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Sedimentation Rate in Sub River Flows Musi PLTA Intake Area

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Abstrak: The quality of a watershed can be seen from the discharge of the river flow. Watershed quality can also be seen from the sedimentation found in river water flows and river bodies. Sedimentation is sediment produced by the erosion process carried by the flow and deposited in a place where the water velocity is smaller than the settling velocity. This research was conducted in the intake area of the Musi Hydroelectric Watershed, Ujan Mas District, Kepahiang Regency, Bengkulu Province in August – October 2022. This study used hydrographic and bathymetric survey methods. The results of research on sedimentation using bathymetric maps and the results of sub- bottom profiling in the intake corridor area of the Musi Hydroelectric Power Plant (up to approximately 500 m from the weir), it is known that an average thickness of 1.7 meters near the intake pond (south side) and is getting higher up to 2.5 meters thick to the north or upstream of the river. The thickness of the sediment tends to thicken towards the east or along the riverbank with an average thickness of 2 meters, while in the west it tends to be thinner, with an average of 1.8–2.0 meters. Based on the results of the grab sampler, the type of sediment layer is sandy silt.
Keywords: sedimentation, watershed, hydrography, bathymetry

1. Introduction

The watershed can be viewed as an area or area bounded by mountains and can receive, collect rainwater, sediment, nutrients and drain them through tributaries which will eventually exit the main river (lake or sea) [1]. In general, watersheds are hydrological systems, resource systems, ecological systems, economic systems, and spatial systems for the development of the surrounding area [2]. The existence of the watershed also acts as a hydrological system and is a very important system. Watersheds play a role in draining, permeating, storing and capturing rainwater [3].

The quality of the watershed is determined by the discharge of the river flow and the volume of sedimentation contained in the flow of river water and river bodies. Sediment [4] is soil and parts of soil that are transported from eroded places, while the sedimentation process is sediment produced by erosion processes carried by flow and deposited in a place where the water velocity is smaller than the sedimentation rate.

The biggest utilization of a watershed is as a source of energy for the Hydroelectric Power Center (PLTA). The Musi hydropower plant processes water as one of the environmentally friendly green energy sources. One of them is a tributary of the Musi River in Ujan Mas District, Kepahiang Regency, Bengkulu Province.

The high water discharge is used to drive turbines at the Musi Hydroelectric Power Plant which is managed by PT PLN South Sumatra Generation Main Unit, Bengkulu Generation Control Implementation Unit (UPDK Bengkulu). It is expected that the Musi hydropower plant will be able to secure electricity in 3 (three) provinces from Bengkulu, South Sumatra to Lampung.

The operation of this hydropower plant is certainly not without obstacles and challenges. Keeping the water flow to remain optimum is necessary to drive the turbine. In this regard, the challenge is sedimentation (silting) in the watershed and reservoir of the Musi hydropower plant. Sedimentation in the Intake Area Sub-watershed will result in the closure of the water inlet (intake) leading to the hydropower turbine. Sediment covering the channel leading to the reservoir will result in low electrical energy generation due to reduction of water capacity by sediment volume.

2. Material and Methods

2.1. Material

The following is a hydrographic survey equipment.

Table 1. Hydrotographic survey equipment

No	Type	Function
1	Tidal Palm	Tidal observation
2	Waterpass	Height difference measurement
3	Laptop	Data Acquisition and Input
4	Current Meter	Current Measurement
5	Grab Sampler	Sediment Sampling
6	Water Sampler	Water Sampling
7	Sediment Trap	Sediment rate measurement

The following are tools for hydrological / hydrometric surveys

Tabel 2. Tools for hydrological/hydrometric surveys

No	Description	Merk
1	DGPS Survey	
	- GNSS Receiver	Trimble Receivers R8s LT
	- GNSS Receiver	Trimble Receivers R8s LT
2	Bathymetry Survey	
	- RTK GPS	Dual frequensi V30
	- GPS Rover	Trimble R8 GNSS Receiver
	- SB Echosounder	Odom Hydrotrach Echosounder
	- Boat	Sarana Survey
	- Tidal Watch	Tide gauge manual
	- Grab sampler	
	- Water Sampler	Nansen Bottle
	- Autoleveling	
3	Current	
	- Current metering	OTT Hydromet
4	Survey Sub Bottom Profiling	
	- SB Profiler	Stratabox HD Sy Qwest

2.2. Research Methods

2.2.1. Sampling Methods

a. Preliminary work which includes initial survey and data collection

b. Primary data survey work which includes
  - Topographic and bathymetric measurements including sub-bottom profiling of the river at the reservoir location and the Musi hydropower watershed
  - Hydrological/water Level survey
  - Sediment sampling (purposive sampling method)
  - Erosion calculations.
  - Community empowerment questionnaire

c. Secondary data collection
  - Hydrological data which consists of rain and climatological data (at least the last 10 years) as well as operating discharge data for the Musi hydropower plant
  - Digital Earth Map
  - Land Use Maps, Administrative and Demographic Boundaries
  - Soil Type Map

2.3. Method of Collecting Data

2.3.1. Study of literature

This study uses some secondary data such as rainfall, location maps, topographic maps, administrative boundaries, watershed catchment area maps, and some other necessary data.

2.3.2. Field survey

The purpose of this field survey is to determined the amount of sediment inflow that enters the study area, namely the Musi hydropower reservoir, as well as to determine the distribution pattern of sediment deposits in the Musi hydropower.

This field survey is expected to predict the contribution of land erosion to the Musi hydropower watershed, calculate the sediment potential in the Musi hydropower reservoir, analyze the distribution of sediment in the Musi hydropower reservoir, identify effective and efficient alternative treatments, and finally understand the role of community empowerment from the interview method.

