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The high cost of poor closure estimates

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Abstract

Planning for closure and its associated costs needs to commence from the early developmental stages of the mine itself and continue through the final relinquishment of the site. Our experience with mine closure estimating over the past several years indicates that most mine closures overrun their initial cost estimates by between 20 and 100 percent. Challenges to accurately estimating mine closure costs include changes to the mine layout over time, extended time to closure execution, execution methodologies, rapidly changing legislation, and managing the multiple disciplines involved in creating a tailored remedial solution, often in remote locations. The concern for miners is that poor closure estimates underestimate capital investment decisions and may even lead to incomplete reporting of financial obligation (liability).

Successfully financing and cost estimating closure, decommissioning, and reclamation programmes requires a strategic and collaborative approach that examines the complexities of the mine site itself, the expectations of the surrounding communities, socio-economic considerations, and regulatory requirements. Successful mine closure and related costs can be improved by using three strategies, avoiding, reducing, and correcting negative impacts (Paricheh & Osanloo 2017).

The paper will focus on improving global perspectives and best practices in mine decommissioning, closure, and reclamation financing and cost estimating.

Our methodology will incorporate our experiences working on global mine closure programmes for major clients, which has enabled us to amass a significant database of cost and schedule information. Additionally, our methodology will incorporate our findings from a collaborative survey, research, and interviews where we explored what it takes to deliver successful outcomes in mine closure estimating.

Key insights include:

- *How mining companies can improve how they estimate closure costs throughout all phases of the mine lifecycle.*
- *How to manage the interdependencies across mine closure programs at each stage to avoid delays to program execution, dissatisfied stakeholders, and the possibility of claims and disputes.*
- *What drives cost escalation and risk across long-term closure programmes, and how to manage this given the current climate of supply chain disruption and commodity volatility.*
- *How climate change is leading to tighter closure and financial assurance arrangements, and what impact this is having on regulatory closure planning requirements including fiscal provisions and liabilities.*

We will draw insights from our data and analysis and combine them with experience gained from working in mine closure for over a decade. This extends to mine types, the expectations of surrounding communities, socio-economic considerations, and regulatory requirements. Our paper will support all those looking to achieve greater accuracy in mine closure financing and cost estimation and those looking to inform the process for due diligence across all phases of the lifecycle, from setting up the mine development to preparing it for acquisition, or for full closure and land remediation, reclamation, and post-mining economic use.

Keywords: *mine closure costs; estimating; asset value creation; best practice; capital requirements*

1 Introduction

Planning for mine closure and its costs needs to commence from the early developmental stages of the mine itself. Successfully financing and cost estimating closure, decommissioning, and reclamation programmes requires a strategic and collaborative approach that examines the complexities of the mine site itself, the expectations of the surrounding communities, socio-economic considerations, and regulatory requirements.

Challenges to accurately estimating mine closure costs include changes to the mine layout over time, execution methodologies, rapidly changing legislation, and managing the multiple disciplines involved in creating a tailored remedial solution that aligns with community and other stakeholder expectations. Further adding to complexity is the often, remote location of the mine.

The concern for miners is that poor closure estimates underestimate capital investment decisions and may even lead to incomplete reporting of financial obligation (liability) resulting in impacts to their future license to operate. Furthermore, our experience delivering mine closure cost estimating services on behalf of major mining houses globally suggests most mine closures continue to overrun their initial cost estimates by between 20 and 100 percent.

The following table (Table 1) shows cost changes from earlier to later phases of closure cost development for the entire closure process. As each mine site is unique, there is not an easily referenced metric to be used as a cost basis, but the primary information is the percent increase to the cost as the closure requirements are defined and the cost impacts estimated.

