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Critical analysis and mine closure: why do things still go wrong in a swirl of feasibility, regulation and planning?

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Abstract

Mine closure planning is attended by increasingly more comprehensive regulatory, technical, corporate and financial planning requirements. However, in some parts of the mining sector in Australia, there are very significant areas of mining disturbance that clearly cannot be relinquished. Further, proposals in the process of approval do not suggest that many of the new developments in these areas will perform significantly better. This paper investigates how this can continue to be the case, when increasing focus continues to be applied to mine closure. Although some of the contributing factors discussed are technical, such as climatic, chemical and physical conditions, modelling and design, several are more centred on corporate, organisational, regulatory and essentially human attributes. These factors frequently involve obstacles to critical analysis that make mine closure predisposed to a failure to meet closure expectations and commitments. These contributing factors are often largely ignored in the processes attendant to understanding long-term mining liability during due diligence, feasibility, approvals, operations and the closure phase. Identifying instances where a number of such factors may be present can indicate that some risks may not be captured in technical risk assessments. In addition to detailing several of the contributing factors which can lead to a failure of mine closure or mine closure planning, this paper proposes mitigating responses for each of the contributing factors presented and expands upon responses which have the greatest probability of being adopted.

1 Introduction

Considering the expense involved in creating new landscapes, the long-term risks involved, and the degree to which regulation, technical investigation, corporate standards and financial surety systems have evolved and are more rigorously applied; it can be surprising that there are so many closed mines not being relinquished. Indeed, the realisation of a ‘walk away’ mine closure occurs in a minority of instances.

There are many and varied examples of success in mine closure that demonstrate the potential for technical success, while integrating the needs and aspirations of a range of stakeholders into final outcomes which are both sustainable and valued as post mining assets. Many studies and papers are available about such projects.

Many improvements in mine closure have occurred over recent decades. However, the ‘wrong’ outcomes are not uncommon and this paper focusses on what contributing factors can lead to things going wrong in mine closure. These outcomes may include:

- A corporate entity or government having to respond to a liability which generates ongoing environmental harm and expense in maintenance of physical and/or chemical discharges.
- A rehabilitation ecology establishing which does not meet expectations or targets, is unduly represented by flora and fauna species not reflected in the baseline data or does not demonstrate the land capability to support agreed post closure land uses.
- The development of long term risks associated with changes in physical or chemical properties and performance or beyond design events which trigger the situation described previously.
- Stakeholders disappointed in a reasonable expectation or failure to fulfil commitments to the standards indicated at project approval.

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The first section of this paper deals with the kinds of factors which contribute to mine closure failure, and the second deals with potential mitigating strategies to address these issues. The paper is not intended to draw attention to specific examples, but to examine the underlying causes, some of which are less frequently discussed, behind mine closure failures.

The limits of this paper to encompass such a topic should be mentioned. The author's exposure is primarily in hard rock mining in Australia. The author's experience includes extensive mine closure benchmarking, and visitation of many closed and operating mine sites in Australia, New Zealand and the United States. Work as a site environmental manager, closure projects manager, corporate closure technical specialist and strategic planner in mine closure provides a wide experience of issues contributing to the failure of mine closure planning and implementation. Additional experience has been gained from observing the dynamics of on-site management teams, major feasibility studies, closure project implementation teams, regional corporate offices and strategic and liability reviews in the corporate sector.

In most cases, the barriers to good mine closure performance are as much motivational, organisational and associated with corporate, community and regulatory culture, as they are physical and technical. Unfortunately, failure or getting things wrong can be an uncomfortable subject, and how we respond to, or rationalise it can result in lost opportunities for improvement and success.

