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Geotechnical Guidelines for Open Pit Closure – a new publication by the Large Open Pit (LOP) project

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Abstract

Closure planning is a fundamental requirement for all existing and planned future mines. However, there are no accepted industry guidelines for how to geotechnically and hydrogeologically assess options for open pit and waste dump closure or for advancement of the closure plan in parallel stages with overall project development and operation. Ideally, closure planning needs to consider the site setting, develop the "big-picture" strategy, and work downward from there, balancing the objectives of the operator, regulator and community. At present, too much binding detail is being included in "early-stage" closure plans that, when approved, become committed. This paper outlines the "State-of-Practice" geotechnical and hydrogeological guidelines for closure planning and implementation being developed by the Large Open Pit (LOP) project research group.

The new Guidelines are intended for use by geotechnical and hydrogeological mining professionals addressing closure design criteria, risk management, detailed planning and implementation. Benchmarks are provided for stakeholders, including regulators and the community, to judge whether adequate investigations and planning have been completed for appropriate stages of overall project development. Three case studies are provided to illustrate how changes of closure approach produced a substantially better outcome.

Keywords: *geotechnical, hydrogeological, open pit, waste dump. mine closure*

1 Introduction

Closure planning is a fundamental requirement of all existing and planned future mines. The program for open pit and waste dump closure must be considered in relation to the entire mine site closure objectives and the requirements of internal and external stakeholders, local regulatory requirements, global experience, leading practice and continuous improvement.

Maintaining a social license to operate increasingly presents a risk to the mining industry, with shifting expectations of investors, insurers, community stakeholders and regulators. These changing expectations, which in part stem from increased global media visibility of mining operations, include demands for reductions in environmental and social impacts from mining activities and sustainable post-closure land use. These challenges are not new. The first chapter in Agricola's De Re Metallica (Agricola 1556) is devoted to arguments for and against mining. The tension and conflicting trade-off in land use is evident: “so let the farmers have for themselves the fruitful fields and cultivate the fertile hills for the sake of their produce; but let them leave to miners the gloomy valleys and sterile mountains, that they may draw forth from these, gems and metals which can buy, not only the crops, but all things that are sold.” Obviously, the scale and range of geographical locations that modern mines operate in is vastly expanded from those in the 16th Century (Figure 1); simplifying overriding the benefits of mining to a net positive economic gain (outweighing the detractors of long-term environmental damage) is not an acceptable outcome.

Figure 1 Mining scene (Agricola, 1556)

2 Key Challenges

Key industry challenges for mine closure include:

- **Strategic planning** for closure during early stages of project development when only limited information is available. Closure planning needs to start “big-picture” and work downward, alongside strategic and tactical planning that considers existing global experience (the “lessons learned”).
- **Integration of multi-disciplinary factors** to scope, design, execute and monitor a closure plan over project stages that may span many decades. Detailed studies often do not consider site-specific conditions, the needs of the operation or the strategic closure objectives.
- **Impractical plans with unrealistic expectations,** developed by Corporate staff and/ or consultants that often do not consider site-specific conditions, the needs of the operation or the integration of closure objectives.
- **Identification of the real risks** and the need to provide flexibility to implement the required mitigation when conditions change. Closure should be approached like operations, with a need to accommodate changing conditions that dictate an observational approach (implement, monitor, adjust, mitigate).
- **Budgeting** associated with closure planning and implementation, avoiding open-ended liability for active management in perpetuity.

At present, too much detail is often required in “early-stage” closure plans that, when approved, become committed, and are subsequently found to be inappropriate as more site-specific detail becomes available during operations. There are examples of long-term closure plan commitments for creek supplementation, which were unfortunately based on incomplete and poorly constrained conceptual hydrogeological (and consequently numerical) models which only became apparent with more detailed monitoring performance data only evident in the last mining stages. Unwinding and revising the closure commitments has proven challenging. Equally, early commitment to full backfilling of all pits, before robust understanding of long-term performance (and material durability) is obtained may lock in a suboptimal outcome, rather than localised focused backfilling or buttressing potentially supported by more detailed information. Much of this problem arises because the closure plan is written for permitting at a time when only limited technical understanding is available. Financial bonding requirements complicate stage-gate closure planning as they generally need to be posted at early permitting stages when there is little to no appreciation of the real closure challenges.

