



## Comparative Analysis of Actual Conditions and Results of Technical Calculations Using Gumbell Method in Mine Dewatering System: A Case Study on Calculation of Rainfall and Runoff Water Discharge

**Wahyu Yudha Pangestu\***  
Departement of Mining Engineering,  
Institut Teknologi Nasional Yogyakarta,  
INDONESIA

**A.A Inung Arie Adnyano**  
Departement of Mining Engineering,  
Institut Teknologi Nasional Yogyakarta,  
INDONESIA

**Novandri Kusuma Wardana**  
Departement of Mining Engineering,  
Institut Teknologi Nasional Yogyakarta,  
INDONESIA

\*Correspondence: E-mail: [710018256@students.itny.ac.id](mailto:710018256@students.itny.ac.id)

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### Abstract

This research was conducted at PT. Antareja Mahada Makmur on the mining concession owned by PT. Multi Harapan Utama which is located in Sungai Payang Village, Loa Kulu District, Kutai Kartanegara Regency, East Kalimantan Province. The rainfall data used is for 10 years (2012-2021) which comes from the Dewatering Mining Engineering Department. Data analysis was performed by statistically calculating rainfall data using the Gumbell method to obtain the planned rainfall value. Then the calculation of runoff water discharge is carried out to analyze the existing mine drainage system by comparing the actual conditions and the results of technical calculations. Based on the results of the research for rainfall data for 2012 – 2021, Gumbell's calculations plan to collect rainfall of 94.23 mm/day, rainfall intensity of 14.74 mm/hour with a return period of 5 years and a hydrological risk of 89.26%. The total for the Gumbell method runoff discharge is obtained for runoff water entering the Sump 90 Besar of 2.19 m<sup>3</sup>/second, runoff water entering the Sump 90 Lorong of 3.03 m<sup>3</sup>/second, and for water discharge runoff that goes into Sump 100 is 3.68 m<sup>3</sup>/second. The three open channels in the form of trapezoids and culverts have met the theoretical calculation dimensions, with dimensions that are still able to accommodate and drain runoff water discharge. For three dimensions of the actual sump that is currently smaller than the theoretical calculation of the well volume, the sump capacity calculation obtained a recommended sump volume of 47,045 m<sup>3</sup> for a 100 sump, for a sump 90 lorong of 43,012 m<sup>3</sup>, and for a sump 90 besar of 40,635 m<sup>3</sup>, with recommended dimension improvements. The operating speed of the pump needs to be increased for the Multiflow MF - 420 pump on a sump 90 lorong from 1159 m<sup>3</sup>/hour to 1224 m<sup>3</sup>/hour with an efficiency of 65%, Multiflow MF - 420 pump on a sump 90 besar from 1123 m<sup>3</sup>/hour to 1269 m<sup>3</sup>/hour with an efficiency of 70 %, for the Multiflow MF - 420 pump at sump 100 from 1282 m<sup>3</sup>/hour to 1584 m<sup>3</sup>/hour with an efficiency of 65%.

**Keywords:** rainfall; open hannels; sump; pump; gumbell method

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## INTRODUCTION

PT. Antareja Mahada Makmur (AMM) is a national private contractor company engaged in coal mining, and has experience in mining activities at various coal mining companies, both IUP and PKP2B (Coal Mining Concession Work Agreement) holders. PT. Antareja Mahada Makmur (AMM) is located in Sungai Payang Village, Loa Kulu District, Kutai Kartanegara Regency, East Kalimantan

Province (PT Antareja Mahada Makmur., 2022). Mining activities are carried out using an open pit mining system (surface mining) with the open pit method (Adnyano et al., 2022).

In the process of coal mining activities, there are several things that become inhibiting factors, one of which is water. Water is a big problem in mining work, both directly and indirectly can affect productivity (Craig, R.F. 1991). Water can directly stop all mining activities, for example when it rains very heavily the water that enters the mining front will stagnate on the bottom of the mine (pit bottom), this will disrupt the process of excavation, loading and transportation. During the digging process, water causes the backhoe heavy equipment to work harder so that it affects the effectiveness of the heavy equipment to decrease causing the loading process to the dump truck conveyance to be disrupted (Kapugu et al., 2022). In the process of transporting water, the mine road becomes waterlogged and makes the mine road slippery, making it difficult for the conveyance to maneuver and climb the incline. Indirectly, water affects the working conditions, affects the minerals, and affects the stability of the mine slopes. Therefore, a good mine dewatering system is needed in mining companies, such as PT. Antareja Mahada Makmur Job Site PT. Multi Harapan Utama.

The mine dewatering system is a series of work units of tools/parts in the drainage system intended to control water in the mine. The process of removing water that has entered the mine is usually carried out using a drainage, sump and pump system (Wang et al., 2021). It is hoped that the water that enters the mining front can be accommodated by a sump so as not to hinder the progress of the mine. The available sump must have a sufficient volume size to accommodate the total incoming water discharge (Kamiana., 2011). Currently, the sump at PT. Antareja Mahada Makmur Job Site PT. Multi Harapan Utama has a volume that does not match the total debit of water entering the mining site. The sump is not enough to accommodate the amount of water that enters so that the water overflows in the sump. Therefore, it is necessary to study the mine drainage system technically regarding mine dewatering of coal mines in open pit mines at PT. Antareja Mahada Makmur Jobsite PT. Multi Harapan Utama.

