INDIVIDUAL POLDERS AS AN ALTERNATIVE TO FLOOD CONTROL IN THE CENTER OF PADANG CITY GOVERMENT AT AIR PACAH

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Abstract

Earthquake and prediction of tsunami divides padang city into three zones areas prone to tsunamis, namely red, yellow and green. Red zone, area that is located along the coast to 1 km to east of padang city and constitute zone very vulnerable by the tsunami, the yellow zone is located 1 to 3 km and the red zone> 3 km from the coast towards the east. The impact of this policy, many residents in the red zone move into the green zone located around the road of by-pass padang city. Including the government of padang city moved the center of his government to Air Pacah and was followed by several other government offices such as BPKP, Bung Hatta University, University of Baiturrahmah, Siti Rahmah Hospital and other public facilities. Unfortunately, locations used for construction of residential complexes, offices and public facilities are located in the low topographic. This location inundated during the rainy season because have the shape of basin (depression) and drainage is bad, as it happened on March 22, 2015 in which this region hit by devastating floods that height until reaching 2-3 m. This area is located in the Watershed (DAS) Batang Kuranji, Sub Das Batang Balimbing with its tributaries Batang Maransi and Batang Lurus and this region flanked by this tributaries. In an effort to control flooding that often occurs in this region, one of the efforts that can be done in a short time is to build a polder in every office, residential complexes and other public facilities were built by owner of the buildings around the boundary of land owned, The system was selected, due to building construction of flood control in wide area will require large funds, either to land aquitation and physical development. For area of government office, based of calculation, the high of polder = 1.50 m, Volume of retention ponds in the rain effectively is same as a concentration time with a pump capacity 2 m^3 / sec = 102 179 m^3, with a capacity 5 m^3 / sec = 75.457m^3 ,

Keywords: Flood, Polder, The gradually varied flow, The standard stage method

INTRODUCTION

Background

Earthquake of September 30, 2009 and prediction of tsunami that struck of padang city and government policy of padang city that divides padang city into three zones areas prone to tsunamis, namely red, yellow and green. Red zone, area that is located along the coast to 1 km to east of padang city and constitute zone very vulnerable by the tsunami, the yellow zone is located 1 to 3 km and the red zone> 3 km from the coast towards the east (Figure 1).

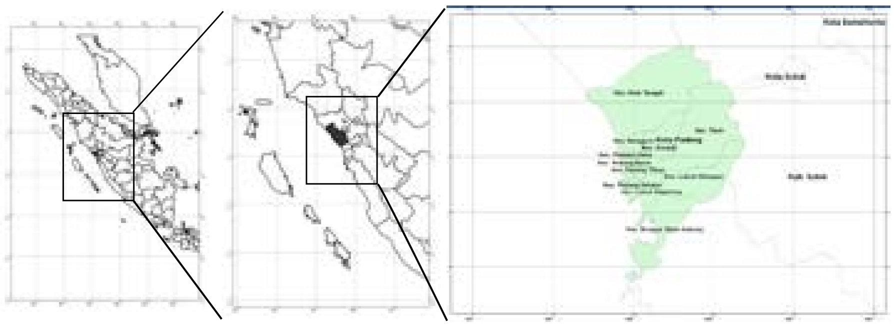

Figure 1. Location of Study

The impact of this policy, many residents in the red zone move into the green zone located around the road of by-pass padang city. Including the government of padang city moved the center of his government to Air Pacah and was followed by several other government offices such as BPKP, Bung Hatta University, University of Baiturrahmah, Siti Rahmah Hospital and other public facilities.

Unfortunately, locations used for construction of residential complexes, offices and public facilities are located in the low topographic. This location inundated during the rainy season because have the shape of basin (depression) and drainage is bad, as it happened on March 22, 2015 in which this region hit by devastating floods that height until reaching 1-2 m (Figure 2 and 3). This area is located in the Watershed (DAS) Batang Kuranji, Sub Das Batang Balimbing with its tributaries Batang Maransi and Batang Lurus and this region flanked by this tributaries.