2.3.3. Laboratory Analysis

Water sample results are tested and analyzed in the laboratory to obtain the type and size of the sediment grains.

2.4. Data Analysis Method

a. The socio-demographic analysis used data from the Local Central Statistics Agency (BPS) and interviews with several stakeholders such as village and sub-district officials as well as village communities regarding development plans around the watershed.

b. Interpretation of land use, identification of critical land in the watershed, and prediction of the magnitude of the occurrence of land erosion in the watershed.

Positioning surveys with GPS satellite observations (GPS surveys) in general can be defined as the process of determining the coordinates of some points to several Global Positioning System (GPS) points whose coordinates are known, using differential positioning methods and observational data. In addition, land use maps, watershed maps, and predictions of areas prone to watershed erosion are obtained from satellite images and secondary data (documents) from PLN.

c. Analysis of sediment potential and sediment distribution

Analysis of sediment potential and sediment distribution using bathymetry. Bathymetry is an activity of collecting bottom-depth data using sensing and recording methods from the bottom surface of the waters which will be processed to produce the bottom relief of the waters. The result will be drawn by some arrangement of the lines of depth (contour). In the measurement, the equipment consists of main tools, namely distance measuring instruments and depth measuring instruments. The distance measuring instruments used in this work are Theodolith, EDM (Electronic Distance Measurement), and GPS (Global Positioning System). While the depth measurement tools were the Garmin Echo sounder and its auxiliary equipment.

d. Data processing for sediment analysis

This using sub-bottom profiling data is carried out using several Sonar Wiz Map data processing software. To display data that looks better and clearer than playback data, the data is processed with several treatment steps for the data such as filtering, stacking, and adding gain. To then interpret the data as well as digitize the interpreted sedimentary layers.

Based on the digitization results in this software, the data obtained are X, Y, and Z.

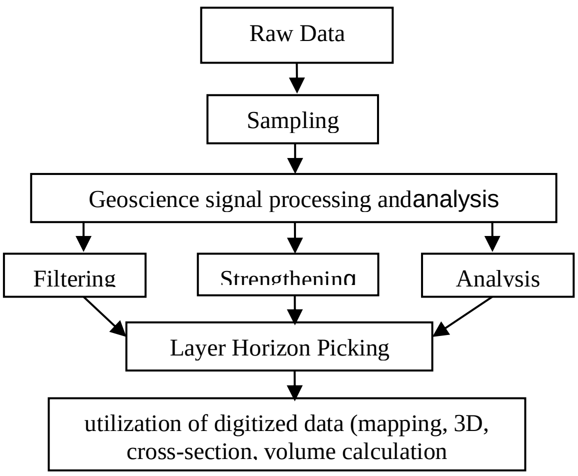


Figure 1. Flowchart of how to process Sub Bottom Profiling (SBP) data

3. Results and Discussion

3.1. General Description

3.1.1. Geographical and Administrative Location

The location of this research was in the intake area of the Musi Hydroelectric Power Center (PLTA) in the Ujan Mas Atas area, Kepahiang Regency, Bengkulu. The coordinate's location is 3°33'53.04" South Latitude and 102°30'19.82" South Latitude. The watershed area is 597.891 km^2, the maximum river length is 48.28 km, the slope is max. river 0.0228 and land slope 0.2357.

Figure 2. Musi hydropower watershed

3.1.2. Characteristics of Kepahiang District

This district coordinates located between 101°55'19" - 103°01'29" east longitude and 02°43"07" - 03°46'48" south latitude. Meanwhile, when viewed from its geographical location, Kepahiang Regency has boundaries, including the northern part – Rejang Lebong Regency; the Southern part – Central Bengkulu Regency; the West – Central Bengkulu and Rejang Lebong Regencies; the Eastern part – South Sumatra Province. Kepahiang Regency is also located in the highlands of the Bukit Barisan Mountains which is one of the districts in Bengkulu Province. It has an area of approximately 66,500 hectares or 665 square kilometers. The capital city of Kepahiang Regency is located in Kepahiang District.

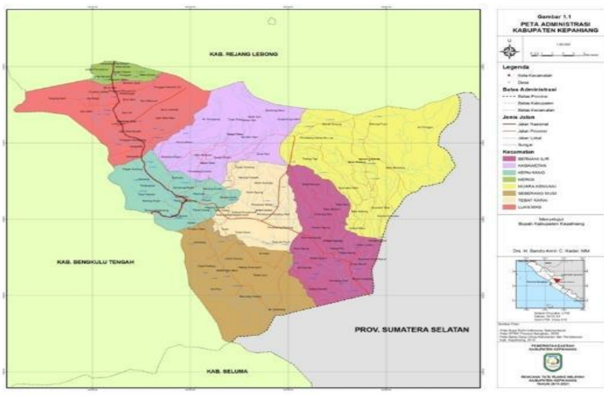


Figure 3. Map of Kepahiang Regency

Rejang Lebong Regency and Kepahiang Regency are two areas that are fed by water from the upper reaches of the Musi River. Kepahiang Regency has regional boundaries, namely the northern border with Curup District, Sindang Kelingi District, and Padang Ulak Tanding District, Rejang Lebong Regency. To the south, it is bordered by Taba Penanjung District, Central Bengkulu Regency. In the west, it is bordered by Pagar Jati District, Central Bengkulu Regency, and Bermani Ulu District, Rejang Lebong Regency. In the east, it is bordered by Ulu Musi Empat Lawang District, South Sumatra Province.

