ISSN: 2063-5346
Section A-Research paper

Hydrodinamic Model of Flood Flow Around Pamarayan Weir in Ciujung River, Banten Province

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Abstract— Pamarayan Weir is a sluice weir located in Ciujung River, Banten Province. It is one of the most important weir of Ciujung River as it serves for irrigation of 21,350 ha of rice fields. The capacity of Paramayan weir is reduced not only for irrigation but also for flood control. Furthermore, the weir safety is then trend to be threatened during the rainy season as the peak discharge of flood hydrograph is trend to increase and the weir capacity is trend to decrease. The purpose of this study to assess the potential sedimentation distribution during the dry season and bed erosion pattern around the weir. The assessment is done based on the flow pattern generated by each of the flow scheme using mathematical model HEC-RAS 6.2 of 2D Unsteady Flow. The dry season scheme is assessed using dependable flow of Q90%. Meanwhile, the flood flow assessment scheme is done using Q50 years of return period. Current simulation results show that the flow velocity on the right side of the weir is higher than on the left side. The flow velocity on the right side shows the occurrence of river bank scouring and on the left side the accumulation of sediment.

Index Terms— *Flood, Pamarayan Weir, Sedimentation, Scouring.*

I. INTRODUCTION

Ciujung river is one of the most important rivers in Banten Province as it serves not only for irrigation and radesa w water supply but also for flood and sedimentation control. Meanwhile, Pamarayan Weir is a sluice weir developed in Ciujung River, Panyabrangan, Serang Regency, Banten Province. It is one of the most important weir of Ciujung River as it supports Ciujung River for irrigation of 21,350 ha of rice fields and flood control in in Banten Province.

Previous study reported that the capacity of Paramayan weir is reduced due to the increasing rate of sedimentation problem generated by land use change (LUC) [1]. Meanwhile, as it is commonly observed in another river located in built environment of Indonesia, LUC of Ciujung River not only generates an increasing of sedimentation but also erosion rate and flood peak [2-6]. The weir safety and function would then be decreased due to the increasing sedimentation and flood peak as discussed above. Further study to get a more reliable sedimentation rate, flood risk and dam failure is then required as a counter measure to mitigate the

potential disaster. Flood risk could be analysed using BNPB standard [7]. Due to the lack of data observation, the analysis of sedimentation and water level on the weir could be done by using

Neural Network Method [8, 9]. The influence of additional sedimentation to weir should be evaluated regarding the potential dam break [10]. Flood risk should be predicted using the updated flood peak and dam break scenario by using mathematical model [10-15]. The influence of the increasing flood peak of Ciujung River to the weir stability, the sedimentation rate and river bed erosion should be studied [16]. However, this paper discuss only the prediction of potential sedimentation distribution during the dry season and bed erosion pattern around the weir based on mathematical model.

Pamarayan weir is located in the Ciujung Pamarayan watershed (see Figure 1 and 2). The catchment area has about 1,468.46 km^2. Based on previous study Dede Sulaeman et al. [1] about analysis of land use change impact on river discharge in Ciujung Watershed. Average annual discharge in the period of 2004-2011 increased by 15% compared to the period of 1999-2003. Watershed conditions analysis indicates that Ciujung watershed quality decreased with increasing in surface runoff coefficient with value of 0.43 (period 1999-2003) and 0.48 (period 2004-2011). The study showed that there are several decreasing landuses during period 2003-2011 such as open land, natural forest, mixed dry land farming, secondary dry forest, primary dry forest, and dry land farming by 47.4; 14.3; 8.4; 2.9; 1.6 and 0.1% respectively. Several increasing land uses during the period including bush, plantations, settlements, and paddy field by 1,974.5; 5.5; 3.8 and 0.9% respectively.

The Ciujung river in the study area has a mild slope so that it becomes vulnerable to sedimentation and flood. Based on previous study Abdul Chalid et al. [6] about erosion effect in Ciujung river, erosion rate in Ciujung river, Lebak district about 168.57 t/ha/year. Sedimentation rate in Ciujung river about 168.57 t/ha/year and sedimentation about 1,342.85 t/year with SDR 0.127.

