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Analysis of the Capacity of the Tanjung Burung Retention Pool, Palembang City

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ABSTRACT

Palembang City is a lowland area with an average height of 4-12 meters. When the rainy season arrives, flooding will occur in several locations, so it is necessary to build retention ponds to overcome this problem. This research aims to analyze whether the capacity of the retention pond is still capable of dealing with rainfall which has increased significantly over the last 10 years. The research results show that the largest rainfall was obtained using the Gumbell method, and the results of the gumbell method analysis passed the chi-square and Smirnov-Kolmogorov goodness-of-fit tests. The 10-year return period results were 139.89 mm/hour, and the peak discharge was 2.83 m3/s. The retention pond catchment area is 13.71 ha, with a rainwater storage volume in accordance with the Regulation of the Minister of Public Works of the Republic of Indonesia No. 11/PRT/M/2014, amounting to 8713.58 m3. The retention pond is considered capable of accommodating this rainfall because the retention pond capacity is 13,400 m3. Simulation results using HEC-RAS software showed that the water level was 3.25 meters.

Keyword: *Retention Pool, Gumbell Method, Palembang*

Introduction

Palembang City is one of the largest cities in Indonesia, with an area of 400.61 km2. Palembang City has topography is generally lowland, with an average height of +4-12 meters above sea level, with a composition of 48% land. plains that are not flooded, 35% of the land is flooded continuously throughout the season, and 15% of the land is flooded seasonally.

Land that is seasonally inundated is influenced by the rainy season. When the rainy season arrives, several areas in Palembang City will experience inundation. If the inundation is not resolved, it will later cause flooding, and this will greatly affect the hydrological conditions of Palembang City. For this reason, it is necessary to manage water systems in several areas to prevent flooding by creating water channels and retention ponds.

Looking at the conditions of the problems that occur, an environmentally friendly flood control effort is needed, one of which is planning a retention pond for flood control at RSMH Palembang City [1]–[4]. Flood control activities recognize the magnitude of flood discharge, isolate flood inundation areas, and reduce the height of floodwater[5]–[8]. Overall, flood control activities can be carried out by considering the most optimal handling system. When preparing a flood control system, it is necessary to pay attention to analysis and evaluation such as analysis of ongoing flood control methods, evaluation and analysis of flood inundation data, evaluation and analysis of land use, evaluation and analysis of existing and future residential areas, paying attention to the potential for water resource development and paying attention to the development of water resource utilization[9]–[13].

Building retention ponds is one way to control flooding in residential areas caused by rainwater. Retention ponds can collect surface water runoff or water from drainage, which is then absorbed into the soil. Correct placement of retention ponds will more effectively impact flood control efforts [14]–[17].

A retention pond is a pool/reservoir that collects rainwater for a certain period of time. It cuts flood peaks in water bodies/rivers [18], [19]. A retention pond is a basin or pond that can hold or absorb water, depending on the type of wall lining material and the bottom of the pond [20].

In 2018, the Palembang City Government plans to increase the number of retention ponds in Palembang City from 34 to 77 retention ponds [21]–[23].

One of the areas where the retention pond was built was the residential area at 32 Ilir. The retention pond being built is located in Lorong Tanjung Burung Utama, Bukit Lama Village, Ilir Barat II District, Palembang City. The retention pond built in this area is the Tanjung Burung retention pond with Pond ID KOL-ORG-00012, which began construction in 2019 and was completed in 2021.

The Tanjung Burung retention pond has an area of 2680 m2. As rainfall increases to 188.7 mm in 2022 [3], of course, this will increase the amount of water runoff that occurs, so it needs to be anticipated by carrying out an analysis of the retention pond's capacity to overcome the problem of waterlogging that occurred in that area.

This research analyzes the retention pond's flood discharge and capacity to determine its flood discharge and capacity.

