

Strategy to Improve the Accuracy of Dewatering Pit Pumping Forecasts by Designing an IoT-Based Realtime Pump Discharge Monitoring System (SIMPATIK) in the Mining Environment of PT Antareja Mahada Makmur (AMM) Jobsite Mifa Bersaudara (2026)

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ABSTRACT

Accurate dewatering forecasts are essential for maintaining production schedules and safe working conditions in open-pit coal mines. At the Mifa Bersaudara jobsite of PT Antareja Mahada Makmur (AMM), weekly manual pump discharge measurements limited the detection of pumping fluctuations, resulting in a dewatering forecast accuracy of approximately 50%. This study aimed to improve dewatering forecast accuracy through SIMPATIK, an Internet of Things (IoT)-based real-time pump discharge monitoring system. An operational improvement approach based on the Plan-Do-Check-Act (PDCA) cycle was implemented from August 2025 to March 2026. The system integrated clamp-on ultrasonic flow sensors, a microcontroller, a data logger, and an online monitoring dashboard to record pump discharge at three-second intervals. Hydraulic calculations were used to determine the optimal pump discharge range, while system performance was evaluated by comparing forecast and actual water-level reductions before and after implementation. The results showed that dewatering forecast accuracy increased from approximately 50% to more than 95%, while equipment assembly costs decreased from IDR 138,236,000 to IDR 16,280,000, representing a cost reduction of approximately 88%. Improved discharge monitoring supported the scheduled exposure of 206,733 metric tons of Seam C coal and was associated with an increase in overburden production from 689,400 to 879,400 bank cubic meters (BCM). Remote monitoring also reduced the need for manual discharge measurements near water bodies. These findings indicate that integrating continuous pump discharge monitoring into mine dewatering planning can improve forecast reliability, support production coordination, reduce monitoring costs, and minimize personnel exposure to operational hazards.



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INTRODUCTION

Mine dewatering is an essential component of open-pit coal mining operations because uncontrolled water accumulation within the pit can disrupt the mining sequence, reduce equipment productivity, and increase occupational safety risks. Planning for sump dewatering and drainage of inundated pit areas requires consideration of pump capacity, pipeline

dimensions, and actual field discharge patterns to ensure that targeted mining areas and materials can be exposed according to schedule (Anapah et al., 2024; Nauli et al., 2024; Sari et al., 2023).

Delays in lowering water levels within inundated areas can directly affect the mining sequence because excavation and loading equipment can operate only after the designated working areas have been sufficiently dewatered in accordance with the planned mining sequence (Aryanda et al., 2014; Prabowo et al., 2023). Therefore, the accuracy of water-level reduction forecasts is an important parameter for maintaining the reliability of monthly production planning in open-pit coal mines.

At the PT Antareja Mahada Makmur (AMM) Mifa Bersaudara jobsite, water-level reduction forecasts for the South Special Design Pit were previously developed using a constant pump discharge derived from the pump performance curve at a specified total dynamic head (TDH). Under actual operating conditions, however, pump discharge may vary because of pipeline leakage, increases in static head, deterioration in pump performance, or other hydraulic and operational factors (Halim et al., 2022). Consequently, forecasts based on constant discharge assumptions may deviate substantially from actual field conditions.

This challenge was evident in the South Special Design Pit at the PT AMM Mifa Bersaudara jobsite. According to the operational records presented in this study, the previous dewatering forecast assumed a constant discharge derived from the pump performance curve at a specified TDH. However, discharge verification was performed manually using a flow bar only once per week because the pump discharge outlet was located approximately 10 km from the operational office. The baseline pumping forecast accuracy was approximately 50%, indicating a substantial discrepancy between forecast and actual dewatering performance. These site-specific conditions established the practical problem addressed by this research: the limited availability of timely pump discharge measurements for updating pit dewatering forecasts.

