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CANAL CAPACITY IN AREA SUMUR BATU PUMP HOUSE – CENTRAL JAKARTA

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ABSTRACT

Sumur Batu Pump House is located at Inpeksi Kali Sunter street, Sumur Batu Village, Kemayoran District – Central Jakarta, with coordinates 6°9'41.29" south latitude and 106°52'25.02" east longitude. In the southern part of Sumur Batu Pump House, there is Kodam Complex where there's a main canal that flows to the Stone Well Pump House. Around the area of Sumur Batu Pump House, especially Kodam Complex, flooding still happens frequently, especially during the rainy season. One of the factors causing the flooding is that many canals are sedimented and the dimension of the canals are insufficient to discharge existing rainfall, as well as insufficient pump capacity. By analyzing the canal using Pearson III Log distribution method and Normal Log, and by predicting the highest planned rainfall score in the next 5 years period, which was calculated using past 25 years of rainfall data obtained from Tanjung Priok Rainfall Station, Kemayoran Rainfall Station, and Halim Rainfall Station, which was then calculated by Thiessen method, it was discovered that the rainfall intensity that occurred for a period of 5 years is 167.01 mm in the Normal Log distribution method. The mononobe equation is then used to find the intensity of rain per hour that occurs. Finally, the rain discharge plan can be sought by using rational method. It is then discovered that there are 4 canals (Canals E, H, I, J) that can't accommodate the occurring rain discharge.

Keywords: *Pump House, Flood, Canal, Thiessen Method*

1. PRELIMINARY

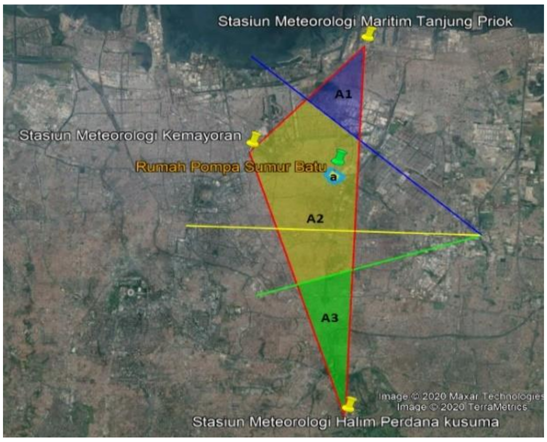
In the area of Sumur Batu Pump House, especially in the Kodam's Complex, floods often occur during the rainy season. Floods that occur in this area are due to high rainfall, and are exacerbated by non-technical canals. The slope of the canal are not extensive to the Pump House and the pump capacity that was designed 10 years ago hasn't been evaluated.

Moreover, there are also natural factors in the form of sedimentation and the lack of awareness of the local community to not dump garbage carelessly. Currently, there is no automatic garbage filter in the field, so they still rely on people to pick up garbage from the Air Gate to the collage pond. The existence of buildings above the canals and utilities that cross the canal on the bottom and side of the canal walls such as electric poles, cables, and pipes caused sedimentation around the drainage stream. It made the drainage area narrow so water cannot be accommodated and it caused the water to overflow. Looking at this condition, the writer wants to analyse the problems of the canal around the Sumur Batu Pump House area, in the hope that it can provide an evaluation of the community and local government so that they can carefully handle the problems surrounding this frequent flooding.

Research Purposes

The purposes of this research are:

1. To know the rain discharge that enters the canal.



2. To know the canal's ability to accommodate rain discharge.

2. THEORETICAL BASIS

Flood

Flood is a natural event that can cause property loss and casualties. It can also damage buildings, facilities, infrastructure, the environment and damage the life order of the community. Flood is a river flow condition where the water level is higher than a certain height (generally equated with the height of the riverbank). Basically, flood control can be done in various ways, but what is more important is to consider the overall system and find the most optimal system.

