Analyze The Characteristic of Rainfall and Intensity Duration Frequency (IDF) Curve at Lampung Province

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Abstract— **This research was done to analyze the characteristic of rainfall based the short term duration of rainfall data at BMG Maritim Lampung station, BMG Raden Inten II Bandar Lampung station, Masgar Tegineneng Climatology station and Kotabumi Geophysical station. From the results of the research intensity duration frequency (IDF) curve will be made based on: (1) Analysis of rain distribution frequency of short term rainfall data from each statios. (2) Analysis of rainfall intensity for every rain duration in particular measurement uses Van breen intensity method and Hasper der weduwen intensity method then least square (kuadrat kecil) is used to calculate rainfall intensity approach by Talbot, Sherman and Ishiguro formula's, the purpose is to determine the equality of rainfall intensity to targeted region.**

From the result of the research, it could be summarized as follows ;(1) The data of rainfall used is short term rainfall data (5, 10, 15, 30, 45, 60, 120 minutes, 3 hours, 6 hours and 12 hours) and as annual maximum series, (2) Type of distribution that appropriate with all observation station is Log Pearson Type III Distribution, (3) The rainfall intensity of Van Breen method used Talbot equality, it is used as reference to form IDF curve. The intensity equality was valid only to data of rain in all observation year at every station. (4) The IDF Curve showed that high rainfall intensity happen in short duration (5) the IDF curve can be used to determine planning flood by using rational method.

Keywords — **Rainfall, intensity, duration and frequency**

I. INTRODUCTION

Earth's globally changing climate conditions due to the greenhouse effect has an impact on weather conditions / Indonesian regional and local climate extreme. The real impact of climate aberration (extreme climate) is the increased intensity of rainfall, flash floods and tide flood (rob), local hurricane / tornado, increased urban temperatures, droughts and landslides. For the first time in 23 years Bandar Lampung city was attacked by flash flood. The floods caused by 4 hours rain since Thursday evening (12.18.8). In addition to threatening floods, landslides also threaten some region such as West Lampung, Tanggamus, and Way Kanan.

These climate change conditions have the potentiality to affect the engineering design standards in the future. In planning the flood control building (drainage channels, levees, etc) the data of rainfall input is needed. Experts in civil engineering (water), geomorphology, and land and water conservation are more interested in analyzing the frequency of extreme climatic events on rainfall intensity and different duration by using IDF curve.

This research is aimed to analyze the rainfall characteristics in Lampung province. The result is IDF curves that can be used to calculate the flood discharge plan which is used for planning flood control building.

Hydrological system is affected by extreme events like floods and droughts. Magnitude of extreme events is inversely to the frequency of the occurrence, remarkable extreme events are very rare. The purpose of frequency analysis related to the extreme events which relate to frequency of occurrence through the application of probability distribution. Frequency analysis based on statistical properties of the past events data was done to obtain the rainfall probability in the future with the assumption that the statistical properties of the future rainfall are still equal to the statistical properties of rainfall in the past.

In statistic, there are four frequency distributions that are widely used in hydrology, they are: normal distribution, log-normal, Gumbel and Log Pearson III. Each distribution has distinctive properties, so that the rainfall data must fit tested with the statistical properties of each distribution. The selection of an incorrect distribution can lead to significant estimation errors, either overestimated of underestimated (Sri Harto 1993).

In the diversion process of rain into streams, there are some traits that are important to be considered, they are: rain intensity (l), rain duration (t), the depth of rain (d), frequency (f), and the influence area of rain (Soemarto, 1987). High intensity of rain means rain or water depth per unit time. In other words, rainfall intensity states the amount of rainfall in the short term that describes rain per hour. To obtain the value of rain intensity in a particular place, the measuring instrument used should be able to record the amount of rainfall volume and duration until the rain had stopped. In this case the measuring instrument used is automated rain measuring instrument. (Asdak, C, 1995).

