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Design Study Of Retainment Pool For Flood Control In Diamond City Residential - Jember

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Abstract:
Controlling inundation in residential areas is not enough by constructing drainage channels with sufficient dimensions, but it is also necessary to think about how to technically absorb rainwater into the ground so that housing construction does not impact the land or lower areas. For the purposes above, a study on the planning of drainage channels and storage ponds was carried out at the Diamond City Housing Complex, located in Jember Regency. The stages of the study include hydrological analysis to determine the planned flood discharge, hydraulics analysis to design the capacity of the drainage canal, soil permeability analysis to plan water catchment ponds. Based on the results of a study for inundation control at Diamond City Housing, it was found that the flood discharge that occurred was 0.651 m3/second, the number of drainage channels was 25 sections with 4 storage ponds capable of holding and absorbing water for 2 hours.
Key words: *Puddles, Drainage, Ponds, Reservoirs, Housing*

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I. Introduction

It is not enough to control inundation by constructing large drainage channels, but you also need to think about how to technically absorb rainwater into the ground. For the purposes mentioned above, it is necessary to study the planning of drainage channels and storage ponds in the Diamon City housing [1] and [2]. The location for the study of the Drainage System is precisely located in the Diamond City Residential Area on Jl. Manyar, Patrang District, Jember Regency with coordinates 113º41'14.23" East Longitude and 8°8'31.13" South Latitude. The land use of the surrounding area is in the form of residential areas, housing plans and most of the rice fields and fields. The land use in the Diamond City Residential Watershed Area (DPS) consists of the land use for public facilities is 7,000 m^2, the land use for housing is 20,000 m^2, so the total is 27,000 m^2.

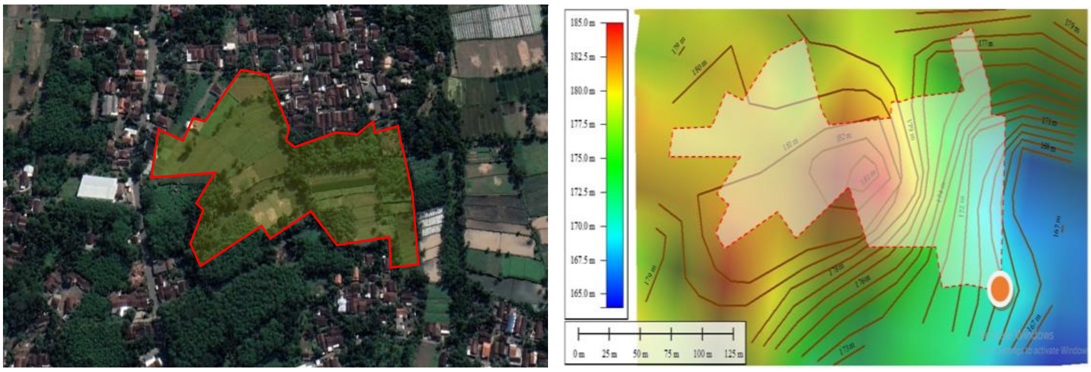


Figure 1. Map of land use and housing contours of diamond city

The aims and objectives of this activity are to obtain information on the magnitude of the potential design flood discharge in diamond city housing, to design the layout of the drainage system and the need for the number of drainage canal sections along with the dimensions of the drainage canals for each segment, to obtain the need for storage ponds and their construction capable of accommodating and absorbing water [3]. A topographic map is a map that has information about the height of the land surface in a place to sea level, which is depicted by contour lines. Topographic maps provide necessary data on slope angles, elevation, watersheds, general vegetation and urbanization patterns. Topographic maps also depict as many of the surface features of a given area within the limits of the scale. To get a contour map is done with the help of google earth [5] dan[6]. In Google Earth, you can also display the layout of the existing river, drainage and irrigation channels which are very helpful in carrying out the analysis. Based on the topographic map the residential area is located at an elevation between + 170 to +

185 m asl with a lower elevation to the east, so that the movement of the water flow will go towards the outlet (red circle).

