IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

The Hydraulic Modelling of Capacity of Water Pool in Universitas Jambi

To cite this article: R C Wijaya and R Rohati 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **391** 012072

IOP Conf. Series: Earth and Environmental Science **391** (2019) 012072 doi:10.1088/1755-1315/391/1/012072

The Hydraulic Modelling of Capacity of Water Pool in Universitas Jambi

R C Wijaya*, R Rohati
Faculty of Engineering, Jambi University, Jambi, Indonesia

*riki.chandra.wijaya@gmail.com

Abstract. This research was carried out with the primary and secondary data collection process. The primary data prepared are data on the cross-section area into the pond, the pool area data, the water level data, the length data of the inlet into the pond, and current pool and the drainage conditions. While the secondary data used in this study is the average daily rainfall data from 2001 to 2010 in the district of Muaro Jambi. Furthermore, by using these data, a direct survey was conducted to see the conditions of land use in every part of the area at Jambi University. Land use data will be used as a CN (curve number) determination in hydrological analysis. Based on the results of hydrological analysis, it is known that the value of UNJA Mendalo water storage capacity is around 85060 m^3. By using the results in the hydrological analysis, further analysis of the hydraulics of the Jambi Mendalo University's channels and ponds can be determined.

1. Introduction

Jambi University (abbreviated as UNJA) is a state university in Jambi, Indonesia, which was established on March 23, 1963. The increase in the number of students from year to year shows the need for improvement of existing facilities and infrastructure at the University of Jambi. One of the important facilities of the University of Jambi is a water storage pond. Water reservoir is a pool that is used for various functions in community needs at Jambi University.

The water needs continue to increase along with the growth in the number of students and employees at the University of Jambi. The development increase that are also an existing problem have a big influence in the rainwater catchment area when the rainy season arrives. the water pool at the University of Jambi function as flood controllers as well as the water storage or the water pool. In addition, the need for water will be met when there is a drought by using the existing water from the water reservoir in the water pool. Fulfillment of water needs must be considered and planned for the future. This is because in the future the level of water demand at the University of Jambi will not be balanced with the existing water capacity. Thus, to overcome these problems requires careful planning in the face of meeting the needs of water in the future.

Planning for optimizing the capacity of water reservoirs at the University of Jambi can be done in advance by making a hydraulics model of a pool. The hydraulics model of the water pool is made to make it easier to do hydraulic calculations in the planning of optimizing the pool reservoir. Complex and complex hydraulic calculations will be easier and faster with the help of the hydraulics model of this pool. In making the hydraulics model the pool storage can be done using HEC RAS software. HEC RAS software is a computer information system created by the US Army Corporation. With the help of this software, the hydraulic model of the pool reservoir at the University of Jambi will be made to assist in the optimization of the pool.

IOP Conf. Series: Earth and Environmental Science **391** (2019) 012072 doi:10.1088/1755-1315/391/1/012072

2. Method

In this study have several calculation methods used include methods in calculating the average rainfall, the method of calculating the concentration time in the channel, the method of calculating time lag in channels and flow areas, to the method in determining the CN constans of the area. The average rainfall calculation in this study is to use data from the Muaro Jambi rain station. In hydraulics analysis using the HEC RAS 4.0 software tool as an information system used to calculate the hydraulic conditions of water channels and ponds of Jambi University.

The calculation of the average rainfall using arithmetic methods can be used as follows:

$$\bar{P} = \frac{P_1 + P_1 + \cdots + P_1 + \cdots + P_1}{N} = \frac{1}{N}\sum_{i=1}^{N} P_i$$

Where:
$\bar{P}$ = the average rainfall
N = the number of rainfall station
$P_1, P_2, \ldots, P_i, \ldots, P_n$ = the rainfall number

(Subramanya, 1994)

The determination of the rainfall in a hours is done to determine the rainfall of the return period every few hours. In this study, the determination of 5 hours of rain is determined. As for some equations used in determining the rain of hours are:

$$R_t = R_0 \left(\frac{5}{T}\right)^{2/3}$$

Where:
R_t = the average rainfall from the beginning to the T-hour
$R_0 = \frac{R_{24}}{5}$
T = the rainfall time from the beginning to the T-hour
R_{24} = the effective rainfall (net rain which causes surface runoff)

Furthermore, to determine the amount of rainfall on the hour to T can be used the following equation:
$$R_T = t.R_t - (t-1)R_{(t-1)}$$

Where:
R_T = the amount of rainfall at hours to t
t = the rain time from the beginning to the hour to t
R_t = the average rainfall from the beginning to the hour to t
$R_{(t-1)}$ = the average rainfall from the beginning to the hour to (t-1)

To determine the time the concentration of water flow in a watershed can be used the Kirprich method. The equation of the Kirprich method is:

$$t_c = 0.0078 L^{0.77} S^{-0.385}$$

Where:
t_c = the time of concentration (minute)
L = the length of channel (ft)
S = the average slope of watershed, (ft/ft)
(Ven Te Chow,Dkk, 1994)

Time lag can be determined after the concentration time has been obtained. In determining the time lag in this study can be used time lag equation in the HEC HMS reference. The time lag equation is as follows.

