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The challenges of identifying, quantifying and managing transferrable residual risks

Sakshi Hazuria Anderson [a,*], Bryan Maybee [b]

[a] *Western Australian School of Mines, Curtin University, Australia*

[b] *CRC TiME, Australia*

Abstract

Residual risks are the ongoing risks that remain after closure and relinquishment of the mining licence, particularly those risks related to the continuing achievement of closure objectives, which can arise due to a variety of factors (e.g. environmental, social, cultural, safety, etc.). Residual risks often exist even when preventative and mitigative measures have been implemented and are performing effectively. The term 'residual risk' itself can also be interpreted and applied differently by people from different disciplines and backgrounds, resulting in confusion and misalignment between stakeholder groups. As a result, managing these risks, in perpetuity, continues to be a significant challenge impeding title transfer to alternative post-mining land uses. Furthermore, under current mining practices in Australia, legislative and regulatory pathways to achieving asset relinquishment remain unclear, resulting in significant delays and adding to the uncertainty faced by those wishing to transition to subsequent uses. This paper outlines the findings of a Cooperative Research Centre for Transformations in Mining Economies (CRC TiME) -sponsored desktop review of global best practices in identifying, quantifying and managing post-relinquishment residual risks. The-research project included a workshop seeking insights from experienced practitioners across Australia and North America. The project identified misaligned nomenclature and expectations, and capability gaps, amongst stakeholders to be significant challenges to effectively managing residual risks. The economic assumption of perfect information underpins the static approach to dealing with risks and uncertainties that may not be well defined. When dealing with residual risk, unclear and complex jurisdictional overlays, unrealistic or ill-defined closure criteria, and legislative rigidity restrict dynamic responses to changing socio-enviro-cultural-economic considerations. Effective management of residual risks, on the other hand, has been demonstrated in cases where the post-mining land use was well defined with a clear business case, the scope of the land disturbance was small or had limited complexity, or the pathway to asset relinquishment was clearly developed and strong stakeholder relationships with impacted communities existed.

Keywords: *residual risk, mine closure, circularity, mining, relinquishment*

1 Introduction

Mining is by its very nature a transformative activity that reshapes the physical, ecological, social and economic environment. Traditionally, the mining life cycle has followed a linear process from initial exploration and various study phases to construction commissioning and operation, closure, post- closure and, in some cases, relinquishment of the mining assets. As a mining asset progresses through its life cycle, knowledge of the impacts of the mining activity on the aforementioned multifaceted environment increases. This in turn allows for greater detail to be included in progressive iterations of mine closure planning and reduces the uncertainty around key operational and post-closure risks (Figure 1).

