The Climate Change on Maximum Rainfall dan Flood in Bandar Lampung

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ABSTRACT

Rapid population growth will never stop as sources of problems that occur in almost all major cities in Indonesia. Local government in handling and anticipating the growth population tend to be less prepared, causing the city to become increasingly chaotic. Reduced and lost of parks and green open area into building area will effect to the hydrological conditions, especially floods event in these area. In addition, the trends and variability of climate change like temperature and rainfall, especially the extream rainfall frequency that occured in Bandar Lampung city. The aim of research are to identify the maximum flood areas due to maximum rainfall with return periods of 2, 5, 10, 20, and 30 years; to assess the maximum capacity of river and drainage channels to maximum flooding; to assess the volume and duration of overflow event. The maximum rainfall calculation has calculated with frequency analysis, the maximum flood has done with rational modification method. Calculation of river capacity or drainage channel was conducted with slope area method and manning formula. Calculation of volume and duration of flooding was used flood hydrograp analysis. The results of the drainage channel capacity of 38% figured that the drainage canal just only able to drain the flood event with a 2year return period. The upcoming flood is expected to increase by approximately 10% by 2030. The largest maximum capacity in Way Kuala and the largets flood volume occur in Way Kuripan, and the longest overflow occurs in Way Kuripan.

Keywords: maximum flood, maximum capacity, rational modification, manning formula.

I. INTRODUCTION

Bandar Lampung city is the capital of Lampung Province with a land area of 19,722 ha, consists of 13 districts and 98 urban villages. The city is traversed by two big rivers namely Way Kuala and Way Kuripan and 23 small rivers. All of these rivers mostly lead to Lampung Bay. Based on the data of 2014, the population of Bandar Lampung approximately 1,167,101 people with population density of 8,316 people/km^2 and population growth estimation reached 2.4 million ppeople in 2030.

Rapid population growth will never cease as sources of problems that occur in almost of all major cities in Indonesia. Local government in handling and anticipating the growth population tend to be less prepared, causing the city to become increasingly chaotic. Reduced and lost of parks and green open area into building area will effect to the hydrological conditions, especially floods event in these area. The great flood disaster in January 2013 that killed 3 people, floods in more than 20 areas with a height of 0.5 m until more than 2 m, flood disaster in every rainy season/year and last flood disaster in 2017 make big financial losses. (nasional.republika.co.id). This condition become worse with the changes of trends and variability of climate variables such as temperature and rainfall, the temperature become warmer and changes of rainfall, especially the frequency of extreme rainfall that occurred in the Bandar Lampung City.

Changes of type or type of land use in urban areas are very influential to hydrological processes in the city, especially the change of forest land use into building areas. This condition will disrupt the natural water balance (Saghafian et.al., 2008; Ali et al., 2011; and Suriya et al., 2012). Changes from forest vegetation types to settlements or industries are examples of land changes. Similarly, land use change for settlements and industries occurs in urban areas.

Change of upstream watershed area function of 15% disturbed river balance. This disorder contributes to the increase in the quality and quantity of flow discharge and sedimentation in rivers (Birkel et al., 2012). It can also be interpreted that an natural watershed areas with dense vegetation can be changed of 15% without change the natural condition. If the change more than 15% then should be found the alternative or need compensation to maintain the river sustainability, for example namely making absorption wells.

Hydrological analysis of flood problem in Bandar Lampung City area is very important to do. Estimate how much a maximum flood can occur, the maximum capacity of the river/canal to accommodate the flood, and how long a flood will occur.

II. RESEARCH METHOD

The study was conducted in Bandar Lampung City, using inlet method or the method to divide the research area into smaller drainage areas that called inlet. At the outlet of the inlet area will relate becomes an outlet that called the drainage area (Bambang, 2010). Observations were did in each inlet and outlet of the drainage areas. Research is emphasized on natural drainage or river as city drainage channel as the river network map (presented in Figure 1).

The maximum flood that occurs in urban areas calculated with Rational method (Hidayat and Hendrawan, 2017).

$$Q = 0.278\ C.I.A\ (m^3/s)$$ in a certain reset period.