To change rainfall into rain intensity can be used various methods including:

1. *Van Breen Method*

   Van Breen formula is based on the assumption that the rainfall duration in java is concentrated for 4 hours with an effective rate of 90% from total rain in 24 hours. The formula is:

ISSN 2301-6590

$$I = \frac{90\%R^{24}}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Note, I = Rain intensity (mm/hour)
R^{24} = Maximum rainfall (mm/24 hour)

Based on Van Breen curve pattern in Jakarta, the amount of rainfall intensity can be approximated by the equation:

$$I_T = \frac{54R_T + 0{,}007R_T{}^2}{t_c + 0{,}31R_T} \quad \ldots\ldots(2)$$

Note,
I_T = Rain intensity (mm/hour) when concentration tc
tc = Concentration time (minute)
R_T = Maximum daily rainfall (mm/24 hour)

2. *Hasper Der Weduwen*
This method is the result of investigation conducted in Indonesia by Hasper and Der Weduwen. The formula is obtained based on the daily rainfall tendency which are grouped on the basis of the assumption that the rain has symmentrical distribution of the rainfall duration (t) is less than 1 hour and rainfall duration are from 1 – 24 hours.

The formula used is:

$1 < t \leq 24$, so

$$R = \sqrt{\frac{11300t}{t+3{,}12}\left[\frac{R_t}{100}\right]} \quad \ldots\ldots\ldots\ldots(3)$$

$0 < t \leq 1$, so $R = \sqrt{\frac{11300}{t+3{,}12}\left[\frac{R_t}{100}\right]}$ $\ldots\ldots(4)$

and

$$R_t = X_t\left[\frac{1218t+54}{X_t(1-t)+1272t}\right] \quad \ldots\ldots\ldots\ldots(5)$$

Note,
t = Rain duration (minute)
R, R_t = rainfall according to Hasper-Der Weduwen
Xt = Selected maximum daily rainfall, (mm/ 24 hour)

To determine the intensity according to Hasper-Der Weduwen used the following formula:

$$I = \frac{R_t}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Note,

I = Rain intensity (mm/hour)
R_t = Rainfall (mm),
t = time (hour)

Analysis on the relationship of two important parameters in the form of intensity and duration can be associated statistically with a frequency of occurrence. The graphical presentation of this relationship is a curve of intensity-duration-frequency (IDF) (Loebis, 1992). This curve can be used for the runoff calculation and for peak discharge calculation when using rational formula by selecting the rainfall intensity proportional to the time of rainfall runoff from the top to the observed point in the downstream of the drainage area (waktu tiba = arrival time). This curve also shows the magnitude probability of rainfall intensity for the duration of rainfall at random.

In the planning of waterworks, it is necessary to plan the amount of water discharge to be channeled through the waterworks. For the water discharge volume to be channeled, we can determine the specific flood discharge which is large enough. When rainfall data is available, then the flood estimation can be done with rational equation, which is expressed in the following formula (Chow, 1964):

Qp = 0,278 C I A ……......(7)

Note,
Qp : Top discharge (m^3/second)
C : Coefficient *run off*, based on Watershead characteristic
I : Rainfall intensity, for rain duration equals concentration duration (tc) (mm/hour)
A : Area of Watershead a (Km^2)

II. RESEARCH METHOD

Rainfall data used in this research were taken from automated rain measuring instrument Hellman type in station:

- Lampung Maritime BMG Station (observed 2000 – 2001; 2003 – 2008)

ISSN 2301-6590

- Raden Inten II BMKG Station Bandar Lampung (observed 2001 – 2008)
- Masgar Climatology Class II Station Tegineneng (observed 2004 – 2008)
- Geophysics Station Kotabumi (observed 1998 – 2005, 2007 – 2008)

To get the IDF curve at each observation station, analysis procedure was performed as follows:

1. Determine the maximum daily rainfall for each year data
2. Determine the statistical parameters of data that has been sorted from smallest to largest, are: mean, standard deviation (S), coefficient of variation (Cv), coefficient of skewness (Cs), coefficient of kurtosis (Ck).
3. Determine the appropriate type of distribution that is based on statistical parameters.
4. Tested with Chi-Square and Smirnov Kolmogorov to determine whether the selected type of distribution is appropriate.
5. Calculate the amount of rainfall design for a specific time based on selected type of distribution, expressed by a simple formula as follows (Haan, 1979):

$$X_T = \overline{X} + K_T . S \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Note :

XT = rain design with time T year

$\overline{X}$ = average magnitude

S = standard deviation

K_T = frequency factor for time T year

6. Calculate rainfall planning to be rainfall intensity using Van Der Breen and Hasper-Der Weduwen for the duration of each rain.
7. Calculate rainfall intensity approach using least squares method that are Talbot formula, Sherman and Ishiguro. This method was used with the intention of determining the intensity of rain which is closest to regional planning / planning area.
8. Depiction of the daily rainfall intensity curve with a certain time.