3.1.3. Characteristics of Ujan Mas District

The intake location for the Musi Hydroelectric Power Plant is located in the western part of Ujan Mas District, Central Bengkulu Regency, the capital of Kepahiang Regency. The area of the Ujan Mas sub-district is approximately 9,308 hectares, has Ujan Mas Atas Village which consists of 16 villages and 1 sub-district, namely Daspetah, Ujan Mas Bawah, Ujan Mas Atas, Suro Lembak, Suro Ilir, Suro Muncar, Suro Baru, Pekalalongan, Pungguk Meranti, Bumi Sari, and Cugung Lalang. The geographical location of Ujan Mas District is in the north bordering Merigi District, in the south bordering Kepahiang District, in the west bordering Central Bengkulu Regency, and in the east bordering South Curup District, Rejang Lebong Regency.

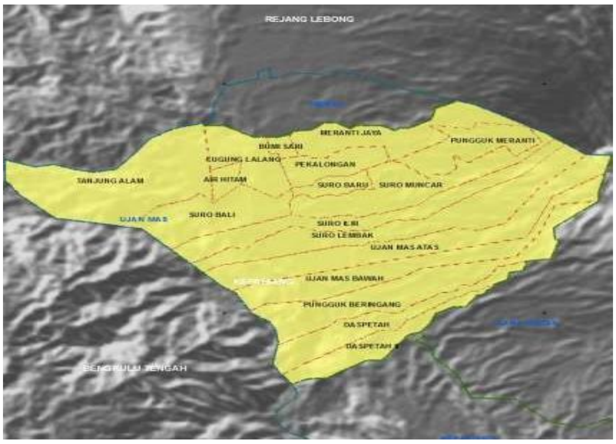


Figure 4. Map of Ujan Mas District

3.1.4. Topography

In general, the topographic profile of the catchment area (CA) of the Musi watershed is dominated by rolling hills with steep hillsides to slightly flat slopes. Based on land elevation above sea level, the Musi Hydroelectric CA is dominated by highland areas, namely from the total area and low mountains. This area consists of various altitude classes. While the topographic profile of Ujan Mas Bengkulu District has a hilly area, with an average altitude of 600 - 700 masl. Based on the slope, the catchment area (CA) of the Musi Hydroelectric Power Plant is dominated by several areas that have flat land, which is around 26,237 ha or around 43.3% of all areas in the Musi Hydroelectric CA. Areas that have slopes in the category of steep and very steep have an area of 5.597 hectares or around 9.2%.

3.1.5. Soil

Soil that develops in the catchment area of the Musi Hydropower Plant consists of acid mineral soils and alluvial soils. According to USDA classification (soil taxonomy) at the order classification level, the soil types are Inseptisol and Ultisol which are acidic mineral soils that dominate the distribution of soil types in the study area. Based on the soil classification at the great group level, it shows that the association of mineral soil types with the widest distribution in the CA PLTA Musi is the Hapludults/ Haplohumults/ Humitropepts association, which has the widest distribution of 10,773.4 ha or 17.8% of the total area, and the association Dsytrandepts/Humitropepts with an area ranging from 8,685.5 ha or 14.3% of the total area.

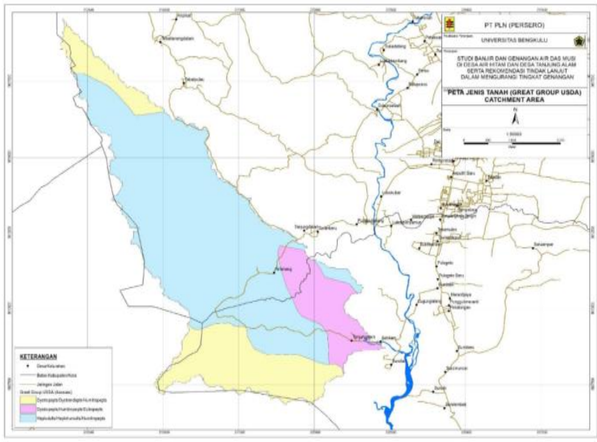


Figure 5. Map of soil types in the Musi hydropower sub-watershed area

Overall, the area of the Musi Hydropower Plantation Area is dominated by soil types of the order Inseptisol and ultisol. The types of soil above are soil types that have undergone a process of advanced development, hence the fertility level is low to moderate, with a high level of acidity, and develops in areas with wavy to hilly topography. This type of soil type of soil that has a soil vulnerability index value, namely entisols, inceptisols, and ultisols which have a relatively small soil vulnerability index [5].

3.1.6. Hydrology and Climate

Drainage has a dependence on topography, geology, climate, and vegetation conditions in the watershed concerned (Primanggara and Suprapto, 2014). The drainage pattern found in the Musi Hydroelectric CA is a dendritic pattern where the river and its tributaries or branches flow from all directions, especially in the upstream part which consists of hills and mountains.

According to (the geography team in Ardi, 2010) Dendritic is a form of river flow similar to the form of tree branching, where the branching is irregular with various directions and angles. It develops in homogeneous rocks and is not controlled by structure, generally formed from sedimentary rocks with horizontal layers, igneous rocks, and homogeneous crystalline rocks. In this area, there is also a breakthrough source rock consisting of acid plutonic rock also known as granite. Many water springs emerge because granite is able to cut through the local land surfaces due to the cut rock arrangement. The spring has been used as a source of clean water for residents and PDAMs, a source of irrigation water, and a potential source of mineral water.