C = flow coefficient (crop coefficient)

I = Rain intensity for rain duration that equal with concentration time (tc, min) in return period T year (mm/h)

A = Area of river basin (km^2)

Flow coefficient (C) calculated based on the ratio between the thickness of the flow and the thickness of the rain for a long period of time. Factors that affecting the flow coefficient of local conditions and physical characteristics of the flow areas, which are usually interpreted with set of land use (Kundu and Olang, 2011)

As the basis for calculating the flow coefficient for the research area is obtained from the value of the flow coefficient multiplied with the set of land use (Fuad, 2014). The equation for calculate the region's flow coefficient value is :

$$(C) = \frac{(C_1.A_1) + (C_2.A_2) + ...(C_n.A_n)}{(A_1 + A_2 + ...A_n)}$$

$C_1, C_2, ... C_n$ = The flow coefficient value in each of land use.
$A_1, A_2, ... A_n$ = Each of land use area

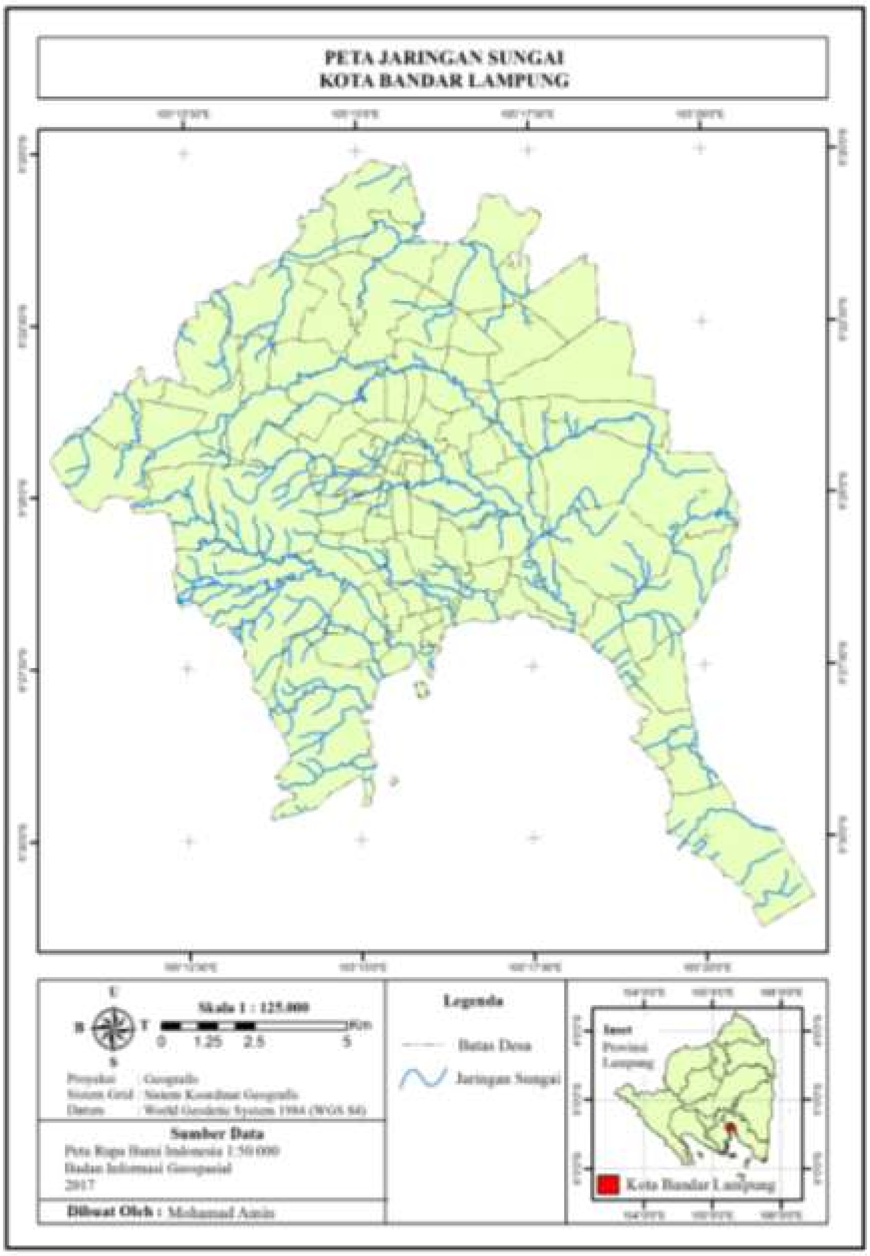

Figure 1. Map of River Networks in Bandar Lampung City

Rain intensity is a function of the amount of rain and long rain. The relationship of both is expressed in the curve of the intensity of rainfall from various repetitions in the duration of rain (Indarto, 2010). The amount of rainfall from various repetition periods is obtained from Gumbel Type 1 frequency analysis method (Soemarto, 1986). In accordance with rainfall data that obtained is the maximum daily rainfall, then the calculation of rain intensity using Mononobe method.

