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The Spatial Decision-Making System in Mitigation of The Southern Ring Road of Inundation Sub Watersheds

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Abstract. The high rainfall Palembang and tidal conditions DAS (watersheds) Keramasan cause the puddle on the surrounding area. Length of inundation that happened will cause impact damage to the road surface. Ring Road South of the city of Palembang is an important access that connects the city of Palembang with Regency Ogan Komering Ilir (OKI). The purpose of the research is the realignment of the South ring road by conducting simulations against a pool of conditions that occur in the appropriate mitigation so that the South Ring Road Sections not inundated again. The methods used are analyzing precipitation and discharge height of tidal river Keramasan so obtained discharge peak puddle, to know the pattern of distribution of pools by using the techniques of SIG (geographic information systems). The condition of the height of the area is modelled with a DEM (Digital Elevation Model) and high standing is modelled with Arcgis. With the expected mitigation modelling can be determined and is planned to determine the appropriate mitigation alternative criteria over the problem of standing water on roads roundabout South of the city of Palembang. Results of analysis showed the magnitude of the Qp Sub DAS Keramasan for 2 years is 55,519 M3/S, the 5-year anniversary period of 75,733 M3/S, and a period for 10 years anniversary of 87,249 M3/S. Based on the calculation of peak discharge and simulated altitude DEM then, the height of the southern Ring Road of the city of Palembang are unaffected is 1.20 meters tall standing.
Key words: Rain Intensity, Peak Discharge, DEM, Inundation Mitigation.

1. Introduction

The high rainfall the city Palembang of South Sumatra and in General. in the sub Keramasan watersheds. the area affected is also tidal river Keramasan so a puddle. Ring Road South of the city of Palembang is one of the important access that connects the city of Palembang Ogan Komering Ilir towns (OKI). South ring road is also located on the Keramasan River system sub Palembang. The frequent inundation caused the destruction of the infrastructure of the South ring road that is constantly changing shape of the layers of the road surface in the form of holes (potholes), wavy (rutting), cracked and the release of granules (ravelling) as well as gerusan edges result in a decrease in functional performance power road. Factors of physical damage excess that is the number of a passing vehicle flow as a result of the growth of road vehicles is also one of the causes of damage to the infrastructure of the ring road south of the city of Palembang.

Yet many efforts made by the authorities to anticipate the puddle that was common in the South Loop Road, puddle that often occur on the roads need to be addressed by looking at the condition of high standing who occurred during the rainy season as well as annual pairs. To conduct mitigation needs to model the conditions of the land in the watershed area Keramasan with model high puddle that occur within a specified time interval. Modeling will be easily done using the techniques of SIG (geographic information systems) where the higher regional conditions modeled by building a DEM (Digital Elevation Model) and high Flood inundation modeling with modelled using Arcgis. In combining both modeling the expected mitigation can be done for the realignment of the South ring road by determining and planning in determining appropriate mitigation alternative kreteria over the problem of standing water on the Southern Ring Road of the city of Palembang. The formulation of the problem in the research is how long the puddle happened and how the extent of water in Keramasan Sub wathershed, How the influence of rainfall and the influence of tidal damage to the South Ring Road infrastructure of

Palembang City. Analyze, rain intensity, runoff discharge, tidal influence, altitude and extent of inundation in sub river system Keramasan Palembang south ring segment. Analyzing the duration of inundation and degree of damage to the South Ring Road of Palembang. Plan the mitigation that must be done to handle the inundation that occurs on the South Ring Road segment of Palembang City.

