Study on Drainage System Planning for Bentuyun's Garden housing*

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ABSTRACT

Bentuyun's Garden is a residential area in Jember Regency which is located in a rather highland area. If the drainage condition is still not good in the area then it is not equipped with an infiltration well, it will cause standing water or flooding, especially in the rainy season in the downstream area. This is due to the inability of the existing drainage to accommodate the increased volume and discharge of water. In the future, it is necessary to plan a drainage system equipped with infiltration wells to accommodate excess water that occurs. The steps that must be carried out in this study are hydrological studies (regional average rainfall analysis, frequency analysis, frequency compatibility test), estimating the rate of water runoff (flood discharge) then conducting a hydraulic study (calculating the maximum Q at the outlet and calculating the cross-sectional capacity at the outlet section and infiltration well). The results of the study show that the watershed (DAS) of Bentuyun's Garden housing area is 0.639 ha2, with a total discharge of rain runoff and discharged domestic waste of 0.037 m^3/second. Drainage channels are planned for 16 sections and sufficient to drain rainwater runoff while 9 infiltration wells are sufficient to absorb rainwater.

Keywords: Drainage, Area, Housing, Wells, Infiltration.

1. Introduction

Bentuyun's Garden is a residential area in Jember Regency which is located in a rather highland area. Generally, highland areas are areas that have very minimal potential for a puddle or flood. Changes in land use from paddy fields to settlements may not have an impact on this housing, but have a profound impact on areas that are located downstream. If the condition of the drainage system is not good in the area then it is not equipped with an infiltration well, it will cause standing water or flooding, especially during the rainy season in the downstream area. This is due to the inability of the existing drainage to accommodate the increasing water discharge. The local government has previously made efforts to overcome the problem of standing water or flooding [1], [2]. Efforts are being made to maximize the performance of the existing drainage and also create additional drainage channels. However, these efforts have not been able to overcome the problems that occur if there is no consistency on the part of the developer in carrying out the planning designs that have been made. In response to the phenomena described above, a drainage system is planned in the form of an absorption well which functions to accommodate the excess water that occurs. The location of the Drainage System study is located in the Bentuyun's Garden residential area, precisely on Jl. Tengiri, Botosari, Dukuhmencek, Sukorambi District, Jember Regency with coordinates 113 ° 39'18.75 "East Longitude and 8 ° 10'00.93" LS. The study period was carried out for two months, starting from the beginning of August to the end of September 2020.

Data collection is divided into 2, namely: primary data collection and secondary data collection. Primary data collection is field survey data, field mapping, elevation measurement, river flow observations, existing drainage & irrigation channels and observation of wells or groundwater [3] at Bentuyun's Garden Housing Sites, while secondary data is data sourced from the Jember Regency Government, including data 10 years of rainfall, topographic map of the area around the housing estate, land use of the area around the housing estate, existing irrigation and drainage channels and the site plan for Bentuyun's Garden housing. Rainfall data is processed into maximum daily rainfall data then used to calculate the design flood discharge. Rainfall data adjacent to the location of the Bentuyun's Garden residential watershed area have 3 stations, namely Karanganom Dam Station, Sembah Dam, Semanggir. The data records have been obtained for 10 years starting from 2009 to 2018. So for the purpose of obtaining data on the mean rainfall, it is calculated using the Thiessen polygon. A topographic map is a map that has information about the height of the land surface at a place against sea level, which is depicted by contour lines. Topographic maps provide the necessary data on slope angles, elevation, watersheds, general vegetation and urbanization patterns. Topographical maps also depict as many surface features as possible of a particular area within scale limits. To get a contour map is done with the help of google earth. In Google Earth at the same time it can be shown the layout of the existing rivers, drainage channels and irrigation which is very helpful in conducting the analysis.

2. Methodology

Based on the topographic map of the residential area, it is located at an elevation between + 89.0016 masl with the lower elevation towards the East, so that the movement of water flow will go to the outlet (red circle). Land use is a land use and land arrangement that is carried out in accordance with existing natural conditions. The land use of the surrounding area is in the form of residential areas, housing plans and most of the rice fields. The land use in the watershed area (DPS) of Bentuyun's Garden consists of only 6.390 m^2 of housing. So for the purposes of a drainage study it is necessary to compare the impact of the initial conditions before housing and after the construction of housing areas.

