International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

Enhancing Asset Performance: Maintenance Strategies for the GBC Pumping System at PT Freeport Indonesia

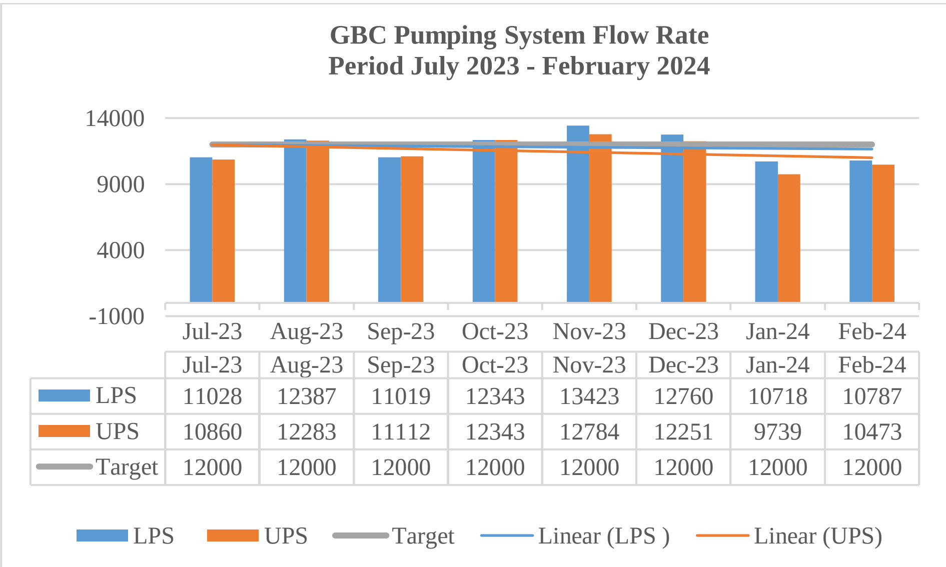
Kiranaratri, Prameswari[1], Basri, M.H.[2]
[1,2]School of Business and Management, Bandung Institute of Technology, 40116, Bandung, Indonesia

ABSTRACT: Focusing on Grasberg Block Caving (GBC) pumping system PT Freeport Indonesia, this study examines the factors of not achieving target and analyze the recommended solution. The research aims to identify the root causes of performance gaps and propose strategies to improve asset performance ultimately to achieve the company targets. The study employs a mixed method (quantitative approach as primary and qualitative as secondary) and analysis conducted with Pareto Chart identifies key factors contributing to performance gaps, Root Cause Analysis using Current Reality Tree to gather potential causes, as well as generating alternative solution and using Kepner-Tregoe Decision Analysis Evaluates and selects the recommended alternative solutions. The results are expected to provide actionable insights for the company. Implementing recommended alternative solution estimated saving 83% of the costs associated with component replacements and reduce overall unscheduled downtime 63.65%.

KEYWORDS: Pumping System, Downtime Analysis, Current Reality Tree, Kepner-Tregoe Decision Analysis.

INTRODUCTION

PT Freeport Indonesia (PTFI) is renowned globally for its production of copper and gold, primarily through its operations at the Grasberg mine located in Papua, Indonesia. Among the various mining operations under PTFI, the Grasberg Block Caving (GBC) mine stands out as the largest and most significant. A crucial component of the GBC mine's dewatering system is the GBC Pumping System, which is essential for the Mill's operations. This system ensures a steady and reliable supply of water, which is vital for the milling process. However, the GBC Pumping System has been facing difficulties in meeting its target flow rate. These challenges have led to substantial production losses, impacting the productivity and disrupt the Milling process.