2. Literature Review

Rain catchment area is an area of land which is one unit with the river and its tributaries, the function hold, store and stream water derived from precipitation rainfall flow is then batasioleh Ridge-Ridge or mountain and then flow naturally into the lake or sea. In this sense of surface water, groundwater, rain water, and the water that was in the ground is also included in the catchment. 2.1 Average Rainfall

Data on the amount of rainfall is average for a catchment or river basin is much needed information in this research. To be able to represent the magnitude of the rainfall in a region needed rainfall in gauge. Precision measurements of rainfall depending on the spatial variability of rainfall, 2.2 Frequency Analysis

Frequency analysis is the magnitude of the likely quantity of rain that is experiencing a period of rehypothetic as the time in which a certain quantity of rain with debit will emulate or exceeded. Maximum rainfall in performing frequency analysis of rainfall data is done by 4 methods of normal distribution method, the log-normal distribution methods, methods of the Gumbel distribution and log Pearson type III distribution method.

2.1 Test the Fit of The Spread

A test match is a provision about the expected pattern of frequencies in a specific category. The expected pattern should match the assumption or presumption over the possibility of a recurrence and impersonal, test match, compare between the frequencies of Observations with theoretical frequency or expectations. What is the frequency of observation results deviate from expectations of frequency. If the value (chi square) are small, meaning both the frequency of very close, leading to acceptance to the hypothesis of zero.

2.2 Tidal River

Fluctuations in the face of the river water as a function of time due to the style of the drag objects in the sky, especially against the mass of the Sun and moon on the Earth is called the water Tides. Although the mass of the Moon is much closer, then the influence of the Moon pull style against the Earth greater than the influence of the Sun's pull style. Tidal river water knowledge important in planning the handling of puddles, taking into account the highest water face elevation (tides) and the lowest (receding). High tide is the vertical distance between the highest peaks of the tide water and water the Valley's lowest low tide sequence. Tidal period is the time it takes from the position of the face of the water on the face of the average water into the same position next. A period of ups and downs can be 12 hours 25 minutes or 24 hours 50 minutes, depending on the type of ups and downs. 2.5 Contour

The contours are imaginary lines connecting the points which had the same height. This information can provide contour relief, both relatively and in absolute. This relative relief information, shown by contour lines depicting in the rugged region meeting, as for the area of ramps can be show by describing the lines are tenuous in absolute relief Information, disclosed by way of writing down the value of the contour of the line height is above a certain reference field. Commonly used reference field is a field sea level average. Contour interval is equal to the difference between the two high contours. The interval is very dependent on the scale of the map, as well as on the relief surface. Contour Interpolation Point. Further application of contour lines is to provide information of slope (slope land average), sliced lengthwise or transverse profile ground level line project (building) and calculation of the minerals as well as a heap (cut and fill) the original ground surface towards the height of vertical lines or building. Contour lines can be formed by creating an upright projection lines intersecting the Earth's surface with horizontal fields to the fields of a flat map. Because the map is generally made with a certain scale, then to contour lines will also experience a corresponding diminution of scale map. Contour line is the way

that many do to describe the shape of the surface of the soil and altitude on a map, because it gives a better precision. Another way to describe the shape of the land surface is by way of shading and hachure.

2.3 Geographic Information Systems

Information systems that have the ability to build, store, manage and display information reference geografisyang have the ability to build, store, manage and display geographic information reference. The goal is to determine the notification zone land in accordance with the characteristics of the land, SIG can help making planning each of these areas and the results could be used as a reference for development needed.

2.4 Inundation Mitigation

Inundation mitigation is all actions/efforts to reduce the impact of a catastrophic inundation. Mitigation efforts are usually intended for long periods of time. In general the mitigation types can be grouped into mitigation structural and non structural mitigation [1].

2.4.1 Structural Mitigation

What is meant by structural mitigation efforts for disaster risk reduction is more physical. Controlling the puddle on a region need to be made good and efficient system, with attention to the existing condition and development of water resource utilization in the upcoming. To tackle the problem of inundation need a method of handling a pool as well as a thorough planning and integrated with the sasaran utama will be achieved i.e. handling area of inundation.

The territory is located on the lower reaches of the river or the region with an elevation of lebih rendah from the face of the river water in the event of a tidal river water, then it needs to be solved by creating a pool of control buildings in the area of research as an alternative problem solving into consideration in order to handle standing in the area of research.

