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THE EFFECT OF RETURN PERIOD AND SEDIMENTATION ON THE CAPACITY OF RIVER DISCHARGE CAPACITY IN SAMARINDA CITY, EAST KALIMANTAN

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ABSTRACT

Factors that affect flooding are due to the dense population that occupies the floodplain of the river, the city's drainage channel which has a relatively flat topography, the rapid development of housing in the floodplain area, the topography of the river in the upstream area has a steep slope so that if heavy rains and high erosion rates causes high peak flows resulting in flooding and erosion, siltation and reduction of river capacity can cause flooding caused by erosion of river beds and river banks due to the absence of vegetation cover, accumulation of sediment in the river sediment deposition causes elevation of the river bed and can reduce the capacity of river channels.Topography greatly influences flood inundation, the lower elevation of the area than the surrounding area often becomes an obstacle to the rate of surface runoff towards the river. Areas on the banks of the river are areas that are most prone to flooding in the event of a river overflow. Areas with a slope of <8% are areas that are difficult to absorb water, such as residential areas with solid pavement, which are more prone to flooding.The aim of this research is to predict the carrying capacity of the river's discharge capacity and provide an overview of flood-prone areas. Design flood discharge, maximum flood discharge and actual river capacity in the KarangMumus sub-watershed return period (years) for the planned flood discharge (Q_{rcn}) = 578.39m^3/s, maximum flood discharge (Q_{mak}) = 578.62 m^3/s, actual river capacity Q = 404.62m^3/s, recommended river capacity = 987.85m^3/s. Less capacity = 173.77m^3/s. So it is necessary to have a recommended river capacity of = 987.85 m^3/s. Due to sedimentation of = 0.2198m^3/s so that the maximum capacity of the river is = 988.0698m^3/s.

KEYWORDS:

River Capacity, Sedimentation Weight, Maximum Capacity.

INTRODUCTION

Sedimentation is the transport or settling of material by water and sedimentation is the result of erosion. In rivers, sediment deposition in the riverbed which causes the riverbed to rise causes high water levels, resulting in frequent flooding that occurs on land that is not protected. Erosion which results in sedimentation in the river so that the capacity of the river decreases due to changes in land use, erosion occurs which results in sedimentation entering the river so that the capacity of the river decreases. The reduction in river flow capacity can be caused by sedimentation originating from sedimentation in the river.

Changes in land use patterns have an effect on a decrease in the potential of the area caused by the increasingly widespread useland for buildings around the Samarinda City area which causes a reduction in water catchment areas. River capacity, drainage and water storage areas in the City of Samarinda are no longer able to accommodate rainwater runoff. Roadside ditches which are supposed to catch rainwater do not function properly so that it will disrupt transportation and can damage the road body. Various efforts that have been made have not been optimal in overcoming the problem of flooding. These efforts are in the form of maintaining and improving the rivers that cross the city, various studies related to urban flood control, but considering the development of the city and increasing settlement fulfillment, this watershed is predicted to have the potential to become a flood area if there is no early handling.

Flooding is a condition of a river where the flow of water is not accommodated by the riverbed, because the flood discharge is greater than the existing capacity of the river. Erosion and sedimentation affect the storage capacity of the river, because eroded soil carried by rainwater into the river will settle and cause sedimentation which will reduce the capacity of the river and when there is a flow that exceeds the capacity of the river it can cause flooding. Changes in the condition of the river's watershed, such as deforestation, urban expansion, and other land use changes can exacerbate the problem of flooding because reduced water catchment areas and sediment carried into the river will reduce the capacity of the river which results in increased flood flow.

The aim of this research is to predict the carrying capacity of the river's discharge capacity and provide an overview of flood-prone areas.

RESEARCH METHODS

Location and Time of Research

This research was conducted in the Karang Mumus sub-watershed. The time required for this research was two month which included literature study, primary data collection, secondary data, data processing and analysis.

Research Object

In this study the object of research was the Karang Mumus Sub-watershed and conducted field surveys on the actual conditions of the Karang Mumus River.

