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Preliminary Modeling of Characteristics of Current and Batimetry in the Confluence of Mahakam River and Karang Mumus River

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ABSTRACT

The movement of currents at the confluence of the Mahakam River and Karang Mumus River is highly influenced by tides and fluvial discharge can result in the movement of mass water. Research at low tide on January 21-22, 2019 at Spring tide. Data used current velocity, current direction, depth and bathymetric map from DISHIDROS of Indonesian Navy. The study aimed to compare the contours of the river measured against bathymetric map from DISHIDROS of Indonesian Navy and the current and vertically and horizontally flow patterns. Research used quantitative methods. Vertically and horizontally current distribution using Surfer software 11. The results of recording bathymetry data compared with bathymetric map from DISHIDROS of Indonesian Navy. the results of the study showed that the vertical velocity from upstream. they were before the confluence of rivers reached 0.11 m/s where the upper layer was down, the middle layer and the bottom layer were horizontal. Meanwhile, the current velocity at the confluence of rivers vertically showed the upper layer and bottom layer towards the middle layer as if it were mixing with its ranging from 0.02 - 0.32 m/s. while, the vertical velocity was larger in the downstream range of 0.04 - 0.38 m/s. the current velocity from upstream reached 1.1 m/s horizontally. they entered confluence of rivers a two-way flow was present. The flow on the right side of the curve was caused by flow output from the Karang Mumus River at a velocity of about 0.8 m/s, the flow on the left side still followed the river flow but the velocity decreased slightly 1 m/s. Then, in the downstream side by side the flow occurred until it merged into the straight part of the river channel from the velocity of 0.8 m/s to 1 m/s. the declining flow velocity at the confluence of the river can occur sediment deposition. It was also seen with bathymetry measured against the DISHIDROS map in 2011 where there was a decrease in depth or deposition along the confluence of rivers.

***Keywords**: Confluence of rivers, current, bathymetry, spring tide.*

1. INTRODUCTION

The confluence of the Mahakam River and Karang Mumus River is located in Samarinda city which has a total city area of around 718 Km^2. It is a riverside city on the edge of Mahakam River and Karang Mumus River [1]. Most of the Samarinda region is estimated at 365.27 Km^2 (50.09% of the total area) included in the Karang Mumus River with a total length of approximately ± 40 Km stretching from the north to the southern area of Samarinda [1]. Mahakam River Region has a bimodal rainfall pattern with two peaks of rainfall that occur gene-rally in December and May reported in river catchments [2]. The regional climate and Global air circulation has always changed, the hydrological conditions in the Mahakam River catchment changed signify-cantly, especially in the year of ENSO (El Nino-Southern Oscillation) as in 1997, leading to significant varia-tions in river flows [2]. Average sediment discharge (8x10^6

m^3/year) and annual river discharge (between 1000 and 3000 m^3/s) was reported in [3]. Recently stated that hydrodynamic simulations showed that tidal movements affect the current pattern [4]. When flood tide enters the river, the behavior of water such as waves traveling upstream, distortion was then lost due to friction under the river flow. The unidirectional flow forced a change in the relationship between the differences in velocity and delph of water in ebb and flood tide that occurred at the low and high tides respectively. In addition, the tidal velocity amplitude would increase with increasing discharge [5]. [6] also explained that river discharge significantly affected circulation. The location of the study was a busy river transportation route. The comparison between river contours measured against the Disidros map in 2011 were expected to provide a development of sedimentation at the confluence of the Mahakam River and tributaries of the Karang Mumus as a river channel protection. Research on current was carried out with the hope that the results could also be beneficial in efforts to maintain safety in the search for people if drifting was swept away and in further research could study river sediment transport in the Mahakam River and Karang Mumus River of the current pattern discussed in this study.