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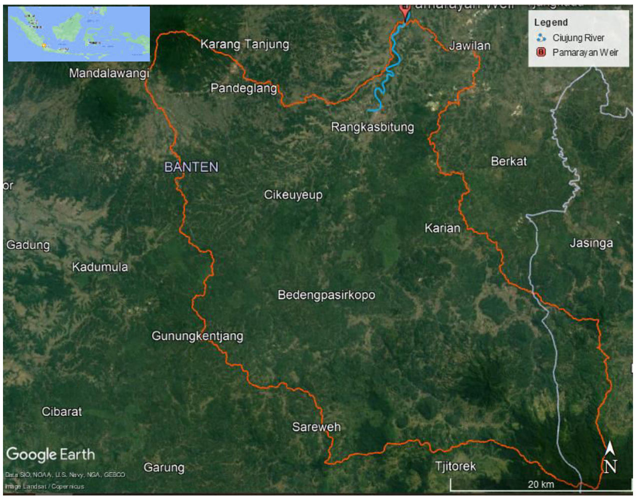

Figure 1 The Ciujung Pamarayan Catchment Area

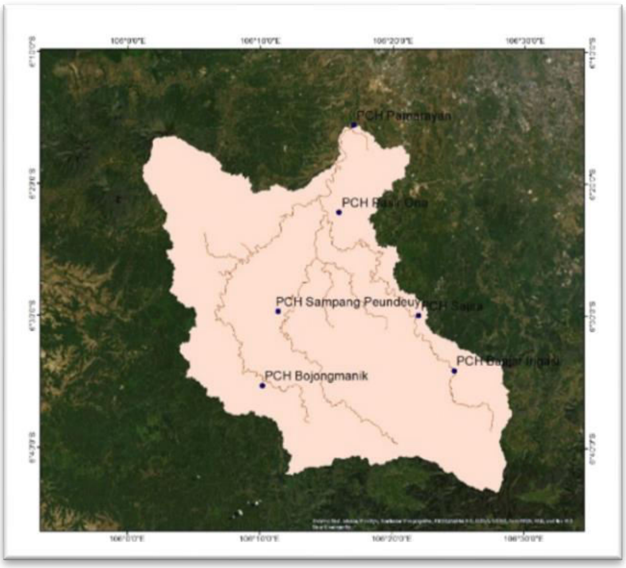

Figure 2 Ciujung River and rainfall station distribution in the study area

II. METHODOLOGY

In general, the stages of this study contain of literature study review, data collection, analysis data, modelling and flow distribution analysis. The flow chart described in Figure 3. The data type collection includes river geometry, rainfall data, topography data, land use data as it is proposed by Farid et al [14].

The purpose of this study to assess the potential sedimentation distribution during the dry season and bed erosion pattern around the weir. The assessment is done based on the flow pattern generated by each of the flow scheme using mathematical model HEC-RAS 6.1 of 2D Unsteady Flow. The dry season scheme is assessed using dependable flow of Q90%. Meanwhile, the flood flow assessment scheme is done using Q50 years of return period.

Rainfall runoff simulation for calculating flood discharge 50 years return period use HEC-HMS version 4.9 based on Synthetic Unit Hydrograph (SUH) technique Snyder.

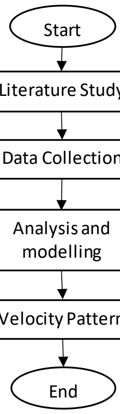

Figure 3 Flow chart of study

The relation between Velocity and the sediment grain sizes shown in Hjulstrom Curve [10].

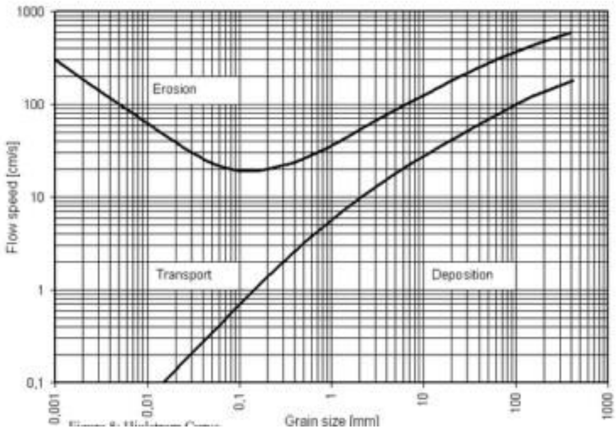

Figure 4 Hjulstrom curve

III. RESULT AND DISCUSSION

Based on land use, catchment area in Ciujung Pamarayan watershed such as settlements, and paddy field, open land, natural forest, and dry land farming. In two decade, the reduced amount of natural forest land also affects the increase in the amount of discharge.