	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24
LPS	11028	12387	11019	12343	13423	12760	10718	10787
UPS	10860	12283	11112	12343	12784	12251	9739	10473
Target	12000	12000	12000	12000	12000	12000	12000	12000

Figure 1 GBC Pumping System Flow Rate period July 2023 - February 2024

To address these issues, the research focuses on the asset performance management practices of the GBC Pumping System Operation Maintenance Division. The investigation aims to:

1. Identify the factors contributing to the system's low productivity.
   This involves a thorough examination of the pumping system to uncover any mechanical issues, operational inefficiencies, or other underlying problems that may be hindering its performance.
2. Recommend strategies to improve the system's efficiency and reliability.
   Based on the findings, the research will propose actionable strategies to enhance the performance of the GBC Pumping System. These recommendations will aim to optimize the system's operation, reduce production losses, and improve the overall reliability and efficiency of the mining operations.

LITERATURE REVIEW

Literature review provides an overview of research topic and help to identify theory, method and gaps in the research. It can also help to develop a theoretical framework and methodology for your research and evaluate the current state of research and demonstrate knowledge around the selected topic. Broadly speaking, literature reviews can take two forms: (1) a review that serves as background for an empirical study and (2) a stand-alone piece (Templier and Paré, 2015). Background reviews are commonly used as justification for decisions made in research design, provide theoretical context, or identify a gap in the literature the study intends to fill (Templier and Paré, 2015; Levy and Ellis 2006). Ideally, a systematic review should be conducted before empirical research, and a subset of the literature from the systematic review that is closely related to the empirical work can be used as background review (Xiao and Watson, 2017). The key topics covered in this review include:

1. Pareto Chart Analysis
   Pareto analysis is a method used to identify and prioritize the causes of problem in the quality improvement process (Gitlaw et al., 2005). Pareto's study of income distribution in Italy revealed that approximately 20% of the population controlled 80% of the country's wealth, while the remaining 80% held only 20% of the wealth. This observation became known as the 80-20 Pareto rule (Bozkurt, 2003). According to this rule, typically 80% of the problem in a system are caused by 20% of the underlying factors (Cravaner et al., 1993).
2. Root Cause Analysis (RCA) and Current Reality Tree (CRT) method
   The CRT is effective in uncovering dynamic cause-and-effect relationships within a system, identifying critical root causes that create most of the problems. It is noted for its structured approach and logical thinking process (Doggett, 2003). The CRT addresses problems by relating multiple factors rather than isolated events. Its purpose is to help practitioners find the links between symptomatic factors, called undesirable effects (UDEs), of the core problem. The CRT was designed to show the current state of reality as it exists in a system. It reflects the most probable chain of cause-and-effect factors that contribute to a specific set of circumstances and creates a basis for understanding complex systems (Dettmer, 1997).
3. Kepner-Tregoe Decision Analysis
   The research explores the application of the Kepner-Tregoe Decision Analysis in making informed decisions about alternative solutions. This method provides a structured approach to problem-solving and decision-making, helping organizations evaluate different options and choose the most effective course of action.

RESEARCH ANALYSIS

Familiarity with essential downtime metrics is vital for establishing robust maintenance practices. It's essential to differentiate between minimizing downtime as a comprehensive KPI and the specific metrics contributing to achieving this overarching objective. Various metrics assess different facets of the repair and maintenance processes, from overall machine uptime to actual repair durations.

There were 4832 hours down time in period July 2023 to February 2024, it presented that scheduled downtime is 66.42% and unscheduled downtime is 33.58% of overall downtime. Most of the planned downtime caused by PM with 142 activities recorded and 3122 hours downtime. It is a good sign that PM is being conducted regularly. However, in maintenance process, the target of good maintenance practice is 80% of scheduled downtime and 20% of unscheduled downtime.

In contrast of scheduled downtime, GBC pumping system experienced significant unplanned downtime, classified into 18 causes. The most frequent and impactful causes were:

1. Barrel: 18 events, totaling 561 hours (40% of total downtime).
2. Impeller: 21 events, totaling 191 hours (14%).

International Journal of Current Science Research and Review

ISSN: 2581-8341

Volume 07 Issue 09 September 2024

DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943

IJCSRR @ 2024

www.ijcsrr.org

3. Power Outage: 20 events, totaling 141.5 hours (10%).
4. Leakage: 17 events, totaling 118 hours (8%).
5. Accumulator: 16 events, totaling 78.5 hours

Other causes, including fiber optic issues, loss of communication, motor problems, and others, each contributed less significantly, with fewer than 12 events and less than 36.5 hours of downtime per category.

