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RISK ANALYSIS AND RISK MONITORING FOR PROJECT: CASE STUDY ON CONVEYOR CONSTRUCTION PROJECT

ANALISIS RISIKO DAN PEMANTAUAN RISIKO UNTUK PROYEK: STUDI KASUS PROYEK KONSTRUKSI KONVEYOR

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ABSTRACT

PT Bukit Asam Tbk has ambitious production and sales targets for its long-term planning. Meanwhile, research shows that coal prices tend to be stable and declining, while oil prices tend to rise. The condition requires PTBA to maintain control over production costs and maximize profits. To improve production efficiency, reengineering is necessary to achieve the lowest possible production costs while maximizing output. One of PTBA's efforts to improve production efficiency is the construction of an in-mine conveyor, a solution for coal handling, which currently relies on trucking for this route. Ensuring sufficient capital expenditure is crucial to project success. In addition to commitment from all parties, consistent risk management is also necessary to identify and mitigate potential risks that could derail project objectives. However, it is understood that, under current conditions, the project's risk management practices are not yet integrated or comprehensive. A gap analysis was conducted to assess the effectiveness of PTBA's current project risk management implementation, comparing it with international standards (ISO 31000:2018) and PTBA procedures. The study revealed that risk management in the PTBA project was not yet well established, as evidenced by risks not identified in the initial risk list. The risk analysis process was not comprehensive, as evidenced by the continued reliance on qualitative expert assessments despite the availability of quantifiable data. Furthermore, risk prioritization was not carried out, leading to all risks being mitigated, even those considered low or low to moderate, and a lack of focus on significant risks. Furthermore, monitoring for the conveyor project within the mine was inconsistent. Recognizing this alignment, a re-identification was conducted by first compiling an analysis document of the project's internal and external factors using the 5M (People, Machines, Methods, Money, Materials) and PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) analysis. A risk analysis of the conveyor project's risk levels within the mine was conducted, specifically calculating their impacts and simulating them in a financial model to determine the project's NPV and IRR. Next, risk prioritization was undertaken to identify the Project's Key Risks. Furthermore, a mitigation plan was developed, including the Project Implementation Unit (PIC), outputs/deliverables, and timeframe. In addition, key risk indicators (KRIs) are designed to provide early warning signs for each risk. Routine monitoring of these Key Risks is planned at least once a month, with more frequent monitoring if needed.

Keywords: *Risk Management, Project Risk Management, Risk Identification, Risk Analysis, Risk Monitoring, ISO 31000:2018, Top Risk, Key Risk Indicators*

ABSTRAK

PT Bukit Asam Tbk memiliki target produksi dan penjualan yang ambisius dalam perencanaan jangka panjangnya. Sementara itu, penelitian menunjukkan bahwa harga batu bara cenderung stabil dan menurun, sedangkan harga minyak cenderung naik. Kondisi ini mengharuskan PTBA untuk menjaga kendali atas biaya produksi dan memaksimalkan keuntungan. Untuk meningkatkan efisiensi produksi, reengineering diperlukan untuk mencapai biaya produksi terendah sambil memaksimalkan output. Salah satu upaya PTBA untuk meningkatkan efisiensi produksi adalah pembangunan konveyor dalam tambang, solusi untuk penanganan batubara, yang saat ini masih mengandalkan truk untuk rute tersebut. Memastikan pengeluaran modal yang cukup sangat krusial untuk kesuksesan proyek. Selain komitmen dari semua pihak, manajemen risiko yang konsisten juga diperlukan untuk mengidentifikasi dan mitigasi risiko potensial yang dapat menggagalkan tujuan proyek. Namun, dipahami bahwa, dalam kondisi saat ini, praktik manajemen risiko proyek PTBA belum terintegrasi atau komprehensif. Analisis kesenjangan dilakukan untuk mengevaluasi efektivitas implementasi manajemen risiko proyek PTBA saat ini, dengan membandingkannya dengan standar internasional (ISO 31000:2018) dan prosedur PTBA. Studi tersebut menunjukkan bahwa manajemen risiko dalam proyek PTBA belum terstruktur dengan baik, sebagaimana terlihat dari risiko yang tidak teridentifikasi dalam daftar risiko awal. Proses analisis risiko tidak komprehensif, sebagaimana dibuktikan oleh ketergantungan yang terus berlanjut pada penilaian ahli kualitatif meskipun data kuantitatif tersedia. Selain itu, prioritas risiko tidak dilakukan, sehingga semua risiko diatasi, termasuk yang dianggap rendah atau rendah hingga sedang, dan kurangnya fokus pada risiko yang signifikan. Selain itu, pemantauan proyek konveyor di dalam tambang tidak konsisten. Mengakui keselarasan ini, dilakukan re-identifikasi dengan terlebih dahulu menyusun dokumen analisis faktor internal dan eksternal proyek menggunakan analisis 5M (Manusia, Mesin, Metode, Uang, Bahan) dan PESTEL (Politik, Ekonomi, Sosial, Teknologi, Lingkungan, dan Hukum). Analisis risiko tingkat risiko proyek konveyor di dalam tambang dilakukan, termasuk perhitungan dampaknya dan simulasi dalam model keuangan untuk menentukan NPV dan IRR proyek. Selanjutnya, prioritas risiko dilakukan untuk mengidentifikasi Risiko Utama Proyek. Selain itu, rencana mitigasi dikembangkan, termasuk Unit Pelaksana Proyek (PIC), output/deliverables, dan jangka waktu. Selain itu, indikator risiko kunci (KRIs) dirancang untuk memberikan peringatan dini untuk setiap risiko. Pemantauan rutin terhadap Risiko Kunci ini direncanakan setidaknya sekali sebulan, dengan pemantauan lebih sering jika diperlukan.

