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Rainfall Analysis Planning to Calculate Runoff Water Discharge at PT. Triaryani Regency of North Musirawas, Sumatera Selatan

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Abstract. PT. Triaryani is a coal mining company with open pit mining method which located in North Musirawas Regency, South Sumatra Province. In the management of water that goes into the mine is done the manufacture of sump contained in the eagle pit. Sump has a function as a place or pond of water reservoirs that enter to the mine, the water will then be pumped to the settling pond (KPL) will then be neutralized by the distribution of lime and alum 1:4 and flowed to the river. The purpose of this study is to find out the discharge of runoff water and make a sump design in 2021 that can accommodate the discharge of runoff water with maximum rainfall. In the manufacture of sump design is taken into account the discharge of runoff water that will enter so that rainfall data is needed in the area. Rainfall data used from 2011 to 2020 which can beobtained from BMKG South Sumatra rainfall data and rainfall data measured by Triaryani's survey team. The rainfall data will be calculated by dispersion of rainfall data. Dispersion is done to know the distribution of rainfall data to be analyzed, so that the analysis method used is the most appropriate method. Determination of rainfall plan in this study was conducted by rainfall analysis by E.J. Gumbel method based on dispersion results. Slope factors and compactness of the area make rainwater that falls to the surface is not infiltrated so that the flow of runoff water. In order to avoid flooding at the mining site, in the manufacture of sump required calculation of runoff water discharge to be able to know the water that enters the pit.From the calculation obtained the value of the coefficient of runoff of the region is 0.9. Rainfall intensity value is 15,285 x 10^{-7} m/s with catchment area 538,600 m2. Runoff water discharge obtaining is 64,016.88 m^3/ day, so the sump plan made to be able to accommodate the discharge of runoff water is with a depth of 6 m, base length of 97.3 m and surface length of 109.3 m. Sump plan can accommodate the discharge of runoff water with maximum rainfall per day without pumping.

Keywords: *catchment area, precipitation, water discharge, dispersion, sump*.

1. Introduction

Dewatering is one of the aspects which concerns in mining activities where water handling activities (dewatering*)* are carried out in conjunction with production activities. Every mining company must be able to cope with the water entering the work area with proper handling so as not to interfere with the company's production operations. One of the companies engaged in mining is PT. Triaryani.

Pt. Triaryani is a company that engaged in the coal mining industry with open pit mining method. Coal mining activities at PT Triaryani have been started since 2012 conducted in the region of Nibung Subdistrict and Rawas Ilir Subdistrict, Musi Rawas North Regency, South Sumatra Province. Mining activities at PT Triaryani are conducted in 3 (three) areas of IUP Production Operations with their respective regions namely du 1427/Sumsel, KW 05 MEP 008 and KW 05 ME P 009. Mining activities at PT. Triaryani based on the Decree of the Regent of Musi Rawas with their respective letter number, Number 249/ KPTS/ DISTAMBEN/ 2011, Number 468/ KPTS/ DISTAMBEN /2011 and Number 469/ KPTS/ DISTAMBEN/ 2011 as amended into a Decree of the Regent of Musi Rawas Utara Number 540/ 220/ KPTS/ DPE• LH/2014 concerning the Merger of IUP of PT Production Operations. Triaryani KW05 MEP 008, KW 05 MEP 009 and DU 1427/Sumsel Became IUP of PT Production Operations. Triaryani 1116053032014001. IUP Production Operations Area PT. Triaryani administratively located in the area of Tebing Tinggi Village, Nibung Subdistrict and in beringin makmur II village, Rawas Illr subdistrict with an area of 2,143 hectares.

As Geologically, the region of IUP Production Operations pt. Triaryani that include in the stratigraphy of the South Sumatra Basin as part of the East Sumatra basin, which is separated from the Central Sumatra Basin by the Asahan High. (Thirty Mountains) in the northwest, stretching to the south bordered by Lampung High, which at the same time separates it from the Sunda Basin. In the southwest part is bounded by the mountains of Bukit Barisan and the pre-tertiary land to the northeast. Sedimentation in the South Sumatra Basin continuously continue during the Tertiary Period accompanied by a decrease in the base of the basin until the thickness of sediment reached 6000 meters (Bemmelen, 1949).

