Towards a positive legacy

Key questions to assess the adequacy of mine closure and post-closure

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NOTE TO THE READER

The text of this document was first published on-line, 02 September 2022 as a "viewpoint" article in the Springer Nature journal, *Mineral Economics* available at https://doi.org/10.1007/s13563-022-00339-x. It has been reformatted in colour for this publication and photos have been added.

ABOVE: **Svartliden Gold Mine, Sweden**
Operated 2004–2015. The mill has since been processing concentrate from other mines with tailings deposition underwater in the open pit. Successive remediation is underway and closure plans include a permanent water cover in the pit and engineered covers over tailings and waste rock. The current owner, Dragon Mining Limited, Perth Australia, is seeking approval for mining at the Faboliden mine, 30 km SE. Ore would be processed at the Svartliden mill. **SOURCE:** presentation to the British Columbia MEND ML/ARD Annual Workshop, 8 December 2021. https://bc-mlard.ca/files/presentations/2021-8-UNE%CC%81E-planned-closure-measures-svartliden.pdf

FRONT COVER: **Thompson Creek Mine, Idaho**
Molybdenum with secondary silver and gold. Operation started in 1981. Owner is Centerra Gold, Toronto, Ontario. Currently under "care and maintenance." **SOURCE:** Idaho Geological Survey, Centerra Gold https://www.centerragold.com/operations/thompson-creek-metals/thompson-creek/history

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1. Purpose

The purpose of this note is to offer a list of questions that will facilitate:

- Enhancement of stakeholders' understanding of the closure/post-closure phases of mining;
- Strengthened assessment of the adequacy of closure/post-closure plans and actions over both the short and long terms;
- Identification of the risks inherent in a company's commitment, plans, and financial capability to close mines in keeping with its long-term environmental, social, and financial obligations; and
- Constructive discussions between stakeholders related to the achievement of a positive legacy.

2. The challenge of mine closure/post-closure

The mine closure phase of a mine project formally starts with the end of operations and includes implementation of worker and community transition plans, removal of extraneous physical plant, site grooming, construction of treatment facilities, implementation and testing of the site monitoring system, and overall preparation of the site for the long term. However, many aspects of closure design, planning, approvals, decision-making and implementation begin long before the end of operations, starting with mine design and related approvals.

Post-closure takes place after the site has been fully prepared for the long term. It includes long term operation of any treatment facilities; monitoring of ecological (physical, biological, bio-geochemical) and social conditions; assessment of performance against socio-economic and environmental obligations; system adjustment if performance is not as projected; and any required reporting to regulatory agencies and the public.

The closure and post-closure phases of the mine project life cycle can carry significant costs, risks, and opportunities.

Costs and risks related to environmental, social, cultural and economic characteristics have been most often connected to physical stability and contaminant migration into the environment along surface and groundwater pathways. However, adverse impacts on social and cultural systems – the "S" in ESG (Environment, Social, Governance) – can also be extremely significant. These also have to be identified and addressed as an integral part of a comprehensive closure planning process.

Importantly, opportunities related to the ability of the closure planning and implementation process to generate outcomes that will be regarded by all stakeholders to be a positive legacy, also require full attention.

Most prominent of the mechanisms leading to contaminant migration in water systems (but not the only one) is bacterially driven oxidation of sulfide minerals, commonly labelled Acid and Metalliferous Drainage (AMD)[4]. Once these bio-geochemical process are unleashed through mining, they cannot be fully stopped, though management techniques can bring varying degree of control depending on the site.

As a result, long-term costs for water treatment and active site management can arise that stretch out for decades and even centuries, long after revenue generation from ore extraction is over. Estimating the nature of this long-term cost and integrating it into company financial statements and government financial assurance requirements is both difficult and contentious.

In the case of AMD, it is not the absence of knowledge that is the problem. Mining companies know the range of possible outcomes

but use management's best estimate or probabilistic average to guide their decisions, provisions and approaches to financial assurance. Unfortunately, one of the results is that residual risks are often obscured, and a false sense of confidence generated. Pushed further, this can lead to a kind of strategic "application of ignorance" a term that has arisen in the analysis of corporate avoidance of effectively addressing social implications (Lawrence and O'Faircheallaigh, 2022).