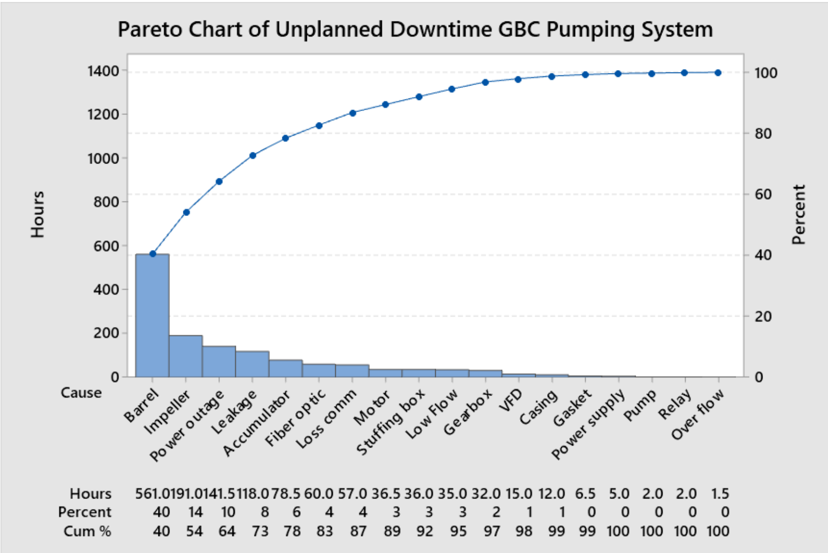


Figure 2. Count of Hours Unplanned Downtime GBC Pumping System Period July 2023 - July 2024

Table 1. Downtime Factor and Cumulative Percentage Breakdown

Downtime Factor	Downtime Hours	Percentage	Cumulative Percentage
Barrel	561	40.35%	40.35%
Impeller	191	13.74%	54.08%
Power Outage	141.5	10.18%	64.26%
Leakage	118	8.49%	72.74%
Accumulator	78.5	5.65%	78.39%
Fiber Optic	60	4.31%	82.70%
Loss of Communication	57	4.10%	86.80%
Motor	36.5	2.62%	89.43%
Stuffing Box	36	2.59%	92.02%
Low Flow	35	2.52%	94.53%
Gearbox	32	2.30%	96.84%
Variable Frequency Drive	15	1.08%	97.91%
Casing	12	0.86%	98.78%
Gasket	6.5	0.47%	99.24%
Power Supply	5	0.36%	99.60%
Pump	2	0.14%	99.75%
Relay	2	0.14%	99.89%
Overflow	1.5	0.11%	100%

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

This research will aim to analyze 78% contributor of unplanned downtime that will be examined further using Root Cause Analysis using Current Reality are as follows:

