How to Cite
Miranda, A. T., Gunawan, T. A., & Juliana, I. C. (2023). Analysis of flood control in Lambidaro sub-watershed using EPA SWMM: Environmental protection agency storm water management model. *International Journal of Life Sciences & Earth Sciences*, *6*(1), 1-18. https://doi.org/10.21744/ijle.v6n1.2068

Analysis of Flood Control in Lambidaro Sub-Watershed Using EPA SWMM: Environmental Protection Agency Storm Water Management Model

Ade Tricia Miranda
Master Degree Program of Civil Engineering, Universitas Sriwijaya, Palembang, Indonesia
Corresponding author email: adede.mira@gmail.com

Taufik Ari Gunawan
Lecturer in Civil Engineering Masters Study Program, Universitas Sriwijaya, Palembang, Indonesia
Email: taufikarigunawan@ft.unsri.ac.id

Imroatul Chalimah Juliana
Lecturer in Civil Engineering Masters Study Program, Universitas Sriwijaya, Palembang, Indonesia
Email: icjuliana@ft.unsri.ac.id

Abstract---*In the Lambidaro sub-watershed, precisely on Jalan Colonel Sulaiman Amin, the problem of flooding continues, especially when it rains. The occurrence of flooding around the canal along the Colonel Sulaiman Amin road drainage is caused by several factors, one of which is the capacity of the reservoir which is not able to control the flood discharge optimally so that water cannot overflow into the canal. and eventually caused flooding in the surrounding area. This study aims to determine whether the drainage capacity is still able to drain surface runoff water or not and determine alternative flood control solutions for Colonel Sulaiman Amin Street. The method used is the EPA Model SWMM (Environmental Protection Agency Storm Water Management Model). From this study, the simulation results obtained from EPA SWMM showed alternative solutions offered such as the use of flood pumps, retention ponds, and optimization of drainage, the most effective solution of the six flood mitigation experiments was channel optimization in the form of changing the shape and size of the channel 7 to a square channel with a width of 1 .5 meters. This alternative is 5.26% more effective with an effective percentage of 85.538% and can drain 36.36% more water flow than drainage with a widening of 1.1 meters.*
Keywords---*capacity, discharge, drainage, effective alternative, flood*.

Introduction

Palembang city is the capital city of South Sumatra province. Based on sources from the Mean Sea Level map of the Public Works and Spatial Planning Office, Palembang City is at an altitude of -3 to 42 meters above sea level. Reporting to the flood and inundation list data from the Palembang City Public Works and Spatial Planning Office, in the Lambidaro sub-watershed, to be precise on Jalan Colonel Sulaiman Amin, flooding problems will continue to occur in 2021 (DPUPR Kota Palembang, 2021) (de Azeredo Freitas et al., 2016; Thyagaraju, 2016; Simpen et al., 2016). Based on the narrative of residents, flooding occurred since there were developments carried out by residents so that according to the narrative of the surrounding community too if there is rain with high intensity there will be flooding as high as 10 cm to 30 cm around the residential canal where the flood occurred hinder and disrupt the activities of affected residents so that further handling is needed for the smooth running of residents' activities. The occurrence of flooding around the canal along the Colonel Sulaiman Amin road drainage is caused by several factors, one of which is the water flowing in the canal exceeding the capacity of the canal which is unable to control the maximum flood discharge so that runoff water overflows and eventually causes inundation in the surrounding

ISSN 2632-9425
Submitted: 27 November 2022 |Revised: 18 December 2022 | Accepted: 09 January 2023

area (Dai et al., 2020; Taghizadeh et al., 2021; Jang et al., 2007; Burns et al., 2012). The cause of lack of channel capacity can result from the inadequate condition of the existing secondary channel due to developments that cause a bottleneck in the existing channel. The problem of flooding must be addressed immediately to improve environmental quality with the first step, namely analyzing the capacity of the drainage channel (Bahunta & Waspodo, 2019; Bai et al., 2018; Prasetyo & Widiyanto, 2009).

The drainage for Jalan Colonel Sulaiman Amin is an open channel that is not disturbed by garbage, so it cannot be denied that the problem of inundation in the area is caused by the capacity of the channel which is no longer able to drain runoff water properly. In addition to the Hydraulic Hydrological Method, analyzing channel capacity can also be carried out by EPA SWMM (Environmental Protection Agency Storm Water Management Model) modeling (Sadewa & Sutoyo, 2018). (Fransiska et al., 2020), used the EPA SWMM (Environmental Protection Agency Storm Water Management Model) program in his research in the Jati Area, Padang City, so the researchers intended to use the same modeling to carry out the analysis. This study was conducted to evaluate the capacity of existing drainage channels to determine alternative solutions to deal with flooding in the area and overcome the problems that occur (Fajri et al., 2022). The pump is the most important flood control facility in the urban drainage system whose function is to drain rainwater, which means that the pump is an efficient alternative for controlling floods or inundation. In addition to the use of pumps, in the journal, Sinrinjala Drainage Capacity Analysis on Operation and Maintenance maintenance of drainage and runoff spaces is also an important thing that must be considered in flood and inundation control. The purpose of this study was to analyze flood control in the Lambidaro sub-watershed with the EPA SWMM (Environmental Protection Agency Storm Water Management Model) modeling (Kastridis et al., 2021; Badaruddin et al., 2021; Ophiyandri et al., 2020).

Method

The method used is the EPA SWMM (Environmental Protection Agency Storm Water Management Model) model by calculating the quantity and quality of surface runoff from each catchment area, flow rate, flow depth, and water quality in each channel during the simulation period. The data used in this study are land use maps to determine the percentage of impervious areas, rainfall data, and drainage channel dimension data in the specified area (Peterson & Wicks, 2006; Martin et al., 2007; Smith, 2001; Zeng et al., 2021). The data needed are primary data and secondary data. In this study, the primary data required is the existing channel dimension data. This existing channel dimension data is needed to analyze the capacity of the existing drainage channel. The secondary data needed in this study are Area Area Data to find the area and determine the catchment area, and Daily Rainfall Data to find the intensity of the planned rainfall. From the area data and daily rainfall data, a flood discharge value will be obtained. Apart from these two data, land use data can also be used to determine water catchment areas and run-off areas.

