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ANALYSIS FLOOD AND CHANNEL CAPACITY IN SUB DRAIN SAWOJAJAR OF BANGO WATERSHED MALANG

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ABSTRAK

Perubahan iklim global telah mengintensifkan curah hujan ekstrem di Kota Malang, menyebabkan seringnya genangan di kawasan Sawojajar, khususnya di sepanjang Jl. Danau Kerinci hingga Jl. Danau Sentani Raya. Penelitian ini bertujuan untuk menganalisis kapasitas sistem drainase yang ada dan mendesain ulang dimensi saluran menggunakan simulasi EPA SWMM 5.2. Data yang digunakan meliputi catatan curah hujan 10 tahun (2015-2024) dari tiga stasiun (Ciliwung, Jabung, Sukun) dan data primer lapangan. Curah hujan desain, yang dihitung melalui Log Pearson Tipe III dan divalidasi, adalah 129,394 mm/hari untuk periode ulang 10 tahun. Hasil simulasi menunjukkan bahwa segmen drainase yang ada (H hingga M), dengan kapasitas berkisar antara 0,732 m3/s hingga 0,846 m3/s, tidak mampu menampung debit desain periode ulang 10 tahun (1,464 m3/s hingga 2,829 m3/s), sehingga diperlukan desain ulang. Segmen yang didesain ulang menggunakan saluran U-Ditch 100 cm x 120 cm (tinggi efektif 105 cm), yang berhasil meningkatkan kapasitas aliran (2,772 m3/s hingga 3,201 m3/s) dan mencegah luapan untuk periode ulang 10 tahun. Namun, dimensi ini terbukti tidak mencukupi untuk periode ulang 25 tahun. Estimasi total biaya untuk rekonstruksi drainase ini adalah Rp 2.001.282.000,00. Penelitian ini menawarkan rekomendasi teknis untuk meningkatkan drainase perkotaan dan mendorong infrastruktur yang tangguh terhadap banjir.

Kata kunci : Drainase, EPA SWMM, redesain, banjir.

ABSTRACT

Global climate change has intensified extreme rainfall in Malang City, leading to frequent inundation in the Sawojajar area, particularly along Jl. Danau Kerinci to Jl. Danau Sentani Raya. This study aimed to analyze the existing drainage system's capacity and redesign channel dimensions using EPA SWMM 5.2 simulation. Data utilized included 10-year rainfall records (2015-2024) from three stations (Ciliwung, Jabung, Sukun) and primary field data. Design rainfall, calculated via Log Pearson Type III and validated, was 129.394 mm/day for a 10-year return period. Simulation results indicated that existing drainage segments (H to M), with capacities ranging from 0.732 m^3/s to 0.846 m^3/s, were unable to accommodate the 10-year return period design discharge (1.464 m^3/s to 2.829 m^3/s), necessitating redesign. The redesigned segments implemented 100 cm x 120 cm U-Ditch channels (105 cm effective height), which successfully increased flow capacity (2.772 m^3/s to 3.201 m^3/s) and prevented overflow for the 10-year return period. However, these dimensions proved insufficient for a 25-year return period. The estimated total cost for this drainage reconstruction is Rp 2,001,282,000.00. This research offers technical recommendations for improving urban drainage and fostering flood-resilient infrastructure.

***Keywords** : Drainage, EPA SWMM, channel redesign, flooding.*

1. INTRODUCTION

Global climate change has intensified extreme rainfall, leading to increased surface runoff and frequent urban flooding, notably in Malang City. The Sawojajar area, specifically Jl. Danau Kerinci - Jl. Danau Sentani Raya, consistently suffers from inundation due to an insufficient existing drainage system. This recurring issue highlights the urgent need for a comprehensive evaluation of current drainage capacity and performance. This study aims to analyze the maximum flood discharge, assess existing channel capacity, determine the 10-year return period design flood using EPA SWMM, and provide a cost estimation for the necessary drainage redesign. The findings are intended to offer technical recommendations for improving flood resilience and promoting sustainable drainage infrastructure in Malang.

2. METHOD

The initial stage of this study involved comprehensive data collection. Topographic maps were utilized to define the study area (Sawojajar sub-drain, 18 ha), identify existing channel layouts, and determine elevation points. For hydrological analysis, rainfall data from 2015-2024, sourced from Ciliwung, Jabung, and Sukun stations, was collected. This data was crucial for testing consistency using the Double Mass Curve method, calculating regional average rainfall, determining the 10-year return period design rainfall (129.394 mm/day) via the Log Pearson Type III Distribution, and validating the distribution's fit through Smirnov-Kolmogorov and Chi-Square tests. The rainfall intensity and design flood discharge were subsequently calculated. Existing channel dimensions were obtained through direct field measurements to evaluate their current capacity.