III. DISCUSSION

Rainfall data used in this research is a maximum daily rainfall data derived from automated rain measurement instrument type Hellman at some stations as follows:

TABLE 3.1
RAINFALL DATA AT MARITIME LAMPUNG BMG STATION

Year	Amount at each time period (in milimeter)									
	5 minute	10 minute	15 minute	30 minute	45 minute	60 minute	120 minute	3 hour	6 hour	12 hour
2008	16.0	20.0	25.0	47.0	62.5	64.1	67.0	81.8	81.8	119.3
2007	6	10	16	25	36	42.0	106.6	109.5	109.5	109.5
2006	6	9	11.5	24	31.5	33	59.8	59.8	62.3	62.3
2005	8.0	20.0	26.0	50.5	60.0	69.0	72.8	73.4	76.0	76.5
2004	10.0	20.0	25.0	40.0	46.0	50.0	60.8	60.8	60.8	72.0
2003	10.0	16.0	20.0	40.0	51.0	51.5	55.5	69.2	69.2	69.2
2001	11.0	17.0	17.0	18.0	18.0	30.0	30.0	30.0	47.0	49.5
2000	10.0	20.0	30.0	40.0	54.5	57.2	59.2	59.5	62.1	62.1
Total	77.0	132.0	170.5	284.5	359.5	396.8	511.7	544.0	568.7	620.4
Average	9.6	16.5	21.3	35.6	44.9	49.6	64.0	68.0	71.1	77.6
n	8	8	8	8	8	8	8	8	8	8

Source: Maritime Lampung BMG Station

TABLE 3.2
RAINFALL DATA RADIN INTEN II BMKG STATION BANDAR LAMPUNG

Year	Amount at each time period (in milimeter)									
	5 minute	10 minute	15 minute	30 minute	45 minute	60 minute	120 minute	3 hour	6 hour	12 hour
2008	10.0	20.0	42.2	52.5	54.2	64.0	70.6	70.6	72.6	72.6
2007	15.0	27.0	30.0	44.0	50.6	83.0	103.0	107.0	113.0	113.0
2006	48.4	68.4	72.4	84.2	90.6	100.4	101.6	101.6	101.6	101.6
2005	12.0	22.0	29.0	37.7	40.0	40.0	51.3	60.0	76.0	76.0
2004	16.0	30.0	38.0	53.5	58.8	67.3	77.1	79.8	84.8	85.0
2003	15.0	27.0	37.0	50.5	57.4	58.6	68.0	68.0	68.0	68.0
2002	50.0	55.0	60.0	60.0	85.0	90.0	109.7	109.7	109.7	109.7
2001	30.0	30.0	36.4	38.0	48.0	48.0	51.2	52.0	52.0	55.7
Total	196.4	279.4	345.0	420.4	484.6	551.3	632.5	648.7	677.7	681.6
Average	24.6	34.9	43.1	52.6	60.6	68.9	79.1	81.1	84.7	85.2
n	8	8	8	8	8	8	8	8	8	8

Source: Radin Inten II BMKG Station, Bandar Lampung

TABLE 3.3
RAINFALL DATA AT MASGAR CLIMATOLOGY CLASS II STATION TEGINENENG

Year	Amount at each time period (in milimeter)									
	5 minute	10 minute	15 minute	30 minute	45 minute	60 minute	120 minute	3 hour	6 hour	12 Hour
2008	20	30	40	41	48	60	74.4	74.4	87.4	87.4
2007	10	20	30	70	84.2	87.8	88	91.7	106	106.8
2006	10.5	20.5	26.2	32.5	69	72.5	91.5	121.1	153	171.4
2005	14	20	28	31	42	51	60	73	79	81
2004	20	30	38	66	97	119	141.4	143	165	167
Total	74.5	120.5	162.2	240.5	340.2	390.3	455.3	503.2	590.4	613.6
Average	14.9	24.1	32.4	48.1	68.0	78.1	91.1	100.6	118.1	122.7
n	5	5	5	5	5	5	5	5	5	5