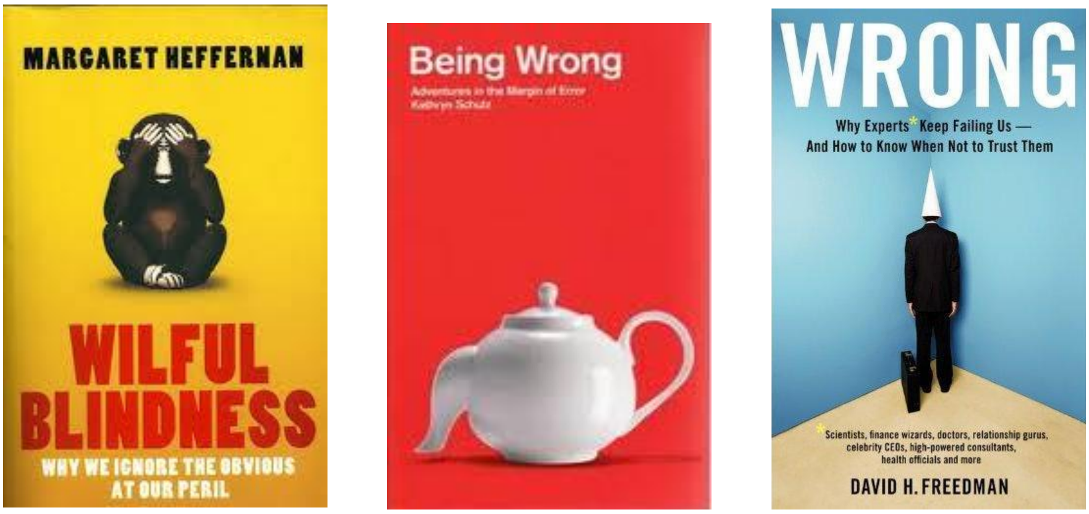

Figure 1 Recommended reading about the causes and responses to individual and collective wrongness

2 Major contributors to mine closure failure

2.1 Baseline conditions

2.1.1 Climatic factors

In climatic regions, where vegetation provides a minor or unreliable contribution to landform stability, and there are periodic instances of high intensity rainfall, sustainable ecosystems and stable landforms are generally not established. Often in these circumstances, long-term rehabilitation does not meet closure expectations. Rehabilitation in these environments can be successful but it largely depends on having appropriate material or a blend of materials on the outer surfaces of landforms. This material is often wasted or is not sufficiently represented in inventory to provide surface stability. Often, in the Australian Rangelands, fine material is placed as 'topsoil' in the final rehabilitation surface in an endeavour to achieve analogue style ecosystem re-establishment. Even if this level of ecosystem function is achieved, which is often not the case because of physical and chemical factors as discussed below, the vegetation contributes too little to surface stability to produce a sustainable landform. Proponents might operate in an area for decades and not experience or plan for the extent of erosive damage that occasional monsoonal influences can deliver.

2.1.2 Physical factors

Highly saline, sodic, hard-setting and acidic materials may look similar to topsoil and, once this material is broken down through the various mining processes, it is used as growth media in the Rangelands of Western Australia. Material which is primarily fines, with not well graded particles, and has a high water holding potential might be considered as good a material as a substrate below an armouring layer for root establishment. However, the rate of saturation may be so slow that it is very difficult to build up a store of plant available water and water generally flows in preferential pathways, forming erosion.

These problems can be easily identified and resolved with simple material characterisation. These materials are regularly used in rehabilitation in Australia. Where low stability or problematic material exist in significant proportion of the total waste volume, there is a major risk of rehabilitation failure. Not because the issues cannot be addressed, but because the responses need subtle understanding of material nature and careful management of material deployment. The mining industry struggles to demonstrate these subtle and careful characteristics consistently or through an entire mine life cycle.

2.1.3 Chemical factors

Chemically hostile material (acidic and neutral metalliferous drainage or highly saline or sodic materials) are the subject of comprehensive study and technical investigation. Irrespective of the potential to understand and manage these materials well, their existence, even in modest proportions, creates a significant probability that they cause problems during mine closure. Typically, even if these materials, and how to best manage them, is well understood, they are often used as construction materials, mixed in otherwise benign waste streams or sent to unplanned locations. Sometimes the encapsulation or neutralisation mechanisms used to manage the materials are well understood but not applied to the correct standard throughout the entire mine life cycle.