Maximum daily rainfall recorded in 2002 – 2021 can be seen in figure 4 and the topography of the study location can be seen in figure 5.

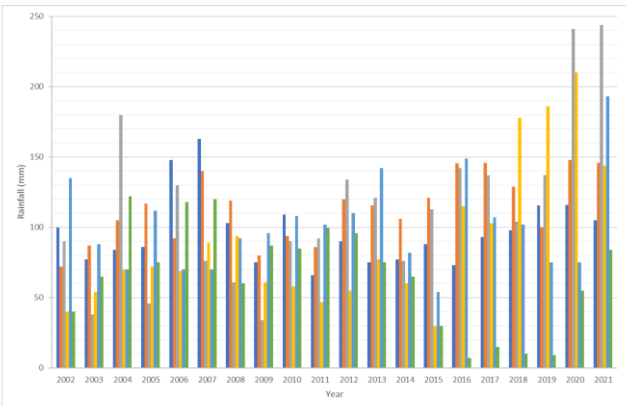

Figure 5 Annual maximum rainfall

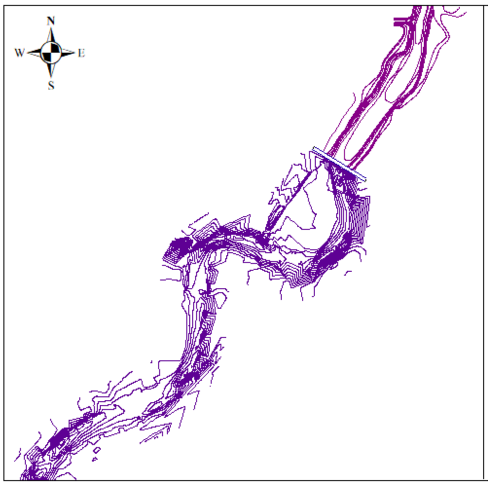

Figure 6 Topography results in 2018 of study location

The model scheme for rainfall runoff simulation by using HEC-HMS 4.9 is based on the original network for the Ciujung river with 3 large catchments (Ciujung Hulu river, Cisimeut river and Ciberang river). The schematic of river network with all sub catchments can be seen in figure 6.

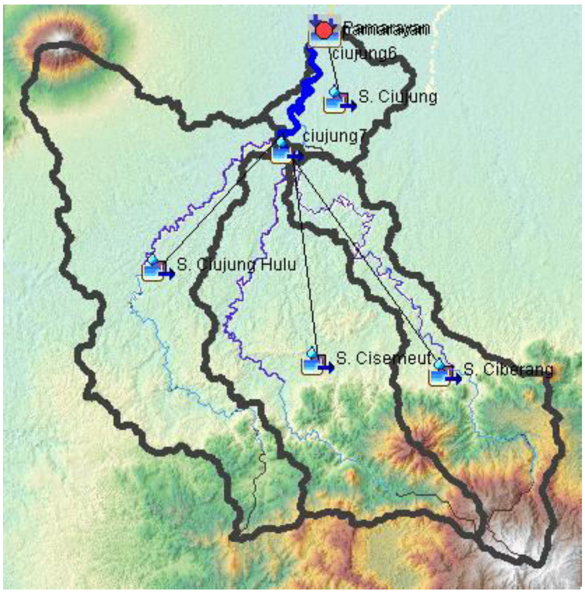

Figure 7 Model scheme for rainfall runoff simulation

Based on the simulation results, the peak discharge for 50 years return period is 1,523.25 m^3/s. its can be seen in figure 7. Flood hydrograph for 50 years return period in Pamarayan can be seen in figure 8.