Kata kunci: Manajemen Risiko, Manajemen Risiko Proyek, Identifikasi Risiko, Analisis Risiko, Pemantauan Risiko, ISO 31000:2018, Risiko Utama, Indikator Risiko Utama

INTRODUCTION

PT Bukit Asam Tbk (PTBA) targets consolidated coal production and sales of around 75 million tons by 2029 under its 2025–2029 Long-Term Corporate Plan, requiring strong cost leadership, operational efficiency, and supply chain optimization. Although global and Indonesian economic growth prospects are relatively positive, coal prices from 2025–2029 are projected to remain stable with a downward trend (Wood Mackenzie, 2024; McCloskey, 2024). At the same time, production costs face pressure from rising crude oil prices, assumed at USD 82 per barrel in the 2025 State Budget, and additional regulatory burdens such as the B40 fuel mandate. This divergence between coal price trends and input costs poses challenges for PTBA in maintaining profitability and cost control.

To address efficiency challenges, PTBA initiated an in-pit conveyor project to replace the trucking system for coal handling from Pit A to Stockpile A. The conveyor system offers lower transportation costs, improved operational reliability, optimized electricity utilization from the Tanjung Enim power plant, enhanced safety, and reduced carbon emissions. A feasibility study indicates the project is financially viable, with an NPV of Rp192 billion and an IRR of 17% at a 13% hurdle rate. With the project's large capital expenditure which is nearly 18% of PTBA's 2024 net profit, ensuring successful implementation through effective risk management and implementation is critical.

However, weaknesses in project-level risk management have emerged. While PTBA adopts enterprise and project risk management frameworks aligned with ISO 31000:2018, monitoring and review of mitigation plans have not been conducted consistently. Some risks, such as a landslide during the pre-implementation phase, were not identified in the initial risk register, highlighting gaps in risk identification and ongoing monitoring. Prior studies note that insufficient risk monitoring can lead to unexpected project issues (Browning, 2019). Given PTBA's large investment portfolio and regulatory requirements from the Ministry of SOEs, strengthening comprehensive and continuous project risk management is essential to ensure project success, regulatory compliance, and sustainable value creation.

LITERATURE REVIEW

Risk Management

The purpose of risk management, according to ISO 31000:2018, is value creation and protection by directing and controlling companies in relation to risk.

Integrity, structure, personalization, inclusivity, dynamic, dependability on best available information, cultural and human element consideration, and continuous improvement are some of its guiding principles. PTBA's Risk Management Guidelines (2023) incorporate these principles by integrating risk management into every aspect of the organization. This is done through a framework that includes leadership and commitment, integration, design, implementation, evaluation, and continuous improvement. By doing so, the guidelines aim to support long-term organizational performance and ensure alignment with both internal and external contexts (PTBA, 2023; ISO, 2018).