## METHOD

In carrying out this research, it was carried out by combining theory and field data. The research method used is: this literature study can be searched through reference books, scientific journals, company activity reports, etc. Field research is direct observation of the problem to be studied, related to topography and geological conditions, the mining system used, as well as the area or land to be made as a mine opening area (Wu et al., 2013). Data Retrieval There are two data used, the first is primary data, namely data collected by making direct observations in the field, and the data obtained includes: the drainage method used, the dimensions of the open channel (ditch), the dimensions of the sump, the length pipe, pipe diameter, type of pump, number of pumps in the field, HDPE (High Density Polyethylene) pipe discharge. Furthermore, secondary data for data collected is based on references obtained by the company such as: rainfall data for 2010 – 2021 in Loa Kulu District, mine drainage map data, location map of the area of delivery, map layout of the research area location, topographic map of the research area, progress map mine PT. Antareja Mahada Makmur, pump and pipe specifications. Data processing is done by processing the data - the data obtained is grouped, processed and analyzed using mathematical formulas, then presented in the form of tables, graphs, pictures and settlement calculations. the data obtained and re-evaluating to ascertain whether the data obtained is related and necessary to the topic of discussion. Data processing was carried out using the software Geovia Surpac 6.6.2, Autocad 2021, Civil 3D, Minescape 5.7 and Microsoft Excel.

### 1. Data Analysis

The data that has been obtained later and analyzed based on the literature related to the problem, are as follows:

#### a. Calculating rainfall data using the Gumbel method and rain intensity using the Mononobe equation. By utilizing the maximum annual rainfall data sample.

The rainfall data used is for 10 years from 2012 – 2021. This data can be processed using the *Gumbell* method, which is a method based on the normal distribution (extreme price distribution) (Gumbel, E.J., 1941). The Gumbel distribution can be written:

$$X_t = \bar{X} + K \cdot S \quad (1)$$

Where, the K value or frequency factor can be calculated with the following equation:

$$K = \frac{Y_t - Y_n}{S_n} \quad (2)$$

Information :

$X_t$  = Rainfall Prediction

$\bar{X}$  = Average Maximum Rainfall during the year of observation

$S$  = *Standar Deviasi* (Can be seen in Equation 1)

$K$  = Frequency Factor

$S_n$  = *Reduced Standar Deviation*

$Y_t$  = *Reduced Variate*

$Y_n$  = *Reduced Mean*

In determining the intensity of rainfall, it can be searched using the *Mononobe* formula (Gautama, 2019).

$$I = \frac{R_{24}}{24} \cdot \left(\frac{24}{t}\right)^{\frac{2}{3}} \quad (3)$$

Information :

$I$  = Rainfall intensity (mm/hour)

$t$  = Length of time it rains or constant time (hours)

$R_{24}$  = Maximum rainfall (24 hours)

**b. Calculating the total debit of incoming water, which comes from runoff discharge plus the total rainwater entering the front area of the mining work area.**

To estimate runoff water discharge, the Rational formula can be used. The amount of runoff water is the amount of rainfall minus the amount of absorption (infiltration) and evaporation (Gautama, 2019):

$$Q = 0,278 \times C \times I \times A \quad (4)$$

Information :

$Q$  = maximum runoff water discharge (m<sup>3</sup>/hour)

$C$  = runoff coefficient

$I$  = Rainfall intensity (mm/hour)

$A$  = Rain catchment area (km<sup>2</sup>)

**c. Calculating the discharge of runoff water and determining the open channel geometry (ditch) that can be used in the mining work area.**

In the drainage system itself, there are several forms of drainage sections that can be used. The cross-sectional shapes of the drainage include rectangular, triangular and trapezoidal shapes (Kapugu et al., 2022). Calculating the discharge of runoff water and determining the open channel geometry (ditch) that can be used in the mining work area.

$$Q = \frac{1}{n} \times S^{1/2} \times R^{2/3} \times A \quad (5)$$

Information :

$Q$  = Debit (m<sup>3</sup>/second)

$R$  = Hydraulic radius (meter)

$S$  = Slope of the channel (%)

$A$  = Wet cross-sectional area (m<sup>2</sup>)

$n$  = Manning hardness coefficient

**d. Find out how much water discharge can be pumped based on the existing pump specifications.**

To flow liquid or fluid from one place to another, the pump must overcome a certain amount of head. The total pump head is determined from the pump and pipe installation conditions (Julianto, A., 2014). The results of the total pump head analysis are used in determining pump capacity (Gautama, 2019):

$$h_s = h_2 - h_1 \quad (6)$$

$$h_{id} = \lambda \left( \frac{L_{keluar} \times (v^2)}{2 \times D \times g} \right) \quad (7)$$

$$h_{is} = \lambda \left( \frac{L_{keluar} \times (v^2)}{2 \times D \times g} \right) \quad (8)$$

$$h_{f2} = f v \left\{ \frac{v^2}{2g} \right\} \quad (9)$$

$$h_v = \frac{v^2}{2(g)} \quad (10)$$

$$h_{f1} = K \left[ \frac{v^2}{2g} \right] \quad (11)$$

$$K = \left[ 0,031 + 1,847 \left( \frac{d}{2R} \right)^{3,5} \right] \times \left( \frac{\theta}{90} \right)^{0,5} \quad (12)$$

$$R = \frac{D}{\tan \frac{1}{2} \theta} \quad (13)$$

The total pump head formula can be written as follows :

$$H_t = h_s + h_v + h_{id} + h_{is} + h_{f2} + h_v + h_{f1} \quad (14)$$

Information :

$H_t$  = Total pump head (meter)

$h_s$  = Pump static head (meter)

$h_f$  = Head exit pipe friction loss (meter)

$h_{is}$  = Head suction pipe friction loss (meter)

$h_{f2}$  = Head velocity loss in inlet pipe valve (meter)

$h_v$  = Velocity head in the exit pipe (Velocity Head)

$h_{f1}$  = Head Loss of pipe bend (m)