Because the performance of closure/post-closure plans and facilities may vary significantly across the long time-horizons that sometimes exist, these phases of a mine's operation reach to the edge of our ability to predict financial requirements over the long term. And importantly, while initial short term cost efficiency is a function of closure facility "build" conditions, long-term cost efficiency is driven by the management capacity to recognize and adapt to changed conditions quickly and before deficiencies in closure/post-closure plans or systems result in unexpected costs. This challenge has been greatly exacerbated by the onset of climate change.

Relevant decision-making related to effectively managing risks through the closure and post-closure phases starts during mine design, long before operations begin. So, risk assessments undertaken as input to design and approvals must address not only short-term conditions during operations but also, long-term conditions to be faced during post-closure. Doing so is at the heart of effective "design- and management-for-closure".

Early versions of design-and-management-for-closure concepts were introduced to the industry in the late 1970s and early 1980s but not broadly applied even amongst leadership companies and service providers until the last two decades. Best practices continue to evolve.

Two critical challenges that mining companies and regulators have yet to fully address are provision of mechanisms and management systems that ensure:

1. mine closure and post-closure bring a positive legacy and sustainable benefits to people and ecosystems, and
2. sufficient human and financial resources are available to meet corporate obligations.

Because deficiencies still exist in both regulations and company practices, examples continue to arise of operations lacking effective closure/post-closure plans and financial resources for effective implementation. In these cases, the resulting liability falls to society (governments) and/or the environment to carry. If capacity to address this liability is lacking, harm occurs. Particular attention needs to be given to the amount and security of government mandated financial assurance to ensure that estimated costs and potential increases are covered in keeping with long-term corporate obligations that go beyond management's best estimates and probabilistic averages.

3. Trust through engagement and dialogue

Successfully meeting the above two challenges is only possible with effective processes of stakeholder engagement and dialogue.

Each closed mining site has unique characteristics that must drive the design and operation of the closure strategy. Because of financial obligation and knowledge base, the operator is best placed to lead the design and implementation of the needed closure/post-closure strategy. However, decisions cannot be left solely to corporate head offices with their prime focus on shareholder value, or indeed, left solely to governments who have not always demonstrated adequate oversight to ensure a positive legacy.

Stakeholders too have a "stake." Such stakeholders include: affected communities and their citizens, Indigenous Peoples, investors and shareholders, company board members, civil society organizations (who are participating in licencing, approvals, and oversight processes), elected officials, and regulators.

Their input is essential to effective design and implementation. This is so because while their insight on technical questions being addressed may be limited, the degree of effort or weight put to the strategy and its component parts, is a judgement that must be guided by their (affected stakeholders) values.

When it comes to stakeholder values, they are the experts as to what constitutes a positive legacy. They, not the company, will have to live with the results. Thus, they have a right to understand the nature of the challenges, to be provided with details of alternative closure and post-closure approaches that are being considered, to offer their thoughts on how to proceed, and to participate in weighing the decisions that must be made. In short, to have their views heard and to play a role in decision-making. It is the only way that a sense of trust will emerge that the mine project will leave a positive legacy.

4. Generic closure/post-closure goals and objectives

The overall goal of the closure and post-closure phases of mining is to leave a positive legacy by ensuring a positive contribution to people and ecosystems over the long term. This general, aspirational goal statement is translated to action through a set of clear, measurable objectives. In the table below, the overall goal is split into three components: people, ecosystems, and management.

