Presenting a case for two closure approaches

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ABSTRACT

This articles makes a case for two closures approaches: (1) a plan developed pre-mining; or (2) a plan developed during late operations or post-mining. A pre-mining closure plan that dovetails with a tailored operating plan can achieve goals with modest and low-volatility post-mining capital expenditure. A post-mining closure plan can capitalize on practical yet innovative techniques to yield best-achievable results with the resources available.

Either case has its place for consideration depending upon where on the timeline the mine owner has taken possession of the property. In the first case, the closure obligation can be closely managed during operations by careful execution of a holistic plan that integrates purposeful operating activities to advance closure efforts and reduce associated costs incurred post-operations. It can be demonstrated that any closure plan can be implemented at lower cost if operations are modified to cater to specific, even if limited, aspects of the closure plan. In the second case, practical objectives can be developed and achieved with a realistic understanding of techniques and activities that can be successfully executed under the circumstances that exist at actual mine closure. One of the keys to success if following this second approach is to employ a skilled and experienced practitioner of closure planning.

The situations that lead to the circumstances where each case is applicable and the general thought process that may be employed are explained in this article. Some practical examples of closure elements to consider and how they can be used to bolster the argument for each case are provided to equip the reader with concrete illustrations.

INTRODUCTION

Closure of mining facilities and mine sites is a topic of increasing interest, not only within the mining industry, but with rapidly increasing level of interest within the public sector--both the communities surrounding the mining developments and society at large (Steenhof, 2015). With this interest comes an increased level of scrutiny, by all interested parties. It is therefore incumbent upon the developer of the closure plan to pay close attention to all details of the plan, and to apply appropriate and prudent methods of analysis when considering and designing the plan components. But how are the closure plans typically developed? Is there an optimal approach? Do approaches differ if the owner has possessed the property from inception of development through to closure versus if the owner has dealt for the property well after it became an operation?

This article deals with the questions posed above and in particular with the notion that a closure plan developed in conjunction with an operational strategy is the most efficient plan and one which is subject to the least degree of risk encompassing environmental, financial and schedule risk. But not all mine sites possess such a closure plan, and in fact many sites change hands during the course of operations, and in some cases may not possess an actionable, effective closure plan when purchased by a new owner. In these cases, a prudent closure approach can still be developed and a strategy for doing so is also discussed in this article.

PHILOSOPHICAL BASIS

It is well recognized that comprehensive mine closure plans contain a wealth of information, rely upon a great deal of data derived from diverse sources, require multi-disciplinary inputs, and must satisfy a very broad and diverse consumer base—one that many times possesses competing motives and goals. To demonstrate a case for closure approach while attempting to address each of these many facets would be futile in an article of this length and scope. Therefore, the focus of the article is distilled to a simpler form and the examples provided will be narrowed to one aspect of one facility for each example. The components from the examples shared are readily extrapolated to multi-component examples with greater complexity, and thereby lead the reader to an understandable overview of a complete and even more complex closure plan. This simplified approach will allow the topic to be presented in a manner suited to the scope of this article.

OPERATING TO CLOSE

Mindset

At the onset, it is readily recognized that tailoring operations to facilitate closure is subject to cost premiums that are typically accounted to the site operating cost. To be more blunt, such extra costs for the purpose of making eventual closure either easier, more effective or less costly will in all likelihood reduce operating profit in the short term. This will not be an easy pill for the mine to swallow especially if the mine general manager (GM) is not fully engaged in the closure planning process and not staunchly supported in this process by his corporate superior. This article does not attempt to tackle this particular mindset issue, but it does presuppose that a mining company can address this mindset issue for the purposes and goals pertaining to effective and efficient closure described in this article. Across time, this mindset has undergone gradual change and is expected to continue to do so.

Nevertheless, the ability exists to tailor various aspects of operations to facilitate a more effective and cost-efficient, and less volatile (lower risk to cost, schedule and ongoing liability), mine closure. In many cases this ability is comprised of relatively simple strategies and actions. When applied with diligence such strategies and actions can yield results which reduce overall capital expenditure and thereby preserve more of the total life of mine profit. It is important to keep in view not only the medium term cost savings aspects of this *operating to close* mindset but to also appreciate the opportunity to improve the effectiveness of the closure and thereby realize a reduced risk in future failure of closure components and corresponding reduced risk in financial and reputation damage. Environmental damage costs can amount to sums far greater than aggregate closure cost sums, and reputation damage costs can potentially outstrip both of these.

