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Research Paper

Evaluating the Technical Feasibility of Retention Basins for Flood Control in Palembang City

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Abstract
Flood control is one of the prevention methods which involves various engineering sciences and is unique. One of structural flood control methods is retention basin with the goal of containing a certain storm event flow volume and obtaining a specific peak flow reduction. This paper's objective is to describe how to assess the performance of retention basin physical components quantitatively on seven retention basins in Palembang City. The reference and the parameter used in this research are referred to Drainage Systems Assessment Design that is based on Standard Procedure of Retention Basins and Polders Construction according to Public Works Ministry of Cipta Karya Directorate General and the Regulation of Public Work Ministry No.32/PRT/M/2007. The result of the assessment is that there are three retention basins which are in fair conditions, namely Kambang Iwak Besak (63,9%), Simpang Polda (60,34%), and Kambang Iwak Kecil (56,8%); meanwhile the other four basins are in bad conditions, namely RS. Siti Khodijah (43,01%), Palembang Icon (41,93%), Kemang Manis (7,03%), and Brimob (0,94%). Therefore, the assessment of the retention basins towards its effectiveness on flood controlling and handling priority level is done by hydraulic modeling simulations and spatial analyses using Geographical Information System. Based on the inundation priority assessment of simulated flood depth and duration, it can be inferred that the retention basin of Kambang Iwak Besak, Kambang Iwak Kecik, Palembang Icon, RS Siti Khodijah, and Kemang Manis have low priority handling level. Meanwhile, Brimob and Simpang Polda retention basins have high priority handling level

Keywords
Retention basin, assessment, flood control

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1. INTRODUCTION

Flood control is one of the prevention methods which involves various engineering sciences and is unique. A flood control system in one area is not definite or cannot be applied directly to other areas. One of flood control methods with the structural method is retention basin (Kodoatie et al., 2003). Retention basin serves to store the discharge of the flood temporarily so that the river discharge can be reduced. Flood reduction stage is determined by flood hydrograph characteristics, basin volume, and dynamics of numerous outlets. The areas that require retention basin are lowland or swamp. With a proper land use planning and implementation, retention basin can be operated for other purposes such as recreation place or tourist attraction.

According to Syahyunan (2014), the feasibility study is one activity that examines the existing information and data, then is measured, calculated, and analyzed with specific method to determine the success rate based on objectives. In determining whether the activity is feasible, various aspects must have a certain standard of value. Technical infrastructures of the retention basin are the feasibility aspects in this paper. Those technical aspects are the site selection towards the construction objectives, the selection of operating system for the construction, and the comparison between planning and existing condition. It is important to consider the analysis of technical infrastructures towards construction objectives because if it is not conducted it will possibly resulting in failure which deviates from initial objectives.

The evaluation of the technical feasibility of waterworks will affect its performance as flood controller. Assessment of the retention basin performance is by making indicators of its components based on its function. The reference of assessment design criteria is The Drainage Network Criteria Design (Vadlon, 2011). The distribution and assessment of the retention basin component are adjusted to the components of the retention basin following the regulations drafted by Cipta Karya General Directorate in the Department of Public Works and People's Housing as each subcomponent value is determined with AHP

(Analytical Hierarchy Process) Method.

The locations of this study are as follow; Sub-district Bukit Kecil, Ilir Barat I, Ilir Barat II, dan Ilir Timur I of Palembang city. Based on Palembang Department of Spatial Public Works, there are 34 retention basins which are spread in 10 sub-districts of Palembang City, yet the flood problems are still not resolved. This research is to determine the physical conditions and performance of the retention basins towards its effectiveness of the flood control.

2. EXPERIMENTAL SECTION

2.1 Materials

Questionnaire data for the priority assessment value of the retention basin are spread on three departments which are related to the field study of this research. Data retrieval is done to 30 respondents and is conducted by stages. Those departments are:

The other data used for spatial analysis and hydraulic modeling simulations are:

1. The 1: 1,000 scale contour map and elevation data in the form of spot height for 0.25m distance interval is used to make the Digital Elevation Model (DEM) of the study area
2. Map of the Land Use Classification from the line map resulting from the interpretation of photo images at a scale of 1: 1000
3. The cross-section of retention basin from site survey results
4. The maximum daily rainfall hydrometry data in the study area, obtained from BMKG of Palembang City
5. The amount of runoff inflow discharge that is streamed into the retention basin inlet

2.2 Methods

This study is conducted on seven retention basins in four subdistricts of Palembang City, namely: Kambang Iwak Besak, Kambang Iwak Kecik, Palembang Icon, Kemang Manis, Brimob, Siti Khodijah, and Simpang Polda as given in figure 1. The retention basin has the depth ranged from 0.8 - 4 meters. Kambang Iwak Besak serves as the largest retention basin area (22,126 m^2), and the smallest retention basin area is Simpang Polda (5,655 m^2) as detailed in Table 2.

