http://journal.uir.ac.id/index.php/JGEET

E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 11 No 2 2026

RESEARCH ARTICLE

Mine Dewatering Design for Re-Mining in a Mined-Out Laterite Nickel Pit: Case Study of South Pit, PT NPM, Central Sulawesi, Indonesia

Sri Sovia Duha Ananda[1], Ichsan Invanni Baharuddin[1]*, Rusli Har[1], Heri Prabowo[1]

[1] *Mining Engineering Department, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia.*

* Corresponding author: ichsan_invanni@unp.ac.id
Tel.:+62 813-4259-5800

Received: Apr 01, 2026; Accepted: May 22, 2026.
DOI: 10.25299/jgeet.2026.11.02.27643

Abstract

This study aims to design an effective mine dewatering system for the South Pit mined-out area of PT Nusajaya Persadatama Mandiri, supporting re-mining activities. The methods used include hydrological analysis to determine the design rainfall using the Log Pearson Type III distribution, calculation of rainfall intensity using the Mononobe method, and estimation of runoff discharge using the rational method based on the catchment area. The results show that the design rainfall is 72.2 mm/day with a rainfall intensity of 49.9 mm/hr and a catchment area of 13.47 ha. The total inflow into the pit is 0.48 m³/s (1,726 .20 m³/hr), requiring a sump capacity of 7,250.03 m³. The pumping system is designed using a DnD LCC-M 100 pump with a capacity of 300 m³/hr, operated for 14 hours/day. The pumped water is conveyed through a 6-inch diameter HDPE pipe to a trapezoidal open channel, where it is then discharged into a Water Management Pond (WMP) with a total capacity of 11,200 m³, consisting of four compartments. The research results indicate that the designed mine drainage system is capable of effectively controlling mine water, thereby supporting safe and efficient re-mining operations.

Keywords: nickel mining, planned rainfall, runoff discharge, mine dewatering, catchment area, re-mining.

1. Introduction

Nickel (Ni) is one of the metal mineral commodities that plays an important role in various industrial sectors. (Handika et al., 2024). Geologically, nickel deposits are generally formed from two main types of ore, namely magmatic sulfide ore and laterite ore, which are formed as a result of the weathering of ultramafic rocks in tropical regions (Schodde and Guj, 2025). Indonesia, as a country with abundant nickel resources, is one of the world's leading nickel producers (Sitohang et al., 2025). In the last five years, global nickel production has increased significantly, with Indonesia contributing about 45 % of total world production and accounting for about 70 % of global production growth until 2025 (IEA, 2021).

The increase in nickel production is inseparable from the increasing demand for nickel as an important metal in the energy transition and renewable energy technology development (Bastianin et al., 2025). However, the availability of high-grade nickel ore is becoming increasingly limited, so mining companies need to optimize the utilization of existing resources, one of which is through adjusting the cut-off grade value. The cut-off grade is an economic parameter that determines the boundary between ore material and waste and affects the amount of reserves that can be mined (Abdollahisharif et al., 2012; Soemarsoem et al., 2025).

In addition, developments in nickel processing technologies, such as the Rotary Kiln Electric Furnace (RKEF) and High Pressure Acid Leaching (HPAL), have made it possible to process low-grade laterite nickel ore economically. The RKEF process is widely used to produce ferronickel from laterite ore, while HPAL is used to extract nickel from low-grade ore into intermediate products such as mixed hydroxide precipitate, which is widely used in the battery industry. (Bahfie et al., 2022). With these technological developments, materials that were previously below the cut-off grade value have the potential to be reused economically.

Similar conditions occur in the mining activities of PT Nusajaya Persadatama Mandiri, located in Matarape Village, Menui Kepulauan Subdistrict, Morowali Regency, Central Sulawesi. One of its mining areas, the South Pit, was previously declared mined out in 2021, with a cut-off grade (COG) of 1.7 % as the threshold for the grade of ore that can be mined (Soemarsoem et al., 2025; Tian et al., 2020). Based on company data, the South Pit still has estimated reserves of approximately ± 202,304 wet metric tons (WMT) with a Ni grade of around 1.5 % and ± 104,500 WMT with a Ni grade of around 1.0 %. The reduction in COG to 1.25 % means that material that previously did not meet economic criteria is now reclassified as ore. Hence, increasing the amount of reserves that can potentially be mined again.

Optimizing mining areas that have been declared mined out through re-mining activities requires adequate mining operational conditions. In open-pit mines, mining activities generally result in depressions that have the potential to accumulate water from rainfall, surface runoff, and groundwater (Adnyano and Bagaskoro, 2020; Latifa et al., 2025). If not managed effectively, these water accumulations can hinder operational activities and potentially reduce productivity, as well as increase occupational safety risks in mining activities (Adnyano and Bagaskoro, 2020; Har et al., 2024; Różkowski et al., 2021; Saputra et al., 2023). Therefore, water control through the implementation of an effective drainage system is necessary to prevent flooding and support the smooth running of mining activities (Baharuddin et al., 2025; Rosada et al., 2024).

In open-pit mines, water management in the mining area is carried out through the application of a mine dewatering system to remove water accumulated in the pit area so that mining operations remain safe (Różkowski et al., 2021). Mine drainage systems generally consist of sumps as temporary storage areas, pumping systems that drain water from the pit, and open channels that drain water from the pumping outlet to mine water management facilities, such as water management ponds (Kasih et al., 2024; Różkowski et al., 2021; Sari et al., 2023). The design of such a system requires a hydrological analysis that includes determining the planned rainfall, catchment area, and estimated total water discharge to ensure that the drainage system can effectively control the volume of water so that the mine work area remains dry from water accumulation in the mine opening (sump) (Saputra et al., 2023).

