

Mine closure plan transition: from a document to a management tool during mine operation

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Abstract

Experience shows that closure plans, in the time it takes for companies to reach a certain degree of maturity in incorporating the closure phase into the mine's ongoing planning (ICMM 2019), generally remain as static documents that, beyond complying with regulatory formality or with the standards promoted by the industry, are not used as a decision-making tool in themselves. Rather, it is understood as the final result of a mine projection, sometimes forgetting it is prepared with the information available at an early stage and it must be continuously revised to reduce uncertainties as time progresses during the mine's lifecycle (LOM).

In this context, the development of tools that facilitate the visibility of the contents, studies, assumptions, criteria, and other variables affect both the definition of closure activities and the estimation of their costs, is essential to:

- *facilitate the review exercises of closure activities by key stakeholders, making risks and opportunities visible*
- *identify gaps and focus the use of resources on continuous improvement of planning inputs*
- *evaluate the effects generated by the identified gaps in terms of their impact on the cost of closure.*

This paper presents the development of a dashboard type platform to keep key information visible in mine closure planning. This platform allows us to provide continuous access to technical, management and stakeholders information needed to identify opportunities for improvement of closure planning and thus minimise the uncertainty that can be dragged over time if this information is not visible for management to take actions during the operation of mine.

Keywords: *mine closure planning, operation for closure, innovation, closure cost estimation*

1 Introduction

The state-of-the-art of regulation related to mine closure shows a growing trend in countries where the mining industry has historically developed, incorporating specific legislation to regulate mine closure and/or mining companies are using international standards like ICMM's as a reference. In the case of Chile, for example, the mining industry has developed continuously since the 16th century (Chilean National Society of Mining 1996) and has adapted to the needs and demands of society as regulatory guidelines were consolidated to regulate, for example, environmental aspects in Law No. 19,300/1994 (Chilean Ministry of the General Secretariat of the Presidency 1994) and much later, the aspects involved at the end of the operation of a mine, mine closure (Chilean Ministry of Mining 2011).

Under Law 20,551/2011, which regulates the closure of mining operations and facilities, it is mandatory in Chile for each mining operation to have an approved closure plan (a sector-specific permit issued by the National Geology and Mining Service). The objective of closure plans is to protect the life, health, safety of people, and the environment, ensuring the chemical and physical stability of the remaining facilities.

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Since Law No. 20,551/2011 was enacted with an industry with a long history, it established a transitional requirement, which required companies to prepare and submit the first closure plan by 2014 based solely on the valuation of the commitments (closure activities) acquired during the processing of environmental permits (Law No. 19,300/1994). These closure activities were valued and based on this, the financial guarantee that mining companies deliver to the state was calculated based on the useful life of each mining project.

Following this milestone in 2014, companies have entered a cycle of updating their closure plans, considering the requirements of the closure law. This cycle is mainly based on determining appropriate closure activities for facilities based on their characteristics and environmental conditions, to correctly assess the risks identified to ensure compliance with the objectives of the law. However, even though the processes of updating closure plans constitutes an opportunity for improvement, since new information is incorporated to improve the understanding of risk, closure activities and costs, it is observed in some cases there is an inertia in not systematically reviewing the closure activities defined in previous processes, losing this opportunity by companies to improve the quality of closure planning information and, above all, reduce uncertainties in closure costs.

While international standards such as the ICMC propose closure planning as an integrated element of mine life planning, through an iterative process that is refined and updated cyclically (Figure 1), in countries where closure regulation is ‘recent’, the implementation of these standards may take longer if the closure plan is used only as a document and alternatives are not explored to manage the information contained therein in a way that is easily visible to planners and decision makers.

