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Comparative analysis of different types of closure cost estimates

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Abstract

This paper explores the types of closure costs and, based on experiences, a hypothetical example will be presented to illustrate the overall differences between: financial assurance (FA), life of mine (LOM), asset retirement obligation (ARO) and sudden closure (SC). These estimates are crucial for accurately reporting financial liabilities, ensuring regulatory compliance, and planning for the eventual closure of mining operations. The FA estimate defines the cost that a government agency would incur to perform all actions documented in an approved closure plan, should the company abandon the site without implementing closure. The LOM estimate incorporates all closure costs associated with the current mine plan, typically reported on a cash flow basis and used for prefeasibility and feasibility studies, due diligence audits, and annual planning. The ARO estimate focuses on the fair value or best estimate of current liabilities associated with mine closure, as required by financial reporting standards such as Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS). Finally, the SC cost estimate is typically developed and used for internal planning purposes to aid in options analysis and decision-making. The estimated SC cost would reflect all costs for immediately implementing closure, with no exclusions. By developing a comprehensive hypothetical example for all four cost types, this paper aims to provide a clear understanding of the details and scope. It analyses the differences between legal and constructive obligations, salvage consideration, cover and grading closure activity, as well as post-closure activities for each cost type.

Keywords: *closure costs, cost estimating*

1 Introduction

Closure plans and cost estimates are developed for specific purposes, such as regulatory submittal and bonding obligations, planning and budgeting, or financial reporting to stakeholders. Closure cost estimate models are typically calculations that are a sum of quantities multiplied by unit rates and can also include indirect and contingencies costs. Typically, there are differences between closure cost estimate types due to specific legal requirements and the components and phase of the mine life cycle for which the estimate is prepared.

This paper aims to provide a clear understanding of the details and scope of each of the cost estimate type using a hypothetical case study using on a waste rock dump (WRD) and some other closure aspects that feature the practical application of these estimate types, and demonstrating the differences.

2 Closure cost types

The following provides a detail description of each of the four types of cost estimates, aiming to highlight their scope and differences.

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2.1 Regulatory or financial assurance cost estimate

In certain jurisdictions, regulations may require a form of financial assurance (FA) that will be available to complete closure work if the mining company goes bankrupt or otherwise abandons the site. This FA is sometimes known as a financial guarantee or a closure bond.

There is considerable variation among jurisdictions in how the FA amount is estimated and administered. Some of the relevant considerations of the FA include the following:

- The cost estimate is based on the closure activities presented in a closure plan that has received approval by the regulator.
- Cost estimates often require the use of third-party costs, intended to be representative of the cost the government would incur to implement the closure plan if the mine was abandoned.
- The cost estimate may be based on the current disturbance, the disturbance planned within some set time limit or the currently approved extent of final disturbance.
- There is often a mechanism for partial release of the FA for satisfactorily completed progressive closure works. This is intended to act as an incentive to encourage progressive closure. When granted, the partial release does not typically occur until the relevant authorities have officially accepted the work as complete and effective.
- Cost estimates usually must be updated on a set schedule, or when there are substantial changes to the mining operation.
- There may be a requirement for third-party audits or certification of the cost estimates made to establish the FA.
- The cost estimate format may be specified by the regulator (i.e. there may be specific unit rates or a standardised cost estimating method or model required).
- The rules relating to present value estimates vary greatly between jurisdictions. If discounting of future costs to present value is permitted, the discount rates may be specified by the regulator or be subject to negotiation.
- Similar to financial reporting obligations, most jurisdictions with FA requirements do not allow for potential salvage value for equipment and infrastructure to be included.
- Internal mining company costs, such as employee severance costs, taxes and financing costs, are not normally included in financial guarantees.
- FA cost estimates may be presented as current cost, undiscounted cash flow, or discounted cash flow, depending on the jurisdiction.

There are various forms of FA accepted in different jurisdictions. Each type has advantages and disadvantages, and the range of feasible options should be considered carefully in terms of their financial implications for the mining company. Third-party guarantees, such as irrevocable/unconditional bank guarantees and insurance bonds, are relatively common, as are renewable letters of credit. Cash deposits, trust funds, collateral and insurance policies are also used, as are a variety of alternative options such as parent company guarantees, balance sheet tests and financial strength ratings (International Council on Mining and Metals [ICMM] 2025).