The design of mine drainage systems in open-pit mines has been extensively studied in previous research, especially in mines that are still in operation. Rosada et al. (2024) showed that proper mine dewatering system planning can minimize the potential for flooding and improve mine operational efficiency. In addition, Nasution et al. (2023) emphasized the importance of analyzing mine water discharge and pumping system capacity to ensure that the drainage system is capable of controlling water entering the pit area. However, studies on the design of mine dewatering systems in mined-out areas that will be reactivated through re-mining activities are still relatively limited, especially in laterite nickel mines.

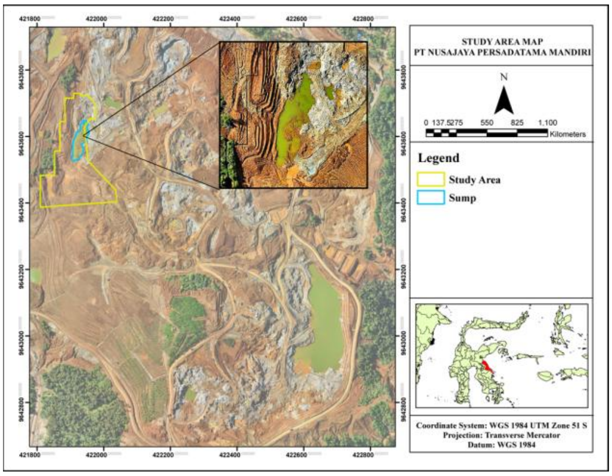

Fig 1. Research location

Based on these conditions, this study aims to design a mine dewatering system for the mined-out area of the South Pit at PT Nusajaya Persadatama Mandiri through hydrological analysis and calculation of the total water discharge in the mining area. This study includes an analysis of the catchment area, determination of planned rainfall, estimation of total water discharge entering the mining area, and the design of a pumping system, open channels, and water management ponds. The results of this study are expected to provide recommendations for an effective drainage system to support the safe and sustainable implementation of laterite nickel re-mining activities.

2. Research Methodology

2.1 Research Location

This research was conducted in the South Pit Work area of PT Nusajaya Persadatama Mandiri, located in Matarape Village, Menui Kepulauan Subdistrict, Morowali Regency, Central Sulawesi Province. Geographically, this mine is located at coordinates 3°16′08″ S and 122°18′51″ E. The research location is shown in Fig. 1.

2.2 Research Methods and Types of Research Data

This study uses a quantitative approach by integrating primary and secondary data to design a mine dewatering system in the mined-out area of the South Pit of PT Nusajaya Persadatama Mandiri. The analysis conducted includes hydrological analysis, determination of the catchment area, and calculation of total water discharge. Details of the types of data, parameters, data sources, and their uses in this study can be seen in Table 1.

Table 1. Types and sources of research data

Data	Data Source	Description
Rainfall data 2018 - 2024	Company data	Hydrological analysis
Topographic	Company data	Determination of catchment area
Orthophoto map	Company data	Research area identification
Groundwater discharge	Field data	Groundwater analysis
Specifications Pumps & Pipes	Catalog Pumps	Pumping system
Temperature data	BMKG	Evapotranspiration analysis

2.3 Data Processing and Analysis Techniques

Data processing and analysis techniques in this study were carried out to design a mine dewatering system in the mined-out area of the South Pit of PT Nusajaya Persadatama Mandiri. The analysis was conducted using a hydrological approach to calculate the water discharge entering the mining area and the technical planning of the mine drainage system. The stages of data processing and analysis in this study included:

2.3.1 Rainfall Catchment Area Analysis

Rainfall catchment area analysis was conducted to determine the area contributing to water flow towards the mined-out South Pit of PT Nusajaya Persadatama Mandiri. The catchment area was determined using ArcGIS 10.8 software based on the company's orthophotography and topographic map data. The obtained rainfall catchment area is then used as the basis for calculating runoff discharge in mine dewatering system planning (Baharuddin et al., 2025; Saputra et al., 2023).

2.3.2 Rainfall Data Analysis

The rainfall data used is the maximum daily rainfall data for the 2018–2024 period, representing the IUP area. The data were analyzed using probability distribution methods to determine the planned rainfall with a specific rainfall return period selected based on the level of hydrological risk in the planning of the mine drainage system (Pratama et al., 2023). Hydrological risk was calculated using the following equation:

$$Pr = 1 - (1 - \left(\frac{1}{Tr}\right))^{TL} \qquad (1)$$

where Pr represents the hydrological risk, Tr is the rainfall recurrence interval (years), and TL is the design life of the drainage system (years).

2.3.3 Calculation of Planned Rainfall Intensity

The available rainfall data consists of daily rainfall data, so rainfall intensity estimates are calculated using the Mononobe method. This method utilizes maximum daily rainfall data to obtain rainfall intensity values used in hydrological analysis (Anggraheni and Gustoro, 2019).

$$I = \frac{R_{24}}{24}\left(\frac{24}{Tc}\right)^{\frac{2}{3}} \qquad (2)$$

$$Tc = 0{,}76 \; x \; A^{0{,}38} \qquad (3)$$

where I denotes rainfall intensity (mm/hr), $R_{(24)}$ denotes maximum rainfall in 24 hours (mm), Tc denotes concentration time (hours) in Mc Dermot's equation, and A denotes catchment area (km²).