Figure 8 Peak discharge for 50 year return period

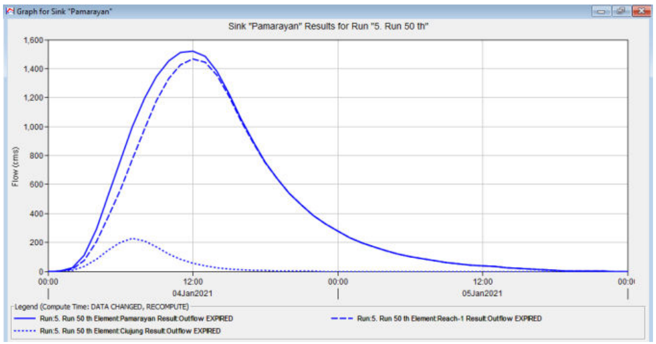

Figure 9 Flood Hydrograph for 50 year return period in Pamarayan

Based on the simulation results, the peak discharge for 2 years return period is 576.62 m^3/s. its can be seen in figure 9. Flood hydrograph for 2 years return period in Pamarayan can be seen in figure 10.

Figure 10 Peak discharge for 2 year return period

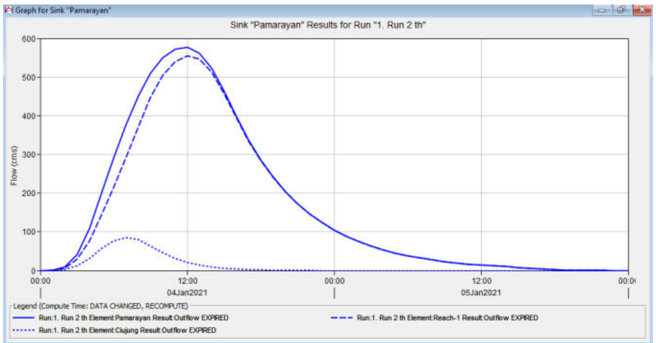

Figure 11 Flood Hydrograph for 2 year return period in Pamarayan

The dry season scheme is assessed using dependable flow of Q90%. Daily discharge can be seen in figure 11. Discharge duration curve of dependable flow, Q90% can be seen in figure 12.

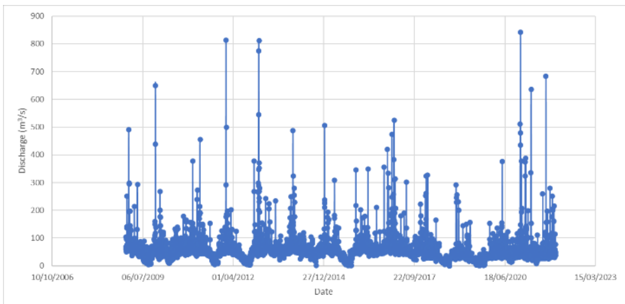

Figure 12 Daily Discharge

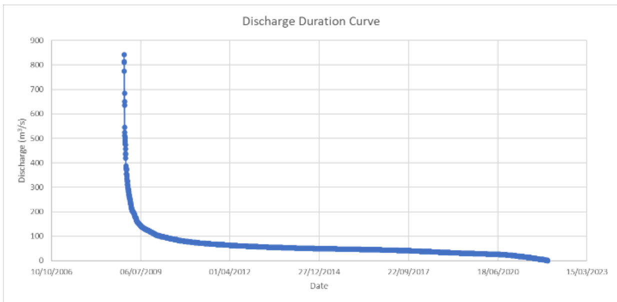

Figure 13 Discharge Duration Curve

Dependable flow Q90% based on discharge duration curve that will be used for modelling about 23.9 m^3/s.

The flow velocity pattern modelling with two type of initial flow condition, normal flow (dry season with dependable flow 90%) and flood flow (flood 50 years return period and flood 2 years return period). The flow scheme using mathematical model HEC-RAS 6.1 of 2D Unsteady Flow can be seen in figure 13, figure 14 and figure 15.