$$I = \frac{R_{24}}{24} + \left(\frac{24}{t}\right)^{2/3}$$

I = Rain Intensity (mm/h)
R_{24} = Maximum rainfall in a particular return period (mm)
T = Duration of rain (hours), if in the calculation then using time concentration (Tc)

The maximum channel/river capacity calculation is determined based on the slope of the method area, which is calculated indirectly by the manning formula (Hidayat and Hendrawan, 2017).

$$Q = V.A$$

Q = Maximum channel/river capacity (m^3/sec)
A = Area of cross section (m^2)
V = Average of flow velocity, using the manning formula (m/sec)

The hydrograph calculation of flood is assumed with triangular shape (presented in Figure 2), with peak discharge hydrograph is Qp and rain duration equal with concentration time, while base time (Tb) of 2.17 Tc (Kimaro et al., 2005)

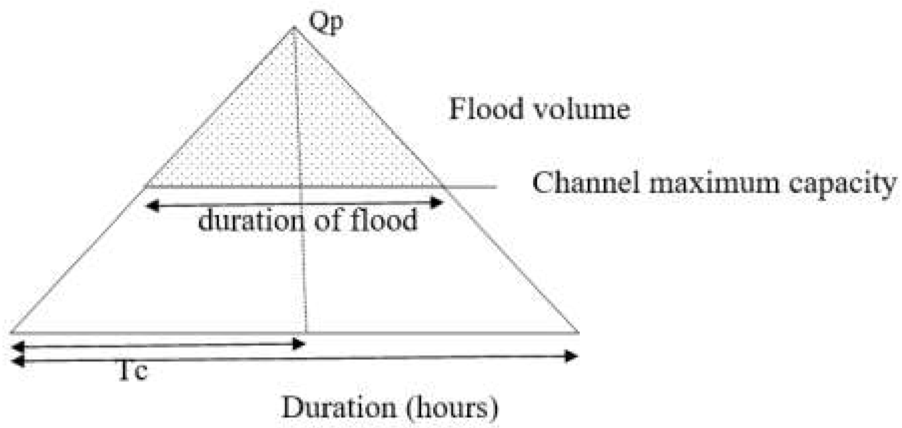

Figure 2. The hydrograph calculation of flood

III. RESULTS AND DISCUSSION

The calculation of frequency analysis for maximum daily precipitation in the study area from 1998 to 2016 used Gumbel distribution, resulted the average of sample or μ = 115.55, standard deviation or σ = 32.15, reduced mean or yn = 0.5220, and reduced standard deviation or sn = 1.0565. Maximum rain in repeat period (2, 5, 10, 20, 30 years) is presented in Table 1, whereas rain intensity in repeat periods (2, 5,10, 20, 30 years) is presented in Table 2.

Table 1. Maximum rain in repeat periods (2, 5, 10, 20, 30 years)

Average =	115.55	Reduced mean =	0.5220
Deviation =	32.15	Reduced standard =	1.0565
Repeat period	Reduced variate	Frequency factor	Maximum rain
2	0.3668	0.1469	106.8750
5	1.5004	0.9261	141.4178
10	2.2510	1.6365	164.2882
20	2.9709	2.3179	186.2260
25	3.1993	2.5341	193.1850

Table 2. Rain intensity in repeat periods (2, 5, 10, 20, 30 years)

Duration (minutes)	Rain intensity in repeat periods (mm)					
	2 years	5 years	10 years	15 years	20 years	25 years
10	191.50	253.34	294.29	317.39	333.57	346.03
20	120.63	159.60	185.39	199.95	210.14	217.99
30	92.06	121.79	141.48	152.59	160.36	166.35
40	76.00	100.54	116.79	125.96	132.38	137.32
50	65.49	86.64	100.65	108.55	114.08	118.34
60	58.00	76.73	89.13	96.12	101.02	104.80
90	44.26	58.55	68.02	73.36	77.09	79.97
120	36.53	48.33	56.15	60.55	63.64	66.02
150	31.48	41.65	48.39	52.18	54.84	56.89
180	27.88	36.89	42.85	46.21	48.57	50.38

The calculation of rain intensity with rainfall duration using Mononobe formula is presented in intensity duration curve or graph of rainfall intensity curve (Figure 3).