Research Methods

The research was conducted in the Lorong Tanjung Burung Utama area, Bukit Lama, Kec. Ilir Barat II, Palembang City, South Sumatra. This area is included in the Boang Sub-Watershed (DAS), which uses residential land, public facilities, swamps, and other facilities. The nature of this research is analytical descriptive, which means explaining the current problem, namely how the retention pond is performing at the location. This research was conducted to evaluate the storage capacity of the retention pond. The data required in this research is secondary data collected, compiled, analyzed, and then presented clearly. Collecting primary data by conducting surveys and mapping to measure the area of retention ponds and channels influencing the research area [24], [25]. This data was taken using a Theodolite and Measuring Signs. I also requested master plan data from the Palembang City PUPR Service to cross-check the original data in the field.

Data processing to analyze retention ponds in Palembang City includes rainfall, flood discharge, and the time needed to accommodate the storage capacity of flow discharge. This includes analysis and calculation of the following data: rainfall, to determine the extreme value of each rainfall data series. The distribution methods used include the Gumbell distribution method, the Log Pearson Type III distribution method, and the Log Normal distribution method. Analysis of maximum rainfall data, with the length used being 10 years. Calculate peak discharge to find the relationship between falling rain and the discharge that occurs. Calculation of the retention pond capacity to find out what the pond's capacity is. Carrying out simulations with the HEC-RAS program.

Results and Discussion

Rainfall Data

The rainfall data used in this analysis is the maximum daily rainfall data obtained from the South Sumatra Meteorology, Climatology, and Geophysics Agency for a 10-year period (2013-2022) . This data was obtained through digital access using the BMKG online website (https://dataonline.bmkg.go.id/cuaca_ekstrim).

Table 1. Rainfall Data

No	Years	Maximum Rainfall
1	02 December 2013	108,0
2	16 December 2014	111,0
3	16 March 2015	116,9
4	13 September 2016	172,4
5	27 March 2017	113,9
6	14 October 2018	97,0
7	27 March 2019	80,5
8	16 February 2020	90,6
9	25 December 2021	150,0
10	06 October 2022	188,7
	Lots of Data	10
	Amount	1229,0
	Average	122,9

Frequency Distribution Analysis

In each distribution method, distribution analysis was conducted to find the largest rainfall values with return periods of 2, 5, 10, 50, and 100 years. The values for each distribution method are as follows:

Table 2. Frequency Distribution Analysis Resume

Frequency Distribution Analysis				
Tr (years)	**Normal**	**Gumbell**	**Log Normal**	**Log Pearson Type III**
100	206,07	277,45	225,73	249,37
50	195,16	251,16	207,46	224,79
25	184,54	224,68	191,09	201,19
10	168,74	188,98	169,10	171,03

5	153,01	160,73	149,72	148,32
2	122,90	118,05	118,61	115,92

Distribution Suitability Test

This test, usually called a goodness-of-fit test, is intended to determine whether the chosen probability distribution equation can represent the statistics of the data sample being analyzed.

In this research, we will use 2 testing methods, namely the Chi-Square method and the Smirnov-Kolmogorof test, to determine whether the value of each distribution meets the data sample being analyzed.

Table 3. Resume Chi-Square Test

Chi-Square Test				
Mark	**Normal**	**Gumbell**	**Log-Normal**	**Log Pearson Type III**
x^2 Chi-Hitung	1,00	3,00	3,00	9,00
x_{cr} Chi-Kritis	5,991	5,991	5,991	5,991
Conclusion	Accepted	Accepted	Accepted	Not accepted

Table 4. Resume of Smirnov-kolmogorof Test Results

Smirnov-Kolmogorof Test				
Mark	**Normal**	**Gumbell**	**Log-Normal**	**Log Pearson Type III**
D_{Hitung}	0,22	0,22	0,18	0,18
D_{Kritis}	0,41	0,41	0,41	0,41
Conclusion	Accepted	Accepted	Accepted	Accepted