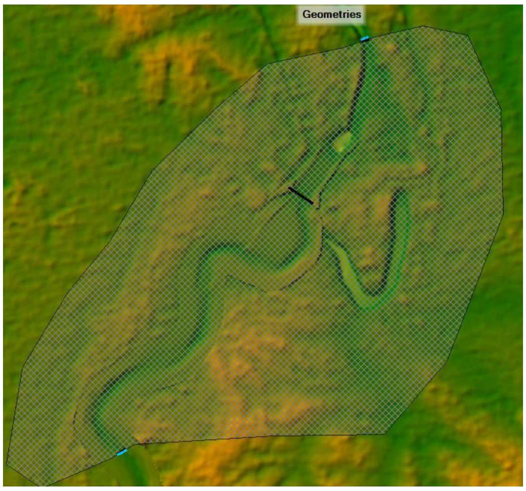

Figure 14 Mesh Modelling

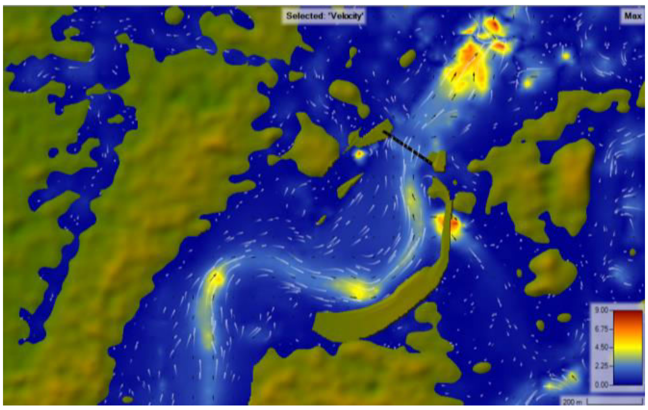

Figure 15 Flow velocity pattern in flood 50 years return period

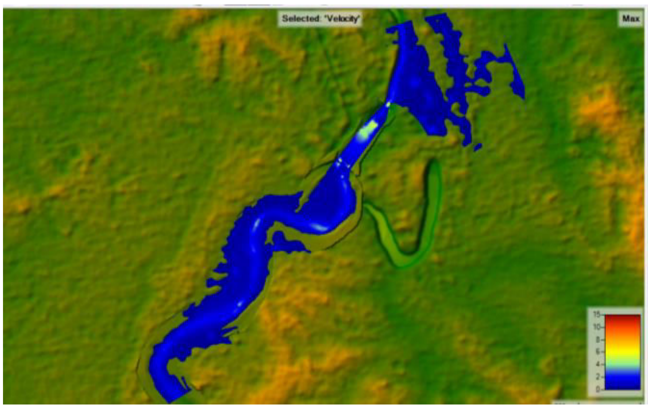

Figure 16 Flow velocity pattern in flood 2 years return period

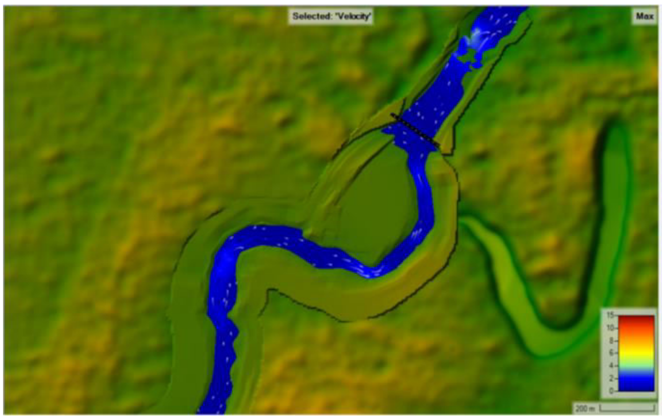

Figure 17 Flow velocity pattern in normal flow condition

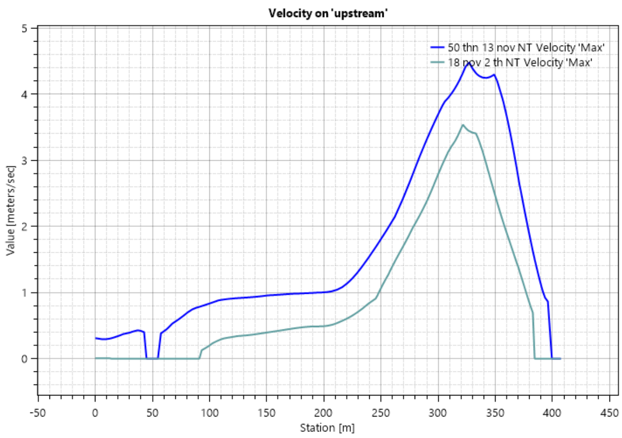

Figure 18 Maximum upstream velocity Pamarayan weir in flood flow condition

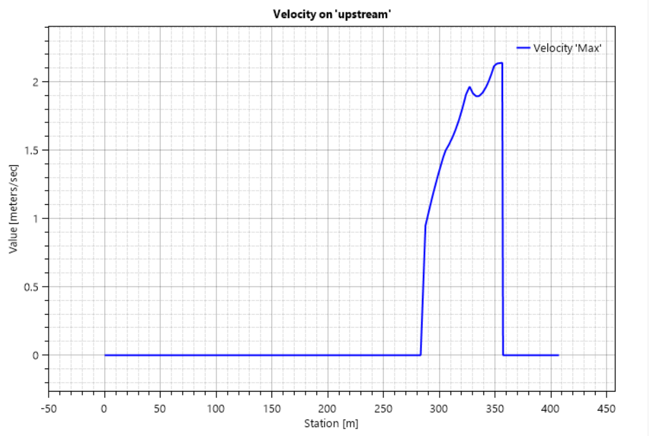

Figure 19 Maximum upstream velocity in normal flow condition

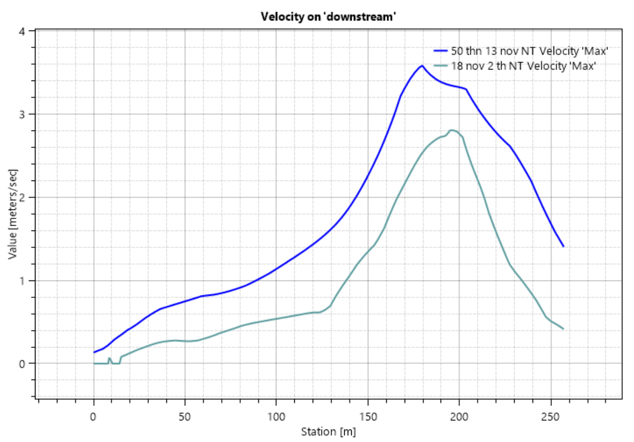