Source: Masgar Climatology Class II Station, Tegineneng

TABLE 3.4
RAINFALL DATA GEOPHYSICS KOTABUMI BMG STATION

Year	Amount at each time period (in milimeter)									
	5 minute	10 minute	15 minute	30 minute	45 minute	60 minute	120 minute	3 hour	6 hour	12 Hour
1998	5.0	13.0	18.0	38.6	56.0	62.0	103.9	109.4	112.8	114.1
1999	5.0	10.0	13.5	31.0	52.0	66.2	100.0	100.0	100.0	127.2
2000	3.0	10.0	20.4	32.0	42.2	49.0	59.8	59.8	59.8	59.8
2001	4.0	22.0	19.0	36.0	43.5	53.2	81.8	82.8	83.4	83.4
2002	8.6	35.0	25.0	46.5	62.0	64.0	74.5	78.5	78.6	104.8
2003	5.2	9.5	14.5	30.0	50.0	50.5	51.5	58.0	73.5	117.0
2004	5.5	10.0	15.0	40.0	73.0	53.0	68.2	68.2	97.7	98.5
2005	10.0	20.0	30.0	60.0	75.0	85.0	85.7	86.0	86.0	102.5
2007	8.5	10.0	20.0	36.0	45.0	65.0	71.8	74.6	80.0	81.2
2008	5.3	14.0	20.0	40.0	40.0	50.0	90.0	93.8	106.0	110.2
Total	60.1	153.5	195.4	390.1	538.7	597.9	787.2	811.1	877.8	998.7
Average	6.0	15.4	19.5	39.0	53.9	59.8	78.7	81.1	87.8	99.9
n	10	10	10	10	10	10	10	10	10	10

Source: GeophysicsStation, Kotabumi

The result of frequency analysis in this research is the type of distribution which is in accordance with statistical parameter at all observation stations are Log Pearson Distribution Type III and has been

tested with Chi_Square Test and Smirnov Kolmogorov test. Rainfall intensity values for all four observation stations shown in table 3.5 to table 3.8

TABLE 3.5
RAINFALL INTENSITY, DURATION & FREQUENCY AT MARITIME LAMPUNG BMG STATION

t (minute)	Intensity (mm/hour), every return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5	64.2135	74.8762	79.2190	83.0001	84.8067	86.5975
10	59.7464	70.1117	74.5136	78.4942	80.4983	82.4605
15	55.8604	65.9172	70.3358	74.4524	76.6064	78.7007
30	46.7402	55.8868	60.2086	64.4902	66.9028	69.2309
45	40.1801	48.5059	52.6306	56.8794	59.3811	61.7953
60	35.2348	42.8471	46.7469	50.8754	53.3798	55.8020
120	23.6108	29.2142	32.3024	35.7716	38.0128	40.2048
180	17.7538	22.1627	24.6773	27.5828	29.5158	31.4220
360	10.1788	12.8545	14.4467	16.3526	17.6678	18.9821
720	5.4922	6.9862	7.8980	9.0132	9.8001	10.5939

Source: Calculation Result

TABLE 3.6
RAINFALL INTENSITY, DURATION, AND FREQUENCY AT RADIN INTEN II BMKG STATION BANDAR LAMPUNG

t (minute)	Intensity (mm/hour), every return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5	92.3998	111.0765	121.9396	133.8093	141.4257	148.2013
10	84.1563	101.2586	111.2007	122.1281	129.1944	135.5168
15	77.2631	93.0353	102.2001	112.3227	118.9103	124.8324
30	62.0225	74.8094	82.2325	90.5197	95.9880	100.9541
45	51.8039	62.5547	68.7921	75.8051	80.4748	84.7441
60	44.4762	53.7498	59.1280	65.2055	69.2784	73.0195
120	28.4047	34.3885	37.8556	41.8170	44.5085	47.0058
180	20.8651	25.2817	27.8398	30.7774	32.7861	34.6585
360	11.6155	14.0887	15.5205	17.1750	18.3150	19.3837
720	6.1568	7.4723	8.2337	9.1166	9.7278	10.3025

Source: Calculation Result

TABLE 3.7
RAINFALL INTENSITY, DURATION, AND FREQUENCY AT MASGAR CLIMATOLOGY STATION

t (minute)	Intensity (mm/hour), every return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5	77.9932	88.5850	94.5692	101.2580	105.7643	109.4291
10	73.6038	84.3891	90.5275	97.4197	102.0736	105.9276
15	69.6823	80.5727	86.8171	93.8617	98.6317	102.6433
30	60.0793	70.9472	77.3110	84.5932	89.5708	93.90831
45	52.8025	63.3761	69.6811	76.9907	82.0346	86.54342
60	47.0980	57.2650	63.4220	70.6419	75.6682	80.24972
120	32.8865	41.3257	46.6578	53.1205	57.7431	62.16611
180	25.2634	32.3276	36.9033	42.5634	46.6841	50.73369
360	14.9012	19.5544	22.6791	26.6652	29.6489	32.69548
720	8.1859	10.9228	12.8066	15.2631	17.1400	19.10794

