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Integrated Urban Drainage Management for Flood Inundation Controlling in Sidokare Area at Sidoarjo Regency

Evi Nur Cahya[1], Dani Eko Guntoro[2], Donny Harisuseno[1]

[1] Water Resources Engineering Department, Universitas Brawijaya, Malang, Indonesia
[2] Department of Public Work Sidoarjo Regency, Indonesia

evi_nc@ub.ac.id

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Abstract. Flood and inundation had become a serious problem in Sidoarjo Regency annually. This study aimed to apply integrated urban drainage management for flood inundation controlling at Sidokare Region in Sidoarjo Regency. This integrated drainage management consisted of retarding pond, drainage channel redesign, and pump utilization. The study region was divided into Sidokare Pump station, Sepande, and Diponegoro Street catchment area. Rainfall intensity during historical floods was analysed using Mononobe formula and Log Pearson Type III method was used to analyze design rainfall. From the result of the analysis, it was found that the historical floods in study region caused by rainfall with return period of 1.01 years, with rainfall intensity of 17.55 mm/hour. It was also found that by implementing this integrated urban drainage management at Sidokare Region, flood could be reduced up to 100%. For Sidokare Pump Station catchment area, the inundation management was conducted by using combination of storage pool, existing drainage channel, and the existing flood pump. For Sepande catchment area, it was managed to use the combination of storage pool and the existing drainage channel. Meanwhile, Diponegoro Street catchment area was solved by utilizing new flood pump combining with new tertiary channel and existing drainage channel.

Keywords: flood, inundation, flood reduction, urban drainage, integrated drainage management.

1. Introduction

The problem of drainage system management has became an important issue in urban areas, especially in rainy season. Urban drainage system are critical and needed complex infrastructures in cities landscape [1]. Base on some researchs, the city growth caused climate change, like increases in heavy rainfalls, and increase flood risk [2], especially in urban areas. Changes in land use occupation, together with vegetation removal lead to greater run-off volumes flowing faster. Floods and drainage concerns are related to city development [3]. It is also important for existing levees, dams, etc. to increase current watershed capacities to mitigate impacts of the floods [4].

The rapid development of urban area, resulting in the transfer of land from the temporary storage, turned into a residential area, thus contradicting the concept of sustainable development. The impact further reduces the ability of flood control facilities and infrastructure in the urban area to dry and drain water into the sea. An integrated drainage management may be the form of problem solving, and development, which will affect other interests.

One form of integrated drainage management in urban areas is through the creation of a storage pool, both retention, detention and a longitudinal channel. The storage pool can provide considerable benefits, because it can reduce the amount of flow discharge (run off) in the channel. It also canbe a community recreation when the surrounding is arranged into a garden. It can even improve the ground water content of a region, as well as an integrated water conservation and flood control effort.

Problems that exist in Sidoarjo regency, especially the area of Sidokare is flood inundation incident that occurs almost every year in the rainy season. The floods have resulted in hundreds of homes, schools and office buildings flooded by 50 cm. Inundation occurs when rainfall exceeds 100 mm/day with a duration of six hours of rain.

From the existing problems, it is necessary to evaluate the condition of the catchment area in the study area, in an effort to handle the inundation in the existing area of drainage infrastructure. By analyzing the historical flood events, an integrated form of drainage management suitable for the study location is expected to be found.

This study aims to determine the occurrence of historical flood and the impact of flood volume increase on the water level in Afvoer Sidokare. It also meant to propose the appropriate form of integrated urban drainage management, and the magnitude of flood reduction, in the Sidokare area.

2. Material and Methods

In the completion of this study, it required supporting data, as primary and secondary data, which includes rainfall data, existing drainage data channel, flow direction data, existing pump station data and drainage outlet, land use data, inundation data, and population data.

Stages of analysis are started by determining the Catchment Area (CA) of the study location. The drainage network and the catchment area of Sidokare Area is shown in Fig. 1. Calculation of the mean of area rainfall by Thiessen polygon method is needed to determine the effect of certain rain stations, to the extent of the affected area. It is analyzed from rainfall data from 1995-2014 (20 years). The rainfall design is calculated using Log Pearson Type III method [5]. This method can be used on all data distribution without having to meet the requirements of skewness and kurtosis coefficient. The intensity of rain in urban areas can be calculated by the Mononobe formula [6]. The approximate number of return period years of the design is based on the volume of floods divided by the length of the flood inundation that occurs. The rainfall discharge for urban drainage is calculated using the Modified Rational formula. The discharge of dirty water or disposal of the population will be considered to calculate the total debit or flood discharge plan.