Following data collection, hydraulic analysis commenced with the evaluation of existing channel capacity. This analysis, along with the simulation of drainage performance, was primarily conducted using EPA SWMM 5.2 software. The findings from this simulation guided the planning of new channel dimensions, specifically using U-ditch, to accommodate the design discharge. Finally, a detailed cost estimation was performed, involving the calculation of the Bill of Quantity (BOQ) and the Unit Price Analysis (AHSP), utilizing the Standard Price Unit Analysis (HSPK) for Malang City in 2024.

3. RESULT AND DISCUSSION

A. Hydrologi Analysis

In the planning of this drainage system, rainfall data from three rain gauge stations closest to the planning location were used: Ciliwung station, Jabung station, and Sukun station. The collected rainfall data covers the last 10 years, from 2015 to 2024. This data consists of annual maximum daily rainfall records, which will then be processed through a Rainfall Data Consistency Test to check for any data inaccuracies. The consistency test is performed by comparing the annual maximum daily rainfall data for each station separately. The consistency test is structured using a table containing the annual maximum daily rainfall data, with comparisons made for each station as follows:

1) Ciliwung Station Consistency Test

The cumulative average values from Jabung Station and Sukun Station were obtained and plotted as the X-axis values, while the cumulative values from Ciliwung Station were plotted as the Y-axis values in the double mass curve graph.

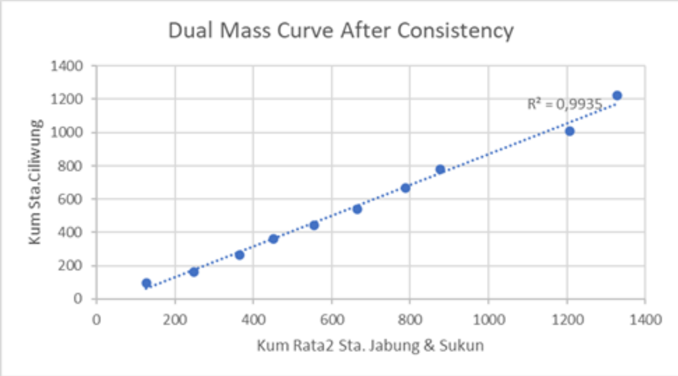

Figure 1. Double Mass Curve Graph of Ciliwung Station Against Jabung & Sukun Stations After Consistency

Soruce: Result Analysis

Based on the double mass curve analysis graph for Ciliwung Station (Figure1), there is no longer a significant change in slope, as indicated by an R^2 value of 0.9935. Therefore, it can be concluded that Ciliwung Station data is consistent with the other two stations, and no further data correction or re-testing is required.

2) Jabung Station Consistency Test

The cumulative average values from Sukun Station and Ciliwung Station were obtained and plotted as the X-axis values, while the cumulative values from Jabung Station were plotted as the Y-axis values in the double mass curve graph.

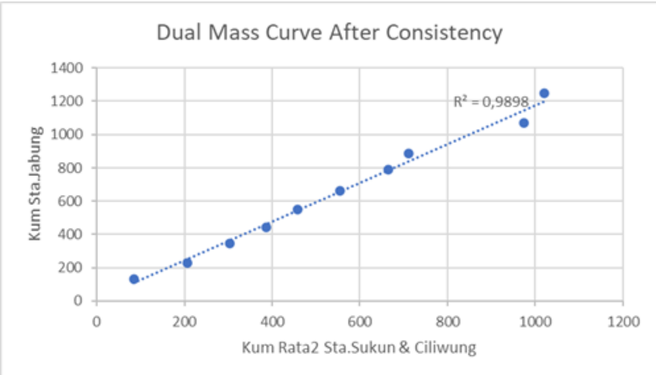

Figure 2. Double Mass Curve Graph of Jabung Station Against Sukun & Ciliwung Stations After Consistency

Source: Result Analysis

Based on the double mass curve analysis graph for Ciliwung Station (Figure 2), there is no longer a significant change in slope, as indicated by an R^2 value of 0.9935. Therefore, it can be concluded that Ciliwung Station data is consistent with the other two stations, and no further data correction or re-testing is required

3) Sukun Station Consistency Test

The cumulative average values from Ciliwung Station and Jabung Station were obtained and plotted as the X-axis values, while the cumulative values from Sukun Station were plotted as the Y-axis values in the double mass curve graph.