Based on The Sarolangun Sheet Regional Geological Map, issued by the Center for Geological Research and Development scale 1 : 250,000 (Nana Suwarna et al., 1992), the IUP area of production operations PT. Triaryani is located in two formations namely Muara Enim Formation and Benakat Water Formation which generally has a northwest -southeast direction. Stratigraphic constituent rocks of this region from old to young.

In open pit mines high rainfall can interfere with mining operations. So a slicing system is needed at the mining site. The way of used to dry or remove water in an area is slicing. While the slicing of the mine is an effort that made to prevent or release water that enters the mine area and disrupt mining activities. Efforts to control water entering mining can affect productivity so it must be done optimally. A place that serves as a water reservoir and a temporary mud shelter that is *sump.* Water that exceeds the mining front can interfere with mining activities, therefore to prevent it needs to be made sump. Most of the water that enters the mine site is rainwater, so currently the mining ignition system plays an over role in the handling of surface water (Haryanto et al., 2019)**.**

In mining activities, especially excavations will result in lower elevations so that water will flood the mining area because water will flow from high elevation to low elevation. Water inundated by excavations will be temporary sump. Therefore, the calculation of runoff water discharge is very important in the manufacture of sump, so that it is optimal so as not to interfere with productivity. Therefore, the author takes a title on rainfall analysis to calculate runoff water discharge in order to optimize the mining flow system at PT. Triaryani Province of South Sumatra. The purpose of this scientific article is to determine the method of calculation of rainfall plans used, calculate the intensity of rainfall and calculate the discharge of runoff water in PT. Triaryani.

2. Method

The needed data is rainfall data for the last 10 years. The data is then processed using dispersion calculations using Ms Excel. Dispersion calculation has done to know the distribution of rainfall data and produce Sx, Cs, Cv, and Ck values which are then matched the values with the conditions on four methods, namely Normal method, Log-Normal method, E.J. Gumbel method and Log Person. From the calculation result, it is obtained that the existing data is eligible from E.J. Gumbel method so that the analysis of rainfall data is done by using that method (Bambang, 2008).

Dispersion calculation can be done by using the following equation:

$$S_x = \sqrt{\frac{\Sigma(x_i - x_r)^2}{n-1}} \quad (1)$$

$$C_s = \frac{S_x}{x_r} \quad (2)$$

$$C_v = \frac{\sqrt{\frac{\sum (x_i - x_r)^2}{n-1}}}{\frac{\sum x}{n}} \tag{3}$$

$$C_k = \frac{\frac{1}{n}\sum (x_i - x_r)^4}{S_x} \tag{4}$$

equation 1 to Eqn. 4 shows the formula to calculate standard deviation (S_x), deviation coefficient (C_s), variation coefficient (C_v), and Kurtosis coefficient (C_k), respectively. Where x_i is data value; x_r is average value; and n is the amount of data.

Furthermore, rainfall data analysis is carried out by E. J. Gumbel method with the following formula shown in Eqn. 5 to Eqn. 9. Equation 5 to 9 used to determine the maximum precipitation average (X), correction of variance (Y_t), average correction (Y_n), Correction of deviation (S_n), and rainfall plan (X_t), respectively.

$$X = \frac{\sum CH}{\sum n} \tag{5}$$

$$Y_t = -\ln\left[-\ln\frac{T-1}{T}\right] \tag{6}$$

$$Y_n = -\ln\left[-\ln\frac{n+1-m}{n+1}\right] \tag{7}$$

$$S_n = \sqrt{\frac{\Sigma (Y_n - Y_N)^2}{n-1}} \tag{8}$$

$$X_t = \frac{X.S}{S_n(Y_t - Y_N)} \tag{9}$$

where $\sum CH$ define total rainfall value (mm); $\sum n$ for Number of records; T for Re-period of rain; m for sort number of data; Y_N for average value of Y_n; S for standard deviation (mm/day).