2.3.4 Total Water Discharge Calculation

Total water discharge calculations are performed to determine the amount of water entering the mining area as a basis for planning the mine dewatering system. Total water discharge is calculated using the following equation**:**

$$Q_{total} = Q_{runoff} + Q_{groundwater} - ETr \qquad (4)$$

2.3.4.1 Runoff Debit

Surface runoff is calculated using the Modified Rational Method with equation 5 and runoff discharge calculation at the mine opening with equation 6 as follows:

$$Q = 0{,}2778\ x\ C\ x\ I\ x\ A \qquad (5)$$

$$Q = \frac{MineOpeningArea}{Catchment\ Area}\ x\ Q\ Catchment\ Area \qquad (6)$$

where Q is the runoff discharge (m³/s), C is the runoff coefficient determined based on land cover type and soil type, I is the rainfall intensity (mm/hr) obtained from rainfall frequency analysis, and A is the catchment area (ha), which is then converted to km² (Isniarno et al., 2020).

2.3.4.2 Groundwater Discharge

Water discharge is the volume of water that passes through a cross-section in a unit of time. Discharge can be calculated using the velocity area method, which is the multiplication of the cross-sectional area and the flow velocity, expressed by the following equation:

$$Q = A\ x\ v \qquad (7)$$

where Q = water flow rate (m³/s), A = flow cross-sectional area (m²), v = water flow velocity (m/s).

This method assumes steady flow with a relatively uniform velocity distribution across the cross-section. In mine hydrology, this approach is commonly used to estimate the contribution of groundwater entering the pit as part of the total water discharge in the mine drainage system (Baharuddin et al., 2025; Sari et al., 2025).

2.3.4.3 Evapotranspiration

Evapotranspiration is the process of water evaporation from the soil surface and plants that occurs through evaporation and transpiration. The rate of evapotranspiration is expressed as the volume of water lost per unit area in a unit of time, generally in mm/day or mm/month (Harmiyati and Fuaji, 2023). In this study, evapotranspiration estimates were calculated using the Turc equation (Rutkowski et al., 2007; Turnip et al., 2022).

$$ETr = \frac{P}{\sqrt{0{,}9 + \frac{P^2}{(300+25Tm+0{,}05Tm^3)^2}}} \qquad (8)$$

where ETr = Evapotranspiration (mm/yr), P = Average annual rainfall (mm/yr), and Tm = Average annual temperature (°C).

2.3.5 Calculation of Water Volume in a Sump

The calculation of water volume in the sump is done to determine the amount of water collected at the bottom of the pit or mine opening before pumping is carried out using the following equation:

$$Volume\ (m^3) = Q_{total}\ x\ Daily\ rainfall\ duration \qquad (9)$$

where the daily rainfall duration is the average of the longest rainfall duration in a day.

2.3.6 Pumping System Design

The pumping system is part of the mine drainage system that functions to remove water from the pit area so that it does not interfere with mining activities (Nauli et al., 2024). Water that enters the pit generally comes from rainwater and surface runoff that collects in areas with the lowest elevation, which can cause flooding and hinder mining activities (Aryanto et al., 2024). Therefore, it is necessary to calculate the total pump head, which consists of static head, friction head, and velocity head, to determine the power requirements and number of pumps based on the water discharge entering the pit and the available pump capacity (Baharuddin et al., 2025).

$$HT = Hs + \Delta Hp + (Hf + \frac{v^2 a}{2g}) \qquad (10)$$

$$Pump\ Capacity = \frac{Hp\ x\ Q\ x\ \gamma}{\eta} \qquad (11)$$

$$Number\ of\ Pumps = \frac{Q_{total}}{Q_{pump}\ x\ Pumping\ Time} \qquad (12)$$

where HT is the total dynamic head (m), Hs is the static head (m), ΔHp is the pressure difference head (m), Hf is the head loss due to friction (m), v is the flow velocity (m/s), and g is the acceleration due to gravity (9.81 m/s²). Hp is the pump head, Q is the flow rate (m/s), γ is the specific gravity of the fluid, η is the pump efficiency, Qtotal is the total water flow rate, and Qpump is the pump flow capacity.

2.3.7 Open Channel Design

Open channel design discusses water flow systems through channels with free surfaces that utilize gravitational force. This design aims to determine the capacity of the channel to accommodate water discharge to prevent overflow (Farida et al., 2025; Rozi et al., 2021). The flow velocity in open channels is influenced by the channel slope (S), hydraulic radius (R), and Manning's roughness coefficient (n), which are calculated using equation 13, and the flow discharge (Q) can be calculated using equation 7.

$$V = \frac{1}{n}\ X\ R^{\frac{2}{3}}\ X\ S^{\frac{1}{2}} \qquad (13)$$

The wet cross-sectional area of a trapezoidal channel is calculated using the equation:

$$A = y(B + my) \qquad (14)$$

The wet perimeter of the channel is calculated using the equation:

$$P = B + 2y\sqrt{1 + m^2} \qquad (15)$$

Hydraulic radius is the ratio between wet cross-sectional area and wet perimeter, calculated using the equation:

$$R = \frac{A}{P} \qquad (16)$$

where v is the flow velocity (m/s), A is the wet cross-sectional area (m²), P is the wet perimeter (m), R is the hydraulic radius (m), n is the Manning roughness coefficient, S is the channel bed slope, B is the channel bed width (m), y is the flow depth (m), and m is the channel side slope.