Table 1 Sample of cost changes through stage development for closure projects (millions)

Location	Commodity	Pre-feasibility	Feasibility	Forecast/actual	% increase
Canada	Diamond	CAD 245	CAD 318	CAD 350	42.8
Canada	Diamond	CAD 185	CAD 206	CAD 289	56.2
United States	Copper	USD 985	USD 1,782	n/a?	80.9
United States	Copper	USD 205	USD 260	USD 376	83.4
United States	Uranium	USD 106	USD 214	n/a	101.8
United States	Aluminium	-	USD 218	USD 260	19.2

In this article we will discuss the key considerations in improving mine closure cost planning:

- Using early planning and consistent updating to provide an accurate estimate of closure costs.
- Managing the interdependencies across mine closure programs at each stage to avoid delays to program execution, dissatisfied stakeholders, and the possibility of claims and disputes.
- Identifying what drives cost escalation and risk across long-term closure programmes, and how to manage this given the current climate of supply chain disruption and commodity volatility.
- How to improve mine closure estimates including a five-step strategy for improvement.

2 Early planning and consistent updating

The closure plan identifies the vision of the company in what the site will look like upon completion of mining operations. Mining companies are generally allowed to self-regulate their compliance to reporting obligations for mine closure planning and associated cost estimates (Slight & Lacy 2015). To meet this vision, the closure plan must be developed at the beginning and updated consistently through the life-of-mine (LOM). Likewise, the closure estimate must be aligned with the plan and updated whenever the closure plan changes.

> *"Mining companies, regulators and investors share a common interest in ensuring the costs of implementing mine closure are accurately identified and clearly communicated. The estimation and reporting of costs present a unique set of challenges as closure costs may need to be estimated based on designs and assumptions made prior to construction of the mine, and then updated regularly over the Life of Asset (LoA) incorporating changing information."* (International Council on Mining & Metals [ICMM] 2019)

According to Paricheh & Osanloo (2017), successful mine closure and related costs can be improved by using three strategies, avoiding, reducing, and correcting negative impacts. This strategy aligns with the development of the closure plan and estimate as well in that early planning will help avoid negative impacts, progressive reclamation will help reduce negative impacts, and closure execution will correct the remaining negative impacts to the site.

3 Managing interdependencies across the closure program

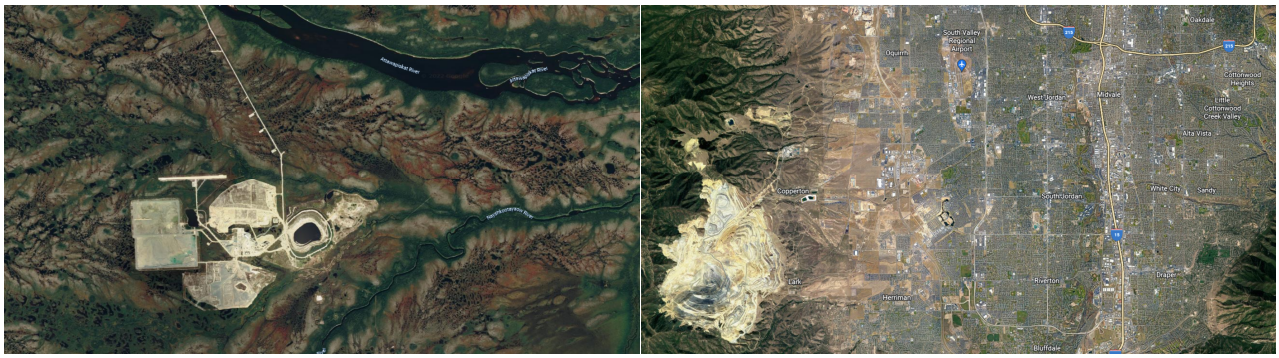
Managing the interdependencies across mine closure programs at each stage is essential to avoid delays to program execution, dissatisfied stakeholders, and the possibility of claims and disputes. This presents an ongoing concern for mining companies and local communities. In our opinion, mine closure plans need to consider four elements in their approach, location, regulation, climate change, communities, and cost.