Hydrological Analysis

a) Regional Rainfall
   1) Arithmetic Method

$$p = \frac{p1 + p2 + p3 + \ldots + pn}{n} \qquad (1)$$

Information :
P = Rainfall area (mm)
n = Number of rainfall stations
P1, P2,…, Pn = Rainfall at each observation point

   2) Thiessen Method

$$P = \frac{(A1P1) + (A2P2) + \ldots + (AnPn)}{A1 + A2 + \ldots + An} \qquad (2)$$

Information :
P = Rainfall area average (mm)
P1,P2,...Pn = Rainfall from each station (mm)
A1,A2,...An = Area of influence of each station (km^2)

3) Isohyet Method

$$P = \frac{A1\frac{(P1+P2)}{2} + A2\frac{(P1+P2)}{2} + \ldots + An\frac{(Pn+Pn+1)}{2}}{A1 + A2 + \ldots + An} \ldots\ldots(3)$$

Information :
P = Rainfall area average (mm)
P1,2,3,…n = rainfall from each station (mm)
A1,2,3…n = Area between 2 histories (km^2)

b) Planned Rainfall
1) The Gumble Method
- Standard Deviation

$$Sx = \sqrt{\frac{\sum_{t=1}^{n}(Xi - Xr)^2}{n-1}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Information :
Sx = Standard deviation
Xi = Average rainfall
Xr = Maximum rainfall
n = Amount of data

- Frequency Factor

$$K = \frac{Yt - Yn}{Sn} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Information :
K = Frequency Factor
Yt = Reduction of Variance
Yn = Average reduction of variance
Sn = Standard deviation of reduced variance

- Planned Rainfall/ Return Period

Xt = Xr + (K.Sx) ……………………...(6)

Information :
Xt = design rainfall
Xr = Average maximum rainfall
K = Frequency Factor
Sx = Standard Deviation

2) Pearson Log Method III
a) Average Rainfall

$$\overline{Log\ X} = \frac{\sum Log\ X}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Information :
$Log\ X$ = Average rainfall in logarithms
$\sum Log\ X$ = total amount of rainfall
n = Number of data

b) Standard Deviation

$$\overline{S\,Log\,X} = \sqrt{\frac{\sum_{t=1}^{n} (Log\,X - \overline{Log\,X})^2}{n-1}} \text{..................(8)}$$

Information :
$\overline{S\,Log\,X}$ = standard deviation
$\underline{\text{Log X}}$ = Average rainfall
$\overline{Log\,X}$ = Maximum rainfall
n = Number of data

c) Slope Coefficient

$$Cs = \frac{n\sum_{t=1}^{n} (Log\,Xi - Log\,X)^3}{(n-1)(n-2)\ldots.(\overline{S\,Log\,X})^3} \text{……….………...…..(9)}$$

Information :
Cs = coefficient of slope

d) Planned Rainfall

Log Rt = Log X + Gt * S Log X ………..….(10)

3) Planned Flood Debt

Q = 0,278 . C.I.A …………………………….…..(11)

Information :
Q = Design flood discharge
0.278 = constant, used if the area unit uses km^2
C = Flow coefficient
I = rainfall intensity during concentration time (mm/hour)
A = Watershed area (km^2)

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3} \text{……………………..…………..…..(12)}$$

Information :
I = rainfall intensity (mm/hour)
t = duration of rainfall (hours)
R24 = design rainfall in 1 return period

Hydraulic Analysis

To calculate the channel capacity or the existing discharge, the continuity equation is used.

Q = A.V……………………………………..……..(13)

Information :
Q = flood discharge (m^3/sec)
A = wet cross-sectional area (m^2)
V = flow rate (m/sec)

Results and Discussion

a) Regional Rainfall Analysis

Figure 1 is a map for the Thiessen Polygon Method. In figure 1, the top shaded area is the area of the Talang Betut SMB 2 Rain Post, the shaded area on the right is the Kenten Rain Post area and the shaded area on the bottom side is the Seberang Ulu 1 area. Then the area of each Rain Post Area is determined. Then, after obtaining the area in each rain post, the researcher looked for the area of the area to be entered into the formula from the Thiessen Method.

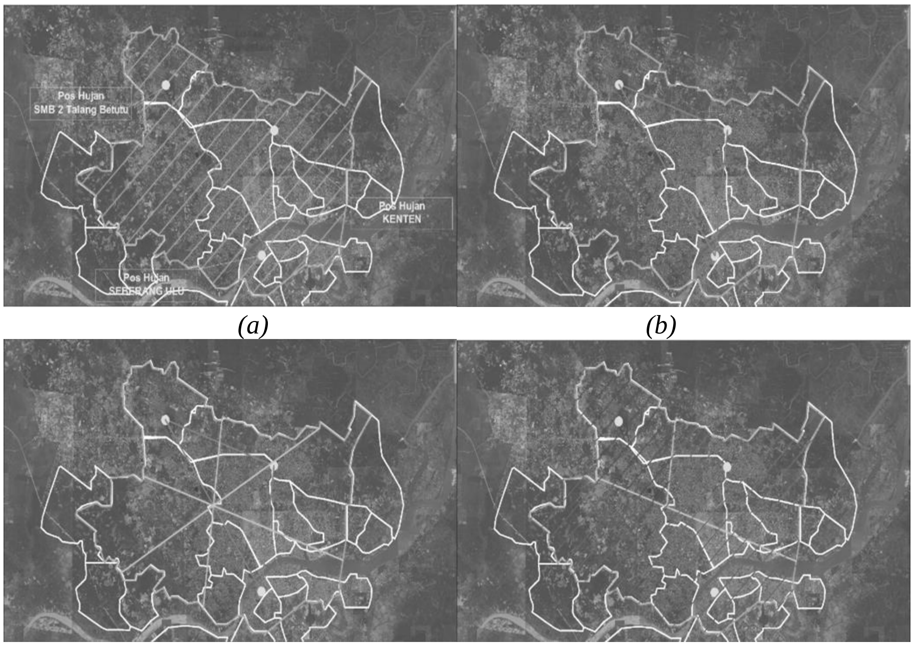


Figure 1. Catchment area map of the Thiessen method

Information :
(a) Determination of rain post station points
(b) Drawing of the Thiessen Polygon line as the meeting point of the rain post station
(c) Determination of regional midpoints for regional rainfall
(d) Distribution of rainfall station areas

1) Calculates the region's average rainfall for January 2016

$$P = \frac{(A1.P1) + (A2.P2) + (A3.P3)}{A1 + A2 + A3}$$
$$P = \frac{(73{,}10\ x\ 60{,}4) + (39{,}24\ x\ 45{,}1) + (106{,}56\ x\ 58)}{73{,}10 + 39{,}24 + 106{,}56}$$
$$P = 54{,}49\ mm$$

Table 1
Recapitulation of average area rainfall analysis results

Year	January	February	March	April	May	Jun	July	August	September	October	November	December
2016	56.49	70.41	65.62	45.61	48.26	34.92	23.96	71.28	104.19	69.48	70.73	78.11
2017	43.96	53.10	72.25	73.67	84.64	51.63	23.38	31.45	27.22	73.79	58.40	83.94
2018	32.31	50.54	102.55	64.20	31.26	62.83	41.65	14.16	74.36	66.25	80.24	53.81
2019	30.49	74.39	81.13	60.39	27.83	35.90	50.38	1.79	29.10	50.76	22.66	91.55
2020	36.64	82.33	77.90	83.37	79.98	42.20	29.44	50.01	28.08	63.29	69.82	49.95