Some jurisdictions or regulatory agencies do not allow for self (or corporate) guarantees and require financial instruments that are backed by a qualified financial institution. Other jurisdictions may allow self-guarantees for a portion of the total cost and/or for an initial period of the operation based on increasing risk as the asset value is depleted.

2.2 Life of mine or life of asset cost estimate

According to the ICMM (2025) the life of mine (LOM) cost estimate responds to the internal planning needs of the mining company. While there are variations in how each company defines these estimates (and the terminology used), the estimates address the full expected closure-related costs that the company will incur for a site that operates through its full life and executes its planned mining activities to exhaust the mineral resources.

The LOM closure cost estimate includes the total cost of ownership expected to be incurred, including costs associated with all existing facilities and mining features, as well as all those facilities not yet constructed, land disturbances not yet incurred, mining not yet undertaken and progressive rehabilitation not yet performed that have been included within the LOM business plan. It also includes monitoring and maintenance costs over the anticipated post-closure period. This cost estimate should be included as part of a mining company's cash flow model for planning and budgeting of capital and operational expenditures and ideally is fully integrated and presented in the mine business plan.

Other common characteristics of the LOM closure cost estimate are as follows:

- Owner costs (rather than third-party costs) are normally used where it is reasonable to assume that the owner would use their staff and equipment for executing the tasks. If the mine owner does not propose to execute the closure works using their staff and equipment, third-party costs should be used to estimate the cost.
- Credit for completed progressive closure can be incorporated directly into the estimate.
- The costs are normally calculated in accordance with the operational cost model.
- Salvage value may be considered where appropriate and internal business standards and guidelines permit. As salvage values are subject to wide variations, conservative valuations should be used, and should be supported by third-party quotes and evaluation.
- The LOM closure cost is usually used for planning, budgeting and cost tracking. Common uses include prefeasibility and feasibility studies, due diligence audits, accrual allocation, annual planning and budgeting, and cost tracking.

2.3 Financial liability or asset retirement obligation cost estimate

In the mining industry, financial liability cost estimates are primarily governed by International Financial Reporting Standards (IFRS) and Generally Accepted Accounting Principles (GAAP). IFRS, established by the International Accounting Standards Board (IASB), seek to promote transparency and comparability in financial reporting across diverse jurisdictions. Conversely, GAAP, a framework of accounting principles developed by the Financial Accounting Standards Board (FASB) in the United States, provides specific guidelines for financial reporting within the US. These frameworks ensure that liability cost estimates accurately reflect the present value of anticipated future expenses, such as those arising from asset retirement obligation (ARO), closure provisions, or reclamation liabilities. To ensure alignment with evolving obligations and regulatory mandates, these estimates are periodically reviewed and updated.

AROs constitute a legally defined aspect of financial reporting, governed by the principles outlined in FASB (2001) statement 143 and IAS 37 (IFRS 2001). These standards delineate the accounting and disclosure requirements for obligations tied to the retirement of tangible long-lived assets. According to FASB (2001) statement 143, entities are mandated to recognise the fair value of an ARO liability during the period it is incurred, provided a reasonable fair value estimate is achievable. Similarly, IAS 37 (IFRS 2001) offers guidance on the recognition and measurement of provisions, contingent liabilities, and contingent assets, including AROs. ARO cost estimates are subject to annual adjustments to account for modifications resulting from new development activities or completed closure work. Such practices ensure compliance with financial reporting standards and provide a transparent representation of the entity's financial standing (Parshley et al. 2009).

In summary, the key considerations and exclusions relating to the ARO cost estimate are described below.

2.3.1 Legal and constructive obligations

AROs must account for all legal obligations. This includes commitments made through laws, permits, agreements with landowners, contracts, or even verbal and written commitments by the company. If a company has publicly made promises – whether in official policies or repeated statements – these commitments are considered legally binding constructive obligations and must be factored into the closure cost estimate.

2.3.2 General considerations

Only the obligations, liabilities, and costs that exist and that are known by the end of the financial reporting period should be incorporated into ARO calculations. For facilities operating as of year-end, all anticipated closure-related costs must be considered.