> *"Effective mine closure planning and implementation consider the views, concerns, aspirations, efforts, and knowledge of internal and external stakeholders to identify mutually beneficial closure outcomes for the company and its host communities. Stakeholder engagement serves as a critical aspect of managing social risks of closure. Many jurisdictions and companies require some level of stakeholder consultation during the design of the Closure Plan."* (ICCM 2019)

3.1 Site location

The first element to consider is the site location. The site location includes all aspects, including climate, topography, access to water sources, and access to materials. Understanding what is possible in terms of the current site conditions, how infrastructure can be repurposed, and any site constraints is key, but ultimately post-closure opportunities are limited by the mine's location and its ability to support post-closure activities.

Analysis of two mining projects is shown below (Figure 1) which provides significantly different approaches based on the site location and conditions.



(a) (b)

Figure 1 Comparison of site use: (a) Remote site in northern Canada; (b) Accessible site in western United States

Figure 1a is a remote mine located in northern Canada. Due to the location, the site offers limited opportunity for revenue generation, so the goal is to return the site to its natural state and enable recreational use. The mining company is leaving some infrastructure in place such as roads and power lines which the local

community can use to support recreational activities. They are also providing vocational training for mine employees to redirect their skills to other industries, such as manufacturing, transportation, and construction.

Figure 1b is a mine that is located near a metropolitan area in the United States. The site offers several revenue-generating opportunities such as water treatment facilities, industrial spaces, alternative energies (solar and wind), and domestic and hazardous landfills. Each of these uses will allow for continued employment of the existing mine staff as well as others. However, these opportunities come with their own challenges in terms of community expectations. Some stakeholders may wish for the return of the site to its natural state, but this will be delayed indefinitely if it is to be repurposed for other uses.

3.2 Regulations

The second element to consider is regulation. Local and national regulators expect certain conditions to be met according to legislation and permit conditions. How the regulator plans to interpret the regulations may impact the ability to implement revenue-generating opportunities – which highlights the importance of effective collaboration between all stakeholders from the earliest opportunity.

The role of regulators is to return the site to beneficial land use, ensure the site is safe, non-polluting, stable, and prevent long-term environmental, social, or economic impacts. Regulators accomplish these objectives by setting clear objectives for mine closure, preparing detailed requirements for the mine closure plan, establishing requirements for mine closure guarantees and implementing processes to make sure mine closure plans are implemented properly. However, in a recent survey (Cann 2020) that was conducted in partnership with Mining Journal Intelligence and SRK Consulting and which shared the opinions of more than 400 mining industry professionals globally, only 15% of survey respondents believe that the regulatory agencies in their jurisdictions have the capability and/or capacity to adequately monitor and approve closure projects. This then puts the burden on the mining companies and the communities to determine and implement closure plans that meet the needs of all stakeholders while complying with local regulations.

It is our recommendation to engage early with regulators to enable more defined scope definition and therefore more clarity in the development of estimates. It is essential for regulatory bodies to establish a specific role with the required technical skills and knowledge around mine closure to support miners with this process.

3.3 Climate change

Climate change will potentially affect the overall closure cost of mines, particularly those with long operational and/or post-closure durations. As the environmental impacts of climate change at a particular site are understood, these impacts need to be included into the closure provisions.

> *"A mine typically features multiple mine closure domains, each with water and energy balances for creating design criteria. Climate change will act to change components of the water and energy balances and only through novel and innovative designs can one manipulate remaining water balance components to achieve the design criteria.*
>
> *Climate change is taken into account in a variety of mining projects. Approaches to incorporate climate change into closure design differ from site to site and are often limited in temporal length."* (Baisley et al. 2016)

As the mine planning progresses, environmental considerations need to be addressed by the engineering firms and included in the closure plan and cost estimate. It is likely that these will change over time and should be a priority in the study phases to ensure they are adequately understood.