1. Barrel issue
2. Impeller issue
3. Power outage issue
4. Pipe leakage
5. Accumulator issue

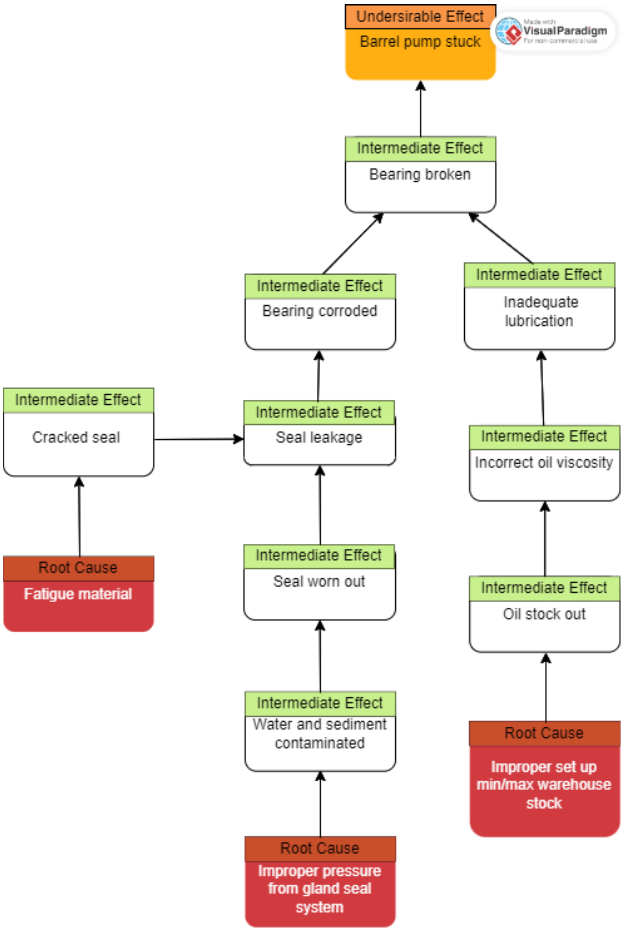


Figure 3. RCA-CRT Barrel Pump Stuck

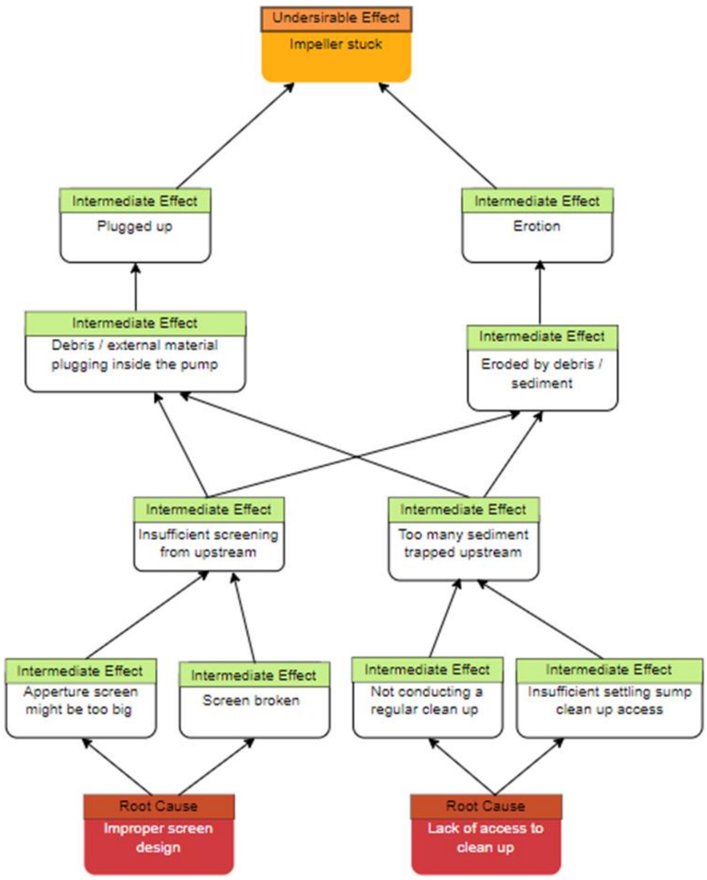


Figure 4. RCA-CRT Impeller Stuck

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024 www.ijcsrr.org

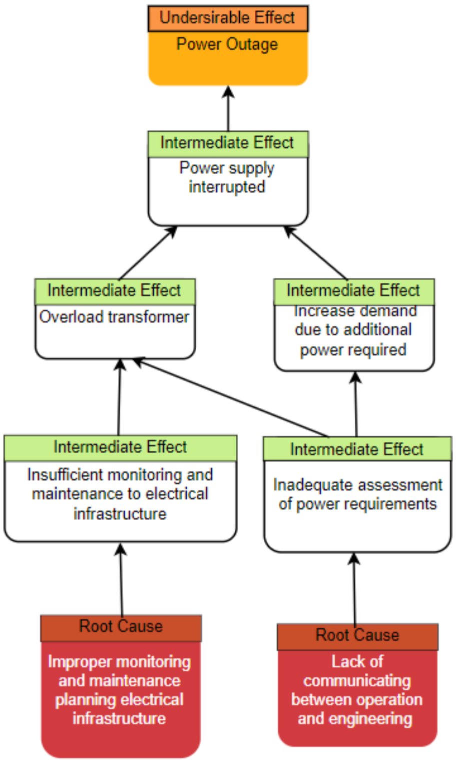


Figure 5. RCA-CRT Power Outage

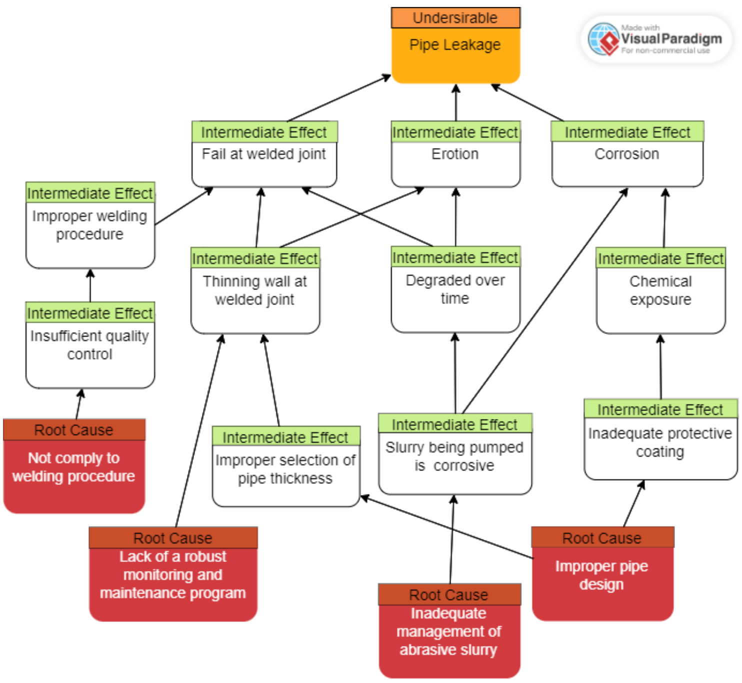


Figure 6. RCA-CRT Pipe Leakage

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

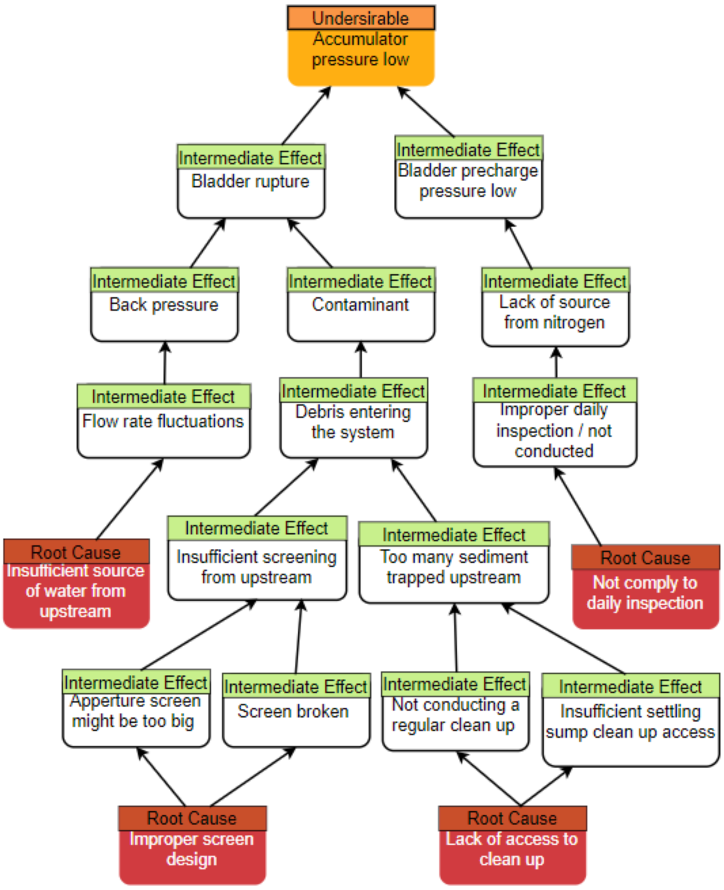


Figure 7. RCA-CRT Accumulator Pressure Low

From the Current Reality Tree method for, there are multiple premises of root cause for each undesirable effect, then being verified with data comparison and on-site observations. Based on the verification results, there are 9 potential causes verified and the alternative solution. The lists are shown as follows:

1. Potential cause: Improper pressure from gland seal system.
   Alternative solutions: Implement mechanical seal instead of gland packing to reduce potential contamination issues.
2. Potential cause: Improper set up material for the warehouse stock.