ARO calculations are reported as a cash flow, a similar approach used in LOM cost estimates. This method ensures seamless integration of closure costs into the broader corporate financial model. But as mentioned, the estimate is based on the end of the financial reporting year is incorporated into ARO calculations.

ARO estimates also assume that the mine will be completed in accordance with the design and schedule as recorded in the current mine plan. ARO estimates do not assume that the mine will be closed in its current configuration – only that the current configuration represents an incremental portion of the total liability.

The estimated cost can be reduced as closure-related work is completed. For example, demolition costs are removed once the demolition is completed.

They are often formulated with the assistance of independent third-party experts and must meet the approval of corporate financial auditors.

2.3.3 Exclusions

Expenses that wouldn't be incurred by a third party fulfilling legal closure obligations are excluded. This means costs such as severance payments for closure staff, corporate overhead expenses, and taxes are not part of the ARO calculations.

Financial reporting standards set by FASB (2001) and IASB expressly forbid companies from including potential revenues in ARO cost estimations. Prohibited revenue factors include residual production income, proceeds from equipment resale, or profits derived from salvaging scrap materials.

2.4 Sudden (or early) closure cost estimate

An SC cost estimate is typically developed and used for internal planning purposes to aid in options analysis and decision-making. The estimated SC cost would reflect all costs for immediately implementing closure, with no exclusions. Costs that would form a part of the SC cost estimate include closure works, workforce retrenchment costs, management, studies, and care and maintenance costs associated with deferring closure works. The cost estimate would also include post-closure costs such as those for maintenance and monitoring. Not all companies calculate this number and commonly use the financial liability number (ICMM 2025).

It is possible that some costs that would ordinarily be incorporated into operational costs if the mine was developed fully and closed as planned would need to be added to an SC cost. For example, a requirement to backfill a pit during operations could still be required as part of SC and the cost for this would become a closure cost. Other costs could differ from LOM costs because the configuration of a facility (e.g. a tailings impoundment) could be significantly different that the LOM configuration and this could result in different or other closure methods being required, which in turn could either increase or decrease the closure cost for that facility.

Table 1 summarises the key considerations for each estimate indicating their general differences.

Table 1 Closure cost type summary (after Parshley et. al. 2009)

Item	Financial assurance	Life of mine	Asset retirement obligation	Sudden closure
Use	Financial assurance	Planning (prefeasibility, feasibility), budgeting, etc.	Financial reporting to shareholders, initial public offerings	Often for planning or dictated by emergency regulations
Purpose	Ensure funds are available for closure if bankrupt or abandoned	Estimates for planning over the life of mine	Report financial liability for closure in accounting (generally accepted accounting principles/ international financial reporting standards)	Cost for immediately implementing closure
Timing of assessment	Periodic update as per regulations	Continues updates throughout mine life	Quarterly or annual financial reporting	When sudden closure becomes possible outcome
Facilities Configuration	Approved life of mine	Approved life of mine or mine plan	Existing at end of financial reporting period	Current
Cost basis	Current cash	Cash flow	Cash flow	Current cash/cashflow
Rate basis	Third party	Operator and/or third party	Operator and/or third party	Operator and/or third party
Stakeholders involved	Government agencies, regulators	Mine operators, investor	Shareholders, financial institutions	Mine operators, government, local communities, emergency responders
Salvage	Depends on the legislation	Yes	No	Depends on the legislation and internal policies

3 Hypothetical case study to compare the different cost estimates

Based on closure cost projects developed over several years on sites from different parts of Latin American, this section presents a hypothetical case study based on the closure activities associated with a waste rock dump (WRD) facility, as well general social commitments of the mine, in order to identify practical implications of these cost estimate types, illustrating their areas of overlap and divergence.

General site description and risk identified on scoping level:

- gold mine located in Latin America; planned closure expected for year 2040
- high altitude 3,500 m above sea level
- temperatures range from a low of −30°C in winter to a high of 25°C during the dry summer months
- the WRD is considered to be potentially acid generating (PAG)
- the WRD is physically stable
- snow accumulation and water infiltration could affect the underlying aquifer
- nearest borrow source for cover material is 80 km away
- in the approved closure plan, there is no legal closure or post-closure commitment to the community, but the company publicly announced construction of solar power generation facility for the community at closure
- the material and equipment from the infrastructure on site could be salvageable.