Figure 2. Top view of government office center in Air Pacah

Figure 3. Top View of Air Pacah District

In an effort to control flooding that often occurs in this region, one of the efforts that can be done in a short time is to build a polder in every office, residential complexes and other public facilities were built by owner of the buildings around the boundary of land owned, The system was selected, due to building construction of flood control in wide area will require large funds, either to land aquitation and physical development.

Literature Review

Flood is the event of overflow the river water exceeds of the cross section of river (PP RI No. 38 Year 2011). The cause of flooding, according Kodoatie & Sugiyanto (2002) classified caused by human actions and by nature. Which includes the causes of flooding by human activities are: 1) Changes in land use; 2) Waste disposal; 3) Slum area along the river; 4) Planning of flood control system is not appropriate; 5) Decrease in land and rob; 6) The non-functioning land drainage system; 7) Dam and waterworks; and 8) Damage to the building of flood control.

And that includes natural causes are: 1) Erosion and sedimentation; 2) Rainfall; 3) The impact of physiographic / geophysical river; 4) The capacity of the river and inadequate drainage; 5) The influence of the tide; 6) Decrease in land and rob; and 7) Drainage and land.

Flood Control

Flooding is one of damage or disasters caused by water damage, flood control is done thoroughly that includes prevention, mitigation and recovery. Prevention is done through both physical and non-physical (Siswoko, 2010). Physical activity is the development of infrastructure and other measures including:

1. Reduction of peak flood in general by creating a flood control reservoir upstream¬
2. Localizing flood flow in the river channel is applied to the levees, flood walls and closed channels¬
3. The decline in the face of the flood peak by increasing the flow¬ rate by improving the flow of a river or a diversion to get the ideal slope The distribution of flood discharge through the water drainage or¬ flood diversion canal kedaerah another river flow, improved cross-section of the river and sediment management in the estuary.
4. Management of flood plains or swamps are housed in the polder to flow through the pump to flood the canal towards the sea¬ Reduction of flood plain and tillage contour and galudan.¬

Polder

Polder is an area that is planned in such a way and is limited by the dike so that runoff water coming from outside the region can not enter (Volker.A, 1990), thus a problem to be solved is how to drainage of water from the polder itself, especially water which comes from rainfall.

Calculation of flow surface profile gradually varied flow

Calculation curved surface gradually varied flow that is basically, completion of dynamic equations of flow gradually varied flow.. The main purpose of calculation the flow surface profile is to determine the shape of curved surface of gradually varied flow by calculating magnitude of flow depth according to its distance from the cross section of the control

All completion of flow equations gradually varied flow to be started from the depth of flow in the cross section control and continued with the calculation of the flow depth towards the upstream or downstream direction, ie which way to the flow control operation. At the boundary upstream and downstream boundary surface gradually varied flow approaching normal asymptotis depth. In this case the meeting point can be predicted a few percent above or below normal depth (Anggrahini, 2005).

Calculation way of the surface profile gradually varied flow there are several ways including:the graphical integration method; Direct integration method; Direct step method; Standard step method and so on. (Ven Te Chow, 1984). For this study used the Standard step method ,

METHODOLOGY

This paper is done by:

1. Calculate the rainfall desaign
2. Calculate the flood discharge with synthetic unit hydrograph Nakayasu method as well as the rational method
3. Based on discharge data obtained using this Nakayasu method calculated water surface profile plans using Standard Step Method to determine the water level of the *elevation +0 , 93 m. This calculation is intended to determine the water level of* river at the junction between Batang Balimbing with Kuranji, water level in junction Batang Maransi, Batang Lurus with Batang Belimbing
4. Calculate the flood water level in the center of government, planning a polder in the center of government offices and determine the volume of retention ponds and capacity of pump ..