Table 3.Climate in the Musi Hydroelectric CA Area

Month	Rainfall (mm)	Rainy	average temper ature (^{0}c)	heat index (I)
January	180,7	24	26,4	13,0
February	168,1	21	26,3	12,9
March	280,7	23	26,3	12,9
April	362,1	22	26,8	13,3
Mey	102,8	13	26,7	13,2
Juny	134,2	13	26,4	13,0
July	152,1	14	26,2	12,8
August	367,7	18	26,3	12,9
September	273,0	18	26,6	13,1
October	202,7	21	26,5	13,1
November	327,0	27	26,2	12,8
December	442,3	27	25,8	12,5
Amount		2993,3		239
Avarage	249,4	20	26,4	13,0

The climate in the Musi Hydroelectric CA region is a wet tropical climate, according to the Smith-Ferguson climate classification, it belongs to zone A with a comparison value of the average number of dry months with the average number of wet months (Q value) = 0.091, the coldest month temperature is greater than 18˚C, and the amount of rain in the wet months can compensate for the lack of rain in the dry months. The maximum average rainfall occurs in December, which is 442.3 mm and the lowest is in May, which is 102.8 mm with an average monthly rainfall of 20 days/month. The average daily temperature is 26.4˚C with an average monthly heat index of 13.0.

3.1.7. Land Use and Cover

Land cover is the physical (visual) manifestation of collection of vegetation, natural objects, and cultural sensors found on the earth's surface (Townshend and Justice, 1981 cited in Syahbana, 2013). Land cover refers to the shape or physical appearance of the earth's surface such as bodies of water, rocks, built-up land, and others. The land cover in the Musi Hydroelectric CA area has 2,306.8 Ha (47.1%) of forest area. While the remaining area of 2,590 Ha (52.9%) is the Other Designated Area (APL) which has been determined by the Ministry of Environment and forestry. Having a large enough forest area shows that the CA area is a very important landscape in maintaining the water system. It is expected that the hydrological eco-function of the catchment area can be sustainable in the future since it sustains the livelihoods of many people, especially those living around the CA area.

Figure 6. Bathymetric survey path in the intake area of the Musi hydropower plant

Based on land cover data released by the Ministry of Environment and Forestry (2018), there are several types of land cover in the catchment area. Forest land cover in the form of secondary forest is around 384.4 Ha (7.9%). Meanwhile, the dominant land cover in this CA is dry land mixed with shrubs covering an area of 4,429.8 Ha 90.6%. This figure shows the current high rate of forest degradation where the number is increasing day by day.

Encroachment that occurs is significant enough to cause the degradation of forest functions as a regulator of water management, biodiversity, and energy sources. When we observ the CA area that enters In the Bukit Daun HL forest area, only 16.5% of the forest area is still forest, and even then its only secondary forest vegetation cover, not the primary forest. Understanding the development of land cover changes is very important to predict future land cover change patterns and to prevent or reduce negative land cover changes [6].

3.2. Hydrologic and Hydrometry Survey Results

3.2.1. Bathymetric Survey Path

The process of depicting the bottom of the waters starting from measurement, and data processing to visualization is called a bathymetry survey [7]. Bathymetric survey paths are made for easy navigation during field measurements. Coverage of the bathymetric survey area is 2 ha. The depth data collection point starts from the spillway gate to the first bridge in the intake area. The orange line indicates the bathymetric measurement area. The black line shows the line with a total of 10 pieces.

Depth measurements were carried out along the bathymetric path.

3.2.2. Tide Observation of Water Level Elevation

Tides (tidal) are fluctuations in sea level due to the attraction of objects in the sky, especially the sun and moon to the mass of sea water on earth [8]. This attractive force depends on the distance between the earth and the celestial body and the mass of the celestial body. This tidal observation can be done to determine the water level which will be the reference material. Tidal data was obtained from the water level monitoring station located in the DAM intake area. This water level elevation data has been recorded automatically using observation intervals every 30 minutes. The following table provides the tidal data during September 2022 which has been processed to determine the average water level elevation. The average water level elevation or Local Mean Sea Level is used as a reference for water level (Zo).

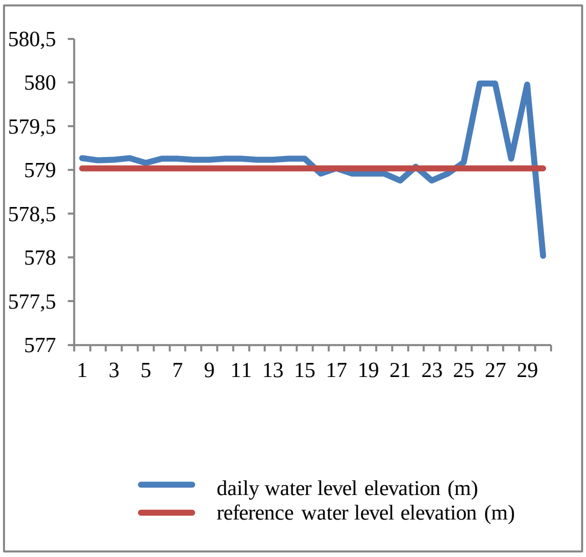


Figure 7. Graph of water level elevation measurement

3.2.3. Watershed Intake Area Depth Measurement

Depth measurements have been carried out in the intake area of the Musi River Basin using a boat that has been installed with a sounding reel. A sounding reel serves as a tool to measure the vertical depth of water. Determination of the horizontal position is carried out using a total station tool that stands on a measurement reference peg which already available in the field, namely the BM stake. Measurement of the depth points is carried out in accordance with the bathymetric lane plan with the help of ropes stretched from the end of the river.