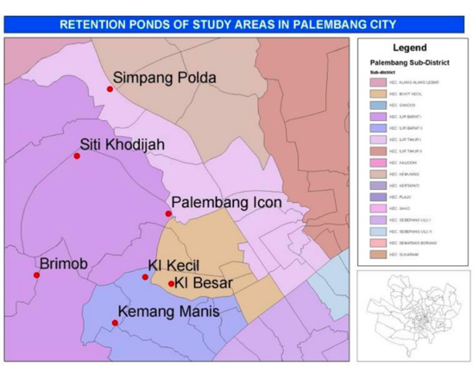


Figure 1. Study Areas

The methodology used in this study is descriptive quantitative by collecting data based on direct observation of retention basin components according to Retention basins and Polders Design and Planning compiled by the Ministry of Public Works Cipta Karya Directorate General and refer to the previous study of Vadlon (2011).

Questionnaire data processing includes: 1) preparation of priority hierarchy (criteria and alternatives) from each component of the retention basin, 2) calculation of hierarchical value factors by Analytical Hierarchy Process (AHP) method for all criteria, 3) assessment of retention basin components to obtain the value of field conditions. The hierarchical structure and calculation of the value factors for the AHP method used in the study are described in Saaty (1992).

Flood modeling comprises two components; hydrological simulation is performed by HEC-HMS to quantify flow hydrograph in the given return period and hydraulic simulation employing the propagation of the flood across the river channel and the mapping of inundated areas using Geographical Information System (GIS). GIS is used to calculate DEM from contour interpolation, delineate catchment area, extracting land use percentage, propagate flood across the river channel and mapping of inundation area.

3. RESULTS AND DISCUSSION

3.1 Retention basin Component Assessment

Hierarchical structure component of retention basin is arranged following the provisions of Retention basins and Polders Design and Planning according to the Ministry of Public Works Cipta Karya Directorate General. In this research, a component of the retention basin is divided into three categories such as: 1) Protection Building, 2) Regulatory Building, and 3) Supporting Building as shown in Figure 2. Protection building consists of a retaining wall, while regulatory building consists of a pump, generator set, pump gate, pump house, and inlet/outlet gate. Supporting building consists of trash rack, drainage channel, and a sediment trap.

Value of each retention basin component is calculated with the AHP method based on data collected from respondents. In principle, the value shows the importance level of each component as the highest value shows the importance of the said component. The result of each hierarchy value factor calculation is given in Figure 2. In general, supporting building has the highest value with 41,9%. However, as an individual, the retaining wall component has the highest value of 35,5%. It shows that the existence of retaining wall of the retention basin has the most critical role among other components. It is quite reasonable considering retaining wall usually serves to maintain water level and the whole capacity in the retention basin.

3.1.1 Physical Condition of the Retention basin Assessment

The physical condition of the retention basin assessment starts with a whole complete inventory of retention basin components. After the direct observation is done to seven locations, then

Table 1. List of Office Data Retrieval Department

No.	Department	Address	Number of Respondents
1	Balai Besar Wilayah Sungai Sumatera VIII	Jl.Soekarno Hatta no.869	10 respondents
2	Dinas PSDA PROV. SUMSEL	Jl. Kapten Anwar Sastro, Sungai Pangeran, Ilir Timur I, Kota Palembang, Sumatera Selatan 30121	10 respondents
3	Dinas PU PR Kota Palembang	Jl. Slamet Riadi	10 respondents

Table 2. Retention basins of Study Areas (Spatial Public Works Departement Palembang City, 2018)

Retention basin	Sub-district	Depth (m)	Area (m^2)
Kambang Iwak Besak	Bukit Kecil	0,8 - 1,5	22.126
Kambang Iwak Kecil	Ilir Barat 2	0,8 - 1,5	7.886
Palembang Icon	Ilir Barat 1	2	8.07
Kemang Manis	Ilir Barat 2	2,3 – 3	12
Brimob	Ilir Barat 1	3 – 4	9.32
Siti Khodijah	Ilir Barat 1	0,8 - 1,5	11.085
Simpang Polda	Ilir Timur 1	0,8 - 1,5	5.655

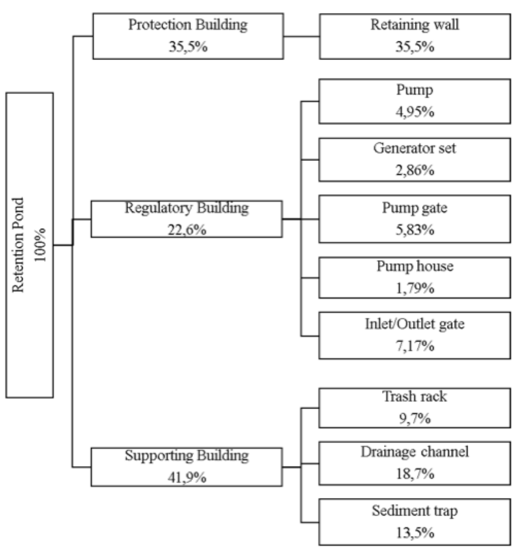


Figure 2. Value of each retention basin component

the physical assessment is conducted. Value assessment of site condition obtained from the result of value multiplied with the physical condition of the observation result. The following table 3 is an example of the value assessment of the site condition for Siti Khodijah Retention basin.

The recapitulation result of overall components condition is given in Table 4.