Gold mine remnants near Johannesburg, South Africa
Mining here started in the 1880s and led to massive drainage and ecological change. Informal settlements sprung up after the end of apartheid and today, contaminant laden water and fine dust from neighbouring mine dumps pose a health hazard. The complex ownership history has made it difficult to assign remediation responsibility. Reworking of tailings has freed land for use and has led to an unexpected partnership between mining companies and the settlements. **SOURCE:** https://placesjournal.org/article/ecologies-of-gold-mining-landscapes-of-johannesburg/#0, last accessed 14 Nov 2022. PHOTO: R. Anthony Hodge, 2010

TABLE 1. Generic closure/post-closure goals and objectives

GOAL 1	**PEOPLE: To ensure a positive contribution to people and their well-being over the short and long terms[5]**
1	**Health and safety.** Maximize worker and public health and safety.
2	**Worker and community transition at closure.** Maximize opportunities for workers and the community to adjust to a post-operation society smoothly and fairly.
3	**Socio-economic, culture, and health benefits.** Maximize local and regional socio-economic, cultural, and health benefits.
4	**Land Use over the short and long terms.** Minimize restrictions on traditional and local land uses.
5	**Engagement, transparency, and trust building.** Maximize engagement, dialogue, and trust-building with all interests on issues and decision-making that may interest or affect them.
GOAL 2	**ENVIRONMENT: To ensure a positive contribution to ecosystem well-being over the short and long terms**
6	**Overall ecosystem health.** Maximize the restoration of a biodiverse and self-reproducing post-closure ecology within the area of influence or ecological footprint of the mine operation.
7	**Contaminant migration off-site.** Minimize off-site contaminant migration through all pathways including: surface water systems, groundwater flow systems, air transport, and biological transport.
8	**Physical and bio-geochemical stability.** Maximize the stability of physical and bio-geochemical storage of tailings, waste rock, slopes, roadways, and waterways.
GOAL 3	**MANAGEMENT: To ensure an effective and efficient closure/post-closure management system**
9	**Management and oversight.** Maximize confidence that a resilient system of management and oversight will be established for implementation throughout the full time horizon of closure and post-closure.
10	**Cost estimate.** Maximize confidence that closure cost estimates will cover all closure and post-closure requirements through the full time period for which costs will be incurred.
11	**Cost minimization.** Minimize costs related to the closure and post-closure phases of the mine.
12	**Cash flow and security.** Maximize assurance that resources will be available to meet closure obligations when needed throughout the closure and post-closure phases of activity.

Objectives must be carefully tailored to any given site. They in turn drive concrete actions. Results achieved can then be tracked over time and publicly reported to bring trust that commitments are being honoured and the site plan is functioning as designed – or if not, system adjustments can be made.

Effective objectives are unambiguously "directional" such that success can be effectively monitored, and "political ambiguity" avoided[6]. However clearly, for any given site, the importance of various objectives and the pace of their achievement will vary depending on how they are weighted in the assessment process. Such weighting is value-driven and appropriately completed through stakeholder dialogue.

The generic objectives in Table 1 serve as a foundation for the questions that are subsequently listed in Table 2 (pages 6–7).

5. Closure/post-closure questions

To achieve best results – for people, for the environment, and for financial efficiency – it is essential that closure/post-closure considerations be addressed from early in the mine design process. This starts prior to approvals being granted. Design and implementation approaches related to closure and post-closure must be then continuously refined through the operation's entire life cycle as the project proceeds and as understanding of site conditions grows. In that life cycle, abrupt temporary closures and bankruptcies can occur that also need consideration.

Questions in Table 2 are presented in the following ten categories:

Company commitment

A. Company direction
B. Company closure/post-closure plans
C. Company provision for closure/post-closure
D. Company financial assurance for closure/post-closure

Individual site closure/post-closure plans

E. Fundamental company planning requirements
F. Government direction and requirements
G. People and their well-being over the short and long terms
H. The environment and its well-being over the short and long terms
I. Site cost estimate for closure/post-closure
J. Financial provision for closure/post-closure

Stillwater Mine, Nye, Montana
Primary palladium, platinum, and other platinum group minerals (PGMs); secondary gold and rhodium; tertiary copper, iridium, nickel, osmium and ruthenium. Production began in 1986 and is ongoing. Community tour of concurrent reclamation areas as per the Stillwater Mining Company Northern Plains Resource Council Good Neighbor Agreement (GNA) which governs company and community responsibilities and accountabilities. PHOTO: Jim Kuipers, 2022