Source: Calculation Result

TABLE 3.8
RAINFALL INTENSITY, DURATION, AND FREQUENCY AT GEOPHYSICS STATION KOTABUMI

t (minute)	Intensity (mm/hour), every return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5	55.5926	66.6064	74.6847	85.3421	93.3654	101.2797
10	53.1747	63.5626	71.0114	80.6842	87.8713	94.8946
15	50.9583	60.7848	67.6825	76.5083	82.9879	89.2668
30	45.2944	53.7393	59.3375	66.2258	71.1290	75.7836
45	40.7637	48.1575	52.8245	58.3797	62.2355	65.8390
60	37.0570	43.6261	47.5998	52.1958	55.3189	58.2016
120	27.1732	31.6962	34.1065	36.6620	38.2950	39.7550
180	21.4517	24.8899	26.5735	28.2535	29.2833	30.1874
360	13.1470	15.1379	15.9832	16.7374	17.1652	17.5304
720	7.4099	8.4872	8.8940	9.2207	9.3920	9.5349

Source: Calculation Result

Results of rainfall analysis in this research were as follows:

1. Based on the observation on all stations showed that rainfall intensity in Van Breen method using Talbot equation was used as a reference to create IDF curve, because it has the smallest different value. The intensity equation is valid only for the rain data in the year of observations at each station.
2. From the rainfall intensity tables, it can be seen that the smaller rainfall duration the bigger rainfall intensity value.

From this research, four IDF curve are obtained (Frequency Duration Intensity Curve) for each return period (2, 5, 10, 25, 50, and 100 years) from each observation station, as shown in Fig. 1 to 4.