2.3.8 Water Management Pond Design

Water management ponds are designed to collect runoff water from rainfall in the mining area before it is discharged into the environment. These ponds serve as temporary storage and also settle sediment carried by the water flow, so that the quality of water leaving the mining area can be controlled (Zulkarnain et al., 2024).

An analysis was conducted to determine the water discharge entering the mining area based on rainfall data and the characteristics of the catchment area, which was then used as the basis for designing a drainage system capable of effectively draining and collecting water.

3. Results and Discussion

3.1 Rainfall Catchment Area Analysis

The analysis results show that the catchment area in the South Pit working area of PT Nusajaya Persadatama Mandiri is 13.47 ha. The catchment area was determined using ArcGIS 10.8 based on the company's topographic data and orthophotography maps, thereby obtaining the boundaries of the area that contributes to water flow towards the pit area.

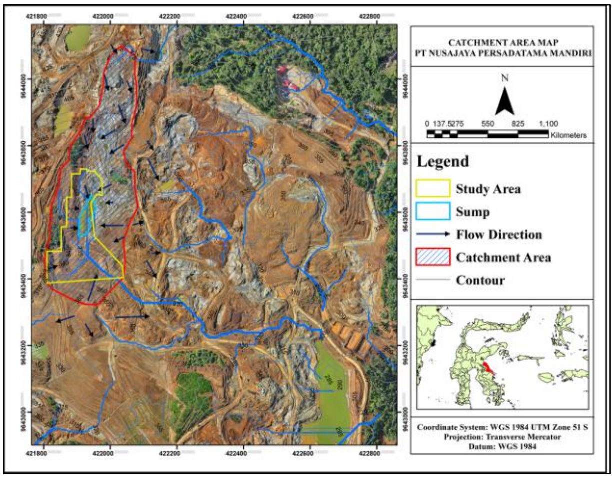

Fig 2. Catchment area map

A catchment area is an area that collects and channels rainwater to a point of flow. The size of the catchment area affects the amount of runoff entering the mining area, making it important in hydrological analysis to determine the potential for mine water flow (Baharuddin et al., 2025). Geographic Information System (GIS)-based hydrological analysis can be used to determine the boundaries of the catchment area and calculate runoff parameters more accurately (Isniarno et al., 2020).

3.2 Rainfall Analysis

Rainfall analysis using maximum daily rainfall data for the period 2018–2024, representing the IUP area of PT Nusajaya Persadatama Mandiri. Based on this data, the average maximum rainfall was 51.95 mm. The frequency analysis results show that the most appropriate probability
The distribution is the Log Pearson Type III distribution, with a skewness coefficient (Cs) value of 0.941 (Table 2).

Table 2. Probability Distribution Test

Probability Distribution Test			
Data Type	Conditions	Calculation	Conclusion
Normal	Cs ≈ 0 Ck ≈ 0	1.347 0.221	Does Not Meet Requirements
Gumbel	Cs ≤ 1.139 Ck ≤ 5.400	1.347 0.221	Does Not Meet Requirements
Log Pearson Type III	Cs ≠ 0	0.941	Meets requirements
Log Normal	Cs ≈ 3 Cv + Cv 2 = 3 Ck = 5.383	0.941 3.308	Does Not Meet Requirements

The rainfall distribution suitability test was conducted using the Chi-Square (χ^2) method. This method is used to compare the frequency of observation data with the theoretical frequency of a probability distribution, so that the level of suitability with the hydrological data can be determined (Upomo and Kusumawardani, 2016). The test results show that the Log Pearson Type III distribution ($\chi^2 = 2.2$) meets the criteria because its value is smaller than the critical χ^2 (Table 3).

Table 3. Distribution goodness-of-fit test

Probability Distribution	X^2 Calculated	X^2 Cr	Description
Gumbel	8.8	7.815	Does not meet requirements
Normal	10	7.815	Does not meet requirements
Log Pearson Type III	3.4	7.815	Meets requirements
Log Normal	2.2	7.815	Meets requirements

3.3 Planned Rainfall Intensity

Frequency analysis of rainfall using the Log Pearson Type III distribution produces planned rainfall values for various return periods. The analysis results show that the maximum daily rainfall is 99.62 mm for a 50-year return period, while for a 10-year return period it is 72.17 mm. These rainfall values were then used to calculate the planned rainfall intensity using the Mononobe method, with a concentration time (Tc) of 0.35 hours (21.29 minutes) and a catchment area of 13.47 ha.

Table 4. Planned rainfall intensity

Year	XT (mm/day)	Planned Rainfall Intensity (mm/hr)						
		60	240	480	720	960	1200	1440
2	47.93	16.62	6.59	4.15	3.17	2.62	2.26	2.00
5	61.65	21.37	8.48	5.34	4.08	3.37	2.90	2.57
10	72.17	25.02	9.93	6.26	4.77	3.94	3.40	3.01
25	87.16	30.22	11.99	7.55	5.76	4.76	4.10	3.63
50	99.62	34.54	13.71	8.63	6.59	5.44	4.69	4.15

In this study, based on the calculated design rainfall intensities presented in Table 4, a rainfall intensity of 25.02 mm/hr was obtained for a duration of 60 minutes, which then decreased to 3.01 mm/hr for a duration of 1,440 minutes, indicating that rainfall intensity decreases as the duration of rainfall increases. The relationship between rainfall intensity, duration, and return period is shown in Fig. 3 as an Intensity-Duration-Frequency (IDF) curve. Furthermore, based on the hydrological risk analysis in Table 5, a 10-year rainfall return period (RRP) was used in accordance with the mine's design life, with a risk level of 65 % which is still acceptable for mine drainage system planning and resulting in a design rainfall intensity of 49.92 mm/hr, which was subsequently used in runoff discharge calculations for the design of the mine drainage system.