2.2 Motivation and organisational

Baseline conditions, such as the chemical and physical factors discussed previously, are usually the focus of where mine closure can go wrong. However, it is often more an issue of whether these issues are appropriately investigated and understood and the mitigations are resourced and consistently and faithfully applied. The following suite of contributing factors discusses the motivational and organisational forces which are often the background reasons behind technical and operational failures.

2.2.1 Consequence free corporations

Mining usually involves a permanent change to the landscape leaving a perpetual legacy (good or bad). But, corporate ownership or involvement in this process, particularly in Australia, is only transient. In Australia, a corporate entity can, at this time, divest an asset and liability package with little accountability for its performance in the long term. Companies can acquire large portfolios and divest the operations which do not fit their requirements or are seen to be coming to the end of their operational lives. Often these properties are taken up by smaller companies with fewer resources and, often less motivation, regarding corporate reputation. This is often beneficial for investment and business, but to the detriment of mine closure. If companies were responsible for long term performance of the site, the approach to due diligence, feasibility, design and construction in Australia would change dramatically. Some argue that the market, via a motivation to build and preserve reputation, mitigates this, however, observations do not bear this out in many circumstances.

2.2.2 Focus on near-term approval

Often at the centre of closure and rehabilitation failure is a feasibility study which is about securing investment and regulatory approval and not weighted towards critical analysis of long term risk and liability. Feasibility studies are often immensely complex, involve considerable pressure regarding the risk of slippage and have exposure to corporate and market influences, whereby entities need to “bring production on stream” and “meet market expectations” which they have often created. Studies are often led by production or engineering professionals who may have little exposure to mine closure, and who operate in fairly short time horizons. The commitment to more studies, resolution of issues during operations, or adoption of standards that are accepted elsewhere are common occurrences that can result in long term liabilities being overlooked.

In his book “Wrong”, David Freeman details how few scientific and journal papers are written which reach a negative conclusion to their hypothesis. Also, of those that are written, how few papers get published citing a negative conclusion. Researchers and academics do not get funding extensions or accolades for having proven their hypothesis wrong. And so, it is with feasibility studies. An ambitious professional with a large budget and a substantial team is quite prone to a certain bias in reviewing the vital statistics of a project. Sometimes, where individuals are raising serious concerns about the accuracy of inputs into project fundamentals, the response is to adjust figures after approval.

2.2.3 Wasted opportunities

During the construction and project development phase, investigation of opportunities, selective handling of pre-strip materials and the preservation of rehabilitation materials against use in construction are often overlooked. Hence, some of the most useful material for mine closure is wasted, buried, blended with hostile material and otherwise sterilised from future use. Some of the best opportunities to investigate closure management issues and build them into project development are actively avoided because cost reduction is seen as imperative at this phase of the mine cycle. Hence, various components of successful mine closure that were available at the outset, become sterilised from use. There are usually no mechanisms to ensure that inventories of materials mined early and needed for later rehabilitation activities are built up and preserved. Additionally, it is difficult to create mechanisms which ensure optimisation processes to promote successful mine closure that are undertaken during the design phase.

2.2.4 Short term accountability

The turn-over of management, technical specialist and operators is very rapid in the Australian mining sector, partly though the influences of fly-in fly-out operations. It is a culture of short cycle rotations through mining careers as managers, technical specialists and operators, regulators and consultants. Some mine sites in Australia have annual turn-over rates of 40 to 50% of their entire employee base. Some sites have experienced 100% turn-over, or more. Mine managers and corporate leaders can be in positions of considerable strategic importance for only one, two or three years and environmental professionals are likely to be only beginning to understand the complexities of environments experiencing a range of long term cycles when they depart to be replaced by fresh individuals.