$h_1$  = Inlet Pipe Elevation

$h_2$  = Outlet Pipe Elevation

$L_{exit}$  = Pipe Length(meter)

$v$  = Flow velocity in the pipe (m/sec)

$Q$  = Pump flow rate (m<sup>3</sup>/second)

$D$  = Pipe diameter (meter)

$g$  = gravitational force (9,8 m/s<sup>2</sup>)

$\lambda$  = Coefficient of pipe friction

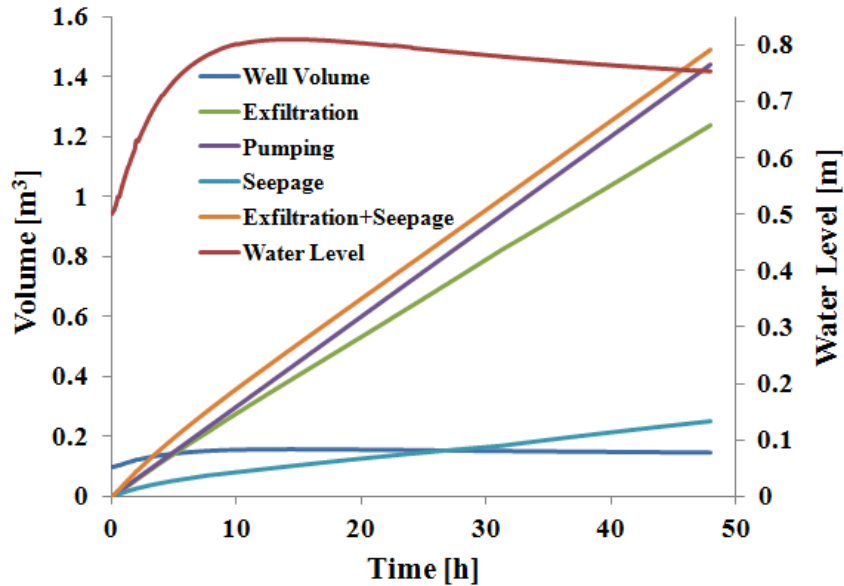
$R$  = radius of bend (meter)

$$R = \frac{D}{\tan \frac{1}{2} \theta}$$

$K$  = Coefficient of loss on the turn

**e. Calculate the dimensions of the sump based on the volume of incoming water per day.**

In planning the volume of the well is determined by combining the graph of rain intensity calculated by the *Mononobe* theory versus time, and the graph of pumping discharge versus time, as shown in (Figure 1) is the graph of determining the volume of the well.



**Figure 1.** Graph of Determination of Sumps (Gautama, 1999)

In The sump at the mine functions as a temporary storage area for water and mud before being pumped out of the mine. To determine the dimensions of the sump based on the sump volume capacity to be used, (Gautama, 2019). equation is used:

$$V = (\text{Top Area} + \text{Bottom Area}) \frac{1}{2} \times T \quad (15)$$

Information :

$$V = \text{Volume (m}^3\text{)}$$

$$T = \text{Height (m)}$$

**2. Conclusions and recommendations**

Collection and results of data calculations that have been analyzed and then provide recommendations for the company.

**RESULTS AND DISCUSSION**

**Rainfall**

The rainfall data used is for 10 years from 2012 – 2021 which comes from the Technical Department of PT. Antareja Mahada Makmur. The rainfall data is calculated based on the maximum monthly rainfall data for a 5 year period taken from January 2012 to December 2021 which was obtained from the company's secondary data. The maximum daily rainfall data used is presented in tabular form. It can be seen that the data can be seen in **Table 1**.

**Table 1.** Maximum Rainfall Data 2012 – 2021

Year	Maximum Rainfall (mm)
2012	43,7
2013	124,7
2014	79,1

2015	48,4
2016	40,7
2017	70,3
2018	51,6
2019	40,3
2020	74
2021	94
Amount	666,8
Average	66,68

Source : Data of this study

The rainfall data obtained is monthly rainfall data obtained from 2012 to 2021. The planned rainfall is calculated using the Gumbell method. Based on the results of the calculation of the planned daily rainfall of 94.23 mm/day, with a 5 year return period of rain and a hydrological risk of 89.26%.

Rainfall intensity is calculated using the *Mononobe* formula (Equation 3). The t (rain duration) value obtained from the average rain duration for 2010-2021 is 3 hours. After processing the data, it was found that the rainfall intensity was 14.74 mm/hour.