   Alternative solutions: Adjust the stock set up to accommodate available stock.
3. Potential cause: Improper screen design.
   Alternative solutions: Re-design integrating multiple screen processes using smaller aperture and removable screen.
4. Potential cause: Lack of access to clean up.
   Alternative solutions: Modify the existing access to settling sump and rearrange the height of settling sump so that equipment can access the settling sump.
5. Potential cause: Improper monitoring and maintenance planning electrical infrastructure.
   Alternative solutions: Develop maintenance schedule to inspect and replace any worn or outdated electrical components.
6. Potential cause: Insufficient source of water from upstream.
   Alternative solutions: Low-pressure alarm system.
7. Potential cause: Not comply to welding procedure.
   Alternative solutions: (1.) Create quality control sheet.
   (2.) Remind welding procedure specifications to all crew.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

8. Potential cause: Lack of robust monitoring and maintenance program.
   Alternative solutions: Develop predictive maintenance plan and schedule to inspect and replace any signs of pipe deteriorating.
9. Potential cause: Improper pipe design.
   Alternative solutions: (1.) Additional polyurethane lining to pipe stock.
   (2.) Additional coating pipe.

Table 2 Weighing Score Kepner-Tregoe Decision Analysis

List of alternatives		**Implement mechanical seal to reduce potential contamination issues**		**Adjust the stock set up to accommodate available stock**		**Re-design integrating multiple screen processes using smaller aperture and removable screen**		**Modify Existing Access to Settling Sump**		**Develop maintenance schedule to inspect and PCR electrical components**		**Adapt infrastructure to capture and store water more efficiently**	
Must-have													
Short term implementation		No		Yes		Yes		No		Yes		No	
Decreasing downtime event		Yes		Yes		Yes		Yes		Yes		Yes	
Decreasing unplanned replacement		Yes		Yes		Yes		Yes		Yes		No	
Want-to-have	**Weight (1-10)**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Low effort	8	6	48	8	64	7	56	5	40	8	64	5	40
Low initial cost	6	7	42	6	36	7	42	6	36	8	48	4	24
Less labor resource	7	9	63	8	56	7	49	7	49	8	56	5	35
High impact in operational	9	9	81	8	72	9	81	9	81	6	54	6	54
High impact in maintenance	9	10	90	8	72	9	81	8	72	8	72	5	45
Total			324		300		309		278		294		198

