Diversion canal to decrease flooding at Kemuning river, Sampang district

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Abstract. Flooding occurs when rain runoff water cannot be accommodated by a river, due to the flow of water that exceeds its drainage capacity. Flooding can occur anywhere, one of which occurs in the Kemuning river, Sampang Regency. The existing ag factor of the river profile that is experiencing siltation is also a cause of flooding, especially in the rainy season. This study aims to reduce flood discharge in the Kemuning river by planning a diversion channel as a solution using HEC HMS and HEC RAS modeling. Diversion channel is a divider discharge channel or shortcut to reduce flood discharge in rivers that flow directly into the sea. In this study three alternative solutions are planned, alternative 1 is planned to use a rectangular cross-section, alternative 2 is planned to use a trapezoidal cross-section and alternative 3 is planned to use a trapezoidal cross-section and adding and raising existing river embankments. The results of the analysis and planning showed that the flood discharge plan for the 25 year return period in the HEC HMS modeling was 781.9 m³/sec. The results of the HEC RAS modeling with flood hydrograph input during the 25-year return period, Kemuning river conditions overtopping at all stations as high as 1-4 m. From the trial and error results in the HEC RAS modeling, the maximum capacity of the Kemuning river is 90 m³/second. Based on the maximum capacity of the Kemuning river, alternative diversion channels 1 and alternative 2 are planned to accommodate flood discharge of 681.9 m³/sec. An alternative diversion channel 3 is planned to only discharge flood discharges of 300 m³/sec by adding and raising embankments on the Kemuning river. All alternative diversion channel planning can reduce flood discharge by a percentage of 88.5% for alternatives 1 and 2, 38.4% for alternative 3. Based on the maximum capacity of the Kemuning river, alternative diversion channels 1 and alternative 2 are planned to accommodate flood discharge of 681.9 m³/sec. An alternative diversion channel 3 is planned to only discharge flood discharges of 300 m³/sec by adding and raising embankments on the Kemuning river. All alternative diversion channel planning can reduce flood discharge by a percentage of 88.5% for alternatives 1 and 2, 38.4% for alternative 3.
1. Introduction
Flooding can occur anywhere, especially in areas that are crossed or have river flow [2]. Floods that often occur in the Sampang Regency due to the overflow of the Kemuning river caused many losses. The overflow of the Kemuning river resulted in delays in transportation between regions around the location, one of which was the interruption of transportation activities between The Bangkalan Regency and Pamekasan Regency [3]. Because one of the locations of the flood was on the provincial road, it killed off-road user activity. Besides, floods that often hit with depths ranging from 0.4 to 2 m also killed local community activities which indirectly had an impact on the economy[9]. Many alternatives can be applied to overcome or at least reduce flood discharge in the Sampang Regency. One of the studies was conducted by the Department of public works, represented by the Pamekasan Irrigation Area Coordinator who planned a project entitled flood control and drainage project to control the Kemuning river flood.

The writer has another alternative, which is to plan the development of a diversion channel. Diversion channel is a divider debit channel or shortcut to reduce flood discharge on the river that can be directed directly to the sea or back to the river[1]. With the diversion channel, when the Kemuning river receives flood discharge from upstream and at the same time high rainfall is expected to reduce the flood discharge at the Kemuning river. Flood discharges that were originally only accommodated by the Kemuning river can be reduced by dividing flood discharges into the diversion channel. the reduction of flood discharge in the Kemuning river flow is directly proportional to the risk of inundation in The Sampang Regency because the flood discharge in the river can be reduced and does not overflow to undue places.

2. Research method

2.1 Research location
The Kemuning river is in Sampang Regency, Madura, East Java Province, and is located between 7°10”-7°20” south latitude and 113°13'18”-113°23'74” east longitude [3]. The Kemuning watershed has an area of 345 km2 with an elevation upstream +200 m and elevation downstream + 4 m above sea level. This river has a length of 58 km and empties into the Madura Strait. The Kemuning River is the estuary of several fairly large tributaries, such as the Kelokat river, the Serpang river, and the Gunung Maddah river. The upstream part of the Kemuning river is a barren, arid and dry hilly area. These areas are the Kedungdung sub-district, the Robatal sub-district, and the Omben sub-district. Also, the position of Sampang Regency is in the basin area. That is because, in the east, west, and north are higher land.

2.2 Research design
The initial concept of this plan is to reduce flood discharge in the Kemuning river when receiving peak discharge by planning a diversion channel. The method used in this planning is data analysis. Data used in this plan include population surveys of inundation, daily rainfall data, land use data, watershed area data (area topography), and river cross-section data[10]. This thesis uses two alternative diversion channel sections, namely quadrilateral, and trapezoidal. As well as three alternative solutions planned namely rectangular cross-section channel diversion for The first alternative, trapezoidal cross channel diversion for the second alternative, and trapezoidal cross channel diversion with addition and height of embankments on the Kemuning river for the third alternative.

2.3 Data analysis
After the necessary data is collected then a hydrological analysis is carried out to obtain the value of the flood discharge plan which is used to determine a sufficient cross-section and can accommodate the flood discharge. In the hydrological analysis, there are several calculations before finally getting the flood discharge plan value [5]. The steps taken are an analysis of regional average rainfall, calculating the height of the planned rainfall, conducting a distribution test and drawing conclusions, calculating the curve number, calculating the time lag, calculating the flood discharge plan based on a 25-year return period (Q25) [8]. In the work of flood discharge, this plan uses the HEC-HMS SCS Model aids program [11][12].