Risk Management Process

The risk management process at PTBA follows ISO 31000:2018 and consists of systematic stages designed to manage risks in a measurable and controlled manner. These stages include communication and consultation, determining scope, context, and criteria, risk assessment (identification, analysis, and evaluation), risk treatment, monitoring and review, and recording and reporting. Risk treatment options include risk acceptance, transfer, avoidance, and reduction, selected based on cost-benefit considerations and alignment with the company’s risk appetite. Continuous monitoring and documentation ensure that risk management remains effective, transparent, and responsive to changes in both the internal and external environment (ISO, 2018; PTBA, 2023).

Project

A project is a temporary endeavor undertaken to create a unique product, service, or result, characterized by a defined beginning and end (Project Management Institute, 2021). Projects operate in environments with varying degrees of uncertainty arising from economic, technical, regulatory, physical, social, and political factors. These uncertainties manifest as risks, ambiguity, and complexity, which can influence project outcomes. Effective project management requires understanding the broader project environment and applying appropriate management approaches to address uncertainty, thereby enabling project teams to manage potential threats and opportunities throughout the project lifecycle (PMI, 2021).

Project Risk Management

Project risk management aims to ensure that project objectives are achieved by proactively identifying, analyzing, and responding to risks that may affect project performance. Risk is defined as an uncertain event or condition that can have positive or negative impacts on project objectives, where negative risks are threats and positive risks are opportunities (PMI, 2021). Effective project risk management requires defining acceptable risk exposure through risk thresholds aligned with organizational risk appetite, managing both individual risks and overall project risk. Comprehensive risk identification is critical, as it forms the foundation for subsequent analysis and mitigation, particularly in complex and uncertain project environments (PMI, 2021; Bai et al., 2025).

Risk Limit

Risk limits define the boundaries within which risks are managed to protect and create organizational value. These limits are derived from key parameters such as risk capacity, risk appetite, and risk tolerance. Risk capacity represents the maximum level of risk a company can bear, while risk appetite defines the level of risk management is willing to accept to achieve strategic objectives, and risk tolerance represents acceptable deviations beyond the appetite (van Greuning & Brajovic Bratanovic, 2020). In Indonesian SOEs, these concepts are regulated under Ministerial Regulation No. 2 of 2023 and its Technical Guidelines SK-6, ensuring that risk limits are clearly defined, measurable, and aligned with financial strength and governance requirements (Ling et al., 2022; Ministry of SOEs, 2023).

Risk Analysis

Risk analysis aims to understand the nature, likelihood, and impact of risks, considering uncertainties, causes, consequences, and the effectiveness of existing controls (ISO, 2018). The analysis may be qualitative, quantitative, or a combination of both, depending on objectives, data availability, and resource constraints. Under Technical Guidelines SK-6, risk impacts are categorized as quantitative or qualitative, with structured approaches used to calculate inherent and residual risks. Risk levels are determined using defined impact and probability scales, enabling organizations to prioritize risks consistently and transparently while acknowledging the limitations and assumptions inherent in risk analysis (ISO, 2018; Ministry of SOEs, 2023).

Project Risk Monitoring

Project risk monitoring and review are essential to ensure the effectiveness of risk management design, implementation, and outcomes. ISO 31000:2018 emphasizes that monitoring and review should be continuous and integrated into organizational performance and reporting systems. In practice, inadequate monitoring systems can cause project problems to remain hidden until they escalate into major issues (Browning, 2019). Consistent monitoring enables early detection of deviations, assessment of mitigation effectiveness, and timely corrective actions, thereby reducing the likelihood of project failure and ensuring compliance with regulatory and governance requirements (ISO, 2018; Browning, 2019; Hubbard, 2009).

Key Risk Indicators

Key Risk Indicators (KRIs) are measurable metrics that provide early warning signals of increasing risk exposure and support proactive risk management (PTBA, 2023). Effective KRIs must be relevant, objectively measurable, sensitive to changes in risk levels, timely, and easily understood. By defining thresholds that trigger specific management actions, KRIs help risk owners monitor risk trends and respond before risks materialize. Regular monitoring and communication of KRI values strengthen organizational resilience and enhance the effectiveness of both enterprise and project-level risk management (PTBA, 2023).

RESEARCH METHODS

Research Design

This study applies a qualitative case study design focusing on the Inpit Conveyor Project to comprehensively examine the implementation of project risk management at PTBA, particularly in risk analysis and monitoring. The approach is chosen to enable an in-depth understanding of current practices and to conduct a gap analysis between existing conditions and ideal standards based on regulations, ISO 31000:2018, and relevant benchmarks. The research process includes formulating research questions, collecting and reviewing risk-related data, updating the risk register, developing mitigation measures, and establishing Key Risk Indicators (KRIs) to support effective risk monitoring and achievement of project objectives.