A consequence of this rapid turn-over is a limited appreciation and understanding of strategic issues. Additionally, deferral of costly activities associated with closure and rehabilitation can shift responsibility to the next manager in that position. This also has a bearing on the degree to which miners engage with the local environment and community and, hence, how much they have invested personally in getting things right. A short term employee, with short term responsibilities, is less likely to invest considerable energies to meet long term commitments and obligations.

2.2.5 Long timeframes

Paradoxically, long time spans can also be a source of poor outcomes and a lack of strategic investment in closure planning. Many mine closures are ten, thirty or even seventy years away. Closure designs may be configured such that it is difficult to create full-scale demonstration trials with representative dimensions. Many professionals involved in project planning are not involved in further planning and design phases and subsequent implementation, and often an operational timeframe will exceed their own lifespan. This can lead to a consideration that closure issues are abstract and can be left to future managers. Much is made of designs which are conceptual and will be proven in the next planning cycle. Those preliminary or conceptual designs are not infrequently translated into the accepted approach without question in later eras of the operation.

2.2.6 Consequence free professionals and consultants

There is little, if any, consequence for managers, technical leads or consultants in the modern mining industry for poor performance in closure and rehabilitation management. Although some would argue that this is not the case. The mine manager, corporate leader, consultant or facility manager can be fairly assured that their careers or reputation will not be impacted by a failure to resource, understand and appropriately implement closure activities. The complexity and diversity of the industry and the myriad of factors contributing to mine closure failure can lead to a similar diminished responsibility mentality as seen in soccer hooligans. One's actions, or more usually one's inactions, can seem small in the collective mix of players and issues. Accountabilities are not often well drawn with regard to mine closure and it is much easier to commit failures of omission, which mine closure planning is much more prone to, than of active commission of mine closure planning errors.

2.2.7 The cost of inquiry

When it is expensive to find out news that is only likely to increase cost and difficulty, it is sometimes a challenge, understandably, to convince companies to invest heavily in finding out more bad news. For example, the understanding of the physical materials, their chemical behaviours in new drainage and weathering environments and the interplay between the biological and physical can involve a highly complex and often subtle interplay of factors which can require considerable research and investigation. The findings along the way may not always be clear cut and may often only indicate further investigation is required. These kinds of needs are often set against commodity and share prices which are fluctuating and under the management of leaders not accustomed to being accountable for long term research requirements. Unfortunately, some investigations do not deliver meaningful results if they are scaled down for cost management purposes.

2.2.8 The inaccurate liability estimate factor

In many cases, liability estimates for mine closure are not comprehensive and do not reflect the total costs of closure. Although there are a number of accounting standards which provide accounting methodologies for estimating liability for the mining industry, there is no authoritative, widely accepted technical estimating methodology for mine closure. This leaves estimates widely susceptible to interpretive processes. Many estimates grossly under-estimate the real cost of mine closure. For example, these aspects are often largely under-estimated in mine closure liability estimates:

- Post-closure water management costs.
- Third party earthworks costs inclusive of.
  - Contractor overheads and profits.
  - Accurate rehabilitation material acquisition and placement costs and volumes based on conditions and commitments.
  - Ancillary equipment.
  - Machine efficiencies calibrated to rehabilitation rather than production tasks.
- Post-closure monitoring.
- Post-closure investigation and reporting.
- Post-closure site management and maintenance.
- Insurance and lease holding costs.
- A realistic term of post-closure management.
- An appropriate level of contingency.

This inaccurate estimation of liability leads to a situation whereby the financial risks and costs do not have an appropriate influence on management and planning. Because mine closure estimates are often reportable externally in some form or another, there are business pressures to keep them as “modest” as possible. This means that they do not receive the management attention they deserve and the cost of earlier intervention appears higher against an unrealistically low closure cost.