Table 2
Recapitulation of maximum average regional rainfall

Year	Average Maximum Rainfall (Xt)
2016	104,19
2017	84,64
2018	102,55
2019	91,55
2020	83,37

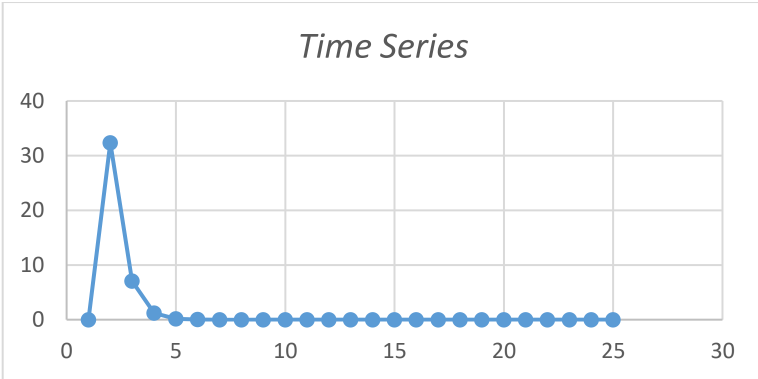


Figure 2. Average Maximum Rainfall Curve

Table 3
Time Series Maximum Average Rainfall

t (time)	R24 (m/dt)
	93,3
0	0
1	32,366
2	7,074
3	1,180
4	0,162
5	0,019
6	0,002
7	0,000
8	0,000
9	0,000
10	0,000
11	0,000
12	0,000
13	0,000
14	0,000
15	0,000
16	0,000
17	0,000
18	0,000
19	0,000
20	0,000
21	0,000
22	0,000
23	0,000
24	0,000

2) Planned Rainfall Analysis
   a) The Gumble Method

Table 4
Recapitulation of the Gumber Method Analysis

No	Period	X	Sd	Sn	Yn	Yt	Xt
1	2	93,26	9,8	1,0206	0,5128	0,3668	91,864
2	5	93,26	9,8	1,0206	0,5128	1,5004	102,701
3	10	93,26	9,8	1,0206	0,5128	2,2510	109,877
4	25	93,26	9,8	1,0206	0,5128	3,1993	118,942
5	50	93,26	9,8	1,0206	0,5128	3,9028	125,668
6	100	93,26	9,8	1,0206	0,5128	4,6012	132,345

   b) Normal Method

Table 5
KT Variable Standards

T (Year)	Kt
2	-0,22
5	0,64
10	1.26
50	2,75
100	3,45

(Source: Soewarno, 1995)

The table above is data from Kt values to carry out analysis with the Normal Method of finding rainfall. The value of Kt is chosen according to the return period of the rainfall data obtained. The following is an example of a calculation using the Normal method.

Xt = X + Kt x S
Xt = 93,26 + 0,64 x 9,8
Xt = 99,5 mm

The conclusion from the analysis using the Gumbel method is that the rainfall value in the 5th year is 102.701 mm while using the normal method is 99.5 mm. To analyze a flooded area, maximum rainfall data is needed to create a time series of rainfall distribution. Then the Gumbel method is what researchers can use, to test the suitability of the results from the Gumbel method, and the Smirnov – Kolmogorov compatibility test is used.

3) Smirnov - Kolmogorov Compatibility Test

Table 6
Critical Delta values for the Smirnov-Kolmogorov alignment test

Number of Data (n)	α degree of confidence			
	0,20	0,10	0,05	0,01
5	0.45	0.51	0.56	0.67
10	0.32	0.37	0.41	0.49
15	0.27	0.30	0.34	0.40
20	0.23	0.26	0.29	0.36
25	0.21	0.24	0.27	0.32
30	0.19	0.22	0.24	0.29
35	0.18	0.20	0.23	0.27

40	0.17	0.19	0.21	0.25
45	0.16	0.18	0.20	0.24
50	0.15	0.17	0.19	0.23
n>50	1.07/n	1.22/n	1.36/n	1.63/n

(Source: Soewarno, 1995)

Table 7
Smirnov - Kolmogorov Compatibility Test

Xi	M	P(x) = M/(n+1)	P(x<)	F(t) = (Xi-Xrt)/Sd	P'(x) = M/(n-1)	P'(x<)	D
1	2	3	4 (Nilai 1 - No.3)	5	6	7 (Nilai 1 - No.6)	8 = 4 - 7
83.4	1	0.167	0.833	-1.011	0.250	0.750	0.083
84.6	2	0.333	0.667	-0.888	0.500	0.500	0.167
91.5	3	0.500	0.500	-0.180	0.750	0.250	0.250
102.6	4	0.667	0.333	0.957	1.000	0.000	0.333
104.2	5	0.833	0.167	1.120	1.250	-0.250	0.417

The DMax value in the table above is 0.417 then the researcher looks again at the DKritis by taking the greatest degree of confidence, namely 0.20 or 20% so that Dmax is < from DKriris 0.450, so the distribution method tested is acceptable.

4) Rainfall Intensity Analysis

Table 8
Rainfall Intensity

t (time)	R24 (m/dt)		
	R2 (m/dt)	R5 (m/dt)	R10 (m//dt)
	91.9	102.7	109.9
0	0	0	0
1	31.881	35.642	38.133
2	6.968	7.791	8.335
3	1.162	1.299	1.390
4	0.160	0.179	0.191
5	0.019	0.021	0.023
6	0.002	0.002	0.002
7	0.000	0.000	0.000
8	0.000	0.000	0.000
9	0.000	0.000	0.000
10	0.000	0.000	0.000
11	0.000	0.000	0.000
12	0.000	0.000	0.000
13	0.000	0.000	0.000
14	0.000	0.000	0.000
15	0.000	0.000	0.000
16	0.000	0.000	0.000
17	0.000	0.000	0.000
18	0.000	0.000	0.000
19	0.000	0.000	0.000
20	0.000	0.000	0.000
21	0.000	0.000	0.000
22	0.000	0.000	0.000
23	0.000	0.000	0.000
24	0.000	0.000	0.000