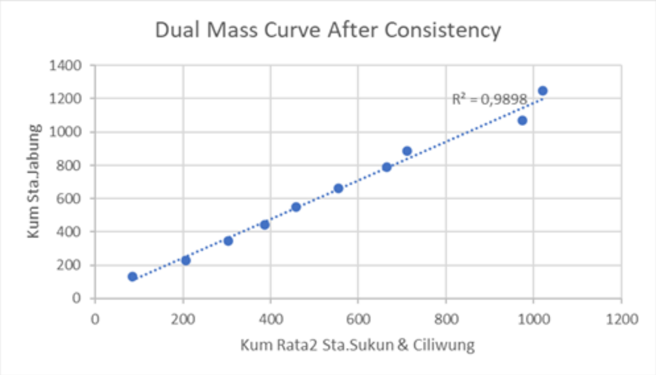

Figure 3. Double Mass Curve Graph of Sukun Station Against Ciliwung & Jabung Stations After Consistency

Soruce: Result Analysis

Based on the double mass curve analysis graph for Sukun Station (Figure 3), there is no longer a significant change in slope, as indicated by an R^2 value of 0.9967. Therefore, it can be concluded that Sukun Station data is consistent with the other two stations, and no further data correction or re-testing is required.

4) Regional Rainfall

Regional rainfall calculation using the algebraic average method. The results of the regional rainfall calculation are as follows:

Table 1. Regioanl Rainfall Average 3 Station

Year	Date	Sta. Ciliwung F 2015-2024 2,252	Sta. Jabung F 2015-2024 0,494	Sta. Sukun F 2015-2024 1,765	Average	Max
2015	3 - Mei	98,000	27,000	0,000	41,667	
	02-Mar	0,000	84,000	7,000	30,333	56,667
	29-Mar	0,000	0,000	170,000	56,667	
2016	12-Apr	64,000	20,000	56,000	46,667	
	11-Apr	0,000	122,000	0,000	40,667	67,333
	29-Jun	45,000	35,000	122,000	67,333	
2017	04-Apr	104,000	0,000	56,000	53,333	
	25-Jan	79,000	98,000	0,000	59,000	59,000
	01-Jan	0,000	0,000	132,000	44,000	
2018	21-Jun	97,000	10,000	64,000	57,000	
	19-Jan	59,000	82,000	0,000	47,000	57,000
	24-Feb	0,000	0,000	94,000	31,333	
2019	11-Feb	82,000	7,000	0,000	29,667	70,667
	19-Mar	2,000	72,000	24,000	32,667	
	10-Feb	56,000	21,000	135,000	70,667	
2020	22-Mar	97,000	29,000	0,000	42,000	
	13-Dec	0,000	96,000	47,000	47,667	47,667
	31-Mar	0,000	7,000	125,000	44,000	
2021	06-Jan	123,000	17,000	42,000	60,667	
	16-Mar	10,000	111,000	8,000	43,000	82,667
	13-Jan	32,000	83,000	133,000	82,667	
2022	15-Mar	115,000	**12,839**	**111,217**	79,685	
	01-Apr	50,000	**46,910**	**26,480**	41,130	79,685
	28-Nov	29,000	**11,851**	**144,758**	61,870	
2023	09-Feb	**229,718**	**11,851**	**12,357**	84,642	
	01-Feb	**18,017**	**261,709**	**15,888**	98,538	150,411
	25-Mar	**175,666**	**39,009**	**236,556**	150,411	
2024	03-Apr	**211,701**	**4,444**	**37,072**	84,406	
	01-Feb	**92,337**	**47,404**	**45,899**	61,880	150,784
	21-Oct	**189,179**	**5,432**	**257,740**	150,784	

Source: Calculation

5) Design Rainfall

Design rainfall is the highest annual rainfall that may occur in a particular area with a specific return period. This calculation is used with a five-year return period. To determine the appropriate distribution method, one must first find the coefficient of skewness (Cs) and the coefficient of kurtosis (Ck).