3.4 Communities

The fourth element is the surrounding communities. For smaller communities, mine closure will result in the loss of major revenue and a job source. The key questions mine closure planners need to ask are what the

community wants and need, what alternative revenue streams are possible given the site and what job planning and vocational training will be required to implement these changes. Mining companies need to engage with communities to understand and set expectations for the mine site post-closure, and what the likely time-scales will be. The expectations of the mining company, the community and regulators need to be aligned. The impact of poor mine closure stakeholder management includes license to operate, less capital for development of expansions, claims and disputes, delayed revenue opportunities in repurposed sites, increased bonding requirements, reputational damage and increased indirect costs if insufficient cash is available.

3.5 Cost

The final element is cost. The key variables in determining closure costs are a complete understanding of the scope including mine infrastructure decommissioning, demolition, and reclamation. This also includes regulator and community expectations and requirements. Costing mine closure needs to consider the wants and needs of stakeholders, especially if the mine is to close in a way that will enable future revenue-generating opportunities to proceed and these costs will inevitably be a key factor. Where the scope is not fully understood, it becomes impossible to develop an accurate cost estimate. Commencing the cost estimation process at an early stage, with focus during the operational life of the mine will support improved understanding of mine closure costs and how they must be re-baselined as the mine develops and changes. Project management expertise is also critical in determining the overall cost. The execution plan, contracting strategy, and logistics plan all impact the cost. Understanding these impacts, and using lessons learned to determine the best approach will help in controlling cost overruns.

On mine decommissioning and closure projects both large and small, taking a structured approach in considering each of these elements, location, regulation, communities, and cost, is essential for closure planning, particularly where the community depends on the mine for employment and other socio-economic benefits.

4 Estimate cost escalation drivers

What drives cost escalation and risk across long-term closure programmes, and how do closure teams manage this given the current climate of supply chain disruption and commodity volatility?

> *"Even with the best will in the world, accurately forecasting closure costs is extremely difficult; the best that might be expected is an approximation. The temptation could be to overestimate to ensure that there is no shortfall in fund, but this should not be done to the detriment of the financial viability of the project."* (Sassoon 2009)

Detailed mine closure planning should be done as part of the early planning stages of the project. However, adequate closure plans are not always completed in the early stages resulting in the true cost of closure not being fully understood or reported (Nehring & Cheng 2016).

Slight & Lacy (2015) identified 17 items that must be included in the closure estimate:

1. Regulator and stakeholder obligations and commitments.
2. Company obligations to manage the site for the entire period.
3. Operational costs for long-term care & maintenance.
4. Costs associated with licenses, leases, and rights of way.
5. Earthworks for rehabilitating all disturbed surfaces.
6. Decommissioning and demolition of all structures.
7. Investigation, removal, and remediation of contaminated materials.
8. Engineering, scientific, and other consultant costs.

9. Mobilisation and demobilisation costs.
10. Project management costs.
11. Site services (water, power, access, fuel, camp, etc.)
12. Inventory and asset disposal costs.
13. Environmental monitoring and reporting.
14. Corporate level costs (insurance, legal, overheads).
15. Employee redundancy costs.
16. Post-closure monitoring.
17. Contingencies for unanticipated changes.

From our experience, the five most common estimating mistakes are:

1. Omission of scope from the estimate.
2. Over-optimistic performance assumptions (construction resources, supply chain and execution planning).
3. Possible risk is omitted, including political (regulatory), economic, social, technological, and environmental.
4. Lack of integrated project management approach with adequate controls and assurance.
5. Inadequate understanding of bonds and insurances.

To prevent these mistakes, the estimator must work closely with an integrated project team that considers the entire closure plan. This team should include representatives from engineering, project management, permitting, stakeholder management, and finance. The team will look at closure holistically and meet regularly to understand any changes that have occurred and the impact on those changes to the closure plan and cost.