Figure 1. Visualization of land use

The water that enters the vicinity of Bentuyun's Garden comes from the residential area itself and can also be from overflows of irrigation / drainage channels located around the housing. Bentuyun's Garden has a site plan stretching from north to south, which is surrounded on the north and east of rice fields while the western part is residential area. After the data is complete for the study of Bentuyun's Garden housing drainage [4], then the next steps that must be taken in this study are:

a. Hydrological Studies
   - Analysis of regional average rainfall
   - Frequency analysis
   - Frequency compatibility test (distribution type)
   - Estimating the rate of water runoff (flood discharge)

b. Hydraulics Studies
   - Calculation of the maximum Q on the oulet
   - Calculation of cross-sectional capacity at the outlet
   - Calculation of infiltration wells

c. Recommendations and Suggestions

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3. Results and Discussion

Hydrological study is needed to determine the amount of planned rainfall and planned flood discharge in a certain return period. In the drainage system in Bentuyun's Garden residential area, design rainfall with a return period of 10 years (R10) and flood discharge with a return period of 10 years (Q10). In this study, four stations were selected which are located around the location of Bentuyun's Garden, namely: Dam Karanganom Station, Dam Sembah and Semangir Station. Then calculated using the polygon thiesen method.

Figure 2. The division of the polygon thiesen area

Effect of changes in standard deviation σ and skewness coefficient G on the Probability Density Function (PDF). With the distribution selection requirements, the value of Cs must meet the following criteria:

1. Normal distribution = Cs = 0, Ck = 3
2. Normal Log Distribution = Cs> 0, Ck> 3
3. Gumbel distribution = Cs = 1.13, Ck = 5.402
4. Distribution Log Person III = Cs = 0 - 0.9

From the data above, it can be concluded that the method suitable for use is the Log Person III method [5], [6]. Obtained the value of Cs from the calculation results of 0.972 according to the conditions for selecting the distribution above, then in hydrological analysis the maximum data (flooding) with extreme values is widely used G. The results of the calculation of the Pearson log distribution type III are presented in table 1.

Table 1. Calculation of rainfall design

Tr (Year)	Pr (%)	K	K. Sv	Log Rt	Rt (mm)
2	50	-0.083	-0.09	0.77	5.89
5	20	0.808	0.90	1.77	58.35
10	10	1.323	1.48	2.34	219.71
25	4	1.910	2.14	3.00	995.70
50	2	2.311	2.58	3.45	2795.47
100	1	2.686	3.00	3.87	7340.30

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The so-called concentration time is the time interval between the onset of rain and the time during which the entire river basin area plays a role in river flow [7]:
Concentration Time Formula (tc)
Tc = 0.0195 0.77
With:

Tc = Concentration time (minutes)
L = Length of wine from the farthest place in the river basin to the flood observation site
H = the difference in height between the farthest place and the place of observation
S = The ratio of the height difference between the farthest place

The coefficient is defined as the ratio of the maximum velocity of water flow from the catchment area. This coefficient is the comparative value between the share of rain that forms direct runoff and the total rainfall that occurs. The value of C depends on several characteristics of the rain catchment area [8], which includes:

a. Relief or slope of the catchment area
b. Regional characteristics, such as vegetation protection, soil type and watertight areas
c. Storage or other detention characteristics.

The amount of runoff can be small, especially if the rainfall does not exceed the infiltration capacity. As long as the rain is small or moderate, surface runoff only occurs in impermeable and saturated areas in a watershed or falls directly on the surface of the water. If the amount of rainfall that falls is greater than the amount of water that is discharged for evaporation, interception, infiltration, depression deposits and depression reserves, then surface runoff can occur. If the rain that occurs is small, almost all of the rainfall that falls is intercepted by dense vegetation. In areas where land use varies, the value of the runoff coefficient used should consider developments in the upstream area, for future catchments. This is particularly relevant in the situation where rural water catchments may develop partially or completely into urban catchment areas during the planning of living welfare services. The effect of land use on surface runoff is expressed in runoff coefficient (C), a number that displays the ratio between the amount of runoff and the amount of rainfall [9].

The runoff coefficient figure is an indicator to determine the physical condition of a watershed. C values range from 0-1. The value of C = 0 indicates that all rainwater is intercepted and infiltrated into the soil, on the other hand, the value of C = 1 indicates that rainwater flows as surface runoff. Suripin (2004) states that if a watershed consists of various land uses with different surface runoff coefficients. In this hydraulics study, the maximum flowable discharge due to housing development will be described and the condition of existing drainage channels to accommodate flood discharge due to housing development. The maximum discharge must be determined based on the review of the previous sub-chapter as previously described in the hydrological study. In the drainage planning, the planned discharge according to table 4 is chosen at the 10 year return period, which is 1.026 m^3/second. Then the discharge of domestic waste from housing must also be taken into account, so that the total water discharged is presented in table 2.