The capacity of the existing channel, including the main drain, is analyzed to be checked with flood discharge plan. According to these parameters, integrated handling plan for each catchment area will be proposed to solve flood inundated in the study area.

3. Result and Discussion

The Sidokare area as presented in Figure 1, is divided into three catchment areas, namely catchment area of Sepande (western part), catchment area of Sidokare pump station (center) and catchment area of Diponegoro street (the eastern part). All three catchment area outlets are flowing into Afvoer Sidokare as main drain.

3.1 Rainfall analysis

Twenty-years of rainfall data, from 1995-2014, is used in hydrological analysis. However, in order to obtain reliable rainfall data, several tests are required, including consistency test with double mass curve analysis and statistical periodic series analysis, which include trend-free test, stationary test and persistence test.

In the analysis, data of four rain stations around the area are used, namely Durungbedug Rainstation, Sidoarjo Rainstation, Sumput Rainstation and Kludan Rainstation. The result of the analysis shown that these four groups of data are consistent. Meanwhile from the periodic statistical test, it showed that in the test of the absence of trend, the four stations data are independent.

In the stationary test, it shown that the four stations data are stable. As for persistence test, data from three stations are random, while data from one station is not random. From these data analysis, it was found that from three stations is acceptable and reliable enough to be used in subsequent hydrological analysis.