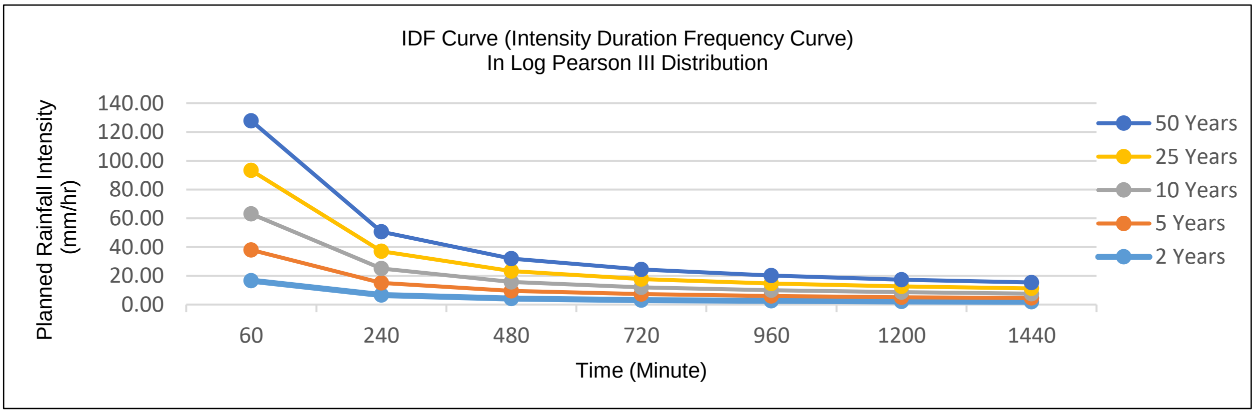

Fig 3. Type III log Pearson intensity duration frequency (IDF) curve

Table 5. Rainfall return period and hydrological risk

Rainfall return period (year)	Hydrological Risk (%)
2	100
5	89
10	65
15	50
25	34
50	18

3.4 Total Water Discharge and Sump Volume Analysis

Total water discharge analysis to determine the amount of water accumulated in the open pit area from the sum of runoff and groundwater discharge, then subtracted by evapotranspiration.

Based on the calculations, the runoff water discharge entering the mine opening area is 0.4790 m^3/s or 1,724.59 m^3/hr. In addition, there is a contribution of groundwater discharge of 0.00068 m^3/s or approximately 0.68 L/s. Meanwhile, the evapotranspiration value is 0.00023 m^3/s. The results of the total water discharge calculation can be seen in Table 6.

Table 6. Total water discharge

Parameter	m^3/s	m^3/hr
Mine opening runoff discharge	0.47905	1,724.59
Groundwater discharge	0.00068	2.44800
Evapotranspiration	0.00023	0.84204
Total water discharge	0.47950	1,726.20

Based on the table, the total water discharge is 0.4795 m^3/s or 1,726.20 m^3/hr. This value indicates that the water entering the mine pit is dominated by surface runoff, while the contribution of groundwater and evapotranspiration is relatively small. This condition is common in open-pit mines because most of the rainwater will flow to the lowest point of the pit before being drained through the mine drainage system (Baharuddin et al., 2025).

The sump volume is calculated based on the total water discharge and a maximum rainfall duration of 4.2 hours, resulting in a water volume of 7,250.03 m^3. This value indicates the minimum sump capacity required to accommodate the water entering the mining area during maximum-rainfall events, without interfering with mining activities.

3.5 Mine Dewatering System Design

3.5.1 Pumping System Design

The pumping system is designed to drain water accumulated in the sump. At the study site, the water flow path from the sump to the open channel passes through an active pit area, so the water cannot be drained directly through the open channel, as this could potentially disrupt mining operations. Therefore, a pumping system is required to drain water from the sump to the open channel.

Based on topographic analysis, the length of the pipeline route from the sump to the outlet is 466.36 m. The pumping system uses HDPE pipes with a diameter of 0.1524 m (6 inches) and a pump capacity of 300 m^3/h (0.0833 m^3/s). The water flow velocity inside the pipe is 0.5468 m/s.

Hydraulic calculations show that the head loss (Hf) along the pipe is 30.70 m, while the elevation difference between the sump and the discharge point results in a static head (Hs) of 4 m. Thus, the total pump head (Ht) is 34.70 m. Based on these parameters, the calculated pump power requirement is approximately 38.70 kW (±52 HP), assuming a pump efficiency of 73%, which aligns with the pumping system's flow rate and head conditions. The pump used is the DnD LCC-M 100 model.

The pumping system operates for 14 hours per workday, divided into two shifts, resulting in a pumping capacity of approximately 4,200 m^3/day. Meanwhile, the volume of water contained in the sump is 7,250.03 m^3, meaning the water can be drained in about two workdays using a single pump unit. This indicates that the designed pumping system can control water accumulation and support the smooth operation of mining activities (Aryanto et al., 2024; Nauli et al., 2024).

The designed dewatering system aims for a final water level of 0 m (dry) in the sump area to enable re-mining. With a pumping capacity of approximately 4,200 m^3/day and a water volume of 7,250.03 m^3, this system can gradually reduce water buildup until the pit floor becomes dry and ready for re-access for mining operations.