$$I = \frac{94,23}{24} \times \left(\frac{24}{3}\right)^{2/3}$$

$$= 14,74 \text{ mm/hour}$$

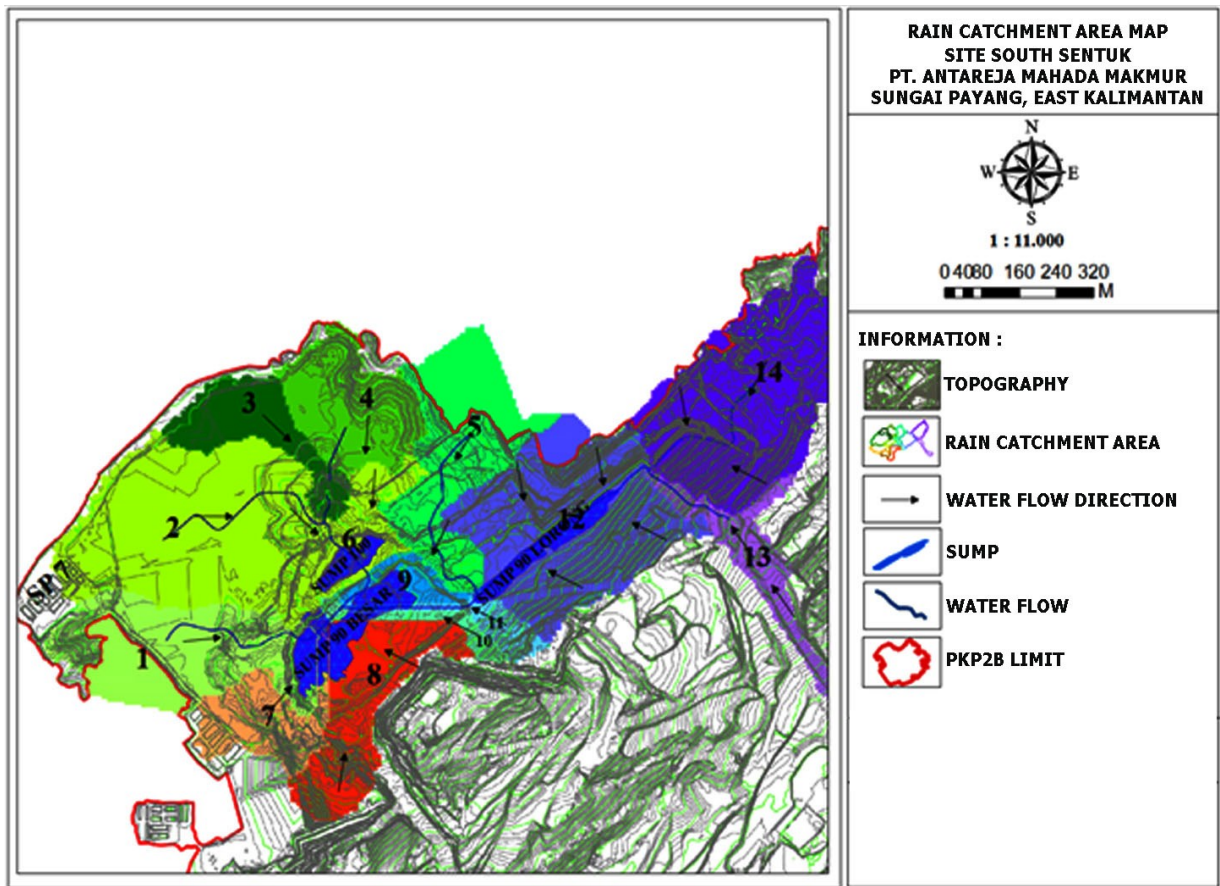


Figure 2. Topographic Rain Catchment Area Map

The catchment area is an area or catchment area where the boundaries of the catchment area are determined from the highest elevation points so that in the end it is a closed polygon whose pattern is adapted to topographical conditions, by following the trend of the direction of water movement (Prematuri et al., 2020). The catchment area (DTH) or catchment area as

(Sosrodarsono,1993) is an area where the boundaries of the catchment area are determined from the highest elevation points so that it ends up being a closed polygon, in which the pattern is adapted to topographical conditions by following the direction of water flow. and for the image of the map determining the boundaries of the catchment area can be seen in the **Figure 2**. The area of the catchment area is 2.44 km<sup>2</sup> which is divided into 14 DTH (**Table 2**). Runoff water originating from the rain catchment area will flow from the highest elevation into open channels, sumps and settling ponds which will then flow into the river.

Runoff water discharge is calculated using the rational formula. The runoff water debit used is for the 5-year rain return period. The parameters for calculating runoff water discharge are the runoff coefficient, the area of the rain catchment area, and the intensity of the rainfall. The amount of runoff water discharge from each catchment area at the Sentuk Pit Site is divided into fourteen catchment areas and can be seen in **Table 2**.

**Table 2.** Rain Catchment Area

Area DTH	DTH	C	Wide DTH (km <sup>2</sup> )	Rainfall Intensity (mm/hour)	Runoff Water Discharge (m <sup>3</sup> /second)	Runoff Water Discharge (m <sup>3</sup> /hour)
DTH SUMP 90 Besar	1	0,6	0,271	14,74	0,66	2363,96
	7	0,8	0,106	14,74	0,34	1231,19
	8	1	0,177	14,74	0,71	2566,92
	9	1	0,049	14,74	0,20	718,32
	10	0,8	0,030	14,74	0,10	354,10
	11	0,8	0,046	14,74	0,15	536,97
DTH SUMP 100	2	0,8	0,384	14,74	1,24	4469,33
	3	0,8	0,110	14,74	0,36	1280,11
	4	0,8	0,161	14,74	0,52	1874,16
	5	1	0,229	14,74	0,92	3324,04
	6	1	0,145	14,74	0,59	2113,76
DTH SUMP 90 Lorong	12	1	0,371	14,74	1,50	5398,84
	13	1	0,016	14,74	0,07	237,73
	14	1	0,353	14,74	1,43	5130,94

**Source :** Data of this study

### Open Channel Debit

CO exposure intake in the air is calculated in real-time. Realtime exposure intake aims to describe the amount of exposure that has been received by respondents from the beginning of being a parking attendant until the time the research was carried out. The magnitude of the intake value is directly proportional to the concentration of contaminants, the rate of intake, the duration of exposure, the exposure frequency, and the duration of exposure, which means that the greater the value, the greater the intake received by the individual (Soewarno., 1995). While the value of intake is inversely proportional to the value of body weight and the average time period, meaning that the greater the weight ate, the smaller the health risk (R. J. Lad and J. S. Samant, 2015).