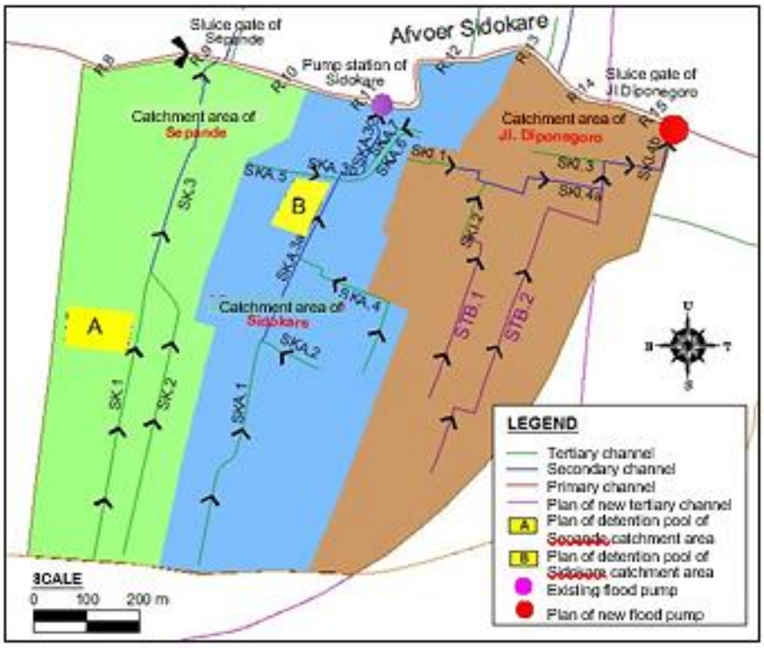

Figure 1. Drainage network of Sidokare Area

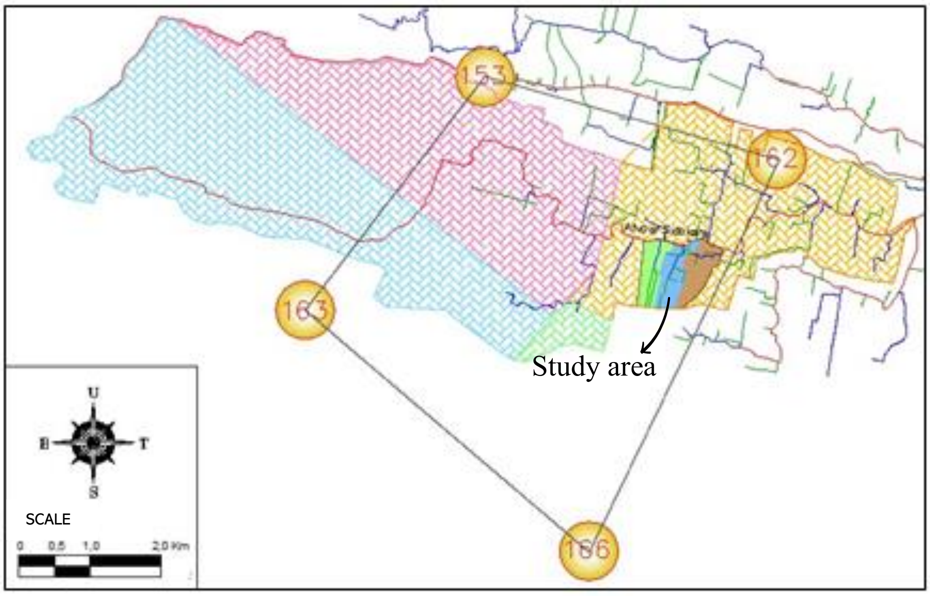

Figure 2. Coverage of Sidoarjo Rain station (162)

In the calculation of the rainfall area mean using the Thiessen polygon method, it is found that the study area is influenced entirely by Sidoarjo Rain station (162), as can be seen in Figure 2, where the rainfall data of Sidoarjo Rain station in the previous test has been qualified and reliable enough to be used in hydrological analysis. Therefore, the other rain stations (153, 163 and 186) can be eliminated for hydrological analysis.

3.2 Rainfall design using Log Pearson Method Type III

In flood engineering and water management, there is a need to determine the flood peak flow for a given *T*-year return period, the annual maximum of river flow quantile X_T (design flood) [7]. In this study, drainage planning in residential areas in urban areas used return period of 1.01 years, 2 years and 5 years. The results of the calculation of rainfall design (X_T) with Log Pearson Method Type III for a specific return period (Tr) can be seen in Table 1.

3.3 Rainfall intensity

The calculation of the intensity of rainfall aims to see the height of the historical rain that caused the flood. According to observations, related institution and historical rainforest information, it was found that the duration of rain in the study site, the average occurred within six hours.

The results of rainfall intensity calculation with the Mononobe formula will be compared with the calculation of historical flood inundation to obtain the historical flood return period. Table 2 shows the results of rainfall intensity analysis based on the return period.

Table 1. Rainfall Design for specific return periods

No	Return Periods Tr (years)	Rainfall Design X_T (mm)
1	1.01	74.26
2	2	98.73
3	5	118.27

Table 2. Rainfall intensity based on return period

Return Periods (years)	Chance of event	Rainfall design (mm)	Rainfall intensity (mm/hour)
1.01	99	74.26	16.503
2	50	98.73	21.939
5	20	118.27	26.283

3.4 Return period

The observation of the length of the inundation that occurred based on historical floods was for two days (2x24 hours) with the assumption that water was not increased nor decreased. From analysis of the inundation volume using contour or topographic maps, it obtained volume of 419,530.30 m^3 for an inundation height of 0.50 m from the soil surface. With the flooded area of 64,068.92 m^2 (29.61% of the area of Sidokare), the accommodated volume is obtained as 124,213.59 m^3. From this volume then reduced with the capacity of the existing drainage channel of 8427.23 m^3 and the result of pumping analysis at the time of flood incident of 100,800.00 m^3. The flood inundation volume is obtained as 14,986.36 m^3. Flood inundation volume then converted into rainfall intensity, the obtained value of historical rainfall intensity is 17.55 mm/hour. The value is close to the rainfall intensity value of the 1.01 years return period plan (16.503 mm/hour). The return period value used in the analysis are 1.01 years, 2 years and 5 years

3.5 Rainfall discharge

With the area of Sidokare of 89.57 Ha or 0.8957 km^2, rainfall discharge for each catchment area for drainage channel is calculated using rational modification equation by entering the storage capacity coefficient (Cs) as the number of corrections to the number of building blocks in urban areas. Furthermore, discharge due to rain is added to the discharge of dirty water or discharge of the population, resulting in total discharge or flood discharge plan.

3.6 Existing drainage channel capacity

The comparison resulting in existing drainage capacity to the flood discharge plan for return period of 1.01, 2 and 5 years can be seen in Table 3.