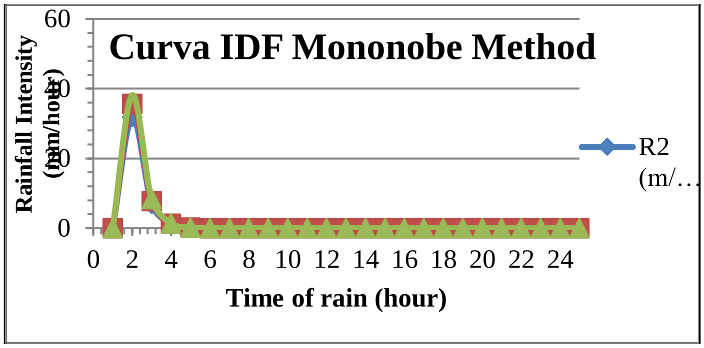
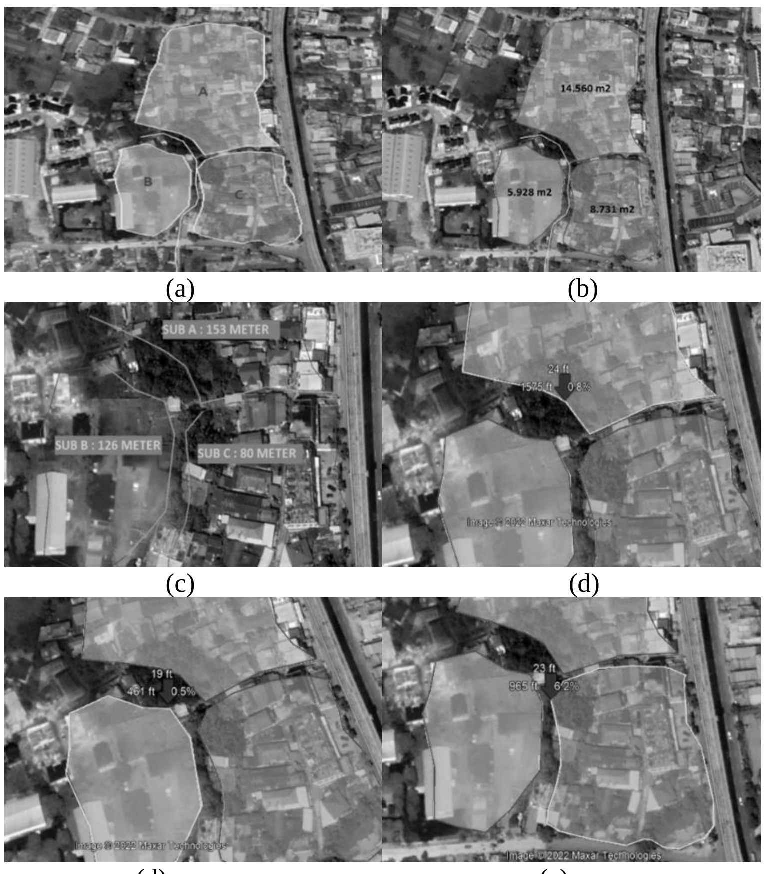


Figure 3. Mononobe Method Curve

5) SWMM EPA method
   a) SWMM modeling
      Figure 4 is the catchment area that will be used in the SWMM EPA modeling:



(a) (b)
(c) (d)
(d) (e)

Figure 4. Sub-DAS Area and % slope area

Table 9
Subcatchment, % Slope, Impervious, and Width

Subcatchment	A (m2)	The width of the road (m2)	A (m2)	A (Ha)	*Slope* %	% *Imperv*	% *Perv*	*Width* (m)
A	14.560	5.824	20.384	2,04	0,8	87	13	153
B	5.928	2.371,2	8.299,2	0,83	0,5	52	48	126
C	8.731	3.492,4	12.223,4	1,22	6,2	80	20	80

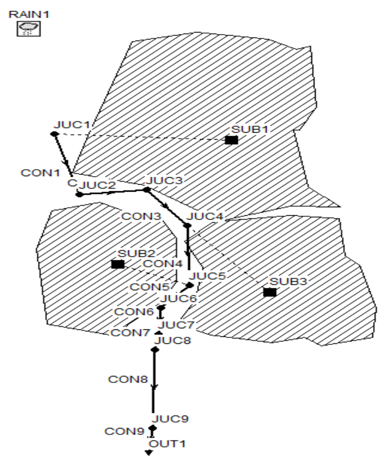


Figure 5. Modeling of the drainage network on Jalan Colonel Sulaiman Amin

b) Flow Response Simulation in Time Series
The planned daily rainfall is 102.7 mm/day, so a flow simulation is carried out as a response to rainfall against time/duration.

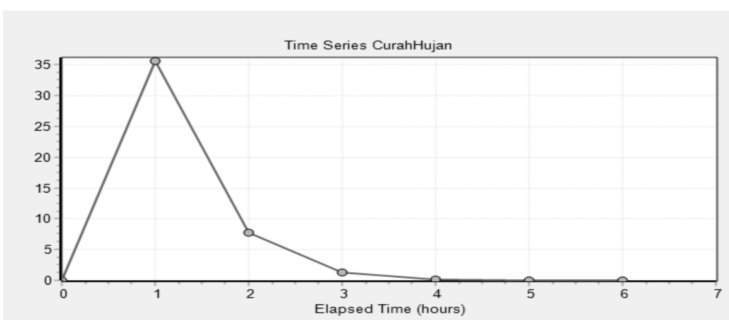


Figure 6. Time Series

As seen in Figure 4.17, the highest rainfall is in the first hour with a value of 35.64 mm/sec.

c) Drainage Capacity Simulation and Analysis
From the simulations carried out, it was obtained that the simulation quality results on Jalan Sulaiman Amin were quite good where the continuity errors for surface runoff and flow tracing were -0.16% and 0.01%, respectively. According to Rossman et al. (2004), if the simulation rate reaches 10%, the quality is doubtful. The results of the SWMM 5.1 EPA status simulation can be seen in Figure 7.

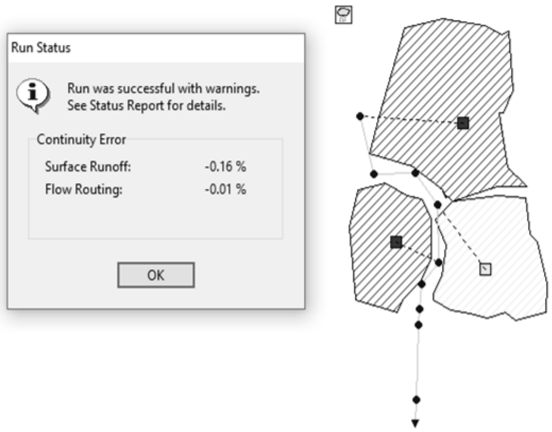


Figure 7. EPA SWMM Status Running Successfully

Table 10
Calculation Results of Infiltration and Runoff with EPA SWMM

Node	Hours Flooded	Maximum Rate LPS	Day of Maximum Flooding	Hour of Maximum Flooding	Total Flood Volume 10^6 ltr	Maximum Ponded Depth Meters
JUC4	0.03	120.16	0	01:14	0.008	0.000
JUC5	0.63	202.75	0	02:00	0.231	0.000
JUC6	0.75	37.91	0	02:04	0.087	0.000
JUC7	3.16	481.73	0	02:05	2.466	0.000

In table 10, the flood values that come out are at Junctions 4,5,6 and 7 where at that point the water queues with a Maximum Rate value of 120.16 LPS, 202.75 LPS, 37.91 LPS and 481.73 LPS (Liters per second) with a flood duration of 3.16 hours and it can be concluded that the water that passes through Junctions 4,5,6 and 7 is decreasing because the water is slow to flow to the next Junction.