The consequences of delayed discharge information extended beyond forecast discrepancies. At the study site, dewatering activities were associated with the planned exposure of 206,733 metric tons of Seam C coal by March 2026. Delays in lowering water levels could therefore affect working-area availability and the scheduling of excavation and loading equipment. Furthermore, manual measurements required personnel to access the discharge outlet near a water body, resulting in avoidable exposure to operational hazards during routine monitoring. The operational need was therefore both informational and organizational: engineers required timely discharge data, technicians needed earlier indications of changes in pumping performance, and field personnel required a monitoring system that reduced repeated travel and manual measurement activities near water bodies.

Previous research provides a foundation for addressing these challenges through automated monitoring. More et al. (2020), in “Automated Measurement Systems in Mine Water Management and Mine Workings—A Review of Potential Methods,” examined digital technologies relevant to mine water management, including the Internet of Things (IoT), wireless sensor networks, and automation. Their review identified applications of sensor networks for collecting flow and physicochemical data while noting limitations in research on digital technologies for managing and treating polluted mine water. This work supports the relevance of automated data acquisition in mining (Vlachos et al., 2024; Worldsensing, 2024;

Zhang et al., 2023); however, its broad review scope differs from the operational focus of the present study. Specifically, the current research examines how continuous pump discharge monitoring can support forecasts of water-level reduction in an active open-pit coal mine.

Research on ultrasonic instrumentation also supports the technical basis for continuous flow measurement. Grzelak et al. (2014) developed a high-resolution ultrasonic flow measurement system based on differences in acoustic transit time and demonstrated the importance of timing resolution, temperature effects, and clock stability for measurement performance. Their findings provide a methodological foundation for ultrasonic flow measurement, although their experimental system differs from the clamp-on configuration implemented at the mining site. More recently, Nugroho et al. (2025) developed an IoT-based water-flow monitoring system integrating ultrasonic measurement, microcontroller-based data acquisition, wireless communication, and a cloud platform. They reported measurement accuracy of $\pm 1\%$ relative to a reference turbine flowmeter under their experimental conditions, demonstrating the feasibility of remote flow monitoring (Das et al., 2025; Sadi & Mulyati, 2026) without establishing equivalent measurement performance under mine-site operating conditions.

Taken together, these studies demonstrate the potential of automated mine-water monitoring, ultrasonic flow measurement, and internet-connected data acquisition. However, the reviewed evidence does not directly establish how integrating continuously measured pump discharge into operational planning affects the accuracy of pit dewatering forecasts at the PT AMM Mifa Bersaudara jobsite. Measurement accuracy and forecast accuracy represent distinct concepts: a flowmeter measures discharge (Ton, 2022), whereas a dewatering forecast must also consider pumping duration, water inflow, and the relationship between stored water volume and water level. The research gap addressed in this study therefore concerns the site-specific relationship between real-time pump discharge information and the reliability of water-level reduction forecasts. Examining this relationship is necessary to determine whether improved monitoring provides information that can meaningfully support operational mining decisions.

To address this gap, the present study developed SIMPATIK, an IoT-based real-time pump discharge monitoring system integrating clamp-on ultrasonic flow sensors, a microcontroller, a data logger, and an internet-accessible monitoring dashboard. The system recorded pump discharge at three-second intervals and provided remote access to flow data for the engineering team. Its novelty lies in integrating established flow measurement technology with the mine dewatering forecasting workflow and a structured Plan–Do–Check–Act (PDCA) improvement process at an operating mine site (Fernandes et al., 2022; Nguyen et al., 2023). This contribution is contextual and operational rather than a claim to have invented ultrasonic flow measurement or IoT-based monitoring. By linking measurement, interpretation, corrective action, and standardization, SIMPATIK provides a practical approach to improving the quality and timeliness of information used in mine dewatering planning.