Data Collection Method

Data collection in this study utilizes both primary and secondary data sources within a qualitative case study framework. Primary data are obtained from internal documents such as risk registers, feasibility studies, project risk criteria, and project reports related to the Inpit Conveyor Project. Secondary data are gathered from PTBA's governance documents, applicable regulations, international standards (ISO 31000:2018), and relevant literature. This combination of data sources supports a comprehensive gap analysis and ensures that the proposed improvements in project risk management align with regulatory requirements and recognized best practices.

Data Analysis Method

The study employs thematic analysis, content analysis, and gap analysis to evaluate and improve project risk management implementation. Content analysis is used to examine documents such as risk registers, feasibility studies, and governance frameworks, while gap analysis compares current practices with ideal standards and benchmarks. These qualitative methods are appropriate because the data are descriptive and the research aims to assess processes rather than test statistical relationships, allowing for flexible and systematic identification of weaknesses and development of practical improvement recommendations.

RESULTS AND DISCUSSION

Analysis

Aligned with ISO 31000:2018 and Ministerial Regulation 02/2023, the risk management process begins with comprehensive risk identification, followed by risk analysis, risk treatment determination, and risk monitoring. In the inpit conveyor project, the risk management process ended at preparing a risk register, and risk monitoring was not yet consistent. In reviewing the landslide incident, it was also understood that the initial risk register was insufficient because it did not capture landslide-related events, so mitigation steps were not planned from the outset. As part of the evaluation, a gap analysis was conducted to identify gaps in the risk management of the inpit conveyor project relative to external practices. After identifying gaps in the implementation of risk management for the inpit conveyor project (the current condition relative to ISO standards and national regulations), the next step was to evaluate and address them.

Gap of Risk Criteria

Currently, the risk criteria use ERM criteria as Table below.

Table 1. Risk Criteria - Impact

Rating	Impact Aspects Non-Fraud Risk				
	Target	Financial	Health & Safety	Community	Enviromental
1	Reduce target achievement by <2.5%	Actual Loss, Potential Loss, Opportunity Loss ≤ 20% Risk Limit	Injury/illness requiring first aid	There were no disruptions due to company operations.	Incidental, controlled, and localized impact / Recovery time ≤ 1 month /

Rating	**Impact Aspects**				
	Non-Fraud Risk				
	Target	**Financial**	**Health & Safety**	**Community**	**Enviromental**
2	Reduce target achievement by 2.5% to 5%	20% Risk Limit < Actual Loss, Potential Loss, Opportunity Loss ≤ 40% Risk Limit	(first aid treatment)	There were incidents of disruption caused by company operations that affected the community, but did not result in public complaints.	Hydrocarbon spill ≤ 200 L
3	Reduce target achievement by 5% to 7.5%	40% Risk Limit < Actual Loss, Potential Loss, Opportunity Loss ≤ 60% Risk Limit	Injury/illness requiring medical treatment and not resulting in lost workdays	There were incidents of disruption caused by company operations that affected the community, resulting in complaints and compensation.	Small-scale loss / Recovery time between 1 month and 1 year / Hydrocarbon spill between 200 and 3,000 L
4	Reduce target achievement by 7.5% to 10%	60% Risk Limit < Actual Loss, Potential Loss, Opportunity Loss ≤ 80% Risk Limit	Injury/illness resulting in lost workdays	There were incidents of disruption caused by company operations that affected the community, resulting in demonstrations and compensation.	Small-scale loss / Recovery time between 1 year and 3 years / Hydrocarbon spill between 3,000 and 20,000 L
5	Reduce target achievement by >10%	Actual Loss, Potential Loss, Opportunity Loss > 80% Risk Limit	Single Fatality / Permanent Disability	There were incidents of disruption caused by company operations that affected the community, resulting in demonstrations, compensation, and lawsuits.	Large-scale loss / Recovery time between 3 years and 5 years / Hydrocarbon spill between 20,000 and 100,000 L