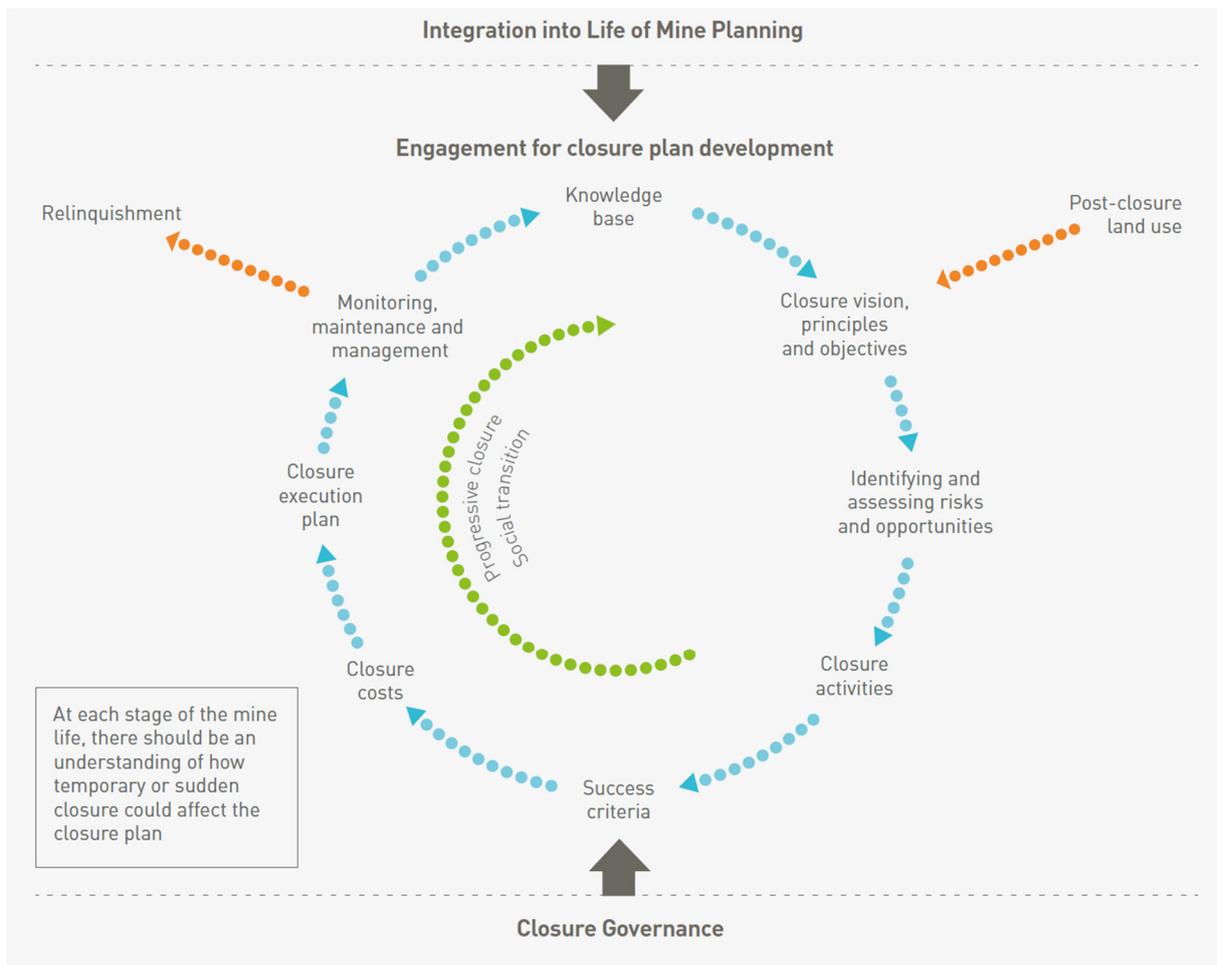


Figure 1 Elements of closure planning

2 Methodology

The methodology for this work is described below. It consists of a comprehensive analysis of a selection of closure plans from mining companies in Chile (information confidentiality remains). These closure plans identified some of the key elements that impact their valuation (direct cost of closure activities) and can be a relevant factor in the continuous improvement of planning through timely internal management.

These factors correspond to:

- risk assessment support
- origin of closure activities
- traceability of facilities or closure activities quantities (origin of quantities)
- origin of unit prices.

2.1 Risk assessment support

Although there are various methodologies for conducting a risk assessment, most aim to identify the need to implement controls (closure activities) for a particular risk scenario based on an analysis of the probability of occurrence and the severity of the consequences for a sensitive receptor (people or environmental component).

In this sense, and depending on the stage of life of mine, the information available to conduct these analyses may initially lack optimal sufficiency, making it necessary to continually update the knowledge base to ensure a robust risk assessment and the appropriateness of the defined closure activities. It is worth mentioning that in cases where information is not considered sufficient for risk assessment, it is common practice to opt for 'penalising' the evaluated factor using conservative values. This can alter the outcome of the risk assessment and, consequently, the definition of the closure activities, potentially leading to inflated costs in some cases.

