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Analysis of Flood Hydrograph Metro Sub Watershed with Synthetic Unit Hydrograph Snyder and SCS (Soil Conservation Service) Methods

Mega Septia Sarda Dewi[1*], *Muh. Aimar Al Qadri* Rahman[1], *Nafi'atus* Sholikhah[1], *Eko* Setyawan[1], *Sugiyanto* Sugiyanto[1], *Pranoto* Pranoto[1], and *Rudianto* Rudianto[2]

[1]Department of Civil Engineering and Planning, Faculty of Engineering, Universitas Negeri Malang, Jl. Semarang No 5, Malang, Indonesia
[2]Faculty of Vocational, Universitas Negeri Malang, Jl. Semarang No 5, Malang, Indonesia

Abstract. Metro Sub-watershed is in Malang City. Based on data from BPBD Malang City, flood disasters have continued to increase from 2016 - 2022. The purpose of this research is to analyse the synthetic unit hydrograph (SUH) which will be used as the basis for planning water resources management. The rainfall data used in 2012-2021 with an average maximum rainfall height of 108 mm... Metro sub-watershed with an area of 31.371 km^2 and a river length of 42 km and land use data with 59% of the residential. All data will be analysed for SUH in return periods Q2 = 2th, Q5 = 5th, Q10 = 10th, Q25 = 25th, Q50 = 50th, and Q100 = 100th. SUH analysis using HEC-HMS auxiliary program with Snyder and SCS (Soil Conservation Service) methods. The peak discharge results of the SUH in the Snyder method are Q2 = 47.8 m^3/s, Q5 = 48.6 m^3/s, Q10 = 50.7 m^3/s, Q25 = 52.8 m^3/s, Q50 = 54.1 m^3/s, Q100 = 55.2 m^3/s, and in the SCS method are Q2 = 37.5 m^3/s, Q5 = 37.9 m^3/s, Q10 = 39.8 m^3/s, Q25 = 41.8 m^3/s, Q50 = 43 m^3/s, Q100 = 44 m^3/s.

1 Introduction

1.1 Backgrounds

Watersheds in Indonesia are increasingly experiencing environmental damage from year to year. As many as 62 out of a total of 470 watersheds in Indonesia are currently in critical condition. This has resulted in a decrease in water capacity and the function of water catchments and water infiltration in several watersheds in Indonesia[1]. Damage to the watershed environment includes biophysical aspects and water quality. Symptoms of watershed environmental damage can be seen from the shrinking forests and damaged land, especially protected areas around the watershed[1,2]. This is due to the increasing population which causes the intensity of land and water use to increase.

* Corresponding author: mega.septia.ft@um.ac.id

In the management of water resources which includes several aspects such as clean water supply, irrigation, flood control, water quality control, water ecosystem conservation, groundwater management, land use and sustainable urban drainage development planning will require hydrological data for flood discharge analysis. [3]

Metro Subwatershed is one of the subwatersheds of the Brantas Watershed located in Malang City. The problems that occur in the Metro Subwatershed are caused by land use changes that are not well planned, causing an increase in surface runoff and a decrease in subsurface flow in watersheds and subwatersheds[4]. One way to overcome this problem is to conduct watershed management. This management requires a study of the extent of the impact of land use change on runoff discharge in a watershed. Therefore, it is necessary to conduct research on the analysis of flood discharge hydrographs in the Metro sub-watershed which can then be used as the basis for water resources management planning in Malang City.

1.2 Purpose

The purpose of this research include:
a. Calculate the design flood discharge by using influential rainfall data in Metro subwatershed with snyder and scs methods.
b. Modeling results from some of these methods can be selected as basic data in determining the planning of water resources management in the city of Malang.

2 Research Method

This research is included in quantitative research, using HEC HMS software to calculate the flood discharge of Metro Sub Watershed. The data used is rain data sourced from 3 Rainfall Stations, namely STA Ciliwung, STA Sukun and STA Petungsewu / Dau to find out rainfall data that will be used to calculate the planned discharge and map of existing conditions of land use in the Metro Watershed area used is the last 3 years data. The data analysis carried out in this study is hydrological analysis with the following stages:
• Conduct analysis to determine the condition of the boundaries of the area to be studied
• Rain analysis, using Thiessen's Polygon method using influential rain stations. Taken from the maximum rainfall that occurs in each year.
• Calculates the magnitude of the flow coefficient, CN and time lag
• Calculate the flood discharge with Snyder and SCS Method using HMS HEC software.