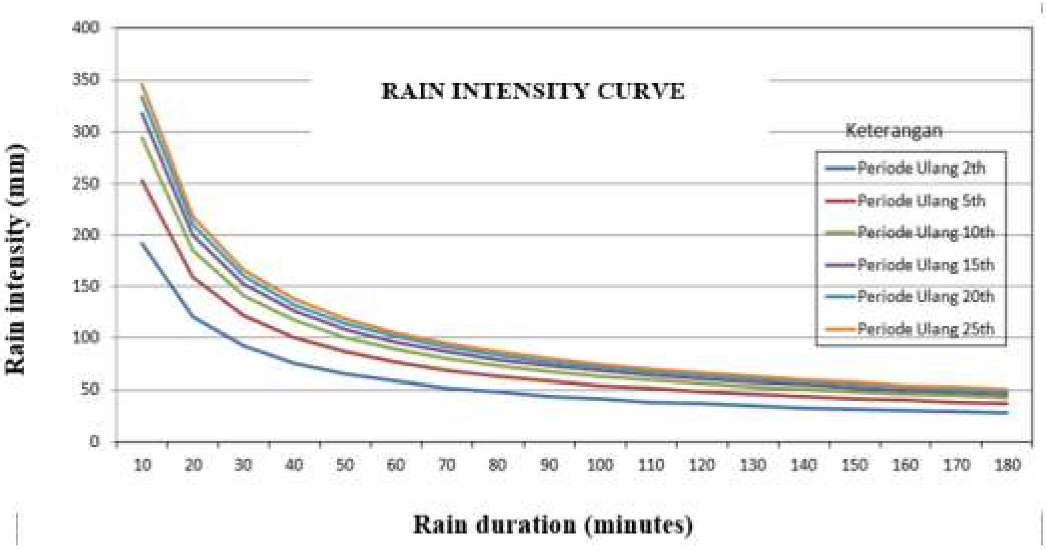

Figure 3. Rainfall Intensity Curve

Some of river and main drainages in Bandar Lampung will evaluate the capacity for saving water from flood in this area. Big River, Way Kuala divided into sub-watershed namely Way Kedamaian, Way Awy, Way Penengahan, Way Simpur and Way Kuala. The smaller river like as Way Kunyit , Way Kupang, dan Way Kripan. Every sub-watershed divided into some of monitoring outlet point for get the information of flood, river capability and drainage capability in repeat period (2, 5, 10, 20, 25, 30 years in were presented in Table 3 and Table 4).

Table 3. Floods in Repeat Period (2, 5, 10, 20, 25, 30 years)

Way Kedamaian								
outlet	Watershed Area	Flow coefficient	Floods in Repeat Period					
			2 y	5 y	10 y	2 y	2 y	3 y
1	0.50	0.7440	11.4678	15.2989	18.6906	21.8870	22.9786	23.8228
2	0.58	0.6480	7.8084	10.4169	12.7263	14.9028	15.6460	16.2208
3	0.32	0.5906	3.8940	5.1949	6.3466	7.4319	7.8026	8.0892
Way Awi								
outlet	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
4	2.86	0.7198	38.9227	51.9255	63.4373	74.2863	77.9912	80.8565
5	0.27	0.7615	3.0788	4.1074	5.0180	5.8761	6.1692	6.3958
6	1.32	0.9606	27.3617	36.5023	44.5948	52.2214	54.8258	56.8400
7	0.25	0.9490	3.6637	4.8876	5.9712	6.9924	7.3411	7.6108
8	0.47	0.8431	6.4425	8.5947	10.5002	12.2959	12.9091	13.3834
12	0.33	0.7500	6.7062	8.9465	10.9299	12.7991	13.4375	13.9312