$T_l = 60\% T_c$
Where:
T_l = time lag (minute)

The water surface profile is calculated from one piece section to the next by using an energy equation with an iterative procedure called the standard step method. The energy equation is written as follows.

$$Z_2 + Y_2 + \frac{a_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{a_1 V_1^2}{2g}$$

The energy loss (hc) between two section of cut is formed by two types of forces. The force caused by friction loss and contraction force from energy loss due to development of the cross section of channel. The equation for energy loss is as follows.

$$h_c = L\overline{S_f} + C\left|\frac{a_2 V_2^2}{2g} - \frac{a_1 V_1^2}{2g}\right|$$

The uniform flow is considered a steady flow because the unsteady uniform flow in reality never existed. In this uniform flow can be divided into several types, namely subcritical, critical and supercritical uniform flow. The difference of each type of uniform flow lies in the channel slope, flow velocity and hydraulic radius of the channel. In determining the uniform flow velocity in Ven Te Chow (1997) formulated as follows.

$$V = CR^x S^y$$

C is the flow resistance factor which varies according to the average velocity, the hydraulic radius, the channel roughness, viscosity and various other factors. Whereas R is the hydraulic radius, S is the slope of energy, x and y are exponents.
At the beginning of 1769 a French engineer, Antonie Chezy gave a formula that could be used in determining the uniform flow velocity which was mathematically written down.

$$V = C\sqrt{RS}$$

In 1889 an Irish engineer, Robert Manning, put forward a formula that was finally fixed into a very well-known formula, namely.

$$V = \frac{1{,}49}{n} R^{3/2} S^{1/2}$$

V is the average velocity of flow, R is the hydraulic radius, S is the slope of energy, and n is the roughness coefficient. When compared between Chezy formulation and Manning formulation in determining the uniform flow velocity can be seen that the difference lies in the value of the constant C.

$$C = \frac{1{,}49}{n} R^{1/6}$$

This research method is systematically started during the data collection process. The data collected is then analyzed hydrologically and hydraulically to obtain the results of the prediction of the condition of the channel and pond at UNJA Mendalo. Schematically, this research method can be drawn in the following figure.

Figure 1. Flow Chart of Research

3. Results

Based on the data, results of the study obtained several results based on the research steps listed in the flow chart above. In the digitization process of the Jambi University map, a digital map has been produced the map of Jambi University. The usefulness of this digital map is to determine the length of the channel, the area of each rain influence area at Jambi University, and determine the concentration time of the channel water flow and the area of influence of rain. The digital map from Jambi University can be seen in the following picture.

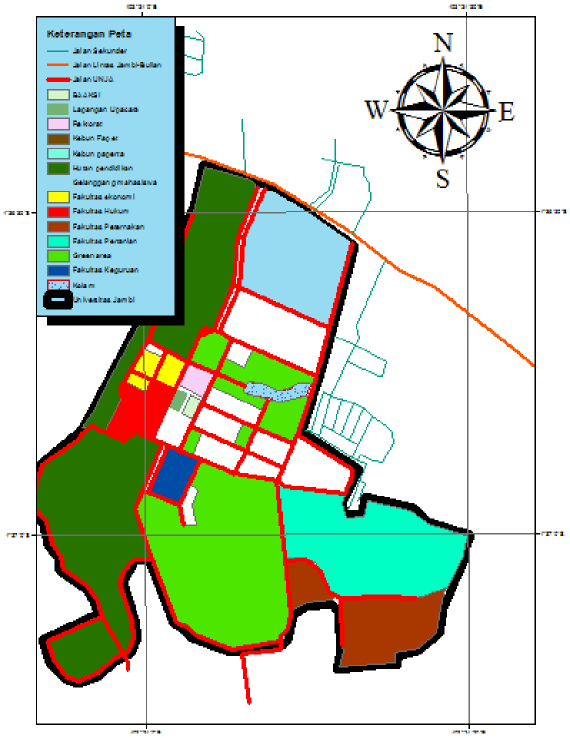

Figure 2. The map of Jambi University

Based on digital maps from the University of Jambi, hydrological analysis can be performed using digital map vector data. Some data that can be obtained from digital maps include data on channel length, area of water storage ponds at Jambi University, as well as the extent of each rain influence area at Jambi University. For the area of influence of rain can be seen in the following figure.

Figure 3. The Area of Rainfall Influence on the Pond Entrance Channels (2017)

Using the area data from digital maps can be done hydrological analysis in determining the volume of runoff water flowing in each channel. Hydrological analysis uses the average rainfall data in the area of Muaro Jambi from 2001 to 2010. Based on the calculation of rainfall data analysis, the rainfall value of the return period is determined as in Table 1 below.

Table 1. The Rainfall Plan Muaro Jambi Regional Period

Time (Hour)	Rainfall (mm)
	Average year
1	7.85
2	2.17
3	1.35
4	1.08
5	1.08

Using the data in the table above can be carried out hydrological analysis so that it can be predicted the value of water discharge into the pool. The results of the hydrological analysis can be seen in table 2 below.