Table 1. Maximum Rainfall Data

Year	Maximum Rainfall (mm)
2012	120
2013	93
2014	120
2015	110
2016	87
2017	114
2018	95
2019	103
2020	125
2021	117

2.1 Study Area

The research was conducted in the the study area is the Metro subwatershed, Malang City (Fig. 1 and 2)

Fig. 1. Study Area in Malang

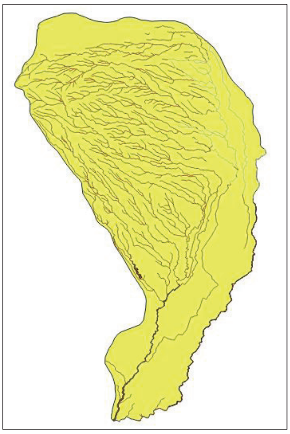

Fig. 2. Metro Subwatershed

2.2 Snyder Synthetic Unit Hydrograph

The Snyder Unit Hydrograph is a parametric unit hydrograph that was developed by Snyder in 1938[5] .The following are the key features of the Snyder Unit Hydrograph[6][7]:

- Basin Lag Time (tl): The basin lag time is the time it takes for water to travel from the farthest point in the watershed to the outlet. It is calculated using the equation tl=Ct(L.Lc)$^{0.3}$, where Ct is a coefficients that depend on the characteristics of the locations of streams, L is the length of the main channel from the centre of gravity of the basin to the outlet[8]
- Peak Discharge (Qp): The peak discharge of the unit hydrograph is given as $Q_p = 0{,}278.C_pA/t_l$, where A is the catchment area in square km and Cp is a regional constant[9]
- Total Time Base: The total time base is the time it takes for the entire hydrograph to pass through the watershed[10]
- Widths at 50% and 75% of Peak Flow Values: The widths at 50% and 75% of the peak flow values are useful for shaping the hydrograph. They are calculated using the equations W50=770(Qp/A)-1.08 and W75=W50/1.75, respectively[11]

2.3 SCS (Soil Conservation Service) Method

The runoff volume model calculates the amount of effective rainfall from subtracting the total rainfall that falls with the volume of water that is intercepted, infiltrated, collected on the surface, and evapotranspiration[12].

To determine precipitation loss in this study will use the SCS (Soil Conservation Service) Curve Number (CN) method which is considered the easiest to apply in the calculation. Curve Number is a function of watershed characteristics such as soil type, cover crops, land use, moisture, and soil treatment. The SCS Curve Number (CN) model estimates precipitation excess or effective rainfall as the portion of rainfall that becomes direct flow in streams. SCS Curve Number consists of several parameters that must be entered, namely the initial abstraction or initial response value, SCS Curve Number, and imperviousness[10]. The calculation model is as follows[13]:

- Peak Discharge (Qp): The peak discharge of the unit hydrograph is given as $Q_p = \frac{0,278.A.Qd}{t_p}$
- Time to peak (tp): $T_p = \frac{t_c+0.133t_c}{1.7}$, where tc is a time of concentration (min): $t_c = 0.0195\left(\frac{L^{0.77}}{S^{0.385}}\right)$, where L is a lenght of channel (m) and S is a slope of channel
- The relationship between the maximum storage capability value and the value of the watershed characteristics represented by the CN (Curve Number) value is as follows: $S = \frac{25400}{CN} - 254$; where S is a retention parameter, CN is a curve number

The CN value of a watershed estimated as a function of land use, soil type, cover crops, moisture and soil treatment has been categorized by the SCS into four notations A, B, C and D. Table 2.[10].