2.4.2 Non-Structural Mitigation

The opposite of structural mitigation, mitigasi non-structural is all disaster risk reduction efforts conducted a non-physical, organizational and social development.

2.5 Simulation modelling

Simulation is a technique to imitate the operations or processes that occur in a system with the help of a computer and is based on certain assumptions by some so that the system can be studied scientifically (Law and Kelton, 1991). In the simulation used a computer to study the numerical system, where do data collection for statistical estimation of doing to get the original characteristics of the system. Simulation is the right tool to use especially if required to perform the experiment in order to find the best comment of system components. This is because it is very expensive and take a long time if the experiment tried in real. By doing a study simulation, then in a short time the right decision can be determined as well as the cost is not too great because everything pretty done with the computer. A simulation approach begins with the construction of a real system model. The model must be able to demonstrate how the various components interacting in the system so that it really illustrates the behavior of the system. After the model is created then the model is transformed into a computer program that allows for simulated.

3. Research Methodology

Rain catchment area (the research was done in Palembang is focused on Sub Das Kramasan. Aim so that the research was not extensive and the location is restricted so that the analysis can be carried out more thoroughly on the southern Ring Road of the city of Palembang. Stages of research started from the process data is average rainfall rainfall maximum daily with repeated periods during the last 10 years, starting in 2007 up to the year 2016 obtained from BMKG Palembang. After analyzing the data of rainfall then calculate tidal data to obtain debit, debit the puddle puddle then simulate so obtained

some alternative that will be decided upon as a result of inundation mitigation at Ring Road South of the city of Palembang. Average rainfall data is a maximum daily rainfall with repeated periods during the last 10 year, started in 2007 to with the year 2016 obtained from BMKG Palembang. The rainfall data is the result of the measurement station rain contained in Plaju. The analysis of the precipitation average is performed using the methods of the rain one point, because there is only one station on the location of research.

3.1 Research Flowchart
Simulation modelling Simulation is a technique to imitate the operations or processes that occur in a study Of references retrieved science to conduct research. Here's the compiled research steps as outlined in the flowchart contained in Figure 1 here.
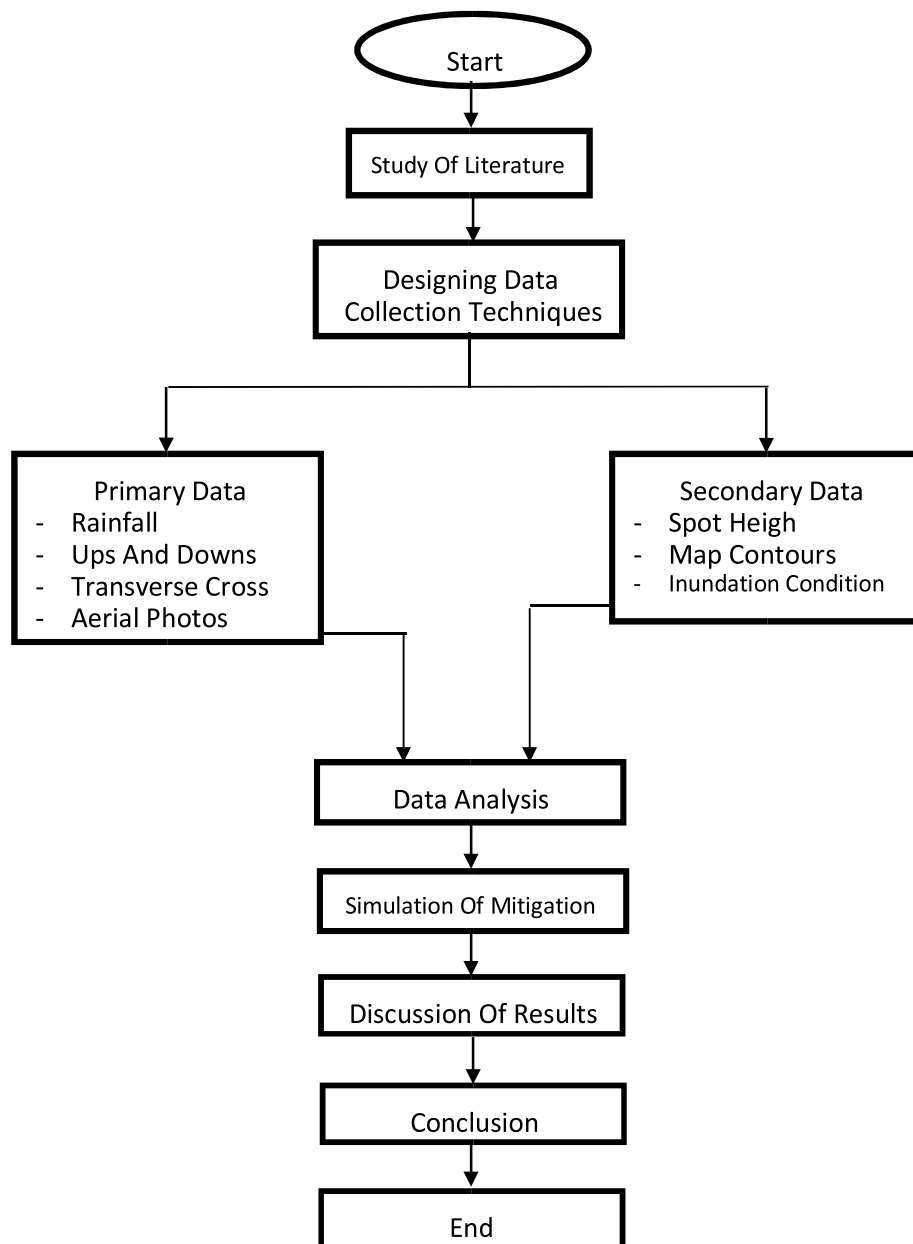

