JOURNAL OF WORLD CONFERENCE
VOLUME 4 | NUMBER 2 | MARCH 2022
Available online at http://proceedings.worldconference.id.
ISSN: 2656-1174 (online)

Analysis of Urban Drainage System (Darmo Satellite Channel Case Study) Surabaya City

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Abstract

Rainage channel designed to accommodate plans with precipitation data, safe based on the use of, land and the dimensions. channelDrainage channel in water catchment areas along a channel darmo satellite is one of infrastructures supporting functioning of an urban system in the city surabaya.Changes in land over the function of the green space into land settlement and trade services responsible for the runoff of the surface in several locations in the city of surabaya.

The problem a runoff a surface that often happens when the rainy season resulting from increased discharge of water drainage channel water catchment areas in the rain along a channel darmo, satellite causing the need for a study to analyze the performance of drainage channel.

The data used in this study is secondary data, namely: the last 10 years of rainfall data obtained from rain stations (gunungsari rain stations, simo, and cages) and drainage channel data. While the methods used are hydrological analysis, arithmetic methods, and gumble methods. The data obtained is then analyzed to find out the plan discharge and drainage channel capacity. The analysis conducted in this study includes hydrological and hydraulic analysis. Hydrological analysis includes: 1) calculation of planned rainfall with Gumbel distribution with a re-period of two and five years, and 2) calculation of plan discharge using HSS Nakayasu.

Keywords
Aritmatik Method, Drainage Channel Capacity, Gumbel Method, HSS Nakayasu, Rainfall, The Dimensions, The Discharge.

1. Introduction

The growth and development of industry in urban areas has a considerable impact on the hydrological cycle and has a major effect on urban drainage systems. The development of dense residential areas is suspected as the cause of flooding and inundation in the surrounding environment. This is due to the development of urbanization that causes changes in land use. Therefore the development of the city must be followed by the improvement and improvement of the drainage system.

Darmo Satellite secondary channel is a channel that passes from upstream on the southern satellite highway to downstream at the Gunung Sari Diversi Primary Channel precisely on the tandes lor highway. This channel has a length of approximately 1.14 km and a catchmen area of approximately 58.31 hectares which is the rayon tandes area and is located in sukomanunggal subdistrict.

Existing conditions in the research area are residential, trade and service areas. Drainage channels that have been used have been reduced due to the presence of part of damaged channel walls and sediment so that there is a rainy season when the rainfall is high on southern satellite highways there are often puddles. The arrangement and improvement of the function of the city's drainage network, especially in the Darmo Satelit area, Sukomanunggal Subdistrict, Surabaya City needs to be done immediately so that the problem of flooding and inundation and all consequences arising from it can be immediately reduced or may be eliminated.

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VOLUME 4 | NUMBER 2 | MARCH 2022
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2. Methodology

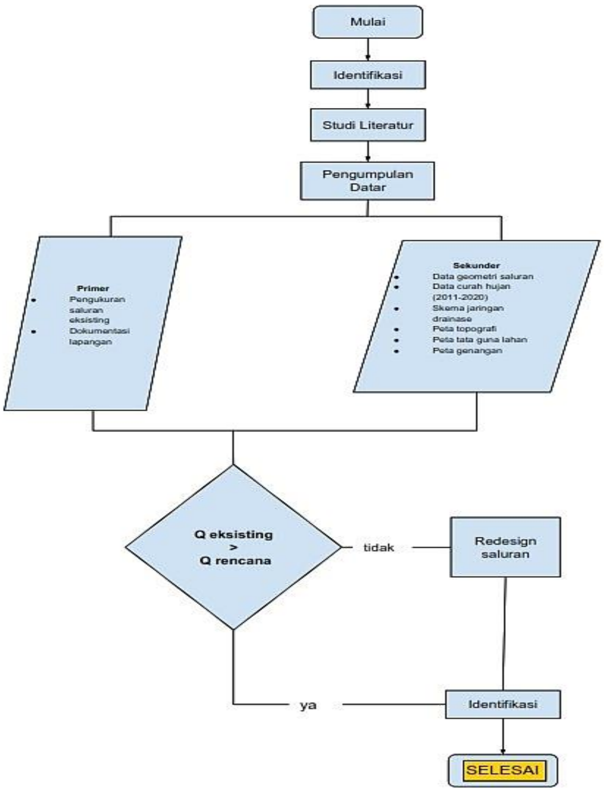

Figure 1. Diagram Alir Penelitian

2.1 Data Analysis and Processing

Data analysis is needed to find out the problem on the drainage system and is used for planning to overcome the problem. The data analysis used is:

a. The calculation of rain in the research area is determined by an algebraic flat method due to the uneven location of the rain-holding station and limited, flat topographical conditions.)

P¯ = 1/n(P_1+P_2+P_3+⋯+P_n)…………………………...…………………………………1

Information:

P¯ = Average rain height
P1, P2, P3, ... Pn = High rain at the station 1,2,3,...n
N = number of stations
(Bambang Triatmodjo. 2010)

b. Calculates planned rainfall by Frequency Analysis of average annual maximum daily rainfall data with 10-year observation length (2011-2020) from one Simo rain observation station and calculates probability distribution using gumbel method, normal log, or type III person log with various birthdays (2 and 5 years).