Mount Morgan Mine, Australia
Copper gold and silver mine as well as brickworks and foundry. Operated from 1882 to 1981. Re-working of tailings continued until 1990. The Government of Queensland is now administering the site and funding rehabilitation and management. Water treatment will be required in perpetuity to address AMD. No long-term closure plan has been developed, costed, or implemented. PHOTO: R. Anthony Hodge, 2018

TABLE 2. Closure Questions

COMPANY COMMITMENT	
A. COMPANY DIRECTION	
1	**Closure/post-closure policy.** What is the company's policy governing mine closure/post-closure issues?
2	**Board oversight.** Does the Board of Directors directly, or through a Board Committee provide oversight of mine closure/post-closure obligations, costs, and risks?
3	**Company oversight.** What specific policies, procedures, organizational structures, accountabilities, and resources are in place or will be in place to maximize confidence that a resilient system of management and oversight will be established for implementation of closure/post-closure commitments throughout the complete time horizon?
4	**Corporate office role in closure.** What is the role of the corporate office in the implementation of the closure/post-closure activities, the development of closure/post-closure plans and cost estimates and the implementation of closure/post-closure plans through all stages of the mining cycle?
5	**Responsible divestment in case of ownership change.** What mechanisms are in place to ensure closure/post-closure liabilities will be addressed in the case of ownership change?
B. COMPANY CLOSURE/POST-CLOSURE PLANS	
6	**Active Plans**. How many sites under the control of the company have active closure/post-closure plans related to the cessation of mining operations?
7	**Classification by mining stage.** For these plans, what is the number of sites that are currently (1) in production but more than 5 years from planned closure, (2) in production but within 5 years of closure, (3) in state of "care maintenance" as a temporary condition, (4) within the closure stage, (5) within the post-closure stage with care and maintenance activities only and (6) in the post-closure stage with ongoing water treatment or other major activities underway?
8	**Independent Review.** Have the current active closure/post-closure plans been reviewed by independent closure experts?
C. COMPANY PROVISION FOR CLOSURE/POST-CLOSURE	
9	**Balance sheet provisions for closure.** What amount is included in the company's financial statements as a provision for closure/post-closure obligations and what discount rate is used to determine the balance sheet provision for closure obligations? If different rates are used for specific jurisdictions, what are the amounts and discount rates for such instances?
10	**Closure obligations.** Does this amount address all closure/post-closure objectives (Table 1) including both socio-economic and environmental obligations?[7]
11	**Long-term obligations.** Of the total provision reported, how much relates to post-closure activities and what time horizon is implied?
D. COMPANY FINANCIAL ASSURANCE FOR CLOSURE/POST-CLOSURE	
12	**Amount of financial assurance required by government.** What is the amount of financial assurance that governments require the company to provide in support of the company's closure/post-closure obligations?
13	**Security/Form of financial assurance.** What forms and amounts of security that has been provided to governments in terms of (1) cash and low risk securities, (2) third party guarantees, and/or (3) corporate balance sheets?
14	**Company credit rating.** What is the company's current credit rating?
15	**Receivership and/or bankruptcy.** If receivership or bankruptcy are declared, how will closure/post-closure provisions be covered?
INDIVIDUAL SITE CLOSURE PLANS FOR CLOSURE/POST-CLOSURE	
E. FUNDAMENTAL COMPANY PLANNING REQUIREMENTS	
16	**Closure/post-closure vision and objectives.** What is the site-specific closure/post-closure vision, including specific objectives, that captures what the company wants to achieve with closure/post-closure actions and that will define the legacy it wants to leave behind?
17	**Site level accountability.** Who is accountable at the site level for implementation of the closure/post-closure plans?
18	**Closure/post-closure approach maturity.** What degree of maturity[7] has been achieved at this site in terms of comprehensive closure/post-closure planning and implementation?
19	**Engagement, transparency, trust building.** What degree of stakeholder involvement and their influence on corporate decisions characterizes your company's approach at this site?[8]

20 **Risk-based planning:** Has a formal risk assessment, that addresses all aspects of the closure/post-closure plan, been conducted for the purpose of ensuring that: (1) all potential cost areas have been included and addressed; and (2) residual risk factors that may require further study and improvement have been identified?