RESULTS AND DISCUSSION

Calculation of rainfall design begins with test data consistency, homogeneity of data, analysis of the probability distribution, test probability distribution used Chi-kuadarat method and Smirnov Kolmogorof methods, based calculations, the amount of rainfall design in DAS Batang Maransi and DAS Batang Lurus selected rainfall design is log Pearson type III method as follows:

Table 1. Rainfall Design

Return Period (years)	2	5	10	25
Rainfall Design (mm)	113	176	233	325

Calculating Rainfall Intensity

Rainfall intensity calculated using Mononobe formula as follows:

$$I_t = \frac{R_t}{24} x \left(\frac{24}{t}\right)^{2/3} \quad \text{......} (1)$$

Where: R_t is rain plan for different return period (mm); concentration t is time (hours) for the tool in minutes t done 60; and I_t is rain intensity for different return period (mm/h)

Rainfall intensity calculation results can be seen in and Figure 4.

No	t (Minutes)	113 2 Year	176 5 Year	233 10 Year	325 25 Year
1	10	128,92	200,80	265,84	370,80
2	20	81,26	126,56	167,54	233,70
3	30	62,03	96,61	127,89	178,39
4	40	51,21	79,76	105,59	147,29
5	50	44,14	68,75	91,01	126,95
6	60	39,09	60,89	80,61	112,43
7	70	35,28	54,95	72,74	101,46
8	80	32,28	50,27	66,55	92,83
9	90	29,84	46,48	61,53	85,83
10	100	27,82	43,33	57,36	80,01
11	110	26,11	40,66	53,83	75,09
12	120	24,64	38,37	50,80	70,86
13	130	23,36	36,38	48,16	67,18
14	140	22,23	34,63	45,85	63,95
15	150	21,24	33,07	43,79	61,08
16	160	20,34	31,68	41,94	58,51
17	170	19,54	30,43	40,28	56,19
18	180	18,81	29,29	38,78	54,09
19	190	18,14	28,26	37,41	52,18
20	200	17,53	27,31	36,15	50,43
21	210	16,97	26,43	35,00	48,81
22	220	16,45	25,63	33,93	47,32
23	230	15,97	24,88	32,94	45,94
24	240	15,53	24,19	32,02	44,66
25	250	15,11	23,54	31,16	43,46

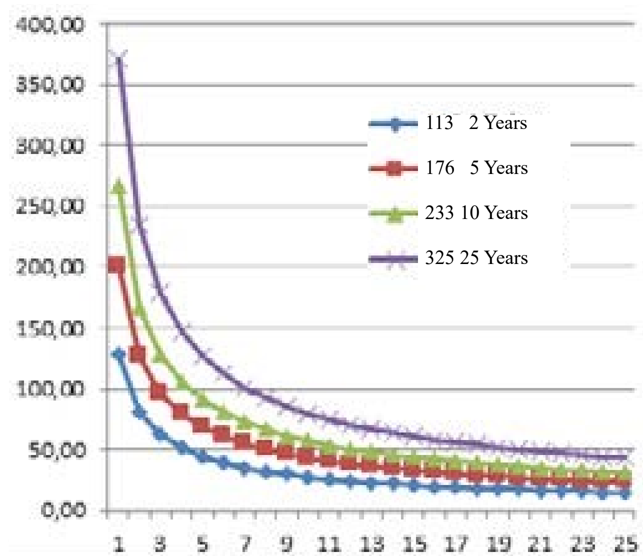

Figure 4. Graph of Analysis of Rain intensity (mm / hour)

Calculation of Design Flood Discharge

This area is located in Batang Kuranji watershed, sub-watershed s Batang Belimbing with Batang Maransi and Batang Lurus tributarie (Figure 4.2) Calculation of flood discharges Batang Kuranji and Batang Belimbing. calculated using of unit hydrograph sintetis (HSS Nakayasu method. flood discharge of Kuranji river = 995 m³/sec for a return period 25 years (Nikken, 2000) .Batang Lurus river = 120 m³/sec for return period 25 years and Batang Maransi river = 34 m³/sec for 10-year return period (Figure 5.).