Rainfall intensity is the volume of rain per unit of time during the period of rain (tc). In calculating the intensity of precipitation first performed calculations to find out the tc value by using the formula of The California Divisions of Highway Formula (Eqn. 10).

$$tc = \left(\frac{0.87 \times L^3}{H}\right)^{0.385} \tag{10}$$

where tc is Length of rain time (hours); L is flat distance from highest elevation to lowest point (m); and H is height difference (m).

By using the calculation equation known long rain time of 204.13552 hours. This value then used in the calculation of rainfall intensity. Rainfall intensity is calculated by using the following Mononobe formula (Eqn. 11).

$$I = \frac{R24}{3}\left(\frac{24}{T}\right)^{\frac{2}{3}} \tag{11}$$

where I is rainfall intensity (mm/h); T is Length of time to rain (hours); R24 is maximum rainfall (mm). Next is the determination of Catchment Area. The area of a surface that in the event of rain then rainwater will flow to a lower area and to the point of flow is catchment area (Zanni et al., 2019).

The area of catchment area is determined by using Minescape 5.7 software based on topographic maps. Runoff coefficient is important in the calculation of runoff water discharge. Runoff coefficients have different values according to slope and land type. At PT. Triaryani land type is mine land with a coefficient value of 0.9 centipedes.

After obtaining the value of rainfall intensity, coefficient of runoff and area catchment area, the calculation of runoff water discharge is calculated. Part of the rain that fall to the surface of the ground, the lake, to the sea is runoff water.

According to (Adnyano & Bagaskoro, 2020), runoff water discharge is the amount of water that can be accommodated in units of time. Discharge of runoff water that enters and accommodate in the sump is influenced by the magnitude of the catchment area runoff coefficient, rainfall intensity and catchment area. Runoff water discharge is calculated using Eqn. 12.

$$Q = C \times I \times A \tag{12}$$

Where Q is debit plan (m^3/s); C is coefficient of runoff; I is intensity rain plan (mm/s); and A is catchment area (m^2).

3. Results and Discussion

3.1. Rainfall Analysis

Rainfall data used for rainfall data analysis is rainfall data from 2011 to 2020. The 10-year rainfall data is then dispersed to be able to know the existing rainfall data can be analyzed using Normal theory, Log-Normal theory, E.J. Gumbel theory or Log Person iii theory. These four theories have several conditions. From the rainfall data in PT Triaryani the eligible conditions are from the theory of E.J. Gumbel (table 2), so that the rainfall data is then analyzed using the formula E. J. Gumbel (Table 3). The maximum rainfall data from each month is used to search for rainfall plans using the formula E. J. Gumbel (Bambang, 2008). The results of dispersion calculation can be seen in table 1.

Table 1. Dispersion Measurement Results

Dispersion Measurement Results			
No	Missing	Dispersion Results	
		Parameter Statisik	Logarithmic Parameters
1	Sx	165.34459	0.39844
2	Cv	0.64061	0.17407
3	Cs	0.91893	-1.95022
4	Ck	4.47596	5.86099

Table 2. Matching Results for Each Method

Selection of Distribution Types from Statistical Parameters				
No	Method	Condition	Result	Information
1	Normal	Cs ≈ 0 Ck ~ 3	Cs = 0.91 Ck = 4.48	Underfilled
2	Log Normal	Cv ~ 0.06 Cs ~ 3Cv + Cv² = 0.204	Cv = 0.64 Cs = 0.91	Underfilled
3	E.J. Gumbel	Cs ≤ 1.14 Ck ≤ 5.40	Cs = 0.91 Ck = 4.48	Meet
4	Log Pearson III	Cs ≠ 0 Cv ~ 0.3	Cs = 0.91 Cv = 0.64	Underfilled

The dispersion results conducted in the last 10 years rainfall data resulted in standard deviation values (Sx), variation coefficients (Cv), deviation coefficients (Cs) and kurtosis coefficients (Ck) and have qualified from the E. J. Gumbel method. If the calculation of dispersion based on statistical parameters has not been met the results of the four conditions then further dispersion calculation can be done based on logarithmic parameters. The data used in this article after the dispersion calculation based on 5 statistical parameters has been qualified from one of the methods, so there is no need for dispersion calculation based on logarithmic parameters.