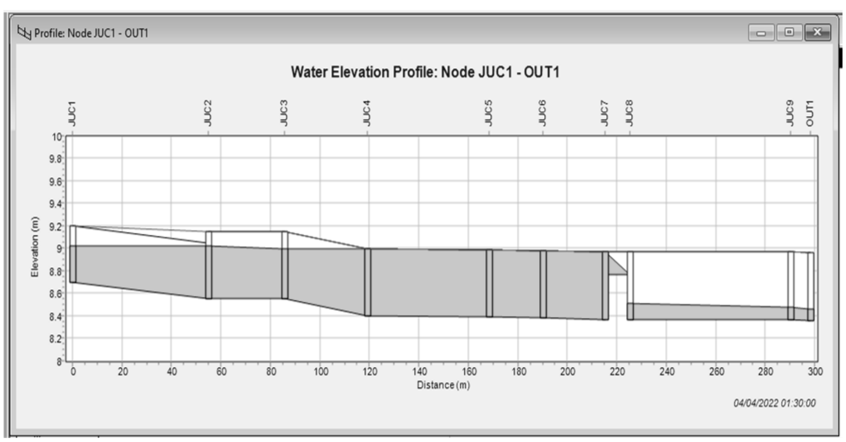


Figure 8. Drainage Flow Profile

In Figure 8 it can be seen in the drainage profile, at junctions 4,5,6 and 7 there was flooding due to the reduction of the channels in Conduit 4,5,6 and 7 which had an impact on settlements in the opposite direction of the water because the water coming was obstructed.

d) Recapitulation of Existing Condition Analysis

Table 11
Recapitulation of Existing Condition Analysis

Existing	Dimensions
C1	Width: 1 meter Height : 0.5 meters Length: 55 meters Qb : 0.6549626 m3/sec Qeks : 0.737 m3/sec
C2	Width: 1.3 meters Height: 0.6 meters Length: 31 meters Qb : 1.0207183 m3/sec Qeks : 1,776 m3/sec
C3	Width: 1.3 meters Height: 0.6 meters Length: 33.7 meters Qb : 0.9503 m3/sec Qeks : 1,696 m3/sec
C4	Width: 1.1 meters Height: 0.6 meters Length: 49 meters Qb : 0.5142088 m3/sec Qeks : 0.807 m3/sec
C5	Width: 1.1 meters Height: 0.6 meters Length: 22 meters Qb : 0.5142088 m3/sec Qeks : 0.807 m3/sec
C6	Width: 1.1 meters Height: 0.6 meters Length: 25 meters Qb : 0.5142088 m3/sec Qeks : 0.807 m3/sec
C7	Diameter: 0.6 meters Filled Depth : 0.4 meters Length: 10 meters Qb : 2.3021 m3/sec Qeks : 1,302 m3/sec
C8	Width: 1.5 meters Height: 0.6 meters Length: 65 meters Qb : 0.274 m3/sec Qeks : 1,793 m3/sec
C9	Width: 1 meter Height: 0.6 meters Length: 8 meters Qb : 1,746 m3/sec Qeks : 2,457m3/sec
STO2	There is no
PUMP1	There is no

e) Alternative Solutions Trial with EPA SWMM

Table 12
Recapitulation of Existing Conditions and Alternative Solutions

Eksisting	Dimensions	EPA SWMM					
		Solution 1	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6
C1	Width: 1 meter Height : 0.5 meters Length: 55 meters Qb : 0.6549626 m3/sec Qeks : 0.737 m3/sec	1 m 0,5 m 55 m	1 m 0,5 m 55 m	1 m 0,5 m 55 m	1 m 0,5 m 55 m	1 m 0,5 m 55 m	1 m 0,5 m 55 m
C2	Width: 1.3 meters Height: 0.6 meters Length: 31 meters Qb : 1.0207183 m3/sec Qeks : 1,776 m3/sec	1,3 m 0,6 m 31 m	1,3 m 0,6 m 31 m	1,3 m 0,6 m 31 m	1,3 m 0,6 m 31 m	1,3 m 0,6 m 31 m	1,3 m 0,6 m 31 m
C3	Width: 1.3 meters Height: 0.6 meters Length: 33.7 meters Qb : 0.9503 m3/sec Qeks : 1,696 m3/sec	1,3 m 0,6 m 33,7 m	1,3 m 0,6 m 33,7 m	1,3 m 0,6 m 33,7 m	1,3 m 0,6 m 33,7 m	1,3 m 0,6 m 33,7 m	1,3 m 0,6 m 33,7 m
C4	Width: 1.1 meters Height: 0.6 meters Length: 49 meters Qb : 0.5142088 m3/sec Qeks : 0.807 m3/sec	1,1 m 0,6 m 49 m	1,1 m 0,6 m 49 m	1,1 m 0,6 m 49 m	1,1 m 0,6 m 49 m	1,1 m 0,6 m 49 m	1,1 m 0,6 m 49 m
C5	Width: 1.1 meters Height: 0.6 meters Length: 22 meters Qb : 0.5142088 m3/sec Qeks : 0.807 m3/sec	1,5 m 1 m 22 m	1,1 m 0,6 m 22 m	1,1 m 0,6 m 22 m	1,1 m 0,6 m 22 m	1,1 m 0,6 m 22 m	1,1 m 0,6 m 22 m
C6	Width: 1.1 meters Height: 0.6 meters Length: 25 meters Qb : 0.5142088 m3/sec Qeks : 0.807 m3/sec	1,5 m 1 m 25 m	1,1 m 0,6 m 25 m	1,1 m 0,6 m 25 m	1,1 m 0,6 m 25 m	1,1 m 0,6 m 25 m	1,1 m 0,6 m 25 m
C7	Diameter : 0,6 meter Filled Depth : 0,4 meter Panjang : 10 meter Qb : 2.3021 m^3/det Qeks : 1.302 m3/det	Square cross section L: 1.5m Q:1m	Square cross section L: 1.5m Q:1m	Square cross section L: 1.1m Q:1m	Square cross section L: 1.5m Q:1m	Square cross section L: 1.1m Q:1m	Square cross section L: 0.6m Q: 0.6m
C8	Width: 1.5 meters Height: 0.6 meters Length: 65 meters Qb : 0.274 m3/sec Qeks : 1,793 m3/sec	1,5 m 0,6 m 65	1,5 m 0,6 m 65	1,5 m 0,6 m 65	1,5 m 0,6 m 65	1,5 m 0,6 m 65	1,5 m 0,6 m 65
C9	Width: 1 meter Height: 0.6 meters Length: 8 meters Qb : 1,746 m3/sec Qeks : 2,457m3/sec	Replaced with Retention pond (storage)	Replaced with Retention pond (storage)	Replaced with Retention pond (storage)	1 m 0,6 m 8 m	1 m 0,6 m 8 m	1 m 0,6 m 8 m
STO2	There is no	10000m^2	10000m^2	10000m^2			
PUMP1	There is no	500 LPS	500 LPS	500 LPS			
	Eksisting	Succeed	Succeed	Succeed	Succeed	Succeed	Fail