From Table 4 above, it can be inferred that no retention basin pertained in good condition. There are only three retention basins that belong to a fair categories, such as Kambang Iwak Besak (63,9%), Simpang Polda (60,34%), and Kambang Iwak Kecik (56,8%). Meanwhile, the other retention basins belong to the bad/broken category, such as RS. Siti Khodijah (43,01%), Palembang Icon (41,93%), Kemang Manis (7,03%), and Brimob (0,94%). These results indicate that most of the retention basins do not have complete components or are in a damaged condition/not operational.

3.2 Retention basin Capacity Calculation

3.2.1 Frequency Analysis

The hydrological analysis in this study uses the results of measurements of maximum rainfall data from some stations, namely Kenten, Plaju, Gandus, and Kertapati stations for the last ten years, starting from 2007 to 2016 obtained from BMKG of Palembang City as seen in Figure 3.

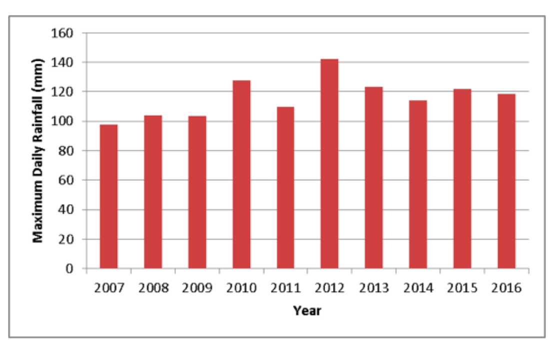
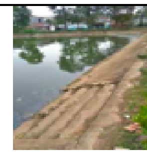
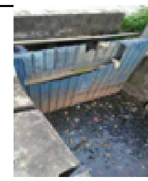


Figure 3. Maximum Rainfall Data of Palembang City (2007-2016)

Table 3. Site Condition for Siti Khodijah Retention basin

Component	Availability	Physical Condition (PC)	Value (V)	Value of Physical Condition	Description	Documentation Photo
Retaining Wall	Yes	92%	35,5%	32,66%	The stability of the retaining wall is good and qualified (it can prevent erosion and flood)	
Pump	No	0%	4,95%	0%	-	-
Generator Set	No	0%	2,86%	0%	-	-
Pump Gate	No	0%	5,83%	0%	-	-
Pump House	No	0%	1,79%	0%	-	-
Inlet/outlet Gate	Yes	40%	7,17%	2,868%	There is a large leakage on the gate, and the sedimentation often flows beyond the gate base.	
Trash Rack	No	0%	9,7%	0%	-	-
Drainage Channel	Yes	40%	18,7%	7,48%	There is a channel that its size and capacity is not qualified, and there are cracks on the lining (>30%)	
Sediment Trap	No	0%	13,5%	0%	-	-
Total				43,008%		

Based on the results of the design rainfall frequency analysis using the four probability distribution methods; Gumbel, Normal, Log-Normal and Log-Pearson III, it can be inferred that each probability distribution gives a different result. The following table shows the recapitulation of the design rainfall calculation.

3.2.2 The goodness of Fit Test

Parameter testers are needed to test the fitness of the frequency distribution data sample towards the probability distribution function that is estimated to be able to describe or represent the frequency distribution. The parameter test is using the Kolmogorov-Smirnov test. Kolmogorov-Smirnov test also called a non-parametric alignment test (non-parametric test), is used because the test does not use a particular distribution function. Testing the distribution fitness with this method is done by comparing the probability for each variable from the empirical and theoretical distribution obtained by a particular difference (Δ). The maximum difference that is calculated (Δmax) is compared to the critical difference (Δcr) for a real degree and the number of specific variances; then the distribution is appropriate if (Δmax)<(Δcr).

From the results of the calculation of fit test of Smirnov-Kolmogorov (Table 6), there are three probability distributions that are accepted. It is caused they have smaller Δi Max value compared to Δi Criticism. From those three accepted distributions, the distribution with log-Pearson III has the smallest value of Δi Max compared to the other accepted distributions, that is 0.111<0.409. Therefore, it can be concluded that the results of calculation using the Log Pearson III distribution (Table 7) is the best to be used for the following calculations.

3.2.3 Rainfall Intensity Calculation

The correlation between intensity, duration, and frequency of rainfall is served as IDF-Curve (Intensity Duration Frequency Curve). IDF analysis is conducted to predict the peak discharge of a small catchment area. Short-period rainfall data is needed in order to make IDF Curve, such as 5 minutes, 10 minutes, 20 minutes, etc.

Table 4. The Assessment Result of all Retention basin Components Condition

No	Retention basin	Kecamatan	Site Condition Value	Value*
1	Kambang Iwak Besak	Bukit Kecil	63,9%	F
2	Kambang Iwak Kecik	Ilir Barat 2	56,8%	F
3	Palembang Icon	Ilir Barat 1	41,93%	B
4	Kemang Manis	Ilir Barat 2	7,03%	B
5	Brimob	Ilir Barat 1	0,94%	B
6	RS. Siti Khodijah	Ilir Barat 1	43,01%	B
7	Simpang Polda	Ilir Timur 1	60,34%	F