Rating	**Impact Aspects**			
	Non-Fraud & Fraud Risk		Fraud Risk	
	Law	Reputation	Financial	Related Parties
1	Violations of regulations with verbal warnings	No publicity and/or resulting in employee dissatisfaction with the Company	< Rp 1.000.000	Outsourced/Contract Employees
2	Violations of regulations, legal issues, and non-compliance with	Limited publicity by local media and/or resulting in integrity issues within the	Rp 1.000.000 ≤ x < Rp 10.000.000	Staff

	regulations, with written warnings	Company that can be resolved immediately		
3	Violations of regulations with the possibility of investigation by the authorities	Publicity by national media and/or resulting in severe and widespread integrity issues within the Company	Rp 10.000.000 ≤ x < Rp 50.000.000	Unit Head/Manager/Section Head
4	Employees and/or management (BOD/BOC) are subject to criminal penalties with a sentence of <5 years	Serious publicity by national media/social media and/or resulting in severe and widespread integrity issues within the Company, as well as increasing employee turnover	Rp 50.000.000 ≤ x ≤ Rp 100.000.000	Division Head/Senior Manager/General Manager/Department Head
5	Employees and/or management (BOD/BOC) are subject to criminal penalties with a sentence of >5 years	Serious publicity by national and international media/going viral on social media, threatening business continuity and/or resulting in severe and widespread integrity issues within the Company, as well as several Company officials resigning	> Rp100.000.000	Group Head/Board of Directors/Board of Commissioners

The ERM impact risk criteria for the in-pit conveyor project remain relevant because the project is being implemented in the PTBA operational area. The potential impact of Health, Safety, and Environment (HSE), community/social, legal, reputational, or fraud of the project will be the same as if they occurred during business-as-usual or operations. However, specifically for financial impacts, it is less relevant to use the corporate risk limit reference, because it is understood that the corporate risk limit refers to the company's risk capacity, which is very large (referring to the calculation of the annual financial target distress, which in 2025, the risk capacity reaches around 3 trillion Rupiah). The company's risk capacity is not commensurate with the project's investment value. Therefore, a recalculation was carried out to determine the risk limit specifically for the in-pit conveyor project. To calculate the risk limit, the risk tolerance was first calculated, as the risk limit is 60% of the risk tolerance. This formula is a directive from the shareholders when preparing the company's risk capacity. The following is the formula and results of the risk tolerance calculation for the inpit conveyor project.

$$RT = \left(\frac{RT\ RKAP}{RC\ RKAP}\right) x\ RC\ Project$$

Risk Capacity Project = Rp919.067.000.000

Risk Tolerance Project =

$$RT = \left(\frac{Rp666.088.000.000}{Rp3.047.604.000.000}\right) x\ 919.067.000.000$$

$$= \text{Rp}200.872.000.000$$

Risk Limit Project = 60% x Risk Tolerance = 60% x Rp200.872.000.000

= Rp120.523.000.000

Thus, the criteria for the project impact of financial risk are as follows:

Table 1. Financial Risk Criteria Project Inpit Conveyor

Rating	Financial Aspects (in Million Rp)
1	Actual Loss, Potential Loss, Opportunity Loss ≤ 24.105
2	24.105< Actual Loss, Potential Loss, Opportunity Loss ≤ 48.209
3	48.209< Actual Loss, Potential Loss, Opportunity Loss ≤ 72.314
4	72.314< Actual Loss, Potential Loss, Opportunity Loss ≤ 96.419
5	Actual Loss, Potential Loss, Opportunity Loss > 96.419

In addition, the probability criteria used in the project are the same as the ERM criteria, as they remain relevant and facilitate aggregation if necessary. The project risk criteria are shown in Table 4 below.

Table 2. Risk Criteria - Likelihood

Rating	Likelihood Aspects			
	Decription	**Likelihood**	**Frequency**	**Remarks**
1	Rare	X < 20%	At most once a year	Very Rare
2	Unlikely	20% ≤ X < 40%	Once every 6 months	Rarely Occurs
3	Possible	40% ≤ X < 60%	Once every 4 months	Could Happen
4	Likely	60% ≤ X < 80%	Once every 2 months	Very Likely to Happen
5	Almost Certain	X ≥ 80%	Once 1 month	Almost Certain to Happen

Risk calculations use mapping results with the following risk scale, which matches ERM (see Table 5 below).

Skala Risiko	Level Risiko
1 – 5	*Low*
6 – 11	*Low to Moderate*
12 – 15	*Moderate*
16 – 19	*Moderate to High*
20 – 25	*High*

Figure 1. Risk Scale of Project

The Risk Map contains information on the position of inherent and residual risks in the mapping of the aggregation and calibration results scale between the probability scale and the impact scale, with reference to the following matrix.