2. METHODOLOGY

The data used in this study were primary data, namely current and bathymetry. The current obtained from field measurements using the Current flow meter Braystoke BFM001 produced output direction, velocity. In addition it also used secondary data in the form of bathymetry maps of the Kutai River and its estuaries in East Kalimantan with a scale of 1: 75,000 obtained from DISHIDROS (Indonesian Navy Hydro-graphic Department) of Indonesian Navy in 2011. The measurement were carried out on January 20-21, 2019 at the confluence of the Mahakam River and Karang Mumus River. It was done by the angular method using Current flow meters equipped with a sounding reel and ballast adjusted to flow conditions (depth and velocity). The working principle of a current meter device is to measure the current velocity based on the number of fan turns on the device. Formula has been regulated by the tool instructions issued by Valeport Marine Scientific Ltd.

$$V = a + b. N \quad (1)$$

If value N (0.07-0.32) then to determine velocity:

$$V = 0,013 + 0.2512 N \quad (2)$$

If value N (0.32-11.28) then to determine velocity:

$$V = 0.008 + 0.2667 N \quad (3)$$

Where V is the flow velocity, a and b are constants and N is the number of fan turns, while the correction table length of the hangers above and in Water and angular flow direction correction tables [7]. In this study, bathymetry measurement was only limited to groundcheck (checking water depth). The tool used echosounder. The workings of this tool use the principle of distance measurement by utilizing acoustic waves from transducers [8].

The processing of the current data were in the form of velocity value and direction then processed again by displaying vertically and horizontally current vector using Surfer 11. It was to determine the movement of current patterns in each layer of depth, so that it could read the distribution of currents in these waters. How to process current data using Microsoft Excel, then the processed results were entered into Surfer 11 software. Data entered into Surfer 11, there were three components, namely x, y, and z which were stored in the form of grid types. Grid is a series of vertical and horizontal lines in a rectangular Surfer and used as a basis for forming three-dimensional contours and surfaces. Horizontal and vertical lines have intersection points and there is a Z point in the form of a point of height or depth. The process of forming a series of regular z values from a collection of XYZ data is called gridding [9]. After that the data was called or processed. The results showed a display of current direction according to depth.

The bathymetry data was described in the form of depth and 3-dimensional contours to see the topography of bed. This Contour Mapping and 3-Dimensional Spatial Modeling was based on Surfer software. Surfer was one of the software used for making contour maps and three-dimensional modeling based on the grid [9]. The data were processed using Surfer 11 with the Kriging method of geostatistical interpolation or as a refiner capable of connecting extreme points without isolating them [10] in [11].

In this study ignored the influence of wind forces that occur on currents. It was based on research done by [12] and also [13]. The significant mean value of wave height of less than 0.6 m and wave energy affecting the Mahakam delta process was very low due to limited extraction in the narrow strait of Makassar and low level wind speed. It is also proven that the influence of higher tides affects the Mahakam delta than winds in the currents [14] before [15] in their research ignoring the influence of wind in tidal currents in the Mahakam estuary.

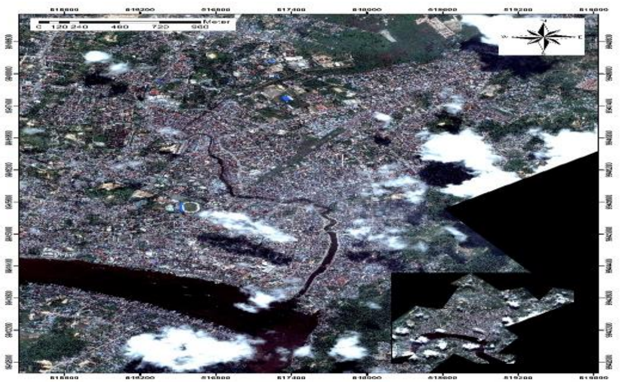

Fig. 1. Locations from the confluence of the Mahakam River and the Karang Mumus River

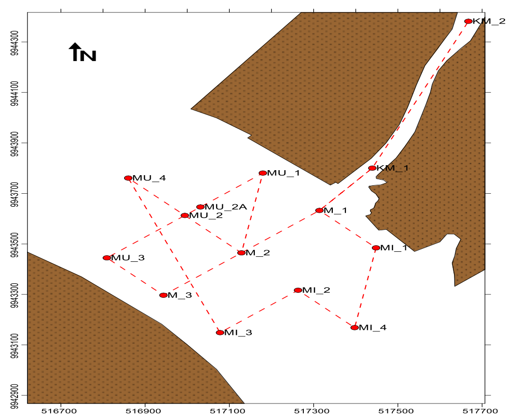

Fig. 2. Map of The Recording Path Point of The Current Meter Data

3. RESULTS AND DISCUSSION

The measurement procedure was carried out on January 20 to 21, 2019 during spring tide conditions (Fig. 3). The measurement data using the current meter had been taken all the points according to Fig. 2. The discussion in the introduction about the current pattern was takes measurement data starting at 09.45 to 15.45. This retrieval when the low to lowest ebb tide.