*Description: G=Good, F=Fair, B=Bad/Broken

Table 5. Recapitulation of Design Rainfall with Four Distribution Methods

Return Period (Year)	Probability Distribution (mm)			
	Gumbel	Normal	Log Normal	Log Pearson III
2	114,389	116,198	115,519,865	1,148,767,796
5	130,363	127,438,578	127,084,122	1,268,577,083
10	140,941	133,326,499	13,359,652	1,340,311,967
25	154,304	138,946,788	140,123,978	1,424,904,352
50	164,217	143,630,362	145,806,499	1,484,534,412
100	174,059	147,377,221	150,517,995	154,158,264

Maximum Daily Rainfall is used to make IDF Curve with Mononobe method. The following equation gives rainfall Intensity calculation with 2 years of return period for 5 minutes rainfall using Mononobe method.

$$I = \left(\frac{R24}{24}\right)\left(\frac{24}{t}\right)^{\frac{2}{3}} = \left(\frac{114.8768}{24}\right)\left(\frac{24}{5/60}\right)^{\frac{2}{3}} = 208.745 \quad (1)$$

The IDF Curve for every return period can be seen on the following Figure 4 .

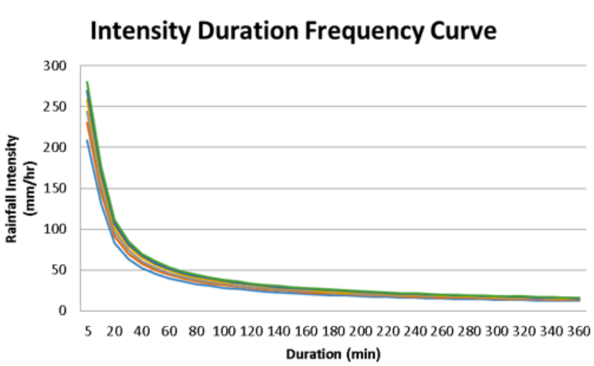


Figure 4. IDF Curve

3.2.4 Digital Elevation Model (DEM) and Watershed Delineation

Watershed is a land area in which the river and other streams naturally hold, store, and flow water from upstream into downstream where topography acts as the land boundary and water as a boundary between the sea and the land activity.

In this research, watershed delineation is determined based on the highest points made by Digital Elevation Model (DEM). Watershed delineation is done using the Hydrology tools of the ArcGIS Spatial Analyst toolset in ArcGIS 10.5, and the task is automated by using Model Builder. DEM is used as the input surface raster and Fill tool fills sinks to remove imperfections from DEM. The Flow Direction tool determines the direction of flow from each cell to its steepest downslope neighbor. The Flow Accumulation tool calculates the accumulated flow to each cell, as determined by the accumulated weight of all cells that flow into each downslope cell. The last step is to create polygon features from the watershed raster. The flow model can be seen in figure 5.

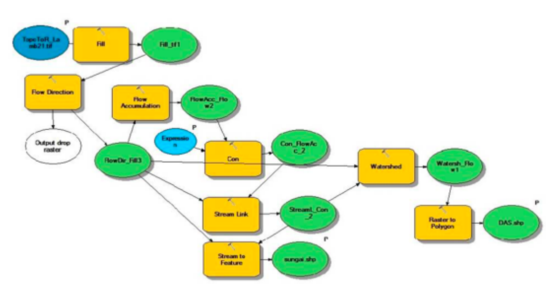


Figure 5. Watershed delineation with ArcGIS 10.5

DEM derived from contour map on Sekanak Watershed can be seen in figure 6. It can be inferred that the catchment area

Table 6. Recapitulation of Kolmogorov-Smirnov Test

Number	Probability Distribution			
	Normal	Log Normal	Log Pearson III	Gumbel
1	0,066	0,058	0,066	0,046
2	0,012	0,006	0,010	0,040
3	0,029	0,014	0,027	0,124
4	0,028	0,045	0,031	0,213
5	0,018	0,039	0,020	0,298
6	0,111	0,092	0,111	0,382
7	0,328	0,317	0,071	0,466
8	0,097	0,101	0,034	0,546
9	0,007	0,012	0,010	0,637
10	0,009	0,022	0,079	0,717
Δi Max	0,328	0,317	0,111	0,717
Δ Criticism	0,409	0,409	0,409	0,409
Goodness of fit	Accepted	Accepted	Accepted	Rejected

Table 7. R_{24} Data According to Log Pearson III Distribution

Tr (Year)	R_{24} (mm)
2	114,8768
5	126,8577
10	134,0312
25	142,4904
50	148,4534
100	154,1583

elevation of Sekanak Area is ranged between -1,529m+MSL and 20,231m+MSL.

In Sekanak watershed, there are three retention basins namely Kambang Iwak Besar, Palembang Icon, and RS Siti Khodijah. Catchment area for each retention basin are 24,391 Ha, 15,459 Ha, and 104,348 Ha. The dividing of the catchment area for each basin in Sekanak watershed can be seen in following figure 7.

After determining the catchment area for each basin in a watershed with DEM as the basic map, then the land use map is clipped to get the land use criteria on each basin. Land use percentage in Siti Khadijah Retention basin described in Table 8.