21 **Residual risk.** What critical assumptions and residual risks have been identified in the defined programs and financial projections and have the possible consequences of such residual risks been quantified?

F. GOVERNMENT DIRECTION AND REQUIREMENTS

22 **Financial assurance required by government.** What is the amount of financial assurance that is currently required by government in support of the company's closure/post-closure obligations at this site, what discount rate and time horizon are used in this determination and what type and amount of security has been provided: (1) in cash and low risk securities? (2) third party guarantees? and /or (3) corporate balance sheet?

23 **Permits:** What aspects of a mine closure/post-closure plan are covered by existing site permitting requirements?

24 **Policy initiatives:** What other closure/post-closure obligations are identified by government for inclusion in the closure plan? Hospitals, schools, infrastructure, services, water, long term planning?

25 **Transition plan cost-sharing with government:** What elements of socio-economic and infrastructure transition programs will government share cost and/or responsibility?

G. PEOPLE AND THEIR WELL-BEING OVER THE SHORT AND LONG TERMS

26 **Worker and public health and safety.** What programs are planned or already in place to maximize worker and public health and safety through closure/post-closure?

27 **Worker and community transition.** What programs are planned or already in place to maximize economic opportunities for workers and the community to achieve a smooth and fair transition to a post-operation society?

28 **Identification and assessment of social/cultural concerns.** Has the closure/post-closure plan considered the immediate and long-term social/cultural implications of mine operation, closure and post-closure?

29 **Transition of social, cultural, and health benefits.** What specific programs are planned or already in place to maximize socio-economic, cultural, and health benefits over the long-term?

30 **Post-closure land uses.** What programs are planned or already in place to use existing land, mine facilities, transportation corridors and infrastructure for the beneficial use of the local economy while minimizing restrictions on traditional and local land use?

H. THE ENVIRONMENT AND ITS WELL-BEING OVER THE SHORT AND LONG TERM

31 **Overall ecosystem health.** What programs are planned or already in place to maximize the restoration of a biodiverse and self-reproducing post-closure ecology within the area of influence or ecological footprint of the mine operation?

32 **Physical stability.** What are the current and projected future consequences of failure for waste and tailings storage structures and what steps will be taken as part of the closure/post-closure plan to maximize long-term stability?

33 **Bio-geochemical stability.** What programs are planned or already in place to minimize off-site contaminant migration through all pathways including: surface water, groundwater flow systems, air transport, and biological transport?

34 **Post-closure water treatment.** Have all rock types been tested for their Acid and Metalliferous Drainage (AMD) potential and, if so, (1) what is the probability of contaminated surface water discharges and/or groundwater flows that may require water treatment during post-closure and (2) what actions have been implemented or are planned to minimize and manage AMD over the long-term?

I. SITE CLOSURE/POST-CLOSURE COST ESTIMATE

35 **Cost estimate.** What is the cost estimate for the current closure/post-closure plan?

36 **High risk elements in the cost estimate.** In the current closure/post-closure cost estimate, what high risk issues and related costs have been identified?

37 **Cost estimate completeness, accuracy, and maturity.** What degree of completeness, accuracy, and maturity characterizes current closure/post-closure cost estimates?[9]

38 **Independent review.** Has the current closure/post-closure plan been reviewed by independent closure experts?

J. FINANCIAL PROVISION FOR CLOSURE/POST-CLOSURE OBLIGATIONS[10]

39 **Balance sheet provisions for site closure/post-closure.** What amount is included in the company's financial statements as a provision for closure/post-closure obligations for this site? What closure/post-closure objectives (Table 1) does it address? What discount rate and time horizon are used in this determination?