Strategy and actions

There are many avenues to take to implement an *operating to close* mindset. The key principle is to envision the ultimate needs for closure and then to apply creative thought to ways of incorporating actions operationally that will later save time, labor and expense in the carrying out of the closure. More so than just these savings, intentional operational actions can promote results that change the requirements for closure, either in a positive or a negative respect. An example of this from the positive perspective: a mine that is limited to heap leach processing forgoes the mining and processing of sulfidic or refractory ore to avoid the potential for acid generation from the closed heaps. Another related example of this: a mine that mills its ore and mines sulfide ore actively manages the sulfidic mine waste in a manner to prevent the onset of oxidation and acid generation such as via compartmentalized storage that minimizes oxygen influx and water transmission. Inattentiveness to these preventive opportunities would result in greater requirements and efforts in closure.

From a simpler earthmoving volumetrics perspective, two examples of intentional operational practices to effect reduction in closure effort and associated costs are provided below. These examples are derived from actual mine operation cases, presenting two optional approaches that result in different effects on total closure cost.

Scenario A represents a North American precious metals mine that exclusively heap leaches its ore and has been in operation for many years. At this property a closure plan has been prepared relatively recently. For the heap leach pads, the closure plan involves placing a dual layered cover to facilitate reclamation and to prevent undue amounts of infiltration into the heap. The lower layer of the cover will be comprised of mine overburden deemed suitable for this purpose. A large quantity of overburden is already available in storage piles from past mining and these are situated in various locations with a mean distance of 3 km from the largest heap leach pad. However, the mine is planning to operate several more years and during this time a considerable quantity of overburden will also be mined. The opportunity exists to utilize either the stored overburden or to plan for use of the newly mined overburden and take advantage of the scale of the mining equipment to strategically place the overburden in new stockpiles as near as possible to its final destination as cover on the heaps. An analysis was completed to evaluate the relative cost of placement of cover material from the two potential locations: either the existing storage areas or the more optimally located temporary stockpile. The more optimal stockpile location is 20% closer in mean distance to the closure placement position on the largest leach pad.

This article is not intended to present the details of the estimate, rather to present the results and its meaning. By using mine-scale equipment to locate the new overburden more optimally for heap reclamation, the owner will be able to save an estimated $0.08 per tonne. This estimated net savings is the result of a combined increased mine-to-stockpile cost and a decreased stockpile-to-heap-cover cost. This modest savings cannot be realized unless the operator appreciates and accepts the need for marginally higher operating cost to effect lower reclamation costs and an ultimate lower total overburden movement cost.

Scenario B represents a South American precious metals mine that mills all of its ore. Like Scenario A, the closure entails reclamation cover placement for stabilization and rehabilitation, but in this case upon a tailings impoundment. Also like Scenario A, this operation has been active for several years and possesses overburden storage areas near the mine pit. However, the tailings facility is nominally 10 km from the mine area. The closure plan for this operation is presently at a conceptual stage and use of overburden may be made to support the lower layer of a two-layered reclamation cover. While overburden is presently stored very near to the pit, the opportunity exists to stockpile future overburden adjacent to the tailings facility. Haul distance differences again comprise the largest cost difference to the future cover placement project. By using mine-scale equipment to locate the newly mined overburden more optimally for eventual tailings reclamation, the owner will be able to save an estimated $0.60 per tonne. Again, this estimated net savings is the result of a combined increased mine-to-stockpile cost and a decreased stockpile-to-reclamation-cover cost. This estimated savings will be much greater than that illustrated in Scenario A due to both the greater unit rate savings and the larger scale of the project; however, by the same token the savings cannot be realized unless the operator accepts the higher operating cost to yield lower reclamation costs and lower total overburden movement costs.