Table 8. Land Use Area in Siti Khadijah Retention basin

Land Use	Area (A)		Area in percentage
	Ha	Km^2	
Tree	0,004	0,00004	0,004
Pond	0,056	0,00056	0,053
Scattered Building	0,446	0,004	0,428
River	0,509	0,005	0,488
Shrub	6,081	0,061	5,827
Resident	97,252	0,973	93,200
Total	104,348	1,043	100

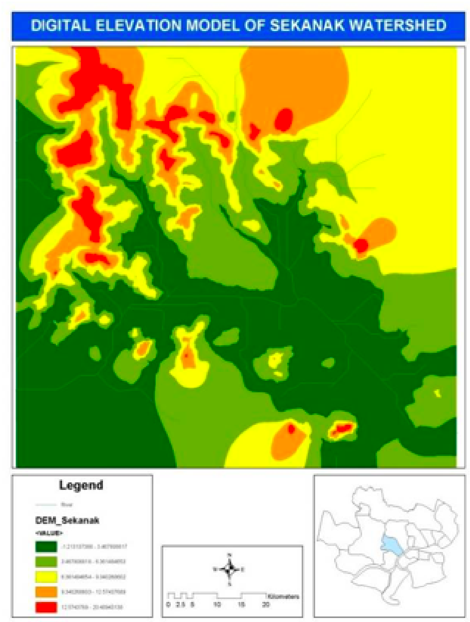


Figure 6. DEM of Sekanak Watershed

3.2.5 Effective Rainfall Calculation on Retention basin Watershed

The calculation of the effective rainfall is using SCS CN (Soil Conservation Service-Curve Number) method. There are several steps to calculate before the effective rainfall calculation, namely CN (curve number), maximum potential retention, and initial abstraction. CN is calculated based on the area, land use type, and characteristics of the soil of catchment area.

The following Table 9 recapitulates CN value and percentage of the impervious in Siti Khodijah Retention basin.

Based on the table above, the average CN and impervious area can be calculated. The average CN for the rainfall catchment

Table 9. CN and Percentage of Impervious in Siti Khodijah Retention basin

Land Use	A (Ha)	CN	A x CN	% Imp	% Impervious Area
Tree	0,004	80	0,32000	2	0,000
Pond	0,056	72	4,03200	0	0,000
Scattered Building	0,446	84	37,46400	85	0,364
River	0,509	72	36,64800	0	0,000
Shrub	6,081	83	504,72300	2	0,117
Resident	97,252	84	8169,16800	60	55,920
Total	104.348		8752,355		56,40042

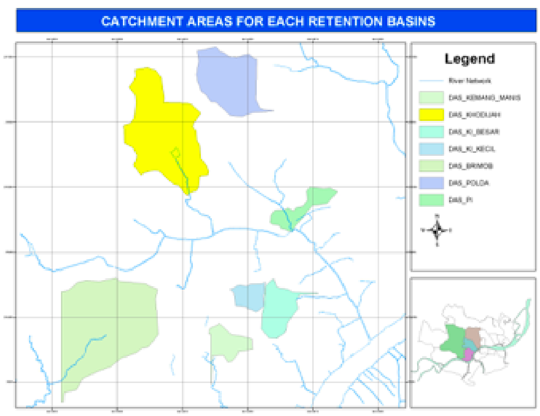


Figure 7. Catchment Area of Retention basins in Sekanak Watershed

area is:

$$\overline{CN} = \frac{\Sigma CN}{\Sigma A} = \frac{8752.355}{104.348} = 83.87659562 \tag{2}$$

The composite CN is obtained from the following correlation graph between the impervious area and composite curve number (Figure 8).

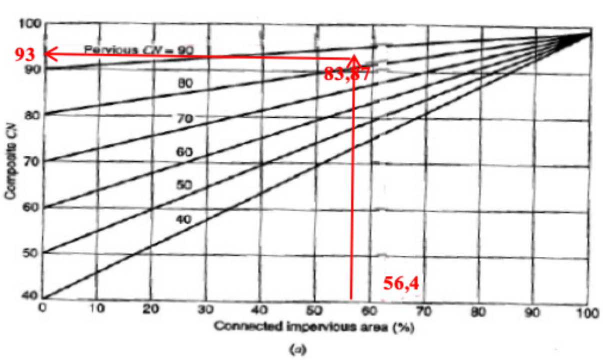


Figure 8. Correlation Graph between Impervious Area and Composite CN

The determination of the return period for the Department of Public Works drainage planning is based on the city typology and catchment area. Palembang is a metropolitan city, and each retention basin has a different catchment area. Therefore, if the catchment area is more than 100 Ha, then return period is 10 years. The recapitulation of the maximum potential retention (S) and initial abstraction (Ia) for each pond can be seen in Table 10.

Table 10. Recapitulation of S and Ia for Each Retention basin

Retention basin	S (mm)	Ia (mm)
KI Besar	52,07761994	10,41552399
KI Kecil	51,30390452	10,2607809
Palembang Icon	51,46894934	10,29378987
Kemang Manis	49,45509207	9,891018415
Brimob	50,07812585	10,01562517
RS. Siti Khodijah	48,82583,373	9,765166,747
Simpang Polda	49,25423544	9,850847087

5-year Hyetograph Modified Mononobe Rainfall data, potential retention, and initial abstraction value then cumulatively calculated in order to obtain the effective rainfall. The correlation graph between the rainfall and the effective rainfall of 5-year return period for Siti Khodijah RB can be seen on the following Figure 9.