Figure 1. Research flowchart

4. Results and Discussion

4.1. Rain Catchment Area

Rain catchment area analysis in this study is taken by means of aerial photographs using a drone. This analysis is carried out with the aid of the Google Earth software. Following the rain catchment area on the site that is reviewed in figure 2.

Figure 2. Rain Catchment Area *Source: The Google mapper app*

4.2 Average rainfall

Rainfall data used in this research is the maximum daily rainfall during the last 10 years, starting from the year 2007 to with the year 2016 obtained from BMKG Palembang. This rainfall data is rain station located in Districts Plaju. The analysis of the precipitation average is performed using the methods of the rain one point, because there is only one station on the site reviewed. The following maximum daily rainfall Data on station Plaju rain can be seen in Table 1.

Table 1. Rainfall Data For 10 Years

Years	The Maximum Rainfall (mm)
2007	697
2008	398
2009	530
2010	612
2011	357
2012	472
2013	540
2014	442
2015	441
2016	491.5

Source: BMKG Kenten Palembang Station

4.3 Frequency Analysis

On the calculation of frequency analysis there are some parameters that are required i.e. average value, By way of baku, the coefficient of variation, skewness and kurtosis coefficients coefficient The following calculation parameters statistics the average precipitation is shown in Table 2.

Table 2. The calculation of statistical parameters

Years	X (mm)	$(X-X_i)$	$(X-X_i)^2$	$(X-X_i)^3$	$(X-X_i)^4$
2007	697	198.950	39581.1025	7874660	1566663675
2008	398	-100.050	10010.0025	-1001501	100200150.1
2009	530	31.950	1020.80250	32614.64	1042037.744
2010	612	113.950	12984.6025	1479595	168599902.1
2011	357	-141.050	19895.1025	-2806204	395815103.5
2012	472	-26.050	678.602500	-17677.6	460501.353
2013	540	41.950	1759.80250	73823.71	3096904.839
2014	442	-56.050	3141.60250	-176087	9869666.268
2015	441	-57.050	3254.70250	-185681	10593088.36
2016	491.5	-6.550	42.902500	-281.011	1840.624506
The total number of	4981	0.000	92369.225	5273263	2256342869.9
n =	10				
Average	498,1				

4.4 Test The Fit Of The Spread

After getting the results of four distribution and continued with test matches from four such distribution to get distribution, namely chi-square test and kolmogorov-smirnov test.