Table 2. Calculation of discharge

No	Type	Houses Total	Residences Total	Domestic discharge	Total
			(person/houses)	(liter/day/person)	(m^3/sec)
1	Domestic Waste	96	6	500	0.003
2	Rain Water				0.027
Total of discharge (m^3/sec) x 1,2					**0.037**

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The outlets from the housing flow through almost all channels then flow directly into the river. The outlet will collect rainwater and domestic waste from residential residents if it is not able to be infiltrated by the infiltration well of each house or communal infiltration. So that in the planning of this drainage channel, it is calculated that the rainwater is first infused into the reservoir well, the rest is discharged into the communal infiltration, then the rest will be discharged into the river. The results of the recapitulation of discharge capacity that can be accommodated in drainage channels are presented in table 3.

Infiltration wells are planned to absorb rainwater from rainwater that spills over from each house and from residential roads. The rainwater runoff from the house first enters the infiltration well, then the rest is discharged into the draianse channel then enters the communal infiltration well, the rest goes back into the downstream drainage channel and then discharged to the outlet. The rainwater from rainwater runoff also enters the drainage channel and then enters the communal infiltration well, then the rest goes back into the downstream drainage channel and then discharged to the outlet. The results of the recapitulation of rainwater absorption capacity by infiltration wells are presented in table 7.

Table 3. Calculation of drainage channel cross-sectional capacity

No.	Channel	B	H	A	P	R	I	V	Q Channel Design	Q Drainage
		m	m	m²	m	m		(m/sec)	(m³/sec)	(m³/sec)
1	A	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.001
2	B	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.001
3	C	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.001
4	D	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.002
5	E	0.4	0.4	0.16	1.20	0.1	0.005	1.85	0.295	0.004
6	F	0.4	0.4	0.16	1.20	0.1	0.005	1.85	0.295	0.004
7	G	0.4	0.4	0.16	1.20	0.1	0.005	1.85	0.295	0.004
8	H	0.45	0.45	0.203	1.35	0.2	0.005	2.00	0.404	0.004
9	I	0.45	0.45	0.203	1.35	0.2	0.005	2.00	0.404	0.003
10	J	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.003
11	K	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.001
12	L	0.4	0.4	0.16	1.20	0.1	0.005	1.85	0.295	0.001
13	M	0.65	0.65	0.423	1.95	0.2	0.005	2.55	1.078	0.004
14	N	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.004
15	O	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.001
16	P	0.3	0.3	0.09	0.90	0.1	0.005	1.52	0.137	0.001

Based on the results of studies that have been carried out in the Bentuyuns Garden Housing area, the results show that the flow rate before and after housing has increased. By planning infiltration wells for each house, then the rest is discharged into the communal infiltration, it is hoped that no rainwater runoff will enter the outlet so that it does not impose additional discharge into the river. By referring to the cross section of the channel as the result of the calculation of the cross-sectional capacity and planning of the infiltration well and the calculation of the need for infiltration wells, the existing drainage channel can accommodate the discharge of rainwater and domestic waste in Bentuyuns Garden Housing, then the existing infiltration wells are able to absorb rainwater.

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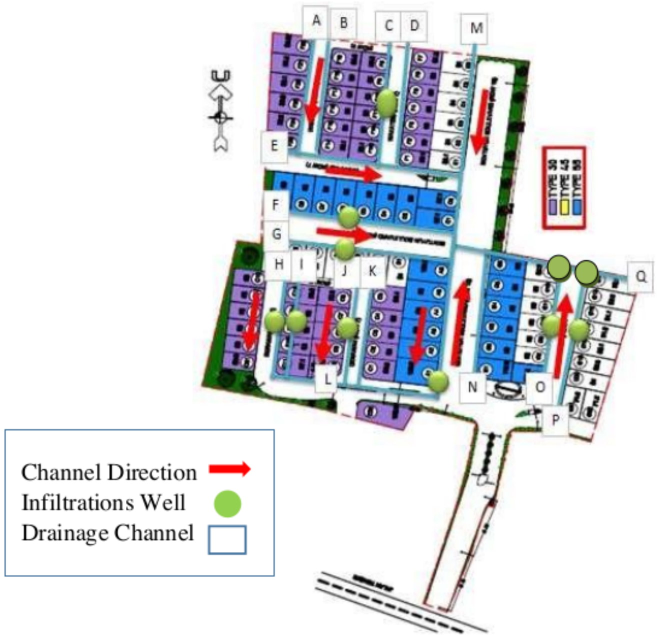

Figure 3. Layout of drainage & infiltration system

4. Conclusion

The other conclusions include the following:

a. The watershed (DAS) of Bentuyun's Garden housing area covering an area of 6.390 km^2
b. The results of the Hydrological Study, the total discharge of rain runoff and discharged domestic waste is 0.037 m^3/second.
c. Drainage channels of 16 sections are sufficient to drain rainwater runoff 9 infiltration wells are sufficient to absorb rainwater.

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