The Mononobe formula used for the calculation of rainfall intensity can be seen in table 3 and table 4. In the Decree of the Minister of Energy and Mineral Resources of the Republic of Indonesia No. 1827 K/30/MEM/2018 the calculation of this intensity uses a 5-year rain reset period but in this case using a 2-year rain anniversary period, this is because the progress of the mine will change every year, and do not use the 1-year rain anniversary period because if using the 1-year rain anniversary period then the hydrological risk that will occur will be greater, therefore the rainy reset period used is the 2-year rains period.

Table 3. Concentration Time Calculation

CONCENTRATION TIME (Tc)				
Location	**Flat Distance (m)**	**Flat Distance (km)**	**Flat Distance^3**	**High Elevation (m)**
lake	418.94	0.418938	73527409.49	80.00
location	Low Elevation (m)	Height Difference (m)	Ordinances	TC
lake	16.00	64.00	0.87	204.13552

Table 4. Rainfall Intensity

RAINFALL INTENSITY (Mononobe Equation)				
Location	TC	Rain Intensity (mm/h)		
	Hours	t = 2 Yrs	t = 5 Yrs	t = 10 Yrs
like	204.13552	5.50	7.18	8.30

3.2. Runoff Coefficient

The number that shows between the ratio of the magnitude of surface runoff to the intensity of rainfall that occurs in each catchment area is the coefficient of runoff. Determination of the coefficient of runoff is based on the absence of vegetation, soil type, density of vegetation, slope slope, and land use. The coefficient of runoff of each region differs depending on the land use of the area and other factors that can affect the coefficient value in each region. The value of the runoff coefficient affects the result of the calculation of runoff water discharge entering the area, so in determining the value of the runoff coefficient must be in accordance with the conditions of the area.

Determination of runoff coefficient values can be seen in the table of runoff coefficient values according to Rudy, S. (1993) (table 5). Runoff coefficients have different values according to slope and land type. At PIT Rajawali obtained a rain catchment area with a coefficient of steep runoff with a slope of >15%. Land type 1 is mine area land with a runoff coefficient of 0.9. From the coefficient of runoff can take into account the discharge of runoff water in the Eagle Pit.

3.3. Rain Catchment Area

The calculation of runoff water discharge takes into account the area of catchment area. Catchment area is a rain catchment area whose area boundary is determined from the highest elevation points based on the topographic map of the area so that it is polygon-shaped. Determine the catchment limit of this area based on the nature of water that flows from the highest elevation to the lowest elevation. Any discharge of rain caught is expected to be concentrated at the lowest elevation of the catchment area due to catchment area restrictions. The topography of the rain catchment area is the basis of determining the area of rain catchment area (Rosadi, 2016).

Rain catchment areas are very influential in determining the discharge of runoff water that enters the mine area. The rain catchment area is the surface area that in the event of rain, the rainwater (runoff water) will flow to the lower area to the point of multiplierran (Zanni et al., 2019).

At PT Triaryani the catchment area in 2021 is very wide (Figure 1. (a)) amounting to 986,100 $m^{2,}$ thus causing the discharge of runoff water into the mine area is also greater, reaching 117,205.81 m^3/day. This resulted in the sump dimension needed to be able to accommodate the discharge of runoff water is also getting bigger and requires a high *cost.* Therefore, in this activity the author sketches an open channel (Figure 1. (b)) that follows the design of the existing open channel on the

RL 50. This has done to reduce the catchment area to 538,600 m^2 (Figure 1. (c)), so that the discharge of runoff water entering the pitwill be less or reduced to 64,016.88 m^3/day (Figure 1. (d)). The area of catchment area in this internship is determined using Minescape 5.7 software. Catchment area at Pit Rajawali PT Triaryani has an area of 538,600 m^2.