* Corresponding author. Email address: sakshi.anderson@curtin.edu.au

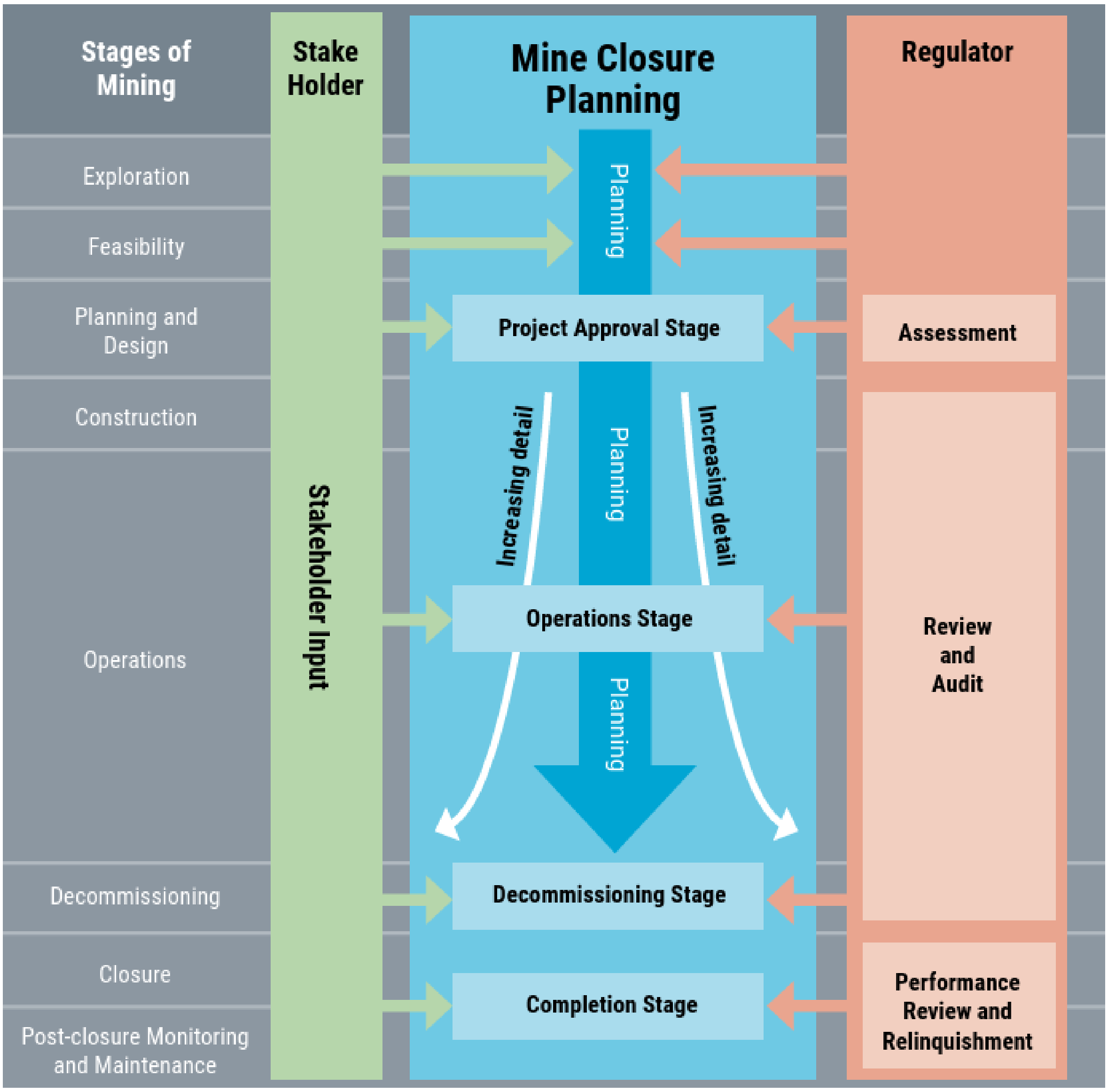

Figure 1 Stages of mine closure and mine closure planning (Government of Western Australia 2024)

Through progressive closure activities and the post-closure phase, identified risks viewed through the lens of a pre-defined post-mining land use (PMLU)are managed down to a socially and environmentally acceptable level – following the principles of risk mitigation and management – to as low as reasonably possible, recognising the unattainability of zero risk in many circumstances. These risks are mitigated and managed within well-established risk frameworks that evaluate the potential severity of the impact alongside the probability of their manifestation (Government of Australia 2016a). As a mining asset approaches closure, the legal and social expectation is that most of these identified risks have either been mitigated or addressed through stakeholder-approved robust risk management plans†. As a prerequisite to achieving sign-off on final closure, an operator must demonstrate completion of all closure criteria and demonstrate the geophysical, geochemical and environmental stability of the mine-affected resources. Establishing stability can take decades, as noted in the case of the Government of Saskatchewan's Institutional Control Program (ICP) (ICP 2025).

† Risk mitigation and management plans are updated at regular intervals by the mining company and submitted for approval to the appropriate regulator. In a number of jurisdictions around the world, including Western Australia, this process also includes stakeholder input (Government of Western Australia 2021b).

1.1 Residual risk

Some ongoing risks may, however, remain post-closure. These ongoing risks, or previously unidentified risks that emerge (Hamblin et al. 2022) post-closure and relinquishment, are referred to as residual risks. As the term signifies, residual risks are the remaining risks once controllable and known mitigatable risks have been mitigated or managed (Figure 2) These remaining risks may need to be managed in perpetuity via a post-closure management plan (Okane Consultants & Anderson 2025). Detailed management and monitoring plans are developed and costed to manage these risks post-closure and after relinquishment. The-uncertainty surrounding these residual risks forms significant challenges to relinquishment, transitioning the mining-disturbed lands to viable third-party post-mining uses and mine sites achieving circularity[‡]. It is worth noting that not all mine-affected lands will be relinquished. In some cases, the post-closure risks may be deemed too great or complex to be managed by a third party. In this case the mine operator will continue to manage these lands, potentially in perpetuity. The remaining domains that have been demonstrated to be safe, stable and non-polluting may be relinquished and associated residual risks transferred to a third party to enable post-mining socio-economic continuity of the asset life cycle.