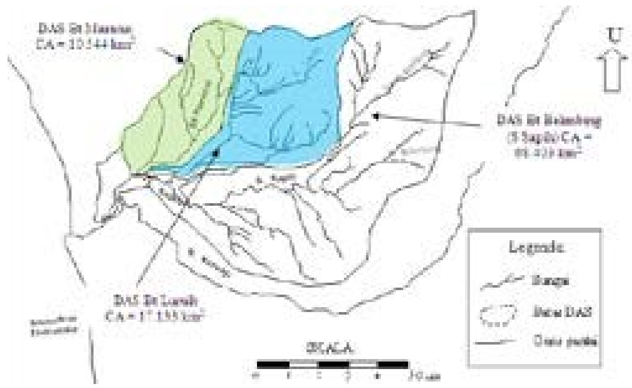

Figure 5. Watershed (DAS) Batang Kuranji

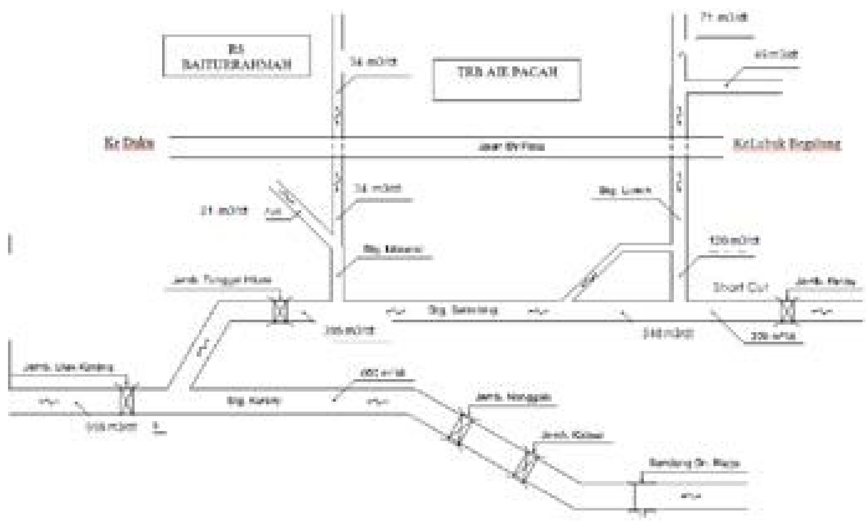

Figure 6. Distribution of Flood Discharge Batang Kuranji Watersheed

Calculation of high water level river by Standard step method

Padang City Government Center is flanked by two tributaries namely Batang Maransi leatherback rod and rod Straight Muara Batang Maransi within ± 2.6 km and a straight rod ± 3.5 km from the mouth of the rod on the beach Kuranji field. Based on calculations by the river water level tingghi stages standard method using the water level control points in the trunk Kuranji estuary when the tide (+ 0.93 m), the result is the water level in the trunk of leatherback precisely dimuara rod maransi + 3.501, at the mouth of the rod +3.669 m long straight and at the mouth of the new straight rod + 4.426 m. Water level is seen still influenced by tides sirutnya sea water. (Figure 4.4). based on the water level in the estuary rod while maransi +3.501 + 2.565 land surface elevation, the height of the flood is 0.936 m. With this data retrieved polder dikes 1.50 m high. (Figure 4.5).

Calculation of high water level of the river by Standard step method

The Government office Center Padang City is flanked by two tributaries Batang Balimbing namely Batang Maransi and Batang Lurus. River mouth of Batang Maransi within ± 2.6 km and a Batang Lurus ± 3.5 km from the mouth of Kuranji river on the Padang beach. Based on calculations high water level with standard standard method using the water level control points in the mouth of river Batang kuranji when the tide (+ 0.93 m), result is the water level in Batang Balimbing precisely at the mouth of river Batang Maransi is + 3.501, at the old mouth of river Batang Lurus +3.669 m, and at the new mouth of river Batang Lurus is + 4.426 m. Water level is seen still influenced by the tides. (Figure 4.4). based on the water level in the mouth of river Batang Maransi +3.501 and elevation of land surface is + 2.565, So, the height of flood is ± 0.936 m in the government center office of Padang City . With this data retrieved polder dikes high is 1.50 m. (Figure 4.5).