The above discussions focus on closure costs and specifically actions to reduce closure cost. How do these examples relate to risk reduction? This topic is addressed more as a focal point in the subsequent section. However, risk reduction can certainly be illustrated within the above examples. Tailoring operations, even modestly, to facilitate closure can have a significant positive impact on risk as it pertains to mine closure. In the cases already illustrated, the planned placement of overburden to better facilitate closure cover construction will tend to reduce the following risks: meeting completion schedule and producing an effective result. By making the effort to create a ready stockpile of suitable material for closure cover use, the mine will have accomplished a number of things:

- Potentially sorted through suitable versus unsuitable materials
- Practically verified suitable quantity for intended end use
- Virtually eliminated uncertainty in material quality, quantity and source location

Each of the above will contribute to a risk reduction in terms of being able to execute the closure activity in a timely manner and produce the required quality of end product, and as a consequence, lower risk to cost increases. The added cost of sourcing suitable overburden material for a closure cover, if those materials had not been identified, segregated and made conveniently available could be significantly higher than just the haulage difference cost in the above examples. In absence of intentionally stockpiling the materials for future use, the materials available otherwise in an amorphous operational overburden storage area might be rendered entirely unsuitable for the purpose of closure leading to either greater costs to source suitable material or potentially much greater costs to sort and process the mixed overburden.

Other examples of an *operating to close* mindset are numerous and include concepts such as:

- Constructing facilities in a configuration that more easily promotes reclamation or closure release (re: slope angles, shapes, etc.)
- Incorporating features that support desired closure behaviour (e.g. appropriate liner types to either prevent or allow drainage according to water quality constraints, operationally developing either a free-draining surface or an impounding surface, etc.)
- Conducting concurrent reclamation on unchanging portions of facilities such as lower benches of upstream-expanding earthen structures
- Backfilling open pits where appropriate and where this is effective for preventing groundwater contamination or acid generation from otherwise stored waste or overburden materials

The list could go on.

REACTIVE CLOSURE

In absence of the opportunity to apply an *operating to close* mindset, a more reactive closure approach may be required. This would be the case where a mine site has been acquired by a new owner near the end of its mine life. In this situation, there may be insufficient if any time for operational modifications to be made to proactively support closure and optimize closure costs. In this case, whether a preliminary closure plan already exists or not, an effective plan for closure can be developed that aims at balancing cost versus liability. The most important aspect of closure for mine sites is typically the restoration of a productive post-closure land use while mitigating environmental impact and its enduring risk (Zobaidul Kabir, et al. 2015). Attaining this goal can be a complex process, involving many factors and challenges, and as a result can also be very costly. A successful closure plan under these circumstances can be developed by: taking into consideration a detailed and accurate inventory of the facilities and installations subject to closure; carefully understanding their characteristics and the proper stabilization measures to employ if these facilities are permanent;

anticipating the effects of their ongoing presence and mitigating them. This can be reliably achieved by employing skilled and experienced practitioners of mine closure.

The implementation of closure is very different from the permitting process and the bonding or financial assurance processes. While the latter can be, at times, an academic exercise to meet administrative requirements, the former is best achieved by practical designers and constructors with specialization in mine closure. It is best practice to get closure right the first time rather than requiring multiple chances to make 'fixes' as problems are encountered across time. The nature of a discovered problem is just that it probably has produced an undesirable effect that must also now be mitigated, which usually requires more of both time and expenses. Therefore, the prevention of problems is another key to controlling closure cost and it points to the need to get it right the first time. Closure encompasses many facets and disciplines, as alluded to earlier, and getting it right requires a team with both the skills and a successful track record in implementation.

CONCLUSION

Mine closure is a complex task and is moving quickly toward being in the very forefront of the process of getting permission to develop and operate a mine. As such, its planning and implementation should be relegated to a qualified team and given the importance it is due. In advancing the mine closure planning process, it should be recognized by the owner that two approaches are apparent and can be taken with confidence. The optimal situation occurs early on even before the first ore is removed from the ground. In this case, an *operating to close* mindset can be adopted to allow the operator to work hand in hand with the closure planning process in order to provide the greatest synergy and result in the highest efficiency in terms of ultimate cost to close the operation. This desirable outcome occurs in tandem with establishing the lowest risk of schedule or cost overruns in implementing the closure along with the lowest liability concerning the environment and the company's reputation.

In absence of being able to apply the *operating to close* mindset due to limited remaining mine life, the owner can still apply a prudent although more reactive approach that develops a plan to balance the cost versus the liability associated with closing an operation. Many times this situation comes into being with limited financial means. However, protecting the owner's reputation is always paramount. The goal in this situation is best achieved using a skilled and experienced team that is known for closure implementation success.

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