2.2.9 The bond size and mechanism factor

Regulatory bonding and surety mechanisms do not always equate to an estimate of “fair value”, with respect to the relinquishment of the liability. Some bonds, as is widely acknowledged in Western Australia, are as low as 15–20% of the real cost of closure. Even when 100% closure costs are required to calculate bonds, these processes can suffer from the same methodological shortcomings of the liability estimating processes discussed previously. Further, the ability of larger companies to lodge bank guarantees rather than cash bond instruments, translates to a comparatively small annualised cost such that they generate relatively little motivation, when compared with the costs incurred of actual progressive closure, to retire the liability.

2.2.10 The net present value effect

Accounting treatments, such as Net Present Value (NPV), can contribute to poor closure outcomes, because the further out costs are, the more they can be discounted. This creates incentives to adopt assumptions which tend to involve processes that occur late in the mine life or post-closure, rather than resolving or mitigating issues in the near term. NPV creates a “fix it at the end” culture. An example of this is where positive water inventories of impacted water are allowed to build or be managed through the operations era with no active mitigation until closure, because it is more acceptable in the short term to apply NPV to water management costs in the distant future, than to invest capital and operating costs to mitigate the problem in the near term.

2.2.11 The stakeholders effect

Influential and informed stakeholders can frequently be one of the greatest indicators of mine closure success. Stakeholder engagement processes can be established which lead to transparency, rigour and peer review. Conversely, when mines are developed where there are few stakeholders, or where those that are involved lack influence over planning, approval or operations, this can be a reasonable indicator that mine closure may not be successful. Another effect on mine closure can be where stakeholders have unrealistic expectations with respect to the capacity of the landscape to support a desired outcome. This can lead to setting targets and criteria which are not achievable. Regardless, these expectations may be committed to during approvals focussed phases, and in some instances, with little intention to see that they are fulfilled.

2.2.12 Regulatory factors

Western Australia is a good example of a regulatory jurisdiction under considerable pressure to deliver approvals, often for large and complex projects, and sometimes with few technical precedents. This occurs in an organisational setting where the majority of regulators have comparatively much less experience and resources than those preparing approval documentation. Further, they are frequently required to review projects in the light of them being major contributors to state government budgets via royalties and taxation. To some extent, regulatory agencies and governments can compensate for these imbalances by generating considerable volumes of regulation. A large amount of regulations is not necessarily good regulation.

2.3 Technical factors

2.3.1 Covers

Significant effort has been expended in the advancement of covers for hostile mine waste materials. This is appropriate given the potential risks, yet it can become a tunnel vision approach to mine waste management. There are two fundamental issues with covers:

1. They will not last forever.
2. They do not perform uniformly and are prone to cracking, because of: root egress, differential subsidence, fauna egress and erosion, and that they are often constructed of heterogenic material by human error. However, their performance is usually predicated on uniform performance across the cover.

This is not to say that covers are a flawed concept, but that they should necessarily be part of an overall strategy to minimise risk. The strategic placement of materials from the outset, including careful use of neutralising material and the design of landforms that deeply encapsulated hostile material, should not be diminished based on a reliance on covers alone.

Put simply, in climatic conditions such as those discussed above, a comparatively thin layer of cover, even one that is well-conceived and constructed, will ultimately fail, at least locally, over the very long term (this may be less of an issue where much of the precipitation falls as snow). Under these conditions, difficulty in retiring mining legacies with this level of residual risk can be expected.

2.3.2 Modelling

Mine designs with few or no precedents and closure dates in the very distant future leads to a reliance on models, prediction and tools to support or justify a particular design which cannot be readily benchmarked. Modelling is used increasingly in slope design, hydrology and hydrochemistry (ground, pit and surface water) and also in cost-estimating. Of course, there is the ongoing problem of poor or inaccurate input into models resulting in inaccurate outputs. In some cases, inaccuracies can be magnified via the model to create strong confidence in what will end up being an entirely incorrect assumption. This may not necessarily be from a lack of care or interest on the part of the modeller or the proponent. It can be difficult to model complex, real world situations. Sometimes the acquisition of accurate information appears prohibitive. Additionally, when the first output of modelling scenario is a comforting and convenient answer, or an answer people have come to accept, there may be a reluctance to review or investigate the answer further. Models can be highly sensitive to two or three key inputs. This can make them subject to manipulation at worst, and optimism bias at best.