Relapse Analysis

Because the research area is in Palembang City, which is a metropolitan city area, according to the Directorate General of Human Settlements, the return period used is 10 years, so the rainfall intensity obtained for the 10-year return period is :

$$I = \left\{\frac{R_{24}}{24}\right\} \times \left\{\frac{24}{T}\right\}^{2/3} \quad (1)$$

$I = \left\{\frac{188{,}98}{24}\right\} \times \left\{\frac{24}{0{,}32}\right\}^{2/3}$

$I = 139{,}89$ mm/jam

Catchment Area

Analysis was carried out using a satellite imagery application, Google Earth. Google Earth is a virtual globe program called Earth Viewer, created by Keyhole, Inc. This program maps the earth by superimposing images collected from satellite mapping, aerial photography, and 3D GIS globes.

Figure 1. Catchment Area

Measurements were carried out based on a survey of the research location and Google Earth satellite imagery; measurements were based on Palembang city drainage flow obtained from the Palembang City PUPR Service, so the area reviewed was 13.71 hectares. Details of the locations reviewed were as follows:

Table 5. Land Use Flow Coefficient

Land Use Management		**Wide (m2)**	**Coefficient (C)**	
Roof Area	Urban Area Settlements	80.121,35	0,7	0,95
Road	Asphalt and Concrete Roads	10.730,34	0,7	0,95
Grass	Parks and Gardens	46.269,33	0,2	0,4
Total Area		137.121,00		

Peak Discharge Calculation

Peak discharge calculations use the rational method formula, which was developed with the following formula:

$$Q = 0{,}00278 \times C \times I \times A \quad (2)$$

So, the peak discharge calculated using the modified rational method is as follows:

$Q = 0{,}00278 \times C \times I \times A$

$Q = 0{,}00278 \times 0{,}53 \times 139{,}89 \times 13{,}71$

$Q = 2{,}83$ m3/dt

Based on the calculation above, the peak discharge value is 2.83 m3/s

Sediment Grain Type Analysis

This research used sediment from the Tanjung Burung retention basin, Palembang City. Sampling was carried out using a purposive sampling method, considering that the selected sample points could represent all the characteristics of the research location. Sediment collection was guided by SNI 3414:2008. The sediment was analyzed using standard sieve analysis (SNI-ASTM C136), which was carried out at the Bina Darma University Laboratory.

Table 6. Grain Diameter Value (mm) Average

Mark	Granule Diameter (mm)			Average
	Sample 1	Sample 2	Sample 3	
D5	0,00	0,00	0,00	0,00
D35	0,20	0,20	0,50	0,30
D50	1,00	0,90	1,50	1,13
D65	1,80	2,00	2,20	2,00
D90	0,00	0,00	0,00	0,00

Based on Table 6, the D50 value obtained is 1.13mm, so the grain classification according to the AGU (American Geophysical Union) type of sediment found in the Tanjung Burung retention pond is included in the Very Coarse Sand particle type.

Analysis of Retention Pool Capacity

The aim of calculating the capacity of the Tanjung Burung retention pond in Palembang City is to find out how much capacity the pond currently has (existing conditions). The analysis uses rainwater storage volume calculations.

Calculations for the volume of rainwater storage are calculated based on the Regulation of the Minister of Public Works of the Republic of Indonesia No. 11/PRT/M/2014 concerning rainwater management in buildings with the following formula:

$$V = 0{,}855 \times C_{tadah} \times A_{tadah} \times T_h \quad (3)$$

Is known:

V : Volume
0.855 : Proportional factor
C_cistern : Runoff coefficient of building cross-section
A_cisterm : Projected cross-sectional area to the horizontal plane (m2)
T_h : Height of rain (m)

So the volume of rainwater storage is as follows:

Tabel 7. Rainwater Storage Volume

Land Use Management		A_{tadah}	C_{tadah}	T_h	Total Volume (m3)
Roof Area	Urban Area Settlements	80.121,35	0,7	0,14	6708,31
Road	Asphalt and Concrete Roads	10.730,34	0,7	0,14	898,42
Grass	Parks and Gardens	46.269,33	0,2	0,14	1106,85
Total Area		137.121,00			8713,58