Table 2. Frequency Distribution Selection Requirements

No	Frequency Distribution	Distribution Terms Cs	Ck
1	Normal	0	3
2	Log Normal	0	>3
3	Gumbel	1,14	5,4
4	Pearson Type III	Fleksibel	Fleksibel
5	**Log Pearson Type III**	**Apart from the above values**	

Source: (Anita Rahmawati, 2015)

From the calculations (Table 2), a Cs value of 1.046 and a Ck value of 0.719 were obtained. Based on the distribution selection table, since the Cs value is not equal to 0 ($Cs \neq 0$), it meets the requirements for the Log Pearson Type III distribution. Therefore, the Log Pearson Type III distribution is the one used. In this distribution, all data must first be converted into logarithmic form. The equation for the design rainfall is as follows:

$$\log X_T = \overline{\log X} + K \cdot S_{\log X}$$

Where:

Log X_T = Logarithm of the design rainfall for a T-year return period
Log X = Mean of the logarithmic rainfall data
G/K = Frequency factor
$Slog_x$ = Standard deviation of the logarithmic rainfall data
Here is the determination of the G/K value and the stages of the Design Rainfall calculation:

$\log X_T = \overline{\log X} + K \cdot S_{\log X}$
= 1,881 + 1,341 . 0,172
= 2,112

R_{design} = $10^{log} = 10^{2,112}$ = 129,394 mm/day
So the design rainfall is 129,394 mm/day.

6) Distribution Confirmity Test

Horizontal deviation (probability) is tested with the Smirnov-Kolmogorov Test, while vertical deviation (rainfall) is tested with the Chi-Square Test. The largest absolute deviation value between the empirical and theoretical probabilities is compared to the critical D0 value found in a table at a certain confidence level and for a specific number of data points. If the calculated D0 value is less than the table's D0, the distribution can be accepted.

For the Chi-Square Test, the total deviation value is calculated with the following equation: The calculated X hit2 value is compared to the X 2 value for a specific degree of freedom. The degrees of freedom for rainfall distribution testing are calculated as n−1−2, where n is the number of data points. Here is the calculation for the Distribution Conformity Test:

Table 3. Conformity Test of Log Pearson Type III

Year	Average Regional Rainfall (mm)	Log R	Log largest sequence	*Pe Empiris*	K	*Pt Teoritis*	Δ_{max}
2024	150,784	2,178	2,1784	0,091	1,727	0,065	0,026
2023	150,411	2,177	2,1773	0,182	1,720	0,065	0,117
2021	82,667	1,917	1,9173	0,273	0,211	0,355	0,083
2022	79,685	1,901	1,9014	0,364	0,118	0,387	0,023
2019	70,667	1,849	1,8492	0,455	-0,185	0,506	0,051
2016	67,333	1,828	1,8282	0,545	-0,306	0,559	0,014
2017	59,000	1,771	1,7709	0,636	-0,640	0,708	0,072
2018	57,000	1,756	1,7559	0,727	-0,727	0,746	0,019
2015	56,667	1,753	1,7533	0,818	-0,741	0,753	0,066
2020	47,667	1,678	1,6782	0,909	-1,178	0,916	0,007
Total (∑)		18,810					
Average		1,881		**Δmax**			**0,117**
Standard Deviation		0,172					
Lots of data (n)		10					
CS		1,046					

Source: Calculation

If Δcount ≤ Δcritical then the null hypothesis (the data follows the distribution) is accepted.
If Δcount > Δcritical, hen the null hypothesis is rejected.
Comparison Δcount ≤ Δcritical = 0,117 ≤ 0,410 (Accepted)
Thus, the annual rainfall data is considered to fit the Log Pearson Type III distribution at the 95% confidence level. Since the results met the criteria, the distribution used is appropriate for the available rainfall data.

7) Calculate Hourly Rainfall Distribution

To run an accurate hydrological simulation with EPA SWMM 5.2, hourly rainfall distribution data is required. This data is crucial for representing the varying intensity of rainfall over time, which directly affects the drainage system's response. Here are the results of the calculation:

Table 4. Rainfall Distribution and Effective Rainfall Distribution

Hour to-(t)	Rainfall Distribution (R_T) 1 Hourly		Rainfall Hour to-		Rasio (%)	cumulative (%)
1	0,550	R_{24}	0,550	R_{24}	55,03%	55,03%
2	0,347	R_{24}	0,143	R_{24}	14,30%	69,34%
3	0,265	R_{24}	0,100	R_{24}	10,03%	79,37%
4	0,218	R_{24}	0,080	R_{24}	7,99%	87,36%
5	0,188	R_{24}	0,067	R_{24}	6,75%	94,10%
6	0,167	R_{24}	0,059	R_{24}	5,90%	100,00%