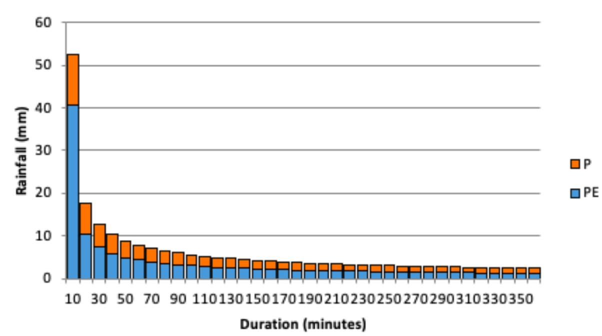


Figure 9. Correlation Graph between Rainfall and Effective Rainfall T-Return Period on Siti Khodijah Retention basin

3.2.6 SCS Synthetic Unit Hydrograph Calculation

Based on the analysis with ArcMap 10.5, the length of the main stream (L), the average land slope (Y), and catchment area (A) are acquired. Thereby lag time (tl), concentration time (tc), storm duration (tr), and peak discharge (Qp) can be obtained. SCS Synthetic Unit Hydrograph of Siti Khodijah Retention Basin as seen on Figure 10.

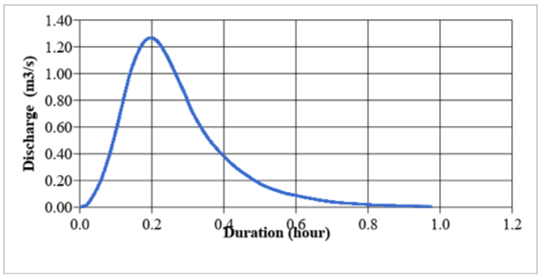


Figure 10. SCS Synthetic Unit Hydrograph of Siti Khodijah Retention basins

3.2.7 Direct Runoff Calculation

Direct runoff calculation is designed using 5 years return period and 10 minutes interval within 24 hours. This graphic on Figure 11 shows direct runoff hydrograph of Siti Khodijah Retention basin.

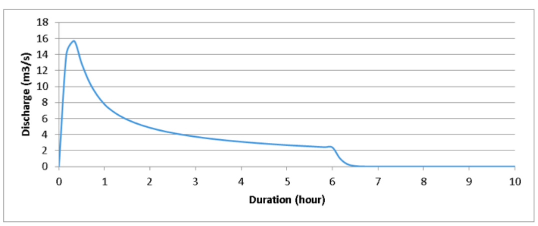


Figure 11. Direct Runoff Hydrograph of Siti Khodijah Retention basin

3.2.8 HEC-HMS Model Simulation

The hydrology analysis is done using HEC-HMS 4.2.1. The components of this program are the basin model, meteorology model, control specification, and time series data. The model from each sub-watershed of the retention basin is elaborated in the following passage.

The analysis is using Flood Hydrograph with SCS method in which the input data are analyzed with the simulation run. The result of this analysis using HEC-HMS is direct runoff hydrograph of the catchment area. Required data for the catchment area simulation can be seen in the following in Table 11.

The simulation model of each retention basin on HEC-HMS can be seen in the Figure 12. The elements are sub-basin creation tool as catchment area, junction creation tool as the outlet stream from the catchment area, and reservoir creation tool as the existing retention basins.

Figure 12. The Hydrology Model of Siti Khadijah Retention basin in HEC-HMS

The analysis is done with SCS Flood Hydrograph in which the input data then computed with simulation run. The shown result from HEC-HMS modeling is Runoff Hydrograph on catchment areas in the form of inflow and outflow discharge of the retention basin. HEC-HMS summary result for Siti Khadijah Retention basin can be seen from figure 12. The comparison between obtained peak elevation from HEC-HMS and the highest elevation from the direct observation of the retention basins can be seen in figure 13.

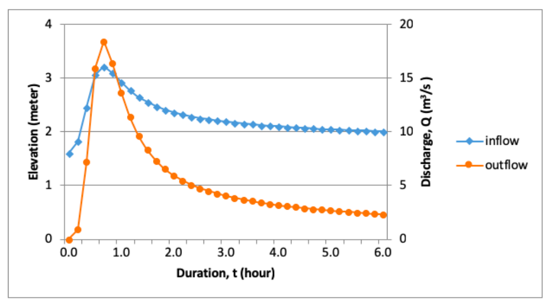


Figure 13. Inflow-Outflow Discharge of Hydrograph from HEC-HMS

The above figure is the flood routing of Siti Khadijah Retention basin that is to see the quantity of the inflow and outflow discharge from the retention basin. Based on the output, it can be seen that the peak inflow discharge is 2,9 m^3/s in the first hour and reduced to 1,38 m^3/s as the peak outflow discharge in 2:20 hour. Therefore, the peak elevation is up to 1,65 m meanwhile the highest elevation of the dike is 1,75 m. This surface level is almost as high as the elevation of the dike and likely to overtop and as the result, the flood would occur on the area around the Kambang Iwak Besar Retention basin.

The recapitulation of between peak elevation and highest elevation of the retention basin from HEC-HMS and direct observation can be seen in table 12.