Today, mine facilities are clearly visible to the general public via Google Earth and other remote platforms. Both industry and regulators alike need “better messaging” of the closure plan which is realistic for the overall stage of the project. Designs must consider eventual relinquishment and, while risk-based approaches are well understood, the design basis and engineering approaches for achieving long-term physical and chemical stability are often poorly defined.

3 Industry Guidelines

Several high-level closure guideline documents exist, providing generic motherhood objectives for closure, such as: “demonstrated safe, stable, will not cause environmental harm and is able to sustain post-mining land use”. However, there is no specific guidance on how to develop and assess realistic options for closure or how to provide geotechnical and hydrogeological input to quantify levels of safety and stability. Guidelines to select appropriate Design Acceptance Criteria (i.e., to define what is acceptably ‘safe’ and ‘stable’), determine input data confidence, list appropriate analytical approaches, and outline long-term monitoring methodologies are conspicuous by their absence. Specific geotechnical and hydrogeological guidance for mine closure design is currently restricted to a few jurisdictions with very narrow focus (such as the 1997 Western Australian guidelines for location of abandonment bunds and various Bureau of Land Management documents in the United States).

The aim of the new Guidelines, funded by the Large Open Pit Project1, is to define a state-of-practice pathway for closure of pits and dumps that reflects industry-wide experience and considers the perspectives of the operator, regulator and community. These guidelines are aligned with and will augment the following existing mine closure guidelines: APEC (2018), ICMM (2019), World Bank (2021); and although focusing on open pits and dumps, the principles are also aligned with the ICMM (2020a) tailings dam guidelines.

This will be achieved through specific focus on documenting geotechnical and hydrogeological aspects of closure planning, definition of pragmatic objectives and measures of success, implementation and monitoring for open pits and waste dumps for closure, and how these interact with adjacent land uses.

The Guidelines draw heavily from actual mine closure experience to date and seek to define a paradigm shift to develop and implement better outcomes. The emphasis is to consider mining as a temporary land-use activity within a much broader regional context. The Guidelines will focus on open pit and waste dumps within the site-wide context, including opportunistic backfilling of pits with waste materials (waste rock and/or tailings) and pit lakes. Mine closure is no longer simply a means to site relinquishment.

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[1] https://www.lopproject.com/

4 Stakeholders

There is a need to communicate the key technical issues, uncertainty, and mitigation options to all stakeholders, including to the intended end users of the land. All stakeholders, including regulators and the community, must understand the real risks and available opportunities for mitigation. Industry accepted benchmarks are needed to allow judgement on whether adequate closure studies and investigations have been completed.

Regardless of its site-specific location, and the prevailing legislative requirements, any mine has key common closure goals centred around long-term stability, visual impact, environmental protection (and particularly water resources) and sustainable land use. In comparing Australian (WA), Canadian (BC), United States (CA), Indian, Chilean, Brazilian and South African regulations, CEM (2014) found that, although the regulatory systems differed, no significant disparities existed in required legal elements needing to be considered for closure or for future pit land use and/or safety. Fundamentally, sound engineering was found a common need for all closure scenarios.

The Guidelines aims to provide a standardized step-by-step approach and framework to allow practitioners to work towards eventual mine closure. Although local site-specific adjustments will be necessary, consistency of industry guidelines needs to be a requirement so that pragmatic and defensible approaches are adopted.

As the Guidelines are being developed based on wide industry participation, they will form a benchmark to all key stakeholders involved in developing or implementing closure plans, notably:

1. Geotechnical and hydrogeological practitioners – for evaluating and managing related risks.
2. Mine management – for developing an understanding of the risks, an awareness of the limitations and an appreciation of the required mitigation prior to eventual site relinquishment.
3. Mining, civil and tailings engineers, and environmental and social practitioners - for developing an appreciation of the recommended geotechnical and hydrogeological workflow, key timing of interactions, and site-wide synergies.
4. Legislators and regulators - through a deeper understanding of the geotechnical and hydrogeological closure risks and an awareness of international leading practice to support innovative solutions and policy guidance.