1) Solution 1

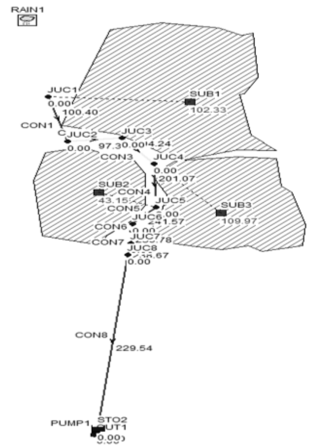


Figure 9. EPA SWMM Run Results

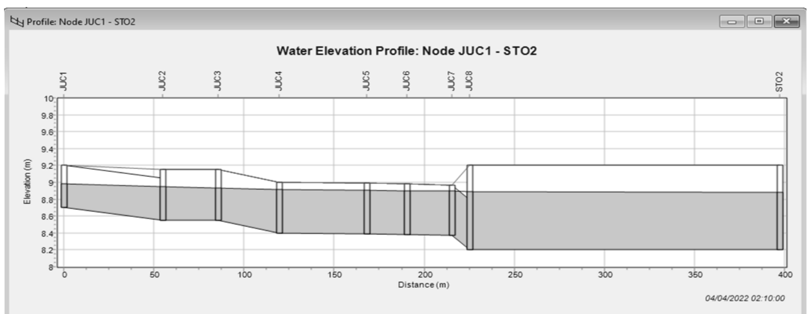


Figure 10. Running the SWMM EPA Simulation

Based on the simulation results of the first solution, the maximum water level in conduits 5, 6 and 7 is 0.58 meters so that no flooding or puddles occur if a solution is made in the form of changing the cross section and widening the channel by L = 1.5 meters and T = 1 meter on conduits 5, 6 and 7 with water discharge to a retention pond with an area of 10,000 m2 and a depth of 0.7 meters.

2) Solution 2

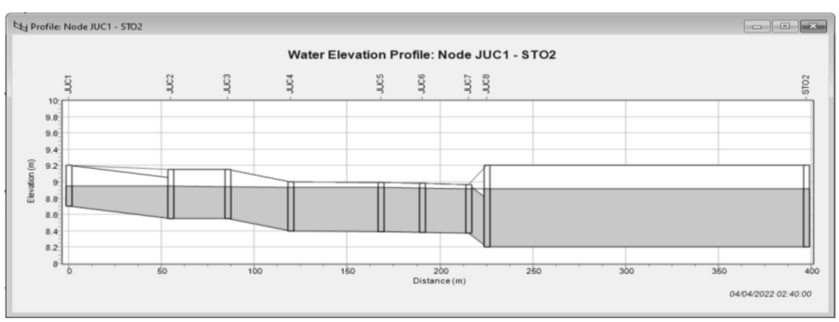


Figure 11. Running the SWMM EPA Simulation

Based on the results of the second solution simulation, the maximum water level in conduits 5, 6 and 7 is 0.59 meters so that no flooding or puddles occur if a solution is made in the form of changing the cross section and widening the channel by L = 1.5 meters and T = 1 meter only in conduit 7 with water discharge to a retention pond with an area of 10,000 m2 and a depth of 0.7 meters.

3) Solution 3

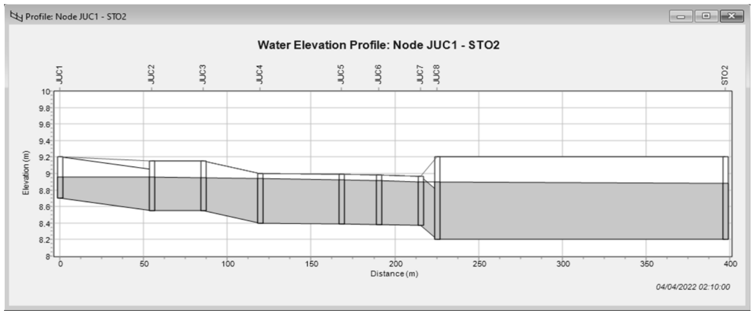


Figure 12. Running the SWMM EPA Simulation

Based on the simulation results of the third solution, the maximum water level in conduits 5, 6 and 7 is 0.6 meters so that no flooding or puddles occur if the solution is made in the form of changing the cross section and widening the channel by L = 1.1 meters and T = 1 meter only in conduit 7 with water discharge to a retention pond with an area of 10,000 m2 and a depth of 0.7 meters.

4) Solution 4

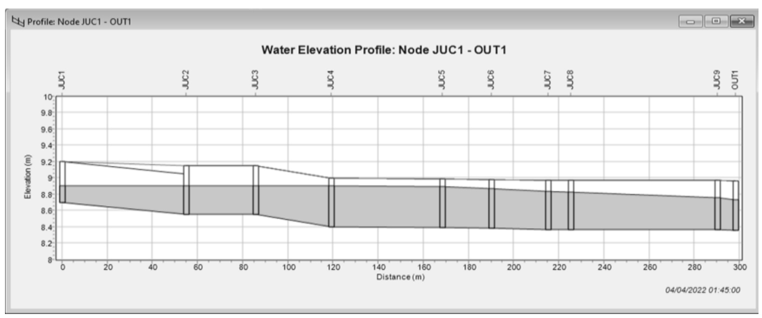


Figure 13. Running Simulasi EPA SWMM

Based on the results of the fourth solution simulation, the maximum water level in conduits 5 and 6 is 0.48 meters and there is a decrease in the water level to 0.4 meters in conduit 7 so that no flooding or puddles occur if a solution is made in the form of changing the cross section and widening the channel with L = 1.5 meters and T = 1 meter only in conduit 7 with water discharge to a connected river or canal so it can be concluded that the fourth solution is more effective than the first, second and third solutions.