To determine the capacity of the retention pond, it is necessary to compare the volume of rainwater storage with the volume of the retention pond. According to data obtained from the PUPR Department of Palembang City, the profile of the Tanjung Burung retention pond is as follows:

Retention pool width : 32 meters
Length of retention pond : 83.75 meters
Depth of retention pond : 5 meters

Normal water level : 4 meters
Retention pool area : 2,680 m2
Retention pond volume : 13,400 m3

Based on the calculations in the table, the volume of rainwater storage (V) is 8713.58 m3. Compared with the volume of the Tanjung Burung retention pond, which is 13,400 m3, the volume (V) of rainwater storage is smaller than the volume (V) of the retention pond. Thus, the current capacity of the retention pond (existing condition) can accommodate water discharge during high rainfall.

HEC-RAS 6.31 Simulation

After analyzing the data, carry out a simulation using the HEC-RAS 6.3.1 program to determine the height of the water level by analyzing the data obtained.

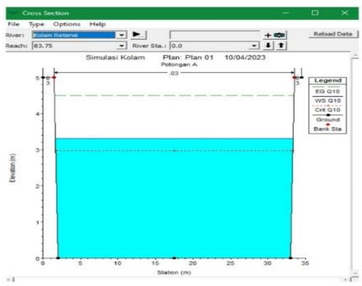

Figure 2. HEC-RAS View Cross Section

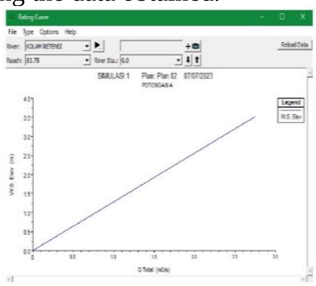

Figure 3. HEC-RAS 3D Plot

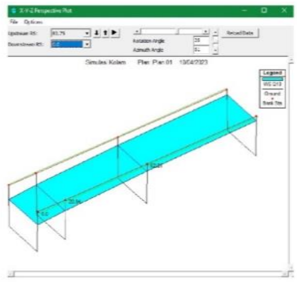

Figure 4. Simulation Results Graph

Table 8. Rainwater Storage Volume

Reach	River Sta	Profile	Q Total (m3/s)	Water Surface Elevation (m)
83.75	83.75	Q10	2.83	3.25
83.75	62.81	Q10	2.83	3.25
83.75	20.94	Q10	2.83	3.25
83.75	0	Q10	2.83	3.25

The results of the HEC-RAS 6.3.1 simulation, with a peak discharge flow for a 10-year return period of 2.83 m3/s, show that the flood water level in the Tanjung Burung retention pond, based on Table 8, is as high as 3.25 meters.

Conclusion

Based on the results of the analysis described in the previous chapters, the results of research on the Tanjung Burung Retention Pond can be concluded as follows: the capacity of the Tanjung Burung Retention Pond at maximum conditions is 13,400 m3 with a rainwater volume (V) of 8713.58 m3 so that it can accommodate the volume of rainwater. From the results of rainfall analysis over a period of 10 years and land use in the area around the Tanjung Burung Retention Pond of 13.71 ha, the peak discharge (Q) was obtained at 2.83 m3/s. Based on simulations carried out using the HEC-RAS 6.3.1 program for the Tanjung Burung Retention Pond, the results obtained are the depth of the flood water surface with a peak discharge Q) of 2.83 m3/s which is 3.25 meters deep, while the depth of the water surface normally 4 meters deep, then from these results,it can be concluded that the retention pond can accommodate peak discharge during high rainfall conditions.

Based on the analysis, the following suggestions can be made: maintenance of the retention pond is needed because several parts of the pond foundation were cracked. More awareness is needed among the public about the importance of protecting the environment because there is still a lot of rubbish around retention ponds, both from inlet and outlet channels.

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