Thiessen's Method

This method is used to calculate the weight of each station which represents the surrounding area. It is used when the distribution of rain in the area under study is uneven. Based on the maximum rainfall data obtained from the 3 chosen rainfall stations, the Thiessen's Method calculation can be found with the following formula:

$$\frac{A_{region}}{A_{total}} \cdot a \qquad (1)$$

Information:

A region : The large area of each rainfall station area (km^2)

A total : The total large area of the entire rainfall station area (km^2)

a : Large *catchment* area (km^2)

$$d = \frac{(d_1 \cdot A_1)+(d_2 \cdot A_2)+(d_3 \cdot A_3)}{A_1+A_2+A_3} \qquad (2)$$

Figure 1. Division of the Polygon Region of Thiessen

Frequency and Probability Analysis

In statistic, there are several parameters related to data analysis which include the average ($\bar{X}$), standard deviation (S), variant coefficient (Cv), skewness (Cs), and sharpness coefficient (Ck).

$$\bar{X} = \sum_{i=1}^{n} Xi/n \qquad (3)$$

$$S = \sqrt{\frac{\sum_{i=1}^{n}(Xi-\bar{X})^2}{n-1}} \qquad (4)$$

$$Cv = \frac{S}{\bar{X}} \qquad (5)$$

$$Cs = \frac{n \text{ x } \sum_{i=1}^{n}(Xi-\bar{X})^3}{(n-1) \text{ x } (n-2) \text{ x } S^3} \qquad (6)$$

$$Ck = \frac{n^2 \text{x } \sum_{i=1}^{n}(Xi-\bar{X})^4}{(n-1) \text{ x } (n-2) \text{ x } (n-3) \text{ x } S^4} \qquad (7)$$

Information:

$\bar{X}$: Average score

Xi : Variant score

n : Amount of data

S : Standard deviation

Cv : Variant coefficient

Cs : Skewness

Ck : Sharpness coefficient

Normal Distribution

Normal distribution is also called Gauss distribution, here is the formula of normal distribution:

$$X_t = X + K_t \cdot S_x \qquad (8)$$

information:

X_t : Rainfall plan return period T years (mm)

X : Rainfall average score (mm)

K_t : Frequency factor (score of the Gauss Variable)

S_x : Standard deviation

Gumbel's Distribution

Here is the formula of Gumbel's distribution:

$$X = \bar{X} + \frac{(Y_t - Y_n)}{S_n} . S_x \quad (9)$$

Information:

X_t : Rainfall plan return period T year (mm)
$\bar{X}$: Rainfall average score (mm)
Y_t : Reduced variate of Gumbel's parameter for period T years
Y_n : Reduced mean is a function of amount of data
S_n : *Reduced* standard deviation
S_x : Standard deviation

Normal Log Distribution

Normal Log Distribution is the result transformation of normal distribution, by changing variate X into logarithmic score of variate X. Here is the formula of Normal Log Distribution:

$$Y = \bar{Y} + K . S_d \quad (10)$$

Information:

Y : Logarithmic score of X score or InS
$\bar{Y}$: Average score of the data count
K : Characteristic of Log normal probability distribution
S_d : Standard deviation of score Y

Log Pearson III Distribution

Karl Pearson developed several kinds of empirical equations from a distribution, one of them is the Log Pearson III Distribution. Here is the formula of Log Pearson III Distribution:

$$\text{Log}\, X_T = Log\ X + G . S_x \quad (11)$$

Information:

Log X_t : Rainfall plan return period T years (mm)
Log X : Rainfall average score (mm)
G : Variable standard for X_t
S_x : Standard deviation

Rainfall Intensity

If there's only daily rainfall, then dr. Mononobe formulates its rainfall intensity as follows:

$$I = \frac{R_{24}}{24}\left[\frac{24}{t}\right]^{2/3} \quad (12)$$

information:

R_{24} : Maximum rainfall in 24 hours (mm)
t : Rainfall duration (hour)
I : Rainfall intensity (mm/hour)

Time of Rain Intensity Concentration (Tc)

To find the concentration time (Tc), it can be calculated using the Kirpich formula as follows:

$$T_c = \frac{0{,}0195 \text{ x } L^{0{,}77}}{S^{0{,}385}} \quad (13)$$

Information:

T_c : Concentration time (minute)
L : Length of the water from farthest point to the point under review (m)
S : River slope

Rain Discharge Plan

To calculate the top discharge at a drainage, the Rational Method calculation is used as follows:

$$Q = 0{,}278. C. I. A \quad (14)$$

Information:

Q : Surface runoff peak discharge (m^3/s)
C : Coefficient *run off*
I : Rainfall intensity (mm/hour)
A : Large of drainage area (km^2)

Calculating Existing Canal Discharge

The purpose of examining the existing canal is to find out the amount of water flow that can be accommodated by the canal with its current state. Capacity analysis of the drainage canal is carried out to determine the ability of the existing drainage canal to accommodate the calculated discharge.