II. Literature Review

Some of the steps and theoretical studies needed include:

a). Hydrological Study

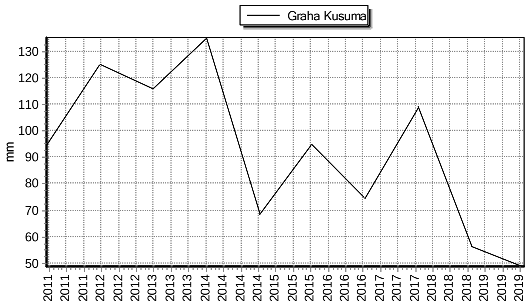
1. Calculate average rainfall with Thiessen or Isohiet polygons
2. Analysis of planned rainfall with the Hydrognomon Application.
3. Examination of goodness of fit to select the most suitable distribution method with the Kolmogorov Smirnov and Chi Square methods.
4. Calculation of concentration time
5. Calculation of hourly rainfall distribution with PSA 007
6. Calculation of the planned flood discharge with the HMS Hec Application

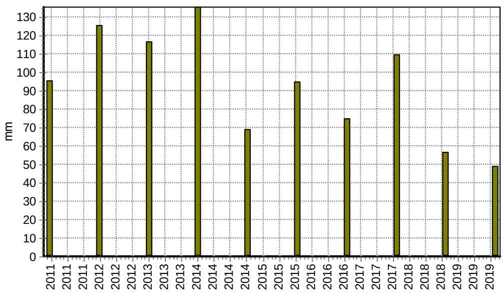
b). Hydraulics Study

1. Layout of the area drainage system
2. Calculation of the maximum Q on the outlet
3. Calculation of the capacity of the cross section at the outlet
4. Calculation of infiltration wells and storage ponds

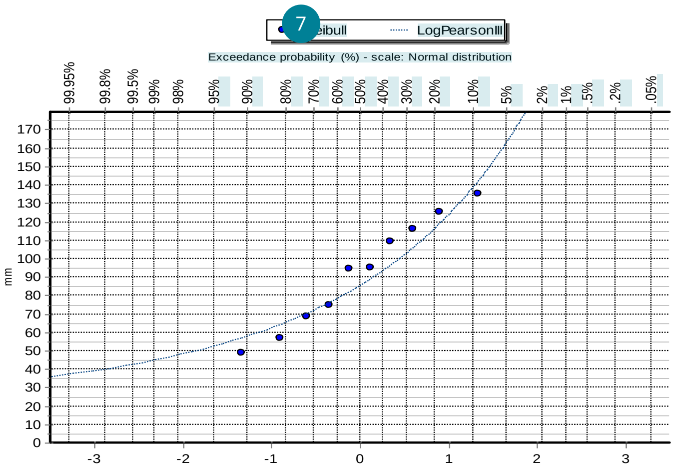
Hydrognomon is a free software application for the analysis and processing of hydrological data, especially in the form of time series. Hydrological data analysis consists of time series processing applications, such as time step aggregation and regularization, interpolation, regression analysis and infilling of missing values, consistency tests, data filtering, and graphical and tabular visualization of time series. The program also supports specialized hydrological applications, including evapotranspiration models, stage-discharge and discharge sediment discharge analysis, homogeneity tests, water balance methods, and hydrometry. This software is free software with a license from the GNU GPLv3 (General Public License). Hydrognom development is intended to process hydrological data, especially for data series. In this study, the data distribution was limited to 3, namely Gamma, Pearson III (Al-Mashidani, et al 1978; Saeideslamian and Husseinfeizi 2007; Mujiburrehman 2013) and Normal (Mujiburrehman 2013). The tests performed were $\chi 2$ and Kolmogorov-Smirnov. The distribution used to predict the return period is the 'ACCEPT/ACCEPTABLE' distribution of the two tests at the significance level (α) = 1%.

1. Open the Hydrognomon software, select the file. Type in the file name “CH 50th Anniversary GH Design. On the Variable Icon select "Precipitation" and Time zone select "GMT". Press next then enter Time Step select Annual then next and press Finish. Select the Icon (red circle), enter the annual maximum daily rainfall data in units (mm) from 2011 to 2020. Press view then Add time series to graph where rain data can be displayed in the form of graphs and bar charts.