RESULT AND DISCUSSION

Planned Rainfall Analysis

Analysis of the planned rainfall with frequency analysis will estimate the magnitude of the flood with certain intervals of events in the return period of 5 years, in this case it does not mean that during one return period there is only one event but it is an estimate that the maximum daily rain will occur once or more once in the return period.

Analysis of Planned Flood Discharge

Analysis of the planned flood discharge is made by hydrographs of floods on the river calculated using the Nakayasu Synthetic Unit Hydrograph. The time lag from the start of the rain to the peak of the flood Tp, is calculated by the equation: Tp = tg+0.80tr

For L<15 km the value of tg = 0.21 L0.70
For L>15 km the value of tg = 0.40+0.058 L
tr = effective rain time (hours), tr = 0.5 tg to tg (hours)

The time required to decrease the T0.30 discharge is calculated by the equation T0.30 = αxtg. The value of α is a coefficient factor that is determined based on the shape of the flood hydrograph that occurs in the watershed. For flow area α =2 . For a slow rising hydrograph and a fast descending section α =1.5. For the slow rising hydrograph and fast descending section α =1.5 for the fast rising hydrograph and slow descending section α =3.
Analysis of the planned flood discharge includes:

1. Determine the area of the watershed;
2. Determining the length of the river;
3. Calculating the peak flood discharge;

$$Q_p = \left[\frac{CAR_o}{3,6\left(0,3T_p + T_{0,3}\right)} \right]$$

4. Calculate runoff discharge before reaching the peak of the flood on the rising curve;

$$Q_t = Q_p \left(\frac{t}{T_p} \right)^{2,4}$$

5. Calculate runoff discharge before reaching the peak of the flood on the down curve 1 ;

$$Q_t = Q_p.0,30^{\left[\frac{t - T_P}{T_{0,30}} \right]}$$

6. Calculate runoff discharge before the peak of the flood on the down curve 2 ;

$$Q_t = Q_p.0,30^{\left[\frac{t - T_{p+0,50T_{0,30}}}{1,50T_{0,30}} \right]}$$

7. Calculate runoff discharge before the peak of the flood on the down curve 3 ;

$$Q_t = Q_p.0,30^{\left[\frac{t - T_{p+0,50T_{0,30}}}{2T_{0,30}} \right]}$$

8. Calculating the design flood discharge using the Nakayasu Synthetic Hydrograph method for a return period of 5 years.

Information:

Qp = peak flood discharge (m^3/s).
Ro = unit rainfall (1 mm).
Tp = time lag and rain level to the peak of the flood (hours)
tg = time of concentration (hours)
T0.3 = time required for discharge to decrease from peak discharge
to 30% peak discharge (hours).

Sedimentation Analysis

Sediment transport analysis using the Einstein formula includes:

1. Calculate the shear intensity of the sediment grains;

$$\Psi = \frac{\rho_s - \rho}{\rho} \text{ x } \frac{D}{S \text{ x } R_b}$$

From the picture of Einstein's graph to get the value

2. Calculate the transport intensity of the sediment grains;

$$\varphi = \frac{q_B}{\rho_s} x \sqrt{\frac{\rho}{(\rho_s - \rho) \text{ x g x } D^3}}$$

3. Calculating the base load rate q_B ;
4. Calculate the weight of sediment per unit time.

$Q_B = Bxq_B$ (kg/s)
$Q_B = Bxq_Bx(\ )$ (m^3/s)

Information:

S = channel slope
Rb = hydraulic radius (m)
D = sediment grain diameter (m)
B = channel width
ρ_s = specific gravity of sediment (kg/m^3)
ρ = specific gravity of water (kg/m^3)
ψ = shear intensity of sediment grains
φ = transport intensity in sediment grains
q_B = bed load rate (kg/mdt)
Q_B = weight of sediment per unit time (kg/s)

Einstein tried to derive the bottom sediment transport equation using a theoretical approach, namely statistical theory. The approach used is based on several concepts supported by laboratory observations. Probability is used as the basis for formula formation and experimental correction is used as a constant, this formula is very suitable for use in determining graded sediment transport. Einstein used $D = D_{35}$ for transport parameters while $D = D_{65}$ was used for roughness. The relationship between the probabilities of the item will be transported bybasic transit intensity. Equation of bottom sediment loading with Einstein's approximation based on the function of: Bottom sediment load intensity,

$$\varphi = \frac{q_B}{\gamma_s} \text{ x } \sqrt{\frac{\gamma}{(\gamma_s - \gamma) \text{ x g x } D^3}}$$