5) Solution 5

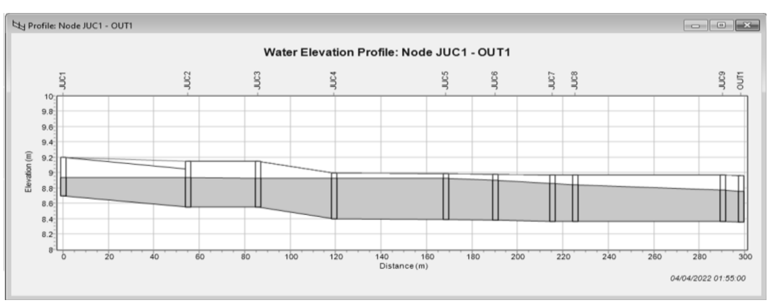


Figure 14. Running the SWMM EPA Simulation

Based on the simulation results of the fifth solution, the maximum water level in conduits 5 and 6 is 0.48 meters and there is a decrease in the water level to 0.42 meters in conduit 7 so that no flooding or puddles occur if a solution is made in the form of changing the cross section and widening the channel with L=1.1 meter and T= 1 meter only in conduit 7 with water discharge to a connected creek or canal. Based on the simulation results up to the fifth solution, it was found that the fourth and fifth solutions were better at controlling floods than the first, second, and third solutions (Siregar et al., 2020; Wahyudi et al., 2019; Alinti, 2016; Behrouz et al., 2020).

6) Solution 6

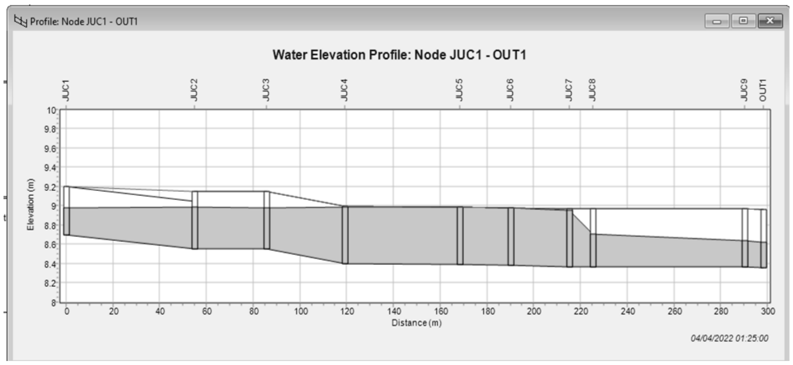


Figure 15. Running the SWMM EPA Simulation

In the 6th solution, it can be seen from the EPA SWMM simulation results in a profile that this 6th alternative is not successful in controlling the inundation that occurs.

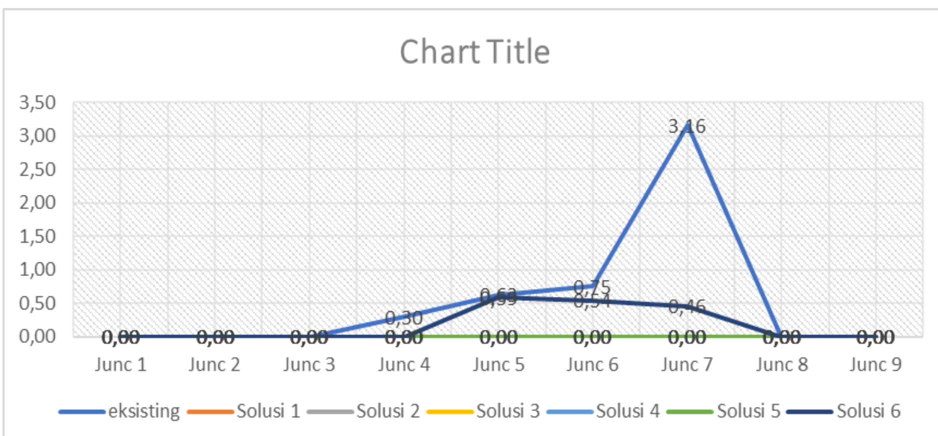


Figure 16. Flood Solution Diagram (comparison of time and channel)

Table 13
Comparison of Existing Debit Solution 4 and Solution 5

Solution 4	Solution 5
Qeks = 1,5 m^2 x 4,61 m/det = 6,915 m^3/det	Qeks = 1,1 m^2 x 4,61 m/det = 5,071 m^3/det

Based on the results of the analysis of the existing discharge between Solution 4 and Solution 5, it was found that solution 4 can flow a water discharge 36.36% greater than solution 5. The flood discharge that occurs is 2.3021 m3/s while the current condition is only capable of flowing discharge of 1.302 m3/sec. So that the remaining delayed flood discharge is 1.0001 m3/s.

Analysis of the percentage effectiveness of the solution:

1) Solution 4
   1,0001 m^3/det / 6.915 m^3/det x 100 % = 14,462 %

100 % - 14,462 % = 85,538 %
2) Solution 5
1,0001 m^3/det / 5,071 m^3/det x 100% = 19,722 %
100 % - 19,722 % = 80,278%

Based on the analysis of the effectiveness of solution 4 and solution 5, it is stated that solution 4 is 5.26% more effective for controlling inundation than solution 5.

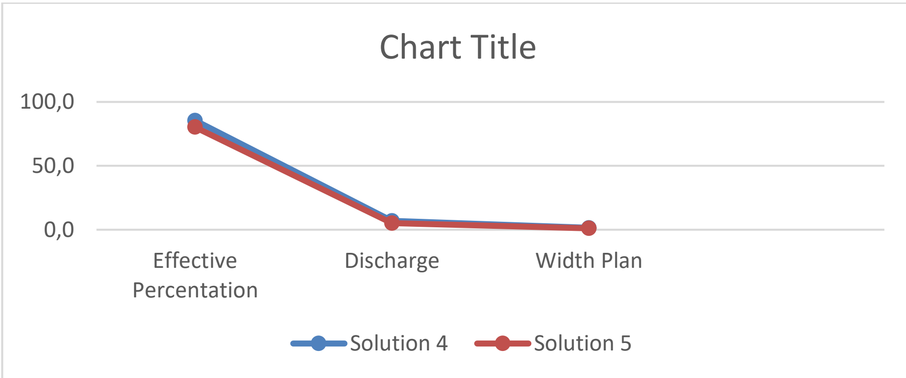


Figure 17. Graph comparison of solution 4 and solution 5

Conclusion

Based on the results of the analysis using the EPA SWMM method and hydraulic analysis, the existing drainage conditions in conduit 7 are unable to accommodate surface water runoff with a planned flood discharge, where the planned flood discharge is 2.3021 m3/s while the existing capacity is only 1.302 m3/s so that Qeks > Qplan . The factor of flooding in the sub-catchment area of the Lambidaro sub-watershed is caused by the bottleneck at Junction 7 (conduits 7 and 8) resulting in a queue of water that causes flooding. An effective solution to deal with the flooding that occurs is the 4th solution where in solution 4 the canal widening in conduit 7 is carried out by 1.5 m.

Acknowledgments
This paper is part of the requirements for completing the Masters in Civil Engineering, Universitas Sriwijaya.