Table 1 Frequency Distribution

Frequency Distribution	Statistical Data Parameters: Skewness coefficient (Cs)	Kurtosis coefficient (Ck)
Normal	≈ 0	≈ 3
Gumbel	1,14	5,4
Log person Tipe III	Free	Free

Calculation/Dispersion Testing

Standard Deviation (s)

$$s = \sqrt{\frac{\sum_{i=1}^{n}(xi-x)^2}{n-1}} \quad \text{……………………………………………………………………………………………2}$$

Kemencengan (skewness)

$$\alpha = \frac{n}{(n-1)(n-2)}\sum_{i=1}^{n}(xi-x)^3 \quad \text{……………………………..………………………………………..3}$$

Calculates asymmetry coefficients with formulas:

$$Cs = \frac{\alpha}{s^3} \quad \ldots 4$$

Calculates kurtosis coefficient with formula:

$$Ck = \frac{n^2}{(n-1)(n-2)(n-3)s^4} \sum_{i=1}^{n} (x1 - x)^4 \quad 5$$

Calculates debit logarithms with reverse time with formula:

$$Log\ X_t = \overline{Log\ X} + K.S_d\ Log\ X \quad \ldots 6$$

Chi Kudrat

$$x^2 h = \sum \frac{(O_i - E_i)^2}{E_1} \quad \ldots 7$$

Smirnov Kolmogorov

$$X = \bar{X} + k \times S_d \quad 8$$

c. Calculate plan debits

Analyze existing cross-sectional channels to find out the ability to receive water discharge (fulbank capacity) repeat period of 2 and 5 years.

Rational Methods

$$Q = \frac{1}{3.6} . \beta . C . It . A \quad \ldots 9$$

Table 2. Coefficient of Rain Spread (β)

Catchment Area (km²)	Coefficient (β)
0-4	1
5	0,995
10	0,98
15	0,995
20	0,92
25	0,875
30	0,82
50	0,5

(Soewarno 1995)

Flow coefficient

$$C_{gabungan} = \frac{C_1A_1 + C_2A_2 + \cdots + C_nA_n}{A_1 + A_2 + \cdots + A_n} \quad \ldots 10$$

Nakayasu Methods

For the calculation of discharge using the hydrograph formula of the synthesis unit, rain data is required every hour. To calculate the average rain every hour is calculated by the formula:

Calculation of The Distribution of Rain Every Hour

$$Rt = \frac{R24}{5}\left(\frac{5}{t}\right)^{2/3} \quad \ldots 11$$

To calculate the height of rain at the t- hour used the formula:

Rt' = t . Rt – (t-1) . R(t-1)……12

In the calculation of the effective distribution of rain every hour, the formula used is:

Re = C . Rt'……13

Bentuk persamaan HSS Nakayasu adalah

$$Qp = \frac{1}{3{,}6}\left(\frac{A*Re}{0{,}3Tp + T0{,}30}\right) \quad \ldots 14$$

To determine Tp and T0.3, the formula approach is used as follows: :

Tp = tg + 0,8 tr ……15

T0,3 = α tg……16

Tr = 0,5 tg sampai tg……17

The value of tg is time lag which is the time between rain to the peak discharge of the flood (hour). tg calculated with the following conditions :

River with long grooves L > 15 km : tg = 0,4 + 0,058 L……18

River with long grooves L < 15 km : tg = 0,21 L0,7……19

Calculation T0.3 using the provisions:

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VOLUME 4 | NUMBER 2 | MARCH 2022
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a. α = 2 in the usual drainage area
b. α = 1, on the part of the slow hydrograph ride, and down fast
c. α = 3 on the up part of the fast hydrograph, and down slowly

1. On the rise: 0 < t < Tp
   Qa = (t/Tp)2,4……………………………………………………………………………………………20
2. On a down curve
   a. Difference in value: Tp ≤ t ≤ (Tp + T0,3)
      Qd1= Qp x $\mathbf{0,3}^{(t-Tp)/T0,3}$………………………………………………………………………...21
   b. Difference in value : (Tp + T0,3) ≤ t ≤ (Tp + T0,3 + 1,5 T0,3)
      Qd2 = Qp x $\mathbf{0,3}^{[(t-Tp)+(0,5T0,3)]\,/(1,5T0,3)}$……………………………………………………………...22
   c. Difference in value: t > (Tp + T0,3 + 1,5 T0,3)
      Qd3 = Qp x $\mathbf{0,3}^{[(t-Tp)+(1,5T0,3)]\,/(2T0,3)}$……………………………………………………………..23

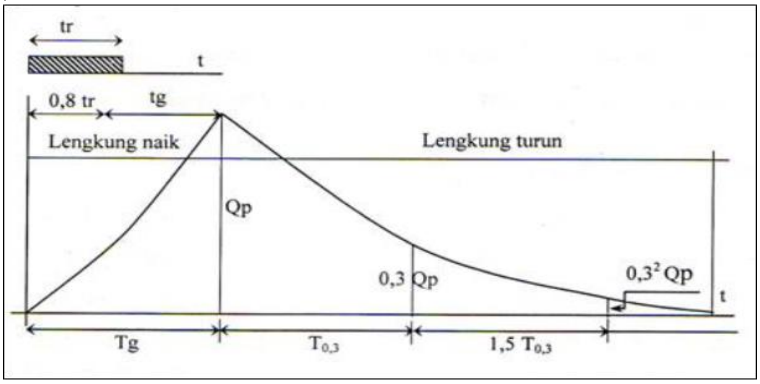

Figure 2. Nakayasu Synthetic Unit Hydrograph

3. Result and Discussion

3.1 Recapitulation of Maximum Rainfall

Table 3 Maximum Rainfall

No	Years Observations	R24 SIMO
1	2011	84
2	2012	67
3	2013	93
4	2014	109
5	2015	88
6	2016	86
7	2017	102
8	2018	49
9	2019	67
10	2020	98