4.4.1 Chi-square test

Chi-square test for Normal distribution

      Statistical parameters for the Normal distribution:
      The amount of data (n)   = 10
      The average value of ($\overline{X}$)   = 498,1 mm
      Standard deviation   = 101,308 mm
      For the calculation of chi-square test for normal distribution based on the following stages:

a) Specify the degree of real (α) of 0.05

b) Specify the number of classes (k)
      $k = 1+3,322 \log n$
      $= 4,3 \approx 5$ class (where n =10)

c) Calculate probability range
      $p = 1/k = 1/5 = 0,2$

d) Calculate the frequency Factor (KT)

$$KT = w - \frac{2,515 + 0,803w + 0,01w^2}{1 + 1,433w + 0,189w^2 + 0,001\,w^3}$$

where:

$$w = \left[\ln\left(\frac{1}{p^2}\right)\right]^{\frac{1}{2}} \qquad \text{for } (0 < p \leq 0{,}5)$$

$$w = \left[\ln\frac{1}{(1-p)^2}\right]^{\frac{1}{2}} \quad \text{for } (p \geq 0{,}5)$$

for $p = 0{,}2$

$$w = \left[\ln\left(\frac{1}{0{,}2^2}\right)\right]^{\frac{1}{2}} = 1{,}79412$$

$$\text{KT} = 1{,}7941 - \frac{2{,}515 + 0{,}803(1{,}7941) + 0{,}01(1{,}7941)^2}{1 + 1{,}433(1{,}7941) + 0{,}189(1{,}7941)^2 + 0{,}001\,(1{,}7941)^3} = 0{,}841$$

$$X_T = \bar{X} + K_{Tr}\,S$$

$= 498{,}1 + 0{,}841(101{,}308)$

$= 583.346$ mm

e) Calculate theoretical frequencies (Ei).

     $Ei = n/\text{kelas} = 2$

f) Calculate the value X^2 for each class using Equation 2.20 and calculate the total number.

h) Determine the value of criticism using the Critical Value Table X^2 for Chi-Square Test Appendix 5.

i) If $X^2 < X^2$ criticism then the Normal Distribution data series hypothesis is accepted.

If $X^2 \geq X^2$ then the hypothesis of Normal Distribution data series is rejected.

The results can be seen in the table below

Table 3. Chi-square Test Calculation for Normal Distribution

K	Probability Range	Rain Range (mm)	Ei	Oi	$(Oi - Ei)^2$	Xi^2
1	$0{,}01 < p \leq 0{,}20$	811.194 > R24 ≥ 583.346	2	2	0	0
2	$0{,}20 < p \leq 0{,}40$	583.346 > R24 ≥ 523.724	2	2	0	0
3	$0{,}40 < p \leq 0{,}60$	523.724 > R24 ≥ 472.476	2	1	1	0,5
4	$0{,}60 < p \leq 0{,}80$	472.476 > R24 ≥ 412.854	2	3	1	0,5
5	$0{,}80 < p \leq 0{,}99$	412.854 > R24 ≥ 262.379	2	2	0	0
	Total			10		1

Value $X2$ criticism for $\alpha = 0{,}05$ and $Dk = 2$ are 5,991. For $X^2 < X^2$ criticism, then Normal Distribution is accepted.

With the same steps done calculations on the normal log distribution, log pearson III and gumbel distribution. Then a recapitulation of each distribution is performed.