However, the evaluation of this system's effectiveness remains limited because it is based solely on a comparison between the sump volume and the pump capacity. Under actual conditions, the mine drainage system is significantly influenced by rainfall intensity, particularly during heavy rainfall events. The system was designed using a 10-year rainfall return period aligned with the mine's planned lifespan, thereby technically accounting for hydrological risk levels throughout the mine's operational life. With a rainfall intensity of 49.92 mm/hr producing a runoff discharge of 0.479 m^3/s (±1,726.20 m^3/hr), the designed system is expected to accommodate these design rainfall conditions.

3.5.2 Open Channel Design

The open channel is designed to drain pumped water from the pump outlet to the Water Management Pond (WMP), ensuring controlled flow and preventing interference with mining activities. The channel cross-section used is an economical trapezoid with a 60° slope.

Hydraulic calculations using Manning's equation with a roughness coefficient of $n = 0.030$ and a channel slope of $S = 0.002$ resulted in channel dimensions with a base width of 0.38 m, a flow depth of 0.33 m, and a channel depth of 0.50 m. These dimensions result in a flow velocity of 0.44 m/s, which is still within the safe range for earthen channels and therefore does not have the potential to cause erosion of the channel bed or walls. A summary of the channel dimensions is presented in Table 7, while the cross-sectional shape of the channel is shown in Fig 4.

Channel capacity and dimensions are important factors in ensuring that drainage systems can drain water effectively and prevent excessive runoff. A well-designed drainage system can maintain the stability of infrastructure and the surrounding environment (Farida et al., 2025). Thus, the planned channel dimensions are considered capable of supporting the effective flow of water from the pump outlet to the WMP.

Table 7. Open channel design

Parameter	Value	Unit
Channel base width (B)	0.38	m
Flow depth (y)	0.38	m
Water surface width (T)	0.77	m
Channel depth (H)	0.50	m
Weir height (J)	0.17	m
Flow velocity (v)	0.44	m/s

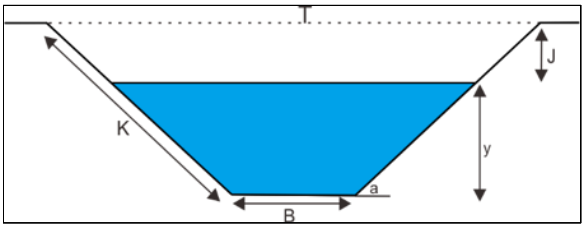

Fig 4. Cross-section of a trapezoidal open channel

3.5.3 Water Management Pond Design

The Water Management Pond (WMP) is designed to collect and control pumped water before it is discharged outside the mining area. Based on calculations, the volume of the sump that must be accommodated is 7,250.03 m³ with an inflow rate into the WMP of 0.083 m³/s.

The WMP is designed with four compartments arranged from the inlet to the outlet to aid the sediment settling process. Each compartment is 35 m long, 20 m wide, and 4 m deep, with a volume of 2,800 m³ per compartment. Thus, the total storage capacity reaches 11,200 m³, so that the pond's capacity is considered capable of accommodating the incoming water discharge. This compartment system also serves to slow down the flow so that sediment can settle before the water is discharged from the pond.

Table 8. Water Management Pond Design

Compartment	L (m)	W (m)	H (m)	V (m^3)
Compartment 1	35	20	4	2,800
Compartment 2	35	20	4	2,800
Compartment 3	35	20	4	2,800
Compartment 4	35	20	4	2,800
Total	140	80	16	11,200

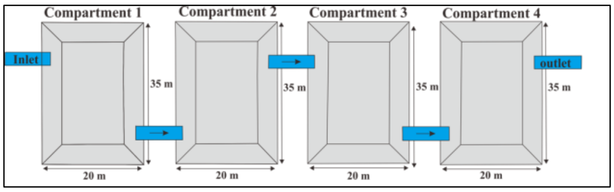

Fig 5. Water Management Pond Design

Fig. 6 is a mine dewatering design map showing the layout of the mine dewatering system, which includes the pipeline from the pump, open channels, and the location of the Water Management Pond (WMP) as a water storage area before it is discharged outside the mine area.

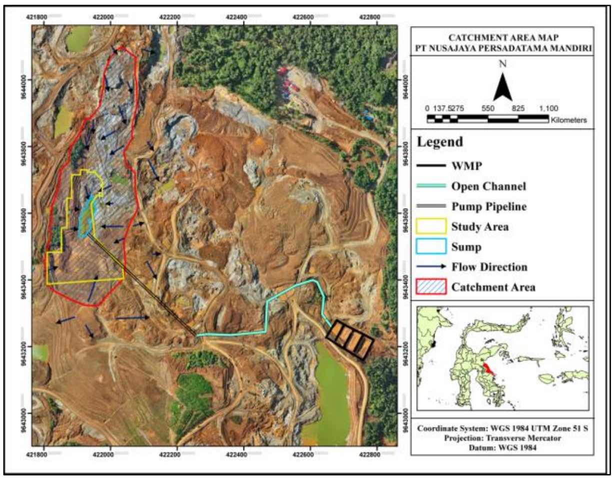

Fig 6. Mine dewatering design map

4. Conclusion

This study resulted in the design of a mine drainage system for the South Pit of PT Nusajaya Persadatama Mandiri that integrates hydrological and hydraulic analysis, with the primary contribution being the determination of the optimal dewatering system capacity based on the relationship between design rainfall, runoff discharge, and the performance of the pumping system, open channels, and water management ponds. With a 10-year rainfall return period corresponding to the mine's lifespan, an intensity of 49.92 mm/hr, and a runoff discharge of 0.479 m³/s were obtained for an area of 13.47 ha. A system with a sump volume of 7,250 m³ and a pump capacity of 300 m³/hr (head 34.70 m; power 38.70 kW) is capable of controlling water accumulation under design conditions. However, this study has not considered sedimentation, water quality, and geotechnical aspects that may affect system performance. Therefore, further research is recommended to integrate these aspects in order to develop a more comprehensive and sustainable dewatering system.