3.2 Frequency Analysis

Table 4 Calculation of Distribution Statistical Parameters

No	Years	X (mm)	Order X (mm)	Average X (mm)	(Xi-X̄)2	(Xi-X̄)3	(Xi-X̄)4

1	2011	84	109	84,3	610,09	15069,22	372209,81
2	2012	67	102		313,29	5545,23	98150,62
3	2013	93	98		187,69	2571,35	35227,54
4	2014	109	93		75,69	658,50	5728,98
5	2015	88	88		13,69	50,65	187,42
6	2016	86	86		2,89	4,91	8,35
7	2017	102	84		0,09	-0,03	0,01
8	2018	49	67		299,29	-5177,72	89574,50
9	2019	67	67		299,29	-5177,72	89574,50
10	2020	98	49		1246,09	-43986,98	1552740,29
Sum					3048,1	-30442,6	2243402,02

Calculation/Dispersion Testing

Calculate Standard Deviation(s) with the formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(xi-x)^2}{n-1}} \quad \text{.......... 24}$$

Calculate skewness with the formula:

$$\alpha = \frac{n}{(n-1)(n-2)}\sum_{i=1}^{n}(xi-x)^3 \quad \text{.......... 25}$$

The asymmetry coefficient is given by the following form:

$$Cs = \frac{\alpha}{s^3} \quad \text{.......... 26}$$

The kurtosis coefficient is given by the following equation :

$$Ck = \frac{n^2}{(n-1)(n-2)(n-3)s^4}\sum_{i=1}^{n}(x1-x)^4 \quad \text{.......... 27}$$

Table 5 Recapitulation of Cs and Ck Value

Frequency Distribution	Statistical Data Parameters: Skewness Coefficient (Cs)	Kurtosis Coefficient (Ck)	Calculation Results: (Cs)	(Ck)	Hasil
Normal	≈ 0	≈ 3	0,000034	3,88	Tidak Memenuhi
Gumbel	1,14	5,4			Tidak Memenuhi
Log person Tipe III	Bebas	Bebas			Memenuhi

3.3 Probability Distribution

Table 6. Probability Distribution Calculation Log Pearson Type III

No	Tahun Pengamatan	X (mm)	Urutan X (mm)	Xrata-rata (mm)	Log X	Log$\overline{X}$	LogX-Log$\overline{X}$	(LogX-Log$\overline{X}$)^2	(LogX-Log$\overline{X}$)^3
1	2011	84	109	84,3	2,04	1,92	0,12	0,0150	0,0018
2	2012	67	102		2,01		0,09	0,0087	0,0008
3	2013	93	98		1,99		0,08	0,0058	0,0004
4	2014	109	93		1,97		0,05	0,0028	0,0002
5	2015	88	88		1,94		0,03	0,0009	0,0000
6	2016	86	86		1,93		0,02	0,0004	0,0000
7	2017	102	84		1,92		0,01	0,0001	0,0000
8	2018	49	67		1,83		-0,09	0,0079	-0,0007
9	2019	67	67		1,83		-0,09	0,0079	-0,0007
10	2020	98	49		1,69		-0,22	0,0506	-0,0114
Jumlah					19,15		0,000	0,1001	-0,0095

$$\log\overline{X} = \frac{\sum \log X}{n} \quad \text{.......... 28}$$

$$S\log\overline{X} = \sqrt{\frac{\sum(LogX - \text{Log}\,\overline{X})^2}{(n-1)}} \quad \text{.......... 29}$$

$$Cs = \frac{n\,.\sum(LogX - \log\overline{X})^3}{(n-1)(n-2)(S\log\overline{X})^3} \quad \text{.......... 30}$$

Tabel 7. K Value Distribution Log Pearson Type III

Cs	Tahun (Periode Ulang)							
	2	5	10	25	50	100	200	1000
-1,0	0,164	0,852	1,128	1,366	1,492	1,588	1,664	1,800
-1,2	0,195	0,844	1,086	1,282	1,379	1,449	1,501	1,625

To get a K value interpolated based on the value of Cs.
Calculation of rainfall plan R24 for the following 5-year re-period:
$\boldsymbol{Log\ X = \overline{LogX} + K.SLogX}$……………………………………………………………………………31

Table 8 Rainfall Recapitulation Plan for Period (T) Year

T	K	log X	Xt
2	0,175	1,934	85,83
5	0,849	2,005	101,08
10	1,113	2,032	107,77
25	1,409	2,064	115,82
50	1,451	2,068	116,99
100	1,538	2,077	119,48
200	1,628	2,087	122,15
1000	1,752	2,100	125,88

3.4 Data Match Test

a. Chi quadratic test
- Sorting rainfall from largest to smallest then ranking.
- Calculate the value of odds with the following formula :

$\boldsymbol{P = \frac{m}{n-1}}$……………………………………………………………………………………………..32
- Specify the number of groups with a formula