Table 4. Recapitulation of Chi-square Test Calculations

k	P Range	Probability Distribution			
		Normal	Log Normal	Log Pearson III	Gumbel
		X^2	X^2	X^2	X^2
1	0,01 < p ≤ 0,20	0	0	0	0
2	0,20 < p ≤ 0,40	0	0	0	0
3	0,40 < p ≤ 0,60	0.5	0	0	0
4	0,60 < p ≤ 0,80	0.5	0	0	0
5	0,80 < p ≤ 0,99	0	0	0	0
	Jumlah	1	0	0	0
	X^2 Kritik	5.991	5.991	5.991	5.991
	Match Test	Passed	Passed	Passed	Passed

After the calculation of the four distributions obtained an acceptable probability because it has a value X^2 which is smaller than X criticism, for X^2 Normal distribution = 1 smaller than X criticism = 5,991, Normal Log distribution X^2 = 0 smaller than X criticism = 5,991, Log Pearson III distribution X^2 = 0 smaller than X criticism = 5,991 and for Gumbel distribution X^2 = 0 smaller than X criticism = 5,991

4.4.2 Smirnov-Kolmogorov Test
    a. Uji Smirnov-Kolmogorov untuk Distribusi Normal
Statistical parameters for Normal Distribution:

        Amount of data (n)   = 10

        Average value ($\overline{X}$)   = 498,1 mm

        Standard deviation (S)   = 101,308 mm

Here is the calculation phase of Smirnov-Kolmogorov Test for Normal Distribution:

a) Find the real degree (α) and the amount of data (n).

        α = 0,05 dan n = 10

b) Sort data from the largest to the smallest (m = 1,2,3, ..., n).

c) Calculate the empirical probability (Pempirik) for each variant x that has been sorted.

        for m = 1

$$Pempirik = \frac{m}{n+1} = \frac{1}{10+1} = 0{,}0909$$

d) Calculate KT for each variant x using Equation below.

$$K_T = \frac{x - \overline{X}}{s}$$

$$= \frac{697 - 498{,}1}{101{,}308}$$

$$= 1{,}96$$

e) Calculate theoretical probabilities (Pteoritik) for each variant x

$$Pteoritik = \frac{1}{2}[1 + 0{,}197\,|Kt| + 0{,}115\,|Kt|^2 + 0{,}0003|Kt|^3 + 0{,}019\,|Kt|^4]^{-4}$$

$$= \frac{1}{2}[1 + 0{,}197\,|1{,}96| + 0{,}115\,|1{,}96|^2 + 0{,}0003|1{,}96|^3 + 0{,}019\,|1{,}96|^4]^{-4}$$

$$= 0{,}0246$$

f) Calculate the difference of probability and determine the highest value (Δmax).

$$\Delta = |Pempirik - Pteoritik|$$

$$= |0{,}0909 - 0{,}0246|$$

$$= 0{,}0663$$

g) Determine the value of criticism using Appendix 6.

    for n = 10 dan α = 0,05 maka Δkritik = 0,409

If Δmaks < Δkritik then the Normal Distribution data series hypothesis is accepted.

If Δmaks $\geq$ Δkritik the Normal Distribution data series hypothesis is rejected.
Furthermore, the calculation results can be seen in the table below:

Table 5. Smirnov-kolmogorov Test Calculation Normal Distribution

m	R24 (mm)	P.Empirik	KT	P.Teoritik	Δi
1	697	0.0909	1.9633	0.0246	0.0663
2	612	0.1818	1.1243	0.1307	0.0512
3	540	0.2727	0.4136	0.3394	0.0667
4	530	0.3636	0.3149	0.3763	0.0127
5	491.5	0.4545	0.0651	0.5258	0.0712
6	472	0.5455	0.2576	0.6016	0.0562
7	442	0.6364	0.5538	0.7103	0.0740
8	441	0.7273	0.5636	0.7137	0.0136
9	398	0.8182	0.9881	0.8382	0.0200
10	357	0.9091	1.3928	0.9181	0.0090
				Δi Max	0.0740
				Δi kritik	0.409

Value Δ critical for α = 0,05 and n = 10 are 0,409. For Δ max < Δ critical, then Normal Distribution is accepted. With the same steps done calculations on the normal log distribution, log pearson III, and gumbel distribution.