Based on the above, as part of the analysis, those factors for which no evidence or support was available for their assessment are identified. To do this, a qualitative categorisation of the level of absence of supporting information is performed for each type of risk, considering the number of technical factors evaluated for each of them and the closure activities defined with said evaluation.

2.2 Closure costs estimation

2.2.1 *Origin of closure activities*

In this aspect, the origin of the closure activities considered in the selected closure plans is analysed, differentiating whether they originate from an environmental commitment (Chilean Ministry of the General Secretariat of the Presidency 1994) or from a risk assessment as indicated by the closure law.

This point is relevant because, as mentioned above, all the initial closure plans were developed solely by assessing the environmental commitments of the closure phase that mining companies had at the time the closure law came into force. Because this commitment is contained in a resolution (legal environmental approval), it cannot be eliminated from the assessment of the closure plan (as indicated by the closure law), even if it is not a necessary closure activity according to the risk assessment conducted for the specific facility.

This makes it possible to visualise:

- Closure activities from environmental commitments which could be eliminated in the future, potentially reducing closure costs.
- Closure activities that do represent control for the assessed risks and match the previous criterion regarding the sufficiency of the information used for the analysis.

- Closure activities that correspond to good industry practices.

2.2.2 *Origin of quantities*

All selected closure plans use the direct costing function indicated by the closure law (Chilean Ministry of Mining 2011) and are based on:

$$\text{Direct Cost} = PU \times Q \quad (1)$$

where:

- PU = unit price of closure activity
- Q = quantity of closure activity.

Therefore, the volume of a facility or closure activities is a relevant factor when estimating the closure cost. For this factor, the level of traceability of the volume value used was identified in the various closure plans analysed. Four qualitative criteria were defined to classify their traceability:

- No traceability[§].
- Calculated/estimated.
- Company information.
- No information**.

2.2.3 *Origin of unit prices*

The unit price (PU) represents the second relevant component for determining the closure plan valuation and corresponds to the monetary value of the closure activity per unit of measurement.

Based on the review of the various PU used in the selected closure plans, it was identified that this data could come from different sources of information. To classify these sources of information, the following categories were defined:

- Company's closure cost model.
- Company's unit price databases.
- Assumptions.

3 Data

The information used in this analysis corresponds to a selection of closure plans available in the Chilean National Geology and Mining Service's public database of closure plans.

For confidentiality reasons, and because it does not affect the analysis performed, the information regarding the mining companies involved in each closure plan remains confidential.

The information used in the analysis basically corresponds to:

- risk assessment files
- criteria used in the valuation of closure activities

[§] This group includes specific quantities without supporting documentation of their origin. Closure activities quantified globally as 1 unit (GL) are also included.

** This category is assigned to any quantity whose source of origin is undetermined and cannot be classified in the previous categories. In some cases, monitoring closure activities were classified here when the monitoring period considered are not supported.

- closure activities calculation reports^{††}
- direct closure cost estimate spreadsheets.

These data were compiled into a database that fed into the Power BI platform developed for visualisation and analysis. The structure of the developed database is presented in Table 1.

Table 1 Selected mine closure plans information database

Attribute name	Linked database
Mine site name	–
Facility name	–
Closure activity	–
Unit price	–
Quantity	–
Origin of mine closure activity	Risk assessment: <ul style="list-style-type: none"> • valuated factors • backup information.
Origin of quantities	–
Origin of unit prices	–

4 Results

The objective of this paper is to demonstrate the usefulness of having a dynamic and interactive platform that allows easy visualisation and access to closure plans, their costs, and information considered relevant for defining closure activities and estimating their costs.

Without delving into the findings or specific characteristics of each of the closure plans selected for this paper, the platform created as a Power BI dashboard is presented in Figure 2.

4.1 Risk assessment support

In an initial approach to assessing the adequacy of the risk assessment process carried out for the selected closure plans, the background information used to evaluate the factors considered in the methodology employed was considered a central element of the analysis.

Figure 2 shows a diagnosis of the risk assessment process for each risk scenario, identifying the technical factors for which no evidence or support was available for their assessment. To this end, a qualitative categorisation of the level of absence of supporting information for each type of risk is presented, considering the number of technical factors evaluated for each risk and the closure activities defined with said assessment.