Table 5. Runoff Coefficient Value

RUNOFF COEFFICIENT (C)		
Slope of Land	**Land Type Cover**	**C**
< 3 % (flat)	paddy field, swamp	0.2
	forests, plantations	0.3
	Housing	0.4
3 % - 15 % (medium)	forests, plantations	0.4
	Housing	0.5
	bushes are quite rare	0.6
	open land	0.7
> 15 % (steep)	forest	0.6
	Housing	0.7
	bushes are quite rare	0.8
	open land of the mining area	0.9

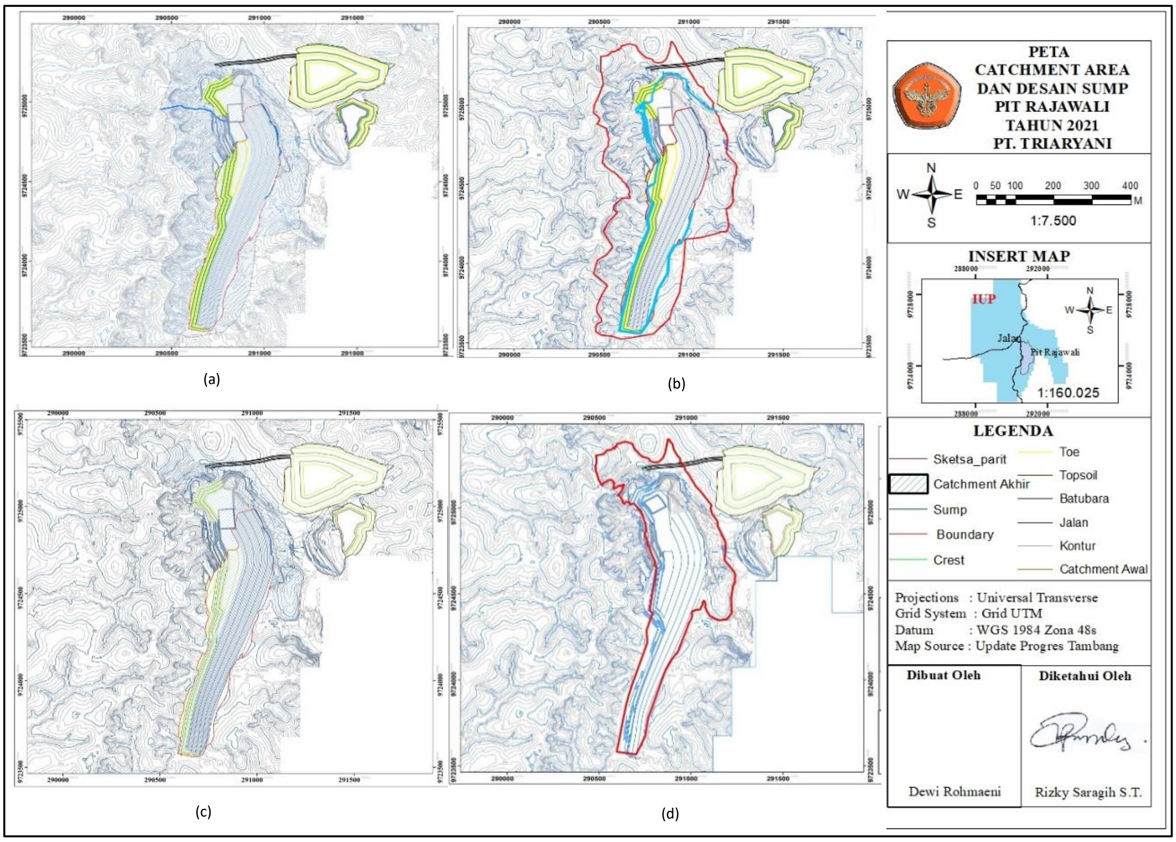

Fig. 1. (a). Catchment area beginning, (b). Trench sketch, (C). Catchment final area, (d). Sump design