Discharge Canal

Here is the formula of discharge canal:

$$Q = A . V \quad (15)$$

Information:

Q : Discharge canal (m^3/s)

A : Large of wet cross-sectional area (m)
V : Average flow velocity (m/s)

Wet Cross-Sectional Area
Here is the formula of wet cross-sectional area:

$$A = b.h \tag{16}$$

Information:
A : large of wet cross-sectional area (m^2)
b : Wide canal (m)
h : Water level (m)

Average Flow Speed (V)
To find the average flow velocity (V) can calculated using the following formula:

$$V = \frac{1}{n} . R^{2/3} . S^{1/2} \tag{17}$$

Information:
V : Average flow velocity (m/s)
n : Manning's roughness coefficient
R : Radius of the hydraulic (m)
S : Canal slope

Hydraulic Radius
Here is the formula of hydraulic radius of the canal:

$$R = \frac{A}{P} \tag{18}$$

Information:
R : Hydraulic Radius (m)
A : Large of wet cross-sectional area (m^2)
P : Wet circumference (m)

Pump
A pump is a mechanical device that has the function of moving or increasing fluid by directly pushing the fluid mechanically, or by converting mechanical energy into compressive energy or fluid kinetic energy that allows it to suck fluid from one place and emit it to the desired place.
Fluid suction on the suction side of the pump is carried out by the pump element by lowering the pressure in the pump room, so that there is a pressure difference between the pump room and the pump suction, the fluid will then flow from the pump suction mouth to the pump room. Next, the pump element will push the fluid or put pressure on the fluid so that the fluid will flow from the pump room into the pressure line (discharge) through the pressure hole.

Pump Capacity
The volume of surface water is obtained by the formula:

$$V = 0{,}278 . C . I . A . T \tag{19}$$

Information:
V : Volume of surface water (m^3)
C : Run off coefficient
I : Rainfall Intensity (mm/hour)
A : Large area (km^2)
T : Drain time

Head Pump
One of the total head of the pump is affected by various losses in the piping system, namely friction in pipes, valves, bends, joints, reducers, etc. To determine the total head that must prepared by the pump, it is necessary to calculate the estimates for the installation in advance. These losses will be added up to determine the head losses that occur in the installation. The following will calculate the loss of the piping head and pump testing installation.

Major Headloss
Major head losses are frictional losses between pipe walls and water flow without taking into account changes in the cross-sectional area and pipe bending using the Darcy formula:

$$Hf = f\frac{L . V^2}{D . 2g} \tag{20}$$

Information:
Hf : Major headlosses
f : Coefficient of friction
L : Pipe length (m)
V : Flow velocity in the pipe (m/s)
D : Pipe diameter (m)
g : Acceleration of gravity (m/s^2)
To find the score (f), you must look for the Reynold number (Re) and the Relative Pipe Roughness depending on the pipe material to be used which uses the formula:

$$Re = \frac{V.D}{\mu} \quad (21)$$

Information:

Re : Reynold number

V : Flow velocity in the pipe (m/s)

D : Pipe diameter (m)

μ : Viscosity kinematics of water (m^2/s)

Minor Head Loss Due to Pipe Bends

The formula for finding minor head losses due to pipe bends is generally stated as follows:

$$Hm = K\frac{V^2}{2g} \quad (22)$$

Information:

Hm : Minor headlosses

K : Coefficient of loss on pipe bends

V : Flow velocity in the pipe (m/s)

g : Acceleration of gravity (m/s^2)

Minor Head Loss Due to Pipe Narrowing

The formula for finding minor head losses due to sudden narrowing is generally stated as follows:

$$Hm = Km\frac{(V2-V1)^2}{2g} \quad (22)$$

Information:

Hm : Minor head losses

km : Coefficient of loss for a sudden narrowing

V1 : Flow velocity in the upstream pipe (m/s)

V2 : Flow velocity in downstream pipe (m/s)

g : Acceleration of gravity (m/s^2)

Total Head Pump

Total head pump is the maximum pressure capability at the pump's working point, so that the pump is able to flow water/fluid from one place to another. The parameter needed to determine total head of the pump is the head loss in the pump pipe, where total head of the pump must be greater than total head loss. To calculate total pump head loss, the following equation is used:

$$\text{Head Loss Total} = Hf + Hm\ (\text{due to the bend}) + Hm\ (\text{Due to the narrowing}) \quad (24)$$

Information:

Hf : Major head loss

Hm (due to the bend) : Minor head loss due to pipe bends

Hm (due to the narrowing) : Minor head loss due to pipe narrowing

3. RESEARCH METHODOLOGY

Research Sites

This research was conducted in area of Sumur Batu Pump House, Central Jakarta. The research starts from a survey that looks at the condition of the drainage canals, data collection, hydrological analysis, hydraulic analysis, and evaluation of the existing drainage system.

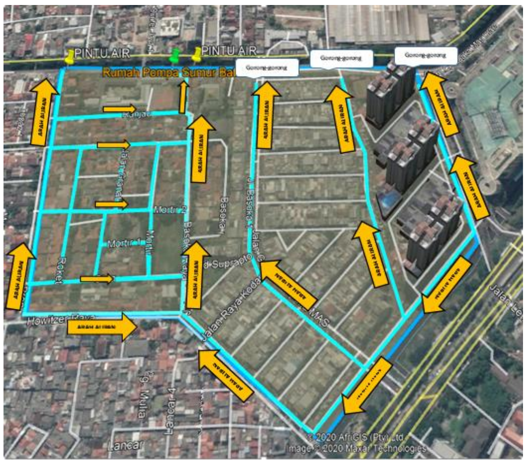


Figure 1. Research Site

4. STAGES OF DATA COLLECTION

Study of Literature

It is used to find theoretical references that are relevant to the cases or problems found. The literature study consists of:

1. Journals.
2. Books.

Field Survey

Direct visits to the field with the aim of knowing the location of the case which include:

1. To know the location of drainage canal that leads to Sumur Batu Pump House.
2. To find out the pump capacity and existing water storage pool at Sumur Batu Pump House.
3. To know the dimensions of drainage canal that enters water storage pool of Sumur Batu Pump House.
4. To know the sedimentation in drainage canal that enters the water storage pool of Sumur Batu Pump House.

Primary Data Collection

Primary data collection is obtained directly in the field which includes:

1. To know the shape and dimensions of drainage canal.
2. To know the conditions of drainage canal slope.
3. To know the flow direction of drainage canal that enters the water storage pool of Sumur Batu Pump House.
4. To know the large catchment area of Sumur Batu Pump House.

Secondary Data Collection

Secondary data collection is obtained from agencies that are related to flood planning, control and management, including:

1. Rainfall data from 1994 to 2019 were obtained from the Meteorology, Climatology and Geophysics Agency (BMKG) of Tanjung Periok, Kemayoran, and Halim Perdana Kusuma.
2. Land use maps were obtained using Google Earth.
3. To know the facilities and capacity of Sumur Batu Pump House.

5. DATA ANALYSIS

Hydrology Analysis

Hydrological analysis which includes analysis of maximum daily rainfall, determining the statistical distribution method to be used, determining the intensity of rainfall that will be used, and knowing the amount of planned flood discharge in water construction planning.

Hydraulics Analysis

Hydraulic analysis which includes canal models, calculation of flow velocity in canal, measuring canal dimensions, and determining the slope of canal.

Effort for Prevention

We can know the drainage system by comparing drainage canal capacity from planned discharge with actual canal discharge, whether it's still fulfilling ($Q_{hydrolika} > Q_{hydrology}$). Also evaluating the existing problems of the canal that needs to be overcome and knowing pump capacity requirements.