^{††} Although the Chilean legislation only requires a summary table of closure activities for conceptual mine closure plans, it is a recommended practice to support the calculations and designs of closure activities with calculation reports. This will be required for detailed mine closure plans.

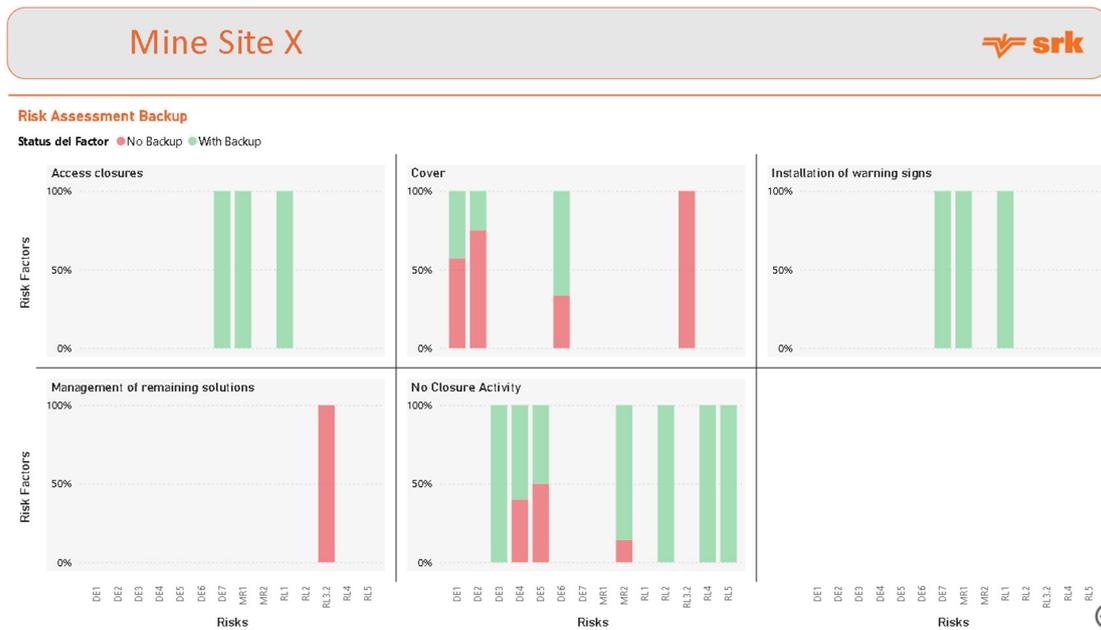


Figure 2 Dashboard risk assessment view

Figure 2 shows the different risk scenarios evaluated (x-axis) and the total technical factors evaluated for each scenario expressed as a percentage (y-axis). Each quadrant of the graph shows the closure activities defined for the evaluation of each scenario.

The green colour shows the percentage of factors in each risk scenario for which backup information was available (with backup), and the red colour shows those factors that did not have backup information (no backup) and that, according to the methodology, were penalised, likely resulting in inadequate or oversized activities.

4.2 Closure costs estimation

Figure 3 corresponds to the general panel (dashboard) developed to review the relevant factors that affect the estimation of closure costs.