Table 3. Comparison of existing channel capacity to flood discharge plan in specific return period

Drainage Channel	Existing channel capacity (m^3/s)	Flood discharge plan (m^3/s)		
		1.01 years	2 years	5 years
Sepande catchment area				
SK.1	0.5544	0.304	0.4406	0.5278
SK.2	0.3300	0.1775	0.2295	0.2749
SK.3	0.8910	0.7449	0.9606	1.1508
Total	**1.7754**	**1.2631**	**1.6307**	**1.9535**
Sidokare pump station catchment area				
SKA.1	0.3300	0.2217	0.2870	0.3438
SKA.2	0.3960	0.4036	0.5253	0.6293
SKA.3a	0.6600	0.6997	0.9034	1.0823
SKA.3b	0.8316	0.7909	1.0208	1.2230
SKA.3c	0.9438	0.8162	1.0527	1.2611
SKA.4	0.3300	0.3403	0.4410	0.5283
SKA.5	0.3630	0.1127	0.1464	0.1754
SKA.6	0.5082	0.0626	0.0813	0.0975
SKA.7	0.1848	0.2022	0.2629	0.3149
Total	**4.5474**	**3.6499**	**4.7209**	**5.6559**
Diponegoro street catchment area				
SKI.1	0.4158	0.3299	0.4297	0.5147
SKI.2	0.3300	0.4244	0.5524	0.6618
SKI.3	0.2970	0.2993	0.3893	0.4663
SKI.4a	0.7128	0.8910	1.1528	1.3810
SKI.4b	2.9700	0.9408	1.2154	1.4561
Total	**4.7256**	**2.8853**	**3.7395**	**4.4799**

3.6.1 Sepande catchment area

The existing drainage channel is quite safe for flood discharge plan with the return period 1.01 years, since it is able to accommodate the entire flood discharge plan. in the other hand, for flood discharge plan with the return period 2 years and 5 years, there is one channel that is overflowing.

3.6.2 Sidokare pump station catchment areare

For flood discharge plan with the return period 1.01, 2 and 5 years, there are four, six and seven overflowing channels, respectively.

3.6.3 Diponegoro street catchment area
For flood discharge plan with the return period 1.01 years return period, there are three overflowing channels, while for flood discharge plan with the return period 2 and 5 years, there are four overflowing channels.

3.7 Integrated urban drainage management plan
Integrated urban drainage management for controlling the flood inundation in Sidokare District of Sidoarjo Regency, defined as the effort of handling inundation on urban drainage network which is done in an integrated with certain combination pattern. The proposed handling is meant to water conservation in the rainy and dry seasons.

Due to limited available land, widen the channel will be an appropriate choice. While deepen the channel will not be the option because the groundwater level in the rainy season is only one meter from the surface of the soil. To meet these requirements, the combination of proposed handling for the Sidokare Area is optimizing existing drainage channels, set up new water gate operation pattern, planning of the pool as a means of conservation of water, create new tertiary channels, operate existing flood pumps, add new flood pump, if necessary.

3.7.1 Sepande catchment area
The flood inundation in this catchment area is proposed to be adjusted to its condition. Because it has a wide area for detention pond, the purpose suitable handling will be optimizing existing drainage channels combine with storage pools.

3.7.2 Sidokare pump station catchment area
In this catchment area, the handling is planned using a combination of existing drainage channels, existing storage ponds and existing flood pumps.

3.7.3 Diponegoro street catchment area
The proposed handling for this area is planned using a combination of existing drainage channels, new tertiary channels and new flood pumps.

3.8 Storage pool
The pool in this study is a detention pond during the rainy season. While in the dry season serves as a storage pool, by retaining the remaining water of the rainy season in it. So that it can be functioned as a place of fishing, parks, urban forest and water and air conservation functions.

3.8.1 Storage pool at Sepande catchment area
The location of the plan for this storage pool is shown in Figure 1 with a notation letter A which is an empty unproductive field. It is planned with the length of 100 m, and width of 60 m and height 2.5 m (measured from ground level, with 0.5 m as freeboard), with slope 1:1. This pool has a maximum capacity of 16,614 m^3. Its function is to serve Sepande catchment area and able to accommodate the water volume of SK.1 for 2 years and 5 years return period.