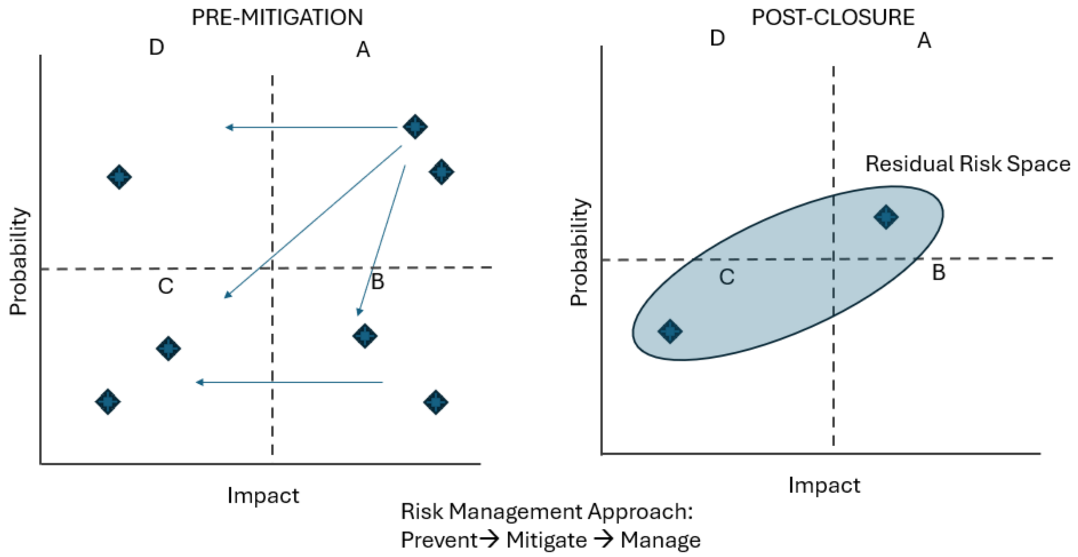

Figure 2 Conceptual visualisation of the post-mitigation residual risk identification process (Anderson 2026) Circularity and mine closure

In the mining industry, circularity considerations focus on the technical operational life of the mining asset. The wider definition of circularity within the mining industry would require this concept to be extended to mining-disturbed land. Once mining operations cease, reclamation, remediation and rehabilitation form the foundations of closure and post-closure activities, opening up the asset to potential re-use and/or repurposing. These activities are conducted in the context of a pre-defined post-mining land use (PMLU), and the applicable jurisdictional requirements for post-closure and eventual final asset relinquishment. A primary driver of these activities is the mitigation of risks hindering the safety, stability and non-polluting nature of the post-mining geochemical, biological and physical resources. These resources[§] include land, air, water and ecology.

[‡] While relinquishment is not a legal pre-condition for third-party post-mining land use (PMLU), liability structures and land tenure overlays can impede effective third-party PMLU. This was identified in the residual risk workshop as a hurdle to transferring residual risk in the case of the Government of Saskatchewan's Institutional Control Program, an advanced post-relinquishment PMLU system that has yet to witness a third-party lease release.

[§] The term 'resources' employed in the current context refers to the colloquial use of the term as the resources of nature. It can include the concept of mineral resources, the often-used conception within the mining industry used to refer to the mineral-bearing material mined and processed into saleable products from the mining value chain.

The end objective of closure and post-closure activities is often the relinquishment of the mining lease to a third party with a view to the continued use of resources. While relinquishment may not be a viable alternative for all mining-disturbed lands, it "should be a desirable end point of the life of the asset (the entire mining life cycle, including post-closure)" (International Council on Mining and Metals [ICMM] 2025) As part of agreed closure criteria for a mine site, a (PMLU with a well-established business case can offer continued economic wellbeing for local communities directly impacted by mining. Socio-economic transition post-closure is critical to effective resource management and continued wellbeing after the cessation of the mining operations. Relinquishment creates an opportunity for the resource to continue contributing value post-mining. In this sense, relinquishment offers an opportunity to broaden the concept of circularity from the mining industry contributing to the circular economy to mining as part of the circular resource management strategy.

2 Methodology

The analysis presented in this paper was founded on a two-staged research project conducted under the aegis of the Cooperative Research Centre for Transformation in Mining Economics (CRC TiME) in 2025. The project undertook a desktop review of global best practices in the identification, quantification and management of acceptable levels of transferrable residual risks in mining (CRC TiME 2026b).

The first stage of the project involved a review of academic and grey literature including peer-reviewed academic articles, guidance notes published by government departments, publications by international and Australian independent organisations like the ICMM and the Centre of Decommissioning Australia, publications by regional development organisations, analysts, mining and energy companies, and mining equipment, technology and services companies. The literature review contributed to the evaluation of the current state of knowledge relating to residual risk identification, quantification and management post-closure and relinquishment.

The literature review identified recurring themes, gaps in current knowledge and focus areas for future research around residual risk. The findings from the first stage founded the structure and priorities of a residual risk workshop. Twenty-eight residual risk practitioners from industry, government, civil society and the research community attended a guided workshop designed to identify case studies, success factors and challenges to achieving relinquishment, and risk partitioning considerations. Some of the findings from this research project and follow-on research is presented in this paper.

3 Residual risk challenges

The relinquishment of a complex mining asset tenure is rare. There are very few examples of complex mining tenure successfully relinquished or surrendered to the government around the globe (Measham et al. 2024; Purtill et al. 2026). Coal mines and quarries constitute the largest number of relinquished tenures post-closure. The closure and post-closure process for these operations is well-understood and relatively straightforward to manage. Furthermore, there is a long history of reclaiming these assets as in the West-Rhineland coal fields in Germany. When the mining operation involves complex processes, the residual risk compounds make management challenging and result in few cases of relinquishment.