Table 2 Soil types and loss rates according to the SCS model

Soil Group	Description	Range of loss rate (in/hr)
A	Deep sand,deep loess, aggregated silts	0.30 - 0.45
B	Shallow loess, sandy loam	0.15 - 0.30
C	Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay	0.05 - 0.15
D	Soils that swell significantly when wet, heavy plastic clays, and certain saline soils	0.0 - 0.05

3 Result and Discussion

3.1 Snyder Synthetic Unit Hydrograph

The parameters of the Sub-watershed area from the analysis using HEC-HMS were obtained: A = 37,371 km^2; L = 42 km, Tl = 6,3 jam, Tp = 8,3 jam. The results of unit hydrograph with return period 2, 5, 10, 25, 50 and 100 year obtained : Q2 = 47.8 m^3/s, Q5 = 48.6 m^3/s, Q10 = 50.7 m^3/s, Q25 = 52.8 m^3/s, Q50 = 54.1 m^3/s, Q100 = 55.2 m^3/s (Fig. 3 and 4)

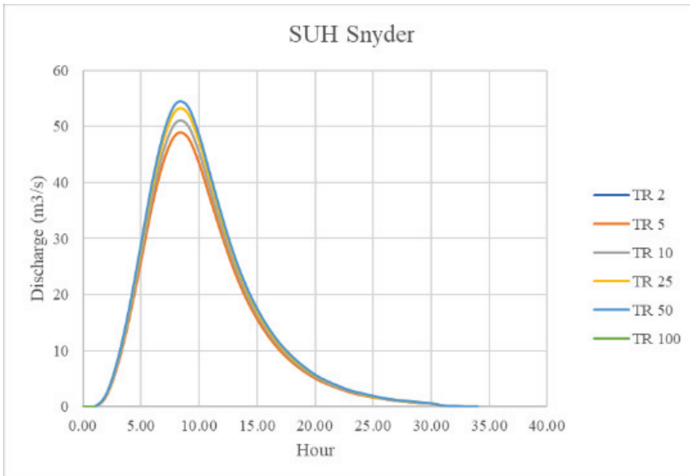

Fig. 3 SUH Snyder's flood discharge hydrograph with various return period

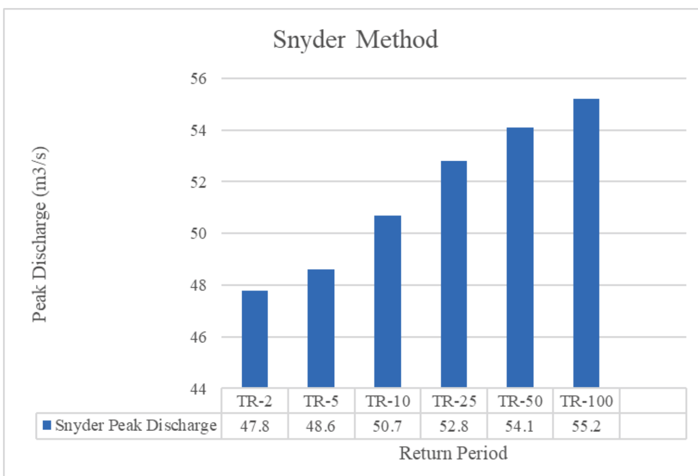

Fig. 4 Peak discharge of SUH Snyder with various return period

3.2 SCS (Soil Conservation Service) Synthetic Unit Hydrograph

The parameters of the Sub-watershed area from the analysis using HEC-HMS were obtained: A = 37,371 km^2; L = 42 km, Tl = 6,3 jam, Tp = 8,3 jam. The results of unit hydrograph with return period 2, 5, 10, 25, 50 and 100 year obtained : Q2 = 37.5 m^3/s, Q5 = 37.9 m^3/s, Q10 = 39.8 m^3/s, Q25 = 41.8 m^3/s, Q50 = 43 m^3/s, Q100 = 44 m^3/s. (Fig. 5 and 6)