$G = 1 + 3{,}322 \log n$……………………………………………………………………………...33

Tabel 9 Calculation of chi square odds

No.	Order X (mm)	$\bar{X}$	S	Rank	P	G
1	109	84,3	18,40	1	0,09	5
2	102			2	0,18	
3	98			3	0,27	
4	93			4	0,36	
5	88			5	0,45	
6	86			6	0,55	
7	84			7	0,64	
8	67			8	0,73	
9	67			9	0,82	
10	49			10	0,91	

- Determines The Value K obtained from gauss table based on group opportunity limits so interpolation is done

P = x

$y = y_o + \frac{(y_1 - y_o)}{(x_1 - x_o)}(x - x_o)$ ……………………………………………………………………..34

Calculate Rainfall Limits with formula

$\boldsymbol{X = \overline{X} + K.S}$……………………………………………………………………………………..35

Table 10 Recapitulation of Rainfall Limits

Peluang	k	x

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ISSN: 2656-1174 (online)

0,182	0,920	101,23
0,364	0,348	90,71
0,545	-0,114	82,21
0,727	-0,602	73,22
0,909	-1,345	59,54

- Calculates Xh2 (calculated squared chi value) with formula

$Xh^2 = \frac{\sum(Oi-Ei)^2}{Ei}$……………………………………………………………………………………...36

Table 11 Calculation of Xh ²

No.	Batasan			Oi	Ei	(Oi-Ei)²	x²
1	73,22	≥	x	3		1,00	0,5
2	73,22	< x ≤	82,21	0		4,00	2
3	82,21	< x ≤	90,71	3	2	1,00	0,5
4	90,71	< x ≤	101,23	2		0,00	0
5	101,23	<	x	2		0,00	0
	Jumlah =			10	2,00	6,00	3,00

Calculate the degree of freedom with the formula:

$\boldsymbol{dk = G - (R+1)}$ ……………………………………………………………………………….37

R = 2 for normal and binomial distributions

R = 1 for Poisson

Table 12 Theoretical X value of Chi-Quadratic Test

dk	α degree of freedom							
	100%	90%	50%	30%	20%	10%	5%	1%
1	0	0.016	0.445	1.074	1.642	2.706	3.841	6.635
2	0.01	0.211	1.366	2.408	3.219	4.605	5.991	9.21
3	0.072	0.584	2.366	3.665	4.642	6.251	7.815	11.345
4	0.207	1.064	3.357	4.878	5.989	7.779	9.488	13.277
5	0.412	1.61	4.351	6.056	7.289	0.236	11.07	15.086
6	0.676	2.402	5.348	7.231	8.558	10.645	12.592	16.812
7	0.989	2.833	6.346	8.383	9.803	12.017	14.067	18.475
8	1.344	3.49	7.344	9.524	11.030	13.362	15.507	20.09
9	1.735	4.168	8.343	10.656	12.242	14.684	16.919	21.666
10	2.156	4.865	9.342	11.781	13.442	15.987	18.307	23.209

Conclusion based on the table above, for dk = 2 with a degree of confidence of 5% obtained theoretical X value = 5,991. Based on the calculation obtained Xh^2= 3.00. Because $Xh^2 < X_{teoritis}$,, then the distribution is acceptable.

b. Smirnov-Kolmogorov Test

Smirnov Kolmogorov's data match test calculation can be seen in the following table

Table 13 Calculation of Dmax

No	X	m	P(X)=m/(n+1)	P(x<)	f(t)=(X-X̄)/s	P'(X)	P'(X<)	D
	1	2	3	4 (value 1 - kol3)	5	6 (value 1- table value)	7 (value 1 - kol6)	8 = 7 - 4

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1	109	1	0,09	0,91	1,34	0,0901	0,9099	0,0008
2	102	2	0,18	0,82	0,96	0,1685	0,8315	0,0133
3	98	3	0,27	0,73	0,74	0,2296	0,7704	0,0431
4	93	4	0,36	0,64	0,47	0,3192	0,6808	0,0444
5	88	5	0,45	0,55	0,20	0,4204	0,5796	0,0341
6	86	6	0,55	0,45	0,09	0,4641	0,5359	0,0814
7	84	7	0,64	0,36	-0,02	0,5080	0,4920	0,1284
8	67	8	0,73	0,27	-0,94	0,8264	0,1736	-0,0991
9	67	9	0,82	0,18	-0,94	0,8264	0,1736	-0,0082
10	49	10	0,91	0,09	-1,92	0,9726	0,0274	-0,0635
				D max				0,1284

Table 14 Value Do Theoretical Test Smirnov Kolmogorov

N	α derajat kepercayaan			
	0.2	0.1	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	0.4
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	0.2	0.23	0.27
40	0.17	0.19	0.21	0.25
45	0.18	0.18	0.2	0.24
50	0.15	0.17	0.19	0.23
n > 50	$\frac{1,07}{\sqrt{n}}$	$\frac{1,07}{\sqrt{n}}$	$\frac{1,07}{\sqrt{n}}$	$\frac{1,07}{\sqrt{n}}$

From the table above for degrees of trust 5% obtained value $Do_{teoritis}$ be 0,41. Based on the calculation table obtained Dmax =0,1284. Because Dmax $< Do_{teoritis}$, Then the distribution can be accepted.