5 Site Characterization

Mine sites exist in all physical and climatological settings. Local topographical, geological, climatological, legislation and political settings dictate options for mine closure. Specific technical challenges for mine closure include high precipitation, steep topography, geochemically reactive rock, seismicity and proximity to population centres. Examples of high-level planning considerations are shown in Table 1. Of importance during project development and operations is definition, and regular updating of the site-specific knowledge base.

Table 1 Broad planning considerations for open pits

Setting	Planning Considerations
Arid Environments	• Mineral acidity often remains local to site. • Can potentially create “hydrologic sinks”. • Evapoconcentration is often key issue. • Erosion of slopes and dumps may be limited
Temperate/humid environments	• Mineral acidity often becomes mobilised and transported. • Wall rocks potentially require covering and isolation, or submergence. • Mixing with other waters may minimize downstream changes. • Erosion of slopes and dumps is important
Upland terrain	• May be difficult to permanently submerge workings. • Often more difficult to achieve hydraulic isolation. • Natural topography above the pit may need to be considered. • Long term geotechnical degradation often a concern
Lowland terrain	• Workings can often be permanently submerged below water table. • Protection of downstream groundwater is often a key issue. • Regional instability issues – Seismicity, stress relief, creep, subsidence and/or rebound • Often easiest setting for closure but may be close to population centres

6 Study Pathway

The overall goal of the Guidelines is to provide practitioners and stakeholders with a pathway to incorporate site-specific geotechnical and hydrogeological conditions into the closure planning and implementation process, and to establish design criteria, assess risk and evaluate mitigation measures to achieve the desired end result. Eight key interactive stages have been defined for planning and execution as outlined in Figure 2.

The Guidelines have been formulated to provide stakeholders with benchmarks to judge the adequacy of closure studies and investigations, initially to support the mining project approval, and ultimately to support the detailed mine closure plan. The focus is on practical and effective outcomes; moving away from the “tick the boxes” process.

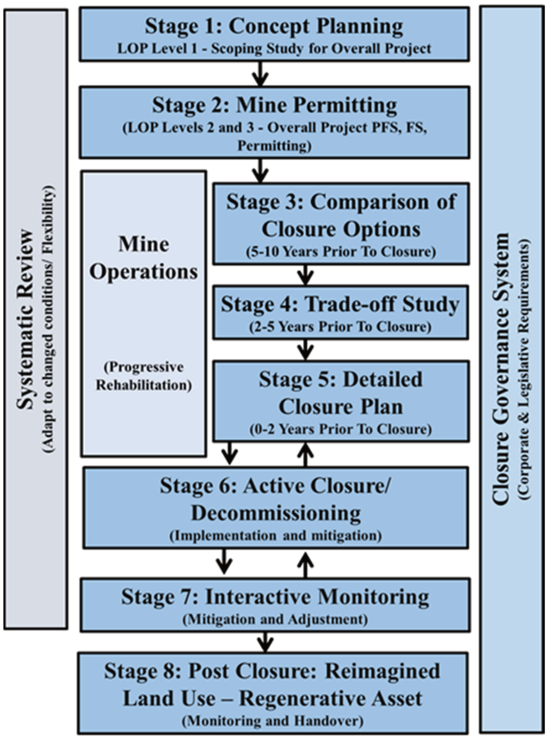

Figure 2 **Study pathway for open pit closure**

7 Closure Reimagined

Closure Reimagined introduces a “blue sky” way of thinking with a set of underlying principles to enable improved outcomes for all stakeholders, based around the following principles:

- Pre-mining long term stewardship vision of serviceable land use (mining is a small part of the plan).
- Closing a mine goes beyond the physical acts of demolition and rehabilitation.
- End goals for the land need to be realistic, risk-based and economically achievable.
- Mining and closure need to consider the next use and whether any of the site and its assets can be repurposed/co-purposed to add value and limit expenditure.
- Collectively, the mining industry and associated stakeholders need to transition their thinking from “managing a liability” to “developing an opportunity and lasting legacy”.

Closure should not be considered a means to an end, we need to move towards a very different paradigm that doesn’t include the term ‘closure’, rather a mining is merely a phase in the life cycle of the landscape enhancing the lives and outcomes of community.