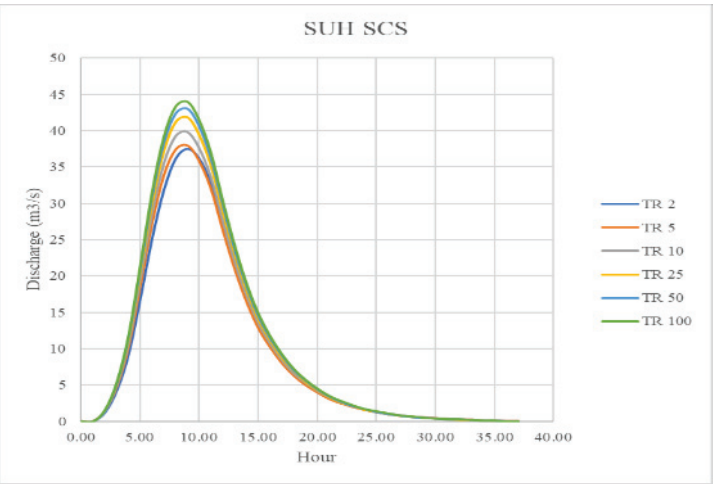

Fig. 5 SCS's flood discharge hydrograph with various return period

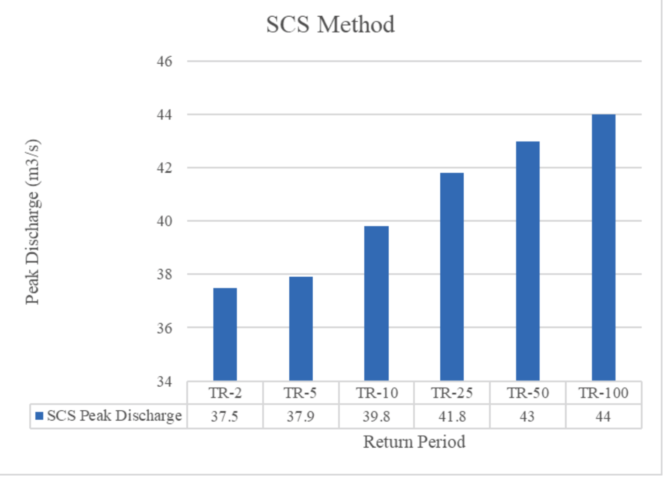

Fig. 6 Peak discharge of SUH SCS with various return period

The results of the unit hydrograph analysis between the Snyder and SCS methods have differences. The values SUH Snyder is higher by 22% than of SCS Method.

4 Conclusion

1. Of the two Synthetic Unit Hydrographs (HSS) calculated, the largest HSS peak discharge (Qp) is the Snyder method with Q2 = 47.8 m3/s, Q5 = 48.6 m3/s, Q10 = 50.7 m3/s, Q25 = 52.8 m3/s, Q50 = 54.1 m3/s, Q100 = 55.2 m3/s. While the SCS method Q2 = 37.5 m3/s, Q5 = 37.9 m3/s, Q10 = 39.8 m3/s, Q25 = 41.8 m3/s, Q50 = 43 m3/s, Q100 = 44 m3/s.
2. Peak discharge (Qp) results at the highest return period of 100 years (Q100) in the Snyder method Q100 = 55.2 m3/s.
3. Time to reach peak discharge (Tp) is 8.3 hours

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References

1. W. Setyaningsih, S. Sriyono, and A. Benardi, Media Komunikasi Geografi **19**, 177 (2019)
2. G. Idfi, A. Yulistyorini, and N. Suryoputro, IOP Conf Ser Mater Sci Eng **930**, 0 (2020)
3. Iswandi U, *Pengelolaan Sumber Daya Air* (CV. Budi Utama, Yogyakarta, 2020)
4. C. Sakdiah and D. Rahmawati, Jurnal Teknik ITS **9**, (2021)
5. B. Labdul and A. Alitu, IOP Conf Ser Mater Sci Eng **1098**, 022067 (2021)
6. F. O. Mohammed and D. A. M. Al-manmi, **19**, (2023)
7. I. G. Tunas, N. Anwar, and U. Lasminto, Jurnal Teknik Sumber Daya Air **1**, 107 (2015)
8. I. Yuliansyah, Aprizal, and A. Nurhasanah, The 4th International Conference on Engineering and Technology Development (ICETD 60 (2017)
9. Y. Yasril, A. Aprizal, A. N.-I. C. On, and U. 2019, Artikel.Ubl.Ac.Id_PROCEEDING 129 (2017)
10. A. W. Salami, S. O. Bilewu, A. B. Ibitoye, and A. M. Ayanshola, Journal of Ecological Engineering **18**, 25 (2017)
11. B. Barid and B. O. Afanda, Astonjadro **11**, 616 (2022)
12. D. Sharaswati, H. Soeryantono, E. Anggraheni, and D. Sutjiningsih, IOP Conf Ser Mater Sci Eng **669**, (2019)
13. A. Kahffi and S. Lipu, REKONSTRUKSI TADULAKO: Civil Engineering Journal on Research and Development 121 (2021)