The existing open channel dimensions include the width of the channel bottom, channel height, and the width of the top surface. In observations around the open channel when it rains, the high air in the open channel almost reaches the height of the open channel so that it is necessary to recalculate and recommend the dimensions of the open channel so that the mine drainage system can run properly and not interfere with coal hauling activities (Asdak., 2004). The open channel recommendation is intended to provide advice to the company to change the size of the existing open channel to an open channel that has been obtained from the calculations, so that the open channel can function optimally and air runoff will not overflow. Comparison of the actual dimensions of the open channel with the results of technical calculations can be seen in **Table 3**.

**Table 3.** Comparison of Actual Dimensions of Open Channel with Calculation Results

Dimensions	Open Channel Dimensional Capacity 1		Open Channel Dimensional Capacity 2		Open Channel Dimensional Capacity 3	
	Calculation Dimension (m)	Actual Dimension (m)	Calculation Dimension (m)	Actual Dimension (m)	Calculation Dimension (m)	Actual Dimension (m)
Wet Section Depth ( <i>h</i> )	0,52 m	0,60 m	0,36 m	0,55 m	0,27 m	0,37 m
Wet Channel Base ( <i>B</i> )	0,60 m	0,80 m	0,42 m	0,50 m	0,32 m	0,43 m
Channel Depth ( <i>d</i> )	0,65 m	0,78 m	0,45 m	0,69 m	0,34 m	0,57 m
Open Channel Width ( <i>b</i> )	1,34 m	1,64 m	0,94 m	1,20 m	0,71 m	1,20 m
The Length Of The Slanted Side Of The Channel ( <i>a</i> )	0,75 m	0,80 m	0,52 m	0,60 m	0,32 m	40
Information	Accommodated		Accommodated		Accommodated	

**Source :** Data of this study

The dimensions do not need to be changed because the actual dimensions are larger than the technical calculations, so that the actual open channels are able to cope. For the problems that exist in the field, namely the presence of steeping of open channels caused by the spoil of the mine road resulting from the laying on the road of the mine by dozers and motor graders which results in the emergence of sewers and steeping in open channels of course this can cause water in open channels to overflow. So that on open channels there is a need for periodic maintenance and repairs on open channels, namely by widening the bottom of the channel, and re-digging the depth of the channel to maintain the dimensions of the channel (Powers et al., 1992).

### Dimensions of The Well (Sump)

As for the estimated sump volume that can accommodate the total volume that enters without pumping activities, it is calculated in accordance with the SOP of PT. Antareja Mahada Makmur, referring to Minister of Energy and Mineral Resources Decree 1827K/30/MEM/2018, believes that the sump construction has a minimum capacity of 1.25 times the volume of mine water during the highest rainfall for 84 hours. The working hours of the pump for one day is 18 hours. To overcome the overflow of mine runoff water, the volume is due to the calculation results showing that the actual volume of the actual existing wells is currently smaller than the volume of the theoretical calculation wells so it is necessary to make changes to each volume (Wolley., 2009). The wells in the mining work area, for sump dimensions and sump recommendations can be seen in **table 4**, these wells or sumps are planned to be in the form of a trapezium using the Trial and Error method to get the size of the sump volume which can be seen in **Table 4**.

**Table 4.** Recommendation Sump Dimension Calculation

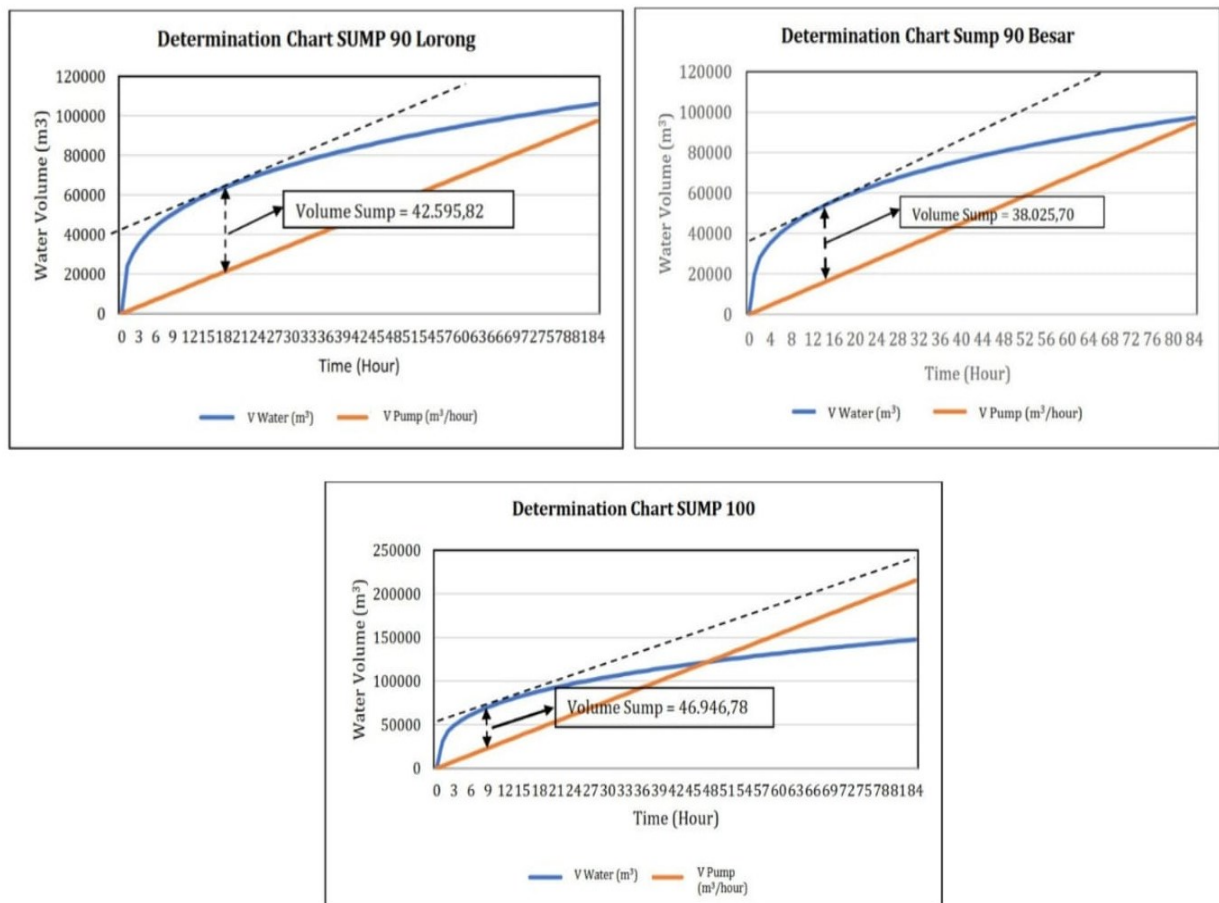
Dimensions	Sump Dimension Capacity 90	Sump Dimension Capacity 100	Sump Dimension Capacity 90
	Calculation Dimension (m)	Calculation Dimension (m)	Calculation Dimension (m)
Sump surface length ( <i>a</i> )	99 m	103 m	98m
Sump surface width ( <i>d</i> )	93 m	97 m	92 m
Sump base length ( <i>b</i> )	87 m	97 m	92 m
Sump base width ( <i>c</i> )	81 m	91 m	86 m
Sump depth ( <i>f</i> )	5 m	5	5