Acknowledgment

The authors would like to thank PT Nusajaya Persadatama Mandiri for the opportunity and data support during the research in the mining area. The authors would also like to thank all parties who have provided support and assistance during the research process and the writing of this article.

References

Abdollahisharif, J., Bakhtavar, E., Anemangely, M., 2012. Optimal cut-off grade determination based on variable capacities in open-pit mining. The Journal of The Southern African Institute of Mining and Metallurgy 112, 1065–1069.

Adnyano, A.A.I.A., Bagaskoro, M., 2020. Kajian Teknis Dewatering System Tambang Pada Pertambangan Batubara. Promine 8, 28–33.

Anggraheni, D., Gustoro, D., 2019. Rainfall Distribution Pattern of Progo Watershed in Observational and Empirical Method. MATEC Web of Conferences 280. https://doi.org/10.1051/matecconf/201928005005

Aryanto, R., Fortuna, H.M., Purwiyono, T.T., Suliestyah, S., 2024. Technical Assessment Of Mud Handling Planning With Dredger Pump In Mining Front Area Of Pt. Makmur Lestari Primatama, Southeast Sulawesi, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology 9, 272–278. https://doi.org/10.25299/jgeet.2024.9.3.16829

Baharuddin, I.I., Har, R., Asshidiqqi, M.H., Anarta, R., Tanjung, D.A., Maryanti, E., 2025. Design analysis of drainage system design on coal mining land. Jurnal Natural 25, 124–132. https://doi.org/10.24815/jn.v25i3.45589

Bahfie, F., Manaf, A., Astuti, W., Nurjaman, F., Prastyo, E., Herlina, U., 2022. Development of laterite ore processing and its applications. Indonesian Mining Journal 25, 89–104. https://doi.org/10.30556/imj.Vol25.No2.2022.1261

Bastianin, A., Li, X., Shamsudin, L., 2025. Forecasting the Volatility of Energy Transition Metals, in: FEEM Working Paper No. 04.2025.

Farida, I., Khadafi, M.H., Wijaya, A., 2025. Integrating Hydrological Modeling and Pavement Evaluation to Analyze the Impact of Drainage Performance on Road Infrastructure. Journal of Geoscience, Engineering, Environment, and Technology 10. https://doi.org/10.25299/jgeet.2025.10.4.24641

Handika, E.T., Sutarto, S., Soesilo, J., 2024. Geologi dan Karakteristik Laterit Nikel Berdasarkan Mineralogi Batuan Dasar dan Geokimia Daerah Routa dan Sekitarnya, Kecamatan Routa, Kabupaten Konawe, Provinsi Sulawesi Tenggara. Jurnal Ilmiah Geologi PANGEA 11, 114. https://doi.org/10.31315/jigp.v11i2.14138

Harmiyati, Fuaji, A.S., 2023. Analysis of Water Availability in the Upper Siak Basin Using the GR2M Model Application. Journal of Geoscience, Engineering, Environment, and Technology 8, 196–202. https://doi.org/10.25299/jgeet.2023.8.3.11559

Har, R., Burhamidar, A.H., Rahman, H.A., Octaviani, H., 2024. Identification Of Secondary Aquifer Using Joint Modeling As Mine Dewatering Preliminary In Level 7 Underground Gold Mines In Pesisir Selatan Regency, West Sumatra Province. Water Conservation and Management 8, 109–114. https://doi.org/10.26480/wcm.01.2024.109.114

Hidayat, S., 2025. Hilirisasi Mineral Pengelolaan Nikel di Indonesia: Regulasi serta Dampak Implementasinya Pada Ekonomi dan Pembangunan Smelter. Journal Scientific of Mandalika (jsm) 6, 3610–3619.

IEA, 2021. The Role of Critical Minerals in Clean Energy Transitions. Paris.

Isniarno, N.F., Aziz, G., Iswandaru, I., 2020. Hydrological monitoring in open PIT mining areas using geodatabase attribute in Geographic Information Systems (GIS), in: IOP Conference Series: Materials Science and Engineering. Institute of Physics Publishing. https://doi.org/10.1088/1757-899X/830/4/042043

Kasih, D.V., Irawan, J.F., Suparno, F.A.D., 2024. Open-pit coal mine drainage system design at PT XYZ, Central Kalimantan. Riset Geologi dan Pertambangan 34, 13–23. https://doi.org/10.55981/risetgeotam.2024.1267

Keliat, A.E., Usup, H.L.D., Murati, F., Lashania, Y., Andri, Y., 2025. Perancangan Saluran Terbuka (Open Channel) Void U210 Berdasarkan Data. Journal Of Social Science Research 5, 6325–6340.