Instead, examples of abandoned mining assets abound. The US Forest Service estimated that there are 38,991 abandoned mine sites in the USA as of 1995 (Forest Services US Department of Agriculture n.d.). In 2021 the United States Geological Survey (USGS) conducted a census of abandoned domestic mining assets. At the time of writing, this process is still ongoing within the USMIN database (US Geological Survey 2025). In Australia 52,534[**] abandoned mines were identified in 2012 by Unger et al. (2012), an estimate validated 10 years later by Salmi et al. (2022). As in the case of the USA, this inventory is still incomplete. The Department of Energy, Mines, Industry Regulation and Safety in Western Australia suggests that the

** This data excludes the Northern Territory.

inventoried mines cover “76% of the high priority historic mines sites in Western Australia” (Government of Western Australia 2021a). While the reasons for the existence of these abandoned mines may include historical regulatory gaps, asset and risk mischaracterisation and potential mismanagement, evolving closure expectations and other related factors, they continue to serve as stark reminders of the historical failures of the custodianship of mining-affected lands and contribute to the deficit of trust in stakeholder engagement fuelled by, and simultaneously intensifying, risk aversion.

The literature review encompassed multiple jurisdictions in Australia, the USA and Canada. These 3 countries have demonstrated some of the more advanced applied processes and frameworks relating to the identification, quantification and management of residual risk. The generally accepted leader is the Government of Saskatchewan’s ICP which, in 2025, added its 50th site to the registry of relinquished mine sites (ICP 2025). While the ICP offers insight into the enablers of successful mine asset relinquishment, academic research, industry publications and government documents provided details of the challenges and expectations for tenure relinquishment[††]. This section identifies the key thematic messages that emerged from the research project.

3.1 Misaligned nomenclature

While the existence of residual risks in mining has long been recognised by all stakeholders from industry to government and civil society, there remains a degree of subjectivity in the definition and use of the term ‘residual risk’ itself. Residual risk practitioners define the term and scope of activities it covers differently, based on the lens used to analyse mine closure. For instance, the ICMM defines residual risks as:

> *“The risk that a rehabilitation area (or closed mine), in the foreseeable future, fails to perform as predicted and the consequence of the failure will result in the need for repair, replacement or maintenance works, and thus associated costs.” (ICMM 2025)*

In this sense, residual risks are seen to be associated with known risks that either may not have been planned appropriately or have manifested in unexpected ways.

In the context of risk assessment, residual risks may be defined as:

> *“…the remaining risk after management and actions have been implemented to reduce the initial risk.” (ICMM 2025)*

Both these preceding definitions are sourced from the Integrated Mine Closure Good Practice Guide (ICMM 2025).

Hamblin et al. (2022) define residual risks in a more general construct, similar to the second ICMM definition, as:

> *“…any ongoing threats or dangers presented by a mine site after it has been closed or is no longer in use”. (Hamblin et al. 2022)*

This generalised definition is more commonly used amongst practitioners and risk analysis experts (Sanders et al. 2019).

The residual risk workshop identified an alternative interpretation of residual risks as being those ongoing or newly identified risks that remain after mine closure and relinquishment. While the risk identification process for residual risks in this context is similar to those previously mentioned, the scope of their applicability differs and is linked to specific milestones including meeting all closure criteria, receiving certificates of completion

[††] Relinquishment relates to mine sites that have met all closure criteria and have been accepted by the relevant regulatory bodies as delivering safe, stable and non-polluting post-mining environments, and which have been devolved back to either the original title holders or a third party with all liability relinquished. This is distinct from historically abandoned mines that have failed to meet one or more of the aforementioned conditions but for which the liability holder cannot be identified or held accountable (Government of Western Australia 2025)

and achieving relinquishment or surrender of mining leases[‡‡]. Extant mine closure frameworks include the asset life cycle from discovery to closure and do not cover the period after relinquishment, which this definition would imply[§§] as being the purview of residual risk.

These different definitions highlight the fact that not only does context matter in defining residual risk but a standardised nomenclature is yet to be developed. The absence of common terminology can cause confusion and misaligned expectations, eroding momentum and trust in the relinquishment process.

3.2 Identification of case studies

There are few examples of successfully relinquished complex mining assets around the world. There are, however, a number of cases where post-mining risks (existing and emergent) have not been appropriately managed and, as a result, title transfer to either the original landholder, the government or a third party has remained incomplete. The identification of both 'positive' and 'negative' instances of residual risk management was deemed to be equally important, as the former sheds light on the success factors and the latter informs potential failure modes. Twenty-four case studies were identified and will be prioritised for detailed analysis in future research. Additionally, the Government of Saskatchewan's ICP was identified as a leading light in the post-closure mine resource relinquishment process, both in the literature review and the workshop. This program holds and manages 50 post-mining sites[***] that have been relinquished by the mining industry (ICP 2025).