8 Strategic Objectives and Legal Requirements

The concept of planning and executing mine closure has existed for several decades with the overarching philosophy “that closure should be considered throughout the lifecycle of a mine, from cradle to cradle” (Grant 2019). The ability to “sustainably” close the mine may be a critical risk, and transition to the birth of a new future. Fundamental to successful closure is a detailed understanding of the physical, biophysical and socio-economic context, documenting the internal (corporate) and external (legislated) requirements and global best practice, and defining a vision for closure of post-mining land uses with agreed success criteria.

Industry, regulators and the public recognize the key closure considerations of long-term stability, visual impact, environmental protection and sustainable land use. However, there is currently a wide range in practice in adopting this spectrum of considerations. On the one hand, many operators are pushing the envelope to increased responsibility for closure planning. However, others focus entirely on short term operational targets. Common ground is required to establish a workable framework that can help address misconnects between industry and regulators due to misalignment in objectives and measures of success, difference in risk tolerance or unforeseen significant changed conditions and force majeure.

9 Closure Planning

The Guidelines will set out best practice closure planning processes in the context of open pits and waste dumps. A key objective is to identify an appropriate level of detail commensurate for each stage, involving:

- Key stakeholders including regulators, future land users and the host community.
- Flexibility in planning to accommodate changes in statutory requirements, mine planning and stakeholder expectations over the life of the mine.
- Defined risks and mitigation options.
- Identified opportunities.

The planning process mandates the integration of operational mine design and closure requirements, recognizing that there will be a much greater understanding of actual closure conditions during the final years of mine operations based on long term data collection. Figure 3 shows important geotechnical and hydrogeological considerations for open pit closure. Experience shows that it is better for the closure studies to identify bounding conditions and uncertainty, and the potential requirement for robust mitigation, rather than attempting to provide exact predictions. Precise closure modelling has consistently proved to be unreliable, particularly in the early stages of closure planning. Focus on the conceptual understanding of both geotechnical and hydrogeological conditions will allow better definition of the uncertainties that may need to be mitigated as the closure plan is implemented.

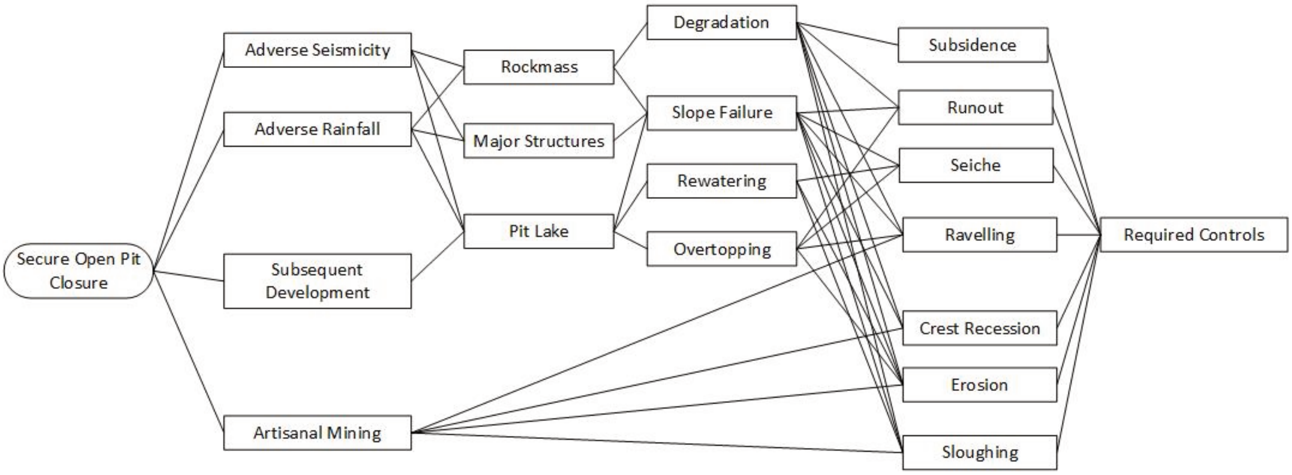

Figure 3 Important considerations for open pit closure

It is important to ensure that “unrealistic” closure plans are not created in early-stage planning, resulting in unacceptable risk in terms of the reality of actual closure requirements and cost. The planning process must allow sufficient time and resources to investigate, characterise and provide sound engineering basis for geotechnical and hydrogeological analysis and recommendations. The planning process must therefore incorporate:

1. Vision – for post mining land use, established in collaboration with key stakeholders. The ICMM Closure Maturity Framework (ICMM, 2020b) provides a tool for planning and assessing closure planning objectives.
2. Knowledge – to ensure focused investigations are undertaken as mining operations progress.
3. Risk management – closure-specific; accounting to divergent risk tolerances and/or perceptions of different stakeholder groups.
4. Completion criteria – for step-by-step transition to the defined post-closure land use.
5. Integrated planning – that must include assessment of operational changes on the proposed closure strategy and design.
6. Cost estimation – based on technical knowledge, identified risks and required mitigation
7. Implementation – schedule and execution must be integrated with operations ramp down and post-closure (rehabilitated) land management handover.

10 Hydrogeological Considerations

Understanding and defining the surface and groundwater hydrology and hydrochemistry is fundamental for all stages of closure planning and the quantification of risk. Depending on the setting, the site-scale hydrogeological model may need to be integrated with regional groundwater studies to define the potential for off-site transport. The hydrological setting will define the overall general closure approach for the pit and waste dumps. Hydrology studies for the pit will need to consider:

- Water balance: inflows, outflows, recovery curve, final pit lake level
- Groundwater inflow below the lake level
- Surface and groundwater inflow above the lake level
- Rainfall, back cutting and erosion
- Transient pore pressure during wet seasons and/or following storm events
- Groundwater interflow, weathering and loss of material strength.
- Limnology (stratification, turnover)
- Long term physical stability
- Long term chemical stability

In situations where pit stability is solely maintained by dewatering, it is usually not realistic to continue these measures in perpetuity; thus, alternatives must be engineered to achieve long term stability and sustainability. Flooding of pits that have been actively dewatered during mine may help equalize pore pressures in the wall rocks and increase stability. In addition to predicting the recovery of water levels within the open pit, or within backfill placed within the pit, it is also necessary to consider the rebound of water pressures in the rocks behind the pit slopes following shut down of the operational dewatering system. If the rebound of pore pressures in the wall rocks occurs at a faster rate than the water level rise within the pit itself, it may have consequences for the stability of the pit walls. This is often a consideration only during the initial stage of closure. It may become less of an issue in the long term if the pore pressures in the wall rocks become equalised by the water within the pit lake itself, once the hydrological system approaches post-closure equilibrium.

The impact of surface water runoff and the potential for erosion and/or back-cutting of the pit slopes is important to address post-mining slope stability. This is an issue for both short term (active closure) and long term (passive closure) planning, for both pits and dumps. The predicted long-term water level and chemistry of the final pit lake also need to be understood when planning the post-closure in-pit surface water control system. Managing water for long term geotechnical stability and optimized water quality requires integration of site facilities into a unified closure plan.

11 Mine Design for Closure

During mine operations, excavation and sequencing drives geotechnical performance, with groundwater, seismicity and other factors playing a role. Upon closure, long term rock and soil degradation behaviour, rainfall patterns, storm events and seismicity often become more important; with the goal of zero post-closure maintenance.

Long-term land use site stability is a key consideration, so different Design Acceptance Criteria are typically required to support the closure designs. Land use options many range from full public access and infrastructure development to complete exclusion and isolation.

Most operational pit slopes are designed as steep as possible. In some cases, slope angles may have marginal stability and require on-going operational controls. Active dewatering may also be required to achieve stability acceptance criteria. Operational Factors of Safety are usually not appropriate for post-closure, and, in some jurisdictions, pit designs must have a safety factor that is commensurate with the surrounding natural environment. Degradable rock behaviour plays a much more important role in long term closure planning that might have been the case in operations, with elevated stability risk often a major concern. Understanding that groundwater change will drive closure design acceptability for post-closure conditions requires a different focus than for operations. Design Acceptance Criteria needs to consider the ‘design life’ for closure, which can vary for difference jurisdictional settings. Plausible and worst-case failure modes need to be considered under the risk assessment process informed by long term design stability analyses.

An understanding of the regional and local geological character of the rock types, faults, structure and degradation characteristics of all rocks is required in order to identify slope sectors that may be susceptible to degradation. For slopes where degradable rocks occur, stability will change with time, resulting potentially also in increased public risk exposure with time, due to slope back-break and extended footprint.