References
Alinti, N. (2016). Tinjauan Rumah Pompa Sebagai Salah Satu Pengendalian Banjir Di Kota Gorontalo. *RADIAL: Jurnal Peradaban Sains, Rekayasa dan Teknologi*, *4*(2), 108-117.
Badaruddin, S., Nahrisa, A., Alam, N., Bustan, B., & Djufri, H. (2021). Analisis Kapasitas Drainase Sinrijala Terhadap Operasi dan Pemeliharaan. *Journal of Applied Civil and Environmental Engineering*, *1*(1), 43-57.
Bahunta, L., & Waspodo, R. S. B. (2019). Rancangan Sumur Resapan Air Hujan sebagai Upaya Pengurangan Limpasan di Kampung Babakan, Cibinong, Kabupaten Bogor. *Jurnal Teknik Sipil dan Lingkungan*, *4*(1), 37-48.
Bai, Y., Zhao, N., Zhang, R., & Zeng, X. (2018). Storm water management of low impact development in urban areas based on SWMM. *Water*, *11*(1), 33.
Behrouz, M. S., Zhu, Z., Matott, L. S., & Rabideau, A. J. (2020). A new tool for automatic calibration of the Storm Water Management Model (SWMM). *Journal of Hydrology*, *581*, 124436. https://doi.org/10.1016/j.jhydrol.2019.124436
Burns, M. J., Fletcher, T. D., Walsh, C. J., Ladson, A. R., & Hatt, B. E. (2012). Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. *Landscape and urban planning*, *105*(3), 230-240. https://doi.org/10.1016/j.landurbplan.2011.12.012
Dai, Y., Chen, L., & Shen, Z. (2020). A cellular automata (CA)-based method to improve the SWMM performance with scarce drainage data and its spatial scale effect. *Journal of Hydrology*, *581*, 124402. https://doi.org/10.1016/j.jhydrol.2019.124402

de Azeredo Freitas, H. R., da Costa Freitas, C., Rosim, S., & de Freitas Oliveira, J. R. (2016). Drainage networks and watersheds delineation derived from TIN-based digital elevation models. *Computers & Geosciences*, *92*, 21-37. https://doi.org/10.1016/j.cageo.2016.04.003

Fajri, N., Andawayanti, U., & Lufira, R. D. (2022). Kajian Evaluasi Genangan Menggunakan Metode SWMM (Storm Water Management Model) di Daerah Jalan Soekarno Hatta (RS UB Hingga Patung Pesawat), Kota Malang. *Jurnal Teknologi dan Rekayasa Sumber Daya Air*, *2*(2), 272.

Fransiska, Y., Junaidi, J., & Istijono, B. (2020). Simulasi Dengan Program EPA SWMM Versi 5.1 Untuk Mengendalikan Banjir pada Jaringan Drainase Kawasan Jati. *Jurnal Civronlit Unbari*, *5*(1), 38-48.

Jang, S., Cho, M., Yoon, J., Yoon, Y., Kim, S., Kim, G., ... & Aksoy, H. (2007). Using SWMM as a tool for hydrologic impact assessment. *Desalination*, *212*(1-3), 344-356. https://doi.org/10.1016/j.desal.2007.05.005

Kastridis, A., Theodosiou, G., & Fotiadis, G. (2021). Investigation of flood management and mitigation measures in ungauged NATURA protected watersheds. *Hydrology*, *8*(4), 170.

Martin, C., Ruperd, Y., & Legret, M. (2007). Urban stormwater drainage management: The development of a multicriteria decision aid approach for best management practices. *European journal of operational research*, *181*(1), 338-349. https://doi.org/10.1016/j.ejor.2006.06.019

Ophiyandri, T., Istijono, B., & Hidayat, B. (2020). Identification Of Drainage Systems Capacity Using Epa-Swmm 5.1 Version Modeling In Gunung Pangilun Of Padang City. *GEOMATE Journal*, *18*(70), 16-22.

Peterson, E. W., & Wicks, C. M. (2006). Assessing the importance of conduit geometry and physical parameters in karst systems using the storm water management model (SWMM). *Journal of hydrology*, *329*(1-2), 294-305. https://doi.org/10.1016/j.jhydrol.2006.02.017

PRASETYO, H., & WIDIYANTO, Y. A. (2009). *Perencanaan sudetan kalitidu kabupaten bojonegoro jawa timur Design of Shortcut Kalitidu Bojonegoro Regency East Java* (Doctoral dissertation, F. TEKNIK UNDIP).

Rossman, L. A., Dickinson, R. E., Schade, T., Chan, C. C., Burgess, E., Sullivan, D., & Lai, F. H. (2004). SWMM 5-the next generation of EPA's storm water management model. *Journal of Water Management Modeling*.

Sadewo, T., & Sutoyo, S. (2018). Kajian Sistem Drainase di Daerah Jalan Pemuda Kota Bogor. *Jurnal Teknik Sipil dan Lingkungan*, *3*(3), 111-120.

Simpen, I. N., Sutama, I. N. S., Redana, I. W., & Zulaikah, S. (2016). Aquifer Porosity Prediction Base on Resistivity Data and Water Conductivity. *International Research Journal of Engineering, IT and Scientific Research*, *2*(5), 7-16.

Siregar, R. I., Nursyamsi, N., & Indrawan, I. (2020). An Approach of Travel Time of Flood Peaks and Runoff Model towards Low Impact Development. *Simetrikal: Journal of Engineering and Technology*, *2*(1), 1-12.

Smith, E. (2001). Pollutant concentrations of stormwater and captured sediment in flood control sumps draining an urban watershed. *Water Research*, *35*(13), 3117-3126. https://doi.org/10.1016/S0043-1354(01)00008-2

Soewarno, S. (1995). Hidrologi: Aplikasi Metode Statistik untuk Analisis Data. *Nova Bandung*.

Taghizadeh, S., Khani, S., & Rajaee, T. (2021). Hybrid SWMM and particle swarm optimization model for urban runoff water quality control by using green infrastructures (LID-BMPs). *Urban Forestry & Urban Greening*, *60*, 127032. https://doi.org/10.1016/j.ufug.2021.127032

Thyagaraju, N. (2016). Water pollution and its impact on environment of society. *International Research Journal of Management, IT and Social Sciences*, *3*(5), 1-7.

Wahyudi, M., Azikin, R., & Rahim, S. (2019). Manajemen Penanggulangan Banjir di Kelurahan Paccerakkang Kota Makassar. *Kolaborasi: Jurnal Administrasi Publik*, *5*(1), 31-45.

Zeng, Z., Yuan, X., Liang, J., & Li, Y. (2021). Designing and implementing an SWMM-based web service framework to provide decision support for real-time urban stormwater management. *Environmental Modelling & Software*, *135*, 104887. https://doi.org/10.1016/j.envsoft.2020.104887