3.5 Concentration Time Analysis

Watershed concentration time is the time it takes for a stream of water to move from a distant point along the draining area to the survey point. Concentration time can be calculated by:

$$\boldsymbol{T_C = T_0 + T_1} \quad \text{.......38}$$

Calculation of Tf with formula

$$\boldsymbol{T_f = \frac{L}{V}} \quad \text{.......39}$$

$$\boldsymbol{V = \frac{1}{n} R^{2/3} I^{1/2}} \quad \text{.......40}$$

Tabel 15 Calculation of Tf

No	Channel Segment	L (M)	V (m/det)	Tf (det)	Tf (menit)	Tf (hour)
1	S. T Darmo Puncak Permai	870	0,11	7948,68	132,48	2,21
2	S.T Jl. Bima Sakti	550	0,39	1412,56	23,54	0,39
3	S.T Jl. Raya Satelit Utara 1	230	0,43	534,32	8,91	0,15
4	S.T Jl. Raya Satelit Utara	210	0,49	424,91	7,08	0,12
5	S.T Jl. Satelit Utara 6	190	0,37	517,58	8,63	0,14
6	Saluran Sekunder	1140	0,41	2784,49	46,41	0,77

Calculation To with formula:

$$\boldsymbol{T_o = \frac{2}{3}\ x\ 3,28\ x\ Lo\ x\ \frac{nd}{\sqrt{s0}}} \quad \text{.......41}$$

Calculation Tc with formula:

Tc = To + Tf.......42

Tabel 16 Calculation of Tc

No	Channel Segment	To (minutes)	To (hour)	Tf (minutes)	Tf (hour)	Tc (minutes	Tc (hour)
1	S. T Darmo Puncak Permai	1203,18	20,05	132,48	2,21	1335,66	22,26
2	S.T Jl. Bima Sakti	760,63	12,68	23,54	0,39	784,18	13,07
3	S.T Jl. Raya Satelit Utara 1	318,08	5,30	8,91	0,15	326,99	5,45
4	S.T Jl. Raya Satelit Utara	290,42	4,84	7,08	0,12	297,51	4,96
5	S.T Jl. Satelit Utara 6	262,76	4,38	8,63	0,14	271,39	4,52
6	Saluran Sekunder	1576,59	26,28	46,41	0,77	1622,99	27,05

3.6 Rain Intensity Calculation

The intensity of the rain varies. The time of rainfall greatly affects the magnitude of the intensity of rain To calculate the intensity of rain can use the formula Dr. Monoboe, which is as follows :

$$I = \frac{R_{24}}{24}\ x \left(\frac{24}{t}\right)^{2/3} \quad \ldots 43$$

Tabel 17 Calculation of rain intensity

No	Channel Segment	Tc (hour)	R2 (mm)	R5 (mm)	R10 (mm)	I (mm/hour) 2 Tahun	5 Tahun	10 Tahun
1	S. T Darmo Puncak Permai	22,26	85,83	101,08	107,77	3,76	4,43	4,72
2	S.T Jl. Bima Sakti	13,07	85,83	101,08	107,77	5,36	6,32	6,73
3	S.T Jl. Raya Satelit Utara 1	5,45	85,83	101,08	107,77	9,61	11,32	12,06
4	S.T Jl. Raya Satelit Utara	4,96	85,83	101,08	107,77	10,23	12,05	12,85
5	S.T Jl. Satelit Utara 6	4,52	85,83	101,08	107,77	10,88	12,81	13,66
6	Saluran Sekunder	27,05	85,83	101,08	107,77	3,30	3,89	4,15

3.7 Calculation of The Flow Coefficient (C)

Tabel 18 Calculation of The Flow Coefficient (C)

No.	Jenis Guna Lahan	Luas Area (Ha)	Koefisien Pengaliran (C)	AC	C gabungan
1	Jalan Aspal	5,31	0,85	4,51	
2	RTH	4,78	0,1	0,48	
3	Settlements	20,39	0,75	15,30	0,70
4	Public Facilities	1,78	0,6	1,07	
5	Trade and Services	26,05	0,75	19,53	

3.8 Flood Discharge Analysis Plan

By using the rational method of calculating flood discharge plan, from the data that has been obtained above it can be calculated flood discharge plan with the formula

$$\boldsymbol{Q = \frac{1}{3,6} . \beta . C_{gab} . It . A} \quad \ldots 44$$

β = 1 , based on the table of Rain Spreading Coefficient (β) with watershed area DAS 0,29 Km2

Table 19 Calculation of Flood Discharge Plan

No	Channel Segment	C	β	I (mm)/hour 2 Tahun	5 Tahun	10 Tahun	A (km²)	Q plan (m³/det) 2 Tahun	5 Tahun	10 Tahun
1	S. T Darmo Puncak Permai	0,70	1	3,76	4,43	4,72	0,29	0,21	0,25	0,26
2	S.T Jl. Bima Sakti	0,69	1	5,36	6,32	6,73	0,08	0,08	0,10	0,11
3	S.T Jl. Raya Satelit Utara 1	0,74	1	9,61	11,32	12,06	0,08	0,15	0,18	0,19
4	S.T Jl. Raya Satelit Utara	0,72	1	10,23	12,05	12,85	0,08	0,16	0,19	0,20
5	S.T Jl. Satelit Utara 6	0,73	1	10,88	12,81	13,66	0,06	0,12	0,15	0,16
6	Saluran Sekunder	0,70	1	3,30	3,89	4,15	0,58	0,38	0,44	0,47