Risk assessments should include the consideration that the outcome of a modelled scenario is inaccurate, and the consequences of this on the mine and mine closure be measured and understood. This is important, given that the likelihood of a model being wrong is at least probable, if not likely.

2.4 Management factors

2.4.1 Fit for purpose construction

Often a sound closure concept, with reasonable designs and approaches, is in place. However, problems can sometimes arise if a mine fleet that is not fit for purpose, with operators and supervisors having little experience in mine closure and rehabilitation is charged with implementation of the closure works. Additionally, where there is a culture more focussed on volumes moved and rate of completion, than quality control, responsiveness to material types and the need to adjust to local circumstances, failure of closure and rehabilitation outcomes is likely. Essentially, mine closure is a construction activity and should be undertaken with civil engineering and a construction mentality and workforce. Too often, because it occurs at a mine site at the end of a mining operation, the wrong machinery, team and approach is used. It is difficult to indicate to contractors, or even owner mining operators and supervisors with long tenure at a mine, that they are not the right fit to close the mine, however this is often, although not always, the case.

2.4.2 Failed precedent

Often a failed precedent will be used to generate landform designs. This is partly because the failure can occur over the long term and failure is fairly subjective. Many proposals are based not on what has succeeded, but on what has been accepted or approved in the past. This was the case for many years in Western Australia with landform designs defaulting to a government guideline because this was treated as if it were a standard. Irrespective of how poorly this approach performed, it continued (and continues) to be the accepted approach for many companies, irrespective of the weight of evidence against it.

2.4.3 Complex systems

Many large miners can produce large and complex systems, procedures, baseline studies and guidance documents for mine closure and rehabilitation. This may indicate that closure and rehabilitation is taken seriously and delivers positive mine closure outcomes. However, it may also indicate that they are adept at producing voluminous and complex systems and documents. The more complex, onerous and difficult it is to implement a system, it may be more likely to be ignored. Complex and bureaucratic arrangements can be seen by large companies as a hedge against closure failure. In fact, the reverse can be true. Environment and rehabilitation professionals become administrators and bureaucrats rather than project managers and those driving and influencing change based on direct technical and operational experience.

2.4.4 Action without a plan

Companies often spend millions of dollars each year producing rehabilitation outcomes which have no chance of success, applying the same techniques as the previous year’s work, which may already be showing signs of failure. The motivation behind this may be to demonstrate progressive rehabilitation to the regulator and community. Sometimes large rehabilitation budgets can be forecasted and, perversely, miners will feel the need to spend this in order to meet expenditure projections. Or a contractor which is unable to progress their primary production task is deployed to do mine closure and rehabilitation work. Where there is a robust plan, good supervision and a learning feedback loop, this may produce positive outcomes. However, this is often not the case, and works are completed based on conceptual plans, failed precedents or the favoured approach of a single consultant. In these circumstances, designs may not be faithfully fulfilled and the work is undertaken to a poor standard of construction.

3 Strategies to mitigate

At some sites, many factors and combined effects may be in play, resulting in the failure of mine closure. For those operating in highly sensitive environments, through agricultural areas, near communities, with long term professional and experienced operations personnel, with good corporate and regulatory controls, the aspects described in this paper may be somewhat unfamiliar and sound unlikely or unreasonable to suggest that these factors contribute to the failure of mine closure in the modern mining industry. However, they can be observed in multiple current operations and the outcomes of such failures can be seen widespread across Australia.

There is a range of strategies to mitigate these more nebulous contributing factors. Solutions need to strike at the heart of the motivational, technical and management contributing influences and respond to the tendencies to delay, rely on commitments and finesse the fundamentals. Three aspects of mitigating strategies are discussed below.