The purpose of making this storage pool is to reduce the secondary channel load of SK.3. The filling processes the pool in the rainy season is done by using one inlet pump unit with a capacity of 0.5 m^3/sec/unit. The pump is operated when it rains heavily and the water level in the drainage channel begins to reach the freeboard. For the 1.01 years return period, this storage pool has not been functional yet, since all existing drainage channels are still able to accommodate flood discharge plans. While on the 2-year and 5-year return period, the filling process of this pool for water volume of 9,517.66 m^3 and 11,401.56 m^3 takes 5.29 hours and 6.33 hours, respectively.

During the dry season, the function of the storage pool is directed to ponds for water conservation, fishing ponds and recreation for the community. There for, the rainwater that descends at the end of the rainy season should be stored entirely in the pond, and not disposed to Afvoer Sidokare.

3.8.2 Storage pool at Sidokare pump station catchment area

The location of the plan for this storage pool is shown in Figure 1 with a notation letter B which is also an empty field. It is planned with the length of 100 m, and width of 60 m and height 3.5 m (measured from ground level, with 0.5 m as freeboard), with slope 1:1. This pool has a maximum capacity of 21,568 m^3. Its function is to serve Sidokare pump station catchment area and able to accommodate the water volume of SKA.1, SKA.2, SKA. 3a and SKA.4, for return period of 1.01 years (1,244.64 m^3), 2 years (10,448.47 m^3) and 5 years (18,742.54 m^3).

The filling process of the storage pool in the rainy season is carried out using two inlet pump units with a capacity of 0.5 m^3/sec/unit. The pump is operated when it rains heavily and the water level in the drainage channel begins to reach the freeboard. Water is pumped into the pool, is the excess water of the SKA.1, SKA.2, SKA.3a and SKA.4 channels, so it is not overflow into the streets and residential area.

For a 1.01 year return period, the duration of water filling into the pool is 0.35 hours. While for the 2 and 5 years return period is 2.90 hours and 5.21 hours, respectively. It is optimal with historical flood inundation conditions caused by the duration of six hours of rain.

Water discharges from the catchment pool in the rainy season should be done periodically, so that the pool is not overcapacity and can accommodate water from the next rainfall. Water discharges can be performed when flood in Afvoer Sidokare have fallen below the existing drainage outlet base elevation (+3.0 m asl), and water conditions in SKA.3b and SKA.3c secondary channels are empty.

During the dry season, the function of the storage pool is directed to ponds for water conservation, fishing ponds and recreation for the community. Therefore, the rain water that descends at the end of the rainy season should be stored entirely in the pond, and not disposed to Sidokare.

3.9 New tertiary channel

The making of new tertiary channels is set in the middle of the street along the way of Diponegoro Street. This arrangement is due to no free land at Diponegoro street catchment area that allows for temporary storage ponds as an attempt to reduce flood discharge plans. The alternative to choose is to create a new tertiary channel in the middle of a residential road that serves to reduce load of existing channels and as a means of water conservation. New tertiary channels to be created are New Tertiary 1 (STB.1) and New Tertiary 2 (STB.2) Channel. STB.1 serves to reduce the tertiary channel of SKI.2. With STB.1, the excess discharge from SKI.2 can be accommodated entirely by STB.1. While STB.2 serves to reduce the load of SKI.4a channel. With STB.2, the excess discharge from SKI.4a can be accommodated entirely by STB.2.

For a 1.01 years return period, SKI.2 secondary channel discharge load of 0.4244 m^3/sec and overflowing because it exceeds the existing channel capacity. And it becomes reduced due to excess water of 0.0944 m^3/sec into STB.1, so the SKI .2 is safe from overcapacity. While on the secondary channel SKI.4a, the discharge load is reduced from 0.8910 m^3/sec to 0.7128 m^3/sec, because the excess water of 0.7001 m^3/sec goes into STB.2, so SKI.4a is safe from overcapacity. Likewise, the reduction of discharge load on the 2 years and 5 years return period.

3.10 Flood pump

A pumping station is important facility to control flood of an urban drainage system to drain urban rainwater to water bodies such as rivers [8]. The flood pump as in Figure 1, is the last alternative selected in controlling flood inundation through water conservation efforts. The operation of the flood pump aims to dispose of the excess debit to the afvoer, if the drainage channel and the storage pool are not able to accommodate the flood discharge plan, as it has exceeded the existing planning.