Tabel 6. Test Smirnov-kolmogorov

M	R_{24}	Probability Distribution			
		Normal	Log Normal	Log Pearson III	Gumbel
		Δ	Δ	Δ	Δ
1	0.066307	0.0536644	0.060578987	0.046726271	0.06630794
2	0.051150	0.0516632	0.053431293	0.057629267	0.05115045
3	0.066654	0.0365443	0.04892318	0.008387935	0.06665465
4	0.012706	0.0204507	0.006258706	0.051188144	0.01270643
5	0.071219	0.0359963	0.037607733	0.002121026	0.07121932
6	0.056178	0.0256573	0.042035649	0.003436549	0.05617881
7	0.073978	0.0587999	0.069403531	0.044417874	0.07397832
8	0.013567	0.0281331	0.017785522	0.041878981	0.01356779
9	0.020044	0.0317719	0.030230654	0.045612716	0.02004492
10	0.009041	0.0344545	0.026027169	0.05585338	0.00904193

Δmaks	0.074	0.059	0.069	0.058
Δkritik	0.409	0.409	0.409	0.409
Match Test	Passed	Passed	Passed	Passed

After performing the Chi-square suit test and the Smirnov-kolmogorov suitability test.The result shows that Normal Log Distribution, Log Pearson III, and Gumbel have the best result for Chi-square suitability test. As for the Smirnov-kolmogorov suitability test, Gumbel Distribution gives the best result.

By value X^2 (for *chi-square*) dan **Δ**maks (for *smirnov-kolmogorov test*) the smallest is the Pearson Log Distribution III. Thus the Pearson Log Distribution III provides the best results and is selected for use in subsequent calculations as the design rainfall.

4.4.3 Spreading Match Test

Rainfall data used in this research is maximum daily rainfall, so to calculate rain intensity can use Mononobe Equation. The R24 data used is from the previously selected Pearson III Log distribution. To draw IDF curves, first calculate the value of daily rain in the duration of each rain.

The calculation of intensity in the 2-year return period for a 5-minute duration is as follows.

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

$$I = \left(\frac{484,35}{24}\right)\left(\frac{24}{5/60}\right)^{\frac{2}{3}}$$

$$I = 880,128 \text{ mm/jam}$$

The next calculation is tabulated in Table 4:19 below:

Table 7. Rain intensity repeats period T years

T	t	Re-Period (Year)					
Minutes	hours	2	5	10	25	50	100
5	0,083	880.12	1099.8	1245.35	1429.17	1565.5	1700.91
10	0,167	554.44	692.87	784.527	900.324	986.22	1071.51
15	0,25	423.121	528.759	598.706	687.076	752.633	817.716
30	0,50	266.550	333.097	377.161	432.831	474.129	515.129
45	0,75	203.416	254.201	287.828	330.312	361.828	393.117
60	1	167.916	209.838	237.597	272.666	298.683	324.511
120	2	105.780	132.190	149.676	171.769	188.158	204.429
180	3	80.726	100.880	114.225	131.084	143.592	156.008
240	4	66.637	83.274	94.290	108.208	118.532	128.782
300	5	57.426	71.764	81.257	93.251	102.148	110.981
360	6	50.854	63.550	71.957	82.578	90.457	98.279