<i>Sump volume</i>	40.635 m <sup>3</sup>	47.045 m <sup>3</sup>	42.767,50 m <sup>3</sup>
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**Source :** Data of this study

Based on calculations and actual in the field, the comparison of sump volume is obtained as follows: The actual volume of the large 90 well (90 large sump) is ± 31,974.71 m<sup>3</sup> and theoretically the recommended large 90 well volume (90 large sump) is ± 40,635 m<sup>3</sup>. Water from the 90 large wells (90 large sump) is runoff water originating from DTH I, DTH VII, DTH VIII, DTH IX, DTH X, DTH XI. The actual conditions at the time of the study for the 90 aisle well volume (90 aisle sump) were ± 42,595.82m<sup>3</sup> and theoretically the recommended 90 aisle well volume (90 aisle sump) was ± 42,767.50 m<sup>3</sup>. The 90 aisle wells (sump 90 lorong) are runoff water originating from DTH XII, DTH XIII, DTH XIV. The actual conditions at the time of the study for the volume of 100 wells (sump 100) were ± 46,946.78 m<sup>3</sup> and theoretically the recommended volume of 100 wells (sump 100) was ± 47,045.00 m<sup>3</sup>. Water from wells 100 (sump 100) is runoff water originating from DTH II, DTH III, DTH IV, DTH V, DTH VI.

For Sump 90 Besar is a type of traveling sump, this sump is made in the mine front area. From the calculation, it is obtained for the recommendation of the volume of wells in the South Sentuk Pit area, the actual volume of the niche is smaller than the calculated volume of the niche so that the niche is unable to accommodate runoff water in the event of rain equal to the maximum planned rainfall. The results of calculating the dimensions of each well/sump in the South Sentuk Pit area can be seen in the **Figure 3**.



**Figure 3.** Graph of Comparison of Runoff Water Volume and Pump Volume at Sump

**Pumping System**

The pump is a tool used to move water in the mine area, be it runoff water that comes from rainwater, groundwater or underground water. In a mine drainage system, a pump is needed to prevent or remove water from entering the mining site (front) (Hilaludin and Joko Santoso., 2008). To flow liquid or fluid from one place to another, the pump must overcome a certain amount of head.

The total head of the pump that must be provided to drain the liquid or fluid as planned can be determined from the condition of the pipe installation to be served by the pump.

In choosing a pump capacity that needs to be known to determine the pump capacity, including the following (Arsyad, K.M., 2017):

### 1. The discharge that the pump can produce

Usually, several alternative pump discharge simulations and several types of pumps are simulated, which are then selected for the pump discharge that produces maximum efficiency.

### 2. Head (julang) total pump

Is the energy that must be provided to drain a certain amount of water as planned. Total pump head includes static pump head, various head losses in pipes, valves (friction loss), turns, joints (shock loss).

### 3. Velocity head

Is the head caused by the velocity of the flowing fluid.

The pumps used in the Seam Pit 90 South Sentuk Site are 3 units. Namely the Multiflo MF 420-EX Pump. The actual pump discharge for Multiflo MF 420-EX is 312 l/s or 1123 m<sup>3</sup>/hour, the actual pump discharge for Multiflo MF 420-EX is 322 l/s or 1159 m<sup>3</sup>/hour, and for the actual pump discharge for Multiflo MF 420-EX Pump of 356 l/s or 1282 m<sup>3</sup>/hour, and for pump operating time of 18 hours/day.

Piping is an important part of the dewatering process. In the piping installation in the pit using HDPE (high density polyethylene) pipes. In accordance with the standards used by PT. Antareja Mahda Makmur said that in the process of dewatering the pipes used to consider the use of HDPE pipes because the head losses due to friction, bends, joints and other pipe accessories in HDPE pipes are smaller than the use of steel pipes (Prastowo et al., 2021). The HDPE pipes used in pump operations are 12 inches and 14 inches in size, with Nominal Pressure type 16 (PN 16) and Standard Dimension Ratio 11 (SDR 11). Based on data obtained from the dewatering engineering department, 1 HDPE pipe has a length of 6 meters. The length of each pipe used based on plotting results in the MineScape 5.7 software can be seen in **Table 5**.