According to the approved closure plan and corporate standards, the following represent the proposed closure activities relating to the WRD:

- grading of the top surface or flat areas to provide runoff water
- cover with material to reduce infiltration on the top surface
- sell equipment and salvage (LOM only)
- post-closure – commitment to the regulator is five-year monitoring water quality (pH), but the corporate standard risk assessment recommends monitoring acid drainage and heavy metal for 10 years.

The purpose of this case is to provide a comprehensive understanding and differences of the following key aspects, relevant to the WRD:

- legal obligation for the community
- salvage potential
- closure activities for different landform configurations of the WRD
- post-closure requirements.

3.1 Legal and constructive obligations

A legal obligation is an obligation that derives from (a) a contract (through its explicit or implicit terms); (b) legislation; or (c) other operation of law (IFRS 2001). This would include any commitment made in a closure plan, required by law or regulation, or included in a mining permit or license. The cost to fulfill legal obligations is normally included in all types of closure cost estimates.

A constructive obligation derives from an entity's actions where an established pattern of past practice, published policies or a sufficiently specific current statement indicates to another party that it will accept responsibilities and, therefore, has created an expectation by those parties that it will discharge those responsibilities in accordance with IAS 37 (IFRS 2001).

An example of a constructive obligation in this specific case is the installation of a solar facility at closure across the upper surface of the WRD for the community. Local and national law does not mandate any formal commitment to the community and the closure plan does not discuss such commitments. However, mine officials stated in a community meeting that they would install a solar power generation facility on the WRD for community use at closure. By making such a specific public statement, the mine has created an expectation in the community of a commitment that will need to be fulfilled at closure. FASB (2001) statement 143 refers to this as a contract made under the doctrine of promissory estoppel and IAS 37 (IFRS 2001) refers to such commitments as constructive obligations, either of which effectively transforms this public statement into a closure obligation. The cost to retire this obligation would need to be included in both the ARO and LOM closure costs.

Because the mine did not include this obligation in their closure plan, and it is not a requirement under law, it may choose to evaluate, during the next FA update, whether or not to formally include the costs related to the solar panel as part of their obligations.

3.2 Salvage

Material and equipment from existing infrastructure at the site could have an economical benefit from salvage. As shown in Table 1, salvage income could be considered in both LOM and SC cost estimates. However, it should not be included in the FA, because for the case study assumes that the local legislation does not allow the inclusion of salvage income.

Credit for salvage value is specifically excluded from ARO cost estimates under both FASB (2001) statement 143 and IAS 37 (IFRS 2001).

3.3 Closure activities for different configurations

This presents the impact of different configurations and closure activities on the WRD throughout all cost types. For the FA and LOM cases, the WRD footprint remains similar, as both represent the end of the mine case to the year 2040. The LOM configuration represents the highest bench of the WRD as this was included in the mine plan's previous FA approval. This modification was developed to reduce the flat surface during operation.

The ARO scenario reflects the WRD configuration as it exists at the end of the financial reporting period (fourth quarter of 2025). On the other hand, the SC scenario represents the current mine site configuration in 2025.

The approved closure plan includes measures to regrade and cover material on the top surface of the WRD to avoid any snow accumulation and reduce water infiltration on the top surface. Figure 1 shows an overall configuration and cross-section of the WRD for each cost type.