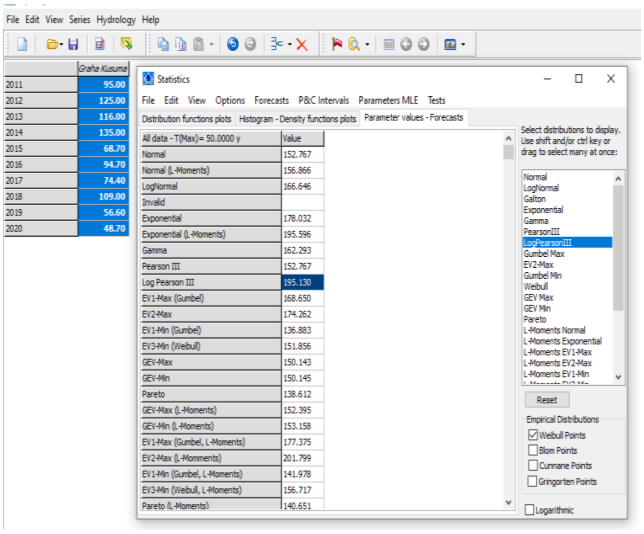




2. Select Hydrology, then select Pythia-Statistical analysis. Then select Logpearson III, the graph will appear as follows:



3. Select Forecast, then select To Return Period (Max). Then enter Tr = 50 years, the results of the design rain calculation with a 50 year return period of 195.150 mm will be obtained.



III. Methodology

The Hec-HMS model can provide a hydrological simulation of the daily peak flow for the calculation of the design flood discharge from a watershed (watershed). The Hec-HMS model packs a variety of methods used in hydrological analysis. In operation it uses a Windows system base, so this model is easy to learn and easy to use, but it is still done with deep understanding and understanding of the model used. The basic concept of calculation from the Hec-HMS model is rainfall data as water input for one or several sub-catchment areas (sub-basins) being analyzed. The type of data is intensity, volume, or cumulative rain volume. Each sub-basin is considered as a non-linear reservoir where the inflow is rain data. Surface runoff, infiltration, and evaporation are components that exit the sub basin. The components in the HEC-HMS application are as follows:

a. Basin model – contains watershed elements, relationships between elements and flow parameters
b. Meteorologic model – contains rain and evaporation data
c. Control Specifications –contains the start and end times of the count
d. Time series data – contains input data including rainfall, discharge. Paired data – contains data pairs such as unit hydrographs

Rain-flow simulation in each sub-catchment requires several model components, namely:

a. Rain (precipitation) model - is an input to the DAS system
b. Loss models - to calculate runoff volume (effective rain)
c. Direct runoff models – to transform from effective rain into surface flow/runoff

d. Baseflow models – to calculate the amount of baseflow

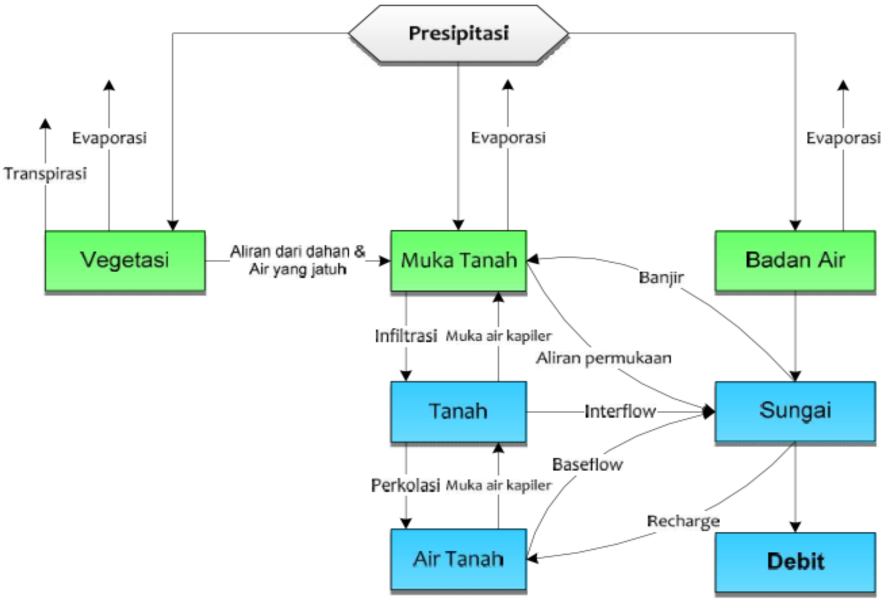


Figure 2. Research Method

IV. Analysis and Calculations

In this study, four stations were selected located around the Diamond City housing area, namely: Karang Anom, Bintoro, Sembah and Semangir Stations, then calculated using the Thiesen polygon method.