13	0.31	0.8045	3.9670	5.2922	6.4655	7.5712	7.9488	8.2409
14	1.03	0.7065	7.5227	10.0358	12.2607	14.3575	15.0736	15.6274
15	1.50	0.5810	10.9004	14.5418	17.7657	20.8040	21.8416	22.6440
16	0.61	0.6156	5.6703	7.5646	9.2416	10.8221	11.3619	11.7793
17	0.20	0.7398	2.3623	3.1515	3.8501	4.5086	4.7334	4.9073
Way Penengahan								
outlets	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
9	1.86	0.6639	34.3257	45.7928	55.9450	65.5126	68.7800	71.3068
10	0.72	0.7998	7.7886	10.3905	12.6941	14.8650	15.6063	16.1797
11	0.38	0.7545	4.8202	6.4304	7.8560	9.1996	9.6584	10.0132
Way Simpur								
outlets	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
18	0.36	0.8000	5.6817	7.5797	9.2601	10.8438	11.3846	11.8028
19	0.51	0.7568	7.1108	9.4864	11.5895	13.5715	14.2483	14.7718
20	0.27	0.7000	5.7955	7.7317	9.4457	11.0611	11.6128	12.0394
21	0.40	0.6463	4.0607	5.4172	6.6182	7.7500	8.1365	8.4354
22	1.17	0.5840	7.7441	10.3312	12.6216	14.7802	15.5173	16.0874
Way Kuala								
outlets	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
23	1.04	0.4500	7.6167	10.1611	12.4138	14.5368	15.2618	15.8225
24	33.40	0.5432	79.7563	106.4004	129.9891	152.2197	159.8114	165.6826
25	1.17	0.4796	8.2870	11.0554	13.5064	15.8163	16.6051	17.2151
26	0.35	0.5500	3.8106	5.0837	6.2107	7.2728	7.6356	7.9161
27	0.36	0.6167	6.1387	8.1895	10.0050	11.7161	12.3004	12.7523
28	0.41	0.7998	5.6894	7.5901	9.2728	10.8586	11.4001	11.8190
29	0.26	0.7808	4.9266	6.5724	8.0295	9.4027	9.8717	10.2343
30	0.06	0.4250	0.2300	0.3069	0.3749	0.4390	0.4609	0.4779
31	0.98	0.7008	6.6567	8.8805	10.8493	12.7047	13.3383	13.8284
Way Kunyit								
outlets	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
1	0.375	0.5613	4.1459	5.5309	6.7571	7.9127	8.3073	8.6125
2	0.530	0.7500	7.2932	9.7296	11.8867	13.9195	14.6137	15.1506
3	1.100	0.5816	20.2753	27.0486	33.0452	38.6966	40.6265	42.1191
4	0.248	0.6895	2.3318	3.1107	3.8004	4.4503	4.6723	4.8439
5	1.020	0.5440	7.3880	9.8562	12.0413	14.1005	14.8038	15.3476
6	0.420	0.7690	6.8768	9.1741	11.2080	13.1248	13.7794	14.2856

7	0.648	0.8698	8.2665	11.0281	13.4730	15.7771	16.5640	17.1725
8	0.570	0.5702	8.6536	11.5446	14.1040	16.5160	17.3397	17.9767
9	0.360	0.6167	2.2090	2.9469	3.6002	4.2159	4.4262	4.5888
10	0.260	0.5596	2.2931	3.0592	3.7374	4.3766	4.5949	4.7637
Way Kuripan								
outlets	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
1	0.435	0.5500	5.9896	7.9906	9.7621	11.4316	12.0017	12.4426
2	1.430	0.5500	17.7022	23.6159	28.8515	33.7857	35.4707	36.7738
3	0.165	0.5500	1.6404	2.1884	2.6736	3.1308	3.2869	3.4077
4	0.583	0.5530	3.6796	4.9089	5.9972	7.0228	7.3731	7.6439
5	0.220	0.7500	2.4978	3.3322	4.0709	4.7671	5.0049	5.1888
6	0.100	0.7500	1.4823	1.9775	2.4159	2.8290	2.9701	3.0793
7	0.030	0.8000	0.6257	0.8347	1.0198	1.1942	1.2537	1.2998
8	0.260	0.8645	4.4989	6.0019	7.3325	8.5865	9.0147	9.3459
9	0.100	0.7500	1.4138	1.8861	2.3043	2.6983	2.8329	2.9370
10	0.050	0.7500	1.3166	1.7564	2.1458	2.5128	2.6381	2.7350
Way Kupang								
outlets	Watershed	Flow	Floods in Repeat Period					
	area	coefficient	2 y	5 y	10 y	2 y	2 y	3 y
1	0.404	0.6448	6.5258	8.7059	10.6360	12.4550	13.0761	13.5565
2	0.160	0.7563	3.8173	5.0926	6.2216	7.2856	7.6490	7.9300
3	0.210	0.7500	6.7338	8.9834	10.9750	12.8519	13.4929	13.9886
4	0.120	0.7500	4.3183	5.7609	7.0381	8.2418	8.6528	8.9707
5	0.160	0.8594	1.8476	2.4649	3.0113	3.5263	3.7022	3.8382
6	0.040	0.9250	1.0038	1.3392	1.6361	1.9159	2.0114	2.0853
7	0.046	0.7563	0.3750	0.5002	0.6111	0.7156	0.7513	0.7789
8	0.100	0.8000	0.8315	1.1093	1.3552	1.5870	1.6661	1.7273
9	0.020	0.9958	0.3400	0.4536	0.5542	0.6489	0.6813	0.7063
10	0.180	0.7668	5.1355	6.8511	8.3700	9.8014	10.2902	10.6683