Latifa, A., Sugiyanto, D., Syukri, M., 2025. Subsurface Interpretation for Groundwater Potential Mapping Using Electrical Resistivity Tomography (ERT) in Mon Ikeun Village, Aceh Besar, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology 10, 295–299. https://doi.org/10.25299/jgeet.2025.10.3.22580

Nasution, B., Prabawa, A.D., Wiratama, J., 2023. Technical Design of Mine Drainage, Mine Dewatering and Critical Level Simulation on Sump Capacity with Water Balance Equation for Flood Handling Pit Eagle at PT Triaryani, North Musirawas Regency, South Sumatra Province. Jurnal GEOSAPTA 9, 137. https://doi.org/10.20527/jg.v9i2.16238

Nauli, F., Irfan, A., Yanti, S.R., Alghifari, A., Deny, A. Van, 2024. Analysis of Pump Requirements for Mine Dewatering Sump at Kerinci PT Cipta Kridatama Jobsite PT Kuansing Inti Makmur. MOTIVECTION : Journal of Mechanical, Electrical and Industrial Engineering 6, 373–382. https://doi.org/10.46574/motivection.v6i3.368

Pratama, F.A., Supandi, Shilvyanora, A.R., 2023. Kajian Teknis Mine Dewatering pada Tambang Terbuka PT. Putra Muba Coal Kabupaten Musi Banyuasin Provinsi Sumatera Selatan, in: Prosiding Nasional Rekayasa Teknologi Industri Dan Informasi XVIII Tahun 2023 (ReTII). pp. 237–243.

Rosada, N.A., Rusli, F.D.S., Ardiyansyah, A., Amir, M.K., 2024. Mine Dewatering Model Dalam Inovasi Sistem Penyaliran Tambang Dengan Pendekatan Matematis Untuk Mencegah Flooding. Akibat Bukaan Tambang. Mining Science and Technology Journal 3, 127–139.

Rozi, M.F., Rosadi, P.E., Nusanto, G., 2021. Kajian Teknis Sistem Penyaliran Pada Tambang Terbuka di Tambang Batubara PT Kalimantan Prima Persada Jobsite Rantau, Kalimantan Selatan. Jurnal Teknologi Pertambangan 7, 180.

Różkowski, K., Zdechlik, R., Chudzik, W., 2021. Open-pit mine dewatering based on water recirculation—case study with numerical modelling. Energies (Basel). 14. https://doi.org/10.3390/en14154576

Rutkowski, T., Raschid-Sally, L., Buechler, S., 2007. Wastewater irrigation in the developing world—Two case studies from the Kathmandu Valley in Nepal. Agric. Water Manag. 88, 83–91. https://doi.org/10.1016/J.AGWAT.2006.08.012

Saputra, A., Adnyano, A.A.I.A., Putra, B.P., Sutrisno, A.D., Zamroni, A., Machmud, A., 2023. A review of Open Channel Design for Mine Dewatering System Based on Environmental Observations. International Journal of Hydrological and Environmental for Sustainability 2, 24–31. https://doi.org/10.58524/ijhes.v2i1.177

Sari, A.S., Cahyono, Y.D.G., Kombongkila, Y., 2023. Technical Design of Wells (Sump) and Pump Requirements in Open Pit Mine Drainage at PT. Mulia Baratama Plan, Long Beleh, Kembang Jagut, Kutai Kartanegara, East Kalimantan. Journal of Applied Sciences, Management and Engineering Technology 4, 73–80.

Sari, A.S., Wardana, N.K., Cahyono, Y.D.G., Sarastika, R.M., 2025. Analysis Of Aquifer Characteristics Using The Method Cooper Jacob At Block X Pt. Geomine Bara Studio Site Kutai Kartanegara, East Kalimantan, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology 10, 282–287. https://doi.org/10.25299/jgeet.2025.10.3.19690

Schodde, R., Guj, P., 2025. Nickel: A tale of two cities. Geosystems and Geoenvironment 4. https://doi.org/10.1016/j.geogeo.2025.100356

Sitohang, C., Azis, H., Hafiz, M.S., 2025. Hilirisasi Komoditi Mineral: Studi Kasus Nikel di Indonesia Politeknik APP Jakarta. Jurnal Ilmiah Ekonomi Dan Manajemen 3, 1–12. https://doi.org/https://doi.org/10.61722/jiem.v3i2.3755

Soemarsoem, B.S.P., Tui, S.N.R., Anas, A.V., 2025. Net Present Value Optimization Approach for Nickel Laterite Open Pit Mines at Southeast Sulawesi, Indonesia. Journal of Information Systems Engineering and Management 10, 378–390.

Tian, H., Pan, J., Zhu, D., Yang, C., Guo, Z., Xue, Y., 2020. Improved beneficiation of nickel and iron from a low-grade saprolite laterite by addition of limonitic laterite ore and CaCO3. Journal of Materials Research and Technology 9, 2578–2589. https://doi.org/10.1016/j.jmrt.2019.12.088

Turnip, B.A., Devy, S.D., Hasan, H., Oktaviani, R., Respati, L.L., 2022. Evaluasi Sistem Penyaliran Tambang Batubara Pit C East Jobsite Binungan Suaran. Jurnal Sosial dan Teknologi (SOSTECH) 2.

Upomo, T.C., Kusumawardani, R., 2016. Pemilihan Distribusi Probabilitas Pada Analisa Hujan Dengan Metode Goodness Of Fit Test. Jurnal Teknik Sipil & Perencanaan 18, 139–148.

Zulkarnain, H., La Ode Prianata, Y., Gunawan, R., LOM Husain, dan, Widiarta, A.B., 2024. Design of Settling Pond In The Open Mine System at Nickel Mining. Mining Science and Technology Journal 3, 79–84.