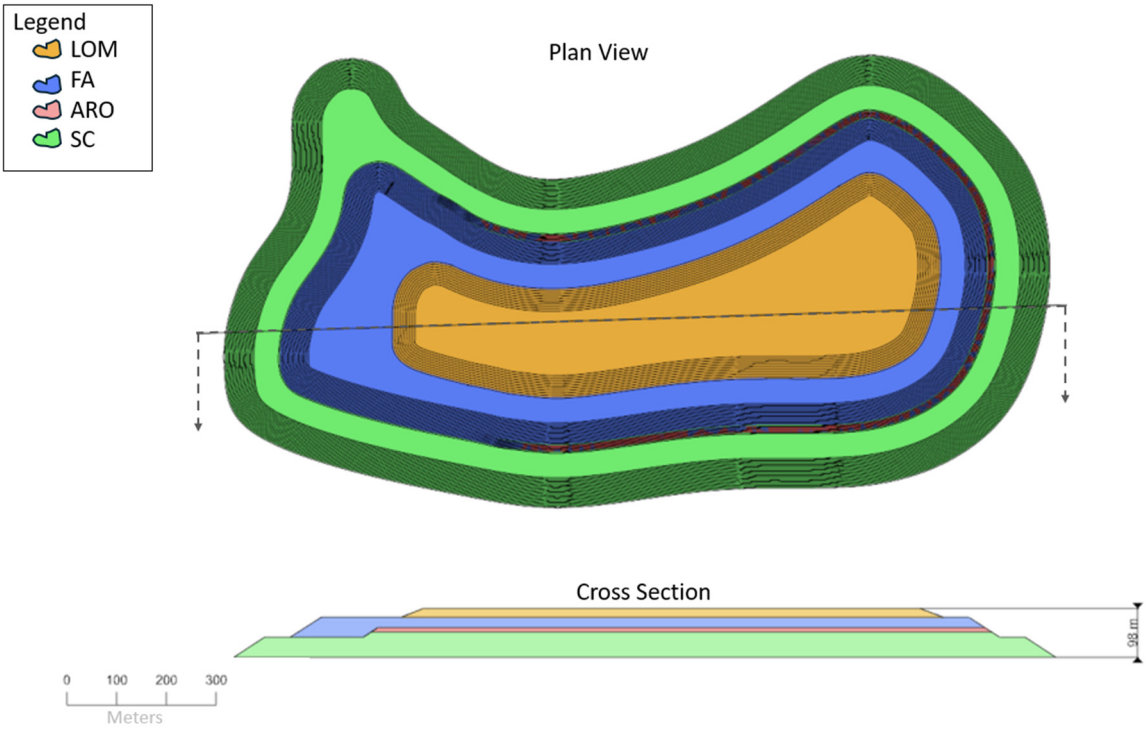

Figure 1 Waste rock dump indicating the different configuration (life of mine [LOM], financial assurance [FA], asset retirement obligation [ARO], sudden closure [SC])

Figures 2 and 3 show the same cross-section above but for each of the WRD landform configurations. Meaning the colours per cost type is maintained for visual understanding, but the overall section corresponds to a specific landform configuration. In the figures indicate the height and the total surface area for grading and cover material of each cost type.