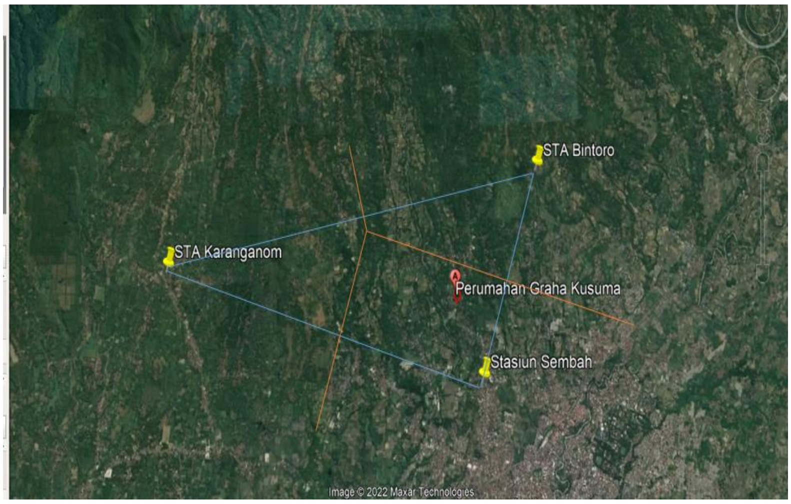


Figure 3. The area division of the Thiessen polygon

Table 1. Calculation of Regional Average Rainfall

No	Year	Rainfall Station (mm)				Average rainfall (mm)
		Bintoro 0.30	Dam Sembah 0.45	Dam Karanganom 0.25	Dam Semangir	
1	2011	0.0	0.0	0.0	95.0	95.0
2	2012	0.0	0.0	0.0	125.0	125.0
3	2013	0.0	0.0	0.0	116.0	116.0
4	2014	0.0	0.0	0.0	135.0	135.0
5	2015	38.0	74.0	96.0		68.7
6	2016	42.0	128.0	98.0		94.7
7	2017	0.0	113.0	94.0		74.4
8	2018	60.0	141.0	110.0		109.0
9	2019	58.0	37.0	90.0		56.6
10	2020	15.0	47.0	92.0		48.7

States that if the watershed consists of various land uses with different runoff coefficients. then the C used is the watershed coefficient which can be calculated by the following equation [6], [7] and [8] :

$$C_{DAS} = \frac{\sum_{i=1}^{n} C_i A_i}{\sum_{i=1}^{n} A_i}$$

With :
Ai = land area with the type of ground cover i
Ci = surface flow coefficient of cover type i
N = the number of types of ground cover
The calculation of the land use coefficient in residential locations is presented in table 2.

Table 2. Land Use Coefficient Calculation

No	Parameters	Unit	I	II
1	Land Use	-	Housing	Utility
2	Coefficient (C)	-	0.700	1.000
3	Area (A)	m^2	25710	14157
4	C.A	-	17997	14157
5	Average CA	-	16077.000	
6	C Composite	-	0.807	

If the watershed system to be modeled is more than 1 sub-basin (multi-basin), then a flow tracing analysis is needed from upstream to downstream. In HEC-HMS the analysis is facilitated by hydrological routing models. In this hydraulics study, it will be explained about the maximum discharge that flows due to housing construction and how the conditions of the existing drainage channels are in accommodating flood discharge due to housing construction. The maximum discharge must be determined based on a review of the previous sub-chapter as previously described in the hydrological study.