Figure 20 Maximum downstream velocity in flood flow condition

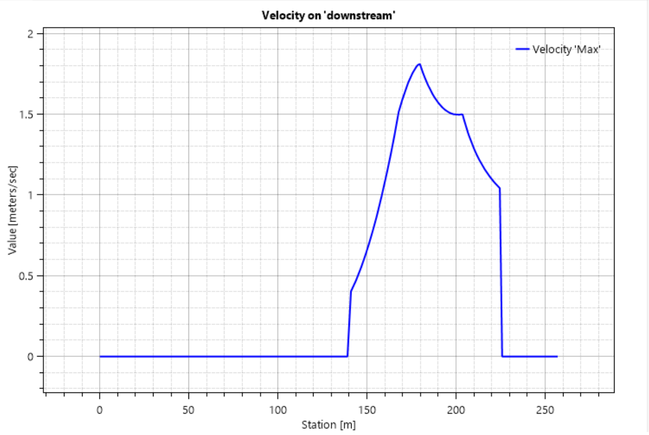

Figure 21 Maximum downstream velocity in normal flow condition

Based on flood flow model simulation where the discharge was about 1,523.25 m^3/s for flood 50 years return period. The average velocity in 100 m distance to Upstream Pamarayan weir was found as follows :

a. About 0.4 – 1.04 m/s (left side)
b. About 1.48 – 4.48 m/s (right side)

The average velocity in 400 m distance to Upstream Pamarayan weir was found as follows :

c. About 0.13 – 1.48 m/s (left side)
d. About 1.48 – 3.58 m/s (right side)

