{10} = 32.178 m^3/sec. The 10-year return period is taken as a benchmark that flooding will occur for 10 years or exceed 10 years.
2. The discharge that occurs when OM (25%) floodgate without operation is 8 m^3/sec and OM (50%) is 16 m^3/sec also without floodgate operation, while OM (75%) with opening and closing the floodgate produces a discharge of 24 m^3/sec.

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