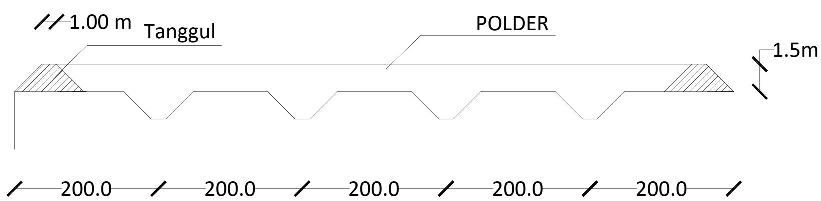

Figure 7. Cross section Design of Polder

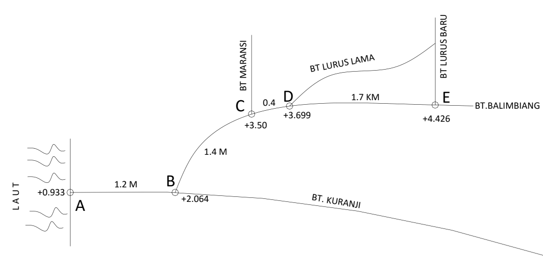

Figure 8. Schematic of the river water level on the calculation standard step method

Design of Polder

Problems in design of polder is how to drain rainwater that fell in the polder region, in this paper flood discharge in the polder is calculated with rational method modified as follows

$$Qt = 0{,}278 \cdot C \cdot Cs \cdot I \cdot A \qquad (2)$$

$$C_s = \frac{2t_c}{2t_c + t_d} \quad ; \quad t_c = t_0 + t_d \quad ; \quad t_d = \frac{L}{V} \qquad (3)$$

Where: Q are flood discharge plan; *C* is coefficient streaming; *Cs* is coefficient of deviation; *I* are rainfall intensity (mm/hour); *A* are area command area (catchment area) (km²); *Tc* is time of concentration for urban drainage channel drainage consists of to and td; *to* is the time it takes the water to flow through the soil surface *to* the nearest channel (minutes); *td* is time required to flow the water in the canal to a planned (minutes)

Calculations to, tc and td carried out in accordance with Figure 9.

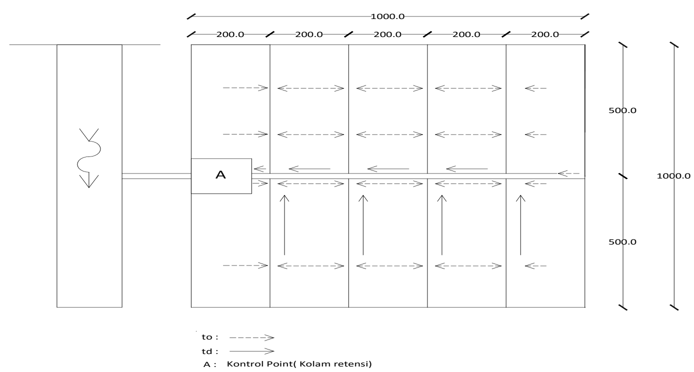

Figure 9. Concentration flow to control points on the location of the district administration center field

Calculation Volume of Retention Pool and Pumps Capacity

1. Area of region office (A) = 100 ha = 1 km^2
2. Flow coefficient (C) = 0.75
3. Starting time (t_0) obtained from the graph to determine t_0 (Subarkah.I, 1980) with C = 0.75; slope of 0.75%, range = 100 m obtained t_0 = 15 minutes.
4. The channel length (L_d) = 4000 m
5. Average velocity = 1.5 m/sec
6. Rainfall design for a return period 10 years = 233 mm

Solution:

1) The time flowing along the channel

$$t_d = \frac{L}{60.V} = \frac{4000}{60.1,5} = 44.44 \sim 45 \text{ sec}$$

2) Time Concentration

$t_c = t_o + t_d = 15 + 45 = 60$ sec

3) The coefficient of deviation

$$C_s = \frac{2t_c}{2t_c + t_d} = \frac{2.60}{2.60 + 45} = 0,727 \sim 0,73$$

4) Rainfall Intencity

$$I = \frac{R}{24} = \left(\frac{24}{t}\right)^{2/3} = \frac{233}{24} = \left(\frac{24}{60/60}\right)^{2/3}$$

= 80,78 mm/hour

5) Discharge Inflow

Qp = 0,278 . C . C_s . I . A
= 0,278 . 0.75 . 0,73 . 80,78 . 1
= 12,30 m^3/sec

Table 2. Cumulative inflows Q_m Rain Effective duration equal to the time of concentration (t_c) and Analysis Volume of retention pond and Pump Capacity

No	Cumola-tive Time (minutes)	Inflow m^3/sec	Average Inflow m^3/sec	At (seconds)	Volume m^3	Cumola-tive Volu-me 1 m^3	Volume Cumolative Pump		Volume Retention Pond	
							2 m^3/sec	5 m^3/sec	2 m^3/sec	5 m^3/sec
1	0.00	0.000	0.000		0	0	0	0		
2	7.50	1.538	0.769	900	692	692	900	2250	-208	-1558
3	15.00	3.075	2.306	900	2076	2768	1800	4500	968	-1733
4	22.50	4.613	3.844	900	3459	6227	2700	6750	3527	-523
5	30.00	6.150	5.381	900	4843	11070	3600	9000	7470	2070
6	37.60	7.708	6.929	900	6236	17306	4512	11280	12794	6026
7	45.00	9.225	8.467	900	7620	24926	5400	13500	19526	11426
8	52.50	10.763	9.994	900	8994	33920	6300	15750	27620	18170
9	60.00	12.300	11.531	900	10378	44298	7200	18000	37098	26298
10	67.50	11.421	11.861	900	10674	54973	8100	20250	46873	34723
11	75.00	10.542	10.982	900	9883	64856	9000	22500	55856	42356
12	82.50	9.663	10.103	900	9092	73949	9900	24750	64049	49199
13	90.00	8.784	9.224	900	8301	82250	10800	27000	71450	55250
14	97.50	7.905	8.345	900	7510	89760	11700	29250	78060	60510
15	105.00	7.026	7.466	900	6719	96479	12600	31500	83879	64979
16	112.50	6.147	6387	900	5928	102407	13500	33750	88907	68657
17	120.00	5.268	5.708	900	5137	107543	14400	36000	93143	71543
18	127.50	4.389	4.829	900	4346	111889	15300	38250	96589	73639
19	135.00	3.510	3.950	900	3555	115443	16200	40500	99243	74943
20	142.50	2.631	3.071	900	2763	118207	17100	42750	101107	75457
21	150.00	1.752	2.192	900	1972	120179	18000	45000	102179	75179
22	157.50	0.000	0.876	900	788	120963	18900	47250	102068	73718
23	165.00	0.000	0.000	900	0	120968	19800	49500	101168	71468
24	172.50	0.000	0.000	900	0	120968	20700	51750	100268	69218
25	180.00	0.000	0.000	900	0	120968	21600	54000	99368	66968
26	187.50	0.000	0.000	900	0	120968	22500	56250	98468	64718
27	195.00	0.000	0.000	900	0	120968	23400	58500	97568	62468
28	202.50	0.000	0.000	900	0	120968	24300	60750	96668	60218
29	210.00	0.000	0.000	900	0	120968	25200	63000	93768	57968
30	217.50	0.000	0.000	900	0	120968	26100	65250	94868	55718
31	225.00	0.000	0.000	900	0	120968	27000	67500	93968	53468
32	232.50	0.000	0.000	900	0	120968	27900	69750	93068	51218
33	240.00	0.000	0.000	900	0	120968	28800	72000	92168	48968
34	247.50	0.000	0.000	900	0	120968	29700	74250	91268	46718
35	255.00	0.000	0.000	900	0	120968	30600	76500	90368	44468
36	262.50	0.000	0.000	900	0	120968	31500	78750	89468	42218
37	270.00	0.000	0.000	900	0	120968	32400	81000	88568	39968
38	277.50	0.000	0.000	900	0	120968	33300	83250	87668	37718
39	285.00	0.000	0.000	900	0	120968	34200	85500	86768	35468
40	292.50	0.000	0.000	900	0	120968	35100	87750	85868	33218
41	300.00	0.000	0.000	900	0	120968	36000	90000	84968	30968
42	307.50	0.000	0.000	900	0	120968	36900	92250	84068	28718
43	315.00	0.000	0.000	900	0	120968	37800	94500	83168	26468
44	322.50	0.000	0.000	900	0	120968	38700	96750	82268	24218
45	330.00	0.000	0.000	900	0	120968	39600	99000	81368	21968
46	337.50	0.000	0.000	900	0	120968	40500	101250	80468	19718
47	345.00	0.000	0.000	900	0	120968	41400	103500	79568	17468