The bathymetric measurement results were obtained in the form of coordinate data called X, Y, and Z coordinates of the total station. Depth data from the sounding reel was obtained together with tidal data to obtain the actual depth in the field. The total station measurement data shows the coordinate position of depth data collection in the UTM 48S coordinate system along with the elevation of the water level. While the sounding reel measurement data shows the depth of the underwater profile measured from the water's surface. The two data are then processed to produce depth elevation data. When bathymetric measurements are carried out at the research location, it always shows that the water conditions, especially the water level, are always changing. The difference in water level at the time of measurement with the reference height (Zo) of 579.12 m was corrected against the elevation data of river water depth using the time parameter.

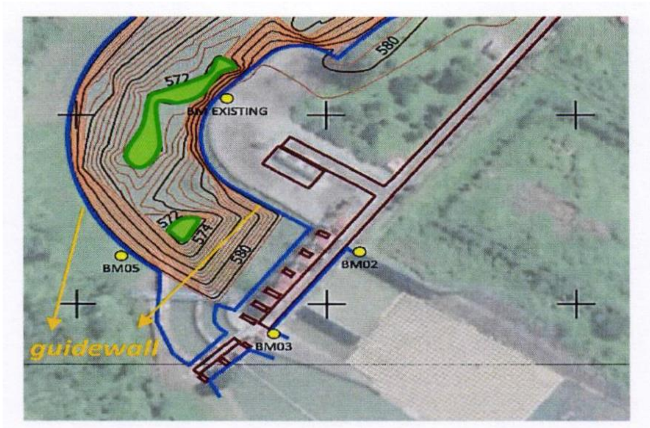


Figure 8. Bathymetric Survey Path Map

Bathymetric measurements were carried out in a watershed area of ± 7 km. The main lane is perpendicular to the river line with a total km line of 55.8 km and the cross lane is 3 lanes (2 sides of the river and 1 middle of the river) along 7 km along with tributaries. The ship used is an engine ship with a small draft that is capable of maneuvering to a depth of less than 1 meter. The sketch of the size and offset of the survey vessel equipment used as well as the documentation (attached). Measurements using the single-beam echosounder Odom Hidrotrac I and positioning using the RTK method with GPS Hi-Target. For locations at the intake and tributary areas, the vessels used are smaller and fit enough to pass through the bridge and enter the intake area of the Musi Hydroelectric Power Plant.

Figure 8 shows the level profile of the watershed intake depth where the riverbed elevation level is at the level of 571.0 m and the results of the bathymetric survey which show the lowest depth elevation at the level of 571.5 m. The lowest bathymetry depth elevation data is at 571.5 m, which is shown in green and appears to have narrowed. It contrasts with the supposed depth elevation of 571 m along the watershed. Conditions in bathymetry at a fairly shallow depth will be more influenced by tidal currents [9].

3.2.4. Water Discharge

The results of the calculation of the Run SWAT discharge at each measurement point on average can be seen in the following table. The results of the SWAT run on the existing conditions, show that the highest monthly average discharge calculation is 4.93 m3/second at the measurement point 2 last August. It is quite weak, namely, the average flow inflow is 1.31 m3/second, and the flow out is 1.16 m3/second. Weak current velocity is not able to move the bottom sediment, unless the sediment floats. It is explained that the current velocity can affect the movement of sediment, where the grain size of 1 mm sediment can move if the current velocity is at least 0.5 m/sec [10].

Tablel 4. Run SWAT discharge data at 2 measurement point

Measuring point	Month	Area (Ha)	Flow_In (M3/Dtk)	Flow_Out (M3/Dtk)
1	1	1,672.5	1,85	1,85
	2	1,672.5	2,32	2,32
	3	1,672.5	1,44	1,44
	4	1,672.5	1,69	1,69
	5	1,672.5	1,24	1,24
	6	1,672.5	1,22	1,22
	7	1,672.5	1,22	1,21
	8	1,672.5	1,28	1,28
	9	1,672.5	1,51	1,51
2	1	967.0	1,06	1,06
	2	967.0	1,34	1,34
	3	967.0	0,83	0,83
	4	967.0	0,98	0,98
	5	967.0	0,72	0,72
	6	967.0	0.71	0,71
	7	967.0	0.70	0,70
	8	967.0	4,93	0,73
	9	967.0	0,86	0,86
totaly			23,63	20,83
everage			1,31	1,16

3.3. Sediment Analysis

3.3.1. Bed Load

Bed load is coarse particles that move along the river bed as a whole. This movement can sometimes be up to a certain distance with the marked mixing of the particles moving towards the downstream direction of the river [11] updated in [12].

Table 5. Result of Basic Sediment Laboratory Analysis

No.	Location		Grain Size Analysis (%)			
			gravel	sand	silt	clay
1	SD-01	STA-01	0.28	40.28	59.43	0.00
2	SD-02	STA-02	1.94	45.05	53.01	0.00
3	SD-03	STA-03	1.89	83.65	14.46	0.00

The sample results are tested and analyzed in the laboratory to obtain the type and size of the sediment grains. The results of grain size were analyzed in the laboratory. Based on the table above, it is dominated by silt and sand sediments at station 1 and station 2. While at station 01 until station 03 is dominated by sand. This result is due to speed the current in this area is a weak current because the area is a sloping plain, so it has a current with a faster speed low and can only transport sediment finer size while Flow with more speed high can transport sized sediment rougher.

3.3.2. Suspended Load

3.3.2.1. Sediment Sample Analysis in the Laboratory

Suspended load is bed material that floats in the river flow and consists mainly of a few grains of fine sand carried by the river water and has little interaction with the riverbed, since it is always pushed upward by the turbulence of the flow.