3.9 Channel Capacity Analysis (Full Bank Capacity)

Full Bank Capacity is the amount of discharge on the channel according to the conditions in the field. This calculation is needed to find out how much the cross-sectional ability of the channel to accommodate rainwater runoff

Table 20 Full Bank Capacity in Tertiary Channel

No	Channel Segment	Penampang Saluran	L (m)	I	n koef	b (m)	h (m)	A (m²)	P (m)	R (m)	V (m/dt)	Q eks (m³/dt)
1	S. T Darmo Puncak Permai	square	870	0,016	0,350	0,5	0,5	0,25	1,5	0,17	0,11	0,03
2	S.T Jl. Bima Sakti	square	550	0,002	0,033	0,5	0,5	0,25	1,5	0,17	0,39	0,10
3	S.T Jl. Raya Satelit Utara 1	square	230	0,002	0,033	0,5	0,5	0,25	1,5	0,17	0,43	0,11
4	S.T Jl. Raya Satelit Utara	square	210	0,003	0,033	0,5	0,5	0,25	1,5	0,17	0,49	0,12
5	S.T Jl. Satelit Utara 6	square	190	0,002	0,033	0,5	0,5	0,25	1,5	0,17	0,37	0,09
6	Saluran Sekunder	trapesium	114 0	0,001	0,003	4,2	0,91	3,82	6,02	0,63	0,41	11,41

3.10 Comparison of Existing Channel Capacity with Plan Debit

For more detail in analyzing the comparison of existing channel capacity with the discharge plan on the Darmo satellite drainage channel, it can be seen in the table

Tabel 20 Perbandingan Obtained debit planPeriode Ulang 2 Tahunan Saluran tersier:

No	Channel Segment	Q plan (m³/det)	Q eksisting (m³/det)	difference	Information
1	S. T Darmo Puncak Permai	0,21	0,03	-0,18	SPILLING OUT
2	S.T Jl. Bima Sakti	0,08	0,10	0,01	SAFE
3	S.T Jl. Raya Satelit Utara 1	0,15	0,11	-0,04	SPILLING OUT
4	S.T Jl. Raya Satelit Utara	0,16	0,12	-0,04	SPILLING OUT
5	S.T Jl. Satelit Utara 6	0,12	0,09	-0,03	SPILLING OUT

Tabel 21 Perbandingan Obtained debit planPeriode Ulang 5 Tahunan Saluran tersier:

No	Channel Segment	Q plan (m^3/det)	Q eksisting (m^3/det)	difference	Information
1	S. T Darmo Puncak Permai	0,25	0,03	-0,22	SPILLING OUT
2	S.T Jl. Bima Sakti	0,10	0,10	0,00	SPILLING OUT
3	S.T Jl. Raya Satelit Utara 1	0,18	0,11	-0,07	SPILLING OUT
4	S.T Jl. Raya Satelit Utara	0,19	0,12	-0,07	SPILLING OUT
5	S.T Jl. Satelit Utara 6	0,15	0,09	-0,05	SPILLING OUT
6	saluran sekunder	0,44	11,41	10,97	SAFE

3.11 Nakayasu's Method of Calculation

The first step taken in calculating the plan's discharge with the Nakayasu HSS method is to calculate the average rain (Rt) from the 1st hour to the 5th hour according to the optimal duration of the rain plan which is 5 hours. After the average rain is known, then the next calculated high rain (Rt') from the 1st hour to the 5th hour. Here is a calculation of the average rain and high rain from the 1st hour to the 5th hour.