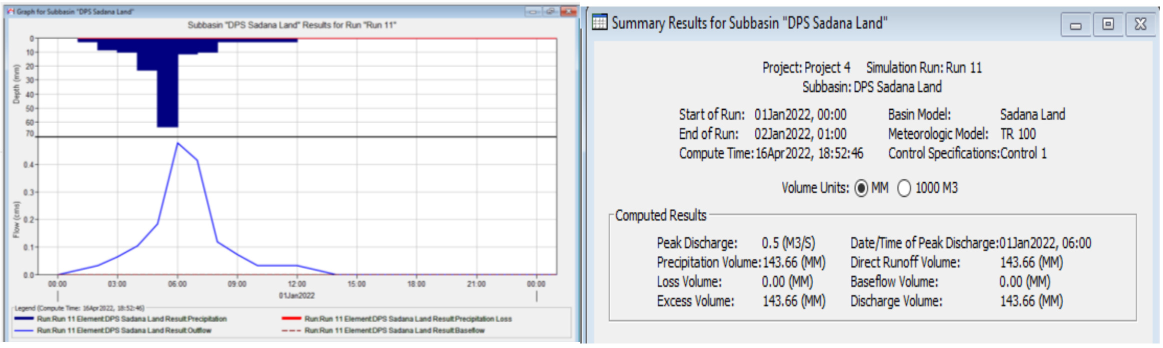


Figure 4. Graph of Planned Flood Discharge Hydrograph

In drainage planning, the design discharge according to the table in Figure 4 is chosen for the 50 year return period, which is 0,600 m^3/second. Then the disposal of domestic waste from housing must also be taken into account, so that the total water discharged. Rainwater runoff from the housing then flows and enters first into the infiltration wells of each house, then the remainder is channeled into the drainage channel of each housing block, then collected into the communal infiltration wells of each housing block, the remainder is then discharged into the outlet of the housing drainage channel located to the west of the housing [9]. However, the drainage channel planning does not consider the amount of water that has been absorbed by house infiltration wells and communal infiltration wells, because the planning considers initial conditions and extreme conditions. The initial condition is that for every house that has been built, not all of the flow from the roof is directed to the house infiltration well even though the house infiltration well has been provided. An extreme condition is that in a long time there may be a lack of maintenance or there is an intentional element of all rain runoff flows not being entered into house absorption wells and communal absorption wells [10]. The results of the recapitulation of discharge capacity that can be accommodated in the drainage channel are presented in table 3.

Table 3. Calculation of Drainage Channel Cross-sectional Capacity

No	Channel	With (m)	High (m)	A (m^2)	P (m)	R (m)	S	V (m/s)	Fr	Q Channel (m^3/s)	Q Drianage (m^3/s)	Channel capacity	Flow condition
A	1	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.019	Ok	sub critical
	2	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.019	Ok	sub critical
	3	0.40	0.40	0.16	1.20	0.13	0.001	0.825	0.42	0.132	0.113	Ok	sub critical
	4	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.028	Ok	sub critical
	5	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.028	Ok	sub critical
	6	0.40	0.40	0.16	1.20	0.13	0.001	0.825	0.42	0.132	0.057	Ok	sub critical
	7	0.40	0.40	0.16	1.20	0.13	0.001	0.825	0.42	0.132	0.038	Ok	sub critical
	8	0.60	0.60	0.36	1.80	0.20	0.001	1.081	0.45	0.389	0.113	Ok	sub critical
B	1	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.025	Ok	sub critical
	2	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.025	Ok	sub critical
	3	0.40	0.40	0.16	1.20	0.13	0.001	0.825	0.42	0.132	0.087	Ok	sub critical
	4	0.30	0.30	0.09	0.90	0.10	0.001	0.681	0.40	0.061	0.012	Ok	sub critical
	5	0.40	0.40	0.16	1.20	0.13	0.001	0.825	0.42	0.132	0.059	Ok	sub critical

Infiltration wells are planned to absorb rainwater from rainwater that overflows from every house and from residential roads. The rain water runoff from the house goes first into the infiltration well, then the rest is discharged into the drainage channel then enters the communal infiltration well, the rest goes back into the downstream drainage channel then is discharged to the outlet [11]. Rainwater originating from rainwater runoff also enters the drainage channel and then enters the communal infiltration well, then the remainder enters the downstream drainage channel and is then discharged to the outlet. The water from the infiltration well is then put into the storage pond with the calculations presented in the table 4.

Table 4. Calculation of Pond Pool

No	Q Drainage (m^3/sec)	V Drainage (m^3)	Pond Diameters (D) (m)	Area (m^2)	Permeability (liter/hour)	Pond High (H) (m)	Storage Volume (m^3)	Volume (m^3)	Excess (m^3)	Note
A	0.148	534	12.0	113.04	8.00	2.0	6.87	54.95	519.37	Ok
B	0.106	382	12.0	113.04	8.00	2.0	226.08	1808.64	147.52	Ok
C	0.106	382	12.0	113.04	8.00	2.0	226.08	1808.64	147.52	Ok
D	0.170	611	12.0	113.04	8.00	2.0	226.08	1808.64	376.48	Ok

After conducting a hydrological and hydraulics study, the dimensions of the drainage channel, infiltration well construction and storage pond construction were obtained as described above. Furthermore, the layout of the drainage channel, the direction of flow and the position of the storage pond is presented in the figure 5.