NOTES

1 Robert M. Buchan Department of Mining, Queen's University, Kingston, Canada
2 Sustainable Minerals Institute, The University of Queensland, Brisbane, Australia
3 Global Sustainability Services Inc., Toronto, Canada
4 The term AMD is used in favour of the earlier term, Acid Rock Drainage (ARD) as it encompasses contaminant mobility under acidic or neutral/alkaline pH conditions. AMD is also known as Acid Mine Drainage or Metal Leaching/Acid Rock Drainage. (INAP, 2022).
5 See Vivoda et al., 2019 for a useful review of the social aspects of mine closure.
6 Objectives are articulated in terms of "maximums" or "minimums" to facilitate establishing relative weights and a means for tracking performance. In application, collaborative processes would establish a scale (of say 0–10), that sets the maximum or minimum along with related gradations. In that way, an assessment can be made of desired and relative performance related to each objective over time from initial design onwards. These concepts draw from well-tested systems of decision-analysis.
7 ICMM (2022) offers a "closure maturity framework" which sets out a process for assessing and tracking over time, how well the systems, processes and practices of a mining company can reliably achieve the aspired long-term closure/post-closure vision that has been set.
8 A useful approach for this assessment is the IAP2 Spectrum of Public Participation scale (IAP2, 2022). Also see ICMM's Closure Maturity Framework (ICMM, 2022).
9 See ICMM (2022) for useful guidance on assessing the maturity of cost estimates.
10 In jurisdictions requiring reporting, provisions are generally listed in corporate financial statements based on guidance provided by either (1) International Accounting Standard (IAS) 37 Provisions, Contingent Liabilities and Contingent Assets for those companies reporting in accord with International Financial Reporting Standards (IFRS) or (2) Accounting Standards Codification 410 (Asset Retirement and Environmental Obligations) for those companies reporting in accord with Financial Accounting Standards Board (FASB). Both approaches seek to provide for the costs or liabilities related to the retirement of long-lived assets as a provision on a company's balance sheet. Neither of these standards provide specific guidance for the scope of mine closure obligations. Mining companies generally specify such provisions to be primarily environmental in nature. Clarification is needed to portray the full extent of a company's closure and post-closure obligations including transition requirements for socio-economic and cultural issues and recognition of liability for residual risks.

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UPPER: **Zortman and Landusky Mine, Montana**
Wildlife grazing on a reclaimed area. The site is near the southern boundary of the Fort Belknap Indian Reservation, Little Rocky Mountains, north-central Montana. The mine operated from 1978 until 1997 and ended through bankruptcy of Pegasus Mining Co. It is currently being managed by the Montana Department of Environmental Quality (DEQ) and the federal Bureau of Land Management (BLM). On-going monitoring, maintenance and active water treatment is expected to continue some 10,000 years until the next ice age.
PHOTO: Jim Kuipers, 1998

LOWER: **Faro Mine, Yukon**
Lead, zinc, silver. Operated from 1969 to 1998. Now owned and managed by the Government of Canada. Closure plan is currently undergoing regulatory review. PHOTO: Gerry Whitley, LightHawk, 2015

Falun copper mine, Sweden

Operated for a millennium from the 10th century to 1992. In the 17th century was the world's largest producer of copper. At its peak, 1,000 miners were underground. Many of Europe's greatest buildings, including the Palace of Versailles, were roofed with Falun copper. The mine is now a museum and in 2001 was designated a UNESCO World Heritage Site. PHOTO: Public domain

Ancient tin, copper, and arsenic mining, Cornwall coast

Mining in Cornwall and Devon, England began in the early Bronze Age, around 2150 BC and continued until 1998. Old mine workings are common and are now source of tourist interest. Cornish miners spread across the world greatly influencing mining practices. Extraction of battery-grade lithium carbonate linked with geothermal energy is now under consideration. PHOTO: R. Anthony Hodge, 2010

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SunMine, Kimberley British Columbia

Located on the closed tailings of Teck Resources' Sullivan lead, zinc, and silver mine which operated from 1909–2001. Electricity production started in 2015. Installation was facilitated by the EcoSmart Foundation Inc. in partnership with the Town of Kimberley and Teck. In 2016, Engineers Canada awarded the facility its National Award for its "significant positive impact on society and/or industry and/or engineering". Energy generation at closed tailings offer a rare opportunity to provide a long-term source of benefit to the host community and to offset long-term maintenance costs. PHOTO: City of Kimberley, EcoSmart Foundation Inc.