This study aimed to evaluate whether SIMPATIK could improve pumping forecast accuracy in the South Special Design Pit compared with the previous practice of weekly manual discharge verification. Specifically, the study sought to identify the principal causes of forecast deviations, determine an appropriate pump operating range through hydraulic calculations, implement continuous pump discharge monitoring, and compare forecast water-

level reductions with actual observations before and after implementation. The improvement target was to increase the site's reported forecast accuracy from approximately 50% to more than 90%. The evaluation also considered quality, cost, delivery, safety, and morale (QCDSM) to assess the broader operational implications of the monitoring system during the implementation period from August 2025 to March 2026.

The expected contribution of this study is field-based evidence regarding the role of timely pump discharge information in strengthening dewatering planning at an active open-pit coal mine. For engineering teams, the study provides a practical basis for updating pumping forecasts and identifying reductions in pump discharge at an earlier stage. For operational management, it may support improved coordination among pit accessibility, coal exposure targets, and equipment scheduling. Remote monitoring may also reduce the frequency of manual measurements near water bodies and provide an accessible historical data record for subsequent performance evaluation. Beyond the immediate jobsite, the findings may inform decisions regarding the adoption of comparable monitoring systems in other mine dewatering areas, while recognizing that their transferability depends on local hydraulic conditions, sensor performance, communication reliability, and the forecasting procedures employed.

METHODS

This study employed a problem-solving approach based on the Plan–Do–Check–Act (PDCA) cycle, comprising eight steps adapted from the Quality Control Project (QCP) framework implemented at PT AMM (Cuya-Acuña et al., 2025; Fernandes et al., 2022). The research was conducted from the initial problem identification in August 2025 through final evaluation and standardization in March 2026. A summary of the research stages is presented in Table 1.

Table 1. Stages of PDCA-Based Research Methods

No.	Stage (PDCA)	Activities	Output
1	Plan (Steps 1–4)	Identification & stratification of problems, determination of themes and titles, impact analysis on stakeholders, goal setting (SMART), determination of root causes and solutions based on 4M factors (Man, Machine, Method, Material), as well as risk analysis and improvement plans.	Approved SMART themes, titles, goals, and improvement action plans
2	Do (Step 5)	Calculation of optimal discharge of pumps, design and installation of microcontroller-based ultrasonic clamp-on flowmeters and data loggers, and implementation of data monitoring and measurement.	Built-in flowmeter tool and real-time discharge data available
3	Check (Step 6)	Evaluation of improvement results based on QCDSM (Quality, Cost, Delivery, Safety, Morale) aspects, analysis of target	Comparison of conditions before and after improvement

Determination of Solution

Table 2. Determination of Solutions Based on 4M Factors

Factors	Root Causes	Improvement Action Plan
Man	Pump discharge monitoring is only carried out once per week due to the remote location of the pump outlet.	Monitor pump discharge every hour through a digital system.
Machine	Pump discharge monitoring is carried out manually using a flowbar.	Create a pump discharge monitoring tool automatically.
Method	There is no actual pump discharge monitoring method available.	Building internet-based (IoT) pump outflow discharge monitoring media.
Material	Delay in lowering water elevation in submerged areas.	Prepare a dewatering plan with a forecast accuracy target of above 90%.

Optimal Pump Discharge Design and Calculation

Before improvement, the verification of pump outflow discharge can only be done manually using a flowbar which requires the operator to be near the point of falling water (Figure 2), so that in addition to being a risk to work safety, the frequency of data collection is also very limited.



Figure 2. Existing Conditions of Manual Discharge Data Retrieval Using the Flowbar

The determination of the optimal discharge of the pump is carried out by calculating the total head of the piping system (H_s , H_v , and H_f) at various discharge variations, based on data on inlet elevation, outlet elevation, length, and diameter of the actual HDPE pipe in the field, then compared to the performance curve of the Multiflo 420EXHV pump (Figure 3) (Halim et al., 2022; Prabawa et al., 2026). The calculation results show that the optimal operational discharge of the pump is in the range of 650–720 m³/h with engine rotation (RPM) of 1200–1250.