Table 11. Input Data of Retention basin Catchment Area

Retention basin	A (km^2)	Ia (mm)	CN	IMP (%)	Lag Time (min)
Kambang Iwak Besar	0,244	10,416	91	54,842	43,245
Kambang Iwak Kecil	0,122	10,261	91	55,581	11,802
Palembang Icon	0,155	10,294	91	56,426	17,550
Kemang Manis	0,173	9,891	90	47,884	11,743
Brimob	1,084	10,016	92	50,164	16,014
RS. Siti Khodijah	1,043	9,765	93	56,400	16,014
Simpang Polda	0,538	98,508	92	57,174	9,887

Table 12. Recapitulation of Analysis Result between the Simulated Peak Elevation Level with HEC-HMS and Embankment Maximum Elevation Level

Kolam Retensi	Embankment Maximum Elevation Level* (m)	Simulated Peak Elevation Level** (m)	Description
Kambang Iwak Besar	1,75	1,65	Below the embankment level
Kambang Iwak Kecil	1,7	1,2	Below the embankment level
Palembang Icon	1,7	1,68	Below the embankment level
Kemang Manis	2,6	2,48	Below the embankment level
Brimob	2,9	4,99	Exceed the Capacity
RS.Siti Khodijah	2,7	3,21	Exceed the Capacity
Simpang Polda	2,1	3,14	Exceed the Capacity

Caption: * = Site observation ** = Simulated by HEC-HMS

3.3 Inundation Analysis

The duration and the depth of the inundation for each retention basin can be obtained from the subtraction of the embankment maximum elevation level with the simulated peak elevation level from HEC-HMS.

Here is an example of the period and elevation of the inundation in Kambang Iwak Besar Siti Khadijah Retention basin. The maximum site elevation is 2,7 m, and the simulated peak elevation from HEC-HMS is 3,21 m. Hence, water level overtops the dike and likely to flood the surrounding area. Figure 14 showing the difference between the maximum site elevation and simulated peak elevation.

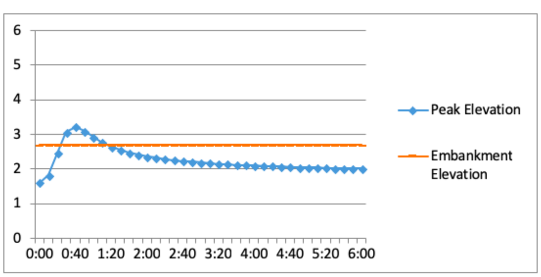


Figure 14. Comparative Graph between Simulated Peak Elevation and Embankment Maximum Elevation in Siti Khadijah Retention basin

The recapitulation of the comparison between the maximum embankment elevation and simulated peak elevation in 7 retention basins can be seen in Table 13.

3.3.1 Flood Discharge Reduction Calculation

The calculation of the flood discharge reduction is done by comparing the inflow and outflow discharge from the HEC-HMS simulation results, the percentage of the reduction in flood discharge on the Kambang Iwak Besar retention basin is:

$$\begin{aligned} Qpreduction(\%) &= \frac{inflow - outflow}{nflow} x100\% \\ &= 2,9 - 1,382,9 \bullet 100\% \\ &= 52,418\% \end{aligned} \quad (3)$$

Table 14 shows recapitulation of the calculation of the reduction of flood discharge to seven existing retention basin

3.3.2 Simulated Inundation Area

The propagation of flood across the drainage channel and the mapping of inundated areas can be simulated using GIS. Peak discharge from HEC-HMS for all retention basins is interpolated using Spatial Analyst Tool and overlayed with DEM (Digital Elevation Model) to create flood distribution map. Flood distribution map then classified based on the depth is shown in Figure 15.

Based on the result derived from spatial data analyses (Table 15), with the given boundary condition and existing capacity, some areas within catchment of Siti Khadijah Retention basin are inundated. 0-1 meter inundation depth covers as much as 19,70 Ha, 1-1,5 meter inundation depth covers the area of 15,15

Table 13. Recapitulation of the Comparison between the maximum embankment elevation and simulated peak elevation

Retention basin	Site Maximum Elevation Level* (m)	Simulated Peak Elevation Level** (m)	Caption
Kambang Iwak Besar	1,75	1,65	Free from Inundation
Kambang Iwak Kecil	1,70	1,20	Free from Inundation
Palembang Icon	1,70	1,68	Free from Inundation
Kemang Manis	2,60	2,48	Free from Inundation
Brimob	2,90	4,99	Inundate from 0:20 to 06:00 (lasted for 5 hours and 40 minutes) 2,09m depth.
Siti Khodijah	2,70	3,21	Inundate from 03:00 to 01:10 (lasted for 40 minutes) 0,51m depth.
Simpang Polda	2,10	3,14	Inundate from 0:20 to 02:00 (lasted for 1 hour and 40 minutes) 1,04m depth.

Caption: * = Site observation ** = Simulated by HEC-HMS

Table 14. Recapitulation of the Flood Discharge Reduction

Retention basin	Inflow (m^3/s)	Outflow (m^3/s)	Reduction Qp (%)
Kambang Iwak Besar	2,9	1,38	52,418
Kambang Iwak Kecil	2,93	1,06	63,822
Palembang Icon	3,03	1,25	58,746
Kemang Manis	3,9	0,76	80,512
Brimob	22.21	9,73	56,191
RS.Siti Khodijah	22,8	18,41	19,255
Simpang Polda	13,83	9,39	32,104

Table 15. lood Area with Given Depth of Siti Khadijah Retention basin

Flood Depth (m)	Flood Area (Ha)
0 - 1	19,7
1 – 1,5	15,15
>1,5	27,54

Ha, and more than 1,5 meter inundation depth covers the area of 27,54 Ha.