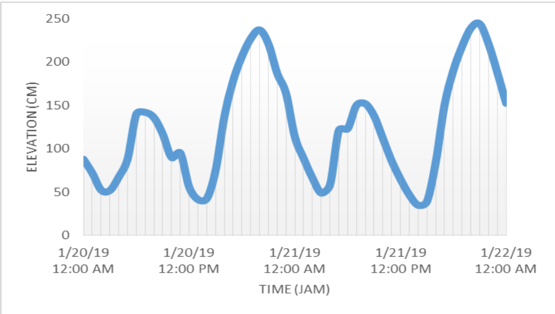

Fig. 3. The measurement of Spring tide from January 20-21, 2019

The results of the bathymetry study on the bed of the waters showed that the confluence of the Mahakam River and Karang Mumus River were shallow waters with depths ranging from 0-20 meters. The region had a sloping basic morphological condition and the condition was increasingly toward the middle of the river confluence deeper. In the part of the Karang Mumus River, it ranges from 1 to 5 meters, after entering the confluence there was a fall to the middle of the Mahakam River with a depth of up to 20 meters (Fig. 4. and Fig. 5.)

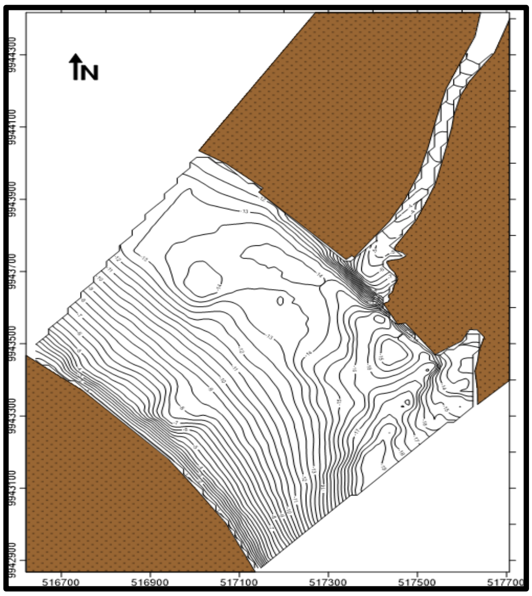

Fig.4. Contour of bathymetry

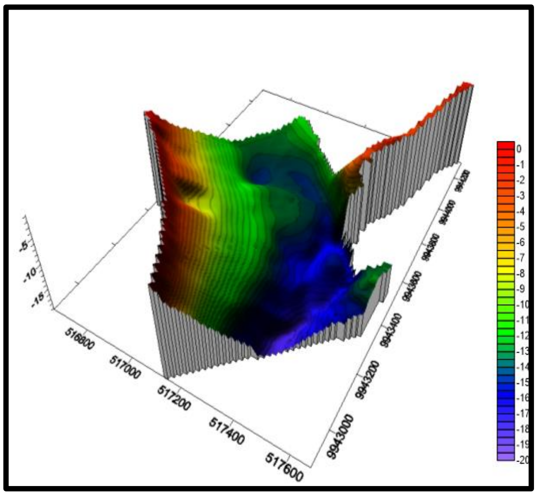

Fig. 5. Morphology of a three-dimensional bed at confluence of river

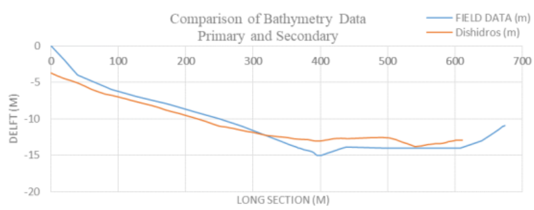

Fig. 6. Comparison between bathymetric data measured and Dishidros data bathymetric map from DISHIDROS of Indonesian Navy

Table 1. Direction and velocity of currents at the confluence of the Mahakam River and Karang Mumus River.