12 Waste Dump Closure

Closure planning for waste dumps is becoming an increasing consideration for early-stage mine planning and design. Optimizing the location of the waste rock facilities within the overall mine site layout may lead to significant risk reduction for closure. The following two key factors are often important for closure:

- How post-closure pore pressures may impact the long-term stability of the dump materials or foundations.
- How post-closure seepage rates and chemistry may contribute to the water balance of the overall reclaimed mine site, and what management controls may be necessary to minimize potential impacts and achieve sustainability.

The following factors may need to be considered:

- long term maintenance of surface water diversions, and whether failure of the diversions may contribute to post-closure environmental risk;
- the potential for post-closure groundwater up flow into the base of the dump; and how this may contribute to instability and/or potential downstream impacts;
- how long the facility water balance may take to reach a steady state condition; and whether seepage rates may increase with time post-closure as the dump materials gradually reach field capacity,
- how the seepage water chemistry may change in the post-closure period,
- whether reclamation covers will reduce long term seepage; and the need to protect the covers from erosional damage, and
- how the reclaimed dump may impact the downstream surface water and groundwater environment including riparian users, water supplies and other receptors, and possible future downstream developments.

13 Implementation, Monitoring & Reporting

During the implementation phase, performance goals and trigger thresholds for non-compliance must be clearly defined by the underlying design considerations, receptors and with respect to appropriate Design Acceptance criteria. Typical performance metrics are provided relating to; Landform stability, water quality, water flows, erosion/sedimentation and isolation.

Closure planning may also need to include the required access to the pit for implementation of the reclamation program and subsequent maintenance, particularly if the pit lake level is to be maintained by pumping. The stability aspects of maintaining this access should be an integral part of the final slope designs. Planning is required to estimate: (i) the length of the monitoring period, (ii) equipment required, (iii) personnel required, and (iv) whether remote monitoring can be used to gradually replace on-site activities.

14 Case Study – Closure in of a pit excavated in weak rocks with a high rainfall setting

In wetter climates, creating a long-term surface water drainage pattern is often a major challenge. As with all good closure implementation, planning needs to start in the early stages of project development. The decision on whether to route surface waters into or away from the final pit needs to be based on the post-closure water balance and chemistry predictions of the lake water, and the ability to construct low maintenance diversions. At the Golden Cross mine in New Zealand, it was also necessary to backfill the pit to cover and submerge geotechnically weak and geochemically reactive pit walls and waste rock, and to avoid a pit lake with poor quality water. Surface waters from other parts of the site were routed through the backfilled pit and discharged to the adjacent river (Figure 4).