At Sepande catchment area, the flood discharge plan can be handled with existing drainage channel and storage polls, so it no longer requires flood pump. While at the outlet of Sidokare pump station catchment area, there are two existing flood pump units with each pump capacity is 0.35 m^3/sec. Functions can be optimized by referring to the existing Standard Operation Procedure (SOP).

In flood discharge conditions the 1.01-year return period, the excess water to be pumped is 0.2561 m^3/sec, derived from SKA.7, SKA.3b and SKA.3c. This pumping aims to empty the secondary channels of SKA.3b and SKA.3c, so that when the water in the afvoer begins to recede, the storage pool in the Sidokare pump station catchment area can be immediately channeled out to Afvoer Sidokare through SKA.3b and SKA.3c channels. For 6 hours rain duration, the time required to pump excess water with the existing pump is 2.19 hours.

As for the 2 and 5 years return period, excess water to be pumped is 0.3953 m^3/sec and 0.5102 m^3/sec. With a duration of six hours of rain, the pumping time required with the existing pump for 3.39 hours and 4.37 hours.

At Diponegoro street catchment area outlet at existing condition there is only a sluice gate to be a regulatory building in the event of a flood. It is proposed to install flood pump with a capacity of 0.5 m^3/sec per unit to pump water from Diponegoro street catchment area to Afvoer Sidokare.
In flood conditions of 1.01 year return period, the excess water to be pumped by 0.0023 m^3/sec. Forsix hour rain duration, the time required to pump the excess water with a new flood pump with a capacity of 0.5 m^3/sec is 0.03 hours.

While, for the 2 and 5 years return period, the excess water to be pumped is 0.1061 m^3/sec and 0.2683 m^3/sec. With a duration of six hours of rain, it takes time to pump with a new flood pump for 1.27 hours and 3.22 hours.

3.11 Afvoer Sidokare Capacity Receiving Additional Flood Volume

Based on the analysis, Afvoer Sidokare which has parapet (additional river bank embankment) as high as 0.50 m and the average width between the left and right parapet is 23,17 m, along 4,767.55 m from the study location to Afvoer Sidokare Sub-basin, able to receive an additional flood volume of 55,235.47 m^3. Addition of flood volume from Sidokare Area to Afvoer Sidokare on 1.01 year return period is 5,579.52 m^3, with afvoer water level increased 0.05 m from maximum water level. While at 2 years return period there is addition of height of water level in afvoer as high as 0.10 m, with additional flood volume equal to 10,831.92 m^3. At 5 years return period, it increases the height of the water level in the afvoer as high as 0.15 m, with additional flood volume of 16,814.88 m^3.

3.12 Flood reduction

The amount of flood reduction after handling in an integrated manner can be seen in Table 4.

Table 4. Flood reduction after handling in an integrated manner

No.	Flood Controlling system	Flood discharge plan (m^3/s)			Flood reduction (%)		
		1.01 years	2 years	5 years	1.01 years	2 years	5 years
A	**Sepande CA**	**1.2631**	**1.3273**	**1.5901**			
1	Exsisting drainage channel	1.2631	0.8867	1.0622	100	66.80	66.80
2	Storage pool	0	0.4406	0.5278	0	33.20	33.20
			Flood reduction (%)		**100**	**100**	**100**
B	**Sidokare PS CA**	**2.2815**	**2.9647**	**3.5516**			
1	Exsisting drainage channel	1.9678	2.0856	2.1737	86.25	70.35	61.20
2	Storage pool	0.0576	0.4837	0.8677	2.53	16.32	24.43
3	Exsisting flood pump	0.2561	0.4406	0.5102	11.22	13.34	14.37

			Flood reduction (%)				
C	**Diponegoro St. C**	**2.8853**	**2.7395**	**4.4799**			
1	Exsisting drainage channel	2.6105	2.9710	3.2117	90.48	79.45	71.69
2	New Tersiery channel 1	0.0944	0.2224	0.3318	3.27	5.95	7.41
3	New Tersiery channel 2	0.1782	0.4400	0.6682	6.17	11.77	14.92
4	New flood pump	0.0023	0.1061	0.2683	0.08	2.84	5.99
			Flood reduction (%)		**100**	**100**	**100**