**Table 5.** Overall Pipe Length and Pipe Diameter

Location	Pipe Diameter	Overall Pipe Length
Sump 90 Besar - Settling Pond 7 (SP 7)	14 In	1069 m
Sump 90 Lorong - Sump 100	14 In	470 m
Sump 100 - Settling Pond 7 (SP 7)	14 In	1110 m

**Source :** Data of this study

Then it is necessary to calculate the total head loss or called the total head. After getting the total head, the total head is plotted onto a graph to determine the pump capacity. It is known that the pump specifications have a maximum discharge that can be carried out at 460 l/s and a maximum total rise is 240 m. And for each total head loss for each pit pump in the sump can be seen in the **Table 6**.

**Table 6.** Table of Calculation of Total Head Loss of Multiflo 420-EX Pump in Well/Sump

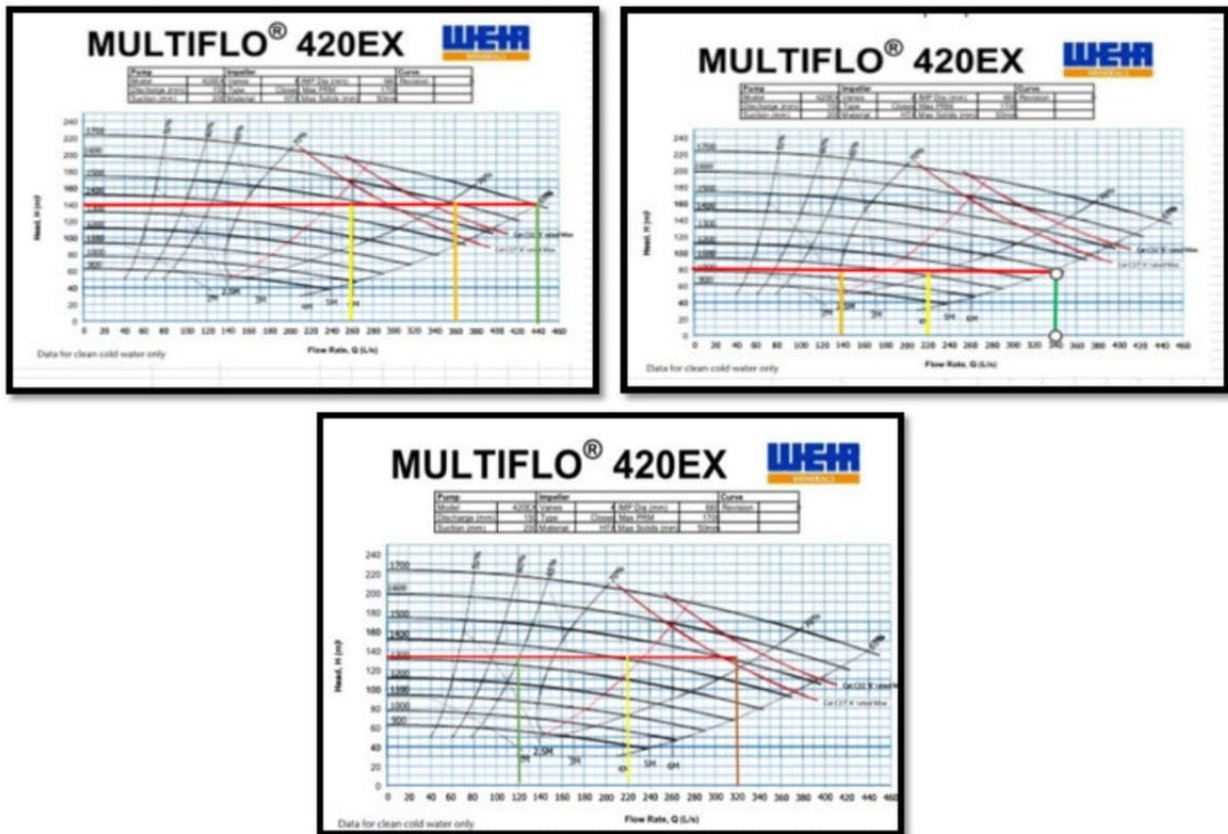
Total Head Pump Formula	Pump Head Multiflo 420-EX on the large Sump 90	Pump Head Multiflo 420-EX on the aisle wells Sump 90	Pump Head Multiflo 420-EX on the Sump 100
Static Head (hs)	52 m	17 m	44 m

Head Outgoing Pipe Friction Loss (hid)	54.16 m	23.19 m	66.95 m
Head Loss of Suction Pipe Friction (his)	2.890 m	0.344 m	3.763 m
Velocity Head Loss in Suction Pipe Valve (hf2)	0.87 m	0.344 m	1.14 m
Velocity Head in the exit pipe (Velocity Head)(hv)	0.5074 m	0.540 m	0.66 m
Pipe Bend Loss Head (hf1)	20.284 m	38.77 m	21.394 m
Head Total Pump	130,711 m	80,784 m	137,903 m

Source : Data of this study

**Recommendations for increasing the operating speed of the Multiflo 420-EX pump on a 90 aisle sump**

From **Figure 4** the graph below, it can be seen the results of the plot on the graph of the characteristics of the MF 420- EX pump, the RPM that can work at a total head of 81 m, namely RPM 1000, RPM 1100 and RPM 1200. At RPM 1000 it produces a flow rate of 504 m<sup>3</sup>/hour = 0.140 m<sup>3</sup>/second = 140 l/second, at RPM 1100 produces a flow rate of 792 m<sup>3</sup>/hour = 0.220 m<sup>3</sup>/second = 220 l/second, and while at RPM 1200 produces a flow rate of 1224 m<sup>3</sup>/hour = 0.340 m<sup>3</sup>/second = 30 l/sec. Using the actual operating speed of 1000 RPM the resulting discharge is 504 m<sup>3</sup>/hour with a pump efficiency of 70%. Based on the calculations, the recommendation for using the operating speed needs to be increased, namely from 1000 RPM to 1200 RPM, so that by increasing the operating speed it is followed by an increase in pump discharge, namely from 792 m<sup>3</sup>/hour to 1224 m<sup>3</sup>/hour with an efficiency of 65%. Recommendations for increasing operating speed can be seen in (**Figure 4**).