Table 4. Maximum capacity of outlets (m^3/sec) and outlets capability (years)

Way Kedamaian							
outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
1	1.4000	0.0350	0.4268	0.0300	2.8053	3.9274	0.28
2	4.5900	0.0500	0.7809	0.0087	1.5819	7.2610	0.56
3	1.0800	0.0160	0.3366	0.0164	3.8730	4.1828	6.80
Way Awi							
outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
4	5.3215	0.3500	0.7083	0.0335	0.4155	2.2112	7.90
5	4.4000	0.4500	0.6894	0.0070	0.1451	0.6384	1.10
6	2.7250	0.0550	0.5134	0.0225	1.7486	4.7650	0.28
7	11.8500	0.0500	1.3167	0.0075	2.0807	24.6568	2.30
8	3.1050	0.0200	0.5258	0.0165	4.1840	12.9913	91.50
12	2.0000	0.0400	0.5183	0.0172	2.1156	4.2311	2.50
13	12.6000	0.0450	1.5501	0.0172	3.9035	49.1846	0.45
14	19.2100	0.0300	0.8353	0.0012	1.0242	19.6740	0.60
15	5.2000	0.0350	1.1766	0.0097	3.1362	16.3082	16.50
16	7.6000	0.0350	0.7251	0.0036	1.3836	10.5155	12.00
Way Penengahan							
outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
9	3.7200	0.0350	0.7880	0.0067	1.9952	7.4222	0.16
10	8.4500	0.0350	1.2210	0.0032	1.8464	15.6018	1.00
11	9.0000	0.0400	1.1002	0.0104	2.7171	24.4538	5.40
Way Simpur							
outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
17	3.3000	0.1600	0.3353	0.0100	0.3016	0.9954	100.00
18	0.7250	0.1600	0.7461	0.0149	0.6276	0.4550	0.25
19	4.5000	0.0200	0.6329	0.0229	5.5776	25.0990	84.00
20	2.9000	0.0287	1.3491	0.0188	5.8330	16.9157	1.00
21	9.6500	0.0345	1.9012	0.0105	4.5582	43.9867	65.00
22	29.6000	0.0402	1.7608	0.0112	3.8387	113.6270	11.80
Way Kuala							
outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
23	39.0000	0.0517	2.1446	0.0256	5.1467	200.7204	30.00

24	36.4000	0.0517	0.4823	0.0161	1.5094	54.9417	85.00
25	164.9000	0.0460	0.2280	0.0132	0.9321	153.7115	100.00
26	3.1250	0.0400	0.3368	0.0268	1.9812	6.1912	95.25
27	0.4800	0.0350	0.3931	0.0250	2.4242	1.1636	0.08
28	0.8800	0.0170	0.4709	0.0191	4.9206	4.3301	2.25
29	1.1200	0.0170	0.3931	0.0268	5.1676	5.7877	3.50
30	1.7000	0.0160	0.4709	0.0010	1.1963	2.0337	0.35
31	65.6000	0.0460	0.4769	0.0853	3.8756	254.2370	25.00

Way Kunyit

outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
1	0.5800	0.0170	0.2682	0.0354	4.6028	2.6696	2.00
2	2.4788	0.0450	0.6339	0.0333	2.9924	7.4176	6.50
3	3.0400	0.0350	0.6598	0.0222	3.2264	9.8082	0.75
4	3.6100	0.0517	0.6792	0.0050	1.0568	3.8150	0.64
5	0.7000	0.0130	0.2652	0.0089	2.9955	2.0968	0.30
6	0.5000	0.0120	0.2049	0.0089	2.7324	1.3662	0.15
7	0.9350	0.0160	0.3202	0.0181	3.9355	3.6797	0.01
8	3.4000	0.0450	0.5667	0.0624	3.8014	12.9249	1.25
9	0.6400	0.0160	0.2667	0.0006	0.6343	0.4060	0.01
10	8.7700	0.0500	1.1383	0.0056	1.6317	14.3096	0.65