5 Improving closure estimates

According to Nehring & Cheng (2016) mine closure and the associated costs need to be included in the overall mine plan as it may significantly impact mine operations such as pit limit, pushback design, production schedule, mine life, resource recovery, and profitability of the operation. This article has reviewed the variables required to estimate mine closure costs and what is required to determine the scope and calculate the company's financial liability to close the mine. But still, as professionals working in this area, and in asset development in general, we know there are huge issues with meeting cost expectations.

In our opinion, the most effective way to avoid the five most common estimating mistakes is to ensure that the estimator chosen for the project has sufficient experience for the type of project, encompassing the full scope including stakeholder and community expectations as well as the right tools, data, and processes for the required level of detail of the estimate. The estimator must understand the local regulatory environment, including bond and insurance requirements, and have access to benchmarks from other closure projects to be able to check on the reasonableness of the estimate. Ideally, the estimator will also have access to local, relevant, and current mine closure cost data and be independent of any project bias, which would mean engaging an estimator who would not be invited to tender to perform the work.

In summary, to provide an accurate estimate of the closure costs, stakeholders require:

- A robust estimating system that calculates resources and costs accurately across the lifecycle.
- Local, relevant, and current mine closure cost data.
- To adopt a progressive reclamation approach and keep up to date on regulations.

- An understanding of benchmarks from other closure projects to be able to check on the reasonableness of the estimate. This will ensure the estimate is realistic and not optimistic about closure planning.
- Take a risk-based approach.
- To maintain relationships with the regulator and the community.
- To engage a project controls team with expertise in mining and closure projects, and who can accurately estimate project cost and effectively manage and control the mine closure against this.

From our previous research, 40% of respondents reported their organisations did not have adequate benchmarks to provide confidence in mine closure costs (Cann 2020). If mine closure is to benefit local communities in a positive way, it is essential to get a true understanding of the cost so that the maximum positive benefit can be realised.

5.1 Five strategies to improve mine closure cost estimates

On mine decommissioning and closure projects both large and small, taking a structured approach in considering each of these elements is essential for closure planning. We have identified five strategies that, when implemented, can help improve closure cost estimates:

1. Methodology: Establish an appropriate estimate methodology to ensure a reliable estimate. The estimate needs to be aligned to the project Work Breakdown Structure and schedule, and, depending on the miner, may need to meet any internal governance/approval processes.
2. Scope: Be realistic, look at all the potential costs and challenges. Verify the level of scope definition and understand the cost drivers. Validating unit rates for labour, plant equipment, marine equipment and materials captures whether appropriate pricing has been applied, considering market conditions, geographical locations, and the proposed procurement strategy. It is critical that the location, nature of the site access and working conditions are accurately assessed with regards to productivity. Continuously update the closure estimate to account for changes to the mine, regulations, or community needs. Use progressive reclamation to close areas of the mine that are no longer used, thus minimising the cost at the end.
3. Assure: Quality assure the estimate. Assurance services can be carried out either by an independent owner team or consultant. Again, continuously update the closure estimate to account for changes to the mine, regulations, or community needs.
4. Risk: Use industry-recognised risk analysis processes. Further improve confidence in the results by assessing if the risks, opportunities, and contingency allowances are proportional to the stage of design, basis of estimate information and schedule of the project. Review and use lessons learned from other closure projects. Continuously review the regulations and update the plan to account for any changes. According to ICCM (2019), a risk assessment should be conducted and documented early in the process and revisited periodically as the closure plan evolves.
5. Benchmark: Use data from similar projects. Benchmarking the estimate cost and schedule against similar projects which have already been completed can identify any final areas of concern.

6 Conclusion

Successful mine closure requires a structured and consistent approach with involvement from all affected parties. Understanding the future of the site post-closure, the wants and needs of communities and regulators, and the financial obligations of the miner all play into developing a closure plan that produces the desired results. Using progressive reclamation to close areas of the mine that are no longer used, will also enable costs to be minimised. Miners must continuously review the regulations and update the plan to

account for any changes. And, finally and perhaps most importantly, maintain strong relationships with regulators and community partners, as they will ultimately determine if the closure was successful or not.

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