Closure planning is a sensitive and closely managed process. Mine closure plans often contain protected or confidential information such as costing assumptions and funding arrangements (Government of Western Australia 2024). Mining companies also tend to see each instance of mine closure as unique and, as such, any learnings across different instances of mine closure are, at most, held within a mining company. While mine sites have certain unique environmental, technical and social considerations, amongst others, for closure and post-closure considerations in differing jurisdictions, there still exists an opportunity to leverage learnings across differing instances of mine closure and residual risk identification, quantification and management. Research on the commonalities and differences between these instances also remains sparse (Anderson 2026). This restricts knowledge accumulation and transmission. While organisations like the ICMM, the Australasian Institute of Mining and Metallurgy and the Intergovernmental Forum on Mining (IGF) attempt to identify best practices, residual risk research still suffers from a lack of sharable data upon which dynamic uncertainty-based predictive models may be constructed.

Future research will include detailed evaluation of select case studies that will help identify critical residual risk exposures, permit knowledge sharing across jurisdictions, and enable unlocking company- and mine site-related learnings which hitherto have been siloed within individual mining companies. This lack of knowledge transfer is impeded by the consideration that each instance of mine closure is unique, resulting in a view of residual risk locked into a 'first-of-a-kind' mindset. The gathering of common factors will enable the development of a data-driven and statistically robust approach to estimating residual risk that improves the accuracy in quantification of residual risk-related exposures.

[‡‡] The terms 'relinquishment' and 'surrender' of mining assets are terms employed in different jurisdictions in Australia and refer, in practice, to the return of post-mining resources to the government, original landowners or a third party after the mine operator has successfully demonstrated the stability, safety and sustainability of all relevant resources.

[§§] Figure 1 is representative of mine closure frameworks that either end before or with asset relinquishment and do not cover the period of post-relinquishment residual risks. This can be seen in both ICMM and AusIMM frameworks (ICMM 2025; Australasian Institute of Mining and Metallurgy 2012).

[***] The 50 sites identified in the ICP correspond to unique domains within mining operations. As such, there may be multiple sites associated with one integrated mining operation, as in the case of Beaver Lodge and Cluff Lake, both of which were associated with a uranium mining and processing operation.

3.3 Framework limitations and stakeholder engagement

In most mining jurisdictions, the PMLU for a proposed mine site is determined early in the life cycle of a mining project. All mine closure activities are designed to enable transition to this pre-determined PMLU. Closure best practices and legislative frameworks require consultation with key stakeholders including, but not limited to, government, local communities and traditional owners, to identify a PMLU for any given proposed mining asset (Government of Australia 2016b).

In several jurisdictions globally and within Australia, a PMLU must be defined as a prerequisite for the issuance of a mining lease (Government of New South Wales 2023). At this early stage of project development, information on final post-mining engineered structures and the total environmental footprint may not be identified. As such, decisions are based on a 'best estimate' of future disturbance. The operating years of a mine furnish the largest dataset to inform PMLU outcomes. Evidence from the residual risk workshop suggests that current legislative frameworks do not allow for sufficient flexibility to adjust with the growing knowledge base and changing operational constraints.

Stakeholder engagement at this stage is also limited (purple line in Figure 3). The residual risk workshop identified early and informed engagement in determining and designing a PMLU in partnership with impacted stakeholders as a significant success factor to achieving relinquishment. A partnership model in the transparent co-design of a PMLU can avoid the challenges of misaligned stakeholder expectations.