PROBABILITAS						
	Hampir Pasti Terjadi 5	Low to Moderate 7	Moderate 12	Moderate to High 17	High 22	High 25
	Sangat Mungkin Terjadi 4	Low 4	Low to Moderate 9	Moderate 14	Moderate to High 19	High 24
	Bisa Terjadi 3	Low 3	Low to Moderate 8	Moderate 13	Moderate to High 18	High 23
	Jarang Terjadi 2	Low 2	Low to Moderate 6	Low to Moderate 11	Moderate to High 16	High 21
	Sangat Jarang Terjadi 1	Low 1	Low 5	Low to Moderate 10	Moderate 15	High 20
		Sangat Rendah 1	Rendah 2	Moderat 3	Tinggi 4	Sangat Tinggi 5
		DAMPAK				

Figure 2. Risk Map of Project

Gap of Risk Identification

Currently, the Conveyor Inpit project's risk register contains 24 risk events, all identified by the Risk Management unit. Recognizing the potential for unidentified risks. The risk register was updated by first compiling the project's internal and external factors. In this risk identification, there is no landslide risk, whereas in the current conditions, landslides have occurred. This indicates that the risk identification is not yet comprehensive. With new input data, including the internal and external context of the project, as well as several other inputs such as the current project conditions, several new risks were identified The addition of these risks increased the number of identified risks for the in-pit conveyor project from 24 to 31 risk events.

GAP Risk Analysis

In addition to reviewing and evaluating the identified risks, the previously used qualitative impact calculation methods were also reviewed. Based on the evaluation, several risks can be quantified, including:

Table 5. Quantitative Impact Calculation

No	Risk Event
5	Completion of the engineering work and detailed engineering design was behind schedule.
17	Investment costs exceed the planned budget.
18	The selected construction contractor and/or construction management consultants fail to perform.
20	Construction of the in-pit conveyor is completed behind schedule.
26	Land development has exceeded the planned timeframe.

The quantitative impact calculation is detailed as calculated on Table 8. If the commercialization schedule cannot utilize the in-pit conveyor, costs will be required to prepare the trucking system infrastructure to Dump Hopper A, which will be as follows.

Table 6. Additional Cost Calculation

Infrastructure cost	**Rp171Billion**
Operational Cost	**Rp 23Billion**

For the R05, if the completion of the engineering work and detailed engineering design was behind schedule, the potential delay for engineering work is 1 month, with the inherent quantitative impact calculation and its influence on NPV and IRR as follows.

Table 7. Impact Calculation for For R05

Infrastructure Costs	Rp 171Billion
Operational Costs (1 months)	Rp23Billion
Total	Rp195Billion
NPV Adjusted	35,821,815,724
IRR	11.64%

For R17, R18, R20, R26, it is assumed that the project will not be commercially viable in August 2026. If the project cannot be finished as scheduled, it will impact the 2026 Work Plan and Budget (RKAP) performance. Therefore, if the project is not operational between September until December 2026, the financial impact on 2026 performance and its influence on NPV and IRR as follows.

Table 8. Impact Calculation for For R17, R18, R20, R26

Infrastructure Costs	Rp 171Billion
Operational Costs (4 months)	Rp94Billion
Total	Rp265Billion
NPV Adjusted	(28,164,237,015)
IRR	9.69%

Based on the quantitative analysis, there is an update on the risk level of the five quantitative risks as table follows.

Table 9. Update on Inherent Risk Level

No	Risk Event	Current Inherent Risk			Update Inherent Risk		
		LI	LP	LR	LI	LP	LR
5	Completion of the engineering work and detailed engineering design was behind schedule.	3	4	18	5	3	23
17	Investment costs exceed the planned budget.	4	4	19	5	4	24
18	The selected construction contractor and/or construction management consultants fail to perform.	4	4	19	5	4	24
20	Construction of the in-pit conveyor is completed behind schedule.	4	4	19	5	4	24
26	Land development has exceeded the planned timeframe.	4	4	19	5	4	24

IV.1.1. Gap of Risk Monitoring

To conduct risk monitoring, key risk indicator parameters are set to serve as an early warning system/trigger, enabling risks to be addressed promptly. For each critical risk, relevant KRI parameters are determined. KRI parameters are determined through discussions with the Project Team. In this initial stage, the risks are monitored most frequently, and the KRIs are determined for each Top Risk of the Inpit Conveyor Project.