Way Kuripan

outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
1	1.4000	0.0240	0.2138	0.0433	3.1001	4.3401	2.80
2	0.6800	0.0120	0.2720	0.0643	8.8710	6.0322	34.50
3	1.3230	0.0350	0.3656	0.0486	3.2205	4.2607	1.28
4	1.5000	0.0170	0.4345	0.0163	4.3083	6.4624	38.50
5	0.3200	0.0200	0.2000	0.0170	2.2295	0.7135	0.75
6	0.7225	0.0200	0.4117	0.0042	1.7933	1.2956	11.00
7	1.0000	0.0230	0.4184	0.0015	0.9420	0.9420	4.50
8	1.6500	0.0230	0.4459	0.0025	1.2688	2.0936	0.80
9	2.3400	0.0230	0.5318	0.0030	1.5631	3.6578	0.20
10	2.6000	0.0250	0.5652	0.0100	2.7344	7.1094	0.95

Way Kupang							
outlets	Cross section of river area	roughness	Radius of	slope	Velocity of flow	Kapasitas Max. Capacity of river	River capability
	(m^2)	Manning	Hydraulic	(S)	(m/sec)	(m^3/sec)	(years)
1	0.7000	0.0170	0.3655	0.0577	7.2232	5.0563	38.50
2	0.9750	0.0402	0.2840	0.0268	1.7595	1.7155	0.25
3	0.5615	0.0200	0.3974	0.0125	3.0216	1.6967	5.25
4	4.8325	0.0460	0.9226	0.0186	2.8098	13.5783	7.50
5	5.2240	0.0350	0.6757	0.0170	2.8685	14.9852	7.30
6	1.0000	0.0172	1.0000	0.3522	34.5037	34.5037	86.50
7	0.8000	0.0170	0.3077	0.0025	1.3405	1.0724	0.50
8	0.5600	0.0170	0.2531	0.0083	2.1443	1.2008	0.50
9	1.0800	0.0200	0.4837	0.0209	4.4541	4.8104	99.00
10	7.8500	0.0450	1.0072	0.0135	2.5944	20.3658	8.00

The main disposal channel of the Tanjungkarang area is Way Kuala with a good capability over 100 years except the main outlet (only 25 year old capability). Reduced ability is due to the sedimentation that occurs. Furthermore, the average drainage ability of Way Kedamaian, Way Awy, Way Penengahan, Way Simpur 6.8 years, 12 years, 5.4 years, and 11.8 years respectively.

Outlet with the lowest ability is the outlet of Kuala 27, because it is not in the residential area, so the effect is not too felt. While the outlets 5, 6, 9, 10 floods that occur are felt because of the densely populated area and the center of activity. It happens because of narrowing the cross section of the river by the buildings on the channel cliffs. Length of puddle occurred 9, 18, 13, 7 minute and volume of puddle 880, 4,635, 4,600, and 700 m^3 for 2 year of flood return period.

The main drainage channels in the bay area are Way Kunyit, Way Kuripan, and Way Kupang. Way Kunyit has a capacity of 0.95 years. The puddle length for Way Kunyit is 18 minutes and the flood volume is 1,500 m^3 for 2 year floods return period.

The Kuripan Way has a channel capability of 0.65 years, length of inundation of 6 minutes and 1,100 m^3 flood volume for 2 years flood return period. At outlets 5, 8, 9, 10 are located in densely populated areas and the activity centers have low channel capability of 0.3 years, 1.25 years, 0.8 years, and 0.65 years respectively.

The puddle period for Way Kupang only occurred in 10 years repeat period of 60 minutes and flood volume of 216 m^3. At 8 Way Kupang outlet become problems because in industrial area and dense activity of channel ability 0.5 year, puddle period of 20 minutes and volume 936 m^3, to 2 year flood return period.

CONCLUSION

1. The main drainage channel of the Tanjung Karang area namely Way Kuala, is basically well-skilled, but the average collector channel is poorly skilled for less than 10 years.

The main drainage channel of Teluk Betung area, Way Kunyit, Way Kupang, and Way Kuripan are generally poorly skilled, the average of capability is less than 10 years.

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