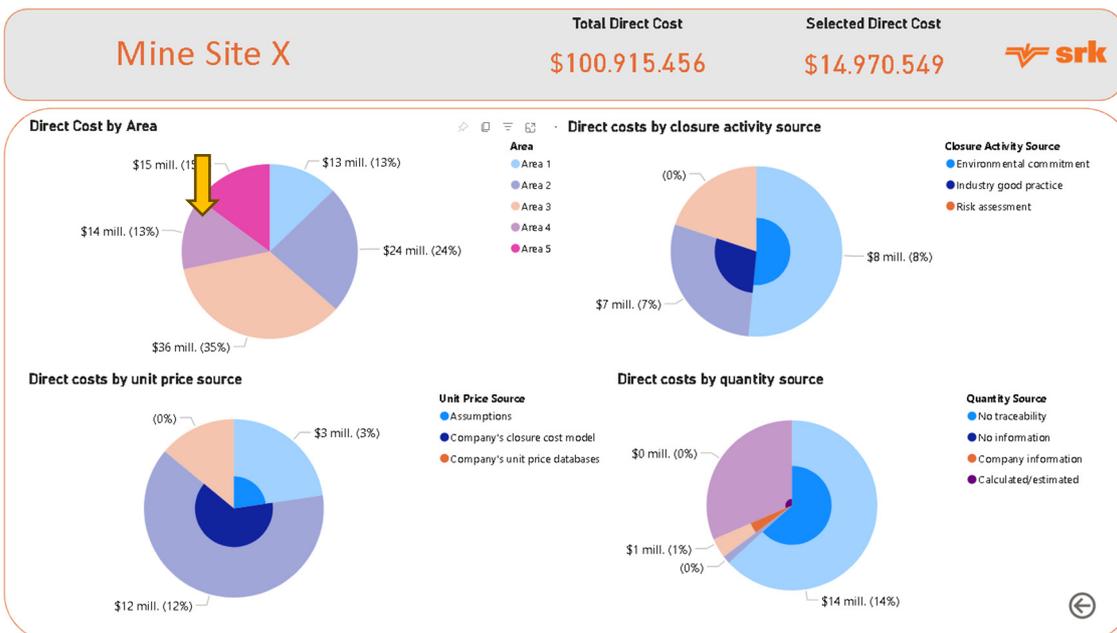


Figure 3 Dashboard cost analysis view

In this example the closure costs for 'Mine Site X' is divided into five areas (Table 2).

Table 2 Mine Site X closure costs distribution

Area	Percentage (%)
Area 1	13
Area 2	24
Area 3	35
Area 4	13
Area 5	15

Figure 3 also shows how the platform works. Being interactive, by selecting in this case 'Area 5' (pink colour) which represents 15% of the Mine Site X closure cost, the platform automatically allows the following to be displayed (how this is 15% composed).

4.2.1 Origin of closure activities

As shown in Figure 4, the closure activities assessed in 'Area 5' are primarily due to environmental commitments and represent 8% of the mine's total direct costs. The remaining closure activities were defined by industry good practice implementation and represent 7% of the mine's total direct costs. In this specific example no closure activity was defined by risk assessment (0%).

Direct costs by closure activity source

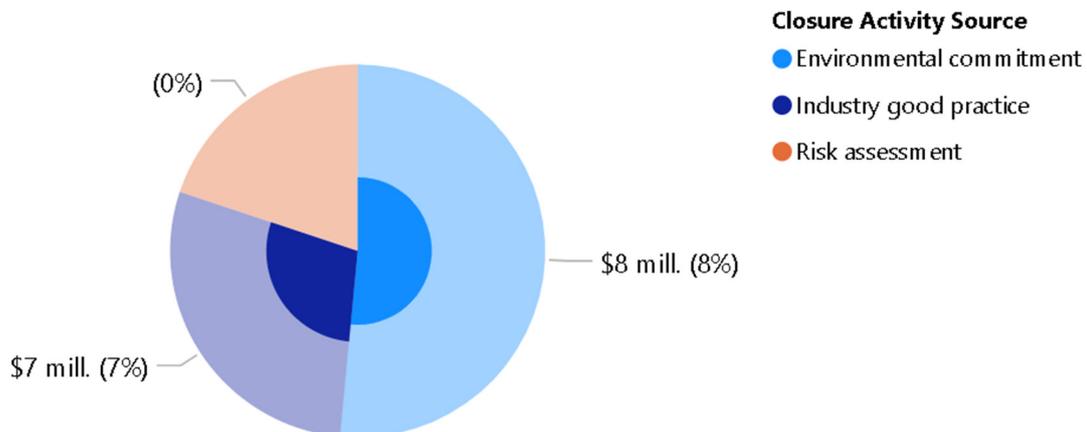


Figure 4 Area 5: origin of closure activities and percentage of total cost

4.2.2 Origin of quantities

As shown in Figure 5, the quantities used in the cost estimate for closure activities in 'Area 5' are largely untraceable and represent 14% of the total cost. The remaining closure activities in this area were valued using quantities determined using information from the company (1%), while a small number were calculated or estimated using a traceable methodology (0.18%).