3.4. Rain Catchment Area

Runoff water is part of the rainfall that falls to the surface of the soil, lakes, to the sea. The flow occurs due to rain falling to the surface is not infiltrated all due to rainfall or slope factors and compactness in the area. The runoff water (overflow) will be discharged or drained outside the mining site or to the nearest river and the sediment sludge (underflow) is disposed of in its entirety.

The areas focused are rainfall, soil, cover, and area of flow area (Haryanto et al., 2019). Discharge of runoff water is calculated to be able to know the amount of water that goes into the mining area. The data used to calculated runoff water discharge is C = 0.9; A = 538,600 m^2; L = 418.94 m; H = 64 m; R24 = 550,887 mm/day. The calculation of runoff water discharge gives result Q = 64,016.88 m^3/day.

3.5. Rain Catchment Area

Sump is a temporary well that is made to hold runoff water before the water is pumped. The dimensions and shape of runoff water reservoirs are made at least able to accommodate total water within a certain period of time (Alam & Mutia, 2017).

Sump making is used to accommodate runoff water that enters the mining area in the rainy season so that there is no flood. Making sump is also to drain water in temporary sump to main sump so that coal can be mined. Main sump is made at the lowest elevation of the mine (mine base). The design of main sump making onpt Triaryani's pens is made at the lowest elevation on the mining front. Main sump is planned to be made at an elevation of 20 with a depth of 6 m (Figure 1. (d)). Here is table 7 as a sump plan.

Table 6. Sump Dimension Plan

CATCHMENT AREA		AS TOTAL
Depth (A)		6
Angle Of Repose (°)		45
Sump Dimensions	(B) $x = \frac{(2 \,.\, depth^2)}{Tan\,(Angle\ Of\ Repose)}$	72
	(C) $x = \left(\frac{2\,.\,A}{Tan\ 45}\right) \times\ (0.5\ .\ A)\ - Qt$	-63966.12088
	Base Length (m) $x = \frac{-b \pm \sqrt{b - 4ac}}{2a}$	97.3
	Surface Length (m) x = 2 (A) + Base Length	109.3
Volume (m3)		64185.12