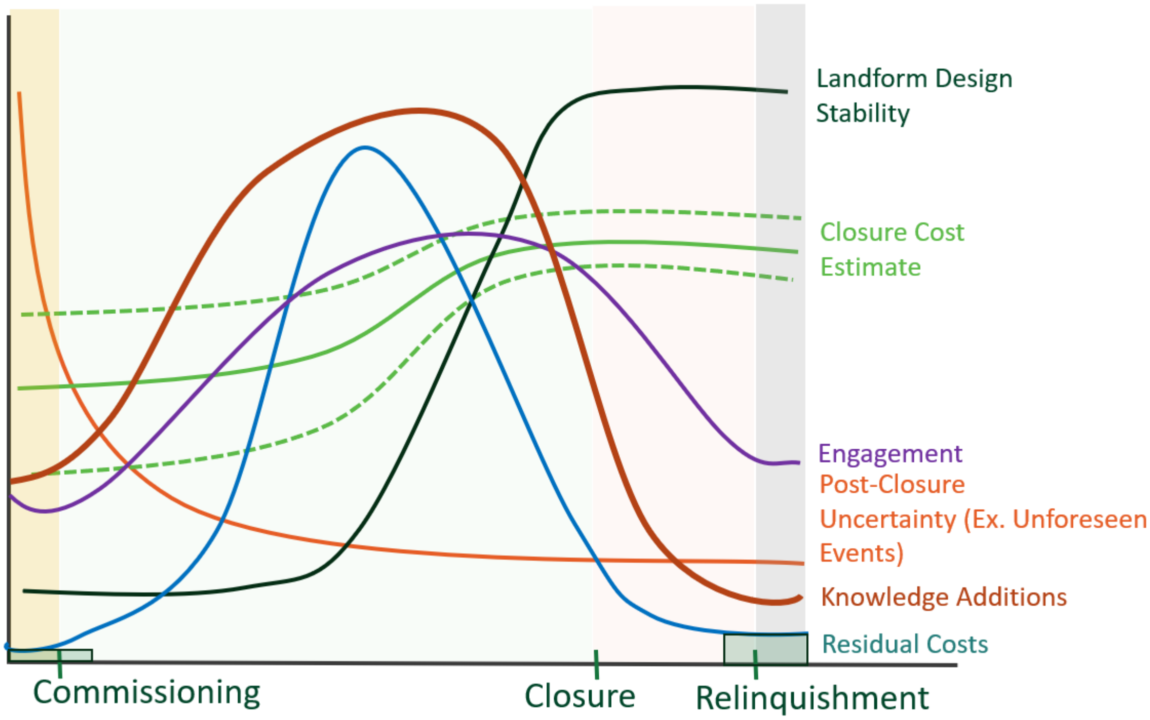

Figure 3 Conceptual visualisation of the knowledge evolution over the asset life cycle

3.4 Evolution of knowledge, asymmetric risk

As project development progresses, knowledge about the magnitude of disturbance, environmental impacts, and operational and closure-related variables grows from a low level in the pre-commissioning stage to a high level during the operating years (Figure 3: red line). By this stage of the asset life cycle, landform designs are finalised (Figure 3: dark green line). This in turn increases the accuracy of the closure cost estimate (Figure 3: light green lines) as known challenges to residual risk, for which the magnitude and probability of occurrence are known (known knowns), are identified – e.g. water ingress at an expected rate into a mine shaft and underground workings. Additionally, risks that are known but whose manifestation is unclear, or intangible risks (unknown knowns) (Maybee et al. 2023), are also incorporated into the closure planning – e.g. the impact of climate change on the pit lake chemistry over time.

Furthermore, as risks are identified, the central closure cost estimate††† may also increase (Figure 3: green line) while the variability around this estimate will reduce (Figure 3: dotted green lines). Likewise, there is an initial increase in residual risk (risks that are initially expected to remain post-closure and relinquishment) management costs as these risks may be identified during the early stages of project development and into operational years. As risk mitigation and management activities are instituted, the costs associated with these risks are accounted for in either operational expenses or in the closure costs, resulting in a reduction in residual risk-related costs (Figure 3: blue line and boxes).

Designing closure for an agreed PMLU requires stakeholder engagement to accelerate and reach a maximum intensity as closure approaches. Upon designing the agreed post-closure end state, engagement will drop off and, if and when relinquishment is achieved, this will drop to a steady state at a level higher than pre-commissioning stage engagement‡‡‡ (Figure 3: purple line). As the project nears closure there is little additional knowledge gained from the operational process that may impact PMLU. The fact of sparse engagement in early stages of the asset life cycle when the PMLU is being designed presents a significant exposure to the relinquishment process. As the asset is developed and land disturbance increases, the flexibility to adjust to an alternative PMLU decreases.

This risk identification and management approach will reduce risk exposure over time so that under ideal conditions, only exposure from unforeseen events remain (Figure 3: orange line). These represent uncertainties that may have various outcomes (unknown knowns). For example, the impacts of the liquefaction of a tailings impoundment facility are clearly quantifiable but, if the cause of the failure is unknown, it very difficult to manage. Yet contingency planning and stringent design criteria can be developed to minimise the impact of such an event.

A final category of uncertainties are those not currently known but which may manifest in the future in ways that are also unknown (unknown unknowns). As these uncertainties are not easily identified, their management presents the greatest challenge to understanding and managing residual risks.

These risks and uncertainties do not manifest uniformly through the asset life cycle (Figure 4). Risks that have been identified and their potential impacts quantified are mitigated effectively in primary design criteria at early stages of project development. Unanticipated challenges may manifest at any time through the asset life cycle and are difficult to predict. These may have known or unknown outcomes and are often managed through maintenance and monitoring plans. Risk remaining with an asset at the point of relinquishment, or residual risks, often consist of known unknowns and unknown unknowns, which present challenges to both the identification and quantification of residual risks.