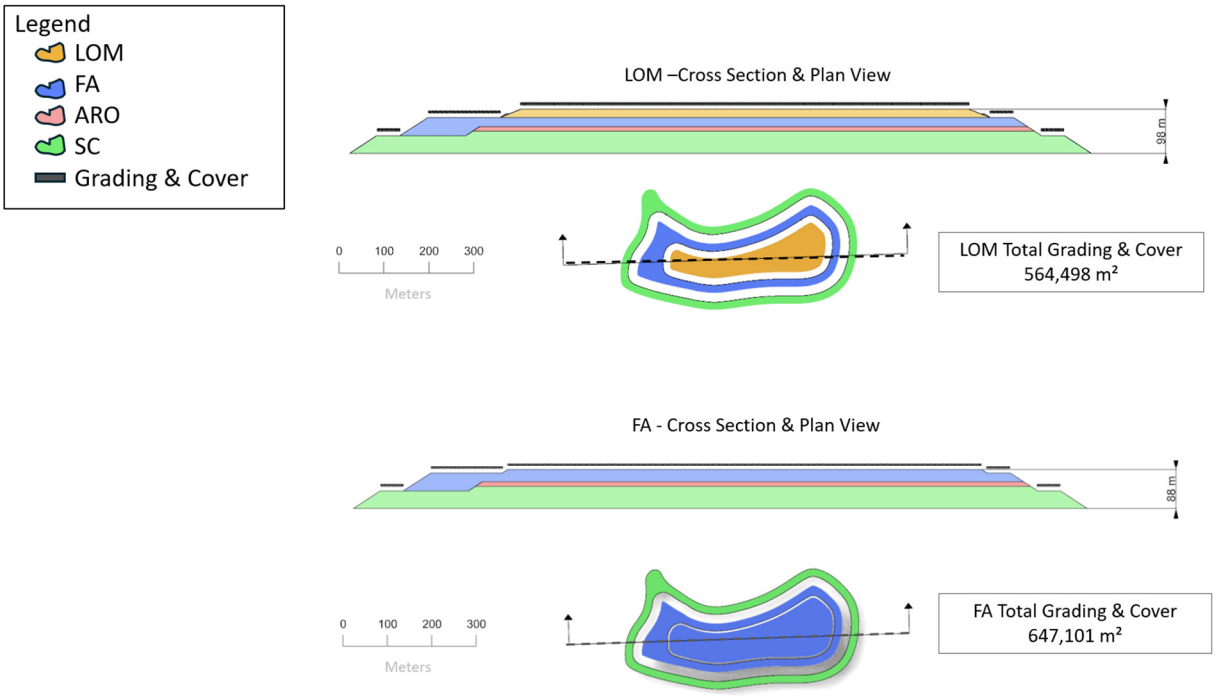

Figure 2 Section indicating grading and cover material for life of mine (LOM) and financial assurance (FA)

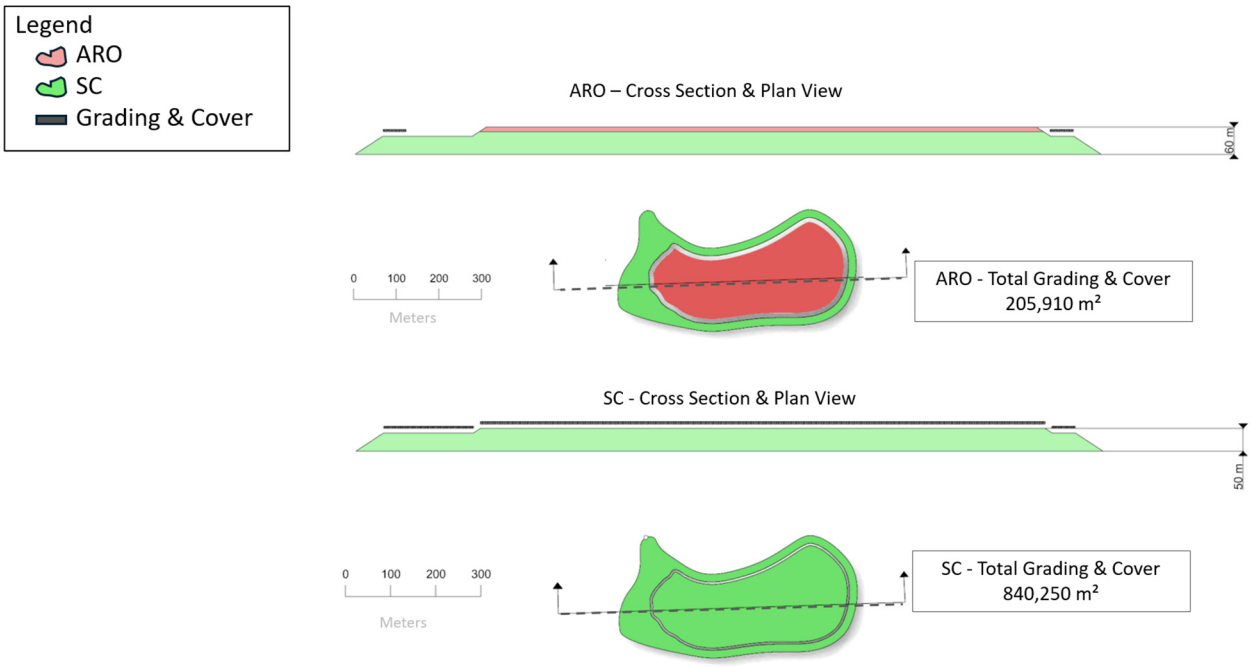

Figure 3 Section indicating grading and cover material for asset retirement obligation (ARO) and sudden closure (SC)

The areas that require regrading and cover with material are shown in the following Table 2.

Table 2 Cost type comparison

Cost type	Surface area (m^2) [1]	Unit rate (USD/m^2) [2]	Direct cost (M USD) [3]	Comments
Life of mine	564,498	14.5	8	Mine plan increases the last bench and reduces top surface area. Mine rates.
Financial assurance	647,101	17.4	11	Represents the approved and legal obligation with third-party rates.
Asset retirement obligation	205,910	14.5	3	The legal obligation applies only to the benches that exist at the end of the fiscal year.
Sudden closure	840,250	14.5	12	The current top area is the most significant. Mine rates.