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

List of alternatives		**Low-pressure alarm system**		**Create quality control sheet**		**Remind welding procedure specification to all crew**		**Develop predictive maintenance plan and schedule to inspect and replace any signs of pipe deteriorating**		**Additional polyurethane lining to pipe stock**		**Additional coating pipe**	
Must-have													
Short term implementation		Yes		Yes		Yes		No		No		No	
Decreasing downtime event		Yes		Yes		Yes		Yes		Yes		Yes	
Decreasing unplanned replacement		Yes		Yes		Yes		Yes		Yes		Yes	
Want-to-have	**Weight (1-10)**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Low effort	8	9	72	8	64	9	72	8	64	7	56	7	56
Low initial cost	6	9	54	8	48	9	54	8	48	3	18	5	30
Less labor resource	7	9	63	7	49	4	28	8	56	7	49	7	49
High impact in operational	9	5	45	5	45	5	45	8	72	9	81	7	63
High impact in maintenance	9	5	45	5	45	5	45	8	72	9	81	8	72
Total			279		251		244		312		285		270

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

Table 3. Adverse Effect Kepner-Tregoe Decision Analysis

Alternative solutions	Adverse Effect	Probability of Occurrence	Potential Impact	Threat
Implement mechanical seal to reduce potential contamination issues	Complexity	5	6	30
	Incorrect Installation	4	4	16
	Lead time purchase	4	5	20
	Total			66
Adjust the stock set up to accommodate available stock	Excess inventory	8	8	64
	Lack of space	7	8	56
	Lead time process	7	7	49
	Total			169
Re-design integrating multiple screen processes using smaller aperture and removable screen	Complexity	5	5	25
	Regular clean up	9	8	72
	Significant blockages	6	8	48
	Total			145
Modify Existing Access to Settling Sump	Complexity	5	8	40
	Time constraint	4	9	36
	Regular clean up	9	8	72
	Total			148
Develop maintenance schedule to inspect and PCR electrical components	Complexity	5	3	15
	Incorrect implementation	4	4	16
	Lead time process	7	6	42
	Total			73
Adapt infrastructure to capture and store water more efficiently	Complexity	8	5	40
	Incorrect design	6	5	30
	Lead time installation	7	8	56
	Total			126
Low-pressure alarm system	Complexity	3	5	15
	False alarm	8	5	40
	Lead time installation	4	3	12
	Total			67
Create quality control sheet	Complexity	4	5	20
	No trained QC person	9	7	63
	Lead time procedure	4	5	20
	Total			103
Remind welding procedure specification to all crew	Complexity	5	4	20
	Disregards the process	9	9	81
	Lead time process	9	4	36
	Total			137
Develop predictive maintenance plan and schedule to inspect and replace any signs of pipe deteriorating	Complexity	4	6	24
	Insufficient facility	8	6	48
	Lead time applied	5	4	20
	Total			92
Additional polyurethane lining to pipe stock	Complexity	5	8	40
	Lead time purchase	7	9	63
	Lead time installation	8	8	64
	Total			167
Additional coating pipe	Complexity	4	3	12
	Lead time purchase	6	4	24
	Lead time installation	7	8	56
	Total			92

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-31, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

From this analysis, it can be concluded that the recommended option is "implement mechanical seal to reduce potential contamination" with highest scoring of the criteria and lowest score of the threats. As the most effective alternative, this will be recommended as the solution to overcome issue of not achieving target in GBC pumping system.
To further mitigate the risks associated with this recommended solution, it is essential to develop a contingency plan for each potential risk identified. This proactive approach will help ensure that any unforeseen issues can be promptly addressed, minimizing their impact on the overall system performance.

Table 4. Contingency Plan each Potential Issue

Potential Issue	**Threat Score**	**Contingency Plan**
Complexity	8	Provide technical assistance from vendor.
		Develop a comprehensive installation plan that includes procedures and timelines.
Incorrect installation	5	Train crew and apply new standard operating procedure in maintaining the gland seal water system.
		Purchase special tools to ease crew installing the new seal.
Lead time purchase	5	Look for possibility of similar specification from vendor
High maintenance cost	8	Allocate a specific budget for maintenance activities and monitor expenses closely.
Empty stock material	7	Maintain an accurate inventory of materials and spare parts, and reorder items before they run out.
		Keep an emergency stock of critical materials to cover unexpected shortages.