Table 6. Result of floating sediment analysis

No.	Location	Water Surface (m)	Concentration of Sediment (gr/lt)
1	STA - 01	0,2d	0.0220
2	STA - 01	0,6d	0.0390
3	STA - 01	0,8d	0.4378
4	STA - 02	0,2d	0.1131
5	STA - 02	0,6d	0.0202
6	STA - 02	0,8d	0.0210
7	STA- 03	0,2d	0.0417
8	STA- 03	0,6d	0.0207
9	STA- 03	0,8d	0.0203

Based on the results of laboratory analysis, floating sediment levels have concentrations ranging from 0.022 to 0.438 gr/lt at station 1, 0.020 gr/lt to 0.113 gr/lt at station 2, and 0.020 gr/lt to 0.041 gr/lt at station 3. The sample results were then carried out for testing and analysis in the laboratory to obtain the type and size of the sediment grains. The following are the results of the laboratory analysis.

Table 7. The result of the data analysis of the sedimentation rate using the sediment trap

No.	Location	Grain Size Analysis			
		gravel (%)	sand (%)	silt (%)	clay (%)
1	St-03	0.00	75.67	24.33	0.00
2	St-02	0.00	28.94	71.06	0.00

Based on the table, it can be seen that the results of laboratory analysis at St-2 Bridge, Surobali Village, sediments are dominated by silt, while in St. 3 Cugung Lalang Village is dominated by sandy sediments. This result is due to speed the current in this area is a weak current because the area is a sloping plain, so it has a current with a faster speed low and can only transport sediment finer size while Flow with more speed high can transport sized sediment rougher.

3.2.2. Sediment Analysis With Sub Bottom Profiling (SBP) Data

Basically, the recordings from the su-bottom profiling equipment, especially the strata box already provide information about the shape and pattern of the subsurface layer. However, the condition of this data is still very polluted by noise, hence data processing stage is needed to further clarify the shape and pattern of layers in the data. One of the stages of processing sub-bottom profiling data is by processing seismic signals. The ultimate goal of this processing is to increase the value of the signal/noise ratio, commonly symbolized by S/N.

Several stages of signal data processing carried out in this sub-bottom profiling include bandpass filer, gain control, and stacking. In this process, the bandpass filer will select a signal with a frequency within a certain range to be passed. Gain Control is a condition every time, when the wave hits the surface, the conditions are very different (the angle of incidence of the wave, the position of the receiver, etc.). Stacking can be done to unite several wave traces, stacking is done, then the shape of the layers that are not so clear at first will appear to form a pattern, because they are combined with close traces. The next stage is the stage of interpretation and data analysis. Sub Bottom Profiling data analysis will provide more information if it is added with surface sediment sampling data.

Sediment sampling is a method for SBP analysis that uses sediment samples in the surface layer. This sediment sample is taken to obtain information on the physical type of rock or sediment. Sediment samples will be subjected to laboratory analysis to obtain more detailed information about the microscopic characteristics of the samples taken. A sampling of the riverbed (seabed sampling) was carried out using the Grab Sampler. Grab is carried out along the planned survey path based on estimates of geological data or river conditions. Soil sampling was carried out from the survey vessel and carried out after the provisional interpretation results.

The result of the grab sample analysis used to help interpret the SBP data is the ST1 sample located at coordinates (222454.07 mE, 9606507.00 mS). From the results of laboratory research, it is obtained that based on: 1). visual classification of sediment type in ST1 is sandy silt; 2). Water content, consists of sediment concentration 0.0220 gr/lt and Salinity 3.0, and the last is 3). Grain size analysis, consists of gravel 0.28%, sand 40.28%, silt 59.43%, and 0.0% clay.

The interpretation of the data from the SBP found that the intake corridor based on the interpretation of the SBP data on the river parallel lane indicated an indication of the sediment layer having an average thickness of 1.7 meters near the intake pond (south side) and getting thicker up to 2.5 meters to the north or upstream. The thickness of the sediment tends to thicken towards the east or along the riverbank with an average thickness of 2 meters, while in the west it tends to be thinner, with an average of 1.8–2.0 meters. Based on the results of the grab sampler, the type of sediment layer is sandy silt.

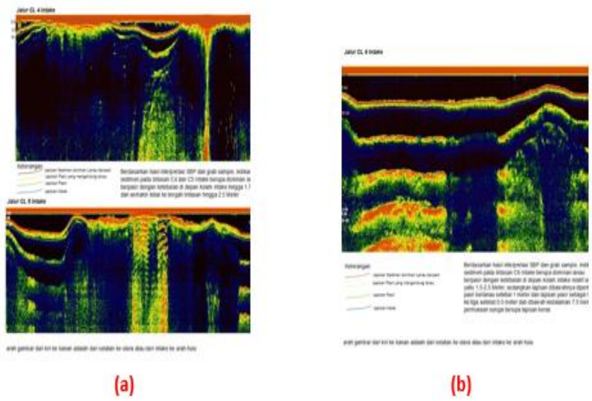


Figure 9. Interpretation of SBP Corridor Intake 4-6

Still in the intake corridor but the interpretation is based on the main lane across the river which generally forms a river depth profile. Based on the interpretation of SBP paths Intakes 9,10,11 and 12 which are located near the intake pond, the thickness of the sediment layer is uniform, which is dominated by sandy silt with an average thickness of 1.5 to 1.9 meters. The second layer below is a thin layer less than 0.5 meters thick, predominantly sand but still contains silt and the third layer is sand with a thickness of approximately 2 meters and SBP detects a hard layer at a depth of more than 10 meters.