Source: Calculation

Net Rainfalltotal = Design Rainfall x Runoff Coefficient (C)
Given runoff coefficient = 0,400
Net Rainfalltotal = 129,394mm x 0,4 = 51,757
After that calculate the effective net rainfall
Net Hourly Rainfall = Net Rainfalltotal x Hourly Percentage
Net Hourly Rainfall = 51,757 x 0,550 (55,03%) = 28,483

Table 5. Net Effective Rainfall Calculation

No	Hour to t	Rain Percentage Hour to-t	Net Rainfall hour (mm/hour) 2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
1	1	55,03%	15,638	22,552	**28,483**	37,786	46,226	56,147
2	2	14,30%	4,065	5,862	**7,403**	9,821	12,015	14,594
3	3	10,03%	2,851	4,112	**5,193**	6,889	8,428	10,237
4	4	7,99%	2,270	3,274	**4,134**	5,485	6,710	8,150

5	5	6,75%	1,917	2,764	**3,491**	4,632	5,666	6,882
6	6	5,90%	1,676	2,416	**3,052**	4,049	4,953	6,016
		100,00%						
Net Rainfall	**(mm/day)**		**28,42**	**40,98**	**51,76**	**68,66**	**84,00**	**102,03**

Source: Calculation

So the data that entered into the SWMM 5.2 application is the 10-year return period.

B. Hydarulic Analysis

The initial stage of hydraulic analysis calculations for the Jl. Danau Kerinci - Jl. Danau Sentani Raya area in Malang City involves calculating the existing capacity of the area's drainage channels. If the existing channel capacity is insufficient to accommodate the water, leading to overflow and flooding, then an alternative plan for redesigning the existing channel dimensions will be carried out.

1) Calculating of Existing Dimension

Here is the calculation of the existing channel dimensions example for channel H-I:

a. Calculating the wetted area of the channel
b = 0,84 m
h = 0,85 m
width (A) = b x h
= 0,84 x 0,85
= 0,714 m^2

b. Calculating the wetted perimeter of the channel
P = b + (2 x h)
= 0,84 + (2 x 0,85)
= 2,540 m

c. Calculating the hydraulic radius
R = A/P
= 0,715 / 2,540
= 0,281 m

d. Calculating the existing flow velocity of the channel
Vexsiting $= \frac{1}{n} \times R^{2/3} \times \sqrt{S}$
$= \frac{1}{0,025} \times 0,281^{2/3} \times \sqrt{0,004}$
= 1,026 m/s

e. Control of the velocity
The flow velocity for river stone material should not exceed the maximum velocity of 3 m/s, while its minimum velocity is 0.2 m/s.
Requirement: Vmax ≥ Vcount ≥ Vmin
3 m/sec ≥ 1,026 m/sec ≥ 0,2 m/sec = (fulfilled)

f. Control ot the Froude number
For flow control in the channel, a Froude number of < 1 is specified. The Froude number for this channel is
Fr $= F_r = \frac{Veksisting}{\sqrt{g \cdot h}}$
$= F_r = \frac{1,026}{\sqrt{9,81 \cdot 0,85}}$
= 0,355 (fulfilled)

g. Calculating the channel discharge
Q existing = V existing x A
= 1,026 x 0,714
= 0,732 m^3/sec

h. Control of the channel discharge
The calculated discharge must be greater than or equal to the design discharge. The design discharge is 1.464 m^3/sec, therefore:
Q existing ≥ Q planned
0,732 ≥ 1,464 (does not fulfilled)
As seen from the channel control above, the dimensions of channel H-I cannot accommodate the discharge and are not sufficient. Therefore, channel H-I requires a redesign of its dimensions.