Based on flood flow model simulation where the discharge was about 576.62 m^3/s for flood 2 years return period. The average velocity in 100 m distance to Upstream Pamarayan weir was found as follows :

a. About 0 – 0.52 m/s (left side)
b. About 0.52 – 3.54 m/s (right side)

The average velocity in 400 m distance to Upstream Pamarayan weir was found as follows :

a. About 0 – 0.64 m/s (left side)
b. About 0.64 – 2.81 m/s (right side)

Based on normal flow model simulation where the discharge was about 23.9 m^3/s. The average velocity in 100 m distance to Upstream Pamarayan weir was found as follows :

a. About 0 m/s (left side)
b. About 0.68 – 1.81 m/s (right side)

The average velocity in 400 m distance to Upstream Pamarayan weir was found as follows :

a. About 0 m/s (left side)
b. About 1 – 2.14 m/s (right side)

The result shows us that there is significant difference of velocity pattern between left side and right side at upstream Pamarayan weir. The increasing velocity around right river bank will increase the potensial scour depth and minimum velocity around left river bank will increase the potential sediment.

Based on the result, when model simulation discharge about 23.9 m3/s, there is no flow in left side river bank. In the right side river bank, maximum velocity about 2.14 m/s. in normal flow. The left side river bank has the potential for sediment accumulation and the right side river bank has the potential for scouring. To reduce the amout of sediment, the flow velocity on the right side river bank needs to be reduced and the velocity on the left side needs to be increased. The sediment can be transported when the discharge increases.

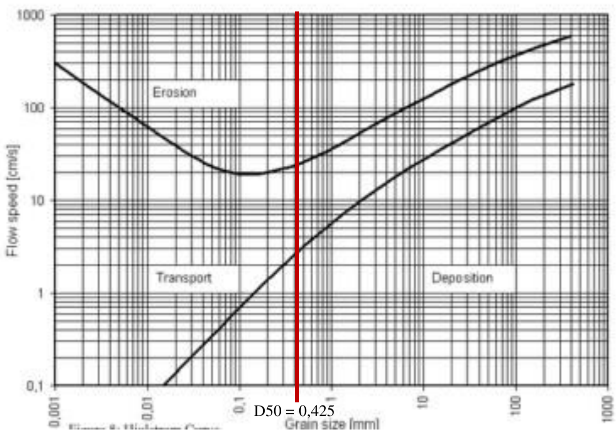

Figure 22 Hjulstrom curve in Pamarayan Weir

According to the sediment grain sizes in Pamarayan Weir, d50 about 0.425 mm, it can also be assumed that velocity more than 25 cm/s, it would be erosion, and velocity lower than 2.7 cm/s, it would be deposition. The velocity between 2.7 cm/s to 25 cm/s, it would be transport.

Based on result simulation and Hjulstrom curve, flood 50 years return period would be erosion on bed river with velocity > 0.027 m/s. flood 2 year return period, 400 m distance to upstream Pamarayan would be sedimentation on left river bank with velocity < 0.027 m/s and right river bank would be erosion. And on normal flow, left river bank would be sedimentation with velocity < 0.027 m/s and rightn river bank would be erosion.

IV. ACKNOWLEDGEMENTS

The author thank to Ministry of Public Works and Housing for providing the field data of Ciujung River. The author also would like thank to reviewers for their valuable comments and suggestion for this study and to Water Resources Engineering Research Group, Faculty of Civil and Eviromental Engineering, Bandung Institute of Technology.

V. CONCLUSION

The flow velocity upstream of the Pamarayan weir on the right side river bank has increased according to the flow rate. On the right side river bank, normal flow condition, the maximum velocity about 2.14 m/s, at flood discharge 2 years return period about 4.1 m/s, and at flood discharge 50 years return period about 4.48 m/s. On the left side river bank, in normal flow there is no flow, at flood discharge 2 years return period about 0.5 m/s, and at flood discharge 50 years return period about 1.2 m/s.

Based on the result simulation, the left side river bank has the potential for sediment accumulation and the right side river bank has the potential for scouring. To reduce the amout of sediment, the flow velocity on the right side river bank needs to be reduced and the velocity on the left side needs to be increased. The sediment can be transported when the discharge increases.

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