3.12.1 Sepande catchment area

The flood discharge of 1.01 year return period at Sepande catchment area of 1.2631 m^3/sec, can be handled entirely by using existing drainage channels (100%). While the flood discharge plan of 2-year return period (1.3273 m^3/sec), should be accommodated in storage pool of 0.4406 m^3/sec (33.20%) and the rest of 0.8867 m^3/sec (66.80 %) flowed through existing drainage channels. Similarly, for flood discharge 5-year return period (1.5901 m^3/sec) should be accommodated in storage pool of 0.5278 m^3/sec (33.20%), and the remaining 1.0622 m^3/sec (66.80%) is channeled through existing drainage channels. So the combination of both will be able to handle the overall flood inundation (100%).

3.12.2 Sidokare pump station catchment area

Flood discharge of 1.01 year return period at Sidokare pump station catchment area is 2.2815 m^3/sec, require combination of integrated handling using existing drainage channel 1,9678 m^3/sec (86,25%), storage pool 0.0576 m^3/sec (2.53%) and the existing flood pump of 0.2561 m^3/sec (11.22%). While for flood discharge 2-year return period (2.9647 m^3/sec), using existing drainage channel of 2.0856 m^3/sec (70.35%), storage pool of 0.4837 m^3/sec (16.32%) and existing flood pumps of 0.3953 m^3/sec (13.34%). For flood discharge the 5 year return period (3.5516 m^3/sec), using the existing drainage channel of 2.1737 m^3/sec (61.20%), storage pool of 0.8677 m^3/sec (24.43%) and the existing flood pump is 0.5102 m^3/sec (14.37%). So, the combination of all three systems will be able to handle the flood inundation (100%).

3.12.3 Diponegoro street catchment area

Flood discharge plan 1.01 year return period at Diponegoro street catchment area of 2.8853 m^3/sec, requires a combination of integrated handling using existing drainage channels of 2.6105 m^3/sec (90.48%), New Tertiary channe1 1 of 0.0944 m^3/sec (3.27%), New Tertiary 2 channels of 0.1782 m^3/sec (6.17%) and new flood pumps of 0.0023 m^3/sec (0.08%).

Meanwhile, for flood discharge the 2-year return period (3.7395 m^3/sec), requires a combination of integrated handling using existing drainage channels of 2.9710 m^3/sec (79.45%), new tertiary channel 1 of 0.2224 m^3/sec (5.95%), new tertiary 2 channels of 0.4400 m^3/sec (11.77%) and new flood pumps of 0.1061 m^3/sec (2.84%). At the flood discharge the 5-year return period (4.4799 m^3/sec), requires a combination of integrated handling using existing drainage channels of 3.2117 m^3/sec (71.69%), New Tertiary 1 Tier 1 0.3318 m^3/sec (7.41%), New Tertiary 2 for 0.6682 m^3/sec (14.92%) and new flood pumps of 0.2683 m^3/sec (5.99%). So the combination of the four will be able to handle the puddle as a whole (100%).

4. Conclusions

From the results of the analysis, it can be concluded as follows:

a. Historical flood inundation in the area of Sidokare caused by rainfall with an intensity value of
17.55 mm/hour. The value is close to the calculation of the rainfall intensity of the 1.01 year return period, which is equal to 16,503 mm/hour.

b. With the parapet (additional river bank embankment) as high as 0.5 m and the integrated handling using existing drainage channels, storage pool and new tertiary channels, the

remaining flood volume to be pumped from the Sidokare Area to Afvoer Sidokare is still in safe condition. The afvour water level at return period of 1.01 years, 2 years and 5 years, increased
0.05 m, 0.10 m and 0.15 m respectively from the maximum water level (the peak of the old embankment).

c. The integrated urban drainage management system for the Sidokare Area is adjusted to the conditions of each catchment area. For Sepande catchment area using existing drainage channels and storage pools. Sidokare pump station catchment area using a combination of existing drainage channels, existing storage pool and existing flood pumps. And Diponegoro street catchment area using a combination of existing drainage channels, new tertiary channels, and new flood pumps.
d. Reduction of flood in Sidokare area after handling in an integrated manner has a success rate of up to 100%. So with the handling of the integrated management system, the problem of inundation in the study location is expected to be immediately addressed.

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