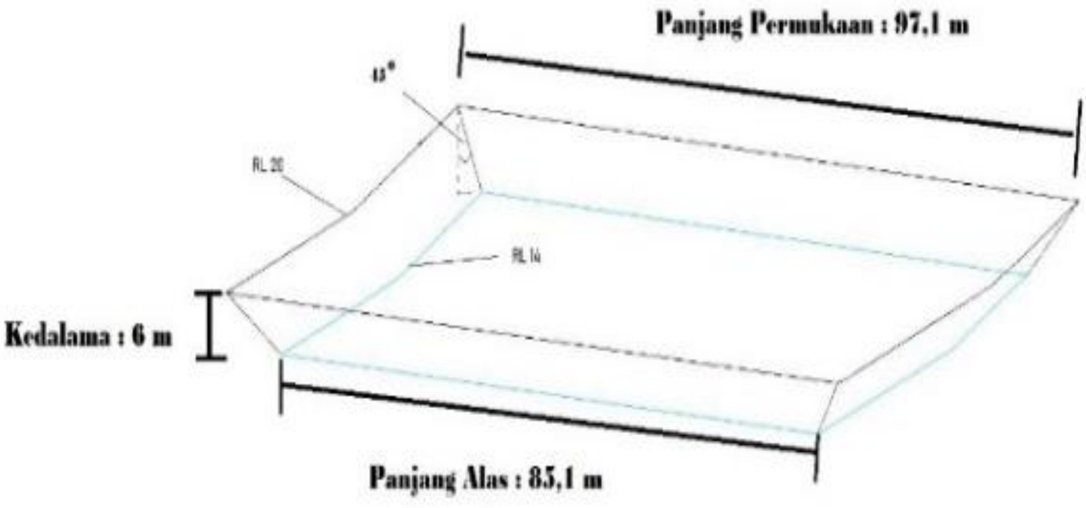

Figure 2. Sump dimensions

Making sump needs to calculate the discharge of runoff water to know the water enters the mine area so that there is no flooding in the mine. The calculation of runoff water discharge takes into account the coefficient of runoff, rainfall intensity and area of catchment area. The coefficient of runoff used in the calculation is that the mining area and bush area are rather rare. Rainfall intensity is obtained from the rainfall data of the 10th year plan. The area of catchment area is obtained from the topographic map that the water will flow from low elevation to high elevation. Figure 2, shows the dimensions of the sump.

4. Conclusion

The conclusion of this article is in determining the method of calculation of rainfall plan used by dispersion, from the results of the dispersion obtained Sx, Cv, Cx and Ck values meet the terms of the E.J. Gumbel method. So the method used in the analysis of rainfall data plan is using E.J. Gumbel method. After the analysis of rainfall data then it is done the calculation of rainfall intensity using the formula Monorobe and obtained an intensity value of 5.50 mm / h using a period of 2 years of rain. So the debit obtained from the data is 64,016.88 m3 /day. Sump design obtained according to the analysis of rainfall data 10 years, with a volume of 64.185.12 m^3 then the surface length *sump* 109.3 m and the length of the base 97.3 m with a depth of 6 m. To continue this research in the manufacture of sump should be done calculation of groundwater discharge, and also pump calculation to be more precise.

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References

Adnyano, A. . I. A., & Bagaskoro, M. (2020). Technical Study Of Mine Dewatering System In Coal Mining. *Promine*, *8*(1), 28–33.

Alam, P. N., & Mutia, F. (2017). Evaluasi Teknis Sistem Penyaliran Tambang, Studi Kasus: PT. Bara Energi Lestari Kabupaten Nagan Raya, Aceh. *Jurnal Ilmiah Mahasiswa Teknik Kebumian*, *1*(1), 30–37.

Bambang, T. (2008). Hidrologi terapan. *Beta Offset, Yogyakarta*, *59*, 50.

Bemmelen, R.W. van. (1949). *The Geology of Indonesia*. vol. IA, Martinus Nijhoff, Leiden: The Hague.

Decree of the Minister of Energy and Mineral Resources of the Republic of Indonesia No. 1827 K/30/MEM/2018 concerning Guidelines for the Implementation of Good Mining Engineering Rules.

Haryanto, S. E., Budiarto, B., Sari, A. S., & Widiatmoko, F. R. (2019). No TKajian Teknis Sistem Penyaliran Tambang Dan Rancangan Sumuran Pada Pit Majapahit PT. Prolindo Cipta Nusantara, Kabupaten Tanah Bumbu, Kalimantan Selatanitle. *Prosiding Seminar Nasional Sains Dan Teknologi Terapan*, 539–544.

Rosadi, P. E. (2016). Kajian Teknis Sistem Penyaliran pada Tambang Batubara PIT 1 Utara Banko Barat PT. Bukit Asam (Persero) Tbk. Tanjung Enim Sumatera Selatan. *ReTII*.

Rudy, S., (1993). Introduction to Mine Mining. Bandung: Bandung Institute of Technology.

Suwarna, N. et al. (1992), *Geological Map of Sarolangun Sheet, map scale 1: 250,000*. Center for Geological Research and Development, Bandung.

Zanni, A., Ashari, Y., & Guntoro, D. (2019). *Pencegahan dan Penanggulangan Air Limpasan yang Masuk ke Kolam Blok Barat terhadap Pit Blok Timur Penambangan Batubara PT. Indoasia Cemerlang (PT. IAC* . 159–167.