Notes: [1] The surface areas for grading and cover material are consider the same.

[2] The operator unit rate is USD 14.5/m^2 and unit rate from a third party USD 17.4/m^2.

[3] Values are in millions of US dollars.

The largest cost corresponds to the SC (USD 12 M), followed by FA at USD 11 M, LOM at USD 8 M and lowest is ARO (USD 3 M). These differences are due to the work required for each different configuration and the use of third-party rates, which are 27% higher than mine rates in this example. This affects the overall costs for some of the cost types, particularly the FA.

3.4 Post closure

The approved closure plan defines five years of monitoring water quality (pH). However, based on new information and corporate standards, the mine intends to monitor water discharge from the WRD for 10 years, including analysis for acid rock drainage and metal leaching.

Although this would increase the LOM costs, until the additional monitoring requirements are included in a closure plan update, these costs would not be included in the FA. As the additional costs are not legally required and the company has not announced its intention to expand the post-closure monitoring, the additional costs are neither a legal obligation nor a constructive obligation. Therefore, these costs do not need to be included in the current ARO estimate.

3.5 Results

Table 3 summarises the case study consideration for each cost type, comparing solar panel installation (Section 3.1), income from salvage material or equipment (Section 3.2), grading and cover material costs (Section 3.3), and post-closure cost for five years and 10 years (Section 3.4).

Table 3 Case study result for each scenario

Direct cost (M USD)	LOM	FA	ARO	SC
Solar panel[(1)]	5	N/A	5	5
Salvage[(2)]	−0.5	N/A	N/A	−0.5
Grading and cover	8	11	3	12
Post closure[(3)]	0.2	0.1	0.1	0.1
Total (M USD)[(4)]	**12.7**	**11.1**	**8.1**	**16.6**

Notes: [(1)] The value for installing solar panel is considered USD 5 M.

[(2)] The income considered from material and equipment is USD 0.5 M.

[(3)] Monitoring for five years is considered USD 0.1 M and 10 years USD 0.2 M.

[(4)] Values in millions of US dollars.

4 Conclusion

Understanding and differentiating closure cost estimates – financial assurance, life of mine costs, asset retirement obligations, and sudden closure costs – provides valuable insights into the complexities of each cost type. Each cost estimate type serves distinct purposes, ranging from ensuring regulatory compliance to planning, financial reporting, and unforeseen emergencies.

The case study of the WRD demonstrates the practical implications of these cost estimate types, illustrating their areas of overlap and divergence. It features how FA prioritises regulatory obligations, while LOM adapts to mine plan changes. Similarly, ARO emphasises on financial period obligations, whereas SC costs assess current unexpected scenarios and unfulfilled obligations. These distinctions are crucial for avoiding cost over- or under-estimation.

Considering the direct costs and acknowledging that some scenarios in this hypothetical study involve different rates and amounts that are applied only by constructive and legal obligation, it is evident that the highest closure activity cost is associated with SC at USD 17 M – primarily because of the wide, flat area that is required to be graded and covered – followed by LOM at USD 13 M as there was an improvement on the landform, and FA at USD 11 M. ARO represents the lowest cost (USD 8 M), primarily because the legal obligation only requires grading and covering the flat areas with material. Also, the 60 m height of the ARO configuration is not final, and for that reason it does not require a cost in the current fiscal year.

In this case study, the mine strategically modified the mine plan to reduce the surface area for LOM configuration by 14% compared to the FA. The primary reason for the modified configuration was to reduce costs and maximise the use of limited cover material. This modification has not yet been incorporated into an approved closure plan and, therefore, the FA considers a more expensive configuration. This example illustrates how the different cost types are integrated and how, sometimes, operational efficiency could benefit closure cost.

It is equally vital to understand the relevance informing stakeholder or public awareness, as it may result in the inadvertent creation of constructive obligations that will increase closure costs. Finally, it is important to recognise that many international standards, legislation, and best practice commonly require consultation with affected stakeholders in the closure planning process, which can reduce the risk of creating constructive obligations without thoughtful consideration.

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