Implementation and Monitoring

Table 3. Improvement Action Plan (What–How–Why–Where)

Yes	Root Cause	What (Action)	How	Why (Purpose)	Where
1	Pump outflow discharge monitoring is done manually using a flowbar.	Creating an actual pump monitoring tool.	Automation of water discharge monitoring using microcontrollers and data loggers.	Improve the accuracy of pump discharge data.	Special Design Pit South
2	Pump discharge monitoring is only carried out once per week due to distant outflow conditions.	Monitor pump discharge every hour.	Build a real-time pump discharge monitoring system based on the internet.	Increase the frequency and speed of pump discharge monitoring.	Office Engineering

After installation, the monitoring dashboard displays the actual flow rate in real-time along with the daily and monthly discharge accumulation (Figure 5), so that discharge decreases due to disruptions in the pumping system can be immediately known and followed up by the engineering team without having to wait for a weekly manual measurement schedule.



Figure 5. Realtime Flowmeter Monitoring Dashboard

RESULTS AND DISCUSSION

The evaluation of the success of the improvement was carried out by comparing the forecast of the decrease in water elevation to the actual conditions, both in the period before the improvement (using the manual flowbar) and after the improvement (using the realtime flowmeter), as shown in Figure 6.

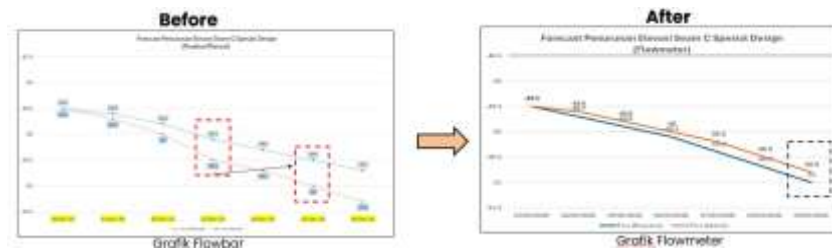


Figure 6. Comparison of Forecast Graph of Water Elevation Decrease Before (Flowbar) and After (Flowmeter) Improvement

Under the conditions before the improvement, the forecast for a decrease in water elevation to -49.5 is planned to be achieved on December 23, 2025, but it will actually only be achieved on December 25, 2025, with an average pump outflow discharge deviation of 23,214 m³/day from the plan or equivalent to the forecast accuracy level of around 50%. After the improvement, the forecast and actual decrease in water elevation show a much more consistent trend, with the forecast accuracy rate increasing to above 90%, even reaching more than 95% in the March 2026 evaluation.

Table 4. Analysis of Target Achievement Based on QCDSM Aspects

Aspect (QCDSM)	Conditions Before Improvement	Improvement Goals	Conditions After Improvement
Quality	The accuracy of the pumping forecast is only 50%.	Pumping forecast accuracy >90%.	Pumping forecast accuracy >95%.
Cost	The cost of assembling the flowmeter (vendor) is IDR 138,236,000.	Reducing the cost of assembly of the tool to ±Rp16,280,000; reducing the potential pending volume of Rp5,076,622,566.	The cost of assembling the tool ±Rp16,280,000; the Special Design area was completed according to plan.
Delivery	Manual discharge data retrieval, takes travel time to the outlet (±10 km) and is only 1×/week.	Debit data collection is done in real-time.	Debit data is automatically monitored through an internet-based dashboard.
Safety	Manual measurements with flowbars are carried out near bodies of water (potential hazards).	Reduce activities near water and potential occupational hazards.	Debit data retrieval is done from an application that can be accessed via the internet.
Morals	The engineering team is not confident in the sump drying forecast.	Increase the team's confidence in the sump drying plan.	The engineering team is more confident in the sump drying plan so that the sequence in the lowest

Aspect (QCDSM)	Conditions Before Improvement	Improvement Goals	Conditions After Improvement
			point area can be done according to plan.