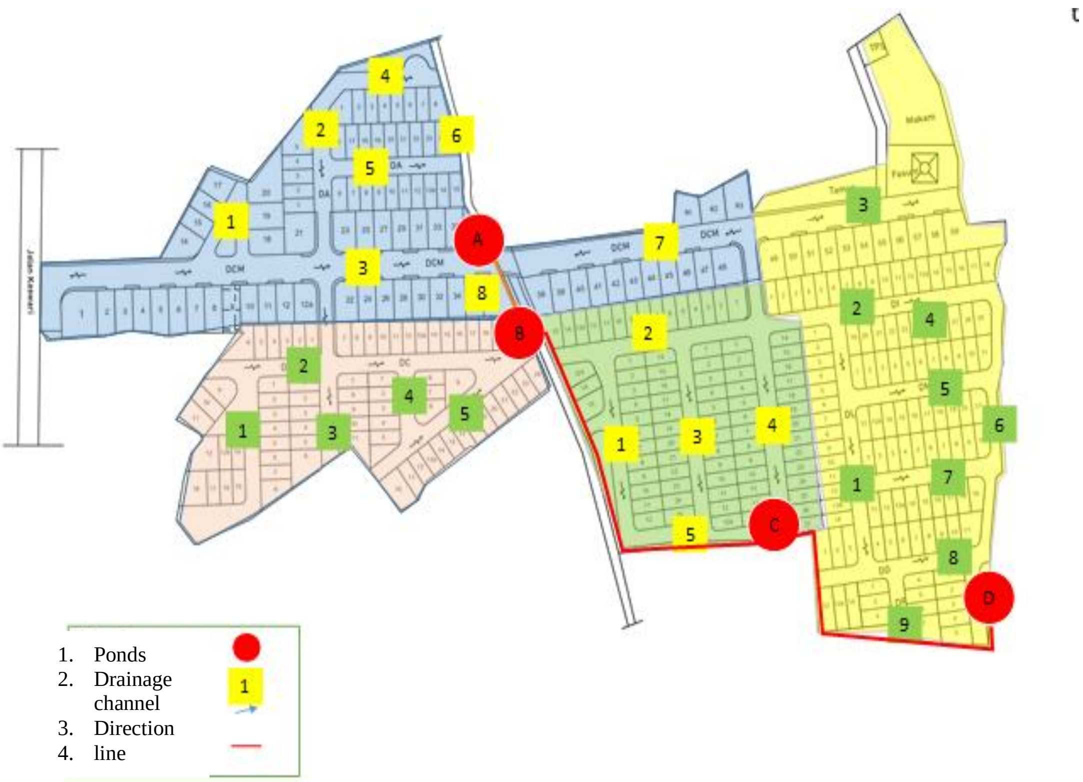


Figure 5. Diamond city residential drainage system layout

V. CONCLUSION

Based on the results of the study conducted, several other conclusions were obtained, including the following:

1. The watershed (DAS) of the Diamond City residential area is 3.98 Ha.
2. Results of the Hydrological Study, the total discharge of rain runoff and domestic waste discharged was 0.651 m^3/second.
3. The average depth of the groundwater table in the Diamond City Housing area is 2.90 m (dry season) and 2.30 m (rainy season).
4. The drainage channel is divided into blocks A, B, C and D with 25 segments sufficient to drain rainwater runoff.
5. The 4 storage ponds are sufficient to accommodate rainwater and minimize runoff into the river in conditions of maximum rainfall.

Based on the description of the conclusions above, several recommendations can be submitted so that the condition of the drainage channels in Diamond City Housing is sufficient to accommodate flood discharge and domestic waste, there are several requirements that need to be implemented in the field including the following:

1. The developer must be able to adjust the design of the drainage channel according to the document and adjust the base elevation of the drainage channel that has been made by dividing the flow according to the flow outlet.
2. The developer must make infiltration wells for each house according to the attached picture and make 4 storage ponds according to the attached picture with the hope of minimizing rainwater entering the river so it doesn't trigger flooding downstream.

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