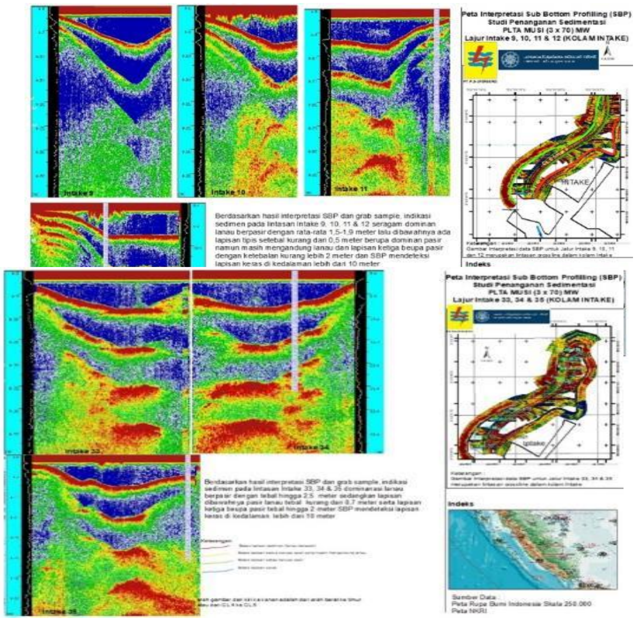
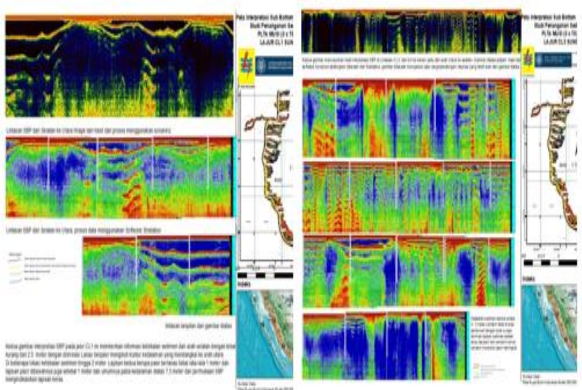


Figure 10. SBP Interpretation on Intake Corridor 9-12

Indications of sediment layers on the Intake paths 13,14,15 and 16 which are located further upstream from the intake pond show the same results, namely the dominant sandy silt but its thickness increases to an average of 1.9 – 2.1 meters, and the layer below it up to hard layer is the same as for other lane interpretations. Subsequent passages that are further north or upstream of the river (away from the intake pond) show increasing sediment thickness as shown in Intake lanes 33,34 & 35 (the end of the path in the intake pond) where the indication of sediment layer thickness is up to 2, 5 meters, and the layer below is a layer of silt sand whose thickness increases to 0.7 meters and the third layer is thick stable sand with a thickness of 2 meters and SBP detects a hard layer at a depth of more than 10 meters.



(a) (b)

Figure 11. Interpretation of SBP on Intake Corridor 33

The river corridor, is also divided into two main lanes, namely the parallel river lane represented by lanes CL1 and CL3 and the river transverse lane represented by lanes ML8 to ML32. From lanes CL1 and CL3, it can be illustrated that the SBP interpretation provides information on sediment thickness from the south with a thickness of less than 2.3 meters with a predominance of sandy silt following shallow depth contours to the north. In some locations, the thickness of the sediment is up to 2.5 meters. The second layer is silty sand with an average thickness of 1 meter and the sand layer below it is also 1 meter thick and generally at a depth of above 7.5 meters from the surface of the SBP indicating a hard layer.

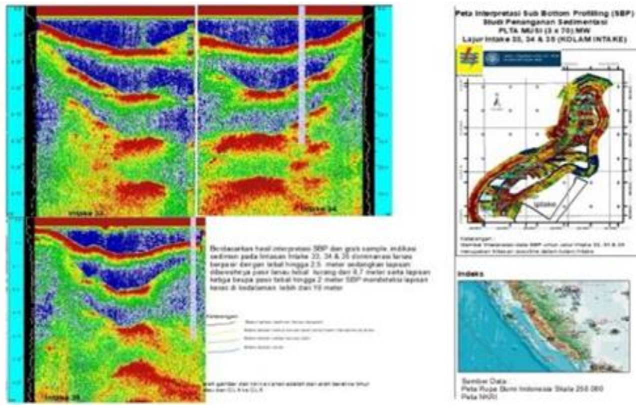


Figure 12. Interpretation of SBP in Corridor Intakes 1 and 3

Based on the transverse trajectory of the river, the entire river corridor shows a sediment thickness ranging from 2 to 2.5 meters, getting thicker towards the upstream of the river, which is dominated by sandy silt, thicker in the west side, while the layer below is silty sand with an average thickness. an average of 0.6 meters, then there is a layer of sand with an average thickness of 1 meter and a hard layer is detected at a depth of more than 10 meters.

In the intake area, there are two main layers of sediment from the SBP interpretation. Sediment distribution patterns are evenly distributed with a regular and homogeneous pattern. The regularity of this pattern follows the bathymetric depth pattern. The regularity and homogeneity occur since the deposition process in this area only follows the current pattern that occurs continuously, the water depth is still relatively shallow and moderate. It indicates that the sedimentation process is not disturbed by tectonic events.

In the Intake corridor, it is defined from the interpretation results that there are two types of sediment layers, namely the top sediment that can still be mobilized by current activity and the second layer below which is still a sediment layer. The formation of the two layers is strongly influenced by river currents. As for the river corridor, the layering of the SBP interpretation gives the same pattern. From the SBP interpretation data, both the intake and river corridors indicate that there are 4 types of coatings that may exist along the survey area. The first and second layers are assumed to be sedimentary layers, while the third layer is a homogeneous compact layer and the fourth layer of SBP has given an indication of a hard layer.