From Einstein's approach
flow intensity

$$\psi = \frac{\gamma_s - \gamma}{\gamma} \text{ x } \frac{D}{S \text{ x } R_b} \text{ x } 10$$

from Einstein's chart is obtained the bed sediment load rate per unit width of the river bed is calculated by the formula:

$$\varphi = \frac{q_B}{\gamma_s} \text{ x } \sqrt{\frac{\gamma}{(\gamma_s - \gamma) \text{ x g x } D^3}}$$

Sediment load rate over the entire width of the river bed:Qb = qbxB

The influence of biophysical conditions on sediment transport, affects the type of soil. In the Karang Mumus sub-watershed, most of the alluvial soil types are found along the river which has a slope of <8% and is a fine material from river sediments that easily absorbs water. Podzolic soils mostly cover areas with a slope > 8% originating from quartz sandstone, with a clay to sandy texture so that it is rather difficult to absorb water.Areas with a slope of >8% have a podzolic soil type with low infiltration capacity resulting in an overflow area for areas with a slope of <8% if rain occurs it causes flooding and inundation, soil type affects the water storage capacity in the soil and affects runoff. For soil types in the Karang Mumus sub-watershed, it is a fine material resulting from river sediments.

The influence of the biophysical conditions of land cover/land use on sedimentation is very influential when the flood discharge increases because there is no watershed to hold it, the surface water flow becomes large and erosion occurs which results in sedimentation in the river so that the capacity of the river decreases due to changes in land use occurring erosion which resulting in sedimentation entering the river so that the capacity of the river is reduced. Reducing the flow capacity of the river can be caused by sedimentation originating from sedimentation in the river due to the absence of vegetation cover and inappropriate land use. The results of soil analysis of grain diameter, % sediment fractionation, and sediment density showed that the total sediment transport for all fractions of the Karang Mumus sub-watershed was QB = 0.2198m^3/s.

Topographical Analysis

Based on the topographical condition of the Karang Mumus Sub-watershed, based on the slope map in SamarindaIlir District, there is a slope of 0-8% area of 169.8 ha of flat slope class and 8-15% of area of 44.7 ha of gentle slope class, slope of 15-25% area of 63.2 ha, rather steep slope class, and 25-40% area of 15.9 ha steep slope class, namely:

1. In Samarinda Kota District, there is a slope of 0-8% area of 292.9 ha of flat slope class and a slope class of 8-15% of area of 6.8 ha of gentle slope class.
2. In SamarindaUlu Districthas a slope of 0-8% area of 432.3 ha of flat slope class and 8-15% area of 93.2 ha of gentle slope class, 15-25% area of 24.5 ha of moderately steep slope class, and slope 25-40% area of 6.7 ha steep slope class.
3. In North Samarinda District, there is a slope of 0-8% area of 12,356.3 ha of flat slope class and a slope class of 8-15% area of 4,141.2 ha of gentle slope class, a slope of 15-25% area of 1,831.6 ha of rather steep slope class, slope 25-40% area 269.2 ha steep slope class and slope > 40% area 12.7 ha very steep slope class.
4. In Sambutan District, there is a slope of 0-8% area of 81.5 ha of flat slope class and a slope class of 8-15% of area of 60.9 ha of gentle slope class, a slope of 15-25% of area of 27 ha of moderately steep slope class, a steep slope class 25-40% area of 4.9 ha steep slope class.
5. In Sungai Pinang District, there is a slope of 0-8% area of 1,592.7 ha of flat slope class and a slope class of 8-15% area of 518.2 ha of gentle slope class, a slope of 15-25% area of 119.6 ha of rather steep slope class , slope of 25-40% area of 3 ha steep slope class.