6. RESULT AND DISCUSSION

Rainfall Data Analysis

Maximum daily rainfall data is obtained from Meteorology, Climatology and Geophysics Agency (BMKG). Rainfall station used in the observation is Tanjung Periok Rainfall Station, Kemayoran Rainfall Station, and Halim Perdana Kusuma Rainfall Station. The data used is from the past 25 years.

Table 1. Rainfall Analysis Data Using Thiessen Method

Year	Kemayoran	Priok	Halim	Maximum Rainfall
1994	92,6	98,2	24	80,32
1995	75,7	103,2	137	90,74
1996	216,2	102,1	70	174,26
1997	125,6	118,3	75	115,11
1998	162,2	110,9	42	133,04
1999	147,2	106	42	122,14
2000	94,8	65,2	54,3	83,43
2001	82,2	210	92,8	100,18
2002	168,5	147,1	107,6	154,30

2003	199,7	126,7	71,7	166,35
2004	129,3	121,4	39,8	111,37
2005	124,1	109,9	96,6	117,12
2006	72	90,3	88,5	77,41
2007	234,7	182,2	217,6	224,90
2008	192,7	87,9	136,1	168,89
2009	122,5	148,9	140,4	129,19
2010	93	88,3	96,8	93,13
2011	119,2	78,5	305	149,28
2012	105,2	75,1	94,4	99,39
2013	193,4	117,8	161	177,82
2014	147,9	284	120,8	159,78
2015	277,5	247	124,6	244,75
2016	124,5	112,7	111,6	120,58
2017	179,7	148,6	136,3	167,60
2018	104,6	129,6	101,2	107,08

Table 2. Calculation of Distribution for Rainfall

Xi	**(Xi-X)**	**(Xi-X)²**	**(Xi-X)³**	**(Xi-X)⁴**
77,41	-57,32	3285,16	-188292,97	10792253,94
80,32	-54,41	2960,04	-161045,00	8761860,04
83,43	-51,29	2630,91	-134945,37	6921665,86
90,74	-43,99	1934,73	-85100,23	3743182,08
93,13	-41,59	1730,10	-71962,75	2993254,42
99,39	-35,33	1248,43	-44110,72	1558567,32
100,18	-34,54	1193,35	-41224,01	1424077,43
107,08	-27,64	764,24	-21127,25	584059,91
111,37	-23,35	545,45	-12738,89	297515,00
115,11	-19,62	384,81	-7548,73	148080,80
117,12	-17,61	309,99	-5457,95	96096,20
120,58	-14,14	200,03	-2828,99	40010,59
122,14	-12,59	158,49	-1995,21	25117,98
129,19	-5,54	30,67	-169,85	940,66
133,04	-1,69	2,86	-4,83	8,18
149,28	14,56	211,86	3083,77	44885,75
154,30	19,57	383,03	7496,41	146713,84
159,78	25,06	627,83	15731,31	394172,73
166,35	31,62	999,83	31614,88	999666,90
167,60	32,87	1080,52	35517,90	1167516,40
168,89	34,16	1166,92	39862,00	1361691,46
174,26	39,54	1563,23	61806,24	2443673,03
177,82	43,09	1856,82	80012,05	3447787,83
224,90	90,17	8131,43	733246,83	66120114,30
244,75	110,02	12104,27	1331705,38	146513465,12
Σ	3368,16		45504,99	1561524,01

Based on the table above, it can be seen that scores include average (X̅), standard deviation (S), variant coefficient (Cv), slope coefficient (Cs), and coefficient of sharpness (Ck):

1. Average score ($\bar{X}$) = 134,73
2. Standard deviation (S_d) = 43,54
3. Variant coefficient (C_v) = 0,32
4. Slope coefficient (C_s) = 0,85
5. coefficient of sharpness (C_k) = 3,72

Table 3. Result Calculation of Distribution Method and Requirements of Distribution Method

No	Distribution	Requirements	Calculation	Information
1	Gumbel	Cs ≈ 1,14	Cs = 0,8566	Not qualify
		Ck ≈ 5,4	Ck = 3,7225	
2	Normal	Cs = 0	Cs = 0,8566	Not qualify
		Ck = 3	Ck = 3,7225	
3	Log Normal	Cs ≈ 3Cv = 0,9696 , atau	Cs = 0,8566	**Qualify**
		Cs/Cv ≈ 3	Ck = 3,7225	
4	Log Pearson III		-	Not qualify