Based on historical component replacement in GBC pumping system from period July 2023 – February 2024, the highest cost of replacement is coming from replacement of barrel occurred in 18 count events and costs 31% of total cost replacement. The second highest cost of replacement is casing pump occurred in 2 events and costs 27% of total cost replacement and followed by gearbox occurred in 3 events and costs 13% of total cost replacement. The next is impeller that occurred replacement in 8 count events and costs 6% of total cost replacement, the followed by lantern ring that occurred 25 count events and costs 6% of total cost replacement.

Table 5. Major Component Replacement GBC Pumping System period July 2023 - February 2024

Major Part	Count of Replacement	Cost of Replacement	Percentage	Cumulative Percentage
Barrel	18	$1,083,996.18	31%	31%
Casing Pump	2	$967,560.48	27%	58%
Gearbox	3	$462,429.65	13%	71%
Impeller	8	$215,433.92	6%	77%
Lantern Ring	25	$214,176.96	6%	83%
Motor	5	$156,471.10	4%	87%
Sleeve Shaft	18	$102,212.80	3%	90%
Stuffing Box	24	$101,516.00	3%	93%
Suction Liner	9	$98,827.65	3%	96%
Suction Plate	5	$81,214.16	2%	98%
Wear Plate	26	$66,825.00	2%	100%

Since the new gland seal water system with mechanical seal will help in preventing leakage or possibility debris entering the pumping system. Direct impact in implementing the alternative solutions will affect the extended life of these components:

1. Barrel
2. Casing Pump
3. Impeller
4. Lantern Ring
5. Sleeve Shaft
6. Stuffing Box
7. Suction Liner
8. Suction Plate
9. Wear Plate

Mechanical seals are designed to maintain a higher and more consistent pressure, effectively preventing debris from entering the system. By preventing debris from entering the system, mechanical seals can significantly reduce the wear and tear on components. This leads to a substantial decrease in the frequency of component replacements. The reduction in component replacements translates to significant cost savings. It is estimated that implementing mechanical seals will save approximately 83% of the costs associated with component replacements. This amounts to an estimated savings of $2,931,763.15. Lower maintenance costs contribute to overall cost savings, freeing up resources for other critical areas of the operation.

Insufficient pressure in the gland seal water system allows debris to enter the pumping system, causing frequent component failures and system breakdowns. By maintaining adequate pressure and preventing debris infiltration, mechanical seals can significantly reduce the frequency of system shutdowns. This leads to less downtime and more consistent production. Reduced downtime translates to higher production efficiency and output, minimizing the financial losses associated with halted operations. Based on this research, applying the recommended solution will reduce overall unplanned downtime minimum 40% to maximum 63.65%.

CONCLUSIONS

This study found that implementing mechanical seals to reduce potential contamination is the most effective solution to address the GBC pumping system's performance issues. The authors recommend this approach to decrease downtime and improve overall efficiency, with estimated cost savings of 83% for component replacements and 63.65% in unscheduled downtime reduction. The study further suggests developing contingency plans for potential risks associated with the recommended solution to minimize their impact on the overall system performance.

REFERENCES

1. Bozkurt, O. 2003 Pareto Analysis: An Effective Tool for Problem Solving. Quality Progress, 36(8), 46-49.
2. Cravaner, R., et al. 1993 The Pareto Principle. London: Chapman & Hall.
3. Dettmer, H. 1997 The Effective Executive: The Definitive Guide to Getting the Right Things Done. New York: Amacom.
4. Doggett, K. 2003 Root Cause Analysis: A Practitioner's Guide to Problem Solving. ASQ Quality Press.
5. Gitlaw, H., et al. 2005 Quality Management for Organizations: Achieving Performance Excellence. New York: McGraw-Hill.
6. Templier, J. L., & Paré, G. 2015 Guidelines for conducting a literature review. Human Resources for Health, 13(1), 1-7.
7. Xiao, R., & Watson, R. T. 2017 Conducting a Literature Review. Sage Publications.
8. Levy, P., & Ellis, T. (2006). A guide to writing a successful thesis and dissertation. Pearson Education.