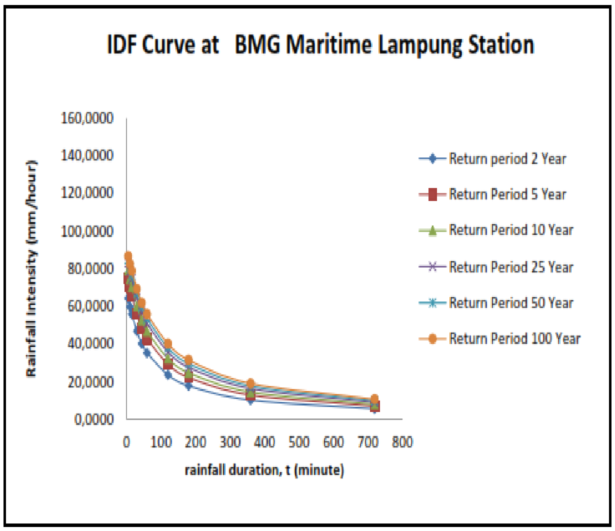

Fig. 1. IDF Curve BMG Maritime Lampung Station

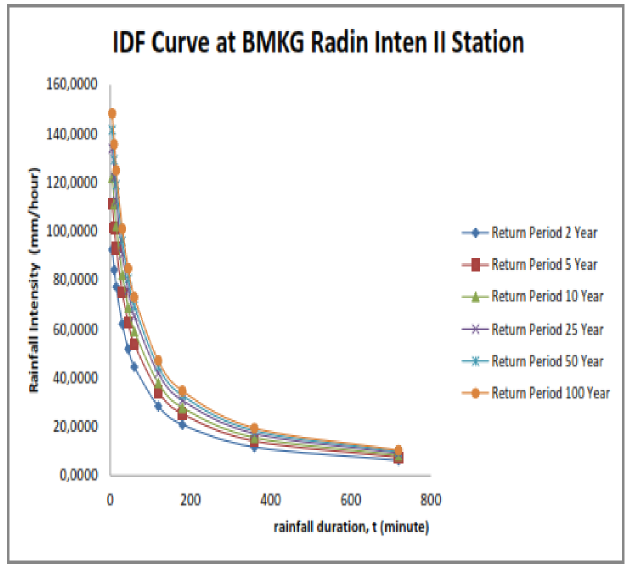

Fig. 2. IDF Curve BMG Radin Inten II Station Lampung Station

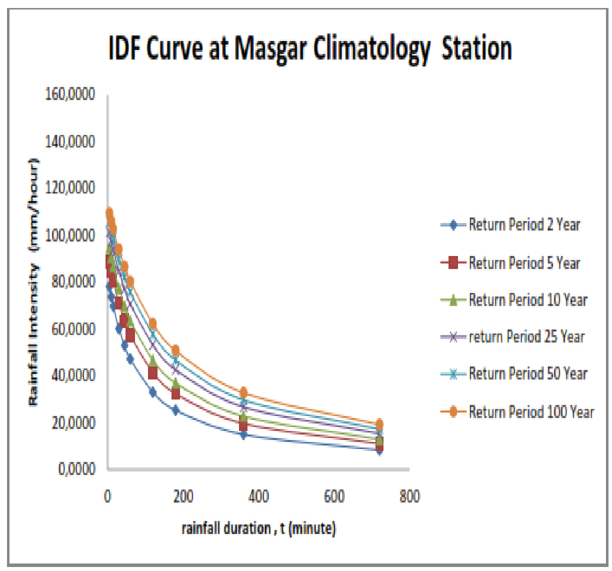

Fig. 3. IDF Curve Masgar Climatology Station

ISSN 2301-6590

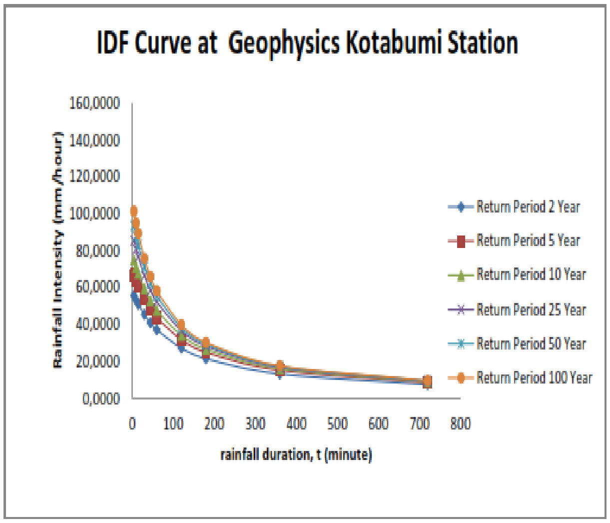

Fig. 4. IDF Curve Geophysics Station Kotabumi

As an example of IDF curves application towards rational method, used to calculate the discharge estimation for design planning Way Tulungmas river sub DPS Bendung Bumi Agung with the following data:

- The area of flow (A) = 88.100 Km^2
- The length of flow (L)= 49.55 Km
- Different height (DH) = 175.00 m
- The slope of the average flow (l) = 0.003532

Rainfall data used from Geophysics Station Kotabumi with variety of time and time concentration (tc) equals to rain observation duration = 12 hours (table 3.8, column t=720 minutes). Table 3.9 showed the discharge design calculation result for Way Tulungmas river sub DPS Bendung Bumi Agung using rainfall intensity data from Sta IDF curve. Geophysics Kotabumi with the discharge design using the data "Final Report, SID Way Abung Flood Control, and Way Sabuk North Lampung District". Public Works Department, 2007.

TABEL 3.9
DISCHARGE ESTIMATION PLAN (Q)-

Time (year)	Q from IDF curve intensity Kotabumi				Q data Project (m^3/second)
	A (Km^2)	I (mm/hour) t = 120 minutes	Flow Coefficient ©	Q (m^3/second)	
2	88,100	7,4099	0,75	136,0025	159,848
5	88,100	8,4872	0,75	155,7755	192,179
25	88,100	9,2207	0,75	169,2383	234,271
50	88,100	9,3920	0,75	172,3823	250,444
100	88,100	9,5349	0,75	175,0051	265,898

IV. CONCLUSSION

From the discussion and the results of the research, it can be concluded as follows:

1. Rainfall used are short term rainfall data (5, 10, 15, 30, 45, 60, 120 minutes, 3 hours, 6 hours, and 12 hours) and an annual maximum data (annual maximum series).
2. Type of distribution which is in accordance with all observation stations is Log Pearson Type III distribution.
3. Rainfall intensity in Van Breen method using Talbot is used as a reference to create the IDF curve.
4. From the IDF curve showed that high intensity rainfall happened in a short duration.
5. IDF curve can be used to determine the flood plan by using rational method.

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