Source: Public Works Department, 2010

Table 4. Result Calculation of Distribution Method and Requirements of Distribution Method

No	Distribution	Requirements	Calculation	Information
1	Gumbel	Cs ≈ 1,14	Cs = 0,8566	Not qualify
		Ck ≈ 5,4	Ck = 3,7225	
2	Normal	Cs = 0	Cs = 0,8566	Not qualify
		Ck = 3	Ck = 3,7225	
3	Log Normal	Cs = Cv^3+3cv =1,0033	Cs = 0,8566	Not qualify
		Ck = $Cv^8+6Cv^6+15Cv^4+16Cv^2+3$ = 4,8419	Ck = 3,7225	
4	Log Pearson III		-	**Qualify**

Source: Bambang Triatmodjo, 2008

Rainfall Log Normal Method

After calculating rainfall, standard deviation, slope coefficient, and sharpness coefficient, then calculate return period according to the method that meets the requirements of Normal Log method.

Table 5. Rainfall Plan Log Normal Method

No	Xi	Log Xi	(Log Xi- Log X)²
1	77,41	1,8888	0,0484
2	80,32	1,9048	0,0416
3	83,43	1,9213	0,0351
4	90,74	1,9578	0,0228
5	93,13	1,9691	0,0195
6	99,39	1,9974	0,0124
7	100,18	2,0008	0,0117
8	107,08	2,0297	0,0063
9	111,37	2,0468	0,0038
10	115,11	2,0611	0,0023
11	117,12	2,0686	0,0016
12	120,58	2,0813	0,0008
13	122,14	2,0868	0,0005
14	129,19	2,1112	0,0000
15	133,04	2,1240	0,0002
16	149,28	2,1740	0,0043
17	154,30	2,1884	0,0063
18	159,78	2,2035	0,0090
19	166,35	2,2210	0,0126
20	167,60	2,2243	0,0133
21	168,89	2,2276	0,0141
22	174,26	2,2412	0,0175
23	177,82	2,2500	0,0199
24	224,90	2,3520	0,0591
25	244,75	2,3887	0,0783
Σ	3368,16	52,7202	0,4416
Log $\overline{X}$	134,73	2,1088	

From the table above, we can find out the score that includes average score Log x ($\overline{X}$), standard deviation Log x (Sd) and slope coefficient Log x (Cs):

1. Average score ($\bar{x}$) Log x = 2,1088
2. Standard deviation (S_d) log x= 0,1356

Table 6. Maximum Rainfall Normal Log Return Period

Period (T)	Frequency Factor (Kt)	Average Log Xi	Sd	Log X	Rain fall Plan (mm)
2	0,00	2,1088	0,1356	2,1088	128,47
5	0,84	2,1088	0,1356	2,2227	167,01
10	1,28	2,1088	0,1356	2,2824	191,61
20	1,64	2,1088	0,1356	2,3313	214,42
50	2,05	2,1088	0,1356	2,3869	243,71
100	2,33	2,1088	0,1356	2,4249	265,98

200	2,58	2,1088	0,1356	2,4488	387,58

Rainfall Plan Log Pearson III Method

After calculating rainfall, standard deviation, slope coefficient, and sharpness coefficient, then calculate return period according to the method that meets the requirements of Log-Pearson III method.