††† Closure costs, like all mine cost estimates, are developed around a central set of assumptions. Several factors feed into this cost estimate. Costs expected to be incurred in the future may change as uncertainties are resolved or emerge. Cost estimating guidelines require a degree of certainty to be established at different stages of planning. As such, the confidence bands around these costs are expected to narrow over the life cycle of an asset (Australasian Institute of Mining and Metallurgy 2012).

‡‡‡ Post- relinquishment, the mining company is no longer the primary engager of remaining stakeholders. The onus of engagement will likely shift to the government or a third party that has secured post-mining title transfer.

POTENTIAL IMPACT OF RISKS OVER ASSET LIFE CYCLE

Intangible Risk	Medium	Medium	Medium	High	High	??
Tangible Uncertainty	Low	Medium	Medium	High	High	??

Figure 4 Potential impact of risks and uncertainty over the asset life cycle (Anderson 2026)

3.5 Expectations gap

PMLU decisions are often made early in the life cycle of a mining asset. At these early stages of project development there is little surface disturbance and correspondingly low-risk exposure. At this stage of the asset life there is generally, a high level of acceptance of these low levels of risks. This is also a period of greater flexibility in PMLU determination and risk management (Figure 5). As the project progresses and more land is disturbed, the optionality for PMLU and associated risk mitigation reduces while the risk exposure increases and is seen by stakeholders as less acceptable. This gap between acceptable and achievable levels of risk mitigation results in an expectations gap and a potential erosion of trust in the closure and post-closure. This misalignment of expectations can have the multiple impacts including the delay and potential derailing of a linear, pre-defined closure process as well as the pathway to relinquishment and effective management of remaining residual risks.

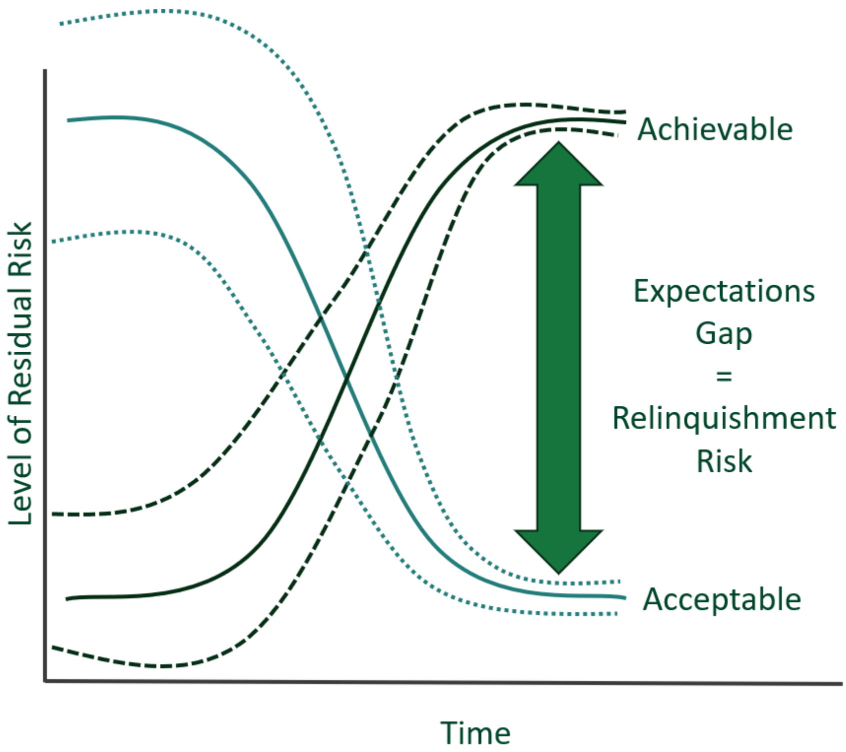

Figure 5 Conceptual representation of the expectations gap (Anderson 2026) Complex legislative structure

The legislative and regulatory requirement for a safe, stable and sustainable environmental post-closure state is not always achievable, and can come under challenge from practicable ground realities (Purtill 2023) before the issuance of completion certificates which indicate that the miner has successfully met all closure criteria. The PMLU defined at the early development stages may no longer be viable or desirable as closure approaches. Experiential evidence from the participants of the residual risk workshop suggests that current legislative structure does not afford the required flexibility needed to arrive at an agreed PMLU different from the initial PMLU determination at the time of the mineral licence issuance.

The mine closure process can take several decades, as exemplified by the experience of sites accepted into the ICP. During this time, social expectations of the closure may change, as may the legislative and regulatory standards. Additionally, the mining entity liable for post-closure processes may morph and even become defunct, creating exposure to the post-closure and relinquishment process. The latter may make funding residual risk mitigation and management plans a challenge. While the ICP addresses these considerations through established processes and the Unforeseen Event Fund that mining companies must contribute to at the time of entry into the registry, few other jurisdictions have similar arrangements.