From the table 4 above was obtained:

1. Pump capacity 2 m³/sec, the volume of retention ponds obtained is 102 179 m³
2. Capacity pumps 5 m /sec, the volume of retention pond obtained is 75.457m³

If the Effective Rainfall longer than the time of concentration (tc), acquired the pump capacity and volume of retention pond is as table 4.7 below:

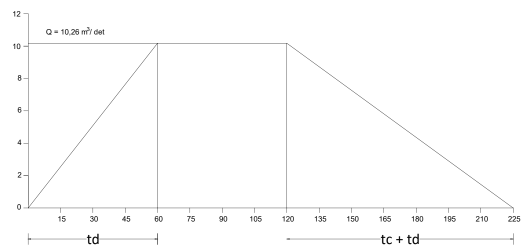

Figure 10. Graph inflow hydrograph (Qm) at the time of Effective Rain longer than the time of concentration (tc)

Table 3. Volume retention pond at the time of Effective Rain longer than the time of concentration (tc)

No	Effective Rainfall (tr) (Minutes)	Intensitas (I) (mm)	Dischart (Q) m³/sec	Time Consentration (tc) (Minutes)	Volume Retention Ponds (m³)	
					Pump (2 m³/sec)	Pump (5 m³/sec)
1	90	61,53	10,26	60	140.006	103.629
2	120	50,80	8,92	60	159.522	114’090
3	150	43,79	7,94	60	174.360	120.021

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

1. Mouth of Maransi Batang and Batang Lurus still influenced by the tidal water level
2. High-polder is planned 1.50 m
3. At the time effective rainfall same same with the time concentration with a pump capacity 2 m³ / sec, obtained volume of retention pond is 102 179 m³ and with a pump capacity 5 m³ / sec, obtained volume of retention pond is 75 457 m³
4. At the time effective rainfall longer than the time of concentration ³ (Rainfall effective 90 minutes) with a pump capacity 2 m³ / sec, obtained volume of retention pond is 140 006 m³ and with a pump capacity 5 m³ / sec, obtained volume of retention pond is 103 629 m³

5. At the time effective rainfall longer than the time of concentration ^{3} (Rainfall effective 120 minutes) with a pump capacity 2 m^3 / sec, volume of retention pond obtained is 159.522m^3. and with a pump capacity 5 m^3 / sec, volume of retention pond obtained is 114 090 m^3
6. At the time effective rainfall longer than the time of concentration ^{3} (Rainfall effective 150 minutes) with a pump capacity 2 m^3 / sec, volume of retention pond obtained is 171 360 m^3 and with a pump capacity 5 m^3 /sec volume of retention pond, obtained is 120 021 m^3

Recommendations

Construction of flood control infrastructure throughout the whole of this region requires substantial funds, apart from making the channel also to built of temporary water storage pon d during high tide. Therefore, are expected the government of Padang city may recommend creating a polder at each office complex or residential independently.

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