Table 7. Rainfall Plan Log Pearson III Method

No	Xi	Log Xi	(Log Xi-Log X)²	(Log Xi-Log X)³
1	77,41	1,8888	0,0484	-0,0106
2	80,32	1,9048	0,0416	-0,0085
3	83,43	1,9213	0,0351	-0,0066
4	90,74	1,9578	0,0228	-0,0034
5	93,13	1,9691	0,0195	-0,0027
6	99,39	1,9974	0,0124	-0,0014
7	100,18	2,0008	0,0117	-0,0013
8	107,08	2,0297	0,0063	-0,0005
9	111,37	2,0468	0,0038	-0,0002
10	115,11	2,0611	0,0023	-0,0001
11	117,12	2,0686	0,0016	-0,0001
12	120,58	2,0813	0,0008	0,0000
13	122,14	2,0868	0,0005	0,0000
14	129,19	2,1112	0,0000	0,0000
15	133,04	2,1240	0,0002	0,0000
16	149,28	2,1740	0,0043	0,0003
17	154,30	2,1884	0,0063	0,0005
18	159,78	2,2035	0,0090	0,0008
19	166,35	2,2210	0,0126	0,0014
20	167,60	2,2243	0,0133	0,0015
21	168,89	2,2276	0,0141	0,0017
22	174,26	2,2412	0,0175	0,0023
23	177,82	2,2500	0,0199	0,0028
24	224,90	2,3520	0,0591	0,0144
25	244,75	2,3887	0,0783	0,0219
Σ	3368,16	52,7202	0,4416	0,0122
Log X̄	134,73	2,1088		

Based on the table above, it can be seen that scores include average Log score (X̄), standard deviation Log x (Sd) and slope coefficient Log x (Cs):

1. Average score (X̄) Log x = 2,1088
2. Standard deviation (Sd) log x= 0,1356
3. Slope coefficient (Cs) log x = 0,2219

Table 8. Return Period Maximum Rainfall Log Pearson III

Period (T)	Coefficient (G)	Average Log Xi	Sd	Log X	Rain fall Plan (mm)
2	-0,036	2,1088	0,1356	2,1038	127,00
5	0,829	2,1088	0,1356	2,2212	166,42
10	1,302	2,1088	0,1356	2,2855	192,98
25	1,824	2,1088	0,1356	2,3563	227,15
50	2,170	2,1088	0,1356	2,4032	253,04
100	2,487	2,1088	0,1356	2,4463	279,41
200	2,783	2,1088	0,1356	2,4863	306,44

From the results of calculated rainfall plan for Log Normal method and Log Pearson III method, the highest score is taken as reference score of rainfall intensity for a period of 5 years and the highest score is found in Log Normal method.

Table 9. Comparison of Rainfall Plan Scores

Period	Calculation Rainfall Plan Method (mm)	
	Log Pearson III	Log Normal
2	127,00	128,47
5	166,42	167,01
10	192,98	191,61
25/20	227,15	214,42
50	253,04	243,71
100	279,41	265,98
200	306,44	287,58

Calculate the Run off Coefficient

Based on the existing canal condition which has different dimensions and location between the residents' house, apartment, shop house, and main road, the catchment area is divided into 10 parts.

Table 10. Run Off Coefficient Calculation Results

Location	Large (Km²)	Coeff. Run Off
A	0,028111	0,725
B	0,043201	0,904
C	0,02596	0,904
D	0,020947	0,726
E	0,046831	0,905
F	0,010667	0,766
G	0,028804	0,765

H	0,019819	0,769
I	0,024673	0,767
J	0,030571	0,766

Calculating Rainfall Intensity

Before looking for the canal rainfall intensity, first calculate the time of rain intensity concentration that occurs using the Kirpich formula.

Table 11. Canal Concentration Time (Tc) Calculation

Location	L	S	TC	
			Minute	Hour
A	269	0,0037	12,5079	0,2084
B	400	0,0025	19,7430	0,3290
C	526	0,0019	27,0940	0,4515
D	347	0,0028	16,9407	0,2823
E	253	0,0039	11,6916	0,1948
F	218	0,0046	9,7832	0,1630
G	389	0,0051	14,6852	0,2447
H	210	0,0095	7,1900	0,1198
I	306	0,0065	11,1190	0,1853
J	205	0,0049	9,1067	0,1518

Table 12. Rainfall Intensity

Location	Return Period (T)	Rainfall Plan		Rainfall Intensity (I)
		Tc (hour)	Log Normal (mm)	Log Normal (mm/hour)
A	5	0,2084	167,01	164,71
B	5	0,3290	167,01	121,49
C	5	0,4515	167,01	98,37
D	5	0,2823	167,01	134,54
E	5	0,1948	167,01	172,29
F	5	0,1630	167,01	194,03
G	5	0,2447	167,01	147,99
H	5	0,1198	167,01	238,25
I	5	0,1853	167,01	178,14
J	5	0,1518	167,01	203,46

Rain Discharge Plan (Qt)

Calculation of rain discharge plan uses a rational method.