In terms of cost, the implementation of the assembled flowmeter itself has succeeded in reducing the cost of assembling monitoring equipment from IDR 138,236,000 (if using vendor services) to around IDR 16,280,000, or cost efficiency of around 88%. In addition, increasing forecast accuracy also prevents potential losses due to the pending volume of waterlogged areas of 190,521 Bcm, which if converted using a unit price of IDR 26,646 per bcm is equivalent to a potential loss of IDR 5,076,622,566 that was successfully avoided.

In terms of production, the improvement in forecast accuracy and the acceleration of the drying of the South Special Design Pit area contributed to an increase in overburden production from 689,400 bcm to 879,400 bcm, in line with the Seam C Coal exposure target of 206,733 MT which can be done according to the planned mining sequence.

From the aspect of work safety, the implementation of real-time flowmeters has succeeded in eliminating the need for operators to manually take discharge data near water bodies, thereby eliminating potential work hazards in the area. This was also confirmed by the SHE team and the field team who stated that discharge monitoring can now be carried out more safely, quickly, and efficiently without the need for risky manual measurements. From the aspect of work morale, the availability of accurate and real-time discharge data also increases the confidence of the engineering team in preparing sump drying plans in the following periods, as well as accelerating the troubleshooting process for the pump technician team when there are indications of a decrease in unit performance.

As a follow-up to the success of this improvement, PT AMM Jobsite Mifa Bersaudara ratified a new standard in the form of Flowmeter Operation Work Instruction (Doc No. AMM-MIFA-IK-ENG-25/26) and planned the replication of the discharge monitoring device installation to all pumping areas. The author and team also set the next improvement theme, namely increasing the accuracy of the pump's Effective Working Hours (EWH) forecast from 70% to 95% by utilizing additional IoT-based sensors to determine the maximum limit of pumping capacity in the South Pit by 2026.

CONCLUSION

The implementation of SIMPATIK, an Internet of Things (IoT)-based real-time pump discharge monitoring system incorporating a clamp-on ultrasonic flow sensor based on the transit-time measurement principle, a microcontroller, and a data logger, improved pumping forecast accuracy in the South Special Design Pit at the PT Antareja Mahada Makmur (AMM) Mifa Bersaudara jobsite from approximately 50% to more than 95%. The improved monitoring supported more reliable dewatering planning and the timely exposure of 206,733 metric tons (MT) of Seam C coal. During the implementation period, overburden production increased from 689,400 to 879,400 bank cubic meters (BCM) in accordance with the planned mining sequence.

In addition to improvements in forecast accuracy and operational performance, the system reduced monitoring equipment assembly costs by approximately 88%, from IDR 138,236,000 to IDR 16,280,000. The implementation was also associated with the avoidance of an estimated potential loss of IDR 5,076,622,566 related to delayed mining activities in inundated areas. From an occupational safety perspective, digitalization of pump discharge monitoring reduced the need for personnel to perform manual measurements near water bodies, thereby minimizing exposure to operational hazards. Continuous access to discharge data also improved the engineering team's ability to plan subsequent sump dewatering activities.

The authors recommend expanding the IoT-based pump discharge monitoring system to other dewatering pumping units at the PT AMM Mifa Bersaudara jobsite after verifying its performance under different hydraulic and operational conditions. Further development could integrate an early warning system and condition-based or predictive maintenance functions to identify deterioration in pump performance. Future research should also examine the relationship between effective working hours (EWH), pump availability, actual discharge, and achievable pumping capacity to support the development of more reliable and sustainable mine water management strategies.

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CONFLICT OF INTEREST

The author states that there are no conflicts of interest, whether personal, commercial, or financial, that can affect the implementation and results of this study.

AUTHOR'S CONTRIBUTION

Felix Suranta Sihotang contributes to research design, data collection and processing, system development, result analysis, and article manuscript preparation.

GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

In the process of compiling this article, the author uses generative artificial intelligence (AI) as a tool in language refinement, writing structure, and grammar improvement. The use of AI is carried out on a limited basis and remains under the supervision of the author. All data, analysis, interpretation, and scientific substance in this article have been checked and verified by the author. The author is solely responsible for the accuracy, authenticity, and final content of the manuscript.

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