Table 2. The Result Of The Hydrologic Analysis (2017)

No.	Variabel	Quantity
1	The total of rain-fall	7.85 mm
2	The volume of rainfall	0.26 x 10^6 liter
3	The Volume of pool water	85060 m^3

The hydrological analysis also obtains information on the flow of water in each channel that affects the pond. The value of water discharge in each channel can be seen in table 3 below.

Table 3. The Discharge of The Channel

Link	Mak.Flow (CMS)	Maks.Velocity (m/detik)	Maks/Full Flow	Maks/Full Depth
1-2	0.072	0.42	0.37	0.43
2-3	0.143	0.63	0.53	0.57
3-4	0.214	0.58	0.91	0.92
4-9	0.496	0.70	0.79	0.71
9-10	0.495	0.70	0.79	0.71
10-pool	0.495	1.06	0.46	0.47
5-6	0.072	0.42	0.37	0.43
6-7	0.143	0.63	0.53	0.57
7-8	0.143	0.55	0.61	0.64
8-4	0.213	0.47	0.61	0.56
11-37	0.072	0.73	0.19	0.25
37-38	0.144	1.26	0.23	0.29
32	0.144	0.54	0.29	0.37
33	0.000	0.00	0.00	0.00

Using the results of the hydrological analysis can be determined the hydraulic analysis of water channels and ponds at Jambi University. in this study the hydraulic analysis was carried out with the help of HEC RAS 4.0 software in determining the capacity of UNJA Mendalo water reservoirs. The hydraulic model from UNJA Mendalo water pond can be seen in Figure 4 below.

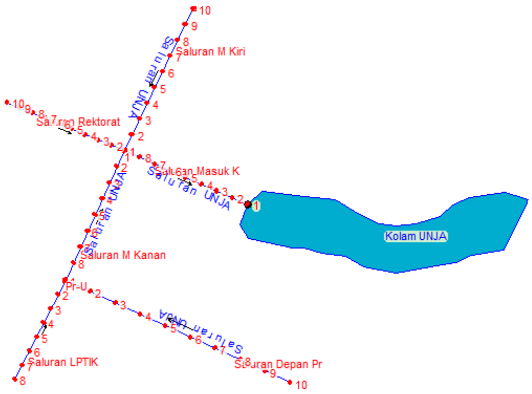

Figure 4. The hydraulic of modeling

The discharge plan from the hydraulic calculation of UNJA Mendalo channel can be seen in table 4 below.

Table 4. The Discharge Plan of The Channels

No.	**The primer of channel**	**The secondary of channel**	**Discharge (m^3/s)**
1	UNJA channel	The front line of the Agriculture Faculty	0.89
2	UNJA channel	LPTIK drainage	0.89
3	UNJA channel	The right channel in the pool water	0.89
4	UNJA channel	The left channel in the pool water	1.5
5	UNJA channel	Rector channel	1.787
6	UNJA channel	Pool channel	0.93

Based on the results of the hydraulic calculation of UNJA Mendalo channel, it can be seen some information about the speed of water flow, discharge, the volume of water entering the pool, and the pool area. Based on the results of hydrological calculations it is known that the pool storage capacity ranges from 85060 m3. If the current pool area is 3835 m2 with a pond depth of 3.5 m then the capacity of water of the UNJA pond is around 13422.5 m3. This value is far from the volume of water entering the UNJA pool. Thus, there is a percentage of the amount of water that can be accommodated by the reservoir by 15.7% of the total water that can be accommodated.

4. Conclusion

This research provides some information regarding the magnitude of the discharge, volume of water, to the return period rainfall that occurred at the Jambi University channel connected to the water pond. Based on the hydrological analysis, it is known that the capacity of UNJA Mendalo water pool is around 85060 m3. This storage capacity shows that it is necessary to optimize the ability of UNJA Mendalo water ponds as water storage facilities as well as water sources during the dry season. This research need to continue to determine how much water optimization UNJA Mendalo has in maintaining the balance of water balance in Jambi Mendalo University. The UNJA pool is only able to accommodate 13422.5 m3 of water from its current storage capacity. While the volume of water that can potentially be accommodated is 85060 m3. Thus, the UNJA pond can only save as much as 15.7% of the water from the total available water when the rainy season arrives.

References

[1] Chow, Ven Te dan Rosalina,Nensi.1997. "Hidrolika Saluran Terbuka (Open Channel Hydraulics)".Jakarta: Erlangga.
[2] Subramanya.1995. "Engineering Hydrology".New Delhi: Tata McGraw-Hill Publishing Company Limited.
[3] USACE (2000). "HEC-HMS Technical Reference Manual". Hydrologic Engineering Center, Davis, CA.
[4] USACE (2000). "HEC-HMS hydrologic modeling system user's manual". Hydrologic Engineering Center, Davis, CA.
[5] [US Army Corps of Engineers, USACE (1998). "HEC-1 flood hydrograph package user's manual". Hydrologic Engineering