After calculating the flood discharge plan is obtained, then the next step is to calculate the river cross-section capacity[6]. In this hydraulic analysis using HEC-RAS aids in the process[13]. The steps
taken are to calculate the capacity of existing river conditions using HEC-RAS modelling[7]. Data needed for the modelling assistance program are river geometric data to illustrate river shape, river cross-section data to illustrate river elevation and state, manning coefficient, river flow data, and boundary conditions [4]. Then compare the river capacity with the discharge plan, plan the Diversion Channel, calculate the river capacity with the Diversion Channel using HEC-RAS modelling [15]

3. Result and discussion

3.1 Rainfall data analysis and Watershed
Rainfall data obtained from the Sampang District Public Works Irrigation Agency thirteen rain stations namely the Ketapang rain gauge station, Banyuates, Sokobanah, Sampang, Torjun, Jrengik, Omben, Camplong, Kedungdung, Robatal, Labuhan, Karang Penang, and Tambelang. The Kemuning watershed area of 358,165 km2 which can be seen in Figure 1. The data used is the maximum daily rainfall at each station for 24 years recorded from 1992 to 2015. From these data then performed calculations to get the average. The value of the coefficient of Thiessen Polygon is presented in the table 1. The source of rainfall data analysis is presented of figure 2 and table 2.

Figure 1. The Kemuning watershed.

Figure 2. Rainfall data.
Table 1. Thiessen coefficient.

| Station           | Large (km²) | Thiessen Coefficient |
|-------------------|-------------|----------------------|
| Sta. Robatal      | 98,244      | 0.274                |
| Sta. Penang Reef  | 82,003      | 0.229                |
| Sta. Lacquer      | 32,419      | 0.091                |
| Sta. Torjun       | 1,845       | 0.005                |
| Sta. Omben        | 56,826      | 0.159                |
| Sta. Camplong     | 16,630      | 0.046                |
| Sta. Kedungdung   | 70,198      | 0.196                |

Table 2. The rainfall return period

| Rainy Return Period | (mm)       |
|---------------------|------------|
| 2                   | 73.444     |
| 5                   | 121.200    |
| 10                  | 171.361    |
| 25                  | 265.514    |
| 50                  | 365.624    |
| 100                 | 501.315    |

3.2 Flood peak discharge of 25-years return period
From the results of running the HEC HMS program each time it will produce each hydrograph unit. Each hydrograph unit is presented in the figure 3.

Figure 3. The hydrograph flood return period.
In this diversion channel planning, the return period flood discharge used is 25 years, this is because the Kemuning river is categorized as a natural channel or main channel with a high risk. Peak discharge for the 25-year return period is 781.9 m$^3$/s.

### 3.3 The Flood water surface elevation using 25-years return period

From the results of the HEC RAS output obtained the ability of the river to accommodate the discharge that occurs [9]. From the HEC RAS output, it appears that the capacity of the river is not able to accommodate the planned flood discharge during the 25 year return period. This is indicated by the elevation of water in the river higher than the elevation of the right and left embankments so that the water overflows to the right and left sides of the river [14]. There are output cross-sections as shown in Figure 4 and Figure 5 for longitudinal sections.

![Cross section of the Kemuning river.](image1)

**Figure 4.** Cross section of the Kemuning river.

![Long Section of the Kemuning river.](image2)

**Figure 5.** Long Section of the Kemuning river.

### 3.4 Design of diversion canal

To overcome the wider flood, diversion channel planning was carried out with several alternatives to reduce flood discharge in the Kemuning river. That condition is presented in figure 6. Alternative figure design of canal is presented of 7, 8, 9.

![Location of diversion canal.](image3)

**Figure 6.** Location of diversion canal.
3.5 Comparation of the result of design

All alternative diversion channel plans can reduce flood discharge by a percentage of 88.5% for alternatives 1 and 2 by decreasing the elevation of flood water surface in the downstream of the Kemuning river +3.46 m to +2.21 m, and 38.4% for alternative 3 with a decrease in the elevation of the flood water surface at the downstream of the Kemuning river +3.46 m to +2.07 m. The result is presented in Table 3.

| Alternative | Flood Discharge m³/sec | Discharge of Canal m³/sec | Existing Water Surface m | Design of Water Surface m | Reduction of Peak Discharge % |
|-------------|------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1           | 781.9                  | 681.9                    | 3.46                     | 2.21                     | 88.5                     |
| 2           | 781.9                  | 681.9                    | 3.46                     | 2.21                     | 88.5                     |
| 3           | 781.9                  | 300                      | 3.46                     | 2.07                     | 38.4                     |
4. Conclusion
The results of the discharge on the 25 year return plan are 781.9 m$^3$/sec. The results of HEC RAS modeling with flood hydrograph input when the 25-year return (Q$_{25}$) Kemuning river existing conditions overtopping at all stations as high as 1-4 m. The first and the second diversion channel alternatives are planned to accommodate flood discharge (Q) 681.9 m$^3$/sec. The third alternative is planned to only flow flood discharge (Q) 300 m$^3$/sec by adding and raising embankments on the Kemuning river. The addition and elevation of the Kemuning river embankment at the third alternative planning is planned with height adjusting water level elevation with free board (w) 0.8 m and width 1 m. All alternative diversion channel plans are able to reduce flood discharge by a percentage of 88.5% for alternatives 1 and 2 by decreasing the elevation of floodwater levels in the downstream of the Kemuning river +3.46 m to +2.21 m, and 38.4% for alternative 3 with a decrease in the elevation of the flood water level at the downstream of the Kemuning river +3.46 m to +2.07 m.

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