Point	Rai	Azimuth	Slope Angle	Hour	Velocity
KM_1	0.2	215	5	9:45:00 AM	0.3870
	0.6		30		0.2937
	0.8		20		0.2800
M_1	0.2	186	10	10:30:00 AM	0.5679
	0.6		30		0.3565
	0.8		15		0.5569
M_3	0.2	149	30	11:00:00 AM	1.0597
	0.6		30		0.4098
	0.8		5		0.8574
MU_3	0.2	125	30	11:05:00 AM	1.0974
	0.6		30		0.9930
	0.8		30		1.0706
MU_2A	0.2	126	30	11:20:00 AM	0.2562
	0.6		5		0.2513
	0.8		5		0.2594
MU_1	0.2	129	10	11:35:00 AM	1.0201
	0.6		30		0.9740
	0.8		10		0.9089
M_2	0.2	145	15	1:50:00 PM	0.9951
	0.6		15		0.7552
	0.8		15		1.2023
MU_2	0.2	128	30	2:05:00 PM	0.7818
	0.6		25		1.0577
	0.8		20		1.0577
MU_4	0.2	128	25	2:15:00 PM	1.1064
	0.6		10		1.0063
	0.8		10		0.9333
MI_3	0.2	135	30	2:30:00 PM	0.8421
	0.6		20		0.9573
	0.8		25		1.3963
MI_2	0.2	158	20	2:45:00 PM	0.8931
	0.6		20		0.6969
	0.8		15		0.7821
MI_4	0.2	174	25	3:00:00 PM	0.4422
	0.6		20		0.5311
	0.8		15		0.6600
MI_1	0.2	82	0	3:10:00 PM	0.8931
	0.6		0		0.6969
	0.8		0		0.7821
KM_2	0.2	192	0	3:45:00 PM	0.9242
	0.6		0		0.5262
	0.8		0		0.2208

In this study, only ground water depth was carried out only (Fig. 5). Besides the results of recording compared to digitizing bathymetric map from DISHIDROS of Indonesian Navy. The results obtained from the comparison of the two data were different depths, but it weren't significant. It was allegedly because the Dis-hidros map used was in 2011, while the study was conducted in 2019. The distance of the year which was quite far also affected the accuracy of the data. Comparison of the results of the bathymetry data measured against Dishidros data was depicted along the tributary of the Karang Mum-us River crossing the Mahakam River, where in this prelimary study there seemed to be sedimen-tation of bed sediments and in the middle of the Mahakam River there was erosion which might be studied further on sedimentation both bedload and suspended load.

The description of vertical-ly flow distribution patterns made 4 transects and 1 horizontally would be discussed next. Table 1 describes the main direc-tion of the current and the dominant current range adjusting the data when low to lowest ebb tide in the spring tides. The transect was divided along M, MI, MU and MU to MI in 3 layers. The top layer, middle layer and bottom layer where layer consists of 0.2; 0.6 and 0.8 to depth.

In Fig. 7.a, it was located in the confluence between the Mahakam River and the Karang Mumus River. The distribution of vertically current on transects from M1-M2-M3 points. The transect was taken in the Mahakam River across the straight part of the Karang Mumus River.

Vertical current velocities in the upper layer ranged from 0.02 - 0.065 m/s moving downward caused by water towards ebb tide, the middle layer at low velocity almost reached flat, while the lower layer moved up towards the middle layer faster around 0.2 - 0.32 m/s. Behavior in this column where the upper layer and the lower layer move towards the middle layer and vertically vector even makes it look like a spin. It was a mixing in this river confluence area but must be studied futher.

In Fig. 7.b, it was taken downstream from point M at the confluence between the Mahakam River and the Karang Mumus River with a distance of 200 meters. The distribution of vertical currents on transects from MI-1 - MI-2 - MI-3 points. The current velocity in the upper layer ranges from 0.04 - 0.38 m/s moving slightly upwards. The upward movement in the upper layer, like a rippling wave because it just came out of the river confluence. Meanwhile, the middle and lower layers were flat with current velocities ranging from 0.14 - 0.28 m/s.

In Fig. 7.c, it was in the upstream part of point M on the Mahakam River and the Karang Mumus River with a range of 200 meters. The distribution of vertical currents on transects from MU-1 - MU-2 –MU-3 points. Vertical current velocity seen the direction down in the upper layer ranged from 0.08 - 0.11 m/s. The top layer at these 3 points at MU-2 had the fastest decline. Meanwhile, MU -1 seemed to be slow to fall like slack. it was caused by the discharge of water from the Karang Mumus River. on the other hand, the direction of MU-3 point velocity dropped rapidly even though it wasn't as fast as at MU-2. The middle layer moved slightly upwards ranging from 0.03 - 0.08 m/s. The bottom layer was almost uniform towards flat until current velocity of 0.14 m/s.