The number of layers that can be recorded is 4 layers where the first layer has a different type of sediment from the layer below it. The SBP data indicates the density change as it enters the different layers. Thus the depth of penetration of the seismic signal in each layer of the surface can be detected. Generally, in the intake corridor, SBP detects sediment layer thickness ranging from 1.5 to 2.5 meters throughout the intake corridor area following the bathymeter contour where in shallow areas the sediment thickness tends to be above 2.2-meters while in deeper areas it tends to be thinner to 1.5 meters. Meanwhile, in the river corridor upstream, the sediment thickness tends to increase compared to the downstream direction, the thickness varies from 2.1 – 2.5 meters. Meanwhile, the thickness of the second layer, both in the intake corridor and in the river, is relatively similar, ranging from 0.3 - 0.6 meters thinner than the thickness of the layer above, while the third layer is on average 2.2 - 2.5 meters. The amount of sediment transport in the watershed is a function of the sediment supply and the energy of the river flow which is also the initial cause is the land cover around the river area which affects the frequency of sedimentation. When the magnitude of the energy flow of the river exceeds the supply capacity sediment by the river then there is river degradation [13].

Conversely, if the supply of sediment is greater than the energy caused by the flow of the river, then there is aggradation of the river. And then the fourth layer is a hard layer based on SBP data found above the 7.5-meter depth of the riverbed surface. One of the weaknesses of the stratabox tool is that when it detects a hard layer, which is generally NPST > 60 SBP, it gives data impulses that tend to be redundant, and this provides an analysis that depth it has reached the hard layer. but the basic things and sources of information are more complete modeling results are more applicable compared to analytical calculations [14].

4. Conclusion

Based on the results of the study, it can be concluded that with respect to sedimentation using bathymetry maps and the results of sub-bottom profiling in the intake corridor of the Musi hydropower plant (up to approximately 500 m from the weir), it is known that it has an average thickness of 1.7 meters near the pond. intake (south side) and getting thicker up to 2.5 meters to the north or upstream of the river. The thickness of the sediment tends to thicken towards the east or along the riverbank with an average thickness of 2 meters, while in the west tends to be thinner, with an average thickness of 1.8–2.0 meters. Based on the results of the grab sampler, the type of sediment layer is sandy silt.

Reference

[1] Rahmawati, F., Winarno, D., J., Kususmatuti, D., I. 2018. Analysis of Sediment in the Way Besai Hydroelectric Watershed Using the USLE (United Soil Loss Equation) Method. JRSDD, December 2018 Edition, Vol. 6, No. 4, Pages:457 – 470 (ISSN:2303-0011)

[2] Amin, M., Ridwan., Zulkarnaen, I. 2018. Watershed Management.Faculty of Agriculture, University of Lampung.Lampung.

[3] Astiningrum, N. 2018. Pedas Besai. PT. PLN (Persero). Southern Sumatra Power Generation Unit.

[4] Sitanala A. (1989) Arsyad, Sitanala. 1989. Soil and Water Conservation. Bogor: Bogor Agricultural University.

[5] Locita, S., Pauzi, G., Supriyanto, A. 2017. Analysis of Ground Vibration Acceleration and Soil Vulnerability Levels in the Lampung Region. Journal of Theory and Application of Physics Vol. 06/01.

[6] Darmawan, A., R., Puspaningsih, N., Saleh, M., B. 2017. Study of Land Cover Change Using Multi Layer Perceptron and Logistic Regression Methods in Mount Ciremai National Park (Study Of Land Cover Change Using Multi Layer Perceptron And Logistic Regression Methods In Gunung Ciremai National Park). Conservation Media Vol. 22 No. December 3, 2017: 252-261.

[7] Hidayat, A., Sudarsono, B., Sasmito, B., Bathymetric Survey for Checking the Depth of Waters in the Kendal Port Area. Geodesy Journal. Diponegoro University.

[8] Lopa, R., T., Maricar, Pahriansyah. 2016. Study of the Effect of Current Velocity Due to Tidal At the mouth of the Jeneberang River. Hassanudin University.

[9] Suaib, S., Rusvan, A., A., Anshari, A., I. 2019. Analysis of Bathymetry and Current Survey Results at Jampea Port, Selayar Regency.Journal of Hydro Engineering. Volume 12 Number 2. Issn : 1979 9764

[10] Siebold, E., and W. H. Berger., 1993. The Sea Floor.An Introduction to Marine Geology.Second Edition Springer-Verlag Berlin. German.350 p.

[11] Soewarno. 1991. Measurement and Management of River Flow Data (Hydrometry). Bandung, pp. 26-29, 644-655, 694-702.

[12] Sembiring, A., E., Mananoma, T., Halim, E., F. 2014. Analysis of Sedimentation at the Panasen River Estuary. Journal of Civil Statistics Vol.2 No.3, March 2014 (148-154) ISSN: 2337-6732 148.

[13] Asriadi and Pristianto, H. 2019. Summary of Erosion and Sedimentation Theory. Sorong Muhammadiyah University Civil Engineering Study Program.

[14] Rohman, S., Henry, M.m, Manik, Hestirianoto, T., and Mudita, I. 2015. Analysis And Classification Of The Near-Surface Sediment Using Sub-Bottom Profiler. Journal of Fisheries and Marine Technology Vol. 6 No. May 1, 2015: 31-39.