Tabel 22 calculation of debit channel Secondary Darmo Satellite PUH 5 Years

T	U (t,l)	Due to rain					Q5
		R1(mm)	R2(mm)	R3(mm)	R4(mm)	R5(mm)	
(hour)	(m3/det)	60,71	15,67	11,10	8,82	7,47	(m3/det)
0,00	0,0000	0,0000					0,0000
0,10	0,0008	0,0474					0,0474
0,20	0,0041	0,2500					0,2500
0,30	0,0109	0,6617					0,6617
0,40	0,0217	1,3197					1,3197
0,50	0,0371	2,2546					2,2546
0,60	0,0575	3,4923					3,4923
0,70	0,0833	5,0557					5,0557
0,80	0,1147	6,9656					6,9656
0,90	0,1522	9,2411					9,2411
1,00	0,1960	11,8999	0,0000				11,8999
1,03	0,2105	12,7799	3,2987				16,0786
1,10	0,1754	10,6466	2,7481				13,3947
1,20	0,1350	8,1965	2,1157				10,3122
1,30	0,1039	6,3102	1,6288				7,9390
1,40	0,0800	4,8580	1,2540				6,1120
1,49	0,0632	3,8340	0,9896				4,8236
1,50	0,0621	3,7711	0,9734				4,7445
1,60	0,0522	3,1677	0,8176				3,9853
1,70	0,0438	2,6608	0,6868				3,3477
1,80	0,0368	2,2351	0,5769				2,8120
1,90	0,0309	1,8775	0,4846				2,3621
2,00	0,0260	1,5771	0,4071	0,0000			1,9841
2,10	0,0218	1,3247	0,3419	0,2423			1,9090
2,18	0,0189	1,1502	0,2969	0,2104			1,6574
2,20	0,0185	1,1220	0,2896	0,2052			1,6168
2,30	0,0162	0,9845	0,2541	0,1801			1,4187
2,40	0,0142	0,8638	0,2230	0,1580			1,2448
2,50	0,0125	0,7579	0,1956	0,1386			1,0922
2,60	0,0110	0,6650	0,1717	0,1216			0,9583
2,70	0,0096	0,5835	0,1506	0,1067			0,8408
2,80	0,0084	0,5120	0,1321	0,0936			0,7378
2,90	0,0074	0,4492	0,1160	0,0822			0,6473
3,00	0,0065	0,3941	0,1017	0,0721	0,0000		0,5680
3,10	0,0057	0,3458	0,0893	0,0633	0,0502		0,5486
3,20	0,0050	0,3034	0,0783	0,0555	0,0441		0,4814
3,30	0,0044	0,2662	0,0687	0,0487	0,0387		0,4224
3,40	0,0038	0,2336	0,0603	0,0427	0,0339		0,3706
3,50	0,0034	0,2050	0,0529	0,0375	0,0298		0,3252
3,60	0,0030	0,1798	0,0464	0,0329	0,0261		0,2853
3,70	0,0026	0,1578	0,0407	0,0289	0,0229		0,2503
3,80	0,0023	0,1385	0,0357	0,0253	0,0201		0,2196
3,90	0,0020	0,1215	0,0314	0,0222	0,0177		0,1927
4,00	0,0018	0,1066	0,0275	0,0195	0,0155		0,1691
4,10	0,0015	0,0935	0,0241	0,0171	0,0136		0,1484
4,20	0,0014	0,0821	0,0212	0,0150	0,0119		0,1302
4,30	0,0012	0,0720	0,0186	0,0132	0,0105		0,1142
4,40	0,0010	0,0632	0,0163	0,0116	0,0092		0,1002
4,50	0,0009	0,0554	0,0143	0,0101	0,0081		0,0879
4,60	0,0008	0,0486	0,0126	0,0089	0,0071		0,0772
4,70	0,0007	0,0427	0,0110	0,0078	0,0062		0,0677
4,80	0,0006	0,0374	0,0097	0,0068	0,0054		0,0594
4,90	0,0005	0,0329	0,0085	0,0060	0,0048		0,0521
5,00	0,0005	0,0288	0,0074	0,0053	0,0042	0,0000	0,0457
5,10	0,0004	0,0253	0,0065	0,0046	0,0037	0,0031	0,0432
5,20	0,0004	0,0222	0,0057	0,0041	0,0032	0,0027	0,0379

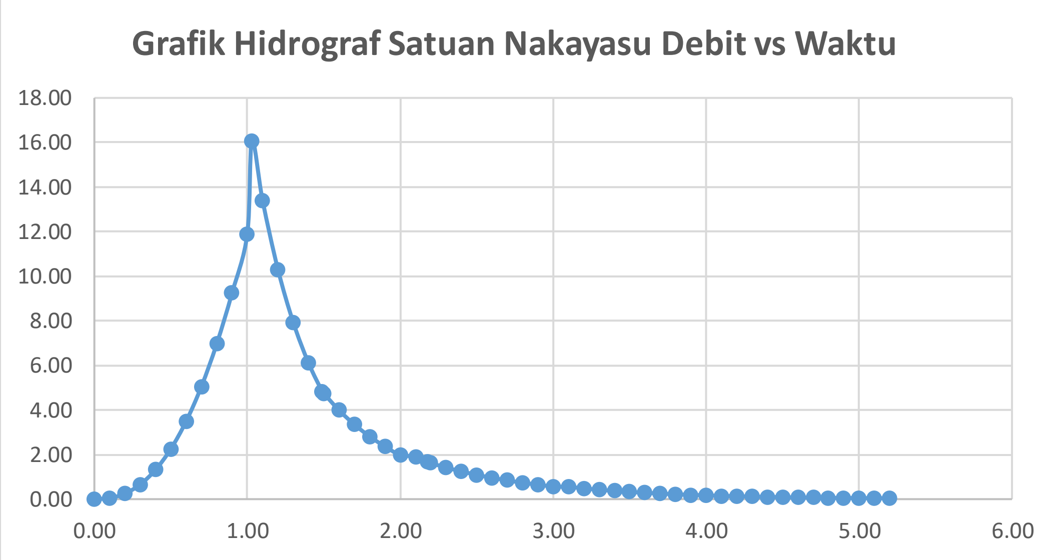

Figure 3 Flood Hydrograph on Secondary Channel (DAS) Darmo Satellite

In column 1 of table 4.31 entered the value t, which is the hydrograph period with an interval of 0.1 hours. Pool 2 is the unit discharge value based on the calculation of hydrograph units. Columns 3 to column 7 are the result of multiplication of unit discharge values with effective rain height that occurs. There are 5 pieces of effective rain in this calculation. 60,71; 15,67; 11,10; 8,82; dan 7,47 mm. so column 3 = 60,71 x column 2. column 4 = 15,67x column 2. And so on until column 7. Column 8 It is a total hydrograph due to the five rains above. Figure is a hydrograph resulting from table calculations.