2) Calculating of New Dimension

Here is the calculatrion of the new channel dimension example for channel H-I:

a. Calculating the wetted are of the channel
b = 1 m
h = 1,05 m
width (A) = b x h
= 1 x 1,05
= 1,050 m^2

b. Calculating the wetted perimeter of the channel
P = b + (2 x h)
= 1 + (2 x 1,050)
= 3,100 m

c. Calculating the hydraulic radius
R = A/P
= 1,050 / 3,100
= 0,339 m

d. Calculating the existing flow velocity of the channel
Vcalculation $= \frac{1}{n} \times R^{2/3} \times \sqrt{S}$
$= \frac{1}{0,011} \times 0,339^{2/3} \times \sqrt{0,004}$
= 2,640 m/s

e. Control of the velocity
The flow velocity for river stone material should not exceed the maximum velocity of 3 m/s, while its minimum velocity is 0.2 m/s.
Requirement: Vmax ≥ Vcount ≥ Vmin
3 m/sec ≥ 2,640 m/sec ≥ 0,2 m/sec = (fulfilled)

f. Control ot the Froude number
For flow control in the channel, a Froude number of < 1 is specified. The Froude number for this channel is
Fr $= F_r = \frac{Veksisting}{\sqrt{g \cdot h}}$
$= F_r = \frac{2,640}{\sqrt{9,81 \cdot 1,050}}$
= 0,823 (fulfilled)

g. Calculating the channel discharge
Q calculation= V calcaulation x A
= 2,640 x 1,050
= 2,772 m^3/sec

h. Control of the channel discharge
The calculated discharge must be greater than or equal to the design discharge. The design discharge is 1.464 m^3/sec, therefore:
Q calculation ≥ Q planned
2,772 ≥ 1,464 (fulfilled)

3) Modeling Using SWMM 5.2 Application

Drainage analysis requires hourly rainfall and field survey data. Rainfall is used for simulation, while field data (dimensions, topography) models the existing system, enabling evaluation and redesign.

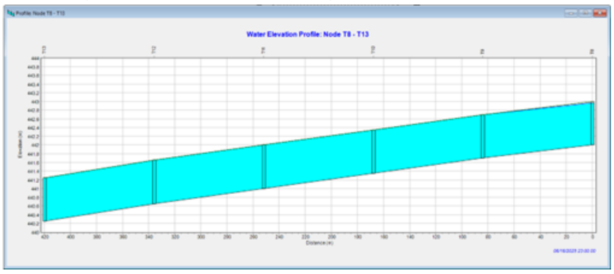

Figure 4. Simulation 10 Year Return Period Before Redesign

Soruce: Result Analysis

Based on the image, the simulation for the 10-year return period shows the drainage channel from Node H to M is at full capacity, with the water level reaching the top. This indicates the existing system is inadequate for the design rainfall, confirming the need for a redesign to prevent overflow and flooding.

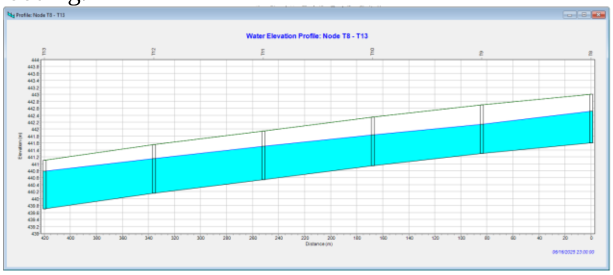

Figure 5. Simulation 10 Year Return Period After Redesign

Soruce: Result Analysis

Based on the post-redesign simulation, the 100x120x120 cm U-Ditch channel for a 10-year return period successfully increased capacity significantly. The water level is now well below the top of the channel, with sufficient freeboard, ensuring there is no risk of overflow or flooding

C. Cost Budget Plan

The cost budget plan is a calculation required to estimate the necessary expenses in a given project plan. Several itemized calculations are needed to determine the total budget, including:

1) Unit Price of Equipment, Materials and Labor

The unit prices of equipment, materials, and labor required for the drainage planning at the study site are based on the Standard Cost Estimation (HSPK) of Malang City for the Year 2024. The details of equipment, material, and labor costs can be seen in Table 5 below:

Table 6. Unit Price Equipment, Materials and Labor

NO	DESCRIPTION	UNIT	UNIT PRICE	
A	**WORKFORCE**			
1	Workers	OH	Rp	139.481,00
2	Masons	OH	Rp	170.560,00
3	Masons	OH	Rp	164.937,00
4	Carpenters	OH	Rp	170.560,00
5	Head Masons	OH	Rp	179.920,00
6	Foreman	OH	Rp	190.320,00
B	**MATERIALS**			
1	U-Ditch 100 x 120 x 120 cm	Unit	Rp	1.934.600
2	Cover U-Ditch 100 x 120 x 120 cm type (HD)	Unit	Rp	528.900
3	Working Floor concrete fc' 10 MPa	m3	Rp	891.956
4	Sand Fill	m3	Rp	96.361
5	Non-Subsidized Fuel	ltr	Rp	11.598
6	Timber Beam 5/7	m3	Rp	5.398.748
7	2-inch to 3-inch Nails	Kg	Rp	22.880
8	Timber Board 3/20	m3	Rp	15.916.291
C	**TOOLS**			
	Crane Truck 3 ton; Winch 5 Ton	hour	Rp	331.423
	Jack hammer	rent-a-day	Rp	403.853