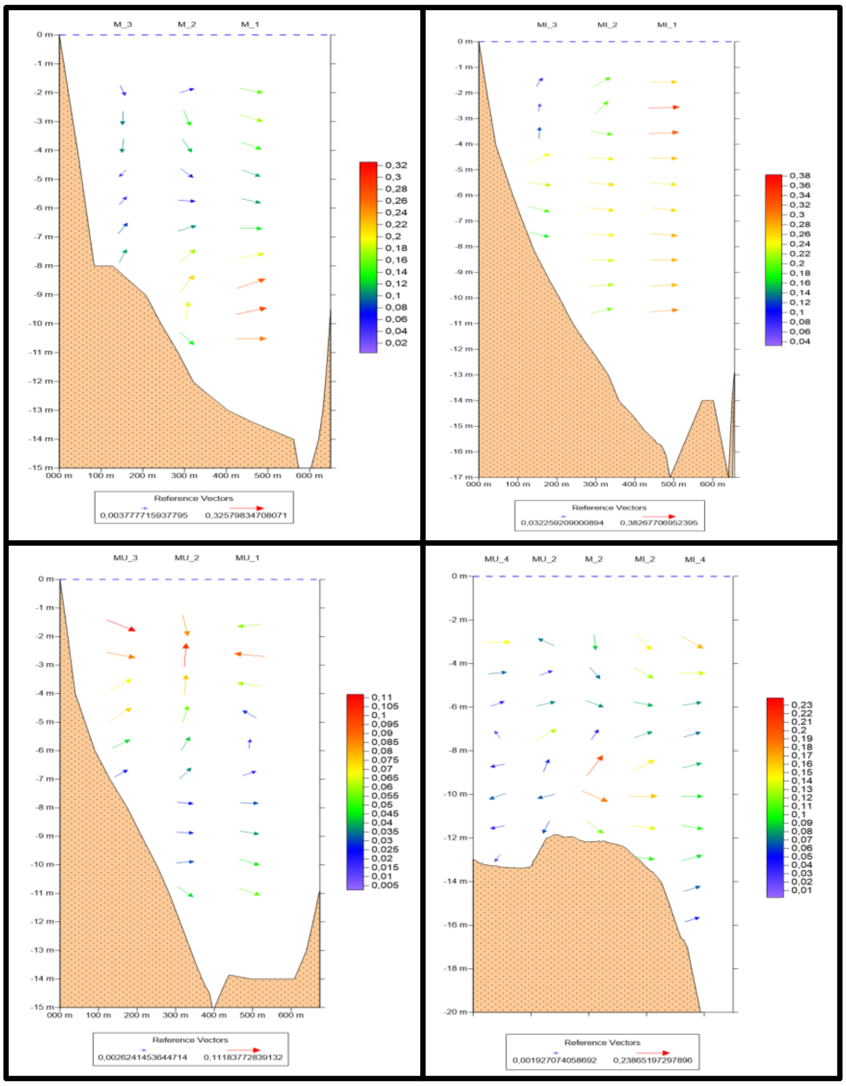

Fig. 7. The distribution of vertically current on M, MI, MU and MU to MI transects

In Fig. 7.d. depicted the distribution of vertically current of MU-4 - MU-2 - MU-3 - MI-4 transect. It was taken long section from up to downstream. The position of the transect at the center of the Mahakam River was 800 meters long. In Fig. 7.d, a new point was taken, namely MU-4, which was 400 meters from the confluence of river deliberately taken to see the position of the flow far from river confluence. Explanation of other points in detail the direction and velocity explained above. Another thing that can be explained, longsection that the velocity of the current in the upper layer of the upstream was a bit blocked downward compared to the downstream. While, the direction of the vector at the confluence of river (M2) was clearly seen going down but the velocity of the decline wasn't as fast as in the up and down stream. The Middle and lower layer in M2 point were very different from MU-4, MU-2, MI-2 and MI-4 points almost uniformly between up and down stream. The difference in M2 shown that turbulence occurs vertically because it was strongly suspected that the flow of the Karang Mumus River brought material towards the confluence of River and there was a mixing at this confluence. The four transects vertically, it was seen that in general the currents at each depth layer weren't always the same pattern. This can be said that in one observation column has different current movements. The reading in Fig. 8. was a distribution of horizontally current of the top layer at ebb tide. The 1st reading of the current direction of the Karang Mumus River towards the confluence of the Mahakam river and the Karang Mumus River then moved downsteam of the Mahakam river or the current moved from the northeast to the southwest and then turns south. The velocity of the Karang Mumus tributary ranged from 0.3 - 0.8 m/s moving while slightly turning at the Mahakam River about 300 meters from the width of the Mahakam River with a decrease in velocity of about 0.5 m/s then moving towards the south by starting the velocity increased by 0.75 m/s <, while the other outer edge of the current from the Mahakam river was approximately 300 meters in the confluence of river goes straight downstream at a velocity of about 1 m/s.