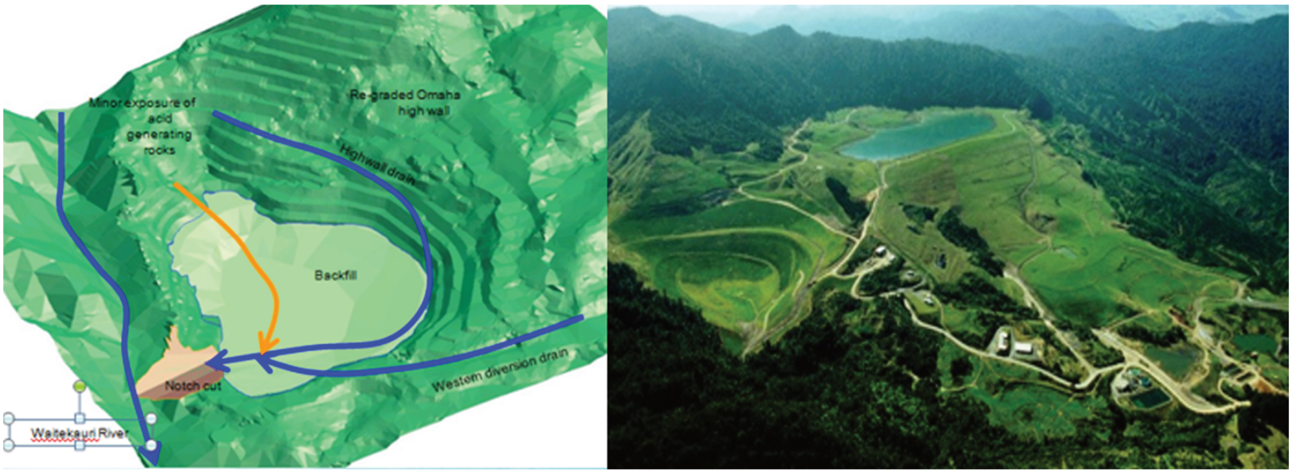

Figure 4 Closure of the Golden Cross mine

15 Case Study – Closure in remote cold-weather setting

The Victor mine is located in a remote region of northern Ontario, Canada. Equipment and supplies need to be transported by winter ice road. All facilities and accommodation are isolated from public services. Therefore, a key consideration for closure was to achieve stability of the site in the shortest possible time frame to minimize the cost of maintaining the remote site.

The pit was excavated through a sequence permeable limestones, mudstones and sandstones. In the pit area, the pre-mining water table was only a few meters below ground level, so a groundwater dewatering system was required from the start of mining operations in 2007. The dewatering rate increased to about 1,000 l/s. Mining operations were completed in February 2019 and the dewatering system was shut down between February and April 2019.

A pit lake model was developed using the understanding of the groundwater system that had been gained over the 12-year dewatering period and empirical water level and water quality results from the groundwater monitoring system around the pit. The model was used to design the shut-down sequence for the dewatering system and to guide the overall closure program for the pit. The model had the following specific objectives:

1. Predict the time for the pit lake to fill, and associated groundwater level recovery
2. Predict the pit lake water quality through time
3. Allow comparison of alternative approaches for enhanced pit filling, including the effect on pit lake recovery, groundwater recovery and pit water chemistry
4. Demonstrate long term stability once the lake and groundwater system have recovered to their final levels

Based on the model results, the closure plan was modified to include pumping of water into the pit from the nearby Attawapiskat River. The revised closure plan was adopted due to the advantages of:

- Reducing the time required for stabilization of the pit lake and surrounding groundwater system
- Improving the post-closure water quality of the pit lake
- Allowing pore pressures to rapidly equalize in order to improve the stability of the pit walls

A pit lake developed immediately upon shut down of the pit floor sump and in-pit dewatering wells (Figure 5). The rise of the lake level has occurred in accordance with the pit lake model predictions developed in 2018, and the lake level is now about 40 m depth below the pit rim. Ultimately, the lake surface will be 1-2 m below the pit rim, so optimization of pit lake water quality is an essential part of the planning and implementation process.

Figure 5 Development of the Victor mine pit lake

16 Case Study – Closure adjacent to large groundwater basin

In pits with weak rocks in the upper slopes, it is sometimes necessary to consider a staged shut down of the dewatering system in order to prevent instability during the short-term closure period. Initially, the deeper bedrock dewatering wells may be shut down, causing a rise in water levels in the pit and in the surrounding bedrock. However, continued pumping from the wells within the weaker rocks in the upper slopes may be necessary to prevent a rebound of pore pressure in the softer materials of the upper wall. The wells in the upper weak rocks would eventually be shut down once the rise in pore pressure within these materials has been balanced by a commensurate rise in the equilibrating water pressure in the pit lake.

Closure at the Sleeper mine commenced in 1996. The mine located along the margins of a large alluvial basin in Nevada USA. The West highwall included up to 50 m of basin-fill. The water table in the area is about 10 m below ground and therefore a major dewatering system was employed throughout the operating life of the mine, with a sustained pumping rate of about 1,300 l/s. The closure program for the Sleeper pit is illustrated in Figure 6 and involved a number of key actions, namely:

- Backfilling adjacent to unstable sectors of weak (altered) rock in the lower walls using chemically reactive waste rock, with the joint goals of permanently submerging the reactive waste materials and buttressing the unstable lower weak slopes;
- Shut down of the 12 bedrock dewatering wells while maintaining pumping from the 35 alluvial wells to rapidly flood the pit, submerge the chemically reactive waste rock and lower pit slope materials as quickly as possible. The rapid filling rate was about 1,000 l/s and lasted for about 18 months;
- Re-grading of the basin fill alluvial materials in the West wall from a mined inter-ramp angle of 38° to a final angle of 29° (Figure 7) over a wall length of about 2 km. The regrading program had the joint objectives of increasing the Factor of Safety for permanent mine closure and allowing alkalinity

and sediment to be added to the water to improve the pit lake chemistry; and

- Artificial vertical lake mixing and slaked lime was added to the influent water to improve the chemistry of the juvenile lake waters, and addition of nutrients to the waters to stimulate algal growth.