Table 10. Key Risk Indicator for Top Risk

No	Risk Event	Level Inherent	KRI
5	Completion of the engineering work and detailed engineering design was behind schedule.	23	Percentage of engineering documents and DED completion
17	Investment costs exceed the planned budget.	24	Cost Performance Index (CPI)

18	The selected construction contractor and/or construction management consultants fail to perform.	24	Percentage of qualified personnel
19	A dispute arises between the agreement and the partners.	22	Number of third-party claim notifications
20	Construction of the in-pit conveyor is completed behind schedule.	24	Schedule Performance Index (SPI)
26	Land development has exceeded the planned timeframe.	24	Slope movement monitoring results, realization of land preparation

For each of these parameters, a KRI threshold is determined, divided into three levels according to PTBA's internal procedures: safe, cautious, and dangerous. The following explains each KRI and its respective thresholds.

Business Solution

After analyzing the risk register, six top risks were identified, and mitigation plans for each were developed as follows.

Table 11. Mitigation Plan for Top Risk

Number	**Risk Event**	**Mitigation Plan**
R07	Completion of the engineering work and detailed engineering design was behind schedule.	Create a design approval flow with deadlines for submission, rework (return and resubmission), and approval from the Contractor and the user.
		Determine the required number and competency of the Engineering Team and monitor compliance.
		Conduct face-to-face discussions if there are document rejections or repeated revisions.
R17	Investment costs exceed the planned budget.	Control and monitor the materials and spare parts used by the Contractor to ensure compliance with the agreed specifications and costs.
		Evaluate the engineering stage to ensure the design is complete and detailed.
		Require in the agreement clause that design changes that impact time and cost be made based on the Work Instruction form approved by PTBA.
		Conduct periodic monitoring and evaluation of project cost realization, including verification of purchase orders/invoices/other payment bases.
		Intensively monitor unit price work and verify work output.
		Strive to ensure costs across the entire scope of work are fixed costs in accordance with the initial budget plan, except for specific tasks (unit price).
R18	The selected construction	Establish prequalification requirements related to the minimum financial conditions that the contractor must meet.

	contractor and/or construction management consultants fail to perform.	Clearly define the contractor and/or consultant assessment qualifications in the procurement documents.
		Evaluate competent and experienced Construction Management Consultant consultants to assist with project oversight.
		Impose fines on the contractor for work delays that do not meet the plan.
		Monitor progress regularly and establish warning indicators if progress is delayed.
		Routinely evaluate the performance and competence of the contractor and Construction Management Consultant.
		Implement a Performance Bond of 5% of the Agreement Value, which can be liquidated if the contractor defaults.
R19	A dispute arises between the agreement and the partners.	Identify and define the main points to be clearly regulated and included in the agreement, particularly regarding rights and obligations of the parties, Scope of work, Warranty clauses, etc
		Check that each point/clause in the contract does not conflict with the attached contract documents.
		Conduct contract explanation discussions to discuss and verify mutual understanding of important clauses before signing.
		Define the payment mechanism in the work contract clearly and with the same understanding for all parties.
		Mediate with the contractor and/or Construction Management Consultant consultant to reach a win-win solution in the event of a dispute.
		Take legal action (or in accordance with the dispute resolution agreement in the contract) if mediation fails to reach a consensus.
		Assist with relevant agencies in the event of claims for additional costs.
R20	Construction of the in-pit conveyor is completed behind schedule.	Synchronize the project schedule with the self-managed activity such as relocation of bucket wheel exavator and land preparation work.
		Prepare a detailed project implementation schedule that includes the project's critical path, referring to the PMBOK, including identifying risks and mitigation measures, and conducting strict supervision/monitoring.
		Plan material procurement well to ensure there are no waiting times.
		Require the necessary personnel competencies in the contract clauses with the contractor and the Construction Management Consultant consultant.
		Analyze the human resource needs of the Infrastructure Development Project Team and fulfill them, coordinating

		with the Human Capital Work Unit during the implementation.
		Provide Construction Management Consultant Consultants before the project begins.
		Conduct consignment meetings to align technical perspectives with the Construction Management Consultant, EPC contractor, PTBA, and the FS and/or design consultants.
		Conduct regular coordination/synchronization meetings with relevant parties.
		Include an explicit late penalty clause in the contract and ensure there are no disputes between the parties.
		Give a warning to the contractor if there is a delay.
26	Land development has exceeded the planned timeframe.	Provide/require the contractor in the agreement clause to provide readytouse equipment for land preparation and monitor its implementation.
		Conduct field inspections prior to the development of the land preparation design.
		Supervise land preparation work (both selfmanaged and contractor managed).
		Design work/land preparation methods, if necessary.
		Prepare a Geotechnical Study and simulate the Banko inpit conveyor project Design based on the Geotechnical Study results and Sondir test results, while still adhering to the contract scope.