The 2nd reading of the movement from upstream current velocity reached 1.1 m/s. two-way flow was present when movement from upstream enters the confluence. half of the Mahakam river on the left side of the Fig. 8. It began to slightly decrease its velocity entering the confluence until it turned down but remained straight to follow the shape of the river with a decrease in velocity to reach 1 m/s. While, the right side when entered circular moving confluence following the discharge of water from the Karang Mumus River with a decrease in velocity of up to 0.6 m/s. The velocity adjustment on side-by-side flow averaged 0.8 m/s to 1 m/s. the state of flow would occur with a two-way flow when confluence of two river and then forming a stream side by side at the output of the stream. In accordance with research such as [16]; [17]; [18].

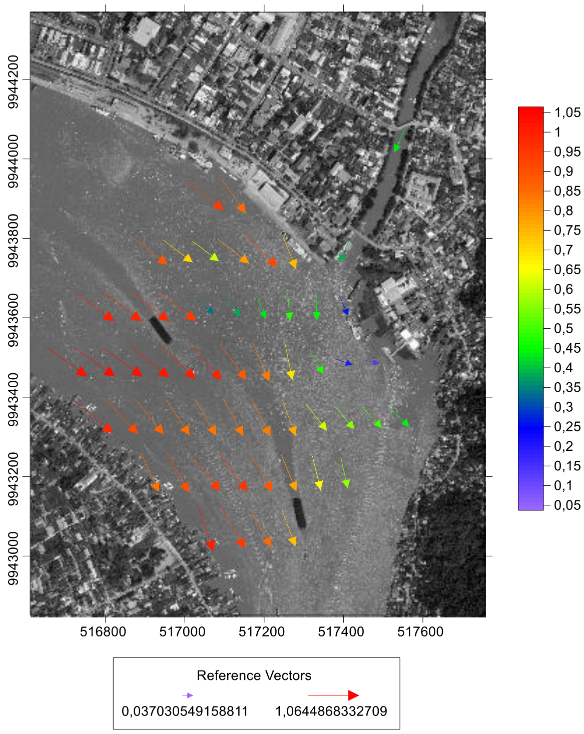

Fig. 8. Top View : The distribution of horizontally current

The confluence of the Mahakam river and the Karang Mumus River clearly gave a decrease in the velocity of the current from upstream. The velocity of the upstream was temporarily detained while waiting for the output of water from the Karang Mumus River. The decrease in velocity at the confluence may cause the sedimentation and can be studied further about the hydrodynamics of tides with their salinity because this confluence of river was about 60 km from the Mahakam delta or the ocean.

4. CONCLUTION

The current at the confluence of the Mahakam River and the Karang Mumus River in the Spring tide at ebb tide moved dominantly from up to downstream. Besides that it could be concluded, the distribution of vertically current from upstream (MU transect) ranged from 0.03 - 0.14 m/s. The top layer was downward, the middle layer and the bottom layer were flat. The river confluence (M Transect) showed upper and lower layers towards the middle layer of the current velocity range from 0.02 - 0.32 m/s. Meanwhile, the condition of the downstream (MI Transect) was flat with velocity ranging from 0.04 - 0.38 m/s.

The distribution of vertically current from upstream reached 1.1 m/s. Two-way flow was present when movement from upstream enters the confluence of river. On the left side the velocity decreased when entering the confluence of river until it turned down but it remained straight following the shape of the river with a decrease in velocity to reach 1 m/s, while the right side when entering the confluence of river moved circularly following the discharge from the Karang Mumus River with a decrease in velocity up to 0.6 m/s. Meanwhile, downstream side-by-side occurs until it merged into the straight part of the river channel to became 1 m/s. The decrease in the velocity of the flow at the confluence of river could occur deposition if it was connected with bathymetry measured against the Dishidros map in 2011, there was a decrease in depth or deposition along the meeting.

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