Table 13. Rain Discharge Plan (Q_t)

Location	Return Period (T)	Coef. Run off (C)	Rainfall Intensity (I) (mm /hour)	Catchment Area (A) (Km²)	Rain Discharge Plan (Q_t) (m³/s)
A	5	0,725	164,710	0,028111	0,933
B	5	0,904	121,490	0,043201	1,319
C	5	0,904	98,370	0,025960	0,642
D	5	0,726	134,54	0,020947	0,569
E	5	0,905	172,29	0,046831	2,219
F	5	0,766	194,03	0,010667	0,441
G	5	0,765	147,99	0,028804	0,907
H	5	0,769	238,25	0,019819	1,311
I	5	0,767	178,14	0,024673	7,328
J	5	0,766	203,46	0,030571	1,627

Table 14. Existing Discharge Canal (Qs)

Location	L	S	b	h	A	P	R	n	V	Qs
	(m)		(m)	(m)	(m)	(m)	(m)		m/s	m³/s
A	269	0,0037	0,90	0,93	0,84	2,76	0,303	0,013	2,112	1,768
B	400	0,00	0,90	0,90	0,81	2,70	0,300	0,013	1,724	1,396

		25								
C	526	0,0019	0,90	0,95	0,85	2,80	0,305	0,013	1,520	1,300
D	347	0,0028	0,90	0,86	0,77	2,62	0,295	0,013	1,805	1,397
E	253	0,0039	1,00	0,71	0,71	2,42	0,293	0,013	2,121	1,506
F	218	0,0046	1,00	0,70	0,70	2,40	0,292	0,013	2,295	1,606
G	389	0,0051	0,90	0,65	0,58	2,20	0,266	0,013	2,272	1,329
H	210	0,0095	0,45	0,42	0,19	1,29	0,147	0,013	2,084	0,394
I	306	0,0065	0,90	1,00	0,90	2,90	0,310	0,013	2,843	2,559
J	205	0,0049	0,85	0,40	0,34	1,65	0,206	0,013	1,879	0,639

Based on rain discharge data and existing canal capacity, it can be compared to know whether canal capacity is able to accommodate the rain discharge.

Table 15. Comparison of Canal Discharge Capacity with Rainfall Discharge

Area	Discharge		Information	Discharge	Information
	Rain Plan (Qt)	Existing Canal (Qs)		Ideal Canal (Qi)	
A	0,933	1,768	ABLE	2,637	ABLE
B	1,319	1,396	ABLE	2,167	ABLE
C	0,642	1,300	ABLE	1,890	ABLE
D	0,569	1,397	ABLE	2,294	ABLE
E	2,219	1,506	NOT ABLE	2,707	ABLE
F	0,441	1,606	ABLE	2,508	ABLE
G	0,907	1,329	ABLE	1,859	ABLE
H	1,311	0,394	NOT ABLE	2,134	ABLE
I	7,328	2,559	NOT ABLE	8,790	ABLE
J	1,627	0,639	NOT ABLE	2,221	ABLE

7. CONCLUSION

Based on the planned flood analysis in Sumur Batu Pump House area using daily rainfall data from Tanjung Periok Rainfall Station, Kemayoran Rainfall Station, and Halim Perdana Kusuma Rainfall Station, it was found that the planned rainfall discharge for the 5 years return period that was calculated using analysis of Log Normal Method is 167,01 mm. The ability to accommodate rain discharge of each canal are as follows, Canal E has the ability of 1,506 m^3/s < 2,219 m^3/s ; Canal H with the discharge of 0,395 m^3/s < 1,311 m^3/s; Canal I with the discharge of 2,559 m^3/s < 7,328 m^3/s; and Canal J with the discharge of 0,639 m^3/s < 1,627 m^3/s. The calculations shows that the canals cannot accommodate the rainfall discharge. By making changes to the dimensions of the canals, then the ideal canal discharge obtained for Canal E is 2,707 m^3/s, Canal H is 2,134 m^3/s, Canal I is 8,790 m^3/s, and Canal J is 2,221 m^3/s.

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