**Figure 4.**Graph of Recommendations for Increasing the Operating Speed of the Multiflo 420-EX Pump at Sump

### Recommendations for increasing the operating speed of the Multiflo 420-EX pump on a 90 large sump

From **Figure 4** the graph below, it can be seen the results of the plot on the graph of the characteristics of the MF 420- EX pump, the RPM that can work at a total head of 130 m, namely RPM 1300, RPM 1400 and RPM 1500. At RPM 1300 it produces a flow rate of  $432 \text{ m}^3/\text{hour} = 0.120 \text{ m}^3/\text{second} = 120 \text{ l/second}$ , at RPM 1400 produces a flow rate of  $792 \text{ m}^3/\text{hour} = 0.220 \text{ m}^3/\text{second} = 220 \text{ l/second}$ , while at RPM 1500 produces a flow rate of  $1152 \text{ m}^3/\text{hour} = 0.320 \text{ m}^3/\text{second} = 320 \text{ l/second}$ . Using the actual operating speed of 1300 RPM the resulting discharge is  $432 \text{ m}^3/\text{hour}$  with a pump efficiency of 65%. Based on the calculations, it is necessary to increase the operating speed recommendation, from 1300 RPM to 1500 RPM, so that by increasing the operating speed it is followed by an increase in pump discharge from  $432 \text{ m}^3/\text{hour}$  to  $1152 \text{ m}^3/\text{hour}$  with an efficiency of 70%. Recommendations for increasing operating speed can be seen in (**Figure 4**).

### Recommendations for increasing the operating speed of the Multiflo 420-EX pump on a 100 sump

From **Figure 4** the graph below, it can be seen the results of the plot on the graph of the characteristics of the MF 420- EX pump, the RPM that can work at a total head of 138 m, namely RPM 1500, RPM 1600, and RPM 1700. At RPM 1500 it produces a flow rate of  $936 \text{ m}^3/\text{hour} = 0.260 \text{ m}^3/\text{second} = 260 \text{ l/second}$ , at RPM 1600 produces a flow rate of  $1296 \text{ m}^3/\text{hour} = 0.360 \text{ m}^3/\text{second} = 360 \text{ l/second}$ , and while at RPM 1700 produces a flow rate of  $1584 \text{ m}^3/\text{hour} = 0.440 \text{ m}^3/\text{second} = 440 \text{ l/sec}$ . Using the actual operating speed of 1350 RPM the resulting discharge is  $1282 \text{ m}^3/\text{hour}$  with a pump efficiency of 70%. Based on the calculations, the recommendation for using operating speed needs to be increased, namely from 1350 RPM to 1600 RPM and 1700 RPM. So that by increasing the operating speed, it is followed by an increase in pump discharge from  $1282 \text{ m}^3/\text{hour}$  to  $1296 \text{ m}^3/\text{hour}$  and  $1584 \text{ m}^3/\text{hour}$ . With the same efficiency of 70% and 65%, recommendations for increasing operating speed can be seen in (**Figure 4**).

## CONCLUSION

Based on the results of the research conducted for the method used to determine the planned rainfall value using the Gumbell method, the planned rainfall value is 94.23 mm, the planned rainfall intensity is 14.74 mm/hour. In the research location there are 14 rain catchment areas with a total area of 2.4496 km<sup>2</sup>. The discharge of runoff water that enters the PIT Site Sentuk seam 90 south comes from 14 catchment areas, for the actual dimensions of the sump/wells that accommodate runoff water entering the mining work area, it has not been able to handle the water entering the mining work area, so it needs to be redesigned according to technical calculations. and for open channels that actually exist or in the field already meet the requirements according to technical calculations so there is no need for redesign. the number of pumps to deal with water entering the sump/wells is also not able to overcome the problem of runoff water discharge so it is necessary to add a Multiflo 420-EX pump unit to handle the water in the sumps/wells in the south pit area of Sentuk. The sump capacity volume corresponding to the sump 90 besar is 38,025.70 m<sup>3</sup> with a sump height of 5 m, the slope at the sump is 600, the base area is 7,047 m<sup>2</sup> and the surface area is 9,207 m<sup>2</sup>, while for the volume sump capacity sump 90 lorong is 47,876.36 m<sup>3</sup> with a sump height of 5 m, the slope of the sump is 600, the base area is 9,016 m<sup>2</sup> and the surface area is 10,192 m<sup>2</sup>, and for a volume capacity of sump 100 is 49,356.73 m<sup>3</sup> with a sump height of 5 m, the slope at the sump is 600, the base area is 9,306 m<sup>2</sup> and a surface area of 11,655 m<sup>2</sup>. To reduce the total incoming volume by 38,025.70 m<sup>3</sup>/day at the sump 90 besar it is recommended to use a 2 unit MFC 420 multiflow pump scheme, while to reduce the total incoming volume by 47,876.36 m<sup>3</sup>/day at the sump 90 lorong it is recommended to use a 2 unit scheme MFC 420 Multiflow pump, and to reduce the total incoming volume of 49,356.73m<sup>3</sup>/day in a sump 100 it is recommended to use a 3 unit Multiflow MFC 420 pump scheme.

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## CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

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