The effect of biophysical conditions on flood discharge in the Karang Mumus Sub-watershed, on the topography/slope of the slopes based on the slope map of <8%, the flat slope class is spread out along the river.Topography greatly influences flood inundation, the lower elevation of the area than the surrounding area often becomes an obstacle to the rate of surface runoff towards the river. Areas on the banks of the river are areas that are most prone to flooding in the event of a river overflow. Areas with a slope of <8% are areas that are difficult to absorb water, such as residential areas with dense pavement, shops, so they are more prone to flooding. The slower the surface runoff so that surface runoff accumulates and becomes a flood. Topography greatly influences the capacity of the river in the Main River Karang Mumus, the length of the river L = 40km, the area of the watershed = 32,052ha.

Analysis of Flood Prone Areas

Flooding is a river condition where the flow of water is not accommodated by the riverbed, because the flood discharge is greater than the existing capacity of the river. Factors that affect flooding are due to the dense population that occupies the floodplain of the river, the City's drainage channel which has a relatively flat topography, the rapid development of housing in the floodplain area, the topography of the river in the upstream area has a steep slope so that if heavy rains and high erosion rates causes high peak flows resulting in flooding and erosion, siltation and reduction of river capacity can cause flooding caused by erosion of river beds and river banks due to the absence of vegetation cover, accumulation of sediment in the river sediment deposition causes elevation of the river bed and can reduce the capacity of river channels.

Flood-prone areas based on the map of flood inundation area, in the Karang Mumus Sub-watershed, flood-prone areas in SamarindaIlir District with an inundation area of 86 ha, Samarinda Kota District with an inundation area of 148 ha, SamarindaUlu District with an inundation area of 68 ha, North Samarinda District with an inundation area of 1506 ha and Sungai Pinang sub-district has an inundation area of 473ha. When viewed from the topographic map for flat and sloping slope classes which result in flood inundation and when viewed from the land cover/use map in the Karang Mumus Sub-watershed, land cover is dominated by shrubs with an area of 21,450.4 ha by 53.8829%, settlements 3,503.4 ha area of 8.797%, mining 2125.3 ha area of 5.317% and open land area of 1461.1 ha of 3.6752% and forest cover area of 2212 ha of 5.5543%.

Analysis of Planned Flood Discharge

Analysis of flood runoff discharge and planned flood discharge in the river using the Nakayasu Synthetic Unit Hydrograph in the Karang Mumus Sub-watershed. Flood runoff discharge is obtained from the results of the Nakayasu Synthetic Unit Hydrograph analysis based on the area of the watershed and the length of the river and follows the up curve, down curve, down curve 2, down curve 3 for the rainy season at t hour and for a period of 5 years which will be used to calculate the discharge flood plan. In the Karang Mumus Q_5 sub-watershed, the planned flood discharge is for a 5-year return period. Analysis of the planned flood discharge in the Karang Mumus sub-watershed uses the Nakayasu Synthetic Unit Hydrograph method for the Q_5 year return period. The design flood discharge for a return period of 5 years, for a planned flood discharge of Q5 = 578.39m^3/sec with a duration of rain t = 5 hours with a flood runoff discharge of Q = 10.4375m^3/sec/mm.