3.3.3 Inundation Priority Assessment

After knowing the level and duration of the inundation and also the reduction percentage of flood discharge, therefore the assessment can be done by looking at the comparison between the maximum site elevation and simulated peak elevation as shown in table 16.

Based on the results, the assessment can be done for the inundation parameter criteria and also priority handling level that refers to Urban Drainage System Masterplan Design and Planning of Ministry of Public Work Cipta Karya Directorate General.

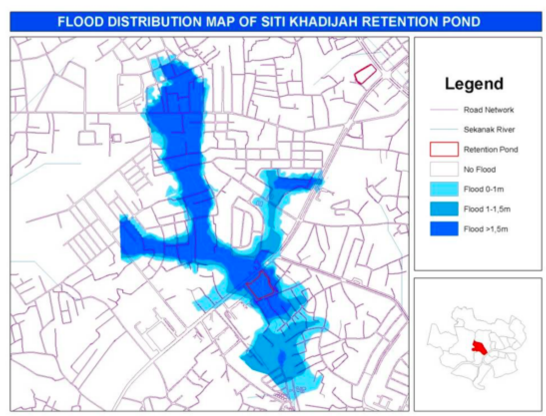


Figure 15. Flood Distribution Map of Classified Depth on Siti Khadijah Retention Basin

4. CONCLUSIONS

1. The result of each hierarchy structure component of retention basin calculated with AHP method as follow; supporting building consist of trash rack (9,7%), drainage channel (18,7%), and sediment trap (13,5%) has the highest total value with 41,9%. However, as an individual, the protec-

Table 16. Recapitulation of the Inundation Parameter Criteria Assessment and Priority Handling Level

Retention basin	Inundation Condition	Value based on the inundation level*	Value based on the inundation duration*	Priority Handling Level**	Description
Kambang Iwak Besar	Free from inundation	0	0	0	Priorirty Handling Level is Low
Kambang Iwak Kecil	Free from inundation	0	0	0	Priorirty Handling Level is Low
Palembang Icon	Free from inundation	0	0	0	Priorirty Handling Level is Low
Kemang Manis	Free from inundation	0	0	0	Priorirty Handling Level is Low
Brimob	Inundation from 20th minute to 6th hour (lasted for 5 hours and 40 minutes) with 2,09 meter level	60	30	90	Priorirty Handling Level is High
RS.Siti Khodijah	Inundation from 30th minute to 1st hour and 10th minute (lasted for 40 minutes) with 0,51 meter level	60	0	60	Priorirty Handling Level is Low
Simpang Polda	Inundation from 20th minute to 2nd hour (lasted for 1 hour and 40 minutes) with 1,04 meter level	60	10	70	Priorirty Handling Level is High

tion building component consists of retaining wall has the highest value of 35,5%. While regulatory building consist of pump (4,95%), generator set (2,86%), pump gate (5,83%), pump house (1,79%), and inlet/outlet gate (7,17%) has the lowest total value of 22,6%. It shows that the existence of retaining wall of the retention basin has the most important role among other components. It is quite reasonable considering retaining wall usually serves to maintain water level and the whole capacity in the retention basin.

2. Value assessment of site condition is obtained from the result of AHP value multiplied with the physical condition of the observation result. From the analysis, it can be inferred that there is no retention basin pertained in good condition. There are only three retention basins that belong to a fair categories, such as Kambang Iwak Besak (63,9%), Simpang Polda (60,34%), and Kambang Iwak Kecik (56,8%). Meanwhile, the other retention basins belong to the bad/broken category, such as RS. Siti Khodijah (43,01%), Palembang Icon (41,93%), Kemang Manis (7,03%), and Brimob (0,94%). These results indicate that most of the retention basins do not have complete components or are in a damaged condition/not operational.
3. The results of the analysis of retention basins are based on technical aspects by comparing between manual calculations and using the assistance of the HEC-HMS program. With the given boundary conditions and existing capacity, Kambang Iwak Besak, Kambang Iwak Kecik, Palembang Icon, and Kemang Manis retention basins can still accommodate inundation volumes. Meanwhile, some areas within the catchment of Siti Khadijah Retention basin are inundated. 0-1 meter inundation depth covers as much as 19,70 Ha, 1-1,5 meter inundation depth covers the area of 15,15 Ha and more than 1,5 meter inundation depth covers the area of 27,54 Ha.
4. Based on the inundation priority assessment of simulated flood depth and duration that refers to Urban Drainage System Masterplan Design and Planning of Ministry of Public Work Cipta Karya Directorate General, it can be inferred that the retention basin of Kambang Iwak Besak, Kambang Iwak Kecik, Palembang Icon, RS Siti Khodijah, and Kemang Manis have low priority handling level. Meanwhile, Brimob and Simpang Polda retention basins have high priority handling level due to flood depth and duration.

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