3.12 Flood Management

Flood Management on the tertiary channel Darmo Puncak Permai, Milky Way, Northern Satellite Kingdom 1, Northern Satellite Kingdom and North Satellite 6 by planning the dimensions of the channel using a culvert box.

Table 23 Calculation of channel type changes

No	Channel Segment	p saluran	L (m)	I	n koef	b (m)	h (m)	A (m²)	P (m)	R (m)	V (m/dt)	Q eks (m³/dt)
1	S. T Darmo Puncak Permai	square	870	0,016	0,010	0,5	0,5	0,25	1,5	0,17	3,83	0,96
2	S.T Jl. Bima Sakti	square	550	0,002	0,010	0,5	0,5	0,25	1,5	0,17	1,28	0,32
3	S.T Jl. Raya Satelit Utara 1	square	230	0,002	0,010	0,5	0,5	0,25	1,5	0,17	1,42	0,36
4	S.T Jl. Raya Satelit Utara	square	210	0,003	0,010	0,5	0,5	0,25	1,5	0,17	1,63	0,41
5	S.T Jl. Satelit Utara 6	square	190	0,002	0,010	0,5	0,5	0,25	1,5	0,17	1,21	0,30

Tabel 24 Re-Design 2-Year Re-Period Tertiary Channels

No	Channel Segment	Q plan (m³/det)	Q eksisting (m³/det)	difference	Information
1	S. T Darmo Puncak Permai	0,21	0,96	0,75	SAFE
2	S.T Jl. Bima Sakti	0,08	0,32	0,24	SAFE
3	S.T Jl. Raya Satelit Utara 1	0,15	0,36	0,20	SAFE
4	S.T Jl. Raya Satelit Utara	0,16	0,41	0,25	SAFE
5	S.T Jl. Satelit Utara 6	0,12	0,30	0,18	SAFE

Tabel 25 Re-Design 5-Year Re-Period Tertiary Channels:

No	Channel Segment	Q plan (m^3/det)	Q eksisting (m^3/det)	difference	Information
1	S. T Darmo Puncak Permai	0,25	0,96	0,71	SAFE
2	S.T Jl. Bima Sakti	0,10	0,32	0,22	SAFE
3	S.T Jl. Raya Satelit Utara 1	0,18	0,36	0,18	SAFE
4	S.T Jl. Raya Satelit Utara	0,19	0,41	0,22	SAFE
5	S.T Jl. Satelit Utara 6	0,15	0,30	0,16	SAFE

4. Conclussion

Based on the analysis and calculations that have been done can be concluded as follows::

1. Based on the results of analysis and calculation of existing flood discharge hydrology:
   a. In the tertiary channel Darmo Puncak Permai on the birthday of 2 years with a rational method of 0,03 m3/det, Bima Sakti 0,1 m3/det, Raya Satelit Utara 1 as much as 0,11 m3/det , Raya Satelit Utara as much as 0,12 m3/det and Satelit Utara 6 as much as 0,09 m3/det
   b. Di saluran Sekunder Darmo Satelit pada kala ulang 5 tahun dengan metode rasional as much as 11,41 m3/det.
   c. Pada kala ulang 5 tahun dengan metode perhitungan nakayasu diperoleh debit puncak 16,0786 m3/det

2. Berdasarkan hasil analisis dan perhitungan perbandingan obtained debit plandengan dimensi saluran yang ada:
   a. Pada kala ulang 2 tahun di saluran tersier
      1) S. T Darmo Puncak Permai obtained debit plan0,21 m^3/det and existing debit 0,03 m^3/det.
      2) S.T Jl. Bima Sakti obtained debit plan 0,08 m^3/det and existing debit 0,10 m^3/det.
      3) S.T Raya Satelit Utara 1 obtained debit plan0,15 m^3/det and existing debit 0,11 m^3/det.
      4) S.T Raya Satelit Utara obtained debit plan0,16 m^3/det and existing debit 0,12 m^3/det.
      5) S.T Raya Satelit Utara 6 obtained debit plan0,12 m^3/det and existing debit 0,09 m^3/det.
   b. Pada kala ulang 5 tahun di saluran tersier dan sekunder
      1) S. T Darmo Puncak Permai obtained plan discharge of 0,25 m3/second and existing discharge of 0,03 m3/det.
      2) S.T Jl. Bima Sakti obtained plan discharge 0,10 m3/det and existing debit 0,10 m3/det.
      3) S.T Raya Satelit Utara 1 obtained plan discharge 0,18 m3/det and existing debit 0,11 m3/det.
      4) S.T Raya Satelit Utara obtained plan discharge 0,19 m3/det and existing debit 0,12 m3/det.
      5) S.T Raya Satelit Utara 6 obtained plan discharge 0,15 m3/det and existing debit 0,09 m3/det.
      6) S. S Darmo Satelit obtained plan discharge 0,44 m3/det and existing debit 11,41 m3/det.

3. Based on the results of analysis and calculation of channel dimensions that correspond to the debit plan:
   a. S. T Darmo Puncak Permai using the box culvert 0,5 x 0,5 m.
   b. S.T Jl. Bima Sakti using the box culvert 0,5 x 0,5 m.
   c. S.T Raya Satelit Utara 1 using the box culvert 0,5 x 0,5 m.
   d. S.T Raya Satelit Utara using the box culvert 0,5 x 0,5 m.
   e. S.T Raya Satelit Utara 6 using the box culvert 0,5 x 0,5 m.

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