Source: (HSPK Kota Malang, 2024)

2) Budget Plan Calculation

The budget plan for drainage work is the calculation of the costs required for materials, labor, equipment, and other expenses related to the execution of the work.

Table 7. Cost Budget Plan

NO	SCOPE OF WORK	VOLUME	UNIT	UNIT PRICE	TOTAL COST	
I	**PREPERATION WORK**					
1	Demolition Work	749,80	m^3	Rp 368.199,93	Rp	276.077.484
2	Bouwplank Installation	1	Ls	Rp 241.973,24	Rp	241.973
		TOTAL			Rp	276.319.457
II	**SOIL WORK**					
1	Excavation Work < 1 m	1126,97	m^3	Rp 102.629,24	Rp	115.660.318
2	Uplift Sand Work	50,39	m^3	Rp 391.169,63	Rp	19.711.037
3	Backfill Work	933,47	m^3	Rp 91.144,98	Rp	85.081.533
		TOTAL			Rp	220.452.888
III			**U-DITCH INSTALATION WORK**			
1	Instalation U-ditch + cover	420	Unit	Rp 3.078.120,55	Rp	1.292.554.122
		TOTAL			Rp	1.292.554.122
IV	**FINISHING**					
1	Land Clearing	505,10	m^2	Rp 26.983,72	Rp	13.629.474
		TOTAL			Rp	13.629.474
	TOTAL IMPLEMENTATION COST				Rp	1.802.955.942
	PPN 11%				Rp	198.325.154

TOTAL IMPKEMENTATION COST + PPN 11%	Rp	2.001.281.096
ROUNDUP	Rp	2.001.282.000
CALLED : Two billion, one million, two hundred eighty-two thousand Indonesian Rupiah		

Source: Calculation

The construction of the drainage channel for this project requires a budget of Rp. 2,001,282,000.00.

3) Implementation Method

This work includes the process of dismantling the old channel, excavation, installation of precast U-Ditch units, and finishing work. Each stage must be carried out in accordance with technical standards so that the channel functions optimally in draining rainwater runoff and is resistant to traffic loads or its surrounding environment. The implementation method is as follows:

a) Old Channel Demolition Work
b) Bowplank Installation
c) Soil Excavation
d) Base and Backfill Work
e) Precast U-ditch Installation
f) Join Grooting Work
g) Backfilling Work
h) Finishing

4. CONCLUSION

Based on the discussion above, several conclusions can be drawn, including:

1. Based on the analysis, the existing drainage system along Jl. Danau Kerinci - Jl. Danau Sentani Raya, particularly in segments H, I, J, K, L, and M, proved to have a highly inadequate capacity. The existing channel capacity (Qexisting) in these segments ranged from 0.732 m^3/s to 0.846 m^3/s. This figure is far below the design flood discharge (Qdesign) which varied from 1.464 m^3/s to 2.829 m^3/s for the same segments.
2. The hydrological analysis results indicate that, at the study location, the design rainfall intensity for a return period of 10 years is 129.394 mm/day.
3. Based on EPA SWMM 5.2 analysis, existing channels did not flood at 2- and 5-year return periods. However, for the 10-year return period, existing channels overflowed. Thus, all channel segments from H to M were redesigned into 100 cm x 120 cm U-Ditch channels (105 cm effective height). Simulations show these new channels can convey flow without overflow in all segments (capacities 2.772 m^3/second upstream to 3.201 m^3/second downstream), effectively addressing flooding. Nevertheless, 25-year return period simulations with these U-Ditch dimensions still show an inability to accommodate discharge, confirming further redesign (e.g., 100 cm x 160 cm U-Ditch) is needed for higher return periods. However, this study's return period remains 10 years with the aforementioned redesigned dimensions.
4. The estimated Budget Plan for the redesign of the drainage in the study area is IDR 2,001,282,000.00 (including 15% VAT), which covers all work items from demolition to finishing.

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