3.1 Perpetual legacy

One consideration for mitigating closure failure is that those who generate a perpetual liability be perpetually accountable for it. It might be argued that this will be a disincentive to investment, but perhaps those who wish to make consequence free investments are not the investors societies really want to have engaged in large-scale ground disturbance and perpetual legacy generation. If a corporate entity, which either acquired or created a disturbance impact was accountable for it, or could be made accountable for it, wherever the current owner or the accountable party did not have the resources to respond to the legacy impacts, the approach to due diligence, liability estimating, design, construction and technical rigour would improve dramatically. If miners are not comfortable with perpetual accountability, perhaps their level of confidence in their capacity to close a mine is not a robust as it needs to be.

3.2 Demonstrated practice and process benchmarks

There is a great deal of mine closure planning which occurs in feasibility phases and then flows onto approval whereby either in dimensions, scale, or management approach, there are no precedents either locally or in some cases, globally. More commonly, there are successful precedents but these are not investigated or understood. Those managing feasibility studies may not be concerned by this, as development of final built structures is in a distant future (which may only be a couple of years away).

Improved accountability would be generated if those proposing final landforms and legacy structures were required to present the understanding and investigation of robust benchmarks that demonstrate that the approach and practice has been used and is effective. An understanding of the processes and mechanisms through which this benchmark was achieved should also be demonstrated; as should the capacity and resources to deliver the outcomes via processes and methodologies which have succeeded elsewhere.

Miners would need to start to look around more broadly than their own companies or projects and try to understand what has worked and what has not in relevant analogue mine operations. Proposals would be based on what has succeeded rather than what has been accepted**.** The processes by which successful mine closure is achieved would be investigated, discussed and distilled into a commitment structure based on proven performance.

3.3 Critical analysis peer review

There are many examples of closure projects that have failed and which, if the entire lifecycle costs were understood, should never have been commenced, as they were simply a bad investment. The returns to the market may not be there, but operators sometimes externalise closure costs so that they are borne by communities and the environment, and not the corporation or investors. It is rarely the case that these failures in planning and risk identification could not have been identified in the early stages of planning. Also, due to the continual scaling up of our industry, demonstrated performance benchmarks do not always exist.

The reason mine closure failures occur is often partly due to review processes which are not critical and rigorous. The New Zealand experience is a good example of how third party peer reviews can be used to give interested parties assurance that the feasibility studies, design approaches and techniques are robust with respect to closure planning. To really test an idea, it needs to be challenged.

As with the peer review processes for science, mine projects incurring closure impacts should have acknowledged discipline experts review proposals in detail and at routine intervals. These reviews might be paid for by the proponent but the experts would be selected by and report to the party requiring the review. This might be the regulator, the financial backer, or a joint venture partner, or a group of stakeholders. If mining companies really had confidence in their closure plan they would be comfortable exposing them to thorough peer review.

This may lead to slower development timeframes, more expensive mine development and indeed in some cases, potential projects being abandoned. Ironically, it would save mining companies and investors a great deal of money and resources in the long term through the avoidance of long term, and in some cases, perpetual legacy which could be avoided through critical analysis and strategic management.

4 Conclusions

Corporations and human beings are not strong on critical analysis that looks inward or over long timeframes. We are all pretty good at critiquing others but dispassionate inventory of our own faults and failings, particularly the strategic, is rare. When such processes occur they are very often skewed by interests, agendas and an undeniable, wilful blindness and optimism that humans and their collective entities are prone too. Mining companies interested in long term performance will be interested in utilising the wealth of good performance benchmarks and practices and will be comfortable to submit to rigorous review. They will be comfortable committing to long term accountability if their plans fail.

Technical issues may often seem to be the primary cause of much mine closure failure. But it is often the human, corporate, organisational and regulatory factors which create an environment whereby these technical failures can persist. An awareness of these factors can at least help one contextualise the mine closure process in terms of the various risks and influences, even when, in some cases, they are difficult to mitigate.