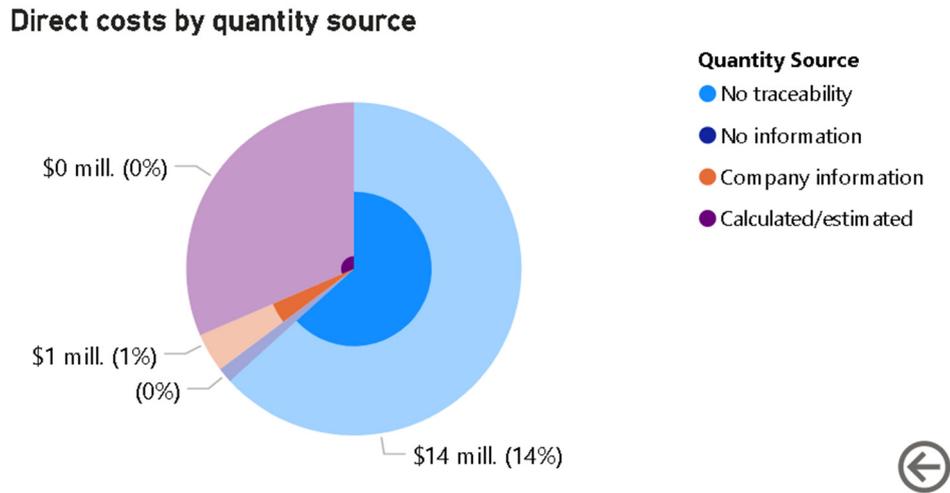


Figure 5 Area 5: quantity’s traceability and percentage of total cost

4.2.3 Origin of unit prices

As shown in Figure 6, the cost of the closure activities for ‘Area 5’ was calculated using unit prices from various sources. Most of the PUs in this area were obtained from the company’s own closure cost model and represent 12% of the total cost. The remaining closure activities were valued using unit prices determined through assumptions and represent 3% of the total cost.

Direct costs by unit price source

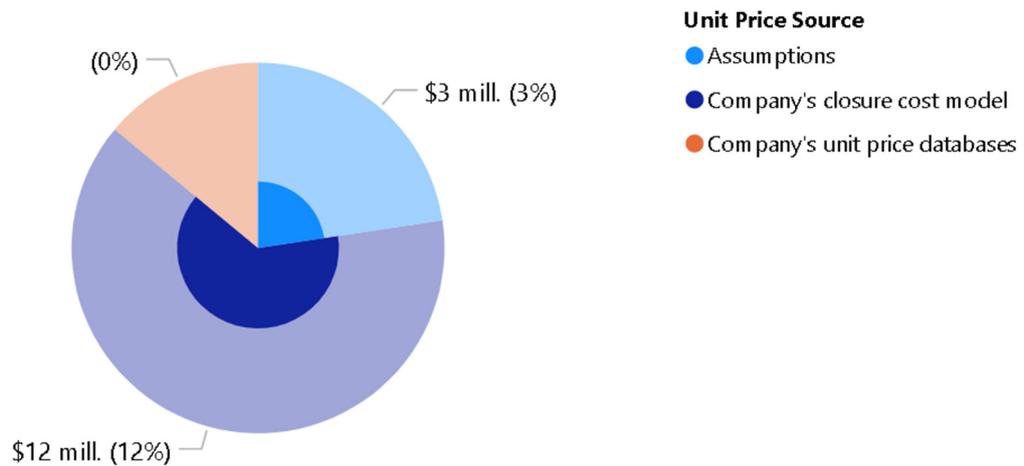


Figure 6 Area 5: origin of unit prices and percentage of total cost

5 Conclusion

Closure planning, as established by international standards, must be a continuous, iterative, and cyclical process that allows for updating and improving the available information both for assessing the risks that determine the controls necessary for regulatory compliance or international standards (closure activities) and for adequately estimating the costs of these closure activities.

Since the closure plan, as a document, must be understood as a dynamic instrument, it is important to have tools that allow for tracing the information used in its development and, at the same time, allow planners, stakeholders, and decision makers to have relevant information available and accessible, adding value to closure plan updates and thereby facilitating the incorporation of the closure phase into life-of-mine planning.

The platform developed (dashboard) and presented in this document has made it possible to identify gaps, focus efforts, and appropriately allocate resources to advance the continuous improvement of closure planning early and to reduce uncertainties in cost estimation.

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