Implementation Plan & Justification

Each mitigation must have a comprehensive implementation plan, including a mitigation plan (PIC), deliverables, and due dates. The following details the mitigation implementation plan related to each phase.

Each mitigation is compiled based on its implementation timeline to ensure no mitigation is missed. Each mitigation is accompanied by a submission and a responsible party (usually abbreviated as “PIC”) for precise and demonstrable implementation. The planned mitigations are then monitored against their timelines, with progress updated at least monthly by the Project Team and the Risk Management Division.

In addition to the progress of each mitigation, KRIs are also monitored periodically, recommended weekly or daily, depending on data availability. It is recommended that KRIs be integrated with project management applications to obtain real-time data. The following is an example of KRI monitoring that has been carried out, as shown in the table below.

Table 12. Example of KRI Monitoring

No	Risk	KRI	Treshold			Status Monthly			
			Safe	Careful	Warning	August	Sept	Oct	Nov

5	Completion of the engineering work and detailed engineering design was behind schedule.	% of engineering documents completion	X ≥ 90%	90% >X ≥ 80%	X < 80%	27.78%	48,41%	55,56%	69,61%
17	Investment costs exceed the planned budget.	Cost Performance Index (CPI)	X ≥ 1	1 > X ≥ 0,9	< 0,9	1,00	1,00	1,00	1,00
18	The selected construction contractor and/or construction management consultants fail to perform.	% of qualified personnel	X ≥ 100%	100% >X ≥ 90%	X < 90%	100%	100%	100%	100%
19	A dispute arises between the agreement and the partners.	Third-party claim notifications	0	-	1	0	0	0	0
20	Construction of the in-pit conveyor is completed behind schedule.	Schedule Performance Index (SPI)	X ≥ 1	1 > X ≥ 0,9	< 0,9	1,03	1,00	0,94	0,73
26	Land development has exceeded the planned timeframe.	Slope movement monitoring results	0	-	1	1	0	0	0
		Realization of land preparation	X ≥ 100%	100% >X ≥ 90%	X < 90%	88%	95%	98%	100%

For KRI with a warning status, it is then submitted to the management of each party (PTBA, contractors, and consultants) to seek additional solutions and mitigation measures to avoid risks from occurring.

CONCLUSION

The conclusions from this research include the following:

1. This research conducted an evaluation and gap analysis to determine the effectiveness of project risk management implementation at PTBA, reviewed in the in-pit conveyor project. The gap analysis revealed that compared to the ISO 31000:2018 standard and PTBA's internal procedures, risk management implementation in the PTBA's project was not well established. This was evidenced by unidentified risks in the initial risk register that become issue. Furthermore, the risk analysis process was not comprehensive enough, evidenced by all risk levels still based on qualitative expert judgment, despite the availability of calculable quantitative data. In addition, risk prioritization was also not carried out, leaving all risks mitigated even the low or low to moderate risk. However, the monitoring process for the inpit conveyor project was inconsistently implemented, making it impossible to assess the effectiveness of the mitigation.
2. Recognizing the incomprehensive risk identification in the inpit banko project, a re-identification was conducted by first compiling an analysis document of the project's internal and external factors through

the 5M (Man, Machine, Method, Money, Material) and PESTEL analysis (Politic, Economic, Social, Technology, Environment, Legal). By re-identifying risks, seven new risks were identified. All those risks had not been identified in the existing risk register.

3. A quantification analysis of the in-pit conveyor project risk level was conducted, specifically calculating the impact level. Financial data that could impact the project was analyzed and then simulated using the existing financial model to determine the impact on the project's NPV and IRR. Based on the updated risk level analysis, five risks were identified as having changed risk levels. Furthermore, the risks to be mitigated were prioritized. This research determined that the high-risk level was designated as the Project's Top Risk, requiring more frequent evaluation and monitoring.
4. For the Top Risks identified in Point 3 above, a complete mitigation plan was established, including the Project Implementation Unit (PIC), deliverables, and timeline. Furthermore, key risk indicators were planned to provide early warning signs for each risk. Regular monitoring of these Top Risks is planned at least once a month, or more frequently.

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