Based on the calculation results, then obtained IDF curve as shown in Figure 3
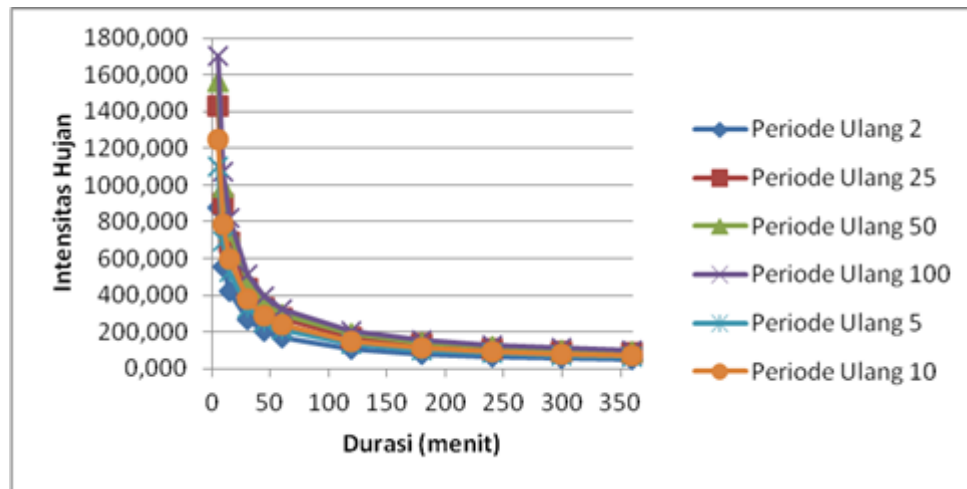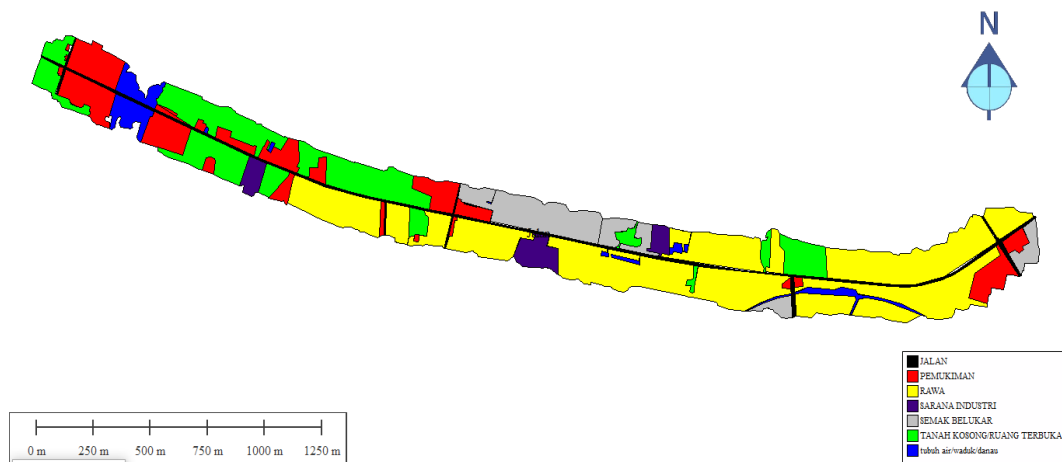

Figure 3. Daily rainfall IDF Curve

4.4.4 Spreading Match Test
Effective rainfall calculations need to know the value of Curve Number (CN) based on land use from the catchment area. The type of land use in the catchment area that has been made can be seen in the picture below:

Source: global mapper app
Figure 4. Type of landuses in the review area

Air photo processing is done by combining the photographs with mosaic projection described in the photo alignment process done in the early stages of the introduction of the body surface of the road object located on each pixel multiple photos to become an object so that the photographs will be incorporated into a single photo layout big. Identification of key photo processing information is generated in this process. At this stage the result of the alignment process. Process alignment in one segment of South Ring Road by using chunk technique (selected area). At this stage the definition and tie-point detection is automatically through the value of pixel similarity in the image. The alignment

process produces images that form cloud points in photographs that have a relationship to overlap and sidelap

Figure 5. 3D texture Display

Subsequent formation of mosaic photo has been generated by the presence of roads, rivers, vegetation, including swamp bog. The greater number of pixels, then the size of 1 pixel the smaller or the more meetings. Connection of the mosaic any resulting is very clearly visible, then results from aerial photographs will be simulated by using the Arcgis software.

5. Conclusions

Based on the results of the research have been presented in the previous chapter, then the following conclusions can be drawn.

1. From the pool area obtained, it is known that the inundation is clearly very influential on road damage.
2. Based on the calculation of peak discharge and simulation of DEM height then, the height of South Ring Road Road of Palembang City which is not affected by the puddle is as high as 1.20 meters.

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