The expectations gap and legislative and regulatory requirements can also lead to misaligned and unrealistic or undefined closure criteria for mining companies to meet. Industry bodies and closure best practices suggest that defined closure criteria based on the SMART§§§ principle be established in consultation with key stakeholders, and address the geophysical, chemical and ecological capability of the resources and the ability of mining companies to achieve these stated criteria (ICMM 2025). Practitioners engaged in the residual risk workshop indicated challenges to the realisability of these closure criteria. Furthermore, the jurisdictional complexity and regulatory overlay can compound these challenges.

3.6 Static tools applied to dynamic considerations

The risk profile of a mining asset evolves with the life of the asset. Current risk identification and evaluation methodologies involve evaluation of the probability of a deleterious event occurring and the potential impact of such an event at any given point in time. These risk and associated cost estimates represent snapshots in time. Likewise, valuation tools like discounted cashflows determine the preset value of closure costs in a given scenario and do not account for the changing nature of risk profiles where dynamic decision tools such as decision trees, options analysis and like methodologies would be more appropriate.

Underpinning risk evaluation frameworks is the economic assumption of perfect information. While it is acknowledged that the closure process progresses on the premise of ‘best current knowledge’, it is assumed that current knowledge gaps will be filled in the future as the asset approaches closure and relinquishment to:

> *“…ensure that the required information to start evaluating options is available”. (ICMM 2025)*

3.7 Capabilities gap

A recurring theme in the literature review and in the residual risk workshop was a capability gap in the ability to identify, quantify and manage residual risks. This gap exists across a wide segment of mining stakeholders and applies equally to regulators, communities, traditional owners and other stakeholders.

As previously mentioned, mine closure is a complex process requiring multidisciplinary knowledge of geochemistry, geophysics, tectonics, and structural and environmental engineering, to name a few disciplines. Experiential evidence from the residual risk workshop participants suggests wide variances in the level of knowledge and understanding of closure-related technical knowledge. This is often skewed in favour

§§§ Closure criteria are expected to be SMART, or specific, measurable, achievable, relevant and time bound. This principle enables complex closure criteria to be defined in clear terms for the benefit of all stakeholders (Mine Land Rehabilitation Authority 2024) of mining companies, necessitating investment in education to enable key stakeholders to participate in closure-related decisions in an effective manner. For instance, CRC TiME is developing a closure-centric training program for indigenous communities (CRC TiME 2026a) and key stakeholders.

3.8 Success factors

A preliminary review of the successful cases of residual risk management and asset relinquishment identified common features in the success stories.

Clearly defined pathways to relinquishment built into legislative and regulatory processes, as in the case of Saskatchewan's ICP and the Nunavut Resources Devolution Agreement (Law 2026), suggest potential roadmaps to achieving relinquishment. Additionally, the Government of New South Wales (2023) has attempted to identify the pathway to relinquishment. This latter process is still untested and requires additional detail.

The analysis also suggested that where relinquishment has been achieved, a large number of cases featured assets with limited footprints, short operating lives, or limited geochemical and geotechnical complexities. For instance, a large number of relinquished German lignite mines have achieved post-mining stability by converting the mining pit voids into pit lakes as the most stable and sustainable solution. This solution is viable in jurisdictions with an abundance of water but in the case of the desert-like environment in much of Australia, this can prove to be a challenge.

Another factor that can facilitate relinquishment of a post-mining asset is if there is a clearly defined business case for redeployment or redevelopment of the mining-affected lands. In the case of Contact Lake (Trident Resources 2026), post-relinquishment asset use has reverted to mining, albeit under the aegis of a mining company different from the original operator. It was a former gold mine that was reclaimed and relinquished into the ICP. With recent increases in gold prices, Trident Resources has assumed the residual liability and is re-evaluating the opportunity to reinstate it as an operating gold mine (Trident Resources 2026).

4 Conclusion

The existence of residual risk has been well recognised by governments, industries, communities and all stakeholders in the post-mining land use and asset relinquishment discussions for decades. Managing these risks, however, continues to be a significant challenge impeding title transfer of mined areas to alternative post-mining land users or the government. There is significant lack of clarity around nomenclature, expectations, methodology and processes used in identifying and evaluating residual risks. This expectations gap is exacerbated by the lack of shareable data and dynamic uncertainty-based predictive modelling. Combined with cross-jurisdictional inefficiencies and lack of transparency, there tends to be low capacity to understand, manage, monitor and assume residual risks in government, communities and potential third parties that may assume this risk after relinquishment by the mine operators. This has resulted in a significant trust deficit that must be overcome by mining companies when engaging in closure conversations. If this is not resolved, the number of abandoned mines may grow and the circularity to which the mining industry aims may never be achieved.

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