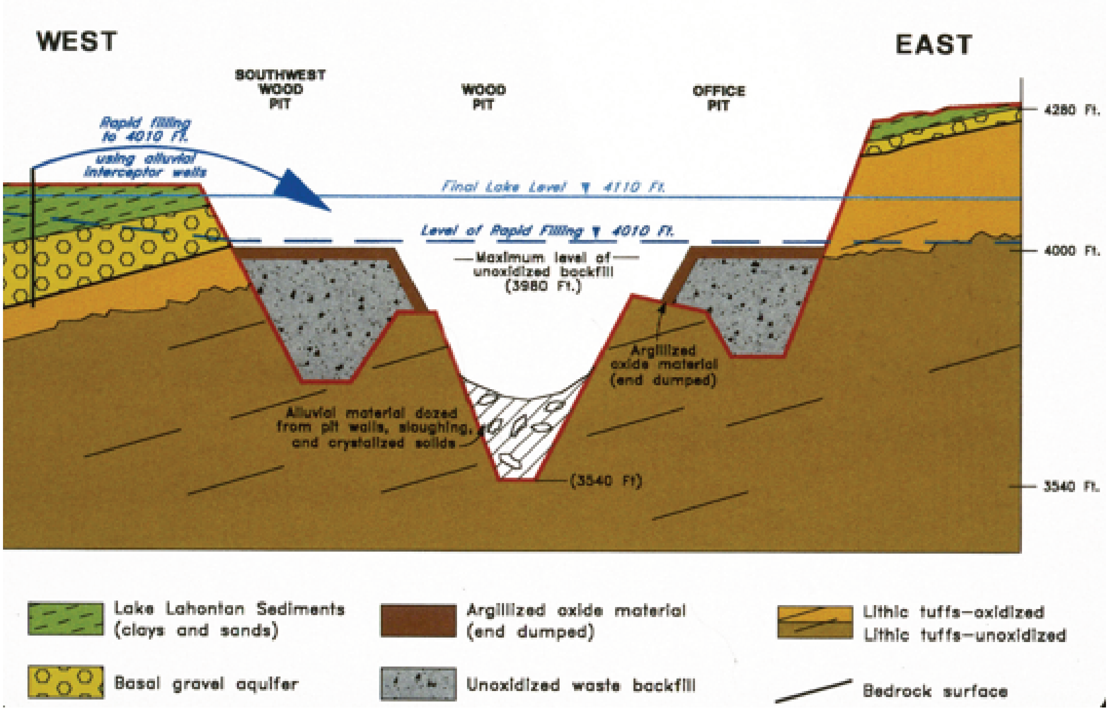

Figure 6 Diagrammatic section through the Sleeper pit lake illustrating the rapid filling process to submerge the reactive waste rock buttress used to stabilize the weak rocks in the lower pit walls

Figure 7 Re-graded final pit slopes at the Sleeper mine.

17 Conclusions

A paradigm shift in closure planning and execution is necessary and requires an increased focus on geotechnical and hydrogeological factors. To guide this, the Guidelines will provide a practical industry reference documenting:

1. **State-of-Practice Guidelines for Open Pit & Waste Dump Closure,** that are both balanced and objective from the perspective of the operator, regulator and community and will draw heavily on actual mine closure experience.
2. **Multiple Case Studies** illustrating "what worked" and "what didn't work and why", to provide credibility and confidence for operators, regulators and community stakeholders in demonstrating industry best practice.
3. **Details on appropriate Design Acceptance Criteria** (i.e., defining what is acceptably 'safe' and 'stable'), input data confidence, options studies, risk management, analysis approaches, and closure plan implementation.
4. **A Strategy Plan for Improving the profile of mine closure studies and implementation practises** within mining houses, amongst regulators and with the public.

Various industry experts in mine closure have volunteered time and resources to contribute to this important document and will be made available to industry early in 2023.

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All opinions and conclusions drawn in this paper are those of the authors alone and it should not be assumed that any views expressed herein are also necessarily those of their employers.

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