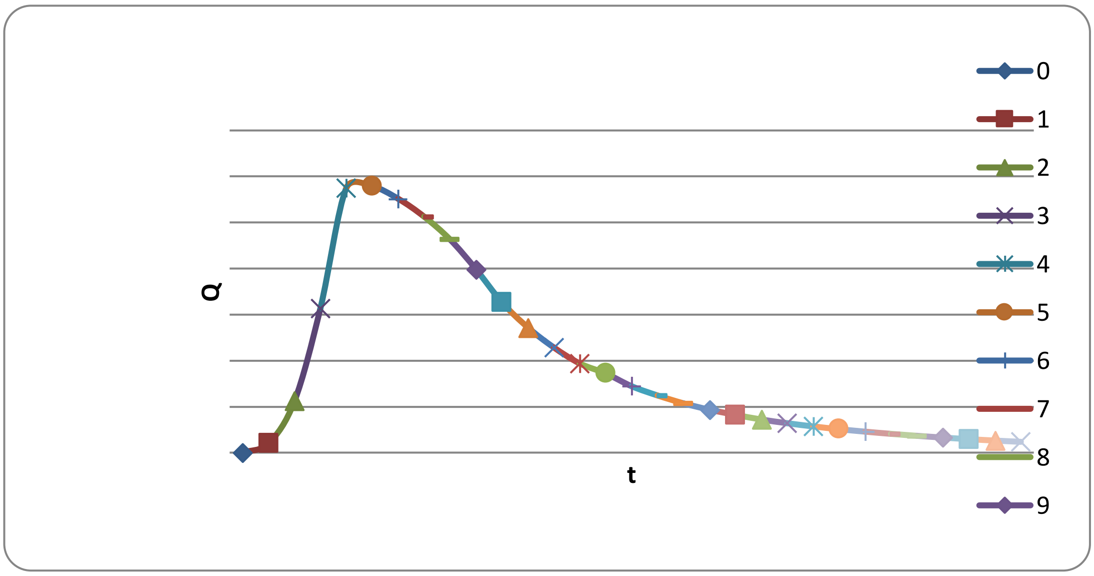

Figure 1. Q5 Year Planned Flood Discharge in the Karang Mumus Sub-watershed

The figure above shows that the planned flood discharge Q_5 year is Q5 =578.39m^3/s with a length of time t = 5 hours. After the rain time t =5 hours the flood runoff discharge and the planned flood discharge are decreasing, the flood runoff discharge is getting smaller so that it affects the planned flood discharge until the time t = 30 hours, the rain intensity begins to decrease. The results of the flood discharge analysis show that the planned flood discharge for the 5-year return period is Q_5 =578.39m^3/s.

River Water Holding Capacity Analysis

The existing capacity is smaller than the planned discharge, so it can be estimated that the canal will not be able to accommodate the volume of water entering the main canal, by increasing the dimensions of the main canal, especially at the height of the canal. Improvements by increasing the dimensions of the canal are expected to be able to accommodate the volume of water when it floods. The effect of biophysical conditions on the analysis of flood discharge in the Karang Mumus Sub-watershed on the topography/slope of the slope based on the slope class <8% slope classflat spread over the area along the river. Topography greatly influences flood inundation, the lower elevation of the area than the surrounding area often becomes an obstacle to the rate of surface runoff towards the river. Areas on the banks of the river are areas that are most prone to flooding in the event of a river overflow. Areas with a slope of <8% are areas that are difficult to absorb water such as residential areas, land with dense pavement, shops, so they are more prone to flooding. The slower the surface runoff so that surface runoff accumulates and becomes a flood. Topography greatly influences the river capacity or river discharge on the Main Karang Mumus River.Design flood discharge, maximum flood discharge and actual river capacity in the Karang Mumus sub-watershed return period (years) for the planned flood discharge (Q_{rcn}) = 578.39m^3/s, maximum flood discharge (Q_{mak}) = 578.62m^3/s, actual river capacity Q =404.62m^3/s, recommended river capacity = 987.85m^3/s. Less capacity = planned flood discharge - actual river capacity = 578.39m^3/s - 404.61m^3/s = 173.77 m^3/s. So it is necessary to have a recommended river capacity of = 987.85m^3/s. Due to sedimentation of = 0.2198m^3/s so that the maximum capacity of the river is = 988.06m^3/s.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

1. Planned flood discharge (Q_{rcn}) using the Nakayasu Synthetic Unit Hydrograph and maximum flood discharge (Q_{mak}) for a 5-year return period on the Main River Karang Mumus. m^3/s>Q_5 maximum flood = 578.62m^3/sec, the river's water holding capacity is sufficient, safe.
2. Total sediment transport for all fractions (Q_B) in the Karang Mumus Main River obtained Q_B = 0.2198m^3/s, so that the results of this sediment transport are thought to cause siltation/sedimentation which can reduce the river's water holding capacity.
3. The actual water holding capacity of the river in the Karang Mumus River, which is 404.61 m^3/sec, is actually smaller when compared to the maximum flood discharge value in the river, so that the river is relatively vulnerable to the possibility of a flood disaster.

Suggestion

If we pay attention to biophysical conditions and especially land cover conditions in the Karang Mumus sub-watershed, vegetative rehabilitation is required, given the condition of land cover which is dominated by shrubs, the presence of settlements, mining and open land so that it has the potential to be a flood-prone area.

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